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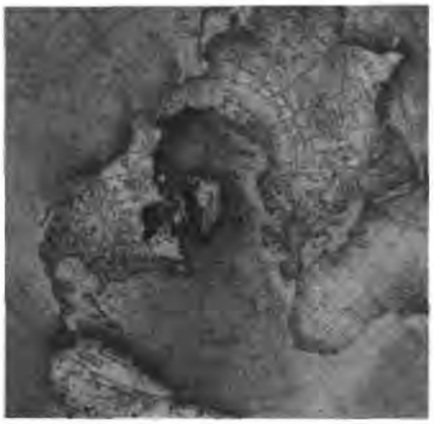
Errata

Table 1-4 and page 19 in Dataquest's *Competitive Markets in Semiconductors, 1997* (SEMI-WW-CT-9801) have been revised. Please insert the enclosed corrected pages in your document and place this letter in the pocket of the binder.

Dataquest regrets the error and apologizes for any inconvenience. For further information, contact Principal Analyst Mary Ann Olsson at (408) 468-8674 or at mary.olsson@gartner.com.



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Dataquest Focus Report: The Asian Financial Crisis

Focus Report

Program: Semiconductors Top Views
Product Code: SCND-WW-FR-9801
Publication Date: January 26, 1998
Filing: Top Views

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Chapter 1
Executive Summary

In this Focus Report, Dataquest has assembled a worldwide team of experts to offer their views on the ongoing Asian financial crisis. There are five viewpoints presented: the Korean regional and Korean DRAM perspectives, a focus on China/Hong Kong, insight into the impact of the crisis on the region's PC market, and discussion of its effect on capital spending.

Analysis of the Korean regional situation suggests that the worldwide DRAM recession is one of the reasons for the Korean financial crisis. DRAM pricing is predicted to fall further if the Korean, Taiwanese, and Japanese currencies continue to slide against the U.S. dollar.

Dataquest believes that China/Hong Kong will not be impaired in the short term by the crisis, but it faces long-term challenges. Although China/Hong Kong's long-term semiconductor forecast has been lowered, it will still account for 26 percent of Asia/Pacific consumption by 2001.

Analysis of the PC market provides insight into the early impacts of currency devaluations in the region on the personal computer industry and suggests that the outlook for recovery has shifted from the near term to the long term for Thailand, Indonesia, and Malaysia, with the Korean economy possibly beginning to turn around earlier.

The Asian financial crisis will affect capital availability and spending in semiconductors. Because of the severe depreciation of the Korean currency, Dataquest now forecasts that Korean companies will cut capital spending in 1998 about 40 to 60 percent, relative to 1997, in dollar terms.

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Chapter 2
Introduction

The beginning of summer 1997 saw the devaluation of the Thai baht amid escalating difficulties in the Thai banking and finance community, which forced the Thai government to finally surrender to the currency speculators. At that time, few people, if any, would have predicted this to be the start of a financial storm, sweeping throughout Asia, with far-reaching global implications.

Shortly after the Thai baht devaluation, the governments of Malaysia, Indonesia, and the Philippines succumbed one by one to the speculative currency attacks. The rapid currency devaluation sent shock waves through the regional stock markets of Thailand, Malaysia, Indonesia, and the Philippines. Singapore and Hong Kong, which remained largely unaffected initially, saw their stock markets tumble in October amid growing investor anxiety.

The financial crisis deepened in November as it spread to Korea and Japan, the world's 11th-largest and second-largest economies respectively. The value of the Korean won dropped sharply, along with Korea's stock market, after the Korean government gave up its battle to prop up its currency in November. A $57 billion rescue package led by the International Monetary Fund (IMF) was negotiated for Korea, after $40 billion and $17 billion were negotiated for Indonesia and Thailand, respectively. In the meantime, Japan saw the closure of its fourth-largest securities firm, Yamaichi Securities Co., on November 24, following the closure of Hokkaido Takushoku Bank, its 10th-largest commercial bank, a week earlier. On December 22, the Nikkei average closed below the psychologically important 15,000 mark for the first time since July 1995.

The beginning of 1998 brought fresh hope to Korea as global bankers agreed to roll over Korea's short-term debt and started to work on a massive debt restructuring to keep the country from defaulting on its loans. This occurred after Korea's president-elect, Kim Dae-jung, reaffirmed his country's commitment to the economic reforms. Contrary to that hope, the situation in Southeast Asia took a dramatic turn for the worse as the regional currencies and stock markets recorded successive new lows, triggered by Indonesia's announcement of a fiscal budget perceived not to be in line with IMF-mandated reforms. On January 12, Peregrine Investment Holdings Ltd., Hong Kong's once high-flying financial power house, filed for liquidation after the company incurred substantial losses from its Indonesian bond operations; the news of the collapse sent the Hang Seng Index plunging 8.7 percent in that day.

Table 1-1 displays the extent of the depreciation of Asian currencies against the U.S. dollar between June 1997 and January 9, 1998. The Hong Kong dollar is the only currency in the region that has withstood the speculative attack so far. The hardest hit have been the Indonesian rupiah, the Thai baht, and the Korean won, which have all lost more than half of their values.

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Table 1-1
Depreciation of Asian Currencies against the U.S. Dollar between June 1, 1997, and January 9, 1998 (Percent)

Currency	Depreciation (%)
Indonesian Rupiah	69.3
Thai Baht	54.3
Korean Won	50.8
Malaysian Ringgit	45.3
Philippine Peso	40.9
Singapore Dollar	19.6
Taiwan Dollar	18.9
Japanese Yen	13.1
Hong Kong Dollar	0.1

Source: Dataquest (January 1998)

The dramatic decline of the currency values combined with the downfall of the local stock markets will have serious impact on the region's economy and, subsequently, the world economy. To analyze the potential impact of the Asian financial crisis, experts from Dataquest's worldwide research operations offer their views on this issue in this Dataquest Focus Report.

There are five viewpoints presented in this report. The Korean regional and Korean DRAM perspectives, respectively, are presented in Chapter 3, by J.H. Son, and Chapter 4, by C.S. Kim, Jerry Yeh, Jim Handy, George Iwanyc, and Clark Fuhs. Chapter 5, by Dan Heyler, focuses on China/ Hong Kong. Chapter 6, by Bruce McCabe, and Chapter 7, by Clark Fuhs, provide insight into the impact of the crisis on the region's PC market and capital spending, respectively.

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Chapter 3
The Korean Regional Perspective

Introduction

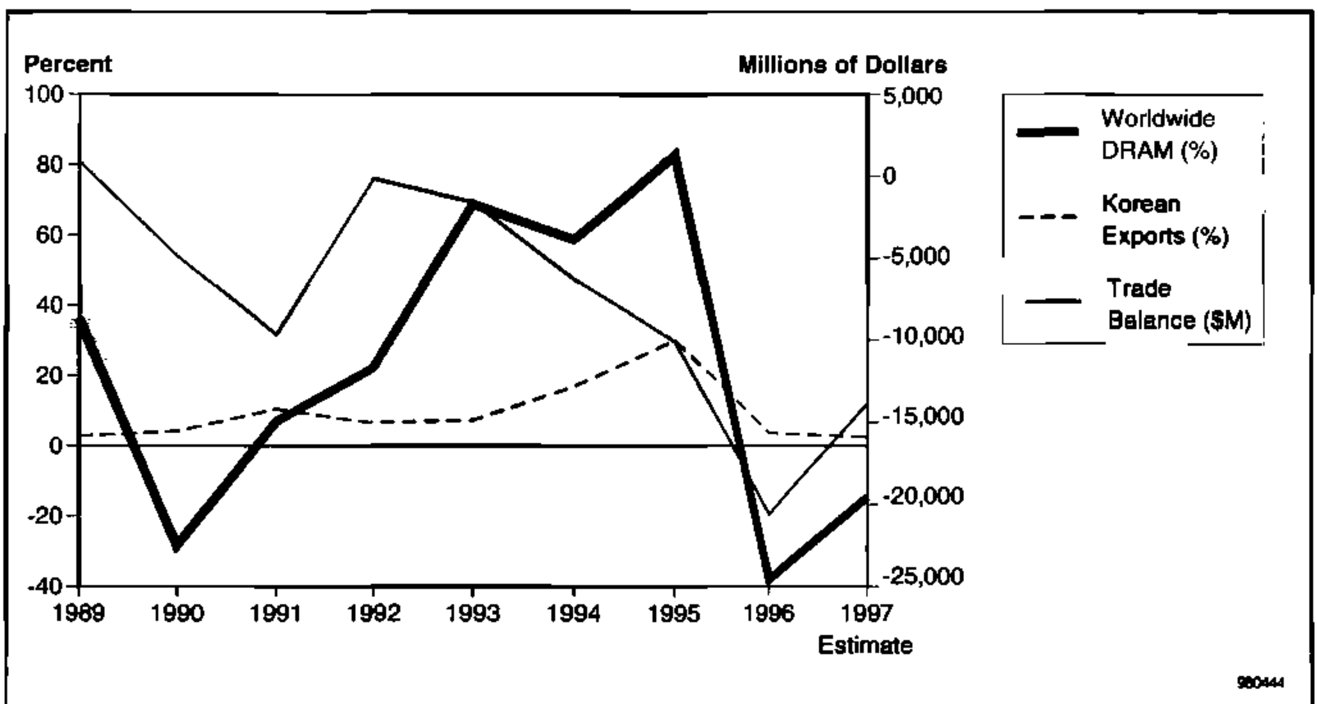
This chapter offers a Korean regional perspective on the reason behind Korea's financial crisis. It argues that the worldwide DRAM recession is one of the reasons for the Korean financial crisis. The impact of the financial crisis on the Korean semiconductor market is also discussed.

Why Did Korea's Financial Crisis Occur?

Figure 3-1 shows the relationship between worldwide DRAM revenue growth and the export growth of Korea. The two elements showed no correlation until the end of the 1980s. After 1990, however, as DRAM became one of Korea's major export items, these two elements started to show a strong correlation.

Korea's exports were solid until 1995. However, Korea's total trade balance was still negative. This means that the semiconductor surplus covered most of the other industries' deficit. In 1996, however, the semiconductor business flagged because of DRAM's drop in prices, so that it could no longer cover the other industries' trade deficit. As a result, a $20.6 billion negative trade balance was recorded in 1996 alone. The drop in DRAM prices continued in 1997—as of the end of September 1997, a $10.6 billion negative trade balance had already been recorded. The cumulative negative balance from 1994 is estimated to be about $50 billion. This amount is very similar to the IMF loan.

Figure 3-1
Relationship between Worldwide DRAM Revenue Growth Rate and Korean Export Growth Rate



Source: Dataquest (January 1998)

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Korea's financial crisis might stem from the worldwide DRAM recession. Comparing the data for semiconductor statistics with Korea's trade balance of Korea offers some support for this assertion. This cannot be the only reason, but Dataquest believes that it is one of the factors generating Korea's financial crisis.

In 1995, Korea had an $8.8 billion trade surplus in semiconductors by virtue of its good DRAM business. At that time, Korea's total trade deficit was only $10.1 billion. In 1996, however, Korea's semiconductor surplus had shrunk to $0.4 billion, a reduction of $8.4 billion from the surplus in 1995. In the same year, the total trade deficit was $20.6 billion, an increase of $10.5 billion over 1995. The reduced semiconductor surplus of $8.4 billion in 1996 was a major contributing factor in the trade deficit of $10.5 billion, as shown in Table 3-1.

Table 3-1
Total Exports and Imports and Semiconductor Exports and Imports for Korea, 1995 through 1997 (Millions of Dollars)

	1995	1996	Change, 1995-1996	First Nine Months of 1997
Total Exports	125,058	129,715	4,657	99,709
Total Imports	135,119	150,339	15,220	110,094
Balance	-10,061	-20,624	-10,563	-10,385
Semiconductor Exports	17,643	15,293	-2,350	12,746
Semiconductor Imports	8,887	14,855	5,968	9,465
Balance	8,756	438	-8,318	3,281

Source: Dataquest (January 1998)

Actually, the financial crisis in Korea dates from the beginning of this year. The key reason for it is the cumulative trade deficit of many years. Many chaebol (conglomerate) companies started to fail, beginning with Hanbo Iron and Steel, and followed by Sammi Steel, Jinro, Kia Motors, New Core, and Halla, among others. Many small and medium-size companies followed the lead of the chaebols and fell also.

The chaebol companies failed in this financial crisis because of their weak financial structures. Most of the companies have capital ratios of under 20 percent. There are many under 10 percent. Tight money controls in this crisis caused the downfall of many companies.

Impact of the Asian Financial Crisis on Korea's Semiconductor Market

Most of the Korean semiconductor companies will reduce their capital spending plans in 1998 to 40 to 60 percent of their 1997 level. Also, many projects will be delayed, including overseas projects. This reduced capital spending will influence mostly 64Mb and 256Mb DRAM production capacity. Korea's 16Mb and 64Mb DRAM production lines will be less affected because, for most 16Mb and 64Mb DRAM lines, investment had already been completed or is in the final stage of the pipeline. Korea will likely lose some market share, and Taiwan semiconductor companies will likely gain. Korean semiconductor companies will invest less for capacity expansion than to increase yield or reduce chip size. As one more way to reduce capital spending, they may try to upgrade their old fabs using an isolated "minienvironment" automation system.

Samsung Electronics Company Ltd.'s direction under this crisis is to suspend capital spending for capacity expansion. Instead, the company will increase productivity by reducing chip size and increasing yield. Samsung's 1998 capital spending will be about 40 to 60 percent of its 1997 level. Hyundai Electronics Company Ltd. has also decided to reduce its 1998 capital spending plan. LG Semicon Co. Ltd. is trying to minimize its capital spending. Anam Semiconductor has decided to delay its second fab investment. Dongbu Group has proceeded with its license with IBM and has already started plant construction. But the company seems to be in a dilemma now as to how to deal with this financial crisis, because there is no funding for this facility.

All overseas semiconductor projects are facing a crisis, also. Samsung's Austin, Texas, plant and Hyundai's second Eugene, Oregon, plant will be delayed, perhaps by more than a year if this financial crisis continues. Hyundai's Scotland project and LG Semicon's Wales project are likely to be delayed, but as yet no company has announced clearly the future of its overseas plants.

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Chapter 4
The Korean DRAM Perspective

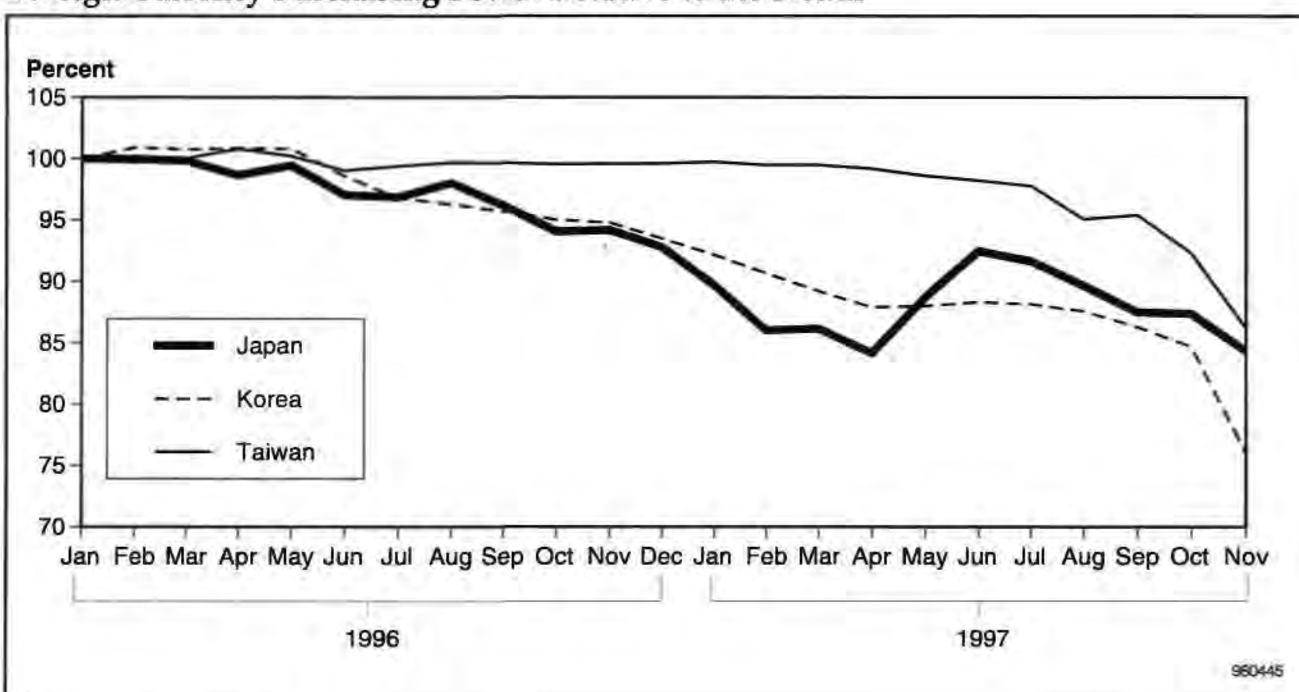
Introduction

This chapter discusses the impact of the Korean financial crisis on the worldwide DRAM market. DRAM pricing is predicted to fall further if the Korean, Taiwanese, and Japanese currencies continue to slide against the U.S. dollar.

The Impact on the DRAM Market of the Korean Financial Crisis

South Korea and the International Monetary Fund have agreed to a rescue package totaling $57 billion. South Korea agreed to implement IMF-recommended measures to revitalize its faltering economy in return for accepting the bailout. Even with the agreement, there are fears that the rescue may not succeed and that Korea's links to other Asia/Pacific countries may endanger those countries, as well. Figure 4-1 shows foreign currency purchasing power relative to the dollar.

Figure 4-1
Foreign Currency Purchasing Power Relative to the Dollar



Source: Dataquest (January 1998)

Given the stringent management and restructuring requirements of the IMF bailout, the Korean semiconductor industry is planning to cut capital investment by 40 to 60 percent over last year. Korean DRAM manufacturers fear that their cutbacks could result in a drastically dwindling share of the world market, with market share lost particularly to Japanese and Taiwanese companies. The threat of shrinking market share is something Korean DRAM manufacturers haven't been accustomed to; they have enjoyed steady market share growth since 1990.

Samsung, currently the world's leading DRAM producer, is expected to implement a 30 percent cut in overall investment and is considering further cuts in coming weeks. Samsung's plans are to earmark W800 billion to W900 billion for semiconductor and LCD investment next year and W400 billion to W500 billion on research and development. LG Semicon and Hyundai are also cutting back investment. LG Semicon plans to lower investment by 30 percent, or W1.05 trillion to W1.10 trillion for next year, and Hyundai is considering a 40 percent cut. As with Samsung, both LG Semicon and Hyundai have yet to make their investment plans final.

What impact will these cutbacks have on projects already under consideration? LG Semicon is expected to delay the construction of its second LCD plant in southern Korea. LG Semicon and Hyundai are re-examining their plans to construct DRAM fabs in the United Kingdom, although both expect to go ahead with plans as scheduled. Most expansion plans for DRAM fabs in the United States by Samsung, LG Semicon, and Hyundai are expected to be suspended. Dongbu, which earlier this year announced plans to enter the semiconductor industry, decided to postpone this indefinitely, citing difficulties in borrowing money.

It will take one to two years for next year's cutbacks in Korean investment to make a significant impact on company market share and DRAM industry capacity. There is more than enough capacity already to support current demand, and as all manufacturers continue to shrink their 16Mb and 64Mb devices, industry overcapacity will continue through most of 1998 and possibly into 1999. To put device die size into perspective, the average die size of 16Mb DRAM at the end of 1998 will be 60 percent of the average die size of 4Mb DRAM at the end of 1995.

Taiwanese DRAM manufacturers will have a significant impact on when the market comes into balance. If Taiwanese companies continue with their aggressive expansion, the equilibrium point may be pushed out three to six months, well into 1999. Before the IMF actions, the Taiwanese companies planned to increase capital spending in local currency (NT dollars) by 10 percent. In U.S. dollar terms, this may actually represent declining capital spending because of currency devaluation (more on this later). The Korean cutback in spending may encourage Taiwanese DRAM vendors to accelerate investment in an effort to take market share away from the Koreans. If Korean companies cut their capital spending as indicated and if Taiwanese companies continue with their capital spending plans for foundry, memory, and joint ventures, Taiwan may surpass Korea in capital spending in 1998. However, not all Taiwanese DRAM vendors are expected to increase capital spending—at this time, Mosel Vitelic Inc. and Powerchip Semiconductor Corporation are expected to decrease their capital spending in 1998, and others may follow.

Dataquest believes there is a good possibility that Taiwanese manufacturers will not implement their aggressive capital spending plans. The Taiwanese companies are newcomers to the DRAM industry and haven't experienced prior industry downturns. As they gain experience in the current downturn, they may decide to stop DRAM spending abruptly. This will come with the realization that, while aggressive expansion will buy market share, it will also lengthen the DRAM industry downturn.

On top of all the changes in Korea's financial situation and the long-term effects of the IMF bailout plan, there is also the short-term phenomenon of a currency devaluation adding to the problem. Korea, Taiwan, and even Japan have seen the value of their currencies slide dramatically in relationship to the U.S. dollar as well as against European currencies.

Normalized to January 1996, an item with a fixed local currency price that could be purchased in the United States for $1 in January 1996 could be purchased in November 1997 for $0.84 if it came from Japan, $0.86 if it came from Taiwan, and $0.76 if it came from Korea. Of course, DRAM per-megabyte prices descend at a relatively steady rate (28 percent per year), but the effects of currency rate changes layer on top of this. If the manufacturing cost, measured in won, of a Korean DRAM drops at 28 percent per year over the course of 1997, and if in that same time the won dropped 20 percent (which it did), then the minimum price that could be charged for that DRAM in the United States without triggering antidumping measures would have dropped 42 percent! This implies that there should continue to be exceptional price slides for DRAMs from Japan, Korea, and Taiwan into the United States and Europe. This has a great impact on the worldwide market because, in 1996, Japan, Korea, and Taiwan had a combined share of 77 percent of the DRAM market, and DRAM consumption in the United States and Europe accounted for 56 percent of the world market.

This, though, is not the end. The November average tells only a part of the story. As of December, the won had dropped to 54 percent of its January 1996 level. The end of the drop is not in sight today. Korean manufacturers accounted for only 34 percent of 1996 DRAM sales, so the impact of the price slide will not perfectly match the exchange rate drop times normal DRAM price declines. The effect will be less than this; however, it will be important!

In short, DRAM prices, which have been falling at a rate based largely on the cost of manufacture, should continue to fall faster than this rate as long as Korean, Taiwanese, and Japanese currencies continue to slide against European and American currencies.

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Chapter 5

Semiconductor Market Forecast: The Impact of Asia/Pacific's Currency Crises on China/Hong Kong

Introduction

Shifting the focus from Korea to China/Hong Kong, this chapter looks at the impact of the Asian financial crisis on electronic equipment assumptions and semiconductor consumption in China/Hong Kong. Dataquest has lowered its regional forecast for 1997 from 15 percent to 8 percent growth. Dataquest believes that China/Hong Kong will not be impaired in the short term, but it faces long-term challenges. Although China/Hong Kong's long-term semiconductor forecast has been lowered, it will still account for 26 percent of Asia/Pacific consumption by 2001.

Asia/Pacific and China/Hong Kong Forecasts

Prior to the financial havoc that has rocked Asia/Pacific's currency markets, Dataquest had lowered its forecast of 1997 electronic equipment production in Asia/Pacific from 17.4 percent to 14.9 percent. Dataquest's October Asia/Pacific semiconductor market forecast was lowered to 8 percent from 14.6 percent. Weaker growth was caused by slower second-half growth exacerbated by the currency crisis during the fourth quarter. Forecasts of electronics production and semiconductor consumption in China/Hong Kong were both lowered insignificantly by about 1 percentage point to 17.8 percent and 14.9 percent, respectively.

Dataquest expects that 1998 will have a higher level of growth than 1997 across the region. Helped by a long-awaited worldwide recovery in the second half of the year, memory prices should have, at long last, bottomed out. Korean and Japanese capital constraints should help to curb fab expansion and alter cutthroat pricing strategies to improve margins.

Figure 5-1 presents Dataquest's regional, country-level forecasts of semiconductor consumption from 1997 to 1999. China/Hong Kong's semiconductor market, helped by the combination of a strong PC industry and memory pricing improvements, will grow by 23 percent in 1998 and 31 percent in 1999. Critical to this high-level growth is also the performance of China's electronics output, which Dataquest assumes will grow by 20 percent in 1998 and 18 percent in 1999. At the top level, industry growth is the result of broad-based equipment investment, active foreign investment in the market, strong and steady local consumption, and competitive electronics exports.

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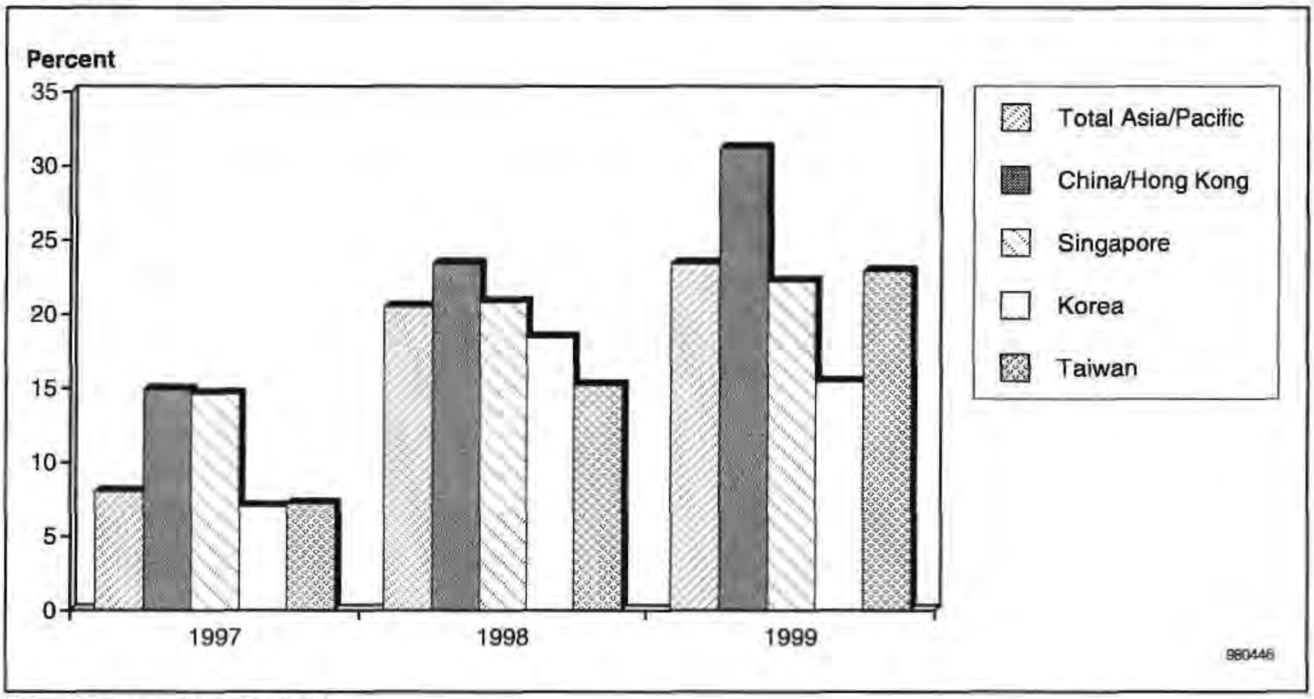
Figure 5-1
Forecast of Semiconductor Consumption Growth by Region in Asia/Pacific, 1997 to 1999 (Percent)



Source: Dataquest (January 1998)

Impact of Currency Depreciation

Dataquest understands the importance of stable financial markets to long-term economic prosperity in the region. But financial markets do not necessarily reflect the fundamental characteristics of the electronics industry's health. The impact of currency volatility needs to be viewed in the context of fundamental industry issues. Dataquest views the following electronics industry and semiconductor market fundamentals as key drivers potentially affected by the currency crisis:

- Slower growth experienced in the second half of 1997 is the result of decelerating exports to key export markets, including Europe, Japan, and North America and, to a lesser extent, slower growth within Asia/Pacific's developing domestic markets.
- There is a short-term effect on manufacturers in currency-depreciating countries that are struggling to make payments and order commitments to suppliers of semiconductors and other components.
- Local consumption has slowed in numerous countries, and deflationary forces have become more pressing. Because a small percentage of Asia/Pacific electronics production relies on Asia/Pacific consumption, the slowdown in local consumption of end equipment has a negligible impact on total production. Nevertheless, industry observers are watching the Japanese and Korean end-equipment markets carefully. Dataquest sees a direct impact of these large markets on Asia/Pacific electronics exports, especially Japan's imports of PCs from Taiwan.

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The degree of the currency devaluation's impact on electronics companies depends, in part, on the percentage of semiconductor components imported by manufacturers in Asia/Pacific. Southeast Asian countries such as India, Indonesia, Malaysia, the Philippines, and Singapore rely almost entirely on foreign suppliers. However, the bulk of electronics production comes from the multinational companies (MNCs) that have relocated production from Europe, Japan, Korea, North America, or Taiwan. The advantages of the MNCs in Asia/Pacific is their ability to secure long-term global procurement contracts in U.S. dollars that buffer currency fluctuations.

Manufacturers in Asia/Pacific, which are part of conglomerates, also manufacture semiconductors that may use internally transferred semiconductors and therefore are not directly affected by currency fluctuations. Japanese consumer electronics manufacturers rely heavily on internally transferred components. In both cases, a major portion of costs are fixed. Export revenue then increases for the same units of goods shipped because more local currency is received for the same U.S. dollar export price.

Stronger Exports Likely to Make Up for Slower Domestic Consumption

Dataquest's long-term forecast of semiconductor consumption by region is shown in Figure 5-2. It shows Asia/Pacific's high growth relative to other worldwide regions but with significant country variances.

In 1997 and 1998, Asia/Pacific's electronics industry as a whole will become more competitive in exports because of devalued currencies. Export markets will continue to be the key to the region's high semiconductor consumption growth rates because of the immaturity of the region's end-equipment markets that are a percentage of the gross domestic product (GDP). Dataquest's electronic equipment and semiconductor forecasts assume a 3 percent to 4 percent economic growth in the United States in 1998 and 1999 and a modest economic recovery in Japan. Weakened industrial growth in Japan and Korea, as well as Asia/Pacific's lower cost base, will continue to benefit Southeast Asia's electronics industry (as has been the case for 10 years).

Singapore Sustains Growth

The China/Hong Kong and Singapore markets will grow by about 15 percent in 1997. Singapore has not experienced the negative short-term effects of currency depreciation because its production is dominated by MNCs that operate global procurement organizations. Real GDP in the third quarter of 1997 rose 10.1 percent, and this growth was fairly broad-based. As reflected in the forecast, a weaker currency may have a long-term positive effect by lowering export costs, Singapore's lifeblood, assuming import component costs increased less, proportionately.

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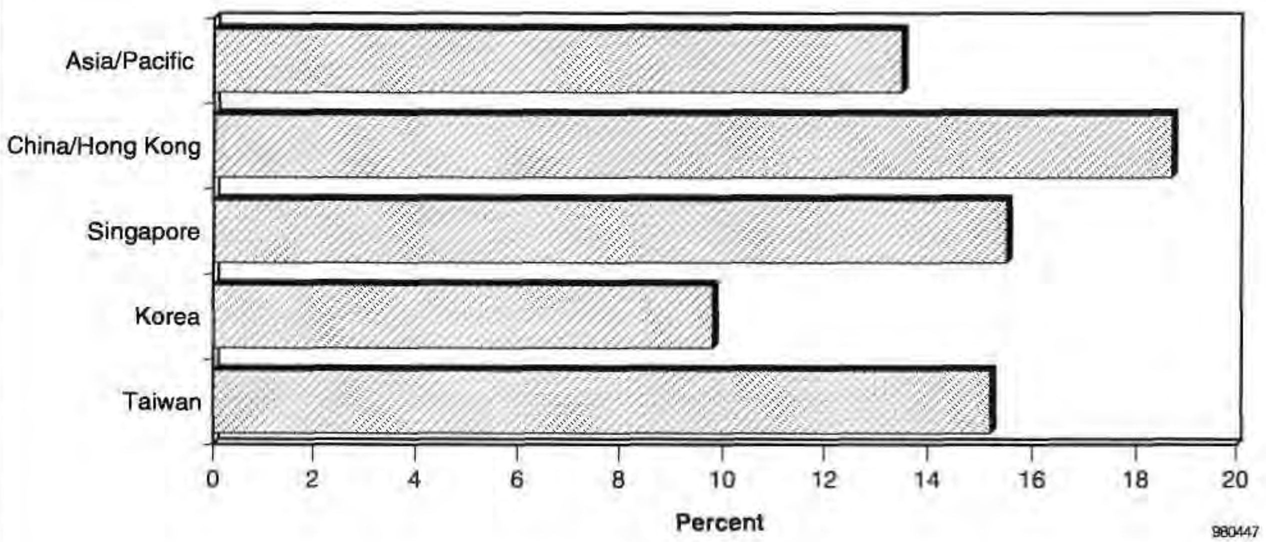
Figure 5-2
Long-Term Forecast of Semiconductor Consumption by Region in Asia/Pacific, 1996 to 2001 (Compound Annual Growth Rate)



Source: Dataquest (January 1998)

Taiwan's Fundamentals Are Still Strong

Anticipated slower growth in Taiwan in 1996 to 1998 is attributable more to memory price erosion than to currency depreciation because memories represent 46 percent of Taiwan's semiconductor consumption. Dataquest believes that Taiwan's economy and financial institutions are fundamentally strong, and GDP growth is forecast to exceed 6 percent in 1998. Dataquest also expects electronic equipment production to show the second-fastest growth in Asia/Pacific from 1997 to 2001. Dataquest, therefore, forecasts a strong semiconductor market in Taiwan in 1999 because of an anticipated recovery in its memory market.

Tighter capital markets will help control capacity spending primarily in Korea and Japan, but to a lesser extent in Taiwan, which shows a higher level of liquidity than the rest of Asia. Overall, it is likely that the crises in Korea and Japan will have a positive effect on memory pricing in the longer term, after late 1998 and in 1999. In segments where Taiwan competes directly with Korea, such as DRAMs, companies may face severe competition from Korean suppliers that now have an exchange advantage. However, note that most business is conducted in U.S. dollars, and prices are rising because of the lack of cash and capital in Korea's chaebols.

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Korean Market Faces Structural, Not Cyclical, Problems

As shown in Dataquest's long-term regional semiconductor market forecast, the weakest market will be Korea from 1998 to 2001. Korea will have trouble increasing exports enough to compensate for the huge increase in its debt-service ratio. When the won drops, the debt-service ratio increases on a one-to-one basis, but exports will not increase on a one-to-one basis. Furthermore, electronic equipment exports will continue to suffer because of a lack of new, higher-margin products and because of falling profits exacerbated by a global consumer electronics slump. On top of these problems, the currency crisis affects these conglomerates insofar as they are dependent on imported semiconductor components. However, the free-falling won makes exports much cheaper—but only if prices are not raised to cover increased component costs. The lack of a diverse component supply base, as seen in Taiwan and Japan, makes the structural nature of Korea's problems more severe. Korean electronics manufacturers have been shifting production offshore in an attempt to develop new markets and increase competitiveness.

China/Hong Kong Is Still the Rising Star, but with Challenges

Dataquest believes that the currency and financial market problems in Asia/Pacific have more to do with speculative "bubbles" in property, construction, and semiconductors than to fundamental economics and manufacturing efficiencies. China and Hong Kong are not immune, but they seem to be dealing with these bubbles more effectively by popping them before they get too big. China's economic czar, Zhu Rongji, successfully burst the stock market bubble, property bubble, and construction bubble in 1996 and 1997. After October's Party Congress, he is now more empowered than ever to pop the next speculative runs, whatever they may be. Next year, he will be promoted to prime minister. Zhu's charter is to fix the state-owned enterprises to avoid overwhelming the financial system with bad loans. If China slacks off, it will face serious problems, potentially worse than those of Korea. Korea's lessons are being learned by others, and China can avoid this kind of crisis (having U.S.$200 billion in combined reserves with Hong Kong will help, too). A strong U.S. and European economy will be critical to China and the rest of the Asia/Pacific region.

As with Russia, a nonconvertible currency does not necessarily insulate China from possible depreciation. Several years ago, China devalued its renminbi and may have to do so again sometime next year because of mounting pressure in the region and competitive pressures on the export front (discussed later in this document). However, because the long-term goal is to merge the renminbi and Hong Kong dollar, it is not likely that the Hong Kong dollar will lose its U.S. dollar peg.

Currency depreciation has lowered production costs in various Southeast Asian countries. So, will China become less competitive in its vital export markets? Dataquest believes that because significant currency depreciation caused lower export costs, there will be increasing competition for foreign investment with China, which could result in more than $20 billion in electronics production revenue by 2001.

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China faces the following three formidable challenges that are becoming more acute because of the recent currency crisis:

- Raising the competitiveness of its faltering domestic companies, especially state-owned enterprises, before entering the World Trade Organization (WTO)
- Countering the serious slowdown in foreign investments because of the rising cost of doing business in China
- Maintaining 7 percent to 10 percent GDP growth and raising the rate of domestic consumption to absorb excess capacity and overdependence on exports
  - A slowdown in Japanese imports of consumer electronics and PCs from Asia/Pacific may hurt China the most because its currency has not depreciated and, therefore, its costs are increasing relative to those of other countries.
  - Korea and other affected countries will rely heavily on exports to try to pull themselves out of their economic turmoil.

All three issues affect the electronics industry. In light of these challenges and Dataquest's survey of producers in China and Hong Kong, Dataquest believes that a 20 percent growth in electronics production is achievable in 1998, decelerating to 18 percent in 1999.

The following factors will help China to overcome these three challenges and maintain high growth rates:

- A large proportion of Chinese electronics companies are successfully competing against major MNCs, particularly in the computer and consumer equipment markets. Dataquest believes that the Chinese government will continue to support these companies before and after entry into the WTO because its international competitiveness will be imperative to its future survival. The priority for the government is improving efficiencies and quality; therefore, information technology will continue to be rapidly deployed as an infrastructure necessity.
- Although total investment is down in 1997, the production capacity of the large MNCs and local electronics manufacturers has increased by more than 50 percent. Business costs are rising in China, but the two main reasons for investing remain to develop the long-term potential of the domestic market and to take advantage of an abundant, inexpensive labor force. Note that efficiencies and quality are increasing faster than costs. Investment from Taiwan to China increased by nearly 30 percent in 1997, despite the attempt of the Republic of China government to slow the flow of business to China.
- Inflation was the major concern last year at this time, but now deflation is the top priority of the government. Interest rates are likely to fall to stimulate growth.
- Japanese manufacturers are shipping goods worldwide from China. Exports of electronics to Japan from China represent 10 to 15 percent of China's total electronics exports. Therefore, Japan's slowdown in consumption will have a minor effect on Chinese production.

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- Korean companies and other affected Asia/Pacific electronics and semiconductor companies may have an increasing currency advantage for exports relative to China in the short term. However, these companies are seriously hurt by increased debt-service costs. With depreciation, there is a debt-service ratio increase of one to one, and exports cannot possibly expand enough to counter such costs. Major cost-cutting measures may be necessary to service foreign and local debt that impairs the level of export expansion necessary for recovery. Certainly, capacity expansion is not viable at this point.

Lower Long-Term Growth Forecast for China/Hong Kong

Figure 5-3 presents Dataquest's long-term regional electronic equipment production forecast. Although Dataquest expects China to maintain a relatively high level of growth, Dataquest has lowered its 1996-to-2001 forecast for China/Hong Kong electronic equipment production from a compound annual growth rate (CAGR) of 26 to 24 percent in light of recent deflationary industry developments in the region. Dataquest expects the industry to reach $70 billion by 2001, rather than $90 billion as previously forecast. The currency devaluation's impact on semiconductor consumption will be lower between 1996 and 2001; in fact, the original CAGR of 39.7 percent is now expected to become 33.9 percent. Dataquest's 2001 forecast has been lowered from $21 billion to $18 billion.

As shown in Figure 5-4, growth in China/Hong Kong is expected to outpace the rest of Asia/Pacific because of its growth in production efficiencies, export growth, and local demand. China/Hong Kong's electronics industry produced 24 percent of Asia/Pacific's electronics in 1997, which will increase to 29 percent by 2001. Semiconductor consumption will grow from a 20 percent to a 26 percent share of Asia/Pacific's consumption. These growth rates may seem very high, but they are actually relatively low in comparison to overall GDP size and growth because China is still a developing economy. Dataquest's industry surveys and detailed analysis of China/Hong Kong's electronics production and companies are presented in a Focus Report (*China/Hong Kong's Computers, Communications, and Consumer Electronics Industry in 2001*, SEMI-CH-FR-9701, November 1997).

Semiconductor Device Forecast

All these issues affect the electronics industry in China and Hong Kong. From 1996 to 2001, China/Hong Kong growth is expected to exceed Asia/Pacific growth in electronics production by 6.8 percent and to exceed semiconductor market growth by 9.6 percent (see Table 5-1). Consequently, its share of Asia/Pacific semiconductor market revenue will grow from 20 percent in 1997 to 26 percent in 2001.

Cautious business planning is required at this time because the volatile financial markets will take another three to six months to begin to stabilize. The situation requires rapid and extreme government action in Korea and Japan before the downward financial slide in the region reverses course.

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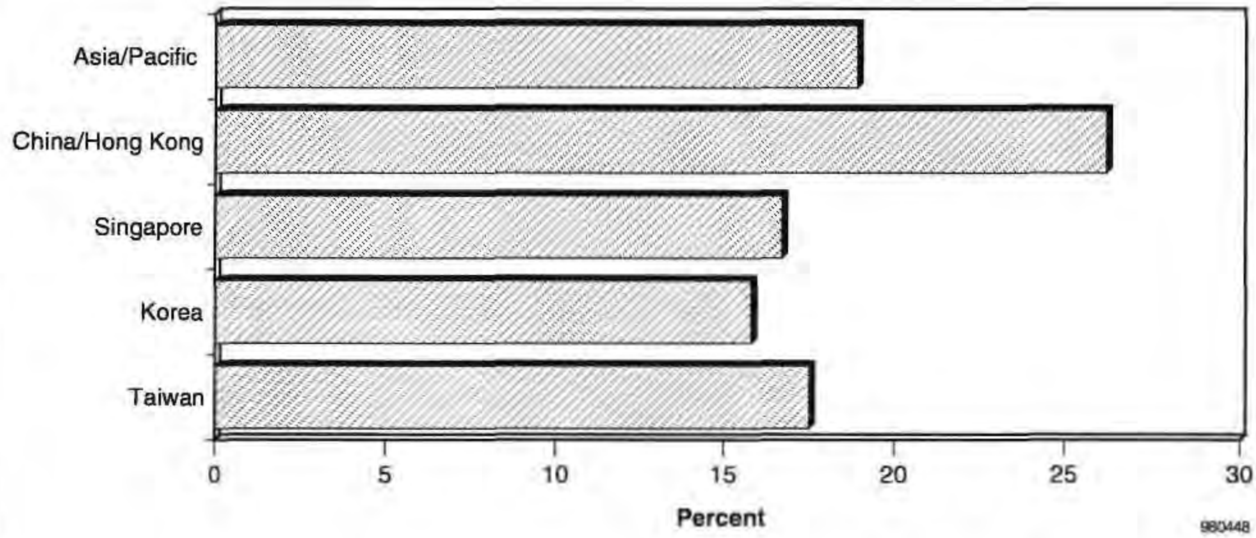
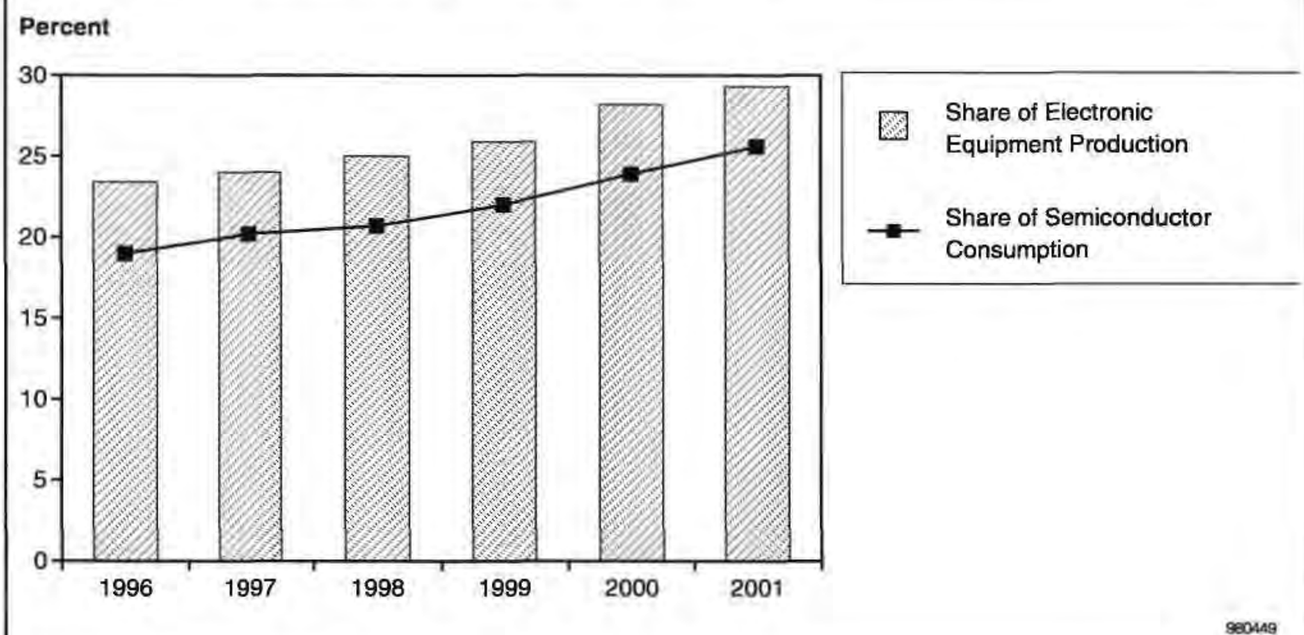
Figure 5-3
Forecast of Electronic Equipment Production by Region in Asia/Pacific, 1996 to 2001 (Compound Annual Growth Rate)



Source: Dataquest (January 1998)

Figure 5-4
China/Hong Kong's Share of Asia/Pacific Electronic Equipment Production and Semiconductor Consumption, 1996 to 2001 (Percent)



Source: Dataquest (January 1998)

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Figure 5-5 compares total semiconductor consumption with DRAM and non-DRAM markets. Dataquest's semiconductor forecast incorporates both the macroeconomic and electronic equipment assumptions discussed earlier. After a flat market performance of 0.5 percent in 1996, the China/Hong Kong semiconductor market picked up a 15 percent growth in 1997. Assuming higher average selling prices (ASPs) for 64Mb DRAMs, the mainstream product in 1998, as well as other memory devices, Dataquest expects 1998 to outperform 1997. With a DRAM growth of 36 percent in China/Hong Kong, the overall market should reach 23 percent in 1998, with stronger DRAM growth occurring in the second half of the year.

The currency devaluation's impact on the DRAM market becomes more pronounced after 1999 because of the anticipated formidable growth in PC production. Boosting the expected DRAM growth is the incredible surge in China's PC market. China, excluding Hong Kong, will take about 30 percent share of Asia/Pacific's PC consumption in 1998 and maintain an average annual growth rate of about 40 percent until 2001, the fastest growth in Asia/Pacific. Non-DRAM products continue to experience more stable, long-term growth because of China/Hong Kong's broad-based electronic equipment production growth.

Table 5-1
Total Electronics Production and Semiconductor Market Forecast in China/Hong Kong and Asia/Pacific, 1997 to 2001 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	CAGR (%) 1996 to 2001
China/Hong Kong						
Electronics Production Revenue	42,387	50,780	59,924	71,763	84,803	23.9
Semiconductor Market Revenue	6,490	8,008	10,504	14,926	18,077	33.7
Electronics Production Growth (%)	17.8	19.8	18.0	19.8	18.2	-
Semiconductor Market Growth (%)	14.9	23.4	31.2	42.1	21.1	-
Asia/Pacific						
Electronics Production Revenue	176,600	202,757	231,740	254,794	289,136	17.1
Semiconductor Market Revenue	32,123	38,707	47,779	62,545	70,605	24.1
Electronics Production Growth (%)	14.9	14.8	14.3	9.9	13.5	-
Semiconductor Market Growth (%)	8.0	20.5	23.4	30.9	12.9	-

Source: Dataquest (January 1998)

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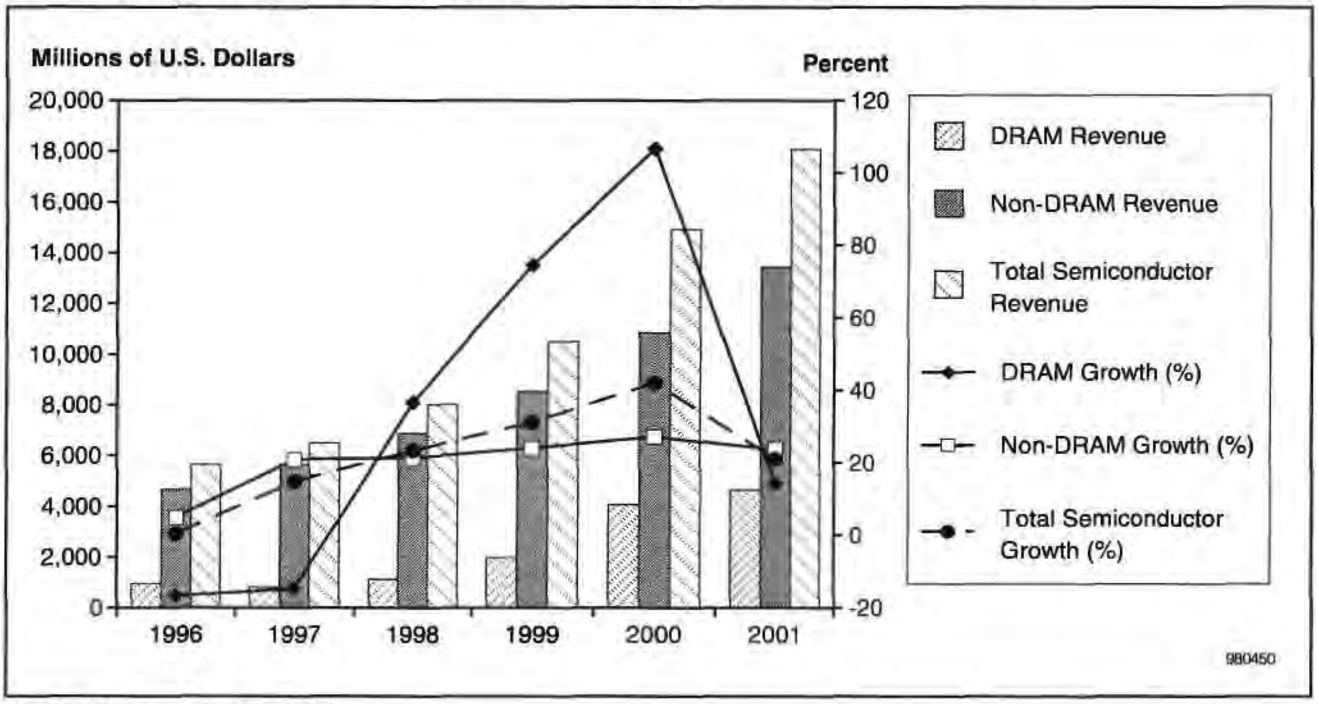
Figure 5-5
China/Hong Kong Semiconductor Consumption Forecast, 1996 to 2001



Source: Dataquest (January 1998)

Dataquest Perspective

The financial crises have adversely affected semiconductor shipments to end-equipment companies that are dependent on sales within the affected countries. Dataquest highlights the economic woes in Japan and Korea because they will weaken Asia/Pacific electronic equipment production overall—again, because of weakened exports mainly in consumer electronics but also in computer-related equipment producer countries. Consumption of electronics in Malaysia, India, Indonesia, Malaysia, Singapore, Thailand, and Taiwan is also damaged by higher import costs and weaker consumer spending in 1997 and 1998. However, the majority of production in the affected countries comes from companies exporting to Europe, Japan, and North America, so a local market slowdown has minimal effect on overall production of Asia/Pacific as a whole. Furthermore, export sales are conducted in U.S. dollars, and semiconductor purchases from multinational vendors are usually conducted in U.S. dollars also—thereby avoiding the ill effects of currency fluctuation.

China/Hong Kong has not been affected by this financial crisis in the short term because of the stable renminbi and Hong Kong dollar, which are backed by about U.S.$200 billion in combined foreign reserves. However, Dataquest has outlined the deflation and investment challenges within China. Dataquest's lower long-term electronic production and semiconductor consumption forecasts for China/Hong Kong assume that Southeast Asia will receive increased investment that would otherwise have gone to China (after four years of very high foreign investment levels in China). However, the power of the Chinese market and its production prowess for international markets will continue to attract investment, enabling it to extend its lead as the largest and fastest-growing semiconductor markets in Asia/Pacific.

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Chapter 6
Currency Meltdown: Impact on Asia/Pacific PC Markets

Introduction

After the previous three chapters' regional perspectives on Korea and China/Hong Kong, Dataquest now turns to the PC market. This chapter aims to provide insight into the currency devaluation's early impacts on the personal computer industry, to assist PC suppliers in understanding the factors involved, and to highlight the key areas on which to focus when steering a path through the crisis.

Background

The economic conditions that have spread to nearly every Southeast Asian country started on a much smaller scale. South Korea was already experiencing severe economic difficulties following a series of bankruptcies among its large industrial conglomerates when difficulties in the Thai banking and finance community escalated to a devaluation of the baht during the first half of 1997. A ripple effect quickly followed, sparking similar devaluations in Malaysia, Indonesia, and the Philippines. Initially, Hong Kong and Singapore remained largely unaffected by the difficulties faced by their neighbors, but this situation changed late in September as investor nervousness spread to other Asian markets. Similarly, the Australian dollar became more seriously affected this October. At the end of October, the Thai baht and Indonesian rupiah were both trading at about half the values they held at the beginning of the year. The Malaysian ringgit had fallen more than 35 percent, closely followed by the Philippine peso, down about 32 percent. Most other currencies were trading between 10 percent and 15 percent lower than their values at the beginning of 1997. China, Hong Kong, and Japan were the least affected. In both Thailand and Indonesia, the IMF has stepped in to assist with the crisis.

Economists have a range of opinions on both the causes and the solutions to the economic crises, but it has become clear that there have been several different underlying factors. These include cozy relationships between government and favored business leaders, irrational investment in high-profile projects (such as in real estate) instead of in productive areas of the economy, and the failure to open up large monopolies to competition. The Thai banking and finance sector has been sharply criticized, as has economic policy in Thailand, Malaysia, Indonesia, and the Philippines. Most other affected countries have been victims of a "contagion" effect, as nervous investors apply the same high-risk label to all Asian markets.

A speedy recovery is not part of the outlook. Investors have been deeply critical of policy response in most countries, which they consider to have been grossly inadequate so far. In Thailand, for example, the government recently decided not to implement higher taxes on oil—as recommended by the IMF—thus placing a U.S.$16 billion rescue package at risk and sparking several ministerial resignations. Malaysia's prime minister, Dr. Mahathir Mohamad, has shifted too much blame onto currency speculators and failed to deliver a budget with the teeth desired by investors. In Indonesia, IMF recommendations have also been actively resisted.

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Instead of easing, investor nervousness has spread to include more countries and has introduced a level of turbulence in stock markets around the world. The relative health of the Asian markets remains highly volatile, and major currency shifts are likely to continue—even as this document goes to print. The general consensus among economists is that the hardest-hit Asian economies will take two years to fully recover, and Dataquest has been revising PC consumption forecasts for the region downward.

Impact on PC Shipments

Figure 6-1 shows the declining growth rates seen so far this year in Korea, Indonesia, Malaysia, and Thailand—the countries most affected by the financial crisis. It reveals the Korean situation to be quite different from that of other countries because PC shipments have been depressed—with no growth—since the fourth quarter of 1996. Conversely, Indonesia, Malaysia, and Thailand suffered a shared impact from the financial crisis much more recently, with the major downturn in PC shipments coming in the third quarter of 1997.

The Malaysian market has been somewhat less affected than the Thai and Indonesian markets (it is the only one in which third quarter 1997 shipments are up over the previous year), although the impact is still clearly visible. This lower impact is in part a reflection of the reduced scale of the currency crisis in that country, which only produced PC price rises late in the third quarter.

Dataquest has observed further price rises in the fourth quarter and expects a larger impact before year's end. PC shipments in most other Asian countries have yet to be affected by the financial crisis, although many have been experiencing lower growth for other reasons, such as market maturity.

In Thailand, Malaysia, and Indonesia, the greatest reduction in PC consumption has consistently been in the corporate sector, especially in the banking and finance industry. As a result, vendors that focus heavily on this segment (such as IBM) have typically suffered the most impact. The next biggest concern for vendors is the potential falloff in government business in Indonesia and Thailand (but not in Malaysia, where the government has reaffirmed its commitment to existing projects). This situation differs in Korea, where the home market has been most affected—probably reflecting the longer period of economic uncertainty and its impact on consumer confidence.

Market Dynamics

Rising Cost of Imports

Fully imported PCs and imported components such as monitors, microprocessors, hard drives, and memory modules are affected equally by exchange rate variation, in theory giving no advantage to vendors buying either one. Locally manufactured components, however, such as Acer Computer International Ltd.'s motherboards in Taiwan, Samsung's memory chips and monitors in South Korea, and batteries and monitors from Delta Electronics Industrial Ltd.'s operation in Thailand, will not be affected by exchange rate variation when sold on the local market, thus handing an advantage to vendors that use these local components over imports. Also, local labor costs have fallen considerably relative to other

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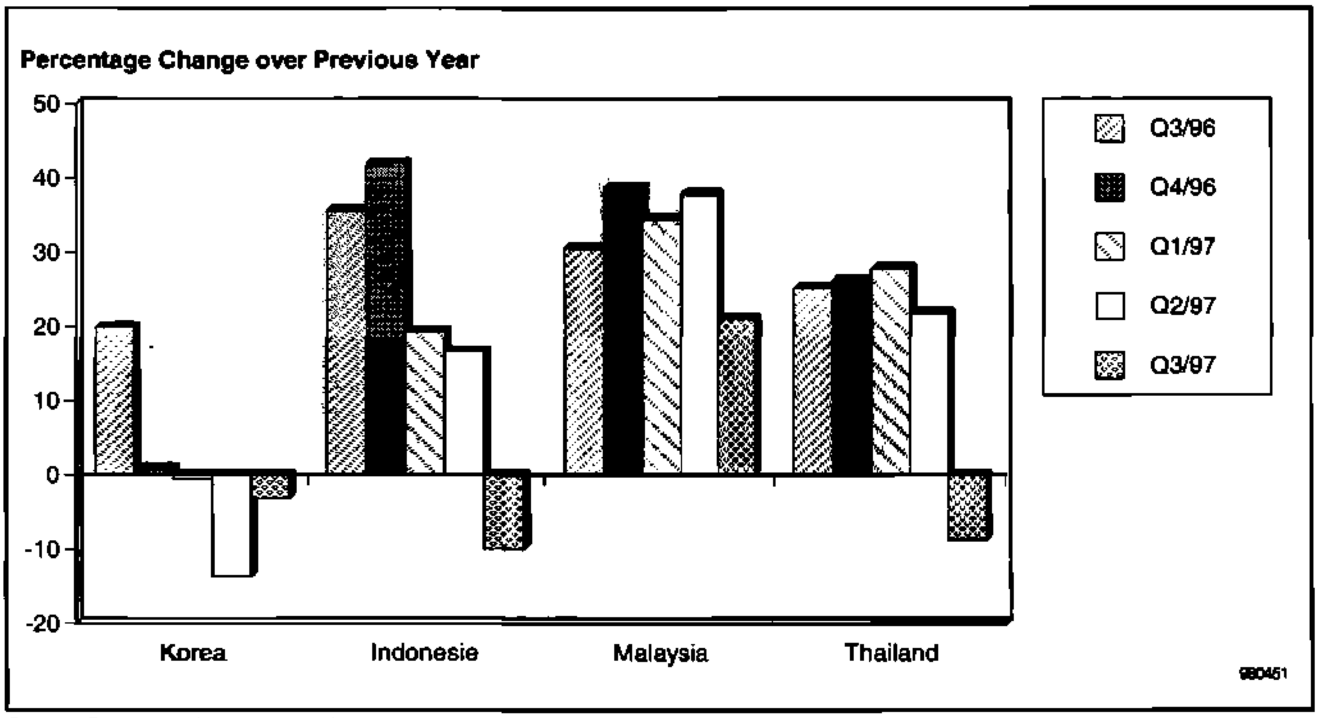
Figure 6-1
Year-on-Year Growth in PC Shipments in Korea, Indonesia, Malaysia, and Thailand: Q3/96 to Q3/97



Source: Dataquest (January 1998)

countries, providing an advantage to any manufacturer (multinational or local) undertaking part or full assembly of PCs in the local market. The same relative advantage applies to most of the facilities and service-related costs for a PC plant.

Rising PC Prices

The most important inhibitor of PC sales within affected economies has been rising prices. At the same time, many suppliers have switched to pricing in U.S. dollars to avoid having to adjust continually for exchange-rate variations. In Thailand and Indonesia, price rises in PC hardware have been offset in part by the regular cycle of worldwide component price cuts, particularly those of Intel Corporation, ensuring that, although currencies might have dropped up to 50 percent in value, PC price rises have generally been limited to under 15 percent. A similar process has taken place in Malaysia, although vendors in that country have managed to delay price increases a little longer.

Canceled and Deferred Purchases

Many buyers are waiting for the local currency to improve to maximize the spending power of their limited budgets, and at the same time many of their budgets are being reduced. Either way, the effect is the same: Premeltdown budgets are inadequate for postmeltdown prices. Within the government and corporate sectors, there is a strong inclination to defer making large purchases. In the case of government, there is considerable pressure to exercise restrained fiscal policy and to set spending priorities toward areas that the investment community sees as most important to stabilizing the economy.

In both Indonesia and Thailand, government information technology (IT) purchases are expected to be especially conservative. The Thai government has already announced that the IT budget for 1998 is to be cut from 7.8 billion to 3.7 billion baht. The Indonesian finance minister announced in August that U.S.$35.6 billion worth of government and state-related projects were to be postponed or reviewed, indicating that mining, energy, public works, and the transportation sector would be hit hardest. This move is expected to have a substantial impact on PC purchases in those sectors.

In the home sector, spending on all high-priced luxury items diminishes during periods of economic uncertainty. Additionally, like business buyers, many families find that what they would have purchased before the currency decline has simply become too expensive. Other factors will indirectly affect PC purchases by reducing spending power. These include an increase in the value-added tax in Thailand from 7 percent to 10 percent (following IMF recommendations), increased import tariffs to 30 percent, and expected increases in fuel and electricity prices in Indonesia—which will ultimately be passed on to all consumer goods.

Late Payments

Maintaining adequate cash flow has been a particularly serious problem for many vendors as companies delay paying for equipment that has been delivered. With their debts owed in U.S. dollars, buyers hold out payments in anticipation of any small rise in local currency value. The risk is, of course, that the local currency value will decline further and that the longer delay will actually increase the debt. Although delayed payments are affecting every stage of the procurement process, the problem is most pronounced when it comes to vendors getting payment from channel partners. This applies particularly to first-tier channel partners, which are most likely to hold stock and have to buy in U.S. dollars (selling to the second tier in local currency).

Technology Lag

Dataquest has found little evidence of "slimming down" of PC configurations to reduce costs, nor of any major switch to upgrade purchases at the expense of new PC purchases. There is, however, strong evidence that microprocessor life cycles, particular for Intel's Pentium 166-MHz chip, have been extended in desktop and deskside machines. This extension is a trade-off for limiting price rises to manageable levels: Under normal circumstances, component price cuts would be accompanied by a strong shift by manufacturers to later-generation processors. Also, fewer buyers are able to afford the latest Pentium II processor, thus contributing to the slow take-up rate across the region. The overall result is a greater technology lag behind the U.S. market. Dataquest expects this lag to lengthen, at least temporarily, in Indonesia, Thailand, and to a lesser extent, Malaysia.

A second, related effect is likely to be the shift by manufacturers and buyers toward cheaper microprocessors from Advanced Micro Devices Inc. and Cyrix Corporation. No data is yet available to confirm if this shift has taken place, but early indications are that Intel was disappointed with its third quarter performance, while AMD reported a strong demand in Asia.

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Export Competitiveness

Vendors that manufacture in countries now heavily impacted by currency depreciation are better positioned for export to less-affected markets within Asia or to other world markets. Acer, for example, has already indicated that a depreciation of the Taiwan dollar, although relatively minor compared with other Asian countries, should prove highly beneficial to its 1997 financial results.

Survival Strategies

New Targets

Preliminary third quarter results show that the Chinese, Taiwanese, Hong Kong, and Australian PC markets have not been affected by the Asian economic crisis. Although this situation may change at any time, Dataquest anticipates that these countries will remain the best opportunities for PC sales while the crisis continues for the rest of Asia. China's growth will be unlikely to slow, and the other markets are all underpinned by solid economic fundamentals. Where opportunity allows, vendors operating in multiple markets through the region should look to put most of their current resources behind sales efforts in these countries. Similarly, within the deeply affected markets, Dataquest has observed that not all sectors have been affected to the same extent, with the education and small business sectors having provided better opportunities relative to other sectors in the third quarter.

Zero Inventory

One ironic result of rapid currency devaluation is that those manufacturers that have poorly managed their inventories gain a short-term advantage. Having purchased or manufactured excess stock under favorable exchange rates, these suppliers are able to hold off on announcing price rises the longest. Having passed this stage, however, inventory management becomes far more critical than under normal market conditions. Vendors will need to keep minimal stocks to take advantage of short-term price fluctuations on components. Acer, for example, has taken the opportunity to announce a more streamlined build-to-order (BTO) and delivery strategy in Thailand. Later, when currency values begin to rise, excess inventory will be punished severely, and it is likely that a number of PC suppliers will sustain large losses.

Compress Channels

The advantages of shorter supply lines will be increased under the present economic circumstances for two reasons. The first is lower inventory through the system, for the same reasons as those mentioned above. The second is that a shorter supply line will minimize the exposure to bad debt, which has already shown itself to be a problem in the third quarter. Vendors that sell direct have only to worry about one set of payments. Vendors that use a multitiered channel are exposed—if the buyer, reseller, or distributor defaults—multiplying their risk.

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Boost Local Content

There is a substantial competitive advantage from increasing use of local hardware and labor content within markets heavily affected by currency depreciation or from importing components from facilities located in those countries wherever possible. Both these actions will reduce overall production costs. Just as important, however, is the need to maintain flexibility in these arrangements so sources of supply can be quickly altered to take advantage of further currency fluctuations and to avoid being locked into arrangements that become less competitive as currencies appreciate.

A Long-Term Opportunity?

Southeast Asia's lower exchange rates have made these countries more attractive for locating full-scale production facilities. For all the difficulties IBM is facing in selling PCs into the Thai market, it is now reaping the rewards for its decision to establish a U.S.$300 million plant to manufacture hard drive and storage products in Prachinburi, Thailand. Fujitsu Ltd. and Seagate Technology Inc. are also establishing new facilities or expanding existing ones in Thailand. At the same time, traditional production locations such as Singapore have become increasingly expensive during the past year. Shifting production facilities to affected countries has high potential rewards, but, because of the size of the investment involved, it also carries high risks.

Do Current Conditions Favor Local Vendors?

In recent years, the unbranded "whitebox" PC clone industry has been a dominant part of the PC mix in Asia, although it shows signs of stabilizing as markets mature and has been forecast to decline as a proportion of most countries' markets in the next few years (see Dataquest report *Cheap, Fast, and Flexible: Whitebox PCs in Asia/Pacific*, PCIS-AP-MT-9702, October 1997). At the same time, Dataquest sees a strong pressure on large, branded, local assemblers—such as Wearnes Technology, V-Tech Systems Limited, Powell Computer Co. Ltd., and Total Peripherals Group Pty. Ltd.—from multinational giants such as IBM, Compaq Computer Corporation, and Dell Computer Corporation, steadily squeezing the former group out of the market.

Economic uncertainty seems to favor many local vendors, however, with indications that buyers have shifted toward these suppliers in Indonesia and Thailand (Powell and ATEC Computer Co. Ltd. are just two examples of local vendors that did well in the Thai market in the third quarter). There is no doubt that, in these markets, a consequence of reduced buying power and higher PC prices has been a shift toward whitebox purchases to achieve required purchase volumes with limited funds or to continue buying PCs with the same equipment levels without paying the higher prices. It would appear that, in these markets, economic pressure has temporarily reduced the perceived value of the warranty/service/quality package offered by brand-name suppliers. Also, Indonesian government departments are following a directive to favor local vendors when buying desktops while the crisis continues.

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The opposite trend has been seen in Malaysia, however. Here, local vendors seem to be having more difficulty capitalizing on component price fluctuations, and buyers are placing greater emphasis on reliability (with a view to extending equipment life) under the present conditions. Nor are local vendors faring better in Korea, although Dataquest has observed an increase in demand for secondhand PC systems.

Dataquest believes that local companies' key advantage lies in their higher proportion of local assembly relative to their multinational competitors (although multinational giants such as Dell and Gateway 2000 Inc. that operate factories in Malaysia or other affected countries are also well positioned). Local assembly gives vendors a critical advantage when it comes to pricing PCs on the local market. On the minus side, local companies are at a disadvantage when it comes to financing their operations. Investment is harder than ever to secure in countries such as Thailand and Indonesia, and many whitebox suppliers—although prosperous in high-growth markets—are ill-equipped to ride out periods of reduced cash flow. In contrast, multinational suppliers can afford a long-term strategy, riding out unprofitable periods in one or two countries to secure a strong market position in the long term.

On balance, although not helping any vendor sell more PCs, the current conditions should temporarily negate many of the advantages held by multinational companies over local vendors. In particular, Asian companies that also manufacture components should be more competitive in their home markets over fully imported products. Overall, Dataquest expects a temporary halt to the market share slide being experienced by local vendors in Southeast Asian markets, with multinationals retaking the upper hand when economic conditions improve.

Dataquest's Market Outlook

Generally speaking, the outlook for recovery has shifted from a near-term to long-term expectation in Thailand, Indonesia, and Malaysia, with Malaysia somewhat better positioned than the other two. PC vendors will thus need to be prepared to survive a sustained period of difficult and depressed trading. Economists are indicating that the Korean economy could begin to turn around earlier—perhaps starting a slow climb early in 1998, but early indications are that the fourth-quarter performance of the PC markets in Indonesia, Malaysia, and Thailand will be even more badly affected than the third quarter. For as long as this situation lasts, Dataquest expects PC shipments to be inhibited, especially as government projects and large corporations play such an important role in driving IT acquisition in Southeast Asian markets.

On the positive side, spending on PCs is unlikely to be as deeply affected as other capital expenditure because improving the communications and technology infrastructure in Southeast Asia is seen as one of the building blocks for recovery. Additionally, the overall growth in the Asian region will continue to be solid in 1998 and 1999, driven by the booming Chinese market. Given the highly contagious nature of currency fluctuations within the region, however, the situation for most of the markets, particularly those in Southeast Asia, remains volatile and unpredictable.

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Chapter 7
The Impact on Capital Spending of the Asian Financial Crisis

Introduction

This final chapter represents a recap of Dataquest's views over the past several months of how the Asian financial situation will affect capital availability and spending in semiconductors. Dataquest has just released the spending forecast for 1998, with both a forecast and downside risk scenario. The details of those scenarios are published in a Dataquest Perspective ("Wafer Fab Equipment Market Forecast Update: Question Marks for 1998 as the Second Half of the 'W' Unfolds," SEMM-WW-DP-9801, January 1998), and an overview is presented here.

Will the Southeast Asia Currency Issue Cause a Decline in Capital Spending in the Region? Yes! Here's Why ...

In early August 1997, when the Asian financial systems began experiencing stress, Dataquest went on record as seeing more downside risk than upside potential to our 1998 capital spending forecast, in part because the Southeast Asia currency issues could put a damper on capital availability in the region. That statement was made before the fourth quarter meltdown, based on fundamentals of capital availability.

The real issue? The entire Southeast Asian banking system is in a liquidity crisis, with declining or negative cash flow. This has caused devaluation of currencies throughout the region as a natural, self-correcting economic response, resulting in equity market upheavals as the world "readjusts." The original, higher-order cause of the liquidity issue is complex, involving factors such as current account imbalances and the DRAM price collapse, among other things.

It is important to understand how capital is raised in the United States and Europe, as opposed to Asia. In the United States and Europe, capital is raised by a combination of debt (usually corporate bonds, sometimes convertible to stock) and equity placements (public offerings on the stock market). A company's ability to raise capital successfully in the equity market depends primarily on profitability. Profits are also a major source of capital, and U.S. and European companies are structured and managed for this goal. In Asia, a much larger portion of the capital raised (sometimes exclusively) is from the banking system in the form of loans. The evaluation criterion is fundamentally different there—cash flow. In a highly leveraged company, cash flow can easily be positive while losses are piling up. Asian companies, as a result, are primarily managed for cash flow. This has been the key reason why the capital spending-to-semiconductor production revenue ratio is estimated to be about 23 percent in the United States while near 70 percent for Asia/Pacific, keeping the worldwide ratio at almost 29 percent—a level that is too high, in Dataquest's opinion.

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The Korean banking system has been in a liquidity crisis for some time, and the Japanese banking system has already been under pressure from the struggling economy of Japan. Debt-to-equity ratios are quite high in Korea, and capital spending from companies in both these countries has been depressed for several quarters now. Both these systems received more pressure from Southeast Asia in late summer. Taiwan's banking system has higher relative reserves than its Southeast Asian neighbors but is feeling the weight as well and is viewing the situation with caution.

Decreasing chip prices have taken a major toll on the cash flow of many semiconductor companies in the region. Less capital is available in the system because cash flow id not available to pay some existing debt.

Assuming demand for chips is not affected by the situation, the natural economic responses to be expected in the region should include:

- Higher interest rates (which will raise the cash flow requirements of companies requesting money)
- Higher cash flow requirements (which will mean the amount for which the companies qualify is less)
- Less capital available (as a result of the previous point and the lower liquidity in the system)
- Significantly lower capital spending plans, complicated by the fact that local currency buys less equipment from U.S. and Japanese companies because of the devaluation

There has been a trend for Asian companies to seek other sources of capital, such as Eurobonds and equity offerings in the United States. Dataquest believes these avenues will be available to some companies but will fall very short of adequately covering the loss of capital from the banking system overall. The recent quakes in equity markets worldwide present a difficult environment in the short term, as well.

What exists today is a situation that will take several quarters to play out, and one that equipment companies must realize will affect them materially. In a sanguine tone, Dataquest must say that, in the long run, capital spending restraint over the next several quarters will ultimately be very healthy for the semiconductor industry, bringing supply and demand into better balance and ultimately stabilizing pricing and profitability.

And Then Korea Falls—What about Taiwan?

In late November 1997, the South Korean government admitted that some outside help was going to be required to address a massive liquidity crisis in the country. The "official" request was initially about $20 billion, but the agreed-upon bailout was $57 billion, and this may be in the process of being increased. Putting this into perspective is key, because we saw a report recently that places the annual capital spending level for *all* Korean companies in *all* industries at about the $50 billion to $55 billion! The three culprits being pointed to in Korea are memory chips, steel, and autos. All industries are in huge states of overcapacity, and the IMF will likely place some restrictions on the use of capital in these industries in the near term.

The Japanese banking system, already under pressure with the struggling economy of Japan, is now feeling added strain. All the banking roads from Asia appear to lead to Japan, and questions are now being raised as to whether this evolving situation will harm the recovery in Japan, perhaps sending the economy into another recession. The closing of the fourth-largest securities firm in Japan because of lack of liquidity has not helped. Trickling repercussions can be expected.

Meanwhile, the currencies have continued to depreciate relative to the U.S. dollar. Since the beginning of the year, the currency of South Korea has depreciated 40 to 50 percent, Taiwan's about 18 to 20 percent, and Japan's about 10 to 11 percent relative to the U.S. dollar. These fell precipitously in the last months of 1997 and may come under further pressure before stabilizing.

What is the likely fallout? Dataquest believes there are three issues to watch in coming months: capital spending cuts, DRAM prices, and the dynamics of the foundry market.

In conversations over the last couple of months, Dataquest described the South Korean situation as the linchpin. If Korea could keep it together, then the crisis could be controlled without turning into something much worse. But if Korea fell, then watch out! Well, Korea fell, and we are officially saying—watch out! The magnitude of the situation is mind-boggling, and we are forecasting that Korean companies will cut capital spending in 1998 about 40 to 60 percent, relative to 1997 in dollar terms. It is safe to say that *all* Korean capital projects are stopped dead in their tracks at present, and we would estimate that it will be late spring before the situation settles to the point at which some of these projects may be cautiously restarted.

Because the Japanese banking system is under strain, there is not much money available, and Dataquest is forecasting that spending plans for Japanese companies in 1998 are likely to be about 7 to 14 percent lower in dollar terms than in 1997.

What about Taiwan? The second and third issues actually are the keys to Taiwan. The currency valuations may actually be of more importance in the intermediate and long term than capital availability. Taiwan is outright defiant at present, and it have some reason to be. Its financial system is based on a stock market system rather than banking, and a major portion of the country's semiconductor business, foundry, is still very profitable and growing.

However, depreciation levels are approaching that will dramatically impact competitiveness and pricing among regional companies. Not quite, but almost, half of the DRAM capacity is in Korea and Taiwan now. These suppliers now have a "cost holiday" relative to competitors in the United States, Europe, and, in part, Japan. Dataquest estimates that perhaps 55 to 60 percent of the cost of making a semiconductor chip is sensitive to local currency.

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Will these companies sit on their marginal profits? If history is a guide, the answer would be no. A continuing free fall of DRAM prices will put profitability pressures on Micron Technology Inc., Siemens AG, and perhaps even Texas Instruments Inc., to a lesser degree. Capital spending plans for these companies may come under review in the near term and perhaps be lowered.

So, will the foundry industry be the savior? Maybe in part, but right now it is the *only* bright spot, and every company is now looking toward it. We can expect a flood of announcements (which have already started) from companies coming into the foundry market. Taiwan Semiconductor Mfg. Co. recently released a forecast stating that its gross margins were increasing in a growing market. This is true and understandable, given the currency valuation trends and the fact that the bulk of its customer base is in U.S. dollars. Although TSMC is the technology leader and premier foundry supplier, it has not typically led pricing downward but has been a price follower. LG Semicon has been a price leader in the past, and Dataquest is expecting LG Semicon to retake the pricing lead, maybe joined by others, giving TSMC's margin improvement a relatively short life. LG Semicon has the capacity, needs the cash, and is motivated to take business through pricing because there is beginning to be a separation in the valuation of the Taiwan dollar and the Korean won.

So what about Taiwan capital spending in 1998? Dataquest believes it will be split. Taiwan is fundamentally different from its Asian neighbors because capital-raising techniques used there rely more heavily on equity markets than debt markets or the banking system. The Taiwan banking system is the soundest in Asia, but we think Taiwan is watching and being very cautious at present so as not to follow Korea to the IMF. A company's ability to raise capital in the equity market depends primarily on profitability. And even then, today's environment is not really favorable to raising capital on the equity markets.

Dataquest believes the equity market will be available to foundry companies but is not likely to be favorable to memory producers. For this reason, we think that the memory producers in Taiwan (Powerchip, Nan Ya Technology Corporation, and Mosel Vitelic) may find it more difficult to raise capital, while the foundry producers will be able to raise spending levels slightly in 1998. However, currency depreciation will lower the spending levels on a U.S. dollar basis. We think only a few leading companies, such as TSMC, Chartered Semiconductor Mfg. Pte. Ltd. , and United Microelectronics Corporation, will be in a position to raise spending levels in U.S. dollar terms for 1998. Memory companies will likely be forced to cut spending in 1998. Overall, Taiwanese spending is expected to increase about 13 percent in 1998 to $7 billion.

The Taiwanese foundries are still very profitable, and although the situation may degrade through the year, spending for 1998 seems fairly secure. Dataquest's forecast assumes that Taiwanese foundry spending will increase more than 40 percent to $4.3 billion (excluding foundries outside Taiwan).

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Dataquest expects spending in DRAM capacity to remain at a high level. Some companies will cut spending, but companies such as Vanguard International Semiconductor Corporation (owned in part by TSMC) will actually increase spending heavily. Overall, in local currency, spending will be flat in the DRAM area but down about 15 percent in U.S. dollars.

This situation is continuing to play out and will not be settled for several months yet. The picture is increasingly beginning to resemble a sharper decline in sequential spending than originally anticipated in the DRAM area.

Thailand fell, Hong Kong crashed, Korea admitted it needed help, and even Japan is feeling added strain and experiencing the collapse of a securities company—each of these events has been accompanied by someone stating, "It is an isolated incident," "We are only minimally affected," or, "It should be possible for this to be controlled within that country." Does anyone still doubt that we are in the midst of a worldwide earthquake? The tremors will be relatively minor in the United States—but they will be, and are starting to be, felt.

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Chapter 1

Market Share Survey Overview

Each year, Dataquest surveys semiconductor vendors to estimate their annual sales. The survey currently covers more than 150 semiconductor vendors worldwide (this varies according to mergers, acquisitions, liquidations, start-ups, and so on) by 61 individual semiconductor product categories (excluding subtotals), six application segments, and four world regions (Europe is split into further subregions). This exercise helps Dataquest maintain its dynamic database of semiconductor supply by company and semiconductor vendor revenue by world region and product. The information gained is supplemented by, and cross-checked with, Dataquest's various other information sources.

The semiconductor market share survey process starts during the fourth quarter of each calendar year. The first-phase, top-level estimates for large companies are completed by the end of the calendar year under review, and the results are summarized in several Dataquest reports.

The final detailed survey of all companies starts just after the end of the calendar year under review. These estimates are published in the second quarter of the year following the calendar year under review.

The categories for which semiconductor revenue is reported are defined comprehensively for the purpose of clarity and guidance to survey participants. These definitions may occasionally be revised, altered, or expanded to reflect changes in the industry. To support these definitions, Dataquest will issue an annual survey guide to all participants in its semiconductor market share survey program. This document is the 1997 survey guide.

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Chapter 2
Semiconductor Companies Surveyed Worldwide

For 1997, Dataquest will survey semiconductor companies throughout the world.

Americas Companies Surveyed

The following Americas companies were surveyed during 1996:

- ACC Microelectronics
- Actel
- Adaptec
- Advanced Micro Devices
- Allegro MicroSystems
- Altera
- Analog Devices
- Applied Micro Circuits
- AT&T
- Atmel
- Brooktree
- Burr-Brown
- C-Cube Microsystems
- California Micro Devices
- Catalyst
- Cherry Semiconductor
- Chips & Technologies
- Cirrus Logic
- Cypress Semiconductor
- Cyrix
- Dallas Semiconductor
- DSP Semiconductor
- Elantec
- Electronic Designs
- ETEQ Microsystems
- Exar
- General Instrument
- Gennum
- Gould AMI

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- Harris
- Hewlett-Packard
- Honeywell
- Hughes
- IBM
- IMI
- Integrated Circuit Systems
- Integrated Device Technology
- Integrated Information Technology
- Integrated Silicon Solution
- Intel
- International CMOS Technology
- International Microelectronic Products
- International Rectifier
- Kulite
- Lattice
- Linear Technology
- Linfinity
- Logic Devices
- LSI Logic
- Maxim
- Micrel
- Micro Linear
- Micro Power Systems
- Microchip Technology
- Micron Technology
- Microsemi
- Mitel
- Motorola
- National Semiconductor
- NCR
- Optek
- OPTi
- Paradigm
- Performance Semiconductor
- Powerex

- Q Logic
- Quality Semiconductor
- Quality Technologies
- QuickLogic
- Ramtron
- Raytheon
- Rockwell
- S3
- Seeq Technology
- Semtech
- Sierra Semiconductor
- Silicon General
- Silicon Systems
- Sipex
- Solitron
- Standard Microsystems
- Supertex
- Symphony Laboratories
- Tektronix
- Telcom
- Texas Instruments
- Trident Microsystems
- TriQuint Semiconductor
- Tseng Labs
- Unitrode
- Universal
- Vitesse
- VLSI Technology
- VTC
- WaferScale Integration
- Weitek
- Western Digital
- Xicor
- Xilinx
- Zilog

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Japanese Companies Surveyed

The following Japanese companies were surveyed in 1996:

- Fuji Electric
- Fujitsu
- Hitachi
- Matsushita Electronics
- Mitsubishi Electric
- NEC
- New Japan Radio
- Nippon Steel
- Oki Electric Industry
- Ricoh
- Rohm
- Sanken Electric
- SANYO Electric
- Seiko Epson
- Sharp
- Shindengen Electric Manufacturing
- Sony
- Toko
- Toshiba
- Yamaha

European Companies Surveyed

The following European companies were surveyed in 1996:

- ABB-Hafo
- ABB-Ixys
- Austria Mikro Systeme
- Elex
- Elmos
- EM Microelectronic
- Ericsson
- Eupec
- European Silicon Structures
- Fagor
- GEC Plessey Semiconductors

- ITT
- Micronas
- Mietec
- Philips Semiconductors
- Semikron
- SGS-Thomson
- Siemens
- TCS (Thomson Composants Spatiaux)
- TEMIC
- Thesys
- Westcode Semiconductors
- Zetex

Asia/Pacific Companies Surveyed

The following Asia/Pacific companies were surveyed in 1996:

- Acer
- Daewoo
- LG Semicon
- Hualon Microelectronics
- Hyundai
- Korean Electronics
- Macronix
- Mosel Vitelic
- Samsung
- Silicon Integrated Systems
- United Microelectronics
- Vanguard
- Winbond Electronics

Summary

The following summarizes the semiconductor companies surveyed in 1996:

- 100 Americas companies
- 20 Japanese companies
- 23 European companies
- 13 Asia/Pacific companies
- 156 companies worldwide

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Chapter 3
General Sales Definitions

Dataquest tracks semiconductor vendors' revenue as defined in the following paragraphs.

Revenue

Revenue is the gross sales generated by a vendor or manufacturer, measured in unit currency.

Semiconductor Vendor

A vendor is the last entity in the chain that brands a product and sells it either directly to end users or through a channel. A semiconductor vendor may design and manufacture its own products, in which case it is also an original component manufacturer, or the vendor may procure semiconductors from a component contract manufacturer.

Vendor Revenue

Vendor revenue is defined as the average selling price of a semiconductor product multiplied by the vendor's unit shipments of that product.

Revenue Based on Customer Location

All revenue from sales is reported according to customer location, that is, the shipping destination. The four regions that Dataquest uses for the purpose of this survey are the Americas; Japan; Europe, Africa, and Middle East; and Asia/Pacific.

Manufacturer

A manufacturer is a producer of branded or unbranded finished products. A semiconductor manufacturer could be a contract manufacturer, an original manufacturer, or both.

Original Component Manufacturer

This is a manufacturer that designs and produces components such as semiconductors and design tools either for sale under its brand name or for use internally. An original component manufacturer is also a vendor.

Contract Component Manufacturer

This is a manufacturer that produces components such as semiconductors under an original manufacturer's brand name or that produces components for a semiconductor vendor that brands them. In the semiconductor industry, a contract component manufacturer is sometimes referred to as a "foundry."

Any business done by a semiconductor manufacturer on a contract manufacturing basis is *excluded* as vendor revenue regarding that manufacturer.

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Companies that produce exclusively on a contract manufacturing basis are excluded from the list of semiconductor vendors.

Finished Semiconductor Products

Finished products are assembled and tested semiconductor products. Count only sales of finished semiconductor products to equipment manufacturers and through channels (that is, distributors). Do not include sales of finished semiconductors to other semiconductor vendors for value-added resale. Resale revenue is counted as revenue of the semiconductor vendor to which it is sold. Also, count only sales made by an overseas subsidiary to a equipment manufacturer or distributor, as opposed to counting sales from headquarters to an overseas subsidiary.

Unfinished Semiconductor Products

These are wafer and die foundry products. Count only sales of unfinished semiconductor products to equipment manufacturers or channels (that is, distributors). Do not include sales of unfinished semiconductors to other semiconductor vendors for resale. Resale revenue will be estimated separately for these companies. Also, count only sales made by an overseas subsidiary to equipment manufacturers or distributors, as opposed to counting sales from headquarters to an overseas subsidiary.

Internal Semiconductor Sales

This is defined as revenue from finished or unfinished semiconductor products from intracompany (internal) transfers to divisions of that company or subsidiaries of the parent company that manufactures end equipment. Internal semiconductor sales are classified as in-house sales or captive sales, depending on whether the company sells semiconductors on the merchant market.

In-House Semiconductor Sales

This is defined as internal semiconductor sales if the company also sells semiconductors on the merchant market. Count all in-house semiconductor sales at market prices. Market price is defined as the price at which the same or equivalent product is sold to equipment manufacturers.

Captive Semiconductor Sales

This is defined as internal semiconductor sales if your company does not sell semiconductors on the merchant market. We do not include any captive semiconductor sales.

Multichip Modules

Multichip modules (MCMs) are semiconductor-based functions that include more than one semiconductor device. The multiple dies are arranged either on a thin-film deposited (MCM-D) substrate, a ceramic (MCM-C) substrate, or a polyimide or laminate (MCM-L) substrate. Count only sales of MCM products and board-level products that conform with the definitions for "finished semiconductor products" or "unfinished semiconductor products." MCMs are not considered hybrids or monolithic ICs. MCMs are an advanced form of package interconnect.

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System-Level Products

These are products that comprise a number of module or board-level products amounting to a single system or subsystem. Examples include development systems, hardware platforms, and box-level products. Do not include any sales from such system-level products. By contrast, do include application-specific ICs (ASICs) that provide system-level integration into silicon.

Nonrecurring Engineering Charges

Nonrecurring engineering (NRE) charges are charges made to customers as the result of costs incurred during the design or customizing of a semiconductor device for that customer. Count NRE charges only when they occur in the following product areas:

- Design charges for ASICs, including gate arrays, cell-based ICs, and full-custom ICs
- Mask charges that result from the customizing of a programmable array logic (PAL), when the customer's fuse pattern is masked into it to produce a hard-wired array logic (HAL)
- Mask charges that result from the customizing of ROMs
- Mask charges that result from the storage of the customer's program in a microcontroller

Count revenue from NRE charges only on active semiconductor products that conform with the definitions for "finished semiconductor products" or "unfinished semiconductor products." Include these NRE charges as part of the revenue received from associated semiconductor product. Do not include revenue from NRE charges incurred during research, feasibility studies, or facility rental to third parties.

Electronic Design Automation Software

Electronic design automation (EDA) software is used to automate the design of semiconductors. Dataquest includes revenue from ASIC semiconductor vendors that also sell their own EDA software. Include any revenue derived from EDA software in the appropriate ASIC product category. The applicable categories are programmable logic device (PLD), gate array, and cell-based IC.

Intellectual Property Rights Income

This includes intellectual property rights (IPR) income from royalties, licensing agreements, technology transfers, and dispute settlements. Do not include any IPR income.

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Chapter 4
Exchange Rate Definitions

When converting a company's local currency sales into U.S. dollars, or vice versa, it is important to use the 1997 exchange rates provided by Dataquest. This will prevent inconsistencies in the conversion of offshore sales between each company.

Dataquest will provide an exchange rate table with the survey in January 1998.

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Chapter 5
Semiconductor Product Category Hierarchy

The semiconductor product category hierarchy in Table 5-1 begins with total semiconductor, and indents each subcategory in the left-hand column according to its position in the hierarchy. At each level in the hierarchy, all subcategories that contribute to this level are shown as a subcategory summation in the right-hand column. Any level in the hierarchy that does not depend on any subcategory is marked as a "Data Point."

Table 5-1
Semiconductor Product Category Hierarchy

Category	Description
Total Semiconductor	Total Monolithic Integrated Circuit + Total Discrete + Total Optical Semiconductor
Total Monolithic Integrated Circuit	Bipolar Digital IC + MOS Digital IC + Analog IC
Bipolar Digital IC	Bipolar Digital Memory IC + Bipolar Digital Logic IC
Bipolar Digital Memory IC	Data Point
Bipolar Digital Logic IC	Bipolar Digital Logic Application-Specific IC + Bipolar Digital Standard Logic IC + Other Bipolar Digital Logic IC
Bipolar Digital Logic ASIC	Bipolar Digital Gate Array + Bipolar Digital Programmable Logic Device + Bipolar Digital Cell-Based IC/Full-Custom IC
Bipolar Digital GA	Data Point
Bipolar Digital PLD	Data Point
Bipolar Digital Cell-Based IC/ Full-Custom IC	Data Point
Bipolar Digital Standard Logic IC	Data Point
Other Bipolar Digital Logic IC	Data Point
MOS Digital IC	MOS Memory IC + MOS Microcomponent IC + MOS Logic IC
MOS Digital Memory IC	DRAM + SRAM + EPROM + EEPROM + Flash Memory + Mask ROM + Other MOS Digital Memory IC
DRAM	Data Point
SRAM	Data Point
EPROM	Data Point
EEPROM	Data Point
Flash Memory	Data Point
Mask ROM	Data Point
Other MOS Memory IC	Data Point

Table 5-1 (Continued)
Semiconductor Product Category Hierarchy

Category	Description
MOS Digital Microcomponent IC	MOS Digital Microprocessor + MOS Digital Microcontroller + MOS Digital Microperipheral + Programmable Digital Signal Processor
MOS Digital MPU	8- and 16-bit CISC MPU + 32-bit and greater CISC MPU + 32-bit and greater RISC MPU
8- and 16-bit CISC MPU	Data Point
32-bit and greater CISC MPU	Data Point
32-bit and greater RISC MPU	Data Point
MOS Digital MCU	4-bit MCU + 8-bit MCU + 16-bit + 32-bit and greater MCU
4-bit MCU	Data Point
8-bit MCU	Data Point
16-bit MCU	Data Point
32-bit and greater MCU	Data Point
MOS Digital MPR	System Core Logic Chipset + Graphics and Imaging Controller + Communications Controller + Mass Storage Controller + Audio/Other Controller
System Core Logic Chipsets	Data Point
Graphics and Imaging Controllers	Data Point
Communications Controllers	Data Point
Mass Storage Controllers	Data Point
Audio/Other Controllers	Data Point
Programmable DSP	Data Point
Logic IC	Total ASIC + Digital Standard Logic IC + Other MOS Digital Logic IC
Total ASIC	Traditional Digital Gate Array + Embedded Gate Array + Digital Programmable Logic Device Digital Cell-Based IC + Digital Full-Custom IC + Mixed ASIC + Linear Array
Traditional Digital Gate Array	Data Point
Embedded Gate Array	Data Point
Digital Programmable Logic Device	Data Point
Digital Cell-BasedIC	Data Point
Digital Full-Custom IC	Data Point
Linear Array/ASIC	Data Point
Mixed-Signal ASIC	Data Point

Table 5-1 (Continued)
Semiconductor Product Category Hierarchy

Category	Description
MOS Digital Standard Logic IC	Data Point
Other MOS Digital Logic IC	LCD Drivers + Other MOS Digital Logic IC
LCD Drivers	Data Point
Other MOS Digital Logic IC	Data Point
Analog IC	Amplifier/Comparator IC + Voltage Regulator/Reference IC + Data Converter/Switch/Multiplexer IC + Interface IC + Telecom IC + Disk Drive IC + Other Special-Function IC + Linear Array/ASIC + Mixed-Signal ASIC + Total Special Consumer IC + Special Automotive IC
Amplifier/Comparator IC	Data Point
Voltage Regulator/Reference IC	Data Point
Data Converter/Switch/Multiplexer IC	Data Point
Interface IC	Data Point
Telecom IC	Data Point
Disk Drive IC	Data Point
Other Special-Function IC	Data Point
Total Special Consumer IC	Video Special Consumer IC + Audio Special Consumer IC + Other Special Consumer IC
Video Special Consumer IC	Data Point
Audio Special Consumer IC	Data Point
Other Special Consumer IC	Data Point
Special Automotive IC	Data Point
Total Discrete	Transistor + Diode + Thyristor + Other Discrete
Transistor	Small-Signal Transistor + Power Transistor
Small-Signal Transistor	Data Point
Power Transistor	Bipolar Power Transistor + MOS Power Transistor + Power Insulated Gate Bipolar Transistor
Bipolar Power Transistor	Data Point
MOS Power Transistor	Data Point
Power IGBT	Data Point
Diode	Small-Signal/Reference Diode + Power Diode/Rectifier
Small-Signal/Reference Diode	Data Point
Power Diode/Rectifier	Data Point
Thyristor	Data Point
Other Discrete	Data Point

Table 5-1 (Continued)
Semiconductor Product Category Hierarchy

Category	Description
Total Optical Semiconductor	Total LED Lamp/Display + Optocoupler + CCD + Laser Diode + Photosensor + Other Optical Semiconductor
Total LED Lamp/Display	Infrared LED + Other LED
Infrared LED	Data Point
Other LED Lamp/Display	Data Point
Optocoupler	Data Point
Charge-Coupled Device	Data Point
Laser Diode	Data Point
Photosensor	Data Point
Other Optical Semiconductor	Data Point

Source Dataquest (December 1997)

Chapter 6

Semiconductor Product Category Definitions

The semiconductor product category definitions in Table 6-1 begin with total semiconductor and continue through each subcategory in the same order as shown in the preceding semiconductor product category hierarchy. At each level in the hierarchy, all subcategories that contribute to this level are shown as a subcategory summation in the right-hand column. Comprehensive definitions are given at every level. Table 6-2 shows microcomponent word widths.

Table 6-1
Semiconductor Product Category Definitions

Category	Definition
Total Semiconductor	(Total Monolithic Integrated Circuit + Total Discrete + Total Optical Semiconductor)
	Defined as an active semiconductor product that contains semiconducting material (such as silicon, germanium, or gallium arsenide but excluding ceramics) and reacts dynamically to an input signal, either by modifying its shape or adding energy to it. This definition excludes standalone passive components, such as capacitors, resistors, inductors, oscillators, crystals, transformers, and relays.
Total Monolithic Integrated Circuit	(Digital Monolithic Bipolar IC + Digital Monolithic MOS IC + Analog IC)
	A monolithic IC is one that is formed on a single chip of semiconducting material. This designation has been applied more broadly to mean any device, even multiple-chip packaged devices, that does not contain other, nonsemiconductor, components. This differentiates monolithic ICs from hybrid ICs that may also be multiple chip, but represent a "hybrid" in the sense of mixing other technologies within the IC package, such as film resistors or chip capacitors.
Digital Bipolar IC	(Bipolar Digital Memory IC + Bipolar Digital Logic IC)
	A bipolar digital IC is defined as a monolithic semiconductor product in which 100 percent of the die area performs digital functions, and, concurrently, 100 percent of the die area is manufactured using bipolar semiconductor technology. A digital function is one in which data is carried as numerical values, usually in a binary code.
Bipolar Digital Memory IC	A bipolar digital semiconductor product in which binary data is stored and electronically retrieved. Includes emitter-coupled logic (ECL) random-access memory (RAM), read-only memory (ROM), programmable ROM (PROM), last-in/first-out (LIFO) memory, and first-in/first-out (FIFO) memory. Not included are products made with mixed bipolar CMOS (that is, BiCMOS) with transistor-transistor logic (TTL) or ECL outputs, which are classified as Other Bipolar Digital Logic.

Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
Bipolar Digital Logic IC	(Bipolar Digital Logic Application-Specific IC + Bipolar Digital Standard Logic IC + Other Bipolar Digital Logic IC) A bipolar semiconductor product that serves a general-purpose function using bit-processing technology. This bit processing is defined by hardwiring, mask programming, or field programming. Logic ICs also include customer-specific logic ICs.
Bipolar Digital Logic ASIC	(Bipolar Digital Gate Array + Bipolar Digital Programmable Logic Device + Bipolar Digital Cell-Based IC/Bipolar Digital Full-Custom IC) A single-user bipolar digital logic IC that is manufactured using vendor-supplied tools or libraries. Does not include bipolar digital ASICs incorporating microprocessor cells or microcontroller cells; these should be reported in the Other Bipolar Digital Logic IC category.
Bipolar Digital Gate Array	A bipolar digital gate array is defined as an ASIC device that is customized by the vendor to end-user specification using layers of interconnect. Included in this category are generic or base wafers with embedded functions, such as static RAM (SRAM) and electrically erasable PROM (EEPROM).
Bipolar Digital Programmable Logic Device	An ASIC device that is customized by the end user after assembly. Included in this category are bipolar field-programmable logic (bipolar FPL), bipolar field-programmable gate array (bipolar FPGA), bipolar programmable array logic (bipolar PAL), bipolar programmable logic array (bipolar PLA), bipolar electrically programmable logic devices (bipolar EPLDs), and bipolar complex PLDs.
Bipolar Digital Cell-Based IC/ Full-Custom IC	A bipolar digital cell-based IC is an ASIC device that is produced from a library of standard circuits/cells to a single-user specification. This process involves automatic routing and placement of cells using a full mask set. Included in this definition are bipolar standard cell ICs. Excluded from this definition are cell-based ICs with processor cores. These should be reported under Other Bipolar Digital Logic IC. A full-custom IC is an ASIC device that is produced for a single user using a full set of masks. This manufacturing process involves manual routing and placement of cells.
Bipolar Digital Standard Logic IC	A commodity bipolar family logic with fewer than 150 gates. Sometimes referred to as glue logic. Examples include TTL, ECL, and the following other family logic: TTL-compatible SSI, MSI, and LSI; standard, AS, FAST, LS, and ALS lines; and ECL-compatible SSI, MSI, and LSI. Also included are RTL and DTL.
Other Bipolar Digital Logic IC	All other bipolar digital logic ICs not accounted for in the preceding categories. Includes bipolar commodity family logic with 150 or more gates, bipolar digital general-purpose logic not belonging to any families, and bipolar digital microcomponent ICs.

Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
MOS Digital IC	(MOS Digital Memory IC + MOS Digital Microcomponent IC + MOS Digital Logic IC) A monolithic semiconductor product in which 100 percent of the die area performs digital functions, and, concurrently, any portion of the die area that is manufactured using metal-oxide semiconductor (MOS) technology. A digital function is one in which data is carried as numerical values, usually in a binary code. Includes mixed-technology manufacturing, such as BiMOS and BiCMOS, where there is some MOS technology employed.
MOS Digital Memory IC	(DRAM + SRAM + EPROM + EEPROM + Flash Memory + Mask ROM + Other MOS Digital Memory IC) A MOS digital IC in which binary data is stored and electronically retrieved.
DRAM	Dynamic RAM, multiport-DRAM (M-DRAM), video RAM (V RAM), synchronous DRAM (SDRAM), cached DRAM (CDRAM), and self-refreshed DRAM. DRAMs have memory cells consisting of a single transistor and require regular memory cell refreshes. These are volatile memories, and addressing is multiplexed.
SRAM	Static RAM, multiport-SRAM (M-SRAM), battery backed-up SRAM (BB-SRAM), and pseudo SRAM (PSRAM). SRAMs have memory cells consisting of a minimum of four transistors, except PSRAM, which has a memory cell consisting of a single transistor and is similar to a DRAM with nonmultiplexed addresses. SRAMs do not require memory cell refreshes (except in the case of PSRAM). These are volatile memories and addressing is not multiplexed. Note that color palette digital-to-analog converters (DACs) are included in the Data Converter/Switch/Multiplexer IC category of analog ICs.
EPROM	Erasable programmable read-only memory. This product classification includes ultraviolet EPROM (UV EPROM) and one-time programmable read-only memory (OTP ROM). EPROMs have nonvolatile memory cells consisting of a single transistor and do not require any memory cell refreshes. These devices are considered nonvolatile memories.
EEPROM	Electrically erasable programmable read-only memory. Includes serial EEPROM (S-EEPROM), parallel EEPROM (P-EEPROM), and electrically alterable read-only memory (EAROM). EEPROMs have memory cells consisting of a minimum of two transistors and do not require memory cell refreshes. Also includes nonvolatile RAM (NV-RAM), also known as shadow RAM. These semiconductor products are a combination of SRAM and EEPROM technologies in each memory cell. The EEPROM functions as a shadow backup for the SRAM when power is lost. These devices are considered nonvolatile memories.

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Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
Flash Memory	Nonvolatile products designed as flash EPROM/EEPROM that incorporate either 5V or 12V programming supplies and one-transistor (1T) or two-transistor (2T) memory cells with electrical programming and fast bulk/block erase. Flash memory can erase data only by bulk/block, not by byte.
Mask ROM	Mask-programmable read-only memory. Mask ROM is a form of memory that is programmed by the manufacturer to a user specification using a mask step. Mask ROM is programmed in hardware rather than software. These devices are considered nonvolatile memories.
Other MOS Digital Memory IC	All other MOS digital memory not already accounted for in the preceding categories. Includes MOS digital content addressable memory (CAM), MOS digital cache-tag RAM, MOS digital first-in/first-out memory (FIFO), MOS digital last-in/first-out (LIFO) memory, and ferroelectric memory.
Microcomponent IC	(Microprocessor + Microcontroller + Digital Signal Processor + Microperipheral)
	Microcomponents are a category of metal oxide semiconductor (MOS) integrated circuits (ICs), which are mostly digital, made up of the microprocessor (MPU), microcontroller (MCU), programmable digital signal processor (DSP), and microperipheral (MPR) product subcategories.
Microprocessor	(8-Bit MPU +16-Bit MPU + 32-Bit and Greater Computational MPU + 32-Bit and Greater Embedded MPU)
	Microprocessor (MPU): An MPU is a MOS digital integrated circuit that includes an instruction decoder, arithmetic logic unit (ALU), registers, and additional logic. It may contain instruction, data, or unified caches, memory management systems, and auxiliary ALUs for floating-point and other special data types. An MPU's functions are determined by fetching and executing instructions and manipulating data held in registers, internal cache, or external memory. MPUs operate out of external memory systems typically ranging from 1MB to 64MB of RAM and often backed by secondary memory systems (such as disks). More highly integrated versions of MPUs may contain on-chip peripherals, interface, and support circuits. The MPU category includes MPUs incorporating or originating from an ASIC design. MPUs are subdivided into 8-bit, 16-bit, or 32-bit and up word width. Beginning in 1997, 32-bit and larger MPUs are further divided into computational and embedded according to the applications into which they are designed. MPUs can be complex-instruction-set-computer (CISC) or reduced-instruction-set computer (RISC) implementations, although Dataquest no longer divides RISC and CISC in favor of architectural family distinctions (68000, x86, MIPS, and SPARC, among others). Similar terms are processor, central processor unit (CPU), and integrated processor.

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Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
Microcontroller	(4-Bit MCU + 8-Bit MCU + 16-Bit MCU + 32-Bit and greater MCU) An MCU is a MOS digital integrated circuit designed for standalone operation that includes a programmable processing unit, program memory, read/write data memory, and some input/output capability. The processing unit contains an instruction decoder, arithmetic logic unit, registers, and additional logic. The MCU's functions are determined by fetching and executing instructions and manipulating data held in on-chip program and data memory (not including cache memories). MCU devices must be available with on-chip program store (ROM, EPROM, and flash, among others), typically ranging from 1KB to 64KB. As an option, some MCU devices can be purchased without on-chip memory for use during the debug and development phase of the system. Peripheral circuits are typically included on chip to assist in sophisticated input, output, and control functions. The MCU category includes MCUs incorporating, or originating from, an ASIC design. Standalone digital signal processors are not included with MCUs. MCUs are subdivided into 4-bit, 8-bit, 16-bit, or 32-bit word width. In 1996, Dataquest began separating 32-bit MCUs from 16-bit MCUs. All MCUs are designed into embedded applications. A similar term is microcomputer.
Digital Signal Processor	A digital signal processor (DSP) is a programmable MOS digital integrated circuit (IC) designed for standalone operation, constituting a high-speed arithmetic unit (typically a multiplier-accumulator unit) designed to perform complex mathematical operations such as Fourier transforms in real time to generate, manipulate, or interpret digital representations of analog signals. Modern DSPs typically access multiple pieces of data in different locations of on-chip memory over separate data paths using specialized addressing modes. Most DSP functions, such as the multiply-and-accumulate function, complete in a single instruction clock. DSPs usually include peripherals, which may include analog circuits like analog-to-digital converters. DSPs typically operate on 16 or 24 bits of fixed-point data or 32 bits of floating-point data, although Dataquest does not currently subdivide DSPs into these categories. DSPs that have no version that can be reprogrammed by the user in assembly or a higher-level language are not included but are classified as fixed-function application-specific standard products (ASSPs) or microperipherals. DSPs integrated on-chip with an independent microprocessor or microcontroller are classified as either an MPU or an MCU, respectively. All DSPs are designed into embedded applications. A similar term is programmable DSP (pDSP).
Microperipheral	(System Core Logic Chipsets +Graphics and Imaging Controllers + Communications Controllers + Mass Storage Controllers + Audio/Other Controllers)

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Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
	A microperipheral is a MOS digital integrated circuit that serves as a dedicated logical support function to a microprocessor or microcontroller in a system, performing sophisticated input, output, and control functions. Microperipherals are not programmable from assembly language, although they are often highly configurable by software or electrical signals. This definition includes MPRs comprising more than one device, such as PC or core logic chipsets. The MPR category includes MPRs incorporating, or originating from, an ASIC design. MPRs might be implemented using microprocessor, microcontroller, or digital signal processing elements, although this is generally not evident to the user. A similar term is peripheral. Note that this definition may change radically for 1998.
System Core Logic Chipset	Devices dedicated to a particular microprocessor interface that perform some of the basic interface functions such as memory management, DRAM control, cache control, bus interface control, DMA control, and interrupt control
Graphics and Imaging Controller	Devices that typically interface to some form of systems bus to interpret, control, and display the visual output systems (computer-generated graphics, live video, and other images).
Communications Controller	Devices that control, format, and perform handshaking for the serial transmission and reception of information between systems or intelligent devices, including network controllers, integrated fax/modem chips, serial UARTs, and other communications interfaces
Mass Storage Controller	Devices that are used to control data storage into and retrieval from all forms of mass storage media (magnetic, optical, and others), which include controllers used within host computers (host-side) and within mass storage drives (device-side)
Audio/Other Controller	Devices used to input or output information through other forms, including audio input/output controllers, keyboard controllers, pen input controllers, parallel port controllers, and various other devices
Word Width	A programmable device's word width is the width, in bits, of one of the inputs to the primary on-chip integer arithmetic and logic unit. This measurement is independent of the data bus width or any other bus associated with the device. Wider and narrower data types might be operated on by the processor, with multiple passes through the ALU or special hardware. The word width classification is not influenced by the existence of additional integer units or of floating point and other special data type processors. A similar term is bit size.
Logic IC	(Total ASIC + MOS Digital Standard Logic IC + Other MOS Digital Logic IC)

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Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
	A MOS semiconductor product that serves a general-purpose function using bit-processing technology. This bit processing is defined by hardwiring, mask programming, or field programming. MOS microcomponents and MOS memory ICs are MOS logic ICs, but are either dedicated to a function (such as MOS microperipherals or MOS memory ICs) or are software programmable (such as MOS microprocessors and MOS microcontrollers). MOS logic ICs also include customer-specific MOS logic ICs.
Total ASIC	(Traditional Digital Gate Array + Embedded Gate Array + Digital Programmable Logic Device + Digital Cell-Based IC + Digital Full-Custom IC + Mixed ASIC + Linear Array)
	Defined as a single-user digital logic IC that is manufactured using vendor-supplied tools or libraries. Does not include digital ASICs incorporating microprocessor cells or microcontroller cells; these should be reported in the microprocessor IC or microcontroller IC category, respectively.
Traditional Digital Gate Array	Traditional gate arrays are ASICs that contain a configuration of uncommitted elements in a prefabricated base wafer. They are customized by interconnecting these elements with one or more metal routing layers. Included in this category are channeled and sea-of-gates architectures.
Embedded Gate Array	Embedded gate arrays are ASICs with a portion of the chip having traditional gate array architecture (channeled or sea-of-gates) and with megacells such as SRAM diffused into the gate array base wafer
Digital Programmable Logic Device	An ASIC device that is customized by the end user after assembly. Included in this category are MOS field-programmable logic (MOS FPL), MOS field-programmable gate array (MOS FPGA), MOS programmable array logic (MOS PAL), MOS programmable logic array (MOS PLA), MOS electrically programmable logic device (MOS EPLD), and MOS complex PLDs.
Digital Cell-Based IC	An ASIC device that is produced from a library of standard circuits or cells to a single-user specification. This process involves automatic routing and placement of cells utilizing a full mask set. Included in this definition is MOS standard cell IC.
Digital Full-Custom IC	An ASIC device that is produced for a single user using a full set of masks. This process involves manual routing and placement of cells.
Linear Array ASIC	A single-user linear IC that is manufactured using vendor-supplied tools or libraries. Linear arrays fall into one of three types, as follows: 1. Arrays of discrete-level cells such as transistors and diodes 2. Arrays of discrete device combinations, referred to as tiles 3. Arrays of higher-level functional macro cells such as operational amplifiers, comparators, voltage-controlled oscillators (VCOs), references, and other analog functions. These arrays are interconnected with a metal mask or by means of some user-programmable interconnect scheme. Unlike cell-based designs, they do not have a unique set of masks for all layers.

Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
Mixed-Signal ASIC	A mixed-signal ASIC that is manufactured for a single user, using vendor-supplied tools or libraries and containing analog in more than 50 percent of the die area. ASICs with analog making up less than 50 percent of the die area should be counted in the appropriate category under digital ASIC.
MOS Digital Standard Logic IC	Commodity MOS family logic with fewer than 150 gates. Sometimes referred to as glue logic. Examples include: HC/HCT, AC/ACT, FACT, and 74BC/BCT BiCMOS family logic.
LCD Driver	Display driver IC designed to control and drive liquid crystal display (LCD) panels. LCD drivers convert digital inputs into the multi-level signals needed to drive liquid crystal displays. Excluded from this category are microperipheral controller/driver ICs that include the LCD drive function and TV LCD drivers that accept analog video inputs. These devices are counted as part of the microcomponent category or analog IC category, respectively.
Other MOS Digital Logic IC	All other MOS digital logic ICs not accounted for in the preceding categories. Includes MOS commodity family logic with 150 or more gates and MOS digital general-purpose logic not belonging to any families.
Total Analog IC	(Amplifier/Comparator IC + Voltage Regulator/Reference IC + Data Converter/Switch/Multiplexer IC + Interface IC + Telecom IC + Disk Drive IC + Other Special-Function IC + Linear Array/ASIC + Mixed-Signal ASIC + Total Special Consumer IC + Special Automotive IC + Smart Power IC) An analog IC is a semiconductor product that deals in the realm of electrical signal processing, power control, or electrical drive capability. It is one in which some of the inputs or outputs can be defined in terms of continuously or linearly variable voltages, currents, or frequencies. Includes only monolithic analog ICs manufactured using bipolar, MOS, or BiCMOS technologies. Includes monolithic linear IC and monolithic mixed-signal IC. A monolithic linear IC is characterized by having 100 percent analog input/output, while a mixed-signal IC carries information in both digital (numeric) and signal/power forms.
Amplifier/Comparator IC	An amplifier is a general-purpose linear IC that provides a voltage or current gain to an input signal. Includes operational amplifiers (mono, dual, and quad, among others), instrumentation amplifiers, buffer amplifiers, and power amplifiers. Consumer-dedicated amplifier ICs are counted in special consumer IC. Amplifier ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in linear array ASIC.

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Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
	A comparator IC is defined as a general-purpose linear IC that compares two analog signal inputs and provides a single logic bit output. Although the output could be considered digital, these products are classed as linear ICs because they are specialty high-gain amplifiers, used in an open-loop mode, for which the output is constrained to only two states. By using a comparator, an unknown voltage can be compared with a known reference voltage. Comparator ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in linear array ASIC.
Voltage Regulator/ Reference IC	A voltage regulator IC is defined as a general-purpose linear IC that outputs a variable current at a regulated DC voltage to other circuits from a variable current and voltage input. Regulator ICs are either linear regulators, in which the device provides an input-to-output voltage drop, or switching regulators, in which the device provides switched quantities of power to a smoothing circuit to gain higher efficiency and reduce power dissipation. Voltage regulator ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in linear array ASIC.
	A voltage reference IC is defined as a general-purpose linear IC that outputs a precise reference voltage to other circuits from a variable voltage input. A reference IC differs from a regulator IC in that it is not expected to power other circuits. In fact, voltage regulator ICs incorporate a voltage reference circuit. Voltage reference ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in linear array ASIC.
Data Converter/Switch/ Multiplexer IC	A data converter IC is defined as a general-purpose mixed-signal IC that converts an analog signal into a digital signal or vice versa. Includes analog-to-digital converters (ADCs), digital-to-analog converters (DACs), sample-and-hold circuits (SHCs), voltage-to-frequency circuits (VFCs), frequency-to-voltage circuits (FVCs), synchro-to-digital circuits (SDCs), and digital-to-synchro circuits (DSCs). All these are general-purpose data ICs. Also included in this category are color-palette DACs. Consumer-dedicated data converter ICs are counted in special consumer IC, under monolithic linear ICs. Data converter ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in mixed-signal ASIC.

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Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
	A switch/multiplexer IC is defined as a mixed-signal IC that digitally controls analog transmission gates. These products connect or disconnect the analog signal path in analog circuits. Analog switches operate in a mode where each switch is operated independently by a single logic bit. Multiplexers are multiple analog switches that are connected in a dependent manner, where only one signal path is connected through to the output, depending on the state of a digital address word (greater than one bit). Thus, analog multiplexers are really addressable signal selector switches that select one of many signals for further analog processing. Because these addressable analog switches were the key element in time-division multiplexing, the term "multiplexer" has remained. They are an important part of the data conversion product family in that they are used to provide time-division multiplexing of signal inputs to a fast analog-to-digital converter. Switch/multiplexer ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in mixed-signal ASIC.
Interface IC	A general-purpose mixed-signal IC that serves as an interface between a digital system and other external nonsemiconductor systems. Includes line drivers, peripherals drivers, receivers, transmitters, and transceivers. Interface ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in mixed-signal ASIC.
Telecom IC	A general-purpose mixed-signal IC that is used for voice band communication or data communication over voice band media. This category includes codecs, combos and SLACs, subscriber line interface circuits (SLICs), modem and fax/modem ICs, dialer and ringer ICs, repeaters, cellular communications ICs, ISDN ICs, telecom filter ICs, and other telecom-specific circuits. Telecom ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in mixed-signal ASIC.
Disk Drive IC	A mixed-signal IC that is designed specifically for the rotating mass storage market. Applications include the read/write path from preamplifier up to the ENDEC, head-positioning controller, and spindle motor control. Disk drive ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in mixed-signal ASIC.
Other Special-Function IC	An IC that is either a general-purpose IC that does not fit into the other categories or market or application specific ICs for which a category does not yet exist. The main products that fall into this category include timers, phase-locked loops (PLLs), voltage-controlled oscillators, signal- or function-generator ICs, and analog multipliers. Other special-function ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in the linear array/ASIC IC category.

Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
Total Special Consumer IC	(Video Special Consumer IC + Audio Special Consumer IC + Other Special Consumer IC) A general-purpose IC that is dedicated to general consumer applications but is not application-specific. Consumer ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in linear array ASIC.
Video Special Consumer IC	An IC implemented for video applications
Audio Special Consumer IC	An IC implemented for audio applications, including radio and speech synthesis and recognition
Other Special Consumer IC	An IC implemented in other consumer applications such as electronic games, personal and home appliances, and electronic cameras
Special Automotive IC	An IC that is used in the following automotive applications: entertainment, engine control, safety, traction, or in-car electrical and suspension systems. Special automotive ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in linear array ASIC.
Total Discrete	(Transistor + Diode + Thyristor + Other Discrete) A discrete semiconductor is defined as a single semiconductor component such as a transistor, diode or thyristor. Although multiple devices may be present in a package, they are still considered discretes if they have no internal functional interconnection and are applied in the same manner as other discrete devices.
Transistor	(Small-Signal Transistor + Power Transistor)
Small-Signal Transistor	Signal transistors, RF microwave transistors, dual transistors, MOS field-effect transistors (MOSFETs), conductivity modulated field-effect transistors (COMFETs), insulated gate bipolar transistors (IGBTs), and MOS-bipolar transistors (MBTs). All rated below 1W power dissipation.
Power Transistor	(Bipolar Power Transistor + MOS Power Transistor + Power IGBT) All are rated at 1W power dissipation and above.
Bipolar Power Transistor	Bipolar Darlington transistor, bipolar microwave transistor, and bipolar radio frequency (RF) transistor.
MOS Power Transistor	MOS field-effect transistor (MOSFET), MOS microwave transistor, and MOS radio frequency (RF) transistor.
IGBT Power Transistor	Insulated gate bipolar transistor (IGBT). Also includes conductivity modulated field-effect transistor (COMFET), MOS-bipolar transistor (MBT), and GEMFET.
Diode	(Small-Signal/Reference Diode + Power Diode/Rectifier)
Small-Signal/Reference Diode	Signal diodes, Schottky diodes, zener diodes, switching diodes, voltage reference diodes, voltage regulator diodes, and rectifier diodes. All are rated below 0.5A.
Power Diode/Rectifier	Zener diodes and rectifier diodes. All are rated 0.5A and above.
Thyristor	Thyristors, silicon-controlled rectifiers (SCRs), diacs, and triacs. Also includes solid-state relays (SSRs) incorporating triacs, thyristors, resistors, and capacitors

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Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
Other Discrete	All other discrete semiconductor products not accounted for in the preceding categories. Includes microwave diodes, varactors, tuning diodes, tunnel effect diodes, and selenium rectifiers. Does not include thermistors and varistors
Total Optical Semiconductor	(Total LED Lamp/Display + Optocoupler + CCD + Laser Diode + Photosensor + Other Optical Semiconductor)
	A semiconductor product in which photons induce the flow of electrons or vice versa. Other functions may also be integrated onto the product. This category does not include LCDs, incandescent displays, fluorescent displays, cathode ray tubes (CRTs), or plasma displays.
Total LED Lamp/Display	(Infrared LED Lamp/Display + Other LED Lamp/Display)
Infrared LED Lamp/ Display	Infrared LED lamps/displays are single light-emitting diodes (LEDs) or an array of LEDs consisting of more than one die (in the case of displays) functioning in the invisible infrared range.
Other LED Lamp/Display	Includes visible LEDs and other LED products not included elsewhere. A visible LED lamp is defined as a light-emitting diode for which the light is visible: a semiconductor product consisting of a single die in which photons are emitted at frequencies dependent upon the semiconductor material employed. An LED display is defined as an array of LEDs: a semiconductor product consisting of more than one die in which photons are emitted at frequencies dependent upon the semiconductor material employed and where the light transmission is visible.
Optocoupler	An optocoupler or optoisolator. A semiconductor product consisting of an LED separated from a photosensor by a transparent, insulating, dielectric layer. These are mounted inside an opaque package. Includes optointerrupters, in which the separation between LED and photosensor is large enough to allow external physical systems to influence the device.
Charge-Coupled Device	A charge-coupled device (CCD) is a semiconductor product consisting of an array of photodiodes, an analog CCD shift register, and an output circuit. Includes linear array CCDs with serial shift registers and area array CCDs with parallel shift registers. Includes charge injection device (CID), charge-coupled photodiode (CCP), charge-priming device (CPD), and self-scanning photodiode (SSP).
Laser Diode	A diode that produces coherent light. A semiconductor product in which the heterojunction structure stimulates light amplification by stimulated emission of radiation (laser), resulting in coherent light. Includes Fabrey-Perot laser diodes, pulsed laser diodes, and phase-shifted laser diodes
Photosensor	(Photodiode + Phototransistor)
	A diode or transistor in which photons are used to affect current flow or electric potential.
Other Optical Semiconductor	All other optical semiconductor devices not accounted for in the preceding categories. Includes solar cells and optical thermal piles.

Source: Dataquest (December 1997)

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Table 6-2
Microcomponent Word Widths

	4-Bit	8-Bit	16-Bit	24-Bit	32-Bit	64-Bit
MPU	-	8-bit	16-bit	-	32-bit and up	32-bit and up
MCU	4-bit	8-bit	16-bit	-	32-bit and up	-
DSP	-	-	DSP	DSP	DSP	-

Source: Dataquest (December 1997)

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Chapter 7

Worldwide Geographic Region Definitions and Regional Roll-Ups

Americas

Includes countries of North America, Central America, and South America.

Dataquest officially treats the countries of South America, Central America, Mexico, and Puerto Rico as the Latin America region.

Japan

Japan is the only single-country region.

Europe, Africa, and Middle East

Europe

Western Europe

Includes Austria, Belgium, Denmark, Finland, France, Germany (including the former East Germany), Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and Rest of Western Europe

Rest of Western Europe. Includes Andorra, Cyprus, Faroe Islands, Gibraltar, Greenland, Guernsey, Iceland, Isle of Man, Jersey, Liechtenstein, Luxembourg, Malta, Monaco, San Marino, and Svalbard

Eastern Europe

Includes Belarus, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Russia, Slovakia, Ukraine, and Rest of Eastern Europe

Rest of Eastern Europe. Includes Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Croatia, Georgia, Kazakstan, Kyrgyzstan, Macedonia, Moldova, Romania, Slovenia, Tajikistan, Turkmenistan, Uzbekistan, and Yugoslavia (Serbia and Montenegro)

Africa

Middle East

Asia/Pacific

Includes Australia, China, Hong Kong, India, Indonesia, South Korea, Malaysia, Singapore, Taiwan, Thailand, and Rest of Asia/Pacific

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Rest of Asia/Pacific. American Samoa, Ashmore and Cartier Islands, Baker Island, Bangladesh, Bhutan, Bouvet Island, Brunei, Cambodia, Christmas Island, Cocos (Keeling) Islands, Cook Islands, Coral Sea Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Howland Island, Jarvis Island, Johnston Atoll, Kingman Reef, Kiribati, Laos, Macau, Maldives, Marshall Islands, Midway Islands, Mongolia, Myanmar (Burma), Nauru, Nepal, New Caledonia, New Zealand, Niue, Norfolk Island, Northern Mariana Islands, North Korea, Pakistan, Palau, Palmyra Atoll, Papua New Guinea, Paracel Islands, Philippines, Pitcairn Islands, Solomon Islands, Spratly Islands, Sri Lanka, Tokelau, Tonga, Tuvalu, Vanuatu, Vietnam, Wake Island, Wallis and Futuna, and Western Samoa.

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Chapter 8
Semiconductor Application Segment Definitions

Data Processing

Defined as computer systems, data storage, input/output devices, dedicated systems, and other data processing equipment:

- Computer systems: The computer estimate does not include the value of the following systems: rigid disk drive, flexible disk drive, keyboards, and displays. The computer estimate does include the value of aftermarket sales of the following: graphics boards, motherboards, memory cards or single in-line memory modules (SIMMs), storage host adapters, and serial and parallel I/O boards. Worldwide computer systems production has been re-estimated and revalued to equal the value of worldwide (factory) revenue and shipments of computer systems as estimated by the Dataquest Computer Systems and Peripherals Worldwide group and to eliminate double-counting of system sales of storage devices, keyboards, and displays. Computer systems include supercomputers, mainframe computers, midrange computers (also known as superminicomputers and minicomputers), workstations, and personal computers (including portable computers). This includes the value of central processing units (that is, boxes) only.
- Data storage includes rigid disk drives, flexible disk drives, optical disk drives, and tape drives.
- Input/output devices include alphanumeric terminals and graphics terminals (for example, X terminals), monitors, and funds-transfer terminals; and printers, media-to-media data conversion, magnetic ink character recognition, optical scanning equipment, plotters, mice, keyboards, and digitizers.
- Dedicated systems include electronic copiers, electronic calculators and personal organizers, smart cards (IC cards), dictation and transcribing equipment, electronic typewriters and dedicated word processors, point-of sale terminals and electronic cash registers, and mailing, letter-handling, and addressing equipment.
- Other data processing includes sound and audio boards, digital video boards, accelerator boards, and embedded CPU boards.

Communications

Defined as premise telecom equipment, public telecom equipment, mobile communications equipment, broadcast and studio equipment, and other telecom equipment:

- Premise telecom equipment includes image and text communication, such as facsimile and facsimile cards, and video teleconferencing; data communications equipment such as modems and modem cards, statistical multiplexers, T1 multiplexers, front-end processors, data service unit/channel service unit (DSU/CSU), protocol converters, (local area) network interface cards, LAN hubs and internetworking equipment, packet data switching systems; premise switching equipment, such as PBX telephone equipment, and key telephone systems; call-processing equipment, such as voice messaging, interactive voice response systems, and automatic call distributors; and desktop terminal equipment, such as telephone sets/pay telephones and cordless telephones, and teleprinters.

- Public telecom equipment includes transmission equipment, such as multiplexers, carrier systems, microwave radio, laser and infrared transmission equipment, and satellite communications equipment; and central office switching equipment.
- Mobile communications equipment includes mobile radio systems such as cellular telephones, microcellular telephones, mobile radios, mobile radio base station equipment and pagers; portable radio receivers and transmitters; and radio checkout equipment.
- Broadcast and studio equipment includes audio equipment, video equipment, transmitters and RF power amplifiers, studio transmitter links, cable TV (head-end) equipment, closed-circuit TV equipment, and other equipment, such as studio and theater equipment.
- Other telecom equipment includes intercom equipment and electrical amplifiers; and communications equipment not elsewhere classified.

Industrial

Defined as security/energy management systems, manufacturing systems/instruments, medical equipment, and other industrial equipment:

- Security/energy management includes alarm systems, such as intrusion-detection and fire-detection systems, and energy management systems.
- Manufacturing systems/instruments include semiconductor production equipment, controls, process controls, control and processing displays and robots and test and measuring equipment such as semiconductor-dedicated automatic test equipment (ATE), other test and measurement equipment, and nuclear electronics.
- Medical equipment includes diagnostic equipment, therapeutic equipment, patient monitoring equipment, surgical support systems, and irradiation equipment.
- Other industrial equipment includes vending machines, power supplies, traffic-control equipment, and industrial equipment not elsewhere classified.

Consumer

Defined as audio equipment, video equipment, personal electronics, appliances, and other consumer equipment:

- Audio equipment includes compact disc players, radios, stereo components, musical instruments, and tape recorders.
- Video equipment includes VCRs and VTRs, video cameras and camcorders, videodisc players, color and monochrome TVs, and cable/satellite set-top decoders.

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- Personal electronics includes electronic games and toys (systems and cartridges), cameras, watches, and clocks.
- Appliances includes air conditioners, microwave ovens, washers and dryers, refrigerators, dishwashers, and ranges and ovens.
- Other consumer equipment includes automatic garage door openers and consumer equipment not elsewhere classified.

Military and Civil Aerospace

Defined as military electronic equipment and civil aerospace.

- Military/civil aerospace: North American military/civil aerospace production has been re-estimated and revalued to reflect U.S. Department of Commerce estimates of U.S. defense and civil (aerospace) electronics. Military/civil aerospace includes radar/sonar/reconnaissance systems, missile/space-related electronics, navigation equipment, electronic warfare, aircraft flight systems, and command and control systems.

Transportation

Defined as in-car entertainment, body control electronics, power train systems, and safety and convenience systems.

- In-car entertainment includes systems such as AM/FM radios, cassette and compact disc players, and radio/cassette combination systems.
- Body control electronics includes four-wheel steering control, two-wheel drive/four-wheel drive (2WD/4WD) control; multiplex systems such as driver's door console, door locks, windshield wipers, heated rear windows, memory seats, memory steering wheel, remote security systems, and suspension control and traction control systems; lighting controls including automatic headlight systems, timers, reminders, and sequential signal controls; and other body control electronics including aerodynamic aid control and power roof/window controls; driver information systems including electronic dashboard/instrument clusters, analog or digital clusters, electronic analog/digital clocks and compasses, electronic thermometers, head-up displays, navigation and location systems, signal and warning lights, and trip computers.
- Power train systems include engine management systems, power train sensors, ignition control, fuel injection systems, fuel flow, engine temperature, air temperature, coolant level, wheel speed sensors, and transmission control.
- Safety and convenience systems include climate control systems (air conditioning/heating), air purifier systems, air bag control systems, antilock braking systems, collision warning systems, and cruise control.

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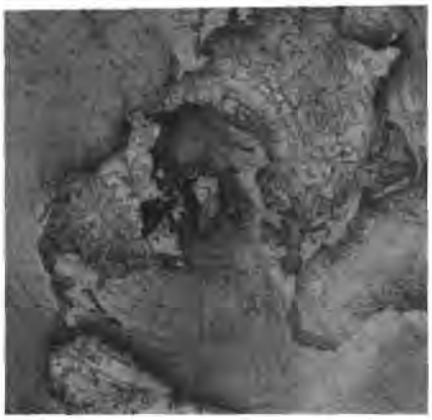
Market Statistics



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Final 1997 Worldwide Semiconductor Market Share

Market Statistics

Program: Semiconductors Worldwide
Product Code: SEMI-WW-MS-9801
Publication Date: April 27, 1998
Filing: Market Statistics

Final 1997 Worldwide Semiconductor Market Share

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List of Tables

Chapter 1
Final 1997 Worldwide Semiconductor Market Share

Introduction

This document contains detailed information on Dataquest's view of the semiconductor market. Included in this document are the following:

- 1995-1997 market share estimates
- 1996-1997 market share rankings

Worldwide market share estimates combine data from many countries, each of which has a different and fluctuating exchange rate. Estimates of non-U.S. market consumption or revenue are based on the average exchange rate for the given year. Refer to the section titled "Exchange Rates" for more information regarding these average rates. As a rule, Dataquest's estimates are calculated in local currencies and then converted to U.S. dollars.

More detailed data on this market may be requested through Dataquest's client inquiry service. Qualitative analysis of this data is provided in Dataquest Perspectives.

Segmentation and Definitions

A detailed explanation of device segmentation and related definitions is contained in the Semiconductor Market Definitions Guide (SCND-WW-GU-9801).

Market Share Methodology

Dataquest uses both primary and secondary sources to produce market statistics data. In the fourth quarter of each year, Dataquest surveys all major participants within each industry. Selected companies are resurveyed during the first quarter of the following year to verify final annual results. This primary research is supplemented with additional primary research and secondary research to verify market size, shipment totals, and pricing information. Sources of data used by Dataquest include the following:

- Information published by major industry participants
- Estimates made by knowledgeable and reliable industry spokespersons
- Government data or trade association data (such as WSTS, MITI, and U.S. DOC)
- Published product literature and price lists
- Interviews with knowledgeable manufacturers, distributors, and users
- Relevant economic data
- Information and data from online and CD-ROM data banks
- Articles in both the general and trade press

- Reports from financial analysts
- End-user surveys

Dataquest believes that the estimates presented in this document are the most accurate and meaningful statistics available.

Despite the care taken in gathering, analyzing, and categorizing the data in a meaningful way, careful attention must be paid to the definitions and assumptions used herein when interpreting the estimates presented in this document. Various companies, government agencies, and trade associations may use slightly different definitions of product categories and regional groupings, or they may include different companies in their summaries. These differences should be kept in mind when making comparisons between data and numbers provided by Dataquest and those provided by other sources.

Notes on Market Share

In the process of conducting data collection and preparing market statistics information, Dataquest will sometimes consolidate or revise a particular company, model, series, or industry's numbers. In this section, we explain any such changes contained within this document for your reference.

Notes to Market Share Tables

1. Cyrix was acquired by National Semiconductor in 1997.

2. National Semiconductor divested itself of Fairchild in 1997.

3. National Semiconductor's 1997 revenue includes all of Cyrix's 1997 revenue and part of Fairchild's calendar first quarter revenue.

4. Power Innovations was formed through the acquisition of the Power Semiconductor interests of Texas Instruments.

5. Melexis was formerly known as Elex.

6. Micronas acquired ITT in 1997.

7. The following companies were added to the market share database in 1997:

- Fairchild
- Vitesse
- TriQuint
- Power Innovations
- Robert Bosch
- Stanley

8. Toko is now tracked in other Japanese companies.

9. IBM's 1996 revenue was restated in 1997.

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Exchange Rates

Dataquest uses an average annual exchange rate in converting revenue to U.S. dollar amounts. Table 1-1 outlines these rates for 1995 through 1997.

Table 1-1
Exchange Rates

	1995	1996	1997
Japan (Yen/U.S.$)	93.90	108.81	121.10
France (Franc/U.S.$)	4.97	5.12	5.84
Germany (Deutsche Mark/U.S.$)	1.43	1.50	1.73
United Kingdom (U.S.$/Pound Sterling)	1.59	1.56	1.64

Source: Dataquest (April 1998)

Project Analyst: Kevin McClure

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Chapter 2
Market Share Tables

Tables 2-1 through 2-10 show each company's factory revenue by technology category. Tables 2-11 through 2-20 show the top companies' factory revenue by technology category.

Table 2-1
Each Company's Vendor Revenue from Shipments of Total Semiconductors Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	151,262	142,150	147,165	100	100	100
Americas Companies	60,021	64,076	72,339	39.7	45.1	49.2
8x8	44	51	60	0	0	0
ACC Microelectronics	40	45	50	0	0	0
Actel	109	149	156	0	0.1	0.1
Adaptec	124	214	238	0	0.2	0.2
Advanced Micro Devices	2,337	1,947	2,341	1.5	1.4	1.6
Allegro MicroSystems	185	200	155	0.1	0.1	0.1
Alliance Semiconductor	220	76	120	0.1	0	0
Altera	402	497	631	0.3	0.3	0.4
Anadigics	0	0	97	0	0	0
Analog Devices	983	1,260	1,370	0.6	0.9	0.9
Appian Technology	9	10	11	0	0	0
Applied Micro Circuits Corp.	49	56	36	0	0	0
ATI Technologies	0	130	260	0	0	0.2
Atmel	589	1,024	950	0.4	0.7	0.6
Burr-Brown	186	207	165	0.1	0.1	0.1
C-Cube	0	150	171	0	0.1	0.1
California Micro Devices	13	8	1	0	0	0
Catalyst	48	54	70	0	0	0
Cherry Semiconductor	87	100	112	0	0	0
Chip Express	0	25	31	0	0	0
Chips & Technologies	138	150	131	0	0.1	0
CID Technologies	5	6	6	0	0	0
Cirrus Logic	1,003	891	880	0.7	0.6	0.6
Crosspoint Solutions	2	2	1	0	0	0
Cypress Semiconductor	553	516	496	0.4	0.4	0.3
Dallas Semiconductor	228	277	304	0.2	0.2	0.2
Digital	0	271	359	0	0.2	0.2
DSP Group	60	67	76	0	0	0
Eastman Kodak	3	3	3	0	0	0
Elantec	25	35	36	0	0	0

Table 2-1 (Continued)
Each Company's Vendor Revenue from Shipments of Total Semiconductors Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Electronic Designs	43	51	10	0	0	0
ESS	0	0	245	0	0	0.2
Eteq Microsystems	7	4	4	0	0	0
Exar	147	96	102	0	0	0
Fairchild	0	0	448	0	0	0.3
G-Link USA	14	15	34	0	0	0
General Semiconductor	413	362	370	0.3	0.3	0.3
Gennum	34	37	39	0	0	0
Gould AMI	72	95	194	0	0	0.1
Harris Semiconductor	685	629	697	0.5	0.4	0.5
Hewlett-Packard	648	945	1,025	0.4	0.7	0.7
Honeywell	64	71	68	0	0	0
Hughes	36	39	38	0	0	0
ISD	0	0	48	0	0	0
IBM	3,522	3,200	3,391	2.3	2.3	2.3
IC Sensors	6	7	7	0	0	0
IMI	35	39	36	0	0	0
IMP	54	35	19	0	0	0
Integrated Circuit Systems	97	79	95	0	0	0
Integrated Device Technology	617	554	536	0.4	0.4	0.4
Integrated Silicon Solution	158	111	125	0.1	0	0
Intel	13,172	17,781	21,746	8.7	12.5	14.8
International CMOS Technology	16	12	5	0	0	0
International Rectifier	486	520	511	0.3	0.4	0.3
Ixys	65	66	69	0	0	0
Lattice	186	200	242	0.1	0.1	0.2
Level One Communications	78	112	127	0	0	0
Linear Technology	305	365	419	0.2	0.3	0.3
Linfinity	50	51	53	0	0	0
Logic Devices	17	14	14	0	0	0
LSI Logic	1,269	1,239	1,290	0.8	0.9	0.9
Lucent Technologies	1,615	2,110	2,762	1.1	1.5	1.9
Maxim	189	387	463	0.1	0.3	0.3
Micrel	26	24	104	0	0	0
Micro Linear	54	54	62	0	0	0
Microchip Technology	271	330	422	0.2	0.2	0.3
Micron Technology	2,601	1,558	1,704	1.7	1.1	1.2
Microsemi	118	146	156	0	0.1	0.1

Table 2-1 (Continued)
Each Company's Vendor Revenue from Shipments of Total Semiconductors Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Mitel	88	145	159	0	0.1	0.1
Motorola	8,722	8,076	8,067	5.8	5.7	5.5
National Semiconductor	2,408	2,380	2,759	1.6	1.7	1.9
NeoMagic	0	0	120	0	0	0
Oak Technology	84	172	163	0	0.1	0.1
Optek	62	69	73	0	0	0
OPTi	167	119	68	0.1	0	0
Paradigm	55	23	11	0	0	0
PMC Sierra Semiconductor	143	188	214	0	0.1	0.1
Powerex	98	98	98	0	0	0
Q Logic	61	67	73	0	0	0
Quality Semiconductor	46	45	47	0	0	0
Quality Technologies	61	52	54	0	0	0
QuickLogic	16	25	29	0	0	0
Ramtron	25	14	15	0	0	0
Raytheon	125	131	127	0	0	0
Rockwell	744	1,351	1,487	0.5	1	1
S3	315	464	437	0.2	0.3	0.3
Seeq Technology	27	32	31	0	0	0
Semtech	48	66	100	0	0	0
Silicon Storage Technology	35	91	75	0	0	0
Solitron	8	9	6	0	0	0
Spectra Diode Labs	15	17	17	0	0	0
Standard Microsystems	150	153	175	0	0.1	0.1
Sun Microsystems	0	170	550	0	0.1	0.4
Supertex	35	33	34	0	0	0
Symbios	395	458	418	0.3	0.3	0.3
Symphony Laboratories	15	17	19	0	0	0
Teccor Electronics	68	83	92	0	0	0
Telcom-	17	18	56	0	0	0
Texas Instruments	7,831	7,064	7,352	5.2	5	5
Trident Microsystems	139	180	144	0	0.1	0
TriQuint	0	0	72	0	0	0
Tseng Labs	105	26	8	0	0	0
Unitrode	103	98	118	0	0	0
Vitesse	0	0	118	0	0	0
VLSI Technology	672	672	713	0.4	0.5	0.5
VTC	155	172	110	0.1	0.1	0

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Table 2-1 (Continued)
Each Company's Vendor Revenue from Shipments of Total Semiconductors Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
WaferScale Integration	36	48	50	0	0	0
Xicor	114	123	122	0	0	0
Xilinx	520	566	612	0.3	0.4	0.4
Zilog	265	286	262	0.2	0.2	0.2
Zoran	0	29	34	0	0	0
Other Americas Companies	33	40	53	0	0	0
Japanese Companies	**60,599**	**50,884**	**47,825**	**40.1**	**35.8**	**32.5**
Fuji Electric	566	486	417	0.4	0.3	0.3
Fujitsu	5,535	4,427	4,622	3.7	3.1	3.1
Hitachi	9,135	8,071	6,298	6	5.7	4.3
Matsushita	3,474	3,003	2,847	2.3	2.1	1.9
Mitsubishi	5,274	4,100	3,925	3.5	2.9	2.7
NEC	11,314	10,428	10,222	7.5	7.3	6.9
New JRC	237	200	230	0.2	0.1	0.2
Nippon Steel Semiconductor	549	198	145	0.4	0.1	0
Oki	2,028	1,177	1,062	1.3	0.8	0.7
Ricoh	213	168	163	0.1	0.1	0.1
Rohm	1,934	1,731	2,053	1.3	1.2	1.4
Sanken	733	622	540	0.5	0.4	0.4
SANYO	2,714	2,491	2,471	1.8	1.8	1.7
Seiko Epson	313	256	205	0.2	0.2	0.1
Sharp	2,592	2,124	2,145	1.7	1.5	1.5
Shindengen Electric	329	298	266	0.2	0.2	0.2
Sony	2,333	1,983	1,974	1.5	1.4	1.3
Stanley	301	0	294	0.2	0	0.2
Toshiba	10,076	8,065	7,253	6.7	5.7	4.9
Yamaha	444	295	239	0.3	0.2	0.2
Other Japanese Companies	392	667	454	0.3	0.5	0.3
European Companies	**12,837**	**13,682**	**14,809**	**8.5**	**9.6**	**10.1**
Alcatel Microelectronics	179	190	215	0.1	0.1	0.1
Austria Mikro Systeme	149	140	130	0	0	0
Elmos	19	7	9	0	0	0
EM Microelectronics Marin	77	85	89	0	0	0
Ericsson	120	170	180	0	0.1	0.1
Eupec	120	160	111	0	0.1	0
Fagor	38	0	32	0	0	0
GEC Plessey	368	338	295	0.2	0.2	0.2
Melexis	33	34	22	0	0	0

Table 2-1 (Continued)
Each Company's Vendor Revenue from Shipments of Total Semiconductors Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Micronas	43	33	285	0	0	0.2
Philips	3,900	4,220	4,440	2.6	3	3
Power Innovations	0	0	29	0	0	0
Robert Bosch	0	0	240	0	0	0.2
Semikron	125	109	116	0	0	0
SGS-Thomson	3,398	4,112	4,019	2.2	2.9	2.7
Siemens	3,063	3,029	3,441	2	2.1	2.3
TCS	100	83	123	0	0	0
TEMIC	773	813	856	0.5	0.6	0.6
Zetex	56	54	93	0	0	0
Other European Companies	105	105	84	0	0	0
Asia/Pacific Companies	**17,805**	**13,508**	**12,192**	**11.8**	**9.5**	**8.3**
Acer	80	50	115	0	0	0
Daewoo	49	45	50	0	0	0
Holtek	87	99	117	0	0	0
Hualon Microelectronics Corp.	107	47	46	0	0	0
Hyundai	4,132	2,247	1,939	2.7	1.6	1.3
Korean Electronic Co.	287	268	300	0.2	0.2	0.2
LG Semicon	2,863	2,243	1,792	1.9	1.6	1.2
Macronix	271	354	365	0.2	0.2	0.2
Mosel Vitelic	502	398	316	0.3	0.3	0.2
Samsung	8,332	6,464	5,856	5.5	4.5	4
Silicon Integrated Systems	127	127	110	0	0	0
United Microelectronics	477	492	378	0.3	0.3	0.3
Vanguard	0	225	334	0	0.2	0.2
VIA	0	110	151	0	0	0.1
Winbond Electronics	491	339	323	0.3	0.2	0.2

Source: Dataquest (April 1998)

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Table 2-2
Each Company's Vendor Revenue from Shipments of Total ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**132,136**	**123,761**	**127,571**	**100**	**100**	**100**
Americas Companies	**55,754**	**59,836**	**67,952**	**42.2**	**48.3**	**53.3**
8x8	44	51	60	0	0	0
ACC Microelectronics	40	45	50	0	0	0
Actel	109	149	156	0	0.1	0.1
Adaptec	124	214	238	0	0.2	0.2
Advanced Micro Devices	2,337	1,947	2,341	1.8	1.6	1.8
Allegro MicroSystems	156	181	153	0.1	0.1	0.1
Alliance Semiconductor	220	76	120	0.2	0	0
Altera	402	497	631	0.3	0.4	0.5
Anadigics	0	0	97	0	0	0
Analog Devices	983	1,260	1,370	0.7	1	1.1
Appian Technology	9	10	11	0	0	0
Applied Micro Circuits Corp.	49	56	36	0	0	0
ATI Technologies	0	130	260	0	0.1	0.2
Atmel	589	1,024	950	0.4	0.8	0.7
Burr-Brown	186	207	165	0.1	0.2	0.1
C-Cube	0	150	171	0	0.1	0.1
California Micro Devices	13	8	1	0	0	0
Catalyst	48	54	70	0	0	0
Cherry Semiconductor	87	100	112	0	0	0
Chip Express	0	25	31	0	0	0
Chips & Technologies	138	150	131	0.1	0.1	0.1
Cirrus Logic	1,003	891	880	0.8	0.7	0.7
Crosspoint Solutions	2	2	1	0	0	0
Cypress Semiconductor	553	516	496	0.4	0.4	0.4
Dallas Semiconductor	228	277	304	0.2	0.2	0.2
Digital	0	271	359	0	0.2	0.3
DSP Group	60	67	76	0	0	0
Elantec	25	35	36	0	0	0
Electronic Designs	43	51	10	0	0	0
ESS	0	0	245	0	0	0.2
Eteq Microsystems	7	4	4	0	0	0
Exar	147	96	102	0.1	0	0
Fairchild	0	0	307	0	0	0.2
G-Link USA	14	15	34	0	0	0
Gennum	34	37	39	0	0	0
Gould AMI	72	95	194	0	0	0.2

Table 2-2 (Continued)
Each Company's Vendor Revenue from Shipments of Total ICs Worldwide
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Harris Semiconductor	457	397	467	0.3	0.3	0.4
Hewlett-Packard	342	380	466	0.3	0.3	0.4
Honeywell	27	30	30	0	0	0
Hughes	36	39	38	0	0	0
ISD	0	0	48	0	0	0
IBM	3,522	3,200	3,391	2.7	2.6	2.7
IMI	35	39	36	0	0	0
IMP	54	35	19	0	0	0
Integrated Circuit Systems	97	79	95	0	0	0
Integrated Device Technology	617	554	536	0.5	0.4	0.4
Integrated Silicon Solution	158	111	125	0.1	0	0
Intel	13,172	17,781	21,746	10	14.4	17
International CMOS Technology	16	12	5	0	0	0
International Rectifier	18	27	31	0	0	0
Lattice	186	200	242	0.1	0.2	0.2
Level One Communications	78	112	127	0	0	0
Linear Technology	305	365	419	0.2	0.3	0.3
Linfinity	50	51	53	0	0	0
Logic Devices	17	14	14	0	0	0
LSI Logic	1,269	1,239	1,290	1	1	1
Lucent Technologies	1,534	2,020	2,489	1.2	1.6	2
Maxim	189	387	463	0.1	0.3	0.4
Micrel	26	24	104	0	0	0
Micro Linear	54	54	62	0	0	0
Microchip Technology	271	330	422	0.2	0.3	0.3
Micron Technology	2,601	1,558	1,704	2	1.3	1.3
Mitel	88	123	143	0	0	0.1
Motorola	7,022	6,584	6,585	5.3	5.3	5.2
National Semiconductor	2,244	2,223	2,624	1.7	1.8	2.1
NeoMagic	0	0	120	0	0	0
Oak Technology	84	172	163	0	0.1	0.1
Optek	8	9	20	0	0	0
OPTi	167	119	68	0.1	0	0
Paradigm	55	23	11	0	0	0
PMC Sierra Semiconductor	143	188	214	0.1	0.2	0.2
Q Logic	61	67	73	0	0	0
Quality Semiconductor	46	45	47	0	0	0
QuickLogic	16	25	29	0	0	0

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Table 2-2 (Continued)
Each Company's Vendor Revenue from Shipments of Total ICs Worldwide
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	**1996**	**1997**	**1995**	**1996**	**1997**
Ramtron	25	14	15	0	0	0
Raytheon	112	118	113	0	0	0
Rockwell	744	1,351	1,487	0.6	1.1	1.2
S3	315	464	437	0.2	0.4	0.3
Seeq Technology	27	32	31	0	0	0
Semtech	19	42	90	0	0	0
Silicon Storage Technology	35	91	75	0	0	0
Solitron	2	4	1	0	0	0
Standard Microsystems	150	153	175	0.1	0.1	0.1
Sun Microsystems	0	170	550	0	0.1	0.4
Supertex	19	17	17	0	0	0
Symbios	395	458	418	0.3	0.4	0.3
Symphony Laboratories	15	17	19	0	0	0
Telcom-	17	18	56	0	0	0
Texas Instruments	7,772	6,974	7,292	5.9	5.6	5.7
Trident Microsystems	139	180	144	0.1	0.1	0.1
TriQuint	0	0	72	0	0	0
Tseng Labs	105	26	8	0	0	0
Unitrode	103	98	118	0	0	0
Vitesse	0	0	118	0	0	0
VLSI Technology	672	672	713	0.5	0.5	0.6
VTC	155	172	110	0.1	0.1	0
WaferScale Integration	36	48	50	0	0	0
Xicor	114	123	122	0	0	0
Xilinx	520	566	612	0.4	0.5	0.5
Zilog	265	286	262	0.2	0.2	0.2
Zoran	0	29	34	0	0	0
Other Americas Companies	0	40	53	0	0	0
Japanese Companies	**49,722**	**40,568**	**36,882**	**37.6**	**32.8**	**28.9**
Fuji Electric	98	85	61	0	0	0
Fujitsu	5,084	3,986	4,135	3.8	3.2	3.2
Hitachi	8,162	6,973	5,233	6.2	5.6	4.1
Matsushita	2,347	1,988	1,882	1.8	1.6	1.5
Mitsubishi	4,644	3,504	3,280	3.5	2.8	2.6
NEC	10,281	9,354	9,014	7.8	7.6	7.1
New JRC	223	188	227	0.2	0.2	0.2
Nippon Steel Semiconductor	549	198	145	0.4	0.2	0.1
Oki	1,988	1,138	1,018	1.5	0.9	0.8

Table 2-2 (Continued)
Each Company's Vendor Revenue from Shipments of Total ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Ricoh	213	168	163	0.2	0.1	0.1
Rohm	877	757	869	0.7	0.6	0.7
Sanken	283	254	70	0.2	0.2	0
SANYO	2,059	1,902	1,818	1.6	1.5	1.4
Seiko Epson	313	256	205	0.2	0.2	0.2
Sharp	1,956	1,507	1,430	1.5	1.2	1.1
Shindengen Electric	28	21	0	0	0	0
Sony	1,898	1,567	1,541	1.4	1.3	1.2
Toshiba	8,025	6,204	5,340	6.1	5	4.2
Yamaha	444	295	239	0.3	0.2	0.2
Other Japanese Companies	205	184	212	0.2	0.1	0.2
European Companies	**9,418**	**10,381**	**11,152**	**7.1**	**8.4**	**8.7**
Alcatel Microelectronics	179	190	215	0.1	0.2	0.2
Austria Mikro Systeme	149	140	130	0.1	0.1	0.1
Elmos	19	7	9	0	0	0
EM Microelectronics Marin	77	85	89	0	0	0
Ericsson	84	119	130	0	0	0.1
GEC Plessey	332	303	268	0.3	0.2	0.2
Melexis	31	34	22	0	0	0
Micronas	43	33	230	0	0	0.2
Philips	2,844	3,279	3,416	2.2	2.6	2.7
Robert Bosch	0	0	155	0	0	0.1
SGS-Thomson	2,807	3,526	3,447	2.1	2.8	2.7
Siemens	2,314	2,238	2,503	1.8	1.8	2
TCS	65	58	70	0	0	0
TEMIC	342	347	461	0.3	0.3	0.4
Zetex	4	1	7	0	0	0
Other European Companies	25	21	0	0	0	0
Asia/Pacific Companies	**17,242**	**12,976**	**11,585**	**13**	**10.5**	**9.1**
Acer	80	50	115	0	0	0
Daewoo	49	45	50	0	0	0
Holtek	87	99	117	0	0	0
Hualon Microelectronics Corp.	107	47	46	0	0	0
Hyundai	4,132	2,247	1,939	3.1	1.8	1.5
Korean Electronic Co.	45	51	60	0	0	0
LG Semicon	2,863	2,243	1,792	2.2	1.8	1.4
Macronix	271	354	365	0.2	0.3	0.3
Mosel Vitelic	502	398	316	0.4	0.3	0.2

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Table 2-2 (Continued)
Each Company's Vendor Revenue from Shipments of Total ICs Worldwide
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Samsung	8,011	6,149	5,489	6.1	5	4.3
Silicon Integrated Systems	127	127	110	0	0.1	0
United Microelectronics	477	492	378	0.4	0.4	0.3
Vanguard	0	225	334	0	0.2	0.3
VIA	0	110	151	0	0	0.1
Winbond Electronics	491	339	323	0.4	0.3	0.3

Source: Dataquest (April 1998)

Table 2-3
Each Company's Vendor Revenue from Shipments of Bipolar Digital Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**2,455**	**1,849**	**1,239**	**100**	**100**	**100**
Americas Companies	**1,295**	**953**	**609**	**52.7**	**51.5**	**49.2**
Advanced Micro Devices	100	62	28	4.1	3.4	2.3
Applied Micro Circuits Corp.	19	30	0	0.8	1.6	0
Harris Semiconductor	4	4	0	0.2	0.2	0
Lucent Technologies	50	70	10	2	3.8	0.8
Motorola	381	271	264	15.5	14.7	21.3
National Semiconductor	209	161	14	8.5	8.7	1.1
Raytheon	19	15	0	0.8	0.8	0
Texas Instruments	513	340	293	20.9	18.4	23.6
Japanese Companies	**972**	**752**	**485**	**39.6**	**40.7**	**39.1**
Fujitsu	203	90	63	8.3	4.9	5.1
Hitachi	442	451	262	18	24.4	21.1
Matsushita	29	19	19	1.2	1	1.5
Mitsubishi	37	25	24	1.5	1.4	1.9
NEC	109	90	82	4.4	4.9	6.6
Oki	36	4	3	1.5	0.2	0.2
Toshiba	116	73	32	4.7	3.9	2.6
European Companies	**174**	**134**	**117**	**7.1**	**7.2**	**9.4**
GEC Plessey	10	12	0	0.4	0.6	0
Philips	123	90	80	5	4.9	6.5
SGS-Thomson	6	0	0	0.2	0	0
Siemens	31	32	37	1.3	1.7	3
Other European Companies	4	0	0	0.2	0	0
Asia/Pacific Companies	14	10	28	0.6	0.5	2.3
LG Semicon	14	10	8	0.6	0.5	0.6
Mosel Vitelic	0	0	20	0	0	1.6

Source: Dataquest (April 1998)

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Table 2-4
Each Company's Vendor Revenue from Shipments of MOS Digital ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**110,410**	**102,209**	**104,680**	**100**	**100**	**100**
Americas Companies	**46,979**	**50,721**	**57,414**	**42.5**	**49.6**	**54.8**
8x8	44	51	60	0	0	0
ACC Microelectronics	40	45	50	0	0	0
Actel	109	149	156	0	0.1	0.1
Adaptec	124	214	238	0.1	0.2	0.2
Advanced Micro Devices	2,064	1,770	2,123	1.9	1.7	2
Allegro MicroSystems	0	7	9	0	0	0
Alliance Semiconductor	220	76	120	0.2	0	0.1
Altera	402	497	631	0.4	0.5	0.6
Analog Devices	116	272	306	0.1	0.3	0.3
Appian Technology	9	10	11	0	0	0
Applied Micro Circuits Corp.	25	23	33	0	0	0
ATI Technologies	0	130	260	0	0.1	0.2
Atmel	573	1,024	919	0.5	1	0.9
C-Cube	0	150	171	0	0.1	0.2
California Micro Devices	6	5	1	0	0	0
Catalyst	48	54	70	0	0	0
Cherry Semiconductor	0	0	11	0	0	0
Chip Express	0	25	31	0	0	0
Chips & Technologies	138	150	131	0.1	0.1	0.1
Cirrus Logic	887	741	604	0.8	0.7	0.6
Crosspoint Solutions	2	2	1	0	0	0
Cypress Semiconductor	553	516	496	0.5	0.5	0.5
Dallas Semiconductor	228	230	251	0.2	0.2	0.2
Digital	0	271	359	0	0.3	0.3
DSP Group	60	67	76	0	0	0
Electronic Designs	43	51	10	0	0	0
ESS	0	0	240	0	0	0.2
Eteq Microsystems	7	4	4	0	0	0
Exar	16	24	33	0	0	0
Fairchild	0	0	307	0	0	0.3
G-Link USA	14	15	34	0	0	0
Gennum	0	0	9	0	0	0
Gould AMI	72	95	194	0	0	0.2
Harris Semiconductor	193	198	209	0.2	0.2	0.2
Hewlett-Packard	342	380	466	0.3	0.4	0.4
Hughes	20	39	38	0	0	0

Table 2-4 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Digital ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
ISD	0	0	48	0	0	0
IBM	3,522	3,200	3,391	3.2	3.1	3.2
IMI	30	39	36	0	0	0
IMP	12	5	0	0	0	0
Integrated Circuit Systems	52	63	77	0	0	0
Integrated Device Technology	617	554	536	0.6	0.5	0.5
Integrated Silicon Solution	158	111	125	0.1	0.1	0.1
Intel	13,163	17,781	21,746	11.9	17.4	20.8
International CMOS Technology	16	12	5	0	0	0
Lattice	186	200	242	0.2	0.2	0.2
Logic Devices	17	14	14	0	0	0
LSI Logic	1,269	1,239	1,290	1.1	1.2	1.2
Lucent Technologies	1,200	1,715	2,374	1.1	1.7	2.3
Micrel	7	6	0	0	0	0
Micro Linear	0	3	11	0	0	0
Microchip Technology	271	330	422	0.2	0.3	0.4
Micron Technology	2,601	1,558	1,704	2.4	1.5	1.6
Mitel	0	24	15	0	0	0
Motorola	5,610	5,113	4,903	5.1	5	4.7
National Semiconductor	993	1,047	1,252	0.9	1	1.2
NeoMagic	0	0	120	0	0	0.1
Oak Technology	84	172	163	0	0.2	0.2
OPTi	167	119	68	0.2	0.1	0
Paradigm	55	23	11	0	0	0
PMC Sierra Semiconductor	47	87	98	0	0	0
Q Logic	61	67	73	0	0	0
Quality Semiconductor	46	45	47	0	0	0
QuickLogic	16	25	29	0	0	0
Ramtron	25	14	15	0	0	0
Raytheon	0	7	28	0	0	0
Rockwell	744	1,230	1,356	0.7	1.2	1.3
S3	315	464	437	0.3	0.5	0.4
Seeq Technology	27	12	19	0	0	0
Silicon Storage Technology	35	91	75	0	0	0
Standard Microsystems	150	153	175	0.1	0.1	0.2
Sun Microsystems	0	170	550	0	0.2	0.5
Supertex	6	5	5	0	0	0
Symbios	293	458	418	0.3	0.4	0.4

Table 2-4 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Digital ICs Worldwide
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Symphony Laboratories	15	17	19	0	0	0
Texas Instruments	6,325	4,950	4,804	5.7	4.8	4.6
Trident Microsystems	139	180	144	0.1	0.2	0.1
Tseng Labs	105	26	8	0	0	0
Vitesse	0	0	53	0	0	0
VLSI Technology	672	672	713	0.6	0.7	0.7
WaferScale Integration	36	48	50	0	0	0
Xicor	114	123	122	0.1	0.1	0.1
Xilinx	520	566	612	0.5	0.6	0.6
Zilog	265	286	262	0.2	0.3	0.3
Zoran	0	29	34	0	0	0
Other Americas Companies	0	40	53	0	0	0
Japanese Companies	**41,677**	**33,361**	**30,597**	**37.7**	**32.6**	**29.2**
Fuji Electric	46	41	37	0	0	0
Fujitsu	4,417	3,471	3,745	4	3.4	3.6
Hitachi	7,228	5,995	4,595	6.5	5.9	4.4
Matsushita	1,679	1,422	1,308	1.5	1.4	1.2
Mitsubishi	3,954	2,895	2,812	3.6	2.8	2.7
NEC	9,401	8,515	8,320	8.5	8.3	7.9
New JRC	40	28	29	0	0	0
Nippon Steel Semiconductor	549	198	145	0.5	0.2	0.1
Oki	1,911	1,103	998	1.7	1.1	1
Ricoh	175	118	103	0.2	0.1	0
Rohm	376	327	334	0.3	0.3	0.3
SANYO	972	945	968	0.9	0.9	0.9
Seiko Epson	297	242	191	0.3	0.2	0.2
Sharp	1,851	1,415	1,332	1.7	1.4	1.3
Sony	1,303	1,050	1,028	1.2	1	1
Toshiba	6,920	5,186	4,288	6.3	5.1	4.1
Yamaha	416	289	237	0.4	0.3	0.2
Other Japanese Companies	142	121	127	0.1	0.1	0.1
European Companies	**4,931**	**5,596**	**5,645**	**4.5**	**5.5**	**5.4**
Alcatel Microelectronics	35	179	204	0	0.2	0.2
Austria Mikro Systeme	68	133	124	0	0.1	0.1
Elmos	19	7	9	0	0	0
EM Microelectronics Marin	2	29	30	0	0	0
Ericsson	19	19	30	0	0	0
GEC Plessey	164	196	197	0.1	0.2	0.2

Table 2-4 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Digital ICs Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Melexis	23	22	16	0	0	0
Micronas	0	33	220	0	0	0.2
Philips	1,418	1,858	1,619	1.3	1.8	1.5
Robert Bosch	0	0	15	0	0	0
SGS-Thomson	1,318	1,651	1,556	1.2	1.6	1.5
Siemens	1,591	1,226	1,384	1.4	1.2	1.3
TCS	41	49	68	0	0	0
TEMIC	165	194	171	0.1	0.2	0.2
Zetex	0	0	2	0	0	0
Asia/Pacific Companies	**16,823**	**12,531**	**11,024**	**15.2**	**12.3**	**10.5**
Acer	80	50	115	0	0	0.1
Daewoo	27	21	21	0	0	0
Holtek	87	99	117	0	0	0.1
Hualon Microelectronics Corp.	98	43	41	0	0	0
Hyundai	4,130	2,246	1,936	3.7	2.2	1.8
LG Semicon	2,807	2,193	1,736	2.5	2.1	1.7
Macronix	271	354	365	0.2	0.3	0.3
Mosel Vitelic	502	398	296	0.5	0.4	0.3
Samsung	7,775	5,889	5,167	7	5.8	4.9
Silicon Integrated Systems	127	127	110	0.1	0.1	0.1
United Microelectronics	477	492	378	0.4	0.5	0.4
Vanguard	0	225	334	0	0.2	0.3
VIA	0	110	151	0	0.1	0.1
Winbond Electronics	442	284	257	0.4	0.3	0.2

Source: Dataquest (April 1998)

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Table 2-5
Each Company's Vendor Revenue from Shipments of MOS Memory Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**55,287**	**38,064**	**30,978**	**100**	**100**	**100**
Americas Companies	**13,641**	**9,656**	**8,375**	**24.7**	**25.4**	**27**
Advanced Micro Devices	719	711	708	1.3	1.9	2.3
Alliance Semiconductor	210	66	111	0.4	0.2	0.4
Atmel	478	793	670	0.9	2.1	2.2
Catalyst	48	54	70	0	0.1	0.2
Cypress Semiconductor	424	382	314	0.8	1	1
Dallas Semiconductor	56	0	0	0.1	0	0
Electronic Designs	43	51	10	0	0.1	0
Fairchild	0	0	80	0	0	0.3
G-Link USA	14	15	34	0	0	0.1
Harris Semiconductor	18	9	17	0	0	0
IBM	2,100	1,253	990	3.8	3.3	3.2
Integrated Device Technology	444	378	365	0.8	1	1.2
Integrated Silicon Solution	158	111	125	0.3	0.3	0.4
Intel	766	950	850	1.4	2.5	2.7
Logic Devices	5	2	2	0	0	0
Lucent Technologies	3	0	0	0	0	0
Microchip Technology	102	117	126	0.2	0.3	0.4
Micron Technology	2,601	1,558	1,704	4.7	4.1	5.5
Motorola	1,237	827	435	2.2	2.2	1.4
National Semiconductor	188	127	2	0.3	0.3	0
Paradigm	55	23	11	0	0	0
Quality Semiconductor	14	1	2	0	0	0
Ramtron	25	14	15	0	0	0
Seeq Technology	6	0	0	0	0	0
Silicon Storage Technology	35	91	75	0	0.2	0.2
Texas Instruments	3,754	1,984	1,524	6.8	5.2	4.9
WaferScale Integration	17	16	3	0	0	0
Xicor	114	123	122	0.2	0.3	0.4
Other Americas Companies	0	0	10	0	0	0
Japanese Companies	**24,062**	**15,708**	**11,827**	**43.5**	**41.3**	**38.2**
Fujitsu	2,589	1,656	1,508	4.7	4.4	4.9
Hitachi	5,132	3,514	2,209	9.3	9.2	7.1
Matsushita	492	300	315	0.9	0.8	1
Mitsubishi	2,547	1,614	1,435	4.6	4.2	4.6
NEC	5,353	3,913	3,215	9.7	10.3	10.4
Nippon Steel Semiconductor	549	198	145	1	0.5	0.5

Table 2-5 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Memory Worldwide
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Oki	1,228	541	448	2.2	1.4	1.4
Ricoh	6	3	8	0	0	0
Rohm	61	51	48	0.1	0.1	0.2
SANYO	257	302	162	0.5	0.8	0.5
Seiko Epson	41	19	15	0	0	0
Sharp	1,030	727	624	1.9	1.9	2
Sony	489	330	193	0.9	0.9	0.6
Toshiba	4,264	2,513	1,485	7.7	6.6	4.8
Yamaha	1	1	1	0	0	0
Other Japanese Companies	23	26	16	0	0	0
European Companies	**2,023**	**1,669**	**1,621**	**3.7**	**4.4**	**5.2**
Philips	0	0	73	0	0	0.2
SGS-Thomson	646	738	502	1.2	1.9	1.6
Siemens	1,353	911	1,028	2.4	2.4	3.3
TEMIC	24	20	18	0	0	0
Asia/Pacific Companies	**15,561**	**11,031**	**9,155**	**28.1**	**29**	**29.6**
Holtek	0	2	5	0	0	0
Hualon Microelectronics Corp.	54	23	20	0	0	0
Hyundai	4,116	2,236	1,931	7.4	5.9	6.2
LG Semicon	2,635	2,021	1,489	4.8	5.3	4.8
Macronix	236	288	300	0.4	0.8	1
Mosel Vitelic	502	398	296	0.9	1	1
Samsung	7,498	5,501	4,623	13.6	14.5	14.9
United Microelectronics	203	177	22	0.4	0.5	0
Vanguard	0	225	334	0	0.6	1.1
Winbond Electronics	317	160	135	0.6	0.4	0.4

Source: Dataquest (April 1998)

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Table 2-6
Each Company's Vendor Revenue from Shipments of MOS Microcomponents Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**34,504**	**41,469**	**48,945**	**100**	**100**	**100**
Americas Companies	**24,204**	**30,450**	**36,974**	**70.1**	**73.4**	**75.5**
8x8	44	51	60	0.1	0.1	0.1
ACC Microelectronics	40	45	50	0.1	0.1	0.1
Adaptec	124	214	238	0.4	0.5	0.5
Advanced Micro Devices	925	624	1,106	2.7	1.5	2.3
Alliance Semiconductor	10	10	9	0	0	0
Analog Devices	116	258	287	0.3	0.6	0.6
Appian Technology	9	10	11	0	0	0
ATI Technologies	0	130	260	0	0.3	0.5
Atmel	28	49	65	0	0.1	0.1
C-Cube	0	150	171	0	0.4	0.3
California Micro Devices	6	5	1	0	0	0
Chips & Technologies	138	150	131	0.4	0.4	0.3
Cirrus Logic	887	741	604	2.6	1.8	1.2
Cypress Semiconductor	50	64	6	0.1	0.2	0
Dallas Semiconductor	35	113	126	0.1	0.3	0.3
Digital	0	271	359	0	0.7	0.7
DSP Group	60	67	76	0.2	0.2	0.2
ESS	0	0	240	0	0	0.5
Harris Semiconductor	67	49	46	0.2	0.1	0
Hughes	3	3	0	0	0	0
IBM	703	889	803	2	2.1	1.6
IMP	1	0	0	0	0	0
Integrated Device Technology	63	70	64	0.2	0.2	0.1
Intel	12,397	16,831	20,896	35.9	40.6	42.7
LSI Logic	107	103	108	0.3	0.2	0.2
Lucent Technologies	510	635	888	1.5	1.5	1.8
Microchip Technology	169	213	296	0.5	0.5	0.6
Motorola	2,987	3,153	3,530	8.7	7.6	7.2
National Semiconductor	542	627	1,101	1.6	1.5	2.2
NeoMagic	0	0	120	0	0	0.2
Oak Technology	84	172	163	0.2	0.4	0.3
OPTi	167	119	68	0.5	0.3	0.1
PMC Sierra Semiconductor	47	62	70	0.1	0.1	0.1
Q Logic	61	67	73	0.2	0.2	0.1
Rockwell	738	1,226	1,351	2.1	3	2.8
S3	315	464	437	0.9	1.1	0.9

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Table 2-6 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Microcomponents Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Seeq Technology	21	12	19	0	0	0
Standard Microsystems	150	153	175	0.4	0.4	0.4
Sun Microsystems	0	170	550	0	0.4	1.1
Supertex	1	0	0	0	0	0
Symbios	85	102	129	0.2	0.2	0.3
Symphony Laboratories	15	17	19	0	0	0
Texas Instruments	1,254	1,550	1,728	3.6	3.7	3.5
Trident Microsystems	139	180	144	0.4	0.4	0.3
Tseng Labs	105	26	8	0.3	0	0
VLSI Technology	193	57	46	0.6	0.1	0
WaferScale Integration	18	30	46	0	0	0
Zilog	265	286	262	0.8	0.7	0.5
Zoran	0	29	34	0	0	0
Japanese Companies	**8,093**	**8,115**	**8,817**	**23.5**	**19.6**	**18**
Fuji Electric	3	3	3	0	0	0
Fujitsu	650	677	967	1.9	1.6	2
Hitachi	1,441	1,629	1,683	4.2	3.9	3.4
Matsushita	555	534	457	1.6	1.3	0.9
Mitsubishi	982	901	936	2.8	2.2	1.9
NEC	2,061	2,179	2,404	6	5.3	4.9
New JRC	4	5	5	0	0	0
Oki	233	175	164	0.7	0.4	0.3
Ricoh	75	76	75	0.2	0.2	0.2
Rohm	71	66	22	0.2	0.2	0
SANYO	187	164	229	0.5	0.4	0.5
Seiko Epson	28	22	24	0	0	0
Sharp	221	184	207	0.6	0.4	0.4
Sony	233	189	173	0.7	0.5	0.4
Toshiba	1,094	1,197	1,336	3.2	2.9	2.7
Yamaha	245	107	123	0.7	0.3	0.3
Other Japanese Companies	10	7	9	0	0	0
European Companies	**1,433**	**1,977**	**1,899**	**4.2**	**4.8**	**3.9**
EM Microelectronics Marin	2	4	4	0	0	0
GEC Plessey	10	10	11	0	0	0
Melexis	23	13	7	0	0	0
Micronas	0	0	50	0	0	0.1
Philips	662	1,085	791	1.9	2.6	1.6
SGS-Thomson	437	482	616	1.3	1.2	1.3

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Table 2-6 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Microcomponents Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	**1996**	**1997**	**1995**	**1996**	**1997**
Siemens	209	284	333	0.6	0.7	0.7
TCS	22	21	28	0	0	0
TEMIC	68	78	59	0.2	0.2	0.1
Asia/Pacific Companies	**774**	**927**	**1,255**	**2.2**	**2.2**	**2.6**
Acer	77	50	115	0.2	0.1	0.2
Daewoo	23	18	18	0	0	0
Holtek	34	44	24	0	0.1	0
Hyundai	1	1	1	0	0	0
LG Semicon	56	59	121	0.2	0.1	0.2
Macronix	35	20	29	0.1	0	0
Samsung	87	99	237	0.3	0.2	0.5
Silicon Integrated Systems	127	127	110	0.4	0.3	0.2
United Microelectronics	274	315	356	0.8	0.8	0.7
VIA	0	110	151	0	0.3	0.3
Winbond Electronics	60	84	93	0.2	0.2	0.2

Source: Dataquest (April 1998)

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Table 2-7
Each Company's Vendor Revenue from Shipments of MOS Digital Logic Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**20,619**	**22,676**	**24,757**	**100**	**100**	**100**
Americas Companies	**9,134**	**10,615**	**12,065**	**44.3**	**46.8**	**48.7**
Actel	109	149	156	0.5	0.7	0.6
Advanced Micro Devices	420	435	309	2	1.9	1.2
Allegro MicroSystems	0	7	9	0	0	0
Altera	402	497	631	1.9	2.2	2.5
Analog Devices	0	14	19	0	0	0
Applied Micro Circuits Corp.	25	23	33	0.1	0.1	0.1
Atmel	67	182	184	0.3	0.8	0.7
Cherry Semiconductor	0	0	11	0	0	0
Chip Express	0	25	31	0	0.1	0.1
Crosspoint Solutions	2	2	1	0	0	0
Cypress Semiconductor	79	70	176	0.4	0.3	0.7
Dallas Semiconductor	137	117	125	0.7	0.5	0.5
Eteq Microsystems	7	4	4	0	0	0
Exar	16	24	33	0	0.1	0.1
Fairchild	0	0	227	0	0	0.9
Gennum	0	0	9	0	0	0
Gould AMI	72	95	194	0.3	0.4	0.8
Harris Semiconductor	108	140	146	0.5	0.6	0.6
Hewlett-Packard	342	380	466	1.7	1.7	1.9
Hughes	17	36	38	0	0.2	0.2
ISD	0	0	48	0	0	0.2
IBM	719	1,058	1,598	3.5	4.7	6.5
IMI	30	39	36	0.1	0.2	0.1
IMP	11	5	0	0	0	0
Integrated Circuit Systems	52	63	77	0.3	0.3	0.3
Integrated Device Technology	110	106	107	0.5	0.5	0.4
International CMOS Technology	16	12	5	0	0	0
Lattice	186	200	242	0.9	0.9	1
Logic Devices	12	12	12	0	0	0
LSI Logic	1,162	1,136	1,182	5.6	5	4.8
Lucent Technologies	687	1,080	1,486	3.3	4.8	6
Micrel	7	6	0	0	0	0
Micro Linear	0	3	11	0	0	0
Mitel	0	24	15	0	0.1	0
Motorola	1,386	1,133	938	6.7	5	3.8
National Semiconductor	263	293	149	1.3	1.3	0.6

Table 2-7 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Digital Logic Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
PMC Sierra Semiconductor	0	25	28	0	0.1	0.1
Quality Semiconductor	32	44	45	0.2	0.2	0.2
QuickLogic	16	25	29	0	0.1	0.1
Raytheon	0	7	28	0	0	0.1
Rockwell	6	4	5	0	0	0
Supertex	5	5	5	0	0	0
Symbios	208	356	289	1	1.6	1.2
Texas Instruments	1,317	1,416	1,552	6.4	6.2	6.3
Vitesse	0	0	53	0	0	0.2
VLSI Technology	479	615	667	2.3	2.7	2.7
WaferScale Integration	1	2	1	0	0	0
Xilinx	520	566	612	2.5	2.5	2.5
Other Americas Companies	0	40	43	0	0.2	0.2
Japanese Companies	**9,522**	**9,538**	**9,953**	**46.2**	**42.1**	**40.2**
Fuji Electric	43	38	34	0.2	0.2	0.1
Fujitsu	1,178	1,138	1,270	5.7	5	5.1
Hitachi	655	852	703	3.2	3.8	2.8
Matsushita	632	588	536	3.1	2.6	2.2
Mitsubishi	425	380	441	2.1	1.7	1.8
NEC	1,987	2,423	2,701	9.6	10.7	10.9
New JRC	36	23	24	0.2	0.1	0
Oki	450	387	386	2.2	1.7	1.6
Ricoh	94	39	20	0.5	0.2	0
Rohm	244	210	264	1.2	0.9	1.1
SANYO	528	479	577	2.6	2.1	2.3
Seiko Epson	228	201	152	1.1	0.9	0.6
Sharp	600	504	501	2.9	2.2	2
Sony	581	531	662	2.8	2.3	2.7
Toshiba	1,562	1,476	1,467	7.6	6.5	5.9
Yamaha	170	181	113	0.8	0.8	0.5
Other Japanese Companies	109	88	102	0.5	0.4	0.4
European Companies	**1,475**	**1,950**	**2,125**	**7.2**	**8.6**	**8.6**
Alcatel Microelectronics	35	179	204	0.2	0.8	0.8
Austria Mikro Systeme	68	133	124	0.3	0.6	0.5
Elmos	19	7	9	0	0	0
EM Microelectronics Marin	0	25	26	0	0.1	0.1
Ericsson	19	19	30	0	0	0.1
GEC Plessey	154	186	186	0.7	0.8	0.8

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Table 2-7 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Digital Logic Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Melexis	0	9	9	0	0	0
Micronas	0	33	170	0	0.1	0.7
Philips	756	773	755	3.7	3.4	3
Robert Bosch	0	0	15	0	0	0
SGS-Thomson	235	431	438	1.1	1.9	1.8
Siemens	29	31	23	0.1	0.1	0
TCS	19	28	40	0	0.1	0.2
TEMIC	73	96	94	0.4	0.4	0.4
Zetex	0	0	2	0	0	0
Asia/Pacific Companies	**488**	**573**	**614**	**2.4**	**2.5**	**2.5**
Acer	3	0	0	0	0	0
Daewoo	4	3	3	0	0	0
Holtek	53	53	88	0.3	0.2	0.4
Hualon Microelectronics Corp.	44	20	21	0.2	0	0
Hyundai	13	9	4	0	0	0
LG Semicon	116	113	126	0.6	0.5	0.5
Macronix	0	46	36	0	0.2	0.1
Samsung	190	289	307	0.9	1.3	1.2
Winbond Electronics	65	40	29	0.3	0.2	0.1

Source: Dataquest (April 1998)

Table 2-8
Each Company's Vendor Revenue from Shipments of Analog-Monolithic Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**17,616**	**18,235**	**21,652**	**100**	**100**	**100**
Americas Companies	**7,294**	**8,013**	**9,929**	**41.4**	**43.9**	**45.9**
Advanced Micro Devices	173	115	190	1	0.6	0.9
Allegro MicroSystems	144	159	144	0.8	0.9	0.7
Anadigics	0	0	97	0	0	0.4
Analog Devices	809	946	1,064	4.6	5.2	4.9
Applied Micro Circuits Corp.	5	3	3	0	0	0
Atmel	16	0	31	0	0	0.1
Burr-Brown	126	157	165	0.7	0.9	0.8
California Micro Devices	7	3	0	0	0	0
Cherry Semiconductor	87	100	101	0.5	0.5	0.5
Cirrus Logic	116	150	276	0.7	0.8	1.3
Dallas Semiconductor	0	47	53	0	0.3	0.2
Elantec	22	32	36	0.1	0.2	0.2
ESS	0	0	5	0	0	0
Exar	131	72	69	0.7	0.4	0.3
Gennum	32	37	30	0.2	0.2	0.1
Harris Semiconductor	260	195	258	1.5	1.1	1.2
Honeywell	27	30	30	0.2	0.2	0.1
Hughes	16	0	0	0	0	0
IMI	5	0	0	0	0	0
IMP	42	30	19	0.2	0.2	0
Integrated Circuit Systems	45	16	18	0.3	0	0
Intel	9	0	0	0	0	0
International Rectifier	18	27	31	0.1	0.1	0.1
Level One Communications	78	112	127	0.4	0.6	0.6
Linear Technology	305	365	419	1.7	2	1.9
Linfinity	47	48	53	0.3	0.3	0.2
Lucent Technologies	284	235	105	1.6	1.3	0.5
Maxim	185	383	463	1.1	2.1	2.1
Micrel	19	18	104	0.1	0	0.5
Micro Linear	54	51	51	0.3	0.3	0.2
Mitel	68	83	128	0.4	0.5	0.6
Motorola	1,031	1,200	1,418	5.9	6.6	6.5
National Semiconductor	1,034	1,015	1,358	5.9	5.6	6.3
Optek	8	9	20	0	0	0
PMC Sierra Semiconductor	96	101	116	0.5	0.6	0.5
Raytheon	93	96	85	0.5	0.5	0.4

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Table 2-8 (Continued)
Each Company's Vendor Revenue from Shipments of Analog-Monolithic Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Rockwell	0	121	131	0	0.7	0.6
Seeq Technology	0	20	12	0	0.1	0
Semtech	19	42	90	0.1	0.2	0.4
Solitron	0	1	1	0	0	0
Supertex	13	12	12	0	0	0
Symbios	102	0	0	0.6	0	0
Telcom-	17	18	56	0	0	0.3
Texas Instruments	934	1,684	2,195	5.3	9.2	10.1
TriQuint	0	0	72	0	0	0.3
Unitrode	103	98	118	0.6	0.5	0.5
Vitesse	0	0	65	0	0	0.3
VTC	155	172	110	0.9	0.9	0.5
Japanese Companies	**5,704**	**5,210**	**5,800**	**32.4**	**28.6**	**26.8**
Fuji Electric	29	23	24	0.2	0.1	0.1
Fujitsu	315	291	327	1.8	1.6	1.5
Hitachi	355	409	376	2	2.2	1.7
Matsushita	639	547	555	3.6	3	2.6
Mitsubishi	455	397	444	2.6	2.2	2.1
NEC	641	624	612	3.6	3.4	2.8
New JRC	183	160	198	1	0.9	0.9
Oki	28	18	17	0.2	0	0
Ricoh	38	50	60	0.2	0.3	0.3
Rohm	423	357	535	2.4	2	2.5
Sanken	0	0	70	0	0	0.3
SANYO	894	780	850	5.1	4.3	3.9
Seiko Epson	16	14	14	0	0	0
Sharp	105	92	98	0.6	0.5	0.5
Sony	554	452	513	3.1	2.5	2.4
Toshiba	915	909	1,020	5.2	5	4.7
Yamaha	28	6	2	0.2	0	0
Other Japanese Companies	49	50	85	0.3	0.3	0.4
European Companies	**4,213**	**4,577**	**5,390**	**23.9**	**25.1**	**24.9**
Alcatel Microelectronics	144	11	11	0.8	0	0
Austria Mikro Systeme	81	7	6	0.5	0	0
EM Microelectronics Marin	75	56	59	0.4	0.3	0.3
Ericsson	50	87	100	0.3	0.5	0.5
GEC Plessey	155	95	71	0.9	0.5	0.3
Melexis	8	12	6	0	0	0

Table 2-8 (Continued)
Each Company's Vendor Revenue from Shipments of Analog-Monolithic Worldwide
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Micronas	33	0	10	0.2	0	0
Philips	1,257	1,291	1,717	7.1	7.1	7.9
Robert Bosch	0	0	140	0	0	0.6
SGS-Thomson	1,483	1,875	1,891	8.4	10.3	8.7
Siemens	692	980	1,082	3.9	5.4	5
TCS	24	9	2	0.1	0	0
TEMIC	177	153	290	1	0.8	1.3
Zetex	4	1	5	0	0	0
Asia/Pacific Companies	**405**	**435**	**533**	**2.3**	**2.4**	**2.5**
Daewoo	22	24	29	0.1	0.1	0.1
Hualon Microelectronics Corp.	9	4	5	0	0	0
Hyundai	2	1	3	0	0	0
Korean Electronic Co.	45	51	60	0.3	0.3	0.3
LG Semicon	42	40	48	0.2	0.2	0.2
Samsung	236	260	322	1.3	1.4	1.5
Winbond Electronics	49	55	66	0.3	0.3	0.3

Source: Dataquest (April 1998)

Table 2-9
Each Company's Vendor Revenue from Shipments of Total Discrete Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**14,314**	**13,474**	**14,255**	**100**	**100**	**100**
Americas Companies	**3,720**	**3,416**	**3,391**	**26**	**25.4**	**23.8**
Allegro MicroSystems	29	19	2	0.2	0.1	0
Fairchild	0	0	141	0	0	1
General Semiconductor	413	362	370	2.9	2.7	2.6
Harris Semiconductor	228	232	230	1.6	1.7	1.6
Hewlett-Packard	146	140	126	1	1	0.9
International Rectifier	468	493	480	3.3	3.7	3.4
Ixys	65	66	69	0.5	0.5	0.5
Microsemi	118	146	156	0.8	1.1	1.1
Motorola	1,650	1,452	1,446	11.5	10.8	10.1
National Semiconductor	164	157	135	1.1	1.2	0.9
Optek	1	1	0	0	0	0
Powerex	98	98	98	0.7	0.7	0.7
Raytheon	13	13	14	0	0	0
Semtech	29	24	10	0.2	0.2	0
Solitron	6	5	5	0	0	0
Supertex	16	16	17	0.1	0.1	0.1
Teccor Electronics	68	83	92	0.5	0.6	0.6
Texas Instruments	16	28	0	0.1	0.2	0
Japanese Companies	**7,142**	**6,774**	**7,187**	**49.9**	**50.3**	**50.4**
Fuji Electric	468	401	356	3.3	3	2.5
Fujitsu	283	290	319	2	2.2	2.2
Hitachi	889	977	949	6.2	7.3	6.7
Matsushita	631	565	577	4.4	4.2	4
Mitsubishi	479	452	460	3.3	3.4	3.2
NEC	831	818	885	5.8	6.1	6.2
New JRC	2	3	3	0	0	0
Oki	12	11	12	0	0	0
Rohm	771	681	827	5.4	5.1	5.8
Sanken	398	328	434	2.8	2.4	3
SANYO	488	441	478	3.4	3.3	3.4
Shindengen Electric	301	277	266	2.1	2.1	1.9
Sony	53	43	39	0.4	0.3	0.3
Toshiba	1,428	1,390	1,484	10	10.3	10.4
Other Japanese Companies	40	42	98	0.3	0.3	0.7

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Table 2-9 (Continued)
Each Company's Vendor Revenue from Shipments of Total Discrete Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
European Companies	**2,915**	**2,784**	**3,102**	**20.4**	**20.7**	**21.8**
Ericsson	20	28	30	0.1	0.2	0.2
Eupec	120	160	111	0.8	1.2	0.8
Fagor	38	0	32	0.3	0	0.2
GEC Plessey	36	35	27	0.3	0.3	0.2
Melexis	2	0	0	0	0	0
Micronas	0	0	55	0	0	0.4
Philips	1,056	941	1,024	7.4	7	7.2
Power Innovations	0	0	29	0	0	0.2
Robert Bosch	0	0	85	0	0	0.6
Semikron	125	109	116	0.9	0.8	0.8
SGS-Thomson	591	586	572	4.1	4.3	4
Siemens	435	452	554	3	3.4	3.9
TCS	1	0	31	0	0	0.2
TEMIC	321	353	281	2.2	2.6	2
Zetex	51	52	86	0.4	0.4	0.6
Other European Companies	65	68	69	0.5	0.5	0.5
Asia/Pacific Companies	**537**	**500**	**575**	**3.8**	**3.7**	**4**
Korean Electronic Co.	220	193	220	1.5	1.4	1.5
Samsung	317	307	355	2.2	2.3	2.5

Source: Dataquest (April 1998)

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Table 2-10
Each Company's Vendor Revenue from Shipments of Total Optical Semiconductors Worldwide (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Worldwide Companies	**4,812**	**4,915**	**5,339**	**100**	**100**	**100**
Americas Companies	**547**	**824**	**996**	**11.4**	**16.8**	**18.7**
CID Technologies	5	6	6	0.1	0.1	0.1
Eastman Kodak	3	3	3	0	0	0
Hewlett-Packard	160	425	433	3.3	8.6	8.1
Honeywell	37	41	38	0.8	0.8	0.7
IC Sensors	6	7	7	0.1	0.1	0.1
Lucent Technologies	81	90	273	1.7	1.8	5.1
Mitel	0	22	16	0	0.4	0.3
Motorola	50	40	36	1	0.8	0.7
Optek	53	59	53	1.1	1.2	1
Quality Technologies	61	52	54	1.3	1.1	1
Spectra Diode Labs	15	17	17	0.3	0.3	0.3
Texas Instruments	43	62	60	0.9	1.3	1.1
Other Americas Companies	33	0	0	0.7	0	0
Japanese Companies	**3,735**	**3,542**	**3,756**	**77.6**	**72.1**	**70.4**
Fujitsu	168	151	168	3.5	3.1	3.1
Hitachi	84	121	116	1.7	2.5	2.2
Matsushita	496	450	388	10.3	9.2	7.3
Mitsubishi	151	144	185	3.1	2.9	3.5
NEC	202	256	323	4.2	5.2	6
New JRC	12	9	0	0.2	0.2	0
Oki	28	28	32	0.6	0.6	0.6
Rohm	286	293	357	5.9	6	6.7
Sanken	52	40	36	1.1	0.8	0.7
SANYO	167	148	175	3.5	3	3.3
Sharp	636	617	715	13.2	12.6	13.4
Sony	382	373	394	7.9	7.6	7.4
Stanley	301	0	294	6.3	0	5.5
Toshiba	623	471	429	12.9	9.6	8
Other Japanese Companies	147	441	144	3.1	9	2.7
European Companies	**504**	**517**	**555**	**10.5**	**10.5**	**10.4**
Ericsson	16	23	20	0.3	0.5	0.4
Siemens	314	339	384	6.5	6.9	7.2
TCS	34	25	22	0.7	0.5	0.4
TEMIC	110	113	114	2.3	2.3	2.1
Zetex	1	1	0	0	0	0
Other European Companies	15	16	15	0.3	0.3	0.3
Asia/Pacific Companies	**26**	**32**	**32**	**0.5**	**0.7**	**0.6**
Korean Electronic Co.	22	24	20	0.5	0.5	0.4
Samsung	4	8	12	0	0.2	0.2

Source: Dataquest (April 1998)

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Table 2-11
Top 40 Total Market Vendor Revenue from Shipments of Total Semiconductors Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Intel	17,781	21,746	22.3	14.8
2	2	NEC	10,428	10,222	-2	6.9
3	3	Motorola	8,076	8,067	-0.1	5.5
6	4	Texas Instruments	7,064	7,352	4.1	5
5	5	Toshiba	8,065	7,253	-10.1	4.9
4	6	Hitachi	8,071	6,298	-22	4.3
7	7	Samsung	6,464	5,856	-9.4	4
8	8	Fujitsu	4,427	4,622	4.4	3.1
9	9	Philips	4,220	4,440	5.2	3
10	10	SGS-Thomson	4,112	4,019	-2.3	2.7
11	11	Mitsubishi	4,100	3,925	-4.3	2.7
13	12	Siemens	3,029	3,441	13.6	2.3
12	13	IBM	3,200	3,391	6	2.3
14	14	Matsushita	3,003	2,847	-5.2	1.9
20	15	Lucent Technologies	2,110	2,762	30.9	1.9
16	16	National Semiconductor	2,380	2,759	15.9	1.9
15	17	SANYO	2,491	2,471	-0.8	1.7
22	18	Advanced Micro Devices	1,947	2,341	20.2	1.6
19	19	Sharp	2,124	2,145	1	1.5
23	20	Rohm	1,731	2,053	18.6	1.4
21	21	Sony	1,983	1,974	-0.5	1.3
17	22	Hyundai	2,247	1,939	-13.7	1.3
18	23	LG Semicon	2,243	1,792	-20.1	1.2
24	24	Micron Technology	1,558	1,704	9.4	1.2
25	25	Rockwell	1,351	1,487	10.1	1
26	26	Analog Devices	1,260	1,370	8.7	0.9
27	27	LSI Logic	1,239	1,290	4.1	0.9
28	28	Oki	1,177	1,062	-9.8	0.7
30	29	Hewlett-Packard	945	1,025	8.5	0.7
29	30	Atmel	1,024	950	-7.2	0.6
31	31	Cirrus Logic	891	880	-1.2	0.6
32	32	TEMIC	813	856	5.3	0.6
33	33	VLSI Technology	672	713	6.1	0.5
34	34	Harris Semiconductor	629	697	10.8	0.5
40	35	Altera	497	631	27	0.4
36	36	Xilinx	566	612	8.1	0.4
73	37	Sun Microsystems	170	550	223.5	0.4
35	38	Sanken	622	540	-13.2	0.4

Table 2-11 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of Total Semiconductors Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
37	39	Integrated Device Technology	554	536	-3.2	0.4
38	40	International Rectifier	520	511	-1.7	0.3
		All Others	16,366	18,036	10.2	12.3
		Americas Companies	**64,076**	**72,339**	**12.9**	**49.2**
		Japanese Companies	**50,884**	**47,825**	**-6**	**32.5**
		European Companies	**13,682**	**14,809**	**8.2**	**10.1**
		Asia/Pacific Companies	**13,508**	**12,192**	**-9.7**	**8.3**
		Total Market	**142,150**	**147,165**	**3.5**	**100**

Source: Dataquest (April 1998)

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Table 2-12
Top 40 Total Market Vendor Revenue from Shipments of Total ICs Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Intel	17,781	21,746	22.3	17
2	2	NEC	9,354	9,014	-3.6	7.1
3	3	Texas Instruments	6,974	7,292	4.6	5.7
5	4	Motorola	6,584	6,585	0	5.2
7	5	Samsung	6,149	5,489	-10.7	4.3
6	6	Toshiba	6,204	5,340	-13.9	4.2
4	7	Hitachi	6,973	5,233	-25	4.1
8	8	Fujitsu	3,986	4,135	3.7	3.2
9	9	SGS-Thomson	3,526	3,447	-2.2	2.7
11	10	Philips	3,279	3,416	4.2	2.7
12	11	IBM	3,200	3,391	6	2.7
10	12	Mitsubishi	3,504	3,280	-6.4	2.6
16	13	National Semiconductor	2,223	2,624	18	2.1
15	14	Siemens	2,238	2,503	11.8	2
17	15	Lucent Technologies	2,020	2,489	23.2	2
19	16	Advanced Micro Devices	1,947	2,341	20.2	1.8
13	17	Hyundai	2,247	1,939	-13.7	1.5
18	18	Matsushita	1,988	1,882	-5.3	1.5
20	19	SANYO	1,902	1,818	-4.4	1.4
14	20	LG Semicon	2,243	1,792	-20.1	1.4
22	21	Micron Technology	1,558	1,704	9.4	1.3
21	22	Sony	1,567	1,541	-1.7	1.2
24	23	Rockwell	1,351	1,487	10.1	1.2
23	24	Sharp	1,507	1,430	-5.1	1.1
25	25	Analog Devices	1,260	1,370	8.7	1.1
26	26	LSI Logic	1,239	1,290	4.1	1
27	27	Oki	1,138	1,018	-10.5	0.8
28	28	Atmel	1,024	950	-7.2	0.7
29	29	Cirrus Logic	891	880	-1.2	0.7
30	30	Rohm	757	869	14.8	0.7
31	31	VLSI Technology	672	713	6.1	0.6
35	32	Altera	497	631	27	0.5
32	33	Xilinx	566	612	8.1	0.5
68	34	Sun Microsystems	170	550	223.5	0.4
33	35	Integrated Device Technology	554	536	-3.2	0.4
34	36	Cypress Semiconductor	516	496	-3.9	0.4
40	37	Harris Semiconductor	397	467	17.6	0.4
42	38	Hewlett-Packard	380	466	22.6	0.4

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Table 2-12 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of Total ICs Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
41	39	Maxim	387	463	19.6	0.4
45	40	TEMIC	347	461	32.9	0.4
		All Others	12,661	13,881	9.6	10.9
		Americas Companies	**59,836**	**67,952**	**13.6**	**53.3**
		Japanese Companies	**40,568**	**36,882**	**-9.1**	**28.9**
		European Companies	**10,381**	**11,152**	**7.4**	**8.7**
		Asia/Pacific Companies	**12,976**	**11,585**	**-10.7**	**9.1**
		Total Market	**123,761**	**127,571**	**3.1**	**100**

Source: Dataquest (April 1998)

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Table 2-13
Top 20 Total Market Vendor Revenue from Shipments of Bipolar Digital Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
2	1	Texas Instruments	340	293	-13.8	23.6
3	2	Motorola	271	264	-2.6	21.3
1	3	Hitachi	451	262	-41.9	21.1
5	4	NEC	90	82	-8.9	6.6
7	5	Philips	90	80	-11.1	6.5
6	6	Fujitsu	90	63	-30	5.1
11	7	Siemens	32	37	15.6	3
8	8	Toshiba	73	32	-56.2	2.6
10	9	Advanced Micro Devices	62	28	-54.8	2.3
13	10	Mitsubishi	25	24	-4	1.9
NA	11	Mosel Vitelic	0	20	NA	1.6
14	12	Matsushita	19	19	0	1.5
4	13	National Semiconductor	161	14	-91.3	1.1
9	14	Lucent Technologies	70	10	-85.7	0.8
17	15	LG Semicon	10	8	-20	0.6
18	16	Oki	4	3	-25	0.2
12	17	Applied Micro Circuits Corp.	30	0	-100	0
15	18	Raytheon	15	0	-100	0
16	19	GEC Plessey	12	0	-100	0
19	20	Harris Semiconductor	4	0	-100	0
		All Others	-	-	NA	0
		Americas Companies	**953**	**609**	**-36.1**	**49.2**
		Japanese Companies	**752**	**485**	**-35.5**	**39.1**
		European Companies	**134**	**117**	**-12.7**	**9.4**
		Asia/Pacific Companies	**10**	**28**	**180**	**2.3**
		Total Market	**1,849**	**1,239**	**-33**	**100**

NA = Not available
Source: Dataquest (April 1998)

Table 2-14
Top 40 Total Market Vendor Revenue from Shipments of MOS Digital ICs Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Intel	17,781	21,746	22.3	20.8
2	2	NEC	8,515	8,320	-2.3	7.9
4	3	Samsung	5,889	5,167	-12.3	4.9
6	4	Motorola	5,113	4,903	-4.1	4.7
7	5	Texas Instruments	4,950	4,804	-2.9	4.6
3	6	Hitachi	5,995	4,595	-23.4	4.4
5	7	Toshiba	5,186	4,288	-17.3	4.1
8	8	Fujitsu	3,471	3,745	7.9	3.6
9	9	IBM	3,200	3,391	6	3.2
10	10	Mitsubishi	2,895	2,812	-2.9	2.7
15	11	Lucent Technologies	1,715	2,374	38.4	2.3
14	12	Advanced Micro Devices	1,770	2,123	19.9	2
11	13	Hyundai	2,246	1,936	-13.8	1.8
12	14	LG Semicon	2,193	1,736	-20.8	1.7
17	15	Micron Technology	1,558	1,704	9.4	1.6
13	16	Philips	1,858	1,619	-12.9	1.5
16	17	SGS-Thomson	1,651	1,556	-5.8	1.5
22	18	Siemens	1,226	1,384	12.9	1.3
21	19	Rockwell	1,230	1,356	10.2	1.3
19	20	Sharp	1,415	1,332	-5.9	1.3
18	21	Matsushita	1,422	1,308	-8	1.2
20	22	LSI Logic	1,239	1,290	4.1	1.2
25	23	National Semiconductor	1,047	1,252	19.6	1.2
24	24	Sony	1,050	1,028	-2.1	1
23	25	Oki	1,103	998	-9.5	1
27	26	SANYO	945	968	2.4	0.9
26	27	Atmel	1,024	919	-10.3	0.9
29	28	VLSI Technology	672	713	6.1	0.7
33	29	Altera	497	631	27	0.6
30	30	Xilinx	566	612	8.1	0.6
28	31	Cirrus Logic	741	604	-18.5	0.6
60	32	Sun Microsystems	170	550	223.5	0.5
31	33	Integrated Device Technology	554	536	-3.2	0.5
32	34	Cypress Semiconductor	516	496	-3.9	0.5
38	35	Hewlett-Packard	380	466	22.6	0.4
35	36	S3	464	437	-5.8	0.4
40	37	Microchip Technology	330	422	27.9	0.4
36	38	Symbios	458	418	-8.7	0.4

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Table 2-14 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of MOS Digital ICs Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
34	39	United Microelectronics	492	378	-23.2	0.4
39	40	Macronix	354	365	3.1	0.3
		All Others	8,328	9,398	12.8	9
		Americas Companies	**50,721**	**57,414**	**13.2**	**54.8**
		Japanese Companies	**33,361**	**30,597**	**-8.3**	**29.2**
		European Companies	**5,596**	**5,645**	**0.9**	**5.4**
		Asia/Pacific Companies	**12,531**	**11,024**	**-12**	**10.5**
		Total Market	**102,209**	**104,680**	**2.4**	**100**

Source: Dataquest (April 1998)

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Table 2-15
Top 40 Total Market Vendor Revenue from Shipments of MOS Memory Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Samsung	5,501	4,623	-16	14.9
2	2	NEC	3,913	3,215	-17.8	10.4
3	3	Hitachi	3,514	2,209	-37.1	7.1
5	4	Hyundai	2,236	1,931	-13.6	6.2
10	5	Micron Technology	1,558	1,704	9.4	5.5
7	6	Texas Instruments	1,984	1,524	-23.2	4.9
8	7	Fujitsu	1,656	1,508	-8.9	4.9
6	8	LG Semicon	2,021	1,489	-26.3	4.8
4	9	Toshiba	2,513	1,485	-40.9	4.8
9	10	Mitsubishi	1,614	1,435	-11.1	4.6
13	11	Siemens	911	1,028	12.8	3.3
11	12	IBM	1,253	990	-21	3.2
12	13	Intel	950	850	-10.5	2.7
18	14	Advanced Micro Devices	711	708	-0.4	2.3
15	15	Atmel	793	670	-15.5	2.2
17	16	Sharp	727	624	-14.2	2
16	17	SGS-Thomson	738	502	-32	1.6
19	18	Oki	541	448	-17.2	1.4
14	19	Motorola	827	435	-47.4	1.4
22	20	Integrated Device Technology	378	365	-3.4	1.2
27	21	Vanguard	225	334	48.4	1.1
25	22	Matsushita	300	315	5	1
21	23	Cypress Semiconductor	382	314	-17.8	1
26	24	Macronix	288	300	4.2	1
20	25	Mosel Vitelic	398	296	-25.6	1
23	26	Sony	330	193	-41.5	0.6
24	27	SANYO	302	162	-46.4	0.5
28	28	Nippon Steel Semiconductor	198	145	-26.8	0.5
30	29	Winbond Electronics	160	135	-15.6	0.4
33	30	Microchip Technology	117	126	7.7	0.4
34	31	Integrated Silicon Solution	111	125	12.6	0.4
32	32	Xicor	123	122	-0.8	0.4
36	33	Alliance Semiconductor	66	111	68.2	0.4
NA	34	Fairchild	0	80	NA	0.3
35	35	Silicon Storage Technology	91	75	-17.6	0.2
NA	36	Philips	0	73	NA	0.2
37	37	Catalyst	54	70	29.6	0.2
38	38	Rohm	51	48	-5.9	0.2

Table 2-15 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of MOS Memory Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
45	39	G-Link USA	15	34	126.7	0.1
29	40	United Microelectronics	177	22	-87.6	0
		All Others	337	155	-54	0.5
		Americas Companies	**9,656**	**8,375**	**-13.3**	**27**
		Japanese Companies	**15,708**	**11,827**	**-24.7**	**38.2**
		European Companies	**1,669**	**1,621**	**-2.9**	**5.2**
		Asia/Pacific Companies	**11,031**	**9,155**	**-17**	**29.6**
		Total Market	**38,064**	**30,978**	**-18.6**	**100**

NA = Not available
Source: Dataquest (April 1998)

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Table 2-16
Top 40 Total Market Vendor Revenue from Shipments of MOS Microcomponents Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Intel	16,831	20,896	24.2	42.7
2	2	Motorola	3,153	3,530	12	7.2
3	3	NEC	2,179	2,404	10.3	4.9
5	4	Texas Instruments	1,550	1,728	11.5	3.5
4	5	Hitachi	1,629	1,683	3.3	3.4
6	6	Rockwell	1,226	1,351	10.2	2.8
7	7	Toshiba	1,197	1,336	11.6	2.7
15	8	Advanced Micro Devices	624	1,106	77.2	2.3
14	9	National Semiconductor	627	1,101	75.6	2.2
12	10	Fujitsu	677	967	42.8	2
9	11	Mitsubishi	901	936	3.9	1.9
13	12	Lucent Technologies	635	888	39.8	1.8
10	13	IBM	889	803	-9.7	1.6
8	14	Philips	1,085	791	-27.1	1.6
17	15	SGS-Thomson	482	616	27.8	1.3
11	16	Cirrus Logic	741	604	-18.5	1.2
31	17	Sun Microsystems	170	550	223.5	1.1
16	18	Matsushita	534	457	-14.4	0.9
18	19	S3	464	437	-5.8	0.9
22	20	Digital	271	359	32.5	0.7
19	21	United Microelectronics	315	356	13	0.7
21	22	Siemens	284	333	17.3	0.7
25	23	Microchip Technology	213	296	39	0.6
23	24	Analog Devices	258	287	11.2	0.6
20	25	Zilog	286	262	-8.4	0.5
37	26	ATI Technologies	130	260	100	0.5
NA	27	ESS	0	240	NA	0.5
24	28	Adaptec	214	238	11.2	0.5
45	29	Samsung	99	237	139.4	0.5
32	30	SANYO	164	229	39.6	0.5
27	31	Sharp	184	207	12.5	0.4
34	32	Standard Microsystems	153	175	14.4	0.4
26	33	Sony	189	173	-8.5	0.4
35	34	C-Cube	150	171	14	0.3
29	35	Oki	175	164	-6.3	0.3
30	36	Oak Technology	172	163	-5.2	0.3
41	37	VIA	110	151	37.3	0.3
28	38	Trident Microsystems	180	144	-20	0.3

Table 2-16 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of MOS Microcomponents Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
36	39	Chips & Technologies	150	131	-12.7	0.3
44	40	Symbios	102	129	26.5	0.3
		All Others	2,076	2,056	-1	4.2
		Americas Companies	**30,450**	**36,974**	**21.4**	**75.5**
		Japanese Companies	**8,115**	**8,817**	**8.7**	**18**
		European Companies	**1,977**	**1,899**	**-3.9**	**3.9**
		Asia/Pacific Companies	**927**	**1,255**	**35.4**	**2.6**
		Total Market	**41,469**	**48,945**	**18**	**100**

NA = Not available
Source: Dataquest (April 1998)

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Table 2-17
Top 40 Total Market Vendor Revenue from Shipments of MOS Digital Logic Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	NEC	2,423	2,701	11.5	10.9
8	2	IBM	1,058	1,598	51	6.5
3	3	Texas Instruments	1,416	1,552	9.6	6.3
7	4	Lucent Technologies	1,080	1,486	37.6	6
2	5	Toshiba	1,476	1,467	-0.6	5.9
4	6	Fujitsu	1,138	1,270	11.6	5.1
5	7	LSI Logic	1,136	1,182	4	4.8
6	8	Motorola	1,133	938	-17.2	3.8
10	9	Philips	773	755	-2.3	3
9	10	Hitachi	852	703	-17.5	2.8
11	11	VLSI Technology	615	667	8.5	2.7
14	12	Sony	531	662	24.7	2.7
16	13	Altera	497	631	27	2.5
13	14	Xilinx	566	612	8.1	2.5
17	15	SANYO	479	577	20.5	2.3
12	16	Matsushita	588	536	-8.8	2.2
15	17	Sharp	504	501	-0.6	2
22	18	Hewlett-Packard	380	466	22.6	1.9
21	19	Mitsubishi	380	441	16.1	1.8
19	20	SGS-Thomson	431	438	1.6	1.8
20	21	Oki	387	386	-0.3	1.6
18	22	Advanced Micro Devices	435	309	-29	1.2
25	23	Samsung	289	307	6.2	1.2
23	24	Symbios	356	289	-18.8	1.2
26	25	Rohm	210	264	25.7	1.1
28	26	Lattice	200	242	21	1
NA	27	Fairchild	0	227	NA	0.9
32	28	Alcatel Microelectronics	179	204	14	0.8
41	29	Gould AMI	95	194	104.2	0.8
29	30	GEC Plessey	186	186	0	0.8
30	31	Atmel	182	184	1.1	0.7
42	32	Cypress Semiconductor	70	176	151.4	0.7
52	33	Micronas	33	170	415.2	0.7
33	34	Actel	149	156	4.7	0.6
27	35	Seiko Epson	201	152	-24.4	0.6
24	36	National Semiconductor	293	149	-49.1	0.6
34	37	Harris Semiconductor	140	146	4.3	0.6
38	38	LG Semicon	113	126	11.5	0.5

Table 2-17 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of MOS Digital Logic Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
37	39	Dallas Semiconductor	117	125	6.8	0.5
36	40	Austria Mikro Systeme	133	124	-6.8	0.5
		All Others	1,452	1,458	0.4	5.9
		Americas Companies	**10,615**	**12,065**	**13.7**	**48.7**
		Japanese Companies	**9,538**	**9,953**	**4.4**	**40.2**
		European Companies	**1,950**	**2,125**	**9**	**8.6**
		Asia/Pacific Companies	**573**	**614**	**7.2**	**2.5**
		Total Market	**22,676**	**24,757**	**9.2**	**100**

NA = Not available
Source: Dataquest (April 1998)

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Table 2-18
Top 40 Total Market Vendor Revenue from Shipments of Analog-Monolithic Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
2	1	Texas Instruments	1,684	2,195	30.3	10.1
1	2	SGS-Thomson	1,875	1,891	0.9	8.7
3	3	Philips	1,291	1,717	33	7.9
4	4	Motorola	1,200	1,418	18.2	6.5
5	5	National Semiconductor	1,015	1,358	33.8	6.3
6	6	Siemens	980	1,082	10.4	5
7	7	Analog Devices	946	1,064	12.5	4.9
8	8	Toshiba	909	1,020	12.2	4.7
9	9	SANYO	780	850	9	3.9
10	10	NEC	624	612	-1.9	2.8
11	11	Matsushita	547	555	1.5	2.6
17	12	Rohm	357	535	49.9	2.5
12	13	Sony	452	513	13.5	2.4
15	14	Maxim	383	463	20.9	2.1
14	15	Mitsubishi	397	444	11.8	2.1
16	16	Linear Technology	365	419	14.8	1.9
13	17	Hitachi	409	376	-8.1	1.7
18	18	Fujitsu	291	327	12.4	1.5
19	19	Samsung	260	322	23.8	1.5
26	20	TEMIC	153	290	89.5	1.3
27	21	Cirrus Logic	150	276	84	1.3
21	22	Harris Semiconductor	195	258	32.3	1.2
23	23	New JRC	160	198	23.8	0.9
29	24	Advanced Micro Devices	115	190	65.2	0.9
25	25	Burr-Brown	157	165	5.1	0.8
24	26	Allegro MicroSystems	159	144	-9.4	0.7
NA	27	Robert Bosch	0	140	NA	0.6
28	28	Rockwell	121	131	8.3	0.6
38	29	Mitel	83	128	54.2	0.6
30	30	Level One Communications	112	127	13.4	0.6
33	31	Unitrode	98	118	20.4	0.5
31	32	PMC Sierra Semiconductor	101	116	14.9	0.5
22	33	VTC	172	110	-36	0.5
20	34	Lucent Technologies	235	105	-55.3	0.5
59	35	Micrel	18	104	477.8	0.5
32	36	Cherry Semiconductor	100	101	1	0.5
37	37	Ericsson	87	100	14.9	0.5
36	38	Sharp	92	98	6.5	0.5

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Table 2-18 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of Analog-Monolithic Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
NA	39	Anadigics	0	97	NA	0.4
47	40	Semtech	42	90	114.3	0.4
		All Others	1,120	1,405	25.4	6.5
		Americas Companies	**8,013**	**9,929**	**23.9**	**45.9**
		Japanese Companies	**5,210**	**5,800**	**11.3**	**26.8**
		European Companies	**4,577**	**5,390**	**17.8**	**24.9**
		Asia/Pacific Companies	**435**	**533**	**22.5**	**2.5**
		Total Market	**18,235**	**21,652**	**18.7**	**100**

NA = Not available
Source: Dataquest (April 1998)

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Table 2-19
Top 40 Total Market Vendor Revenue from Shipments of Total Discrete Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
2	1	Toshiba	1,390	1,484	6.8	10.4
1	2	Motorola	1,452	1,446	-0.4	10.1
4	3	Philips	941	1,024	8.8	7.2
3	4	Hitachi	977	949	-2.9	6.7
5	5	NEC	818	885	8.2	6.2
6	6	Rohm	681	827	21.4	5.8
8	7	Matsushita	565	577	2.1	4
7	8	SGS-Thomson	586	572	-2.4	4
10	9	Siemens	452	554	22.6	3.9
9	10	International Rectifier	493	480	-2.6	3.4
12	11	SANYO	441	478	8.4	3.4
11	12	Mitsubishi	452	460	1.8	3.2
16	13	Sanken	328	434	32.3	3
14	14	General Semiconductor	362	370	2.2	2.6
13	15	Fuji Electric	401	356	-11.2	2.5
17	16	Samsung	307	355	15.6	2.5
18	17	Fujitsu	290	319	10	2.2
15	18	TEMIC	353	281	-20.4	2
19	19	Shindengen Electric	277	266	-4	1.9
20	20	Harris Semiconductor	232	230	-0.9	1.6
21	21	Korean Electronic Co.	193	220	14	1.5
24	22	Microsemi	146	156	6.8	1.1
NA	23	Fairchild	0	141	NA	1
23	24	National Semiconductor	157	135	-14	0.9
25	25	Hewlett-Packard	140	126	-10	0.9
26	26	Semikron	109	116	6.4	0.8
22	27	Eupec	160	111	-30.6	0.8
27	28	Powerex	98	98	0	0.7
28	29	Teccor Electronics	83	92	10.8	0.6
32	30	Zetex	52	86	65.4	0.6
NA	31	Robert Bosch	0	85	NA	0.6
30	32	Ixys	66	69	4.5	0.5
NA	33	Micronas	0	55	NA	0.4
33	34	Sony	43	39	-9.3	0.3
NA	35	Fagor	0	32	NA	0.2
NA	36	TCS	0	31	NA	0.2
36	37	Ericsson	28	30	7.1	0.2
NA	38	Power Innovations	0	29	NA	0.2

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Table 2-19 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of Total Discrete Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
34	39	GEC Plessey	35	27	-22.9	0.2
39	40	Supertex	16	17	6.3	0.1
		All Others	350	213	-39.1	1.5
		Americas Companies	**3,416**	**3,391**	**-0.7**	**23.8**
		Japanese Companies	**6,774**	**7,187**	**6.1**	**50.4**
		European Companies	**2,784**	**3,102**	**11.4**	**21.8**
		Asia/Pacific Companies	**500**	**575**	**15**	**4**
		Total Market	**13,474**	**14,255**	**5.8**	**100**

NA = Not available
Source: Dataquest (April 1998)

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Table 2-20
Top 33 Total Market Vendor Revenue from Shipments of Total Optical Semiconductors Worldwide (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Sharp	617	715	15.9	13.4
4	2	Hewlett-Packard	425	433	1.9	8.1
2	3	Toshiba	471	429	-8.9	8
5	4	Sony	373	394	5.6	7.4
3	5	Matsushita	450	388	-13.8	7.3
6	6	Siemens	339	384	13.3	7.2
7	7	Rohm	293	357	21.8	6.7
8	8	NEC	256	323	26.2	6
NA	9	Stanley	0	294	NA	5.5
14	10	Lucent Technologies	90	273	203.3	5.1
11	11	Mitsubishi	144	185	28.5	3.5
10	12	SANYO	148	175	18.2	3.3
9	13	Fujitsu	151	168	11.3	3.1
12	14	Hitachi	121	116	-4.1	2.2
13	15	TEMIC	113	114	0.9	2.1
15	16	Texas Instruments	62	60	-3.2	1.1
17	17	Quality Technologies	52	54	3.8	1
16	18	Optek	59	53	-10.2	1
18	19	Honeywell	41	38	-7.3	0.7
19	20	Motorola	40	36	-10	0.7
20	21	Sanken	40	36	-10	0.7
21	22	Oki	28	32	14.3	0.6
22	23	TCS	25	22	-12	0.4
23	24	Korean Electronic Co.	24	20	-16.7	0.4
24	25	Ericsson	23	20	-13	0.4
26	26	Spectra Diode Labs	17	17	0	0.3
25	27	Mitel	22	16	-27.3	0.3
28	28	Samsung	8	12	50	0.2
29	29	IC Sensors	7	7	0	0.1
30	30	CID Technologies	6	6	0	0.1
31	31	Eastman Kodak	3	3	0	0
27	32	New JRC	9	0	-100	0
32	33	Zetex	1	0	-100	0
		All Others	457	159	-65.2	3
		Americas Companies	**824**	**996**	**20.9**	**18.7**
		Japanese Companies	**3,542**	**3,756**	**6**	**70.4**
		European Companies	**517**	**555**	**7.4**	**10.4**
		Asia/Pacific Companies	**32**	**32**	**0**	**0.6**
		Total Market	**4,915**	**5,339**	**8.6**	**100**

NA = Not available
Source: Dataquest (April 1998)

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Americas Fab Database, 1998

Market Statistics

Program: Semiconductors Worldwide
Product Code: SEMI-WW-MS-9803
Publication Date: February 8, 1999
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Chapter 1
Americas Fab Database

Background and Methodology

This report contains the Americas portion of Dataquest's wafer fab database. The records in these tables are fabs located in the Americas region. The Semiconductor Equipment, Materials, and Manufacturing Worldwide (SEMM) program conducts extensive annual surveys, complemented with quarterly secondary research to maintain this database. Published once a year, this document represents Dataquest's best insights and estimates into the end-market of semiconductor equipment.

The tables in this report cover planned and existing merchant, captive, and foundry fab lines. A fab line is a series of equipment to do front-end (from initial oxide through wafer probe) semiconductor manufacturing. Occasionally, two or more separate product-specific fab lines or wafer sizes operate in a single clean room or physical plant. In this situation, Dataquest divides the clean room as separate fab lines if the company dedicates equipment to each wafer size or product line. If a company installs substantially different equipment during an expansion (for example, equipment to increase its maximum wafer diameter), again Dataquest divides the clean room and creates two entries into the database. Therefore, a company may operate many fab lines at one location.

Worldwide Geographic Region Definitions and Regional Roll-Ups

Americas
Includes Central America (all nations), Canada, Mexico, United States, Puerto Rico, and South America (all nations).

Japan
Japan is the only single-country region.

Europe, Africa, and Middle East
Includes Africa (all nations), Albania, Andorra, Armenia, Azerbaijan, Belarus, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Gibraltar, Hungary, Iceland, Israel, Italy, Kazakhstan, Kyrgyzstan, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Middle East (all nations), Moldova, Monaco, Netherlands, Norway, Poland, Romania, Russia, San Marino, Scandinavia, Slovakia, Spain, Sweden, Sweden, Switzerland, Tajikistan, Turkey, Turkmenistan, Ukraine, United Kingdom, Uzbekistan, Vatican City, and all nations within the former Yugoslavia.

Asia/Pacific
Includes Australia, Bangladesh, Cambodia, China, Hong Kong, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, New Zealand, Pakistan, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, and Vietnam.

Field Definitions

The Company field indicates the operator of the fab line. For contract manufacturers that trade capacity for capital investment in the fab, Dataquest lists the contract manufacturer. For incorporated joint ventures, Dataquest lists either the incorporated entity or the major investors, separated with slashes.

The City field displays the most detailed location information. This reference is usually a city or town, but could be an often-used district name (for example, Science Park in the city of Hsinchu, Taiwan). If this field lists a district, Dataquest will list the city in the State or Province field. In some cases, a reference to a state or province will be included in the City or District field to create a unique identifier for this location.

The Prefecture field denotes the second most detailed location. This reference is usually a state (for the United States), province (for Canada and many European and Asian countries), or a prefecture (for Japan). For countries within the United Kingdom, Dataquest lists the country name (for example, "Scotland") in this field so Dataquest can list the descriptor "U.K." in the Country field.

The Country field indicates the broadest location identifier in this report. This reference is usually a country, except in the case of the United Kingdom (see "State or Province" above). Because Japan is a single-country region, there is no regional qualifier for fabs in Japan.

The Fab Name field provides a reference to a particular fab or fab line to distinguish it from other fabs or lines owned by that company. Although Dataquest makes every attempt to match the nomenclature used by the company, occasionally some additional qualifiers (for example, "Phase 1") will appear to provide insight to the facility's history or organization.

The Products field lists the products manufactured at this site. The listings generally fall into five product groups, with the following nomenclature and definitions (when warranted):

- MOS memory
  - DRAM: Dynamic RAM
  - EEPROM: Electrically erasable PROM
  - EPROM: Ultraviolet erasable PROM
  - FERRAM: Ferroelectric RAM
  - FIFO: First-in/first-out memory
  - Flash: Flash memory
  - Mem: Memory
  - NV Mem: Nonvolatile memory (ROM, PROM, EPROM, EEPROM, and FERRAM)
  - PROM: Programmable ROM
  - RAM: Random-access memory

- ROM: Read-only memory
- SGRAM: Synchronous graphics RAM
- Sp Mem: Other specialty memory (such as dual-port, shift-register, or color lookup)
- SRAM: Static RAM
- VRAM: Video RAM

- MOS microcomponent/digital logic
  - Array: Gate array
  - ASIC: Application-specific IC
  - ASSP: Application-specific standard product
  - Bit: Bit slice (subset of MPU functions)
  - CBIC: Cell-based IC
  - Custom: Full-custom IC (single user)
  - DSP: Digital signal processor
  - FPGA: Field-programmable gate array
  - LISP: 32-bit list instruction set processor for AI
  - Logic: Standard logic
  - LSI: Large-scale integration
  - MCU: Microcontroller unit
  - MixSig ASIC: Mixed-signal ASIC
  - MPR: Microperipheral
  - MPRCom: MPR digital communication (ISDN, LAN, UART, or modem)
  - MPU: Microprocessor unit
  - PLD: Programmable logic device
  - RISC: Reduced-instruction-set computation 32-bit MPU
  - Telecom: Telecommunications chip
- Power/discrete/analog (including bipolar power)
  - A/D D/A: Analog-to-digital, digital-to-analog converter
  - Automotive: Dedicated to automobile applications
  - CODEC: Coder/decoder
  - Diode
  - Discrete
  - FET: Field-effect transistor
  - GTO: Gate turn-off thyristor
  - HEMT: High-electron-mobility transistor
  - IGBT: Insulated-gate bipolar transistor

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- Interface: Interface IC
- Linear: Linear/analog device
- MDiode: Microwave diode
- MESFET: Metal semiconductor field-effect transistor
- MFET: Microwave field-effect transistor
- Modem: Modulator/demodulator
- MMIC: Monolithic Microwave IC
- MOSFET: MOS-based field-effect transistor
- Op Amp: Operational amplifier
- Pwr IC: Power IC
- Pwr Tran: Power transistor
- Rectifier
- Reg: Voltage regulator
- RF: Radio frequency
- SCR: Schottky rectifier
- Sensor
- Smart Pwr: Smart power
- SST: Small-signal transistor
- Switches: Switching device
- Thyristor
- Tran: Transistor
- Zener Diode

- Optoelectronic
  - CCD: Charge-coupled device (imaging)
  - Coupler: Photocoupler
  - IED: Infrared-emitting diode
  - Image Sensor
  - Laser: Semiconductor laser or laser IC
  - LED: Light-emitting diode
  - Opto: Optoelectronic
  - PDiode: Photo diode
  - PTran: Photo transistor
  - SAW: Surface acoustic wave device
  - SIT Image Sensor: Static induction transistor image sensor

- Bipolar Digital and Other Devices (includes all digital ICs using a bipolar process)
    - Darlington
    - Micromachining sensors
    - MilStd: Military Standard Logic
    - RadHard: Radiation hardened

The Process Technology field indicates each fab's use of five major types of processes. The process grouping is as follows:

- P/CMOS: P-channel metal-oxide semiconductor (PMOS) or complementary metal-oxide semiconductor (CMOS)
- NMOS: N-channel metal-oxide semiconductor (NMOS)
- BiCMOS: Bipolar and CMOS combined on a chip
- Bipolar
- III-V: Gallium arsenide and other compound semiconductor processes

The Estimated Minimum Geometry is the smallest linewidth feature size, measured in microns, attainable in production volume.

The Wafer Diameter represents the maximum wafer size that the fab or fab line can process. Wafer diameters, although expressed colloquially in inches, conform to metric specifications. For wafers greater than 3 inches in diameter, expression in inches becomes inaccurate. When calculating square inches, Dataquest uses the following approximations:

- Stated diameter of 4 inches (100mm) = Approximate diameter of 3.938 inches
- Stated diameter of 5 inches (125mm) = Approximate diameter of 4.922 inches
- Stated diameter of 6 inches (150mm) = Approximate diameter of 5.906 inches
- Stated diameter of 8 inches (200mm) = Approximate diameter of 7.87 inches
- Stated diameter of 12 inches (300mm) = Approximate diameter of 11.84 inches.

The Year and Quarter of Initial Production displays the year (and quarter, if available) in which this line, having completed all qualifications, began manufacturing in production volumes. The format for this reference is "year.quarter" (for example, 1994.3 translates to the third calendar quarter of 1994).

The Initial Monthly Wafer Starts field indicates the initial monthly volume of production wafer throughput.

The Estimated Maximum Monthly Wafer Starts field contains the equipment-limited wafer start capacity per four-week period. Only the throughput of the installed equipment and the process complexity limits the maximum starts. Dataquest does not consider current staffing or the number of shifts operating in determining this metric.

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The Fab Type field shows the types of semiconductor manufacturing performed at this location. The fab types include the following:

- "F" indicates that this is a production-based fab.
- "R" indicates a semiconductor R&D and/or trial production facility.
- "P" means that this location produces a pilot line.
- "T" means that this location performs assembly or testing.
- "N" indicates that this is location performs foundry production, or contract manufacturing.
- "VD" means that this location performs VHDL design.
- "PD" means that this location performs IC place and route design.

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Chapter 2
Market Statistics Tables

Tables 2-1 and 2-2 provide information on fabs located in the Americas region.

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Table 2-1
Americas Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Advanced Micro Devices	Austin	TX	U.S.	Fab 14	EPROM 1Mb 2Mb 4Mb 8Mb Flash PLD	P/CMOS	0.70	150	1984.0	3,000	13,600	FR
Advanced Micro Devices	Austin	TX	U.S.	Fab 15	x86 MPU MCU MPR DSP	P/CMOS	0.70	150	1984.0	2,000	14,400	FR
Advanced Micro Devices	Sunnyvale	CA	U.S.	Fab 17	16Mb 32Mb Flash K6 K7	P/CMOS	0.18	150	1991.1	500	2,000	FTRVDPD
Advanced Micro Devices	Austin	TX	U.S.	Fab 25	K6 K7 MPU	P/CMOS	0.25	200	1995.4	1,200	22,000	F
Advanced Power Technology	Bend	OR	U.S.	Fab 1	Power MOSFET; IGBT	NMOS	2.00	100	1989.0	200	1,500	FTRVD
Allegro Micro Systems	Willow Grove	PA	U.S.	-	SRAM ROM Analog	P/CMOS	2.20	100	1982.0	3,900	13,000	FTN
Allegro Micro Systems	Worcester	MA	U.S.	-	Custom Discrete	-	4.00	100	1987.0	5,700	19,000	F
Allied Signal Aerospace	Columbia	MD	U.S.	Microelectronics Ctr	SRAM MPU MixSig ASIC Custom	P/CMOS	0.80	100	1985.0	1,400	1,400	FTRVDP-DNP
Alpha Industries	Woburn	MA	U.S.	-	RF Transistor and Linear ICs	III-V	0.25	75	1987.0	160	160	FN
American Microsystems Incorporated	Pocatello	ID	U.S.	Fab 10	Arrays PLD CBIC Custom MixSig ASIC	P/CMOS	0.35	200	1998.3	6,500	5,200	FTRVD-PDN
American Microsystems Incorporated	Pocatello	ID	U.S.	Fab 9	Arrays PLD CBIC Custom MixSig ASIC EEPROM	P/CMOS	0.50	125	1984.2	200	21,500	FTRVD-PDN
Anadigics	Warren	NJ	U.S.	35 Technology	GaAs IC	III-V	0.50	100	1986.0	100	5,000	FTRVD-PDP
Analog Devices	Wilmington	MA	U.S.	Wilmington Fab #1	Analog Linear IC ASIC	BiCMOS Bipolar	2.00	100	1979.0	4,800	7,000	FTR
Analog Devices	Santa Clara	CA	U.S.	-	Analog Mixed Signal Linear IC	-	1.50	100	1979.0	1,400	4,900	FTRVDP-DNP
Analog Devices	Santa Clara	CA	U.S.	-	Analog Mixed Signal	P/CMOS	1.50	100	1983.0	600	2,000	FTVD-PDN
Analog Devices	Sunnyvale	CA	U.S.	Fab 1	Linear IC	BiCMOS	3.00	100	1985.0	400	14,000	FTP
Analog Devices	Wilmington	MA	U.S.	Wilmington Fab #2	Analog Linear IC ASIC DSP	BiCMOS Bipolar	1.00	150	-	2,400	2,400	FTR
Analog Devices	Cambridge	MA	U.S.	-	ASIC Sensors	BiCMOS	1.00	150	-	2,400	2,400	FTR
Applied Micro Circuits (AMCC)	San Diego	CA	U.S.	Fab 1	ASIC ASSP Foundry	Bipolar	0.80	100	1983.2	400	1,500	FTVD-PDN
Atmel	Colorado Springs	CO	U.S.	Fab 3	EPROM Flash EEPROM EPLD Analog	P/CMOS	0.35	150	1990.1	1,000	29,000	FTRVD-PDN
Atmel	Colorado Springs	CO	U.S.	Fab 5	EPROM EEPROM Flash	P/CMOS	0.35	150	1994.4	2,500	34,000	FTRVDPD
Ball Aerospace	Boulder	CO	U.S.	-	Military Aerospace	-	1.20	150	1989.0	1,700	5,000	FP
Bell Northern Research	Ottawa	Ontario	Canada	-	-	III-V	1.40	100	1982.0	4,400	12,700	FRP
Bipolarics	Los Gatos	CA	U.S.	Bipolarics	Discrete Tran RF IC ASIC	Bipolar	0.50	100	1988.0	1,000	3,000	FTR
Burr-Brown	Tucson	AZ	U.S.	Wafer Fab	Hybrid Analog	Bipolar	0.50	100	1984.0	4,300	14,500	FTRVDPD
California Micro Devices	Milpitas	CA	U.S.	Milpitas Fab	Passive RC Thin Film Device	-	2.00	100	1976.0	2,000	2,000	FRVD
California Micro Devices	Tempe	AZ	U.S.	CMD Tempe Fab	DTMF Termination Network	P/CMOS	1.50	125	1979.0	500	3,300	FN
Calogic	Fremont	CA	U.S.	NA	A/D D/A	-	3.00	100	1985.0	1,000	3,000	FTNP
Celeritek	San Jose	CA	U.S.	-	FET Amp	III-V	0.80	75	1985.0	3,800	11,000	FP

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Table 2-1 (Continued)
Americas Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Cherry Semiconductor	East Greenwich	RI	U.S.	Bipolar BiC-MOS	Analog (Mixed Signal)/Power	Bipolar	1.00	150	1981.1	7,700	22,000	FTRVDPD
Commodore Semiconductors	Norristown	PA	U.S.	Fab 1	ASIC	P/CMOS	0.80	125	1986.4	5,000	20,000	FRN
Compensated Devices	Melrose	MA	U.S.	Compensated Devices	Discrete Semiconductor Zener Schottky	III-V	3.00	75	1974.0	800	1,500	FTR
Crystalonics	Burlington	MA	U.S.	Crystalonics	Diodes Hybrid Diode Tran	-	3.00	100	1995.1	700	2,000	FTP
Cypress Semiconductor	Round Rock	TX	U.S.	Fab II	SRAM EEPROM EPROM FPGA	P/CMOS	0.50	150	1987.3	12,600	10,000	FRN
Cypress Semiconductor	Bloomington	MN	U.S.	Fab IV-A	SRAM EPROM FPGA	P/CMOS	0.25	200	1995.3	500	12,000	FR
Dallas Semiconductor	Dallas	TX	U.S.	Fab 10	SRAM Logic	P/CMOS	0.80	150	1986.4	2,500	5,000	FTRVDPD
Dallas Semiconductor	Dallas	TX	U.S.	Fab 11	SRAM Logic	P/CMOS	0.35	150	1994.4	7,500	7,000	FTRVDPD
David Sarnoff Labs	Princeton	NJ	U.S.	Sarnoff Corp. IC Center	ASIC Power IC Imager MEM ASSP	-	0.50	100	1983.0	200	1,000	FTRVD-PDP
Delco Electronics	Kokomo	IN	U.S.	Fab 1	Pressure Sensor Accelerometer Darlington	III-V	5.00	100	1962.0	5,200	15,000	FTVDPD
Delco Electronics	Kokomo	IN	U.S.	Fab 2	Power Discrete ASIC	III-V	2.00	125	1978.2	4,000	14,000	FTVD-PDN
Delco Electronics	Kokomo	IN	U.S.	Fab 3	ASIC MPU Linear Power	Bipolar	1.00	125	1985.4	5,000	23,000	FTVDPD
Dionics	Westbury	NY	U.S.	Rushmore Fab	Bipolar Discrete CKTS and Opto Device	Bipolar	2.50	75	1969.1	1,000	5,000	FTVDP-DNP
Elantec	Milpitas	CA	U.S.	Fab 1	Analog	Bipolar	2.00	100	1984.2	250	4,000	FTVDPDP
Exel	San Jose	CA	U.S.	-	64Kb EEPROM PLD SRAM MCU	P/CMOS	1.30	75	1987.0	2,500	10,000	FR
Extel	Livermore	CA	U.S.	-	Foundry	-	0.70	150	1996.4	5,000	15,000	FN
Fairchild (formerly Raytheon)	Mountain View	CA	U.S.	Linear	Logic Analog Power	Bipolar	2.00	100	1986.0	2,100	6,000	FTVD-PDN
Fairchild Semiconductor	South Portland	ME	U.S.	Bipolar	Logic	-	2.50	100	1967.0	13,000	43,520	FTVDPD
Fairchild Semiconductor	South Portland	ME	U.S.	CMOS	Logic Array	P/CMOS	1.00	125	1985.0	1,300	5,500	FTVDPD
Fairchild Semiconductor	West Jordan	UT	U.S.	MOS 3	DMOS, ESPROM, ISPROM	III-V	0.60	150	1986.0	10,000	16,000	FRN
Filtronics (formerly Litton)	Santa Clara	CA	U.S.	Fab 1	Microwave Diode FET MMIC	III-V	0.25	-	1991.4	15	150	FTVD-PDN
Fluke Corporation	Everett	WA	U.S.	FMO	ASIC	P/CMOS	1.80	100	1981.0	2,000	10,000	FTR
Foxboro ICT	San Jose	CA	U.S.	Wafer Fab	Discrete Pressure Sensor	Bipolar	3.00	75	1982.0	2,000	400	FTRVDN
Frequency Sources	Lowell	MA	U.S.	-	Discrete ASIC	P/CMOS	1.00	100	1986.0	200	1,000	FTRVDPD
Fujitsu	Gresham	OR	U.S.	No. 2	64Mb SDRAM	P/CMOS	0.25	200	1997.2	5,000	10,000	F
General Electric	Schenectady	NY	U.S.	PSF	Smart Pwr	-	2.00	100	1985.0	500	1,600	FRP
General Electric	Syracuse	NY	U.S.	MMIC Fab	MMIC	III-V	0.50	100	1986.0	700	2,000	FTP
Gennum Corporation	Burlington	Ontario	Canada	Landmark	Signal Processor Amplifier Data Transport	Bipolar	1.20	100	1974.0	200	1,500	FRP
Germanium Power Devices	Andover	MA	U.S.	-	Opto Discrete	-	3.00	75	1974.0	3,500	10,000	F
GMT Microelectronics	Norristown	PA	U.S.	Fab No. 2	Foundry	-	0.60	150	1988.0	2,700	18,000	FN
GMT Microelectronics	Norristown	PA	U.S.	Fab No. 1	Foundry	-	1.00	125	1995.3	900	6,000	FN

Table 2-1 (Continued)
Americas Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Government of the United States	Lexington	MA	U.S.	Hanscom AFB	Custom Mil Std	-	2.00	100	1986.0	2,000	8,000	FT
Government of the United States	Livermore	CA	U.S.	Lawrence Livermore Labs	Wafer Scale Computer	NMOS	0.25	150	1987.0	500	2,000	FRP
Government of the United States	Fort Monmouth	NJ	U.S.	Army ETDL	-	-	2.00	125	1987.0	2,500	5,000	FP
Government of the United States	Fort Meade	MD	U.S.	Natl. Security Admin.	Custom Mil Std	-	1.00	150	1988.0	2,500	10,000	F
Government of the United States	San Diego	CA	U.S.	Naval Ocean Sys. Ctr.	-	-	1.60	100	1988.0	2,500	5,000	FP
Government of the United States	Fort Meade	MD	U.S.	Natl. Security Admin.	Mil Std	-	0.80	150	1990.4	1,500	5,000	FP
Government of the United States	Berkeley	CA	U.S.	Lawrence Berkeley National Labs Micro-systems Lab	Radiation Detector	P/CMOS NMOS	1.00	100	1991.0	5,200	17,400	FRN
Government of the United States	Berkeley	CA	U.S.	Lawrence Berkeley National Labs Instru-ment Lab	Radiation Detector	P/CMOS III-V	5.00	75	1993.0	3,800	11,000	FRN
Harris Semiconductor	Findlay	OH	U.S.	Fab 3	ASIC Automotive Digital MPU	Bipolar	3.00	100	1973.2	12,000	18,000	FR
Harris Semiconductor	Findlay	OH	U.S.	Fab 2	ASIC Automotive Digital MPU	P/CMOS	2.00	100	1973.2	6,000	20,000	FR
Harris Semiconductor	Findlay	OH	U.S.	Fab 4	MPU MCU MPR ASIC	P/CMOS	2.00	100	1973.2	36,000	18,000	FR
Harris Semiconductor	Palm Bay	FL	U.S.	Fab 54	4-Inch Linear	Bipolar	0.90	100	1979.1	3,000	10,000	FTVD-PDN
Harris Semiconductor	Palm Bay	FL	U.S.	Fab 59	6-Inch BICMOS	BiCMOS	0.50	150	1984.2	1,000	12,000	FTVDPD
Harris Semiconductor	MountainTop	PA	U.S.	Fab 6	Power MOS IGBT Rectifier	NMOS	1.50	150	1989.4	3,000	12,600	FTRVDPD
Harris Semiconductor	MountainTop	PA	U.S.	Fab 6	MOSFET IGBT MCT	NMOS	2.00	150	1991.3	1,500	19,500	FVDPD
Harris Semiconductor	Findlay	OH	U.S.	Fab 5	MixSig ASIC	P/CMOS	1.20	125	1993.3	6,500	9,000	FR
Harris Semiconductor	MountainTop	PA	U.S.	Fab 8	Power MOS IGBT	NMOS	0.75	200	1997.1	6,000	9,000	FRVDPD
Hewlett-Packard	Santa Rosa	CA	U.S.	2-Inch	GaAs IC Analog	III-V	0.25	51	1976.0	75	75	FTVDPDP
Hewlett-Packard	Fort Collins	CO	U.S.	6-Inch	MPU ASIC DSP Analog	P/CMOS	0.35	150	1979.0	4,400	11,000	FTRVDPD
Hewlett-Packard	San Jose	CA	U.S.	Diode	Diode	Bipolar	3.00	51	1981.0	800	2,400	FTP
Hewlett-Packard	San Jose	CA	U.S.	Bipolar	Tran	III-V	0.50	51	1981.0	200	200	FTP
Hewlett-Packard	San Jose	CA	U.S.	OED	Opto	III-V	5.00	75	1984.0	700	2,050	FTP
Hewlett-Packard	Santa Clara	CA	U.S.	-	Logic ASIC	Bipolar	1.50	75	1986.0	400	1,600	FP
Hewlett-Packard	Santa Clara	CA	U.S.	GaAs	Discrete Power	III-V	0.15	75	1987.0	200	600	FRP
Hewlett-Packard	Newark	CA	U.S.	RF Bipolar	Si RFIC MMIC RF Bipolar Tran RF diode	III-V	2.00	75	1988.4	300	900	P
Hewlett-Packard	Corvallis	OR	U.S.	6-Inch	-	P/CMOS	0.25	150	1990.4	6,200	12,500	FVDPD
Hewlett-Packard	Santa Rosa	CA	U.S.	3-Inch	GaAs IC Analog	III-V	0.25	75	1994.1	100	300	FTVDPD
Holt Integrated Circuits	Irvine	CA	U.S.	-	Op Amp EEPROM Logic ASIC	-	2.50	100	1981.0	3,000	10,000	FTN

Table 2-1 (Continued)
Americas Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Honeywell Electronics	Richardson	TX	U.S.	Opto Fab	Optoelectronics	III-V	10.00	51	1973.4	100	400	FRP
Honeywell Electronics	Plymouth	MN	U.S.	SSEC Fab	SRAM ASIC Analog High Temp Sensors MRAM	P/CMOS	0.35	100	1974.0	600	2,500	FTRVDP-DNP
Honeywell Electronics	Richardson	TX	U.S.	Sensor Fab	Sensors	Bipolar	2.00	75	1985.0	100	6,000	FVDPD
Hughes Microelectronics	Newport Beach	CA	U.S.	Fab 2	ASIC Lin	P/CMOS	3.00	100	1973.0	1,200	4,000	FTRNP
Hughes Microelectronics	Torrance	CA	U.S.	III-V	MMIC	III-V	0.25	75	1977.0	240	240	FTRP
Hughes Microelectronics	Sylmar	CA	U.S.	-	Solar Cell Array	-	1.60	100	1982.0	8,400	24,000	FTR
Hughes Microelectronics	Newport Beach	CA	U.S.	SPC-Fab 3	Arrays Custom Mix Signal ASIC	P/CMOS	0.60	100	1983.0	1,500	6,000	FR
Hughes Microelectronics	Carlsbad	CA	U.S.	HTC	Mil Std Opto ASIC Lin	-	1.50	100	1987.0	3,000	8,800	FP
IBM Microelectronics	Essex Junction	VT	U.S.	Bldg. 970	ASIC 64Mb DRAM MPU	P/CMOS	0.35	200	1988.0	6,000	24,000	F
IBM Microelectronics	Hopewell Junction	NY	U.S.	ASTC	64Mb 256Mb DRAM	P/CMOS	0.35	200	1989.0	5,000	10,000	F
IBM Microelectronics	Essex Junction	VT	U.S.	Bldg. 617	DRAM ASIC MPU	-	0.80	150	1989.0	4,600	18,400	NOT
IBM Microelectronics	Essex Junction	VT	U.S.	Bldg. 962	DRAM ASIC MPU	-	0.80	150	1989.0	4,600	18,400	NOT
IBM Microelectronics	Essex Junction	VT	U.S.	Bldg. 963	ASIC 4Mb DRAM MPU	P/CMOS	0.50	125	1989.4	8,000	16,000	FTN
IBM Microelectronics	Essex Junction	VT	U.S.	Bldg. 973	ASIC 16Mb DRAM MPU	P/CMOS	0.50	200	1989.4	10,000	20,000	F
IBM Microelectronics	Hopewell Junction	NY	U.S.	Bldg. 322	Logic	P/CMOS	0.25	200	1995.3	5,000	20,000	F
IC Sensors	Milpitas	CA	U.S.	Wafer Fab	Micro Machining Sensor	III-V	1.00	100	1988.0	1,200	4,000	FTR
IMP	San Jose	CA	U.S.	Building 1	Analog Mixed Signal	P/CMOS	0.50	125	1982.4	1,200	3,000	FTN
Integrated Circuit Works	San Jose	CA	U.S.	-	Foundry	-	0.60	150	1987.0	1,000	7,000	FN
Integrated Device Technology	Salinas	CA	U.S.	Fab 2	SRAM LOGIC SMP FIFO RISC CPU	P/CMOS	0.35	150	1987.0	1,000	10,500	FN
Integrated Device Technology	Hillsboro	OR	U.S.	Fab 4	SRAM, X86, CPU, RISC CPU	P/CMOS	0.18	200	1996.1	1,000	7,500	FR
Intel	Aloha	OR	U.S.A	Fab 5	MCU	-	0.50	150	1978.0	3,700	15,000	F
Intel	Chandler	AZ	U.S.A	Fab 6	MCU	III-V	0.80	150	1982.0	6,000	24,000	F
Intel	Rio Rancho	NM	U.S.A	Fab 7	Flash	-	0.50	150	1984.0	8,000	23,000	F
Intel	Rio Rancho	NM	U.S.A	Fab 9	Flash	-	0.35	150	1988.0	19,200	48,000	F
Intel	Santa Clara	CA	U.S.A	D2	MPU	-	0.18	200	1991.0	11,000	12,000	FR
Intel	Rio Rancho	NM	U.S.A	Fab 11	MPU	-	0.18	200	1994.0	19,000	33,000	F
Intel	Chandler	AZ	U.S.A	Fab 12	MPU	-	0.18	200	1996.0	9,600	24,000	F
Intel	Hillsboro	OR	U.S.A	D1B	MPU	-	0.25	200	1996.0	10,000	24,000	FRP
Intel	Aloha	OR	U.S.A	Fab 15	MPU	-	0.18	200	1996.0	8,000	20,000	F
Intel	Hudson	MA	U.S.A	Fab 17	MPU	P/CMOS BiCMOS NMOS Bipolar III-V	0.18	-	1997.0	-	-	F
International Microcircuits Incorporated	Milpitas	CA	U.S.	IMI	ASIC	P/CMOS	1.00	125	1991.0	200	800	FVDP
International Rectifier	El Segundo	CA	U.S.	233 Kansas Wafer Fab	Rad Hard Devices MER PIC	-	1.60	100	1976.0	4,400	12,700	F
International Rectifier	El Segundo	CA	U.S.	330 Kansas Wafer Fab	Schottky FRED IGBT ABB	NMOS	5.00	100	1981.0	4,500	13,000	FTRVDPD
International Rectifier	Temecula	CA	U.S.	Temecula-Fab 1	Power FET	-	5.00	125	1987.3	14,700	42,000	FT

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Table 2-1 (Continued)
Americas Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
International Rectifier	Temecula	CA	U.S.	Temecula-Fab II	Pwr Trans MOSFET	-	2.00	150	1995.3	3,500	10,000	FT
International Rectifier	El Segundo	CA	U.S.	R&D Wafer Fab	HEXFET IGBT	-	1.20	200	1997.2	6,600	19,100	FT
Kodak	Rochester	NY	U.S.	-	Imaging Arrays CBIC CCD	-	1.50	100	1984.0	1,700	5,000	FRP
Konica Technology	Silicon Valley	CA	U.S.	-	Opto Logic ASIC	-	0.80	125	1985.0	4,800	13,900	FR
Kulite	Leonia	NJ	U.S.	-	Discrete	Bipolar	3.00	100	1980.0	8,400	24,000	F
Linear Technology	Milpitas	CA	U.S.	Fab 1	Linear Interface A/D D/A	Bipolar	3.00	100	1982.0	2,700	9,000	FTVDPD
Linear Technology	Milpitas	CA	U.S.	Fab 2	Linear	Bipolar	1.20	100	1992.4	3,900	13,000	FTVDPD
Linear Technology	Camas	WA	U.S.	Fab 3	Linear	P/CMOS	0.80	150	1996.0	3,000	10,000	F
Linfinity Microelectronics	Garden Grove	CA	U.S.	Markon Bldg.	Linear Bipolar Analog	Bipolar	3.00	100	1982.0	200	9,000	FTRVD-PDN
Linfinity Microelectronics	San Jose	CA	U.S.	IMP	CMOS BiCMOS, Analog	P/CMOS	0.80	100	1982.0	200	16,000	FTRVD-PDN
Lockheed-Martin	Syracuse	NY	U.S.	E Lab	Analog Discrete PHEMT	III-V	0.10	75	1983.0	1,200	3,600	FRP
Lockheed-Martin	Lowell	MA	U.S.	S/C	RF and Microwave Diodes	Bipolar	0.80	75	1985.0	700	2,000	FTRVD-PDP
Lockheed-Martin	Sanders Nashua	NH	U.S.	Sanders Nashua	Analog MMIC	III-V	0.15	75	1985.0	6,700	19,200	FRP
Lockheed-Martin	Fort Worth	TX	U.S.	-	-	NMOS	0.80	100	1987.0	2,500	5,000	F
Lockheed-Martin	Sunnyvale	CA	U.S.	113	ASIC Mil Std Rad Hard	P/CMOS	1.50	125	1988.3	100	640	FP
LSI Logic	Eugene	OR	U.S.	Oregon Fab	16Mb 64Mb DRAM	-	0.25	200	1998.0	3,000	30,000	FR
LSI Logic	Fremont	CA	U.S.	Fremont Fab	ASIC	P/CMOS	1.50	150	1988.0	1,500	6,000	FTRP
LSI Logic	Santa Clara	CA	U.S.	R&D Pilot	ASIC MPU	P/CMOS	0.50	150	1989.0	1,200	5,000	FRP
LSI Logic (formerly Hyundai)	Gresham	OR	U.S.	Gresham Fab 1	ASIC CBIC MPU MPR SRAM	P/CMOS	0.25	200	1998.2	3,700	15,000	F
LSI Logic (formerly Symbios Logic)	Colorado Springs	CO	U.S.	Colorado Springs (CS 3)	CBIC ASIC MPB Analog Mixed Signal	P/CMOS	0.25	200	1994.0	2,200	9,600	FRP
Lucas Novasensor	Fremont	CA	U.S.	LCSP	Processing Pressure Sensors MEMP	P/CMOS	4.50	100	1987	800	2500	FTRVD
Lucent Technologies	Lees Summit	MO	U.S.	-	Diodes Tran Discrete Mod ASIC	Bipolar	1.50	125	1967.0	3,000	10,000	FRN
Lucent Technologies	Murray Hill	NJ	U.S.	VLSI Research Lab	SRAM ASIC Opto	-	2.20	125	1975.0	1,400	4,000	FRP
Lucent Technologies	Allentown	PA	U.S.	MOS 2	Network Communication ASIC DSP	P/CMOS	0.90	125	1979.2	4,000	16,000	FTVD-PDN
Lucent Technologies	Allentown	PA	U.S.	BIC 2	Bipolar Linear Digital and RF Wireless	PCMOSBipolar	0.55	100	1980.2	2,400	8,000	FTVD-PDN
Lucent Technologies	Reading	PA	U.S.	Linear I	Linear Analog	Bipolar	1.50	125	1981.4	4,800	16,000	FRVD-PDN
Lucent Technologies	Reading	PA	U.S.	High Voltage II	Power	III-V	1.50	125	1982.3	5,200	15,000	FRVDPD
Lucent Technologies	Allentown	PA	U.S.	MOS V	Flash Gate DSP FPGA ASSP Custom ASIC	P/CMOS	0.30	125	1984.1	7,500	30,000	FTVDPD
Lucent Technologies	Orlando	FL	U.S.	OR 1	ASIC DSP FPLD Logic Flash	P/CMOS	0.25	150	1985.0	5,400	16,000	FRN

Table 2-1 (Continued)
Americas Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Lucent Technologies (Formerly Cirent)	Orlando	FL	U.S.	OR 2	ASIC DSP FPLD Logic Flash	P/CMOS	0.25	200	1997.1	200	21,250	FRN
M-A-Com	Burlington	MA	U.S.	-	Discretes	Bipolar	0.20	75	1960.0	1,800	15,000	FTVDPD
M-A-Com	Lowell	MA	U.S.	Adv. S/C	MMIC	III-V	0.25	75	1985.0	200	800	FTNP
Magnavox	Fort Wayne	IN	U.S.	-	Arrays CBIC Hybrid	P/CMOS	5.00	75	1976.0	100	400	FTVDPDP
Mass. Microelectronics Center (M2C)	Westborough	MA	U.S.	ICFF	ASIC	-	2.00	125	1989.0	300	1,200	FTVDP-DNP
Maxim Integrated Products	Sunnyvale	CA	U.S.	CMOS	Analog and Mixed Signal	P/CMOS	3.00	100	1990.2	1,200	4,000	FP
Maxim Integrated Products	Beaverton	OR	U.S.	Bipolar	Analog Mixed Signal	Bipolar	0.80	100	1994.0	1,200	4,000	FTNP
McDonnell Douglas	Huntington Beach	CA	U.S.	3-Inch Pilot	4Kb 16Kb SRAM 6Kb Array MPU	III-V	1.00	75	1985.0	100	400	FTRNP
McDonnell Douglas	Huntington Beach	CA	U.S.	Development	MPU Logic ASIC Discrete	III-V	1.00	75	1988.1	3,800	11,000	FTRP
Medtronic- Micro-Rel	Tempe	AZ	U.S.	Wafer Fab	ASIC	Bipolar	0.30	150	1984.3	3,000	4,000	FTVD-PDN
Micrel Semiconductor	San Jose	CA	U.S.	Fab 1	MixSig Linear	P/CMOS	1.20	100	1992.0	1,200	4,000	F
Micro Power Systems	Santa Clara	CA	U.S.	-	Linear Custom	-	4.00	75	1975.0	4,500	15,000	FT
Micro Quality Semiconductor	Garland	TX	U.S.	-	Rectifier Multiplier	Bipolar	2.20	100	1982.0	3,500	10,000	F
Microchip Technology	Chandler	AZ	U.S.	Fab 3	MCU OTP EPROM	-	0.35	200	1998.2	7,800	19,700	F
Microchip Technology	Tempe	AZ	U.S.	Fab 2	MCU EEPROM ROM Flash	P/CMOS	0.35	150	1994.0	4,500	15,000	FRVDPD
Microchip Technology	Chandler	AZ	U.S.	Fab 1	EEPROM MCU ASIC	P/CMOS	0.50	150	1994.3	1,500	6,000	FTVDPD
Micro-Circuit Eng	West Palm Beach	FL	U.S.	-	Custom	NMOS	4.00	100	1979.0	3,000	12,000	FVDPDN
Micron	Dallas	TX	U.S.	DMOS 5 Phase 1	16Mb DRAM	P/CMOS	0.50	200	1995.0	8,000	16,000	FR
Micron	Dallas	TX	U.S.	DMOS 5 Phase 2	64Mb 256Mb DRAM	P/CMOS	0.25	200	1997.0	8,000	16,000	FR
Micron Technology	Boise	ID	U.S.	Fab 1	DRAM SRAM Flash RFIC	P/CMOS	0.18	200	1981.0	10,000	20,000	FTRP
Micron Technology	Boise	ID	U.S.	Fab 2	DRAM SRAM Flash RFIC	P/CMOS	0.18	200	1985.0	10,000	20,000	FTR
Micron Technology	Boise	ID	U.S.	Fab 3	DRAM SRAM Flash RFIC	P/CMOS	0.18	200	1989.0	12,500	25,000	FTR
Micron Technology	Richardson	TX	U.S.	Twinstar	16Mb 64Mb DRAM	P/CMOS	0.30	200	1996.2	10,000	15,000	F
Micropac Industries	Garland	TX	U.S.	725	Opto	Bipolar III-V	1.40	100	1984.0	500	1,500	FTP
Micropac Industries	Garland	TX	U.S.	905	Hybrid	Bipolar	1.40	100	1984.0	500	1,500	FTP
Micropac Industries	Garland	TX	U.S.	1,005	Power	Bipolar	1.40	100	1984.0	500	1,500	FTP
Microsemi	Broomfield	CO	U.S.	-	Schottky Diode Rectifier	NMOS	5.00	100	1981.0	3,000	8,800	FT
Microsemi	Torrance	CA	U.S.	-	Mil Std Discrete	Bipolar	12.00	75	1982.0	1,600	4,800	FP
Mitel Semiconductor	Bromont	Quebec	Canada	150mm # 5	-	BiCMOS	0.80	-	1998.1	1,500 150mm/mo.	1,500 150mm/mo.	FTRN
Mitel Semiconductor	Bromont	Quebec	Canada	100mm # 4	-	BiCMOS	1.20	-	1982.4	6,000 100mm/mo.	10,000 100mm/mo.	FTN
Motorola	Phoenix	AZ	U.S.	Zener/ Rectifier	Zener Diode Rectifier	Bipolar	10.00	100	1978.0	19,600	56,000	F

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Table 2-1 (Continued)
Americas Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Motorola	Guadalajara		Mexico	Guad Power	Thyristor	-	2.50	75	1982.0	12,600	36,000	F
Motorola	Austin	TX	U.S.	MOS 2	Logic A/D MCU	-	1.00	100	1983.0	15,000	50,000	FR
Motorola	Mesa	AZ	U.S.	Bipolar 1	Telecom Op Amp Automotive Analog	-	3.00	100	1983.0	12,000	40,000	FN
Motorola	Mesa	AZ	U.S.	Bipolar 2	Logic	Bipolar	2.50	100	1983.0	10,800	36,000	F
Motorola	Mesa	AZ	U.S.	Bipolar 3	Analog Gate Arrays	-	1.25	100	1983.0	4,000	16,000	F
Motorola	Austin	TX	U.S.	MOS 3	MCU	-	1.00	100	1983.0	12,500	50,000	FRN
Motorola	Austin	TX	U.S.	STL	MCU Flash	-	1.00	125	1984.0	18,200	36,550	FR
Motorola	Research Triangle Park	NC	U.S.	MOS 15	8-Bit MCU Logic	-	0.80	150	1984.0	6,000	12,000	FR
Motorola	Phoenix	AZ	U.S.	MOS 4	MOSFET Smart Pwr Discrete	Bipolar	3.00	150	1986.0	6,300	26,000	F
Motorola	Mesa	AZ	U.S.	MOS 5	MCU	Bipolar	0.80	125	1988.0	5,500	22,000	F
Motorola	Austin	TX	U.S.	MOS 8	MCU FSRAM DSP Linear RISC	P/CMOS	0.65	125	1988.4	7,200	20,800	FR
Motorola	Mesa	AZ	U.S.	MOS 6	ASIC Analog Logic	-	0.50	150	1988.4	8,000	12,000	F
Motorola	Oakhill	TX	U.S.	MOS 11	SRAM DSP MCU MPU PowerPC	-	0.35	200	1992.0	3,140	15,700	F
Motorola	Chandler	AZ	U.S.	MOS 12	MCU MPU ASIC DSP MOS D/A IC	-	0.35	200	1994.2	6,700	16,800	FR
Motorola	Mesa	AZ	U.S.	MOS 21	Logic ASIC Analog Discrete	-	0.60	200	1995.0	4,600	9,200	F
National Semiconductor	Santa Clara	CA	U.S.	5-Inch	Bipolar Linear	Bipolar	0.50	125	1982.4	2,000	12,000	FVDPD
National Semiconductor	Arlington	TX	U.S.	Fab 1	Telecom ICs MixSig ASICs-Analog	P/CMOS	1.25	150	1985.0	3,400	18,000	FT
National Semiconductor	Arlington	TX	U.S.	Fab 2	LAN Audio PC MixSig ASICs-Analog	P/CMOS	0.50	150	1992.0	4,000	9,000	FT
National Semiconductor	Santa Clara	CA	U.S.	6-Inch	EPROM MPR MCU DSP ASIC	BiCMOS	0.50	150	1992.1	700	2,000	FVDPD
National Semiconductor	Santa Clara	CA	U.S.	ATG Fab—8-Inch	MPR MCU MPR DSP ASIC (Including Cyrix 6x686)	P/CMOS	0.25	200	1995.4	3,700	15,000	FRVDPDP
National Semiconductor	Arlington	TX	U.S.	Fab 2A	LAN Audio PC MixSig ASICs	P/CMOS	0.50	150	1996.0	4,000	9,000	FT
National Semiconductor	South Portland	ME	U.S.	New 8-Inch Fab	Logic Array, Prod of Cyrix 6x686	P/CMOS	0.25	200	1997.3	12,500	35,000	FTPD
N-Chip	San Jose	CA	U.S.	-	MCM	-	3.00	125	1986.0	300	1,000	FP
NEC	Roseville	CA	USA	K-Line	ASIC MCU	PCMOSPcl	1.00	125	1984.0	20,000	25,000	FT
NEC	Roseville	CA	USA	M-Line	16Mb DRAM	PCMOSPcl	0.25	150	1991.0	20,000	35,000	FT
Northern Telecom	Nepean	Ontario	Canada	Mod4	CBIC Custom	P/CMOS	0.80	150	1990.1	1,500	6,000	FTRVDPD
Northrop Grumman	Baltimore	MD	U.S.	-	Si- BiPolar MOS	-	0.15	150	1980.0	100	500	FTVD-PDN
Northrop Grumman	Baltimore	MD	U.S.	-	GaAs RF	III-V	0.15	100	1985.0	100	300	FTVD-PDN
Optek Technology	Carrollton	TX	U.S.	Fab 1	Mil Std Pwr IC	NMOS	6.00	100	1987.0	5,200	15,000	F
Optek Technology	Carrollton	TX	U.S.	Fab 2	Mil Std Pwr IC	NMOS	6.00	125	1987.0	5,200	15,000	F
Opto Diode	Newbury Park	CA	U.S.	-	Opto Diode	III-V	1.60	100	1981.0	4,400	12,700	F
Orbit Semiconductor	San Jose	CA	U.S.	Fab	ASIC Foundry	P/CMOS	0.60	150	1996.0	3,000	3,500	FTRN
Philips	Sunnyvale	CA	U.S.	Fab 1	Amplifiers Converters Timers	III-V	1.80	100	1964.1	50	22,500	FTVD-PDN
Philips	Albuquerque	NM	U.S.	Fab 22	MCU ASSP Analog	BiCMOS	1.20	100	1980	9,600	32,000	FTRVDPD
Philips	Albuquerque	NM	U.S.	Fab 23	ASSP MCU	NMOS	0.8	150	1988	5,900	17,000	FTRVDPD

Table 2-1 (Continued)
Americas Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Powerex	Youngwood	PA	U.S.	SCR/Diode	High Pwr Discrete Diode SCRS Transistor	Bipolar	5.00	75	1980.1	20,000	40,000	FTRN
Powerex	Youngwood	PA	U.S.	Planar Transistor	Discrete Diode Pwr Tran Thyristor	Bipolar	5.00	100	1988.0	1,000	5,000	FTRP
Precision Mono	Santa Clara	CA	U.S.	Fab 2	Custom	Bipolar	2.50	100	1981.0	900	3,200	FTP
Ramtron International	Colorado Springs	CO	U.S.	Northgate	Ferroelectric RAM	P/CMOS	1.00	150	1993.0	100	300	FTRVDP-DNP
Raytheon	Andover	MA	U.S.	Research Fab	GaAs MMIC	III-V	0.15	75	1985.3	15	50	FTRVDPD
Raytheon	Andover	MA	U.S.	MMIC Fab	GaAs MMIC	III-V	0.15	100	1989.3	150	2,500	FTVD-PDN
Rockwell Semiconductor System	Newbury Park	CA	U.S.	GaAs Wafer Fab	DAC Power Amplifier Front End Receiver	III-V	0.90	100	1985.0	250	250	FTRVD-PDP
Rockwell Semiconductor System	Newport Beach	CA	U.S.	Fab IV	DSP Mixed Signal	-	0.80	125	1987.4	600	2,100	FTRVD-PDP
Rockwell Semiconductor System	Newport Beach	CA	U.S.	Fab V	DSP Mixed Signal MCU	-	0.50	200	1995.0	600	2,500	FTRVD-PDP
Rockwell Semiconductor System	Newport Beach	CA	U.S.	Fab I	Telecom IC DSP Mixed Signal	-	2.00	100	1996.0	7,500	25,000	FTRVD-PDP
Rockwell Semiconductor System	Newport Beach	CA	U.S.	Fab VI	DSP Mixed Signal MCU	-	0.25	200	1997.0	300	1,100	FTRVD-PDP
Samsung	Milpitas	CA	U.S.	III-V	GaAs Fet MMIC	III-V	0.25	100	1982.0	1,200	3,500	FTVDP-DNP
Samsung	Austin	TX	U.S.	Austin Plant	64Mb DRAM	P/CMOS	0.23	200	1997.4	13,000	25,000	FRVDPD
Sanders Associates	Nashua	NH	U.S.	III-V	Linear MMIC	III-V	0.50	75	1985.0	100	400	FTP
Sandia National Labs	Albuquerque	NM	U.S.	MDL	CMOS SONOS MEMS	P/CMOS	0.50	150	1989.0	200	400	FT XVD-PDN
Santa Barbara Rsch	Goleta	CA	U.S.	SBRC	Mil Std Infrared Detector	-	1.60	100	1967.0	300	1,000	FP
Sematech	Austin	TX	U.S.	ATDF	R&D	-	0.15	200	1988.3	1,100	10,000	FRP
Semicoa	Costa Mesa	CA	U.S.	-	Custom Hi Rel Pwr Photo	Bipolar	7.00	75	1969.0	4,200	12,000	F
Semiconductor Laser International	Endicott	NY	U.S.	-	High Powered Diode Lasers (HPDL)	-	0.65	150	1996.0	5,000	14,400	F
Semikron	Sao Paulo		Brazil	-	Discrete	III-V	4.00	100	1985	1,000	3,000	FT
Semtech	Newbury Park	CA	U.S.	Newbury Park	Discrete Rectifier Zener Diode	Bipolar	6.00	51	1968.0	3,500	10,000	FTR
Semtech	Corpus Christi	TX	U.S.	Corpus Christi	Bipolar Voltage Regulator Suppressor	Bipolar	2.00	75	1974.0	1,000	8,000	FTVDPD
Semtech	Santa Clara	CA	U.S.	Semtech	Bipolar and CMOS IC	Bipolar	2.00	100	1974.0	3,200	8,000	FRVD-PDN
Semtech(formerly ECI Semiconductor)	Santa Clara	CA	U.S.	Santa Clara	Analog ASIC Discrete Opto Power	Bipolar	2.00	125	1974.0	5,900	17,000	FRVDN
Sensor Solid State	Quakertown	PA	U.S.	Sensor Solid State Services	Sensors and Transducers	NMOS	3.00	100	1982.3	100	500	FTP
Sensym	Milpitas	CA	U.S.	Fab1	Pressure Tranducers	Bipolar	3.50	100	1993.0	600	2,000	FTVD-PDN

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Table 2-1 (Continued)
Americas Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
SGI (formerly Cray Research)	Chippewa Falls	WI	U.S.	NTL	SMC, MCM Wafers	III-V	6.00	-	1988.0	20	1,000	FA&TRN
SGI (formerly Cray Research)	Chippewa Falls	WI	U.S.	Fab 2	Custom ASIC Array	Bipolar	0.40	200	1993.0	120	650	FTRNP
Sid Microelectronics	Contagoem		Brazil	-	Linear Pwr Tran SST Pwr IC	Bipolar	30.00	75	1984.0	4,200	12,000	F
Sid Microelectronics	Contagoem		Brazil	-	Pwr IC	P/CMOS	2.00	100	1990.0	4,500	13,000	F
Siemens-Motorola (White Oak)	Richmond	VA	U.S.	MOS 18	64Mb 256Mb DRAM Logic SRAM	-	0.25	200	1998.4	1,000	25,000	FP
Silicon Systems (Texas Instruments)	Santa Cruz	CA	U.S.	Fab III	Digital ASIC MixSig ASIC Bipolar ASIC	BiCMOS	0.80	150	1992.2	800	3,400	FR
Silicon Transistor Corporation	Chelmsford	MA	U.S.	STC	Bipolar Discrete	Bipolar	4.00	75	1971.0	200	300	FT
Sipex	Milpitas	CA	U.S.	Fab 1	Low Pwr ASIC High Voltage ASIC Electroluminescent Driver	BiCMOSBipolar	3.00	100	1986.0	1,200	4,000	FTRP
S-MOS Sysyems	Vancouver		Canada	-	-	-	1.20	150	1991.0	8,500	19,000	FVDPD
Solid Power Company	Farmingdale	NY	U.S.	-	Pwr Tran	Bipolar	20.00	51	1967.0	8,400	24,000	FT
Solid State Devices	La Mirada	CA	U.S.	-	Hi Rel Custom	Bipolar	1.20	100	1985.0	1,000	4,000	FP
Solitron Devices	West Palm Beach	FL	U.S.	-	Power Tran Diode Hybrid FET Resistor	Bipolar	2.00	75	1992.0	500	500	FTVD-PDN
Sony	San Antonio	TX	U.S.	Fab 12	ASIC PLD	Bipolar	1.25	150	1982.0	3,200	12,800	F
Sony	San Antonio	TX	U.S.	Fab 11	SRAM	P/CMOS	0.45	150	1991.0	5,600	16,000	F
Standard Microsystems	Hauppauge	NY	U.S.	SMSC	Microelectromechanical Systems	III-V	1.25	100	1984.0	6,100	17,600	FRVD-PDN
STMicroelectronics	Carrollton	TX	U.S.	Fab 4	SRAM ASIC	Bipolar	1.20	150	1979.2	1,700	6,800	FRVD-PDN
STMicroelectronics	Texas	TX	U.S.	CF6 # 8	SRAM HP Product	NMOSBipolar	0.60	150	1989	1,500	6,000	FVDPD
STMicroelectronics	Phoenix	AZ	U.S.	Phoenix Fab	EPROM	BiCMOS	0.35	200	1995	3,700	15,000	FRVDPD
STMicroelectronics	Rancho Bernardo	CA	U.S.	Fab1 # 17	Printer IC	NMOS	2.00	100	1997	4,200	14,000	F
Supertex	Sunnyvale	CA	U.S.	Supertex Fab	Analog Power	-	2.00	100	1976.0	8,000	6,000	FTR
Synergy Semiconductor	Santa Clara	CA	U.S.	Scott	SRAM Mixed Signal Analog and Digital	Bipolar	1.00	150	1996.4	300	300	FTP
Sypex	Milpitas	CA	U.S.	Fab 1	Op Amp CBIC Custom	P/CMOS	4.00	100	1986.0	400	1,600	FTNP
Teccor Electronics	Irving	TX	U.S.	Triacs Stand	Discrete Thyristor	III-V	0.35	75	1986	5,600	16,000	FTRVDPD
Teccor Electronics	Irving	TX	U.S.	Sideator	ASIC Analog	III-V	0.24	75	1988	2,500	10,000	FTRVDPD
Telcom Devices	Camarillo	CA	U.S.	-	Photodiode LED	III-V	1.60	25	1993.0	200	800	FTRVDPD
Teledyne	Mountain View	CA	U.S.	-	Pwr IC Pwr MOSFET Hybrid	-	6.00	100	1972.0	1,700	5,000	FTP
Teledyne	Los Angeles	CA	U.S.	-	Hi Rel Hybrid and A/D D/A	Bipolar	1.40	100	1983.0	1,500	5,000	FP
Teledyne	Mountain View	CA	U.S.	III-V	FET	III-V	0.50	75	1987.0	80	80	FTP
Temic	Santa Clara	CA	U.S.	Fab 2	Smart Pwr A/D D/A	PCMOSBiCMOS	2.00	100	1982.0	100	3,500	FTVDPD
Temic	Santa Clara	CA	U.S.	Fab 3	Pwr Smart Pwr	P/CMOS	0.60	150	1986.0	100	15,800	FTVD-PDP
Texas Instruments	Lubbock	TX	U.S.	LMOS	EPROM Flash DSP Speech	P/CMOS	0.80	150	1978.2	15,000	25,200	F
Texas Instruments	Sherman	TX	U.S.	S-Fab	Logic	Bipolar	1.00	125	1980.0	12,900	51,600	F

Table 2-1 (Continued)
Americas Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Texas Instruments	Houston	TX	U.S.	H-Fab	Adv Bip ASSP ASIC	-	1.00	125	1984.0	7,600	25,466	F
Texas Instruments	Dallas	TX	U.S.	DMOS	Logic MPU	P/CMOS	0.60	150	1985.2	11,600	29,200	F
Texas Instruments	Dallas	TX	U.S.	Dlog	Linear ASSP	-	0.80	150	1989.0	8,000	16,000	FR
Texas Instruments	Dallas	TX	U.S.	Dlin	Linear	Bipolar	1.00	150	1989.0	8,100	27,000	FR
Texas Instruments	Dallas	TX	U.S.	DMOS 6	DSP	-	0.25	200	1997.4	10,000	30,000	FR
Toshiba-IBM	Manassas	VA	U.S.	Dominion Semiconductor Module 1	64Mb DRAM	-	0.25	200	1998.1	15,000	27,000	F
TRW	Manhattan Beach	CA	U.S.	-	Linear Tran Pwr Tran Hybrd	NMOS	2.20	100	1982.0	1,700	5,000	FP
TRW	Redondo Beach	CA	U.S.	D1	Linear Tran Pwr Tran Hybrd	-	1.50	100	1985.0	500	1,600	FTP
TRW	Redondo Beach	CA	U.S.	D1	VHSIC Mil Std FERRAM	-	0.50	100	1986.0	2,200	6,400	FT
TRW	La Jolla	CA	U.S.	-	A/D D/A Multiplier	NMOS	2.00	100	1987.0	1,500	5,000	FRP
TRW	Redondo Beach	CA	U.S.	R1	Automotive MEM / Sensor	III-V	0.10	75	1995.0	200	300	F
TSMC Group	Camas	WA	U.S.	WaferTech	Foundry	-	0.25	200	1998.3	3,000	30,000	FN
Unitrode	Watertown	MA	U.S.	-	Hybrid Discrete	Bipolar	2.20	100	1982.0	3,500	10,000	F
Unitrode	Merrimack	NH	U.S.	-	Linear Smart Pwr Custom	Bipolar	5.00	100	1987.0	1,400	4,000	FTP
Universal Semiconductor	San Jose	CA	U.S.	-	Linear Array ASIC Power IC	P/CMOS	2.00	100	1980.0	3,000	10,000	FTRVDP-DNP
Vitesse Semiconductor	Colorado Springs	CO	U.S.	Pierre Lamond Wafer Fabrication Facility	GaAs IC	III-V	0.30	150	1998.1	-	-	FT
Vitesse Semiconductor	Camarillo	CA	U.S.	Camarillo Fab	GaAs IC	III-V	0.30	100	1986.1	100	3,000	FTVDPD
VLSI Technology	San Antonio	TX	U.S.	Module A	Arrays CBIC MPU Telecom IC	P/CMOS	0.60	150	1988.4	1,250	7,200	FRN
VLSI Technology	San Antonio	TX	U.S.	Module B	Arrays CBIC MPU Telecom IC	P/CMOS	0.35	150	1991.4	800	3,200	FRN
VLSI Technology	San Antonio	TX	U.S.	Module C	Arrays CBIC MPU Telecom IC	P/CMOS	0.35	150	1994.0	900	3,800	FRN
VLSI Technology	San Antonio	TX	U.S.	Module D	Arrays CBIC MPU Telecom IC	P/CMOS	0.35	150	1996.0	900	3,800	FRN
VTC Inc.	Minneapolis	MN	U.S.	-	Analog MixSig ASIC	-	-	150		-	14,000	F
Xicor	Milpitas	CA	U.S.	Phase 2	EEPROM	P/CMOS	0.50	150	1981.0	1,000	8,000	FTRVDPD
Zilog	Nampa	ID	U.S.	Module 2	MPU MCU Custom	P/CMOS	0.65	125	1985.0	1,000	24,000	FT
Zilog	Nampa	ID	U.S.	Module 3	Z8XXX MPU MCU Custom	P/CMOS	0.35	200	1995.0	500	6,200	FRVD-PDN

NA = Not applicable
Source: Dataquest (December 1998)

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Table 2-2
Americas Future Pilot and Production Fab Lines (Including Fabs Beginning Operation during 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
American Microsystems Incorporated	Pocatello	ID	U.S.	Fab 10	Arrays PLD CBIC Custom MixSig ASIC	P/CMOS	0.35	200	1998.3	6,500	5,200	FTRVD-PDN
Applied Micro Circuits (AMCC)	San Diego	CA	U.S.	Fab 2	ASIC ASSP Foundry 6-Inch Bipolar	Bipolar	0.40	150	2001.0	5,700	19,100	FN
Gennum Corporation	Burlington	Ontario	Canada	Fraser	Signal Processor Amplifier Data Transport	Bipolar	1.00	-	1999.0	500	-	FT
Hewlett-Packard	Fort Collins	CO	U.S.	8-Inch	ASIC, Differentiated Products	P/CMOS	0.18	200	1999.0	2,000	-	FTRVDPD
IBM Microelectronics	East Fishkill	NY	U.S.	Bldg. 323	DRAM ASIC MPU (1GB)	P/CMOS	0.15	-	1999.3	2,000	10,000	FRP
Intel	Hillsboro	OR	U.S.	D1C	MPU	-	0.18	200	2000.0	2,000	15,000	FRP
Intel	Fort Worth	TX	U.S.	Fab 16 (Alliance)	MPU	-	0.13	300	2002.0	24,000	24,000	F
Intel	Hillsboro	OR	U.S.	D1C-Phase II	MPU	-	0.13	300	2003.0	2,000	-	FRP
LSI Logic	Eugene	OR	U.S.	Oregon Fab	16Mb 64Mb DRAM	-	0.25	200	1998.0	3,000	30,000	FR
LSI Logic (formerly Hyundai)	Gresham	OR	U.S.	Gresham Fab 1	ASIC CBIC MPU MPR SRAM	P/CMOS	0.25	200	1998.2	3,700	15,000	F
Microchip Technology	Chandler	AZ	U.S.	Fab 3	MCU OTP EPROM	-	0.35	200	1998.2	7,800	19,700	F
Mitel Semiconductor	Bromont	-	Canada	150mm # 5	-	BiCMOS	0.80	-	1998.1	1,500 150mm/mo.	1,500 150mm/mo	FTRN
NEC	Roseville	CA	U.S.	Fab 4	128Mb DRAM (for PCs)	Bipolar	0.22	150	2000.1	10,000	7,000	FTR
Siemens-Motorola (White Oak)	Richmond	VA	U.S.	MOS 18	64Mb 256Mb DRAM Logic SRAM	-	0.25	200	1998.4	1,000	25,000	FP
Texas Instruments	Dallas	TX	U.S.	DMOS 6 Pilot	DSP	-	0.25	300	1999.4	-	2,000	FRP
Toshiba-IBM	Manassas	VA	U.S.	Dominion Semiconductor Module 1	64Mb DRAM	-	0.25	200	1998.1	15,000	27,000	F
TSMC Group	Camas	WA	U.S.	WaferTech	Foundry	-	0.25	200	1998.3	3,000	30,000	FN
Vitesse Semiconductor	Colorado Springs	CO	U.S.	Pierre Lamond Wafer Fabrication Facility	GaAs IC	III-V	0.30	150	1998.1	-	-	FT

NA = Not applicable
Source: Dataquest (December 1998)

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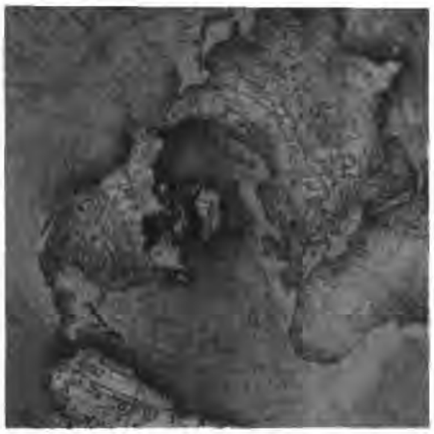

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Final 1997 Americas Semiconductor Market Share

Market Statistics

FILE COPY:
MARIA VALENZUELA

Program: Semiconductors Worldwide
Product Code: SEMI-WW-MS-9802
Publication Date: June 22, 1998
Filing: Market Statistics

Final 1997 Americas Semiconductor Market Share

Market Statistics

Program: Semiconductors Worldwide
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Publication Date: June 22, 1998
Filing: Market Statistics

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List of Tables

Chapter 1

Final 1997 Americas Semiconductor Market Share

Introduction

This document contains detailed information on Dataquest's view of the semiconductor market. Included in this document are the following:

- 1995-1997 market share estimates
- 1996-1997 market share rankings

Americas market share estimates combine data from various countries, each of which has a different and fluctuating exchange rate. Estimates of non-U.S. market consumption or revenue are based on the average exchange rate for the given year. Refer to the section titled "Exchange Rates" for more information regarding these average rates. As a rule, Dataquest's estimates are calculated in local currencies and then converted to U.S. dollars.

More detailed data on this market may be requested through Dataquest's client inquiry service. Qualitative analysis of this data is provided in Dataquest Perspectives.

Segmentation and Definitions

A detailed explanation of device segmentation and related definitions is contained in the Semiconductor Market Definitions Guide (SCND-WW-GU-9801).

Market Share Methodology

Dataquest uses both primary and secondary sources to produce market statistics data. In the fourth quarter of each year, Dataquest surveys all major participants within each industry. Selected companies are resurveyed during the first quarter of the following year to verify final annual results. This primary research is supplemented with additional primary research and secondary research to verify market size, shipment totals, and pricing information. Sources of data used by Dataquest include the following:

- Information published by major industry participants
- Estimates made by knowledgeable and reliable industry spokespersons
- Government data or trade association data (such as WSTS, MITI, and U.S. DOC)
- Published product literature and price lists
- Interviews with knowledgeable manufacturers, distributors, and users
- Relevant economic data
- Information and data from online and CD-ROM data banks
- Articles in both the general and trade press

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- Reports from financial analysts
- End-user surveys

Dataquest believes that the estimates presented in this document are the most accurate and meaningful statistics available.

Despite the care taken in gathering, analyzing, and categorizing the data in a meaningful way, careful attention must be paid to the definitions and assumptions used herein when interpreting the estimates presented in this document. Various companies, government agencies, and trade associations may use slightly different definitions of product categories and regional groupings, or they may include different companies in their summaries. These differences should be kept in mind when making comparisons between data and numbers provided by Dataquest and those provided by other sources.

Notes on Market Share

In the process of conducting data collection and preparing market statistics information, Dataquest will sometimes consolidate or revise a particular company, model, series, or industry's numbers. In this section, we explain any such changes contained within this document for your reference.

Notes to Market Share Tables

1. Cyrix was acquired by National Semiconductor in 1997.

2. National Semiconductor divested itself of Fairchild in 1997.

3. National Semiconductor's 1997 revenue includes all of Cyrix's 1997 revenue and part of Fairchild's calendar first quarter revenue.

4. Power Innovations was formed through the acquisition of the Power Semiconductor interests of Texas Instruments.

5. Melexis was formerly known as Elex.

6. Micronas acquired ITT in 1997.

7. The following companies were added to the market share database in 1997:

- Fairchild
- Vitesse
- TriQuint
- Power Innovations
- Robert Bosch
- Stanley

8. Toko is now tracked in other Japanese companies.

9. IBM's 1996 revenue was restated in 1997.

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Exchange Rates

Dataquest uses an average annual exchange rate in converting revenue to U.S. dollar amounts. Table 1-1 outlines these rates for 1995 through 1997.

Table 1-1
Exchange Rates

	1995	1996	1997
Japan (Yen/U.S.$)	93.90	108.81	121.10
France (Franc/U.S.$)	4.97	5.12	5.84
Germany (Deutsche Mark/U.S.$)	1.43	1.50	1.73
United Kingdom (U.S.$/Pound Sterling)	1.59	1.56	1.64

Source: Dataquest (April 1998)

Project Analyst: Kevin McClure

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Chapter 2
Market Share Tables

Table 2-1 gives vendor revenue from shipments to North and Latin America. Tables 2-2 through 2-11 show each company's factory revenue by technology category. Tables 2-12 through 2-21 show the top companies' factory revenue by technology category.

Table 2-1
Individual Company Vendor Revenue from Shipments of Total Semiconductors to North and Latin America, 1997 (Millions of U.S. Dollars)

	*North America	*Latin America	Americas
Total Market	**43,548**	**4,538**	**48,086**
Intel	8,713	908	9,621
Motorola	3,513	366	3,879
IBM	2,426	253	2,679
Texas Instruments	1,994	208	2,202
NEC	1,930	201	2,131
Samsung	1,906	199	2,105
Lucent Technologies	1,223	128	1,351
Toshiba	1,211	126	1,337
Micron Technology	1,158	121	1,279
Hitachi	1,070	111	1,181
National Semiconductor	1,011	105	1,116
Advanced Micro Devices	935	97	1,032
SGS-Thomson	862	90	952
Philips	753	78	831
Mitsubishi	733	76	809
Fujitsu	685	71	756
Rockwell	657	69	726
Siemens	590	61	651
Analog Devices	571	59	630
LSI Logic	560	58	618
Hyundai	557	58	615
Hewlett-Packard	501	52	553
Cirrus Logic	359	37	396
Harris Semiconductor	352	37	389
Atmel	350	36	386
Xilinx	350	36	386
Integrated Device Technology	324	34	358
VLSI Technology	324	34	358
Altera	320	33	353
All Others	7,610	796	8,406

* These estimates are modeled and not based on vendor surveys.
Source: Dataquest (June 1998)

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Table 2-2
Individual Company Vendor Revenue from Shipments of Total Semiconductors, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	48,343	45,672	48,086	100.0	100.0	100.0
Americas Companies	28,877	30,124	34,235	59.7	66.0	71.2
8x8	21	24	27	0	0	0
ACC Microelectronics	16	18	20	0	0	0
Actel	68	100	111	0.1	0.2	0.2
Advanced Micro Devices	1,034	975	1,032	2.1	2.1	2.1
Allegro MicroSystems	98	110	79	0.2	0.2	0.2
Alliance Semiconductor	126	33	72	0.3	0	0.1
Altera	213	265	353	0.4	0.6	0.7
Anadigics	0	0	34	0	0	0
Analog Devices	433	520	630	0.9	1.1	1.3
Appian Technology	8	9	10	0	0	0
Applied Micro Circuits Corp.	37	46	31	0	0.1	0
ATI Technologies	0	100	195	0	0.2	0.4
Atmel	288	368	386	0.6	0.8	0.8
Burr-Brown	67	68	58	0.1	0.1	0.1
C-Cube	0	57	64	0	0.1	0.1
California Micro Devices	8	3	1	0	0	0
Catalyst	22	24	27	0	0	0
Cherry Semiconductor	65	87	98	0.1	0.2	0.2
Chip Express	0	22	25	0	0	0
Chips & Technologies	30	31	5	0	0	0
CID Technologies	5	6	6	0	0	0
Cirrus Logic	457	412	396	0.9	0.9	0.8
Crosspoint Solutions	2	2	1	0	0	0
Cypress Semiconductor	386	361	304	0.8	0.8	0.6
Dallas Semiconductor	85	106	117	0.2	0.2	0.2
Digital	0	149	201	0	0.3	0.4
DSP Group	6	7	8	0	0	0
Eastman Kodak	3	3	3	0	0	0
Elantec	15	18	15	0	0	0
Electronic Designs	32	37	0	0	0	0
ESS	0	0	57	0	0	0.1
Eteq Microsystems	2	2	2	0	0	0
Exar	80	57	63	0.2	0.1	0.1
Fairchild	0	0	162	0	0	0.3
G-Link USA	8	7	13	0	0	0
General Semiconductor	130	115	112	0.3	0.3	0.2

Table 2-2 (Continued)
Individual Company Vendor Revenue from Shipments of Total Semiconductors, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Gennum	15	16	18	0	0	0
Gould AMI	67	88	181	0.1	0.2	0.4
Harris Semiconductor	388	363	389	0.8	0.8	0.8
Hewlett-Packard	375	480	553	0.8	1.1	1.2
Honeywell	26	30	30	0	0	0
Hughes	34	37	36	0	0	0
IBM	1,772	2,405	2,679	3.7	5.3	5.6
IC Sensors	6	7	7	0	0	0
IMI	18	20	18	0	0	0
IMP	43	35	19	0	0	0
Integrated Circuit Systems	30	24	29	0	0	0
Integrated Device Technology	385	344	358	0.8	0.8	0.7
Integrated Silicon Solution	62	58	69	0.1	0.1	0.1
Intel	6,501	7,458	9,621	13.4	16.3	20.0
International CMOS Technology	13	9	5	0	0	0
International Rectifier	212	240	240	0.4	0.5	0.5
ISD	0	0	10	0	0	0
Ixys	18	22	24	0	0	0
Lattice	122	112	127	0.3	0.2	0.3
Level One Communications	54	70	79	0.1	0.2	0.2
Linear Technology	153	189	224	0.3	0.4	0.5
Linfinity	43	44	46	0	0	0
Logic Devices	14	11	11	0	0	0
LSI Logic	752	705	618	1.6	1.5	1.3
Lucent Technologies	942	1,057	1,351	1.9	2.3	2.8
Maxim	88	146	177	0.2	0.3	0.4
Micrel	18	14	104	0	0	0.2
Micro Linear	37	34	39	0	0	0
Microchip Technology	100	133	145	0.2	0.3	0.3
Micron Technology	1,874	1,144	1,279	3.9	2.5	2.7
Microsemi	96	113	122	0.2	0.2	0.3
Mitel	39	48	63	0	0.1	0.1
Motorola	4,266	4,140	3,879	8.8	9.1	8.1
National Semiconductor	1,004	962	1,116	2.1	2.1	2.3
NeoMagic	0	0	120	0	0	0.2
Oak Technology	11	23	18	0	0	0
Optek	45	51	55	0	0.1	0.1
OPTi	82	54	7	0.2	0.1	0

Table 2-2 (Continued)
Individual Company Vendor Revenue from Shipments of Total Semiconductors, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Paradigm	39	20	9	0	0	0
PMC Sierra Semiconductor	79	96	108	0.2	0.2	0.2
Powerex	80	80	82	0.2	0.2	0.2
Q Logic	24	27	30	0	0	0
Quality Semiconductor	33	25	26	0	0	0
Quality Technologies	26	26	29	0	0	0
QuickLogic	16	18	13	0	0	0
Ramtron	5	14	15	0	0	0
Raytheon	89	95	95	0.2	0.2	0.2
Rockwell	270	550	726	0.6	1.2	1.5
S3	180	310	138	0.4	0.7	0.3
Seeq Technology	25	25	21	0	0	0
Semtech	29	35	60	0	0	0.1
Silicon Storage Technology	10	21	16	0	0	0
Solitron	8	9	6	0	0	0
Spectra Diode Labs	15	17	17	0	0	0
Standard Microsystems	60	50	55	0.1	0.1	0.1
Sun Microsystems	0	55	300	0	0.1	0.6
Supertex	16	15	16	0	0	0
Symbios	318	366	320	0.7	0.8	0.7
Symphony Laboratories	1	1	1	0	0	0
Teccor Electronics	55	69	76	0.1	0.2	0.2
Telcom	8	9	20	0	0	0
Texas Instruments	2,501	2,192	2,202	5.2	4.8	4.6
Trident Microsystems	33	35	40	0	0	0
TriQuint	0	0	56	0	0	0.1
Tseng Labs	73	14	1	0.2	0	0
Unitrode	59	45	58	0.1	0	0.1
Vitesse	0	0	63	0	0	0.1
VLSI Technology	341	330	358	0.7	0.7	0.7
VTC	14	20	5	0	0	0
WaferScale Integration	11	24	32	0	0	0
Xicor	60	68	67	0.1	0.1	0.1
Xilinx	338	363	386	0.7	0.8	0.8
Zilog	106	111	137	0.2	0.2	0.3
Zoran	0	12	14	0	0	0
Other Americas Companies	45	40	53	0	0	0.1

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Table 2-2 (Continued)
Individual Company Vendor Revenue from Shipments of Total Semiconductors, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Japanese Companies	**11,547**	**8,596**	**7,481**	**23.9**	**18.8**	**15.6**
Fuji Electric	26	23	23	0	0	0
Fujitsu	1,007	670	756	2.1	1.5	1.6
Hitachi	2,414	1,778	1,181	5.0	3.9	2.5
Matsushita	241	175	148	0.5	0.4	0.3
Mitsubishi	1,124	809	809	2.3	1.8	1.7
NEC	2,726	2,294	2,131	5.6	5.0	4.4
New JRC	9	11	12	0	0	0
Nippon Steel Semiconductor	141	69	46	0.3	0.2	0
Oki	647	320	265	1.3	0.7	0.6
Ricoh	8	7	8	0	0	0
Rohm	101	87	125	0.2	0.2	0.3
Sanken	27	26	21	0	0	0
SANYO	167	223	179	0.3	0.5	0.4
Seiko Epson	70	51	49	0.1	0.1	0.1
Sharp	199	123	135	0.4	0.3	0.3
Shindengen Electric	12	17	15	0	0	0
Sony	234	185	138	0.5	0.4	0.3
Stanley	43	0	40	0	0	0
Toshiba	2,254	1,613	1,337	4.7	3.5	2.8
Yamaha	35	25	30	0	0	0
Other Japanese Companies	50	80	33	0.1	0.2	0
European Companies	**2,513**	**2,671**	**2,951**	**5.2**	**5.8**	**6.1**
Alcatel Microelectronics	0	4	5	0	0	0
Austria Mikro Systeme	12	13	11	0	0	0
EM Microelectronics Marin	2	5	6	0	0	0
Ericsson	21	52	50	0	0.1	0.1
Eupec	28	32	31	0	0	0
Fagor	3	0	1	0	0	0
GEC Plessey	79	101	95	0.2	0.2	0.2
Melexis	1	1	6	0	0	0
Micronas	8	8	33	0	0	0
Philips	851	829	831	1.8	1.8	1.7
Power Innovations	0	0	6	0	0	0
Robert Bosch	0	0	20	0	0	0
Semikron	26	20	23	0	0	0
SGS-Thomson	846	934	952	1.7	2	2
Siemens	432	466	651	0.9	1	1.4

Table 2-2 (Continued)
Individual Company Vendor Revenue from Shipments of Total Semiconductors, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
TCS	13	10	12	0	0	0
TEMIC	146	172	198	0.3	0.4	0.4
Zetex	14	15	15	0	0	0
Other European Companies	9	9	5	0	0	0
Asia/Pacific Companies	**5,406**	**4,281**	**3,419**	**11.2**	**9.4**	**7.1**
Acer	0	10	4	0	0	0
Holtek	1	2	1	0	0	0
Hualon Microelectronics Corp.	0	2	2	0	0	0
Hyundai	1,395	845	615	2.9	1.9	1.3
Korean Electronic Co.	25	20	7	0	0	0
LG Semicon	532	446	351	1.1	1	0.7
Macronix	53	83	45	0.1	0.2	0
Mosel Vitelic	175	104	107	0.4	0.2	0.2
Samsung	3,076	2,661	2,105	6.4	5.8	4.4
Silicon Integrated Systems	29	20	47	0	0	0
United Microelectronics	0	4	4	0	0	0
Vanguard	0	4	64	0	0	0.1
VIA	0	18	18	0	0	0
Winbond Electronics	120	62	49	0.2	0.1	0.1

Source: Dataquest (June 1998)

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Table 2-3
Individual Company Vendor Revenue from Shipments of Total Integrated Circuits, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**44,691**	**42,009**	**44,042**	**100.0**	**100.0**	**100.0**
Americas Companies	**26,772**	**28,011**	**31,947**	**59.9**	**66.7**	**72.5**
8x8	21	24	27	0	0	0
ACC Microelectronics	16	18	20	0	0	0
Actel	68	100	111	0.2	0.2	0.3
Advanced Micro Devices	1,034	975	1,032	2.3	2.3	2.3
Allegro MicroSystems	81	94	77	0.2	0.2	0.2
Alliance Semiconductor	126	33	72	0.3	0	0.2
Altera	213	265	353	0.5	0.6	0.8
Anadigics	0	0	34	0	0	0
Analog Devices	433	520	630	1	1.2	1.4
Appian Technology	8	9	10	0	0	0
Applied Micro Circuits Corp.	37	46	31	0	0.1	0
ATI Technologies	0	100	195	0	0.2	0.4
Atmel	288	368	386	0.6	0.9	0.9
Burr-Brown	67	68	58	0.1	0.2	0.1
C-Cube	0	57	64	0	0.1	0.1
California Micro Devices	8	3	1	0	0	0
Catalyst	22	24	27	0	0	0
Cherry Semiconductor	65	87	98	0.1	0.2	0.2
Chip Express	0	22	25	0	0	0
Chips & Technologies	30	31	5	0	0	0
Cirrus Logic	457	412	396	1.0	1.0	0.9
Crosspoint Solutions	2	2	1	0	0	0
Cypress Semiconductor	386	361	304	0.9	0.9	0.7
Dallas Semiconductor	85	106	117	0.2	0.3	0.3
Digital	0	149	201	0	0.4	0.5
DSP Group	6	7	8	0	0	0
Elantec	15	18	15	0	0	0
Electronic Designs	32	37	0	0	0	0
ESS	0	0	57	0	0	0.1
Eteq Microsystems	2	2	2	0	0	0
Exar	80	57	63	0.2	0.1	0.1
Fairchild	0	0	110	0	0	0.2
G-Link USA	8	7	13	0	0	0
Gennum	15	16	18	0	0	0
Gould AMI	67	88	181	0.1	0.2	0.4
Harris Semiconductor	249	218	260	0.6	0.5	0.6

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Table 2-3 (Continued)
Individual Company Vendor Revenue from Shipments of Total Integrated Circuits, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Hewlett-Packard	239	247	301	0.5	0.6	0.7
Honeywell	21	24	24	0	0	0
Hughes	34	37	36	0	0	0
IBM	1,772	2,405	2,679	4.0	5.7	6.1
IMI	18	20	18	0	0	0
IMP	43	35	19	0	0	0
Integrated Circuit Systems	30	24	29	0	0	0
Integrated Device Technology	385	344	358	0.9	0.8	0.8
Integrated Silicon Solution	62	58	69	0.1	0.1	0.2
Intel	6,501	7,458	9,621	14.5	17.8	21.8
International CMOS Technology	13	9	5	0	0	0
International Rectifier	5	10	9	0	0	0
ISD	0	0	10	0	0	0
Lattice	122	112	127	0.3	0.3	0.3
Level One Communications	54	70	79	0.1	0.2	0.2
Linear Technology	153	189	224	0.3	0.4	0.5
Linfinity	43	44	46	0	0.1	0.1
Logic Devices	14	11	11	0	0	0
LSI Logic	752	705	618	1.7	1.7	1.4
Lucent Technologies	908	1,020	1,146	2.0	2.4	2.6
Maxim	88	146	177	0.2	0.3	0.4
Micrel	18	14	104	0	0	0.2
Micro Linear	37	34	39	0	0	0
Microchip Technology	100	133	145	0.2	0.3	0.3
Micron Technology	1,874	1,144	1,279	4.2	2.7	2.9
Mitel	39	43	56	0	0.1	0.1
Motorola	3,355	3,331	3,080	7.5	7.9	7.0
National Semiconductor	931	901	1,061	2.1	2.1	2.4
NeoMagic	0	0	120	0	0	0.3
Oak Technology	11	23	18	0	0	0
Optek	8	9	19	0	0	0
OPTi	82	54	7	0.2	0.1	0
Paradigm	39	20	9	0	0	0
PMC Sierra Semiconductor	79	96	108	0.2	0.2	0.2
Q Logic	24	27	30	0	0	0
Quality Semiconductor	33	25	26	0	0	0
QuickLogic	16	18	13	0	0	0
Ramtron	5	14	15	0	0	0
Raytheon	82	88	87	0.2	0.2	0.2

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Table 2-3 (Continued)
Individual Company Vendor Revenue from Shipments of Total Integrated Circuits, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Rockwell	270	550	726	0.6	1.3	1.6
S3	180	310	138	0.4	0.7	0.3
Seeq Technology	25	25	21	0	0	0
Semtech	4	18	56	0	0	0.1
Silicon Storage Technology	10	21	16	0	0	0
Solitron	2	4	1	0	0	0
Standard Microsystems	60	50	55	0.1	0.1	0.1
Sun Microsystems	0	55	300	0	0.1	0.7
Supertex	8	7	7	0	0	0
Symbios	318	366	320	0.7	0.9	0.7
Symphony Laboratories	1	1	1	0	0	0
Telcom	8	9	20	0	0	0
Texas Instruments	2,501	2,176	2,192	5.6	5.2	5.0
Trident Microsystems	33	35	40	0	0	0
TriQuint	0	0	56	0	0	0.1
Tseng Labs	73	14	1	0.2	0	0
Unitrode	59	45	58	0.1	0.1	0.1
Vitesse	0	0	63	0	0	0.1
VLSI Technology	341	330	358	0.8	0.8	0.8
VTC	14	20	5	0	0	0
WaferScale Integration	11	24	32	0	0	0
Xicor	60	68	67	0.1	0.2	0.2
Xilinx	338	363	386	0.8	0.9	0.9
Zilog	106	111	137	0.2	0.3	0.3
Zoran	0	12	14	0	0	0
Other Americas Companies	12	40	53	0	0	0.1
Japanese Companies	**10,800**	**7,836**	**6,645**	**24.2**	**18.7**	**15.1**
Fuji Electric	5	5	5	0	0	0
Fujitsu	812	494	565	1.8	1.2	1.3
Hitachi	2,365	1,707	1,127	5.3	4.1	2.6
Matsushita	210	145	116	0.5	0.3	0.3
Mitsubishi	1,084	771	770	2.4	1.8	1.7
NEC	2,672	2,234	2,022	6.0	5.3	4.6
New JRC	9	11	12	0	0	0
Nippon Steel Semiconductor	141	69	46	0.3	0.2	0.1
Oki	647	320	265	1.4	0.8	0.6
Ricoh	8	7	8	0	0	0
Rohm	56	49	59	0.1	0.1	0.1
Sanken	12	13	3	0	0	0

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Table 2-3 (Continued)
Individual Company Vendor Revenue from Shipments of Total Integrated Circuits, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
SANYO	147	190	142	0.3	0.5	0.3
Seiko Epson	70	51	49	0.2	0.1	0.1
Sharp	189	110	122	0.4	0.3	0.3
Shindengen Electric	0	1	0	0	0	0
Sony	228	179	133	0.5	0.4	0.3
Toshiba	2,077	1,427	1,154	4.6	3.4	2.6
Yamaha	35	25	30	0	0	0
Other Japanese Companies	29	24	17	0	0	0
European Companies	**1,769**	**1,930**	**2,073**	**4.0**	**4.6**	**4.7**
Alcatel Microelectronics	0	4	5	0	0	0
Austria Mikro Systeme	12	13	11	0	0	0
EM Microelectronics Marin	2	5	6	0	0	0
Ericsson	10	33	27	0	0	0
GEC Plessey	78	94	86	0.2	0.2	0.2
Melexis	1	1	6	0	0	0
Micronas	8	8	23	0	0	0
Philips	617	639	615	1.4	1.5	1.4
Robert Bosch	0	0	9	0	0	0
SGS-Thomson	716	810	814	1.6	1.9	1.8
Siemens	237	247	363	0.5	0.6	0.8
TCS	8	6	10	0	0	0
TEMIC	56	66	97	0.1	0.2	0.2
Zetex	0	0	1	0	0	0
Other European Companies	4	4	0	0	0	0
Asia/Pacific Companies	**5,350**	**4,232**	**3,377**	**12.0**	**10.1**	**7.7**
Acer	0	10	4	0	0	0
Holtek	1	2	1	0	0	0
Hualon Microelectronics Corp.	0	2	2	0	0	0
Hyundai	1,395	845	615	3.1	2.0	1.4
LG Semicon	532	446	351	1.2	1.1	0.8
Macronix	53	83	45	0.1	0.2	0.1
Mosel Vitelic	175	104	107	0.4	0.2	0.2
Samsung	3,045	2,632	2,070	6.8	6.3	4.7
Silicon Integrated Systems	29	20	47	0	0	0.1
United Microelectronics	0	4	4	0	0	0
Vanguard	0	4	64	0	0	0.1
VIA	0	18	18	0	0	0
Winbond Electronics	120	62	49	0.3	0.1	0.1

Source: Dataquest (June 1998)

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Table 2-4
Individual Company Vendor Revenue from Shipments of Bipolar Digital, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**760**	**597**	**357**	**100.0**	**100.0**	**100.0**
Americas Companies	**599**	**476**	**281**	**78.8**	**79.7**	**78.7**
Advanced Micro Devices	55	35	15	7.2	5.9	4.2
Applied Micro Circuits Corp.	14	25	0	1.8	4.2	0
Harris Semiconductor	4	4	0	0.5	0.7	0
Lucent Technologies	38	70	10	5.0	11.7	2.8
Motorola	204	149	136	26.8	25.0	38.1
National Semiconductor	77	58	10	10.1	9.7	2.8
Raytheon	15	11	0	2.0	1.8	0
Texas Instruments	192	124	110	25.3	20.8	30.8
Japanese Companies	**82**	**60**	**17**	**10.8**	**10.1**	**4.8**
Fujitsu	41	19	10	5.4	3.2	2.8
Hitachi	36	33	1	4.7	5.5	0.3
Mitsubishi	2	2	1	0.3	0.3	0.3
NEC	2	5	4	0.3	0.8	1.1
Toshiba	1	1	1	0.1	0.2	0.3
European Companies	**78**	**60**	**56**	**10.3**	**10.1**	**15.7**
GEC Plessey	5	8	0	0.7	1.3	0
Philips	72	50	46	9.5	8.4	12.9
SGS-Thomson	1	0	0	0.1	0	0
Siemens	0	2	10	0	0.3	2.8
Asia/Pacific Companies	**1**	**1**	**3**	**0.1**	**0.2**	**0.8**
LG Semicon	1	1	1	0.1	0.2	0.3
Mosel Vitelic	0	0	2	0	0	0.6

Source: Dataquest (June 1998)

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Table 2-5
Individual Company Vendor Revenue from Shipments of MOS Digital ICs, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	39,706	36,795	38,208	100.0	100.0	100.0
Americas Companies	22,962	24,094	27,567	57.8	65.5	72.1
8x8	21	24	27	0	0	0
ACC Microelectronics	16	18	20	0	0	0
Actel	68	100	111	0.2	0.3	0.3
Advanced Micro Devices	892	886	948	2.2	2.4	2.5
Allegro MicroSystems	0	5	6	0	0	0
Alliance Semiconductor	126	33	72	0.3	0	0.2
Altera	213	265	353	0.5	0.7	0.9
Analog Devices	37	108	143	0	0.3	0.4
Appian Technology	8	9	10	0	0	0
Applied Micro Circuits Corp.	19	19	29	0	0	0
ATI Technologies	0	100	195	0	0.3	0.5
Atmel	280	368	361	0.7	1.0	0.9
C-Cube	0	57	64	0	0.2	0.2
California Micro Devices	4	3	1	0	0	0
Catalyst	22	24	27	0	0	0
Cherry Semiconductor	0	0	11	0	0	0
Chip Express	0	22	25	0	0	0
Chips & Technologies	30	31	5	0	0	0
Cirrus Logic	369	301	244	0.9	0.8	0.6
Crosspoint Solutions	2	2	1	0	0	0
Cypress Semiconductor	386	361	304	1.0	1.0	0.8
Dallas Semiconductor	85	88	97	0.2	0.2	0.3
Digital	0	149	201	0	0.4	0.5
DSP Group	6	7	8	0	0	0
Electronic Designs	32	37	0	0	0.1	0
ESS	0	0	55	0	0	0.1
Eteq Microsystems	2	2	2	0	0	0
Exar	10	15	21	0	0	0
Fairchild	0	0	110	0	0	0.3
G-Link USA	8	7	13	0	0	0
Gennum	0	0	5	0	0	0
Gould AMI	67	88	181	0.2	0.2	0.5
Harris Semiconductor	117	108	136	0.3	0.3	0.4
Hewlett-Packard	239	247	301	0.6	0.7	0.8
Hughes	20	37	36	0	0.1	0
IBM	1,772	2,405	2,679	4.5	6.5	7.0

Table 2-5 (Continued)
Individual Company Vendor Revenue from Shipments of MOS Digital ICs, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
IMI	15	20	18	0	0	0
IMP	8	5	0	0	0	0
Integrated Circuit Systems	23	20	24	0	0	0
Integrated Device Technology	385	344	358	1.0	0.9	0.9
Integrated Silicon Solution	62	58	69	0.2	0.2	0.2
Intel	6,501	7,458	9,621	16.4	20.3	25.2
International CMOS Technology	13	9	5	0	0	0
ISD	0	0	10	0	0	0
Lattice	122	112	127	0.3	0.3	0.3
Logic Devices	14	11	11	0	0	0
LSI Logic	752	705	618	1.9	1.9	1.6
Lucent Technologies	681	775	1,056	1.7	2.1	2.8
Micrel	4	3	0	0	0	0
Micro Linear	3	2	8	0	0	0
Microchip Technology	100	133	145	0.3	0.4	0.4
Micron Technology	1,874	1,144	1,279	4.7	3.1	3.3
Mitel	0	4	3	0	0	0
Motorola	2,832	2,679	2,344	7.1	7.3	6.1
National Semiconductor	483	478	587	1.2	1.3	1.5
NeoMagic	0	0	120	0	0	0.3
Oak Technology	11	23	18	0	0	0
OPTi	82	54	7	0.2	0.1	0
Paradigm	39	20	9	0	0	0
PMC Sierra Semiconductor	22	42	47	0	0.1	0.1
Q Logic	24	27	30	0	0	0
Quality Semiconductor	33	25	26	0	0	0
QuickLogic	16	18	13	0	0	0
Ramtron	5	14	15	0	0	0
Raytheon	0	5	22	0	0	0
Rockwell	270	504	664	0.7	1.4	1.7
S3	180	310	138	0.5	0.8	0.4
Seeq Technology	25	10	13	0	0	0
Silicon Storage Technology	10	21	16	0	0	0
Standard Microsystems	60	50	55	0.2	0.1	0.1
Sun Microsystems	0	55	300	0	0.1	0.8
Supertex	5	4	4	0	0	0
Symbios	239	366	320	0.6	1.0	0.8
Symphony Laboratories	1	1	1	0	0	0

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Table 2-5 (Continued)
Individual Company Vendor Revenue from Shipments of MOS Digital ICs, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Texas Instruments	2,013	1,582	1,548	5.1	4.3	4.1
Trident Microsystems	33	35	40	0	0	0.1
Tseng Labs	73	14	1	0.2	0	0
Vitesse	0	0	28	0	0	0
VLSI Technology	341	330	358	0.9	0.9	0.9
WaferScale Integration	11	24	32	0	0	0
Xicor	60	68	67	0.2	0.2	0.2
Xilinx	338	363	386	0.9	1.0	1.0
Zilog	106	111	137	0.3	0.3	0.4
Zoran	0	12	14	0	0	0
Other Americas Companies	12	40	53	0	0.1	0.1
Japanese Companies	**10,353**	**7,405**	**6,299**	**26.1**	**20.1**	**16.5**
Fuji Electric	2	2	1	0	0	0
Fujitsu	728	434	528	1.8	1.2	1.4
Hitachi	2,284	1,619	1,083	5.8	4.4	2.8
Matsushita	199	134	102	0.5	0.4	0.3
Mitsubishi	1,033	719	735	2.6	2.0	1.9
NEC	2,639	2,198	1,980	6.6	6.0	5.2
New JRC	1	2	1	0	0	0
Nippon Steel Semiconductor	141	69	46	0.4	0.2	0.1
Oki	647	320	265	1.6	0.9	0.7
Ricoh	8	7	3	0	0	0
Rohm	29	26	23	0	0	0
SANYO	87	147	121	0.2	0.4	0.3
Seiko Epson	69	50	48	0.2	0.1	0.1
Sharp	189	110	122	0.5	0.3	0.3
Sony	209	161	120	0.5	0.4	0.3
Toshiba	2,031	1,359	1,075	5.1	3.7	2.8
Yamaha	28	25	30	0	0	0
Other Japanese Companies	29	23	16	0	0	0
European Companies	**1,061**	**1,089**	**985**	**2.7**	**3.0**	**2.6**
Alcatel Microelectronics	0	4	5	0	0	0
Austria Mikro Systeme	0	12	10	0	0	0
EM Microelectronics Marin	0	0	2	0	0	0
GEC Plessey	22	46	65	0	0.1	0.2
Melexis	0	1	3	0	0	0
Micronas	0	8	23	0	0	0
Philips	378	412	255	1.0	1.1	0.7

Table 2-5 (Continued)
Individual Company Vendor Revenue from Shipments of MOS Digital ICs, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
SGS-Thomson	436	426	357	1.1	1.2	0.9
Siemens	173	134	221	0.4	0.4	0.6
TCS	8	6	10	0	0	0
TEMIC	32	40	34	0	0.1	0
Asia/Pacific Companies	**5,330**	**4,207**	**3,357**	**13.4**	**11.4**	**8.8**
Acer	0	10	4	0	0	0
Holtek	1	2	1	0	0	0
Hualon Microelectronics Corp.	0	2	2	0	0	0
Hyundai	1,395	845	615	3.5	2.3	1.6
LG Semicon	531	445	350	1.3	1.2	0.9
Macronix	53	83	45	0.1	0.2	0.1
Mosel Vitelic	175	104	105	0.4	0.3	0.3
Samsung	3,027	2,609	2,054	7.6	7.1	5.4
Silicon Integrated Systems	29	20	47	0	0	0.1
United Microelectronics	0	4	4	0	0	0
Vanguard	0	4	64	0	0	0.2
VIA	0	18	18	0	0	0
Winbond Electronics	119	61	48	0.3	0.2	0.1

Source: Dataquest (June 1998)

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Table 2-6
Individual Company Vendor Revenue from Shipments of MOS Memory, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**20,480**	**14,642**	**11,898**	**100.0**	**100.0**	**100.0**
Americas Companies	**6,579**	**5,135**	**4,463**	**32.1**	**35.1**	**37.5**
Advanced Micro Devices	336	360	334	1.6	2.5	2.8
Alliance Semiconductor	124	25	65	0.6	0.2	0.5
Atmel	222	265	245	1.1	1.8	2.1
Catalyst	22	24	27	0.1	0.2	0.2
Cypress Semiconductor	302	277	194	1.5	1.9	1.6
Dallas Semiconductor	20	0	0	0	0	0
Electronic Designs	32	37	0	0.2	0.3	0
Fairchild	0	0	25	0	0	0.2
G-Link USA	8	7	13	0	0	0.1
Harris Semiconductor	14	6	9	0	0	0
IBM	892	950	655	4.4	6.5	5.5
Integrated Device Technology	269	221	225	1.3	1.5	1.9
Integrated Silicon Solution	62	58	69	0.3	0.4	0.6
Intel	402	415	337	2.0	2.8	2.8
Logic Devices	5	2	2	0	0	0
Lucent Technologies	3	0	0	0	0	0
Microchip Technology	29	28	25	0.1	0.2	0.2
Micron Technology	1,874	1,144	1,279	9.2	7.8	10.7
Motorola	614	529	285	3.0	3.6	2.4
National Semiconductor	85	38	2	0.4	0.3	0
Paradigm	39	20	9	0.2	0.1	0
Quality Semiconductor	14	1	2	0	0	0
Ramtron	5	14	15	0	0	0.1
Seeq Technology	6	0	0	0	0	0
Silicon Storage Technology	10	21	16	0	0.1	0.1
Texas Instruments	1,122	621	552	5.5	4.2	4.6
WaferScale Integration	4	4	1	0	0	0
Xicor	60	68	67	0.3	0.5	0.6
Other Americas Companies	0	0	10	0	0	0
Japanese Companies	**8,393**	**5,233**	**3,961**	**41.0**	**35.7**	**33.3**
Fujitsu	553	253	245	2.7	1.7	2.1
Hitachi	2,067	1,338	830	10.1	9.1	7.0
Matsushita	159	96	37	0.8	0.7	0.3
Mitsubishi	806	521	504	3.9	3.6	4.2
NEC	2,235	1,546	1,270	10.9	10.6	10.7
Nippon Steel Semiconductor	141	69	46	0.7	0.5	0.4

Table 2-6 (Continued)
Individual Company Vendor Revenue from Shipments of MOS Memory, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Oki	542	235	196	2.6	1.6	1.6
Rohm	14	13	13	0	0	0.1
SANYO	11	58	27	0	0.4	0.2
Seiko Epson	10	4	3	0	0	0
Sharp	127	63	73	0.6	0.4	0.6
Sony	144	106	84	0.7	0.7	0.7
Toshiba	1,572	920	633	7.7	6.3	5.3
Other Japanese Companies	12	11	0	0	0	0
European Companies	**346**	**264**	**320**	**1.7**	**1.8**	**2.7**
SGS-Thomson	181	144	122	0.9	1	1
Siemens	160	114	193	0.8	0.8	1.6
TEMIC	5	6	5	0	0	0
Asia/Pacific Companies	**5,162**	**4,010**	**3,154**	**25.2**	**27.4**	**26.5**
Hualon Microelectronics Corp.	0	1	1	0	0	0
Hyundai	1,390	842	614	6.8	5.8	5.2
LG Semicon	511	429	322	2.5	2.9	2.7
Macronix	49	58	44	0.2	0.4	0.4
Mosel Vitelic	175	104	105	0.9	0.7	0.9
Samsung	2,983	2,549	1,984	14.6	17.4	16.7
Vanguard	0	4	64	0	0	0.5
Winbond Electronics	54	23	20	0.3	0.2	0.2

Source: Dataquest (June 1998)

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Table 2-7
Individual Company Vendor Revenue from Shipments of MOS Microcomponents, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**12,425**	**14,587**	**17,785**	**100.0**	**100.0**	**100.0**
Americas Companies	**11,264**	**13,236**	**16,367**	**90.7**	**90.7**	**92.0**
8x8	21	24	27	0.2	0.2	0.2
ACC Microelectronics	16	18	20	0.1	0.1	0.1
Advanced Micro Devices	326	313	457	2.6	2.1	2.6
Alliance Semiconductor	2	8	7	0	0	0
Analog Devices	37	103	133	0.3	0.7	0.7
Appian Technology	8	9	10	0	0	0
ATI Technologies	0	100	195	0	0.7	1.1
Atmel	10	20	27	0	0.1	0.2
C-Cube	0	57	64	0	0.4	0.4
California Micro Devices	4	3	1	0	0	0
Chips & Technologies	30	31	5	0.2	0.2	0
Cirrus Logic	369	301	244	3	2.1	1.4
Cypress Semiconductor	33	42	4	0.3	0.3	0
Dallas Semiconductor	14	42	47	0.1	0.3	0.3
Digital	0	149	201	0	1.0	1.1
DSP Group	6	7	8	0	0	0
ESS	0	0	55	0	0	0.3
Harris Semiconductor	39	32	30	0.3	0.2	0.2
Hughes	3	3	0	0	0	0
IBM	395	611	585	3.2	4.2	3.3
Integrated Device Technology	44	55	53	0.4	0.4	0.3
Intel	6,099	7,043	9,284	49.1	48.3	52.2
LSI Logic	43	35	49	0.3	0.2	0.3
Lucent Technologies	231	270	311	1.9	1.9	1.7
Microchip Technology	71	105	120	0.6	0.7	0.7
Motorola	1,412	1,539	1,635	11.4	10.6	9.2
National Semiconductor	284	315	511	2.3	2.2	2.9
NeoMagic	0	0	120	0	0	0.7
Oak Technology	11	23	18	0	0.2	0.1
OPTi	82	54	7	0.7	0.4	0
PMC Sierra Semiconductor	22	25	28	0.2	0.2	0.2
Q Logic	24	27	30	0.2	0.2	0.2
Rockwell	264	500	659	2.1	3.4	3.7
S3	180	310	138	1.4	2.1	0.8
Seeq Technology	19	10	13	0.2	0	0
Standard Microsystems	60	50	55	0.5	0.3	0.3

Table 2-7 (Continued)
Individual Company Vendor Revenue from Shipments of MOS Microcomponents, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Sun Microsystems	0	55	300	0	0.4	1.7
Supertex	1	0	0	0	0	0
Symbios	66	81	91	0.5	0.6	0.5
Symphony Laboratories	1	1	1	0	0	0
Texas Instruments	520	579	589	4.2	4.0	3.3
Trident Microsystems	33	35	40	0.3	0.2	0.2
Tseng Labs	73	14	1	0.6	0	0
VLSI Technology	96	16	13	0.8	0.1	0
WaferScale Integration	6	18	30	0	0.1	0.2
Zilog	106	111	137	0.9	0.8	0.8
Zoran	0	12	14	0	0	0
Japanese Companies	**679**	**793**	**952**	**5.5**	**5.4**	**5.4**
Fujitsu	100	109	183	0.8	0.7	1
Hitachi	173	204	193	1.4	1.4	1.1
Matsushita	10	9	10	0	0	0
Mitsubishi	51	54	71	0.4	0.4	0.4
NEC	159	260	286	1.3	1.8	1.6
Oki	32	22	21	0.3	0.2	0.1
Ricoh	4	4	3	0	0	0
Rohm	9	8	3	0	0	0
SANYO	16	19	17	0.1	0.1	0
Seiko Epson	2	2	2	0	0	0
Sharp	11	9	14	0	0	0
Sony	6	5	3	0	0	0
Toshiba	84	66	119	0.7	0.5	0.7
Yamaha	22	22	27	0.2	0.2	0.2
European Companies	**437**	**483**	**359**	**3.5**	**3.3**	**2**
GEC Plessey	6	6	6	0	0	0
Micronas	0	0	11	0	0	0
Philips	233	273	172	1.9	1.9	1.0
SGS-Thomson	162	158	118	1.3	1.1	0.7
Siemens	13	20	28	0.1	0.1	0.2
TCS	8	6	10	0	0	0
TEMIC	15	20	14	0.1	0.1	0
Asia/Pacific Companies	**45**	**75**	**107**	**0.4**	**0.5**	**0.6**
Acer	0	10	4	0	0	0
LG Semicon	0	0	7	0	0	0
Macronix	4	6	1	0	0	0

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Table 2-7 (Continued)
Individual Company Vendor Revenue from Shipments of MOS Microcomponents, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Samsung	9	12	21	0	0	0.1
Silicon Integrated Systems	29	20	47	0.2	0.1	0.3
United Microelectronics	0	4	4	0	0	0
VIA	0	18	18	0	0.1	0.1
Winbond Electronics	3	5	5	0	0	0

Source: Dataquest (June 1998)

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Table 2-8
Individual Company Vendor Revenue from Shipments of MOS Digital Logic, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	6,801	7,566	8,525	100.0	100.0	100.0
Americas Companies	5,119	5,723	6,737	75.3	75.6	79.0
Actel	68	100	111	1.0	1.3	1.3
Advanced Micro Devices	230	213	157	3.4	2.8	1.8
Allegro MicroSystems	0	5	6	0	0	0
Altera	213	265	353	3.1	3.5	4.1
Analog Devices	0	5	10	0	0	0.1
Applied Micro Circuits Corp.	19	19	29	0.3	0.3	0.3
Atmel	48	83	89	0.7	1.1	1.0
Cherry Semiconductor	0	0	11	0	0	0.1
Chip Express	0	22	25	0	0.3	0.3
Crosspoint Solutions	2	2	1	0	0	0
Cypress Semiconductor	51	42	106	0.7	0.6	1.2
Dallas Semiconductor	51	46	50	0.7	0.6	0.6
Eteq Microsystems	2	2	2	0	0	0
Exar	10	15	21	0.1	0.2	0.2
Fairchild	0	0	85	0	0	1.0
Gennum	0	0	5	0	0	0
Gould AMI	67	88	181	1.0	1.2	2.1
Harris Semiconductor	64	70	97	0.9	0.9	1.1
Hewlett-Packard	239	247	301	3.5	3.3	3.5
Hughes	17	34	36	0.2	0.4	0.4
IBM	485	844	1,439	7.1	11.2	16.9
IMI	15	20	18	0.2	0.3	0.2
IMP	8	5	0	0.1	0	0
Integrated Circuit Systems	23	20	24	0.3	0.3	0.3
Integrated Device Technology	72	68	80	1.1	0.9	0.9
International CMOS Technology	13	9	5	0.2	0.1	0
ISD	0	0	10	0	0	0.1
Lattice	122	112	127	1.8	1.5	1.5
Logic Devices	9	9	9	0.1	0.1	0.1
LSI Logic	709	670	569	10.4	8.9	6.7
Lucent Technologies	447	505	745	6.6	6.7	8.7
Micrel	4	3	0	0	0	0
Micro Linear	3	2	8	0	0	0
Mitel	0	4	3	0	0	0
Motorola	806	611	424	11.9	8.1	5.0
National Semiconductor	114	125	74	1.7	1.7	0.9

Table 2-8 (Continued)
Individual Company Vendor Revenue from Shipments of MOS Digital Logic, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
PMC Sierra Semiconductor	0	17	19	0	0.2	0.2
Quality Semiconductor	19	24	24	0.3	0.3	0.3
QuickLogic	16	18	13	0.2	0.2	0.2
Raytheon	0	5	22	0	0	0.3
Rockwell	6	4	5	0	0	0
Supertex	4	4	4	0	0	0
Symbios	173	285	229	2.5	3.8	2.7
Texas Instruments	371	382	407	5.5	5.0	4.8
Vitesse	0	0	28	0	0	0.3
VLSI Technology	245	314	345	3.6	4.2	4.0
WaferScale Integration	1	2	1	0	0	0
Xilinx	338	363	386	5.0	4.8	4.5
Other Americas Companies	12	40	43	0.2	0.5	0.5
Japanese Companies	**1,281**	**1,379**	**1,386**	**18.8**	**18.2**	**16.3**
Fuji Electric	2	2	1	0	0	0
Fujitsu	75	72	100	1.1	1.0	1.2
Hitachi	44	77	60	0.6	1.0	0.7
Matsushita	30	29	55	0.4	0.4	0.6
Mitsubishi	176	144	160	2.6	1.9	1.9
NEC	245	392	424	3.6	5.2	5.0
New JRC	1	2	1	0	0	0
Oki	73	63	48	1.1	0.8	0.6
Ricoh	4	3	0	0	0	0
Rohm	6	5	7	0	0	0
SANYO	60	70	77	0.9	0.9	0.9
Seiko Epson	57	44	43	0.8	0.6	0.5
Sharp	51	38	35	0.7	0.5	0.4
Sony	59	50	33	0.9	0.7	0.4
Toshiba	375	373	323	5.5	4.9	3.8
Yamaha	6	3	3	0	0	0
Other Japanese Companies	17	12	16	0.2	0.2	0.2
European Companies	**278**	**342**	**306**	**4.1**	**4.5**	**3.6**
Alcatel Microelectronics	0	4	5	0	0	0
Austria Mikro Systeme	0	12	10	0	0.2	0.1
EM Microelectronics Marin	0	0	2	0	0	0
GEC Plessey	16	40	59	0.2	0.5	0.7
Melexis	0	1	3	0	0	0
Micronas	0	8	12	0	0.1	0.1

Table 2-8 (Continued)
Individual Company Vendor Revenue from Shipments of MOS Digital Logic, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Philips	145	139	83	2.1	1.8	1.0
SGS-Thomson	93	124	117	1.4	1.6	1.4
TEMIC	12	14	15	0.2	0.2	0.2
Asia/Pacific Companies	**123**	**122**	**96**	**1.8**	**1.6**	**1.1**
Holtek	1	2	1	0	0	0
Hualon Microelectronics Corp.	0	1	1	0	0	0
Hyundai	5	3	1	0	0	0
LG Semicon	20	16	21	0.3	0.2	0.2
Macronix	0	19	0	0	0.3	0
Samsung	35	48	49	0.5	0.6	0.6
Winbond Electronics	62	33	23	0.9	0.4	0.3

Source: Dataquest (June 1998)

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Table 2-9
Individual Company Vendor Revenue from Shipments of Analog-Monolithic, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**3,994**	**4,425**	**5,477**	**100.0**	**100.0**	**100.0**
Americas Companies	**3,110**	**3,369**	**4,099**	**77.9**	**76.1**	**74.8**
Advanced Micro Devices	87	54	69	2.2	1.2	1.3
Allegro MicroSystems	71	77	71	1.8	1.7	1.3
Anadigics	0	0	34	0	0	0.6
Analog Devices	370	395	487	9.3	8.9	8.9
Applied Micro Circuits Corp.	4	2	2	0.1	0	0
Atmel	8	0	25	0.2	0	0.5
Burr-Brown	37	52	58	0.9	1.2	1.1
California Micro Devices	4	0	0	0.1	0	0
Cherry Semiconductor	65	87	87	1.6	2.0	1.6
Cirrus Logic	88	111	152	2.2	2.5	2.8
Dallas Semiconductor	0	18	20	0	0.4	0.4
Elantec	13	16	15	0.3	0.4	0.3
ESS	0	0	2	0	0	0
Exar	70	42	42	1.8	0.9	0.8
Gennum	13	16	13	0.3	0.4	0.2
Harris Semiconductor	128	106	124	3.2	2.4	2.3
Honeywell	21	24	24	0.5	0.5	0.4
Hughes	14	0	0	0.4	0	0
IMI	3	0	0	0	0	0
IMP	35	30	19	0.9	0.7	0.3
Integrated Circuit Systems	7	4	5	0.2	0	0
International Rectifier	5	10	9	0.1	0.2	0.2
Level One Communications	54	70	79	1.4	1.6	1.4
Linear Technology	153	189	224	3.8	4.3	4.1
Linfinity	40	41	46	1.0	0.9	0.8
Lucent Technologies	189	175	80	4.7	4.0	1.5
Maxim	85	143	177	2.1	3.2	3.2
Micrel	14	11	104	0.4	0.2	1.9
Micro Linear	34	32	31	0.9	0.7	0.6
Mitel	33	34	53	0.8	0.8	1.0
Motorola	319	503	600	8.0	11.4	11.0
National Semiconductor	366	365	464	9.2	8.2	8.5
Optek	8	9	19	0.2	0.2	0.3
PMC Sierra Semiconductor	57	54	61	1.4	1.2	1.1
Raytheon	67	72	65	1.7	1.6	1.2
Rockwell	0	46	62	0	1.0	1.1

Table 2-9 (Continued)
Individual Company Vendor Revenue from Shipments of Analog-Monolithic, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Seeq Technology	0	15	8	0	0.3	0.1
Semtech	4	18	56	0.1	0.4	1.0
Solitron	0	1	1	0	0	0
Supertex	3	3	3	0	0	0
Symbios	79	0	0	2.0	0	0
Telcom	8	9	20	0.2	0.2	0.4
Texas Instruments	296	470	534	7.4	10.6	9.7
TriQuint	0	0	56	0	0	1.0
Unitrode	59	45	58	1.5	1.0	1.1
Vitesse	0	0	35	0	0	0.6
VTC	14	20	5	0.4	0.5	0
Japanese Companies	**258**	**273**	**329**	**6.5**	**6.2**	**6.0**
Fuji Electric	3	3	4	0	0	0
Fujitsu	18	19	27	0.5	0.4	0.5
Hitachi	38	49	43	1.0	1.1	0.8
Matsushita	11	11	14	0.3	0.2	0.3
Mitsubishi	25	29	34	0.6	0.7	0.6
NEC	31	31	38	0.8	0.7	0.7
New JRC	8	9	11	0.2	0.2	0.2
Ricoh	0	0	5	0	0	0
Rohm	24	20	36	0.6	0.5	0.7
Sanken	0	0	3	0	0	0
SANYO	28	15	21	0.7	0.3	0.4
Seiko Epson	1	1	1	0	0	0
Sony	18	17	13	0.5	0.4	0.2
Toshiba	45	67	78	1.1	1.5	1.4
Yamaha	7	0	0	0.2	0	0
Other Japanese Companies	0	1	1	0	0	0
European Companies	**607**	**759**	**1,032**	**15.2**	**17.2**	**18.8**
Austria Mikro Systeme	12	1	1	0.3	0	0
EM Microelectronics Marin	2	5	4	0	0.1	0
Ericsson	10	32	27	0.3	0.7	0.5
GEC Plessey	51	40	21	1.3	0.9	0.4
Melexis	1	0	3	0	0	0
Micronas	8	0	0	0.2	0	0
Philips	148	160	314	3.7	3.6	5.7
Robert Bosch	0	0	9	0	0	0.2
SGS-Thomson	279	384	457	7.0	8.7	8.3

Table 2-9 (Continued)
Individual Company Vendor Revenue from Shipments of Analog-Monolithic, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Siemens	64	111	132	1.6	2.5	2.4
TEMIC	24	26	63	0.6	0.6	1.2
Zetex	0	0	1	0	0	0
Asia/Pacific Companies	**19**	**24**	**17**	**0.5**	**0.5**	**0.3**
Samsung	18	23	16	0.5	0.5	0.3
Winbond Electronics	1	1	1	0	0	0

Source: Dataquest (June 1998)

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Table 2-10
Individual Company Vendor Revenue from Shipments of Total Discrete, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**3,027**	**2,924**	**3,074**	**100.0**	**100.0**	**100.0**
Americas Companies	**1,855**	**1,770**	**1,754**	**61.3**	**60.5**	**57.1**
Allegro MicroSystems	17	16	2	0.6	0.5	0
Fairchild	0	0	52	0	0	1.7
General Semiconductor	130	115	112	4.3	3.9	3.6
Harris Semiconductor	139	145	129	4.6	5.0	4.2
Hewlett-Packard	75	72	60	2.5	2.5	2.0
International Rectifier	207	230	231	6.8	7.9	7.5
Ixys	18	22	24	0.6	0.8	0.8
Microsemi	96	113	122	3.2	3.9	4.0
Motorola	885	791	783	29.2	27.1	25.5
National Semiconductor	73	61	55	2.4	2.1	1.8
Optek	1	1	0	0	0	0
Powerex	80	80	82	2.6	2.7	2.7
Raytheon	7	7	8	0.2	0.2	0.3
Semtech	25	17	4	0.8	0.6	0.1
Solitron	6	5	5	0.2	0.2	0.2
Supertex	8	8	9	0.3	0.3	0.3
Teccor Electronics	55	69	76	1.8	2.4	2.5
Japanese Companies	**520**	**530**	**607**	**17.2**	**18.1**	**19.7**
Fuji Electric	21	18	18	0.7	0.6	0.6
Fujitsu	173	153	164	5.7	5.2	5.3
Hitachi	41	60	47	1.4	2.1	1.5
Matsushita	21	20	27	0.7	0.7	0.9
Mitsubishi	20	19	18	0.7	0.6	0.6
NEC	46	48	76	1.5	1.6	2.5
Rohm	38	31	54	1.3	1.1	1.8
Sanken	14	12	17	0.5	0.4	0.6
SANYO	16	19	19	0.5	0.6	0.6
Shindengen Electric	12	16	15	0.4	0.5	0.5
Sony	4	4	3	0.1	0.1	0
Toshiba	106	124	149	3.5	4.2	4.8
European Companies	**596**	**575**	**671**	**19.7**	**19.7**	**21.8**
Ericsson	6	9	10	0.2	0.3	0.3
Eupec	28	32	31	0.9	1.1	1.0
Fagor	3	0	1	0	0	0
GEC Plessey	1	7	9	0	0.2	0.3
Micronas	0	0	10	0	0	0.3

Table 2-10 (Continued)
Individual Company Vendor Revenue from Shipments of Total Discrete, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	**1996**	**1997**	**1995**	**1996**	**1997**
Philips	234	190	216	7.7	6.5	7.0
Power Innovations	0	0	6	0	0	0.2
Robert Bosch	0	0	11	0	0	0.4
Semikron	26	20	23	0.9	0.7	0.7
SGS-Thomson	130	124	138	4.3	4.2	4.5
Siemens	70	80	115	2.3	2.7	3.7
TEMIC	80	94	83	2.6	3.2	2.7
Zetex	14	15	14	0.5	0.5	0.5
Other European Companies	4	4	4	0.1	0.1	0.1
Asia/Pacific Companies	**56**	**49**	**42**	**1.9**	**1.7**	**1.4**
Korean Electronic Co.	25	20	7	0.8	0.7	0.2
Samsung	31	29	35	1.0	1.0	1.1

Source: Dataquest (June 1998)

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Table 2-11
Individual Company Vendor Revenue from Shipments of Total Optical Semiconductors, Americas (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**625**	**739**	**970**	**100.0**	**100.0**	**100.0**
Americas Companies	**250**	**343**	**534**	**40.0**	**46.4**	**55.1**
CID Technologies	5	6	6	0.8	0.8	0.6
Eastman Kodak	3	3	3	0.5	0.4	0.3
Hewlett-Packard	61	161	192	9.8	21.8	19.8
Honeywell	5	6	6	0.8	0.8	0.6
IC Sensors	6	7	7	1.0	0.9	0.7
Lucent Technologies	34	37	205	5.4	5.0	21.1
Mitel	0	5	7	0	0.7	0.7
Motorola	26	18	16	4.2	2.4	1.6
Optek	36	41	36	5.8	5.5	3.7
Quality Technologies	26	26	29	4.2	3.5	3.0
Spectra Diode Labs	15	17	17	2.4	2.3	1.8
Texas Instruments	0	16	10	0	2.2	1.0
Other Americas Companies	33	0	0	5.3	0	0
Japanese Companies	**227**	**230**	**229**	**36.3**	**31.1**	**23.6**
Fujitsu	22	23	27	3.5	3.1	2.8
Hitachi	8	11	7	1.3	1.5	0.7
Matsushita	10	10	5	1.6	1.4	0.5
Mitsubishi	20	19	21	3.2	2.6	2.2
NEC	8	12	33	1.3	1.6	3.4
Rohm	7	7	12	1.1	0.9	1.2
Sanken	1	1	1	0.2	0.1	0.1
SANYO	4	14	18	0.6	1.9	1.9
Sharp	10	13	13	1.6	1.8	1.3
Sony	2	2	2	0.3	0.3	0.2
Stanley	43	0	40	6.9	0	4.1
Toshiba	71	62	34	11.4	8.4	3.5
Other Japanese Companies	21	56	16	3.4	7.6	1.6
European Companies	**148**	**166**	**207**	**23.7**	**22.5**	**21.3**
Ericsson	5	10	13	0.8	1.4	1.3
Siemens	125	139	173	20.0	18.8	17.8
TCS	5	4	2	0.8	0.5	0.2
TEMIC	10	12	18	1.6	1.6	1.9
Other European Companies	1	1	1	0.2	0.1	0.1

Source: Dataquest (June 1998)

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Table 2-12
Top 40 Worldwide Companies' Vendor Revenue from Shipments of Total Semiconductors, Americas (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Intel	7,458	9,621	29.0	20.0
2	2	Motorola	4,140	3,879	-6.3	8.1
4	3	IBM	2,405	2,679	11.4	5.6
6	4	Texas Instruments	2,192	2,202	0.5	4.6
5	5	NEC	2,294	2,131	-7.1	4.4
3	6	Samsung	2,661	2,105	-20.9	4.4
10	7	Lucent Technologies	1,057	1,351	27.8	2.8
8	8	Toshiba	1,613	1,337	-17.1	2.8
9	9	Micron Technology	1,144	1,279	11.8	2.7
7	10	Hitachi	1,778	1,181	-33.6	2.5
12	11	National Semiconductor	962	1,116	16.0	2.3
11	12	Advanced Micro Devices	975	1,032	5.8	2.1
13	13	SGS-Thomson	934	952	1.9	2.0
15	14	Philips	829	831	0.2	1.7
16	15	Mitsubishi	809	809	0	1.7
18	16	Fujitsu	670	756	12.8	1.6
19	17	Rockwell	550	726	32.0	1.5
22	18	Siemens	466	651	39.7	1.4
20	19	Analog Devices	520	630	21.2	1.3
17	20	LSI Logic	705	618	-12.3	1.3
14	21	Hyundai	845	615	-27.2	1.3
21	22	Hewlett-Packard	480	553	15.2	1.2
24	23	Cirrus Logic	412	396	-3.9	0.8
27	24	Harris Semiconductor	363	389	7.2	0.8
25	25	Atmel	368	386	4.9	0.8
28	26	Xilinx	363	386	6.3	0.8
30	27	Integrated Device Technology	344	358	4.1	0.7
31	28	VLSI Technology	330	358	8.5	0.7
34	29	Altera	265	353	33.2	0.7
23	30	LG Semicon	446	351	-21.3	0.7
26	31	Symbios	366	320	-12.6	0.7
29	32	Cypress Semiconductor	361	304	-15.8	0.6
72	33	Sun Microsystems	55	300	445.5	0.6
32	34	Oki	320	265	-17.2	0.6
35	35	International Rectifier	240	240	0	0.5
37	36	Linear Technology	189	224	18.5	0.5
41	37	Digital	149	201	34.9	0.4
40	38	TEMIC	172	198	15.1	0.4

Table 2-12 (Continued)
Top 40 Worldwide Companies' Vendor Revenue from Shipments of Total Semiconductors, Americas (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
54	39	ATI Technologies	100	195	95.0	0.4
57	40	Gould AMI	88	181	105.7	0.4
		All Others	5,254	5,627	7.1	11.7
		Americas Companies	30,124	34,235	13.6	71.2
		Japanese Companies	8,596	7,481	-13.0	15.6
		European Companies	2,671	2,951	10.5	6.1
		Asia/Pacific Companies	4,281	3,419	-20.1	7.1
		Total Market	**45,672**	**48,086**	**5.3**	**100.0**

Source: Dataquest (June 1998)

Table 2-13
Top 40 Worldwide Companies' Vendor Revenue from Shipments of Total Integrated Circuits, Americas (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Intel	7,458	9,621	29.0	21.8
2	2	Motorola	3,331	3,080	-7.5	7.0
4	3	IBM	2,405	2,679	11.4	6.1
6	4	Texas Instruments	2,176	2,192	0.7	5.0
3	5	Samsung	2,632	2,070	-21.4	4.7
5	6	NEC	2,234	2,022	-9.5	4.6
9	7	Micron Technology	1,144	1,279	11.8	2.9
8	8	Toshiba	1,427	1,154	-19.1	2.6
10	9	Lucent Technologies	1,020	1,146	12.4	2.6
7	10	Hitachi	1,707	1,127	-34.0	2.6
12	11	National Semiconductor	901	1,061	17.8	2.4
11	12	Advanced Micro Devices	975	1,032	5.8	2.3
14	13	SGS-Thomson	810	814	0.5	1.8
15	14	Mitsubishi	771	770	-0.1	1.7
18	15	Rockwell	550	726	32.0	1.6
19	16	Analog Devices	520	630	21.2	1.4
16	17	LSI Logic	705	618	-12.3	1.4
13	18	Hyundai	845	615	-27.2	1.4
17	19	Philips	639	615	-3.8	1.4
20	20	Fujitsu	494	565	14.4	1.3
22	21	Cirrus Logic	412	396	-3.9	0.9
23	22	Atmel	368	386	4.9	0.9
25	23	Xilinx	363	386	6.3	0.9
32	24	Siemens	247	363	47.0	0.8
27	25	Integrated Device Technology	344	358	4.1	0.8
28	26	VLSI Technology	330	358	8.5	0.8
31	27	Altera	265	353	33.2	0.8
21	28	LG Semicon	446	351	-21.3	0.8
24	29	Symbios	366	320	-12.6	0.7
26	30	Cypress Semiconductor	361	304	-15.8	0.7
33	31	Hewlett-Packard	247	301	21.9	0.7
66	32	Sun Microsystems	55	300	445.5	0.7
29	33	Oki	320	265	-17.2	0.6
34	34	Harris Semiconductor	218	260	19.3	0.6
36	35	Linear Technology	189	224	18.5	0.5
38	36	Digital	149	201	34.9	0.5
47	37	ATI Technologies	100	195	95.0	0.4
52	38	Gould AMI	88	181	105.7	0.4

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Table 2-13 (Continued)
Top 40 Worldwide Companies' Vendor Revenue from Shipments of Total Integrated Circuits, Americas (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
39	39	Maxim	146	177	21.2	0.4
41	40	Microchip Technology	133	145	9.0	0.3
		All Others	4,118	4,402	6.9	10.0
		Americas Companies	28,011	31,947	14.1	72.5
		Japanese Companies	7,836	6,645	-15.2	15.1
		European Companies	1,930	2,073	7.4	4.7
		Asia/Pacific Companies	4,232	3,377	-20.2	7.7
		Total Market	**42,009**	**44,042**	**4.8**	**100.0**

Source: Dataquest (June 1998)

Table 2-14
Top 18 Worldwide Companies' Vendor Revenue from Shipments of Bipolar Digital, Americas (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Motorola	149	136	-8.7	38.1
2	2	Texas Instruments	124	110	-11.3	30.8
5	3	Philips	50	46	-8.0	12.9
6	4	Advanced Micro Devices	35	15	-57.1	4.2
3	5	Lucent Technologies	70	10	-85.7	2.8
4	6	National Semiconductor	58	10	-82.8	2.8
9	7	Fujitsu	19	10	-47.4	2.8
15	8	Siemens	2	10	400.0	2.8
12	9	NEC	5	4	-20.0	1.1
56	10	Mosel Vitelic	0	2	NA	0.6
7	11	Hitachi	33	1	-97.0	0.3
14	12	Mitsubishi	2	1	-50.0	0.3
16	13	Toshiba	1	1	0	0.3
17	14	LG Semicon	1	1	0	0.3
8	15	Applied Micro Circuits Corp.	25	0	-100.0	0
10	16	Raytheon	11	0	-100.0	0
11	17	GEC Plessey	8	0	-100.0	0
13	18	Harris Semiconductor	4	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	476	281	-41.0	78.7
		Japanese Companies	60	17	-71.7	4.8
		European Companies	60	56	-6.7	15.7
		Asia/Pacific Companies	1	3	200.0	0.8
		Total Market	**597**	**357**	**-40.2**	**100.0**

NA = Not available
Source: Dataquest (June 1998)

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Table 2-15
Top 40 Worldwide Companies' Vendor Revenue from Shipments of MOS Digital ICs, Americas (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Intel	7,458	9,621	29.0	25.2
4	2	IBM	2,405	2,679	11.4	7.0
2	3	Motorola	2,679	2,344	-12.5	6.1
3	4	Samsung	2,609	2,054	-21.3	5.4
5	5	NEC	2,198	1,980	-9.9	5.2
7	6	Texas Instruments	1,582	1,548	-2.1	4.1
9	7	Micron Technology	1,144	1,279	11.8	3.3
6	8	Hitachi	1,619	1,083	-33.1	2.8
8	9	Toshiba	1,359	1,075	-20.9	2.8
12	10	Lucent Technologies	775	1,056	36.3	2.8
10	11	Advanced Micro Devices	886	948	7.0	2.5
13	12	Mitsubishi	719	735	2.2	1.9
15	13	Rockwell	504	664	31.7	1.7
14	14	LSI Logic	705	618	-12.3	1.6
11	15	Hyundai	845	615	-27.2	1.6
16	16	National Semiconductor	478	587	22.8	1.5
18	17	Fujitsu	434	528	21.7	1.4
23	18	Xilinx	363	386	6.3	1.0
21	19	Atmel	368	361	-1.9	0.9
25	20	Integrated Device Technology	344	358	4.1	0.9
26	21	VLSI Technology	330	358	8.5	0.9
19	22	SGS-Thomson	426	357	-16.2	0.9
30	23	Altera	265	353	33.2	0.9
17	24	LG Semicon	445	350	-21.3	0.9
22	25	Symbios	366	320	-12.6	0.8
24	26	Cypress Semiconductor	361	304	-15.8	0.8
31	27	Hewlett-Packard	247	301	21.9	0.8
55	28	Sun Microsystems	55	300	445.5	0.8
27	29	Oki	320	265	-17.2	0.7
20	30	Philips	412	255	-38.1	0.7
29	31	Cirrus Logic	301	244	-18.9	0.6
35	32	Siemens	134	221	64.9	0.6
33	33	Digital	149	201	34.9	0.5
44	34	ATI Technologies	100	195	95.0	0.5
46	35	Gould AMI	88	181	105.7	0.5
37	36	Microchip Technology	133	145	9.0	0.4
42	37	Analog Devices	108	143	32.4	0.4
28	38	S3	310	138	-55.5	0.4

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Table 2-15 (Continued)
Top 40 Worldwide Companies' Vendor Revenue from Shipments of MOS Digital ICs, Americas (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
39	39	Zilog	111	137	23.4	0.4
41	40	Harris Semiconductor	108	136	25.9	0.4
		All Others	2,552	2,785	9.1	7.3
		Americas Companies	24,094	27,567	14.4	72.1
		Japanese Companies	7,405	6,299	-14.9	16.5
		European Companies	1,089	985	-9.6	2.6
		Asia/Pacific Companies	4,207	3,357	-20.2	8.8
		Total Market	**36,795**	**38,208**	**3.8**	**100.0**

Source: Dataquest (June 1998)

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Table 2-16
Top 40 Worldwide Companies' Vendor Revenue from Shipments of MOS Memory, Americas (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Samsung	2,549	1,984	-22.2	16.7
4	2	Micron Technology	1,144	1,279	11.8	10.7
2	3	NEC	1,546	1,270	-17.9	10.7
3	4	Hitachi	1,338	830	-38.0	7.0
5	5	IBM	950	655	-31.1	5.5
6	6	Toshiba	920	633	-31.2	5.3
7	7	Hyundai	842	614	-27.1	5.2
8	8	Texas Instruments	621	552	-11.1	4.6
10	9	Mitsubishi	521	504	-3.3	4.2
12	10	Intel	415	337	-18.8	2.8
13	11	Advanced Micro Devices	360	334	-7.2	2.8
11	12	LG Semicon	429	322	-24.9	2.7
9	13	Motorola	529	285	-46.1	2.4
15	14	Atmel	265	245	-7.5	2.1
16	15	Fujitsu	253	245	-3.2	2.1
18	16	Integrated Device Technology	221	225	1.8	1.9
17	17	Oki	235	196	-16.6	1.6
14	18	Cypress Semiconductor	277	194	-30.0	1.6
20	19	Siemens	114	193	69.3	1.6
19	20	SGS-Thomson	144	122	-15.3	1.0
22	21	Mosel Vitelic	104	105	1.0	0.9
21	22	Sony	106	84	-20.8	0.7
26	23	Sharp	63	73	15.9	0.6
28	24	Integrated Silicon Solution	58	69	19.0	0.6
25	25	Xicor	68	67	-1.5	0.6
33	26	Alliance Semiconductor	25	65	160.0	0.5
43	27	Vanguard	4	64	1,500.0	0.5
24	28	Nippon Steel Semiconductor	69	46	-33.3	0.4
29	29	Macronix	58	44	-24.1	0.4
23	30	Matsushita	96	37	-61.5	0.3
27	31	SANYO	58	27	-53.4	0.2
34	32	Catalyst	24	27	12.5	0.2
32	33	Microchip Technology	28	25	-10.7	0.2
69	34	Fairchild	0	25	NA	0.2
35	35	Winbond Electronics	23	20	-13.0	0.2
36	36	Silicon Storage Technology	21	16	-23.8	0.1
38	37	Ramtron	14	15	7.1	0.1
39	38	Rohm	13	13	0	0.1

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Table 2-16 (Continued)
Top 40 Worldwide Companies' Vendor Revenue from Shipments of MOS Memory, Americas (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
40	39	G-Link USA	7	13	85.7	0.1
37	40	Paradigm	20	9	-55.0	0
		All Others	110	35	-68.2	0.3
		Americas Companies	5,135	4,463	-13.1	37.5
		Japanese Companies	5,233	3,961	-24.3	33.3
		European Companies	264	320	21.2	2.7
		Asia/Pacific Companies	4,010	3,154	-21.3	26.5
		Total Market	**14,642**	**11,898**	**-18.7**	**100.0**

NA = Not available
Source: Dataquest (June 1998)

Table 2-17
Top 40 Worldwide Companies' Vendor Revenue from Shipments of MOS Microcomponents, Americas (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Intel	7,043	9,284	31.8	52.2
2	2	Motorola	1,539	1,635	6.2	9.2
5	3	Rockwell	500	659	31.8	3.7
4	4	Texas Instruments	579	589	1.7	3.3
3	5	IBM	611	585	-4.3	3.3
6	6	National Semiconductor	315	511	62.2	2.9
7	7	Advanced Micro Devices	313	457	46.0	2.6
11	8	Lucent Technologies	270	311	15.2	1.7
26	9	Sun Microsystems	55	300	445.5	1.7
12	10	NEC	260	286	10.0	1.6
9	11	Cirrus Logic	301	244	-18.9	1.4
15	12	Digital	149	201	34.9	1.1
20	13	ATI Technologies	100	195	95.0	1.1
13	14	Hitachi	204	193	-5.4	1.1
17	15	Fujitsu	109	183	67.9	1.0
10	16	Philips	273	172	-37.0	1.0
8	17	S3	310	138	-55.5	0.8
16	18	Zilog	111	137	23.4	0.8
19	19	Analog Devices	103	133	29.1	0.7
18	20	Microchip Technology	105	120	14.3	0.7
97	21	NeoMagic	0	120	NA	0.7
22	22	Toshiba	66	119	80.3	0.7
14	23	SGS-Thomson	158	118	-25.3	0.7
21	24	Symbios	81	91	12.3	0.5
27	25	Mitsubishi	54	71	31.5	0.4
24	26	C-Cube	57	64	12.3	0.4
29	27	Standard Microsystems	50	55	10.0	0.3
99	28	ESS	0	55	NA	0.3
25	29	Integrated Device Technology	55	53	-3.6	0.3
32	30	LSI Logic	35	49	40.0	0.3
31	31	Dallas Semiconductor	42	47	11.9	0.3
45	32	Silicon Integrated Systems	20	47	135.0	0.3
33	33	Trident Microsystems	35	40	14.3	0.2
34	34	Harris Semiconductor	32	30	-6.3	0.2
36	35	Q Logic	27	30	11.1	0.2
47	36	WaferScale Integration	18	30	66.7	0.2
37	37	PMC Sierra Semiconductor	25	28	12.0	0.2
43	38	Siemens	20	28	40.0	0.2

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Table 2-17 (Continued)
Top 40 Worldwide Companies' Vendor Revenue from Shipments of MOS Microcomponents, Americas (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
38	39	8x8	24	27	12.5	0.2
41	40	Yamaha	22	27	22.7	0.2
		All Others	516	323	-37.4	1.8
		Americas Companies	13,236	16,367	23.7	92.0
		Japanese Companies	793	952	20.1	5.4
		European Companies	483	359	-25.7	2.0
		Asia/Pacific Companies	75	107	42.7	0.6
		Total Market	**14,587**	**17,785**	**21.9**	**100.0**

NA = Not available
Source: Dataquest (June 1998)

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Table 2-18
Top 40 Worldwide Companies' Vendor Revenue from Shipments of MOS Digital Logic, Americas (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	IBM	844	1,439	70.5	16.9
4	2	Lucent Technologies	505	745	47.5	8.7
2	3	LSI Logic	670	569	-15.1	6.7
3	4	Motorola	611	424	-30.6	5.0
5	5	NEC	392	424	8.2	5.0
6	6	Texas Instruments	382	407	6.5	4.8
8	7	Xilinx	363	386	6.3	4.5
11	8	Altera	265	353	33.2	4.1
9	9	VLSI Technology	314	345	9.9	4.0
7	10	Toshiba	373	323	-13.4	3.8
12	11	Hewlett-Packard	247	301	21.9	3.5
10	12	Symbios	285	229	-19.6	2.7
20	13	Gould AMI	88	181	105.7	2.1
14	14	Mitsubishi	144	160	11.1	1.9
13	15	Advanced Micro Devices	213	157	-26.3	1.8
18	16	Lattice	112	127	13.4	1.5
17	17	SGS-Thomson	124	117	-5.6	1.4
19	18	Actel	100	111	11.0	1.3
32	19	Cypress Semiconductor	42	106	152.4	1.2
23	20	Fujitsu	72	100	38.9	1.2
24	21	Harris Semiconductor	70	97	38.6	1.1
21	22	Atmel	83	89	7.2	1.0
117	23	Fairchild	0	85	NA	1.0
15	24	Philips	139	83	-40.3	1.0
26	25	Integrated Device Technology	68	80	17.6	0.9
25	26	SANYO	70	77	10.0	0.9
16	27	National Semiconductor	125	74	-40.8	0.9
22	28	Hitachi	77	60	-22.1	0.7
33	29	GEC Plessey	40	59	47.5	0.7
37	30	Matsushita	29	55	89.7	0.6
30	31	Dallas Semiconductor	46	50	8.7	0.6
29	32	Samsung	48	49	2.1	0.6
27	33	Oki	63	48	-23.8	0.6
31	34	Seiko Epson	44	43	-2.3	0.5
35	35	Hughes	34	36	5.9	0.4
34	36	Sharp	38	35	-7.9	0.4
28	37	Sony	50	33	-34.0	0.4
43	38	Applied Micro Circuits Corp.	19	29	52.6	0.3

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Table 2-18 (Continued)
Top 40 Worldwide Companies' Vendor Revenue from Shipments of MOS Digital Logic, Americas (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
123	39	Vitesse	0	28	NA	0.3
39	40	Chip Express	22	25	13.6	0.3
		All Others	355	386	8.7	4.5
		Americas Companies	5,723	6,737	17.7	79.0
		Japanese Companies	1,379	1,386	0.5	16.3
		European Companies	342	306	-10.5	3.6
		Asia/Pacific Companies	122	96	-21.3	1.1
		Total Market	**7,566**	**8,525**	**12.7**	**100.0**

NA = Not available
Source: Dataquest (June 1998)

Table 2-19
Top 40 Worldwide Companies' Vendor Revenue from Shipments of Analog-Monolithic, Americas (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Motorola	503	600	19.3	11.0
2	2	Texas Instruments	470	534	13.6	9.7
3	3	Analog Devices	395	487	23.3	8.9
5	4	National Semiconductor	365	464	27.1	8.5
4	5	SGS-Thomson	384	457	19.0	8.3
8	6	Philips	160	314	96.3	5.7
6	7	Linear Technology	189	224	18.5	4.1
9	8	Maxim	143	177	23.8	3.2
10	9	Cirrus Logic	111	152	36.9	2.8
11	10	Siemens	111	132	18.9	2.4
12	11	Harris Semiconductor	106	124	17.0	2.3
47	12	Micrel	11	104	845.5	1.9
13	13	Cherry Semiconductor	87	87	0	1.6
7	14	Lucent Technologies	175	80	-54.3	1.5
16	15	Level One Communications	70	79	12.9	1.4
17	16	Toshiba	67	78	16.4	1.4
14	17	Allegro MicroSystems	77	71	-7.8	1.3
18	18	Advanced Micro Devices	54	69	27.8	1.3
15	19	Raytheon	72	65	-9.7	1.2
33	20	TEMIC	26	63	142.3	1.2
22	21	Rockwell	46	62	34.8	1.1
19	22	PMC Sierra Semiconductor	54	61	13.0	1.1
20	23	Burr-Brown	52	58	11.5	1.1
23	24	Unitrode	45	58	28.9	1.1
40	25	Semtech	18	56	211.1	1.0
144	26	TriQuint	0	56	NA	1.0
27	27	Mitel	34	53	55.9	1.0
25	28	Linfinity	41	46	12.2	0.8
21	29	Hitachi	49	43	-12.2	0.8
24	30	Exar	42	42	0	0.8
30	31	NEC	31	38	22.6	0.7
36	32	Rohm	20	36	80.0	0.7
79	33	Vitesse	0	35	NA	0.6
32	34	Mitsubishi	29	34	17.2	0.6
145	35	Anadigics	0	34	NA	0.6
28	36	Micro Linear	32	31	-3.1	0.6
29	37	Ericsson	32	27	-15.6	0.5
38	38	Fujitsu	19	27	42.1	0.5

Table 2-19 (Continued)
Top 40 Worldwide Companies' Vendor Revenue from Shipments of Analog-Monolithic, Americas (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
73	39	Atmel	0	25	NA	0.5
34	40	Honeywell	24	24	0	0.4
		All Others	281	270	-3.9	4.9
		Americas Companies	3,369	4,099	21.7	74.8
		Japanese Companies	273	329	20.5	6.0
		European Companies	759	1,032	36.0	18.8
		Asia/Pacific Companies	24	17	-29.2	0.3
		Total Market	**4,425**	**5,477**	**23.8**	**100.0**

NA = Not available
Source: Dataquest (June 1998)

Table 2-20
Top 40 Worldwide Companies' Vendor Revenue from Shipments of Total Discrete, Americas (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Motorola	791	783	-1.0	25.5
2	2	International Rectifier	230	231	0.4	7.5
3	3	Philips	190	216	13.7	7.0
4	4	Fujitsu	153	164	7.2	5.3
7	5	Toshiba	124	149	20.2	4.8
6	6	SGS-Thomson	124	138	11.3	4.5
5	7	Harris Semiconductor	145	129	-11.0	4.2
9	8	Microsemi	113	122	8.0	4.0
11	9	Siemens	80	115	43.8	3.7
8	10	General Semiconductor	115	112	-2.6	3.6
10	11	TEMIC	94	83	-11.7	2.7
12	12	Powerex	80	82	2.5	2.7
14	13	Teccor Electronics	69	76	10.1	2.5
17	14	NEC	48	76	58.3	2.5
13	15	Hewlett-Packard	72	60	-16.7	2.0
15	16	National Semiconductor	61	55	-9.8	1.8
19	17	Rohm	31	54	74.2	1.8
93	18	Fairchild	0	52	NA	1.7
16	19	Hitachi	60	47	-21.7	1.5
20	20	Samsung	29	35	20.7	1.1
18	21	Eupec	32	31	-3.1	1.0
22	22	Matsushita	20	27	35.0	0.9
21	23	Ixys	22	24	9.1	0.8
23	24	Semikron	20	23	15.0	0.7
26	25	SANYO	19	19	0	0.6
25	26	Mitsubishi	19	18	-5.3	0.6
27	27	Fuji Electric	18	18	0	0.6
33	28	Sanken	12	17	41.7	0.6
31	29	Shindengen Electric	16	15	-6.3	0.5
32	30	Zetex	15	14	-6.7	0.5
71	31	Robert Bosch	0	11	NA	0.4
34	32	Ericsson	9	10	11.1	0.3
103	33	Micronas	0	10	NA	0.3
35	34	Supertex	8	9	12.5	0.3
37	35	GEC Plessey	7	9	28.6	0.3
36	36	Raytheon	7	8	14.3	0.3
24	37	Korean Electronic Co.	20	7	-65.0	0.2
164	38	Power Innovations	0	6	NA	0.2

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Table 2-20 (Continued)
Top 40 Worldwide Companies' Vendor Revenue from Shipments of Total Discrete, Americas (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
39	39	Solitron	5	5	0	0.2
29	40	Semtech	17	4	-76.5	0.1
		All Others	49	10	-79.6	0.3
		Americas Companies	1,770	1,754	-0.9	57.1
		Japanese Companies	530	607	14.5	19.7
		European Companies	575	671	16.7	21.8
		Asia/Pacific Companies	49	42	-14.3	1.4
		Total Market	**2,924**	**3,074**	**5.1**	**100.0**

NA = Not available
Source: Dataquest (June 1998)

Table 2-21
Top 28 Worldwide Companies' Vendor Revenue from Shipments of Total Optical Semiconductors to Americas (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
5	1	Lucent Technologies	37	205	454.1	21.1
1	2	Hewlett-Packard	161	192	19.3	19.8
2	3	Siemens	139	173	24.5	17.8
166	4	Stanley	0	40	NA	4.1
4	5	Optek	41	36	-12.2	3.7
3	6	Toshiba	62	34	-45.2	3.5
15	7	NEC	12	33	175.0	3.4
6	8	Quality Technologies	26	29	11.5	3.0
7	9	Fujitsu	23	27	17.4	2.8
8	10	Mitsubishi	19	21	10.5	2.2
12	11	SANYO	14	18	28.6	1.9
14	12	TEMIC	12	18	50.0	1.9
10	13	Spectra Diode Labs	17	17	0	1.8
9	14	Motorola	18	16	-11.1	1.6
13	15	Sharp	13	13	0	1.3
18	16	Ericsson	10	13	30.0	1.3
19	17	Rohm	7	12	71.4	1.2
11	18	Texas Instruments	16	10	-37.5	1.0
16	19	Hitachi	11	7	-36.4	0.7
20	20	IC Sensors	7	7	0	0.7
23	21	Mitel	5	7	40.0	0.7
21	22	Honeywell	6	6	0	0.6
22	23	CID Technologies	6	6	0	0.6
17	24	Matsushita	10	5	-50.0	0.5
25	25	Eastman Kodak	3	3	0	0.3
24	26	TCS	4	2	-50.0	0.2
26	27	Sony	2	2	0	0.2
27	28	Sanken	1	1	0	0.1
		All Others	57	17	-70.2	1.8
		Americas Companies	343	534	55.7	55.1
		Japanese Companies	230	229	-0.4	23.6
		European Companies	166	207	24.7	21.3
		Asia/Pacific Companies	0	0	NA	0
		Total Market	**739**	**970**	**31.3**	**100.0**

NA = Not available
Source: Dataquest (June 1998)

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Competitive Markets in Semiconductors, 1997

Competitive Trends

Program: Semiconductors Worldwide
Product Code: SEMI-WW-CT-9801
Publication Date: November 30, 1998
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Competitive Markets in Semiconductors, 1997

Competitive Trends

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Chapter 1
Executive Summary

Dataquest's worldwide semiconductor forecast for year-end 1998 through 2002, as shown in Table 1-1, projects a market in severe decline in 1998. Worldwide semiconductor revenue is expected to decline 5.9 percent to $138 billion in 1998. If the market experiences price stability and a strengthening in demand in 1999, a market rebound could see worldwide revenue return to stronger double-digit growth in 2000. Within the scope of the current forecast for 1999, the non-DRAM sector could grow 9.7 percent, while DRAM revenue could grow 30 percent.

As shown in Figure 1-1, the comparison of DRAM versus non-DRAM product revenue illustrates the disastrous effects of DRAM downturns on the market. The non-DRAM products usually represent revenue stability in the semiconductor market.

Table 1-1
Worldwide Semiconductor Forecast, 1997-2002 (Millions of Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1998-2002
Total Semiconductor	**147,165**	**138,437**	**154,820**	**190,153**	**234,823**	**253,842**	**16.4**
Total Semiconductor (Without DRAM)	**126,421**	**124,161**	**136,263**	**158,298**	**183,129**	**208,247**	**13.8**
Bipolar Digital	1,239	1,112	946	835	707	604	-14.2
MOS Memory	30,978	24,474	30,349	45,987	68,765	64,694	27.5
Dynamic RAM	20,744	14,276	18,557	31,855	51,694	45,595	33.7
Static RAM	4,008	4,372	5,050	6,250	7,893	8,578	18.3
Nonvolatile Memory	5,571	5,100	5,933	6,992	8,193	9,432	16.6
Other MOS Memory	655	726	809	889	984	1,089	10.7
MOS Microcomponent	48,945	48,170	52,440	59,990	69,280	79,690	13.4
Microprocessor	23,659	24,440	27,180	30,300	33,670	38,080	11.7
Microcontroller	10,896	9,720	10,430	12,350	14,860	17,390	15.7
Microperipheral	10,736	9,850	9,870	11,070	12,720	14,530	10.2
Digital Signal Processor	3,654	4,160	4,960	6,270	8,030	9,690	23.5
MOS Digital Logic	24,757	23,551	24,900	29,342	34,497	40,474	14.5
ASIC	16,527	15,898	17,213	20,895	25,332	30,540	17.7
Total Gate Array	5,260	4,330	3,850	3,592	3,371	3,103	-8.0
PLD	2,103	2,081	2,332	2,866	3,488	4,154	18.9
Cell-Based IC	9,164	9,486	11,032	14,437	18,472	23,283	25.2
Custom IC	1,514	1,074	710	480	300	176	-36.4
MOS Standard Logic	2,266	2,109	2,177	2,305	2,355	2,359	2.8
Total Other MOS Logic	4,450	4,470	4,799	5,661	6,510	7,400	13.4
Analog-Monolithic	21,652	22,020	25,532	30,346	35,609	40,601	16.5
Total Discrete	14,255	13,829	15,073	17,573	19,388	20,562	10.4
Total Optical Semiconductor	5,339	5,281	5,580	6,081	6,577	7,217	8.1

Source: Dataquest (October 1998)

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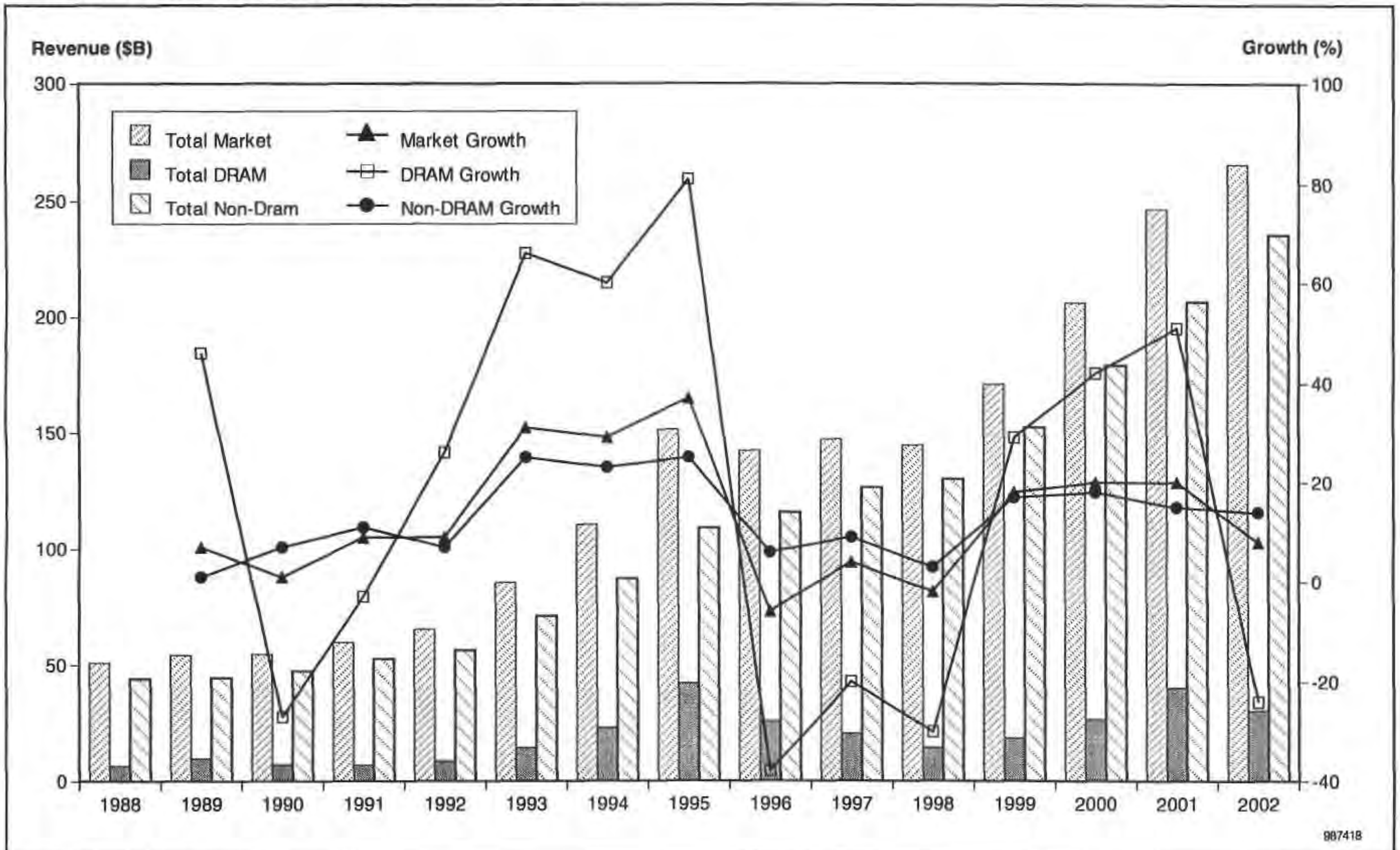
Figure 1-1
Worldwide Semiconductor Market Growth, 1988-2002



Source: Dataquest (October 1998)

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DRAMs have always been the key driver for growth and the culprit for decline in the semiconductor industry. In the major DRAM and overall semiconductor market downturns, excess capacity or strategic inventory is the real culprit. A series of worldwide events from 1995 to 1998 resembles previous market downturns, especially those that occurred in 1985 through 1987. These are listed in Table 1-2.

The DRAM market declined 52 percent, from $3.5 billion in 1984 to $1.7 billion in 1985. In 1984, suppliers hoarded product and buyers double-ordered on contracts to guarantee shipments. In 1985, as suppliers began dumping products and lowering prices, buyers canceled long-range contracts to reap the benefits of lower prices. Pricing wars raged until trading wars and dumping issues resulted in government intervention, and foreign market value (FMV) duties were imposed. The suppliers to this market suffered worse losses and faced worse price erosion than in any other device market. Several companies made well-publicized withdrawals from the DRAM market during that year. Manufacturers that fared best were those that were well positioned in the 256Kb DRAM market, which enabled them to shift their revenue base over as the 64Kb market declined.

Table 1-2
Market Comparisons: 1985-1987 versus 1995-1998

1985-1987 Market	1995-1998 Market
Product hoarding/double-ordering led to supply excess, which precipitated price erosion.	Excessive capital spending added to an overcapacity situation precipitated price erosion.
Capital spending was depressed in the U.S. because of uncertainty about proposed tax reforms.	Capital spending depressed in the U.S., Japan, Europe, and Korea because of capital spending binge.
International trade issues over product prices reaching below fair market values led to antidumping duties on DRAMs and EPROMs.	Uncertainty of antidumping duties on DRAMs as rumors abound over dumping product below cost to gain market share.
Damaged by price erosion, a depressed market, and aggressive competitors, Mostek, Intel, and Inmos disappeared from key market sectors.	Damaged by excessive spending, price erosion, and aggressive competitors, some DRAM suppliers are evaluating departure from the market.
A crossover point in price was reached between the 64Kb DRAM and 256Kb DRAM. The 1Mb DRAMs reached price per bit parity with 256Kb year-end 1987.	In a dance of death, 64Mb DRAM chases the 16Mb DRAM. Price per bit parity could be reached by year-end 1998. A 4Mb to 16Mb crossover occurred during this time.
The yen exchange rate changed dramatically, from 254 in 1985 to 128.4 at year-end 1987.	The yen exchange rate changed dramatically, assumed at 129.73 for the spring forecast period and 143 for 1999. The Korean won devalued to 50 percent of its dollar exchange rate this time, as the yen did in the 1985-1987 time frame.
Prices for all memory products eroded.	Prices for the majority of ICs eroded.

Source: Dataquest (October 1998)

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The stability of the top 20 semiconductor suppliers in retaining vendor positions during a downturn reflects their ability to grow the non-DRAM portion of their product sector and to reposition their products into applications beyond the PC, where non-DRAM products are of greater importance.

A brief look at historical market share provides interesting insight into the fluctuations of DRAM versus non-DRAM focus and its effect on vendor rankings. The DRAM versus non-DRAM competitive highlights are listed in Table 1-3. Typically, the top 10 suppliers to the world garnered their largest revenue share via DRAM products. During the last two years, almost all of the top 20 suppliers suffered revenue losses. There appeared to be very few safe havens in the semiconductor market in 1997 and 1998. Only a few companies in Table 1-4 experienced positive growth as they moved into 1998, a second year of downturn. The top 20 suppliers listed in this table will be profiled in this report.

Table 1-3
DRAM versus Non-DRAM Competitive Trends (Millions of Dollars)

	1998	1989	1990	1991	1992	1993	1994	1995	1996	1997
Total Semiconductor	**50,859**	**54,339**	**54,654**	**59,695**	**65,260**	**85,514**	**110,513**	**151,262**	**141,690**	**147,165**
Total DRAM	6,688	9,759	7,166	6,982	8,765	14,581	23,266	42,249	25,927	20,744
Top 10 DRAM	5,041	6,539	4,948	4,431	5,218	10,855	15,349	31,227	15,588	11,546
Top 10 Non-DRAM	24,069	22,999	24,865	28,314	29,810	35,339	45,090	52,296	63,119	68,329
Top 10 DRAM Share (%)	75	67	69	63	60	74	66	74	60	56
Top 10 Non-DRAM Share (%)	54	52	52	54	53	50	52	48	55	54

Source: Dataquest (October 1998)

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Table 1-4
Top 20 Competitors' Sales, 1997 (Millions of Dollars)

Competitors	Corporate Sales	Semiconductor Sales	Semiconductor Share of Sales (%)	Semiconductor Capital Spending
1. Intel	25,070	21,746	27.7	4,501
2. NEC	39,907	10,222	25.6	1,467
3. Motorola	29,794	8,067	27.1	1,153
4. Texas Instruments	9,750	7,352	75.4	1,040
5. Toshiba	44,052	7,253	16.5	1,367
6. Hitachi	68,735	6,298	9.2	1,015
7. Samsung	19,900	5,856	29.4	1,572
8. Fujitsu	36,379	4,622	12.7	1,443
9. Philips	37,737	4,440	11.8	385
10. STMicroelectronics	4,019	4,019	100.0	1,035
11. Mitsubishi	30,092	3,925	13.0	754
12. Siemens	60,718	3,441	5.7	1,730
13. IBM	78,508	3,391	4.3	1,180
14. Matsushita	61,903	2,847	4.6	744
15. Lucent Technologies	26,360	2,762	10.5	555
16. National Semiconductor	2,232	2,759*	100.0	720
17. SANYO	14,889	2,471	16.6	434
18. Advanced Micro Devices	2,356	2,341	99.4	723
19. Sharp	14,464	2,145	14.8	527
20. Rohm	2,402	2,053	85.5	337
Total Top 20	**662,705**	**105,251**	-	**22,682**

Note: Company corporate sales and R&D expenditure extracted from annual reports and company documents.
Semiconductor sales and shares are from Dataquest 1997 Market Share reports.
Company data is listed by calendar year for corporate sales.
*National's 1997 revenue includes all of Cyrix's 1997 revenue and part of Fairchild's calendar first quarter revenue.
Source: Dataquest (October 1998)

*Please see Errata

Table 1-4
Top 20 Competitors' Sales, 1997 (Millions of Dollars)

Competitors	Corporate Sales	Semiconductor Sales	Semiconductor Share of Sales (%)	Semiconductor Capital Spending
1. Intel	78,508	21,746	27.7	4,501
2. NEC	39,907	10,222	25.6	1,467
3. Motorola	29,794	8,067	27.1	1,153
4. Texas Instruments	9,750	7,352	75.4	1,040
5. Toshiba	44,052	7,253	16.5	1,367
6. Hitachi	68,735	6,298	9.2	1,015
7. Samsung	19,900	5,856	29.4	1,572
8. Fujitsu	36,379	4,622	12.7	1,443
9. Philips	37,737	4,440	11.8	385
10. STMicroelectronics	4,019	4,019	100.0	1,035
11. Mitsubishi	30,092	3,925	13.0	754
12. Siemens	60,718	3,441	5.7	1,730
13. IBM	78,508	3,391	4.3	1,180
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Total Top 20	**662,705**	**105,251**	-	**22,682**

Note: Company corporate sales and R&D expenditure extracted from annual reports and company documents.
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Company data is listed by calendar year for corporate sales.
*National's 1997 revenue includes all of Cyrix's 1997 revenue and part of Fairchild's calender first quarter revenue.
Source: Dataquest (October 1998)

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Chapter 2
Competitive Analysis by Product

The total number of semiconductor suppliers to the world varies with estimates now ranging above 300. Table 2-1 is an alphabetical listing of semiconductor suppliers of products surveyed by Dataquest.

Of the top 20 suppliers for 1997, Intel ranked No. 1 because of its strength in microprocessor products. Suppliers No. 2 through No. 9, listed in Table 2-2, were broad-line suppliers—suppliers to every major product segment.

Figure 2-1 illustrates the strength of the top 20 suppliers by product revenue and the dependency of some companies on single products for revenue. Figures 2-2 and 2-3 illustrates memory versus nonmemory product revenue for the top 20. Figure 2-3 strongly illustrates how a company's revenue (for example, Intel's) is highly leveraged by high-growth products. Intel has used its core technology as a profit center by expanding into applications beyond or in conjunction with the PC. The figure also illustrates the relative positions of companies that have maintained market strength and growth potential through product diversification.

Table 2-1
Semiconductor Suppliers and Product Offerings

Company	Bipolar	Memory	Micro-components	Logic/ ASIC	Analog	Discretes	Optical
8X8			X				
ACC Microelectronics			X				
Acer			X				
Actel				X			
Adaptec			X				
Advanced Micro Devices	X	X	X	X	X		
Alcatel Microelectronics				X	X		
Allegro Microsystems				X	X	X	
Alliance		X	X				
Altera				X			
Anadigics					X		
Analog Devices			X	X	X		
Appian Technology			X				
Applied Micro Circuits				X	X		
ATI Technologies			X				
Atmel		X	X	X	X		
Austrian Mikro Systeme				X	X		
Burr-Brown					X		
CID Technologies							X
California Micro Devices			X				
Catalyst		X					

Table 2-1 (Continued)
Semiconductor Suppliers and Product Offerings

Company	Bipolar	Memory	Micro-components	Logic/ ASIC	Analog	Discretes	Optical
C-Cube			X				
Cherry Semiconductor				X	X		
Chips & Technologies			X				
Chip Express				X			
Cirrus Logic Inc.			X		X		
Crosspoint Solutions				X			
Cypress Semiconductor		X	X	X			
DSP Group			X				
Daewoo Telecom		X	X	X	X		
Dallas Semiconductor			X	X	X		
Digital Equipment Corp.			X				
EM Microelectronics Marin			X		X		
ESS			X		X		
ETEQ Microsystems				X			
Eastman Kodak							X
Elantec					X		
Electronic Designs		X					
Elmos				X			
Ericsson				X	X	X	X
Eupec						X	
Exar Corporation				X	X		
Fagor Electronic						X	
Fairchild		X		X		X	
Fuji Electric			X	X	X	X	
Fujitsu	X	X	X	X	X	X	X
GEC Plessey		X	X	X	X	X	
General Semiconductor						X	
Gennum				X	X		
G-Link USA		X					
Gould AMI				X			
Harris Semiconductor		X	X	X	X	X	
Hewlett-Packard				X		X	X
Hitachi	X	X	X	X	X	X	X
Holtek		X	X	X			
Honeywell					X		X
Hualon Microelectronics		X		X	X		
Hughes Microelectronic			X	X			
Hyundai Semiconductor		X	X	X	X		
IBM		X	X	X			

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Table 2-1 (Continued)
Semiconductor Suppliers and Product Offerings

Company	Bipolar	Memory	Micro-components	Logic/ASIC	Analog	Discretes	Optical
IC Sensors							X
IMI				X			
IMP		X			X		
ISD				X			
IXYS						X	
Integrated Circuit Systems				X	X		
Integrated CMOS Technology				X			
Integrated Device Technology		X	X	X			
Integrated Silicon Solution		X					
Intel Corporation		X	X				
International Rectifier					X	X	
Korean Electronics Co.					X	X	X
LG Semicon	X	X	X	X	X		
LSI Logic Corporation			X	X			
Lattice Semiconductor				X			
Level One Communications						X	
Linear Technology					X		
Linfinity					X		
Logic Devices		X		X			
Lucent Technologies	X		X	X	X		X
Macronix		X	X	X			
Matsushita Electronics	X	X	X	X	X	X	X
Maxim Integrated Products					X		
Melexis				X	X	X	
Micrel					X		
Micro Linear Corp.				X	X		
Microchip Technology		X	X				
Micron Technology		X					
Micronas			X	X	X	X	
Microsemi						X	
Mitel Semiconductor				X	X		X
Mitsubishi Electric	X	X	X	X	X	X	X
Mosel Vitelic	X	X					
Motorola Semiconductor	X	X	X	X	X	X	X
Music Semiconductor							
NEC Corporation	X	X	X	X	X	X	X
National Semiconductor	X	X	X	X	X	X	
New Japan Radio			X	X	X	X	
Nippon Steel Semiconductor		X					

Table 2-1 (Continued)
Semiconductor Suppliers and Product Offerings

Company	Bipolar	Memory	Micro-components	Logic/ASIC	Analog	Discretes	Optical
OPTi			X				
Oak Technology			X				
Oki Semiconductor	X	X	X	X	X	X	X
Optek Technology Inc.					X	X	X
PMC Sierra Semiconductor				X	X		
Paradigm		X					
Philips Electronics	X	X	X	X	X	X	
Powerex Inc.						X	
Power Innovations						X	
Q Logic			X				
Quality Semiconductor		X		X			
Quality Technologies							X
Quick Logic				X			
Ramtron		X					
Raytheon				X	X	X	
Ricoh		X	X	X	X		
Robert Bosch				X	X	X	
Rockwell International			X	X	X		
Rohm		X	X	X	X	X	X
S3			X				
Samsung Electronics		X	X	X	X	X	X
Sanken					X	X	X
SANYO		X	X	X	X	X	X
SEEQ Technology			X		X		
Seiko Epson		X	X	X	X		
Semikron International						X	
Semtech Corporation					X	X	
Sharp		X	X	X	X		X
Shindengen Electric						X	
Siemens AG	X	X	X	X	X	X	X
Silicon Storage Technology			X				
Solitron Devices					X	X	
Sony Corporation		X	X	X	X	X	X
Spectra Diode Labs							X
Standard Micro Systems			X				
Stanley Electric							X
STMicroelectronics		X	X	X	X	X	
Sun Microsystems			X				
Supertex				X	X	X	

Table 2-1 (Continued)
Semiconductor Suppliers and Product Offerings

Company	Bipolar	Memory	Micro-components	Logic/ASIC	Analog	Discretes	Optical
Symbios			X	X			
Symphony Labs			X				
TCS			X	X	X	X	X
Teccor Electronics						X	
Telcom					X		
TEMIC		X	X	X	X	X	X
Texas Instruments	X	X	X	X	X	X	X
Toshiba Corporation	X	X	X	X	X	X	X
Trident Microsystems			X				
Triquent					X		
Tseng Labs			X				
United Microelectronics		X	X				
Unitrode Corporation					X		
Vanguard		X					
VIA			X				
Vitesse				X	X		
VLSI Technology			X	X			
VTC					X		
WaferScale Integration		X	X	X			
Winbond Electronics		X	X	X	X		
Xicor Inc.		X					
Xilinx				X			
Yamaha		X	X	X	X		
Zetex Semiconductors				X	X	X	
Zilog			X				
Zoran			X				

Source: Dataquest (October 1998)

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Table 2-2
Top 20 Semiconductor Suppliers' Revenue, 1997 (Millions of Dollars)

Company	Semi-conductors	ICs	Bipolar Digital	Memory	Micro-components	Logic	Analog	Discretes	Optical
Intel	21,746	21,746	0	850	20,896	0	0	0	0
NEC	10,222	9,014	82	3,215	2,404	2,701	612	885	323
Motorola	8,067	6,585	264	435	3,530	938	1,418	1,446	36
Texas Instruments	7,352	7,292	293	1,524	1,728	1,552	2,195	0	60
Toshiba	7,253	5,340	32	1,485	1,336	1,467	1,020	1,484	429
Hitachi	6,298	5,233	262	2,209	1,683	703	376	949	116
Samsung	5,856	5,489	0	4,623	237	307	322	355	12
Fujitsu	4,622	4,135	63	1,508	967	1,270	327	319	168
Philips	4,440	3,416	80	73	791	755	1,717	1,024	0
STMicroelectronics	4,019	3,447	0	502	616	438	1,891	572	0
Mitsubishi	3,925	3,280	24	1,435	936	441	444	460	185
Siemens	3,441	2,503	37	1,028	333	23	1,082	554	384
IBM	3,391	3,391	0	990	803	1,598	0	0	0
Matsushita	2,847	1,882	19	315	457	536	555	577	388
Lucent Technologies	2,762	2,489	10	0	888	1,486	105	0	273
National Semiconductor	2,759	2,624	14	2	1,101	149	1,358	135	0
SANYO	2,471	1,818	0	162	229	577	850	478	175
Advanced Micro Devices	2,341	2,341	28	708	1,106	309	190	0	0
Sharp	2,145	1,430	0	624	207	501	98	0	715
Rohm	2,053	869	0	48	22	264	535	827	357
Total Market	**147,165**	**127,571**	**1,849**	**30,978**	**48,945**	**24,757**	**21,652**	**14,255**	**5,339**

Source: Dataquest (October 1998)

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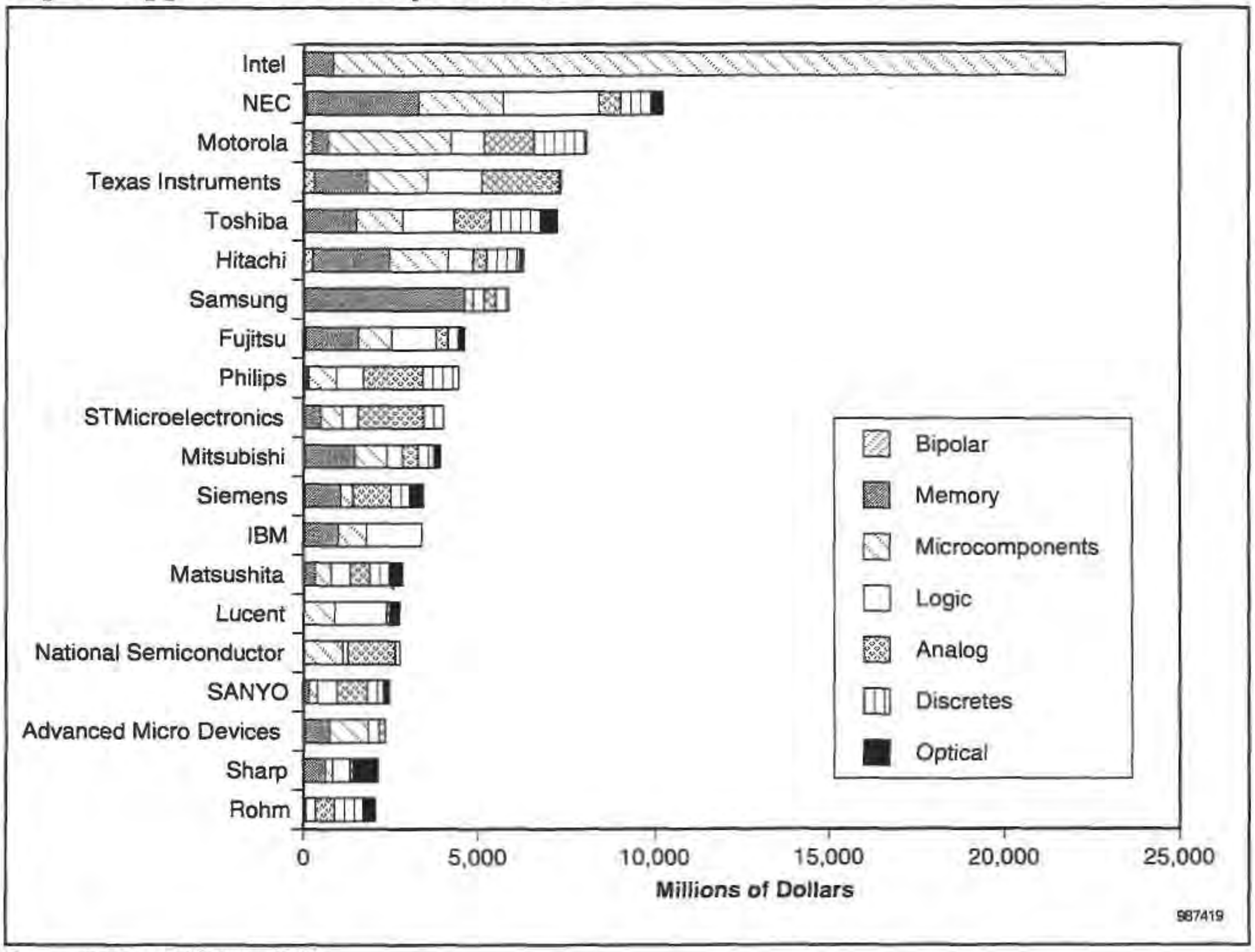
Figure 2-1
Top 20 Suppliers' Revenue by Product, 1997



Source: Dataquest (October 1998)

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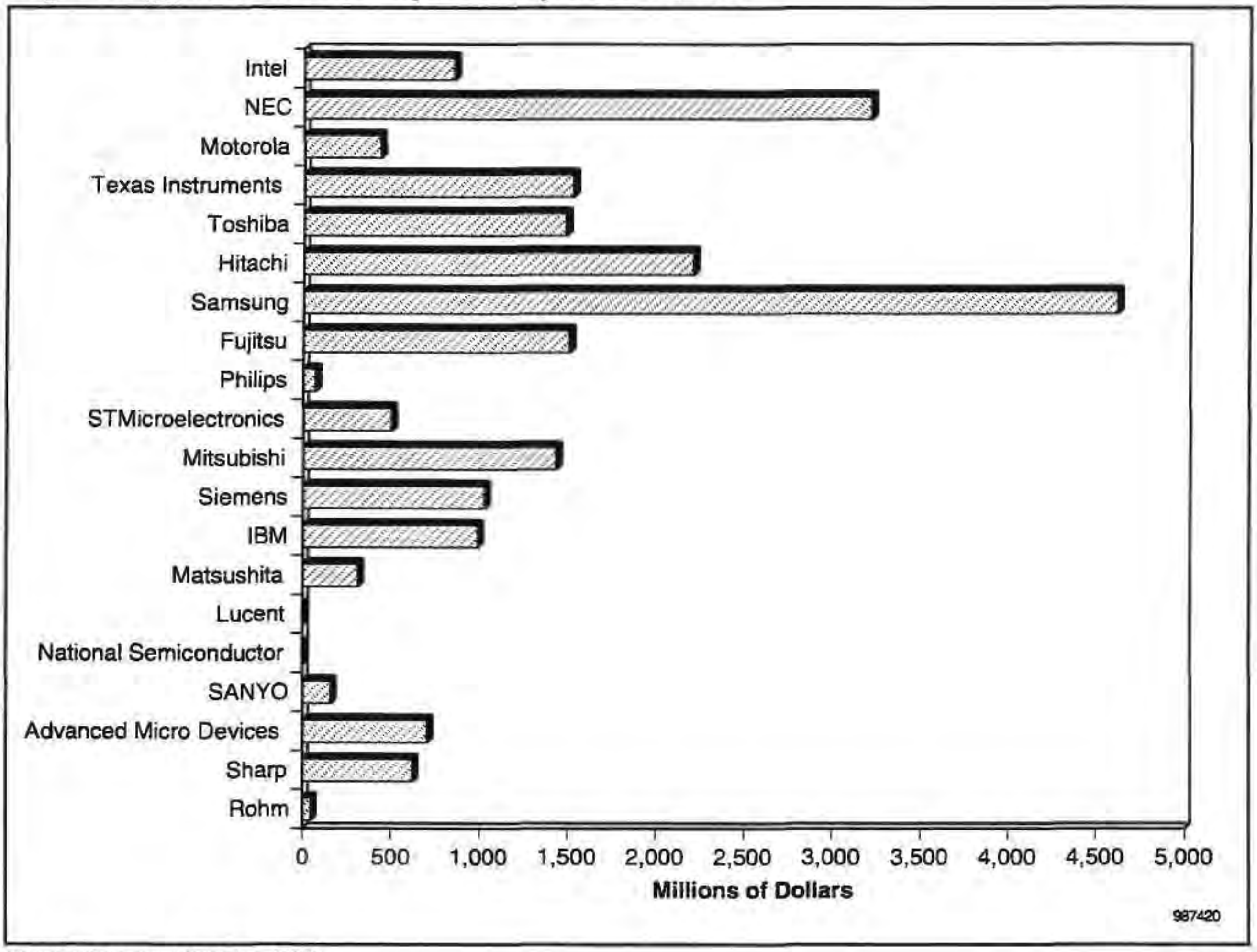
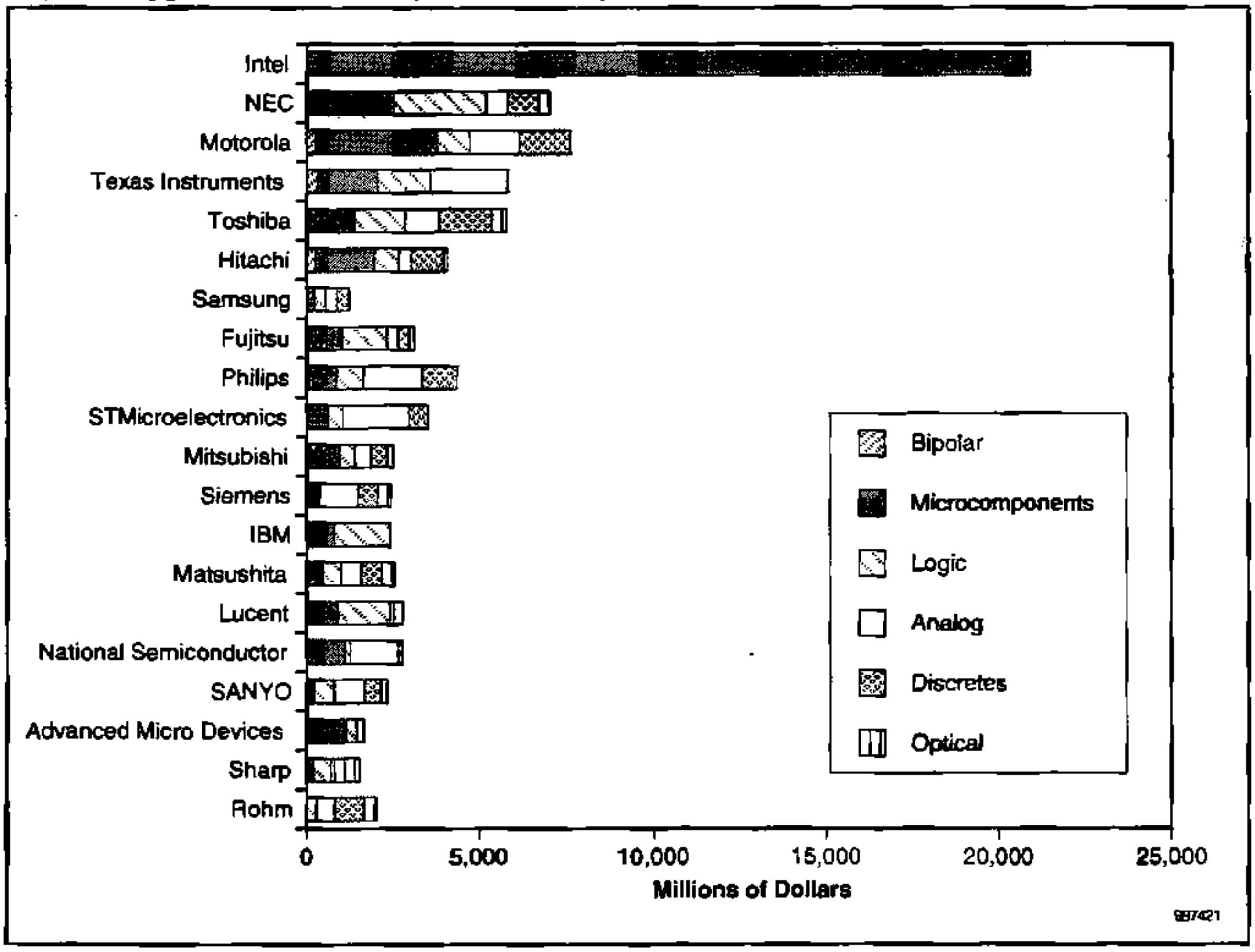
Figure 2-2
Top 20 Suppliers' Revenue by Memory Product, 1997



Source: Dataquest (October 1998)

Figure 2-3
Top 20 Suppliers' Revenue by Nonmemory Product, 1997



Source: Dataquest (October 1998)

Chapter 3
Competitive Positions by Region

Two decades of incremental changes in process technology, monumental capital investment in fab equipment and facilities, and a serious market downturn resulted in a major reshuffling of the top 20 in 1997. Table 3-1 offers a quick review of regional consumption. The market has seen significant fluctuations in regional shares. Price instability, moderate growth of PCs, currency devaluations, and regional recessions changed regional shares for vendors in Japan and Asia/Pacific. Table 3-2 provides the production by region. A vendor's region is defined as its home base of origin, not the region where the vendor's devices are fabricated.

Table 3-3 is a summary of product share for the suppliers headquartered in the four regions. The regions with the largest share of product revenue have been highlighted. Americas vendors' strength is in the bipolar digital, microcomponent, logic, and analog product areas. Japan is the second-largest vendor region and is dominant in the memory, discrete, and optical product arenas. Table 3-4 is a review of the top 20 semiconductor suppliers by their regional market revenue and share of the worldwide market. Intel is the only semiconductor supplier that maintains strong revenue share in all four regions. More specific company details for the top 20 are outlined in Chapter 4.

Table 3-1
Semiconductor Consumption by Region, 1987-1997 (Millions of Dollars)

Region	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Americas	12,858	15,844	17,070	16,540	16,990	20,430	27,924	35,773	48,343	45,672	48,086
Japan	14,927	20,772	21,491	20,257	22,496	20,582	24,645	31,008	42,086	38,413	36,499
Europe	6,498	8,491	9,498	10,415	11,014	12,218	15,459	20,900	28,416	28,379	30,046
Asia/Pacific	3,968	5,752	6,280	7,333	9,194	12,034	17,486	22,832	32,465	29,686	32,534
Total	**38,251**	**50,859**	**54,339**	**54,545**	**59,694**	**65,260**	**85,514**	**110,513**	**151,310**	**142,150**	**147,165**

Source: Dataquest (October 1998)

Table 3-2
Semiconductor Production by Region, 1987-1997 (Millions of Dollars)

Region	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Americas	14,930	18,586	19,515	21,047	22,940	26,943	37,083	46,052	60,021	64,076	72,339
Japan	18,450	25,942	27,510	25,278	27,685	27,576	34,573	44,778	60,599	50,884	47,825
Europe	4,200	4,917	5,300	6,108	6,336	6,666	7,645	9,834	12,837	13,682	14,809
Asia/Pacific	671	1,414	2,014	2,112	2,734	4,075	6,213	9,849	17,805	13,508	12,192

Source: Dataquest (October 1998)

Table 3-3
Vendors' Share of Product Revenue, 1997 (Percent)

Product Categories	Total Revenue ($M)	Americas	Japan	Europe	Asia/Pacific
Bipolar Digital	1,239	**49.2**	39.1	9.4	0
MOS Memory	30,978	27.0	**38.2**	5.2	29.6
MOS Microcomponents	48,945	**75.5**	18.0	3.9	2.6
MOS Logic	24,757	**48.7**	40.2	8.6	2.5
Analog	21,652	**45.9**	26.8	24.9	2.5
Discretes	14,255	23.8	**50.4**	21.8	4.0
Optical Semiconductors	5,339	18.7	**70.4**	10.4	0.6
Total	**147,165**	**49.2**	**32.5**	**10.1**	**8.3**

Source: Dataquest (October 1998)

Table 3-4
Top 20 Suppliers' Revenue by Regional Market, 1997 (Millions of Dollars)

Company	Americas	Japan	Europe	Asia/Pacific	Worldwide Share (%)
Intel	9,621	5,811	2,237	4,077	14.8
NEC	2,131	1,099	5,666	1,326	6.9
Motorola	3,879	1,885	621	1,682	5.5
Texas Instruments	2,202	1,748	1,549	1,853	5.0
Toshiba	1,337	625	3,484	1,807	4.9
Hitachi	1,181	759	3,355	1,003	4.3
Samsung	2,105	1,240	589	1,922	4.0
Fujitsu	756	621	2,768	477	3.1
Philips	831	1,847	182	1,580	3.0
STMicroelectronics	952	1,777	215	1,075	2.7
Mitsubishi	809	397	2,030	689	2.7
Siemens	651	2,182	57	551	2.3
IBM	2,679	332	132	248	2.3
Matsushita	148	15	2,244	440	1.9
Lucent Technologies	1,351	593	186	632	1.9
National Semiconductor	1,116	707	227	709	1.9
SANYO	179	99	1,292	901	1.7
Advanced Micro Devices	1,032	679	160	470	1.6
Sharp	135	86	1,491	433	1.5
Rohm	125	134	968	826	1.4

Source: Dataquest (October 1998)

Chapter 4
Top 20 Supplier Profiles

No. 1: Intel

Intel posted a 20 percent increase in corporate revenue in 1997 over 1996. One of the company's major announcements concerned the purchase of Digital Equipment Corporation's semiconductor operations for $700 million. This acquisition brought several facilities under the expanding Intel umbrella. The facilities include the Hudson, Massachusetts, group and development operations in Jerusalem, Israel, and Austin, Texas.

Intel's net sales from all business sectors were more than $25 billion. The company grew its semiconductor share of revenue by 22.3 percent in 1997. Intel surpassed the No. 2 supplier, NEC, by more than $11.5 billion and the No. 3 supplier, Motorola, by $13.6 billion. As of 1997, Intel had introduced its latest 0.25-micron manufacturing process technology for its next generation of microprocessor products. Intel's R&D spending for 1997 was $2.4 billion. Intel's strategy is to introduce higher-performance microprocessors for the worldwide computer market that includes servers, workstations, higher-end PCs, basic PCs, and other product lines. Intel's geographic distribution for total revenue was as follows: North America, 44 percent; Europe, 27 percent; Asia/Pacific, 19 percent; and Japan, 10 percent. Table 4-1 illustrates the distribution of Intel's semiconductor revenue in 1997 by product and by region.

Intel's strength lies in the microprocessor market. It now lays claim to more than 42 percent of the world's microprocessor market. Intel is not a broad-line semiconductor supplier. Table 4-2 is a 10-year history of Intel's revenue for each of the major semiconductor product categories.

Figure 4-1 illustrates the difference between Intel's growth rate and that of the total semiconductor industry since 1987. Intel's level of spending for microprocessor technology has ranked as high as that of the largest memory capital spenders in the industry. Intel introduced its 0.25-micron technology in 1997. Figure 4-2 illustrates Intel's capital spending versus the Americas region's spending history. The majority of Intel's spending is targeted at development of high-performance microprocessor technology and related manufacturing technology. Table 4-3 lists the contribution of each of Intel's product types to Intel's total semiconductor revenue.

Table 4-4 lists the market shares of Intel's products in the worldwide market.

Table 4-1
Intel's Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**9,621**	**5,811**	**2,237**	**4,077**	**21,746**
Total Integrated Circuit	9,621	5,811	2,237	4,077	21,746
MOS Digital IC	9,621	5,811	2,237	4,077	21,746
MOS Memory	337	222	108	183	850
MOS Microcomponent	9,284	5,589	2,129	3,894	20,896

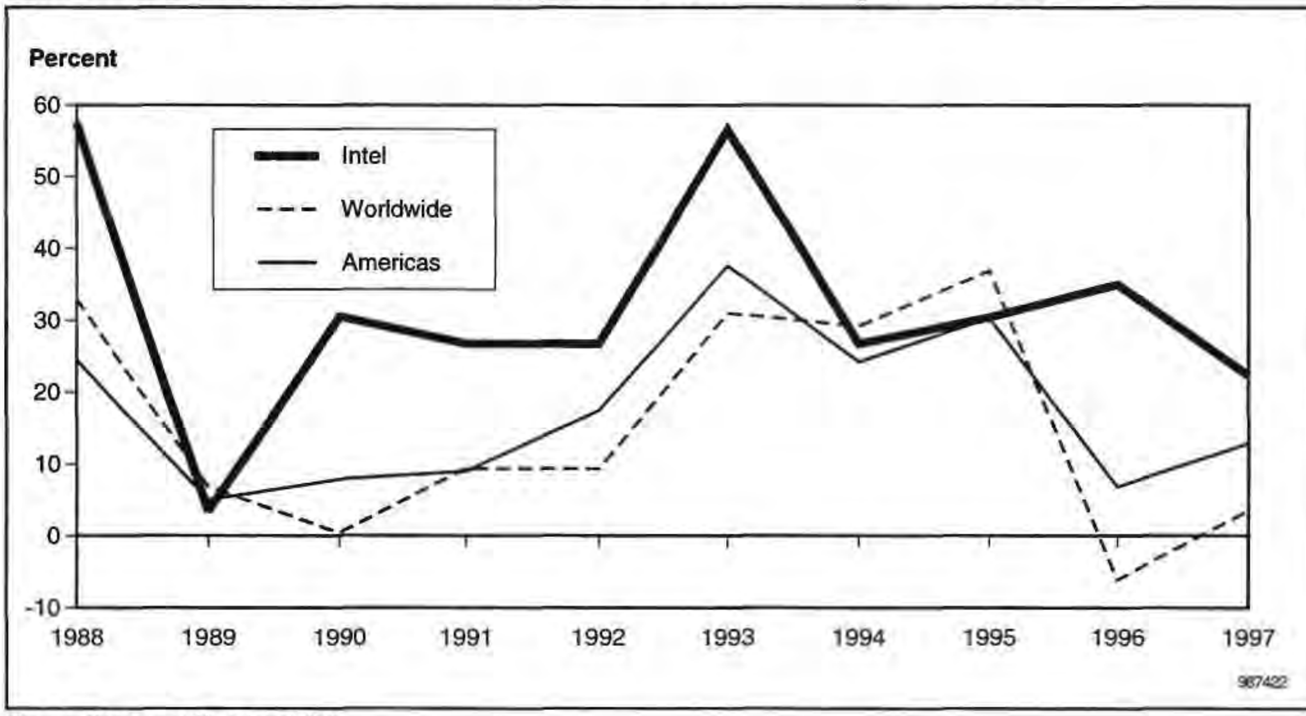
Source: Dataquest (October 1998)

Table 4-2
Intel's Product Profile, 1987-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	1,491	1,491	326	1,087	78	0	0	0
1988	2,350	2,350	392	1,835	123	0	0	0
1989	2,430	2,430	433	1,929	68	0	0	0
1990	3,171	3,171	371	2,726	65	9	0	0
1991	4,019	4,019	395	3,578	37	9	0	0
1992	5,091	5,091	324	4,721	36	10	0	0
1993	7,970	7,970	468	7,444	46	12	0	0
1994	10,099	10,099	458	9,595	26	20	0	0
1995	13,171	13,171	766	12,397	0	9	0	0
1996	17,781	17,781	950	16,831	0	0	0	0
1997	21,746	21,746	850	20,896	0	0	0	0
1996-1997 Growth (%)	22.3	22.3	-10.5	24.2	0	0	0	0

Source: Dataquest (October 1998)

Figure 4-1
Intel's Annual Growth versus the Semiconductor Industry's, 1987-1997



Source: Dataquest (October 1998)

Chapter 4

Top 20 Supplier Profiles

Please see Errata

No. 1: Intel

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Intel's net sales from all business sectors were more than $78.5 billion. The company grew its semiconductor share of revenue by 22.3 percent in 1997. Intel surpassed the No. 2 supplier, NEC, by more than $11.5 billion and the No. 3 supplier, Motorola, by $13.6 billion. As of 1997, Intel had introduced its latest 0.25-micron manufacturing process technology for its next generation of microprocessor products. Intel's R&D spending for 1997 was $2.4 billion. Intel's strategy is to introduce higher-performance microprocessors for the worldwide computer market that includes servers, workstations, higher-end PCs, basic PCs, and other product lines. Intel's geographic distribution for total revenue was as follows: North America, 44 percent; Europe, 27 percent; Asia/Pacific, 19 percent; and Japan, 10 percent. Table 4-1 illustrates the distribution of Intel's semiconductor revenue in 1997 by product and by region.

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Source: Dataquest (October 1998)

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Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	1,491	1,491	326	1,087	78	0	0	0
1988	2,350	2,350	392	1,835	123	0	0	0
1989	2,430	2,430	433	1,929	68	0	0	0
1990	3,171	3,171	371	2,726	65	9	0	0
1991	4,019	4,019	395	3,578	37	9	0	0
1992	5,091	5,091	324	4,721	36	10	0	0
1993	7,970	7,970	468	7,444	46	12	0	0
1994	10,099	10,099	458	9,595	26	20	0	0
1995	13,171	13,171	766	12,397	0	9	0	0
1996	17,781	17,781	950	16,831	0	0	0	0
1997	21,746	21,746	850	20,896	0	0	0	0
1996-1997 Growth (%)	22.3	22.3	-10.5	24.2	0	0	0	0

Source: Dataquest (October 1998)

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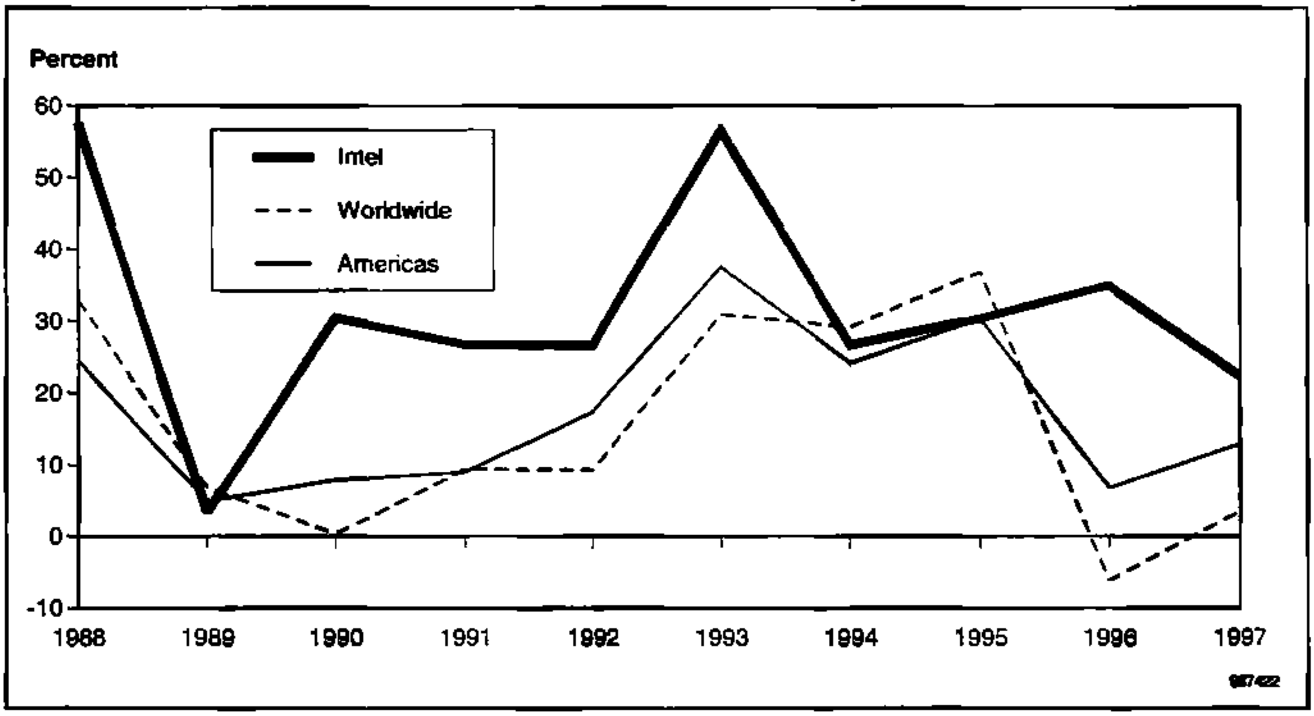
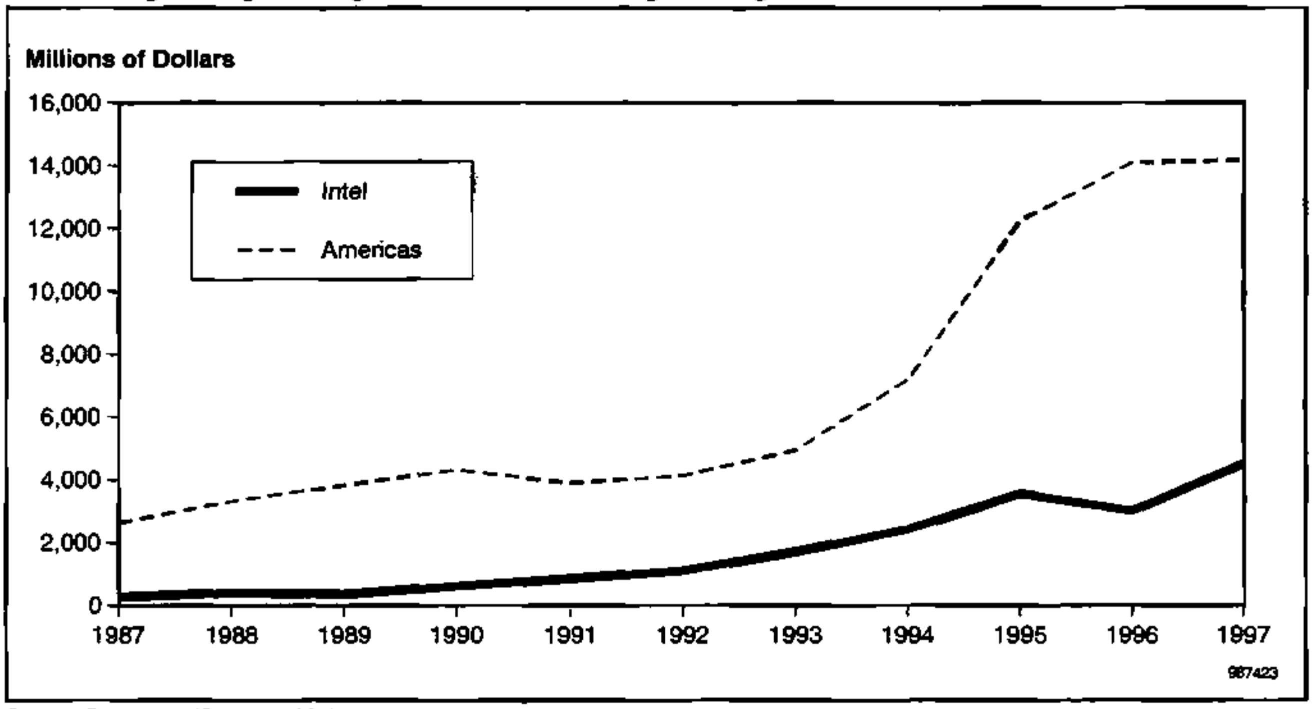


Source: Dataquest (October 1998)

Figure 4-2
Intel's Capital Spending versus Americas Spending



Source: Dataquest (October 1998)

Table 4-3
Intel's Product Profile, 1987-1997 (Percentage of Intel's Total Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	100.0	100.0	21.9	72.9	5.2	0	0	0
1988	100.0	100.0	16.7	78.1	5.2	0	0	0
1989	100.0	100.0	17.8	79.4	2.8	0	0	0
1990	100.0	100.0	11.7	86.0	2.0	0.3	0	0
1991	100.0	100.0	9.8	89.0	0.9	0.2	0	0
1992	100.0	100.0	6.4	92.7	0.7	0.2	0	0
1993	100.0	100.0	5.9	93.4	0.6	0.2	0	0
1994	100.0	100.0	4.5	95.0	0.3	0.2	0	0
1995	100.0	100.0	5.8	94.1	0	0.1	0	0
1996	100.0	100.0	5.3	94.7	0	0	0	0
1997	100.0	100.0	3.9	96.1	0	0	0	0

Source: Dataquest (October 1998)

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Table 4-4
Intel's Worldwide Market Shares by Product, 1987-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	3.9	5.0	4.9	21.3	0.7	0	0	0
1988	4.6	5.7	3.2	25.7	1.0	0	0	0
1989	4.5	5.4	2.7	24.7	0.6	0	0	0
1990	5.8	7.1	3.0	28.4	0.5	0.1	0	0
1991	6.7	8.2	3.0	30.4	0.3	0.1	0	0
1992	7.8	9.4	2.1	32.9	0.3	0.1	0	0
1993	9.3	10.9	2.0	37.3	0.3	0.1	0	0
1994	9.1	10.5	1.4	36.3	0.1	0.1	0	0
1995	8.7	9.9	1.4	35.9	0	0	0	0
1996	12.5	14.4	2.5	40.7	0	0	0	0
1997	14.8	17.0	2.7	42.7	0	0	0	0

Source: Dataquest (October 1998)

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No. 2: NEC

NEC maintained the No. 2 position, but lost market share worldwide. The company's market share declined from 7.3 percent in 1996 to 6.9 percent in 1997. Like many DRAM manufacturers, NEC saw its semiconductor revenue decline as memory prices dropped below cost and relative price pressures affected all semiconductor products. Table 4-5 shows the source of NEC's revenue in 1997 by product and region.

NEC was established in 1899; its 1997 business sectors encompassed computers and industrial electronic systems (42 percent), communication systems and equipment (34 percent), electronic devices (20 percent), and other products (4 percent). A 10-year history of NEC's revenue for each of the major semiconductor product categories is given in Table 4-6. NEC's overall revenue ranking suffered because of a decline in memory revenue. NEC's ASIC and microcomputer sectors reported higher sales because of brisk demand for notebook PCs in Japan and other regions in 1997.

Figure 4-3 illustrates the difference between NEC's growth rate and that of the total semiconductor industry since 1987. Figure 4-4 illustrates NEC's capital spending history and how it compares to the region's total spending during the same time frame.

The contribution of each of the product categories to NEC's total semiconductor sales is shown in Table 4-7. Over 10 years, NEC's product mix has shown a decline in the importance of analog and discrete devices as microcomponents, memory, and logic ICs have gained in importance.

NEC's market shares for the worldwide market by product are shown in Table 4-8. The company's share of worldwide memory at 10.4 percent is stronger than before 1989. NEC continues to prove that it can survive severe DRAM downturns.

Table 4-5
NEC's Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**2,131**	**1,099**	**5,666**	**1,326**	**10,222**
Total Integrated Circuit	2,022	1,029	4,880	1,083	9,014
Total Bipolar Digital	4	17	59	2	82
MOS Digital IC	1,980	981	4,424	935	8,320
MOS Memory	1,270	446	1,067	432	3,215
MOS Microcomponent	286	301	1,510	307	2,404
MOS Digital Logic	424	234	1,847	196	2,701
Analog-Monolithic	38	31	397	146	612
Total Discrete	76	54	604	151	885
Total Optical Semiconductor	33	16	182	92	323

Source: Dataquest (October 1998)

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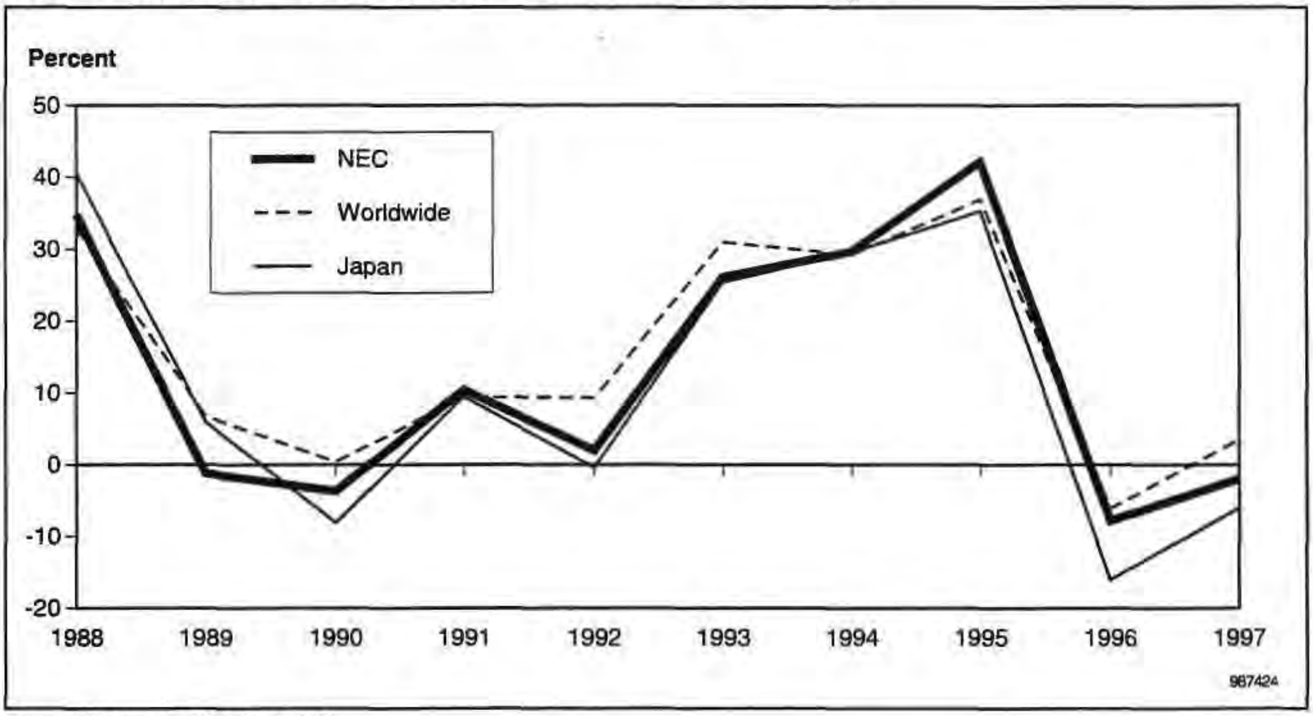
Table 4-6
NEC's Product Profile, 1987-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	3,368	2,795	871	566	816	542	518	55
1988	4,543	3,884	1,534	790	1,091	469	571	88
1989	4,489	3,893	1,615	841	1,060	377	489	107
1990	4,322	3,735	1,253	981	1,124	377	479	108
1991	4,774	4,109	1,261	1,149	1,277	422	544	121
1992	4,869	4,227	1,441	1,130	1,242	414	532	110
1993	6,141	5,444	2,189	1,341	1,439	475	579	118
1994	7,961	7,159	3,112	1,678	1,765	604	652	150
1995	11,314	10,281	5,362	2,061	2,087	641	831	202
1996	10,428	9,354	3,921	2,179	2,505	624	818	256
1997	10,222	9,014	3,215	2,404	2,701	612	885	323
1996-1997 Growth (%)	-2.0	-3.6	-17.8	10.3	11.5	-1.9	8.2	26.2

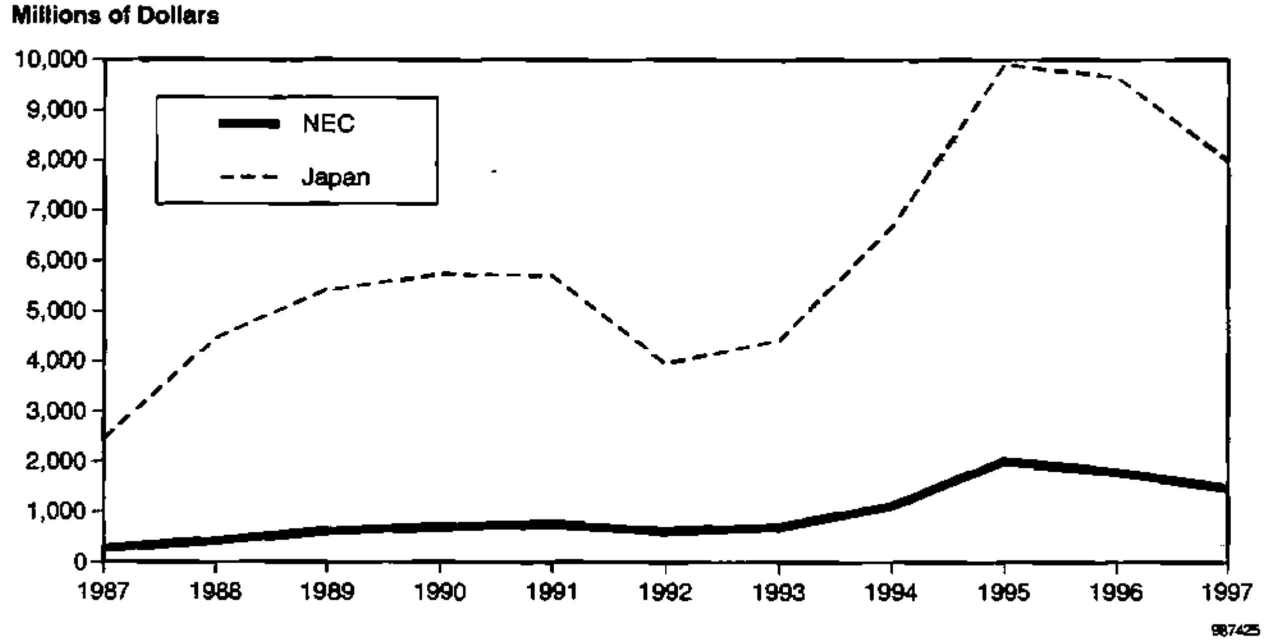
Source: Dataquest (October 1998)

Figure 4-3
NEC's Annual Growth versus the Semiconductor Industry's



Source: Dataquest (October 1998)

Figure 4-4
NEC's Capital Spending versus Japan's Spending



Source: Dataquest (October 1998)

Table 4-7
NEC's Product Profile, 1987-1997 (Percentage of NEC's Total Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	100.0	83.0	25.9	16.8	24.2	16.1	15.4	1.6
1988	100.0	85.5	33.8	17.4	24.0	10.3	12.6	1.9
1989	100.0	86.7	36.0	18.7	23.6	8.4	10.9	2.4
1990	100.0	86.4	29.0	22.7	26.0	8.7	11.1	2.5
1991	100.0	86.1	26.4	24.1	26.7	8.8	11.4	2.5
1992	100.0	86.8	29.6	23.2	25.5	8.5	10.9	2.3
1993	100.0	88.7	35.6	21.8	23.4	7.7	9.4	1.9
1994	100.0	89.9	39.1	21.1	22.2	7.6	8.2	1.9
1995	100.0	90.9	47.4	18.2	18.4	6.8	7.4	1.8
1996	100.0	89.7	37.6	20.9	24.0	6.0	7.8	2.5
1997	100.0	88.2	31.5	23.5	26.4	6.0	8.7	3.2

Source: Dataquest (October 1998)

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Table 4-8
NEC's Worldwide Market Shares by Product, 1987-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	8.8	9.4	13.0	11.1	7.8	7.1	7.8	3.2
1988	8.9	9.5	12.4	11.1	8.6	5.3	7.5	4.0
1989	8.3	8.7	10.2	10.8	9.0	4.1	6.7	4.4
1990	7.9	8.4	10.0	10.2	9.2	3.7	6.2	4.5
1991	8.0	8.4	9.6	9.8	9.8	3.9	6.8	4.3
1992	7.5	7.8	9.2	7.9	9.6	3.6	6.5	4.1
1993	7.2	7.4	9.3	6.7	9.0	3.4	6.4	3.9
1994	7.2	7.5	9.2	6.4	9.4	3.6	6.1	3.9
1995	7.5	7.8	9.7	6.0	9.1	3.9	5.9	4.2
1996	7.4	7.6	10.3	5.3	11.2	3.2	6.1	5.2
1997	6.9	7.1	10.4	4.9	10.9	2.8	6.2	6.0

Source: Dataquest (October 1998)

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No. 3: Motorola

Motorola kept its No. 3 position in 1997. The company has been one of the leading providers of wireless communication, semiconductor, and advanced electronic systems components and servers. Motorola's equipment sector includes cellular telephones, two-way radio paging, and data communications, as well as personal communications, automotive, defense and space electronics, and computers. Motorola continues to shift a major portion of its semiconductor-related operations to outsourcing. Motorola's total R&D spending for 1997 was $2.8 billion. Table 4-9 shows the source of Motorola's semiconductor revenue in 1997 by product and region.

Motorola's company sales reached $29.8 billion in 1997. This was a marginal climb from $28 billion in 1996 and $27 billion in 1995. A 10-year history of Motorola's revenue by product is listed in Table 4-10.

Figure 4-5 illustrates the difference between Motorola's growth rate and that of the total semiconductor industry since 1987. Figure 4-6 illustrates Motorola's capital spending history and how it compares to the region's total spending during the same time frame.

The contribution of each of the product categories to Motorola's total semiconductor revenue is shown in Table 4-11. The company's share of the worldwide market is listed in Table 4-12.

Table 4-9
Motorola's Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**3,879**	**1,885**	**621**	**1,682**	**8,067**
Total Integrated Circuit	3,080	1,577	556	1,372	6,585
Total Bipolar Digital	136	40	59	29	264
MOS Digital IC	2,344	1,254	358	947	4,903
MOS Memory	285	71	29	50	435
MOS Microcomponent	1,635	986	224	685	3,530
MOS Digital Logic	424	197	105	212	938
Analog-Monolithic	600	283	139	396	1,418
Total Discrete	783	302	64	297	1,446
Total Optical Semiconductor	16	6	1	13	36

Source: Dataquest (October 1998)

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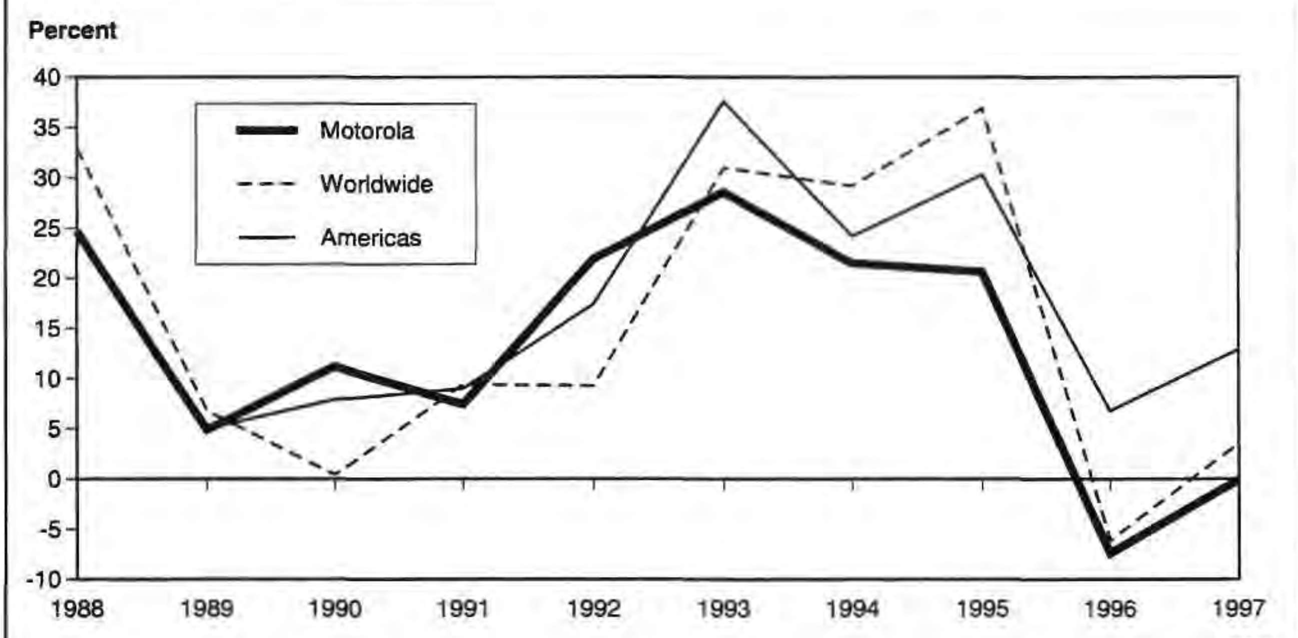
Table 4-10
Motorola's Product Profile, 1987-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	2,434	1,758	99	520	800	339	652	24
1988	3,035	2,259	243	699	892	425	752	24
1989	3,183	2,392	411	767	778	436	766	25
1990	3,539	2,714	398	970	864	482	799	26
1991	3,802	2,980	415	1,171	938	456	794	28
1992	4,634	3,741	613	1,464	1,013	651	857	36
1993	5,957	4,922	764	2,065	1,215	878	994	41
1994	7,238	6,096	949	2,363	1,634	1,150	1,097	45
1995	8,722	7,022	1,259	2,987	1,745	1,031	1,650	50
1996	8,076	6,584	847	3,153	1,374	1,210	1,452	40
1997	8,067	6,585	435	3,530	938	1,418	1,446	36
1996-1997 Growth (%)	-0.1	0	-47.4	12.0	-17.2	18.2	-0.4	-10.0

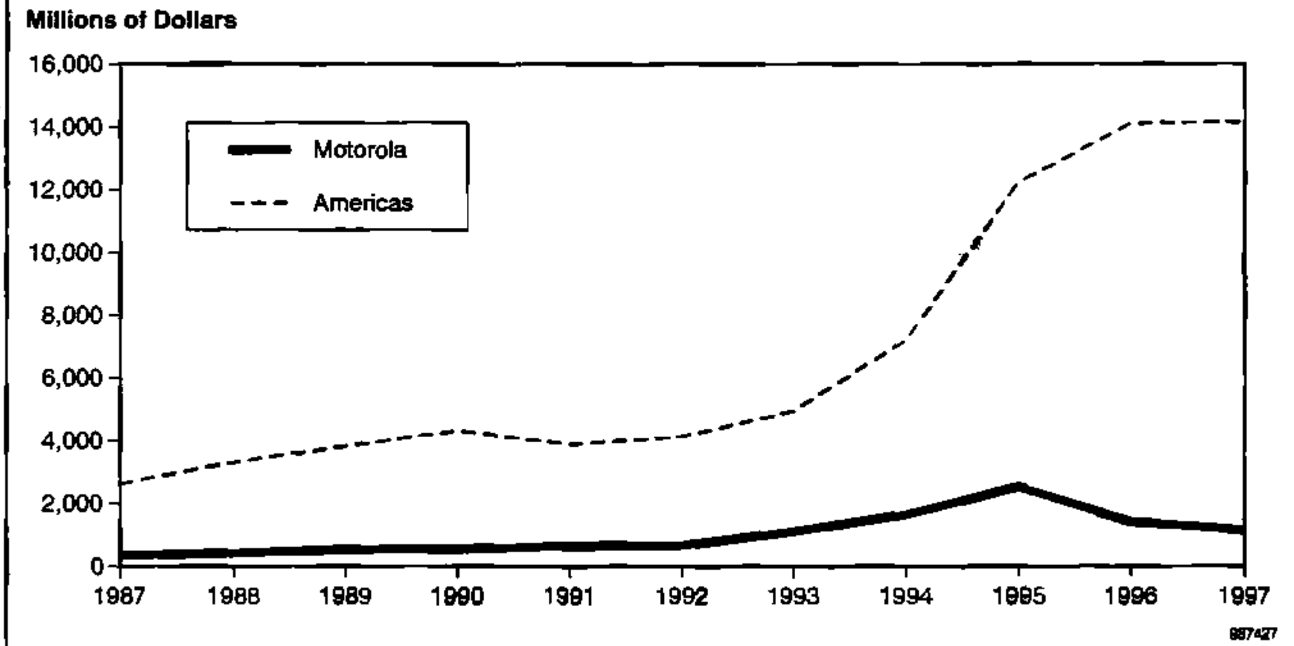
Source: Dataquest (October 1998)

Figure 4-5
Motorola's Annual Growth versus the Semiconductor Industry's



Source: Dataquest (October 1998)

Figure 4-6
Motorola's Capital Spending versus Americas Spending



Source: Dataquest (October 1998)

Table 4-11
Motorola's Product Profile, 1987-1997 (Percentage of Motorola's Total Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	100.0	72.2	4.1	21.4	32.9	13.9	26.8	1.0
1988	100.0	74.4	8.0	23.0	29.4	14.0	24.8	0.8
1989	100.0	75.1	12.9	24.1	24.4	13.7	24.1	0.8
1990	100.0	76.7	11.2	27.4	24.4	13.6	22.6	0.7
1991	100.0	78.4	10.9	30.8	24.7	12.0	20.9	0.7
1992	100.0	80.7	13.2	31.6	21.9	14.0	18.5	0.8
1993	100.0	82.6	12.8	34.7	20.4	14.7	16.7	0.7
1994	100.0	84.2	13.1	32.6	22.6	15.9	15.2	0.6
1995	100.0	80.5	14.4	34.2	20.0	11.8	18.9	0.6
1996	100.0	81.5	10.5	39.0	17.0	15.0	18.0	0.5
1997	100.0	81.6	5.4	43.8	11.6	17.6	17.9	0.4

Source: Dataquest (October 1998)

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Table 4-12
Motorola's Worldwide Market Shares by Product, 1987-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	6.4	5.9	1.5	10.2	7.7	4.4	9.8	1.4
1988	6.0	5.5	2.0	9.8	7.0	4.8	9.9	1.1
1989	5.9	5.4	2.6	9.8	6.6	4.8	10.5	1.0
1990	6.5	6.1	3.2	10.1	7.1	4.8	10.4	1.1
1991	6.4	6.1	3.1	9.9	7.2	4.2	9.9	1.0
1992	7.1	6.9	3.9	10.2	7.8	5.7	10.5	1.3
1993	7.0	6.7	3.2	10.4	7.6	6.3	10.9	1.4
1994	6.5	6.4	2.8	8.9	8.7	6.8	10.2	1.2
1995	5.8	5.3	2.2	8.7	6.0	5.9	11.5	1.0
1996	5.7	5.3	2.2	7.6	5.9	6.3	10.8	0.8
1997	5.5	5.2	1.4	7.2	3.8	6.5	10.1	0.7

Source: Dataquest (October 1998)

No. 4: Texas Instruments

Texas Instruments jumped into the No. 4 position, displacing Hitachi in 1997. Table 4-13 lists the distribution of TI's 1997 semiconductor revenue by product and region.

TI sold off its DRAM business to Micron Technology in 1997. A 10-year history of TI's revenue for each of the major semiconductor product categories is given in Table 4-14.

Figure 4-7 illustrates the difference between TI's growth rate and that of the total semiconductor industry since 1987. Figure 4-8 illustrates TI's capital spending history and how it compares to the region's spending during the same time frame.

The contribution of each of the product categories to TI's total semiconductor sales is shown in Table 4-15. Up through 1993, logic ICs have been the dominant piece of TI's product line. TI has shifted its focus to microcomponents and analog. Table 4-16 lists TI's worldwide shares by product.

Table 4-13
Texas Instruments' Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**2,202**	**1,748**	**1,549**	**1,853**	**7,352**
Total Integrated Circuit	2,192	1,741	1,506	1,853	7,292
Total Bipolar Digital	110	43	90	50	293
MOS Digital IC	1,548	1,333	868	1,055	4,804
MOS Memory	552	421	230	321	1,524
MOS Microcomponent	589	554	203	382	1,728
MOS Digital Logic	407	358	435	352	1,552
Analog-Monolithic	534	365	548	748	2,195
Amplifier/Comparator	61	60	20	45	186
Total Optical Semiconductor	10	7	43	0	60

Source: Dataquest (October 1998)

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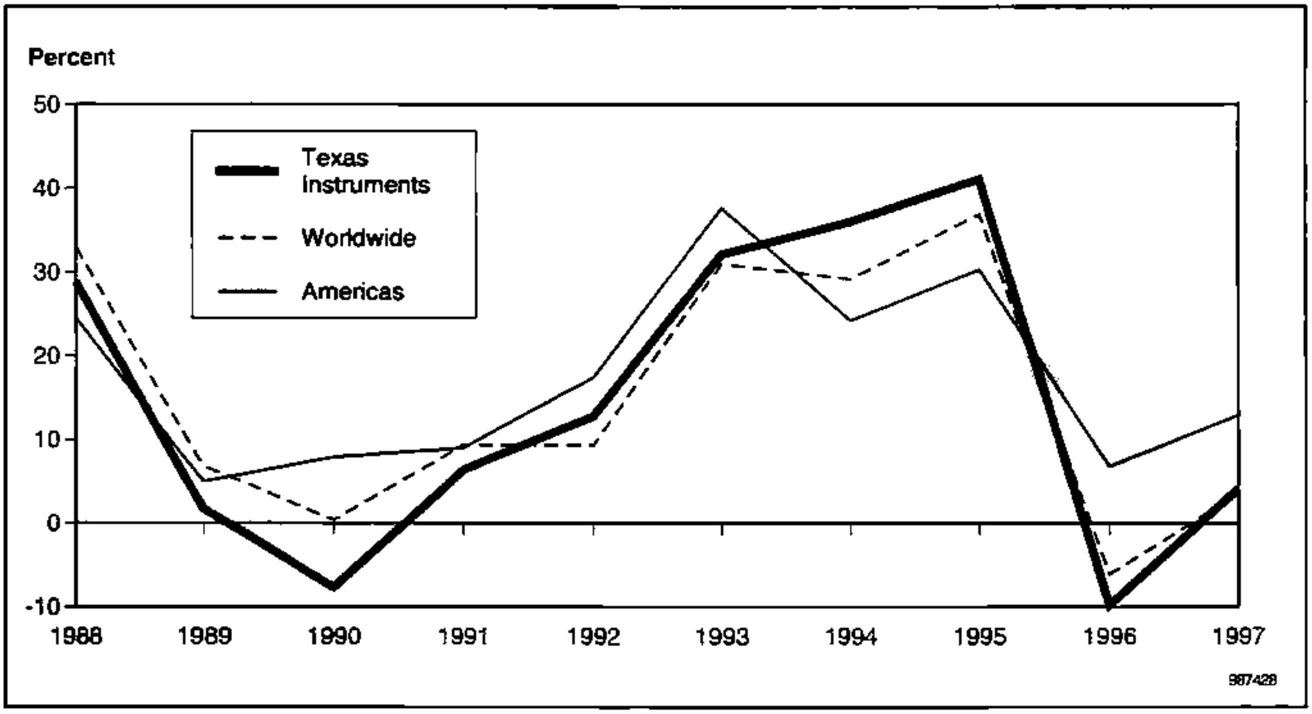
Table 4-14
Texas Instruments' Product Profile, 1987-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	2,127	2,024	495	169	974	386	64	39
1988	2,741	2,637	884	234	1,093	426	63	41
1989	2,787	2,691	1,105	252	917	417	60	36
1990	2,574	2,488	751	320	959	458	53	33
1991	2,738	2,652	741	419	1,053	439	28	58
1992	3,087	3,016	877	530	1,117	492	29	42
1993	4,079	4,000	1,278	781	1,324	617	29	50
1994	5,548	5,471	1,936	1,006	1,687	842	32	45
1995	7,831	7,772	3,762	1,254	1,822	934	16	43
1996	7,064	6,974	1,988	1,550	1,706	1,730	28	62
1997	7,352	7,292	1,524	1,728	1,552	2,195	0	60
1996-1997 Growth (%)	4.1	4.6	-23.2	11.5	9.6	30.3	0	-3.2

Source: Dataquest (October 1998)

Figure 4-7
Texas Instruments' Annual Growth versus the Semiconductor Industry's



Source: Dataquest (October 1998)

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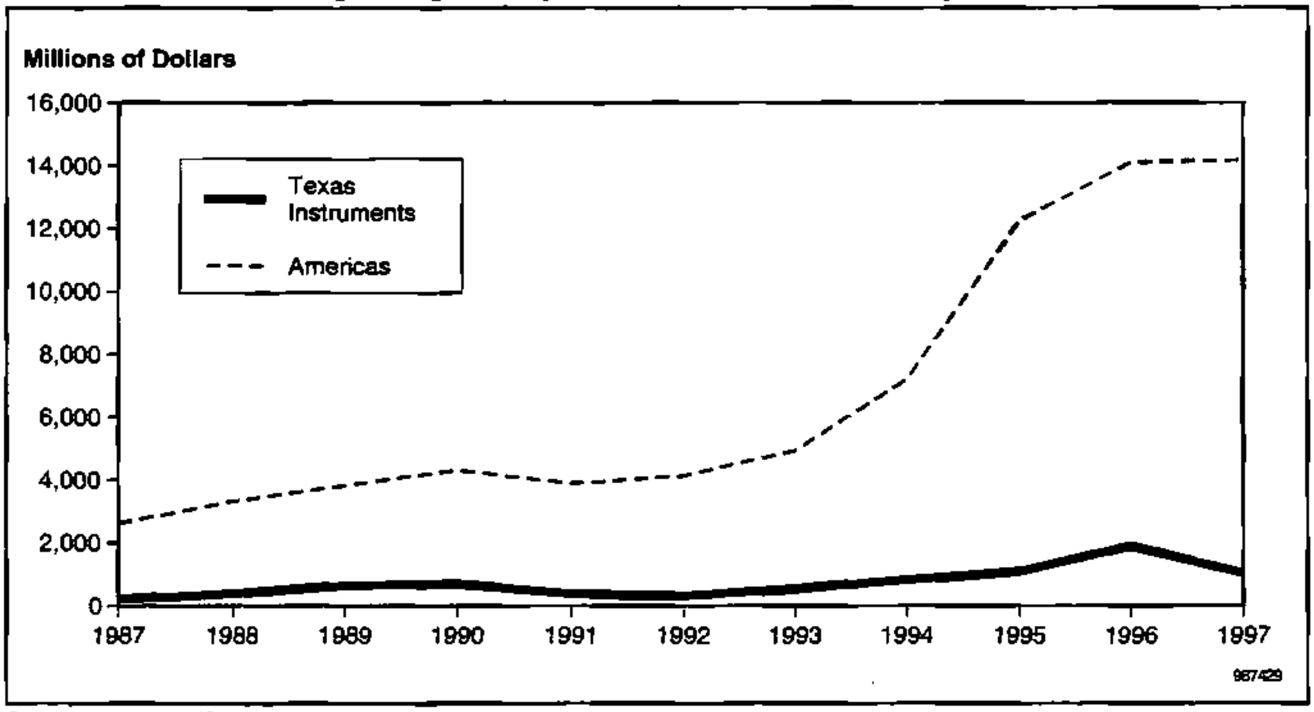
Figure 4-8
Texas Instruments' Capital Spending versus Americas Spending



Source: Dataquest (October 1998)

Table 4-15
Texas Instruments' Product Profile, 1987-1997 (Percentage of Texas Instruments' Total Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	100.0	95.2	23.3	7.9	45.8	18.1	3.0	1.8
1988	100.0	96.2	32.3	8.5	39.9	15.5	2.3	1.5
1989	100.0	96.6	39.6	9.0	32.9	15.0	2.2	1.3
1990	100.0	96.7	29.2	12.4	37.3	17.8	2.1	1.3
1991	100.0	96.9	27.1	15.3	38.5	16.0	1.0	2.1
1992	100.0	97.7	28.4	17.2	36.2	15.9	0.9	1.4
1993	100.0	98.1	31.3	19.1	32.5	15.1	0.7	1.2
1994	100.0	98.6	34.9	18.1	30.4	15.2	0.6	0.8
1995	100.0	99.2	48.0	16.0	23.3	11.9	0.2	0.5
1996	100.0	98.7	28.1	21.9	24.2	24.5	0.4	0.9
1997	100.0	99.2	20.7	23.5	21.1	29.9	0	0.8

Source: Dataquest (October 1998)

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Table 4-16
Texas Instruments' Worldwide Market Shares by Product, 1987-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	5.6	6.8	7.4	3.3	9.3	5.0	1.0	2.3
1988	5.4	6.4	7.1	3.3	8.6	4.8	0.8	1.9
1989	5.1	6.0	7.0	3.2	7.8	4.6	0.8	1.5
1990	4.7	5.6	6.0	3.3	7.9	4.5	0.7	1.4
1991	4.6	5.4	5.6	3.6	8.1	4.0	0.3	2.1
1992	4.7	5.5	5.6	3.7	8.6	4.3	0.4	1.6
1993	4.8	5.4	5.4	3.9	8.3	4.4	0.3	1.7
1994	5.0	5.7	5.7	3.8	9.0	5.0	0.3	1.2
1995	5.2	5.9	6.8	3.6	8.0	5.3	0.1	0.9
1996	5.0	5.7	5.2	3.8	7.4	9.0	0.2	1.3
1997	5.0	5.7	4.9	3.5	6.3	10.1	0	1.1

Source: Dataquest (October 1998)

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No. 5: Toshiba

Toshiba maintained its No. 5 position in 1997. The company's corporate sales totaled $43,979 million. Toshiba expects significant growth in DVD-video players as well as system LSIs, including microprocessors, digital signal processors, and memory-embedded logic, to boost revenue in the semiconductor area. A drop in sales prices severely impacted the performance of the company's semiconductor memory operations. Therefore, the company plans to accelerate efforts to reduce reliance on memory devices. Table 4-17 shows the source of Toshiba's revenue in 1997 by product and region.

Toshiba's share of net sales by business segments includes information/communications equipment and electronics (56.8 percent), heavy electrical apparatus (20.5 percent), and consumer products and others (22.7 percent). A 10-year history of Toshiba's revenue for each of the major semiconductor product categories is given in Table 4-18.

Figure 4-9 illustrates the difference between Toshiba's growth rate and that of the total semiconductor industry since 1987. Toshiba's capital spending history and its comparison to the region's spending are illustrated in Figure 4-10.

The contribution of each of the product categories to Toshiba's total semiconductor sales is shown in Table 4-19. Toshiba, like NEC, Motorola, and Hitachi, continues to be a well-balanced broad-line supplier of semiconductors. Except during periodic downturns, memory ICs have historically boosted all of these suppliers' revenue growth and strength in the overall market. Toshiba's worldwide market share by product over the past 10 years is presented in Table 4-20.

Table 4-17
Toshiba's Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**1,337**	**625**	**3,484**	**1,807**	**7,253**
Total Integrated Circuit	1,154	444	2,479	1,263	5,340
Total Bipolar Digital	1	2	26	3	32
MOS Digital IC	1,075	402	1,993	818	4,288
MOS Memory	633	164	534	154	1,485
MOS Microcomponent	119	100	722	395	1,336
MOS Digital Logic	323	138	737	269	1,467
Analog-Monolithic	78	40	460	442	1,020
Total Discrete	149	141	740	454	1,484
Total Optical Semiconductor	34	40	265	90	429

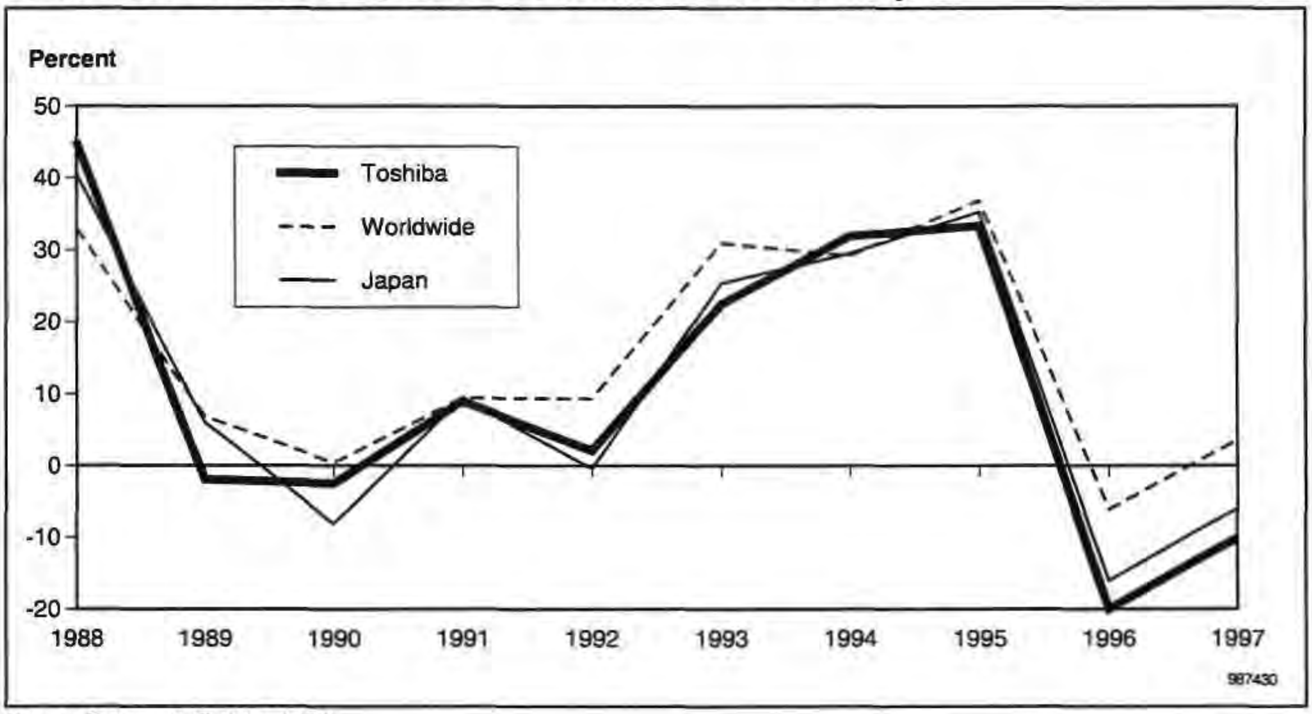
Source: Dataquest (October 1998)

Table 4-18
Toshiba's Product Profile, 1987-1997 (Millions of Dollars)

Year	Semiconductor	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	3,029	2,194	679	283	756	476	703	132
1988	4,395	3,316	1,516	346	885	569	864	215
1989	4,310	3,329	1,681	361	778	509	724	257
1990	4,202	3,183	1,431	386	831	535	764	255
1991	4,579	3,409	1,425	454	918	612	884	286
1992	4,675	3,537	1,618	440	898	581	883	255
1993	5,727	4,384	2,101	540	1,070	673	1,017	326
1994	7,556	5,931	3,018	718	1,347	848	1,204	421
1995	10,076	8,025	4,269	1,094	1,673	915	1,428	623
1996	8,065	6,204	2,581	1,197	1,481	909	1,390	471
1997	7,253	5,340	1,485	1,336	1,467	1,020	1,484	429
1996-1997 Growth (%)	-10.1	-13.9	-40.9	11.6	-0.6	12.2	6.8	-8.9

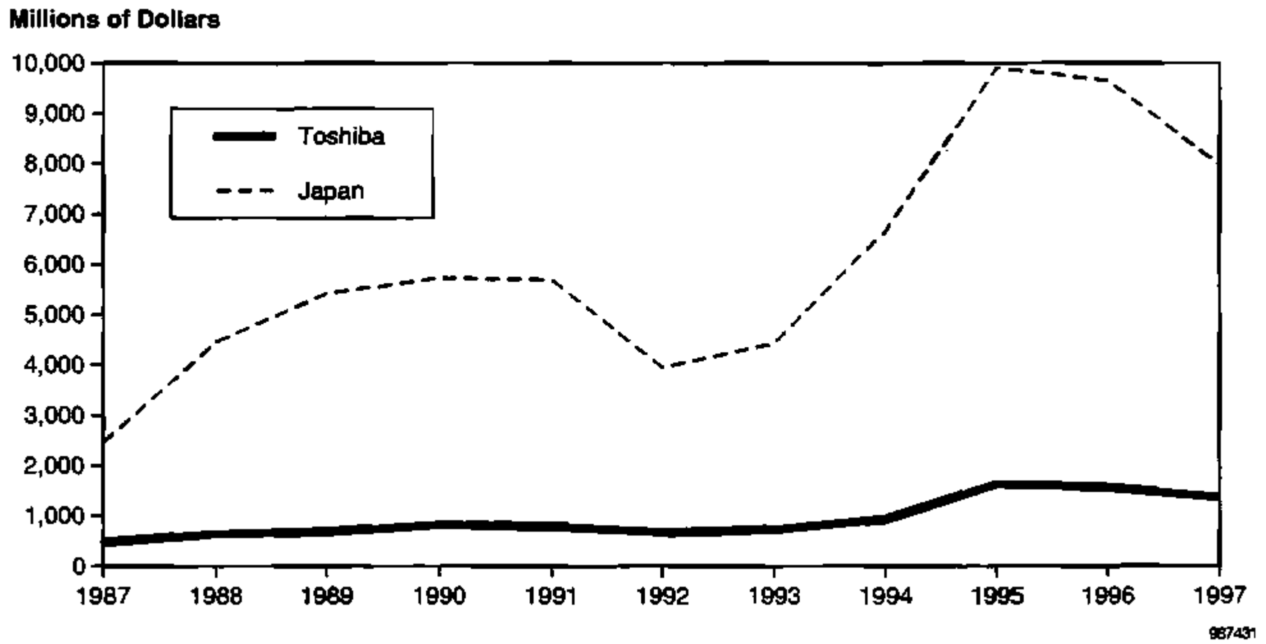
Source: Dataquest (October 1998)

Figure 4-9
Toshiba's Annual Growth versus the Semiconductor Industry's



Source: Dataquest (October 1998)

Figure 4-10
Toshiba's Capital Spending versus Japan's Spending



Source: Dataquest (October 1998)

Table 4-19
Toshiba's Product Profile, 1987-1997 (Percentage of Toshiba's Total Semiconductor Revenue)

Year	Semiconductor	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	100.0	72.4	22.4	9.3	25.0	15.7	23.2	4.4
1988	100.0	75.4	34.5	7.9	20.1	12.9	19.7	4.9
1989	100.0	77.2	39.0	8.4	18.1	11.8	16.8	6.0
1990	100.0	75.7	34.1	9.2	19.8	12.7	18.2	6.1
1991	100.0	74.4	31.1	9.9	20.0	13.4	19.3	6.2
1992	100.0	75.7	34.6	9.4	19.2	12.4	18.9	5.5
1993	100.0	76.5	36.7	9.4	18.7	11.8	17.8	5.7
1994	100.0	78.5	39.9	9.5	17.8	11.2	15.9	5.6
1995	100.0	79.6	42.4	10.9	16.7	9.1	14.2	6.2
1996	100.0	76.9	32.0	14.8	18.4	11.3	17.2	5.8
1997	100.0	73.6	20.5	18.4	20.2	14.1	20.5	5.9

Source: Dataquest (October 1998)

Table 4-20
Toshiba's Worldwide Market Shares by Product, 1987-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	7.9	7.3	10.2	5.5	7.2	6.2	10.6	7.7
1988	8.6	8.1	12.2	4.8	7.0	6.4	11.4	9.9
1989	7.9	7.5	10.6	4.6	6.6	5.6	9.9	10.7
1990	7.7	7.2	11.4	4.0	6.8	5.3	10.0	10.6
1991	7.7	7.0	10.8	3.9	7.1	5.6	11.0	10.2
1992	7.2	6.5	10.4	3.1	7.0	5.0	10.8	9.5
1993	6.7	6.0	8.9	2.7	6.7	4.8	11.2	10.9
1994	6.8	6.2	9.0	2.7	7.2	5.0	11.2	10.8
1995	6.7	6.1	7.7	3.2	7.3	5.2	10.0	12.9
1996	5.7	5.0	6.8	2.9	6.4	4.7	10.3	9.6
1997	4.9	4.2	4.8	2.7	5.9	4.7	10.4	8.0

Source: Dataquest (October 1998)

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No. 6: Hitachi

Hitachi's ranking position declined from No. 4. Of the top 20, Hitachi suffered the largest year-to-year change in revenue, experiencing a decline of 22 percent in 1997. Table 4-21 shows the source of Hitachi's revenue in 1997 by product and region.

Founded in 1910, Hitachi's business segments are divided into systems and electronics, power and industrial systems, consumer, materials, and services. The 10-year history of Hitachi's revenue for each of the major semiconductor product categories is given in Table 4-22.

Figure 4-11 illustrates the difference in growth rate between Hitachi and the total semiconductor industry since 1987. Figure 4-12 illustrates Hitachi's capital spending history and how it compares to the region's total spending during the same time frame.

The contribution of each of the product categories to Hitachi's total semiconductor sales is shown in Table 4-23. Hitachi's share of the worldwide market by product is shown in Table 4-24.

Table 4-21
Hitachi's Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**1,181**	**759**	**3,355**	**1,003**	**6,298**
Total Integrated Circuit	1,127	577	2,808	721	5,233
Total Bipolar Digital	1	1	206	54	262
MOS Digital IC	1,083	566	2,406	540	4,595
MOS Memory	830	236	949	194	2,209
MOS Microcomponent	193	270	917	303	1,683
MOS Digital Logic	60	60	540	43	703
Analog-Monolithic	43	10	196	127	376
Total Discrete	47	161	489	252	949
Total Optical Semiconductor	7	21	58	30	116

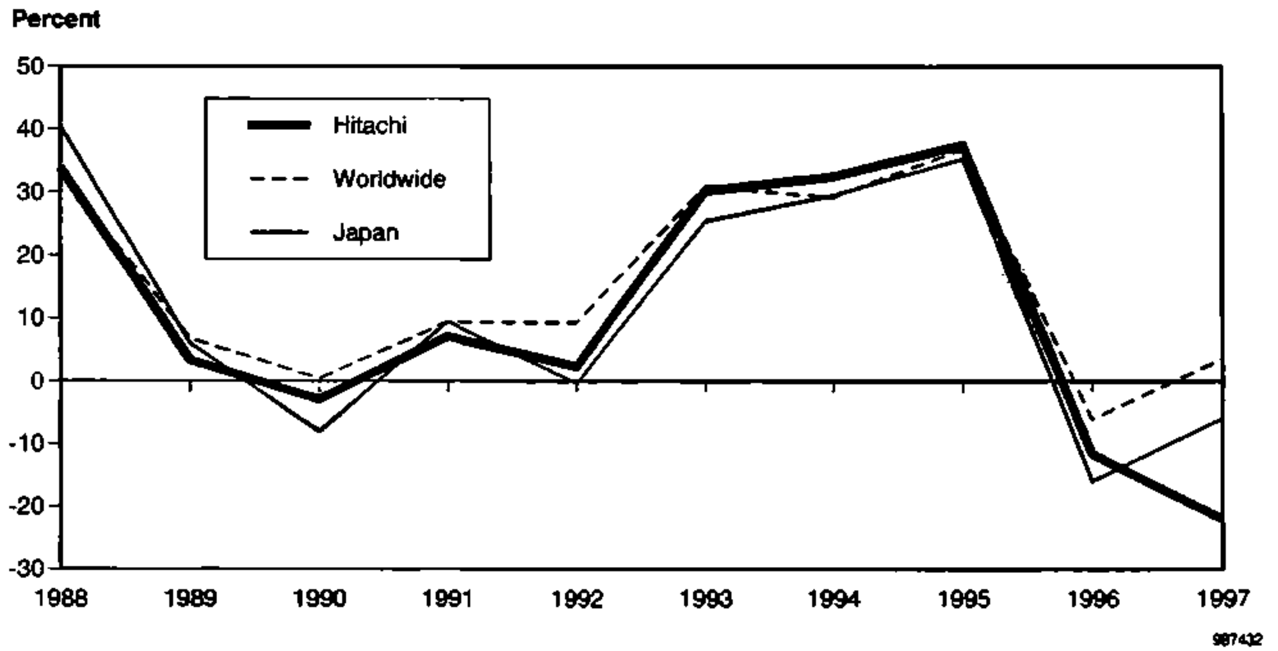
Source: Dataquest (October 1998)

Table 4-22
Hitachi's Product Profile, 1987-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	2,618	1,946	671	402	563	310	625	47
1988	3,506	2,729	1,233	525	628	343	707	70
1989	3,622	2,966	1,493	505	659	309	594	62
1990	3,516	2,878	1,319	546	700	313	575	63
1991	3,765	3,099	1,429	583	729	358	598	68
1992	3,851	3,225	1,613	596	677	339	566	60
1993	5,015	4,286	2,454	718	732	382	662	67
1994	6,644	5,757	3,325	998	941	493	798	89
1995	9,135	8,162	5,213	1,441	1,016	355	889	84
1996	8,071	6,973	3,593	1,629	1,224	409	977	121
1997	6,298	5,233	2,209	1,683	703	376	949	116
1996-1997 Growth (%)	-22.0	-25.0	-37.1	3.3	-17.5	-8.1	-2.9	-4.1

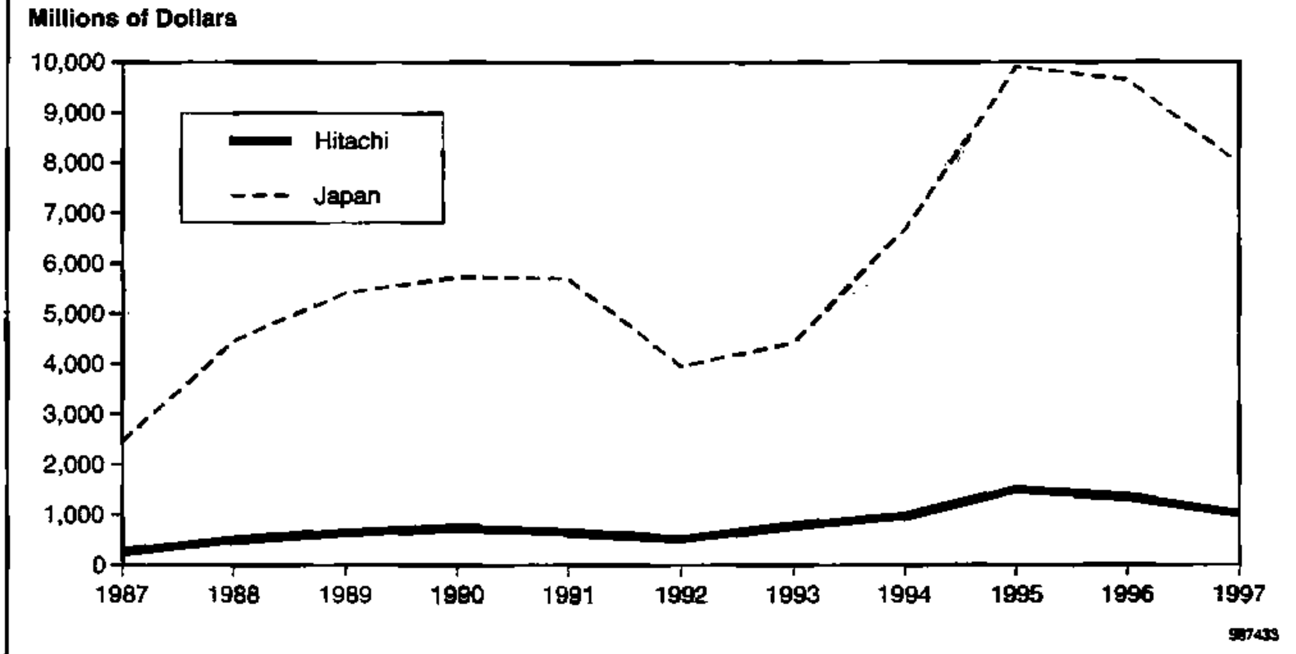
Source: Dataquest (October 1998)

Figure 4-11
Hitachi's Annual Growth versus the Semiconductor Industry's



Source: Dataquest (October 1998)

Figure 4-12
Hitachi's Capital Spending versus Japan's Spending



Source: Dataquest (October 1998)

Table 4-23
Hitachi's Product Profile, 1987-1997 (Percentage of Hitachi's Total Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	100.0	74.3	25.6	15.4	21.5	11.8	23.9	1.8
1988	100.0	77.8	35.2	15.0	17.9	9.8	20.2	2.0
1989	100.0	81.9	41.2	13.9	18.2	8.5	16.4	1.7
1990	100.0	81.9	37.5	15.5	19.9	8.9	16.4	1.8
1991	100.0	82.3	38.0	15.5	19.4	9.5	15.9	1.8
1992	100.0	83.7	41.9	15.5	17.6	8.8	14.7	1.6
1993	100.0	85.5	48.9	14.3	14.6	7.6	13.2	1.3
1994	100.0	86.6	50.0	15.0	14.2	7.4	12.0	1.3
1995	100.0	89.3	57.1	15.8	11.1	3.9	9.7	0.9
1996	100.0	86.4	44.5	20.2	15.2	5.1	12.1	1.5
1997	100.0	83.1	35.1	26.7	11.2	6.0	15.1	1.8

Source: Dataquest (October 1998)

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Table 4-24
Hitachi's Worldwide Market Shares by Product, 1987-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	6.8	6.5	10.0	7.9	5.4	4.1	9.4	2.8
1988	6.9	6.6	10.0	7.3	5.0	3.9	9.3	3.2
1989	6.7	6.6	9.4	6.5	5.6	3.4	8.1	2.6
1990	6.4	6.5	10.5	5.7	5.7	3.1	7.5	2.6
1991	6.3	6.3	10.8	5.0	5.6	3.3	7.4	2.4
1992	5.9	5.9	10.3	4.2	5.2	2.9	6.9	2.2
1993	5.9	5.8	10.4	3.6	4.6	2.7	7.3	2.2
1994	6.0	6.0	9.9	3.8	5.0	2.9	7.4	2.3
1995	6.0	6.2	9.4	4.2	4.5	2.0	6.2	1.7
1996	5.7	5.7	9.4	3.9	5.3	2.1	7.3	2.5
1997	4.3	4.1	7.1	3.4	2.8	1.7	6.7	2.2

Source: Dataquest (October 1998)

No. 7: Samsung

Samsung was the second company of the top 20 to report a large year-to-year decline in total semiconductor revenue. Its revenue declined 9.4 percent; most of this decline stemmed from significant losses taken in memory revenue. Table 4-25 shows the source of Samsung's revenue in 1997 by product and region.

Samsung was established in 1969. Its revenue is drawn from semiconductors, home appliances, computers, and communications. Samsung continues to invest heavily in the memory area with developments of the 1Gb DRAM in 1998. Table 4-26 shows 10 years of Samsung's revenue by product family.

Figure 4-13 illustrates the difference in growth rate between Samsung and the total semiconductor industry since 1987. Because of the enormous growth rate seen in 1987, the scale of this chart is quite different from that of the others in this chapter. Samsung has consistently grown faster than the market, even when DRAMs were growing more slowly than the market, because of consistent growth in market share, even in down markets. Figure 4-14 illustrates Samsung's capital spending history in comparison to the region's spending.

The contribution of each of the product categories to Samsung's total semiconductor sales is shown in Table 4-27. Memory ICs dominate Samsung's product line, but the other product categories are showing signs of growth. Table 4-28 lists Samsung's share of worldwide product revenue. Samsung continues to gain share of memory revenue even in a market downturn.

Table 4-25
Samsung's Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**2,105**	**1,240**	**589**	**1,922**	**5,856**
Total Integrated Circuit	2,070	1,216	588	1,615	5,489
MOS Digital IC	2,054	1,206	586	1,321	5,167
MOS Memory	1,984	1,184	563	892	4,623
MOS Microcomponent	21	8	1	207	237
MOS Digital Logic	49	14	22	222	307
Analog-Monolithic	16	10	2	294	322
Total Discrete	35	24	1	295	355
Total Optical Semiconductor	0	0	0	12	12

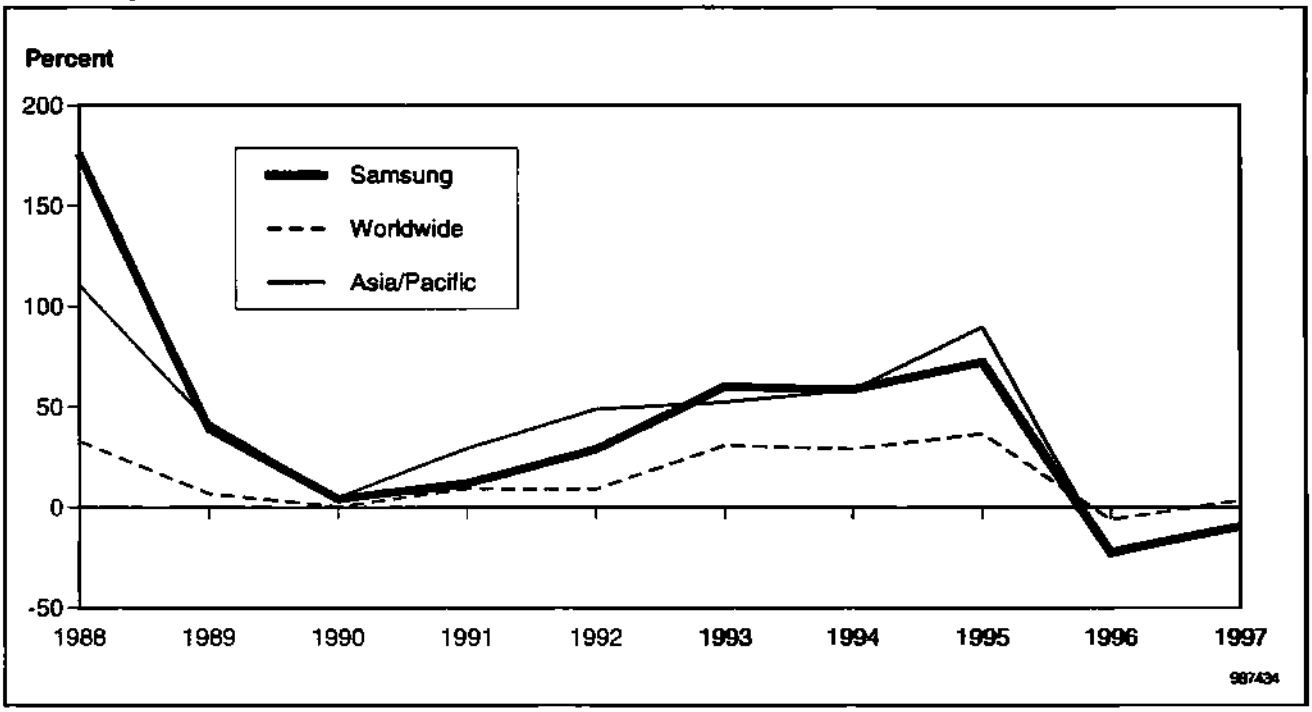
Source: Dataquest (October 1998)

Table 4-26
Samsung's Product Profile, 1987-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	328	291	170	8	64	49	37	0
1988	905	850	650	15	100	85	55	0
1989	1,260	1,182	935	8	123	116	78	0
1990	1,315	1,238	971	22	153	92	77	0
1991	1,473	1,381	1,066	27	176	112	92	0
1992	1,900	1,781	1,516	24	124	117	119	0
1993	3,044	2,897	2,512	46	173	166	143	4
1994	4,832	4,642	4,194	44	171	233	187	3
1995	8,332	8,011	7,498	87	190	236	317	4
1996	6,464	6,149	5,501	99	289	260	307	8
1997	5,856	5,489	4,623	237	307	322	355	12
1996-1997 Growth (%)	-9.4	-10.7	-16.0	139.4	6.2	23.8	15.6	50.0

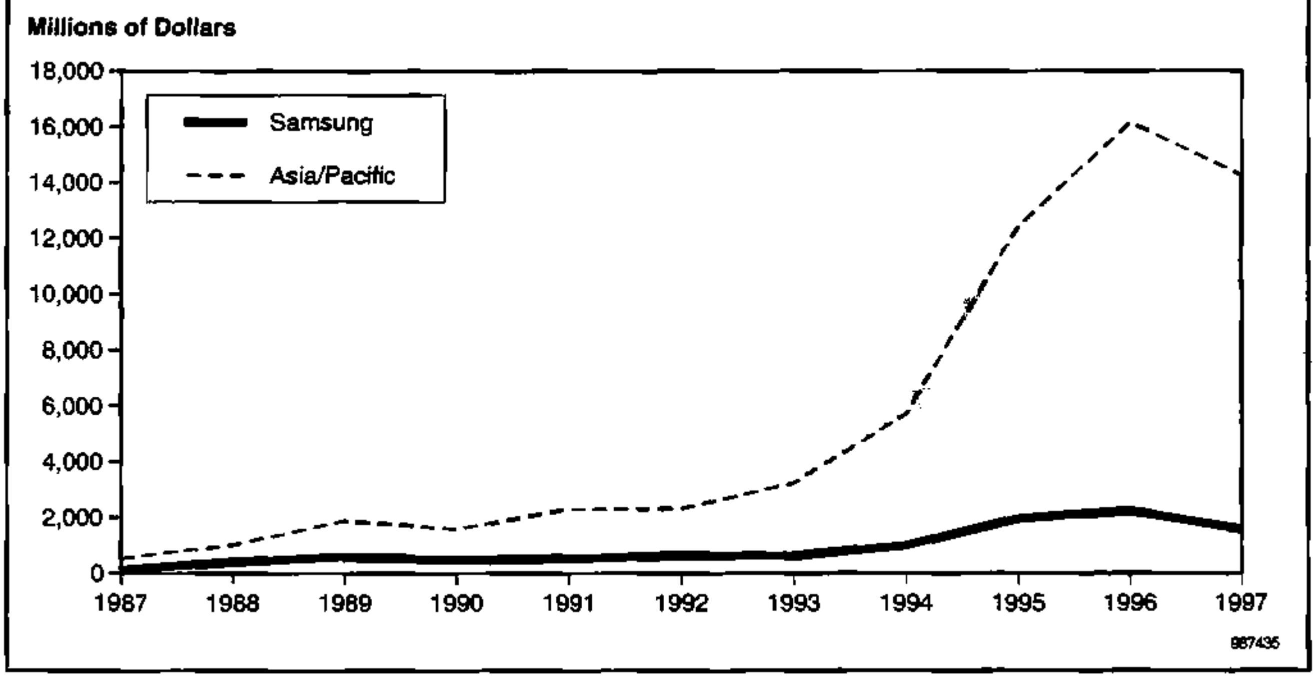
Source: Dataquest (October 1998)

Figure 4-13
Samsung's Annual Growth versus the Semiconductor Industry



Source: Dataquest (October 1998)

Figure 4-14
Samsung's Capital Spending versus Asia/Pacific's Spending



Source: Dataquest (October 1998)

Table 4-27
Samsung's Product Profile, 1987-1997 (Percentage of Samsung's Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	100.0	88.7	51.8	2.4	19.5	14.9	11.3	0
1988	100.0	93.9	71.8	1.7	11.0	9.4	6.1	0
1989	100.0	93.8	74.2	0.6	9.8	9.2	6.2	0
1990	100.0	94.1	73.8	1.7	11.6	7.0	5.9	0
1991	100.0	93.8	72.4	1.8	11.9	7.6	6.2	0
1992	100.0	93.7	79.8	1.3	6.5	6.2	6.3	0
1993	100.0	95.2	82.5	1.5	5.7	5.5	4.7	0.1
1994	100.0	96.1	86.8	0.9	3.5	4.8	3.9	0.1
1995	100.0	96.1	90.0	1.0	2.3	2.8	3.8	0
1996	100.0	95.1	85.1	1.5	4.5	4.0	4.7	0.1
1997	100.0	93.7	78.9	4.0	5.2	5.5	6.1	0.2

Source: Dataquest (October 1998)

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Table 4-28
Samsung's Worldwide Market Shares by Product, 1987-1997 (Percent)

Year	Semiconductor	IC	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	0.9	1.0	2.5	0.2	0.6	0.6	0.6	0
1988	1.8	2.1	5.2	0.2	0.8	1.0	0.7	0
1989	2.3	2.6	5.9	0.1	1.0	1.3	1.1	0
1990	2.4	2.8	7.7	0.2	1.3	0.9	1.0	0
1991	2.5	2.8	8.1	0.2	1.4	1.0	1.1	0
1992	2.9	3.3	9.7	0.2	1.0	1.0	1.5	0
1993	3.6	3.9	10.7	0.2	1.1	1.2	1.6	0.1
1994	4.4	4.8	12.4	0.2	0.9	1.4	1.7	0.1
1995	5.5	6.1	13.6	0.3	0.9	1.3	2.2	0
1996	4.6	5.0	14.6	0.2	1.3	1.3	2.3	0.2
1997	4.0	4.3	14.9	0.5	1.2	4.9	2.5	0.2

Source: Dataquest (October 1998)

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No. 8: Fujitsu

Fujitsu retained the No. 8 position. Table 4-29 shows the sources of Fujitsu's 1997 semiconductor revenue by product and region.

Fujitsu was established in 1935. Its business revenue is drawn from computer and data processing systems, communications systems, and electronic devices including ICs, relays, and connectors, as well as from other product operations. A 10-year history of Fujitsu's revenue for each of the major semiconductor product categories is given in Table 4-30.

Figure 4-15 illustrates the difference between Fujitsu's growth rate and that of the total semiconductor industry since 1987. Figure 4-16 shows Fujitsu's capital spending history and how it compares with regional spending.

The contribution of each of the product categories to Fujitsu's total semiconductor sales is shown in Table 4-31. Table 4-32 lists Fujitsu's share of the worldwide market by product.

Table 4-29
Fujitsu's Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**756**	**621**	**2,768**	**477**	**4,622**
Total Integrated Circuit	565	546	2,566	458	4,135
Total Bipolar Digital	10	2	50	1	63
MOS Digital IC	528	514	2,263	440	3,745
MOS Memory	245	341	643	279	1,508
MOS Microcomponent	183	74	635	75	967
MOS Digital Logic	100	99	985	86	1,270
Analog-Monolithic	27	30	253	17	327
Total Discrete	164	61	77	17	319
Total Optical Semiconductor	27	14	125	2	168

Source: Dataquest (October 1998)

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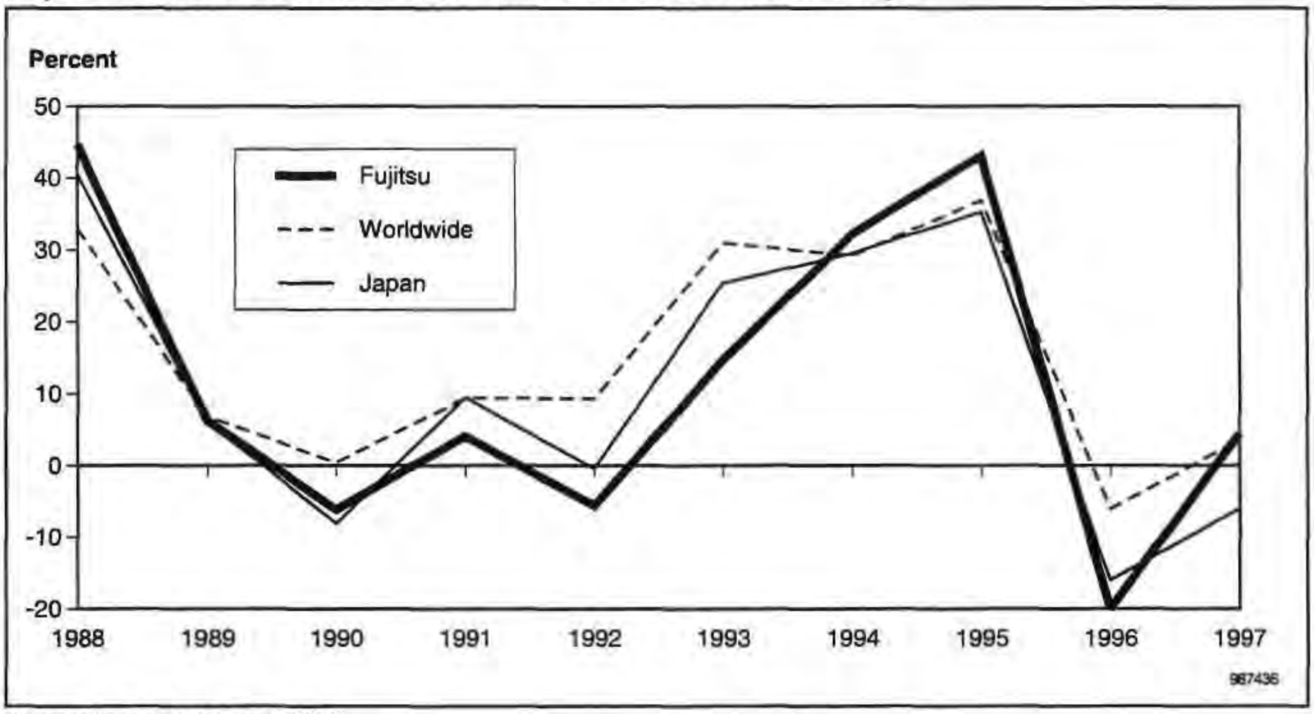
Table 4-30
Fujitsu's Product Profile, 1987-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	1,801	1,660	812	146	551	151	70	71
1988	2,607	2,420	1,321	202	746	151	82	105
1989	2,770	2,563	1,323	197	892	151	100	107
1990	2,599	2,384	1,057	213	966	148	107	108
1991	2,705	2,426	1,022	244	981	179	152	127
1992	2,553	2,294	1,017	233	872	172	142	117
1993	2,928	2,648	1,216	282	966	184	157	123
1994	3,869	3,542	1,724	390	1157	271	192	135
1995	5,535	5,084	2,609	650	1361	315	283	168
1996	4,427	3,986	1,676	677	1208	291	290	151
1997	4,622	4,135	1,508	967	1,270	327	319	168
1996-1997 Growth (%)	4.4	3.7	-8.9	42.8	11.6	12.4	10.0	11.3

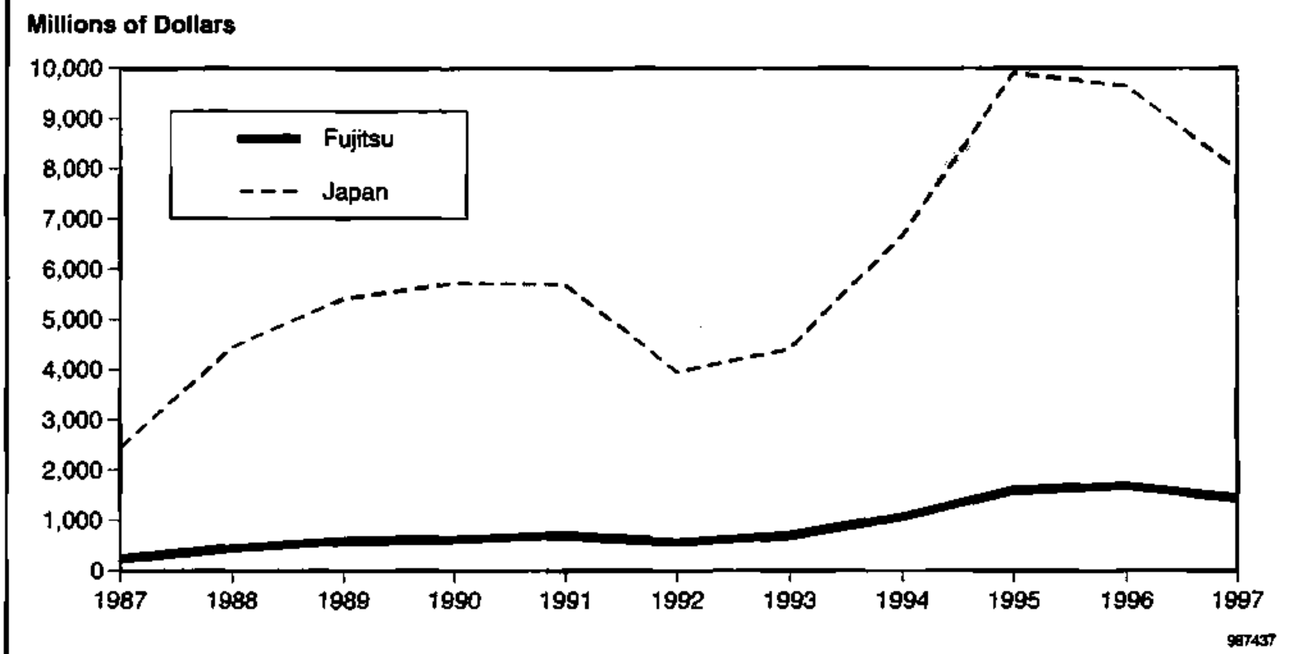
Source: Dataquest (October 1998)

Figure 4-15
Fujitsu's Annual Growth versus the Semiconductor Industry's



Source: Dataquest (October 1998)

Figure 4-16
Fujitsu's Capital Spending versus Japan's Spending



Source: Dataquest (October 1998)

Table 4-31
Fujitsu's Product Profile, 1987-1997 (Percentage of Fujitsu's Total Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	100.0	92.2	45.1	8.1	30.6	8.4	3.9	3.9
1988	100.0	92.8	50.7	7.7	28.6	5.8	3.1	4.0
1989	100.0	92.5	47.8	7.1	32.2	5.5	3.6	3.9
1990	100.0	91.7	40.7	8.2	37.2	5.7	4.1	4.2
1991	100.0	89.7	37.8	9.0	36.3	6.6	5.6	4.7
1992	100.0	89.9	39.8	9.1	34.2	6.7	5.6	4.6
1993	100.0	90.4	41.5	9.6	33.0	6.3	5.4	4.2
1994	100.0	91.5	44.6	10.1	29.9	7.0	5.0	3.5
1995	100.0	91.9	47.1	11.7	24.6	5.7	5.1	3.0
1996	100.0	90.0	37.9	15.3	27.3	6.6	6.6	3.4
1997	100.0	89.5	32.6	20.9	27.5	7.1	6.9	3.6

Source: Dataquest (October 1998)

Table 4-32
Fujitsu's Worldwide Market Shares by Product, 1987-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	4.7	5.6	12.2	2.9	5.3	2.0	1.1	4.2
1988	5.1	5.9	10.7	2.8	5.9	1.7	1.1	4.8
1989	5.1	5.7	8.3	2.5	7.6	1.6	1.4	4.4
1990	4.8	5.4	8.4	2.2	7.9	1.5	1.4	4.5
1991	4.5	5.0	7.7	2.1	7.6	1.6	1.9	4.5
1992	3.9	4.2	6.5	1.6	6.8	1.5	1.7	4.4
1993	3.4	3.6	5.2	1.4	6.1	1.3	1.7	4.1
1994	3.5	3.7	5.1	1.5	6.1	1.6	1.8	3.5
1995	3.7	3.8	4.7	1.9	6.0	1.8	2.0	3.5
1996	3.1	3.2	4.4	1.6	5.2	1.5	2.2	3.1
1997	3.1	3.2	4.9	2.0	5.1	1.5	2.2	3.1

Source: Dataquest (October 1998)

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No. 9: Philips

Philips was one of 11 of the top 20 semiconductor suppliers to show positive growth in most areas. Table 4-33 shows the distribution of Philips' 1997 semiconductor revenue by product and region.

Philips' business revenue is drawn from six major divisions: consumer products, professional products and systems, lighting, components, semiconductors, and other miscellaneous products. Philips' revenue for each of the major semiconductor product categories in 1997 is given in Table 4-34.

Figure 4-17 illustrates the difference between Philips' growth rate and that of the total semiconductor industry since 1987. Figure 4-18 illustrates Philips' capital spending history and how it compares to the region's total spending during the same time frame.

The contribution of each of the product categories to Philips' total semiconductor sales is shown in Table 4-35. Philips' share of the worldwide market by product is listed in Table 4-36.

Table 4-33
Philips' Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**831**	**1,847**	**182**	**1,580**	**4,440**
Total Integrated Circuit	615	1,350	166	1,285	3,416
Total Bipolar Digital	46	19	2	13	80
MOS Digital IC	255	660	44	660	1,619
MOS Memory	0	65	2	6	73
MOS Microcomponent	172	317	16	286	791
MOS Digital Logic	83	278	26	368	755
Analog-Monolithic	314	671	120	612	1,717
Total Discrete	216	497	16	295	1,024

Source: Dataquest (October 1998)

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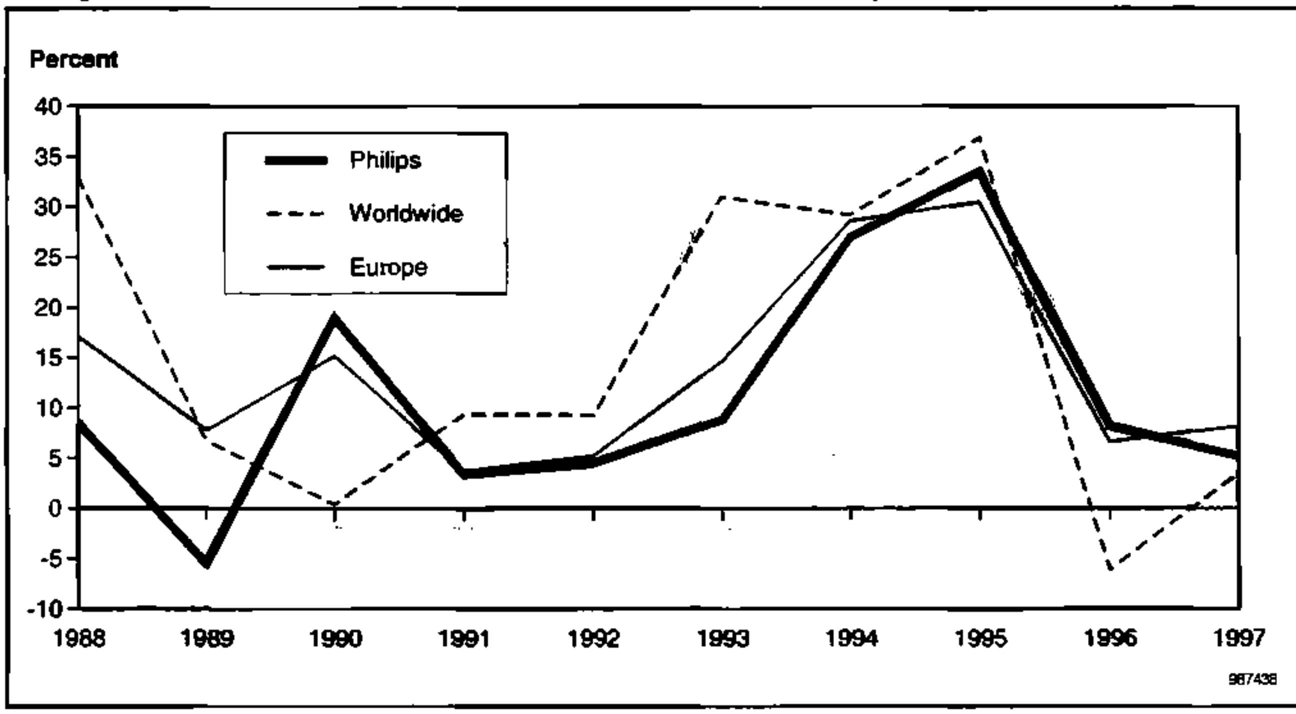
Table 4-34
Philips' Product Profile, 1987-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	1,602	1,186	79	100	568	439	390	26
1988	1,738	1,281	93	114	608	466	432	25
1989	1,643	1,177	107	131	417	522	442	24
1990	1,955	1,417	141	192	431	653	507	31
1991	2,022	1,455	111	212	468	664	531	36
1992	2,113	1,562	67	287	533	675	551	0
1993	2,300	1,696	35	305	549	807	604	0
1994	2,920	2,159	28	403	717	1,011	761	0
1995	3,900	2,844	14	662	865	1,257	1,056	0
1996	4,220	3,279	0	1,085	773	1,291	941	0
1997	4,440	3,416	73	791	755	1,717	1,024	0
1996-1997 Growth (%)	5.2	4.2	NA	-27.1	-2.3	33.0	8.8	0

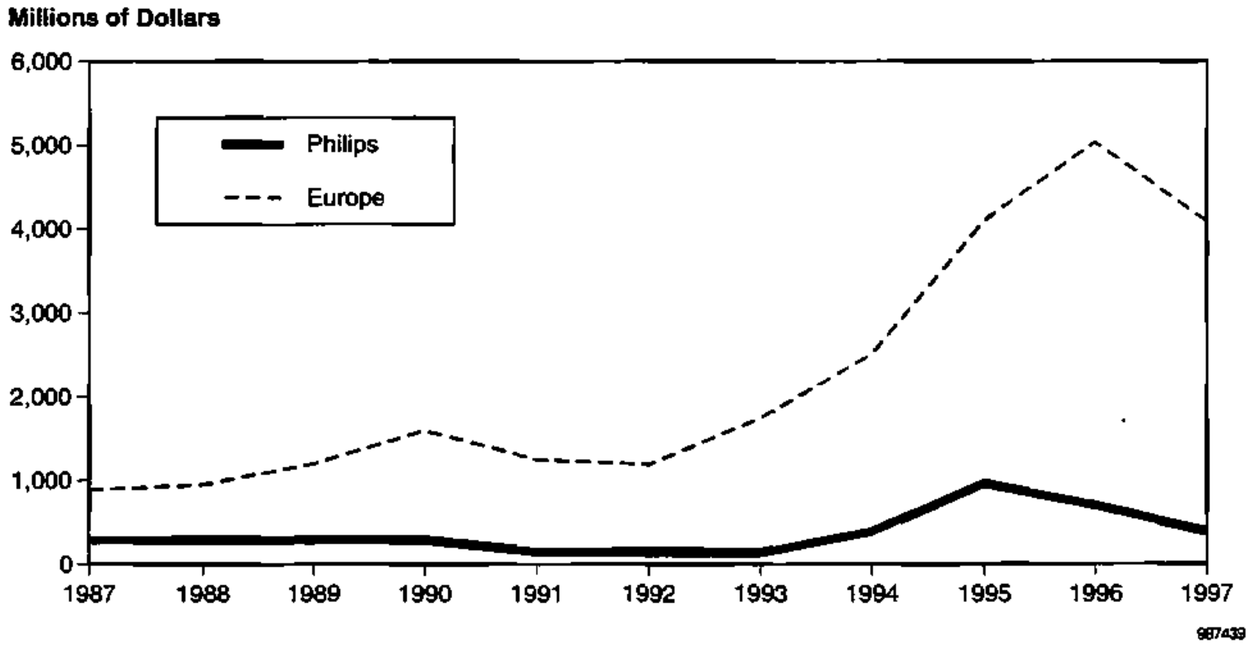
NA = Not available
Source: Dataquest (October 1998)

Figure 4-17
Philips' Annual Growth versus the Semiconductor Industry's



Source: Dataquest (October 1998)

Figure 4-18
Philips' Capital Spending versus Europe's Spending



Source: Dataquest (October 1998)

Table 4-35
Philips' Product Profile, 1987-1997 (Percentage of Philips' Total Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	100.0	74.0	4.9	6.2	35.5	27.4	24.3	1.6
1988	100.0	73.7	5.4	6.6	35.0	26.8	24.9	1.4
1989	100.0	71.6	6.5	8.0	25.4	31.8	26.9	1.5
1990	100.0	72.5	7.2	9.8	22.0	33.4	25.9	1.6
1991	100.0	72.0	5.5	10.5	23.1	32.8	26.3	1.8
1992	100.0	73.9	3.2	13.6	25.2	31.9	26.1	0
1993	100.0	73.7	1.5	13.3	23.9	35.1	26.3	0
1994	100.0	73.9	1.0	13.8	24.6	34.6	26.1	0
1995	100.0	72.9	0.3	17.0	22.2	32.2	27.1	0
1996	100.0	77.7	0.2	25.7	20.2	30.6	22.3	0
1997	100.0	76.9	1.6	17.8	17.0	38.7	23.1	0

Source: Dataquest (October 1998)

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Table 4-36
Philips' Worldwide Market Shares by Product, 1987-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	4.2	4.0	1.2	2.0	5.4	5.7	5.9	1.5
1988	3.4	3.1	0.8	1.6	4.8	5.2	5.7	1.1
1989	3.0	2.6	0.7	1.7	3.5	5.7	6.0	1.0
1990	3.6	3.2	1.1	2.0	3.5	6.4	6.6	1.3
1991	3.4	3.0	0.8	1.8	3.6	6.1	6.6	1.3
1992	3.2	2.9	0.4	2.0	4.1	5.9	6.8	0
1993	2.7	2.3	0.1	1.5	3.4	5.8	6.6	0
1994	2.6	2.3	0.1	1.5	3.8	6.0	7.1	0
1995	2.6	2.2	0	1.9	3.8	7.1	7.4	0
1996	3.0	2.7	0	2.6	3.7	6.7	7.0	0
1997	3.0	2.7	0.2	1.6	3.0	7.9	7.2	0

Source: Dataquest (October 1998)

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No. 10: STMicroelectronics

STMicroelectronics, formerly named SGS-Thomson, maintained its No. 10 position but saw a 2.3 percent decline in revenue from 1996 to 1997. Table 4-37 lists the distribution of the company's 1997 semiconductor revenue by product and region.

STMicroelectronics' revenue in 1997 for each of the major semiconductor product categories is given in Table 4-38.

Figure 4-19 illustrates the difference between STMicroelectronics' growth rate and that of the total semiconductor industry since 1987. Figure 4-20 illustrates STMicroelectronics' capital spending history and how it compares to regional spending.

The contribution of each of the product categories to STMicroelectronics' total semiconductor sales is shown in Table 4-39, and its product share of the worldwide market is shown in Table 4-40.

Table 4-37
STMicroelectronics' Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**952**	**1,777**	**215**	**1,075**	**4,019**
Total Integrated Circuit	814	1,494	207	932	3,447
MOS Digital IC	357	835	114	250	1,556
MOS Memory	122	203	75	102	502
MOS Microcomponent	118	387	31	80	616
MOS Digital Logic	117	245	8	68	438
Analog-Monolithic	457	659	93	682	1,891
Total Discrete	138	283	8	143	572

Source: Dataquest (October 1998)

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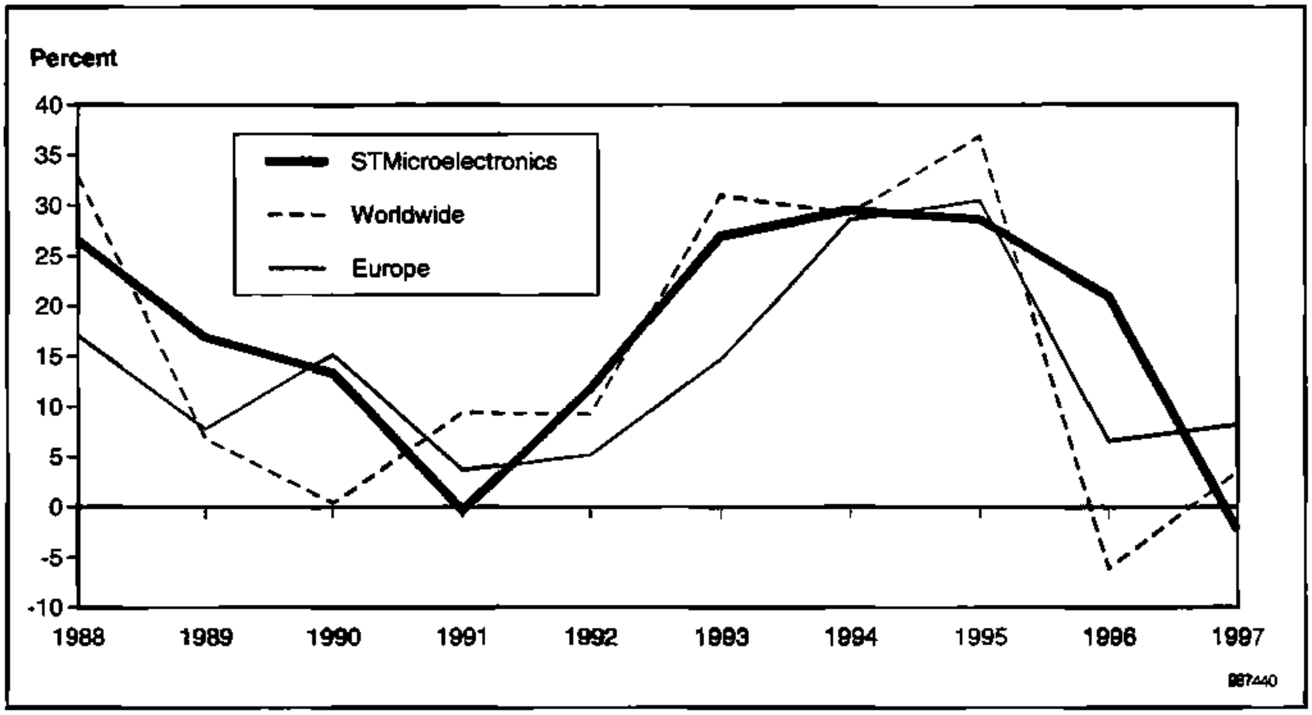
Table 4-38
STMicroelectronics' Product Profile, 1987-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	859	646	95	95	174	282	213	0
1988	1,087	833	185	118	178	352	254	0
1989	1,271	989	239	161	196	393	282	0
1990	1,441	1,126	279	175	118	554	315	0
1991	1,436	1,137	273	167	119	578	299	0
1992	1,605	1,270	304	167	141	658	335	0
1993	2,038	1,654	467	162	167	858	384	0
1994	2,640	2,207	589	227	194	1,197	433	0
1995	3,398	2,807	646	437	241	1,483	591	0
1996	4,112	3,526	738	482	431	1,875	586	0
1997	4,019	3,447	502	616	438	1,891	572	0
1996-1997 Growth (%)	-2.3	-2.2	-32.0	27.8	1.6	0.9	-2.4	0

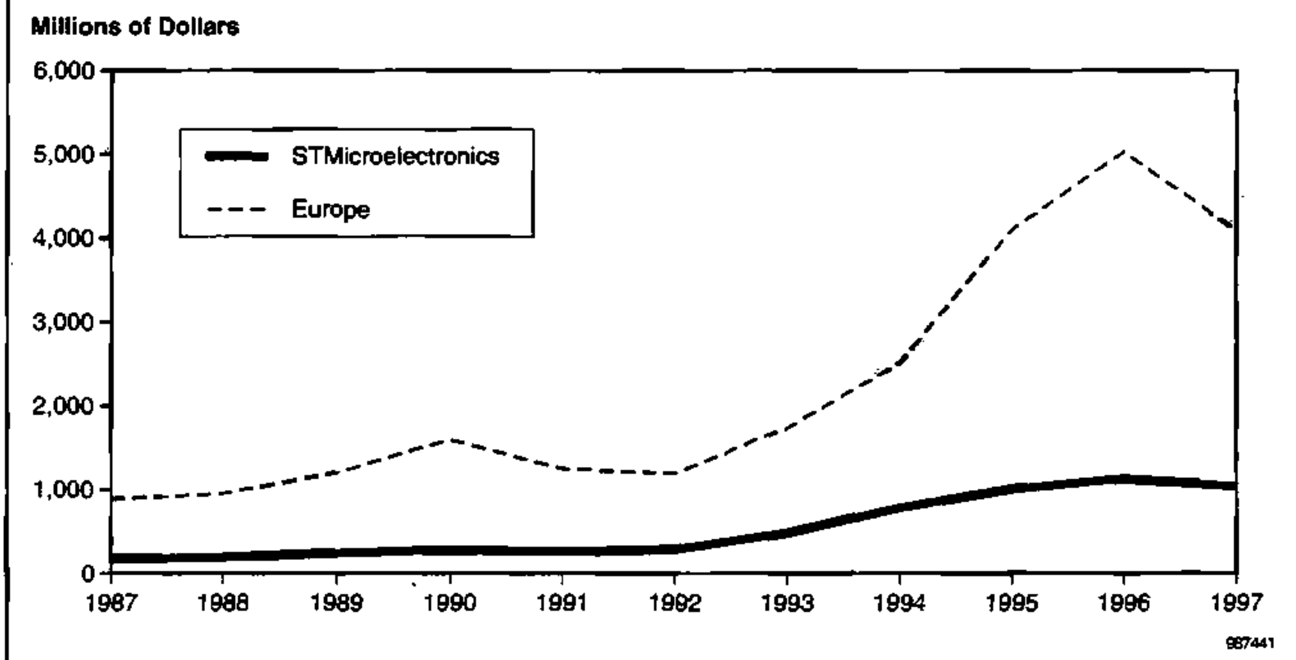
Source: Dataquest (October 1998)

Figure 4-19
STMicroelectronics' Annual Growth versus the Semiconductor Industry's



Source: Dataquest (October 1998)

Figure 4-20
STMicroelectronics' Capital Spending versus Europe's Spending



Source: Dataquest (October 1998)

Table 4-39
STMicroelectronics' Product Profile, 1987-1997 (Percentage of STMicroelectronics' Total Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	100.0	75.2	11.1	11.1	20.3	32.8	24.8	0
1988	100.0	76.6	17.0	10.9	16.4	32.4	23.4	0
1989	100.0	77.8	18.8	12.7	15.4	30.9	22.2	0
1990	100.0	78.1	19.4	12.1	8.2	38.4	21.9	0
1991	100.0	79.2	19.0	11.6	8.3	40.3	20.8	0
1992	100.0	79.1	18.9	10.4	8.8	41.0	20.9	0
1993	100.0	81.2	22.9	7.9	8.2	42.1	18.8	0
1994	100.0	83.6	22.3	8.6	7.3	45.3	16.4	0
1995	100.0	82.6	19.0	12.9	7.1	43.6	17.4	0
1996	100.0	85.7	17.9	11.7	10.5	45.6	14.3	0
1997	100.0	85.8	12.5	15.3	10.9	47.1	14.2	0

Source: Dataquest (October 1998)

 ©1998 Dataquest

Table 4-40
STMicroelectronics' Worldwide Market Shares by Product, 1987-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	2.2	2.2	1.4	1.9	1.7	3.7	3.2	0
1988	2.1	2.0	1.5	1.7	1.4	4.0	3.3	0
1989	2.3	2.2	1.5	2.1	1.7	4.3	3.9	0
1990	2.6	2.5	2.2	1.8	1.0	5.5	4.1	0
1991	2.4	2.3	2.1	1.4	0.9	5.3	3.7	0
1992	2.5	2.3	1.9	1.2	1.1	5.7	4.1	0
1993	2.4	2.3	2.0	0.8	1.0	6.1	4.2	0
1994	2.4	2.3	1.7	0.9	1.0	7.1	4.0	0
1995	2.2	2.1	1.2	1.3	1.1	8.4	4.1	0
1996	2.9	2.8	1.9	1.2	1.9	10.3	4.3	0
1997	2.7	2.7	1.6	1.3	1.8	8.7	4.0	0

Source: Dataquest (October 1998)

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No. 11: Mitsubishi

Mitsubishi maintained its No. 11 position, and and its revenue declined by only 4.3 percent in 1997. Table 4-41 shows the sources of Mitsubishi's 1997 semiconductor revenue by product and region.

A 10-year history of Mitsubishi's revenue for each of the major semiconductor product categories is given in Table 4-42.

Figure 4-21 illustrates the difference between Mitsubishi's growth rate and that of the total semiconductor industry since 1987. Figure 4-22 illustrates Mitsubishi's capital spending history and how it compares with regional spending.

The contribution of each of the product categories to Mitsubishi's total semiconductor revenue is shown in Table 4-43. Its share of the worldwide market by product is shown in Table 4-44.

Table 4-41
Mitsubishi's Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**809**	**397**	**2,030**	**689**	**3,925**
Total Integrated Circuit	770	324	1,586	600	3,280
Total Bipolar Digital	1	1	19	3	24
MOS Digital IC	735	299	1,287	491	2,812
MOS Memory	504	211	415	305	1,435
MOS Microcomponent	71	67	625	173	936
MOS Digital Logic	160	21	247	13	441
Analog-Monolithic	34	24	280	106	444
Total Discrete	18	53	319	70	460
Total Optical Semiconductor	21	20	125	19	185

Source: Dataquest (October 1998)

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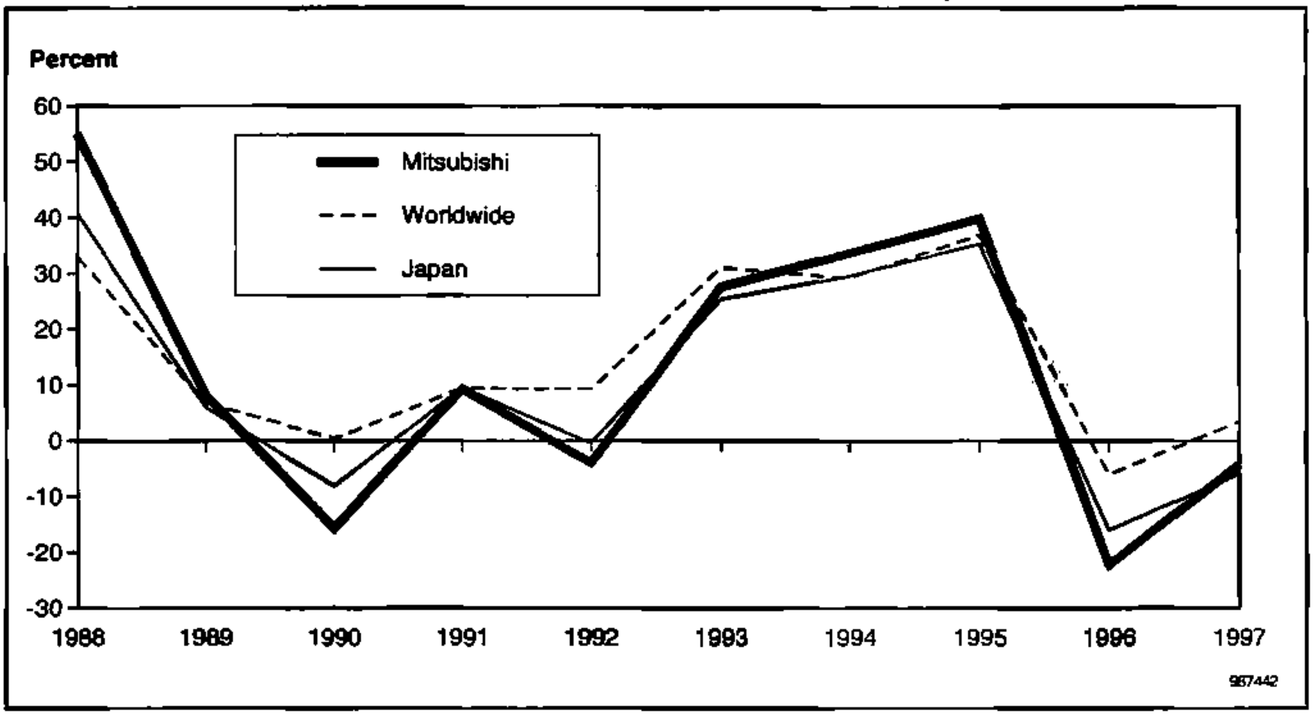
Table 4-42
Mitsubishi's Product Profile, 1987-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	1,492	1,239	492	267	175	305	227	26
1988	2,312	1,975	966	381	233	395	310	27
1989	2,500	2,136	1,117	431	202	386	337	27
1990	2,108	1,768	745	441	169	413	311	29
1991	2,304	1,954	762	543	171	478	325	25
1992	2,213	1,906	878	456	155	417	284	23
1993	2,823	2,413	1,206	532	192	483	380	30
1994	3,772	3,172	1,652	698	257	565	424	176
1995	5,274	4,644	2,547	982	462	455	479	151
1996	4,100	3,504	1,614	901	380	397	452	144
1997	3,925	3,280	1,,435	936	441	444	460	185
1996-1997 Growth (%)	-4.3	-6.4	-11.1	3.9	16.1	11.8	1.8	28.5

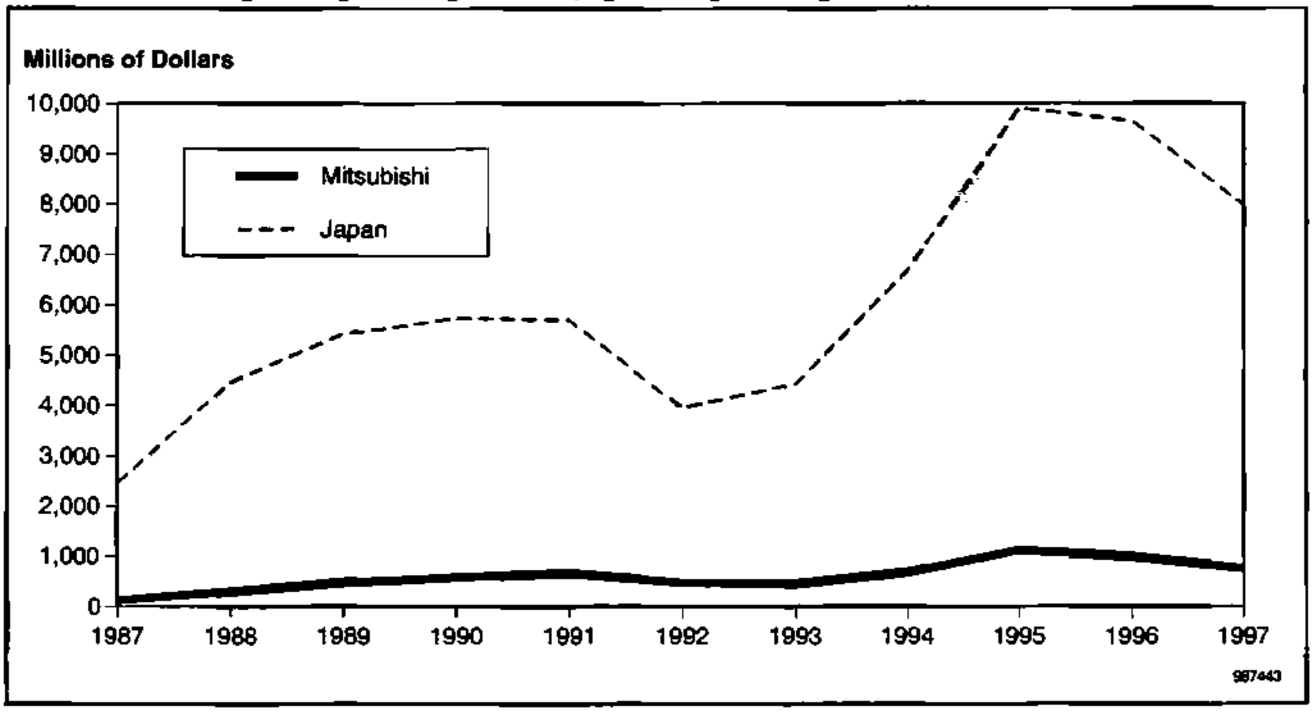
Source: Dataquest (October 1998)

Figure 4-21
Mitsubishi's Annual Growth versus the Semiconductor Industry's



Source: Dataquest (October 1998)

Figure 4-22
Mitsubishi's Capital Spending versus Japan's Spending



Source: Dataquest (October 1998)

Table 4-43
Mitsubishi's Product Profile, 1987-1997 (Percentage of Mitsubishi's Total Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	100.0	83.0	33.0	17.9	11.7	20.4	15.2	1.7
1988	100.0	85.4	41.8	16.5	10.1	17.1	13.4	1.2
1989	100.0	85.4	44.7	17.2	8.1	15.4	13.5	1.1
1990	100.0	83.9	35.3	20.9	8.0	19.6	14.8	1.4
1991	100.0	84.8	33.1	23.6	7.4	20.7	14.1	1.1
1992	100.0	86.1	39.7	20.6	7.0	18.8	12.8	1.0
1993	100.0	85.5	42.7	18.8	6.8	17.1	13.5	1.1
1994	100.0	84.1	43.8	18.5	6.8	15.0	11.2	4.7
1995	100.0	88.1	48.3	18.6	8.8	8.6	9.1	2.9
1996	100.0	85.5	39.4	22.0	9.9	9.7	11.0	3.5
1997	100.0	83.6	36.6	23.8	11.2	11.3	11.7	4.7

Source: Dataquest (October 1998)

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Table 4-44
Mitsubishi's Worldwide Market Shares by Product, 1987-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	3.9	4.1	7.4	5.2	1.7	4.0	3.4	1.5
1988	4.5	4.8	7.8	5.3	1.8	4.4	4.1	1.2
1989	4.6	4.8	7.0	5.5	1.7	4.2	4.6	1.1
1990	3.9	4.0	5.9	4.6	1.4	4.1	4.1	1.2
1991	3.9	4.0	5.8	4.6	1.3	4.4	4.0	0.9
1992	3.4	3.5	5.6	3.2	1.2	3.6	3.5	0.9
1993	3.3	3.3	5.1	2.7	1.2	3.5	4.2	1.0
1994	3.4	3.3	4.9	2.6	1.4	3.3	3.9	4.5
1995	3.5	3.5	4.6	2.8	2.1	2.6	3.3	3.1
1996	2.9	2.8	4.2	2.2	1.7	2.2	3.4	2.9
1997	2.7	2.6	4.6	1.9	1.8	2.1	3.2	3.5

Source: Dataquest (October 1998)

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No. 12: Siemens

Siemens strengthened its ranking and was one of six of the top 20 companies that showed double-digit growth in revenue in 1997. Table 4-45 lists Siemens' 1997 semiconductor revenue by product and region.

Siemens AG was founded in 1847 by Werner von Siemens. After 151 years in business, its revenue is drawn from five sectors: communications systems, industrial technology, power generation, information technology, and other technology. Siemens' semiconductor revenue in 1997 for each of the major semiconductor product categories is given in Table 4-46.

Figure 4-23 illustrates the difference between Siemens' growth rate and that of the total semiconductor industry since 1987. Figure 4-24 illustrates Siemens' capital spending history and how it compares to the region's total spending.

The contribution of each of the product categories to Siemens' total semiconductor revenue is shown in Table 4-47. Table 4-48 lists Siemens' share of the worldwide market by product.

Table 4-45
Siemens' Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**651**	**2,182**	57	**551**	**3,441**
Total Integrated Circuit	363	1,648	33	459	2,503
Total Bipolar Digital	10	27	0	0	37
MOS Digital IC	221	776	7	380	1,384
MOS Memory	193	479	4	352	1,028
MOS Microcomponent	28	274	3	28	333
MOS Digital Logic	0	23	0	0	23
Analog-Monolithic	132	845	26	79	1,082
Total Discrete	115	373	10	56	554
Total Optical Semiconductor	173	161	14	36	384

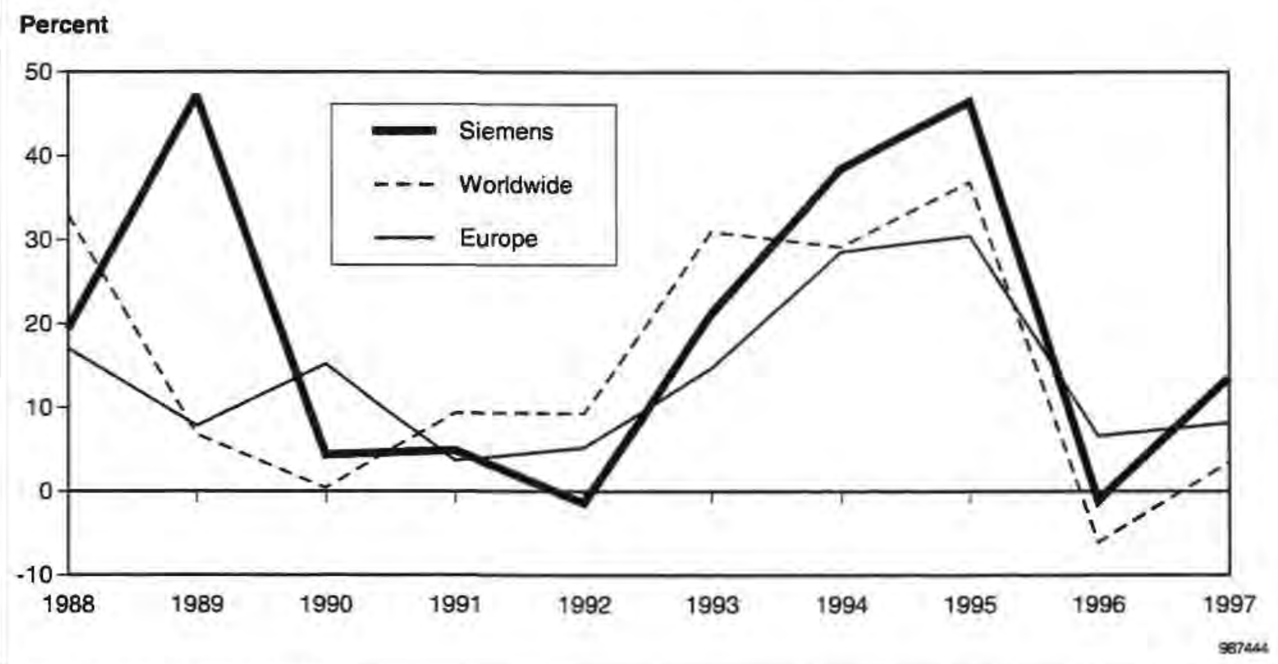
Source: Dataquest (October 1998)

Table 4-46
Siemens' Product Profile, 1987-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	657	354	56	44	134	120	218	85
1988	784	483	150	88	125	120	201	100
1989	1,154	807	376	92	187	152	232	115
1990	1,204	817	312	116	207	182	256	131
1991	1,263	829	298	134	216	181	245	189
1992	1,245	847	336	116	220	175	219	179
1993	1,509	1,110	556	107	65	382	229	170
1994	2,090	1,586	858	128	54	546	284	220
1995	3,063	2,314	1,353	209	60	692	435	314
1996	3,029	2,238	911	284	31	980	452	339
1997	3,441	2,503	1,028	333	23	1,082	554	384
1996-1997 Growth (%)	13.6	11.8	12.8	17.3	-25.8	10.4	22.6	13.3

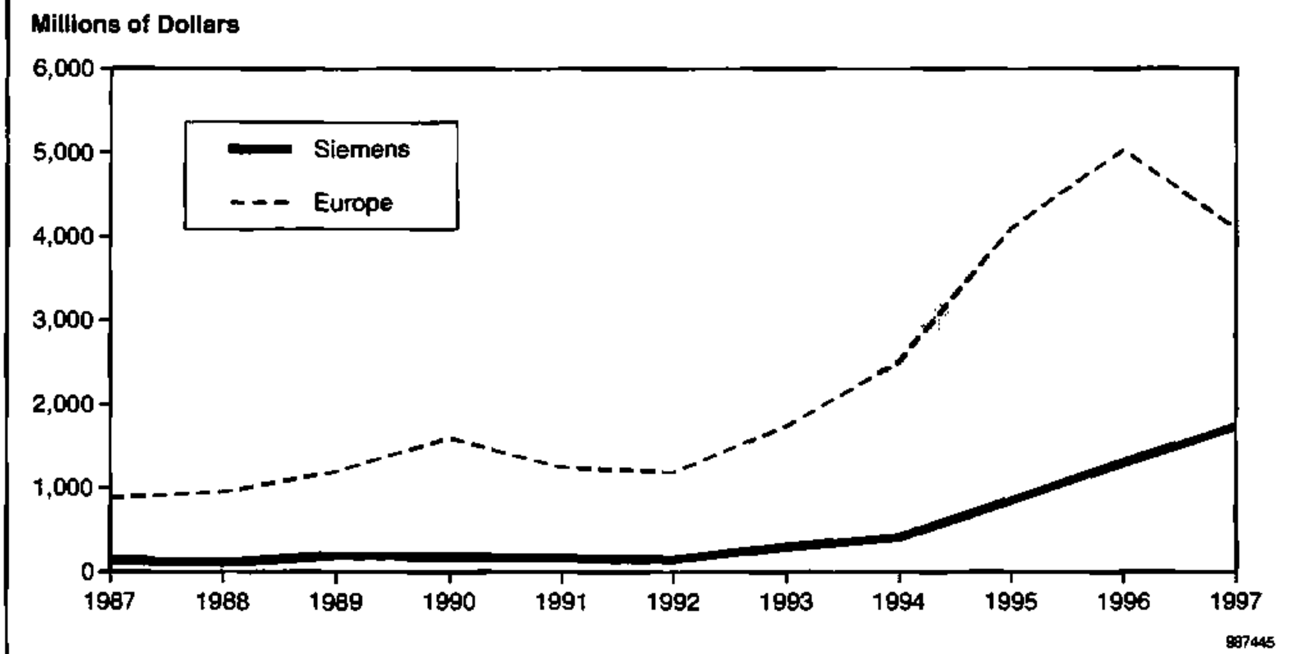
Source: Dataquest (October 1998)

Figure 4-23
Siemens' Annual Growth versus the Semiconductor Industry's



Source: Dataquest (October 1998)

Figure 4-24
Siemens' Capital Spending versus Europe's Spending



Source: Dataquest (October 1998)

Table 4-47
Siemens' Product Profile, 1987-1997 (Percentage of Siemens' Total Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	100.0	53.9	8.5	6.7	20.4	18.3	33.2	12.9
1988	100.0	61.6	19.1	11.2	15.9	15.3	25.6	12.8
1989	100.0	69.9	32.6	8.0	16.2	13.2	20.1	10.0
1990	100.0	67.9	25.9	9.6	17.2	15.1	21.3	10.9
1991	100.0	65.6	23.6	10.6	17.1	14.3	19.4	15.0
1992	100.0	68.0	27.0	9.3	17.7	14.1	17.6	14.4
1993	100.0	73.6	36.8	7.1	4.3	25.3	15.2	11.3
1994	100.0	75.9	41.1	6.1	2.6	26.1	13.6	10.5
1995	100.0	75.5	44.2	6.8	2.0	22.6	14.2	10.3
1996	100.0	73.9	30.1	9.4	2.1	32.4	14.9	11.2
1997	100.0	72.7	29.9	9.7	0.7	31.4	16.1	11.2

Source: Dataquest (October 1998)

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Table 4-48
Siemens' Worldwide Market Shares by Product, 1987-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	1.7	1.2	0.8	0.9	1.3	1.6	3.3	5.0
1988	1.5	1.2	1.2	1.2	1.0	1.4	2.6	4.6
1989	2.1	1.8	2.4	1.2	1.6	1.7	3.2	4.8
1990	2.2	1.8	2.5	1.2	1.7	1.8	3.3	5.4
1991	2.1	1.7	2.3	1.1	1.7	1.7	3.0	6.7
1992	1.9	1.6	2.2	0.8	1.7	1.5	2.7	6.7
1993	1.8	1.5	2.4	0.5	0.4	2.7	2.5	5.7
1994	1.9	1.7	2.5	0.5	0.3	3.2	2.6	5.7
1995	2.0	1.8	2.4	0.6	0.1	3.9	3.0	6.5
1996	2.1	1.8	2.4	0.7	0.1	5.4	3.4	6.9
1997	2.3	2.0	3.3	0.7	0	5.0	3.9	7.2

Source: Dataquest (October 1998)

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No. 13: IBM

IBM's overall semiconductor revenue stabilized at 6 percent in 1997. Table 4-49 shows the sources of IBM's 1997 semiconductor revenue by product and region. IBM's business revenue is drawn from five sectors: hardware, which includes the company's high-end and midrange processors, PCs, and RISC workstations; services; software; maintenance; and financing and other operations. Table 4-50 lists IBM's product profile for 1993 to 1997.

Without a full set of historical data to look at, the comparison of IBM revenue growth with that of the semiconductor industry is of limited value but is nonetheless presented in Figure 4-25. The company's capital spending history for the same time frame is illustrated in Figure 4-26.

IBM's product contribution and focus is digital. Each of its major product families is shown in Table 4-51. IBM's share of the worldwide market by product is shown in Table 4-52.

Table 4-49
IBM's Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**2,679**	**332**	**132**	**248**	**3,391**
Total Integrated Circuit	2,679	332	132	248	3,391
MOS Digital IC	2,679	332	132	248	3,391
MOS Memory	655	197	88	50	990
MOS Microcomponent	585	65	8	145	803
MOS Digital Logic	1,439	70	36	53	1,598

Source: Dataquest (October 1998)

Table 4-50
IBM's Product Profile, 1993-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1993	2,510	2,510	1,133	337	1,040	0	0	0
1994	2,532	2,532	1,520	399	613	0	0	0
1995	3,522	3,522	2,100	703	719	0	0	0
1996	3,200	3,200	1,253	889	1,058	0	0	0
1997	3,391	3,391	990	803	1,598	0	0	0
1996-1997 Growth (%)	6.0	6.0	-21.0	-9.7	51.0	0	0	0

Source: Dataquest (October 1998)

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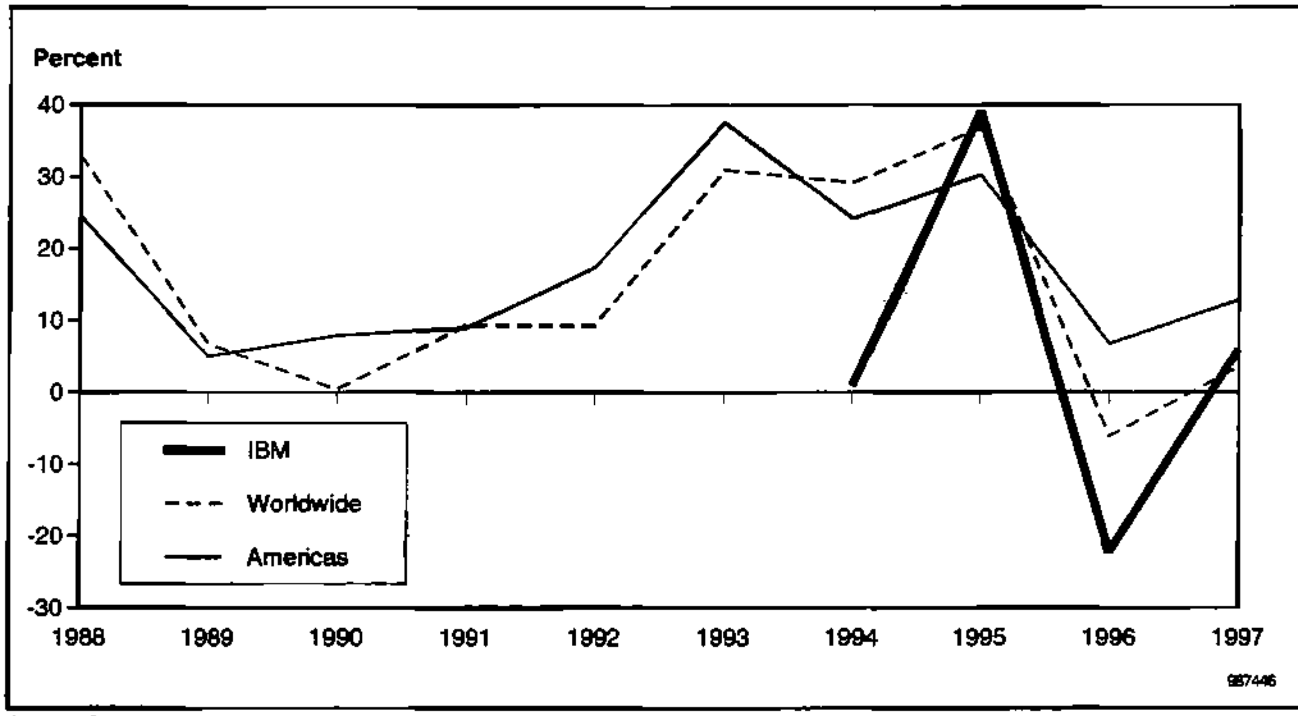
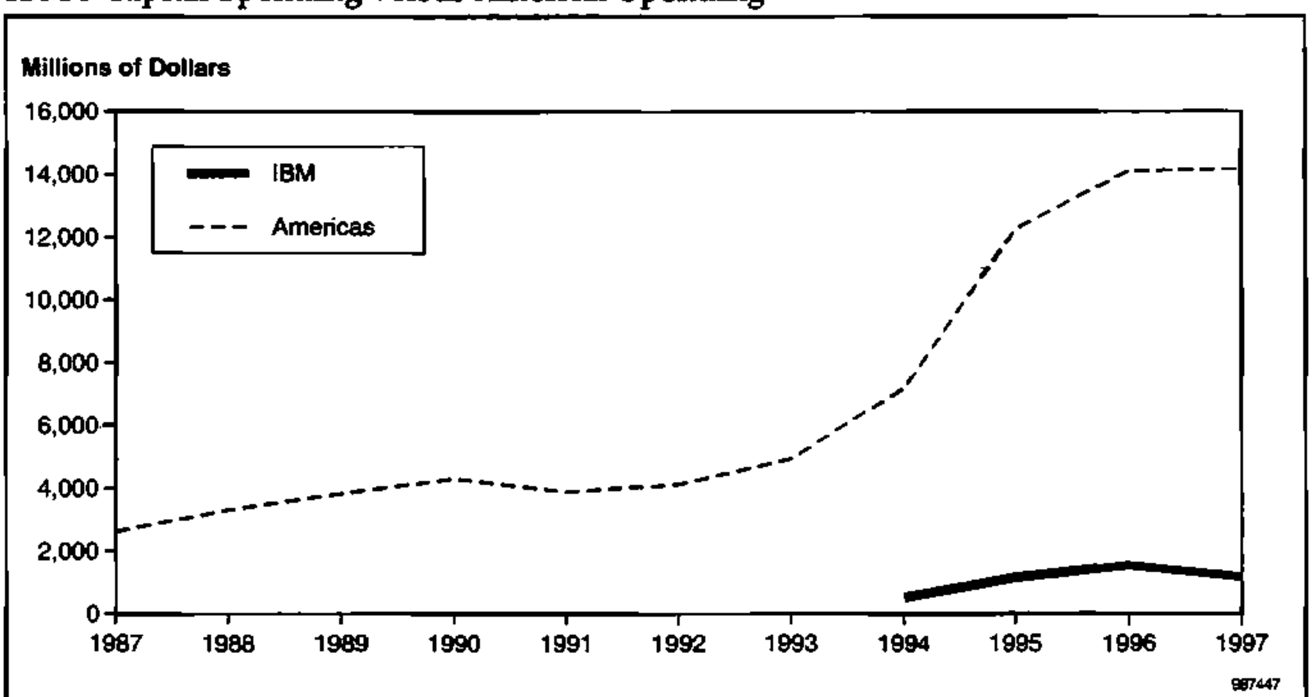
Figure 4-25
IBM's Annual Growth versus the Semiconductor Industry's



Source: Dataquest (October 1998)

Figure 4-26
IBM's Capital Spending versus Americas Spending



Source: Dataquest (October 1998)

Table 4-51
IBM's Product Profile, 1993-1997 (Percentage of IBM's Total Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1993	100.0	100.0	45.1	13.4	41.4	0	0	0
1994	100.0	100.0	60.0	15.8	24.2	0	0	0
1995	100.0	100.0	59.6	20.0	20.4	0	0	0
1996	100.0	100.0	39.2	27.8	33.1	0	0	0
1997	100.0	100.0	29.2	23.7	47.1	0	0	0

Source: Dataquest (October 1998)

Table 4-52
IBM's Worldwide Market Shares by Product, 1993-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1993	2.9	3.4	4.8	1.7	6.5	0	0	0
1994	2.3	2.6	4.5	1.5	3.3	0	0	0
1995	2.3	2.7	3.8	2.0	3.5	0	0	0
1996	1.9	2.2	2.6	1.8	4.7	0	0	0
1997	2.3	2.7	3.2	1.6	6.5	0	0	0

Source: Dataquest (October 1998)

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No. 14: Matsushita

Matsushita's ranking did not change much from 1996, but its revenue declined 5.2 percent in 1997. Matsushita is a very strong vertically integrated company; its merchant market presence is small, but its Panasonic, National, Technics, and Quasar name brands are well-known product consumers. Table 4-53 shows the sources of Matsushita's 1997 semiconductor revenue by product and region.

Matsushita was established in 1918. Its semiconductor revenue is but a small portion of a very large corporation whose business revenue is drawn from four major segments: communications/industrial equipment, audio-visual equipment, home appliances, and other appliances. Matsushita's 1997 revenue for each of the major semiconductor product categories is given in Table 4-54.

Figure 4-27 illustrates the difference between Matsushita's growth rate and that of the total semiconductor industry since 1987. Matsushita's presence in memories is small. Therefore, the company's growth or decline will not be as rapid as that of the total market. Figure 4-28 illustrates Matsushita's capital spending history and how it compares to its region's spending history.

The contribution of each of the product categories to Matsushita's total semiconductor revenue is shown in Table 4-55. Its share of the worldwide market by product is shown in Table 4-56. Matsushita is a very stable broad-line semiconductor supplier as would be expected of a vertically integrated consumer electronics vendor. The product lines support the end-equipment needs, but the end-equipment market for non-PC-related products has been slowing.

Table 4-53
Matsushita's Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**148**	**15**	**2,244**	**440**	**2,847**
Total Integrated Circuit	116	9	1,483	274	1,882
Total Bipolar Digital	0	0	8	11	19
MOS Digital IC	102	7	1,065	134	1,308
MOS Memory	37	2	217	59	315
MOS Microcomponent	10	5	409	33	457
MOS Digital Logic	55	0	439	42	536
Analog-Monolithic	14	2	410	129	555
Total Discrete	27	4	392	154	577
Total Optical Semiconductor	5	2	369	12	388

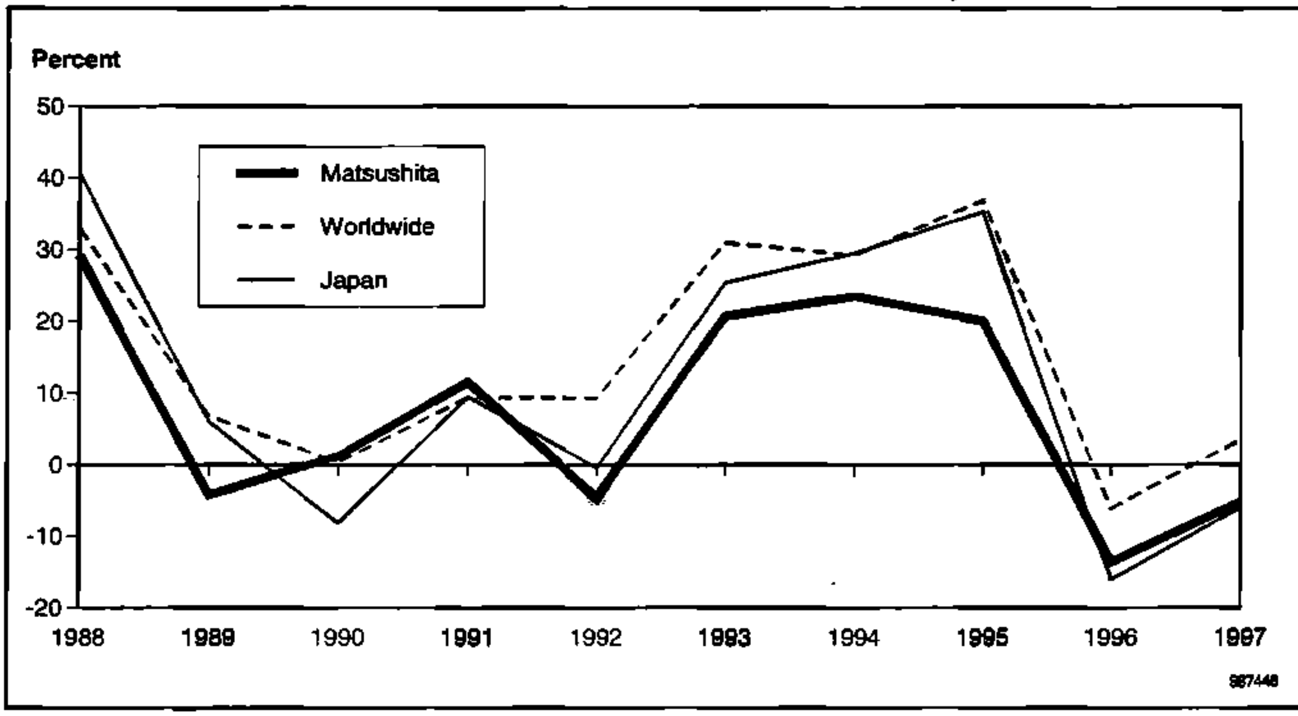
Source: Dataquest (October 1998)

Table 4-54
Matsushita's Product Profile, 1987-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	1,457	994	91	199	328	376	318	145
1988	1,883	1,328	230	230	445	423	377	178
1989	1,804	1,203	362	218	265	358	314	287
1990	1,826	1,206	265	250	295	396	339	281
1991	2,037	1,340	217	321	390	412	379	318
1992	1,942	1,248	217	275	353	403	379	315
1993	2,344	1,536	305	286	472	473	450	358
1994	2,896	1,968	396	460	501	611	511	417
1995	3,474	2,347	495	555	658	639	631	496
1996	3,003	1,988	300	534	607	547	565	450
1997	2,847	1,882	315	457	536	555	577	388
1996-1997 Growth (%)	-5.2	-5.3	5.0	-14.4	-8.8	1.5	2.1	-13.8

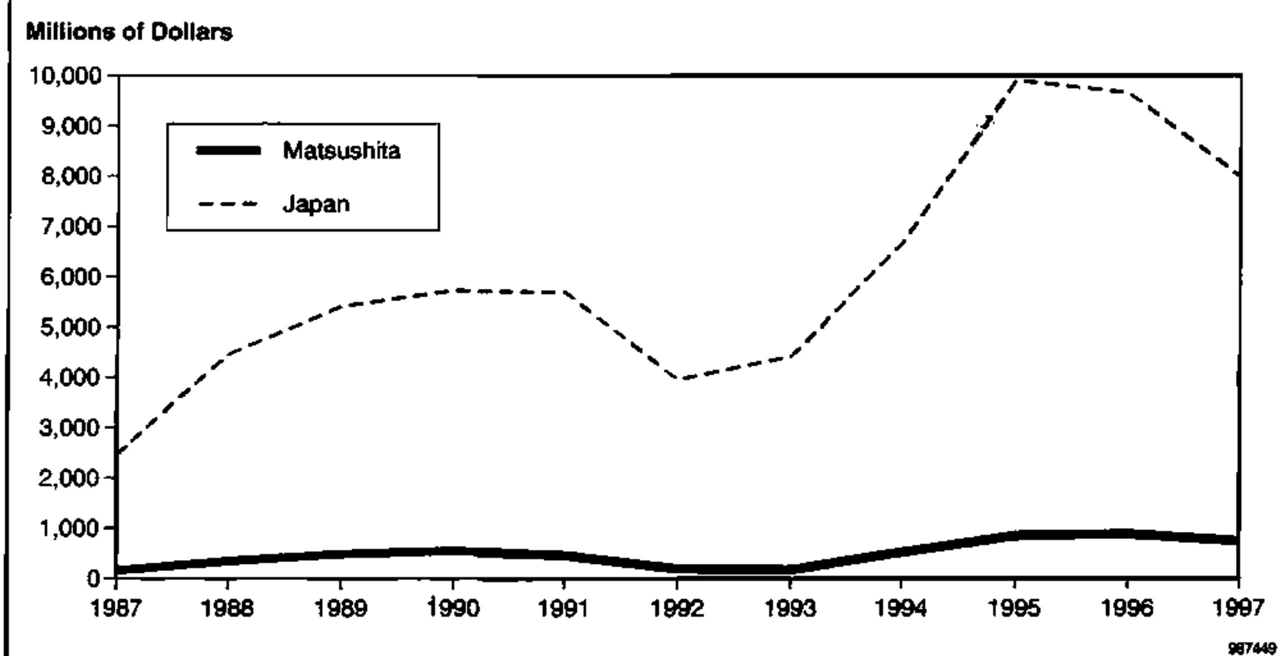
Source: Dataquest (October 1998)

Figure 4-27
Matsushita's Annual Growth versus the Semiconductor Industry's



Source: Dataquest (October 1998)

Figure 4-28
Matsushita's Capital Spending versus Japan's Spending



Source: Dataquest (October 1998)

Table 4-55
Matsushita's Product Profile, 1987-1997 (Percentage of Matsushita's Total Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	100.0	68.2	6.2	13.7	22.5	25.8	21.8	10.0
1988	100.0	70.5	12.2	12.2	23.6	22.5	20.0	9.5
1989	100.0	66.7	20.1	12.1	14.7	19.8	17.4	15.9
1990	100.0	66.0	14.5	13.7	16.2	21.7	18.6	15.4
1991	100.0	65.8	10.7	15.8	19.1	20.2	18.6	15.6
1992	100.0	64.3	11.2	14.2	18.2	20.8	19.5	16.2
1993	100.0	65.5	13.0	12.2	20.1	20.2	19.2	15.3
1994	100.0	68.0	13.7	15.9	17.3	21.1	17.6	14.4
1995	100.0	67.6	14.2	16.0	18.9	18.4	18.2	14.3
1996	100.0	66.2	10.0	17.8	20.2	18.2	18.8	15.0
1997	100.0	66.1	11.1	16.1	18.8	19.5	20.3	13.6

Source: Dataquest (October 1998)

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Table 4-56
Matsushita's Worldwide Market Shares by Product, 1987-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	3.8	3.3	1.4	3.9	3.1	4.9	4.8	8.5
1988	3.7	3.2	1.9	3.2	3.5	4.8	5.0	8.2
1989	3.3	2.7	2.3	2.8	2.2	3.9	4.3	11.9
1990	3.3	2.7	2.1	2.6	2.4	3.9	4.4	11.7
1991	3.4	2.7	1.6	2.7	3.0	3.8	4.7	11.3
1992	3.0	2.3	1.4	1.9	2.7	3.5	4.6	11.7
1993	2.7	2.1	1.3	1.4	3.0	3.4	5.0	11.9
1994	2.6	2.1	1.2	1.7	2.7	3.6	4.7	10.7
1995	2.3	1.8	0.9	1.6	2.9	3.6	4.4	10.3
1996	2.1	1.6	0.8	1.3	2.6	2.8	4.2	9.2
1997	1.9	1.5	1.0	0.9	2.2	2.6	4.0	7.3

Source: Dataquest (October 1998)

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No. 15: Lucent Technologies

The microelectronics division of Lucent Technologies grew by more than 30 percent in 1996 and 30.9 percent in 1997. The company moved from the No. 25 spot in 1995 to the No. 20 rank in 1996 and up to the No. 15 position in 1997. Lucent's strength in product acceptance and improvement in product marketing is well worth mentioning, because the company did not even rank in the top 40 in 1994. Lucent's semiconductor revenue from the merchant market has been available only since 1994. Spun off from AT&T in 1994, Lucent's revenue is drawn from the following segments: network systems, business communications systems, microelectronics, consumer products, and other products. Table 4-57 illustrates Lucent's semiconductor revenue in 1997 by product and region. At 30.9 percent, Lucent had the largest year-to-year growth of the top 20 in 1997. The company's product profile is listed in Table 4-58.

Figure 4-30 illustrates the difference between Lucent's growth rate and that of the total industry. Figure 4-31 shows Lucent's capital spending history and how it compares to the region's total spending during that time frame. Table 4-59 lists the contribution of each of Lucent's products to its total semiconductor revenue. Table 4-60 lists the market shares of Lucent's products in the worldwide market.

Table 4-57
Lucent Technologies' Product Distribution by Region, 1997 (Millions of Dollars)

	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**1,351**	**593**	**186**	**632**	**2,762**
Total Integrated Circuit	1,146	555	184	604	2,489
Total Bipolar Digital	10	0	0	0	10
MOS Digital IC	1,056	540	184	594	2,374
MOS Microcomponent	311	255	97	225	888
MOS Digital Logic	745	285	87	369	1,486
Analog-Monolithic	80	15	0	10	105
Total Optical Semiconductor	205	38	2	28	273

Source: Dataquest (October 1998)

Table 4-58
Lucent Technologies' Product Profile, 1994-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1994	1,307	1,250	6	305	537	402	0	51
1995	1,615	1,534	8	510	732	284	0	81
1996	2,110	2,020	0	635	1,084	301	0	90
1997	2,762	2,489	0	888	1,486	105	0	273
1996-1997 Growth (%)	30.9	23.2	0	39.8	37.8	-55.3	0	203.3

Source: Dataquest (October 1998)

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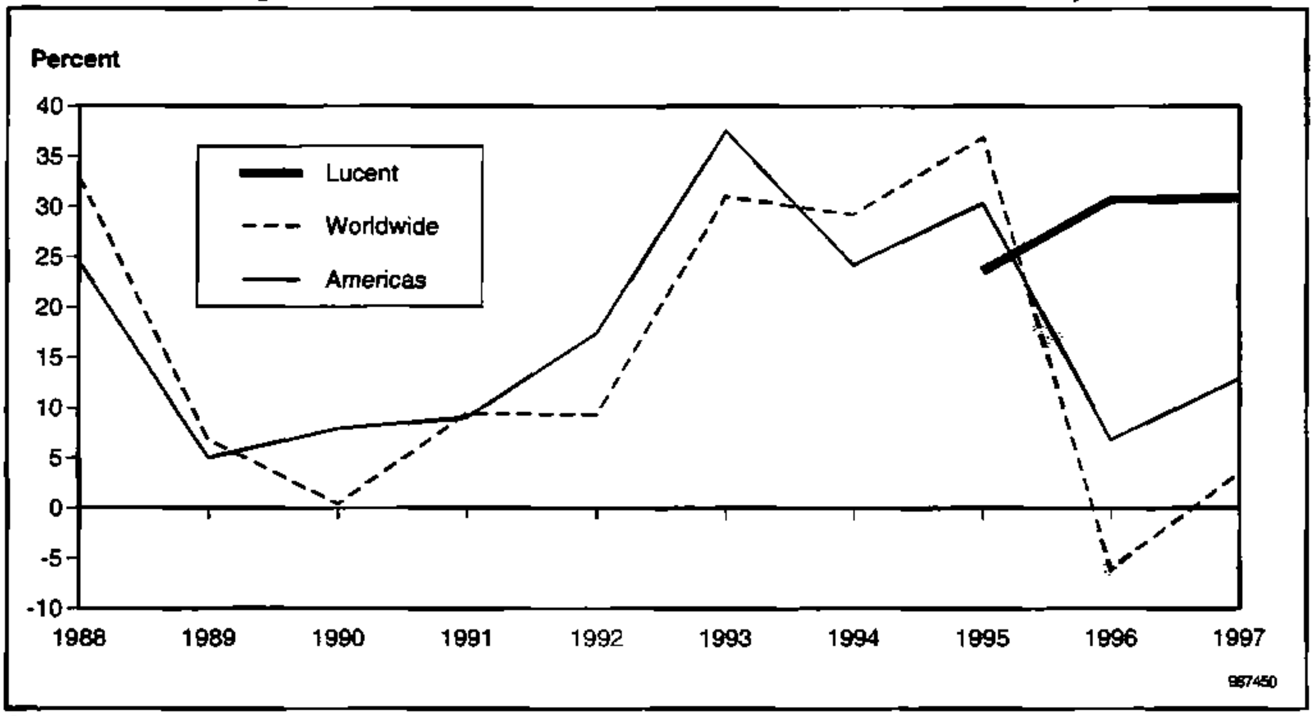
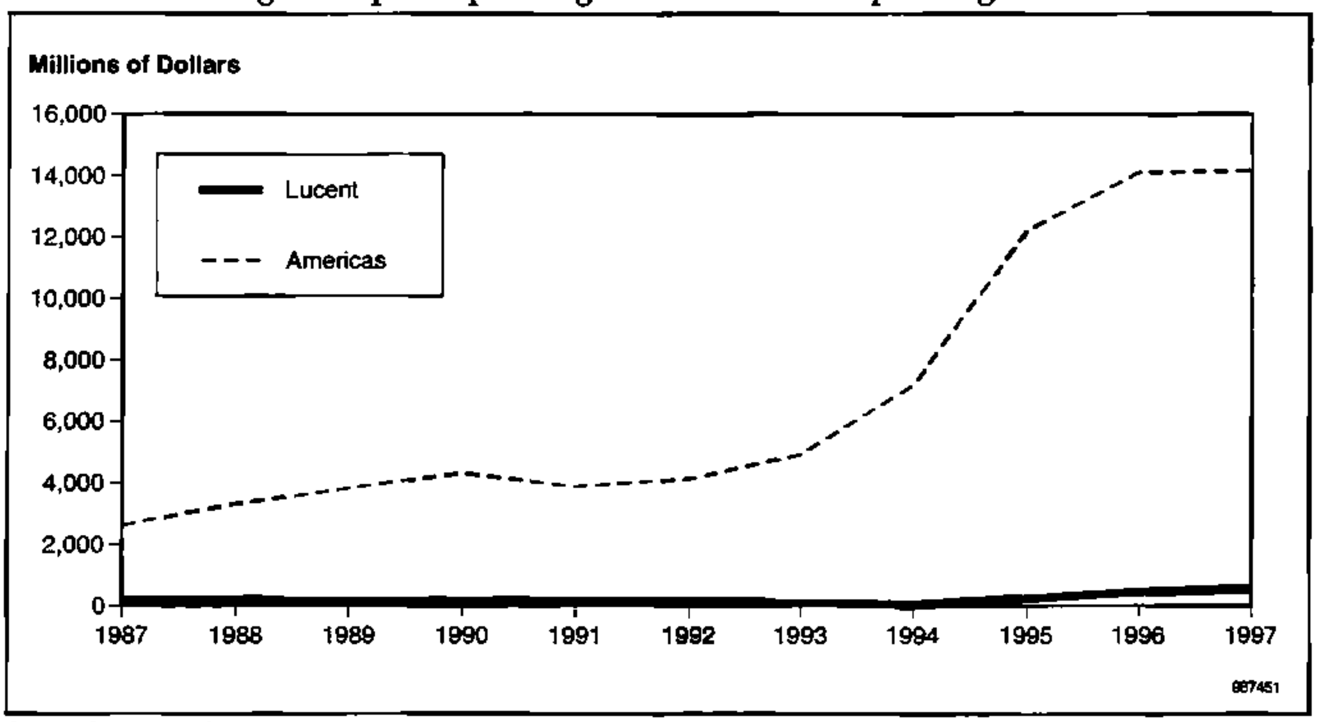
Figure 4-29
Lucent Technologies' Annual Growth versus the Semiconductor Industry's



Source: Dataquest (October 1998)

Figure 4-30
Lucent Technologies' Capital Spending versus Americas Spending



Source: Dataquest (October 1998)

Table 4-59
Lucent Technologies' Product Profile, 1994-1997 (Percentage of Lucent Technologies' Total Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1994	100.0	95.6	0.5	23.3	41.1	30.8	0	3.9
1995	100.0	95.0	0.5	31.6	45.3	17.6	0	5.0
1996	100.0	95.7	0	30.1	51.4	14.3	0	4.3
1997	100.0	90.1	0	32.2	53.8	3.8	0	9.9

Source: Dataquest (October 1998)

Table 4-60
Lucent Technologies' Worldwide Market Shares by Product, 1994-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1994	1.2	1.3	0	1.2	2.9	2.6	0	1.3
1995	1.1	1.2	0	1.5	3.2	1.6	0	1.7
1996	1.5	1.6	0	1.5	4.7	1.6	0	1.8
1997	1.9	2.0	0	1.8	6.0	0.5	0	5.1

Source: Dataquest (October 1998)

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No. 16: National Semiconductor

National Semiconductor maintained its No. 16 ranking but grew its year-to-year revenue by 15.9 percent. Table 4-61 shows the sources of National's 1997 semiconductor revenue by product and region. National's revenue in 1997 for each of the major semiconductor product categories is listed in Table 4-62.

Figure 4-31 illustrates the difference between National's growth rate and that of the total semiconductor industry since 1987. Figure 4-32 shows National's capital spending history and how it compares to the region's total spending during the same time frame.

The contribution of each of the product categories to National's total semiconductor revenue is shown in Table 4-63. National's shares of the worldwide market by product are shown in Table 4-64.

Table 4-61
National Semiconductor's Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**1,116**	**707**	**227**	**709**	**2,759**
Total Integrated Circuit	1,061	672	215	676	2,624
Total Bipolar Digital	10	3	0	1	14
MOS Digital IC	587	323	61	281	1,252
MOS Memory	2	0	0	0	2
MOS Microcomponent	511	262	51	277	1,101
MOS Digital Logic	74	61	10	4	149
Analog-Monolithic	464	346	154	394	1,358
Total Discrete	55	35	12	33	135

Source: Dataquest (October 1998)

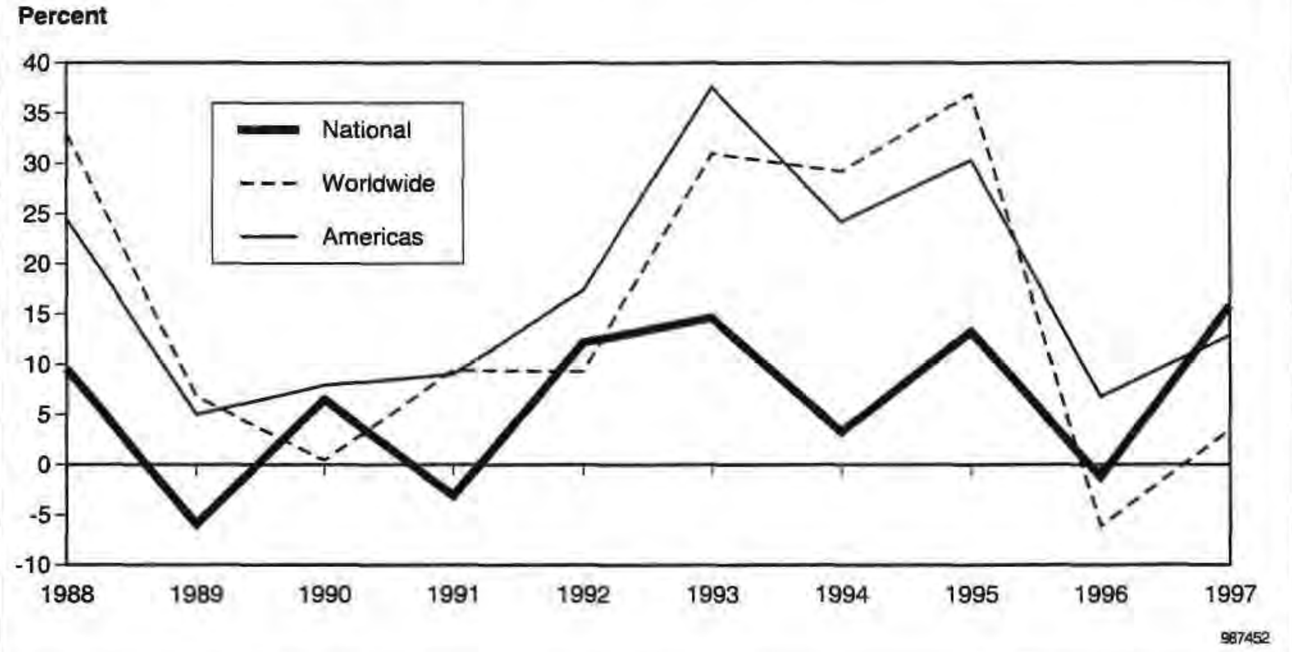
 ©1998 Dataquest

Table 4-62
National Semiconductor's Product Profile, 1987-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	1,506	1,431	125	140	671	495	75	0
1988	1,650	1,575	170	150	715	540	75	0
1989	1,552	1,482	181	169	604	528	70	0
1990	1,653	1,583	162	242	586	593	70	0
1991	1,602	1,542	125	286	502	629	60	0
1992	1,797	1,727	136	383	469	739	70	0
1993	2,060	1,983	177	477	527	802	77	0
1994	2,127	2,028	184	452	478	914	99	0
1995	2,408	2,244	188	542	263	1,034	164	0
1996	2,380	2,223	127	627	293	1,015	157	0
1997	2,759	2,624	2	1,101	149	1,358	135	0
1996-1997 Growth (%)	15.9	18.0	-98.4	75.6	-49.1	33.8	-14.0	0

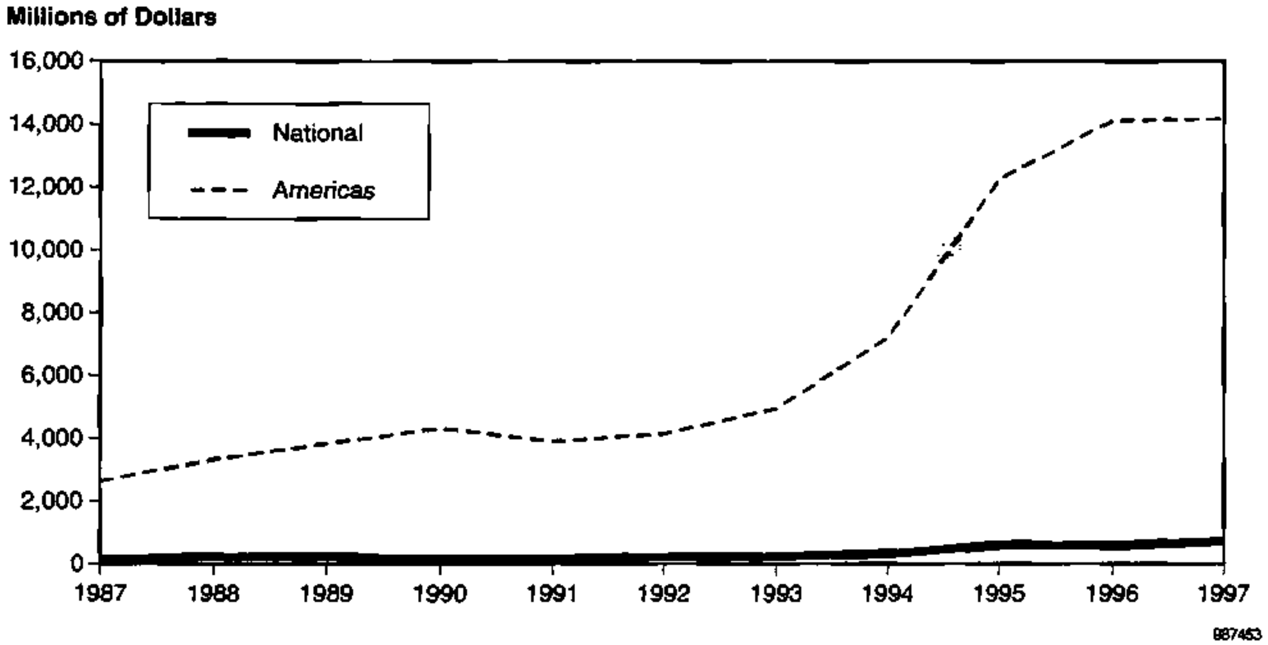
Source: Dataquest (October 1998)

Figure 4-31
National Semiconductor's Annual Growth versus the Semiconductor Industry's



Source: Dataquest (October 1998)

Figure 4-32
National Semiconductor's Capital Spending versus Americas Spending



Source: Dataquest (October 1998)

Table 4-63
National Semiconductor's Product Profile, 1987-1997 (Percentage of National Semiconductor's Total Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	100.0	95.0	8.3	9.3	44.6	32.9	5.0	0
1988	100.0	95.5	10.3	9.1	43.3	32.7	4.5	0
1989	100.0	95.5	11.7	10.9	38.9	34.0	4.5	0
1990	100.0	95.8	9.8	14.6	35.5	35.9	4.2	0
1991	100.0	96.3	7.8	17.9	31.3	39.3	3.7	0
1992	100.0	96.1	7.6	21.3	26.1	41.1	3.9	0
1993	100.0	96.3	8.6	23.2	25.6	38.9	3.7	0
1994	100.0	95.3	8.7	21.3	22.5	43.0	4.7	0
1995	100.0	93.2	7.8	22.5	10.9	42.9	6.8	0
1996	100.0	93.4	5.3	26.3	12.3	42.6	6.6	0
1997	100.0	95.1	0.1	39.9	5.4	49.2	4.9	0

Source: Dataquest (October 1998)

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Table 4-64
National Semiconductor's Worldwide Market Shares by Product, 1987-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	3.9	4.8	1.9	2.7	6.4	6.5	1.1	0
1988	3.2	3.8	1.4	2.1	5.6	6.1	1.0	0
1989	2.9	3.3	1.1	2.2	5.1	5.8	1.0	0
1990	3.0	3.6	1.3	2.5	4.8	5.9	0.9	0
1991	2.7	3.2	0.9	2.4	3.9	5.8	0.7	0
1992	2.8	3.2	0.9	2.7	3.6	6.4	0.9	0
1993	2.4	2.7	0.8	2.4	3.3	5.7	0.8	0
1994	1.9	2.1	0.5	1.7	2.5	5.9	0.9	0
1995	1.6	1.7	0.5	1.6	1.8	5.9	1.1	0
1996	1.7	1.8	0.3	1.5	1.8	5.4	1.2	0
1997	1.9	2.1	0	2.2	0.6	6.3	0.9	0

Source: Dataquest (October 1998)

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No. 17: SANYO

SANYO's ranking dropped from No. 15 to No. 17 in 1997. Its revenue declined 0.8 percent from 1996 to 1997. SANYO's product and revenue strength has traditionally been in the analog and discrete areas. The sources of SANYO's revenue, by product and regional market, are shown in Table 4-65.

SANYO was established in 1947. Its corporate revenue is drawn from seven business segments: information systems and electronic devices, home appliances, industrial and commercial equipment, video equipment, audio equipment, batteries and other products, and other products. SANYO's 1997 revenue for each of the major product categories is given in Table 4-66.

Figure 4-33 illustrates the difference between SANYO's growth rate and that of the total semiconductor industry since 1987. Figure 4-34 illustrates the company's capital spending history and how it compares to the region's total spending.

The contribution of each of the product categories to SANYO's total semiconductor sales is shown in Table 4-67. SANYO's revenue contribution by product has remained quite stable over the past 10 years. SANYO's shares of the worldwide market by product are shown in Table 4-68.

Table 4-65
SANYO's Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**179**	**99**	**1,292**	**901**	**2,471**
Total Integrated Circuit	142	86	879	711	1,818
MOS Digital IC	121	22	516	309	968
MOS Memory	27	4	99	32	162
MOS Microcomponent	17	2	125	85	229
MOS Digital Logic	77	16	292	192	577
Analog-Monolithic	21	64	363	402	850
Total Discrete	19	11	283	165	478
Total Optical Semiconductor	18	2	130	25	175

Source: Dataquest (October 1998)

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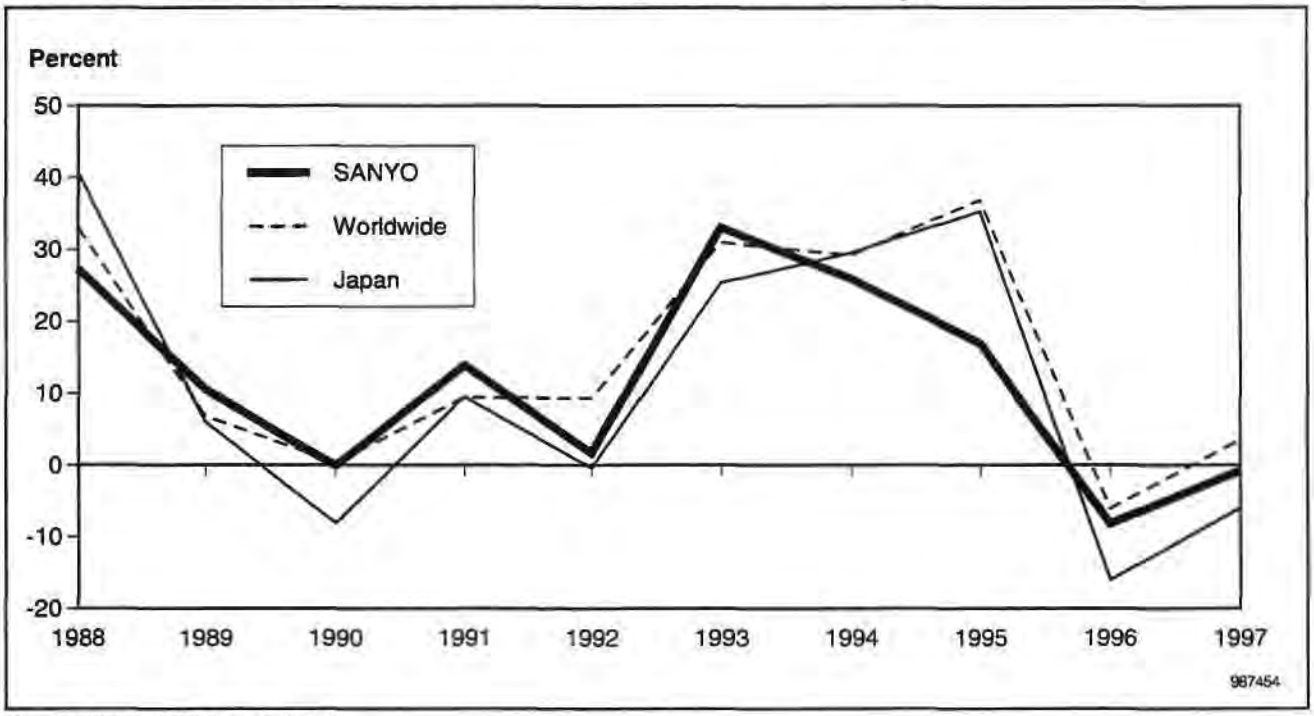
Table 4-66
SANYO's Product Profile, 1987-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	851	556	27	53	99	377	210	85
1988	1,083	811	87	70	183	471	210	62
1989	1,197	862	118	63	214	467	199	136
1990	1,196	850	86	71	226	467	197	149
1991	1,362	919	82	69	169	599	250	193
1992	1,385	1,005	95	100	191	619	244	136
1993	1,843	1,370	155	145	271	799	336	137
1994	2,321	1,782	183	161	453	985	389	150
1995	2,714	2,059	257	187	528	894	488	167
1996	2,491	1,902	302	164	479	780	441	148
1997	2,471	1,818	162	229	577	850	478	175
1996-1997 Growth (%)	-0.8	-4.4	-46.4	39.6	20.5	9.0	8.4	18.2

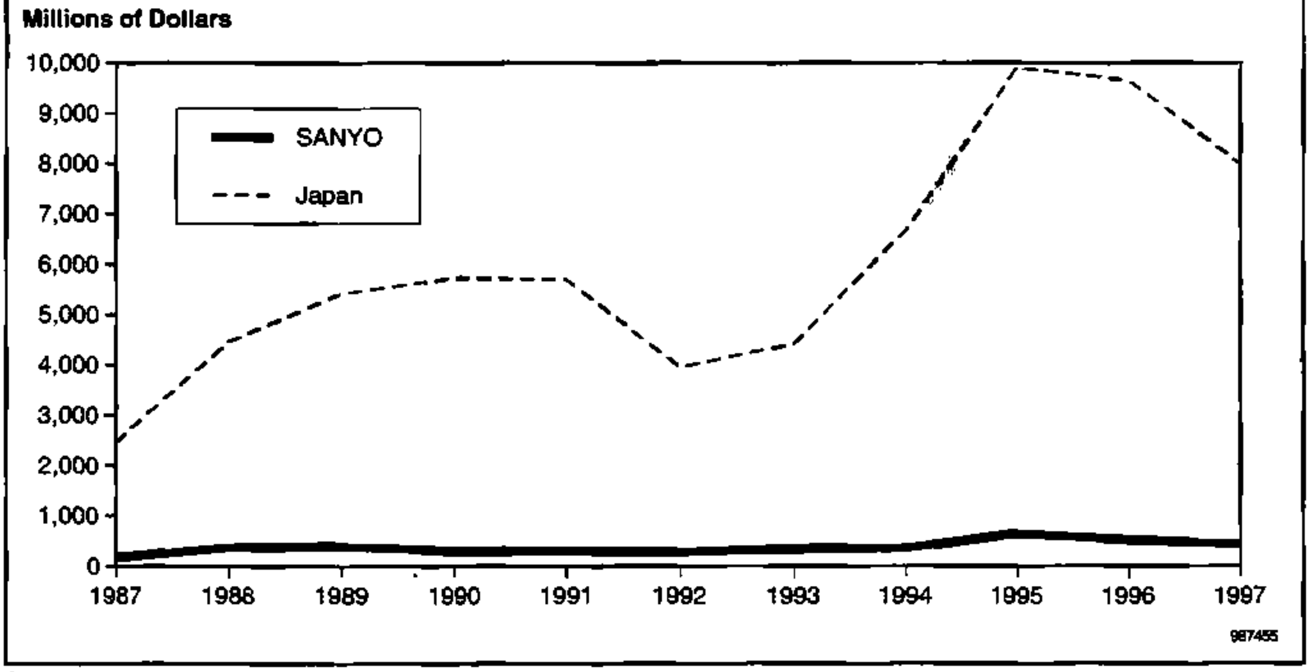
Source: Dataquest (October 1998)

Figure 4-33
SANYO's Annual Growth versus the Semiconductor Industry's



Source: Dataquest (October 1998)

Figure 4-34
SANYO's Capital Spending versus Japan's Spending



Source: Dataquest (October 1998)

Table 4-67
SANYO's Product Profile, 1987-1997 (Percentage of SANYO's Total Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	100.0	65.3	3.2	6.2	11.6	44.3	24.7	10.0
1988	100.0	74.9	8.0	6.5	16.9	43.5	19.4	5.7
1989	100.0	72.0	9.9	5.3	17.9	39.0	16.6	11.4
1990	100.0	71.1	7.2	5.9	18.9	39.0	16.5	12.5
1991	100.0	67.5	6.0	5.1	12.4	44.0	18.4	14.2
1992	100.0	72.6	6.9	7.2	13.8	44.7	17.6	9.8
1993	100.0	74.3	8.4	7.9	14.7	43.4	18.2	7.4
1994	100.0	76.8	7.9	6.9	19.5	42.4	16.8	6.5
1995	100.0	75.8	9.5	6.9	19.5	32.9	18.0	6.2
1996	100.0	76.4	12.1	6.6	19.2	31.3	17.7	5.9
1997	100.0	73.6	6.6	9.3	23.4	34.4	19.3	7.1

Source: Dataquest (October 1998)

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Table 4-68
SANYO's Worldwide Market Shares by Product, 1987-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	2.2	1.9	0.4	1.0	0.9	4.9	3.2	5.0
1988	2.1	2.0	0.7	1.0	1.4	5.3	2.8	2.8
1989	2.2	1.9	0.7	0.8	1.8	5.1	2.7	5.7
1990	2.2	1.9	0.7	0.7	1.9	4.6	2.6	6.2
1991	2.3	1.9	0.6	0.6	1.3	5.5	3.1	6.9
1992	2.1	1.8	0.6	0.7	1.5	5.4	3.0	5.1
1993	2.2	1.9	0.7	0.7	1.7	5.7	3.7	4.6
1994	2.1	1.9	0.5	0.6	2.8	5.3	3.6	3.9
1995	1.8	1.6	0.5	0.5	2.6	5.1	3.4	3.5
1996	1.8	1.5	0.8	0.4	2.2	4.0	3.3	3.0
1997	1.7	1.4	0.5	0.5	2.3	3.9	3.4	3.3

Source: Dataquest (October 1998)

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No. 18: Advanced Micro Devices

Advanced Micro Devices was founded in 1969. AMD's share of market and ranking has changed radically since the company's beginning. AMD shifted its ranking position from No. 22 to No. 18 in 1997 through the growth of its memory, logic, and microprocessor product groups. Net sales in 1997 for each of AMD's business segments were as follows: the Memory Group ($724 million); the Communications Group ($702 million); the Computation Products Group ($682 million); and Vantis, its programmable logic subsidiary ($243 million). Table 4-69 lists AMD's products for 1997 by region. Table 4-70 presents a 10-year history of AMD's products.

Figure 4-35 illustrates the difference between AMD's growth rate and that of the total semiconductor industry since 1987. Figure 4-36 illustrates AMD's capital spending history and how it compares to the region's total spending. Table 4-71 lists AMD's total product revenue as a share of the company's revenue. Table 4-72 lists AMD's share of the worldwide market by product.

Table 4-69
Advanced Micro Devices' Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**1,032**	**679**	**160**	**470**	**2,341**
Total Integrated Circuit	1,032	679	160	470	2,341
Total Bipolar Digital	15	7	4	2	28
MOS Digital IC	948	622	130	423	2,123
MOS Memory	334	253	28	93	708
MOS Microcomponent	457	303	62	284	1,106
MOS Digital Logic	157	66	40	46	309
Analog-Monolithic	69	50	26	45	190

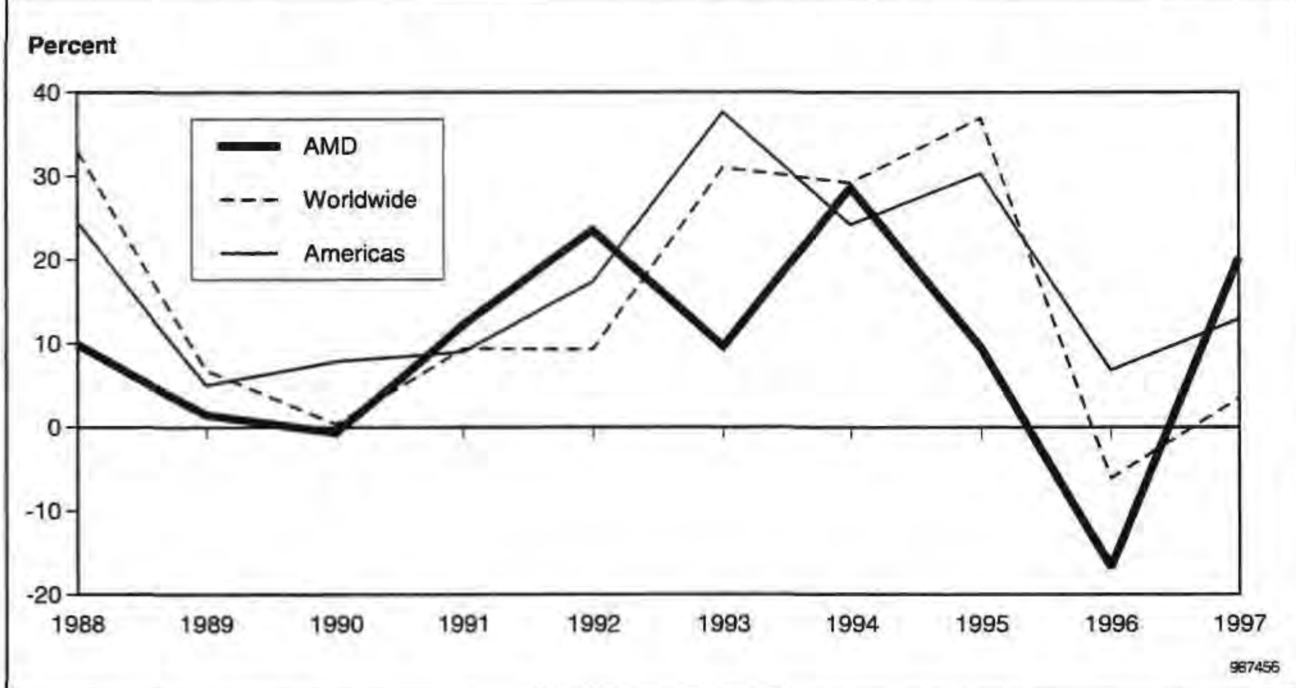
Source: Dataquest (October 1998)

Table 4-70
Advanced Micro Devices' Product Profile, 1987-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discrete	Optical
1987	986	986	155	178	81	72	0	0
1988	1,084	1,084	207	183	92	66	0	0
1989	1,100	1,100	258	172	119	77	0	0
1990	1,093	1,093	253	178	139	76	0	0
1991	1,226	1,226	270	395	167	94	0	0
1992	1,514	1,514	282	642	233	110	0	0
1993	1,660	1,660	427	563	317	154	0	0
1994	2,134	2,134	442	1,021	341	187	0	0
1995	2,337	2,337	719	925	420	173	0	0
1996	1,947	1,947	711	624	435	115	0	0
1997	2,341	2,341	708	1,106	309	190	0	0
1996-1997 Growth (%)	20.2	20.2	-0.4	77.2	-29.0	65.2	0	0

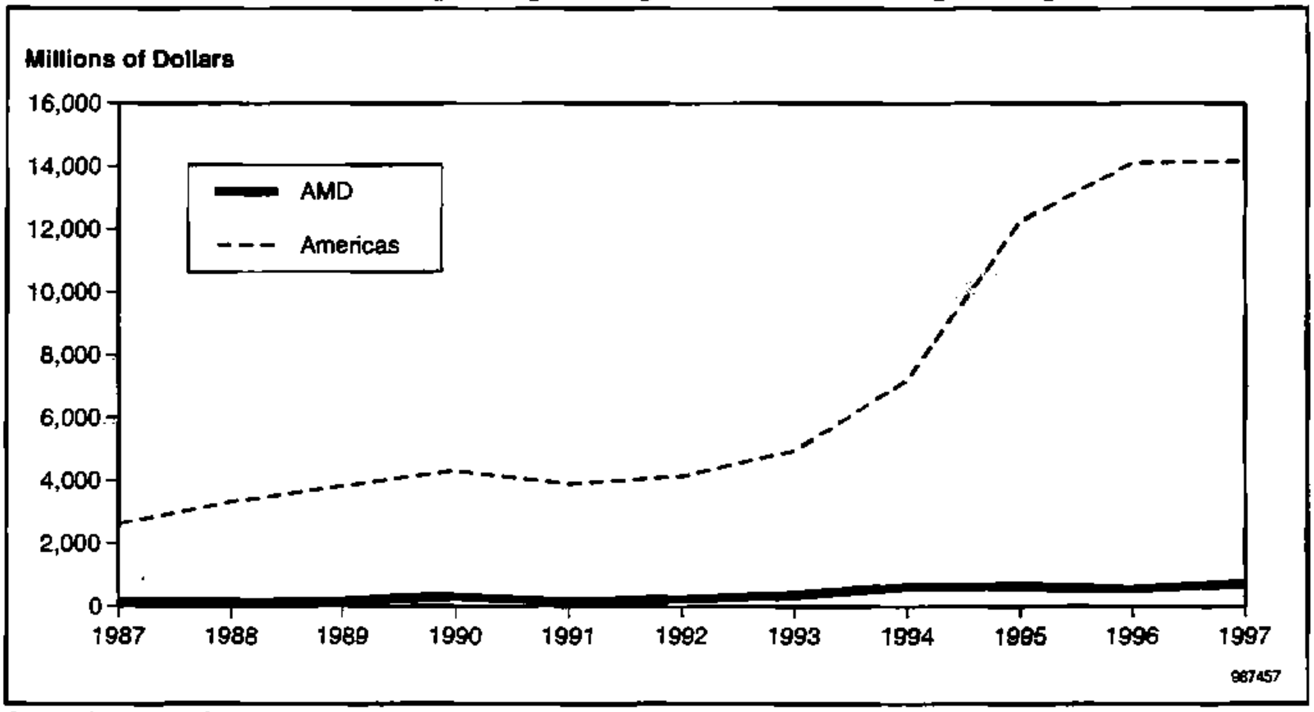
Source: Dataquest (October 1998)

Figure 4-35
Advanced Micro Devices' Annual Growth versus the Semiconductor Industry's



Source: Dataquest (October 1998)

Figure 4-36
Advanced Micro Devices' Capital Spending versus Americas Spending



Source: Dataquest (October 1998)

Table 4-71
Advanced Micro Devices' Product Profile, 1987-1997 (Percentage of Advanced Micro Devices' Total Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	100.0	100.0	15.7	18.1	8.2	7.3	0	0
1988	100.0	100.0	19.1	16.9	8.5	6.1	0	0
1989	100.0	100.0	23.5	15.6	10.8	7.0	0	0
1990	100.0	100.0	23.1	16.3	12.7	7.0	0	0
1991	100.0	100.0	22.0	32.2	13.6	7.7	0	0
1992	100.0	100.0	18.6	42.4	15.4	7.3	0	0
1993	100.0	100.0	25.7	33.9	19.1	9.3	0	0
1994	100.0	100.0	20.7	47.8	16.0	8.8	0	0
1995	100.0	100.0	30.8	39.6	18.0	7.4	0	0
1996	100.0	100.0	36.5	32.0	22.3	5.9	0	0
1997	100.0	100.0	30.2	47.2	13.2	8.1	0	0

Source: Dataquest (October 1998)

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Table 4-72
Advanced Micro Devices' Worldwide Market Shares by Product, 1987-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	2.6	3.3	2.6	3.5	1.3	1.1	0	0
1988	2.1	2.6	1.8	2.6	1.1	0.9	0	0
1989	2.0	2.5	1.7	2.2	1.5	1.0	0	0
1990	2.0	2.5	2.1	1.9	1.6	0.9	0	0
1991	2.1	2.5	2.1	3.4	1.7	1.0	0	0
1992	2.3	2.8	1.8	4.5	2.3	1.1	0	0
1993	1.9	2.3	1.8	2.8	2.4	1.2	0	0
1994	1.9	2.2	1.3	3.9	2.1	1.2	0	0
1995	1.5	1.8	1.3	2.7	2.0	1.0	0	0
1996	1.4	1.6	1.9	1.5	1.9	0.6	0	0
1997	1.6	1.8	2.3	2.3	1.2	0.9	0	0

Source: Dataquest (October 1998)

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No. 19: Sharp

Sharp Corporation was founded in 1912 by Tokuji Hayakawa. From snap-buckles and "Ever-Sharp" pencils, the company, as of March 1998, emerged into a ¥1,790,542 million electronics company with four major business segments. For fiscal 1997 the company's segments' shares of sales revenue were as follows: audiovisual equipment (24.3 percent), home appliances (15.8 percent), communications and information equipment (33.2 percent), and electronic components (26.8 percent). In semiconductors, Sharp achieved a 1 percent revenue increase in 1997, after an 18 percent decline in 1996. Table 4-73 lists Sharp's semiconductor revenue by product and region. The product segments of this company cater to the electronics world. Sharp's semiconductor revenue by product categories in 1997 is listed in Table 4-74.

Figure 4-37 illustrates the difference between Sharp's growth rate and that of the total semiconductor industry since 1987. Sharp is still the No. 1 supplier in optical semiconductors. Figure 4-38 illustrates Sharp's capital spending history and how it compares to the region's total spending. Table 4-75 lists the contribution of each of the product categories to Sharp's total semiconductor revenue. Sharp's share of the worldwide market by product is shown in Table 4-76.

Table 4-73
Sharp's Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**135**	**86**	**1,491**	**433**	**2,145**
Total Integrated Circuit	122	79	969	260	1,430
MOS Digital IC	122	79	903	228	1,332
MOS Memory	73	77	387	87	624
MOS Microcomponent	14	1	139	53	207
MOS Digital Logic	35	1	377	88	501
Analog-Monolithic	0	0	66	32	98
Total Optical Semiconductor	13	7	522	173	715

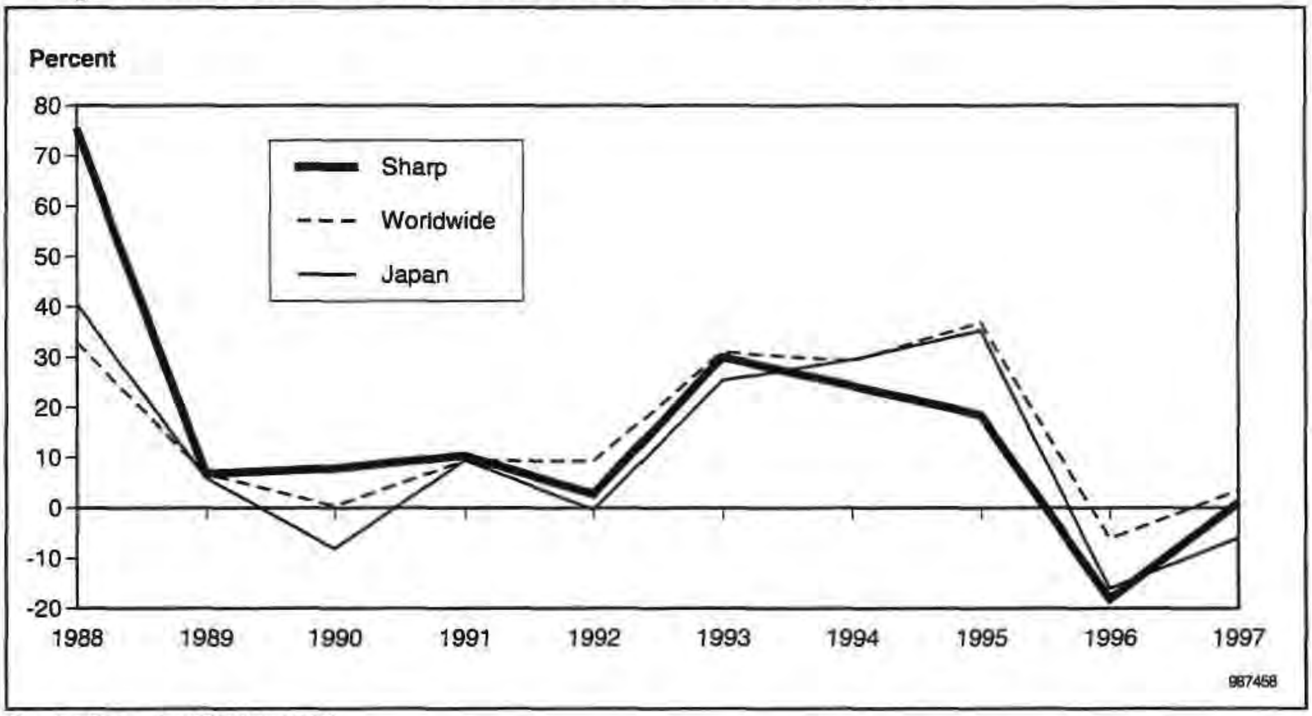
Source: Dataquest (October 1998)

Table 4-74
Sharp's Product Profile, 1987-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	590	367	130	34	148	55	0	223
1988	1,036	751	344	54	284	69	0	285
1989	1,107	815	434	104	218	59	0	292
1990	1,194	891	454	124	248	65	0	303
1991	1,318	956	476	134	280	66	0	362
1992	1,354	1,002	519	129	290	64	0	352
1993	1,760	1,342	697	170	388	87	0	418
1994	2,188	1,678	867	192	523	96	0	510
1995	2,592	1,956	1,030	221	600	105	0	636
1996	2,124	1,507	727	184	504	92	0	617
1997	2,145	1,430	624	207	501	98	0	715
1996-1997 Growth (%)	1.0	-5.1	-14.2	12.5	-0.6	6.5	0	15.9

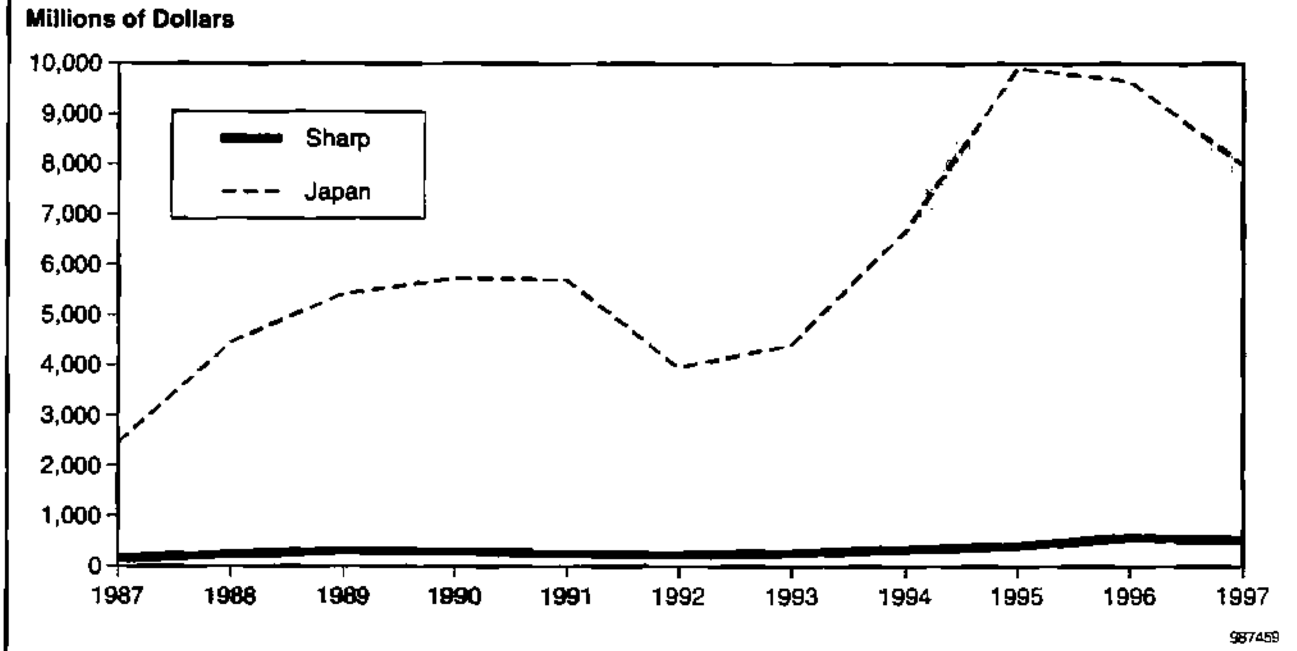
Source: Dataquest (October 1998)

Figure 4-37
Sharp's Annual Growth versus the Semiconductor Industry's



Source: Dataquest (October 1998)

Figure 4-38
Sharp's Capital Spending versus Japan's Spending



Source: Dataquest (October 1998)

Table 4-75
Sharp's Product Profile, 1987-1997 (Percentage of Sharp's Total Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	100.0	62.2	22.0	5.8	25.1	9.3	0	37.8
1988	100.0	72.5	33.2	5.2	27.4	6.7	0	27.5
1989	100.0	73.6	39.2	9.4	19.7	5.3	0	26.4
1990	100.0	74.6	38.0	10.4	20.8	5.4	0	25.4
1991	100.0	72.5	36.1	10.2	21.2	5.0	0	27.5
1992	100.0	74.0	38.3	9.5	21.4	4.7	0	26.0
1993	100.0	76.3	39.6	9.7	22.0	4.9	0	23.8
1994	100.0	76.7	39.6	8.8	23.9	4.4	0	23.3
1995	100.0	75.5	39.7	8.5	23.2	4.1	0	24.5
1996	100.0	71.0	34.2	8.7	23.7	4.3	0	29.0
1997	100.0	66.7	29.1	9.7	23.4	4.6	0	33.3

Source: Dataquest (October 1998)

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Table 4-76
Sharp's Worldwide Market Shares by Product, 1987-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	1.5	1.2	1.9	0.7	1.4	0.7	0	13.0
1988	2.0	1.8	2.8	0.8	2.2	0.8	0	13.1
1989	2.0	1.8	2.7	1.3	1.9	0.6	0	12.1
1990	2.2	2.0	3.6	1.3	2.0	0.6	0	12.6
1991	2.2	2.0	3.6	1.1	2.2	0.6	0	12.9
1992	2.1	1.8	3.3	0.9	2.2	0.6	0	13.1
1993	2.1	1.8	3.0	0.9	2.4	0.6	0	13.9
1994	2.0	1.8	2.6	0.7	3.2	0.6	0	13.1
1995	1.7	1.5	1.9	0.6	2.9	0.6	0	13.2
1996	1.5	1.2	1.9	0.4	2.3	0.5	0	12.6
1997	1.5	1.1	2.0	0.4	2.0	0.5	0	13.4

Source: Dataquest (October 1998)

No. 20: Rohm

Rohm was established in Kyoto, Japan, in 1958. The company's semiconductor products include hybrid ICs, transistors, diodes, LEDs, laser diodes as well as resistors, capacitors, LCDs, thermal heads, image sensor heads, and LED displays. As of March 1998, sales were distributed among product categories as follows: ICs (40.1 percent), discrete devices (39.1 percent), passives (12.0 percent), and displays (8.8 percent). Sales by region during that same time were distributed as follows: North America/South America (9.7 percent), Europe (8.8 percent), Japan (46.2 percent), and Asia (35.3 percent). Table 4-77 illustrates the source of Rohm's semiconductor revenue in 1997 by product and region. The company's product profile for 10 years is listed in Table 4-78.

Figure 4-39 illustrates the difference between Rohm's growth rate and the total industry for 10 years. Figure 4-40 shows Rohm's capital spending history and how it compares to the region's total spending during that time frame. Table 4-79 lists the share of each of Rohm's product revenue to its total semiconductor revenue. Table 4-80 lists the market shares of Rohm's products in the worldwide market.

Table 4-77
Rohm's Product Distribution by Region, 1997 (Millions of Dollars)

Products	Americas	Europe	Japan	Asia/Pacific	Total
Total Semiconductor	**125**	**134**	**968**	**826**	**2,053**
Total Integrated Circuit	59	26	404	380	869
MOS Digital IC	23	7	151	153	334
MOS Memory	13	3	22	10	48
MOS Microcomponent	3	1	12	6	22
MOS Digital Logic	7	3	117	137	264
Analog-Monolithic	36	19	253	227	535
Total Discrete	54	93	345	335	827
Total Optical Semiconductor	12	15	219	111	357

Source: Dataquest (October 1998)

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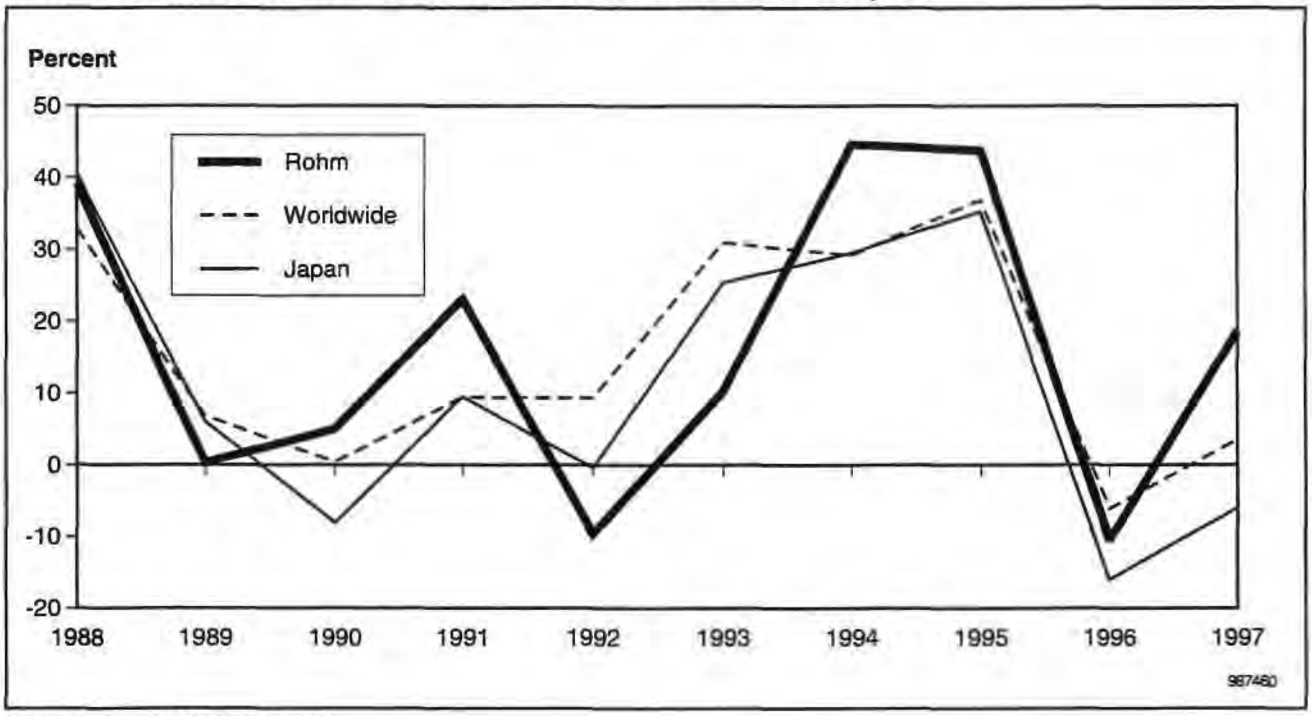
Table 4-78
Rohm's Product Profile, 1987-1997 (Millions of Dollars)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	518	248	0	3	10	203	200	70
1988	721	325	8	16	30	235	287	109
1989	723	333	5	17	37	215	297	93
1990	759	343	13	17	39	214	314	102
1991	934	438	28	23	46	272	374	122
1992	844	391	27	20	43	238	343	110
1993	930	438	39	23	50	258	380	112
1994	1,345	643	56	50	104	361	524	178
1995	1,934	877	61	71	244	423	771	286
1996	1,731	757	51	66	210	357	681	293
1997	2,053	869	48	22	264	535	827	357
1996-1997 Growth (%)	18.6	14.8	-5.9	-66.7	25.7	49.9	21.4	21.8

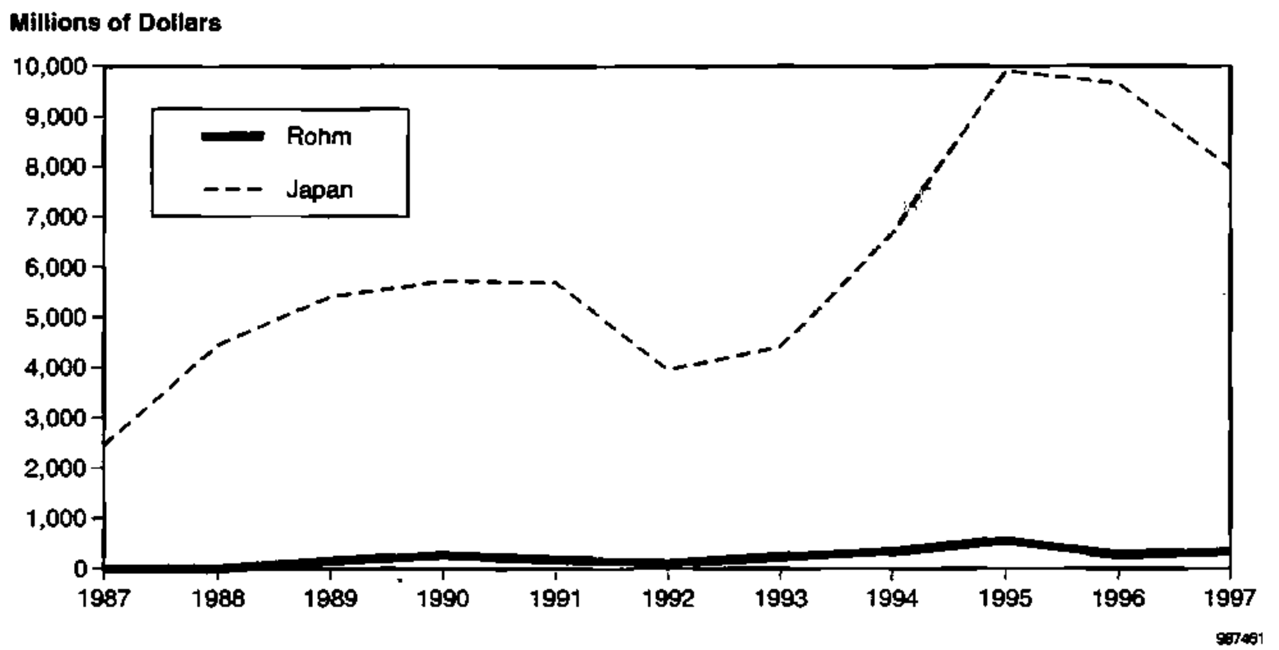
Source: Dataquest (October 1998)

Figure 4-39
Rohm's Annual Growth versus the Semiconductor Industry's



Source: Dataquest (October 1998)

Figure 4-40
Rohm's Capital Spending versus Japan's Spending



Source: Dataquest (October 1998)

Table 4-79
Rohm's Product Profile, 1987-1997 (Percentage of Rohm's Total Semiconductor Revenue)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	100.0	47.9	0	0.6	1.9	39.2	38.6	13.5
1988	100.0	45.1	1.1	2.2	4.2	32.6	39.8	15.1
1989	100.0	46.1	0.7	2.4	5.1	29.7	41.1	12.9
1990	100.0	45.2	1.7	2.2	5.1	28.2	41.4	13.4
1991	100.0	46.9	3.0	2.5	4.9	29.1	40.0	13.1
1992	100.0	46.3	3.2	2.4	5.1	28.2	40.6	13.0
1993	100.0	47.1	4.2	2.5	5.4	27.7	40.9	12.0
1994	100.0	47.8	4.2	3.7	7.7	26.8	39.0	13.2
1995	100.0	45.3	3.2	3.7	12.6	21.9	39.9	14.8
1996	100.0	43.7	2.9	3.8	12.1	20.6	39.3	16.9
1997	100.0	42.3	2.3	1.1	12.9	26.1	40.3	17.4

Source: Dataquest (October 1998)

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Table 4-80
Rohm's Worldwide Market Shares by Product, 1987-1997 (Percent)

Year	Semiconductors	ICs	Memory	Microcomponents	Logic	Analog	Discretes	Optical
1987	1.4	0.8	0	0.1	0.2	3.2	3.0	4.1
1988	1.4	0.8	0.1	0.2	0.4	3.2	3.8	5.0
1989	1.3	0.7	0	0.2	0.5	2.8	4.1	3.9
1990	1.4	0.8	0.1	0.2	0.5	2.4	4.1	4.2
1991	1.6	0.9	0.2	0.2	0.5	2.9	4.7	4.4
1992	1.3	0.7	0.2	0.1	0.4	2.3	4.2	4.1
1993	1.1	0.6	0.2	0.1	0.4	2.1	4.2	3.7
1994	1.2	0.7	0.2	0.2	0.6	2.4	4.9	4.6
1995	1.3	0.7	0.1	0.2	1.2	2.4	5.4	5.9
1996	1.2	0.6	0.1	0.2	0.9	2.0	5.1	6.0
1997	1.4	0.7	0.2	0	1.1	2.5	5.8	6.7

Source: Dataquest (October 1998)

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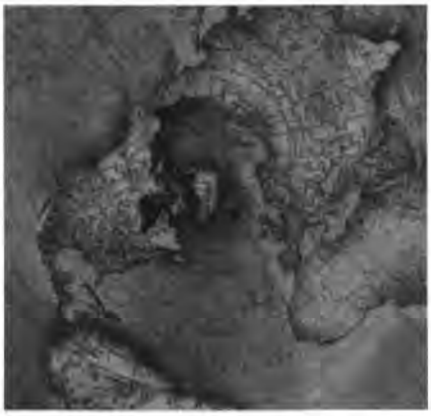

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1997 Semiconductor Strategic Alliances: Japanese Companies

Focus Report

Program: Semiconductors Worldwide
Product Code: SEMI-WW-FR-9801
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1997 Semiconductor Strategic Alliances: Japanese Companies

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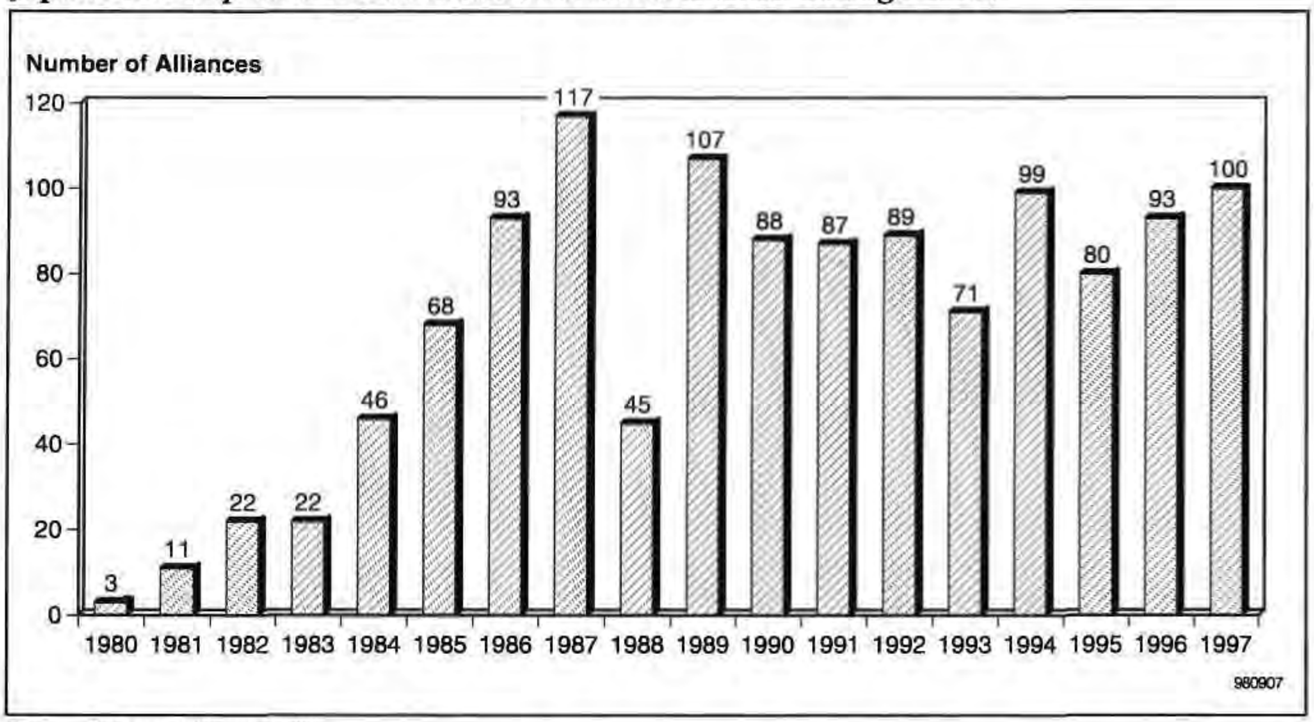
Chapter 1
Executive Summary

Despite continued economic troubles in Japan and elsewhere in Asia, Japanese vendors still engaged in a relatively high number of semiconductor-related alliances in 1997. For the second year in a row, the number of Japanese semiconductor-related alliances rose. Figure 1-1 illustrates the Japanese semiconductor alliance rate from 1980 through 1997.

There are growing indications from alliance activity in 1997 that Japanese vendors are banking on the market success of merged logic-DRAM technology as the future mainstay of their semiconductor businesses. The timing of a transition from a DRAM-centric to an embedded DRAM-centric strategy is significant, because a miscalculation by Japanese vendors could cause them to lose ground in the development of next-generation commodity DRAMs while they divert resources toward the development of embedded DRAM products. The possible gains, however, are significant because the technology has the potential to increase market share in the application-specific IC (ASIC) and logic businesses, a goal that most Japanese vendors have targeted for several years. Alliances not only will allow Japanese vendors to redistribute their resources from a DRAM to an embedded DRAM production orientation, which would effectively merge their now separate memory and logic businesses into a single unit, but they might also provide a fast-response safety net in case the companies' projected time line is off and they need to retreat to a more conservative strategy. If the embedded DRAM technology, for whatever reason, fails to mature before commodity DRAMs return to a supply-limited market, alliances will almost certainly be used as a mechanism for Japanese companies to get back into the commodity DRAM business.

Project Analyst: Junko Matsubara

Figure 1-1
Japanese Companies' Semiconductor Alliances (1980 through 1997)



Source: Dataquest (March 1998)

Chapter 2

Diversification and Resource Allocation with Alliances

Many parts of the electronics industry were showing signs of weakness as 1997 came to a close. DRAM production lines were either being shut down or had their expansion plans delayed. Semiconductor fabrication equipment manufacturers experienced order cancellations that eventually led to layoffs of substantial portions of their workforces. Even application vendors, such as disk drive producers, were experiencing market pressures that have resulted in corporate restructuring. While the economic crisis in many parts of Asia, particularly Korea, has forced a change in the semiconductor business practices at companies in these countries and will undoubtedly have a ripple effect on electronics companies worldwide, Japan's economy has, for several years, remained in a state bordering on recession. Despite the weak economic condition of Japan, its domestic PC markets were expected to continue the growth trend that had been established during the previous year. During 1996, PC prices had fallen to world market levels, which caused a growth spurt in PC sales. However, by mid-1997, sales had flattened even though DRAM prices continued to fall, lower-priced machines had been introduced into the Japanese market, and PCs had far less penetration in the Japanese home market than in the United States.

The economic crisis that was beginning to affect many Asian countries in the last quarter of 1997 does not seem to have had much impact on the overall number of alliances that Japanese companies signed in specific countries or regions in the past two years. Nearly 60 percent of the Japan's semiconductor alliances formed in 1997 were with U.S.-based partners. This level is more or less unchanged from 1996 and reflects the continued importance that Japanese vendors place on partnerships with American companies. Figure 2-1 shows the percentage of the alliances that pair a Japanese company with a U.S.-based company over the last 13 years.

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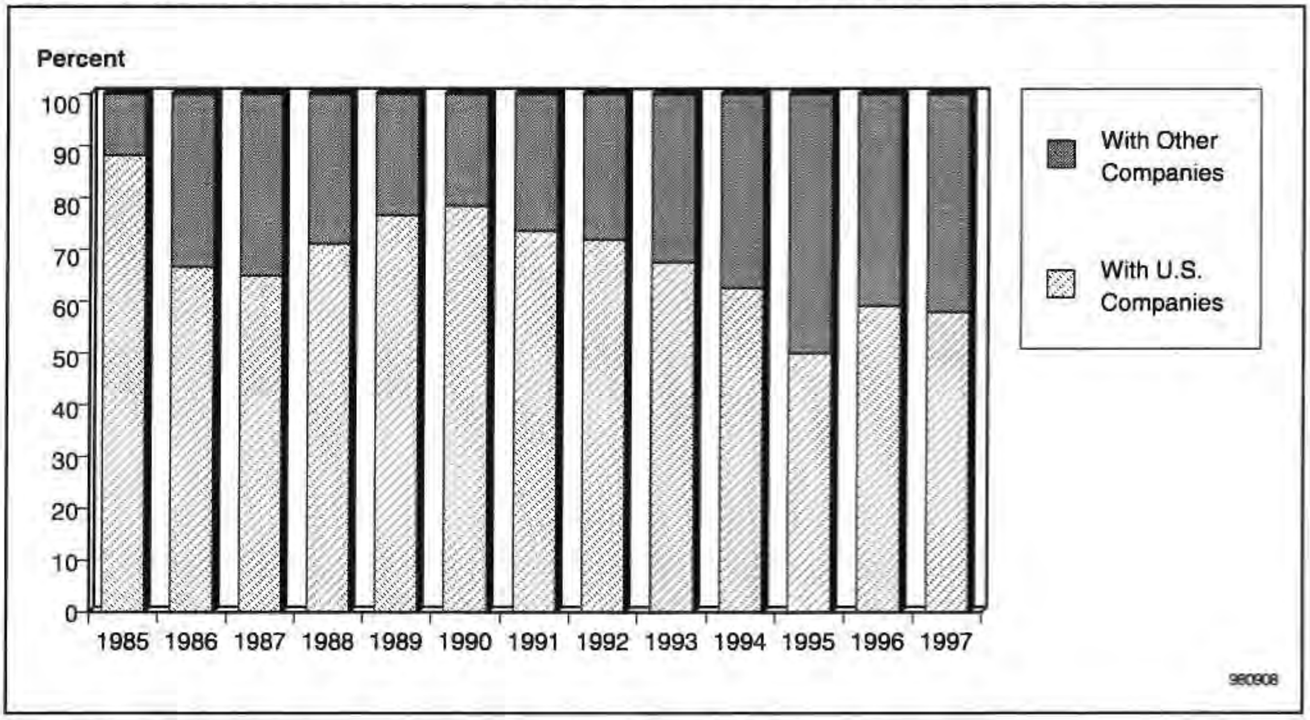
Figure 2-1
Japanese Semiconductor Alliances (U.S. Partners versus Non-U.S. Partners)



Source: Dataquest (March 1998)

DRAMs and 300mm Equipment

In 1997, Japanese vendors continued their quest to diversify away from their traditional overdependence on DRAM revenue. However, in implementing diversification plans, there are often conflicting goals that require a delicate balance of priorities in business strategy, particularly with regard to alliances. A transition to 300mm wafer production is clearly a long-term technology change that all major Japanese vendors will seek to make to remain cost competitive, but it will be difficult to justify the necessary investment in the face of a money-losing DRAM business. Furthermore, most vendors will need to secure permanent sources of commodity DRAMs for both internal consumption and to maintain their semiconductor sales organizations. The difficulty of achieving these goals increased during the year as DRAM prices continued to fall in an oversupplied market. The mass transition to 300mm production technology will occur eventually, but the weak DRAM market will likely delay or slow the adoption rate, because the large-scale equipment consumption of the commodity DRAM manufacturers will be a prerequisite to reducing the cost of 300mm equipment and make it affordable to the majority of logic and ASIC producers. For this reason, commodity DRAM alliances will likely continue with specific emphasis on 300mm equipment development. On the other hand, if DRAMs do not return to profitability before deployment of embedded DRAM products that can generate self-sustaining revenue, then a company could justify minimizing its DRAM-specific investments, farm out commodity DRAM production, and focus resources on building and accelerating its embedded DRAM capabilities. Alliances seem to provide a lot of flexibility for companies to distribute their resources to match their particular array of priorities.

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Alliances Send DRAM Production to Partners

Four alliances explicitly involving commodity DRAM occurred in 1997, but almost all can be interpreted within the context of a strategy that diversifies away from an emphasis on the commodity DRAM business (see Table 2-1). This has generally meant developing 300mm technology in joint ventures or licensing DRAM production technology to foreign-based companies, of which the Japanese company may hold a minority stake, in order to secure production output. As an example of transferring DRAM production to foreign companies, Toshiba Corporation agreed in February 1997 to purchase 20 percent of the Austin, Texas-based 64Mb DRAM facility of Samsung Electronics Company Ltd., allowing OEM procurement for Toshiba of 20 percent of the production output. In September 1997, Toshiba also provided Taiwan-based Winbond Electronics Corporation with DRAM production technology, which will secure a supply of both 64Mb and 256Mb from the Taiwan-based facility. Finally, in October 1997, Mitsubishi Electric Corporation agreed to provide Seiko Epson Corporation with 64Mb production technology. Mitsubishi will initially purchase all the production output of Seiko Epson's Sakata plant. Earlier, in May 1997, Mitsubishi had licensed Seiko Epson to produce video memory, also to be built at the Sakata plant, that would integrate 10Mb of DRAM with 2Kb of SRAM and graphics interface logic. All these alliances are consistent with a strategy of diversifying resources away from commodity DRAMs.

The only major joint venture of 1997 involving DRAMs was signed in February by Hitachi Ltd., Mitsubishi, and Texas Instruments Inc. and specified that the partners would jointly develop 1Gb DRAMs. However, this project was put on hold in February 1998. Although the partners have specified that they will resume joint development of 1Gb DRAM in one year, the future of this project will probably depend on the market outlook in 1999.

Table 2-1
DRAM and Next-Generation Wafer/Production Alliances

File Number	Company 1	Company 2	Product	Date
9	Fujitsu	Advantest	Advanced electron beam exposure system	February
23	Hitachi /Mitsubishi	Texas Instruments	1Gb DRAM	February
85	Toshiba	Samsung	64Mb DRAMs	February
82	Tokyo Seimitsu	Super Silicon Institutes	400mm-wafer wire saw	March
66	Sankyo Engineering	Sugai	Wet-type cleaning system for 300mm wafers	April
54	NEC	Samsung	300mm wafer production	July
94	Toshiba	IBM	300mm wafer production	July
34	Lapmaster SFT	Super Silicon Crystal Research	CMP machine for 400mm wafers	August
95	Toshiba	Winbond	64Mb, 256Mb DRAMs	September
70	Seiko Epson	Mitsubishi	64Mb DRAM design, technology	October

Source: Dataquest (March 1998)

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When Will 300mm Standardization Arrive?

Several other alliances made in 1997 address 300mm technology development.

Toshiba and IBM will cooperate in commercializing 300mm production, and will possibly set up a 300mm line at their joint production plant. Similarly, NEC Corporation and Samsung have agreed to share development of 300mm wafer fabrication equipment and technology across their memory plants. Both alliances are expected to have operational 300mm wafer production lines up and running by 1999. The oversupply of DRAMs, along with weak Asian currencies and economies, are contributing to very tentative ramp-ups of Japanese, Korean, and Taiwanese next-generation DRAM and 300mm wafer facilities. However, although no company has voiced concern, it seems that, if Japanese companies intend to focus their semiconductor businesses on embedded DRAM products, then they would not want any delay in the arrival of next-generation DRAM capabilities that would impede the transition to the next level of embedded DRAM products. This, of course, assumes there exists a next-level single-chip device or application that can use the higher amounts of DRAM, and presumably faster logic, provided by the next-generation merged processes. The applications that will drive the adoption of next-generation embedded DRAM products are not clear, but there are a few candidates, as described in the following sections. This uncertainty is a looming factor in the decision process that will dictate how Japanese vendors structure their alliance activities.

From DRAMs to Embedded DRAMs: How Fast Can We Get There?

There are skeptics, including individuals representing companies such as Intel Corporation, who have voiced their conviction that embedded DRAM technology will never become a mainstream technology. The basis of their argument is that the logic and memory processes of the future are incompatible. Nevertheless, if the critics are proven wrong, this would be somewhat ironic because Intel itself has essentially used its own processing expertise, including the use of BiCMOS, to counter the assault of RISC, with its inherent performance advantages, over the last few years. There have been many processing transitions over the years, such as NMOS to CMOS and bipolar to BiCMOS, and with each transition, there were always a few who either did not believe the new technology would ever become competitive or who miscalculated the timing of the transition. Today, there are enough companies that seem convinced that combining DRAM with fast logic is both feasible and an inevitable mainstream technology that one must consider the implications if these companies are correct. History has frequently proven that processing and circuit innovation has consistently surmounted the barriers they have encountered. The accuracy of Moore's law is a testament to the steady progress being made in integration capabilities. Table 2-2 lists the alliances occurring in 1997 that explicitly covered embedded DRAM technology. However, many of the other alliances of 1997, particularly those relating to RISC MPUs—described in a subsequent section—have also been extended to cover embedded DRAM technology. This is a logical extension of these alliances, since many RISC alliances involve the use of cores in ASIC libraries, which have recently been expanded to include embedded DRAM in addition to the usual RISC cores.

Table 2-2
Embedded-Related Alliances

File Number	Company 1	Company 2	Product	Date
87	Toshiba	Sun Microsystems	Embedded Java processors	April
41	Mitsubishi	Seiko Epson	3-D video chips	May
90	Toshiba	NeoMagic	Embedded memory	May
91	Toshiba	Chartered Semiconductor	Embedded DRAM process technology	June
77	Sony	Oki Electric	System-on-a-chip	August
45	Mitsubishi	Powerchip Semiconductor	Embedded DRAM technology	November
57	NEC	Lucent Technologies	V-series RISC core	December

Source: Dataquest (March 1998)

Notebook Graphics Accelerators Still the Only Application for Embedded DRAM in 1997

In contrast to the splash that embedded DRAM alliances made in 1996, the alliance activity involving embedded DRAM technology in 1997 was very subdued. Part of the reason for this is that the graphic accelerator market, the initial market to capitalize on the benefits of embedded DRAM technology, had become overcrowded in 1997. Too many players meant steep drops in accelerator prices and shrinking market windows that resulted in some once high-flying start-ups dropping off the radar screen. With these conditions, it wasn't surprising that the shifts in the market diverted attention away from the progress being made on the merged logic-DRAM processing front. Moreover, falling graphics controller and accompanying memory prices may have also confined the embedded DRAM graphics controllers to the notebook segment only, where power efficiency is the primary selling point, and prevented migration to the desktop world, where the ratio of processing power to cost is usually the only criterion that determines market success.

Although only three or four alliances explicitly involving embedded DRAM technology were signed by Japanese companies in 1997, two of the 1997 alliances were inked by Toshiba. In June, Toshiba licensed its 0.35-micron DRAM-mixed logic technology, later to be migrated to 0.25-micron, to Chartered Semiconductor Mfg. Pte. Ltd. of Singapore. Chartered is expected to launch production with this technology in 1998. As an update to a Toshiba-Chromatic Research Inc. alliance formed in 1995, Toshiba has disclosed plans to use the second generation of Chromatic's Mpact 2 core in an embedded DRAM chip targeting notebook computers. The Mpact DSP uses a very long instruction word architecture, and the Toshiba part will be built sometime in 1998 with 4MB of DRAM and a 128-bit internal bus using Toshiba's 0.25-micron merged logic-DRAM process. The Mpact 1 and 2 were originally designed to use the Rambus DRAM and interface, and the move to an embedded DRAM part is expected to reduce power consumption by several watts, an important savings for notebook applications.

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Interestingly, Toshiba also signed an alliance agreement in May 1997 to act as foundry for NeoMagic Corporation notebook graphics controllers. Strong demand for NeoMagic controllers has evidently required the company to supplement its supply of controllers being produced by Mitsubishi. Mitsubishi, an original investor in NeoMagic, will continue to make embedded DRAM controllers for NeoMagic; however, both Mitsubishi and Toshiba are, or shortly will become, competitors to NeoMagic because both have plans to build graphic controllers for notebook applications using their own designs and embedded DRAM technology. As seen below, the Mpact digital signal processor (DSP) is not the only device intended to make a transition from an external Rambus memory interface to an embedded DRAM solution.

Teams Research Multiple-MPU Parallel Processing with Embedded DRAM

Although no Japanese vendor has yet announced a formal alliance with the start-up PixelFusion Limited, based in Bristol, England, its work is particularly interesting in that it is specifically addressing the needs of the very high end of 3-D graphics accelerators by using massively parallel designs, developed at the University of North Carolina at Chapel Hill, in conjunction with an implementation in a merged logic-DRAM process. Silicon prototypes have been built by Chartered Semiconductor Manufacturing of Singapore, but the demands of building numerous processing units with large amounts of memory on a single chip may call for cutting-edge processes. It would therefore not be surprising if PixelFusion sought Japanese vendors as alliance partners to build its production designs. Indeed, the work at PixelFusion parallels the three-year research project being conducted at a Japanese consortium formed at the end of 1996. Based on the work of Professor Murakami from Kyushu University, the consortium initially anticipated that media processors using parallel processing architecture would reach the market by 1998. Similarly, a European research consortium, based at a university in Belgium, announced in December 1997 its intention to develop MPEG-4 chips that will be implemented with mixed logic-DRAM technology. Japanese partners have been included in the consortium, and project is also scheduled to run for three years, beginning in January 1998.

Because Japanese vendors arguably have been working on the development of embedded DRAM technology the longest, they have entered into several noteworthy alliances covering embedded DRAMs. This alliance activity is expected to continue; however, it should also be noted that there are conflicts within the industry that seem to be having a distinctly antialliance effect. Japanese vendors are currently suing several of their major Korean DRAM competitors for royalty payments, and, in some cases, seeking injunctions designed to prevent Korean vendors from selling their parts in the United States. With the Koreans expected to follow the Japanese vendors into the merged DRAM-logic markets, it may be that recent legal actions against the Korean companies are designed to force these competitors to pay for some of the cost of developing an embedded DRAM technology that is likely to benefit all manufacturers eventually, including Korean vendors.

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As strange as it might sound, the legal action may actually have the effect of promoting alliances involving embedded DRAM development between Japanese and Korean vendors. Considering the lack of profit from the sales of commodity DRAMs, the cost of developing embedded DRAM technology will be difficult to sustain—predicting when a profitable return-on-investment will occur is not trivial, because it is dependent on finding the right uses for the technology at the right time. Furthermore, once an effective embedded DRAM process is achieved, the learning curve for nondevelopers will be simplified by information passing by way of both direct and indirect alliances. The Korean memory vendors will benefit from the pioneering work and probably cannot afford to pioneer the technology independently. The recent legal action by Japanese vendors is expected to force some Korean vendors to at least discuss either royalty payments, which would help defray the cost of developing technology, or more alliances in which vendors share the development cost of next-generation technologies.

ASICs Combine RISC Cores with Embedded DRAM to Open New Application Areas

Embedded DRAM may need to become the primary driver of the transition to 300mm technology if DRAMs continue to provide inadequate return on investment. Intel is sufficiently afraid of a mass vendor exit from the commodity DRAM business and the potential for a subsequent DRAM shortage that might affect its own microprocessor sales that the company is considering boosting its investments in major DRAM vendors by $1 billion. Meanwhile, most Japanese vendors are pushing ahead with research and development of merged logic and DRAM processes that seeks to minimize performance compromises. Besides graphics controllers for portable computing platforms, embedded DRAM products were expected to make their next appearance in hard disk drives. Because the disk drive industry seems to be in turmoil, there is less discussion of this happening soon. However, many other applications are being discussed as possible system-on-a-chip implementations that would include on-chip DRAM. A number of alliances that originally covered collaboration or licensing of RISC technology have been expanded to include RISC microcontroller (MCU) cores combined with embedded DRAM.

Alliances in Video Games, Windows CE Machines, ...

NEC is working with Nintendo Company Ltd. to eventually migrate its MIPS RISC-based video game controllers away from use of a Rambus memory interface architecture to a more efficient embedded DRAM solution. As with most custom ASICs, this can result in a lower cost-to-performance ratio in very high-volume applications only, such as video game consoles. This application is interesting because it represents a mass market product that, unlike the notebook graphics controller, is probably not using the superior power consumption efficiency of the embedded DRAM technology as its primary selling point. NEC expects to have available to ASIC customers by spring 1998 the capability of merging 200-MHz logic with 32Mb of 100-MHz DRAM connected over a 128-bit bus.

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The electrical and market performance of both the Nintendo embedded DRAM video controller and Toshiba's embedded DRAM Mpact 2 chip, both having potentially abandoned the Rambus interface and memory combination, may provide an interesting comparison benchmark for ASIC customers thus far unconvinced of the advantages of using embedded DRAM technology.

In early February 1998, Sega Inc. confirmed a long-rumored alliance with Microsoft Corporation to cooperate on the construction of a game machine. The confirmation by Sega included the revelation that the new platform will use the Windows CE operating system. Just as with the Nintendo-NEC alliance, the Sega-Microsoft game console is an application that can benefit from the use of an integrated game controller that merges embedded DRAM with logic. Dataquest would therefore expect to see in the not too distant future an alliance with a semiconductor producer, such as a manufacturer already building RISC cores for Windows CE platforms and probably at least planning on an embedded DRAM version of the Windows CE device. A large and growing number of vendors would qualify for such a project.

In the first quarter of 1997, Mitsubishi began working with ACCESS Corporation to customize a Mitsubishi chipset for use in portable Internet terminals, which include the M32R/D, a 32-bit RISC processor currently embedded with 2MB of DRAM. This processor family is scheduled to reach a clock speed of 400 MHz with 16MB of embedded DRAM, built with a 0.2-micron geometry, by the year 2000. Mitsubishi will also codevelop, as well as cross license, microcomponent cores embedded with DRAM with Motorola Incorporated, as a continuation of an alliance formed in October 1996. This alliance involves an embedded DRAM version of Mitsubishi's M32R and Motorola's 68EC000 and Coldfire processors.

In the second quarter of 1997, Toshiba partnered with Sun Microsystems Inc. to develop a Java processor for use in network computers. The microJava chip will incorporate a picoJava core, a memory controller, and embedded DRAM. Toshiba also announced in July 1997 the development of its MIPS based, Virtual Socket Interface (VSI)-compliant, TX19. This is a low-power, low-cost, embedded RISC processor that Toshiba intends to combine with embedded DRAM in the company's 0.25-micron DRAM-ASIC process.

In the third quarter of 1997, Hitachi announced that its SH-3 and SH-4 RISC MPU cores would be available in an embedded DRAM-enabled 0.35-micron process that ASIC clients can use to add DRAM in 256Kb increments, called "micromodules" by Hitachi. By 1999, Hitachi expects to field an SH-4 core with flash and micromodules based on 256Mb 0.25-micron DRAM technology. The number of RISC core license agreements, combined with embedded DRAM agreements, would suggest that mobile computing devices, particularly Windows CE machines, are expected to become a significant product segment making heavy use of system-on-a-chip designs that include embedded DRAM.

In the fourth quarter of 1997, NEC and Lucent Technologies formalized an alliance that has Lucent licensing NEC's V800 series of RISC MCUs. As part of this alliance and possibly two previous alliances formed between the partners in June and October 1996, the two companies are said to be working together on an embedded DRAM process that Lucent expects to incorporate into its own 0.25-micron ASIC process by mid-1999.

Table 2-3 shows the alliances that covered RISC technology in 1997.

Table 2-3
RISC-Related Alliances

File Number	Company 1	Company 2	Product	Date
38	Mitsubishi	Access	M32R-base embedded DRAM chipset	February
49	NEC	Wind River Systems	Embedded RISC operating system	January
19	Hitachi	Mentor Graphics	CAD tools for SH RISC processor	April
88	Toshiba	MIPS Technologies	MIPS RISC technology	April
44	Mitsubishi	Mentor Graphics	M32R-base system-on-a-chip development	June
75	Sony	Advanced RISC Machines	ARM7 RISC core	July
55	NEC	Tseng Labs	PowerVR RISC core	September
59	NKK	Toshiba	32-bit RISC microcontroller	September
20	Hitachi	Seiko Epson	SH-3 microcontroller	November
21	Hitachi	NTT Electronics	SH-3 RISC processor core	November
57	NEC	Lucent Technologies	V-series RISC core	December
22	Hitachi	SGS-Thomson	64-bit RISC processor	December

Source: Dataquest (March 1998)

Chapter 3

Displays, Micromachines, and Sensors Also Head toward Merged Processes

The synergy between traditional semiconductor circuits and integrated displays, sensors, and micromachines continues to grow and, in some cases, is already showing signs of merging with mainstream IC manufacturing. Moreover, VSI will facilitate the connection of not only standard IC cores, but also a growing array of new, CMOS-compatible devices that include sensors, micromachines, and even displays. Although start-up companies have always been expected to gamble on some of these esoteric technologies, many traditional IC companies, never having strayed too far from standard analog or digital IC fabrication technologies (at least in production), are also aggressively building exotic production-worthy process portfolios. For example, National Semiconductor Corporation is attempting to build active-matrix LCDs on standard wafers, Toshiba and Atmel Corporation are building CMOS image sensors, and Texas Instruments has made a heavy, highly publicized investment in its micromachined mirrors, also on standard wafers. The integration of such technologies with a memory-logic process should allow for the creation of such things as a true system-on-a-chip digital camera.

Although traditional IC manufacturing processes are incorporating more nonstandard components, from the opposite end of the processing spectrum, flat panel display manufacturers are starting to build circuits on their thin semiconductor films on glass or quartz substrates. There has been a recent surge in active-matrix LCDs research as this segment of the flat panel display industry continues to give upstart flat panel technologies a moving target. Nine new alliances involving LCDs occurred in 1997, which outpaced the LCD alliance activity of 1996. These alliances are listed in Table 3-1. The breadth of the technologies that are being combined with liquid polarizing crystals is beginning to overwhelm the work in other nascent technologies, such as field emission devices (FEDs), to the degree that some may already have missed their window of opportunity for commercialization because of the rapidly falling cost and improving performance of active-matrix LCDs. Active-matrix LCD reflective displays are being touted for their extreme power efficiency in mobile computing and communications applications, as well as for use in head-mounted displays or viewfinders in digital cameras and camcorders. Windows CE machines and personal digital assistants (PDAs) are expected to be among the first application markets to benefit from efficient reflective devices, some equipped with part-time backlighting capabilities. Sharp Electronics Corporation announced in September 1997 a reflective display for Windows CE machines that features a 30 percent reflection and 10:1 contrast ratio.

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Table 3-1
Display-Related Alliances

File Number	Company 1	Company 2	Product	Date
37	Mitsubishi	Compaq	TFT LCDs	January
5	Dainippon Screen	Kyoto Technica	Semiconductor/LCD equipment maintenance	March
28	Itochu	Grand Pacific Petrochemical	LCD production	April
65	Ryosho Electronics	NeoParadigm Labs	LCD signal-processing ICs	April
42	Mitsubishi	Chungwa Picture Tube	TFT display technology	May
74	Sony	Toyota Group	Low-temperature polysilicon LCDs	June
99	Ulvac	Idemitsu Kosan	TFT panel transparent conductive film	June
76	Sony	Sharp/Philips	Next-generation large LCDs	July
8	Fuji Film	Kopin	Display technology	November

Source: Dataquest (March 1998)

On the materials research front, the films used to make active-matrix LCD panels are continuing to reach higher quality levels—meaning fewer defects. Although low-temperature polysilicon films are just beginning to reach commercialization, the films still in development are even closer in characteristics to bulk crystalline silicon. The fundamental materials and thin-film transistor research is yielding advances that suggest that active-matrix LCD and system ICs may well merge into another hybrid class of devices based on yet another merged process. Along these lines, Sharp's continuous grain silicon has continued the trend of improving thin films from amorphous films toward the ultimate goal of crystalline silicon-like electrical characteristics. Achieving this goal would improve the performance of active-matrix LCDs, as well allow the construction of all peripheral circuits right on the same substrate, with improved yield. If this trend continues, the 300mm technology of the silicon wafer industry may begin to have even more in common with the flat panel TFT processing technology than it already has.

Chapter 4
Dataquest Perspective

There is a prevailing notion that for some Japanese vendors, DRAMs and embedded DRAMs have become one and the same industry. During the current DRAM oversupply, it appears that many Japanese chip vendors will continue to use alliances either to shift their commodity DRAM production to offshore joint ventures or to completely transfer their commodity production to licensed Asian partners. At the same time, the major Japanese vendors will attempt to accelerate the transition to embedded DRAM technology for a widening array of multichip products that currently use separate memory parts, particularly those that either require better power-consumption performance, such as notebook computer components, or that rely on high-speed logic-to-memory buses, such as the Rambus interface. There is certainly risk in this strategy, because the Japanese vendors may be forcing themselves to exit the commodity DRAM prematurely, at a time when embedded DRAM revenue may be insufficient to support the upgrades to 300mm equipment. However, the DRAM business for many Japanese vendors is a losing proposition with a cloudy outlook, and the successful deployment of a competitive embedded DRAM technology has the potential to boost the competitiveness of Japanese ASIC and logic businesses substantially. Moreover, alliances may also provide a fast recovery mechanism if the transition to systems-on-a-chip, using embedded DRAM technology, is delayed or the commodity DRAM business again becomes too lucrative to ignore. Regardless of how individual Japanese companies will implement their particular memory and ASIC strategies, the common denominator is certain to be their use of alliances to adapt quickly to market conditions and technology shifts. There are just too many advantages to alliances that outweigh the potential drawbacks.

The last U.S.-Japan Semiconductor Trade Agreement was allowed to expire over a year ago. The robust rate at which Japanese and U.S. companies have entered into new alliances since the expiration, as well as the continuing high market share of foreign companies in Japan, often exceeding 30 percent in the past year, provides some support for those that argue that the decision not to renew the trade agreement at the end of July 1996 was correct.

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Appendix A
1997 Japanese Semiconductor Strategic Alliances

Table A-1 lists the companies involved in publicly announced strategic alliances occurring in 1997. The individual alliance agreements are summarized in Appendix.

Dataquest classifies strategic alliances into the following 12 major categories.

- LA—Licensing agreement: A Japanese company receives or issues a license to a partner for an up-front fee or royalties.
- SS—Second-source agreement: Both companies agree to develop consistent specifications to ensure a second source.
- SA—Sales agency agreement: A Japanese company sells its partner's products, either as a sales representative or value-added reseller (VAR).
- FA—Fab agreement: A Japanese company offers fab capacity for a partner's product technology.
- AT—Assembly and testing agreement: A Japanese company sends or receives devices for assembly or testing.
- TE—Technology exchange: Both companies exchange technology, which may or may not include a transfer of money.
- JV—Joint venture: The two companies form a new joint-venture company to develop, manufacture, and market new products.
- JD—Joint development: Both companies agree to develop new products jointly, which may or may not be marketed separately.
- IV—Investment: A Japanese company invests in a partner company to secure new technology or access to new markets.
- CO—Coordination of standards: A Japanese company and a partner agree to device standards to ensure compatibility.
- PC—Procurement agreement: A Japanese company agrees to buy more foreign semiconductors as part of market access program.
- OT—Other: Joint symposia and programs

Table A-1
1997 Semiconductor Strategic Alliances: Japanese Companies

File Number	Company 1	Company 2	Product	Type	Date
1	Access	National Semiconductor	Internet TV chip	JD	September
2	Asahi Glass	Aspec Technology	ASIC libraries	SA	January
3	Asahi Glass	Advanced Micro Devices	AMD-K6 microprocessor	SA	March
4	Canon	Scientech	Stepper sales and support	JV	January
5	Dainippon Screen	Kyoto Technica	Semiconductor/LCD equipment maintenance	JV	March
6	DSI	Korean company	Vertical electric furnaces	JV	October
7	Enplas	Hicad	IC test socket	LV	June
8	Fuji Film	Kopin	Display technology	LA	November
9	Fujitsu	Advantest	Electron beam exposure system	JD	February
10	Fujitsu	LG Semicon	Chip-scale package	CO	March
11	Fujitsu	Sand Microelectronics	USB chip	LA	March
12	Fujitsu	Nantong Huada Microelectronics	Assembly of MCUs and linear ICs	JV	May
13	Fujitsu	Rambus	High-speed memory interface technology	LA	July
14	Fujitsu	Orckit	ADSL modem chip	JD, SA	August
15	Fujitsu	AMD	64Mb NAND flash	JD	October
16	Fujitsu	Sun Microsystems	picoJava core	LA	November
17	Furukawa Electric	Lucent Technologies	Assembly of optical semiconductors	JV	February
18	Gunze Sangyo	Plasmaquest	Plasma etching, plasma CVD systems	IV	February
19	Hitachi	Mentor Graphics	CAD tools for SH RISC processor	JD	April
20	Hitachi	Seiko Epson	SH-3 microcontroller	LA	November
21	Hitachi	NTT Electronics	SH-3 RISC processor core	JD	November
22	Hitachi	SGS-Thomson	64-bit RISC processor	JD	December
23	Hitachi/Mitsubishi	Texas Instruments	1Gb DRAM	JD	February
24	Hitachi Chemical	DuPont	Polyimide material	JV	September
25	Hitachi Construction Machinery	Hitachi Medico	X-ray-based inspection system	PC	December
26	Hitachi Maxell	Singlechip Systems	IC tag	TE	December
27	Innotech	Credence Systems	Memory tester	JV	November

Table A-1 (Continued)
1997 Semiconductor Strategic Alliances: Japanese Companies

File Number	Company 1	Company 2	Product	Type	Date
28	Itochu	Grand Pacific Petrochemical	LCD production	JV	April
29	Itochu	Comdisco	Semiconductor equipment leasing	JV	September
30	Kaijo	Robotic Vision Systems	BGA inspection system	SA	November
31	Kaijo	Quad Systems	Flip-chip bonder system	SA	December
32	Kanematsu Semiconductor	Integraphics Systems	Internet TV chip	SA	September
33	Kyocera	Johnson Matthey	Cross-license for packaging	LA	October
34	Lapmaster SFT	Super Silicon Crystal Research Institutes	CMP machine for 400mm wafers	JD	August
35	Matsushita	Texas Instruments	Digital video camera ICs	JD	January
36	Matsushita	CBL	Blue laser	JD	July
37	Mitsubishi	Compaq	TFT LCDs	JD	January
38	Mitsubishi	Access	Communications chipset, embedded MCU	LA	February
39	Mitsubishi	Wind River Systems	Embedded operating system	LA	March
40	Mitsubishi	Rambus	High-speed memory interface	LA	April
41	Mitsubishi	Seiko Epson	3-D video chip	LA	May
42	Mitsubishi	Chungwa Picture Tube	TFT display technology	LA	May
43	Mitsubishi	Stone Group	Semiconductor sales	JV, SA	June
44	Mitsubishi	Mentor Graphics	System-on-a-chip development	JD	June
45	Mitsubishi	Powerchip Semiconductor	Embedded DRAM technology	LA	November
46	Mitsubishi Materials	Symmetrix	Ferroelectric material	LA	December
47	Mitsui & Co.	Micron Communication	Noncontact tag	JD	April
48	Mitsui High-Tec	Ball Semiconductor	Ball-shaped silicon wafer	IV	August
49	NEC	Wind River Systems	Embedded RISC operating system	LA	January
50	NEC	Datapath	EPRML LSIs	LA, JD	February
51	NEC	Synopsys	ASIC design verification technology	JD	April
52	NEC	Shanghai Huahong Micro	Semiconductor front-end fab	JV, FA	May
53	NEC	Cadence Design Systems	Cadence CAD design tool	SA	July
54	NEC	Samsung	300mm wafer production	JD, TE	July

Table A-1 (Continued)
1997 Semiconductor Strategic Alliances: Japanese Companies

File Number	Company 1	Company 2	Product	Type	Date
55	NEC	Tseng Labs	PowerVR RISC core	JD	September
56	NEC	Philips Semiconductor	Consumer LSIs	JD	November
57	NEC	Lucent Technologies	V-series RISC core	LA	December
58	Nichimen Electronics	Luxsonor	MPEG-2 decoder chip	SA, JD	May
59	NKK	Toshiba	32-bit RISC microcontroller	LA	September
60	Nomura Microscience	Ionics	Electrical deionization equipment	SA	July
61	Nozaki Industry	High Yield Technology	Particle monitor system	SA	May
62	Oki	Synopsys	CBA technology	LA	January
63	Oki	Artisan Components	Memory generator	LA	April
64	Rohm	DSP Group	DSP technology	LA	March
65	Ryosho Electronics	NeoParadigm Lab	LCD signal processing ICs	SA	April
66	Sankyo Engineering	Sugai	Wet-type semiconductor cleaning system	JD	April
67	Santoku /Mitsui & Co.	Merck	Ultrapure hydrogen peroxide water	JV	October
68	Seiko Epson	Lattice	Fabrication service	FA, IV	March
69	Seiko Epson	Exemplar Logic	ASIC library environment	LA	June
70	Seiko Epson	Mitsubishi	64Mb DRAM design, technology	LA, SS	October
71	Seiko Seiki	Jenoptik Infab	SMIF system	SA	December
72	Sharp	SanDisk	Cross-license for flash memory	LA	January
73	Shin-Etsu Handotai	Soitec	SOI wafer production	LA, JD	May
74	Sony	Toyota Group	Low-temperature polysilicon LCDs	JD	June
75	Sony	Advanced RISC Machines	ARM RISC	LA	July
76	Sony	Sharp/Philips	Next-generation large LCD	JD	July
77	Sony	Oki Electric	System-on-a-chip	JD	August
78	Sumitomo Chemical	Olin	I-line photoresist	LA, JV	September
79	Sumitomo Corporation	Tokyo Kaseihin and others	Lead frame	JV	January
80	Sumitomo Corporation	R. Howard Strasbaugh	CMP system	JV	June
81	Sumitomo Corporation	Pixtec	FED	SA, IV	November
82	Tokyo Seimitsu	Super Silicon Institutes	400mm-wafer wire saw	JD	March

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Table A-1 (Continued)
1997 Semiconductor Strategic Alliances: Japanese Companies

File Number	Company 1	Company 2	Product	Type	Date
83	Tokyo Seimitsu	Seiko Seiki	Wafer dicing system	JD, TE	December
84	Toshiba	Unigen	Memory module	SS	February
85	Toshiba	Samsung	64Mb DRAMs	FA, IV	February
86	Toshiba	Motorola /Fairchild	CMOS standard logic	JD	March
87	Toshiba	Sun Microsystems	Java processors	LA, JD	April
88	Toshiba	MIPS Technologies	MIPS RISC technology	LA	April
89	Toshiba	Technology Modeling Associates	3-D process simulation	JD	April
90	Toshiba	NeoMagic	Embedded memory	LA, FA	May
91	Toshiba	Chartered Semiconductor	Embedded DRAM process technology	LA	June
92	Toshiba	iReady	Internet access LSI	LA	June
93	Toshiba	ViewLogic	Logic design tool	JD	July
94	Toshiba	IBM	300mm wafer production	JD, TE	July
95	Toshiba	Winbond	64, 256Mb DRAMs	PC	September
96	Toshiba	WSMC	Logic foundry service	FA	October
97	Tosoku	Samsung Aerospace	Wire bonding	SA, JD	October
98	Ulvac	Ramtron International	Ferroelectric materials	JD	March
99	Ulvac	Idemitsu Kosan	TFT panel transparent conductive film	JD	June
100	Yamaha	Xicor	EEPROM	SA, FA	February

Source: Dataquest (March 1998)

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Appendix B
1997 Alliance Agreements

Access

1. National Semiconductor (United States), September 1997

National Semiconductor Japan has teamed up with Tokyo-based software developer Access in the systems development for Internet-capable home electronics. The Japanese subsidiary of National Semiconductor intends to supply home electronics makers in Japan with a system-on-a-chip LSI that supports Access' Internet connection and search program, Netfront. The system-on-a-chip LSI centers around National's NS486 processor core, complying with Intel's x86 architecture, and integrates PCMCIA controller, IrDA, and other peripherals, providing all the functionality necessary to give a TV or satellite receiver Internet connectivity.

Asahi Glass

2. ASPEC Technology (United States), January 1997

Asahi Glass will market ASIC libraries developed by ASPEC Technology of the United States in Japan. ASPEC already handles ASIC libraries supporting the production processes of 15 chipmakers. The price is ¥300 million per kit. Asahi Glass has also started taking orders from customers in Japan for the ASIC Division of Hyundai Electronics, which uses ASPEC's libraries.

3. Advanced Micro Devices (United States), March 1997

Asahi Glass will step up sales of Advanced Micro Devices microprocessors this fiscal year. The company deals with AMD's Windows PC MPUs and in-built processors. For Windows PC MPUs, Asahi Glass hopes to tap demand for the K6 chip from domestic PC makers. In a move to market built-in processors for numerical control and point-of-sale systems, Asahi Glass has signed a distribution agreement with Microsoft to obtain an MS-DOS license. Plans also call for commercializing AMD MPU boards that incorporate Asahi Glass hybrid ICs.

Canon

4. Scientech (Taiwan), January 1997

Canon set up a stepper sales and support joint venture in Taiwan in early February. The company's third service center in Asia, Canon Semiconductor Equipment Taiwan will be headquartered in Taipei and will be capitalized at about ¥300 million, 80 percent by Canon and 20 percent by a local distributor, Scientech. The new company will initially be staffed by 22 employees. Canon, which has already won an order for more than 20 steppers from ProMos Technologies, a joint venture between Siemens and Mosel Vitelic of Taiwan, is aiming to nearly double its share to about 50 percent of the Taiwanese stepper market by 1999.

Dainippon Screen

5. Kyoto Technica (Japan), March 1997

Dainippon Screen Manufacturing and Kyoto Technica will jointly set up a semiconductor/LCD equipment maintenance service company. Based in Kyoto, DS Tec Kansai is capitalized at ¥50 million, with Dainippon Screen investing 82 percent and Kyoto Technica 15 percent; it will start operations with more than 100 employees. Dainippon Screen, which has entrusted maintenance service to a subsidiary and Kyoto Technica, will commission delivery and maintenance of equipment for its customers in the Kinki, Chugoku, and Shikoku regions to the new company. DS Tec Kansai is expected to achieve annual revenue of ¥1.1 billion in its first year.

DSI

6. Korean company (Korea), October 1997

DSI, a Japan-based semiconductor equipment production venture, will establish a joint venture in Korea in October to manufacture vertical electric furnaces for use in next-generation semiconductor production. To be capitalized at ¥40 million, DSI Korea will be owned 70 percent by a local company and 30 percent by DSI. With an initial staff of three salespeople and two engineers, the joint venture will have a clean room at its main office. DSI, which has been assembling vertical high-vacuum annealing systems at its Shizuoka plant, intends to scale down its domestic operations and shift manufacturing technologies and equipment to the Korean company.

Emplas

7. Hicad (China), June 1997

Emplas will set up an IC test socket sales joint venture in Shanghai with its Singapore distributor, Hicad. To be capitalized at $600,000, Emplas Hicad National Trading will import IC test sockets from Japan and launch sales in late July. The joint venture will target chipmakers, including NEC and Motorola, with IC manufacturing operations in China and will aim for annual sales of ¥2 billion in three years.

Fuji Film Microdevices

8. Kopin (United States), November 1997

Kopin and Fuji Film Microdevices, Japan, announced a strategic business agreement under which the companies will incorporate Kopin's CyberDisplay active-matrix LCD into Fuji's digital camera chipsets. Fuji and Kopin will work together to integrate Fuji charge-coupled device analog and logic circuits with Kopin's CyberDisplay. The goal of the strategic alliance is to make the chipsets available to Fuji internal and external customers by the second quarter of 1998. Based on Kopin's patented Smart Slide technology, the CyberDisplay is a 0.24-inch diagonal transmissive active-matrix LCD imaging device that displays information at 320 x 240 full-color-pixel resolution. It enables portable communications devices and personal information products to display photographic images and other data or video sources.

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Fujitsu

9. Advantest (Japan), February 1997

Fujitsu and Advantest will concentrate their joint electron beam (EB) exposure system business at Advantest. The two companies jointly developed the F5120 EB exposure system for use in 256Mb or larger DRAM production, and Advantest has started marketing it. From April 1997, about 50 Fujitsu employees engaged in EB systems development will be on loan at Advantest's R&D center now under construction. Advantest expects to sell five of the ¥1 billion systems the first year.

10. LG Semicon (Korea), March 1997

Fujitsu and LG Semicon in Korea will unify the design guides of their proprietary chip-scale packages under the name "USON," for ultrathin small-outline nonleaded package. The companies plan to ask the Joint Electronic Device Engineering Council (JEDEC) to designate USON as a new standard package for memory devices. Fujitsu developed a chip-scale SON package, which has been used for its flash memory since September 1996. Compared with the conventional thin small-outline package (TSOP), the company claims, the SON package takes up about half the space in mounting, is two-thirds of the thickness, and is half the weight for 16Mb flash memory. LG Semicon developed the bottom-leaded plastic (BLP) package and has been using it for DRAM packaging. BLP is almost the same size as SON.

11. Sand Microelectronics (United States), March 1997

Fujitsu will license Virtual Socket Interface (VSI)-compliant Universal Serial Bus (USB) microcomponents from Sand Microelectronics and will commercialize a microcontroller with integrated USB microcomponents for use in monitors. The USB interface allows peripheral equipment to be connected with the PC with ease. By supporting the USB macro, Fujitsu will be able to offer LSIs that support various standard interfaces, including IEEE 1394, SCSI, and IrDA.

12. Nantong Huada Microelectronics (China), May 1997

Fujitsu has reached agreement with leading Chinese chipmaker Nantong Huada Microelectronics to establish a semiconductor assembly joint venture in China in late June. To be capitalized at $10 million, Nantong Fujitsu Microelectronics will be owned 40 percent and 60 percent by the Japanese and the Chinese companies, respectively. The joint venture will initially employ 400 people to assemble 10 million microcontrollers and linear ICs per month and will construct a new facility starting in fiscal 1998 to raise output to 40 million units.

13. Rambus (United States), July 1997

Fujitsu will team up with Rambus of California in 64Mb high-speed DRAM technology. Fujitsu will receive high-bandwidth Direct Rambus DRAM technology to develop memory systems with gigabyte-per-second-class data transfer speeds. A major reason for the alliance seems to be Intel's plan to use DRAMs with the Rambus interface as the main memory for PCs that will ship starting from 1999. Rambus' high-speed DRAM technology has been transferred to most of DRAM makers including NEC, Toshiba, Hitachi, Samsung, LG Semicon, and Hyundai.

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14. Orckit (Israel), August 1997

Fujitsu Microelectronics and Orckit Communications are teaming up to produce a single-chip, discrete multitone-standard-based Asymmetric Digital Subscriber Line (ADSL) modem. The companies will recast Orckit's two-chip digital solution and its analog front-end, currently based on discrete components, into a 0.35-micron mixed-signal CMOS chip. They will also add Asynchronous Transfer Mode (ATM) and rate-adaptation features in line with a new definition of ADSL known as Issue II. Fujitsu will market the device commercially and to Orckit. The chip is expected to be available in mid-1998.

15. Advanced Micro Devices (United States), October 1997

Advanced Micro Devices and Fujitsu will codevelop a serial NAND-type flash memory architecture, and they expect to begin production with a 64Mb device by October 1999. The two companies currently manufacture NOR-type flash at a joint-venture fab in Aizuwakamatsu, Japan, and have not sold serial flash, which offers a smaller cell size at the expense of random access speeds. A team with staff from both companies is being formed to develop the NAND-type architecture.

16. Sun Microsystems (United States), November 1997

Fujitsu has reached agreement with Sun Microsystems to license Sun's picoJava I, a Java microprocessor core. The company will develop 32-bit RISC microcontroller core specialized in Java software using 0.35-micron technology in 1998 and begin marketing the core for use in PDAs and cellular phones in 1999. The Java processor based on picoJava I is reported to outperform conventional RISC processors such as the SPARClite by a factor of five, and Fujitsu plans to use 0.25-micron technology to expand the core's applications to Network Computers. The company is aiming for Java MPU core sales of ¥10 billion in 2001, and ¥50 billion, or 30 percent of the dedicated Java MPU market, in 2003.

Furukawa Electric

17. Lucent Technologies (United States), February 1997

Furukawa Electric and Lucent Technologies have established an optical semiconductor assembly joint venture in the United States. Fitel Technologies will assemble laser diodes, photo detectors, and other optical semiconductors starting in April and will market the products through the partners' sales channels in Japan and the United States. Furukawa and Lucent, already joined in an optical fiber cable manufacturing venture, Fitel Lucent Technologies, plan to invest a total of about $10 million in the new joint venture by fiscal year 2000.

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Gunze Sangyo

18. Plasmaquest (United States), February 1997

Gunze Sangyo has acquired a capital stake in Texas-based semiconductor equipment maker Plasmaquest. Gunze, which has been distributing plasma etching and plasma chemical vapor deposition systems made by Plasmaquest in Japan since 1993, has bought with its U.S. subsidiary, Gunsan America, 14.81 percent of the U.S. company for $1 million. Plasmaquest needed financial support to expand production capacity to keep up with brisk demand for etching equipment in the North American market. Gunze wants to expand Japanese sales of Plasmaquest products to ¥1 billion in two years.

Hitachi

19. Mentor Graphics (United States), April 1997

Hitachi will work with Mentor Graphics to strengthen its 32-bit RISC processor development environment. Plans call for jointly developing SeamlessCVE, a hardware/software coverification tool for the Hitachi SH series microcontrollers. The tool, which will support MCUs in the SH-1, SH-2, and SH-3 series, will allow system designers to verify hardware and software and debug the software in the early stage of SH MCU-based equipment development, slashing development time by over one month. The tool is priced at ¥12 million.

20. Seiko Epson (Japan), November 1997

Hitachi and Seiko Epson announced an agreement concerning the licensing of Hitachi's 32-bit RISC microprocessor core technology to Seiko Epson. Seiko Epson intends to combine its low-power semiconductor technology with Hitachi's SH-3 core to build new ASICs and application-specific standard products (ASSPs) that better meet system requirements. Hitachi has been actively forming partnerships as part of establishing its 32-bit SH RISC engine family as an industry standard. The present agreement makes Seiko Epson the first Japanese partner and, for customers, will mean that more PC peripheral devices and portable information products built around SH MPUs will be available. Seiko Epson has developed 4-, 8-, and 32-bit CPUs. With the SH-3, Seiko Epson will address the need for products with a standard embedded CPU capable of running a standard operating system with its associated development environment.

21. NTT Electronics (Japan), November 1997

Hitachi and NTT Electronics will work together to develop a low-power SH-3 RISC microprocessor using a 0.25-micron process technology. Hitachi will provide its SH-3, designed for a 0.35-micron process, while NTT Electronics, which develops and manufactures ICs for its parent company, Nippon Telegraph & Telephone, will provide its 0.25-micron technology. Hitachi expects the collaboration will help it lower the power consumption of the SH-3 nearly 3 percent and shorten the 0.25-micron SH-3's time to market. The CPU is expected by spring of 1999.

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22. SGS-Thomson (France), December 1997

Hitachi and SGS-Thomson Microelectronics formally unveiled plans to undertake joint development of 64-bit microprocessor cores for the Super-H family. The processor architecture will be backward compatible with Hitachi's SH-4 and is being targeted as a general-purpose engine for a wide range of products. The architecture of the first core that the companies will work on together, called SH-5 by Hitachi and ST50 by SGS-Thomson, is due to be disclosed in 1998, with first implementations sampled in the second half of 2000 and volume production in 2001.

Hitachi/Mitsubishi

23. Texas Instruments (United States), February 1997

Hitachi, Mitsubishi Electric, and Texas Instruments have signed an agreement to jointly develop 1Gb DRAM. The agreement, part of a trend toward huge investments to develop complex and expensive technologies, will allow the three chipmakers to share resources and leading-edge technologies. The three companies are aiming for sample shipments of the next-generation chips by early 2000, sharing the estimated development cost of more than ¥100 billion. Since 1988, TI and Hitachi have been teaming up to research and develop 16Mb, 64Mb, and 256Mb DRAMs, while Hitachi and Mitsubishi have jointly developed 8Mb, 16Mb, and 64Mb flash memory chips. In 1995, Hitachi and TI formed a joint venture, Twinstar, a $0.5 billion wafer fab located in Richardson, Texas.

Hitachi Chemical

24. DuPont (United States), September 1997

Hitachi Chemical and DuPont of the United States will jointly set up ventures in both countries to produce and market liquid polyimide materials for semiconductors and other electronic devices. The two companies have established Hitachi Chemical DuPont Microsystems LLC in the United States, slated to open in April 1999. An initial capital contribution of $14 million for the venture will be shouldered equally by DuPont and Hitachi Chemical's sales subsidiary, Hitachi Chemical America. The new joint venture will then establish Hitachi Kasei DuPont Microsystems K.K., as a wholly owned subsidiary in Japan, with capital of ¥400 million and a targeted operation date in 2002.

Hitachi Construction Machinery

25. Hitachi Medico (Japan), December 1997

Hitachi Construction Machinery has formed a partnership with Hitachi Medico in the semiconductor inspection equipment business. The company will procure as an OEM two types of x-ray-based semiconductor inspection systems from Hitachi Medico. Its goal is to nearly double its factory automation system sales to ¥3.6 billion by 2001 by broadening its x-ray inspection system product line. The MF130M and the MF80M feature focuses of 10 micron, and 8 micron, respectively.

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Hitachi Maxell

26. Singlechip Systems (United States), December 1997

Hitachi Maxell has teamed up with Singlechip Systems of California to enter the IC tag business. The partners will combine Hitachi Maxell's non-contact IC card production technology with SCS' single-chip technology to manufacture and market an IC tag that will measure 10 x 60 x 0.25mm and have a memory capacity of 1,024 bits. A reader/writer will use 2.45-GHz signals to simultaneously read data on more than 30 write-once tags that can be 35cm apart. A set of the reader/writer and 100 tags will be priced at ¥600,000 to ¥1,000,000.

Innotech

27. Credence Systems (United States), November 1997

Innotech has established in Yokohama a semiconductor tester production joint venture with Credence Systems of California. Capitalized at ¥100 million, Innotech Credence is 49.9 percent owned by the Japanese semiconductor equipment distributor and 50.1 percent by the U.S. tester maker. The joint venture will manufacture logic and memory testers and put them on the market by spring 1998, aiming to ship a total of 50 units the first year. The first-year sales target is set at ¥4 billion.

Itochu

28. Grand Pacific Petrochemical (Taiwan), April 1997

Itochu, in cooperation with Fukushima-based technical consulting company Sumcon and Taiwanese chemical company Grand Pacific Petrochemical, will set up a joint LCD production company in Taiwan. The new company, Grand Pacific Optoelectronics, will be capitalized at about (4 billion, in which Itochu, Sumcon, and Grand Pacific Petrochemical invest 25 percent, 5 percent, and 70 percent, respectively. The joint venture expected to start constructing a plant in the Hsinchu industrial park in April 1997 and to produce sub-10-inch STN color LCDs for portable information devices and notebook computers from June 1998, aiming for first-year sales of about ¥10 billion.

29. Comdisco Inc. (United States), September 1997

Itochu and U.S. semiconductor equipment leasing company Comdisco have established a joint semiconductor equipment leasing company, Commit Equipment Management Service. Capitalized at ¥490 million, the joint venture is owned 60 percent by the U.S. company and 40 percent by the Japanese trading house. The joint venture is aiming for 20 billion in leasing contracts by 2000. Predicting that demand for used equipment may expand in Asia, the partners plan to sell used equipment to Taiwanese and Korean chipmakers. The used semiconductor equipment market in Japan is estimated at ¥5 billion, about 1/10th of the size of the U.S. used equipment market.

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Kaijo

30. Robotic Vision Systems Inc. (United States), November 1997

Kaijo has teamed up with Robotic Vision Systems Inc. of New York to expand its inspection system business. Kaijo will start marketing and providing support for RVSI's ball grid array (BGA) inspection and bump attachment systems in December. Through an alliance with Kaijo, RVSI wants to boost its Japanese market share, currently about 20 percent of the market.

31. Quad Systems (United States), December 1997

Kaijo has begun marketing a flip-chip bonder made by Quad Systems of Pennsylvania, signing an exclusive domestic sales contract with the U.S. company. The Advanced Packaging System APS-1 supports various types of packaging, including chip-scale package (CSP) and chip on board (COB) and uses an optical noncontact alignment system to achieve a high level of alignment. The price is ¥40 million.

Kanematsu Semiconductor

32. Intergraphics Systems (United States), September 1997

Intergraphics Systems of California will team up with semiconductor distributor Kanematsu Semiconductor and software house Access to market in Japan the CyberPro2010, a system-on-a-chip LSI enabling users to browse Internet home pages on TV. The chip integrates monitor output circuit and image control functions and a flicker-prevention function and features a built-in interface called Flexibus that makes the chip usable with all existing CPUs, including x86 and PowerPC microprocessors and Hitachi SH series microcontrollers. Intergraphics Systems claims that the chip helps Internet TV makers slash development time and design costs by nearly 60 percent, enabling them to lower retail prices from the current ¥300,000 to ¥100,000.

Kyocera Electronics Inc.

33. Johnson Matthey (United Kingdom), October 1997

Kyocera has signed a cross-license agreement with Johnson Matthey of London in the semiconductor plastic package business. The company will introduce plastic package technology from Johnson Matthey and start mass production of plastic land grid arrays (PLGAs) for microprocessors at its Sendai plant in Kagoshima Prefecture in January 1998. In return, Kyocera will provide the U.K. company with build-up substrate technology. Plans call for launching production at 500,000 units per month (45 x 45mm, 540 pins) and boosting output to 1.5 million units by July 1998, when the company will complete a new 10 billion production facility at the plant. Kyocera is aiming for PLGA sales of ¥5 billion to ¥6 billion in fiscal 1998.

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Lapmaster SFT

34. Super Silicon Crystal Research Institute (Japan), August 1997

Lapmaster SFT of Tokyo will collaborate with Super Silicon Crystal Research Institute of Gunma Prefecture to develop a fully automated chemical mechanical polishing machine for processing 400mm wafers. Super Silicon will provide wafer samples, while Lapmaster will be in charge of hardware design and software development. Development costs are estimated at (100 million. Scheduled to be developed by May 1998, the machine will achieve a wafer-processing flatness of less than 0.13 micron, a surface particle diameter size of 0.04 micron, and a surface metal impurity level of 10 x 8 stoms/cm^2. The 400mm wafer-processing machine is likely to be priced at about ¥200 million.

Matsushita

35. Texas Instruments (United States), January 1997

Texas Instruments Japan and Matsushita Electric have jointly developed a digital video camera DV terminal IC that conforms to IEEE 1394, a high-speed serial bus standard for next-generation PCs and consumer electronics. The TSB13LV01 integrates on a single chip the functions of conventional LINK and PHY chips and is available in a 144-pin CSP. TI Japan will initially mass-produce the new IC exclusively for use in the latest NV-DE digital video camera from Matsushita Electric.

36. CBL (United States), July 1997

Matsushita Electronics signed an agreement with a California-based venture CBL under which the companies will jointly develop a blue-light laser. Matsushita is aiming by 1999 to commercialize a blue-light laser, necessary for next-generation DVD drives with a storage capacity of 15GB, three times the current level. Set up by Stanford University researchers, CBL has developed large-diameter gallium nitride substrates. Use of this type of substrates increases the life of a blue-light laser from the conventional 30 hours to 5,000.

Mitsubishi

37. Compaq (United States), January 1997

Compaq Computer Corporation has teamed up with Mitsubishi Electric and with Advanced Display, Mitsubishi's LCD production subsidiary, in PC LCD monitor development. The alliance brings together Compaq's understanding of customer needs, Mitsubishi's flat panel technology, and Advanced Display's motherboard and glass processing technologies. The companies developed an LCD monitor and put it on the market in the second half of 1997. Compaq will be in charge of sales and will initially target the financial and health care sectors.

38. Access (Japan), February 1997

Mitsubishi Electric has teamed up with Access, an Internet appliance operating system developer, in the development of a portable Internet terminal chipset. The two companies will jointly develop a three-chip set including Mitsubishi's M32R/D DRAM-embedded microcontroller and a mask ROM and market the chipset at $30 to $40. Mitsubishi plans to develop a two-chip set in 1998 by integrating an ASIC and the M32R/D on a single chip. Mitsubishi, which started shipping samples of the DRAM-embedded MCU in October 1996, will launch production in April and produce 1 million units a month in late 1997. Access' Internet OS has been adopted by Sharp in its Internet TVs and word processor.

39. Wind River Systems (United States), March 1997

Wind River Systems, Japan, will develop the Tornado embedded system development environment for Mitsubishi Electric's 32-bit M32R/D RISC processor, based on an agreement the two companies have signed. The agreement will allow domestic M32R/D users to collectively purchase from Mitsubishi the license to use the VxWorks real-time operating system that is integrated into the Tornado development environment, helping them reduce system development time. Mitsubishi, which teamed up with Integrated Systems Inc. of the United States regarding its pSOS real-time OS in 1996, will support the real-time operating systems that account for some 70 percent of the world market.

40. Rambus (United States), April 1997

Mitsubishi Electric has licensed the Rambus interface technology needed to make 1.6GB/sec Direct Rambus DRAMs. The company has previously been a vocal proponent of other next-generation DRAM technologies. Nine DRAM makers have taken Rambus licenses, and some of the holdouts are believed to be negotiating with Rambus. IBM has a license for the Rambus logic interface but has yet to take a license for the memory-interface technology.

41. Seiko Epson (Japan), May 1997

Mitsubishi Electric will license 3-D video memory technology to Seiko Epson. Mitsubishi's 3D-RAM integrates 10Mb DRAM, 2Kb SRAM, and logic functions on a chip. Seiko Epson is expected to ship samples of the SDM 10092, a 3D-RAM-compatible chip, this fall and launch volume production at 20,000 units per month at its Sakata plant next spring. The sample price is likely to be set at about ¥5,000.

42. Chunghwa Picture Tube (China), May 1997

Mitsubishi Electric and Advanced Display have agreed to license their advanced thin-film transistor (TFT) LCD technologies to Chunghwa Picture Tube, a cathode-ray tube (CRT) manufacturer in Taiwan. Under the agreement, Chunghwa Picture will receive key technologies for the manufacture of TFT LCDs from Advanced Display. The displays to be manufactured by Chunghwa include 12.1-inch SVGA and XGA and 15.1-inch XGA and SXGA models. Volume production is expected to begin in January 1999. Chunghwa, an affiliate of Tatung, develops CRTs for the television and display market as well as super-twisted nematic (STN) LCD flat-panel displays.

43. Stone Group (China), June 1997

Mitsubishi Electric has teamed up with Chinese electric equipment maker Stone Group in semiconductor sales. Mitsubishi, Stone, and Mitsui & Co. established a joint venture in Beijing in 1996, and the joint venture is building a semiconductor plant expected to be ready for operations in April 1998. Mitsubishi plans to market semiconductors to be made by the plant for use in electric appliances. First-year China semiconductor sales are expected to be ¥10 billion, including sales to be generated through distribution via Hong Kong.

44. Mentor Graphics (United States), June 1997

Mitsubishi Electric will develop system-on-a-chip LSI development software with Mentor Graphics. Hardware-Software Cosimulation Environment, the software the two companies will develop, will combine Mentor's Seamless CVE and Mitsubishi's 32-bit M32R RISC microcontroller core instruction set simulator. The new software will allow system-chip LSI design engineers to test software as hardware is being designed, helping reduce design and development time from the current eight months to five months. Sample shipment is slated for late this year.

45. Powerchip Semiconductor (Taiwan), November 1997

Mitsubishi Electric expects to provide Powerchip Semiconductor of Taiwan with DRAM-embedded microcontroller production technology in early 1998. A joint venture established by Mitsubishi, a trading company, Kanematsu, and a Taiwanese electronics maker, the UMAX Group, Powerchip will begin to produce eRAM, a system-on-a-chip LSI that integrates Mitsubishi's proprietary 32-bit RISC MCU and DRAM on a single chip. Slated to begin in mid-1998, production will reach 4,000 eight-inch wafers per month by September 1998.

Mitsubishi Materials

46. Symmetrix (United States), December 1997

Mitsubishi Materials has licensed technology to produce and market ferroelectric materials from Symmetrix of Colorado. Plans call for producing Y-1, a ferroelectric material developed by the U.S. company for forming thin-film capacitors through enhanced metallorganic deposition (EMOD) at a mass production facility under construction in the company's Mita plant. Construction will be completed by year's end, and operations have been slated to start in March 1998. The company is aiming for sales of ¥200 million in 2000.

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Mitsui & Co.

47. Micron Communications/ID Micro Systems (United States), April 1997

Mitsui & Co. will work with Micron Communications and ID Micro Systems, both of the United States, to develop a low-cost noncontact tag. The new tag will have a storage capacity of 256 bits and use the spread spectrum format to read and write data. The companies aim to price the product at about (100, enabling it to be used as a disposable tag in production and distribution management and IC card applications. Mitsui and Micron Communications will share the development cost, while ID Micro will provide noncontact tag technology. Mitsui will sell the tag in Japan and overseas, except for the United States. The tag was expected to reach the market in late 1997, with a first-year sales goal set at 10 million units.

Mitsui High-Tec

48. Ball Semiconductor (United States), August 1997

Mitsui High-Tec has invested in Ball Semiconductor of Texas, acquiring nearly 50 percent of the U.S. company for $26 million. Ball Semiconductor was established by former Texas Instruments vice president Akira Ishikawa in October 1996. Ball has developed technology to create semiconductor circuits on the surface of a silicon ball in order to increase the level of integration. The U.S. company claims that the silicon balls are easier to manufacture than silicon wafers and that a silicon ball semiconductor plant can be constructed at lower cost than conventional chip plants. Semiconductor equipment maker Disco is also reported to have chipped in more than ¥100 million to the U.S. venture.

NEC

49. Wind River Systems (United States), January 1997

NEC will procure an embedded RISC microprocessor operating system from Wind River Systems. NEC and the Japanese arm of Wind River have signed an agreement, under which the U.S. software company will develop a version of the Tornado operating systems supporting NEC's V830 series of 32-bit RISC MPUs. The B830 family is popular among office business machines and car navigation system applications, and the combination of the RISC MPU and Tornado will allow designers to develop such application systems easily. Japanese customers have been able to purchase the Tornado runtime version license together with the MPU from April 1997.

50. Datapath Systems (United States), February 1997

NEC has teamed up with U.S. venture Datapath Systems to develop an extended partial response maximum likelihood (EPRML) LSI for use in large-capacity hard disk drives (HDDs). NEC will continue its process technology with the U.S. company's circuit design technology to develop as early as this year the LSI that will enable 30 percent HDD capacity expansion over the conventional PREL system. NEC, which has to date manufactured HDD write and read LSIs, intends to expand its semiconductor business by moving into the HDD LSI market, a promising segment with huge growth potential.

51. Synopsys (United States), April 1997

NEC and Synopsys of California have reached an agreement to jointly develop microcontroller-embedded ASIC design verification technology. The move is aimed at providing a tool to enable single-chip embedded system designers to simultaneously verify both hardware and software functions and at reducing development lead time. For the development of embedded systems, hardware functions are typically verified using EDA capability and software functions using an in-circuit emulator. NEC expects the new tool will help expand sales of its V850 family of ASICs.

52. Shanghai Hua Hong Microelectronics (China), May 1997

NEC announced that it will set up a joint venture with Chinese chipmaker Shanghai Hua Hong Microelectronics to supply technology to a Chinese national project to boost domestic semiconductor output. Shanghai Hua Hong is affiliated with the Chinese government. The Chinese government will own about a 70 percent stake in the venture, to be capitalized at $700 million, and NEC will own the rest. The project, which is part of China's five-year economic plan, is called Project 909. Running through 2000, the venture will produce 20,000 chips a month. NEC will provide technology for processing memory chips.

53. Cadence Design Systems (United States), July 1997

Cadence Design Systems has signed an IC design tool contract with NEC. The three-year, $18 million contract will allow NEC to use Silicon Ensemble-DSM, an IC design tool, for deep-submicron design at its design centers worldwide. The tool boosts circuit design speed more than 20 times that of conventional tools.

54. Samsung (Korea), July 1997

NEC and Samsung have decided to cooperatively design a plant for 300mm wafers and help each other in equipment development. The alliance is aiming to get its 300mm wafer line up and running around 1999.

55. Tseng Labs (United States), September 1997

NEC Electronics announced the availability of an OEM reference design that combines the PowerVR PCX2 3-D graphics accelerator with Tseng Labs' 128-bit ET6100 2-D graphics and multimedia engine. NEC has formed a strategic alliance with Tseng Labs to develop PCI-compliant single-card reference designs based on the PowerVR architecture. This design offers PC OEM and graphics board manufacturers an all-in-one graphics solution that delivers arcade-quality 3-D rendering and high-performance 2-D acceleration for Windows applications. The single-slot PCI card supports game and entertainment titles written for Direct3D, PowerSGL, and DirectDraw, including more than 100 game titles that have been developed for or ported to the PowerVR architecture. VideoLogic's Apocalypse 5-D graphics board is the first product using the technology from NEC and Tseng Labs.

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56. Philips Semiconductor (Netherlands), November 1997

NEC and Philips Semiconductor have reached agreement to jointly develop system-on-a-chip LSIs for use in digital consumer electronic products. They will use the 64-bit VR4300 RISC microprocessor based on MIPS Technologies architecture as a core for the system-chip LSIs and share peripheral circuit libraries. Consumer sales account for 15 percent of NEC's semiconductor sales and 45 percent of Philips', respectively. The two companies plan to begin to commercialize system-chip LSIs in the second half of 1998, cooperating in production as well as marketing.

57. Lucent Technologies (United States), December 1997

Lucent Technologies' Microelectronics Group and NEC announced that Lucent has licensed NEC's 32-bit V850 MCU family core. Lucent will integrate the core into its 0.25- and 0.35-micron Silicon Suite system-level IC offering, enabling customers to design system-level integrated circuits based on NEC's 32-bit RISC MCU architecture. The agreement means the V850 core will now be available from the two companies. The core will be available to Lucent customers for integration in April 1998.

Nichimen Electronic Components

58. Luxsonor (United States), May 1997

Nichimen Electronic Components has teamed up with Luxsonor of California in DVD chip sales. The U.S. fabless company focuses on MPEG-2 decoder part development, and Nichimen planned to release as early as June the LS220, a DVD decoder chip built into a PC motherboard. To be made in Taiwan, the chip will be sold for less than 4,000. The Japanese distributor is aiming for first-year sales of ¥500 million. Luxsonor is working on the LS240, a power-saving chip, and Nichimen intends to market it, targeting notebook computer makers, within the year.

NKK Corporation

59. Toshiba (Japan), September 1997

NKK will reorganize its semiconductor business by introducing state-of-the-art semiconductor technology from Toshiba. Plans call for starting 32-bit RISC microcontroller production within the year. The steel company will pay Toshiba a one-time fee of an estimated ¥1 billion as well as license fees and will manufacture RISC chips at its Ayase Research Laboratory. NKK, which entered the semiconductor business in 1992, hopes to put its semiconductor operations into the black by fiscal year 2000, reducing its dependence on the memory business significantly.

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Nomura Microsciences

60. Ionics (United States), July 1997

Nomura Microsciences has teamed up with Ionics Inc. of Massachusetts to market pure water-processing electrical deionization (EDI) equipment targeting semiconductor, pharmaceutical, and food processing companies in Japan, Korea, and Taiwan. The EDI system uses no chemicals and requires no waste water processing and therefore can remove 99 percent of silica, a task considered difficult. The U.S. company has supplied its EDI equipment to more than 50 plants worldwide, and Nomura is aiming to sell ¥20 billion to ¥30 billion worth of ultrapure water-processing systems over the next five years.

Nozaki Industry

61. High Yield Technology (United States), May 1997

Nozaki Industry will import a particle monitor system from High Yield Technology of California. The In Situ Particle Monitor (ISPM) is attached to vacuum process semiconductor equipment and eliminates use of a dummy safer. The standard system is priced at about ¥4 million. Nozaki is aiming first-year shipment of 100 ISPM systems.

Oki

62. Synopsys (United States), January 1997

Silicon Architects of Synopsys has announced that Oki Electric of Japan has licensed Synopsys' cell-based array (CBA) architecture for its 0.35-micron ASIC products. Oki will use the CBA architecture to develop 0.35-micron ASICs for both internal and commercial use. Other products will include microcontrollers, MPU and peripheral ICs, speech ICs, and telecom ICs. Oki will develop designs using CBA design tools, which integrate CBA libraries, CBA compilers, the CBA Design Systems, and commercial EDA tools. Over the past year, Synopsys has also announced CBA licensing agreements with Fujitsu, Matsushita, Mitsubishi, NEC, Toshiba, and TriTech.

63. Artisan (United States), April 1997

Artisan Components, formerly VLSI Libraries, a supplier of embedded memories and other physical component intellectual property (IP), has received a multimillion dollar worldwide purchase agreement from Oki Electric. Oki has selected Artisan as its sole external supplier of memory generators and has agreed to incorporate Artisan's family of physical IP components into all of its new 0.35- and 0.45-micron internal standard products and ASSPs. Under the agreement, Oki will purchase a complete family of Artisan's memory generator, including standard single-port and dual-port SRAMs. Also, Oki's R&D centers in both Japan and the U.S. are adopting Artisan's technology.

Rohm

64. DSP Group (United States), March 1997

Rohm will license DSP core technology from DSP Group of California. Rohm will use DSP Group-developed 16-bit fixed-point PineDSPCore and OakDSPCore to develop system-on-a-chip LSIs for mobile communications and multimedia equipment. Specifically, Rohm expected to commercialize controllers for cellular phones, high-speed modems, and CD-ROM/DVD drives by the end of 1997. DSP Group licenses its audio-compression technology to a dozen companies, including AT&T, Intel, and Microsoft, and its DSP core technology to more than 20 companies, including Asahi Chemical, Kenwood, and NEC.

Ryosho Electronics

65. NeoParadigm Labs (United States), April 1997

Ryosho Electronics signed an exclusive agreement to sell in Japan LCD signal processing ICs developed by NeoParadigm Lab (NPL) of California, a start-up developer of multimedia LSIs. Designed for large STN LCD panels, the new LCD signal-processing IC directly processes analog RGB signals from the PC, reducing the signal-processing circuit cost to less than ¥10,000. Sample shipment was expected to begin in September, and Ryosho aims to sell 50,000 units the first year. Ryosho was established to sell DRAMs produced by Powerchip Semiconductor, a Taiwan-based joint venture, and by Mitsubishi Electric, Kanematsu and the UMAX Group of Taiwan, and aimed for fiscal 1997 sales of ¥6 billion.

Sankyo Engineering

66. Sugai (Japan), April 1997

Japan-based Sankyo Engineering and Sugai revealed that the companies will form a partnership for developing new auto wet stations, which can be used for 256Mb DRAM cleaning processes and new processes for 12-inch wafers. The companies will also begin developing common part specifications for their equipment in order to reduce parts inventory, and hence cost, while maintaining availability. According to the announcement, Sankyo Engineering and Sugai will consider exchanging stock or further investment in future partnerships if they find enough benefits.

Santoku Chemical

67. Mitsui & Co./Merck (Germany), October 1997

Santoku Chemical, Mitsui & Co., and Merck of Germany have established a joint venture in Singapore to produce ultrapure hydrogen peroxide water for cleaning semiconductor chips. Capitalized at about ¥700 million, Santoku Merck is owned 49 percent by Merck, 31 percent by Santoku, and 20 percent by Mitsui. The partners will invest ¥2 billion to construct a plant with an annual processing capacity of 10,000 tons, which will start operations in November 1998. Plans call for producing hydrogen peroxide water with particle per trillion-level purity. Santoku Merck is aiming for sales of ¥2.5 billion in 2005.

Seiko Epson

68. Lattice Semiconductor (United States), March 1997

Lattice Semiconductor has signed an agreement to advance Seiko Epson up to $150 million to assist in the funding of a new 8-inch wafer fab, currently under construction in Sakata, Japan. The agreement calls for Lattice to make a $90 million advance payment to Seiko Epson to set up the new fab over the next two years, with an option for an additional $60 million advance. In return, Lattice will receive guaranteed 8-inch, submicron wafer capacity. The advance payments will be repaid by Seiko Epson with wafers over a multiyear period. Lattice planned to manufacture next-generation, high-density, in-system programmable logic devices (PLDs) at the new facility beginning in 1998, initially using 0.35-micron CMOS process technology and later migrating to 0.25-micron process technology.

69. Exemplar (United States), June 1997

California-based logic synthesis tool supplier Exemplar Logic announced an agreement to jointly develop libraries for Seiko Epson/SMOS ASIC libraries for Exemplar's Leonardo design environment. As a result of this agreement, Seiko Epson/SMOS ASIC libraries are being distributed by both Seiko Epson and Exemplar Logic, and Exemplar's Leonardo becomes part of Seiko Epson/SMOS ASIC design flow worldwide. The high-precision delay models jointly developed by both companies interface to the Seiko Epson ASIC development system, Auklet. They are available to Seiko Epson/SMOS customers.

70. Mitsubishi (Japan), October 1997

Seiko Epson has tied up with Mitsubishi Electric in the DRAM business. The companies have agreed that Mitsubishi will provide Seiko Epson with 64Mb DRAM design and production technology and that the latter will launch production at 1 million units per month at its Sakata plant from the second quarter of 1998. Mitsubishi will initially purchase all units to be produced at the plant, but Seiko Epson is considering marketing the memory chips under its own brand name. Seiko Epson, which recently completed a ¥100 billion semiconductor production facility at the plant, had been looking for memory products, which will help with stability of operation.

Seiko Seiki

71. Jenoptik Infab (Germany), December 1997

Seiko Seiki, a Seiko Instruments Group company, will team up with German automated semiconductor production system maker Jenoptik Infab. The companies are signing an agreement concerning the standard mechanical interface SMIF() system, a localized clean environment system for wafer transport. Under the agreement, Seiko will provide installation, maintenance, and servicing in Japan for Jenoptik's SMIF systems, which are widely used in Europe, the United States, and Taiwan.

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Sharp

72. SanDisk (United States), January 1997

SanDisk and Sharp signed a cross-licensing agreement that gives the companies worldwide rights to each other's patents for flash memory products. Terms of the agreement were not disclosed.

Shin-Etsu Handotai

73. Soitec (France), May 1997

Shin-Etsu Handotai will form a partnership with France-based Silicon on Insulator Technologies to mass-produce next-generation SOI wafers. Soitec has a cutting-edge SOI wafer technology known as Smart Cut, which combines a hydrogen ion implantation process with a conventional wafer-bonding method. This process seems to have an advantage in fabricating so-called ultrathin-film SOI wafers. Soitec has shipped the wafers under the Unibond name since the middle of 1996, and the company plans to expand its production facility in Grenoble, France. SEH and Soitec will develop mass-production technology for this process, and SEH also will construct a factory for SOI wafer production in Japan. Both companies plan to provide 1 million 8-inch wafers per year by 2000.

Sony

74. Toyoda Automatic Loom (Japan), June 1997

Sony and Toyoda Automatic Loom, the funding company of the Toyota Motor Group, are negotiating joint manufacturing of low-temperature, polysilicon active-matrix LCDs. The arrangement would give Sony the production capability to take advantage of emerging high-volume display opportunities, including the enormous automotive market, and it would provide Toyota with captive access to leading-edge display components.

75. Advanced RISC Machines (United Kingdom), July 1997

Sony has forged an alliance with Advanced RISC Machines of the United Kingdom in the 32-bit RISC processor business. Sony will develop and supply system-on-a-chip LSIs based on the ARM7TDMI RISC processor core targeting digital AV equipment, cellular phone, and PDA applications. Sony positions the ARM7 core as an MPU core for its 0.4-micron ASCS ASIC products. ARM's MPU core has been licensed to about 20 chipmakers and used for a range of applications.

76. Sharp/Philips (Netherlands), July 1997

Sony, Sharp, and Philips are jointly developing a next-generation large LCD for such applications as a wall TV. Not to be outdone by its competitors, including Fujitsu, that are leading in the large-screen display competition by concentrating on plasma display panels, the three partners will develop a plasma address LCD that they believe can be as large as 40 inches. Plans call for installing a pilot line at Sony Mizunami, where the partners will send their engineers to develop mass production technology. The companies are aiming for commercialization in 1998.

77. Oki (Japan), August 1997

Sony and Oki Electric will team up in the system-on-a-chip LSI business. They are discussing mutually commissioning production of a chip that integrates a microprocessor and DRAM on a single chip using a 0.25-micron process technology. The two companies, which reached agreement to jointly develop 0.25-micron system-chip LSIs in May 1995, are independently marketing system-chip LSI made using a 0.35-micron process. Sony and Oki, which are about to see the result of their joint development effort, seek to effectively use their management resources by commissioning production to each other.

Sumitomo Chemical

78. Olin (United States), September 1997

Sumitomo Chemical announced that it will cooperate with Olin, a U.S. chemical company, in the area of i-line photoresists used in production of 16Mb to 64Mb memories. Olin will have exclusive manufacturing rights to Sumitomo Chemical's advanced i-line photoresists in the United States and Europe. Olin, a supplier of i-line photoresists in the U.S. and European markets, will also have nonexclusive rights to sell such materials in those regions. Use of Olin's production facilities will enable Sumitomo Chemical to secure a foothold in these markets. Sumitomo Chemical is planning to increase annual sales of i-line photoresists from the current ¥12 billion to ¥30 billion in five years.

Sumitomo Corporation

79. Tokyo Kaseihin and others (Japan), January 1997

Tokyo Kaseihin will establish a lead frame production venture in Singapore with two Japanese manufacturers through its local subsidiary. To be capitalized at $50,000, the new venture will be owned by Tokyo Kaseihin subsidiary TOK Singapore, Osaka-based parts maker Iijima Metal Seisakujo, and Osaka-based packaging materials maker Shinko at a ratio of 1:2:2.

80. R. Howard Strasbaugh (United States), June 1997

Sumitomo Corporation set up in July a joint venture with R. Howard Strasbaugh of California to sell next-generation wafer-polishing machines developed by Strasbaugh. SC Semicon Technology is capitalized at 300 million, in which Sumitomo and Strasbaugh invested 85 percent and 10 percent, respectively. The CMP machine developed by Strasbaugh features a wafer surface roughness of 250 angstroms, 10 times the precision of conventional machines, and can process about 60 wafers per hour, three times the usual throughput. It is priced at ¥200 million. SC Semicon is aiming for first-year sales of ¥3.5 billion, targeting manufacturers of 64Mb DRAM chips.

81. Pixtec (United States), November 1997

Sumitomo Corporation has bought exclusive domestic sales rights to field-emission display (FED) panels from California-based Pixtec. The company, which is also authorized to market the products in Asia, will invest $10 million in the U.S. company in return. Pixtec plans to commission 5.2-to 8.0-inch FED panel production to leading Taiwanese LCD maker Unipac and ship 10,000 units per month starting in April 1998. Sumitomo, which handles ¥50 billion worth of CRT and LCD materials and products annually, is aiming to expand FED sales to ¥3 billion and ¥10 billion in the first and third years, respectively.

Tokyo Seimitsu

82. Super Silicon Institutes (Japan), March 1997

Tokyo Seimitsu will develop a 400mm-wafer wire saw jointly with the Super Silicon Institutes (SSI). The company will deliver a wire saw to the SSI by November, and the parties will jointly make enhancements with the goal of completing a practical unit by 2001. The SSI is a Gunma-based institute specialized in 400mm wafer technologies, established in March 1996.

83. Seiko Seiki (Japan), December 1997

Tokyo Seimitsu will form an alliance with Seiko Seiki in the semiconductor equipment business. The partners will combine Tokyo's alignment-measuring technology with Seiko's high-precision processing technology to develop wafer dicing and other technologies. In the meantime, Seiko Seiki, which has been marketing dicing saws since 1995, will stop production and procure products from Tokyo Seimitsu.

Toshiba

84. Unigen (United States), February 1997

Unigen announced that it will work with Toshiba America Electronic Components as a manufacturer of Toshiba-certified memory modules for sale under the Toshiba brand name. Toshiba expected to audit and qualify Unigen's production facility in the first quarter of 1997, and the Unigen/Toshiba team could begin shipping Toshiba product in the second quarter. Unigen is a Fremont, California-based third-party memory module manufacturer that focuses on the OEM channel.

85. Samsung (Korea), February 1997

Toshiba will acquire 20 percent of Samsung Austin Semiconductor of Texas, a Samsung Electronics subsidiary, and procure the 20 percent of 64Mb DRAMs the Texas company will manufacture for sales under its own brand name. Slated for completion in June 1997, the first facility of the Korean subsidiary, in which Intel also has a capital stake, expected to launch 64Mb DRAM production by year's end and have a monthly output capacity of 2.3 million units by the end of 1998, when it expects to be fully operational. Samsung Austin Semiconductor plans to invest $1.3 billion to construct three facilities by 2003.

86. Motorola/Fairchild (United States), March 1997

Toshiba, Motorola, and Fairchild Semiconductor will jointly develop next-generation high-speed CMOS standard logic ICs. The three companies will work together to develop 2.5- and 3.3V CMOS standard logic ICs with a propagation delay time of 2ns. The new devices will be suited for ATM and ISDN network and engineering workstation memory address control use. They will introduce compatible products simultaneously to develop an untapped market. Plans called for commercializing the fast standard logic ICs by the end of 1997. The high-speed standard logic IC market is forecast to grow to ¥35 billion in 2000.

87. Sun Microsystems (United States), April 1997

Toshiba and Sun Microsystems have agreed to develop a Java processor chip for use in network computer terminals. The chip will consist of picoJava, microJava, and ultraJava. PicoJava will be the microprocessor's core, and microJava will integrate DRAM and a controller into picoJava. UltraJava will be an advanced model. Toshiba will be involved in developing a low-power microJava chip, with commercialization by Sun in 1998.

88. MIPS Technologies (United States), April 1997

Toshiba has licensed RISC microcontroller technology from the MIPS Group. The MIPS 16ASE is a 32-bit MCU core that helps to reduce the size and power consumption of printers and portable information devices. It allows for significant reduction of overall code size by compressing some instruction sets to 16-bit. The company plans to commercialize TX19 series MCUs based on the licensed core. The RISC type accounts for less than 10 percent of the company's total MCU sales in volume terms.

89. Technology Modeling Associates (United States), April 1997

Toshiba and Technology Modeling Associates have entered into a multi-year agreement in which the two companies will work jointly on development of software for 3-D simulation of semiconductor processes. The software tool will perform advanced modeling for diffusion, oxidation, ion implantation, rapid thermal annealing, silicidation, and point defects modeling. Toshiba is expected to use the simulator for the development of future generations of memory, microprocessor, and ASIC devices. Under the term of the agreement, Toshiba will provide funding, deep-submicron process technology development requirements, and test data. The TMA product, part of TMA's suite of semiconductor simulation tools, is expected to be released in late 1998.

90. NeoMagic (United States), May 1997

Toshiba announced in May that the company was about two months away from first silicon on a notebook graphics controller, with embedded DRAM, that will be manufactured for NeoMagic. To date, NeoMagic has worked with Mitsubishi Electric as the foundry for its graphics controllers. Toshiba will employ a 0.25-micron process optimized for embedded memory and a 128-bit on-chip memory bus.

91. Chartered Semiconductor (Singapore), June 1997

Toshiba will license DRAM-mixed logic IC technology to Chartered Semiconductor of Singapore, to which it licensed CMOS logic technology in November 1994. The Singapore company will use Toshiba's 0.25- to 0.35-micron process technology to launch production in 1998. The DRAM-mixed system-chip LSI market is expected to reach about ¥400 billion in 2000.

92. iReady (United States), June 1997

Toshiba will license Internet access LSI technology from iReady of California. The company has signed a five-year contract to use the U.S. company's Internet tuner technology for providing Internet access using an LSI, which eliminates control by a CPU and cuts power to 1/700th the level of software-driven Internet access. Toshiba planned to develop by the fall a functional block that will be embedded on a system-on-a-chip LSI to be built into cellular phones and TVs.

93. ViewLogic (United States), July 1997

Toshiba has teamed up with ViewLogic of the United States in the ASIC business. The companies will support Motive, a static timing tool that helps significantly reduce the time needed to design system ASICs with 1 million gates, and Testgen, a tool to automatically generate test patterns to test path delay trouble. Toshiba explained that, with the tools, logic testing time can be slashed to 1/40th the time it takes now. They were expected to become available starting in October.

94. IBM (United States), July 1997

Toshiba and IBM will form an alliance in new memory plant construction. The two companies will cooperate in commercializing a 300mm wafer by exchanging equipment technology information and are considering installing a joint production line at their joint production plant.

95. Winbond (Taiwan), September 1997

Toshiba has expanded its relationship with Winbond Electronics of Taiwan to include 256Mb DRAM production. Toshiba will provide Winbond with 256Mb DRAM production technologies and procure chips as an OEM starting around 2000, when demand is expected to pick up. As part of its move to establish a global DRAM production system, Toshiba expected to begin procuring 64Mb DRAMs from the Taiwanese chipmaker in January 1998.

96. Worldwide Semiconductor Manufacturing Co. (Taiwan), October 1997

Toshiba has teamed up with WSMC of Taiwan in semiconductor production. Toshiba will provide 0.25-micron logic PC process technology to the Taiwanese chipmaker and commission some of its logic IC production. A dedicated foundry set up in May 1996, WSMC is expected to start foundry production in July 1998 and launch a new line in 1999.

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Tosoku

97. Samsung (Korea), October 1997

Automotive part and precision machinery maker Tosoku has teamed up with Samsung Aerospace of Korea in the semiconductor wire bonder business. The partners planned to begin in December marketing a IC wire bonder they developed cooperatively by combining the Japanese company's semiconductor equipment and the Korean maker's linear motor technologies. The wire bonder achieves a leadframe transfer speed of 0.5 seconds/26.42mm and can process 400 42SOJ packages per hour. The companies are inclined to set the price below ¥9 million and intend to sell 100 units the first year.

Ulvac

98. Ramtron International (United States), March 1997

Semiconductor equipment maker Ulvac teamed up with Ramtron International of Colorado in ferroelectric RAM (FRAM) technology development. The companies will jointly develop ferroelectric materials such as lead zirconium titanate, ferroelectric thin-film process technology, and sputtering, etching, and ashing equipment over the next four years. Ulvac will start in 1999 to supply the new equipment it is developing in the joint project to chipmakers such as Hitachi, Rohm, Samsung, and SGS-Thomson, which uses Ramtron's FRAM technology.

99. Idemitsu Kosan (Japan), June 1997

Ulvac and Idemitsu Kosan will jointly develop a TFT panel transparent conductive film for larger substrates. They will combine Idemitsu-developed indium lead-based IDIXO film and Ulvac's sputtering equipment and process techniques to develop a transparent conductive film for use with LCD substrates of 13 and 14 inches to 17 and 20 inches. At present, polycrystal indium thin oxide film is typically used for TFT transparent conductive film. Ulvac and Idemitsu expect that LCD panel makers will start using the new film on production lines as early as 1998.

Yamaha

100. Xicor (United States), February 1997

Yamaha has teamed up with Xicor of California in the EEPROM business. Initially, the U.S. company will commission the Japanese company to manufacture EEPROMs, and both companies will cooperate in process technology development. Yamaha Kagoshima Semiconductor will start production in May 1998 at 2,000 six-inch wafers per month and will supply EEPROMs to cellular phone makers under Xicor's brand name. The world's No. 3 EEPROM maker, Xicor is reported to control the largest share, 30 percent, of the Japanese market for EEPROM used in cellular phones. Yamaha projects that Xicor-brand sales will reach ¥2 billion in the first year.

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Dataquest Focus Report: The Asian Financial Crisis

Focus Report

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Chapter 1
Executive Summary

In this Focus Report, Dataquest has assembled a worldwide team of experts to offer their views on the ongoing Asian financial crisis. There are five viewpoints presented: the Korean regional and Korean DRAM perspectives, a focus on China/Hong Kong, insight into the impact of the crisis on the region's PC market, and discussion of its effect on capital spending.

Analysis of the Korean regional situation suggests that the worldwide DRAM recession is one of the reasons for the Korean financial crisis. DRAM pricing is predicted to fall further if the Korean, Taiwanese, and Japanese currencies continue to slide against the U.S. dollar.

Dataquest believes that China/Hong Kong will not be impaired in the short term by the crisis, but it faces long-term challenges. Although China/Hong Kong's long-term semiconductor forecast has been lowered, it will still account for 26 percent of Asia/Pacific consumption by 2001.

Analysis of the PC market provides insight into the early impacts of currency devaluations in the region on the personal computer industry and suggests that the outlook for recovery has shifted from the near term to the long term for Thailand, Indonesia, and Malaysia, with the Korean economy possibly beginning to turn around earlier.

The Asian financial crisis will affect capital availability and spending in semiconductors. Because of the severe depreciation of the Korean currency, Dataquest now forecasts that Korean companies will cut capital spending in 1998 about 40 to 60 percent, relative to 1997, in dollar terms.

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Chapter 2
Introduction

The beginning of summer 1997 saw the devaluation of the Thai baht amid escalating difficulties in the Thai banking and finance community, which forced the Thai government to finally surrender to the currency speculators. At that time, few people, if any, would have predicted this to be the start of a financial storm, sweeping throughout Asia, with far-reaching global implications.

Shortly after the Thai baht devaluation, the governments of Malaysia, Indonesia, and the Philippines succumbed one by one to the speculative currency attacks. The rapid currency devaluation sent shock waves through the regional stock markets of Thailand, Malaysia, Indonesia, and the Philippines. Singapore and Hong Kong, which remained largely unaffected initially, saw their stock markets tumble in October amid growing investor anxiety.

The financial crisis deepened in November as it spread to Korea and Japan, the world's 11th-largest and second-largest economies respectively. The value of the Korean won dropped sharply, along with Korea's stock market, after the Korean government gave up its battle to prop up its currency in November. A $57 billion rescue package led by the International Monetary Fund (IMF) was negotiated for Korea, after $40 billion and $17 billion were negotiated for Indonesia and Thailand, respectively. In the meantime, Japan saw the closure of its fourth-largest securities firm, Yamaichi Securities Co., on November 24, following the closure of Hokkaido Takushoku Bank, its 10th-largest commercial bank, a week earlier. On December 22, the Nikkei average closed below the psychologically important 15,000 mark for the first time since July 1995.

The beginning of 1998 brought fresh hope to Korea as global bankers agreed to roll over Korea's short-term debt and started to work on a massive debt restructuring to keep the country from defaulting on its loans. This occurred after Korea's president-elect, Kim Dae-jung, reaffirmed his country's commitment to the economic reforms. Contrary to that hope, the situation in Southeast Asia took a dramatic turn for the worse as the regional currencies and stock markets recorded successive new lows, triggered by Indonesia's announcement of a fiscal budget perceived not to be in line with IMF-mandated reforms. On January 12, Peregrine Investment Holdings Ltd., Hong Kong's once high-flying financial power house, filed for liquidation after the company incurred substantial losses from its Indonesian bond operations; the news of the collapse sent the Hang Seng Index plunging 8.7 percent in that day.

Table 1-1 displays the extent of the depreciation of Asian currencies against the U.S. dollar between June 1997 and January 9, 1998. The Hong Kong dollar is the only currency in the region that has withstood the speculative attack so far. The hardest hit have been the Indonesian rupiah, the Thai baht, and the Korean won, which have all lost more than half of their values.

Table 1-1
Depreciation of Asian Currencies against the U.S. Dollar between June 1, 1997, and January 9, 1998 (Percent)

Currency	Depreciation (%)
Indonesian Rupiah	69.3
Thai Baht	54.3
Korean Won	50.8
Malaysian Ringgit	45.3
Philippine Peso	40.9
Singapore Dollar	19.6
Taiwan Dollar	18.9
Japanese Yen	13.1
Hong Kong Dollar	0.1

Source: Dataquest (January 1998)

The dramatic decline of the currency values combined with the downfall of the local stock markets will have serious impact on the region's economy and, subsequently, the world economy. To analyze the potential impact of the Asian financial crisis, experts from Dataquest's worldwide research operations offer their views on this issue in this Dataquest Focus Report.

There are five viewpoints presented in this report. The Korean regional and Korean DRAM perspectives, respectively, are presented in Chapter 3, by J.H. Son, and Chapter 4, by C.S. Kim, Jerry Yeh, Jim Handy, George Iwanyc, and Clark Fuhs. Chapter 5, by Dan Heyler, focuses on China/ Hong Kong. Chapter 6, by Bruce McCabe, and Chapter 7, by Clark Fuhs, provide insight into the impact of the crisis on the region's PC market and capital spending, respectively.

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Chapter 3
The Korean Regional Perspective

Introduction

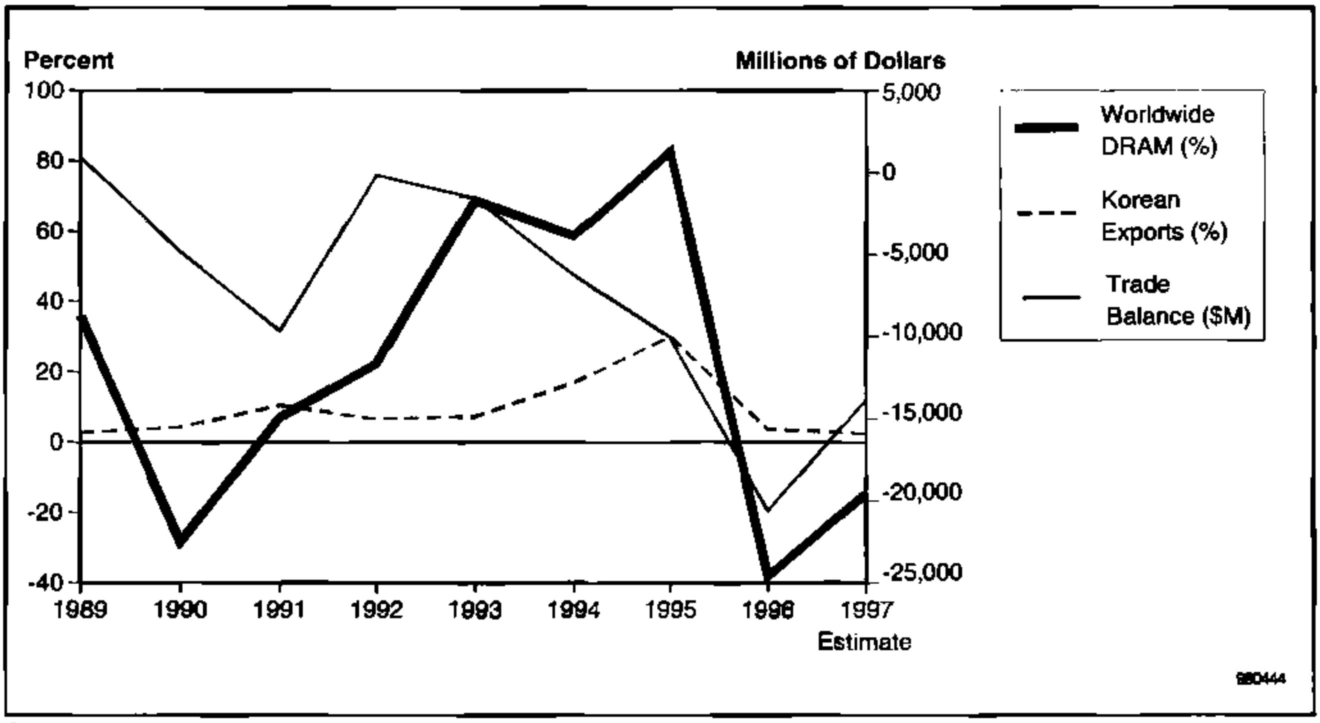
This chapter offers a Korean regional perspective on the reason behind Korea's financial crisis. It argues that the worldwide DRAM recession is one of the reasons for the Korean financial crisis. The impact of the financial crisis on the Korean semiconductor market is also discussed.

Why Did Korea's Financial Crisis Occur?

Figure 3-1 shows the relationship between worldwide DRAM revenue growth and the export growth of Korea. The two elements showed no correlation until the end of the 1980s. After 1990, however, as DRAM became one of Korea's major export items, these two elements started to show a strong correlation.

Korea's exports were solid until 1995. However, Korea's total trade balance was still negative. This means that the semiconductor surplus covered most of the other industries' deficit. In 1996, however, the semiconductor business flagged because of DRAM's drop in prices, so that it could no longer cover the other industries' trade deficit. As a result, a $20.6 billion negative trade balance was recorded in 1996 alone. The drop in DRAM prices continued in 1997—as of the end of September 1997, a $10.6 billion negative trade balance had already been recorded. The cumulative negative balance from 1994 is estimated to be about $50 billion. This amount is very similar to the IMF loan.

Figure 3-1
Relationship between Worldwide DRAM Revenue Growth Rate and Korean Export Growth Rate



Source: Dataquest (January 1998)

Korea's financial crisis might stem from the worldwide DRAM recession. Comparing the data for semiconductor statistics with Korea's trade balance of Korea offers some support for this assertion. This cannot be the only reason, but Dataquest believes that it is one of the factors generating Korea's financial crisis.

In 1995, Korea had an $8.8 billion trade surplus in semiconductors by virtue of its good DRAM business. At that time, Korea's total trade deficit was only $10.1 billion. In 1996, however, Korea's semiconductor surplus had shrunk to $0.4 billion, a reduction of $8.4 billion from the surplus in 1995. In the same year, the total trade deficit was $20.6 billion, an increase of $10.5 billion over 1995. The reduced semiconductor surplus of $8.4 billion in 1996 was a major contributing factor in the trade deficit of $10.5 billion, as shown in Table 3-1.

Table 3-1
Total Exports and Imports and Semiconductor Exports and Imports for Korea, 1995 through 1997 (Millions of Dollars)

	1995	1996	Change, 1995-1996	First Nine Months of 1997
Total Exports	125,058	129,715	4,657	99,709
Total Imports	135,119	150,339	15,220	110,094
Balance	-10,061	-20,624	-10,563	-10,385
Semiconductor Exports	17,643	15,293	-2,350	12,746
Semiconductor Imports	8,887	14,855	5,968	9,465
Balance	8,756	438	-8,318	3,281

Source: Dataquest (January 1998)

Actually, the financial crisis in Korea dates from the beginning of this year. The key reason for it is the cumulative trade deficit of many years. Many chaebol (conglomerate) companies started to fail, beginning with Hanbo Iron and Steel, and followed by Sammi Steel, Jinro, Kia Motors, New Core, and Halla, among others. Many small and medium-size companies followed the lead of the chaebols and fell also.

The chaebol companies failed in this financial crisis because of their weak financial structures. Most of the companies have capital ratios of under 20 percent. There are many under 10 percent. Tight money controls in this crisis caused the downfall of many companies.

Impact of the Asian Financial Crisis on Korea's Semiconductor Market

Most of the Korean semiconductor companies will reduce their capital spending plans in 1998 to 40 to 60 percent of their 1997 level. Also, many projects will be delayed, including overseas projects. This reduced capital spending will influence mostly 64Mb and 256Mb DRAM production capacity. Korea's 16Mb and 64Mb DRAM production lines will be less affected because, for most 16Mb and 64Mb DRAM lines, investment had already been completed or is in the final stage of the pipeline. Korea will likely lose some market share, and Taiwan semiconductor companies will likely gain. Korean semiconductor companies will invest less for capacity expansion than to increase yield or reduce chip size. As one more way to reduce capital spending, they may try to upgrade their old fabs using an isolated "minienvironment" automation system.

Samsung Electronics Company Ltd.'s direction under this crisis is to suspend capital spending for capacity expansion. Instead, the company will increase productivity by reducing chip size and increasing yield. Samsung's 1998 capital spending will be about 40 to 60 percent of its 1997 level. Hyundai Electronics Company Ltd. has also decided to reduce its 1998 capital spending plan. LG Semicon Co. Ltd. is trying to minimize its capital spending. Anam Semiconductor has decided to delay its second fab investment. Dongbu Group has proceeded with its license with IBM and has already started plant construction. But the company seems to be in a dilemma now as to how to deal with this financial crisis, because there is no funding for this facility.

All overseas semiconductor projects are facing a crisis, also. Samsung's Austin, Texas, plant and Hyundai's second Eugene, Oregon, plant will be delayed, perhaps by more than a year if this financial crisis continues. Hyundai's Scotland project and LG Semicon's Wales project are likely to be delayed, but as yet no company has announced clearly the future of its overseas plants.

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Chapter 4
The Korean DRAM Perspective

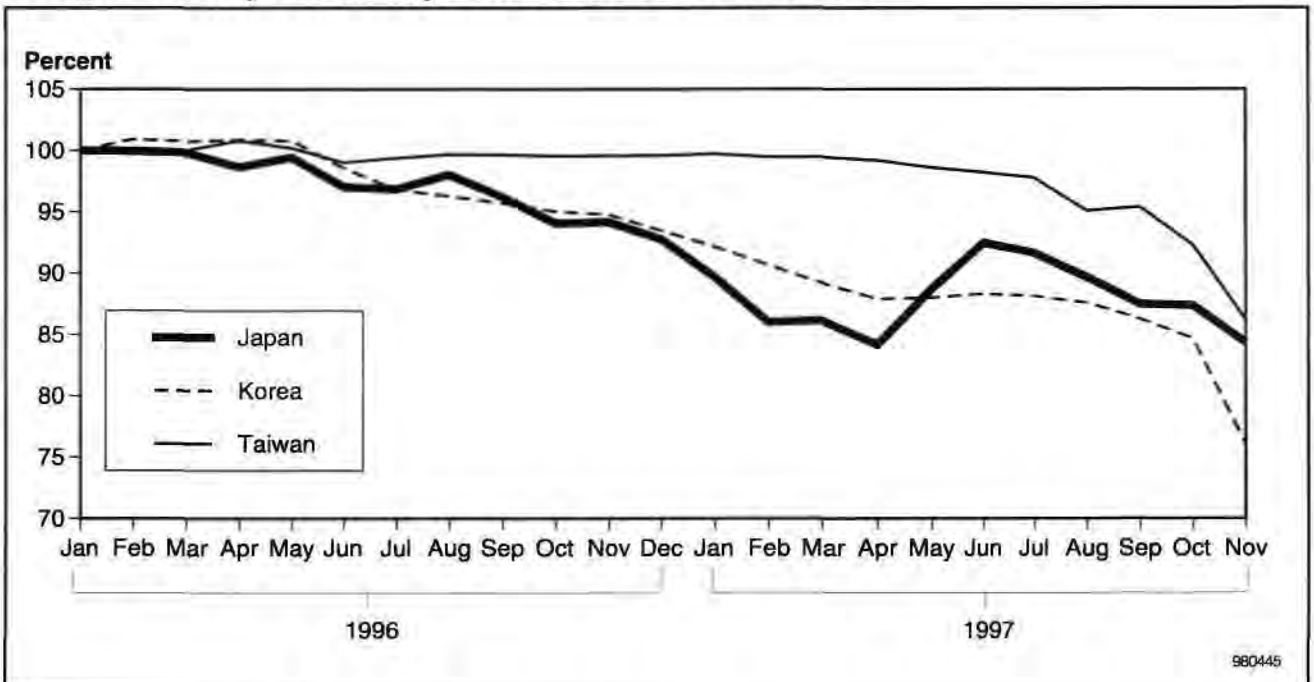
Introduction

This chapter discusses the impact of the Korean financial crisis on the worldwide DRAM market. DRAM pricing is predicted to fall further if the Korean, Taiwanese, and Japanese currencies continue to slide against the U.S. dollar.

The Impact on the DRAM Market of the Korean Financial Crisis

South Korea and the International Monetary Fund have agreed to a rescue package totaling $57 billion. South Korea agreed to implement IMF-recommended measures to revitalize its faltering economy in return for accepting the bailout. Even with the agreement, there are fears that the rescue may not succeed and that Korea's links to other Asia/Pacific countries may endanger those countries, as well. Figure 4-1 shows foreign currency purchasing power relative to the dollar.

Figure 4-1
Foreign Currency Purchasing Power Relative to the Dollar



Source: Dataquest (January 1998)

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Given the stringent management and restructuring requirements of the IMF bailout, the Korean semiconductor industry is planning to cut capital investment by 40 to 60 percent over last year. Korean DRAM manufacturers fear that their cutbacks could result in a drastically dwindling share of the world market, with market share lost particularly to Japanese and Taiwanese companies. The threat of shrinking market share is something Korean DRAM manufacturers haven't been accustomed to; they have enjoyed steady market share growth since 1990.

Samsung, currently the world's leading DRAM producer, is expected to implement a 30 percent cut in overall investment and is considering further cuts in coming weeks. Samsung's plans are to earmark W800 billion to W900 billion for semiconductor and LCD investment next year and W400 billion to W500 billion on research and development. LG Semicon and Hyundai are also cutting back investment. LG Semicon plans to lower investment by 30 percent, or W1.05 trillion to W1.10 trillion for next year, and Hyundai is considering a 40 percent cut. As with Samsung, both LG Semicon and Hyundai have yet to make their investment plans final.

What impact will these cutbacks have on projects already under consideration? LG Semicon is expected to delay the construction of its second LCD plant in southern Korea. LG Semicon and Hyundai are re-examining their plans to construct DRAM fabs in the United Kingdom, although both expect to go ahead with plans as scheduled. Most expansion plans for DRAM fabs in the United States by Samsung, LG Semicon, and Hyundai are expected to be suspended. Dongbu, which earlier this year announced plans to enter the semiconductor industry, decided to postpone this indefinitely, citing difficulties in borrowing money.

It will take one to two years for next year's cutbacks in Korean investment to make a significant impact on company market share and DRAM industry capacity. There is more than enough capacity already to support current demand, and as all manufacturers continue to shrink their 16Mb and 64Mb devices, industry overcapacity will continue through most of 1998 and possibly into 1999. To put device die size into perspective, the average die size of 16Mb DRAM at the end of 1998 will be 60 percent of the average die size of 4Mb DRAM at the end of 1995.

Taiwanese DRAM manufacturers will have a significant impact on when the market comes into balance. If Taiwanese companies continue with their aggressive expansion, the equilibrium point may be pushed out three to six months, well into 1999. Before the IMF actions, the Taiwanese companies planned to increase capital spending in local currency (NT dollars) by 10 percent. In U.S. dollar terms, this may actually represent declining capital spending because of currency devaluation (more on this later). The Korean cutback in spending may encourage Taiwanese DRAM vendors to accelerate investment in an effort to take market share away from the Koreans. If Korean companies cut their capital spending as indicated and if Taiwanese companies continue with their capital spending plans for foundry, memory, and joint ventures, Taiwan may surpass Korea in capital spending in 1998. However, not all Taiwanese DRAM vendors are expected to increase capital spending—at this time, Mosel Vitelic Inc. and Powerchip Semiconductor Corporation are expected to decrease their capital spending in 1998, and others may follow.

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Dataquest believes there is a good possibility that Taiwanese manufacturers will not implement their aggressive capital spending plans. The Taiwanese companies are newcomers to the DRAM industry and haven't experienced prior industry downturns. As they gain experience in the current downturn, they may decide to stop DRAM spending abruptly. This will come with the realization that, while aggressive expansion will buy market share, it will also lengthen the DRAM industry downturn.

On top of all the changes in Korea's financial situation and the long-term effects of the IMF bailout plan, there is also the short-term phenomenon of a currency devaluation adding to the problem. Korea, Taiwan, and even Japan have seen the value of their currencies slide dramatically in relationship to the U.S. dollar as well as against European currencies.

Normalized to January 1996, an item with a fixed local currency price that could be purchased in the United States for $1 in January 1996 could be purchased in November 1997 for $0.84 if it came from Japan, $0.86 if it came from Taiwan, and $0.76 if it came from Korea. Of course, DRAM per-megabyte prices descend at a relatively steady rate (28 percent per year), but the effects of currency rate changes layer on top of this. If the manufacturing cost, measured in won, of a Korean DRAM drops at 28 percent per year over the course of 1997, and if in that same time the won dropped 20 percent (which it did), then the minimum price that could be charged for that DRAM in the United States without triggering antidumping measures would have dropped 42 percent! This implies that there should continue to be exceptional price slides for DRAMs from Japan, Korea, and Taiwan into the United States and Europe. This has a great impact on the worldwide market because, in 1996, Japan, Korea, and Taiwan had a combined share of 77 percent of the DRAM market, and DRAM consumption in the United States and Europe accounted for 56 percent of the world market.

This, though, is not the end. The November average tells only a part of the story. As of December, the won had dropped to 54 percent of its January 1996 level. The end of the drop is not in sight today. Korean manufacturers accounted for only 34 percent of 1996 DRAM sales, so the impact of the price slide will not perfectly match the exchange rate drop times normal DRAM price declines. The effect will be less than this; however, it will be important!

In short, DRAM prices, which have been falling at a rate based largely on the cost of manufacture, should continue to fall faster than this rate as long as Korean, Taiwanese, and Japanese currencies continue to slide against European and American currencies.

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Chapter 5
Semiconductor Market Forecast: The Impact of Asia/Pacific's Currency Crises on China/Hong Kong

Introduction

Shifting the focus from Korea to China/Hong Kong, this chapter looks at the impact of the Asian financial crisis on electronic equipment assumptions and semiconductor consumption in China/Hong Kong. Dataquest has lowered its regional forecast for 1997 from 15 percent to 8 percent growth. Dataquest believes that China/Hong Kong will not be impaired in the short term, but it faces long-term challenges. Although China/Hong Kong's long-term semiconductor forecast has been lowered, it will still account for 26 percent of Asia/Pacific consumption by 2001.

Asia/Pacific and China/Hong Kong Forecasts

Prior to the financial havoc that has rocked Asia/Pacific's currency markets, Dataquest had lowered its forecast of 1997 electronic equipment production in Asia/Pacific from 17.4 percent to 14.9 percent. Dataquest's October Asia/Pacific semiconductor market forecast was lowered to 8 percent from 14.6 percent. Weaker growth was caused by slower second-half growth exacerbated by the currency crisis during the fourth quarter. Forecasts of electronics production and semiconductor consumption in China/Hong Kong were both lowered insignificantly by about 1 percentage point to 17.8 percent and 14.9 percent, respectively.

Dataquest expects that 1998 will have a higher level of growth than 1997 across the region. Helped by a long-awaited worldwide recovery in the second half of the year, memory prices should have, at long last, bottomed out. Korean and Japanese capital constraints should help to curb fab expansion and alter cutthroat pricing strategies to improve margins.

Figure 5-1 presents Dataquest's regional, country-level forecasts of semiconductor consumption from 1997 to 1999. China/Hong Kong's semiconductor market, helped by the combination of a strong PC industry and memory pricing improvements, will grow by 23 percent in 1998 and 31 percent in 1999. Critical to this high-level growth is also the performance of China's electronics output, which Dataquest assumes will grow by 20 percent in 1998 and 18 percent in 1999. At the top level, industry growth is the result of broad-based equipment investment, active foreign investment in the market, strong and steady local consumption, and competitive electronics exports.

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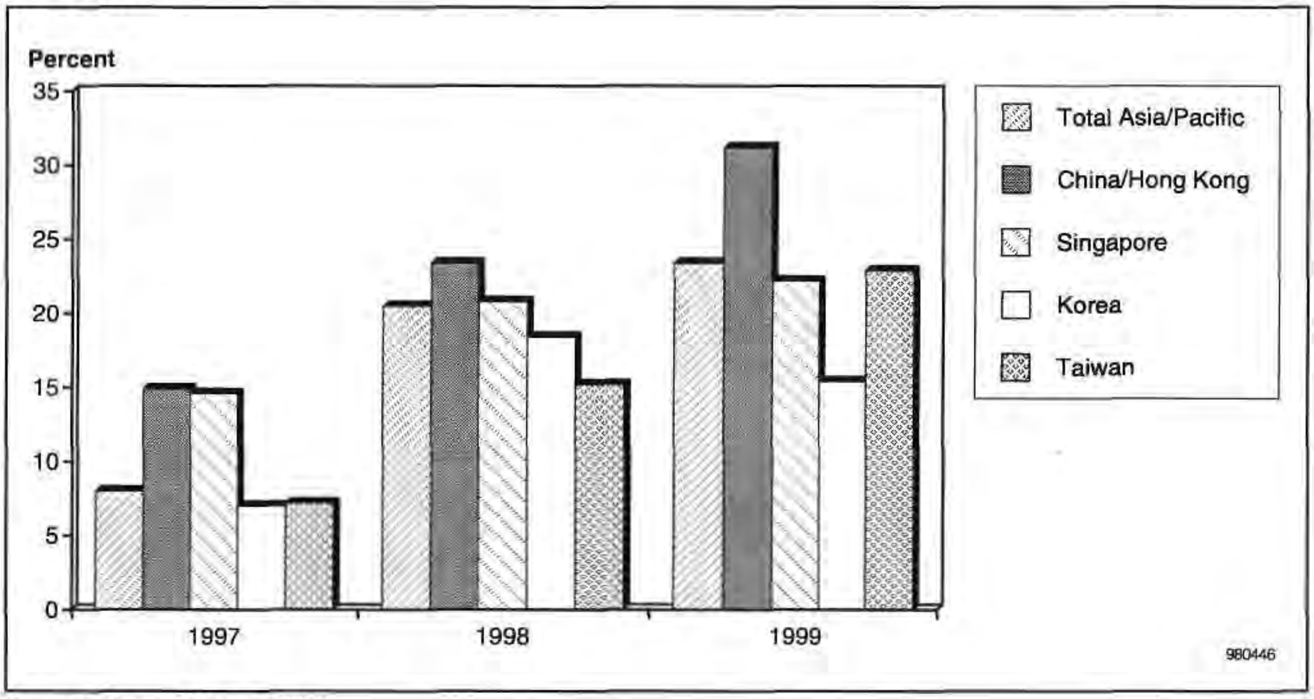
Figure 5-1
Forecast of Semiconductor Consumption Growth by Region in Asia/Pacific, 1997 to 1999 (Percent)



Source: Dataquest (January 1998)

Impact of Currency Depreciation

Dataquest understands the importance of stable financial markets to long-term economic prosperity in the region. But financial markets do not necessarily reflect the fundamental characteristics of the electronics industry's health. The impact of currency volatility needs to be viewed in the context of fundamental industry issues. Dataquest views the following electronics industry and semiconductor market fundamentals as key drivers potentially affected by the currency crisis:

- Slower growth experienced in the second half of 1997 is the result of decelerating exports to key export markets, including Europe, Japan, and North America and, to a lesser extent, slower growth within Asia/Pacific's developing domestic markets.
- There is a short-term effect on manufacturers in currency-depreciating countries that are struggling to make payments and order commitments to suppliers of semiconductors and other components.
- Local consumption has slowed in numerous countries, and deflationary forces have become more pressing. Because a small percentage of Asia/Pacific electronics production relies on Asia/Pacific consumption, the slowdown in local consumption of end equipment has a negligible impact on total production. Nevertheless, industry observers are watching the Japanese and Korean end-equipment markets carefully. Dataquest sees a direct impact of these large markets on Asia/Pacific electronics exports, especially Japan's imports of PCs from Taiwan.

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The degree of the currency devaluation's impact on electronics companies depends, in part, on the percentage of semiconductor components imported by manufacturers in Asia/Pacific. Southeast Asian countries such as India, Indonesia, Malaysia, the Philippines, and Singapore rely almost entirely on foreign suppliers. However, the bulk of electronics production comes from the multinational companies (MNCs) that have relocated production from Europe, Japan, Korea, North America, or Taiwan. The advantages of the MNCs in Asia/Pacific is their ability to secure long-term global procurement contracts in U.S. dollars that buffer currency fluctuations.

Manufacturers in Asia/Pacific, which are part of conglomerates, also manufacture semiconductors that may use internally transferred semiconductors and therefore are not directly affected by currency fluctuations. Japanese consumer electronics manufacturers rely heavily on internally transferred components. In both cases, a major portion of costs are fixed. Export revenue then increases for the same units of goods shipped because more local currency is received for the same U.S. dollar export price.

Stronger Exports Likely to Make Up for Slower Domestic Consumption

Dataquest's long-term forecast of semiconductor consumption by region is shown in Figure 5-2. It shows Asia/Pacific's high growth relative to other worldwide regions but with significant country variances.

In 1997 and 1998, Asia/Pacific's electronics industry as a whole will become more competitive in exports because of devalued currencies. Export markets will continue to be the key to the region's high semiconductor consumption growth rates because of the immaturity of the region's end-equipment markets that are a percentage of the gross domestic product (GDP). Dataquest's electronic equipment and semiconductor forecasts assume a 3 percent to 4 percent economic growth in the United States in 1998 and 1999 and a modest economic recovery in Japan. Weakened industrial growth in Japan and Korea, as well as Asia/Pacific's lower cost base, will continue to benefit Southeast Asia's electronics industry (as has been the case for 10 years).

Singapore Sustains Growth

The China/Hong Kong and Singapore markets will grow by about 15 percent in 1997. Singapore has not experienced the negative short-term effects of currency depreciation because its production is dominated by MNCs that operate global procurement organizations. Real GDP in the third quarter of 1997 rose 10.1 percent, and this growth was fairly broad-based. As reflected in the forecast, a weaker currency may have a long-term positive effect by lowering export costs, Singapore's lifeblood, assuming import component costs increased less, proportionately.

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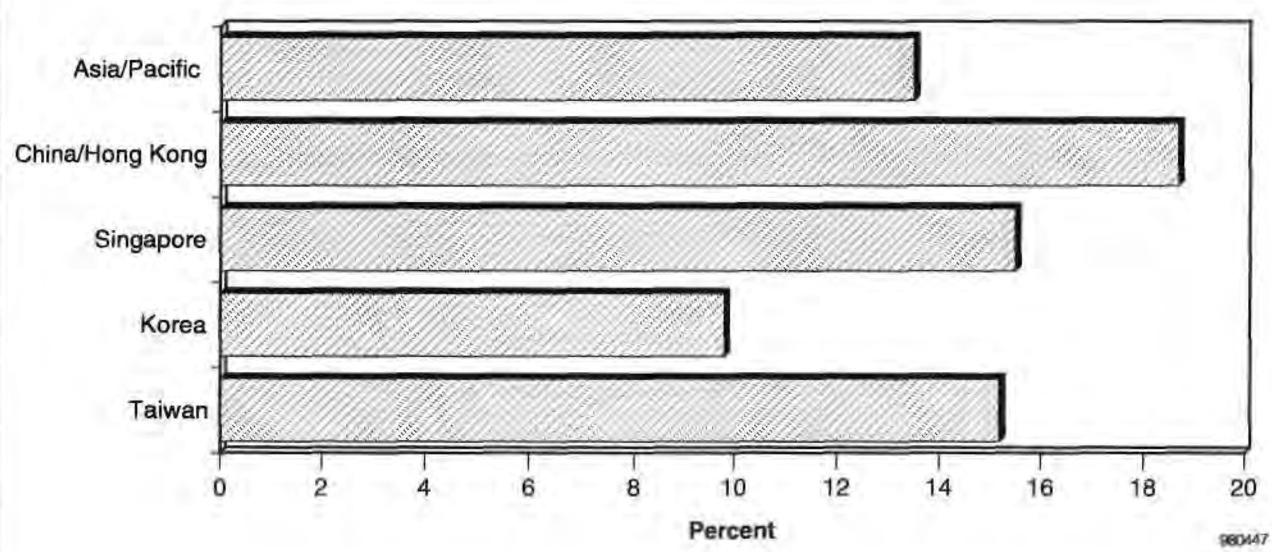
Figure 5-2
Long-Term Forecast of Semiconductor Consumption by Region in Asia/Pacific, 1996 to 2001 (Compound Annual Growth Rate)



Source: Dataquest (January 1998)

Taiwan's Fundamentals Are Still Strong

Anticipated slower growth in Taiwan in 1996 to 1998 is attributable more to memory price erosion than to currency depreciation because memories represent 46 percent of Taiwan's semiconductor consumption. Dataquest believes that Taiwan's economy and financial institutions are fundamentally strong, and GDP growth is forecast to exceed 6 percent in 1998. Dataquest also expects electronic equipment production to show the second-fastest growth in Asia/Pacific from 1997 to 2001. Dataquest, therefore, forecasts a strong semiconductor market in Taiwan in 1999 because of an anticipated recovery in its memory market.

Tighter capital markets will help control capacity spending primarily in Korea and Japan, but to a lesser extent in Taiwan, which shows a higher level of liquidity than the rest of Asia. Overall, it is likely that the crises in Korea and Japan will have a positive effect on memory pricing in the longer term, after late 1998 and in 1999. In segments where Taiwan competes directly with Korea, such as DRAMs, companies may face severe competition from Korean suppliers that now have an exchange advantage. However, note that most business is conducted in U.S. dollars, and prices are rising because of the lack of cash and capital in Korea's chaebols.

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Korean Market Faces Structural, Not Cyclical, Problems

As shown in Dataquest's long-term regional semiconductor market forecast, the weakest market will be Korea from 1998 to 2001. Korea will have trouble increasing exports enough to compensate for the huge increase in its debt-service ratio. When the won drops, the debt-service ratio increases on a one-to-one basis, but exports will not increase on a one-to-one basis. Furthermore, electronic equipment exports will continue to suffer because of a lack of new, higher-margin products and because of falling profits exacerbated by a global consumer electronics slump. On top of these problems, the currency crisis affects these conglomerates insofar as they are dependent on imported semiconductor components. However, the free-falling won makes exports much cheaper—but only if prices are not raised to cover increased component costs. The lack of a diverse component supply base, as seen in Taiwan and Japan, makes the structural nature of Korea's problems more severe. Korean electronics manufacturers have been shifting production offshore in an attempt to develop new markets and increase competitiveness.

China/Hong Kong Is Still the Rising Star, but with Challenges

Dataquest believes that the currency and financial market problems in Asia/Pacific have more to do with speculative "bubbles" in property, construction, and semiconductors than to fundamental economics and manufacturing efficiencies. China and Hong Kong are not immune, but they seem to be dealing with these bubbles more effectively by popping them before they get too big. China's economic czar, Zhu Rongji, successfully burst the stock market bubble, property bubble, and construction bubble in 1996 and 1997. After October's Party Congress, he is now more empowered than ever to pop the next speculative runs, whatever they may be. Next year, he will be promoted to prime minister. Zhu's charter is to fix the state-owned enterprises to avoid overwhelming the financial system with bad loans. If China slacks off, it will face serious problems, potentially worse than those of Korea. Korea's lessons are being learned by others, and China can avoid this kind of crisis (having U.S.$200 billion in combined reserves with Hong Kong will help, too). A strong U.S. and European economy will be critical to China and the rest of the Asia/Pacific region.

As with Russia, a nonconvertible currency does not necessarily insulate China from possible depreciation. Several years ago, China devalued its renminbi and may have to do so again sometime next year because of mounting pressure in the region and competitive pressures on the export front (discussed later in this document). However, because the long-term goal is to merge the renminbi and Hong Kong dollar, it is not likely that the Hong Kong dollar will lose its U.S. dollar peg.

Currency depreciation has lowered production costs in various Southeast Asian countries. So, will China become less competitive in its vital export markets? Dataquest believes that because significant currency depreciation caused lower export costs, there will be increasing competition for foreign investment with China, which could result in more than $20 billion in electronics production revenue by 2001.

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China faces the following three formidable challenges that are becoming more acute because of the recent currency crisis:

- Raising the competitiveness of its faltering domestic companies, especially state-owned enterprises, before entering the World Trade Organization (WTO)
- Countering the serious slowdown in foreign investments because of the rising cost of doing business in China
- Maintaining 7 percent to 10 percent GDP growth and raising the rate of domestic consumption to absorb excess capacity and overdependence on exports
  - A slowdown in Japanese imports of consumer electronics and PCs from Asia/Pacific may hurt China the most because its currency has not depreciated and, therefore, its costs are increasing relative to those of other countries.
  - Korea and other affected countries will rely heavily on exports to try to pull themselves out of their economic turmoil.

All three issues affect the electronics industry. In light of these challenges and Dataquest's survey of producers in China and Hong Kong, Dataquest believes that a 20 percent growth in electronics production is achievable in 1998, decelerating to 18 percent in 1999.

The following factors will help China to overcome these three challenges and maintain high growth rates:

- A large proportion of Chinese electronics companies are successfully competing against major MNCs, particularly in the computer and consumer equipment markets. Dataquest believes that the Chinese government will continue to support these companies before and after entry into the WTO because its international competitiveness will be imperative to its future survival. The priority for the government is improving efficiencies and quality; therefore, information technology will continue to be rapidly deployed as an infrastructure necessity.
- Although total investment is down in 1997, the production capacity of the large MNCs and local electronics manufacturers has increased by more than 50 percent. Business costs are rising in China, but the two main reasons for investing remain to develop the long-term potential of the domestic market and to take advantage of an abundant, inexpensive labor force. Note that efficiencies and quality are increasing faster than costs. Investment from Taiwan to China increased by nearly 30 percent in 1997, despite the attempt of the Republic of China government to slow the flow of business to China.
- Inflation was the major concern last year at this time, but now deflation is the top priority of the government. Interest rates are likely to fall to stimulate growth.
- Japanese manufacturers are shipping goods worldwide from China. Exports of electronics to Japan from China represent 10 to 15 percent of China's total electronics exports. Therefore, Japan's slowdown in consumption will have a minor effect on Chinese production.

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- Korean companies and other affected Asia/Pacific electronics and semiconductor companies may have an increasing currency advantage for exports relative to China in the short term. However, these companies are seriously hurt by increased debt-service costs. With depreciation, there is a debt-service ratio increase of one to one, and exports cannot possibly expand enough to counter such costs. Major cost-cutting measures may be necessary to service foreign and local debt that impairs the level of export expansion necessary for recovery. Certainly, capacity expansion is not viable at this point.

Lower Long-Term Growth Forecast for China/Hong Kong

Figure 5-3 presents Dataquest's long-term regional electronic equipment production forecast. Although Dataquest expects China to maintain a relatively high level of growth, Dataquest has lowered its 1996-to-2001 forecast for China/Hong Kong electronic equipment production from a compound annual growth rate (CAGR) of 26 to 24 percent in light of recent deflationary industry developments in the region. Dataquest expects the industry to reach $70 billion by 2001, rather than $90 billion as previously forecast. The currency devaluation's impact on semiconductor consumption will be lower between 1996 and 2001; in fact, the original CAGR of 39.7 percent is now expected to become 33.9 percent. Dataquest's 2001 forecast has been lowered from $21 billion to $18 billion.

As shown in Figure 5-4, growth in China/Hong Kong is expected to outpace the rest of Asia/Pacific because of its growth in production efficiencies, export growth, and local demand. China/Hong Kong's electronics industry produced 24 percent of Asia/Pacific's electronics in 1997, which will increase to 29 percent by 2001. Semiconductor consumption will grow from a 20 percent to a 26 percent share of Asia/Pacific's consumption. These growth rates may seem very high, but they are actually relatively low in comparison to overall GDP size and growth because China is still a developing economy. Dataquest's industry surveys and detailed analysis of China/Hong Kong's electronics production and companies are presented in a Focus Report (*China/Hong Kong's Computers, Communications, and Consumer Electronics Industry in 2001*, SEMI-CH-FR-9701, November 1997).

Semiconductor Device Forecast

All these issues affect the electronics industry in China and Hong Kong. From 1996 to 2001, China/Hong Kong growth is expected to exceed Asia/Pacific growth in electronics production by 6.8 percent and to exceed semiconductor market growth by 9.6 percent (see Table 5-1). Consequently, its share of Asia/Pacific semiconductor market revenue will grow from 20 percent in 1997 to 26 percent in 2001.

Cautious business planning is required at this time because the volatile financial markets will take another three to six months to begin to stabilize. The situation requires rapid and extreme government action in Korea and Japan before the downward financial slide in the region reverses course.

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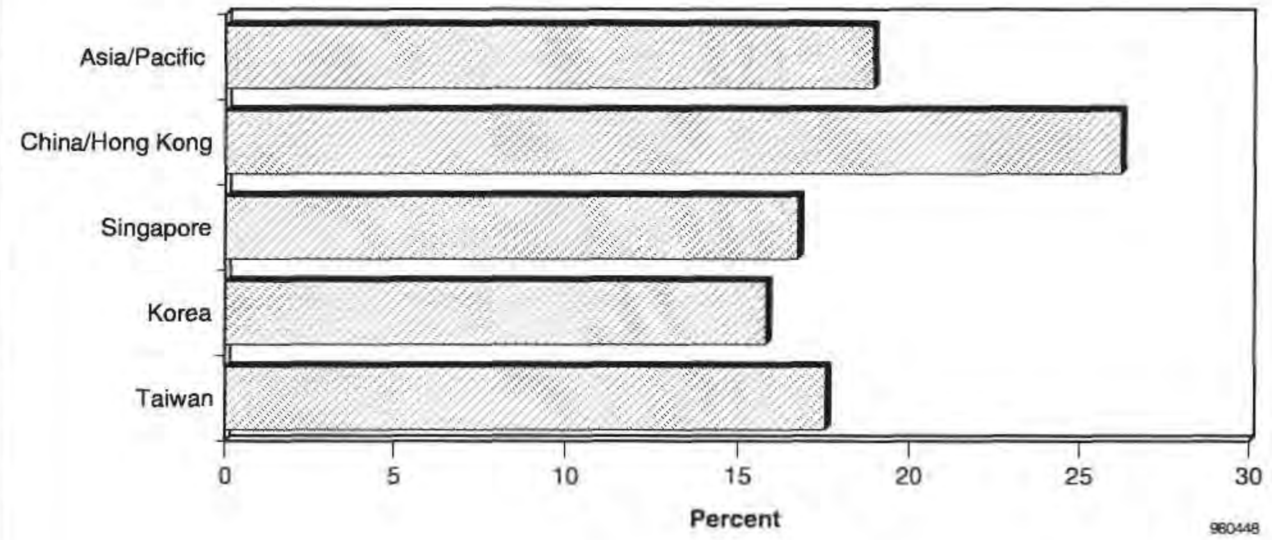
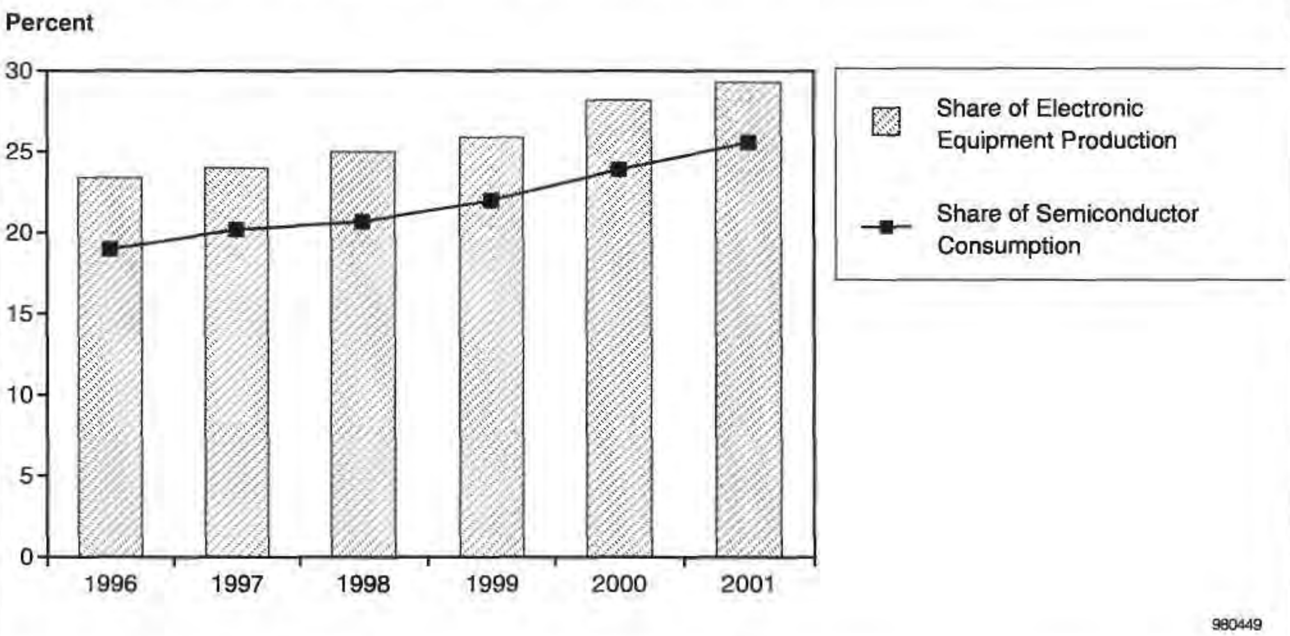
Figure 5-3
Forecast of Electronic Equipment Production by Region in Asia/Pacific, 1996 to 2001 (Compound Annual Growth Rate)



Source: Dataquest (January 1998)

Figure 5-4
China/Hong Kong's Share of Asia/Pacific Electronic Equipment Production and Semiconductor Consumption, 1996 to 2001 (Percent)



Source: Dataquest (January 1998)

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Figure 5-5 compares total semiconductor consumption with DRAM and non-DRAM markets. Dataquest's semiconductor forecast incorporates both the macroeconomic and electronic equipment assumptions discussed earlier. After a flat market performance of 0.5 percent in 1996, the China/Hong Kong semiconductor market picked up a 15 percent growth in 1997. Assuming higher average selling prices (ASPs) for 64Mb DRAMs, the mainstream product in 1998, as well as other memory devices, Dataquest expects 1998 to outperform 1997. With a DRAM growth of 36 percent in China/Hong Kong, the overall market should reach 23 percent in 1998, with stronger DRAM growth occurring in the second half of the year.

The currency devaluation's impact on the DRAM market becomes more pronounced after 1999 because of the anticipated formidable growth in PC production. Boosting the expected DRAM growth is the incredible surge in China's PC market. China, excluding Hong Kong, will take about 30 percent share of Asia/Pacific's PC consumption in 1998 and maintain an average annual growth rate of about 40 percent until 2001, the fastest growth in Asia/Pacific. Non-DRAM products continue to experience more stable, long-term growth because of China/Hong Kong's broad-based electronic equipment production growth.

Table 5-1
Total Electronics Production and Semiconductor Market Forecast in China/Hong Kong and Asia/Pacific, 1997 to 2001 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	CAGR (%) 1996 to 2001
China/Hong Kong						
Electronics Production Revenue	42,387	50,780	59,924	71,763	84,803	23.9
Semiconductor Market Revenue	6,490	8,008	10,504	14,926	18,077	33.7
Electronics Production Growth (%)	17.8	19.8	18.0	19.8	18.2	-
Semiconductor Market Growth (%)	14.9	23.4	31.2	42.1	21.1	-
Asia/Pacific						
Electronics Production Revenue	176,600	202,757	231,740	254,794	289,136	17.1
Semiconductor Market Revenue	32,123	38,707	47,779	62,545	70,605	24.1
Electronics Production Growth (%)	14.9	14.8	14.3	9.9	13.5	-
Semiconductor Market Growth (%)	8.0	20.5	23.4	30.9	12.9	-

Source: Dataquest (January 1998)

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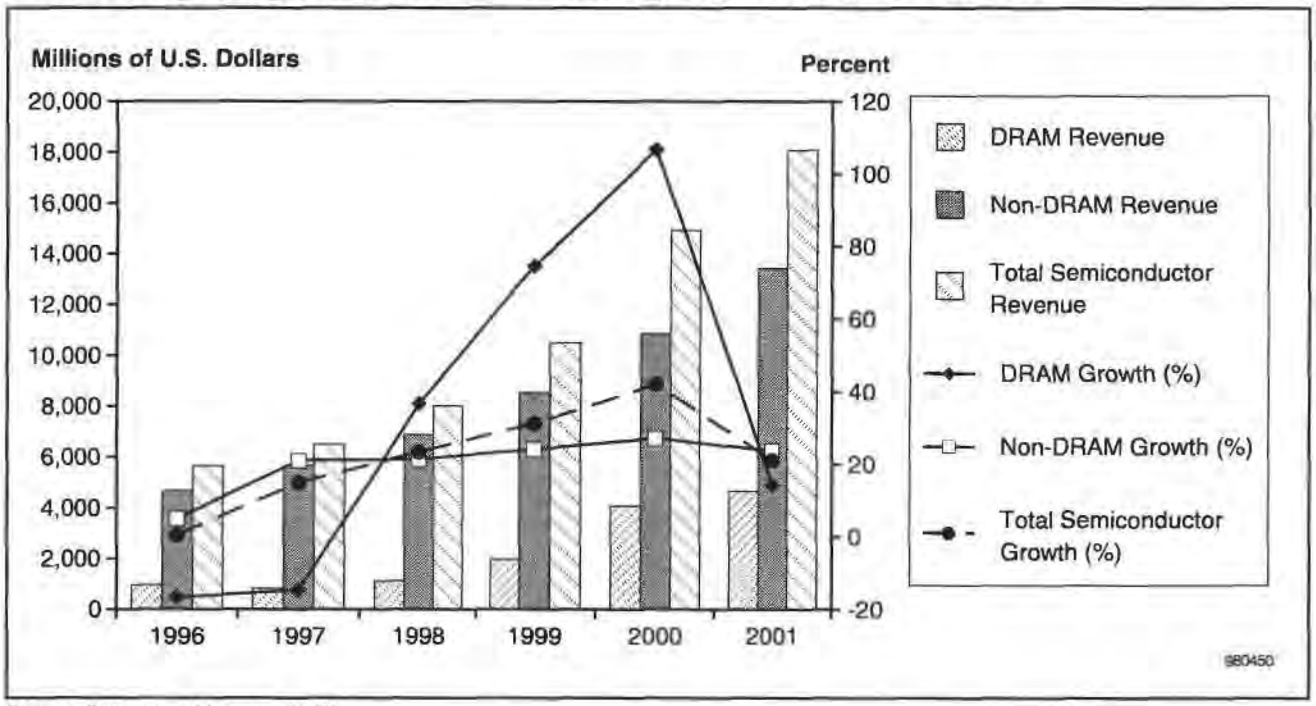
Figure 5-5
China/Hong Kong Semiconductor Consumption Forecast, 1996 to 2001



Source: Dataquest (January 1998)

Dataquest Perspective

The financial crises have adversely affected semiconductor shipments to end-equipment companies that are dependent on sales within the affected countries. Dataquest highlights the economic woes in Japan and Korea because they will weaken Asia/Pacific electronic equipment production overall—again, because of weakened exports mainly in consumer electronics but also in computer-related equipment producer countries. Consumption of electronics in Malaysia, India, Indonesia, Malaysia, Singapore, Thailand, and Taiwan is also damaged by higher import costs and weaker consumer spending in 1997 and 1998. However, the majority of production in the affected countries comes from companies exporting to Europe, Japan, and North America, so a local market slowdown has minimal effect on overall production of Asia/Pacific as a whole. Furthermore, export sales are conducted in U.S. dollars, and semiconductor purchases from multinational vendors are usually conducted in U.S. dollars also—thereby avoiding the ill effects of currency fluctuation.

China/Hong Kong has not been affected by this financial crisis in the short term because of the stable renminbi and Hong Kong dollar, which are backed by about U.S.$200 billion in combined foreign reserves. However, Dataquest has outlined the deflation and investment challenges within China. Dataquest's lower long-term electronic production and semiconductor consumption forecasts for China/Hong Kong assume that Southeast Asia will receive increased investment that would otherwise have gone to China (after four years of very high foreign investment levels in China). However, the power of the Chinese market and its production prowess for international markets will continue to attract investment, enabling it to extend its lead as the largest and fastest-growing semiconductor markets in Asia/Pacific.

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Chapter 6
Currency Meltdown: Impact on Asia/Pacific PC Markets

Introduction

After the previous three chapters' regional perspectives on Korea and China/Hong Kong, Dataquest now turns to the PC market. This chapter aims to provide insight into the currency devaluation's early impacts on the personal computer industry, to assist PC suppliers in understanding the factors involved, and to highlight the key areas on which to focus when steering a path through the crisis.

Background

The economic conditions that have spread to nearly every Southeast Asian country started on a much smaller scale. South Korea was already experiencing severe economic difficulties following a series of bankruptcies among its large industrial conglomerates when difficulties in the Thai banking and finance community escalated to a devaluation of the baht during the first half of 1997. A ripple effect quickly followed, sparking similar devaluations in Malaysia, Indonesia, and the Philippines. Initially, Hong Kong and Singapore remained largely unaffected by the difficulties faced by their neighbors, but this situation changed late in September as investor nervousness spread to other Asian markets. Similarly, the Australian dollar became more seriously affected this October. At the end of October, the Thai baht and Indonesian rupiah were both trading at about half the values they held at the beginning of the year. The Malaysian ringgit had fallen more than 35 percent, closely followed by the Philippine peso, down about 32 percent. Most other currencies were trading between 10 percent and 15 percent lower than their values at the beginning of 1997. China, Hong Kong, and Japan were the least affected. In both Thailand and Indonesia, the IMF has stepped in to assist with the crisis.

Economists have a range of opinions on both the causes and the solutions to the economic crises, but it has become clear that there have been several different underlying factors. These include cozy relationships between government and favored business leaders, irrational investment in high-profile projects (such as in real estate) instead of in productive areas of the economy, and the failure to open up large monopolies to competition. The Thai banking and finance sector has been sharply criticized, as has economic policy in Thailand, Malaysia, Indonesia, and the Philippines. Most other affected countries have been victims of a "contagion" effect, as nervous investors apply the same high-risk label to all Asian markets.

A speedy recovery is not part of the outlook. Investors have been deeply critical of policy response in most countries, which they consider to have been grossly inadequate so far. In Thailand, for example, the government recently decided not to implement higher taxes on oil—as recommended by the IMF—thus placing a U.S.$16 billion rescue package at risk and sparking several ministerial resignations. Malaysia's prime minister, Dr. Mahathir Mohamad, has shifted too much blame onto currency speculators and failed to deliver a budget with the teeth desired by investors. In Indonesia, IMF recommendations have also been actively resisted.

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Instead of easing, investor nervousness has spread to include more countries and has introduced a level of turbulence in stock markets around the world. The relative health of the Asian markets remains highly volatile, and major currency shifts are likely to continue—even as this document goes to print. The general consensus among economists is that the hardest-hit Asian economies will take two years to fully recover, and Dataquest has been revising PC consumption forecasts for the region downward.

Impact on PC Shipments

Figure 6-1 shows the declining growth rates seen so far this year in Korea, Indonesia, Malaysia, and Thailand—the countries most affected by the financial crisis. It reveals the Korean situation to be quite different from that of other countries because PC shipments have been depressed—with no growth—since the fourth quarter of 1996. Conversely, Indonesia, Malaysia, and Thailand suffered a shared impact from the financial crisis much more recently, with the major downturn in PC shipments coming in the third quarter of 1997.

The Malaysian market has been somewhat less affected than the Thai and Indonesian markets (it is the only one in which third quarter 1997 shipments are up over the previous year), although the impact is still clearly visible. This lower impact is in part a reflection of the reduced scale of the currency crisis in that country, which only produced PC price rises late in the third quarter.

Dataquest has observed further price rises in the fourth quarter and expects a larger impact before year's end. PC shipments in most other Asian countries have yet to be affected by the financial crisis, although many have been experiencing lower growth for other reasons, such as market maturity.

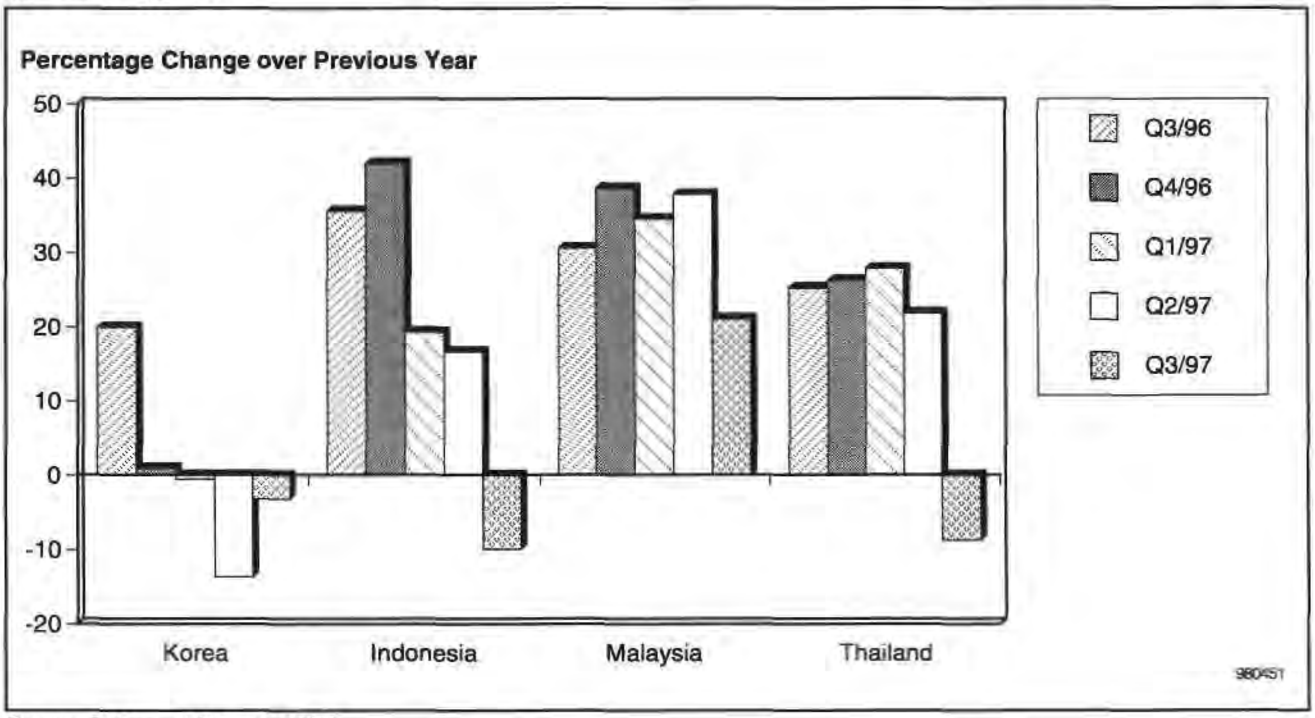
In Thailand, Malaysia, and Indonesia, the greatest reduction in PC consumption has consistently been in the corporate sector, especially in the banking and finance industry. As a result, vendors that focus heavily on this segment (such as IBM) have typically suffered the most impact. The next biggest concern for vendors is the potential falloff in government business in Indonesia and Thailand (but not in Malaysia, where the government has reaffirmed its commitment to existing projects). This situation differs in Korea, where the home market has been most affected—probably reflecting the longer period of economic uncertainty and its impact on consumer confidence.

Market Dynamics

Rising Cost of Imports

Fully imported PCs and imported components such as monitors, microprocessors, hard drives, and memory modules are affected equally by exchange rate variation, in theory giving no advantage to vendors buying either one. Locally manufactured components, however, such as Acer Computer International Ltd.'s motherboards in Taiwan, Samsung's memory chips and monitors in South Korea, and batteries and monitors from Delta Electronics Industrial Ltd.'s operation in Thailand, will not be affected by exchange rate variation when sold on the local market, thus handing an advantage to vendors that use these local components over imports. Also, local labor costs have fallen considerably relative to other

Figure 6-1
Year-on-Year Growth in PC Shipments in Korea, Indonesia, Malaysia, and Thailand: Q3/96 to Q3/97



Source: Dataquest (January 1998)

countries, providing an advantage to any manufacturer (multinational or local) undertaking part or full assembly of PCs in the local market. The same relative advantage applies to most of the facilities and service-related costs for a PC plant.

Rising PC Prices

The most important inhibitor of PC sales within affected economies has been rising prices. At the same time, many suppliers have switched to pricing in U.S. dollars to avoid having to adjust continually for exchange-rate variations. In Thailand and Indonesia, price rises in PC hardware have been offset in part by the regular cycle of worldwide component price cuts, particularly those of Intel Corporation, ensuring that, although currencies might have dropped up to 50 percent in value, PC price rises have generally been limited to under 15 percent. A similar process has taken place in Malaysia, although vendors in that country have managed to delay price increases a little longer.

Canceled and Deferred Purchases

Many buyers are waiting for the local currency to improve to maximize the spending power of their limited budgets, and at the same time many of their budgets are being reduced. Either way, the effect is the same: Premeltdown budgets are inadequate for postmeltdown prices. Within the government and corporate sectors, there is a strong inclination to defer making large purchases. In the case of government, there is considerable pressure to exercise restrained fiscal policy and to set spending priorities toward areas that the investment community sees as most important to stabilizing the economy.

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In both Indonesia and Thailand, government information technology (IT) purchases are expected to be especially conservative. The Thai government has already announced that the IT budget for 1998 is to be cut from 7.8 billion to 3.7 billion baht. The Indonesian finance minister announced in August that U.S.$35.6 billion worth of government and state-related projects were to be postponed or reviewed, indicating that mining, energy, public works, and the transportation sector would be hit hardest. This move is expected to have a substantial impact on PC purchases in those sectors.

In the home sector, spending on all high-priced luxury items diminishes during periods of economic uncertainty. Additionally, like business buyers, many families find that what they would have purchased before the currency decline has simply become too expensive. Other factors will indirectly affect PC purchases by reducing spending power. These include an increase in the value-added tax in Thailand from 7 percent to 10 percent (following IMF recommendations), increased import tariffs to 30 percent, and expected increases in fuel and electricity prices in Indonesia—which will ultimately be passed on to all consumer goods.

Late Payments

Maintaining adequate cash flow has been a particularly serious problem for many vendors as companies delay paying for equipment that has been delivered. With their debts owed in U.S. dollars, buyers hold out payments in anticipation of any small rise in local currency value. The risk is, of course, that the local currency value will decline further and that the longer delay will actually increase the debt. Although delayed payments are affecting every stage of the procurement process, the problem is most pronounced when it comes to vendors getting payment from channel partners. This applies particularly to first-tier channel partners, which are most likely to hold stock and have to buy in U.S. dollars (selling to the second tier in local currency).

Technology Lag

Dataquest has found little evidence of "slimming down" of PC configurations to reduce costs, nor of any major switch to upgrade purchases at the expense of new PC purchases. There is, however, strong evidence that microprocessor life cycles, particular for Intel's Pentium 166-MHz chip, have been extended in desktop and deskside machines. This extension is a trade-off for limiting price rises to manageable levels: Under normal circumstances, component price cuts would be accompanied by a strong shift by manufacturers to later-generation processors. Also, fewer buyers are able to afford the latest Pentium II processor, thus contributing to the slow take-up rate across the region. The overall result is a greater technology lag behind the U.S. market. Dataquest expects this lag to lengthen, at least temporarily, in Indonesia, Thailand, and to a lesser extent, Malaysia.

A second, related effect is likely to be the shift by manufacturers and buyers toward cheaper microprocessors from Advanced Micro Devices Inc. and Cyrix Corporation. No data is yet available to confirm if this shift has taken place, but early indications are that Intel was disappointed with its third quarter performance, while AMD reported a strong demand in Asia.

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Export Competitiveness

Vendors that manufacture in countries now heavily impacted by currency depreciation are better positioned for export to less-affected markets within Asia or to other world markets. Acer, for example, has already indicated that a depreciation of the Taiwan dollar, although relatively minor compared with other Asian countries, should prove highly beneficial to its 1997 financial results.

Survival Strategies

New Targets

Preliminary third quarter results show that the Chinese, Taiwanese, Hong Kong, and Australian PC markets have not been affected by the Asian economic crisis. Although this situation may change at any time, Dataquest anticipates that these countries will remain the best opportunities for PC sales while the crisis continues for the rest of Asia. China's growth will be unlikely to slow, and the other markets are all underpinned by solid economic fundamentals. Where opportunity allows, vendors operating in multiple markets through the region should look to put most of their current resources behind sales efforts in these countries. Similarly, within the deeply affected markets, Dataquest has observed that not all sectors have been affected to the same extent, with the education and small business sectors having provided better opportunities relative to other sectors in the third quarter.

Zero Inventory

One ironic result of rapid currency devaluation is that those manufacturers that have poorly managed their inventories gain a short-term advantage. Having purchased or manufactured excess stock under favorable exchange rates, these suppliers are able to hold off on announcing price rises the longest. Having passed this stage, however, inventory management becomes far more critical than under normal market conditions. Vendors will need to keep minimal stocks to take advantage of short-term price fluctuations on components. Acer, for example, has taken the opportunity to announce a more streamlined build-to-order (BTO) and delivery strategy in Thailand. Later, when currency values begin to rise, excess inventory will be punished severely, and it is likely that a number of PC suppliers will sustain large losses.

Compress Channels

The advantages of shorter supply lines will be increased under the present economic circumstances for two reasons. The first is lower inventory through the system, for the same reasons as those mentioned above. The second is that a shorter supply line will minimize the exposure to bad debt, which has already shown itself to be a problem in the third quarter. Vendors that sell direct have only to worry about one set of payments. Vendors that use a multitiered channel are exposed—if the buyer, reseller, or distributor defaults—multiplying their risk.

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Boost Local Content

There is a substantial competitive advantage from increasing use of local hardware and labor content within markets heavily affected by currency depreciation or from importing components from facilities located in those countries wherever possible. Both these actions will reduce overall production costs. Just as important, however, is the need to maintain flexibility in these arrangements so sources of supply can be quickly altered to take advantage of further currency fluctuations and to avoid being locked into arrangements that become less competitive as currencies appreciate.

A Long-Term Opportunity?

Southeast Asia's lower exchange rates have made these countries more attractive for locating full-scale production facilities. For all the difficulties IBM is facing in selling PCs into the Thai market, it is now reaping the rewards for its decision to establish a U.S.$300 million plant to manufacture hard drive and storage products in Prachinburi, Thailand. Fujitsu Ltd. and Seagate Technology Inc. are also establishing new facilities or expanding existing ones in Thailand. At the same time, traditional production locations such as Singapore have become increasingly expensive during the past year. Shifting production facilities to affected countries has high potential rewards, but, because of the size of the investment involved, it also carries high risks.

Do Current Conditions Favor Local Vendors?

In recent years, the unbranded "whitebox" PC clone industry has been a dominant part of the PC mix in Asia, although it shows signs of stabilizing as markets mature and has been forecast to decline as a proportion of most countries' markets in the next few years (see Dataquest report *Cheap, Fast, and Flexible: Whitebox PCs in Asia/Pacific,* PCIS-AP-MT-9702, October 1997). At the same time, Dataquest sees a strong pressure on large, branded, local assemblers—such as Wearnes Technology, V-Tech Systems Limited, Powell Computer Co. Ltd., and Total Peripherals Group Pty. Ltd.—from multinational giants such as IBM, Compaq Computer Corporation, and Dell Computer Corporation, steadily squeezing the former group out of the market.

Economic uncertainty seems to favor many local vendors, however, with indications that buyers have shifted toward these suppliers in Indonesia and Thailand (Powell and ATEC Computer Co. Ltd. are just two examples of local vendors that did well in the Thai market in the third quarter). There is no doubt that, in these markets, a consequence of reduced buying power and higher PC prices has been a shift toward whitebox purchases to achieve required purchase volumes with limited funds or to continue buying PCs with the same equipment levels without paying the higher prices. It would appear that, in these markets, economic pressure has temporarily reduced the perceived value of the warranty/service/quality package offered by brand-name suppliers. Also, Indonesian government departments are following a directive to favor local vendors when buying desktops while the crisis continues.

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The opposite trend has been seen in Malaysia, however. Here, local vendors seem to be having more difficulty capitalizing on component price fluctuations, and buyers are placing greater emphasis on reliability (with a view to extending equipment life) under the present conditions. Nor are local vendors faring better in Korea, although Dataquest has observed an increase in demand for secondhand PC systems.

Dataquest believes that local companies' key advantage lies in their higher proportion of local assembly relative to their multinational competitors (although multinational giants such as Dell and Gateway 2000 Inc. that operate factories in Malaysia or other affected countries are also well positioned). Local assembly gives vendors a critical advantage when it comes to pricing PCs on the local market. On the minus side, local companies are at a disadvantage when it comes to financing their operations. Investment is harder than ever to secure in countries such as Thailand and Indonesia, and many whitebox suppliers—although prosperous in high-growth markets—are ill-equipped to ride out periods of reduced cash flow. In contrast, multinational suppliers can afford a long-term strategy, riding out unprofitable periods in one or two countries to secure a strong market position in the long term.

On balance, although not helping any vendor sell more PCs, the current conditions should temporarily negate many of the advantages held by multinational companies over local vendors. In particular, Asian companies that also manufacture components should be more competitive in their home markets over fully imported products. Overall, Dataquest expects a temporary halt to the market share slide being experienced by local vendors in Southeast Asian markets, with multinationals retaking the upper hand when economic conditions improve.

Dataquest's Market Outlook

Generally speaking, the outlook for recovery has shifted from a near-term to long-term expectation in Thailand, Indonesia, and Malaysia, with Malaysia somewhat better positioned than the other two. PC vendors will thus need to be prepared to survive a sustained period of difficult and depressed trading. Economists are indicating that the Korean economy could begin to turn around earlier—perhaps starting a slow climb early in 1998, but early indications are that the fourth-quarter performance of the PC markets in Indonesia, Malaysia, and Thailand will be even more badly affected than the third quarter. For as long as this situation lasts, Dataquest expects PC shipments to be inhibited, especially as government projects and large corporations play such an important role in driving IT acquisition in Southeast Asian markets.

On the positive side, spending on PCs is unlikely to be as deeply affected as other capital expenditure because improving the communications and technology infrastructure in Southeast Asia is seen as one of the building blocks for recovery. Additionally, the overall growth in the Asian region will continue to be solid in 1998 and 1999, driven by the booming Chinese market. Given the highly contagious nature of currency fluctuations within the region, however, the situation for most of the markets, particularly those in Southeast Asia, remains volatile and unpredictable.

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Chapter 7
The Impact on Capital Spending of the Asian Financial Crisis

Introduction

This final chapter represents a recap of Dataquest's views over the past several months of how the Asian financial situation will affect capital availability and spending in semiconductors. Dataquest has just released the spending forecast for 1998, with both a forecast and downside risk scenario. The details of those scenarios are published in a Dataquest Perspective ("Wafer Fab Equipment Market Forecast Update: Question Marks for 1998 as the Second Half of the 'W' Unfolds," SEMM-WW-DP-9801, January 1998), and an overview is presented here.

Will the Southeast Asia Currency Issue Cause a Decline in Capital Spending in the Region? Yes! Here's Why ...

In early August 1997, when the Asian financial systems began experiencing stress, Dataquest went on record as seeing more downside risk than upside potential to our 1998 capital spending forecast, in part because the Southeast Asia currency issues could put a damper on capital availability in the region. That statement was made before the fourth quarter meltdown, based on fundamentals of capital availability.

The real issue? The entire Southeast Asian banking system is in a liquidity crisis, with declining or negative cash flow. This has caused devaluation of currencies throughout the region as a natural, self-correcting economic response, resulting in equity market upheavals as the world "readjusts." The original, higher-order cause of the liquidity issue is complex, involving factors such as current account imbalances and the DRAM price collapse, among other things.

It is important to understand how capital is raised in the United States and Europe, as opposed to Asia. In the United States and Europe, capital is raised by a combination of debt (usually corporate bonds, sometimes convertible to stock) and equity placements (public offerings on the stock market). A company's ability to raise capital successfully in the equity market depends primarily on profitability. Profits are also a major source of capital, and U.S. and European companies are structured and managed for this goal. In Asia, a much larger portion of the capital raised (sometimes exclusively) is from the banking system in the form of loans. The evaluation criterion is fundamentally different there—cash flow. In a highly leveraged company, cash flow can easily be positive while losses are piling up. Asian companies, as a result, are primarily managed for cash flow. This has been the key reason why the capital spending-to-semiconductor production revenue ratio is estimated to be about 23 percent in the United States while near 70 percent for Asia/Pacific, keeping the worldwide ratio at almost 29 percent—a level that is too high, in Dataquest's opinion.

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The Korean banking system has been in a liquidity crisis for some time, and the Japanese banking system has already been under pressure from the struggling economy of Japan. Debt-to-equity ratios are quite high in Korea, and capital spending from companies in both these countries has been depressed for several quarters now. Both these systems received more pressure from Southeast Asia in late summer. Taiwan's banking system has higher relative reserves than its Southeast Asian neighbors but is feeling the weight as well and is viewing the situation with caution.

Decreasing chip prices have taken a major toll on the cash flow of many semiconductor companies in the region. Less capital is available in the system because cash flow id not available to pay some existing debt.

Assuming demand for chips is not affected by the situation, the natural economic responses to be expected in the region should include:

- Higher interest rates (which will raise the cash flow requirements of companies requesting money)
- Higher cash flow requirements (which will mean the amount for which the companies qualify is less)
- Less capital available (as a result of the previous point and the lower liquidity in the system)
- Significantly lower capital spending plans, complicated by the fact that local currency buys less equipment from U.S. and Japanese companies because of the devaluation

There has been a trend for Asian companies to seek other sources of capital, such as Eurobonds and equity offerings in the United States. Dataquest believes these avenues will be available to some companies but will fall very short of adequately covering the loss of capital from the banking system overall. The recent quakes in equity markets worldwide present a difficult environment in the short term, as well.

What exists today is a situation that will take several quarters to play out, and one that equipment companies must realize will affect them materially. In a sanguine tone, Dataquest must say that, in the long run, capital spending restraint over the next several quarters will ultimately be very healthy for the semiconductor industry, bringing supply and demand into better balance and ultimately stabilizing pricing and profitability.

And Then Korea Falls—What about Taiwan?

In late November 1997, the South Korean government admitted that some outside help was going to be required to address a massive liquidity crisis in the country. The "official" request was initially about $20 billion, but the agreed-upon bailout was $57 billion, and this may be in the process of being increased. Putting this into perspective is key, because we saw a report recently that places the annual capital spending level for *all* Korean companies in *all* industries at about the $50 billion to $55 billion! The three culprits being pointed to in Korea are memory chips, steel, and autos. All industries are in huge states of overcapacity, and the IMF will likely place some restrictions on the use of capital in these industries in the near term.

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The Japanese banking system, already under pressure with the struggling economy of Japan, is now feeling added strain. All the banking roads from Asia appear to lead to Japan, and questions are now being raised as to whether this evolving situation will harm the recovery in Japan, perhaps sending the economy into another recession. The closing of the fourth-largest securities firm in Japan because of lack of liquidity has not helped. Trickling repercussions can be expected.

Meanwhile, the currencies have continued to depreciate relative to the U.S. dollar. Since the beginning of the year, the currency of South Korea has depreciated 40 to 50 percent, Taiwan's about 18 to 20 percent, and Japan's about 10 to 11 percent relative to the U.S. dollar. These fell precipitously in the last months of 1997 and may come under further pressure before stabilizing.

What is the likely fallout? Dataquest believes there are three issues to watch in coming months: capital spending cuts, DRAM prices, and the dynamics of the foundry market.

In conversations over the last couple of months, Dataquest described the South Korean situation as the linchpin. If Korea could keep it together, then the crisis could be controlled without turning into something much worse. But if Korea fell, then watch out! Well, Korea fell, and we are officially saying—watch out! The magnitude of the situation is mind-boggling, and we are forecasting that Korean companies will cut capital spending in 1998 about 40 to 60 percent, relative to 1997 in dollar terms. It is safe to say that *all* Korean capital projects are stopped dead in their tracks at present, and we would estimate that it will be late spring before the situation settles to the point at which some of these projects may be cautiously restarted.

Because the Japanese banking system is under strain, there is not much money available, and Dataquest is forecasting that spending plans for Japanese companies in 1998 are likely to be about 7 to 14 percent lower in dollar terms than in 1997.

What about Taiwan? The second and third issues actually are the keys to Taiwan. The currency valuations may actually be of more importance in the intermediate and long term than capital availability. Taiwan is outright defiant at present, and it have some reason to be. Its financial system is based on a stock market system rather than banking, and a major portion of the country's semiconductor business, foundry, is still very profitable and growing.

However, depreciation levels are approaching that will dramatically impact competitiveness and pricing among regional companies. Not quite, but almost, half of the DRAM capacity is in Korea and Taiwan now. These suppliers now have a "cost holiday" relative to competitors in the United States, Europe, and, in part, Japan. Dataquest estimates that perhaps 55 to 60 percent of the cost of making a semiconductor chip is sensitive to local currency.

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Will these companies sit on their marginal profits? If history is a guide, the answer would be no. A continuing free fall of DRAM prices will put profitability pressures on Micron Technology Inc., Siemens AG, and perhaps even Texas Instruments Inc., to a lesser degree. Capital spending plans for these companies may come under review in the near term and perhaps be lowered.

So, will the foundry industry be the savior? Maybe in part, but right now it is the *only* bright spot, and every company is now looking toward it. We can expect a flood of announcements (which have already started) from companies coming into the foundry market. Taiwan Semiconductor Mfg. Co. recently released a forecast stating that its gross margins were increasing in a growing market. This is true and understandable, given the currency valuation trends and the fact that the bulk of its customer base is in U.S. dollars. Although TSMC is the technology leader and premier foundry supplier, it has not typically led pricing downward but has been a price follower. LG Semicon has been a price leader in the past, and Dataquest is expecting LG Semicon to retake the pricing lead, maybe joined by others, giving TSMC's margin improvement a relatively short life. LG Semicon has the capacity, needs the cash, and is motivated to take business through pricing because there is beginning to be a separation in the valuation of the Taiwan dollar and the Korean won.

So what about Taiwan capital spending in 1998? Dataquest believes it will be split. Taiwan is fundamentally different from its Asian neighbors because capital-raising techniques used there rely more heavily on equity markets than debt markets or the banking system. The Taiwan banking system is the soundest in Asia, but we think Taiwan is watching and being very cautious at present so as not to follow Korea to the IMF. A company's ability to raise capital in the equity market depends primarily on profitability. And even then, today's environment is not really favorable to raising capital on the equity markets.

Dataquest believes the equity market will be available to foundry companies but is not likely to be favorable to memory producers. For this reason, we think that the memory producers in Taiwan (Powerchip, Nan Ya Technology Corporation, and Mosel Vitelic) may find it more difficult to raise capital, while the foundry producers will be able to raise spending levels slightly in 1998. However, currency depreciation will lower the spending levels on a U.S. dollar basis. We think only a few leading companies, such as TSMC, Chartered Semiconductor Mfg. Pte. Ltd. , and United Microelectronics Corporation, will be in a position to raise spending levels in U.S. dollar terms for 1998. Memory companies will likely be forced to cut spending in 1998. Overall, Taiwanese spending is expected to increase about 13 percent in 1998 to $7 billion.

The Taiwanese foundries are still very profitable, and although the situation may degrade through the year, spending for 1998 seems fairly secure. Dataquest's forecast assumes that Taiwanese foundry spending will increase more than 40 percent to $4.3 billion (excluding foundries outside Taiwan).

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Dataquest expects spending in DRAM capacity to remain at a high level. Some companies will cut spending, but companies such as Vanguard International Semiconductor Corporation (owned in part by TSMC) will actually increase spending heavily. Overall, in local currency, spending will be flat in the DRAM area but down about 15 percent in U.S. dollars.

This situation is continuing to play out and will not be settled for several months yet. The picture is increasingly beginning to resemble a sharper decline in sequential spending than originally anticipated in the DRAM area.

Thailand fell, Hong Kong crashed, Korea admitted it needed help, and even Japan is feeling added strain and experiencing the collapse of a securities company—each of these events has been accompanied by someone stating, "It is an isolated incident," "We are only minimally affected," or, "It should be possible for this to be controlled within that country." Does anyone still doubt that we are in the midst of a worldwide earthquake? The tremors will be relatively minor in the United States—but they will be, and are starting to be, felt.

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Perspective

Semiconductors Top Views
Market Analysis

The Impact of the Asian Financial Crisis on Worldwide Electronics Production and the Semiconductor Market

Abstract: *The Asian financial crisis will dampen the growth in 1998 of worldwide electronic equipment production and the semiconductor market to lower than previously forecast by Dataquest. This document examines the negative impact the Asian crisis will have on these forecasts.*
By Semiconductor Industry Analysts

Section I: Introduction

The financial crisis in Asia is a daily topic of discussion and in publications as the world tries to assess the impact of the crisis on worldwide financial markets, stock markets, banking systems, and national economies. At Dataquest, clients are continually asking us to assess the impact of the Asian crisis on the electronics, PC, and semiconductor industries, and much has been written by Dataquest about this.

In particular, our semiconductor clients are asking us how Asia's financial woes will affect Dataquest's 1998 semiconductor industry and electronic equipment production forecasts. These forecasts were released in October 1997, and much has happened since then. To date, we have refrained from issuing new formal forecasts mainly because the situation is still very, very fluid, and we felt we were unable to publish accurate 1998 forecasts until more information was at hand. Nevertheless, our clients want to know what our thinking is.

This document is a summary of Dataquest's current thinking about the impact of the Asian financial crisis on electronics production, the semiconductor market, including DRAMs, and semiconductor capital

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spending. The analysis presented in this document represents a qualitative point of view of the potential impact. Dataquest will issue new formal 1998 forecasts at the end of April. In the interim, we will keep our clients up to date as the Asian crisis evolves and more information becomes available.

This analysis represents the collective thinking of Dataquest's semiconductor analysts in all regions of the world. Further information on any of the topics is available from the analysts listed at the end of each section or by referring to the other documents, noted in the text, that Dataquest has already published on Asia's financial crisis.

The Bottom Line

The following are the major conclusions of this analysis:

- In 1998, worldwide electronic equipment production will likely decline from Dataquest's previously forecast $1,009 billion to $953 billion. This means that 1998 electronic equipment production will grow only about 3 percent instead of the 9 percent previously forecast.
- Solely because of the decrease in electronic equipment production, the worldwide semiconductor market is likely to decline from our previously forecast $175 billion to $165 billion.
- Also, because of the potentially lower cost of DRAM manufacturing, the 1998 DRAM market could decline by $3 billion to $5 billion from our previous forecast.
- Combining the effects of decreased electronic equipment production and the lower DRAM market, the overall 1998 worldwide semiconductor market could be as low as $160 billion. Our previous 1998 forecast (released in October 1997) was $175 billion, for a growth of 17 percent over 1997. The new forecast of $160 billion represents a growth of about 7 percent over 1997.
- Capital spending is forecast to be down 4 percent in 1998 to $43 billion and does reflect the conditions in Asia through December. Dataquest has also published a detailed downside capital spending scenario with a set of changed assumptions that places the downside risk at $39 billion, about a 12 percent decline from 1997 levels.

It is important to note that the numbers presented in this document are not "official forecasts" but are meant to provide guidance to clients until we do publish firmer forecasts. This forecast represents our current thinking about the impact of the Asian financial crisis and is subject to change as the situation continues to unfold.

Section II: Background on the Asian Financial Crisis

The beginning of summer 1997 saw the devaluation of the Thai baht amid escalating difficulties in the Thai banking and finance community, which forced the Thai government to finally surrender to the currency speculators.

At that time, few people, if any, would have predicted this to be the start of a financial storm sweeping throughout Asia, with far-reaching global implications.

Shortly after the Thai baht devaluation, the governments of Malaysia, Indonesia, and the Philippines succumbed one by one to the speculative currency attacks. The rapid currency devaluation sent shock waves through the regional stock markets of Thailand, Malaysia, Indonesia, and the Philippines. Singapore and Hong Kong, which remained largely unaffected initially, saw their stock markets tumble in October amid growing investor anxiety.

The financial crisis deepened in November as it spread to Korea and Japan, the world's 11th-largest and second-largest economies, respectively. The value of the Korean won dropped sharply, along with Korea's stock market, after the Korean government gave up its battle to prop up its currency in November. A $57 billion rescue package led by the International Monetary Fund (IMF) was negotiated for Korea, after $40 billion and $17 billion were negotiated for Indonesia and Thailand, respectively. In the meantime, Japan saw the closure of its fourth-largest securities company, Yamaichi Securities Company, on November 24, following the closure of Hokkaido Takushoku Bank, its 10th-largest commercial bank, a week earlier.

Behind these events lies a tale of massive regional expansion based largely on politically manipulated debt directed over the past 40 years to conglomerates that are now unable to pay the money back.

Simply stated, the current Asian financial crisis stems from the inability of South Korean and other regional companies to repay their short-term debts. The expansion that has given South Korea an average annual gross domestic product (GDP) growth rate of 8.6 percent during the past 30 years has been achieved largely on the back of massive, politically backed short-term borrowing, which was rolled over regularly and renewed by the country's top companies—family-run conglomerates, commonly known as chaebols. Problems have occurred with this short-term borrowing strategy because many of the investments made were long term and not suited to short-term returns. More important, the primarily South Korean banks, which in turn borrowed mainly U.S. dollars from Japanese banks, are now unable to continue rolling over the debts and granting extensions. Inevitably, huge debts are now due for repayment. There are several factors that have caused this.

Until mid-1997, the Southeast Asian currencies and the Korean won were pegged to the U.S. dollar. With the growth in the strength of the dollar since mid-1995, caused by the improving performance of the U.S. economy, the won and the Southeast Asian currencies also strengthened, in conjunction with the U.S. dollar. The strong local currencies resulted in the slowdown of Southeast Asian and Korean exports because they became more expensive and less competitive in a worldwide market that was already showing signs of slowing and overcapacity. The slowdown in exports contributed to the large current account deficit in Southeast Asian countries and Korea, which ultimately left the currencies in those countries susceptible to devaluation.

The dramatic currency devaluation that occurred in Southeast Asian countries and Korea will now make exports more cost-competitive. However, these devaluations increased the local value of debts borrowed in foreign currencies, massively increasing the amount of home currencies required by banks and conglomerates to repay their debts.

The second catalyst for the crisis concerns the primarily Japanese banks that, by lending to the region's banks, including South Korean banks, financed the growth of South Korea and other countries. Japanese banks were unable to renegotiate their South Korean debts because of their own liquidity problems. Much of the security on which Japanese banks based their value was property and stock market-based investments; however, in the early 1990s, the Japanese property and stock markets collapsed, taking with them much of the equity on which Japanese banks relied. The loss of equity and the effectively defaulted loans of Japanese companies caught in the collapse impaired their ability to borrow money on the international money markets; thus, less new money was available to renegotiate South Korean debts. South Korean loans therefore came due for repayment.

The problem is so severe that the South Korean ministry of finance and economy estimates that about $21.5 billion of external debt will be due for repayment in the first three months of 1998. In the first six months of 1998, about $70 billion of external liabilities will be payable—this represents about 70 percent of the nation's total external debt.

These debt levels, devaluing currencies, and slowing revenue mean that mass restructuring will be needed in the South Korean and other Southeast Asian economies to restore the market confidence necessary to allow the region to recover. This restructuring will involve mass layoffs as loss-making companies and insolvent banks are closed down and the giant chaebols are restructured to focus on core competencies.

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Section III: The Macroeconomic Effects of Asia's Financial Crisis and the Impact on Electronics Production and Semiconductor Consumption

Asia's Macroeconomic Outlook for 1998 Has Changed Dramatically

Asia's currency and financial crisis has dramatically changed the macroeconomic outlook for most Asian economies. Changes in outlook have been the greatest for the economies most affected by the crisis: Indonesia, South Korea, and Thailand. Economic forecasters have uniformly downgraded their estimates of GDP for Asia's troubled Pacific Basin region in 1998. Based on a survey of prominent forecasters, Dataquest estimates that 1998 GDP for the region will be reduced about $690 billion from the levels expected at the time of Dataquest's fall forecasts. GDP estimates for

Indonesia, South Korea, and Thailand have been reduced especially sharply. These significant changes in the outlook for GDP have been accompanied by equally significant changes in the outlook for inflation. Inflation is expected to increase markedly throughout the region, especially for Indonesia, South Korea, and Thailand, as lower currency values push up the prices of imports.

Macroeconomic Outlook Elsewhere Remains Mixed but Could Sour If Asia's Troubles Worsen

The macroeconomic outlook for the rest of the world remains mixed in the face of Asia's troubles. Forecasters have generally downgraded their outlook for Japan in 1998. They have done this not so much because of Asia's crisis but because of continuing economic difficulties in Japan. Japan remains deeply mired in an ongoing economic recession. Continued troubles in Asia pose a significant threat to Japan's recovery. Because most Asian currencies have depreciated far more against the dollar than the yen has since summer, Japan has lost much of the competitive advantage it had regained from its Asian rivals during the past few years. More important, Japan holds significant amounts of the dollar-denominated debt floated by Asian economies before the onset of the crisis. Outright default on this debt would likely paralyze Japan's already crippled financial system. As things currently stand, Dataquest estimates that Japanese 1998 GDP will prove $650 billion lower than expected.

Forecasters' outlooks for the United States remain surprisingly bright. The prospects for economic growth in the United States remain strong in spite of Asia's troubles. Asia's difficulties are expected to exert some drag on the U.S. economy, but America's domestic economy is currently so strong it appears capable of overcoming adverse effects from Asia. The outlook for Western Europe is somewhat more enigmatic. For the moment, most forecasters appear to believe that economic growth will not be adversely impacted by Asia's troubles. But this outlook is qualified with the recognition that Western Europe could suffer serious impacts if Asia's difficulties were to worsen significantly. Western Europe has extensive economic and financial ties with many of Asia's crisis-afflicted economies. What is more, ongoing economic growth in Western Europe is still heavily dependent on exports. A tidal wave of Asian debt default combined with a collapse of Asian imports would hobble Western European economic performance. All in all, Dataquest estimates that 1998 GDP for the United States and Western Europe combined will be about $80 billion lower than previously expected because of the U.S. dollar's continuing strength against Western European currencies.

Macroeconomic Impacts on 1998 Electronics Production and Semiconductor Consumption

We can use this information about changing macroeconomics in combination with Dataquest's fall forecasts of electronics production and semiconductor consumption to infer the potential impact of changing macroeconomics on worldwide electronics production and semiconductor consumption. We want to warn readers up front that the following discussion is an inexact first-order analysis based on some very simplifying assumptions about the

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links between macroeconomics and the markets for electronics and semiconductors. It is important to note that a comprehensive and conclusive analysis would require extensive study of interrelated demand and supply impacts in both the electronics and semiconductor markets.

Worldwide Electronics Production to Decline about $56 Billion

The analysis begins by linking macroeconomic changes to electronics demand. For this simplified analysis, we believe it is reasonable to assume that electronics demand is related to GDP and will vary with changes in GDP. Research by the Technology Foresight Programme, a British government-sponsored organization, estimates that Asia's Pacific Basin economies expend about 5 percent of their GDP on electronics consumption. For Japan, it estimates that about 3 percent of GDP is expended on electronics consumption. For the United States and Western Europe, the estimate is 3.5 percent. These numbers compare favorably with Dataquest's own estimates of worldwide expenditure on electronics relative to GDP. Based on figures from our fall forecasts and IMF estimates of world GDP, we estimate worldwide electronics spending amounted to about 3 percent of world GDP in 1997.

Unfortunately, these various figures reflect average rates of expenditure on electronics from GDP. They do not tell us how electronics spending will change as a result of changes in GDP. For that, we would need to know the marginal rates of expenditure on electronics from GDP. There is good reason to believe the marginal rates of expenditure on electronics from GDP in all these regions are actually higher than the average rates cited earlier. Because of this, impacts based on these average rates could be understated.

Nonetheless, the result of applying these average rates to the changes in 1998 GDP noted earlier is that electronics demand is likely to be reduced $34.5 billion in Asia's Pacific Basin, $19.5 billion in Japan, and $2.8 billion in the United States and Western Europe combined. For the sake of simplified analysis, the decline in worldwide demand reflected in the sum of these figures is assumed to generate an equal decline in worldwide electronics production. Please note that Dataquest is not assuming that the declines in demand for each region generate equal declines in production for each region. As discussed later, this certainly will not be the case. Given this assumption, Dataquest expects 1998 electronics production to decline $56 billion relative to the fall forecast, which was $1,009 billion. This represents a decrease of 5.6 percent from the fall forecast.

Semiconductor Consumption to Decline about $10 Billion

Naturally, the forecast decline in electronics production has implications for semiconductor consumption. Here again, Dataquest makes a simplifying assumption. In the fall semiconductor consumption forecast, we estimated that worldwide semiconductor consumption would average 17.3 percent of worldwide electronics production value in 1998. Assuming that semiconductor content remains unaffected by the changing macroeconomics stemming from Asia's financial crisis, Dataquest estimates that worldwide semiconductor consumption will fall about $9.8 billion from the previous

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forecast for 1998. This would (again) represent a 5.6 percent decline from the fall semiconductor forecast, which was $175 billion, resulting in an estimated $165 billion semiconductor forecast for 1998.

More Detailed Demand and Supply Analysis Needed

Once again, it is important to emphasize that these results are based on several simplifying assumptions in lieu of more detailed demand and supply analysis. These assumptions are open to serious question. The potential bias to these results that stems from using average rates of expenditure on electronics from GDP in the analysis instead of marginal rates of expenditure has already been discussed. Also, these results may be biased by the assumption that a forecast decline in worldwide electronics demand will generate an equal decline in worldwide electronics production.

In the final analysis, the dollar-valued volume of electronics produced worldwide is determined by the interaction of demand and supply in the market for electronics. Dataquest's assumption that declining electronics demand will generate an equal decline in electronics production is tantamount to assuming that electronics supply is perfectly price elastic and will remain unaffected by the changing macroeconomics of Asia's crisis. The former seems highly unlikely, and the latter is almost certainly not true. Although we cannot be absolutely certain, we suspect that electronics production may ultimately decline less than electronics demand. As demand subsides, it is likely that electronics prices will fall, especially for Asian goods whose producers are both willing and able to press the production cost advantage that currency devaluations have given them. Backed by aggressive marketing, declining electronics prices could stimulate sufficient new demand to counter much of the decline being forecast.

Dataquest's results are also likely to be biased by the assumption that the semiconductor content of electronics will remain unaffected by changing macroeconomics. Like the dollar-valued volume of electronics produced and semiconductors consumed from which it is derived, semiconductor content emerges from the outcome of market interactions among electronics and semiconductor producers. Precisely because semiconductor content is ultimately determined by the mechanics of the electronics and semiconductor markets, it is unreasonable to assume values for it. Changes in semiconductor content must be deduced from detailed analysis of forecast changes in market demand and supply for both the electronics and semiconductor markets. On the whole, we are inclined to believe that semiconductor content will decline in 1998. Dataquest believes that the interaction of declining semiconductor demand induced by lower electronics production and of increased semiconductor supply induced by lower production costs in Asia will cause dollar-valued semiconductor consumption to decline more than electronics production. This would de facto lower semiconductor content.

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Currency and Financial Impacts on Electronics and Semiconductor Supply—Asian Producers Face Potential Double Bind

The dramatic declines in Asian currency values, the most visible aspect of the crisis, have at least temporarily altered the relative economics of both electronics and semiconductor production across regions. Despite the very real pain these devaluations have caused, they have imparted a potentially large production cost advantage to Asia, especially to countries such as South Korea that have experienced the sharpest devaluations. Of course, this cost advantage is somewhat tempered by devaluation-induced increases in the cost of components and subsystems that must be imported from Japan and outside Asia. Still, there is an advantage to exploit if Asian electronics producers can maintain the working capital needed to finance their day-to-day operations.

In this regard, South Korean producers could paradoxically emerge as the crisis' biggest winner, at least over the short term. Assuming that Korean electronics producers can retain sufficient working capital, they appear well-positioned to increase significantly their share of electronics and semiconductors sold outside Asia. Unfortunately, they could have trouble defending their increased share over the long term if they are unable to generate the investment capital necessary to expand capacity. By the same token, producers outside Asia now have increased incentive to locate production in the region. Although this is unlikely to happen so long as economic and political uncertainty remained heightened, it is likely to occur once stability is re-established and the crisis appears to be moving toward resolution, especially if Asian currency values remain at or near their current levels.

Non-Asian Producers Also Face Risks

The currency upheavals and financial upset of Asia's crisis threaten consequences not only to the fortunes of Asian companies but also to the operations of non-Asian companies. In 1996, Asia/Pacific-based electronics equipment manufacturers accounted for $29.7 billion, or about 21 percent, of worldwide semiconductor sales. About 18 percent of American semiconductor sales, 18 percent of Japanese sales, and nearly 25 percent of European sales were derived from sales to Asia/Pacific. This, in turn, fed electronics manufacturing worth $153.7 billion, about 18 percent of the worldwide total. Clearly, a significant decline in semiconductor demand among Asian electronics producers could harm non-Asian semiconductor companies dependent on the region.

The perils to continuing business in Asia for both Asian and non-Asian companies is probably best illustrated with circumstances in South Korea. Most manufacturing locations within South Korean are locally owned. This means liquidity problems arising from Korea's financial difficulties are a real issue for these manufacturers. With IMF restrictions in place, South Korean companies will now find it very difficult to obtain letters of guarantee, which are essential if they are to make purchases on credit. Without these letters, their only option is to pay cash for purchases of semiconductors. Currency devaluation has made this cash now twice as expensive to obtain, and obtaining it may prove very difficult.

The availability of credit is potentially one of the major issues of the crisis. Should credit in the form of letters of guarantee and the like become available again through IMF intervention, the liquidity issues that indigenous manufacturers face will be significantly reduced, and they will be able to continue purchasing the raw materials needed for manufacturing. Only then will they be able to press home the cost advantage that currency devaluations have given them. If, however, these letters do not become available, manufacturing in South Korea, as well as in other crisis-impacted countries, could be seriously curtailed as manufacturers run out of raw materials, with only a diminished ability to purchase operational stocks. Indeed, the issue of credit availability has already been raised in a recent announcement from Atmel Corporation.

Just recently, this American supplier of nonvolatile memory and application-specific ICs (ASICs) announced a fourth quarter charge of $160 million, citing "credit problems with specific Asian customers." Although this statement may be open to further scrutiny, it does raise the important point that non-Asian companies may be exposed to the risk of potential bad debts and future loss of market because of the inability of Asian OEMs and contract equipment manufacturers (CEMs) to obtain letters of guarantee. Should similar problems be encountered by other semiconductor manufacturers with their "Asian customers," then potentially significant semiconductor market share could be put at risk.

Summing Up

Dataquest believes that both worldwide electronics production and semiconductor consumption will be affected in 1998 as a result of Asia's financial crisis. Our simplified analysis suggests that electronics production will be reduced about $56 billion and semiconductor consumption about $10 billion. These changes represent about a 5.6 percent decline from Dataquest's fall forecast for 1998. We remain uncertain about the prospects for individual regions and consumers. Although it is clear that Asian-based electronics and semiconductor producers have gained some production cost advantages owing to currency devaluations, it is not clear that they will be able to press home those advantages because of potential problems with liquidity and credit arising from the financial upsets of the crisis. Moreover, many non-Asian companies are clearly at risk owing to their strong dependence on Asia and their close financial relationships with Asian producers. Although we do not believe that Asia's financial crisis will break worldwide electronics and semiconductor markets, we do believe it will test them as never before.

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Section IV: Impact of the Crisis on DRAM Costs and the Forecast

The effect of the Asian financial crisis on Dataquest's DRAM forecast will be caused mainly by the fall of the Korean won against other world currencies and by some of the restructuring of financing the IMF has required of the Korean chaebols. These two causes will result in two key effects, one short term and the other long term. Taiwanese DRAM manufacturers are disregarded in this analysis because, in 1996, Korean companies provided 33.6 percent of the world DRAM market, while Taiwanese companies shipped only 2.4 percent (*Worldwide Memory Market Share 1994 to 1996*, MMRY-WW-MS-9701, May 1997).

Short-Term Effects

Throughout 1997, DRAMs have been priced at a level near their manufacturing cost, a minimum that must be followed if antidumping measures are to be avoided. Going into 1998, Dataquest sees a continuing overcapacity, forcing manufacturers to continue their efforts to keep prices low to win the fight for their share of their customers' business, a fight they encounter at buyers' desks.

In a competitive market, semiconductor manufacturers use manufacturing cost reductions to reduce the selling price of their products. A knowledge of semiconductor manufacturing cost trends is useful for projecting long-term costs/selling price relationships, which vary from product to product and company to company, as well as by market and business conditions.

What happens with a devaluation of the Korean won against other currencies? It only stands to reason that a devaluation of the won would lower manufacturing costs (as measured in any other currency). How much impact will the devaluation have? Dataquest has analyzed the situation, and it appears that at least 55 percent of the cost to manufacture a DRAM is in won-based transactions rather than foreign currency-based transactions ("Dataquest's Tactical Memories Newsletter, Volume II, No. 26," MMRY-WW-DP-9733, December 1997).

The Dataquest semiconductor cost model uses 16 variables of semiconductor manufacturing. These variables cover the main areas where costs accrue and processes can improve. The variables that have the most influence over cost are wafer processing, wafer size, die size, sort yield, package type, and final test yield. The financial crisis in Asia has caused major changes in Asian cost structures based on devalued local currencies, compared with the U.S. dollar. The costs affected are those whose basis is predominantly local Asian currencies. This category includes all the major costs associated with wafer processing and test ("Dataquest's Tactical Memories Newsletter, Volume II, No. 26," MMRY-WW-DP-9733, December 1997). For the purposes of this conservative model, we have assumed that 50 percent of all wafer processing and test costs are won-based.

Table 1 shows the DRAM cost model and compares the DRAM costs before won devaluation and after devaluation. Differences in this cost model are based mainly on exchange rate variations, but Dataquest has also included a

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comparison of costs for different die sizes (Micron Technology Inc. alone has a 42mm^2 16Mb DRAM, whereas die sizes for Korean and Japanese manufacturers range from 58mm^2 to over 90mm^2.)

Table 1
1998 16Mb DRAM Cost Model

	Micron Q3/97	Micron Q1/98	Korea Q3/97	Korea Q1/98	Korea Q1/98
Die Size (Sq. mm)	42mm	30mm	60mm	60mm	42mm
Exchange Rate (Won/U.S.$)	-	-	912	1,748	1,748
Wafer Sort					
Wafer Size (Inches Diameter)	8	8	8	8	8
Capacity Utilization (%)	100.00	100.00	100.00	100.00	100.00
Geometry (Micron)	0.35	0.35	0.35	0.35	0.35
Processed Wafer Cost ($)	*1,450*	*1,305*	*1,450*	*725*	*725*
Die Area (Square Mils)	65,487	46,887	93,091	93,091	65,487
Active Area Factor	1.00	1.00	1.00	1.00	1.00
Number of Masks	18	18	18	18	18
Defect Density per Square Inch	0.056	0.056	0.056	0.056	0.056
Gross Die per Wafer	614	858	432	432	614
Processed Wafer Cost per Gross Die ($)	2.36	1.52	3.36	1.68	1.18
Test Cost per Hour ($)	*110.00*	*110.00*	*110.00*	*55.00*	*55.00*
Wafers Tested per Hour	0.10	0.07	0.14	0.14	0.10
Wafer Sort Cost per Gross Die ($)	1.83	1.83	1.83	0.92	0.92
Cost per Gross Die at Wafer Sort ($)	4.19	3.35	5.19	2.60	2.10
Wafer Sort Yield (%)	94	95	91	91	94
Cost per Sorted Die ($)	4.48	3.52	5.70	2.85	2.24
Assembly					
Material Cost/Sorted Die, SOJ Package($)	*0.34*	*0.34*	*0.34*	*0.20*	*0.20*
Number of Pins	28	28	28	28	28
Assembly Yield (%)	99	99	99	99	99
Cost per Assembled Die ($)	4.87	3.89	6.10	3.08	2.46
Final Test					
Test Time per Die (Sec.)	10.00	10.00	10.00	10.00	10.00
Cost per Hour of Testing ($)	*90.00*	*90.00*	*90.00*	*45.00*	*45.00*
Test Cost per Die ($)	0.25	0.25	0.25	0.13	0.13
Final Test Yield (%)	98	98	98	98	98
Cost per Final Tested Unit ($)	5.22	4.23	6.48	3.27	2.64
Mark, Pack, and Ship					
Cost at 99% Yield (%)	0.05	0.04	0.06	0.03	0.03
Total Fabricated Cost per Net Unit ($)	**5.27**	**4.27**	**6.54**	**3.30**	**2.67**

*Costs directly affected by local currency devaluation:-50 percent wafer/test costs
Source: Dataquest (January 1998)

For the past year, DRAM price levels have hovered at or near cost levels to the extent that few suppliers were or are profitable in this business. The cost model highlights how changes in local currency costs dramatically alter the cost structure as reported in dollars. Using Micron as an efficient 16Mb

DRAM cost benchmark, this model shows that, even with die shrinks and lower wafer processing costs, Micron still cannot produce at a lower cost than the Korean companies, because the revalued won has substantially reduced wafer processing and test costs, even with a larger Korean die.

The upshot of this analysis is that Asian companies now have a significantly less expensive DRAM cost of manufacture in dollar terms than either their Japanese or American competitors. This also means that the Korean companies could sell DRAM at a lower price than the other regional manufacturers without running the risk of dumping charges. In other words, the Korean suppliers could reduce the selling price of a DRAM to a point at which the Japanese or American companies will not be able to compete without being accused of dumping. How will the Korean companies behave?

If they are interested in simply increasing market share, then they can drop DRAM prices, outprice their competitors, and sell a larger DRAM volume. Using this approach, these companies could run their facilities at full capacity while forcing their competitors to close their fabs. Although it is unlikely that such a severe change will occur, Dataquest believes that in 1998 Korean manufacturers' share of the DRAM market will increase.

Alternatively, they could maintain current DRAM market prices and reap the windfall of much greater profits per device sold. Both scenarios are win/win situations for the Korean DRAM manufacturers. In both, their foreign currency cash flow increases significantly, as do their profit margins.

Buyers outside Asia/Pacific, always eager to get the best deal, will be pushing hard for price reductions, playing the trump card of continued market oversupply to force the Korean companies' hand. In the current oversupplied market, it remains to be seen which way Asia/Pacific suppliers will go in pricing their newly profitable product lines.

This discussion has examined Asia/Pacific only as a DRAM supplier. What about the demand side? Most of the DRAM consumed in Asia/Pacific is used to produce computing equipment sold in the Americas, Europe, and Japan. The cost of DRAM to the end users in these three regions is unaffected by the exchange rate in the Asia/Pacific country where the system is assembled. Dataquest believes that the devaluation will not affect the price or quantity of DRAM purchased in Asia/Pacific as much as it affects Asia/Pacific wages compared with the wages in other regions. More competitive wages should shift more manufacturing away from other regions and into Asia/Pacific.

Dataquest expects to lower the DRAM forecast by $3 billion to $5 billion to compensate for the combined effects of the Asian financial crisis and the additional DRAM capacity that was put into place in 1997. The net effect will be a decrease of the 1998 DRAM market to between $22 billion and $25 billion, representing a growth range of 0 to 7 percent over 1997's estimated $22 billion.

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Long-Term Effects

One condition of the IMF bailout is that loans must be granted based on standard good business practice, rather than on less tangible reasons. For this reason, Korean DRAM manufacturers find it harder to get loans for new equipment. Previously, a company's mission to become a market leader was a sufficient reason for a loan to be granted, but now the prospects for repayment are more important. Under this restriction, Korean DRAM manufacturers have cut their spending plans to the bare essentials.

The full ramifications of reduced capital spending in 1998 will take about two years to appear. In 2000, Dataquest expects to see a relatively severe deficiency of competitive manufacturing capacity in Korea as Korean fabs start to lag the technology available in other countries. As a result of this, the Korean market share gains that Dataquest expects to see in 1998 will be lost to other countries in 2000. The winners will be those that have invested continuously during the time that Korean companies have cut back.

This coincides with the period in which Dataquest expects to see a mild worldwide DRAM capacity shortage, and prices will firm for about half a year to a full year.

There will be a Dataquest Telebriefing on February 13, 1998, at 8:30 PST, discussing the impact of the Asian financial crisis on the spring memory forecast. To confirm attendance, please call Carole Phillips at (408) 468-8376 or Jenny Williams at (408) 468-8263 or fax them at (408) 468-8044.

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Section V: How Will the Asian Financial Crisis Impact Capital Spending?

Even without the Asian financial crisis, the fundamentals have not changed much and indeed may have gotten worse as a result of the aggressive spending patterns in 1997. Overcapacity never went away, and acceleration of shrinks has actually exacerbated the situation.

In DRAM, with the shrink factor and the addition of net capacity of the last 18 months, the situation has not improved. Given these facts, Dataquest is no longer convinced that the market will be balanced by the end of 1998 unless capacity is actively removed from the market.

Dataquest's analysis of supply and demand in the foundry industry at 0.35-micron technology continues to show that, although demand is strong, supply base plans are about three months ahead of demand for the leading-edge 0.35-micron technology through 1999. Evidence supporting this can be found in the continued pricing pressure, with greater than normal declines. Given the evidence that more suppliers are entering the foundry business, this situation is likely to deteriorate somewhat during the next year.

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Dataquest is therefore continuing to call 1998 an essentially flat spending year overall. The stronger-than-expected 1997 actually pushes the sustained recovery in spending, driven by a balance in capacity, into mid-1999. Companies will continue to concentrate on technology, with emphasis on 0.25-micron and 300mm technology, along with investments in new interconnect materials and processes.

What Are the Assumptions and Downside Risks for 1998 Capital Spending?

Dataquest's forecast and assumptions are more explicitly detailed in a Perspective ("Wafer Fab Equipment Market Forecast Update: Question Marks for 1998 as the Second Half of the 'W' Unfolds," SEMM-WW-DP-9801, January 1998) and a Market Trends Report to be published shortly (*Year-End 1997 Forecast: Capital Spending, Wafer Fab Equipment, and Silicon Markets,* SEMM-WW-MT-9801). The base forecast calls for an essentially flat year, with capital spending down 3 percent and wafer fab equipment experiencing 2 percent growth.

Dataquest has developed a detailed second scenario for the 1998 wafer fab equipment market to give clients a "window" of outcomes possible if several of the key assumptions are changed based on the Asian financial crisis. For the most part, these changes simply reflect the timing differences of spending plans. For the "downside risk" scenario, the following assumptions are made:

- Korean companies will cut back spending almost 60 percent in U.S. dollar terms, with at least one project in Europe falling out of 1998 (quite likely Hyundai's, because LG Semicon. has significantly lower debt-to-equity ratios). Dataquest's forecast assumes a 40 percent cut.
- Taiwanese companies' DRAM spending will be cut by 45 percent overall in U.S. dollar terms as funding from Japan is lost and profitability concerns govern loan approvals. The forecast assumes a 15 percent cut.
- Taiwanese foundry spending growth is assumed to remain at 40 percent, because the primary source of funds is the profitable players.
- Taiwanese company spending overall would therefore be down only 2 percent, to $6 billion. The forecast assumes growth of 13 percent to $6.9 billion.
- Japanese companies will cut spending overall by 8 to 10 percent in yen terms, or 14 percent in U.S. dollar terms, compared to 1997. Dataquest's forecast assumes an overall spending cut of only 5 percent in U.S. dollar terms.
- Spending on 300mm equipment will be reduced to $700 million, based on the timing of shipments into Japan and the United States. Siemens' project appears safe in 1998 because the German government is funding a portion. Dataquest's forecast assumes that $1.1 billion will be spent on 300mm equipment.

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- The U.S. and European major companies that are increasing spending in 1998 will cut these levels back 5 to 10 percent. This places the group at a 4 percent growth instead of the forecast scenario of 10 percent and makes Intel Corporation's spending flat (excluding the Digital Equipment Corporation plant acquisition), compared to 1997. Philips Electronics NV, SGS-Thomson Microelectronics B.V., and Advanced Micro Devices Inc. will continue to increase spending in this scenario for 1998.

Putting this all together, capital spending levels would be cut by about $3.7 billion compared to the 1998 forecast scenario, with these cuts reflected primarily in discretionary equipment spending and with all regions being affected. The wafer fab equipment market would be reduced by about $2.4 billion, with about 70 percent of the difference being related to lower DRAM spending. These reductions have about a 9 to 10 percentage point negative impact on growth of spending in 1998.

The U.S. market would be the least affected, because the reduction in Korean company spending is already accounted for in the forecast scenario; the European and Asia/Pacific markets are likely to see the largest negative impacts. The equipment technologies focused on enabling logic and 0.25-micron processing, such as chemical mechanical polishing (CMP) and deep-UV steppers, would not be affected much by these changed assumptions. However, the equipment segments dependent on capacity or DRAM-sensitive investment, such as diffusion tubes and implant, would be more heavily affected.

Should the downside scenario come to pass, there should be a silver lining—the DRAM market will likely come into balance sooner, leading to stronger profitability in the chip sector and renewed higher growth in spending on equipment.

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Section VI: Worldwide PC Market Overview

Despite the volatility experienced in some Asia/Pacific countries during the second half of 1997, preliminary Dataquest estimates indicate that the worldwide PC industry's unit growth rate was just under 16 percent, off slightly from Dataquest's original forecast of 17 percent. Dataquest estimates that more than 82 million PCs were shipped by manufacturers in 1997.

Although both Japanese and Asia/Pacific demand for PCs did not meet our expectations in 1997, flourishing markets in the United States and Western Europe aided greatly in keeping the global PC industry healthy. At the beginning of last year, Dataquest had predicted that the Japanese market would grow by 9.6 million PCs and that Asia/Pacific would experience growth resulting in 11.4 million additional units.

Dataquest now estimates that actual PC shipments into Japan were 7.9 million units and that Asia/Pacific absorbed 9.7 million units. We expect that

Japan's unit growth rate will be less than 10 percent in 1998 and that the Asia/Pacific region will grow at a respectable 15 percent.

Dataquest believes now that the strong growth in the United States and Western Europe will continue to offset in part the setbacks in Japan and Asia/Pacific. We still expect worldwide PC unit growth to be in the mid-teens. Total PC production will exceed 94 million units.

For many years, total worldwide demand for personal computers has sustained sensational growth, and Dataquest expects this trend to continue through the foreseeable future. Regardless of fluctuating economies, the demand fundamentals are compelling for both the commercial PC market and the consumer market. The most significant of these demand fundamentals is the concept of "critical mass." In effect, this Dataquest theory asserts that when the majority of participants in a specific PC market segment require a personal computer, then all participants in that segment must acquire and use a PC.

"Critical mass" has already been reached in the United States and other regional commercial PC market segments, and the requirement for personal computers in U.S. homes is growing each year. Dataquest estimates that more than 42 percent of all U.S. households have at least one PC. We are near "critical mass" in the U.S. home market, and this phenomenon will spread throughout the world well into the next century.

Solid unit growth will continue for years to come. However, solid revenue growth may elude many PC manufacturers and component suppliers in the coming years. Dataquest believes that the pricing trends followed in the U.S. consumer market last year will spill over into the commercial PC market as early as the second quarter of 1998. The sub-$1,000 PC is a harsh reality, and this price point is as appealing to the business segment as to the home segment; its allure will reach all regions by year's end.

The sub-$1,000 PC is possible for two major reasons. First, component suppliers have been drained of their customary "rightful share of profits." There simply is not enough money in a $700 PC for everyone. Second, successful PC manufacturers have adjusted to a business model of return on investment rather than gross margin. "Velocity manufacturing" is a requisite in this industry, and it manifests itself as build to order, channel assembly, and contract manufacturing.

Finally, Dataquest expects that the "elite few" PC manufacturers that captured nearly 70 percent of growth in the worldwide PC market in 1997 will continue to dominate the industry, forcing continued consolidation and straining the deep pockets of some megaparents.

Contributing Analyst: Bill Schaub (United States)

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Section VII: What about China?

Dataquest has recently published a detailed analysis of China/Hong Kong's electronics production in a Focus Report (*China/Hong Kong's Computers, Communications, and Consumer Electronics Industry in 2001*, SEMI-CH-FR-9701, November 1997). The highlights are presented in this section.

Dataquest believes that the Asian financial crisis has a lot to do with speculative investment "bubbles" in property, construction, semiconductors, and other industries. It is clear what happens when rapid economic growth occurs in the absence of a transparent financial system and clean government regulations: overcapacity and irrational loans. The effects of these bubbles can become so serious as to bring down entire financial systems and impair international confidence and, hence, economic growth.

China and Hong Kong are not immune to these problems, although they seemed to be dealing with these bubbles more effectively by popping them before they get too big. China's economic czar, Zhu Rongji, burst the stock market bubble, property bubble, and construction bubble in 1996 and 1997. After 1997's October party congress, he is now more empowered than ever to pop the next speculative runs, whatever they may be. In 1998, he will be promoted to prime minister. Zhu's charter is to fix the state-owned enterprises to avoid overwhelming the financial system with bad loans. If China slacks off, its financial system will face serious problems, potentially worse than those of Korea. China is learning to avoid Korea's expensive lesson—although having $200 billion in combined reserves with Hong Kong will help, too. Strong economic growth in North America and Europe will be critical to China and the region because Japanese consumption is weakening with its own economic malaise.

That China's currency is not convertible may help in the short run, although this does not necessarily insulate China from the possibility of a major depreciation. In 1994, the Chinese government significantly devalued its renminbi. It may have to do so again in the near future because of mounting pressure in the region and because of competition from Asian neighbors on the export front. However, because the government's stated long-term goal is to merge the renminbi with the Hong Kong dollar, it is not likely that the Hong Kong dollar will lose its U.S. dollar peg.

Currency depreciation has lowered production costs in various Southeast Asian countries and Korea. So, will China become less competitive for its vital export markets? Currency depreciation will lower export costs in numerous Asia/Pacific countries, but only to the extent that they do not need imported components (most do, though).

This means that short-term competition with China for exports and possible long-term competition for foreign investment will come from Southeast Asian countries and Korea. However, there are even broader issues facing China, including the currencies and economies in neighboring countries, which are highlighted as follows:

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- Raising the competitiveness of its faltering domestic companies, especially state-owned enterprises, before entering the World Trade Organization
- Countering the serious slowdown in foreign investments resulting from rising costs of doing business in China
- Maintaining 7 percent to 10 percent GDP growth and raising the rate of domestic consumption to absorb excess capacity and overdependence on exports
- Dealing with a slowdown in Japanese imports of consumer electronics and PCs from Asia/Pacific. China may be hurt most because its currency has not depreciated, and therefore its costs are increasing relative to other countries.
- Responding to the heavy reliance on exports by Korea and other affected countries as they try to pull themselves out of their economic turmoil

The following factors will help China counter these major challenges and maintain relatively strong electronic growth:

- A large proportion of Chinese electronics companies are successfully competing against major multinational corporations, particularly in the computer and consumer equipment markets. The priority for the government is to improve efficiencies and quality; therefore, information technology will continue to be rapidly deployed as an infrastructure necessity.
- Although total investment was down in 1997, production capacity of the large multinational corporations and local electronics manufacturers has increased by more than 50 percent. Furthermore, the two main reasons for investing in China remain intact: to develop the long-term potential of the domestic market and to take advantage of an abundant, inexpensive labor force.
- Inflation was the major concern in 1996; now deflation is the top priority of the government. Interest rates are likely to fall to stimulate growth.
- Japanese manufacturers are shipping goods worldwide from China. Exports of electronics to Japan from China represent 10 to 15 percent of China's total electronics exports. Therefore, Japan's slowdown in consumption has a minor effect on Chinese production.
- Korean and other affected Asia/Pacific electronics and semiconductor companies may have an increasing currency advantage for exports relative to China in the short term. However, these companies are being seriously hurt by increasing debt-service costs.

In summary, China/Hong Kong has not been affected significantly by this financial crisis in the short term because of the stable renminbi and Hong Kong dollar, which are backed by about U.S.$200 billion in combined foreign reserves. However, Dataquest has outlined the deflation and investment challenges within China. Most notably, Southeast Asia and Korea are likely to receive increased investment in the future that would otherwise have

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gone to China (after four years of very high foreign investment levels in China). However, the power of the Chinese market and its production prowess for international markets will continue to attract investment, enabling it to extend its lead as the largest and fastest-growing semiconductor market in Asia/Pacific.

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Perspective

Semiconductors—Top Views

Competitive Analysis

A Comprehensive Analysis of Compaq's Acquisition of Digital Equipment

Abstract: *On January 26, Compaq Computer Corporation announced an agreement to acquire Digital Equipment Corporation for $9.6 billion, the largest acquisition in the history of the computer industry. The ramifications of this merger impact every corner of the IT industry. This Perspectives provides a Dataquest-wide analysis of the effects of this acquisition on the IT market, the competition, and on the future of Compaq and Digital Equipment.*

By Dataquest Analysts

Introduction

This Perspective represents a Dataquest-wide effort to explore the significance and meaning behind Compaq Computer Corporation's acquisition of Digital Equipment Corporation. This acquisition is touted as the largest deal ever to take place in the history of the computer industry, thus catapulting Compaq to new heights as one of the world's top computer companies. The following pages explore the impact this merger will have on the industry, the competitive landscape, and the future of Compaq and Digital Equipment.

The Largest Acquisition in the History of the Computer Industry

On January 26, Compaq Computer Corporation and Digital Equipment Corporation announced, to a somewhat surprised public, that Compaq will acquire Digital Equipment. The deal, worth $9.6 billion, is the largest acquisition in the history of the computer industry. This announcement came amidst ongoing speculation that Compaq was talking with Digital

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Equipment, but many industry pundits would have bet that the resulting deal was for Digital Equipment's profitable services business, as opposed to the entire company. Under the terms of the agreement, Compaq will complete the purchase with a combination of stock and cash. Digital Equipment shareholders will receive $30 in cash and about 0.945 shares of Compaq common stock for each share of Digital Equipment stock. Compaq will issue about 150 million shares of Compaq common stock and $4.8 billion in cash. Estimates indicate that the acquisition cost works out to between $60 and $65 per share. Pending approval by Digital Equipment's shareholders and clearance under antitrust laws, Digital Equipment will become a wholly owned subsidiary of Compaq.

The true cost of Digital Equipment to Compaq, however, is much less. Digital Equipment, at the end of December 1997, had just over $2 billion in cash—making the net cash outlay only $2.8 billion and the 150 million shares representing 19 percent of Compaq's shares outstanding. This means that if Digital Equipment produces no earnings, Compaq's earnings per share would be diluted by 19 percent. However, if Compaq is successful in making whatever parts of Digital Equipment it keeps, as profitable as the rest of Compaq, there will be no dilution. As a result, Dataquest expects Compaq to act swiftly in realigning the parts of Digital Equipment it will keep and spinning off whatever remains.

Who Is the Biggest of Them All?

As part of its announcement, Compaq made the claim that once combined with Digital Equipment, the resulting company will be the second largest computer company in the world after IBM; Table 1, in some ways, supports Compaq's boast. In total revenue, Compaq combined with Digital Equipment comes in fifth place. Backing out noncomputer revenue is difficult at best. However, Dataquest's best estimate shows the combined revenue of computer-related products from Compaq and Digital Equipment to be second only to IBM. Table 1 and Table 2 present a breakout of this data.

Table 1
Total Worldwide Company Revenue, 1996 and 1997 (Millions of Dollars)

Company	1996	1997
IBM	75,947	78,508
Hitachi	65,207	68,735
Hewlett-Packard	38,420	42,895
NEC	34,904	39,907
Compaq and Digital Equipment	34,572	37,646
Fujitsu	29,160	36,318

Note: All numbers are Dataquest estimates.
Source: Dataquest (January 1998)

Table 2
Total Worldwide Computer Revenue, 1996 and 1997 (Millions of Dollars)

Company	1996	1997
IBM	72,222	74,777
Compaq and Digital Equipment	32,593	35,800
Hewlett-Packard	31,559	35,449
Hitachi	34,174	35,325
Fujitsu	23,286	30,887
NEC	27,340	30,540

Note: All numbers are Dataquest estimates.
Source: Dataquest (January 1998)

For Compaq to maintain its role as the second largest computer company, it must effectively integrate Digital Equipment's operations into its own with minimal cannibalization, while continuing to grow at its stated growth rate of 25 percent per year or better. Clearly, Compaq will not be able to keep all of Digital Equipment's market share in PCs and low-end servers, making the combined companies' revenue not completely additive. However, even with an assumed loss of 75 percent of Digital Equipment's PC revenue, Compaq is still ahead of Hewlett-Packard Company after backing out HP's test and medical equipment revenue (but not by much). In essence, the race for the No. 2 position in the computer industry is a dead heat between the combined Compaq and Digital Equipment, HP, and Hitachi. Fujitsu and NEC are not far behind.

A key benefit for Compaq is Digital Equipment's core enterprise business, which occupies a market position that Compaq has been unsuccessful at penetrating because of its Intel-based architecture. However, Digital Equipment's Alpha business is the clear technical leader in large computing system hardware, but it has been unsuccessful in a marketing sense. Compaq can take the Alpha systems business and dramatically accelerate it through Compaq's powerful sales and marketing skills. If it succeeds, the prize will be large—Table 2 indicates that there is plenty of money in this particular pot.

How Does the Acquisition Impact the Competition?

Prior to the acquisition, Compaq competed against IBM's and HP's products. Today and in the future, the battle will be waged over solutions that Dataquest defines as the strategic bundling of products and services. IBM is still by far the world's largest computer company. However, its hardware revenue is dominated by aging legacy systems such as S/390 mainframes, AS/400 midrange systems, and its UNIX-based RS/6000 products. The inevitable maturation of Windows NT should have a profound effect on IBM's ability to keep its business from shrinking. Compaq's acquisition of Digital Equipment puts increasing pressure on IBM to decide whether to aggressively pursue a Windows NT-based product and services strategy as have HP and Compaq. If IBM continues to shy away from a similar strategy,

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its customers may become fodder for HP and Compaq's growth. The ultimate key challenge for Compaq is to create its own solutions methodology, thus moving away from a products-only strategy.

As for PC companies, Compaq has moved significantly ahead of its traditional competition. Dell Computer Corporation must decide whether to become a computer company or stay a very efficient channel for PC products. A major risk for PC and other systems vendors is that Compaq, IBM, and HP will become the primary product and service suppliers for end users. Customers may not see the need to include more than three vendors on their short lists. This may have force other competitors to become niche solution providers.

How Will the Acquisition Impact Products and Technologies?

A Dataquest analyst made the analogy that "the merger of these two enterprises and cultures will be like two galaxies colliding: slow to happen, and some worlds may collide and be destroyed." This comment reflects the multitude of perceived product overlaps within Compaq, Tandem, and Digital Equipment. Understandably, these redundancies will be remedied—the perceived outcome is the eradication of certain products and technologies. Perhaps the more interesting question is which products and technologies have enough brand and market value to succeed under the new Compaq regime. Dataquest briefly explores these questions by product and technology type.

Workstations

With the workstation market in a period of major transition, Compaq's acquisition of Digital Equipment has the potential to significantly change the balance of power. Although it is relatively new to the workstation business, Compaq has shown itself to be one of the movers and shakers in the rapidly growing Windows NT workstation market. By comparison, Digital Equipment has not been doing as well—not only losing market share in the stagnant UNIX market, but more importantly losing ground in the Windows NT segment where it was one of the early leaders. Digital Equipment workstation customers stand to gain from Compaq's leadership and momentum. Almost immediately, Compaq can challenge HP more effectively for the No. 1 position in the Windows NT market segment by pooling the market share of both companies (Compaq and Digital Equipment).

Compaq also gains significantly on the technology front with a technically credible UNIX offering. The most significant impact of this could be in the graphics area. Until now, Compaq has had no graphics strategy of its own, relying upon third-party cards while HP and Intergraph have been able to differentiate their Windows NT product lines with proprietary high-end graphics capabilities. Along with Digital Equipment's workstation business, Compaq has gained the high-end graphics technology from Megatek, which Digital Equipment acquired in 1996. Compaq has the opportunity to add the

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fruits of this venture to its workstation business potentially filling one area of weakness.

Servers

The issues dealing with the operating system of choice take place most predominantly in the server space. Compaq supports Windows NT, SCO UnixWare, and Novell's NetWare; Digital Equipment provides Windows NT and its proprietary UNIX, as well as systems based on VMS. The third element of the new company, Tandem (acquired by Compaq in June 1997), has its proprietary NonStop Kernel (NSK), a small investment in UNIX, and Windows NT. Also there is a mix of processors (that is Intel, Alpha, and MIPS) within the new company and the operating system decision goes jointly with the chip selection.

Dataquest foresees that Compaq will opt to keep Tandem's high-end systems and operating system while at the same time maintaining Digital Equipment's UNIX variety. There may be an opportunity to migrate the NSK operating system to an Intel design in the future, but it is well after the turn of the century. The Alpha solutions gain credibility with Compaq's endorsement and can provide a path from IA 32-bit to the Merced technology. The real test of strengths will be the price/performance ratings of the processors and operating systems after Merced is stabilized and Microsoft's next generation matures.

Personal Computers

Through the first three quarters of 1997, Compaq sold roughly as many PCs every month as Digital Equipment did the entire period. This underscores the fragility of the Digital Equipment PC business as part of a much larger Compaq. Although Dataquest believes that Digital Equipment brings valuable technology and engineering to the table, these attributes will be more effectively leveraged in Compaq branded PCs. Therefore, Dataquest ultimately foresees the death of Digital Equipment branded PCs.

As customers' short list of vendors becomes dominated by IBM, HP, and Compaq, this may force other computer vendors (PC and otherwise) to target niche markets. Ultimately, this standardizes and simplifies the desktop, leading to a real commodity market where vendors must search long and hard to add significant value and differentiation. Whether customers will accept single vendor solutions is an open question.

As for the mobile portion of the PC business, there are no immediate magic bullets—it is truly a draw between the mobile technology of Compaq or Digital Equipment. Dataquest believes, however, that the acquisition may allow Compaq to finally get a shot at obtaining the kind of flagship product that instantly defines the entire line and its potential. Additionally, Digital Equipment design engineers and marketers have a chance to join a mobile team that has been one of the top three in the world for the past few years. Compaq has been vying for the top spot on the mobile PC vendor heap for almost as long as there have been mobile PCs. The addition of Digital Equipment's products and skills will help Compaq compete more effectively.

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Microprocessors

Digital Equipment's Alpha chip will afford Compaq the chance to penetrate and grow its business in the data center environment. It raises Compaq to the elite ranks of HP and IBM as a provider of a full suite of systems and services and allows Compaq to let the PC business evolve into a box-delivery component of its overall system strategy. Compaq's server growth will no longer be limited by any perception that Compaq is just a PC company, and the opportunity to mate the advanced Alpha servers with Compaq's marketing and sales skills could lead Compaq to significantly higher overall margins by the end of the decade. Therefore, after the dust settles, there is a third major contender for the enterprise systems market as Compaq joins HP and IBM.

What's the Impact on IT Services?

The addition of Digital Equipment's services business to Compaq fills an immense void that has kept Compaq from becoming a significant player in the enterprise computing market. Compaq's distinct lack of a service business (especially in terms of field personnel), even with its acquisition of Tandem last June, had a "pigeonhole" effect on it as a product company. It could offer great technology that was admissible for workgroup computing, but would never fly in the enterprise because of the company's lack of mission-critical services infrastructure and IT integration and management skills. Compaq attempted to minimize its lack of robust enterprise services by crafting partnerships with Digital Equipment and Unisys. However, IBM and HP continually attacked this leveraged support model in competitive bid situations, even though they, too, used partners.

The addition of a direct service business is a major boost for Compaq. It now has a chance at the enterprise and may be able to give IBM and HP a run for their money, provided the integration runs smoothly and there is an increased focus on providing solutions. This move also places more distance between Compaq and its PC competitors, particularly Dell and Apple. Compaq can now go to market competing on product and service while most others will not be able to compete at this level in the services arena.

In terms of skills and resources, Digital Services Division consists of 22,000 service professionals split between its three service business units. These business units and the specific skills sets contained therein are as follows:

- Multivendor Customer Services (MCS): This group accounts for 66 percent of fiscal 1997 service revenue ($3.8 billion). MCS delivers hardware service, support, and maintenance services, as well as multivendor availability and management services that focus on providing technical expertise in UNIX and Windows NT for mission-critical environments. Compaq leverages the MCS organization as a global service partner. Overall, the MCS group will be challenged to maintain its vendor neutrality as a vendor-to-vendor service partner.
- Network and System Integration Services (NSIS): This group accounted for 24 percent of fiscal 1997 service revenue ($1.4 billion). It has

competencies in application solutions for mail and messaging, Internet/intranet services, electronic commerce, and manufacturing and telecomm industry solutions. Strong technology solutions have also been built around NT. Compaq made an initial foray into the network business with its acquisition of Thomas Conrad and Networth several years ago. To date, Compaq has not figured the nuances in delivering service for networks versus delivering services for desktops. This NSIS group will help better define Compaq's role as a network integrator.

- Operations Management Services (OMS): This group accounted for 10 percent of fiscal 1997 service revenue ($0.6 billion). Service offerings include operations support for distributed client/server environments, including desktop systems infrastructure management, application operations management, and Internet/intranet management. The services and skills in OMS will enable Compaq to offer life cycle management services to its customer base.

The integration of Digital Services into Compaq is, in theory, like finishing a puzzle—almost. Dataquest perceives certain weaknesses in Digital Equipment's services business that may directly translate into lost opportunity for Compaq. Specifically, Dataquest cites its lack of a mature applications integration practice as a major hole in Digital Equipment's capabilities. These skills are essential for a major play in the enterprise. As both companies are aware of this distinct lack, there is a chance that there may be additional acquisitions down the road.

Once the integration process gets under way between the two companies, Dataquest foresees a potential culture clash between product-oriented Compaq and the Digital Equipment's services business. Although Compaq's executives understand the need for services, there is a distinct lack of understanding about how to shift from a product to a solutions model. Compaq needs to make a concerted effort to leverage the knowledge and expertise housed within Digital Equipment in order to effectively make this transition. Compaq may very well end up integrating into Digital Equipment's service culture rather than the other way around. Dataquest believes Compaq's best bet is to let current Digital Services management remain in full control of services.

The existence of a Compaq/Digital Equipment service partnership prior to the acquisition may help move the integration process along. In fact, Compaq stated that talks between the companies first began because of the services partnership. However, there's a concern that Compaq will continue to be quite focused on the capabilities offered by Digital Equipment's Multivendor Customer Services (MCS) business unit, which are quite product support oriented. Compaq needs to expand its services vision and leverage the outsourcing and network services skills housed in Digital Equipment's other services units.

Lastly, there are several looming questions—the answers will directly impact the success of Compaq's merger with Digital Equipment and their future success as a unified company. Some of these key questions are as follows:

- How will Compaq manage its channel relationships given that it now has a direct service capability?
- Will Digital Equipment be able to sustain its reputation and viability as a multivendor service provider given that it is now a Compaq-owned company?
- Does Digital Equipment bring the right mix of service expertise that Compaq needs to deliver enterprise solutions to the Fortune 1000?
- How will Compaq integrate the Tandem and Digital Equipment professional services capabilities?

Dataquest believes that most of the elements are in place for Compaq to compete squarely in the demanding enterprise services arena. However, it needs to take a hint from IBM and HP: lead with solutions, not just products.

What's the Impact on the Channel?

The potential for product channel conflict is technology dependent. Clearly in an open technology market such as PCs, channel conflict is a key issue because a reseller can make the decision to switch brands if it is concerned that it is competing for business with the vendor. With Digital Equipment's PC business expected to be merged into Compaq's business, this should not be an issue—particularly since Digital Equipment's existing business is almost exclusively indirect.

Further up the technology curve, segmenting between direct and indirect channels is more difficult; it is a question that companies such as HP and Digital Equipment have struggled with, especially as WinTel technology has encroached into the workstation and midrange computer spaces. If technology is proprietary and demanded by users, then a vendor can operate through both direct and indirect channels. More difficult for vendors is how to stop and separate sales organizations from competing against each other. HP's solution is to put both sales organizations under the same umbrella. Compaq will need to move in this direction.

Channel relations regarding service could be a touchy subject, as Compaq now has direct service capabilities. However, considering Compaq's recent redesign of its Authorized Service Provider (ASP) program around customer requirements and satisfaction, and Digital Equipment's multivendor services accomplishment of integrating services at point of product purchase, there will be plenty of service opportunity for the channel. Current business partners focused on the services side of the equation have compelling reasons to stay the course or even upgrade their relationships with both companies.

Compaq needs the channel's support. Even with the Digital Services Division under its belt, the company still needs the channel's core competencies such as broad customer reach and custom software expertise. HP and IBM have recognized this and it is reflected in their channel

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strategies. The Digital Equipment acquisition puts Compaq in a more powerful position when dealing with the channel, but there are alternatives that resellers can choose. Resellers will be watching Compaq very closely in the coming months.

What's the Impact on Sales and Marketing?

Neither Compaq nor Digital Equipment has as yet determined the overlap between accounts. Digital Equipment's MCS organization is already supporting many Compaq environments—all signs indicate that Compaq intends to preserve this vendor neutral asset. Digital Equipment's product and service top accounts map closely in Fortune 1000 market segments. Its services business has helped Digital Equipment penetrate Fortune 2000 and middle market segments with little overlap on the product side. Digital Equipment's strengths are in middle market and global enterprise organizations. Compaq views its markets slightly differently. Compaq clearly plays in the small office/home office segment and in what it labels the small/medium business, middle market, and global/mission-critical enterprises.

In terms of sales resources, Digital Equipment has about 1,000 dedicated service sales specialists worldwide who prospect for and close the company's service business. A number of these dedicated service sellers line up to strategic accounts and sell to end users as members of Digital Equipment's Enterprise Sales Force (ESF) account teams. They also include channel sales representatives who sell to, through, and with partners. ESF staffs about 2,000 people worldwide and sells the company's technology products; it segments into three types of selling orientations. One group is assigned to about 500 strategic corporate accounts, another group has a territory responsibility covering from two to 25 accounts, and the rest are devoted to prospecting for new business and generating leads for Digital Equipment's partners.

A potential concern however, before the acquisition and now, is the lack of sufficient consultative selling talent in both companies. Compaq's model is indirect through partners, with limited experience in the business solution sell at the top of the enterprise. Digital Equipment's only real engagement managers are in the OMS business and are already stretched. Pockets of excellence exist within Digital Equipment's service sales organization, with considerable talent in networks, business-critical support, migration, mail, and messaging. However, the new entity will require a prudent sales retention, conversion, and recruitment effort designed to bring the enterprise selling talent to a level commensurate with the new and considerable enterprise capabilities.

The new value proposition is one of client choice of highly engineered products and technology platforms, superb service capability, true global distribution and service infrastructure, and a wealth of experience in managing complex distributed computing environments. This proposition

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gives the combined salesforce some powerful new selling opportunities that cannot afford to wait six months or even one year.

Dataquest Perspective: What's the Bottom Line?

Overall, Dataquest regards Compaq's acquisition of Digital Equipment as a positive move. Critical synergies exist that will greatly improve both companies' future positions and bring added value to existing and future customers. In the short term, Compaq will continue as it has been: driving NT over UNIX and proprietary systems, and leading the world selling PCs. Further down the road, Dataquest foresees significant product, technology, and service implications as a result of the acquisition.

One of the primary overlaps between companies is in the personal computer market. It is likely that Digital Equipment's PC business will be subsumed totally under the Compaq brand because of overlap and limited brand equity. Digital Equipment's mobile PC business will also be absorbed, but the company's pioneering work in low-profile large-screen products could combine with Compaq's solid mainstream devices to allow the combined company to challenge Toshiba from the No. 1 slot. Dataquest believes that Compaq will retain Alpha and Digital UNIX because they have the strategic implication of expanding Compaq's reach into the enterprise—that is until Intel's IA-64 architecture delivers a compelling alternative to the market (not until 2001 at the earliest) and NT matures. The combination of Tandem's NonStop Kernel, Alpha and Digital UNIX, and Compaq's PC contribution creates a powerful technology engine that will allow the combined company to compete against a wide variety of competitors.

On the services side, Compaq has historically been penalized for its lack of a substantial services business. With the acquisition, it gains a service giant, 22,000-people strong with global capabilities. Dataquest anticipates some form of a culture clash between the two companies as Compaq struggles to make room for services in its product world. Despite the addition of a formidable services business, Dataquest questions whether Digital Services has the precise array of services required to provide full solutions to enterprise customers. One of Digital Equipment's key weaknesses is its lack of application integration skills that are quickly becoming a requirement given the burgeoning enterprise resource planning market. Because both companies seem to be aware of this deficiency, Dataquest can't help but wonder if there are other acquisitions waiting in the wings.

Taken as a whole, the ultimate challenge will be the integration of products and technology with services. Compaq's goals of becoming one of the top three computer companies in the world and reaching $50 billion in revenue by the millennium are largely dependent on its success at solutions selling. Dataquest perceives that most of the working materials are in place to make the new Compaq a full solutions provider, with the exception of data center and application integration skills. Aside from these holes, Dataquest anticipates a success-filled future for Compaq as an enterprise player.

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Perspective

Semiconductors—Top Views
Market Analysis

Semiconductors Second Quarter 1998: A Buyer's Boon and a Supplier's Gloom

Abstract: *Since the release of Dataquest's spring worldwide semiconductor forecast, severe DRAM price erosion and economic downturns have begun to affect the revenue not only of MOS memory but also of all other major semiconductor product categories. The consumer and data processing electronic equipment markets are showing further signs of weakening. Capital spending forecasts have declined 15 percent. Weakened by economic turmoil in Asia/Pacific and financial weakness in Japan, prices on electronic imported goods arriving at Europe's and America's doorsteps have declined for seven consecutive months. The DRAM downturn that began in December 1995 is taking the rest of the market down. This very long downturn is reminiscent of the DRAM nosedive that began in January 1985. Many companies barely survived, and those that did were lucky to walk away bruised and battered. How do these events affect Dataquest's clients and current forecast?*
By Mary Ann Olsson

A Worldwide Forecast Update

For two and one-half years, there has been both decline and growth in semiconductor products. MOS memory devices have led the decline. In terms of historical volume and driving overall profit, DRAMs, the powerhouse products, have been pivotal to this decline (down 38 percent in 1996, down 20 percent in 1997). Judging from the decline in prices during the first half of 1998, there will be a third year of decline in DRAMs. This decline could go beyond 23 percent, taking DRAM revenue below $16 billion in 1998.

Although multiple forecasts and scenarios different from Dataquest's original forecast have been publicized, Dataquest has tried to avoid following the herd. This Perspective offers the most likely scenario for the market and, possibly, moments of sanity that rise above soothsaying.

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The spring publication of Dataquest's worldwide semiconductor forecast for semiconductors and ICs showed the optimistic forecast; the most likely downside scenario for 1998 is shown in Table 1. Barring major economic downturns that even Dataquest cannot predict, we believe that the market will fall within this range.

Table 1
1998 Worldwide Semiconductor Forecast Downside Scenario (Millions of Dollars)

	Actual 1993	Actual 1994	Actual 1995	Actual 1996	Actual 1997	Optimistic 1998	Most Likely 1998
Total Semiconductors	85,514	110,513	151,310	142,150	147,165	159,249	149,198
Total ICs	73,429	95,861	132,184	123,761	127,571	138,617	129,121
Total MOS DRAM	14,581	23,266	42,249	26,012	20,744	20,960	16,000
Semiconductor Growth (%)	31.0	29.2	36.9	-6.1	3.5	8.2	1.4

Source: Dataquest (June 1998

Analysis and Assumptions

Since the first quarter of 1998, significant events have occurred that have affected not only industry dynamics but also Dataquest's initial forecast. The Asian financial crisis has worsened, weakening the financially struggling Korean semiconductor companies. Overcapacity is still prevalent. A price collapse continues to erode the DRAM market. Continued oversupply and unbalanced currencies in Asia/Pacific and Japan and competitive posturing by the 64Mb DRAM suppliers are the main cause of this erosion. Are those cries of dumping in the distance?

It is Dataquest's view that vendors will continue to lower prices, even to the point of selling at or below cost, to gain share or just to fill the fabs. The aggressive capital spending and overexpansion that continued through 1997 exacerbated the problems of a market already in the throes of overcapacity and accelerated DRAM technology die shrinks. In 1996, overcapacity in DRAM was about 20 percent, and it was rumored to be at 40 percent in 1997. With the shrink factor and the addition of net capacity over the last year and a half, the signs do not bode well for an 8 percent growth in 1998. Add to that a recent downward trend in microprocessor (MPU) and logic prices, and Dataquest's most likely scenario becomes more reasonable.

Buyers of semiconductor products are happy about these prices. But the risks are great. Building too much inventory in a shaky market with weak trading partners coupled with low import pricing could send the entire semiconductor industry spiraling into a recession. Many suppliers (merchant and foundry) are scurrying to fill fabs with non-DRAM products, offering lucrative contract pricing for products in the non-DRAM sectors. Many buyers are building low-priced inventories to keep up with pricing pressures while meeting demand for lower-end systems in the data processing, consumer, and communications sectors. Is the market spiraling out of control, and is this a market transition of electronic equipment demand growth from less sophisticated business sectors? Or is this simply a downshift in revenue growth as the equipment market becomes a commodity market?

Unless something miraculous happens during the next two quarters, stronger near-term semiconductor market growth is not expected.

Product Analysis

MOS Memory

DRAM has always been the key driver of growth and the key culprit in decline in the semiconductor industry. In the major DRAM and overall semiconductor market downturns, excess (capacity or strategic inventory) is the real culprit. There are many similarities between this market downturn and the market downturn that began in 1985. Some of these are listed in Table 2.

Table 2
Market Comparisons: 1985 through 1987 versus 1995 through 1998

1985-through-1987 Market	1995-through-1998 Market
Product hoarding/double-ordering led to supply excess, which precipitated price erosion.	Excessive capital spending added to overcapacity that precipitated price erosion.
Capital spending was depressed in the United States because of uncertainty about proposed tax reforms.	Capital spending was depressed in the United States, Japan, Europe, and Korea because of a capital spending binge.
International trade issues over product prices below fair market values led to antidumping duties on DRAMs and EPROMs.	Uncertainty about antidumping duties on DRAMs rises as rumors abound about dumping products at below cost to gain market share.
Damaged by price erosion, a depressed market, and aggressive competitors, Mostek, Intel, and Inmos disappeared from key market sectors.	Damaged by excessive spending, price erosion, and aggressive competitors, some DRAM suppliers are evaluating departure from the market.
A crossover point in price was reached between the 64K DRAM and 256K DRAM. The 1Mb DRAMs reached price-per-bit parity with 256K at the end of 1987.	In a dance of death, 64Mb DRAM chases the 16Mb DRAM. Price-per-bit parity could be reached by the end of 1998. A 4Mb-to-16Mb crossover could occur during this time.
There was a dramatic change in the yen exchange rate, from ¥254/dollar in 1985 to ¥128.4 at the end of 1987.	The yen/dollar exchange rate changed dramatically from ¥129.73 for the spring forecast period to ¥143 for 1999. The Korean won lost 50 percent of its value against the dollar, like the yen in 1985 through 1987.
Price erosion affected all memory products.	Price erosion affects the majority of ICs.

Source: Dataquest (June 1998

A stroll down memory lane might jangle some nerves but would help many to understand what is happening in the semiconductor industry. The DRAM market declined 52 percent, from $3.5 billion in 1984 to $1.7 billion in 1985. In 1984, suppliers hoarded products and buyers double-ordered on contracts to guarantee shipments. In 1985, as suppliers began dumping products and lowering prices, buyers canceled long-range contracts to reap the benefits of lower prices. Pricing wars raged until trading wars and dumping issues resulted in government intervention, and foreign market value (FMV) duties were imposed. The suppliers in this market suffered the worst losses and

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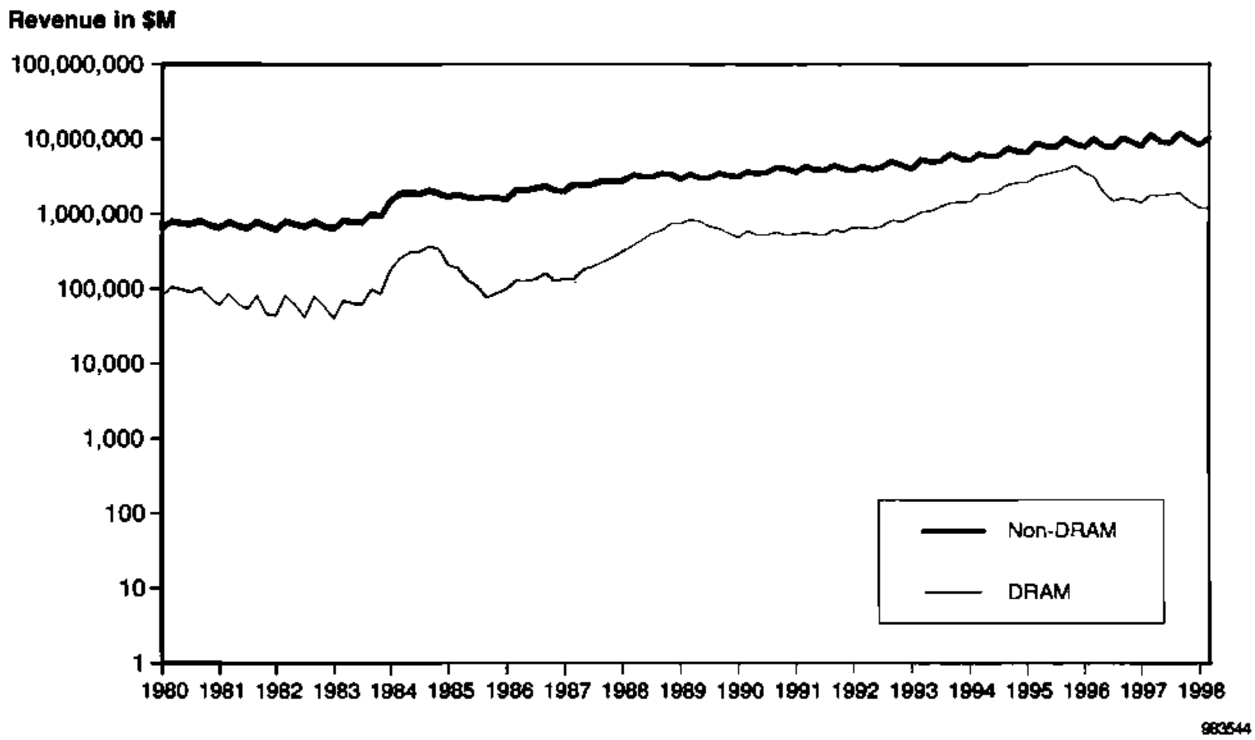
faced the worst price erosion. Several companies made well-publicized withdrawals from the DRAM market during that year. The manufacturers that fared best were those well positioned in the 256K DRAM market, which enabled them to shift their revenue base as the 64K market declined.

The historical path of DRAM revenue versus non-DRAM revenue through the historical eyes of World Semiconductor Trade Statistics (WSTS) data reveals that a slowdown in market growth actually occurred in the last three months of 1984 (see Figure 1), before the DRAM market took a nosedive in January 1985. It took the market and its suppliers 27 months, from January 1985 through March 1987, to return to growth.

Figure 1
DRAM versus Non-DRAM Revenue over Time



Source: WSTS

Today's market is very reminiscent of that downturn. DRAM growth slowed during the fourth quarter of 1995, and the decline began December 1995. From that time, it has been 29 months of more or less declining revenue. There was a brief respite in September 1996. There were gasps of minor growth in February and March 1997, growth mostly propelled by the Korean suppliers. There was a lull in April before revenue strengthened from May through September, and then the second downturn hit during the fourth quarter of 1997.

Figure 2 shows that DRAM shipments over time were very smooth in the shortage years (1992 through 1995) but quite bumpy in times of oversupply (all other years). Do smooth shipments represent extremely tight allocation,

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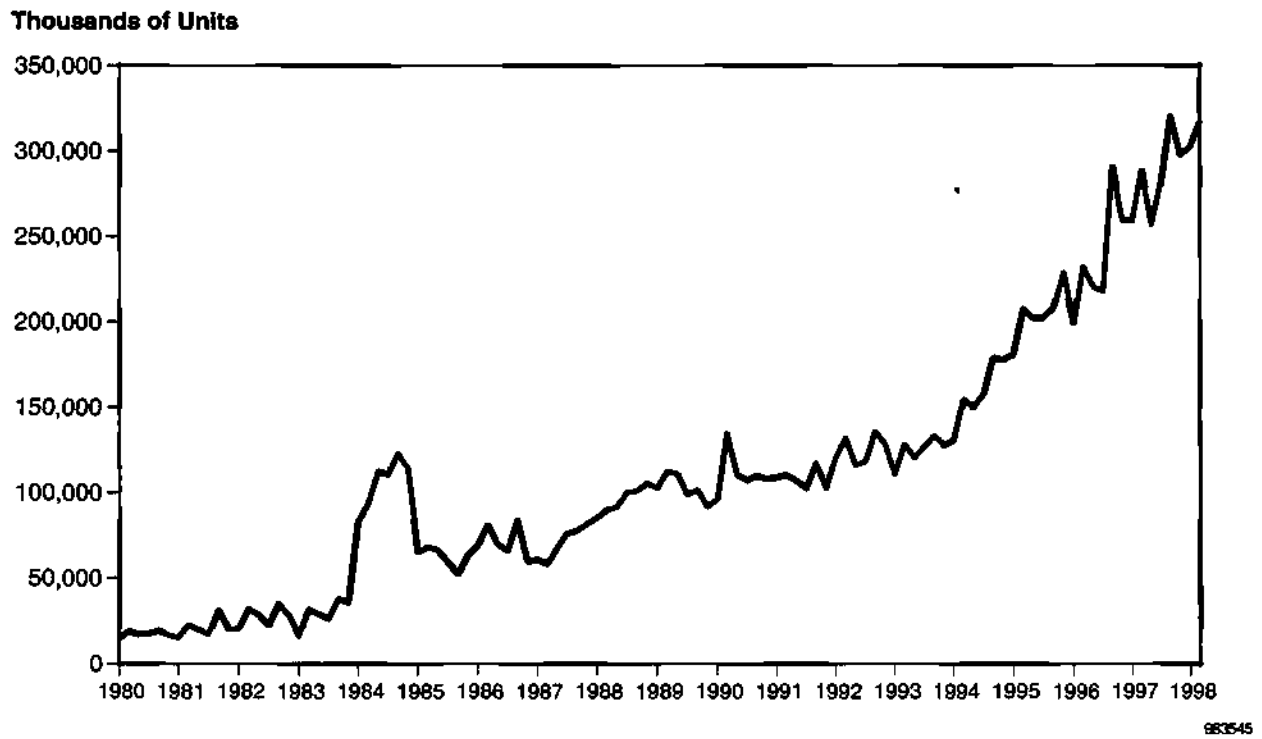
with factories operating at maximum efficiency? If this is true, then the bumpy times reflect opportunistic buying binges followed by times of feasting off the excess purchases. This figure has been extended to include the first four months of shipments in 1998. Given the fact that overcapacity remains, this period of decline could extend beyond 29 months into a 31-to-34-month decline in revenue.

Figure 2
Historical DRAM Shipments



Source: WSTS

There are two major differences between history (1986) and the present day. First, the 1997 market had about a six-month resurgence in spending in DRAM, which did not happen in 1986. On the bright side, the market for front-end equipment grew over 50 percent in 1988, which would correspond to 2000 in Dataquest's current forecast. Second, changes occurring now in the PC sector, the major area of consumption for all semiconductor products, not just DRAM, are exacerbating the situation even further.

Microcomponents

What are the lingering effects of this lengthy price pressure on the market? As with memory, microprocessor pricing is also in the throes of downturn. Some attribute this to increased competition from Advanced Micro Devices Inc. and Cyrix Corporation, while others blame the increasing visibility of sub-$1,000 personal computers. Dataquest argues that the real culprit behind microprocessor price erosion is the declining number of $2,000 and $3,000 personal computers in the sales mix. With the performance of today's low-

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end and midrange machines, few users feel the need to pay top dollar for the fastest machines they can buy. Some of this desktop MPU price pressure may be offset later in the year as Intel introduces processors priced at $1,000, $2,000, and $4,000, specifically targeted at servers and workstations. Although sold in far smaller volumes than desktop MPUs, the new high-end devices could still contribute mightily to microprocessor average selling prices (ASPs). The combination of one $4,000 microprocessor and 38 $100 processors still results in a $200 average for the lot overall. If Intel's plan works as expected, the second half of the year will produce far stronger MPU revenue than the first.

Logic

Logic is also under pricing pressure and feeling the effects of the turmoil in Asia, but to a much lesser degree than DRAM and microprocessors. Programmable logic devices (PLDs) are a good leading indicator among logic products, and this market has slowed noticeably in the first half of 1998. Pricing pressure can be blamed to some degree, but this market has seen rapid price reductions for some time as suppliers bid for market share. The gate array market is most vulnerable because a large portion of these devices are consumed in Japan, so at least a 10 percent decline can be expected in this market in 1998. Cell-based ICs are still the shining star, but they too have slowed in the first six months of the year.

Price/Cost Analysis

Although megabytes of DRAM grew 77 percent in 1996 and 95 percent in 1997, price-per-bit and price-per-byte declines have eroded DRAM revenue growth potential. Non-DRAM products are expected to continue on a growth path through the end of the year, but pricing pressures in microprocessors, logic, analog, and discrete products have reduced the market's non-DRAM revenue potential from Dataquest's original estimate of $138.3 billion to a more likely scenario of $133.2 billion.

The price forecasts for the most popular 1Mbx16 DRAM part had a contract price value of $3.50 in first quarter 1998. The second quarter 1998 price dropped to $2.55 and could drop to $1.80 by the year's end. The 4Mbx16 DRAM part was $24.00 in first quarter 1998. By second quarter 1998, it had dropped to $11.40 (below Dataquest's $15.00 estimate) and is expected to decline to $8.00 by the end of the year.

Dataquest's original forecast was based on a price per megabyte averaging $2.37 in 1998. A quick review of WSTS worldwide DRAM data (note that revenue for February and April 1998 was restated) is an eye-opening documentation of the disastrous downturn the market has taken since our forecast (see Table 3).

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Table 3
Price per Megabyte Stays below the Cost Line

Month	Price/Megabyte ($)	Growth (%)	Cost Trend ($)	Price/Cost Change (%)
October 1997	3.10	-9	2.99	104
November 1997	2.59	-16	2.89	90
December 1997	2.19	-15	2.80	78
January 1998	1.96	-11	2.71	72
February 1998	1.97	0	2.63	75
March 1998	1.67	-15	2.54	66
April 1998	1.63	-2	2.46	66

Source: WSTS, Dataquest (June 1998)

Specific densities show even more cause for concern. Units of 16Mb DRAMs have declined significantly, while 64Mb units increased less, causing an overall decline in bit shipments of 11 percent from March 1998 to April 1998.

Application Market Analysis

Economic growth in Asia/Pacific and now Japan is grinding to a standstill, and that will almost certainly lower electronics demand even further. Japan's deteriorating economic circumstances are particularly distressing. Most forecasters now expect Japan to experience a sharp contraction in economic activity this year. If recent estimates of this contraction (a drop of 0.2 to 0.9 percent) are realized, then Japanese electronics demand will decline precipitously. This downward tumble in Japan would not only affect Japan's already hobbled electronics industry, but it would also seriously affect Asia/Pacific's export production.

The falling yen compounds this problem. The yen recently fell below ¥140 to the dollar and appears well on its way to falling even further, U. S. Treasury Department intervention notwithstanding. To be sure, the continuing depreciation of the yen could provide some stimulus to Japan's sagging economy. However, it is likely to reduce dollar-valued Japanese electronics activity. Moreover, by making Japanese exports less expensive, it almost certainly increases the economic stress of Japan's afflicted Asia/Pacific competitors. In the worst case, a deflating yen could raise the specter of competitive currency devaluation between Japan and its Asia/Pacific neighbors (notably China) that could depress both electronics and semiconductor activity well beyond 1998.

Given all these potential developments, it is not too unreasonable to believe that Dataquest's electronic equipment forecast, shown in Table 4, could also have a most likely scenario that may go well below 4.4 percent. When analyzing semiconductor activity from an end-use perspective, it is important to remember that semiconductor growth is ultimately driven by growth in electronics production and the semiconductor content of electronics. In short, the formula is as follows:

Semiconductor Growth = Electronic Equipment Growth + Semiconductor Content Growth

For 1998, a no-growth scenario is possible if (dollar-valued) electronics production slows significantly and average semiconductor content is reduced. Slower electronics growth now seems very likely, given economic circumstances in Japan and Asia/Pacific. A decline in the average semiconductor content of electronic equipment also appears highly likely, given the apparent inelasticity of DRAM demand in the face of falling DRAM prices. Added to that, Dataquest believes that the growing price competition in several key electronics markets (PCs!) is likely to curtail average semiconductor content as manufacturers struggle to preserve margins by holding the line on semiconductor consumption.

Inventory was a real issue for some PC suppliers during the fourth quarter of 1997 and the first quarter of 1998, and they have slowed their chip orders significantly in the second quarter of 1998. Added to this, server systems are sluggish as spending on these is being cut in favor of funding year 2000 software consultants. The cost concerns of year 2000 issues could be enormous if the additional cost hits from insurance protection and litigation potential are included.

More worrisome is the state of the rigid disk drive business. This sector remains in a prolonged overcapacity as prices and production plans continue to be cut. This pain has also been passed along to the semiconductor suppliers.

In the communications sectors, LAN and Internet access systems saw even worse price pressure than expected. This also affected the semiconductor suppliers because they were also pressured into lowering prices.

The segment that should come under close scrutiny in all regions is consumer electronics. Reports now indicate that the consumer sector is faring worse than expected as the financial turmoil in Japan and Asia/Pacific cuts spending in that area.

Table 4
1998 Electronic Equipment Production Forecast Downside Scenario (Billions of Dollars)

	Actual 1997	Actual 1998	Most Likely 1998 Scenario
Electronic Equipment Production	906.6	968.9	946.5
Growth (%)	6.8	6.9	Greater than or equal to 4.4

Source: Dataquest (June 1998

Regional Analysis

Asia/Pacific

The overall business climate in the Asia/Pacific region is weak and unstable. It is Dataquest's opinion that the Korean semiconductor market is dead. Korean semiconductor capital spending as a percentage of Asia/Pacific capital spending has traditionally been very aggressive. Korean DRAM suppliers originally gained access to the DRAM market during the government negotiations between Japan and U.S. DRAM suppliers during the trade wars of 1986 and 1987. Korean companies accounted for just over 14 percent of all capital spending worldwide in 1997, but it now appears that all new Korean semiconductor investment projects have stopped. Dataquest's capital spending forecast assumes that Korean companies will cut spending 40 percent in U.S. dollars. This is a total of about $3.3 billion for the big three companies (Hyundai Electronics Company Ltd., LG Semicon Co. Ltd., and Samsung Electronics Company Ltd.). DRAM price drops caused by the Asian turmoil are changing the outlook for 1998 DRAM growth in the region. DRAM, which originally was expected to contract 0.7 percent, is now expected to drop 31.0 percent. This could translate to a 0.6 percent contraction in Asia/Pacific semiconductor revenue for 1998. Asia/Pacific is a trade-intensive region that is basically in a trade recession. Its largest trading partner, Japan, has now become its largest trading competitor. China and Taiwan appear to be the more stable areas of the region. However, capital spending in Taiwan has begun to slow this quarter compared with the previous quarter.

Japan

The analysis from Japan does not bode well for a quick return to market growth. The biggest change has been felt in price declines in various MOS digital products—not just DRAM but also flash memory, microprocessors, microcontrollers, and application-specific ICs (ASICs). In the logic product markets, there have been mild price changes in cell-based ICs, while prices for application-specific standard products (ASSPs, the "other MOS logic" category) are falling rapidly. DRAM prices have come down below cost. In the microprocessor and logic product markets, vendors are offering aggressive prices that could bring revenue growth down substantially from the levels forecast at the beginning of 1998. It now appears that the yen/dollar exchange rate, assumed for Dataquest's spring forecast to be ¥129.73, will be closer to ¥138 for 1998 and ¥143 for 1999. This translates to a 6.3 percent yen depreciation against the spring forecast assumption. During recent interviews with Japanese semiconductor vendors, they gave estimates for growth in Japan ranging from a 5 percent contraction to flat for 1998. Contacts in the consumer applications believe that there may be a yen-based total semiconductor contraction this year.

Europe

The continued decline in DRAM pricing is affecting all device categories for European vendors, although analog, discrete, and optoelectronic product growth appears to be more robust than that of the more complex products. Microcomponent growth is down, even though unit demand continues to

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grow. Regional PC demand in the first quarter was unexpectedly strong, with first quarter 1998 shipments up 26 percent over the first quarter of 1997. Demand has been weaker in the second quarter. The third quarter is historically weakest; however, strong fourth quarter demand should hold the year to the 14.3 percent PC unit growth forecast.

Production of other high-volume products, such as digital cellular handsets, remains robust, with the equipment manufacturers reveling in low prices, short lead times, and minimal inventories. A de facto just-in-time ordering system seems to be the norm on commodity products, with equipment manufacturers happy to have the semiconductor vendors acting as their warehouses and transferring products to their own ownership at the last possible moment. This has enabled them to decrease their inventories, but this is a dangerous game because, when the upturn comes, lead times will rise overnight, leaving less astute purchasers without adequate backlog coverage.

The current forecast for Europe is for 8.6 percent growth, but that the change in circumstances makes this an unlikely occurrence. On the basis of the reasonably strong end-equipment growth still forecast for Europe, Dataquest expects the region to outperform the worldwide market with growth, at best, at about 3 percent for the year.

Americas

The Americas region, originally forecast to grow around 10.9 percent, could instead decline to growth of about 4 to 5 percent. Americas investment in DRAM is minor compared with that of Asia/Pacific and Japan. The major price declines in other memory products (SRAM, flash, and EEPROM), microprocessors, and logic/ASIC devices are an indirect result of other market downturns and DRAM system price pressures. All the major North American semiconductor and front-end equipment suppliers are posting declines in quarterly earnings. Some have chosen more drastic measures, layoffs, to stem the revenue decline. National Semiconductor Corporation, Motorola Incorporated, and Applied Materials Inc. have all announced major layoffs. Lam Research Corporation has chosen a two-week plant shutdown. Even with the U.S. Federal Trade Commission breathing down its back, Intel Corporation has buckled under the system pricing pressures and announced price reductions of up to 20 percent on various MPU products. The automotive and consumer application markets are stable, but the communications sector, especially the cellular telephone market, has weakened.

What about Capital Spending Now?

A "technology" spending cycle during 1997, normal in the middle stages of an oversupply-driven downturn, was much stronger than expected, driven by the sheer momentum of an increased number of new and inexperienced players in the market. The correction in spending is now under way, following very closely, and perhaps exceeding, the downside scenario presented by Dataquest in January ("Wafer Fab Equipment Market Forecast

Update: Question Marks for 1998," SEMM-WW-DP-9801, and "Conference Call on Capital Spending and Wafer Fab Equipment Year-End Forecast Update," SEMM-WW-DP-9803). A revised capital spending forecast will be released in mid-July; however, the current view is that 1998 spending is likely to be 14 to 16 percent lower in 1998 than 1997. The weakness is the underlying chip market in 1998 should delay a recovery in spending until 2000, meaning that 1999 should be a single-digit growth year, at best.

Dataquest Perspective

The tried and true survivors of the semiconductor industry understand the angst of these memory boom-to-bust death cycles. The length of this DRAM downturn will weaken the growth potential of 1999. At this time, Dataquest does not expect memory IC revenue to return to 1995 growth levels until after 2000, when balance returns to the market. Despite the ups and downs of the semiconductor industry, semiconductors are fundamental to information technology. The market has seen revenue set back for the last two and one-half years. This may turn into a full three-year downturn or it may be temporary, unless the markets in Asia/Pacific and Japan weaken further.

Is there a bright side somewhere? A return to growth could come from many of the top 10 emerging consumer, communications, and data processing equipment markets. These are expected to account for about 70 percent of semiconductor consumption through 2002. The PC market is undergoing an intense transition from the high-end desktop products to the low-end, low-priced systems. There is concern about demand for the system above 300 to 400 MHz, which will drive DRAM megabyte growth. Is real demand developing for high-end thin servers and workstations? Intel could make that demand real, based on its recent price decrease efforts. Prices for various 300-to-400-MHz devices have recently been cut from 12 to 20 percent. The wireless and new digital consumer application markets continue to drive digital signal processor, embedded, and digital ASIC growth.

Dataquest will continue to closely monitor regional, product, and application events as they occur. Comments on updates are always welcome.

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Perspective

Semiconductors—Top Views

Market Analysis

Asian Financial Crisis: Status Report

Abstract: *To keep our clients up-to-date on the impact of the Asian financial crisis (AFC) on the semiconductor industry, Dataquest is providing a high-level view of the current state of the AFC, looking briefly at how the AFC is affecting the major countries in the region.*
By J. H. Son, Jerry Yeh, Chang Soo Kim, Ken Ng, Daniel Heyler, and Yoshihiro Shimada

Asia/Pacific Regional Overview

The Asian financial crisis (AFC) can be compared to the tornado that sweeps through the Eastern part of the United States almost every year. Once it lands, it destroys everything indiscriminately, including buildings, automobiles, and road construction. Its direction is unpredictably random, and it moves anywhere depending on atmospheric phenomena. The financial crisis is taking place when the economic situation is unstable, and like a tornado, it can travel to any country, depending on the conditions.

To keep our clients up-to-date on the impact of the AFC on the semiconductor industry, Dataquest is providing a high-level view of the current state of the AFC, looking briefly at how the AFC is affecting the major countries in the region.

The AFC that we are facing seems to have originated when most Asian countries did not respond quickly enough to the fast-changing world economy. While the world economy required rapid globalization and democratization, most of Asian countries couldn't keep pace with these trends. In addition, they neither caught the right direction of the international fund flow nor secured enough international confidence from the West. Also, they were inattentive to the revolution bringing about a new,

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economy-oriented society. This eventually resulted in the Asian countries' financial crisis.

The AFC, which started in July 1997, landed in Thailand first. After that, it traveled to Indonesia, and then Korea. It destroyed those countries' economies, and its power was extended to Japan, Singapore, Malaysia, and many other Asian countries. Fortunately, China has not yet been influenced by the AFC as deeply, but it may be subject to damage if the value of the yen continues depreciating. As the duration of the AFC lengthens, it shows symptoms of expanding to Russia, Europe, and the United States. This crisis seems not to be finished with the Asia/Pacific region.

The AFC will cause the gross domestic product (GDP) of most Asian countries to drop in 1998. Specifically, Indonesia, Thailand, and South Korea are expected to show negative growth in 1998, and Japan will again record under 1.0 percent growth this year. The other Asian countries will record positive numbers, but much lower growth rates than in 1997. Average GDP growth rate in 1997 was 5.0 percent, and it is expected to be 2.5 percent in 1998, which is just half of 1997 growth. Dataquest forecasts that this poor growth will not recover even in 1999. The details are referred to in Table 1.

Table 1
Real GDP Growth for Asia/Pacific Countries (Percent)

	1997	1998	1999
Indonesia	4.6	-6.4	-1.7
Thailand	-0.5	-3.5	1.5
South Korea	5.5	-1.8	2.2
Japan	0.9	0.6	1.7
Malaysia	7.8	2.0	3.0
Singapore	7.8	2.5	4.0
Hong Kong	5.2	2.7	4.2
New Zealand	2.2	2.7	3.0
The Philippines	5.1	3.0	4.5
Australia	3.1	4.0	3.8
Pakistan	3.4	4.5	5.2
Taiwan	6.8	5.2	5.6
India	5.0	5.4	5.8
China	8.8	7.0	7.5
Vietnam	8.7	9.0	9.4

Source: Dataquest (June 1998)

The AFC's first effect was the depreciation of local currencies in Asia/Pacific region. Table 2 shows the average exchange rates of local currencies against the U.S. dollar for 1997 and 1998. Among the 13 local currencies, the renminbi (also called the yuan) is the only currency to keep positive value against the U.S. dollar. The other Asian currencies lost value against the U.S. dollar, and the currencies in Indonesia, South Korea, Malaysia, and Thailand are experiencing deep depreciation in this year.

Table 2
Foreign Currency per U.S. Dollar (Annual Average)

Country	1997	1998*	Change (%)
Indonesia (Rupiah)*	2,872.61	11,525.00	-75.1
South Korea (Won)	954.14	1,450.74	-34.2
Malaysia (Ringgit)	2.82	3.86	-26.9
Philippines (Peso)*	29.47	39.16	-24.7
Thailand (Baht)	31.07	41.13	-24.5
New Zealand (Dollar)	1.51	1.82	-16.8
Taiwan (Dollar)	28.79	33.36	-13.7
Australia (Dollar)	1.35	1.56	-13.5
Singapore (Dollar)	1.49	1.64	-9.6
India (Rupee)	36.36	40.12	-9.4
Japan (Yen)	121.10	132.95	-8.9
Hong Kong (Dollar)	7.74	7.75	-0.1
China (Renminbi)	8.32	8.31	0.1

* Estimate
Source: Dataquest (June 1998)

The AFC has also influenced stock market prices. High depreciation of local currency requires higher interest rates, which badly affect the management of companies. Foreign investors have a tendency to withdraw their money from the stock market to avoid losing more value. For this reason, the local currency has depreciated, and stock market prices are falling. Table 3 shows how much stock prices dropped during the past year. As in the case of exchange rates, China is the only country that showed an increased stock price index in Asia/Pacific region. The price indices of the other countries all show negative numbers. Indonesia, Malaysia, South Korea, Thailand, Singapore, and the Philippines have a stock price drop of more than 50 percent within a year. Stock prices in June dropped much more than in February, which means that the AFC is getting more serious.

In the early days of the AFC, manufacturing in the Asia/Pacific region increased a little more than before the beginning of the AFC. This was because the higher exchange rate created greater profit margins and increased competitiveness. As the AFC lasts longer, however, it has shrunk capital spending and resulted in falling growth rates for the electronics market as well as the semiconductor market. Dataquest has reflected this in the recent revision of the semiconductor market forecast.

In the spring, Dataquest estimated that the semiconductor market would reach $159 billion with 8.2 percent growth in 1998. Recently, however, the 1998 forecast was revised to $149 billion for 1.4 percent growth. This is a $10 billion reduction from the April version of the forecast (see Table 4). As for the $10 billion, the DRAM reduction will share 50 percent. The worldwide DRAM growth rate in this year was estimated at 1.0 percent in April, but Dataquest revised it by negative 22.9 percent in its latest forecast.

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Table 3
Stock Market Price Index in U.S. Dollars—Year-on-Year Change (Percent)

Country	2/23/98	6/8/98
Indonesia (Rupiah)	-81.7	-85.44
Malaysia (Ringgit)	-62.0	-72.50
South Korea (Won)	-62.1	-68.21
Thailand (Baht)	-59.3	-66.35
Singapore (Dollar)	-40.5	-55.85
Philippines	-57.9	-54.10
Hong Kong (Dollar)	-21.0	-46.43
Japan (Yen)	-15.1	-34.85
New Zealand (Dollar)	-18.3	-33.58
Taiwan (Dollar)	-0.9	-30.46
Australia (Dollar)	-6.7	-20.05
India (Rupee)	-9.9	NA
China (Renminbi)	28.6	NA

NA = Not available
Source: Dow Jones News Service

Table 4
Total Semiconductor Market Forecast Scenario (Millions of U.S. Dollars)

	1997	Spring Forecast (April 1998) for 1998	Revised Forecast (June 1998) for 1998
Worldwide	147,165	159,249	149,198
Americas	48,086	53,326	49,986
Japan	36,499	37,397	36,028
Europe	30,046	32,627	30,854
Asia/Pacific	32,534	35,899	32,330

Source: Dataquest (June 1998)

Dataquest's spring 1998 forecast was for the Asia/Pacific semiconductor market to grow 10.3 percent. Recently, however, we reduced the growth rate to negative 0.6 percent, considering the AFC situation. The main reason for this decrease is the DRAM price drop, which is much more serious than our original estimation. We estimate that the DRAM market in Asia/Pacific will be reduced by 31.0 percent in 1998.

Among the countries in the Asia/Pacific region, South Korea will be influenced by the AFC the most, followed by Singapore. China and Taiwan are less influenced than the other Asian countries. Table 5 shows each country's revised market forecast.

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Table 5
Asia/Pacific Semiconductor Market Forecast (Millions of U.S. Dollars)

	1997	Spring 1998 Forecast for 1998	Growth Rate (%)	Revised Forecast for 1998	Growth Rate (%)
Total Semiconductor	32,535	35,899	10.3	32,330	-0.6
Total IC	7,804	30,803	10.8	27,497	-1.1
DRAM	4,642	4,611	-0.7	3,201	-31.0
South Korea	5,490	5,989	9.1	5,311	-3.3
Taiwan	6,754	7,694	13.9	7,022	4.0
China	6,769	7,819	15.5	7,197	6.3
Singapore	4,972	5,560	11.8	4,959	-0.3
Rest of Asia	8,551	8,837	3.4	7,841	-8.3

Source: Dataquest (June 1998)

By J. H. Son (Asia/Pacific Semiconductor Group), J.H.Son@dataquest.com

South Korea

Electronics Industries Are Staring at External Surroundings, Especially Japan's Yen

Economic Trends

The weakening yen and a possible devaluation of the Chinese renminbi are also posing an enormous threat. Reflecting the dismal sentiment, the Daewoo Securities financial institute projected in its latest report that Korea's economy would be reduced by up to 5 percent this year because of surging import prices and negative economic growth, adding that unemployment will exceed 8 percent. The institute expected this year's trade surplus to range from $27 billion to $31 billion. But the state-run Korea Institute for Industrial Economics and Trade issued an even gloomier forecast, saying that the trade surplus will amount to a mere $10 billion this year and less than $10 billion next year.

At the current exchange rates, according to financial experts, a 1 percent loss of the yen's value against the dollar, or the won's 1 percent gain against the dollar, will raise the won's strength against the yen by about W11. The nation's auto and electronics firms, which are competing fiercely with Japanese rivals in global markets, expect a 10 percent fall in the yen's value to cut their export profits by W1.1 trillion and $630 million, respectively.

Electronics Production Trends

Korean products will be able to keep their price competitiveness over Chinese products at least for the next two years, even after the Chinese government imposes a devaluation of its currency. The nation needs to sharpen the competitiveness of products that are in direct rivalry with China in the global market to cope with the cheaper Chinese currency.

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As the Japanese yen depreciated to the level of ¥140 to the U.S. dollar, Korean exporters were on alert over a loss of competitiveness that had increased with the fall of the won. Most analysts in Korea predicted that if the yen fell to ¥150 per U.S. dollar, then annual exports from Korea would be reduced by $4.63 billion and imports by $920 million.

Korea's electronics industry's exports are expected to grow by 6 percent this year, according to the Korea Institute for Industrial Economics and Trade. The institute estimates that the recent low growth in exports is the result of difficulty in trade financing, a rise in trade incidentals, falling export prices, retrenchment of the Asian economy, and fiercer competition. Other elements slowing exports in this area are insufficient restructuring of operations and excessive dependence on semiconductors.

Korea as Semiconductor Consumer

Although exports of Korea's electronics equipment products are expected to grow by 6 percent this year, the electronics industry may be heading for its worst economic difficulties in the latter half of this year, according to the current situation. Signs of an imminent collapse of the industrial base are rampant in consumption and the factory operating rate. With the average factory operating rate sinking to 60 percent lately, especially for small and medium-size companies, sluggish domestic demand and sky-high interest rates have forced industrial companies to cut equipment investment by 40 percent. As a result, the production of data processing equipment is expected to decline by 2.1 percent this year and production of consumer electronics is expected to decline by 5.1 percent. However, communications products will grow at 12.2 percent, owing to expanding digital cellular phone and mobile systems. The growth rate of the combined production of data processing, communications, and consumer electronics is expected to be below 1 percent this year.

Dataquest's spring forecast had assumed that DRAM prices would bottom out at about manufacturers' variable costs. Unfortunately, DRAM prices have sunk below cost and have not yet hit bottom. At this rate, DRAM revenue could decline 44.8 percent in Korea. Assuming non-DRAM products grow a slight 1.1 percent, the total semiconductor market would decline by 3.3 percent in 1998 because of a slowdown in overall electronic equipment production and severe global price erosion. Dataquest will continue to update clients on the Korean market. Dataquest's fall forecast for the Korean semiconductor market, available in the fourth quarter of 1998, will present an in-depth analysis of the situation and will include itemized product forecasts for all semiconductor devices.

Korea as Semiconductor Supplier

Semiconductor exports including assembly business during the first quarter of this year reached $4.08 billion, an increase of 12.8 percent over the same period last year. Exports of semiconductors are expected to increase only by 6 percent this year because of weak prices of memories. Domestic semiconductor manufacturers' exports of nonmemory products are increasing, including media processors and chip designs such as system-level integration (SLI), Alpha, and quadrature phase shift keying (QPSK).

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LG Semicon, which developed the MPACT media processor chip with Chromatic of the United States, produces 200,000 chips. LG's Java chip, which it plans to ship in the second half of this year, can be used for a variety of network-based information technology appliances, including network computers, Internet TVs, and Internet set-top boxes. Exports of SLI chips by Samsung Electronics increased from $200,000 in January to $5 million in April. Samsung plans to expand SLI chips to SRAMs and flash memories. The company also forecasts that its revenue from Alpha chips will increase substantially in the future. Although Hyundai Electronics recently sold Symbios, its nonmemory subsidiary in the United States, Hyundai intends to enter the market for CMOS image sensors this year and will ship QPSK modules for satellite broadcast receivers. Hyundai's revenue target for these nonmemory products is $5 million this year.

Korea's semiconductor manufacturers are placing more emphasis on marketing their nonmemory or system integrated circuit products in the domestic market. Dataquest estimates that this is part of their strategy to make up for declining revenue from memory chips sales overseas and enhance the competitiveness of their nonmemory products in the domestic market, which is dominated by imports. While recognition of Korean semiconductor companies as memory chip producers brings difficulties in expanding exports of nonmemory chips, these products are gaining popularity among domestic electronic appliance manufacturers because of their improved price competitiveness.

Dataquest Perspective

Korea's financial crisis has resulted in local electronics vendors not being able to sustain the sales volume necessary to maintain their competitiveness and justify continued investment in the electronics industry. As a result, the local electronics vendors are experiencing massive core business restructuring, corporate mergers, acquisitions, and downsizing this year.

Having overcome a dangerous liquidity crisis in March, Korea must diligently continue with the reform under way to leave the crisis behind. Potential obstacles include political infighting among the nation's leaders, social unrest resulting from layoffs and a high unemployment rate, and less than genuine restructuring efforts by the nation's conglomerates. Any of these factors can result in delay on the road to recovery, potentially plunging the country further into crisis. However, the international financial community has sustained confidence in Korea's ability to recover, as demonstrated by Korea's brisk and successful sale of U.S.$4 billion of bonds in the U.S. financial market in April. The first positive effects of successful restructuring should be felt by the beginning of 1999, if all goes well.

Under the terms of the International Monetary Fund (IMF) emergency loan extended to Korea in late November 1997, the economy will undergo massive and fundamental restructuring in 1998. The economy can be expected to experience low growth, high unemployment, and high interest rates this year. The nation's conglomerates, having already instituted deep cuts throughout their business units, will continue to implement radical self-reform measures and increase financial transparency. The financial sector

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will be deeply affected, as banks and other financial institutions with massive amounts of bad or underperforming loans will be shut down or seek mergers and acquisitions. Domestic vendors will also focus their energies on boosting exports in order to improve their balance sheets while reaping the short-term benefits of lower product prices in overseas markets because of the devalued won.

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Taiwan

New Storm near Taiwan, Asian Crisis Spreading

Another wave of financial crisis is building in Asia as the negative influences of the financial storm gradually spread across the region. The Taiwanese government has started planning to prevent another wave of the financial storm, which has been on the horizon since March, from swamping Taiwan. Under the circumstances, the public is concerned about whether the Taiwanese economy is able to maintain steady growth. Taiwanese exports to Southeast Asian countries, as well as South Korea and Japan, dropped considerably in the first four months of the year. Taiwanese export and import trade with those countries during this period declined 6.7 percent and 3.2 percent, respectively, from the same period last year. The phenomenon indicated that Taiwanese international trade has been under the influence of the Asian financial crisis since the middle of last year.

Tables 6, 7, 8, and 9 provide a same-period comparison. Table 6 provides Taiwanese exports by region for the January-through-April period of 1997 and 1998. Table 7 shows Taiwanese exports by country in the Asia/Pacific region. Table 8 covers Taiwanese exports by commodity. Table 9 shows the Hsinchu Science-Based Industrial Park exports classified by commodity (January through April 1997 and 1998).

Table 6
Taiwanese Exports by Region, January through April 1997 and 1998 (Millions of U.S. Dollars)

Region	January to April 1998	January to April 1997	Growth Rate (%)
Asia/Pacific	13,959	16,051	-13.0
Japan	3,138	4,075	-23.0
Americas	10,987	10,934	1.0
Europe	7,928	7,528	5.3
Total	**36,011**	**38,588**	**-6.7**

Source: Taiwanese Customs, Dataquest adjusted (June 1998)

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Table 7
Taiwanese Exports by Country in Asia/Pacific, January through April 1997 and 1998 (Millions of U.S. Dollars)

Asia/Pacific Country	January to April 1998	January to April 1997	Growth Rate (%)
Hong Kong	8,092	8,459	-4.3
Singapore	1,109	1,505	-26.3
Malaysia	718	953	-24.7
Thailand	655	899	-27.2
Philippines	603	736	-18.0
South Korea	481	872	-44.8
Indonesia	365	684	-46.7
Others	1,937	1,944	-0.4
Total	**13,959**	**16,051**	**-13.0**

Source: Taiwanese Customs, Dataquest adjusted (June 1998)

Table 8
Taiwanese Exports by Commodities, January through April 1997 and 1998 (Millions of U.S. Dollars)

Commodities	January to April 1998	January to April 1997	Growth Rate (%)
Electronics	5,396	5,405	-0.2
Information and Communications	4,405	4,605	-4.3
Fiber, Yarn, and Linen	3,445	3,667	-6.1
Machinery	2,600	2,797	-7.1
Plastics	2,324	2,505	-7.2
Others	17,841	19,609	-9.0
Total	**36,011**	**38,588**	**-6.7**

Source: Taiwanese Customs, Dataquest adjusted (June 1998)

Table 9
Hsinchu Science-Based Industrial Park Exports by Commodities, January through April 1997 and 1998 (Millions of U.S. Dollars)

	January to April 1998	January to April 1997	Growth Rate in U.S. Dollars (%)	Growth Rate in NT Dollars (%)
Electronics	1,514	1,464	3.4	23.2
Semiconductor	977	874	11.8	33.0
Others	13	13	2.4	21.0
Total	**2,504**	**2,351**	**6.5**	**27.0**

Source: Hsinchu Science-Based Industrial Park Administration, Dataquest adjusted (June 1998)

Dataquest Perspective

Taiwan has seen its exports decline for the first time in the past 10 years, which has been a warning signal for the year-long AFC. AFC and economic

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recession in the region, including Japan, is reducing the number of electronic products imported from Taiwan. Some production shift to Taiwan from Southeast Asia/Pacific is occurring because of the AFC's turmoil (such as the Indonesian political and economic crisis). However, this additional strength cannot overcome the impact of sluggish import demand from the major industrial countries. The impact has begun to shake this trade-driven island since the first quarter of 1998. Electronics exports show a single-digit decline, but this dramatic change (compared to previous years) is significant. Fortunately, the island has credit available for expansion, the economic fundamentals are healthy, and most local companies have a well-controlled financial performance. Also sufficient capital exists to support local companies during the crisis, and the government has more than U.S.$80 billion in reserves. Is Taiwan safe, in the eye of the storm? Someone may get hurt, but should survive.

Singapore

AFC Hits Singapore

Lower Growth

Singapore's economy is headed for lower growth in 1998 as a result of the Asian financial crisis. Regional economies have not recovered yet despite adopting measures recommended by international institutions. With the worsening Japanese situation, fears abound of an impending round of currency devaluation among the Asia/Pacific economies. The Singapore government has earlier forecast a GDP growth rate of between 2.5 percent to 4.5 percent for the year. However, the government is now looking to revise official growth rates toward the lower end of the forecast range. Dataquest estimates that Singapore's economy is likely to record 2.5 percent growth. The Singapore government's consistent budget surpluses should allow the city state to better weather the financial crisis compared to other regional economies.

Lower Electronic Exports

Singapore's electronics sector is a key component of the island's export-driven economy. Nonoil domestic exports, as measured in local currency terms, declined 1.6 percent in April (see Table 10). Exports of electronics products drove the decline, decreasing by 3 percent. Electronic exports have fallen more significantly in U.S. dollar terms when we take into account the 18 percent depreciation of the Singapore dollar since February this year.

Trade data for the first few months of 1998 has shown an evident slowing down of electronic exports. This trend reflects the negative impact on demand and increased pricing pressure for electronics products brought on by excess capacity and the AFC. Oversupply and increased competition has hit Singapore's major export earners. Rigid disk drives (RDDs), the single largest export item, have shown weak growth this year. Major RDD manufacturers, such as Seagate and Western Digital, have reacted to the slowdown by cutting their workforce. Even the high-growth semiconductor industry has succumbed to the trend despite new investments in capacity

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and equipment. Personal computers registered consistent declines in export value as a result of declining prices and inventory corrections.

Table 10
Singapore Trade Growth (Year-on-Year Percent Change)

	January 1998	February 1998	March 1998	April 1998
Nonoil Domestic Exports	-0.8	28.1	9.6	-1.6
Electronics	-2.4	24.0	8.3	-3.0
Rigid Disk Drives	-6.5	12.2	2.6	-0.4
ICs	5.8	41.1	21.2	1.8
Personal Computers	-15.9	0.1	-1.3	-28.8

Source: Trade Development Board and Dataquest (June 1998)

The regional economic outlook appears to be bleak going forward. With more bad news than good news on the horizon, hopes of an export-led recovery in Singapore this year are fading.

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China/Hong Kong

Assessing the Downside Risk of China's Electronics Industry and Semiconductor Demand in 1998

This section assesses the potential threat that the Japanese and Asian economic slowdown pose to China's electronics industry and semiconductor demand in 1998. In revenue terms, China/Hong Kong is the largest and fastest-growing semiconductor market in Asia/Pacific, accounting for over 20 percent of consumption and 26 percent of electronic equipment production in 1997. In the current downturn, while most of the region is contracting, vendors are turning to China for growth. Although Dataquest will publish a detailed Market Trends report on the subject in July, this is an executive summary of key findings.

Currency Devaluation

The currency devaluation created critical problems for Asia/Pacific semiconductor suppliers and users that are almost entirely dependent on imports. Although most vendors denominate their prices in dollars, cash-flow problems—attributed to rising credit costs and falling sales—have resulted in weakened demand from local manufacturers. Indonesia's currency was devalued more than 80 percent during the past six months, and its equity market dropped more than 80 percent. As a result of the financial turmoil, stock markets in Korea, Thailand, the Philippines, and Malaysia declined by more than 60 percent. Equity markets in China and Hong Kong have also dropped, but their strong cash account reserves have enabled them to support the Hong Kong dollar and Chinese renminbi.

Few economists expect a devaluation in 1998, but there are concerns in the region that falling exports and a slowing economy will force China to devalue, potentially sparking another round of disastrous currency depreciation in Asia. It is a question of time. Of course, China will devalue, but whether it is before or after the region has recovered is the issue. In 1998, the Chinese government is under extreme pressure to maintain strong economic growth and create new jobs because of the dismantling of state-owned industries, which is creating millions of surplus workers. So far, the Chinese leadership has responsibly held its currency at the expense of economic growth, in addition to committing U.S.$250 billion in infrastructure spending projects to increase GDP vis-à-vis domestic consumption.

GDP Forecast

Data from the Organization of Economic Cooperation and Development (OECD) forecasts China's economy to grow between 7.5 percent and 8.0 percent. However, because of the region's worsening economies and slowing exports, GDP is expected by a number of sources in Hong Kong to fall between 6.5 percent and 7.5 percent. GDP in the first quarter of 1998 slowed to 7.2 percent and is expected to slow to 7.0 percent in the second quarter. The trend is expected to continue, with the second half of 1998 averaging less than 7 percent. One of the advantages China has over the rest of Asia/Pacific is that its economy is far more diversified, with economic expansion taking place in heavy industries, manufacturing, electronics, services, and agriculture. This broad-based growth, including electronics, has been an important buffer to Asia's economic woes. In fact, the major growth burden has been from the state-owned enterprises (SOEs) that account for about 60 percent of the economy. Prime Minister Zhu Rongji is in the process of structuring SOEs, which is the main factor behind slower growth and rising unemployment. However, China depends heavily on foreign capital and markets to sustain its current growth rate.

Foreign Investment

In addition to increased efficiencies in Chinese companies, economic growth has been boosted by direct foreign investment. Foreign investments need to continue to flow into China for it to achieve a 7 percent GDP growth. Hong Kong, which has been hurt financially by its falling stock market, accounted for 59 percent of foreign-invested capital in China from 1980 to 1997. Contracted investments in China declined from $88 billion in 1994 to $72 billion in 1997. However, the actual utilized investment increased from $33 billion to $44 billion during this period. There is uncertainty in 1998, and most forecasts indicate a decline in utilized investments, to $35 billion, for the first time in at least five years. However, Dataquest continues to see communications, computer, and consumer electronic companies maintaining a high strategic interest in investing in manufacturing in China for long-term needs: to increase market access, reduce distribution costs, and improve time to the market.

Trade

China is exposed to the Asian financial crisis by about 11 percent because 11 percent of its exports go to Southeast Asia and Korea. In the past few years, China's exports to Japan have declined to about 15 percent of total exports, but exports to Europe, North America, and Taiwan increased to more than 60 percent. Based on export exposure, a dramatic trade downturn as experienced by the rest of Asia is not likely. The free-falling yen was clearly a threat, but China still holds a (dangerous) wild card: devaluing the renminbi. So when China hinted at devaluing its currency as the yen collapsed without response, the United States and Japan quietly negotiated overnight to support the yen.

Electronic Equipment Production

Dataquest has lowered its electronic equipment production growth for China/Hong Kong from 19.8 percent to 16.3 percent because of slower investments, domestic consumption, and exports than previously forecast. Of China's $190 billion exports, 12 percent related to electronics, and the sector is increasing in total share. With the United States and Europe occupying about two-thirds of China's electronic equipment exports, the only major downside is Japan and Southeast Asia, which account for about one-fourth of exports. Slower exports and China's consumer electronics glut mean that production will expand by only 13 percent, while communications and consumer will have a combined growth of 23 percent.

The most dramatic falls in PC consumption in Asia/Pacific during the quarter were in Indonesia (with revenue shrinking 82 percent), Thailand (negative 62 percent), and South Korea (negative 46 percent). PC sales in 10 key Asia/Pacific markets shrank 25 percent in the first quarter, compared to a year ago. Only China and Singapore showed positive revenue growth, of 21 percent and 19 percent, respectively. However, China represents one-third of Asia/Pacific consumption.

The inevitable, long-term market is continuing to attract multinationals to invest in manufacturing, even during the current uncertainty. It is these investments that will enable accelerated growth in 1999 and beyond. The main reason for continued confidence is that China is not only the largest consumer electronics market in Asia/Pacific, it is the largest consumer of computer and communications equipment. Currently, China represents 30 percent of PCs shipped to Asia/Pacific and about 40 percent of all cellular handsets. The Internet is booming in China. Nationwide, there are about 1 million accounts. In Guangzhou, 1,000 new users sign up for the Internet every month. In five years, the number of users is expected to hit 10 million. Intel Corporation estimates that China will overtake Germany this year and become the world's third-largest PC market. And 11 million new telephone lines are installed every year, which is equal to starting a new regional Bell operating company every 12 months. Nokia Corporation, Motorola Incorporated, and Ericsson all have multiple major manufacturing facilities in switching, handsets, and other communications equipment and continue to announce expansion plans. Recently, Cisco Systems Inc. announced an investment plan involving $100 million to accelerate its technology transfers to China, including a solely owned networking technology company in Beijing and a network laboratory. Other semiconductor and IT vendor investments—by companies such as Intel Corporation, Texas Instruments Inc., NEC Corporation, and IBM—are expanding beyond manufacturing investments to R&D ventures, which are serving both local and global R&D requirements.

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In summary, Dataquest believes that of the $54 billion in electronic equipment production in 1998, an estimated 52 percent, or $28 billion, will be exported. Overall electronic equipment production will slow from 21 percent in 1997 to 16 percent in 1998. Dataquest has established that the exports' downside risk per se is moderate, as long as the domestic consumption of key equipment sustains current growth levels, and the economy sustains a slower, but reasonable, growth level of 6 percent to 7 percent.

Semiconductor Market Forecast

Dataquest believes the China/Hong Kong semiconductor market will fall short of 1997's impressive 19.5 percent growth because of a slowdown in overall electronic equipment production and severe global price erosion. Dataquest's spring forecast had assumed that DRAM prices would bottom out at about the level of manufacturers' variable costs. Unfortunately, DRAM prices have sunk below cost and have yet to hit bottom. At this rate, DRAM revenue could decline 27 percent in China/Hong Kong, despite expected PC unit production growth of more than 40 percent. Assuming non-DRAM products expand by 10 percent, the total semiconductor market would achieve only 6.3 percent growth in 1998. Dataquest considers this forecast to be at the low end of its overall forecast range, while 15.5 percent growth is at the high end, with DRAMs achieving flat growth (which is unlikely). Dataquest will continue to update clients on the Chinese market. Stay tuned. Dataquest's July Market Trends report will present its in-depth analysis of the situation and itemized product forecasts for all semiconductor devices.

Dataquest Perspective

The effect of the global DRAM glut on the Asia/Pacific and Chinese semiconductor markets is the greatest threat to overall revenue growth. However, there is a wide variance in growth prospects across semiconductor products, which Dataquest will highlight in subsequent reports.

The financial crises and economic recessions across Asia/Pacific are expected to recover in two to three years. Despite China's mammoth economic challenges, its management of the economy has, thus far, avoided Southeast Asia's fate. Semiconductor demand continues to be robust, but global overcapacity will dim hopes of another year of double-digit revenue growth in China. However, China will be relatively better off than the rest of Asia/Pacific because of the following obvious fundamental advantages:

- A diverse electronics production base spread across various major sectors in the computer, consumer, and communications industries
- An emerging domestic market, which now consumes almost half of overall electronics production. The other half is exported (of which 31 percent is shipped to the healthy European and U.S. markets, while only 26 percent is exported to Japan and Asia/Pacific).
- Continued confidence and desire to invest by foreign investors, owing primarily to optimistic long-term prospects of the Chinese economy, rising disposable income, and evident market prospects

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- Unwavering government support, with financial resources to spare, for IT adoption in infrastructure development (and the localization of domestic content for communications and computer equipment)
- Rising exports of equipment to the United States and Europe, which account for more than 31 percent of China's total production

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Japan

What's Going on in Japan after the AFC?

Starting with electronics equipment production of Japanese companies in Asian countries, the equipment targeted at internal consumption continues to show low production levels, including audio and video consumer products, as well as that related to PCs, such as storage. Video CDs are still suffering from excess inventory, which is rumored to be a few million units.

On the contrary, image scanner production in Taiwan is booming, and the fast increase in orders for charge-coupled device (CCD) image sensors has resulted in shortage of CCDs, while other semiconductor products suffer excess inventory because production of scanners is now forced to be lower than originally planned.

To take advantage of depreciated currencies, there are notions of intra-Asian shift of production sites. One Japanese audio equipment company decided to move its minicomponent production from mainland China to Malaysia, reportedly for the following two reasons:

- Lowered costs in member countries of Association of Southeast Asian Nations (ASEAN)
- High defect rate at Chinese production site of about 5 percent compared to about 1 percent at the Malaysia site

However, some industry contacts indicate infrastructure problems in ASEAN countries, especially the lack of human resources and of water supply.

These production site shifts, as well as the depreciation of the yen, prompted buyers of semiconductors at the Japanese affiliates to ask their colleagues in Japan to buy Japan-made semiconductors. The currency situation has made initial public offerings (IPOs) difficult for the time being because many Japanese companies assumed ¥130 to 135 to a dollar in their business plan for fiscal 1998. Further yen depreciation—especially if it becomes a constant trend—will make the purchase shift a solid move. (Usually the direct effect of rapid currency change becomes felt in about three to six months, depending on foreign exchange reservations.)

Another factor that is driving the purchase shift is the shortened order cycle. Seeing the fast-falling prices of semiconductors, buyers are unwilling to place long-term orders. Excess capacity in the semiconductor industry is another factor that is encouraging purchasing managers to withhold long-term orders. To cope with the short order cycle, "buying near production site" is preferred, while it is becoming important for semiconductor vendors to produce near the consumption site.

Along with the price fall of DRAMs, Japanese semiconductor companies' revenue outlook in the Asia/Pacific countries is becoming gloomy again, and it looks like the second wave of AFC impact has arrived. The first wave was, of course, all the turmoil caused by the sudden changes in currencies, and the plummeting economy. The second wave is the stage when the AFC hits both countries and corporations (within and outside Asia/Pacific) that are trying to change tactics and strategies to incorporate the new business environment, while the overall economic situation remains turbulent in selected countries.

Japanese semiconductor companies' capital spending this year is decreasing by more than 20 percent on the whole, with a couple of major companies cutting their expenditure in half.

The AFC has hit the semiconductor manufacturing equipment companies hardest here in Japan. The industry association in this area is reporting a reduction of over 40 percent in production of equipment, and the decrease is coming both from domestic semiconductor companies and Asian companies. Especially in Korea, there are indications that Japanese companies with their careful attitude are withholding shipment and future contracts while non-Japanese counterparts are being flexible in terms of trade. Wafers do not seem to suffer as much, but photoresist demand has been lowered substantially.

Looking at the Japanese domestic situation, consumption of end-user products in Japan continues to be sluggish, and even some digital consumer products, such as digital still cameras, seem to be suffering from lowered growth. Infrastructure-related industries, including automobiles, are being affected by reduced demand in various Asian countries.

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Perspective

Semiconductors—Top Views

Market Analysis

How Long Will DRAMs Remain a Quagmire?

The pending sale by Texas Instruments of its memory business to Micron Technology throws the global spotlight on DRAMs. This report provides a comprehensive third quarter 1998 outlook for the worldwide DRAM market. The report provides estimates of 4Mb, 16Mb, and 64Mb DRAM quarterly unit shipments by vendor for the 1998-1999 period. It shows the quarterly DRAM supply and demand outlook for this time frame including detailed analysis of PC DRAM consumption. This Perspective is based on the Executive Summary of **DRAM Supply/Demand Quarterly Statistics: Third Quarter 1998 Outlook** *(DSDR-WW-MS-98Q2).*
By Ronald Bohn, Jim Handy, James Seay, and Masahiro Suzuki

Introduction

This report provides the third quarter 1998 outlook on worldwide DRAM supply based on the results of recent DRAM vendor surveys and related information. The report sets out the DRAM supply/demand scenario for the period from first quarter 1998 through fourth quarter 1999, including detailed analysis of the 16Mb and 64Mb markets. The report also analyzes DRAM demand in detail, based on a forecast of worldwide production of electronic equipment, including PCs, and estimated DRAM megabytes (MB) consumed for each category of equipment.

Objectives

The objective of this forecast and market trends information is to serve as a basis for near-term planning concerning worldwide and regional DRAM manufacturing, sales, and procurement tactics; long-term strategic planning for DRAM product strategy and supply base management; and decision making concerning DRAM capital formation.

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Key Findings

Highlights from the analysis are as follows:

- DRAM vendors should prepare for a 25 percent DRAM bit oversupply in 1998.
- DRAM market conditions likely will improve little for vendors during 1999, which will be another year of large DRAM oversupply.
- DRAM suppliers are aggressively ramping 64Mb output while also producing a large supply of 16Mb devices.
- The oversupply means strong price competition among vendors of 16Mb and 64Mb DRAM—and extreme pressure on these suppliers.

Suppliers' Strategies

Major DRAM manufacturers have achieved two top priorities: the development of high-speed DRAM for PC100 and 64Mb DRAM die-size reductions (or shrinks). The current priority is to achieve higher production yields on high-speed 64Mb parts.

Major manufacturers, especially Japanese companies, will accelerate their shift to 64Mb DRAM and away from 16Mb this year. By contrast, Korean manufacturers will not only increase 64Mb production this year but also maintain a high level of 16Mb production.

The pending sale of Texas Instruments Inc.'s memory business to Micron Technology Inc. indicates that additional company consolidation will occur in the worldwide DRAM market should the severe oversupply continue for another 18 months, as is expected.

16Mb

Suppliers of 16Mb DRAM have forged two main strategies:

- **Moderate shift from 16Mb DRAM**—One approach is to maintain 16Mb production at a relatively high level while proceeding to reduce production moderately. These suppliers have already completed the 16Mb chip shrinks, but low 16Mb pricing means profitability problems. Unless major DRAM manufacturers sharply reduce 16Mb production, the 16Mb market will remain largely oversupplied as forecast.
- ■ **Rapid shift to 64Mb DRAM**—The other approach calls for as rapid a migration to 64Mb and away from 16Mb as possible. These suppliers have focused on 64Mb die shrinks (and not on 16Mb die shrinks). These suppliers face the challenge that 64Mb capacity far exceeds demand, a problem that is exacerbated by low pricing and large supply of 16Mb parts.

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64Mb

The large 16Mb oversupply causes a continual decline in 64Mb pricing. Oversupply in 16Mb has caused vendors to seek any means to avoid the profitless bloodbath in 16Mb pricing. Their efforts have spread the oversupply and the corresponding price erosion to 64Mb as well.

The key applications for 64Mb DRAM are PCs and high-end computers, including PC servers and workstations. Although the 64Mb DRAM provides four times more capacity than 16Mb DRAM, the main memory size of PCs and other computers has increased by less than a factor of four. The result, if DRAM manufacturers ramp their 64Mb production as expected, will be a large 64Mb oversupply.

Even so, major DRAM manufacturers will ramp 64Mb production to keep and increase their market share. This is the basic reason that the DRAM market encounters such a large oversupply. This situation happens historically whenever total DRAM production capacity far exceeds the magnitude of demand.

Currently, there are four kinds of 64Mb DRAM in the market: extended data out (EDO) DRAM, 66-MHz synchronous DRAM (SDRAM), 100-MHz SDRAM (CAS Latency 3, or CL3), and 100-MHz SDRAM (CAS Latency 2, or CL2). The main player as of mid-1998 is the 66-MHz SDRAM. For 1999, that role shifts to the 100-MHz SDRAM, especially the CL2 version. There is some price premium for 100-MHz SDRAM, but that premium will erode gradually toward the end of this year because production capacity will balance with demand for this part by year-end 1998.

4Mb

Major DRAM manufacturers continued to reduce total 4Mb supply; however, they increased the production rate for 256K x16 DRAM. This shift caused an oversupply and a sharp price decline for the 256K x16 part.

DRAM Market Trends

DRAM production capacity continues to clearly exceed DRAM bit demand as of the third quarter 1998. In part because of factors like the Asian crisis, the large DRAM bit oversupply should persist well into 1999. If this prediction proves true, the DRAM oversupply will endure for a longer period (1996-1999) than ever in history. What explains the likelihood of a three-year DRAM oversupply?

Oversupply Factors

The factors involved in this probable oversupply are as follows:

- Factor 1. DRAM manufacturers avoided capital spending reductions as much as possible; this tendency keeps current DRAM production capacity at a high level.

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- Factor 2. Japanese DRAM vendor/manufacturers also use foundries (that is, contract manufacturers), a practice that enables these vendors to maintain high levels of shipments without large investments. Capital spending by Taiwan foundries in effect increases the total DRAM capital spending.
- Factor 3. DRAM manufacturers historically linked DRAM die shrinks to their process technology road map. The chip-shrink methodology was a "linear scaling" type of technology. But most DRAM manufacturers changed their die shrink strategy because of the strong re-emergence of Micron during the mid 1990s. Now, most DRAM manufacturers actively focus on new DRAM shrink technology, with the result being smaller DRAMs (and more bits).

In addition, major DRAM manufacturers have accelerated the use of advanced process technologies for chip shrinks. Historically, process technologies were updated every three years, but this period dramatically shortened starting in 1997. This trend will persist into 1999.

Two-Stage Oversupply

The oversupply that started in 1996 reflects two stages. The first stage is the historical pattern of an overcapacity caused by excessive capital spending. As indicated, the newly emerged second stage results from advanced die-shrink technology, which enables increases in DRAM production without increases in silicon usage.

The DRAM market stands as of mid-1998 at the beginning of the second stage. Barring dramatic organizational change among major DRAM manufacturers in the near future (à la the Micron-TI deal), the oversupply situation will continue until the end of 1999.

64Mb Die Shrinks

A key DRAM supply-side issue centers on the die size of 64Mb DRAM. Major DRAM manufacturers are working aggressively to shrink their 64Mb DRAM die. They plan to develop a 50mm-square, 64Mb die by the end of this year. Dataquest believes the development is possible for major manufacturers.

However, DRAM manufacturers will find it difficult to use the 50mm-square device for mass production at the end of this year because of the lack of appropriate production equipment. A more reasonable 64Mb die size for year-end 1998 mass production will be around 80mm square. If manufacturers rapidly shrink the 64Mb die to 50mm square, some will likely encounter low production yields. (For reference, the advanced 16Mb chip size announced by leading manufacturers was about 60 to 65mm square with 0.35-micron design rules; the size of the 4Mb chip was just under 50mm square.)

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High-Speed DRAM for PC100

As noted, there are two kinds of DRAM for PC100 now. One is the CAS Latency 2 (CL2) and the other is the CAS Latency 3 (CL3).

Originally, Intel expected to have the CL2 version for PC100, but DRAM manufacturers found the device difficult to produce. As a result, Intel accepted a compromised specification (the CL3 version). In order to produce the CL2 version, a 0.27-micron (or less) type of process is likely to be necessary. Both CL3 and CL2 will be used for PC100 during the second half of 1998, but the main player in 1999 will be CL2. If the chip shrink proceeds, the current CL3 version will satisfy the specification of CL2.

Inventory control means PC vendors prefer to use the mainstream device whenever possible, so they will not use CL2 until the CL2 supply capacity is sufficient. Under the current oversupply situation, the DRAM price for PC100 will decline toward the end of this year.

The possible stages of this price decline will be first a CL3 price decline, followed by a CL2 price decline. Eventually, the CL2 version will be used for all PC100 systems in 1999. Therefore, all DRAM manufacturers have to accelerate, as soon as possible, the development and high-yield production of CL2.

As noted in Dataquest's second quarter 1998 report, high-speed DRAM could be a difficult design choice for DRAM users. Users cannot easily switch their high-speed DRAM demand among different manufacturers. For this reason, DRAM manufacturers that release high-speed DRAM before other manufacturers do—and that win device qualification from DRAM users—should secure a better business position. Thus the best strategy for DRAM manufacturers might be to aim for an early release of CL2 so as to win device qualification from PC vendors ahead of the competition.

128Mb DRAM

Dataquest does not include 128Mb DRAM in this report yet because the product is not in mass production. DRAM manufacturers have announced that more than eight manufacturers will develop 128Mb DRAM. Dataquest conservatively forecasts that 24 million units of 128Mb will ship in 1999.

The forecast assumes that the target applications for 128Mb DRAM will be PC servers or higher-level computers and high-end notebook PCs. Just several suppliers could generate 25 million units next year. If eight or more DRAM manufacturers enter the 128Mb market, the market will become oversupplied and the price will drop.

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In terms of pricing, the 128Mb sweet spot for targeting PC servers and high-end notebook PCs will be a price that is just 1.5 to two times more expensive than the 64Mb equivalent. If the bit price of 128Mb declines below this range, the 128Mb device might secure adoption in desktop PCs. In that case, the consumption of 128Mb DRAM would dramatically increase—but so would 128Mb bit supply.

This situation could lengthen the DRAM oversupply beyond the year 1999. At the same time, DRAM price declines will accelerate. If this scenario happens, Dataquest believes that DRAM business will remain unprofitable into the year 2000.

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Perspective

Semiconductors—Top Views

Dataquest Predicts

The Semiconductor Slump: Is There Light at the End of the Tunnel?

Abstract: *The semiconductor industry is mired in a slump that has lasted for several years and shows no sign of immediate relief. Worse than the depth of this down cycle is the growing uncertainty about how long it will be before the industry begins to turn around. In this Perspective, Dataquest analyzes qualitative supply and demand factors affecting semiconductors and what might happen to turn the industry back toward health.*
By Jordan Selburn

Widespread Uncertainty in the Industry

The current semiconductor downturn has continued longer than almost anyone had predicted. Recently, there seems to have been a fundamental change in attitude among industry leaders and watchers. The story at the quarterly financial announcements used to be, "This quarter is flat, we have limited visibility into the following quarter, but things should pick up after that." This has changed to, "This quarter is flat, we have limited visibility into the following quarter and very little idea about what will follow." The uncertainty about the duration of the downturn is widespread, and very few semiconductor companies—certainly no major companies—have escaped its effects.

The question of when semiconductors will pull out of the current slump is on everyone's mind. One approach to finding an answer would be to analyze previous downturns and chart typical semiconductor cycles. However, the factors that have driven past cycles (if there have been common causes in the past, a debatable assertion) are certainly different from those driving the current cycle. A much more rigorous approach, and that taken in this Perspective, is to examine first causes and analyze the supply and demand

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factors for semiconductors. Only when these two components have shifted will there be any change in the semiconductor market.

As part of Dataquest's regular forecast cycle, a number of analysts covering all aspects of semiconductors meet to discuss the factors driving the industry. This Perspective represents the qualitative thinking leading to the actual forecast. The quantitative results of the forecast have been published in a Dataquest Alert on September 22, 1998, with detailed results to be published in a Focus Report in October.

Demand Factors

The Economy

Global Conditions

Asia's economic troubles have definitely thrown the global economy for a loop. In short, the current situation is not pretty. The economic woes that first engulfed Korea and Southeast Asia last summer appear to be spreading throughout Asia. Economic activity has slowed across the region, and most Asian economies now find themselves battling a host of seemingly intractable economic ills. The deteriorating situation in Japan compounds matters. Japanese economic data leaves little doubt that Japan has lapsed into its worst recession since World War II. Added to that, the yen continues to gyrate downward against the dollar, putting devaluation pressure on currencies around the world. Meanwhile, Asia's ills have begun to impose punishing economic strains on economies elsewhere. The effects have been hitting especially hard in emerging economies dependent on industrial commodity exports, notably oil, and inflows of foreign capital. Mexico, Russia, and Brazil top the list of emerging economies victimized by Asia's troubles. Even advanced economies such as the United States and Canada, once judged immune to Asia's woes, have suffered economic bruises. The good news is that the outlook for 1999 looks better. Economic forecasters generally expect an upturn in global economic activity next year. However, most caution that the strength and breadth of this upturn very much depend on how 1998 plays out.

Naturally, all this is taking a toll on the global semiconductor market. Macroeconomic turmoil primarily affects semiconductors on the demand side of the market. There is strong evidence that changes in global gross domestic product (GDP) impact the demand for electronics. This, in turn, affects electronics production and the demand for semiconductors. Macroeconomic upset can also exert secondary effects on the supply side of the semiconductor market through its impact on credit and the availability of capital. Dataquest anticipates a strong adverse impact on semiconductor demand this year because of the economic troubles in Asia and Japan. Economists are virtually unanimous in the belief that gross world product (GWP), valued in U.S. dollars at current exchange rates, will decline in 1998. Worse, they expect especially strong GDP contraction in the Asia/Pacific region and Japan. Indeed, the latest global economic forecast from the WEFA Group indicates that the combined GDP of Asia/Pacific and Japan will decline some 11 percent. Given the size and significance of Asia/Pacific and

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Japanese electronics consumption, these results suggest that semiconductor demand will suffer a substantial setback in 1998.

Macroeconomic-related supply-side impacts are harder to figure and document. The potential for significant macroeconomic supply-side effects certainly exists in Asia. Capital inflows to the region have given way to significant outflows, and there is ample indication that credit has become extremely scarce and costly within the region. Still, aside from anecdotal evidence, there is little clear indication that Asian semiconductor producers face binding macroeconomic-related supply-side constraints.

Fortunately, the economic outlook for 1999 at this point suggests the makings of a turnaround for semiconductors, at least for the demand side of the market. Economists generally agree that world GWP will rise next year. More important, most expect renewed GDP growth for Asia and Japan. For its part, the WEFA Group forecasts that world GWP could jump 7 percent next year (versus a projected decline of 0.4 percent for 1998), with combined GDP growth in Asia/Pacific and Japan pushing 7.5 percent. Should it occur, growth of this sort would provide a powerful demand-side boost to the semiconductor market. Renewed growth in Asia would also greatly ease any macroeconomic-related supply-side constraints that Asian producers currently face. For all their optimism, however, these forecasts can hardly be considered sure bets. As noted earlier, the outlook for 1999 very much depends on how 1998 plays out. On this score, four economies in particular merit close watching through the end of the year: Japan, China, Russia, and the United States.

Russia

Russia could well provide the spark needed. The Russian ruble has faced strong devaluation pressures more or less continuously since last fall. Although the ruble has successfully withstood three aggressive speculative assaults to date, there is growing doubt that it could withstand a fourth. Russia may be resolved to uphold the ruble, but Russia's means to do so are growing dangerously small. Russia is low on foreign reserves and strapped for hard-currency export revenue. The issue is not so much whether the ruble devalues, but how. The greatest fear of economists is that any speculation-induced devaluation of the ruble would be sudden, very chaotic, and virtually without limit. Given the anxious state of international financial markets, a free fall of the ruble would likely induce a panic in equity and currency markets around the world, with devastating effects. As this Perspective was being written, Russia had announced plans to "float" the ruble between R6 and R9.5 to the dollar through at least the end of 1998. (Note: the ruble had already depreciated below R12 to the dollar as of the date of this document and is fluctuating wildly as political events unfold.) Since the value of the ruble will almost certainly "float" downward under this plan, the policy effectively amounts to a devaluation. Whether Russia's new policy will be successful in controlling the ruble's descent is open to debate. Russia's economy remains plagued by a swarm of structural ills that will continue to worry international investors. Added to that, investors will justifiably remain nervous about the impact of woefully depressed oil and natural gas prices on Russian tax and export revenue. Without efforts to

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address these concerns, Russia's latest policy move is unlikely to assuage international anxiety about the ruble. And that spells added danger for semiconductors in the months ahead.

United States

What of the United States? Economists have been changing their tune about the impact of Asia's woes on the U.S. economy over the last few weeks. At the onset of Asia's troubles last fall, the general consensus was that the United States would escape reasonably unscathed. Now many forecasters are not so sure. The Commerce Department's second quarter GDP estimate was the most recent of a series of economic data releases indicating that the U.S. economy has been impacted by Asia far more than first expected. On balance, it still looks as if the U.S. economy as a whole is benefiting from the economic difficulties in Asia and Japan. On the plus side, the influx of less expensive Asian and Japanese imports, together with the lower prices for imported oil that have followed in the wake of Asia's difficulties, are helping to keep U.S. inflation in check. What is more, reduced Asian and Japanese demand for U.S. exports is helping to counterbalance the economic impact of unprecedented growth in U.S. domestic spending. On the minus side, U.S. corporate earnings have begun to slow in response to sagging Asian demand and the general effects of a rising dollar. More important, the U.S. trade deficit is ballooning, and the United States' current account is soaring to levels that could trigger a move against the dollar in world currency markets. Economists fear that both these developments could abruptly reverse the stock market boom that appears to have fueled much of the domestic consumer and capital spending responsible for recent U.S. economic growth. In fact, some see the stock market's recent weakness as the beginning of a recession-inducing downturn. Unfortunately, Asia's ills have been less kind to the U.S. semiconductor industry. U.S. semiconductor and semiconductor equipment makers have suffered sharp slowdowns and, in some cases, significant losses. A downturn in U.S. economic activity at this juncture would be very unwelcome indeed.

In sum, the macroeconomic prospects for a near-term semiconductor turnaround range from poor to fair. A turnaround before the end of 1998 seems highly unlikely. The situation in Asia and Japan is simply too distressed to allow the demand growth the market requires. A turnaround in 1999 seems a better bet but is certainly less than sure. We expect semiconductor demand to revive next year provided the global economy can successfully overcome the threats to renewed 1999 GDP growth. In general, two things must be accomplished. Asia must be revived, and the risk of new currency turmoil must be reduced, if not eliminated. To date, policy efforts aimed at these goals have been carried out on a country-by-country basis. It increasingly appears that this piecemeal approach has failed. Indeed, if anything, the approach appears to have created more problems than it has solved. Many economists now believe that resolving these matters requires altogether new policy prescriptions that stress multilateral and cooperative solutions. These new prescriptions will undoubtedly require rethinking the notions of moral hazard and economic culpability that have dominated the unilateral approaches tried so far. The semiconductor industry would be wise

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to support these new efforts since the future health of the semiconductor market ultimately depends on the vigor of the world's macroeconomy.

Japan

The International Monetary Fund (IMF) announced in August a forecast for Japan of a 1.7 percent GDP contraction over the previous year. This recession is being caused by decline in various factors, such as private consumption, private investment, residential construction, and both exports and imports. Along with the additional stimulus package including ¥10 trillion of additional public spending and ¥7 trillion in tax cuts, as well as measures for financial stability, it will be vital for Japanese domestic private consumption and investment to regain momentum.

The Japanese semiconductor market is still suffering from oversupply and subsequent weak pricing. The economic sluggishness weakened demand for semiconductors because electronics equipment produced within Japan has, over the recent few years, become primarily dependent on the domestic market. Therefore, the key to recovery lies in increasing demand stemming from emerging applications in digital consumer and communication areas. Both electronics companies and semiconductor companies have taken whatever measures they themselves can take, including developing new systems and bringing prices down quickly. Now the electronics industry is beginning to feel that the growth of electronics production, hence the growth of semiconductor consumption, depends on an overall recovery in the global economy. An increase in private consumption will also mean an increase of imports from Asia/Pacific countries, helping them secure the path for recovery from the Asian financial crisis.

The yen has been depreciated to a level unseen since early 1990s, discouraging imports that were already affected by reduced domestic demand. In electronics, yen depreciation is not expected to bring the great advantages it might have in the 1980s because goods exported to overseas markets are now manufactured at foreign sites—mostly in Asia/Pacific countries. The falling yen is likely hurting Japan more than helping it. To be sure, the yen's fall is helping to stimulate Japanese exports, but it is also intensifying domestic uncertainty and encouraging capital outflows from Japan. More important, it is imposing substantial economic punishment on Japan's troubled Asian trading partners. Despite some recent strength, a reversal in the overall trend of the yen's weakening with respect to the dollar is not expected in the foreseeable future, and the majority of economists expect the exchange rate to hit ¥150 or more to the dollar by the end of 1998. Further deterioration in the yen-to-dollar exchange rate will pose threats to the currencies of Asia/Pacific countries, hampering economic recovery in those countries.

Japan's long-term economic prosperity is inextricably linked to the economic health and vigor of its Asian neighbors. The weak yen, however it may improve terms of trade for exports, cannot be translated into an increase in exports from Japan at the expense of slowing economies in Asia/Pacific, because further deterioration in other Asian economies will affect Japan. The continuing fluctuation in exchange rates has made Japanese semiconductor

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users tend to buy semiconductors in Japan, even though they use the parts in their electronics production sites overseas, mainly in various Asian countries. Stability in the yen exchange rate itself will encourage a return to global semiconductor purchasing.

China

Although China remains a relatively minor electronics consumer and semiconductor producer, it could make the one move in 1998 that would almost certainly break the 1999 semiconductor market: devalue its currency, the renminbi-yuan. Economists generally agree that a Chinese devaluation would likely plunge both Asia and the rest of the world into an economic crisis that could rival the Great Depression of 1929. Their concern is that a renminbi-yuan devaluation would set off a disastrous round of competitive currency devaluation around the world that would paralyze financial markets and freeze international trade. To date, China has steadfastly maintained the value of its currency, albeit at significant economic cost. China has seen its growth slow, its exports contract, and its competitiveness erode as Asia's troubles have deepened. The question of devaluation is not black and white, because simply devaluing the currency does not solve China's growth challenges. It is the combination of domestic spending, foreign investment, government projects, and exports that determines growth in China's large economy. Exports account for less than 25 percent of industrial output and less than 20 percent of GDP. But no one gets something from nothing. A weaker yuan obviously means higher import costs, which China's exporters depend on in the form of key components and raw materials (semiconductors, textiles, steel and so on). Unlike Taiwan, Japan, and Korea, China's industries are not fully integrated. Hence, economists in Hong Kong and China are against devaluation at this point. There are geopolitical concerns as well. Because China is running a huge trade deficit with the United States, its main trading partner, sudden devaluation would no doubt result in a congressional backlash.

But there are concerns that falling exports *and* a slowing economy will force China to devalue, potentially sparking another round of disastrous currency depreciation in Asia. It is a question of time. Certainly, China will devalue, but whether it will be before or after the region has recovered is the issue. Japan's yen is at the center of China's currency question. A weaker yen will seriously hurt China's economy, which is why China continues to hint at devaluing each time the yen falls. China's efforts to restructure its economy require growth. If Asia continues to falter or the yen falls too much more, China may reach a point at which it feels it has sacrificed enough and may move to devalue.

In 1998, the Chinese government has been under extreme pressure to maintain strong economic growth and create new jobs because of the dismantling of state-owned industries, which is creating millions of surplus workers. So far, the Chinese leadership has supported its currency at the expense of economic growth and is using infrastructure spending (and microeconomic levers), not currency-driven exports, to foster growth. Recently, the government committed some U.S.$250 billion in infrastructure spending projects. Dataquest cannot make a direct connection between communications equipment spending and a yuan valuation. If spending is needed to bolster the economy, then these outlays will continue to be made, especially since they are viewed as long-term necessities (to modernize the economy).

Korea

Korea has been greatly impacted by the Asian financial crisis and the continuing free fall in DRAM prices. The Korean won has depreciated by over 50 percent versus the U.S. dollar over the past year, and the overall Korean trade surplus could drop to $10 billion in 1998, according to the Korea Institute for Industrial Economics and Trade.

The weakening yen poses a particular threat to the Korean semiconductor industry. Some estimates show that each 1 percent loss of the yen's value versus the dollar could result in a $630 million decrease in Korean exports; for example, a fall in the yen to ¥150 per dollar could reduce Korean exports by over $4.5 billion. Until the economic situation solidifies in the rest of Asia, particularly Japan, it is unlikely that Korea will see a major upturn. Offsetting the current regional stagnation, however, are two trends. First, the global reduction of DRAM manufacturing capacity now beginning should stabilize DRAM pricing, which will disproportionately help Korea. Second, the potential merger between Hyundai's and LG Semicon's semiconductor groups could allow for cost reductions and greater profitability in the Korean electronics industry, helping the Korean economy as a whole.

Semiconductor Application Markets

Consumer

The prior Dataquest forecast for consumer electronics relied on legacy consumer electronics markets eroding minimally while digitally enhanced and next-generation products drove overall growth. However, legacy products are declining at a more rapid pace, and digitally enhanced products are not compensating for this drop. In the next-generation category, price pressure is again causing reduced expectations. The brightest spot in the next-generation category is digital set-top boxes, driven by new opportunities in digital cable. However, video games will have a negative impact on the market in the next two years. In 1998, video games, which have been a major driver of next-generation growth over the past three years, will grow only slightly, hitting a peak before the start of a new video game market cycle, which will result in overall video game hardware market declines for the next 24 months or longer.

Digital set-top box shipments are undergoing rapid growth. However, the price erosion of semiconductors is dampening the growth of the associated chip market. In 1999, this should begin to change some as new, more sophisticated digital cable boxes come to market that have more valuable semiconductor content. This will help the digital cable box semiconductor market to grow and will serve as an engine of overall consumer semiconductor growth over the next several years.

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Wireless Communications

The high-flying wireless semiconductor market growth crashed to earth in 1998. During the past three or four years, the strong growth in the semiconductor market for mobile communications has been dominated by the ramp-up in the digital cellular handset market. The growth in production of associated mobile communications infrastructure has also contributed to this growth. These product categories have been the dominant drivers of strong double-digit growth for semiconductors from 1994 through 1997. Although Dataquest still forecasts relatively strong growth for production of digital cellular handsets, the severe price erosion for semiconductors in these handsets, along with integration trends, is placing a major damper on semiconductor market growth expectations. The mobile communications category does not include cordless handsets, which are grouped in the premise telecommunications category. The increase in the popularity of digital cordless products such as DECT and 900-MHz digital and spread-spectrum handsets is expected to add some growth to the overall wireless communications semiconductor market in the near term, but this will fade as a growth driver in 2000 and beyond. Dataquest is predicting that wireless semiconductor market growth will drop into the high single digits in 1998 and 1999.

A number of elements are taking shape that Dataquest expects will help boost the growth of the wireless communications semiconductor market into double digits beginning in 2000. First, it is anticipated that semiconductor prices in handsets will start to stabilize about this point. Also, there will be increased opportunity for creating additional value for functions such as global positioning system (GPS) location services and higher data rate services in handsets. There is a great deal of discussion revolving around the introduction of third-generation (3G) wireless services starting in 2000, but Dataquest is very skeptical about this timeline. Dataquest does not expect a significant 3G wireless market to take shape before 2003. Even though there have been a number of semiconductor product announcements related to 3G products during 1998, this segment of the market will be delayed beyond current industry expectations. However, new initiatives and products related to home and personal wireless networks, such as Shared Wireless Access Protocol (SWAP) and Bluetooth, do show promise for boosting wireless growth in 2000 and beyond. These efforts could help wireless semiconductors penetrate a wide range of electronics products in an increasingly networked environment.

Wired Communications

During 1997, enterprise networking created strong demand for 10/100-Mbps Ethernet solutions. Although this upgrade cycle is continuing, competition and ASP erosion will keep growth in check. There is no really hot new technology waiting to take the enterprise networking area by storm in the next one to two years. Gigabit Ethernet is expected to remain a backbone technology until at least 2002. If copper Gigabit Ethernet proves to be successful, there could be some upside in about 2001, but prices must fall significantly first. Home networking is not expected to have significant market impact before 2000, but this outcome depends to some extent on a single "killer application": distributing Internet bandwidth in the home.

When all is said and done, unit demand for converged voice/data/video networks remains very strong from a unit perspective. The LAN segment remains on track; although this is good for current market participants, it also means that the semiconductor industry cannot look to wired communications to single-handedly turn the overall market around.

Personal Computers

The excitement in PCs lately has come from the emerging sub-$1,000 machine. These inexpensive boxes have maintained the market's unit growth, but a significant part of the cost cutting that makes these PCs so attractive has come from the semiconductor content. One of the reasons that the sub-$1,000 PC is flourishing is the impressive computing power a few dollars buys. In the home at least, but to some extent in businesses as well, there is little need for a processor beyond today's low-cost entry-level chips from Intel (the Celeron) and its competitors, principally Advanced Micro Devices (the K6) and Cyrix. These processors can easily handle the vast majority of today's computing tasks, giving customers little reason to spend more for a state-of-the-art PC. Renewed growth in the overall PC market will be driven by new applications, such as voice recognition, that push desktop data processing to the limit and force users to ante up for a new high-end personal computer.

Supply Factors

Semiconductor Devices

DRAM

While many semiconductor industry watchers are predicting a fundamental change and an end to cyclicity (where have we heard that before?), a few are beginning to suggest that an upturn may be just round the corner. The last time an end to cyclicity was mooted was in 1995, at the end of a prolonged growth cycle, when it seemed impossible that the market could crash ever again. But crash it did, principally because of a huge buildup of DRAM capacity. Many are convinced that something new is going on because the current DRAM recession has resulted in an unprecedented third consecutive year of revenue contraction—about a 40 percent drop in 1996 and a 20 percent drop in 1997, with a further decline of 20 percent forecast for 1998. What is more interesting, though, is the rolling annual growth profile during the past three years. Here, a more familiar story is unfolding. Figure 1 shows the current semiconductor market downturn, which began in 1996, superimposed on the two previous market downturns, which began in 1981 and 1985. All three of these downturns were DRAM induced, and it is possible to deduce a common rolling annual growth profile split into four sections: crash, recovery, stall, and takeoff. Not only that, there is common seasonality as well. So, maybe the current semiconductor market downturn is not unique, and a common trend is being masked by the absolute level of annual growth measured at the end of a particular year.

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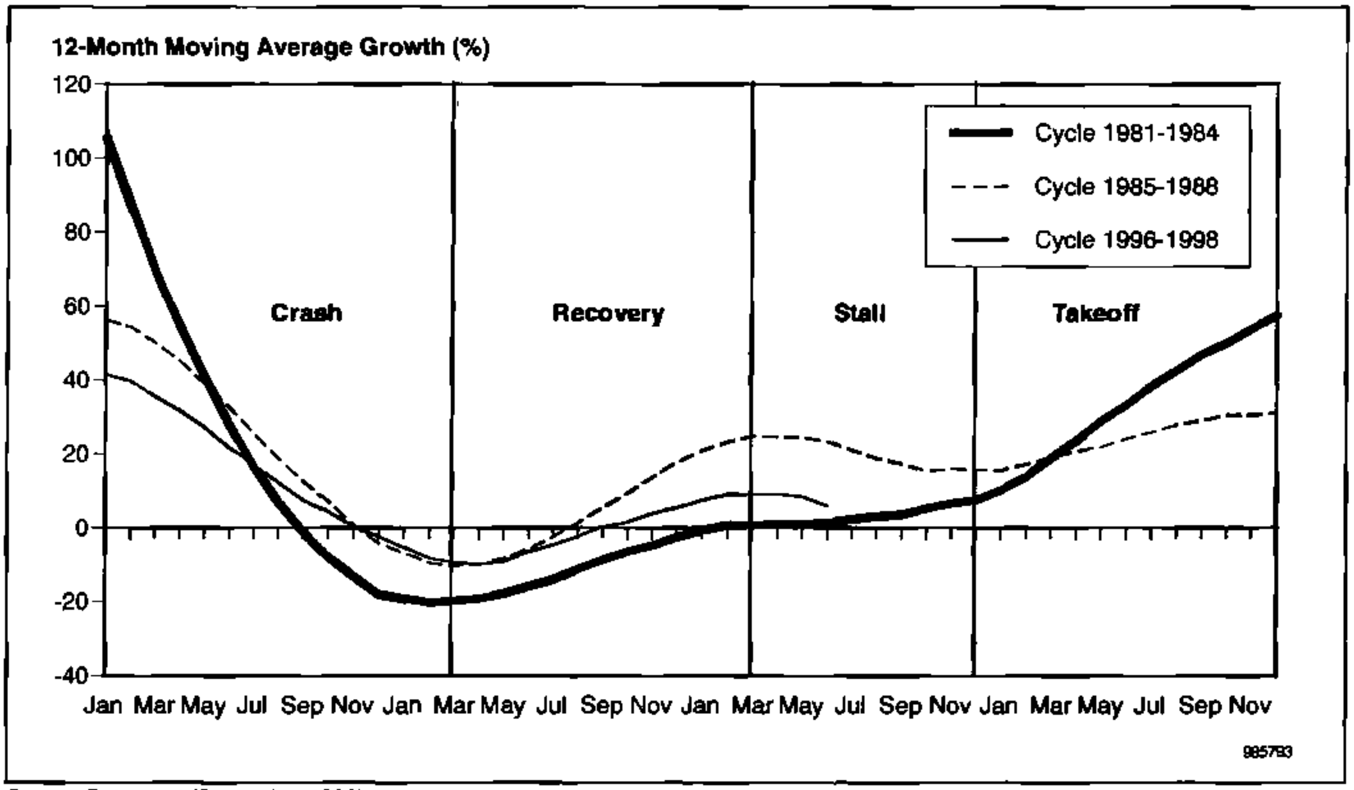
Figure 1
Comparison of Semiconductor Industry Cycles



Source: Dataquest (September 1998)

It must be remembered that the semiconductor industry is influenced by the DRAM market more than by any other product category. And DRAM is pure commodity—the balance between supply and demand is critical and the link to capital spending inextricable. So, when forecasting the growth prospects of the semiconductor industry as a whole, DRAM market conditions are key. Sophisticated arguments about macroeconomic conditions, GDP growth, end-user equipment demand, and structural changes in the semiconductor industry (for example, the trend toward system-level integration, or SLI) all have their place and should be considered during the forecast process, but special consideration should be given to how they affect the core growth influence: the DRAM market. The latest slump in the semiconductor market was caused primarily by DRAM overcapacity and a resulting price crash; the overcapacity was driven by the first causes mentioned earlier. It should be noted that the demand for DRAM, as measured by the bit growth rate, continues to be relatively strong, with only the overcapacity driving prices down.So one of the most important factors in a semiconductor industry recovery is a reversal of the DRAM market conditions that caused the malaise.

Assuming that the number of DRAM bits shipped continues to increase at a rate consistent with history (about 70 percent, for the sake of argument), then it is the level of production capacity that will determine whether the DRAM market is oversupplied or undersupplied and whether prices, revenue, and margins are low or high. The continuous increase in DRAM bit demand sits uneasily with short but intensive bursts of periodic investment, and it is this relationship that causes DRAM market cyclicity. As with all commodities, today's investment affects tomorrow's market, and the recent switch in DRAM capital investment will have its effect. Demand will catch up with supply, and a period of improving market growth will begin in late 1999/early 2000 and last through 2002. In today's oversupplied DRAM market, prices remain depressed and continue to decline, and it is all too easy to continue to predict a gloomy outlook. Forget all the rational arguments and all the reasons why a recovery may not happen—trust in the industry cycles and look forward to a DRAM boom.

Analog

Given the analog IC industry's characteristics of broad-end application market exposure, relatively stable pricing, and high gross margins, analog IC companies have been largely immune to the semiconductor downturn until now. In fact, since 1996, the analog IC market has been outperforming the general semiconductor market. In 1996, the total semiconductor market declined 6 percent, compared with a 10 percent growth rate for analog ICs. In 1997, analog ICs grew 19 percent, while the overall semiconductor market grew a mere 4 percent. The analog IC market has declined progressively since April 1998, and many companies have cited the U.S. and overseas distribution channels as contributing significantly to the weakness. Distribution typically accounts for 40 to 50 percent of a company's total analog IC sales, and a large portion of the sales through distribution goes to the industrial sector. As a result, the health of the analog IC market is closely linked to the strength of the industrial sector or the GDP growth rate. While the U.S. economy remained robust through the first quarter of 1998, it slowed considerably in the second quarter as the Asian economic crisis deepened. U.S. GDP grew a mere 1.4 percent in the second quarter, compared to the 5.5 percent registered in the first quarter. The U.S. industrial sector slowed considerably in the second quarter from the first quarter, as measured by the purchasing managers' composite index of industrial activity. Dataquest believes that the slowdown of U.S. industrial activity in the second quarter has contributed significantly to the decline of the analog IC market (which also started in April).

Distribution sales typically account for 30 to 50 percent of a company's total analog IC sales, and a large portion of the sales through the distribution channel goes to the industrial sector. Therefore, the distribution weakness signals a reduction or pause of demand from the industrial OEMs. This is likely caused by the weak economic conditions in Asia/Pacific and Japan, and the effects on U.S. industrial companies.

Analog IC companies have finally become victims of the semiconductor downturn. Does this mean that the downturn will become prolonged now that the most resilient companies have surrendered? Historically, analog IC company performance tends to lag behind the decline of the semiconductor market because of the industry's unique characteristics. Therefore, if history is of any relevance, it is less likely that the current weakness of the analog IC market signals the beginning of a much-prolonged downturn than that it signals the proximity of the trough.

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However, this downturn might be unique in that global economic conditions, especially in Japan and the emerging markets, could be different from those in historical downturns. If Japan and the emerging economies from Asia to Russia to Latin America could avoid a worsening of the crisis and regain stability, then an end to the semiconductor decline might indeed be close. On the other hand, if the turmoil were to deepen and spread, this would not be likely to result in healthy demand for electronics equipment, and hence the road to semiconductor recovery could become longer. The next few months will be crucial in determining which scenario is likely to occur, and Dataquest will be watching closely.

Semiconductor Manufacturing Equipment

Suppliers of equipment and materials to the semiconductor industry have been suffering now on and off for two years as the semiconductor industry dealt with a severe case of overcapacity. Flowering in the second half of 1997 was the Asian financial crisis, which has caused the economies of that region to grind to a halt, along with the semiconductor consumption that goes with it. If the industry cannot get off this falling elevator, it must at least try to find the "up" button—the fundamental issues that will get the semiconductor industry and spending back on track.

Aggressive investment in 0.25-micron technology throughout 1997 has only exacerbated the persistent overcapacity in the industry. Dataquest has been calling for a W-shaped recovery pattern in wafer fab equipment, with the second-phase downturn being caused by the fundamentals of overcapacity and with financial health eventually winning over the desire for technology. As this second phase now unfolds with very deep spending cuts in 1998, the questions begin for 1999. Were the cutbacks deep enough to correct the oversupply? When can a sustainable recovery really begin? What will fundamentally bring it back?

We can now say, for the first time in the last several forecast cycles, that we see the fundamental issue that will bring the next spending boom in 2000 and 2001, starting in about the fourth quarter of 1999. The main fuel for the 2000-2001 boom will be the return of DRAM spending resulting from an undersupply that will emerge.

In DRAM, there has been a net addition of capacity in the last two years beyond the requirements for silicon area. At present, Dataquest is estimating the overcapacity in DRAM to be between 20 and 25 percent. The movement of the industry to the more silicon-efficient 64Mb density will sustain the oversupply throughout 1999. Our silicon demand model shows that, with the forecast 60 to 70 percent bit growth rate in 1998 and 1999, about 6 to 9 percent less silicon will be required by the end of 1999 than is now consumed.

However, net supply will be tending to decrease as well over the next 18 months as capital spending cuts make their mark on reducing the rate of supply increase. As time passes, larger line-width capacity naturally exits the market, and Dataquest is estimating that this "attrition" will actually outpace new supply. In addition, we expect capacity to actively exit the market, meaning that fabs now in commission will be closed or mothballed. This could take several forms, including companies leaving the market, consolidation in the industry, and outright mothballing of fabs. A recent example is the net loss of the TwinStar fab in the United States, which was part of the sale of Texas Instruments' memory business to Micron Technology. This fab is being mothballed as a result of the consolidation of capacity, and the equipment is being reallocated and sold. The situation should set up nicely for a shortage of capacity in 2000.

Silicon consumption in the DRAM market accounts for 13 to 16 percent of silicon consumption, and, in order to meet the bit demand in 1999, about 8 percent less silicon will be required at the end of 1999, compared to the end of 1998, primarily because of the silicon efficiencies generated by the 64Mb density. As the DRAM density transition is completed, sequential silicon demand should accelerate into 2000, giving continued double-digit millions of square inches (MSI) growth rates through 2001. The reduced capital spending pattern of 1998 and 1999 should actually set net capacity in the DRAM area on a downward trend. In 2000, these two trends meet to produce an undersupply.

The foundry market has also made a transition to overcapacity. Unfortunately, the stall in semiconductor demand has made the forecast oversupply much more acute, and it is now calculated to be between 30 and 40 percent. Foundry suppliers have reacted to this oversupply much faster than DRAM suppliers by planning to cut back spending heavily for the remainder of 1998. The growth of total spending in 1998 for foundry suppliers is now estimated at 20 percent, compared to earlier estimates of 40 percent. We expect 1999 spending to be cut significantly, perhaps 20 to 30 percent below 1998 levels, in the foundry area.

Today's excess foundry capacity is also technologically mismatched, with the current demand creating a "technology glut." The greatest oversupply exists in the leading-edge technology. This is confirmed by recent trends in wafer processes, where the most severe declines could be seen first in 0.35-micron and now in 0.25-micron wafers.

Compared to Dataquest's forecast of six months ago, the picture has changed. Both the upswing and the start of the next down cycle have been pushed out by one year. Why? The answer is that semiconductor demand has stalled in 1998. Economies in Japan and other Asian countries have slowed tremendously in recent months, and this has impacted electronic equipment demand in consumer electronics and automotive, with a slight impact on computing.

One way to view 1998 is that the semiconductor industry demand profile has inserted a one-year "holding pattern," as well as a one-year delay, in any recovery that was previously forecast. This has made the secondary downturn we were expecting appear much more severe, because the industry will be making only minimum investments during the next 12 months. Because a sustainable recovery in spending and the equipment market must come from capacity buying, there must be a healthy chip market in 1998 if the equipment market is to grow in 1999. It does not appear that the

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chip market can mount a recovery until next year, so we have downgraded the 1999 wafer fab equipment forecast to be essentially flat from 1998 levels.

As with Dataquest's year-end forecast process, the midyear forecast was being developed against the background of a rapidly changing picture in capital spending, emanating from changes in semiconductor demand and the present downward spiral in spending levels. Despite what feels to the industry like falling off a cliff, Dataquest believes that the downturn will reach bottom in the third quarter of 1998, with a slight uptick in the fourth quarter. The uptick is motivated by seasonality as much as by a possible increase in Japanese spending as Japanese companies head into the second half of the fiscal year, having "underspent" in the first half. There is even some upside potential, although we believe that the probability of the upside occurring is only 15 percent.

In this time of gloom, thinking of an upside potential might seem odd. Yet an examination of the history of wafer fab equipment shipments reveals that this industry does not normally make small moves from quarter to quarter. And change can happen relatively fast.

The upside scenario is based on the possibility that the PC market, which is the strongest driver of semiconductor consumption, shows unexpected signs of life in the second half of 1998. Recent DRAM order surprises from PC manufacturers lend some credence to the scenario. If the PC market strengthens, it would lead to an uptick in semiconductor demand overall and, in particular, in DRAM demand. The consequences are clear. Increased semiconductor revenue could arrive after a delay of six to nine months as capital spending levels increase.

Overall, Dataquest assumes in the 1999 upside scenario that capital spending could grow by nearly 12 percent, compared to about 4.5 percent in the forecast mentioned earlier. The assumption about which companies would differentially increase spending is directly related to the assumption that PC unit shipments will be unexpectedly strong in the second half of 1998. Under this scenario, it is quite conceivable that Intel could accelerate capacity spending in the second quarter of 1999, rather than the fourth quarter of 1999, as assumed in the forecast. Further, since the PC market accounts for 70 percent of fabless company shipments, an increase in foundry demand over Dataquest's forecast could renew spending in the second half of 1999. Our current forecast for foundry spending throughout all of 1999 calls for spending at the rate of the second half of 1998, leading to a year-over-year spending cut of about 20 to 30 percent. Renewed second half 1999 spending could essentially make year-over-year comparisons flat. These assumptions mean that logic-oriented spending will be favored in the upside scenario over DRAM spending, because Dataquest believes that the DRAM oversupply will persist in the face of a better-than-expected market.

What is the probability of the upside scenario coming to pass? Dataquest believes that it is low, only about 10 to 15 percent. But it is a possibility.

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Dataquest Perspective: Where Is the Balance?

The semiconductor industry has been mired in a slump for longer than most participants would have predicted. Of even more concern is the uncertainty that the industry faces: Is this a cyclical slump, such as has been seen in the past, or is there a fundamental change in the industry? It is possible, after all, that the semiconductor market is maturing and that average annual growth of about 17 percent will no longer be seen. Some of the signs of a mature market are already here. There has been and continues to be a great deal of consolidation in the industry as medium-size companies seek to survive by becoming major players and large companies seek to maintain their competitive position and attain even better economies of scale. Not unlike the automobile industry, in most segments of the semiconductor industry, the top few companies represent the dominant part of the market. Even given some of these trends, it is unlikely, for now at least, that the semiconductor industry will achieve the status of a mature industry. There are still too many opportunities for growth, and the primary question is "when," not "if." New markets such as home networking and digital video seemed poised to expand rapidly when overall economic conditions permit.

When will the semiconductor industry break out? Dataquest will publish the detailed quantitative forecast in the near future, but barring any of several "killer asteroid" events, such as a complete collapse of the Japanese economy, the most likely scenario points to the second half of 1999 as the start of the turnaround for semiconductors, with manufacturing equipment following six months to a year later. Other major events, such as the ubiquitous year 2000 problem, could shift this turnaround substantially either way. This means that lean times will continue for the next year or slightly longer and that 1999 overall will not be a spectacular year. However, the pieces are in place for a return to better times when the new millennium arrives. Although a return to the heady days of the mid-1990s is unlikely, from today's perspective, the 17 percent historic norms for semiconductors look quite attractive indeed.

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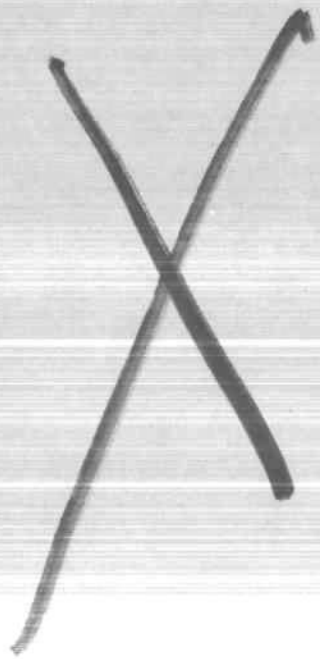

Perspective

Semiconductors Worldwide

Technology Analysis

Next-Generation High-Density Packaging Technology

Abstract: *Low-cost chip scale package (CSP) technology is now entering its growth stage as a package for system-level integration ASICs, memory, and standard logic devices. Demand from compact and lightweight systems, such as mobile communications and digital consumer equipment, is a major driver for the growth of CSP and other emerging package technologies, such as ball grid array and flip chip. This Perspective analyzes these new technologies, which hold the key to the miniaturization and successful implementation of next-generation submicron devices.*

By Yoshihisa Toyosaki and Mary Ann Olsson

Emerging Package Technology Drivers

The economic turmoil in Asia, coupled with the financial troubles in Japan, resulted in tremendous price pressure on electronic goods being shipped to Europe and the Americas during the past 12 months. The industry downturn that began in December 1995 continues to depress the pricing of most devices. A handful of semiconductor companies are reporting early signs of improvement in sales of new low-voltage, high-performance products. However, most semiconductor suppliers, including fabless suppliers, are still in the throes of a serious demand and pricing slump. System-pricing pressure has forced many competitors to increase the pressure on manufacturing margins for several key electronics products. Declining system average selling prices (ASPs) in many applications are putting pressure on semiconductor makers. Although volume demand is good in many communications, consumer, and data processing segments, declining ASPs are damaging system revenue growth and putting pressure on the dollar value of semiconductor content.

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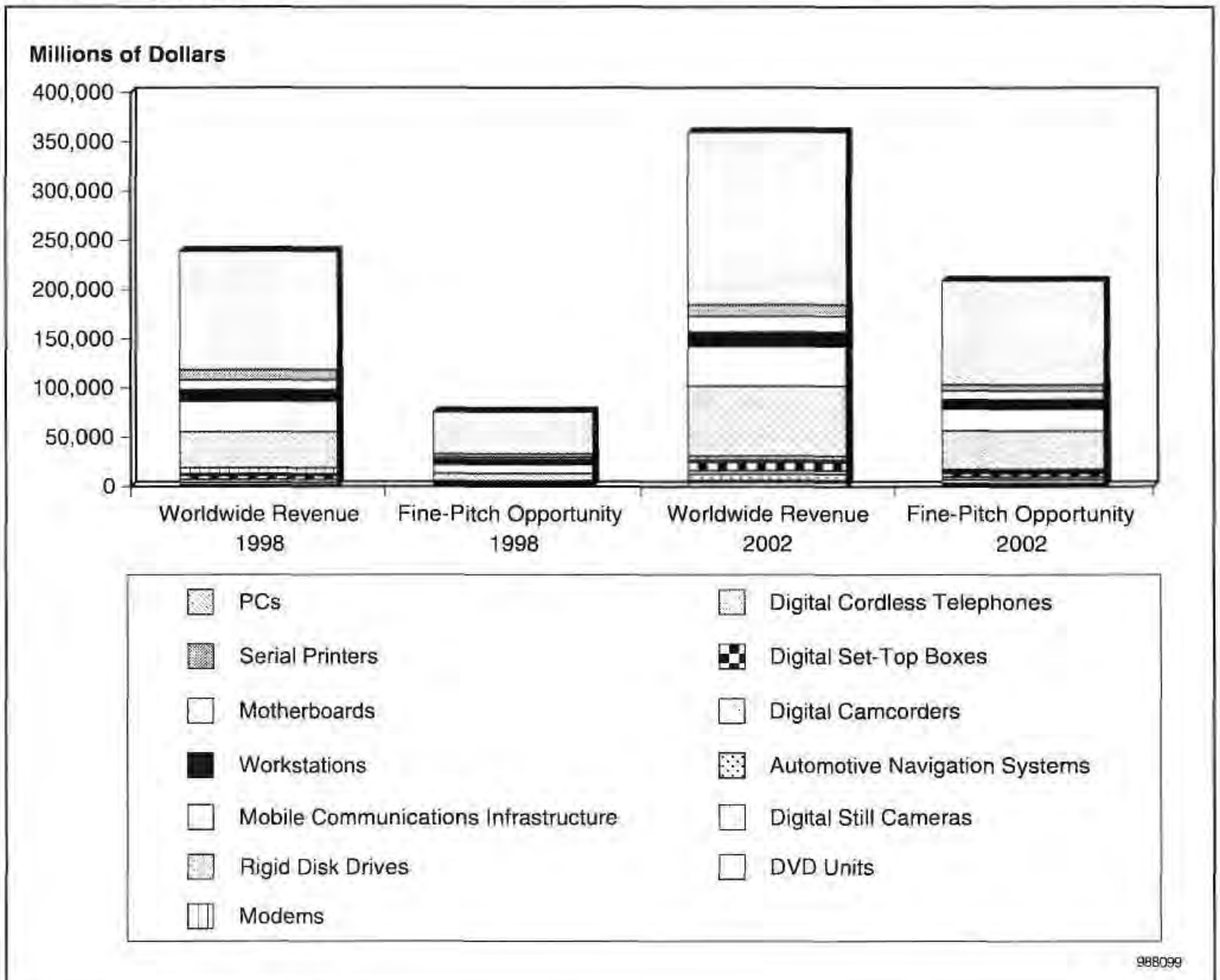
To increase their profit margins and distinguish their value-added products, many semiconductor manufacturers are positioning their emerging products and technologies for growth. They are offering new cost-effective, high-performance value-added product and technology solutions that meet various price points for both high-end and low-end systems. Manufacturers are concentrating their efforts on growth opportunities in the top emerging consumer, communications, and data processing equipment markets. In particular, wireless and digital consumer applications have the potential to enhance growth of digital signal processors (DSPs) and embedded and digital application-specific IC (ASIC) products. A large proportion of these value-added solutions will come from new and emerging package technologies. Figure 1 highlights selected applications that are revenue opportunities for new fine-pitch packages. These applications, in addition to next-generation digital consumer applications, PC cards, memory modules, switches and routers, base stations, thin server workstations, and notebook and laptop PCs, are increasing demand for small form-factor packages.

Figure 1
Selected Worldwide Semiconductor Application Opportunities for Fine-Pitch Packages (Millions of Dollars)



Source: Dataquest (November 1998)

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Emerging Package Developments

The greatest package challenge in 1979 came from two electronics sectors. First, the consumer sector began its initial phase of growth of semiconductor content. Valued at less than $5 billion in the United States in 1970, the consumer sector's semiconductor content represented about 5 percent of total semiconductor consumption. Between 1970 and 1975, this percentage grew to 12 percent, which precipitated one of the greatest changes in semiconductor package technology. Through-hole technology remained king of the computer, industrial, and military sectors. Hybrids were the mainstay technology for communications and automotive equipment. However, the need for low cost and miniaturization drove the consumption of new small outline (SO) and chip carrier surface mount technology (SMT) packages that offered up to 5:1 area reductions and up to 84 input/output (I/O) pins. The improved parameters offered by SMT became critical in the consumer sector in watches, calculators, video games, clocks, handheld radios, disk cameras, and TVs. Development of these systems would not have been possible without SMT.

Second, the semiconductor industry's shift to VLSI technology and the rapid entry of Japanese companies into the DRAM markets pushed through-hole technology to its limits. SMT technology offered not only low cost and reduced board space, but also high I/O capability, improved electrical performance characteristics, and ease of handling by automated assembly processes. Japanese companies, by virtue of their majority share of the consumer business, their lead in automated assembly, and their strong SMT focus on SO for logic and memory devices, led the charge and changed the course of package history.

Current Market Status

Today's semiconductor package industry is in the throes of another major upheaval. Volume production is currently focused on shrink versions of existing SO and quad flat packages (QFPs). Advanced area array packages and attach techniques such as ball grid array (BGA), flip chip, multichip module (MCM), direct chip attach (DCA), column grid array (CGA), and chip scale package (CSP) formats are being designed in at a faster pace than previously forecast. Widely used in new applications, these packages meet the increased demand for miniaturization, lower cost, and improved electrical performance. Because of their chip-size appearance, many of these package techniques are lumped into the very popular market category now referred to as CSP.

By industry definition, a true CSP is a die size no larger than 1.2 times the size of the chip design. The Ultra BGA, microBGA and other advanced BGA packages with flip chip attach are advertised as CSPs. This marketing cognomen adds even more confusion to a market already overburdened with package-acronym proliferation. From a density point of view, a CSP by any other name is positioned between standard packages and wafer-level techniques such as flip chip, chip stacks, and DCA. These various technical idiosyncrasies or nuances will eventually be surpassed by volume design wins. Given the industrywide trend toward increasingly high-density ultra-VLSI designs, most of the latest CSP and BGA designs are feasible solutions for a wide range of applications. Figure 2 illustrates the evolution of some of these ultra-VLSI and system-level interconnect designs. Table 1 shows new technologies implemented by some of the major semiconductor companies.

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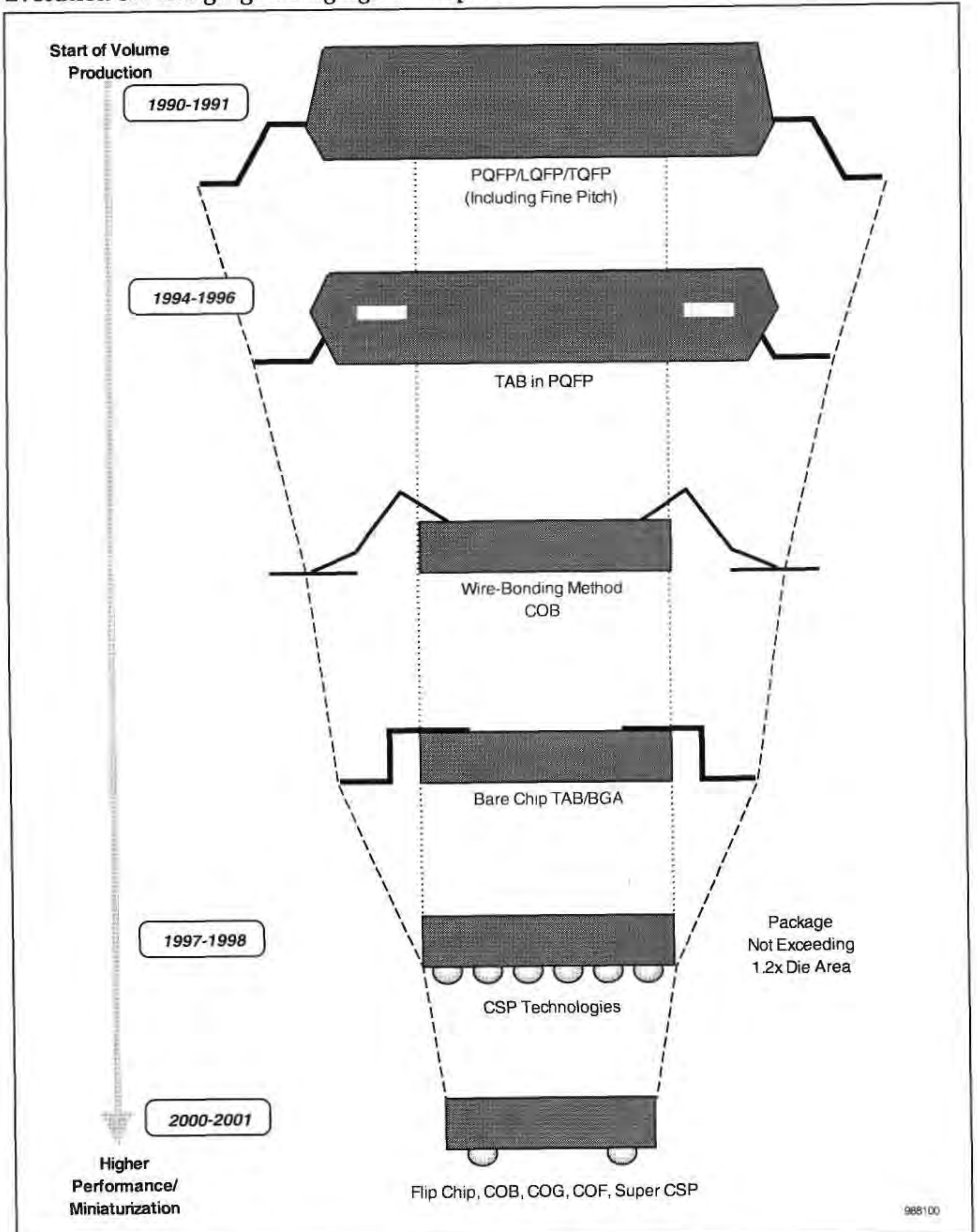
Figure 2
Evolution of Emerging Packaging Techniques



Source: Dataquest (November 1998)

Table 1
Emerging Package Technologies by Selected Companies

	Fujitsu	Hitachi	Hyundai	Intel	LG Semicon	LSI Logic	Matsushita	Mitsubishi	NEC	Oki	Rohm	Samsung	Sharp	Sony	Texas Instruments	Toshiba	VLSI Technology
Product	SON	μBGA	μBGA	μBGA	BLP	Sharp agreement	MNPAC	FPBGA	D2BGA	μBGA	FμBGA	μBGA	-	TGA	microStar BGA	CSTP	FPBGA
CSP Technologies	FPBGA, μBGA, FC-BBG, BCC, SOC	T-TFBGA, P-TFBGA	-	-	-	SFP	QFN	P-FBGA	FPBGA, Mold BGA	Tab BGA, FC-BGA, WB-BGA, WB-LGA	TFBGA	-	μBGA	NT-CSP, FPBGA	-	μBGA, P-FPBGA	FPBGA
Terminal Pitch (mm)	0.5	0.8, 0.75, 0.5	0.75, 0.65	0.75	0.8, 0.65, 10.5	1.0, 0.8, 0.5	1.0, 0.8	0.8	0.8, 0.5	0.8, 0.75	0.8	0.75	1.0, 0.8	0.8, 0.5	0.8, 0.65, 0.5	0.8, 0.75	0.8, 0.5
Interposer Substrate Material	Lead frame	Polyimide	Polyimide	Polyimide	Polyimide	Polyimide	Ceramic (alumina)	Glass epoxy	Polyimide	Polyimide	Polyimide	Polyimide	Polyimide	Organic resin	Polyimide	Polyimide	Polyimide
Die Connection Technology	Wire bond	Beam lead bond	Beam lead bond	Beam lead bond	Wire bond	Wire bond	Flip chip	Wire bond	Wire bond	Beam lead bond	Wire bond	Beam lead bond	Wire bond	Flip chip	Wire bond	Wire bond	Wire bond
Die Electrode Layout	Peripheral/ center	Peripheral	Peripheral	Peripheral	Center	Peripheral	Peripheral/ full array	Peripheral	Adaptable to all types	Peripheral/ full array	Peripheral	Peripheral/ Center	Peripheral	Peripheral/ full array	Peripheral	Peripheral/ Center	Peripheral
Die Circumference (mm)	0.6	0.3, 0.5	0.5	0.5	0.6	0.5	0.4	1.0	0.5	0.5	1.0	0.3-0.5	0.5	1.0	1.0	0.3	0.3
Devices	Flash	DRAM, ASIC	SRAM	Flash	DRAM	ASIC	ASIC	DRAM	ASIC	DRAM, ASIC	ASIC	DRAM	Flash	ASIC	ASIC, DSP	DRAM, ASIC	ASIC
Volume Production	Now	Now	Now	Now	Now	Now	Now	Now	Now	Now	Now	Now	Now	Now	Now	Q4/98	Now
Proprietary CSP Technology	Yes	No (Tessera license)	No (Tessera license)	No (Tessera license)	Yes	No (Sharp foundry agreement)	Yes (joint development with Kyocera)	Yes	Yes	Yes	Yes	No (Tessera license)	Yes	Yes	Yes	Yes	No (Amkor)

Source: Dataquest (November 1998)

Traditionally, the time scale involved from package technology acceptance to implementation has been substantially longer than a semiconductor device or system application life cycle. To illustrate the time required for market penetration of a new package technology, the cycle has been divided into four phases, as shown on Table 2. We have attempted to position the new package categories (area arrays, CSPs, flip chip, and wafer level interconnects) in this time line.

Table 2
Emerging Package Technology Timeline, 1992 to 2010

Category/Description	Year of Adoption
Development	
Preliminary package design, selection of materials, process development, standards development	1992 to 1997
Prototype Use	
Sample shipment, reliability testing, socket and manufacturing equipment developments	1995 to 1998
Application Development	
Product evaluation, supply of printed circuit board and CAD tools	1996 to 1999
Volume Production	
Enhancement of product offerings, diversification of printed circuit board and CAD vendors, diversification of test tools	1998 to 2010

Source: Dataquest (November 1998)

Package Opportunities

From a demand side, the largest group of users of new miniature, below-100 I/O CSP designs will be suppliers of passive, discrete, flash memory, RDRAM, and optical components, IC cards, and memory modules. According to Amkor, about 80 percent of CSP designs have involved lead counts of between 28 and 48 pins.

The second-largest group of users for fine-pitch or CSP designs is the high-I/O ASIC suppliers. Figure 3 illustrates a road map littered with new CSP designs that will satisfy form factor requirements for ASIC users. This market is being driven by system cost, form factor and size, feature set, and time to market. VLSI Technology is shipping ASIC devices in 0.8mm fine-pitch BGAs (FPBGAs), in volume (over 1 million) in the fourth quarter of 1998. The second-generation 0.5mm FPBGAs will be shipped in 1999. These products were designed for the wireless/portable market. Suppliers such as VLSI Technology, LSI Logic, and Xilinx and equipment manufacturers such as Ericsson, Nokia, QUALCOMM, and Motorola all agree that the new FPBGAs, which will represent 10 percent of the handset market in 1999, could represent almost 50 percent of that wireless market by 2000. For many of the ASIC designs in the high-lead arena, current FPBGAs are priced at 1.2 times the cost of a thin quad flat package (TQFP) design.

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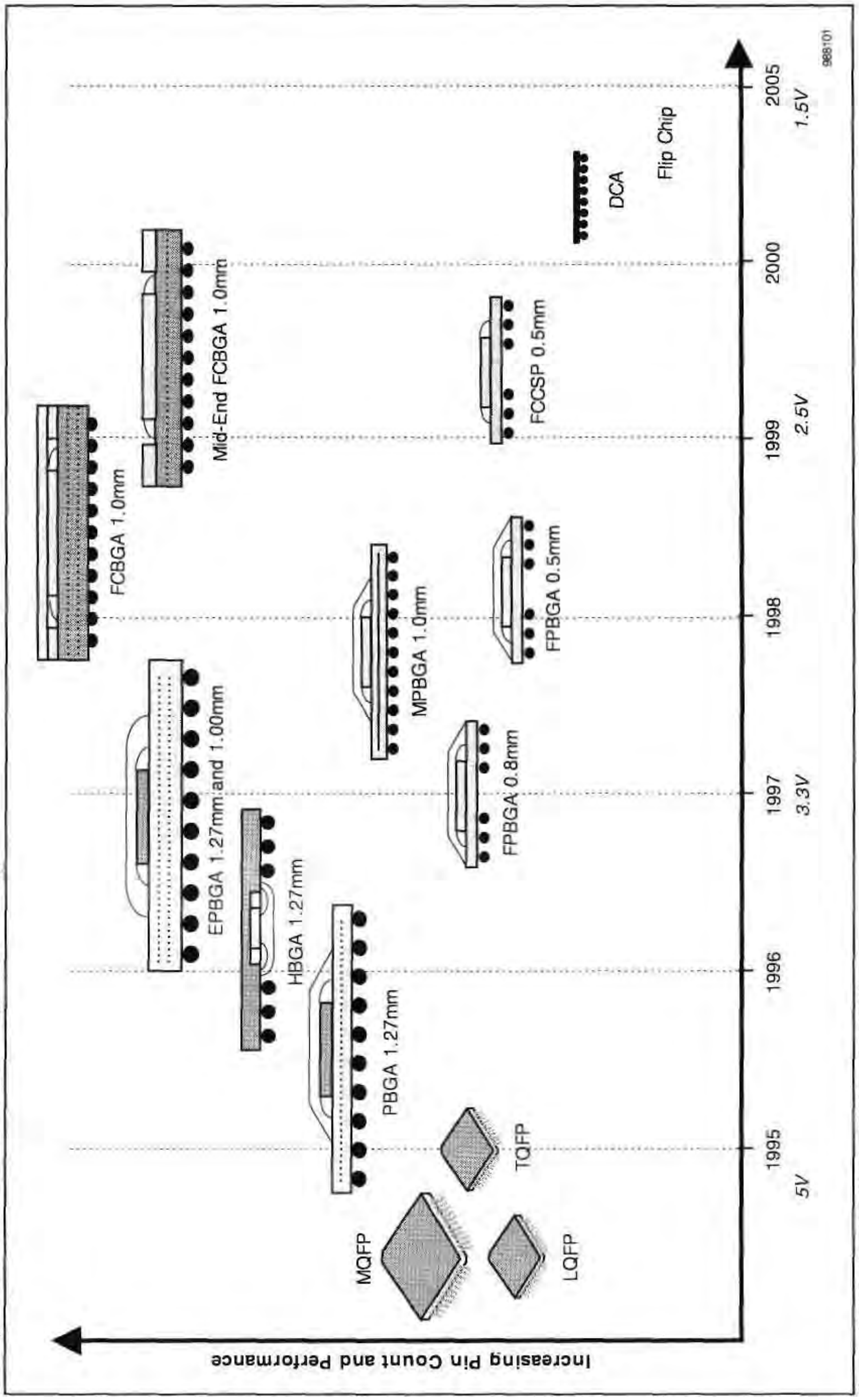
Figure 3
A High-Density Fine-Pitch Package Road Map



Source: VLSI Technology, Dataquest (November 1998)

In the memory category, flash memory suppliers entered the CSP market using various microBGA designs. The larger-volume DRAM suppliers could turn the tide of capacity challenges when and if they switch package designs from thin small-outline packages (TSOPs) to some of the new, smaller BGA designs. As cost per lead of CSPs and BGAs reaches parity with comparable TSOP and QFP designs in 1999, the capacity of advanced packaging technologies could become constrained.

In the memory area, some of the most recent announcements from Mitsubishi include new molded CSP (M-CSP), multichip package (MCP), and stacked MCP (S-MCP) designs for SRAMs and flash memories. Mitsubishi and Sharp are collaborating on common pin compatibility and package size configurations. Xicor has introduced the XBGA for EEPROM. Toshiba and Fujitsu have jointly agreed on the BGA MCP design, which allows mounting of both SRAM and flash in a single package. This new configuration takes up about 70 percent less space than two TSOPs. In volume production, the new MCP will be priced the same as a flash and an SRAM in separate TSOP packages.

In the logic area, Integrated Device Technology, Philips Semiconductors, and Texas Instruments have jointly agreed to source several logic device designs in new low-profile fine-pitch BGAs (LFBGAs) with 0.8mm 96-lead designs. Compared to thin shrink small-outline packages (TSSOPs), the new LFBGAs reduce board space up to 65 percent for the same functionality. The companies have announced that these new designs are up to 50 percent more efficient at dissipating heat than TSSOPs.

Technology Advantages and Disadvantages

It is not the role of Dataquest to sing the praises or assess the capability of one supplier's or subcontractor's package over another's. It is important to report the user concerns about the advantages or disadvantages of various technologies. Many of the advanced BGA and CSP designs proliferating in the market pose multiple challenges, obstacles, and advantages that need to be addressed before complete market acceptance is reached. Some of these obstacles include the following:

- Limited test techniques and higher test costs
- Narrow terminal pitch width
- Increased costs of wiring patterns on PCs
- Lack of standards on lead and package design
- Test socket connection
- Standardization on tape and reel
- Assembly-handling equipment
- Visual inspection equipment requirements
- Routing, signal integrity, thermal, and mechanical issues

Some of the advantages include the following:

- Smaller form factor than standard SO and QFP packages

- Board space savings from miniaturization
- Higher chip performance because of electrical and thermal characteristics
- Lower power consumption in application
- Lower system board cost

Some of the design challenges result from increased demand for alternative technologies, which now include flip chip attach and known good die. Most of the latest advanced BGA and CSP designs have reached the 0.8mm-to-0.5mm ball pitch required for the 0.35-micron-to-0.25-micron device regime. The high cost of substrates, assembly techniques (either flip chip or wire bond), smaller die, and smaller pad pitch require a more advanced regime of testing, handling, and inspection and CAD tools not readily available. Ultimately, the level of market penetration will govern the price. A technology cannot achieve the lowest possible cost unless it follows the learning curves determined by very high-volume production. Any advanced package technology involves certain risk until official standards or pseudo-standards are established to determine a "technological winner."

Dataquest Perspective

The semiconductor industry has entered the age of system-level integration (SLI) for ASICs and embedded applications for memory, microprocessor, DSP, and other logic products. It has become imperative for semiconductor suppliers and package subcontractors to respond effectively to the needs of application equipment vendors. Advanced package developments, analyzed in this light, promise to be a haven for profit and growth. Historically, most semiconductor companies have developed products on the basis of supply-side dynamics, but they lacked the marketing savvy to serve the needs of the application market. Their future success will be based on their ability to cooperate with subcontractors (foundry and assembly). The shift from 0.8mm to 0.5mm and below pitch packages will involve a tremendous technological challenge over the next few years. The differences among the various BGA- or CSP-type designs and standards being proposed clearly indicate that all efforts must be directed toward package miniaturization, increased lead counts, and low cost. As the industry drives semiconductor process technology into the realm of 0.18-micron geometries between 2005 and 2010, the next package challenge will be faced by the users and developers of the DCA and flip chip technology platforms.

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Perspective

Semiconductors Worldwide

Market Analysis

Mergers and Acquisitions in the Analog and Mixed-Signal IC Industry

Abstract: *This Perspective reviews the mergers and acquisitions in the analog and mixed-signal IC industry and provides analysis of their strategic implications. The long-term trend for mergers and acquisitions in the analog and mixed-signal IC industry is also discussed.*
By Jim Liang

Introduction

The analog IC market is a unique segment of the semiconductor industry in that there are more than 60 players with annual revenue larger than $20 million, 40 of which are based in North America. Moreover, competition in the analog IC market is diffused, with no single company occupying more than 11 percent of the total market. Factors contributing to the diffused competition include low capital requirements for analog IC companies, diverse end markets for analog ICs that give rise to many niche-oriented small companies, and relatively high and stable margins on analog ICs, which allow many companies to be consistently profitable.

Although the analog IC market has been growing at a compound annual growth rate (CAGR) of over 17 percent since 1975, the industry's growth rate has slowed in recent years to about 15 percent per year, in line with the overall semiconductor market. Dataquest projects that the analog IC market will grow at a CAGR of 13.4 percent between 1997 and 2002. It is likely that the analog IC industry is entering into a more mature stage, together with the overall semiconductor industry.

On the other hand, analog ICs have revived their importance in the digital age. As the world goes more and more digital, the demand for analog ICs has

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actually increased. This is because the digital revolution has dramatically reduced the cost of the systems and, in turn, stimulated larger demand for digital systems. Moreover, in every digital system, analog ICs are needed to interface with the real world. In particular, the demand for power management ICs such as voltage regulators has soared in both portable systems, such as cell phones and notebook PCs, and in desktop PCs. As a result, there have been many new players entering the market in the past few years to capitalize on the growing need for analog ICs used in digital systems. These are mostly smaller players with revenue of around $50 million and who are targeted toward a specific niche market.

Mergers and acquisitions have been increasing in the analog IC market space, partly as a result of the large number of small players and partly because the industry's growth rate is not as fast as before. This Perspective takes a look at the merger and acquisition activities in the North American analog IC market and analyzes the outlook.

Industry Overview

In order to understand merger and acquisition activities in the analog IC industry, it is important to study the industry landscape first. The North American analog IC industry can be divided into three segments: the large-capitalization companies, the small-capitalization companies, and the medium-capitalization companies. Listed next are the major companies in the three segments. These companies all have analog IC sales as a major portion of their total revenue.

The large-capitalization companies include the following:

- Analog Devices (ADI)
- Motorola
- National Semiconductor
- Texas Instruments (TI)

The small-capitalization companies include the following:

- Elantec
- TelCom Semiconductor
- Linfinity Semiconductor
- Supertex
- Exar
- IMP
- Integrated Circuit Systems
- Unitrode
- Micro Linear
- Sipex

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- Cherry Semiconductor
- Dallas Semiconductor
- IC WORKS
- IMI
- Siliconix
- Anadigics
- TriQuint Semiconductor
- Pericom Semiconductor
- Power Integrations
- Impala Linear
- Calogic
- CP Clare

The medium-capitalization companies include the following:

- Linear Technology
- Maxim
- Micrel
- Semtech
- Burr-Brown

The three segments represent very different business strategies and characteristics. Table 1 outlines the major differences between the three segments.

Table 1
Business Strategies and Characteristics for Analog IC Companies in the Three Segments

Segment	Strategy	Characteristic
Large-Capitalization Companies	Provide both digital and analog IC solutions and develop systems-level chips for mass markets by integrating both digital and analog ICs on the same chip.	Are diversified in terms of end markets and have more stable revenue growth rates. All have significant digital IC expertise. TI, Motorola, and ADI have digital signal processing (DSP) technology. National has microprocessor technology.
Small-Capitalization Companies	Focus on a specific high-growth end market and become a niche supplier to that market.	Can have a very high growth rate when the targeted end market is growing quickly but could falter once that end market slows.
Medium-Capitalization Companies	Focus on multiple high-growth end markets and provide proprietary high-performance analog ICs to those markets.	Recognized as the leading high-performance analog IC suppliers, they have the highest gross margins and fastest growth rates and, as a result, the highest valuation multiples in the analog IC industry.

Source: Dataquest (December 1998)

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Now that we understand the industry landscape, what kind of merger and acquisition activities have occurred in the analog IC industry recently? The following section offers an analysis of the major merger and acquisition activities in the analog IC market in 1998.

Mergers and Acquisitions

Unitrode and BENCHMARQ Merge to Tackle the Portable Power Market

On March 2, 1998, Unitrode Corporation and BENCHMARQ Microelectronics Inc. announced a definitive merger agreement under which BENCHMARQ shareholders will receive one share of Unitrode common stock for each share of BENCHMARQ common stock outstanding. The combined company aims to accelerate penetration of the portable power market and increase growth opportunities in other rapidly growing markets.

Dataquest Analysis

Unitrode is one of the leading power management IC suppliers. Of its 1997 revenue of about $170 million, more than 70 percent was supplied to the power management market, with the remaining going to the disk drive industry. In the power management area, Unitrode offers the pulse-width modulation (PWM) voltage regulation modules (VRMs) that are supplied mostly to the desktop PC market. The growing power requirement of the Pentium and the Pentium II processor modules has spurred the growth of the desktop PC power management market and benefited players such as Unitrode, Semtech, Harris Semiconductor, and Cherry Semiconductor that supply to the desktop PC market.

BENCHMARQ Microelectronics, with 1997 revenue of about $44 million, is a leading supplier of battery management ICs. Battery management products represented about 60 percent of BENCHMARQ's 1997 revenue and grew 30 percent from 1996 to 1997. The remaining revenue came from nonvolatile static RAM (NVSRAM) products. The battery management products are supplied to the portable electronics market, including the wireless phone and notebook PC market.

Dataquest views this merger favorably as a sound strategic move for the following four reasons:

- This merger has brought together two closely related product lines—the power management ICs from Unitrode and battery management ICs from BENCHMARQ—to create a broad-based power IC supplier.
- The merger offers the combined company the channel that BENCHMARQ has established with the portable electronics vendors, including the wireless phone and notebook PC suppliers, which gives the combined company an opportunity to make significant inroads into the wireless phone and notebook PC power management arena.

- BENCHMARQ's mixed-signal CMOS design capability should complement Unitrode's BiCMOS process technology and a new 6-inch wafer fab.
- The combined company overall will be less dependent on the disk drive and NVSRAM markets, which were experiencing difficult market conditions.

Semtech Acquires Acapella to Enter High-Speed Communications Market

On April 29, 1998, Semtech Corp. announced the acquisition of Acapella Ltd. in the United Kingdom, a designer of complex mixed-signal ICs for fiber-optic communications. Acapella also provides design consultancy services for a wide range of electronic companies. Semtech has exchanged 175,000 shares of its common stock for all outstanding shares of common stock of Acapella.

Dataquest Analysis

Semtech has transformed itself from a military-focused company a couple of years ago to a largely commercial manufacturer today. Military business accounted for 40 percent of its business four years ago and accounts for about 10 percent today. The transformation of Semtech started with its move into the analog power management market for PCs. In 1997, Semtech was among the leading suppliers of power management ICs for the Pentium and Pentium II processor modules. To further diversify its business, Semtech acquired Edge Semiconductor in 1997 and entered the Automatic Testing Equipment (ATE) IC market. The acquisition of Acapella is Semtech's latest endeavor to diversify, this time into the high-speed communications market.

Acapella is a fabless design house with about 12 designers focused on providing IC solutions for the emerging fiber local loop market. Acapella has developed a proprietary technology to implement time-division multiplexing (TDM). It named this technology "Ping Pong" because just as a ball goes back and forth between two ends in a ping pong game, the Acapella technology is about fiber-optic transceivers deployed at the two ends of the fiber that can both transmit (convert electrical signal to optic and send to fiber) and receive (receive from fiber and convert optical to electrical) signals. Given the potential emergence of the fiber local loop technology, where fiber is used to replace copper as the signal carrier to dramatically increase speed and bandwidth, Semtech has a shot in pulling off another successful diversification move.

CP Clare Acquires Analog ASIC Vendor Micronix to Enter Analog IC Market

On July 6, 1998, CP Clare Corporation announced the acquisition of Micronix Integrated Systems Inc. Micronix, a privately held fabless analog ASIC company located in Aliso Viejo, California, had about $9 million in revenue for the year ending June 30, 1998. CP Clare paid $15.8 million in cash for all of the outstanding shares of common stock of Micronix.

Dataquest Analysis

CP Clare provides high-voltage discrete semiconductor components and packages, electromagnetic relays and switches, and surge protection devices, mostly for the communications market. Of its 1997 revenue of $156 million, about 45 percent came from high-voltage discrete semiconductor components. One of CP Clare's core competencies is its deep trenching technology to manufacture circuits with high-breakdown voltages approaching 300 volts.

Micronix is a specialized analog ASIC design house with about 10 experienced analog designers. This acquisition provides CP Clare with the analog IC design talents that are scarce today. Moreover, this marks an entry point for CP Clare to venture into the high-performance analog IC market for telecom applications. With Micronix's analog IC design expertise and CP Clare's high-voltage BiCMOS process technology and fab capacity, combined further with CP Clare's channel relationship with the communications OEMs, this marriage certainly makes strategic sense.

Micrel Acquires Synergy Semiconductor to Target the High-Speed Communications Market

On October 22, 1998, Micrel Inc. and Synergy Semiconductor Corp. announced that they entered into a definitive merger agreement whereby Micrel will acquire all of Synergy's shares for about $13 million in cash. Synergy, a provider of mixed-signal and digital integrated circuits for the communications, high-performance computing, and ATE industries, had about $28 million in revenue in 1998.

Dataquest Analysis

Micrel Semiconductor has emerged as one of the brightest stars in the "pure play" analog universe over the past few years. In the last three years, Micrel's revenue has been growing at a CAGR of over 50 percent. While the core competency of the company has been in supplying low dropout (LDO) regulators for the wireless market and has garnered great success in winning key business from wireless OEMs such as QUALCOMM, Micrel has been actively broadening its high-performance analog business portfolios. The company has not only expanded its LDO regulator business to other portable markets but has also become a leading supplier of power controllers for PC Memory Card Interface Association (PCMCIA) and universal serial bus (USB). In June 1998, Micrel ventured into the consumer radio frequency (RF) market with a radio transceiver product for remote actuation systems. With annual revenue of around $140 million, Micrel has until now grown its business without any acquisition.

Synergy, a privately held company founded in 1987, provides high-performance bipolar ICs for the networking, telecommunications, computing, and ATE markets. Synergy's products include communications transceivers, clock generators, clock recovery circuits, and high-speed logic and memory.

Micrel's ability to build on its core competency in power management design and process technology and aggressively identify and occupy fast-growing niche markets has been the key reason behind its rapid growth. In the meantime, Micrel's relatively small revenue base has been a contributing factor for the rapid growth rate. It is not inconceivable that the company's internal growth could slow down from the current rate as the company's revenue base hits $250 million and beyond. In that case, Micrel's internal growth rate would likely be more comparable to that of Linear Technology, which is around 20 to 25 percent per year. To realize the company's stated goal of becoming the leading high-performance analog IC manufacturer, Micrel needs to do more than just grow internally. This acquisition of Synergy is likely the first of more to come from Micrel.

This acquisition signifies more than just revenue expansion. What Micrel receives from the acquisition is about 16 analog designers, a 40 percent expansion of analog design resource for Micrel. Also, Micrel obtains Synergy's new 10,000-sq. ft., 6-inch bipolar fab, located in Santa Clara, California. More importantly, Micrel now has something that it did not have before—Synergy's high-speed bipolar technology called All Spacer Separated Element Transistor (ASSET). This patented technology makes possible high-speed circuits using the bipolar process, eliminating the need to go to subquarter-micron CMOS to achieve comparable speed. As a result, Micrel is now equipped to jump into the fast-growing SONET, Gigabit Ethernet, and Fiber Channel arenas and is now positioned to compete with companies such as Applied Micro Circuits and Vitesse Semiconductor. These competitors are certainly not amateurs, and Dataquest expects a fierce contest ahead.

Dataquest Perspective

With the analog IC industry growing at a slower rate than before and the small-capitalization segment crowded by many participants, Dataquest expects more consolidation to occur as the industry moves forward. The small-capitalization players, in an effort to diversify their end markets and lessen their business volatility, could potentially merge with other small players or be acquired by larger players. Private start-ups may seek strategic acquirers, rather than go public, to gain access to critical channels and resources. Ambitious medium-capitalization players, such as Micrel and Semtech, that are growing rapidly with the aim of joining the league of large-capitalization companies in the not-too-distant future will continue to seize opportunities to expand through acquisition. The large-capitalization companies, in an effort to maintain leading market shares and fend off competition from both medium-capitalization and small-capitalization players, are likely to be acquirers in the future. Digital IC companies may acquire analog IC companies in an attempt to add analog technology to their portfolios and provide single-chip mixed-signal solutions for high-volume markets. Leveraged buyout (LBO) firms, enticed by the analog IC industry's unique characteristics of high profit margin, high return on equity (ROE), and stable growth rate, combined with many companies' rich cash positions, may decide to invite themselves into the game.

Stay tuned.

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Perspective

Semiconductors Worldwide

Event Summary

1998 Analog and Mixed-Signal Applications Conference

Abstract: *This Perspective summarizes the Analog and Mixed-Signal Applications Conference held in July in San Jose, California. This Event Summary briefly relates all significant announcements and comments pertaining to key developments. Further details on technical presentations are available from the Dataquest inquiry service.*
By Jim Liang

Event Background and Overview

This year's Analog and Mixed-Signal Applications Conference, sponsored by *EE Times*, was held on July 13 and 14 in San Jose, California. The event was started in 1991 and has been held annually, except in 1993 and 1996. The conference addresses both traditional analog and contemporary mixed-signal issues in a variety of fast-growing market segments, including computer, communications, and consumer markets.

In addition to industry heavyweights Texas Instruments, Motorola, STMicroelectronics, Philips, and Lucent Technologies, conference presenters included not only traditional analog names such as National Semiconductor, Analog Devices, Linear Technology, Micrel Semiconductor, Cirrus Logic, Cherry Semiconductor, Burr-Brown, Harris Semiconductor, TelCom Semiconductor, and Micro Linear, but also new players, such as LSI Logic (a digital ASIC supplier), which is entering the mixed-signal field from the digital end.

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Technical Session Topics

The following lists the technical session topics from this year's conference:

- High-speed communications
- Low power design
- Advanced electronic design automation
- Buses and motors
- Radio frequency (RF) and cell phone design issues
- Modeling techniques
- Pentium power supplies
- Analog-to-digital performance issues
- Multimedia
- Advanced integration issues
- Using operational amplifiers

There were a total of about 60 papers presented. Among them, Dataquest believes that the following two are worth an extra look because they represent key application trends for the analog and mixed-signal IC market:

- "Low-Dropout Regulators for Battery-Operated System Applications," from TelCom Semiconductor
- "A Comparison of High-Speed, Mixed-Signal VLSI Technologies for RF/Wireless Applications," from National Instruments

Low-Dropout Regulators for Battery-Operated Systems

The physical size of battery-operated systems, such as cell phones and personal digital assistants (PDAs), shrinks with each new generation. The decrease of system size results in the reduction of battery size, which in turn causes the battery's energy capacity to drop, forcing the system to operate on smaller amounts of current. A major performance benchmark in battery-operated systems is the operating time between battery charges. In order to achieve longer operating time, with decreasing energy capacity, power efficiency maximization has become an increasingly important task.

Low-dropout regulators (LDOs) are linear regulators capable of operating with small input-output voltage differentials (that is, dropout voltage). Low dropout voltage and low supply current make LDOs particularly attractive in battery-operated systems, because these characteristics result in better power efficiency. A major application of LDOs is in digital cellular phones, where battery life (or talk time) is of key importance. As discussed in the Dataquest Perspective "Analog and Mixed-Signal IC Applications in Digital Cellular

Phones," the market for LDOs used in digital cellular phones is estimated to be about $290 million for 1997, and is projected to grow at a compound annual growth rate (CAGR) of 18 percent to reach over $660 million by 2002. This strong growth is the result of the rapid expansion of the cellular phone market, combined with the increasing need for better power efficiency.

Although bipolar process technology traditionally is used to fabricate LDOs, there is an increasing trend toward using CMOS process technology. TelCom Semiconductor presented a paper comparing these two technologies.

A bipolar LDO uses either an NPN or a PNP series pass transistor, whereas a CMOS LDO generally uses P-channel MOSFET as the pass transistor. As a result, bipolar LDOs have the drawbacks of relatively high dropout voltage and high ground current. CMOS LDOs, in contrast, have the advantages of both low dropout voltage and low ground current. Also, CMOS LDOs allow for the possibility of future integration of LDOs with other digital circuitry. This integration could pave the way for system-on-a-chip solutions, such as single-chip cellular phones. TelCom Semiconductor performed side-by-side testing of the performance characteristics of both bipolar and CMOS LDOs and confirmed CMOS LDOs' advantages of low dropout voltage and low ground current. However, bipolar LDOs generally have better RF performance characteristics, such as lower noise and faster transient response. Therefore, in applications where battery life is more critical than noise characteristics, CMOS LDOs are the preferred choice.

Dataquest believes that there is room for further technology advancement to achieve LDOs with the ideal characteristics of low dropout voltage and low noise, because in applications such as cell phones, both battery life and RF performance are important.

VLSI Technologies for RF

RF semiconductors have emerged as one of the fastest-growing segments within the semiconductor industry, mostly as a result of the burgeoning wireless communications market . The semiconductors used in wireless systems can be partitioned into two major segments: RF semiconductors, which are used in the radio portion of a wireless system, and baseband semiconductors, which include microcontrollers, DSPs, microprocessors, memory, power management, and display semiconductors.

The explosive growth of the wireless communications market has driven the demand for systems with low cost, low power, and small size. In order to meet this demand, Dataquest expects the total semiconductor content of a typical wireless product, such as a digital cellular phone, to be reduced from $73 worth in 1997 to $40 worth by 2002. This reduction is driven by higher levels of CMOS integration in both the RF section and the baseband section. Furthermore, Dataquest expects that the RF section and the baseband section will eventually be integrated to achieve the lowest cost and power and the smallest size. Therefore, there will be an increasing trend toward integration in the RF section and ultimately in the entire system.

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While the growth of the PC market has resulted in the advancement of digital VLSI technology in manufacturing memory and microprocessors, the growth of the wireless market is likely to advance VLSI technology for RF. However, the technical requirement for RF ICs, such as low noise, high gain, linearity, and power efficiency, are much more complex and do not necessarily improve with lithographic scaling or integration levels. Also, the typical RF section is made up of various components, such as amplifiers, synthesizers, transmitters, receivers, and switches. Each of these components tends to achieve optimum performance in widely different and incompatible technologies, which include silicon-based technologies such as CMOS and BiCMOS, gallium arsenide-based technologies such as MESFET and HBT, and silicon germanium-based technologies.

The optimum technology choice for an RF application is determined by issues of performance, wafer cost, level of integration, and time to market. National Instruments presented a paper comparing various technologies used for RF ICs.

Until recently, gallium arsenide (GaAs) technology was expected to dominate the RF IC arena because of its proven microwave performance. However, its limitations include higher wafer cost and lower level of integration. In fact, history has shown that silicon CMOS won out over GaAs for high-speed digital VLSI implementation, in spite of GaAs technology's superior material properties. This outcome was due primarily to the aggressive scaling of silicon CMOS, which allowed unprecedented levels of performance to be achieved. Silicon CMOS devices, through aggressive scaling, should be able to operate at speeds as high as those achieved with GaAs. However, GaAs MESFETs have a much lower noise figure than silicon devices. National Instruments' paper concluded that the ideal goal of a radio-on-a-chip will most likely be realized using silicon CMOS. In the near term, given the superior RF performance of GaAs, RF system designers will continue to push for hybrid solutions utilizing both silicon and GaAs technologies.

Industry Business Panel

Another highlight of this year's conference was a dinner panel discussion: "Business and Market Perspective on Analog and Mixed-Signal Semiconductors." The panel, moderated by the author, featured industry executives from National Semiconductor and STMicroelectronics, a security analyst from Hambrecht & Quist, the CEO of a startup, and a venture capitalist. The panel is probably the first of its kind to focus on high-level business and financial issues facing the analog IC industry.

The panel reviewed the landscape of the analog IC industry, which consists of two major segments—standard linear ICs and analog application-specific standard products (ASSPs). The standard linear IC industry is characterized by long product life cycles, low capital intensity, low selling prices, relatively stable pricing, high gross margins, broad application market exposure, and stable growth rates. The key factors for success in this industry include specialized analog design expertise and versatile analog process technology. The analog ASSP industry, on the other hand, has the characteristics of shorter product life cycles, higher selling prices, high volume, and high growth rates. Mixed-signal technology, systems know-how, and fast time to market are among the key success factors for this industry.

Companies that focus on the standard linear IC industry include Analog Devices, National Semiconductor, Linear Technology, Maxim, Micrel, Burr-Brown, and Semtech. Players that participate in the analog ASSP segment include vertically integrated companies such as Philips, Toshiba, SANYO, Sony, Siemens, and Motorola. Texas Instruments is unique because it participates actively in both standard linear IC and analog ASSP segments.

Looking at the stock performance of analog IC companies, it is evident that analog IC companies tend to outperform the semiconductor industry in general. Furthermore, the high-performance standard linear IC companies, such as linear Technology, Maxim, Micrel, and Burr Brown, have generated even higher returns than the overall analog IC industry. The primary reason is that these companies, as the "pure-play" high-performance analog IC suppliers, have shown high but stable growth rates over the years, with high gross margins at the same time. What more can a shareholder ask for?

There are two very different business strategies for success in the analog IC market: the profit strategy and the growth strategy. The profit strategy allows companies to position themselves as broad-based high-performance standard linear IC suppliers. The name of the game here is to capitalize on specialized analog design expertise and continually find niche applications in which high-performance analog design offers advantage. As a result of the proprietary nature of these analog designs, rich pricing premiums and high gross margins can be achieved. Linear Technology and Maxim have been following this strategy and have thrived on it.

To follow the growth strategy, companies attempt to identify high-growth and high-volume markets and to develop system-type products for these markets—although profit margins tend to be low because of the pricing erosion induced by high volume and fierce competition. Texas Instruments has been very successful in supplying analog ASSPs for the modem and cell phone markets. The downside of the growth strategy is the dependence of a company's fortunes on a narrow list of markets. In fact, Texas Instruments has modified its strategy and broadened the portfolio of its standard linear IC offerings in an effort to reduce this very risk.

Dataquest expects the standard linear IC suppliers to remain focused on the high-performance end of the market as new niche applications are constantly being identified. Also, Dataquest expects competition to intensify in this segment as newcomers, such as Micrel, Sipex, Semtech, Unitrode, and Power Integration, have grown significantly in the last few years by focusing on their respective niche markets. Today, these newcomers present an increasing challenge to the leaders, Linear Technology and Maxim.

For companies such as Texas Instruments and National Semiconductor, Dataquest expects that their drive toward system-level products will continue. Texas Instruments will continue to capitalize on its digital signal processing (DSP) technology and provide both analog and DSP solutions for

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high-volume markets such as modems, cell phones, and disk drives, with the goal of achieving single-chip solutions for these markets in the future. National Semiconductor, in contrast, is trying to leverage both its in-house analog expertise and the acquired Cyrix x86 technology to build system-level products for low-cost PCs and other information appliances.

Dataquest Perspective

Analog ICs have regained vitality in recent years even though the world is increasing going digital. The primary reason is that the proliferation of digital technology has expanded significantly the demand for analog ICs. The digital revolution has dramatically increased the overall market size for digital systems and hence the demand for the analog ICs deployed in these systems. After all, every digital system requires analog ICs to interface with the real world. In other words, a world that is increasingly going digital is indeed a beautiful thing for the analog IC market.

In 1998, the analog IC market has taken a pause, as the demand for analog ICs and semiconductors in general has weakened as a result of the Asian economic downturn. Dataquest expects growth to return to the analog IC market in 1999, provided that stability can be regained in the emerging economies. Within the analog IC market, Dataquest believes that power management will lead the growth of standard linear ICs as the demand for power efficiency continues to be strong, and telecom ICs will lead the growth of analog ASSPs, driven by the expanding wired and wireless communications markets.

Dataquest expects the business landscape for the analog IC market to become increasingly interesting in the years ahead. How Linear Technology and Maxim can continue their high growth rates while maintaining high gross margins, in the face of increasing competition from the smaller niche players, remains an open question. Dataquest believes that the key to their continued success rests with their ability to continue to identify emerging niche applications where analog performance offers differentiated advantage. For system-level product suppliers such as Texas Instruments and National Semiconductor, Dataquest believes their success depends on their ability to get their system products to market quickly, as these high-volume markets continually shift to newer generations.

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Perspective

Semiconductors Worldwide

Market Analysis

It's Penny-Pinching Time for Semiconductor Spenders

Abstract: *Projected worldwide capital spending for 1998 is $31.6 billion, down 22 percent from 1997. This is a paltry sum in comparison to previous spending rates. For the industry, this represents a second year of decline for semiconductor capital spending. For the top 20 semiconductor spenders, which represent 68.3 percent of worldwide spending, total spending for 1998 is expected to reach only about $21.6 billion, which represents a 15.6 percent decline from the 1997 top 20 spending totals. Of the top 10, five companies have increased their spending over 1997 totals. Motorola, UMC Group, Advanced Micro Devices, IBM Microelectronics, and Winbond are posting a positive return to spending in 1998.*

By Mary Ann Olsson and Clark Fuhs

Capital Spending, 1998

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The top 20 capital spenders in 1998, listed in Table 1, represent a sizable share of the industry's spenders and exemplify strengths and strategies. These top 20 represent a 68.3 percent share of the worldwide capital spending total. Their revenue share of $21.6 billion represents a 15.6 percent decline in spending from 1997. But for a few exceptions, a decline in the top 20 spending patterns reflects an industry that is still in a holding pattern expected to continue through 1998.

Of the top 20 companies listed in Table 1, only six are expected to post positive spending revenue in 1998. Motorola, UMC Group, Advanced Micro Devices, IBM Microelectronics, Winbond, and Micron Technology have jumped in ranking and in spending revenue in 1998. Also, three of the top 10 are foundry suppliers.

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Table 1
Comparison of 1997 and Projected 1998 Worldwide Capital Spending by Top 20 Spenders (Millions of U.S. Dollars)

1998 Rank	1997 Rank	Company	1998	Change (%)	1998 Share (%)	1997
1	1	Intel	3,700.0	-17.8	11.7	4,501.0
2	12	Motorola	1,550.0	34.4	4.9	1,153.0
3	2	Siemens	1,351.0	-21.9	4.3	1,729.8
4	10	UMC Group (including joint ventures)	1,316.5	9.7	4.2	1,200.3
5	5	NEC	1,258.2	-14.2	4.0	1,467.0
6	21	Advanced Micro Devices	1,200.0	66.0	3.8	723.0
6	11	IBM Microelectronics	1,200.0	1.7	3.8	1,180.0
8	9	TSMC Group (including joint ventures)	1,095.0	-10.7	3.5	1,226.0
9	18	Winbond Group (including joint ventures)	1,083.2	23.8	3.4	875.3
10	7	Toshiba	1,031.0	-24.5	3.3	1,366.5
11	14	Texas Instruments	1,000.0	-3.8	3.2	1,040.0
12	23	Micron Technology	820.0	26.2	2.6	650.0
13	15	STMicroelectronics	800.0	-22.7	2.5	1,035.4
14	6	Fujitsu	778.2	-46.1	2.5	1,443.3
15	4	Samsung	645.7	-58.9	2.0	1,572.1
16	16	Hitachi	629.1	-38.0	2.0	1,014.8
17	24	Rockwell	580.0	-10.8	1.8	650.0
18	17	Chartered Group (including joint ventures)	535.0	-43.1	1.7	939.6
19	13	Anam Electronics	531.9	-49.3	1.7	1,048.1
20	20	Matsushita	471.8	-36.5	1.5	743.5
-	-	Total Top 20 Companies	21,576.7	-15.6	-	25,558.7
-	-	Total Worldwide Capital Spending	31,582.6	-22.0	-	40,505.3
-	-	Top 20 Companies' Percentage of Total	68.3	-	-	63.1

Note: Assumes an exchange rate of 1,400 Korean won per U.S. dollar and 138 Japanese yen per U.S. dollar for 1998.
Source: Dataquest (August 1998)

Current Industry Environment

Overall capital spending declined in 1997 by 9.9 percent. Dataquest expects this spending reduction to extend through the fourth quarter of 1998. The result would be an additional 22 percent decline over 1997 levels. This forecast reflects our belief that industry overcapacity will delay a sustainable capital spending growth pattern until at least late 1999. We would expect supply-and-demand dynamics to be corrected by late 1999 to early 2000, driving a robust resumption of growth in capital spending to about $77 billion in the year 2002, from nearly $31.6 billion in 1998.

Regionally, Americas capital spending remained more or less flat with 0.5 percent growth in 1997. For 1998, Dataquest expects that investment in advanced technology will continue in a "minimal investment" pattern. Spending in the region will decline by more than 17 percent. We are forecasting a modest recovery of 7 to 10 percent for U.S. companies in 1999. This recovery could be greater if the PC market shows signs of unexpected life in the second half of 1998. Preliminary worldwide PC vendor unit shipments (at 21.1 million units) posted a 13.9 percent growth in second quarter 1998 over second quarter 1997. The U.S. market sustained double-digit growth, increasing 12 percent. The Americas region is forecast to have the second-highest compound annual growth rate (CAGR) in capital spending for the period from 1997 to 2003 (12.1 percent), as foreign multinationals and foundry companies invest in capacity in the United States.

Japanese companies are reducing spending overall by 20 percent in yen terms. Continued weakness in DRAM and the depreciation of the yen affect dollar-based capital spending in Japan. With the yen weakness, this shift results in a 30 percent cut in U.S. dollar terms compared with 1997. Companies continue spending on 0.25-micron fabs for next-generation products, and their spending into the domestic sites will increase in proportion to other regions. The Japanese region on the whole will show milder growth in capital spending in the foreseeable future. Japanese companies will refurbish their fabs for "portfolio" production (mixed product manufacturing), with fewer dedicated DRAM, or logic, fabs. Most fabs will be ready to produce any products, thus closely following market trends.

The slowdowns that Europe experienced during 1996 continued in 1997 with a 19 percent decline for investments in the Europe region. We are expecting Europe to reflect the overall worldwide market because there is a good mix of multinational investment currently in the region. Europe is currently at equilibrium with the world, with a stable percentage of the demand and production mix. This stability is what has attracted more companies to produce in the region. Europe's long-term above-market growth and focus on specific projects in Europe during 1998, particularly the 300mm pilot facility in Germany, mean a more moderate spending decline than in other parts of the world.

Year-end DRAM declines and the dramatic Asian financial crisis show a nearly 12 percent decline in capital spending in the Asia/Pacific region for 1997. The market clearly overspent in this region, as is evidenced by the region's poor financial health. For 1998, constrained capital, especially by Korean companies, is estimated to result in a 27 percent decline in capital spending as the industry deals with capital constraints and the DRAM market remains under pressure. Over the longer term, we expect Asia/Pacific to rebound with aggressive growth in 2000 and 2001. The CAGR (at 11.6 percent for 1997 to 2003) should, however, be much closer to overall market growth rates than in the recent past.

Tied to the regional dynamics is the foundry market. Despite the competitive pricing environment that has existed for the past 18 months, dedicated foundry companies have managed to remain profitable. Yet, the foundry industry has shifted into an "acute" overcapacity situation. In a reaction to price pressure and decreased fab utilization, Taiwan foundries are rapidly

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cutting back on spending. Their spending will grow only 20 percent in 1998, resulting in an overall decline in spending on the island of about 7 percent. For 1999, we are expecting DRAM spending to remain low and perhaps down, but foundry spending to be cut again, resulting in an overall island decline of roughly 20 percent.

The Outlook for 1999

The year 1999 is forecast to see only slight growth. Yet, the year is significant in the overall picture as it should mark the bottom point for the spending ratio in the current slowdown. From 1997 to 1999 and during 1999, semiconductor revenue will grow ahead of capital spending. In early 2000, the tide should turn and equipment revenue will start to grow again ahead of semiconductor revenue. Thus, another hot equipment market lies ahead. At that time "underspending" of the semiconductor industry not only will have resulted in a balance of supply and demand but the pendulum will have turned in the other direction, toward an undercapacity situation. Dataquest's forecast for 2000 and 2001 is for, respectively, more than 38 percent and 49 percent growth in capital spending while the industry should remain in a state of net underinvestment even in the year 2000. However, the year 2002 should bring the onset of the next down cycle, triggered by the industry transition to the 256Mb DRAM and overcapacity once again created by silicon efficiency.

Compared to our forecast half-year ago, the picture has changed in that both the upswing as well as the start of the next down cycle have been pushed out by one year. Why? The answer is that semiconductor demand has stalled in 1998. The Japanese and other Asian economies have slowed tremendously in recent months, and this slowdown has impacted electronic equipment demand in the areas of consumer electronics and automotive, with a slight impact to computing. Dataquest has recently reduced the electronic equipment production forecast for 1998 from 6.9 to 4.4 percent growth. This reduction has made a dramatic impact on semiconductor demand from a unit perspective, and our most likely forecast for semiconductors in 1998 now calls for a 1.4 percent growth—essentially flat.

One way to view 1998 is that the semiconductor industry demand profile has inserted a one-year "holding pattern," and likewise a one-year delay, in any recovery that was previously forecast. This condition has made the secondary downturn we were expecting appear much more severe, as the industry will be making only "minimum investments" during the next 12 months. Because a sustainable recovery in spending and the equipment market must come from capacity buying, we must have a healthy chip market in 1998 to have a growing equipment market in 1999. It does not appear to us that the chip market can mount a recovery until next year, so we have downgraded our 1999 wafer fab equipment forecast to be essentially flat from 1998 levels.

So 1998 is a gloomy year. Dataquest forecasts capital spending to decline by more than 22 percent (see Table 2). Strategic investments into new technologies continue to remain the focus, but there is a limit. Certainly, 300mm spending is not a savior for this year. In fact, after a lot of hype by semiconductor companies, the only words recently heard from these companies are "push-out" and "delay." Spending on 0.25-micron technology has been and should remain solid. However, we believe that with semiconductor revenue flat and overspending in prior years, there is frankly not much capital in the industry to be allocated for new equipment. Dataquest believes that the industry shifted in 1998 into a minimal investment pattern, which should last into the middle of next year. In this spending pattern, all purchases, even for 0.25-micron technology and strategic equipment, will be tightly scrutinized. Only what is really essential to move ahead and keep up with new technology developments will be purchased. This is quite a change for many segments, which were hot even during the initial phases of the down cycle.

In short, it all boils down to the question, "How much technology spending is enough?" Has the industry reached technology saturation—a technology glut? When one looks at foundry companies, the answer is yes. Although TSMC proclaimed at the beginning of the year that it was running at more than 100 percent utilization, the question remained: 100 percent utilization of fabs according to their technology capabilities or with any technology? We believe the latter to be the true situation, as foundries now admit they were running a lot of 0.5- and 0.6-micron products through their 0.35-micron fabs. When there is no money, even technology is hard to sell.

Turning to the tactical side, 1998 will be a year of minimal investment with a technology focus. Certainly, new fab construction is hard to find in these times. Yet, strategic investments also include any fabs that open up new production market locations and those that are tied to partnerships and joint ventures. Of particular interest are companies in new alliances, in which other factors, such as a strategic development or supply relationship, may be more important than the capacity being added. These two kind of strategic investments, although to some extent capacity-related, are historically less affected by an industry slowdown.

Table 2
Worldwide Capital Spending Forecast, 1997 to 2003, Including Merchant and Captive Semiconductor Companies (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	2003	CAGR (%) 1997-2003
Worldwide	40,505	31,583	32,990	45,749	68,302	77,164	76,784	11.2
Growth (%)	-9.9	-22.0	4.5	38.7	49.3	13.0	-0.5	-

Source: Dataquest (August 1998)

Many fabs started or upgraded in 1997 fall specifically into these categories, including: the U.S. fabs being built by TSMC, Samsung, and Hyundai; the U.K. fab being built by Siemens; the array of initial joint venture fabs such as Dominion (IBM/Toshiba) and White Oak (Motorola/Siemens) in the United States; Taiwan companies Winbond, Powerchip Semiconductor, Nan Ya Technology, and Macronix, whose activities are tied to Japanese companies; Mosel Vitelic, which is tied to Siemens; and Texas Instruments' venture in

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Korea (with Anam). In 1998, most of these fabs will not be stopped, but will likely have slower ramp rates than planned.

An exception are the Korean fab investments. In the near term, the liquidity crisis in Korea impacts these strategic investments. All new Korean semiconductor investment projects have stopped in their tracks, and nobody has definitive answers about when the situation will stabilize to the point that these projects can be restarted. In fact, the key issue to be looked at today is when and in what order planned projects will be restarted for Korean companies. In summary, we believe that the market will hit bottom in the third quarter of 1998, and a sustainable recovery should not be expected until the end of 1999.

Dataquest Perspective: Is There a Bright Side?

The industry is still in the throes of severe spending cutbacks, with many companies resorting to layoffs or shutdowns to rein in losses. Overspending in 1997 and softening in semiconductor demand have pushed out a sustainable recovery into late 1999. In the quarterly picture, we believe that capital investment will be in for sluggish business conditions after hitting bottom in third quarter 1998. There is a bright side, but it appears to be in the somewhat distant future. The fundamentals of capacity supply-and-demand balance simply do not support a major recovery occurring in the memory manufacturing segment before the end of 1999, unless capacity exits the industry. Dataquest believes that companies will continue to follow a "minimum investment pattern" with respect to technology, with shifting emphasis from 0.25-micron toward 300mm and 0.18-micron technology. Yet, the 300mm investment picture for 1998 has severely softened, as most investments have slipped into 1999. It appears that Japanese companies have adopted the strategy of investing in less capital-intensive extended R&D centers rather than full-blown pilot lines.

After increasing strength in the second half of 1997, every quarter of 1998 brought equipment revenue declines. This weakness is expected to continue through the third quarter 1998, before a slight, largely seasonally motivated uptick in fourth quarter 1998. Overspending during 1997 and the "holding pattern" in semiconductor revenue growth in 1998 have taken strength from any recovery in 1999.

More in-depth analysis on capital spending and wafer fab equipment can be found in the Dataquest Market Trends report *Midyear 1998 Forecast: Capital Spending, Wafer Fab Equipment, and Silicon Markets* (SEMM-WW-MT-9803).

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Perspective

Semiconductors Worldwide

Market Analysis

European Inward Investment Opportunities

Abstract: *In this Market Analysis, Dataquest examines what the key factors are in attracting inward investment from the semiconductor industry and analyzes eight major locations. Funding is no longer the critical factor it once was, while educational infrastructure is playing an increasingly significant role.*
By Edmund Gemmell

Executive Summary

Most countries in Europe are interested in, and are actively seeking, inward investment from semiconductor manufacturers. With most countries offering broadly similar incentives by way of capital grants and taxation benefits, the battleground to win high-quality inward investment is shifting to skills management. The future winners in this battle will be those that offer a combination of the correct skills in the right numbers, as well as attractive financial packages. This calls for an integrated response by each country to the demands of the semiconductor industry.

Some countries have recognized this and are rising to the challenge of developing methods to meet these demands. These will be the countries that attract the added-value inward investment projects. Some countries or regions will continue to offer large grants, but as this becomes more expensive, and as their competitors become more differentiated, the quality of inward investment that these regions or countries attract will suffer. While the focus of this Market Analysis is the semiconductor industry, many of the financial and fiscal incentives described are equally applicable to other industries.

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Introduction

The location of a wafer fabrication plant or assembly and test plant is a key decision made by semiconductor vendors when considering capital expenditure programs. Identifying where sufficient staffing, reliable infrastructure, and suitable land can be found is becoming increasingly important. At the same time, many countries in the European Union have realized the potential benefits of having semiconductor plants located within their borders, in terms of direct employment, indirect employment, enterprise creation, and regional regeneration. It is no surprise, therefore, that many countries, and specific regions in countries, are positioning themselves as high-technology centers and competing vigorously for new inward investment proposals. This report analyzes some of the regions that a semiconductor manufacturer might consider when deciding on a location in the European Union. This Market Analysis also provides details of appropriate staffing availability, as well as training infrastructure and an overview of the financial incentives and support available in each location.

The locations covered in this Market Analysis are as follows:

- Flanders, Belgium
- Southeast France
- Western France
- Eastern Germany (Saxony)
- Ireland
- Northern England
- Central Scotland
- Central and eastern Spain

Table 1 shows the regions that have been most successful in promoting themselves to the semiconductor vendor community.

Flanders

Recently, Flanders has been one of the more proactive regions in Europe trying to attract inward investment. The main focus of activity has been on attempting to attract a semiconductor wafer fabrication facility into the region. It is hoped that this will act as a catalyst for the further development of the semiconductor industry in the region.

One of the most interesting ideas being investigated by the Flanders Foreign Investment Office (FFIO) is the concept of building its own wafer fabrication plant and leasing this out to semiconductor vendors on a long-term basis. The model would have the Flanders government consortium managing the plant and issues such as chemical, gas, and waste handling, while the tenant vendor would be responsible for manufacturing development and core competencies. This business model is still being developed by the FFIO and Meissner and Wurst, a wafer fab design company.

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Table 1
Semiconductor Inward Investment Projects in Europe since 1990

Year	Investment Location	Company
1990	Scotland	Motorola
	Scotland	Motorola
	Italy	Texas Instruments
1991	Northern England	Fujitsu
	Sweden	Mitel
	Northern Germany	Philips
	Northern Italy	SGS-Thomson*
1993	Southern Germany	Hitachi
	Southern France	SGS-Thomson*
1994	Ireland	Intel
1995	Western France	Philips
	Ireland	Analog Devices
1996	Scotland	NEC
	Northern England	Philips
	Netherlands	Philips
	Southern Italy	SGS-Thomson*
	Southern France	SGS-Thomson*
	Eastern Germany	Siemens
	Italy	Texas Instruments
1997	Southern France	Atmel
	Corbielle-Essomes, France	IBM
	Ireland	Intel
	Northern Italy	International Rectifier
	Germany	Mitsubishi
	Southern Italy	SGS-Thomson*
	Northern England	Siemens
1998	Israel	Intel
1999	Eastern Germany	AMD
	Northern England	Fujitsu
	Scotland	Hyundai
	Wales	LG Semicon

*Now *STMicroelectronics*
Source: Dataquest (July 1998)

Flanders is home to two semiconductor fabrication facilities: Alcatel Microelectronics, which is based in Oudenaarde, near Gent, and Interuniversities MicroElectronics Center (IMEC), which has a smaller-scale facility in the region. IMEC is the largest independent microelectronics R&D center in Europe. IMEC's R&D activities are concentrated on the development of novel design methodologies, the development of processing technologies for the next generation of ultralarge-scale integration (ULSI) chips, and the support of the training of very large-scale integration (VLSI)

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design engineers on behalf of both educational institutes and industry. IMEC also provides training facilities for industrial partners on request.

However, there are about 10 other fabrication modules located within 150km of Brussels. In addition to the semiconductor wafer fabrication plants and IMEC, Flanders has two other universities with specialist electronics faculties. The Flanders region also has 15 industrial engineering colleges that provide four-year electronics courses toward degrees.

The principal financial incentive offered by the Flanders government to inward investors is a series of cumulative direct subsidies. The first is a basic subsidy of 4 percent of total investment, which is available to qualifying investments that are the first operational unit by the company in Flanders. The second is a direct subsidy of up to 8 percent of the total investment, depending on the economic importance of the investment in the region. Given Flanders' eagerness to attract a semiconductor fabrication plant, it would be fair to assume that such an investment would be considered as being of great economic importance and, thus, would attract a significant part of this 8 percent. The third subsidy is based on employment growth and can be up to 9 percent of the total investment. The combination of these three subsidies means a total direct subsidy of 21 percent of total investments is available to any qualifying inward investment project.

In addition to the direct subsidies that are available as incentives, Flanders also offers several fiscal measures to increase the value of inward investment support packages. These measures include an exemption of real estate tax for the investment site for five years and accelerated depreciation programs. The FFIO will also participate in site acquisition and preparation.

The Flanders employment agency also participates in the sourcing of staff for any inward investment project. The Flanders employment agency, as part of an incentive package, will meet the expenses of new staff's first six to eight weeks of employment, when they usually will be in training.

France

In France, the regions of western France and Marseilles-Provence in the southeast are two of the primary high-technology and IT conurbations. Consequentially, both regions are being given a great deal of support from the Invest in France Agency. Philips Semiconductor, Temic Matra (now part of Atmel Corporation), and SGS-Thomson have all located wafer fabrication plants in western France. Marseilles-Provence hosts wafer fabrication plants belonging to SGS-Thomson and Atmel. Motorola Incorporated is nearby in Toulouse, and SGS-Thomson has more plants nearby in Grenoble.

The importance of this high level of wafer fabrication plants is that both regions have been acclimatized to the high levels of service that wafer fabrication investments need in terms of ground preparation requirements, planning permission, waste material management, traffic and customs infrastructure, and supply infrastructure. The regions also have an existing skill base and orientation toward high-technology industries.

Western France

As well as the wafer fabrication plants located in western France, the region has a high concentration of R&D facilities, including CNET (applied telecommunications research organization), CCETT (applied audiovisual research), and the microelectronics center for the west of France (CCMO), which is a collaboration among three electronics educational establishments in Rennes together with SGS-Thomson, Temic Matra, and SOREP Technology Corporation. CCMO provides R&D facilities as well as further training facilities and courses for workers in the electronics industry.

Western France is also home to more than 50 university- or engineering-school-based laboratories or departments with a high-technology orientation. These laboratories and departments are in 13 universities or engineering schools specializing in electronics, data processing, and telecommunications.

The primary financial incentive available to companies investing in western France is the regional development grant (PAT). Most areas in western France qualify for a subsidy of up to FF 50,000 (about $8,250) per job created, although some areas in the region qualify for up to FF 70,000 (about $11,500) per job created. PAT is available to all companies investing at least FF 20 million (about $3.3 million) and creating 20 permanent jobs over three years. Neither of these restrictions would pose much of a problem for a semiconductor vendor considering investing in a new operation. The PAT incentive is limited to 17 percent of total investment. Some exceptional levels of financial assistance are available from PAT in western France, however, because of the restructuring of the French defense industry.

In addition to PAT, other assistance is available for training programs and ensuring that manufacturing facilities are environmentally friendly. Full or partial exemption from business tax (a local tax) is negotiable for up to five years for inward investment projects. In PAT-qualifying areas, local authorities are also prepared to become involved in land acquisition and preparation and may provide a discount of up to 25 percent on purchase or lease costs.

Marseilles-Provence

The Marseilles-Provence region in the southeast of France has, as stated earlier, many wafer fabrication plants either in the region or close by. Additionally, the region has several technology parks serving the electronics industry, including Rousset, the Aixles-Milles industrial development park, the Chateau-Gombert science park, and the Arbois Europole project.

In these parks and the region's universities, 30 laboratories are carrying out research in various fields of microelectronics. These laboratories are based around the four universities in the Bouches du Rhone region. Also, Marseilles-Provence is home to the Microelectronics Regional Study Center on Silicon (CREMSI), which has some 40 members, including SGS-Thomson, Atmel, Gemplus SA, and DuPont Photomasks Inc., and 10 R&D laboratories. CREMSI is focused on furthering microelectronics in the Marseilles-Provence region and undertakes joint research for those companies involved. The Marseilles-Provence region also provides training programs and facilities for

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the technicians and senior technicians required to populate semiconductor fabrication plants.

Financial incentives in the Marseilles-Provence region are structured as those for western France. Marseilles-Provence is one of the few regions in the southeast of France that qualifies for PAT. The PAT rate for Marseilles-Provence is FF 70,000 (about $11,500) per job created, subject to a maximum of 25 percent of total investment.

Ireland

Analog Devices Inc.'s investment in Limerick in 1976 was the catalyst for Ireland's interest in attracting electronics-related investment. Since then, in addition to attracting a prestigious investment from Intel Corporation, Ireland has attracted several other semiconductor-related inward investments in the form of design houses.

Ireland has focused its efforts to attract future inward investment by building an infrastructure to supply the key staff for future technology. The National Microelectronics Research Centre base at University College Cork has a 3-inch foundry, IC design group, and interconnect and packaging laboratory. In addition, Ireland has eight universities with electronic engineering faculties, which produce between 600 and 700 electronics engineering graduates per year. Also, the Irish government has put in place an Ir£50 million ($68 million) program aimed at developing additional engineering courses.

As well as its higher-education establishments, Ireland also has 12 regional technical colleges offering electronics-related courses. Included in these courses is one codesigned by Hewlett-Packard Company and Intel to develop a suitably educated pool of technician-level staff.

One of the major financial attractions for investing in Ireland is the level of corporation tax levied against companies. The standard corporate tax rate is set at 10 percent until 2010. From 2010 until 2025 the rate will be 12.5 percent, which is significantly lower than that of most other countries. Surprisingly, other financial incentives aimed at attracting investment are significantly lower than those that some other regions are offering. The Irish Development Agency (IDA) offered Intel about Ir£30,000 ($40,000) per job, which was significantly below some other offers, for a total commitment of 2,800 jobs, yet it still won the bid. This speaks volumes for the quality of staff on offer.

The IDA tends to work on an investment incentive per job created basis. However, once an amount per job has been fixed, it is broken down into three constituent parts: a capital grant based on the value of fixed assets; an employment grant, which, typically, would not exceed Ir£10,000 ($14,000) per job; and a training grant, which would cover up to 100 percent of agreed training costs.

Saxony, Germany

The former East German state, now one of the new German *Länder*, is positioning itself as the microelectronics center of eastern Germany. Since the reunification of Germany, Siemens Semiconductor has built a new DRAM wafer facility, in which it is planning its new 300mm pilot line, and Advanced Micro Designs Inc. is close to completing a new wafer fabrication plant for the manufacture of microprocessors. These developments are on top of the semiconductor infrastructure that existed when Saxony was part of East Germany. Zentrum Mikroelektronik Dresden (ZMD), which produces primarily memory products, has been located in Dresden since 1987. Before reunification, ZMD employed more than 3,000 employees in the microelectronics industry. Today it employs about 500, but the supply base for skilled employees, many of which worked in high-technology industries prior to reunification, remains.

Saxony, and Dresden in particular, offers a significant R&D and university infrastructure; Dresden has more than 30 educational and research institutes. Included in this number are the Institute for Semiconductor and Microsystems Technology, the Institute for Communications Systems, the Institute for Information Systems, and the Institute for Technical Informatics, all at the Technical University (TU) Dresden, which has 21,000 students. In addition to TU Dresden, these other institutions all offer IC design courses: TU Chemnitz, Freie Hoch Schule (FHS) Mittweida, FHS Zwickau, and FHS Zittau-Goerlitz. Dresden is also home to the Fraunhofer Institutes for Microelectronic Circuits and Systems, the Fraunhofer Institute for Material Physics and Layer Technology, and the Fraunhofer Institute for Integrated Circuits.

The financial incentives offered to inward investors in Saxony, and the new *Länder* of eastern Germany in general, are quite significant. Both Siemens and AMD received funding of about DM 800 million (about $450 million) to assist in their fabrication plant location decision.

Start-up grants can reach 28 percent for large inward investment firms in the surrounding areas of Dresden and Leipzig. In other regions of the new federal states, grants can reach 35 percent of total inward investment. These grants are from the Improvement of Regional Economic Structures Program, which is funded by the Saxony Government, the federal government of Germany, and the European Union.

In addition to grants, several tax incentives are available to inward investors. Included in these are an investment allowance and a special accelerated depreciation allowance. The investment allowance returns 5 percent of any investment in movable depreciable equipment. Given that the cost of setting up a state-of-the-art wafer fabrication plant facility is in the region of $1 billion, this allowance on its own is worth about $50 million. The special accelerated depreciation allowance allows companies to depreciate their capital equipment by between 20 percent and 40 percent above the normal depreciation rates.

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United Kingdom

In the United Kingdom, three regions are focusing attention on attracting semiconductor inward investment. These regions are the central belt of Scotland, stretching from the east coast around Edinburgh to the west coast around Glasgow, northern England, and South Wales.

In 1996, semiconductor companies with manufacturing locations in the United Kingdom, along with the U.K. government, founded the National Microelectronics Institute (NMI). The NMI's role is to coordinate and enhance the activities of all parts of the United Kingdom semiconductor industry's support infrastructure. Included in this is the development of supporting industries and the coordination of further- and higher-education activities related to the microelectronics industry, as well as facilitating cooperation between companies in noncompetitive areas.

The NMI treats the three geographic areas as a single cluster, given their relative geographical proximity, coordinating all its activities to assist each area equally. The NMI has, with semiconductor vendors, developed two further-education courses designed to supply the semiconductor industry with appropriately qualified operators and technicians. To date, four further-education colleges in Scotland, and 10 in the United Kingdom, offer these courses. The NMI has also created and had accredited a microelectronics MSc qualification for the development of engineer-level staff.

The main financial incentives provided to those considering investing in any of the three regions are, in principle, the same, although in the last round of inward investment, a peculiar situation occurred of two regions within the cluster trying to outbid each other. Regional Selective Assistance (RSA) is the main financial incentive and applies to all three regions. "Locate in Scotland" (the inward investment agency) and the Northern Development Agency say only that RSA is negotiable on an individual basis, but is based on levels of capital expenditure and jobs created. In addition to RSA, all three regions have enterprise zones, which attract additional benefits of exemption from property taxes for 10 years and 100 percent depreciation allowance for buildings in the first year of operation.

Investors in the three regions will also be eligible for training and employment grants. Typically, these grants cover up to 50 percent of training costs, with a maximum of £4,000 ($6,500) per eligible employee.

An example that shows other potential benefits for investors is available in Scotland, where other substantial benefits including site acquisition and preparation, as well as considerable assistance with site management costs, have been made available. An example of these is Hyundai's ongoing (and delayed) investment in Dunfermline. It was reported that the assistance package, which totaled £151 million ($250 million) for a total maximum investment of £2.3 billion ($3.8 billion), included amounts of £9.6 million ($16 million) for site acquisition, £23.4 million ($39 million) for site preparation (including new road infrastructure), and £9 million ($15 million) for waste treatment facilities.

Central Scotland

Since the mid-1970s, when National Semiconductor Corporation opened its first fabrication plant in Greenock, Scotland has recognized the increasing importance of high-technology manufacturing as a driver of national growth and large-scale provider of jobs. Since the 1970s, central Scotland has tried to reposition itself as the high-technology center of Europe, going so far as to coin the term "Silicon Glen."

The central belt of Scotland is home to six semiconductor companies, which have a total of 10 wafer fabrication plants between them, and two more plants are in planning or under construction. Central Scotland is therefore very adept at dealing with the requirements of semiconductor wafer fabrication plants.

In addition to the NMI infrastructure, central Scotland also houses 11 institutes and research centers related to the microelectronic industry. These are based at eight universities throughout the central belt region. Four of these universities are participating in a project with Cadence Design Systems Inc. to establish the world's first system-level integration institute. There are also 46 further education colleges, in and around the central belt, offering two-year electronic or electronic engineering courses.

Northern England

In addition to the region's participation in the NMI, northern England has a significant electronics-oriented training infrastructure, which produces more than 800 electronics-related graduates per year. In early 1998, the North of England Microelectronics Institute, a joint venture between the region's universities, Siemens, and Fujitsu Ltd., opened in North Tyneside. The £16.5 million ($26 million) site includes laboratories for testing post-wafer processing reliability and design fault analysis, together with a new interconnection research project.

The region also has two universities: the University of Newcastle upon Tyne and Durham University, both of which have a number of research groups related to the microelectronics industry. The University of Newcastle upon Tyne includes the Semiconductor Technology Group, the Microelectronic Systems Design Group, and the DSP Group. Durham University includes the Centre for Molecular Electronics and the Centre for Electronic Systems. Durham University also manages a course developed by Fujitsu and continued by Siemens to fulfill the educational needs of both companies.

Spain

Spain appears to be something of an enigma in terms of winning inward investment from the semiconductor industry. Since attracting Lucent Technologies to Madrid in the late 1980s, it has not brought in any other major semiconductor fabrication investment.

Spain has set up two scientific parks focusing on the semiconductor industry. The first is Valles Technology Park located just outside Barcelona, and the second is Tres Cantos Technology park in Madrid, where Lucent

Technologies has its wafer fabrication plant. In and around Valles Technology Park are the Spanish National Microelectronics Center, the Regional General Testing and Research Laboratory, and the New Materials Center, which is part of the Higher Center for Scientific Research. The National Microelectronics Center also has a site in the Tres Cantos Technology Park.

The principal financial incentive offered in Spain is for investment in certain regions. This is offered by the state and varies from 20 percent to 60 percent of a project's capital expenditure. However, neither of the scientific parks mentioned above falls into one of the qualifying regions. Thus, these parks receive no regional incentive from the Spanish central government. In addition to the central government regional aid, each autonomous region offers its own smaller-scale investment packages.

Spain has also created a $420 million high-technology fund called the ATYCA initiative, which will run until the end of 1999. The program is financed by the Ministry of Industry and Energy and can provide funding for the improvement of the technology infrastructure and training.

Dataquest Perspective

Potentially useful manufacturing locations are essentially products for which there is a very small, but valuable, customer base. When Europe started attracting semiconductor inward investment, each country's offerings were essentially commodities, where, typically for commodities, price played the pivotal role in deciding which country won the inward investment. Price in this marketplace was represented by the amount of cash a region or country would pay to convince the prospecting company to move to their location.

However, the market has moved on; in the marketplace of inward investment, the emerging key differentiator is the supply chain for appropriate human resources. Those regions or countries that develop a coherent and integrated road map to supply sufficient numbers of appropriate graduates and other technical staff will be the winners in attracting the quality inward investment projects in most cases.

For some companies, though, location will still be a commodity product, and price (in the form of capital grants) will still have a key role to play. It could be argued that AMD's investment in Dresden, Germany was a case where "price" was the determinant factor. In contrast, Intel's investment in Ireland was an occurrence where the differentiator won out over the highest bidder—the differentiating factor being the availability of staff at all levels of engineering expertise.

Some regions are farther along the differentiation curve than others. For those lagging behind, price, in the form of subsidies, will continue to be their major attraction. For some companies this may be enough, although the dynamic is changing. Companies are beginning to want more than just a massive cash handout at the beginning of a project. They now want to ensure the long-term future of their plants and maximize the value they add to the

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company. On the other hand, countries want more than a cash-for-jobs equation, especially as the amount of cash required to win becomes unaffordable. They want investment in their communities and participation in their educational infrastructure. We may not have seen the last of the bidding wars that occurred in the fight to attract inward investment in the 1980s and early 1990s, but they will be fewer, as will be the participants involved in the fight. The next step for the inward investment market may well be its segmentation, on both the part of the semiconductor vendor and the regions.

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Perspective

Semiconductors Worldwide

Technology Analysis

Analog and Mixed-Signal IC Applications in Digital Cellular Phones

Abstract: *Digital cellular telephones represent one of the most important application markets for analog and mixed-signal ICs. Total consumption of analog and mixed-signal ICs in digital cellular phones, excluding RF ICs, is projected to exceed $1.9 billion by 2002. This Perspective examines the forces driving the success of the wireless market and the use of analog and mixed-signal IC in digital cellular phones.*

By Jim Liang and Dale Ford

Cellular Telephone Market Overview

The number of worldwide cellular/PCS subscribers has grown tremendously in the last few years. As this growth continues, the wireless handset market will expand from 124 million units in 1997 to 293 million units in 2002. Worldwide production of cellular telephone handsets is projected to grow at a solid 19 percent compound annual growth rate (CAGR) during the next five years, as shown in Table 1. Although analog handsets represented 38 percent of total production in 1996, digital handsets, growing at a CAGR of 24 percent, will account for 98 percent of worldwide production by 2002.

The digital handset market exploded in Europe during the 1990s as the European countries agreed on the unified standard, called the Global Standard for Mobile Communications (GSM). The European market had experienced very low cellular penetration rates before then. With the introduction of the GSM standard, which allowed easier roaming among countries, the market took off and quickly became the largest digital cellular market in the world. Many countries in other regions have adopted the GSM standard. The Americas market has been slower than expected to adopt

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digital technology; as a result, digital handset shipments accounted for less than 10 percent of the total Americas handset shipments in 1996. However, the digital handset market in the Americas region has grown rapidly in the last few years and should continue to experience strong growth.

Table 1
Worldwide Cellular and Broadband PCS Telephone Handset Production by Type (Thousands of Units)

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Total Cellular/PCS	78,624	123,841	149,562	179,333	217,102	256,097	293,445	19
Total Analog	29,835	25,241	18,362	14,148	11,397	8,547	4,520	-29
Total Digital	48,789	98,600	131,200	165,185	205,705	247,550	288,925	24

Source: Dataquest (June 1998)

Further insight into the wireless market is available in Dataquest's Market Trends Report *Communications Application Markets—Cellular/Broadband PCS and Cordless Telephones* (CSAM-WW-MT-9707, December 1997).

How Cellular Phones Work

Cellular telephones involve a relatively low-power handset corresponding with a local base station, of which there are many. The area surrounding the base station is called a "cell," and this can be visualized as a honeycomb. This simple concept yields powerful benefits. The handset can be small and light because it does not need to transmit over long distances. A large number of subscribers can be connected simultaneously because their signals travel only short distances and do not overlap with those in other cells. Traveling phones moving from one cell to another during a conversation can be accommodated by a central control's handing over responsibility for the handset from one base station to another.

Analog Cellular Phones

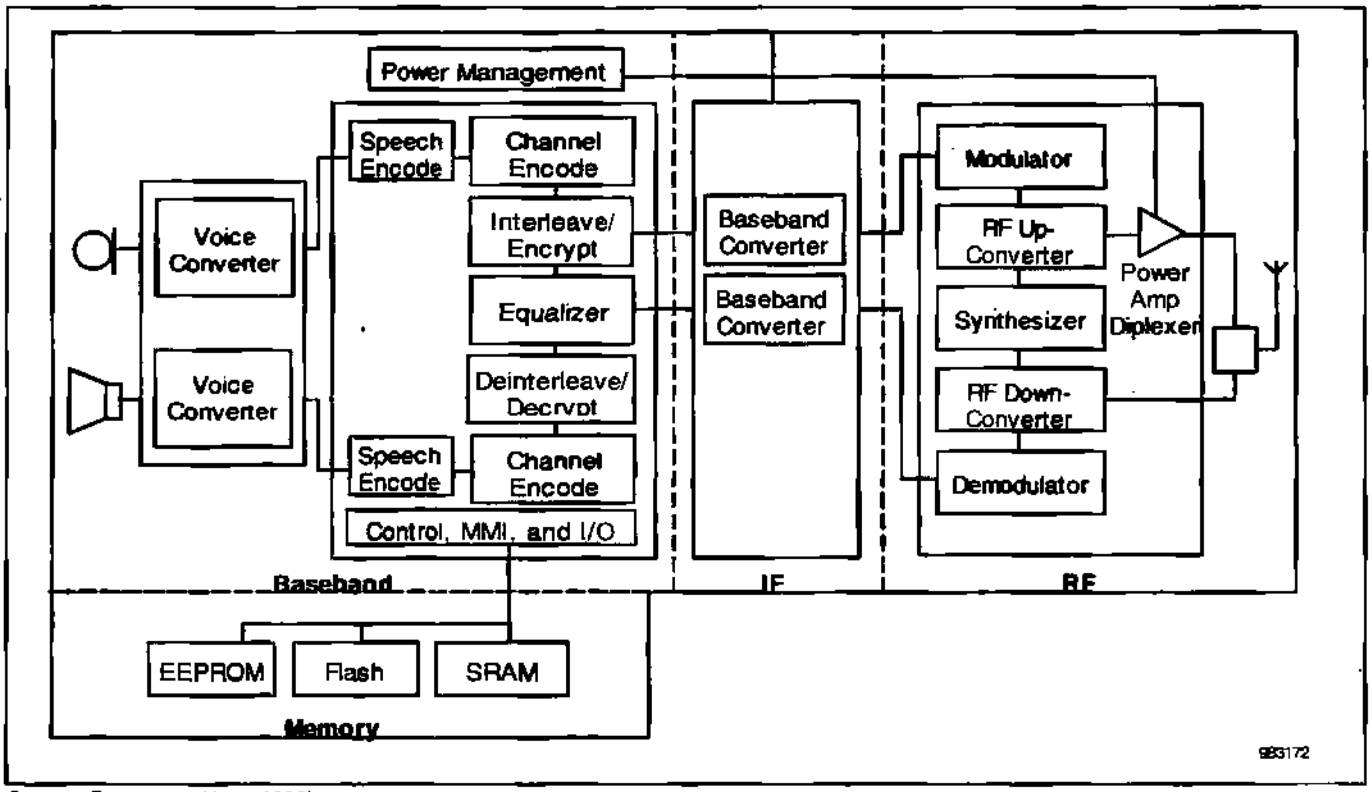
Analog cellular telephones were the initial standard deployed in the early days of cellular telephony. Voices are transmitted and received using a time-division multiplexing scheme, in which periodic samples of the voice are frequency modulated (FM) on a carrier frequency. The advantage of an analog approach is a straightforward, minimal design for both handsets and base stations. A disadvantage, it turns out, is a lack of security for both the information (the voice) and the control signals the phone uses to stay synchronized with the cellular network. This minor technical issue became a major financial opportunity for some ethically challenged members of society, who "clone" telephone serial numbers to circumvent usage fees. Another segment of society was able to listen in on, and record, phone calls with simple scanning receivers. A better solution was needed.

Digital Cellular Phones

Digital cellular telephones were the answer to these issues. Instead of transmitting the voice as an FM signal, the signal was digitized and sent as ones and zeros over a network optimized for digital traffic. A major benefit of this change is the ability to service multiple handsets with a single operation frequency instead of tying up a frequency slot per handset, yielding a dramatic increase in network call capacity. Digital handsets also have better energy efficiency, yielding longer battery lives. Furthermore, encryption was added for both serial number and voice data, making cloning extremely difficult. The initial digital standard was a European product using the GSM standard; since then, other digital standards—code-division multiple access (CDMA, or IS-95) and time-division multiple access (TDMA, or IS-54 and IS-136)—have emerged.

Figure 1 shows a block diagram of a typical digital cellular telephone, which comprises a radio frequency (RF)/intermediate frequency (IF) section, and a baseband section. The RF/IF section handles transmission and reception of RF signals. The baseband section processes communication signals at baseband frequencies.

Figure 1
Digital Cellular Telephone Block Diagram

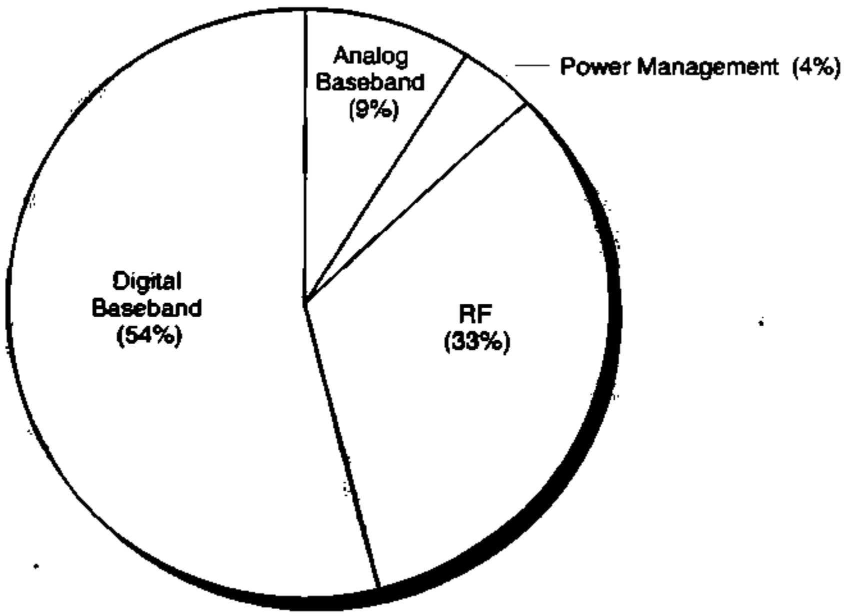


Source: Dataquest (June 1998)

Analog and Mixed-Signal ICs in Digital Cellular Phones

The semiconductors used in digital cellular phones can be categorized into three major types: power management semiconductors, baseband semiconductors, and RF semiconductors. Power management semiconductors are involved in supplying power to the phone. Baseband semiconductors include digital baseband ICs and analog baseband ICs. RF semiconductors include RF ICs and discrete transistors and diodes. Figure 2 shows an estimated breakout of semiconductor content in today's typical digital cellular handsets.

Figure 2
Estimated Semiconductor Content in Digital Cellular Handset



Source: Dataquest (June 1998)

The digital baseband semiconductors include digital signal processors (DSPs), microcontrollers (MCUs), and memory. Power management ICs, analog baseband ICs, and RF ICs are the analog and mixed-signal ICs used in digital cellular phones, and these are discussed further in the following sections.

Power Management ICs

Power management in cellular phones represents one of the hottest applications for analog ICs, not only because of the growth of the cellular phone market itself, but also because of the increasing need for longer battery life (which translates into longer talk time) and higher performance.

Power management ICs in cellular phones, also called voltage regulators, provide regulated voltage supply to various sections of the phone. Voltage regulators convert one DC voltage to another DC voltage. In the broad category of voltage regulators, there are two subcategories: linear regulators and switching regulators.

Linear regulators can only step down, providing output voltage that is smaller than input voltage. Switching regulators, which consist of switch, inductor, rectifier, and capacitor, can either step up (or "boost") voltage or step down (or "buck") voltage. Linear regulators have the advantages of low noise and good transient response but the disadvantage of poor power dissipation on the pass element. Switching regulators, on the other hand, can provide higher levels of power with greatly reduced thermal problems, because the power transistor is on for only a small fraction of the total time.

As a result, switching regulators are favored today for use with Pentium II-based microprocessors because of the high power involved. In digital cellular phones, a special type of linear regulators called low dropout (LDO) regulators are used. This is because they not only have lower noise, which contributes to good RF performance, but they also provide very low dropout voltage, resulting in higher conversion efficiency. Typically, multiple LDO regulators are used in a cellular phone to supply voltages to different sections of the phone.

The drive toward longer battery life and higher performance has challenged LDO regulator suppliers. Longer battery life means high conversion efficiency from the LDO regulator, which requires low dropout voltage and low quiescent current; higher performance means good RF characteristics from the LDO regulator, such as high ripple rejection and low noise. LDO regulators have been available in three different process technologies: bipolar, CMOS, and BiCMOS. Bipolar LDO regulators provide low noise but have the disadvantage of high dropout voltage and high quiescent current, which contribute to shortened battery life. CMOS LDOs offer very low dropout voltage and quiescent current orders of magnitude lower than bipolar LDOs, but they have higher noise. BiCMOS LDOs employ a bipolar pass transistor for high ripple rejection and hence low noise and CMOS circuitry for reduced quiescent current, but they still fall short in the area of low dropout voltage, compared to CMOS LDOs. The BiCMOS solution probably offers the best performance of the three options, but the cost of using a BiCMOS process is higher than that of straight CMOS. There certainly exist ample opportunities for more innovative solutions that provide "ideal" LDO regulators for cellular phones at the lowest cost.

The major players participating in the power management arena for digital cellular phones include National Semiconductor Corporation, Micrel Semiconductor Inc., Linear Technology Corporation, Maxim Integrated Products Inc., Texas Instruments Inc., SGS-Thomson Microelectronics B.V., Toko Inc., and Impala Linear Corporation. Table 2 lists all the major players, with comments on their competitive positions. Dataquest does not provide power management IC revenue estimates for individual suppliers of ICs for digital cellular because they have not been surveyed at this detailed level.

The total power management IC market in 1997 is estimated to be about $2.5 billion, and the total value of power management ICs used in digital cellular phones in 1997 is estimated to be about $291 million.

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Table 2
Major Players in Power Management ICs for Digital Cellular Phones

Companies	Comments
National Semiconductor	First to market with LDO regulator solution for wireless market; the current market leader
Micrel	Fast-growing new entrant; gaining market share
Linear Technology	Specializes in high-performance LDOs
Maxim	Specializes in high-performance LDOs
Texas Instruments	Made significant inroads in 1997 in power management to complement its DSP and mixed-signal leadership in cellular phone market
SGS-Thomson	Expertise in power processes; close relationship with Nokia and Ericsson
Toko	Specializes in low-cost LDOs
Impala Linear	Start-up company specializing in high-performance CMOS LDOs

Source: Dataquest (June 1998)

Although there is increasing trend to integrate separate functions of the cellular phone into a single chip, power management will likely remain independent because of the complexity of the analog processes involved in making power management ICs. Furthermore, the increasing need for longer battery life and higher performance will continue to stimulate the growth of power management solutions. As a result, power management ICs in digital cellular phones are projected to grow at a strong CAGR of 18 percent for the next five years, from $291 million in 1997 to $665 million by 2002.

Analog Baseband ICs

The analog baseband functions include voice coder/decoder (CODEC), and RF CODEC. The voice CODEC, linking the digital baseband to the microphone and speaker, sends a user's voice to the digital baseband and allows the received signal to be heard through the earphone speaker. The RF CODEC, linking the digital baseband to the RF subsystem, converts an outgoing digital data stream from the digital baseband into a modulation format appropriate to the transmission standard and converts an incoming signal received by the RF subsystem for further processing by the digital baseband. These two analog baseband functions, often referred to as baseband interface functions, provide an analog front end to digital communication systems and not only link digital baseband with users' voices and RF signals but also carry a great deal of the processing workload, such as maintaining signal quality, extending talk time, and improving overall system performance.

Unlike power management, where analog technology is key, the name of the game in supplying analog baseband CODECs is mixed-signal technology. Only companies with both analog and digital design and process expertise can compete well in this market. The major players that supply analog baseband CODECs include Texas Instruments, Motorola Incorporated, Lucent Technologies Microelectronics Group, NEC Corporation, Philips Semiconductors Inc., Siemens AG, VLSI Technology Inc., QUALCOMM Incorporated, DSP Communications Inc., and Analog Devices Inc. Table 3 lists the major players, with comments on their competitive positions.

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Dataquest does not provide analog baseband revenue estimates for individual vendors because they have not been surveyed at this detailed level.

It is evident that all these suppliers have very significant mixed-signal expertise. And not surprisingly, the four leading DSP suppliers—Texas Instruments, Lucent Microelectronics, Analog Devices, and Motorola—are all active players, aiming to offer complementary mixed-signal DSP solutions for the wireless market. Furthermore, some of the players are vertically integrated wireless OEMs themselves, with in-house semiconductor business units that supply both internal and external customers.

The total analog baseband IC market for digital cellular phones in 1997 is estimated to be around $641 million. Since there is an increasing trend toward integrating the analog baseband CODECs and the digital baseband functions onto a single chip, the analog baseband ICs are projected to grow at a moderate CAGR of 14 percent for the next five years, from $641 million in 1997 to more than $1.2 billion by 2002.

Table 3
Major Players in Analog Baseband ICs for Digital Cellular Phones

Companies	Comments
Texas Instruments	Major supplier to first-tier OEMs Ericsson and Nokia; in-house DSPs
Motorola	Wireless OEM itself; in-house DSPs; trying to shift away from analog cellular and ramp up digital cellular
Lucent Microelectronics	In-house DSPs; announced an integrated DSP and voice CODEC chip for CDMA
NEC	Strong system-level ASIC technology
Philips	Wireless OEM itself with in-house semiconductor unit
Siemens	Wireless OEM itself with in-house semiconductor unit
VLSI Technology	Supplier of baseband ASICs for GSM
QUALCOMM	Wireless OEM itself; strong player in supplying baseband chipsets for CDMA
DSP Communications	Supplier of baseband ASICs for TDMA and CDMA; licensed CDMA technology from QUALCOMM
Analog Devices	Supplier of GSM chipsets to wireless OEMs such as Philips and Siemens

Source: Dataquest (June 1998)

RF ICs

RF ICs are mainly amplifiers, transmitters/receivers, and synthesizers. Amplifiers include power amplifiers for transmission of the radio signal and low-noise amplifiers (LNAs) for reception of a radio signal. Transmitters/receivers, along with synthesizers, handle many of the transceiver modulation/demodulation functions.

RF amplifiers represent the largest segment within RF ICs. A large portion of amplifiers, especially the power amplifiers supplied for cellular phones today, are based on gallium arsenide (GaAs), with the major players being Anadigics Inc., TriQuint Semiconductor Inc., and RF Micro Devices Inc. The other RF ICs, such as transmitters/receivers and synthesizers, are mostly silicon-based and made with a bipolar process. The major suppliers of transmitters/receivers include Hewlett-Packard Company, Motorola, Philips, Siemens, and NEC; the major suppliers of synthesizers include National Semiconductor, Motorola, Philips, and Fujitsu Ltd.

Texas Instruments has thrived on supplying baseband semiconductors for the digital cellular market. In a move to provide full solutions for the digital cellular market and lay the groundwork for the single-chip cellular phone, TI has announced its own RF products such as LNAs, receivers, and synthesizers, and is expected to announce power amplifier products in the near future. More detailed analysis of TI's wireless move is available in the Dataquest Perspective "Texas Instruments and its New Analog Thrust" (SEMI-WW-DP-9804, May 1998).

Silicon germanium (SiGe) technology has emerged as a potential alternative to GaAs and silicon technologies. The primary advantage of SiGe technology is that it leverages traditional silicon CMOS and bipolar processing to achieve higher-frequency performance and reduced power consumption. IBM has been the leading proponent of SiGe technology for the wireless market and has developed extensive SiGe technology in-house over the past few years. In a move to remedy its lack of wireless design expertise, IBM acquired CommQuest Technologies Inc., a chip design house known for its wireless communications design skills. With CommQuest's wireless know-how and its own pioneering SiGe effort, IBM has laid plans to provide single-chip cellular solutions, including RF and baseband parts, using its SiGe technology.

A more detailed analysis of RF semiconductors for wireless applications, including an RF IC market size forecast, will be available from Dataquest's Wireless Semiconductor Application Markets Worldwide (WSAM-WW) program, to be launched in July.

Analog and Mixed-Signal IC Market Size Estimate

Table 4 shows current market size estimates and growth projections for power management ICs and analog baseband ICs in digital cellular phones. Total consumption of analog and mixed-signal ICs in digital cellular phones, excluding RF ICs, is projected to exceed $1.9 billion by 2002. The RF IC market size and projections will be published by Dataquest's Wireless Semiconductor Application Markets Worldwide program.

Table 4
Digital Cellular Handset Consumption of Power Management and Analog Baseband ICs

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	48,789	98,600	131,200	165,185	205,705	247,550	288,925	24
Power Management ($M)	178	291	365	443	518	592	665	18
Analog Baseband ($M)	398	641	771	894	1,018	1,136	1,245	14
Total ($M)	575	932	1,136	1,336	1,537	1,728	1,910	15

Source: Dataquest (June 1998)

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Dataquest Perspective

Although the remarkable growth of the PC market in the last decade has been the driving force behind the growth of semiconductors, Dataquest believes the communications market, including wireless communications and wired communications, will join the PC market as driving forces behind semiconductor growth for the next decade.

The surge in sales of digital cellular telephones has provided tremendous profit opportunities for companies supplying this market. With further penetration of digital cellular in underdeveloped regions of the world, the digital cellular market will continue to expand. Dataquest believes that analog/mixed-signal and RF technologies will be among the key weapons that allow semiconductor vendors to win in this expanding wireless market.

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Perspective

Semiconductors Worldwide

Market Analysis

Integrated Circuit Packaging, 1998

Abstract: *As IC package design transcends to emerging flip chip, ball grid array (BGA), and chipscale package (CSP), proliferation of designs haunts both suppliers and users. It took the package industry over 10 years to shift its focus from through-hole to surface-mount technology (SMT). Package proliferation abounded with every new product and application. Package architectures became both product and application specific. It was a costly experience for both supplier and user. If this trend continues, what changes should one expect over the horizon?*
By Mary Ann Olsson

The Industry in 1997

If you are involved in any aspect of the semiconductor packaging world, then you are definitely experiencing a case of déjà vu. At a recent seminar on the use of advanced packaging materials challenges, arguments broke out about the proliferation of chipscale packages (CSPs), the lack of standards, and the probability of materials suppliers, package designers, and fab engineers working together to overcome today's package challenges.

The French have a great expression for this: *Plus les choses changent, plus elles restent le même,* which translates as, "The more things change, the more things remain the same." Surface-mount technology (SMT) entered the realm of semiconductor packaging in early 1970. The arguments over package proliferation, the lack of standards, and the advantages or disadvantages of small-outline (SO) packages over through-hole packages still held the industry in awe in 1984. The desire to compete with Japan and the shift in level of integration from large-scale integration to very large-scale integration (LSI to VLSI) prompted Texas Instruments Inc., Signetics Company, National Semiconductor Corporation, and Motorola Incorporated

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to invest heavily in surface mount equipment and assembly facilities. At that time, SO package costs were about 25 percent higher than the traditional through-hole designs.

By 1988 SMT package designs represented only 28 percent of all IC packaged devices shipped worldwide. By 1992 SMT reached 60 percent of IC packaged parts shipped. The level of integration was now in the middle of ultra-large-scale integration (ULSI), with device feature sizes dropping from 1.25 micron to 0.5 micron. Package proliferation was abundant as suppliers inundated users with numerous variations of SO and quad flat pack (QFP) designs. On the horizon, IBM projected a market of the future that would have to deal with 600-MHz microprocessors by 2000. Other mainframe and workstation vendors promoted the benefits of multichip modules and complex single-chip designs for 1997 and 1998 production. Wire bonder manufacturers and materials suppliers were in R&D stages, preparing for the onset of a flip-chip technology ramp-up by 2000.

It is now midyear 1998. The search goes on for the ultimate package. Motorola once described this as the universal package with only three leads: one lead for power, one for ground, and a third for a multiplexed fiber-optic link. However, the market remains inundated with multiple categories of package styles. Standards procedures are still long and arduous. However, there is evidence of change and improvement in how materials suppliers, package designers, and fab engineers work to form a cohesive process flow.

Table 1 represents the package categories for all semiconductor devices shipped in 1997. Each category has multiple subcategories of package styles and sizes that are too numerous to list in one Perspective.

Table 2 is an example of only one package subcontractor's capability in chip-size BGAs. Dataquest is not marketing one company's capability over another's. This is merely one example of package proliferation. Virtually every semiconductor supplier and package subcontractor now offers BGA and CSP package designs, as well as most other package styles listed in Table 1. Some have licensed other company designs, as well as patenting their own company designs.

The cost for manufactured plastic BGAs has reached parity with comparable plastic QFPs. The cost for CSPs varies by supplier and design and ranges by volume from 25 to 30 and even 50 percent higher than comparable thin small outline plastic (TSOP) and shrink small outline plastic (SSOP) designs, as shown in Table 3. If volume production ramps up in 1999 for CSP designs, especially in the low pad count range, CSPs could reach parity with some TSOP designs.

The Future of Packaging

Table 4 lists the unit shipment forecast for just IC packages. Table 5 lists the share of total shipments for IC packages. These tables do not include data for optical or discrete packaged devices. As noted in Tables 1, 4, and 5, SO packages dominate the market through the forecast period. The

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microprocessor and ASIC devices will drive the need for high-performance and higher pin count (108-pin and above) package designs in both plastic and ceramic. The need will be for both single chip and multichip, using BGA and flip-chip attach, as well as older QFP and PGA designs.

Table 1
Worldwide Semiconductor Products Shipped by Package Category, 1997

	Semiconductor	IC	Optical	Discrete	Bipolar Memory	Bipolar Logic	MOS Digital DRAM	SRAM[1]	Nonvolatile
Plastic DIP	11,429	2,120	521	8,788	1	55	38	28	450
Ceramic DIP	68	56	12	0	11	0	0	0	0
Plastic QFP	15,011	15,011	0	0	1	0	0	0	15
Ceramic QFP	172	172	0	0	1	0	0	0	0
Ceramic Chip Carrier	86	26	47	13	1	0	0	0	0
Plastic Chip Carrier	632	604	14	14	0	22	2	26	198
SO	103,988	27,257	5,645	71,087	0	1,670	3,166	996	1,655
Ceramic PGA	141	141	0	0	0	0	0	0	0
Plastic PGA	271	140	131	0	0	0	0	0	0
Ceramic BGA	144	144	0	0	0	0	0	0	0
Plastic BGA	1,631	1,583	48	0	0	0	4	44	0
Bare Chip	5,073	3,096	446	1,531	0	0	160	72	200
CSP	264	189	1	74	0	0	6	6	148
Others	85,641	1,986	6,780	76,875	0	0	53	0	0
Total	**224,551**	**52,525**	**13,644**	**158,382**	**15**	**1,747**	**3,429**	**1,172**	**2,666**

	Other MOS Memory	MPU	MCU	MPR[2]	DSP	MOS ASIC	MOS Standard Logic	Other MOS Logic	Analog
Plastic DIP	0	0	188	0	0	20	588	108	644
Ceramic DIP	0	0	43	0	0	2	0	0	0
Plastic QFP	0	77	1,544	1,448	130	1,400	0	421	9,975
Ceramic QFP	0	4	21	47	1	98	0	0	0
Ceramic Chip Carrier	0	0	3	0	0	2	2	18	0
Plastic Chip Carrier	1	0	200	2	2	41	89	21	0
SO	328	0	756	0	0	0	5,241	1,335	12,111
Ceramic PGA	0	123	0	0	0	18	0	0	0
Plastic PGA	0	4	0	14	1	121	0	0	0
Ceramic BGA	0	64	0	0	5	75	0	0	0
Plastic BGA	0	5	266	177	175	663	0	4	245
Bare Chip	34	2	381	0	0	65	689	71	1,422
CSP	1	0	3	3	2	1	0	0	19
Others	0	0	0	0	0	0	0	0	1,933
Total	**364**	**279**	**3,405**	**1,691**	**316**	**2,506**	**6,609**	**1,978**	**26,349**

[1]Includes pseudo SRAM
[2]Microperipheral
Source: Dataquest (June 1998)

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Table 2
Abpac Inc. Chip-Size Package BGA Availability (1mm Pitch)

Maximum Ball Count	Body Size (mm)	Ball Array
20	5 x 5	5 x 5
28	6 x 6	6 x 6
36	7 x 7	7 x 7
44	8 x 8	8 x 8
68	9 x 9	9 x 9
84	10 x 10	10 x 10
112	11 x 11	11 x 11
128	12 x 12	12 x 12
144	13 x 13	13 x 13

Source: Abpac

The older PGA designs will decline in share while microprocessor giants such as Intel Corporation migrate to ceramic and plastic BGA and eventually even to advanced ceramic and plastic CSP designs. As noted by Evan Davidson (1998 IEEE Symposium, "Long Lossy Lines (L3) and Their Impact upon Large Chip Performance," IBM) at the 200-MHz MPU, internal delays on the clock rates were a problem; the effects worsened as the die grew larger and the ground rules got smaller. Many designers do not have the wire capacity allowances and cannot wire the design. Intel's Ricardo Suarez-Gartner suggested (1998 IEEE Symposium, "System Technology Challenges Facing the PC Industry") that the design challenge was to get the mostly small, multiple component suppliers to work together on the up-front design. With each process improvement, from 0.35-micron down to 0.09-micron, the component challenge would be a package challenge.

Beyond the Pentium II, Intel sees a heavy investment in flip-chip technology, but it admits that the magic will be the interaction of its chip's compatibility with the PCB and the other system components. What are future solutions for microprocessor and ASIC designers? Other solutions in R&D stages are die-packs or smaller cores. Die-packs are in reality small multichip modules (MCMs) that would use thin-film wiring in a BGA carrier. The BGA carrier would consist of four small chips instead of one big, complex chip. For ASICs, fine-line and enhanced BGA packages are addressing ASIC vendors' solutions to high input/output (I/O). These BGA designs are sufficient for complex ASIC designs with higher levels of integration and increased I/O counts that also need to address system-level miniaturization. An example of this type of development, from Altera Corporation, is shown in Table 6.

Table 3
Package Cost Comparisons (Cents per Pin)

Low I/O Range: 40-50	1998	2000
CSP	0.025	0.020
TSOP-SSOP	0.015	0.011

Source: Dataquest (June 1998)

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The SO family of packages has long been the mainstay for memory, analog, standard logic and discrete devices. This has been the most cost-efficient and reliable surface-mount package available to the largest product sector of the market. It first grew in acceptance and in variation in Japan in the consumer electronics boom of the early 1980s and via selected digital products that required higher-density packaging. SO designs were the great contributor to memory module manufacturing and the eventual growth of the desktop PC market. On the horizon, CSP designs may be the package that displaces the SO.

The CSP package is now in production for flash memory devices. Some of the DRAM companies are evaluating CSP and lead-on-chip (LOC) designs for the 64M- and beyond generations of DRAMs. For many DRAM manufacturers, the SO and TSOP designs remain the most cost-effective, reliable product for most applications. CSPs are chip-size or slightly larger than chip-size in scale, as illustrated in Figure 1. In Xilinx Incorporated's complex programmable logic device (CPLD) product, the footprint of the 48-pin CSP is three times smaller than that of the 44-pin, very thin QFP.

Just as the consumer market initially drove the need for miniaturization of the devices in the 1980s, the new pocket-size consumer market, as well as portable and wireless applications, will drive the need and growth for this next generation of SMTs, the CSPs. Some of the new application designs incorporating the smaller CSP as well as BGA and flip-chip technologies are listed in Table 7.

Ultimately, 1997 was the turning point for increased demand for all of the new and emerging advanced package designs such as flip-chip attach, MCMs, BGAs, and CSPs. The new portable and consumer market applications were part of this enabling structure.

Table 4
Worldwide IC Package Production (Millions of Units)

	1995	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Plastic DIP	4,200	2,386	2,120	1,431	1,013	734	519	422	-27.6
Ceramic DIP	171	54	56	50	46	38	34	30	-11.7
QFP	15,823	13,923	15,183	17,344	19,899	21,815	24,000	23,750	9.4
Ceramic Chip Carrier	115	34	26	25	32	31	28	18	-7.1
Plastic Chip Carrier	546	669	604	482	315	270	233	178	-21.7
SO	25,250	24,650	27,257	29,442	32,147	36,465	38,878	40,647	8.3
Ceramic PGA	119	171	141	117	109	101	94	89	-8.8
Plastic PGA	117	188	140	138	126	119	112	106	-5.4
Ceramic BGA	9	37	144	151	220	300	386	470	26.7
Plastic BGA	271	647	1,583	2,353	3,110	4,353	6,020	7,288	35.7
Bare Chip	4,119	2,918	3,096	4,001	4,788	5,990	8,000	9,000	23.8
Chipscale	0	15	189	448	830	1,320	1,930	2,558	68.4
Others	0	1,853	1,986	2,560	3,033	3,238	3,435	3,520	12.1
Total	**50,740**	**47,545**	**52,525**	**58,542**	**65,668**	**74,774**	**83,669**	**88,076**	**10.9**

Source: Dataquest (June 1998)

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Table 5
Worldwide IC Package Production (Percentage of Total Units)

	1995	1996	1997	1998	1999	2000	2001	2002
Plastic DIP	8.3	5.0	4.0	2.4	1.5	1.0	0.6	0.5
Ceramic DIP	0.3	0.1	0.1	0.1	0.1	0.1	0	0
QFP	31.2	29.3	28.9	29.6	30.3	29.2	28.7	27.0
Ceramic Chip Carrier	0.2	0.1	0	0	0	0	0	0
Plastic Chip Carrier	1.1	1.4	1.1	0.8	0.5	0.4	0.3	0.2
SO	49.8	51.8	51.9	50.3	49.0	48.8	46.5	46.1
Ceramic PGA	0.2	0.4	0.3	0.2	0.2	0.1	0.1	0.1
Plastic PGA	0.2	0.4	0.3	0.2	0.2	0.2	0.1	0.1
Ceramic BGA	0	0.1	0.3	0.3	0.3	0.4	0.5	0.5
Plastic BGA	0.5	1.4	3.0	4.0	4.7	5.8	7.2	8.3
Bare Chip	8.1	6.1	5.9	6.8	7.3	8.0	9.6	10.2
Chipscale	0	0	0.4	0.8	1.3	1.8	2.3	2.9
Others	0	3.9	3.8	4.4	4.6	4.3	4.1	4.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Dataquest (June 1998)

Table 6
Fine-Line BGA Technology Road Map

Size/Pitch	1.27mm	1.0mm	0.8mm	0.5mm
27mm	256 balls	674 balls	1,024 balls	2,500 balls
17mm	-	256 balls	-	-
13mm	-	-	256 balls	-
9mm	-	-	-	256 balls

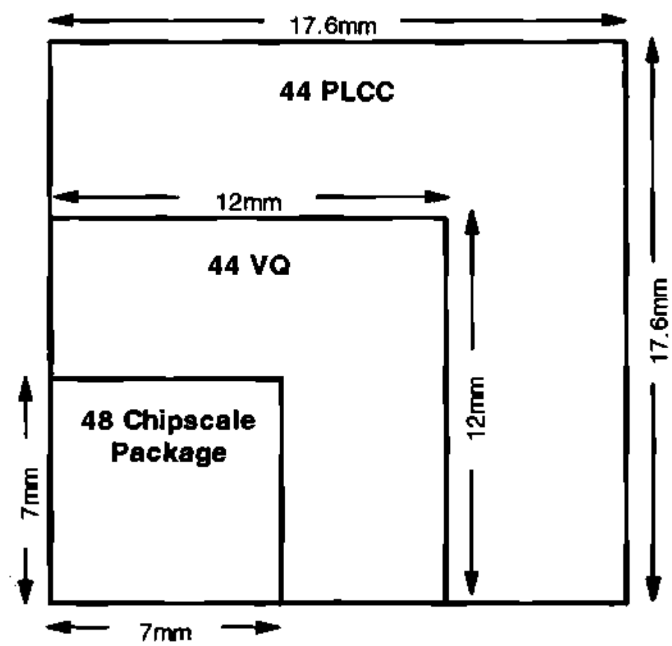
Source: Altera

Challenges on the Horizon

Perhaps the biggest challenge for today's package designer is the shrinking cycle time. Proliferation of packages may be a marketing department's answer to addressing all customer and all application needs, but who will bear the cost, when the lowest cost is a major challenge. Equipment cycle time for many companies, especially those in the data processing and communications sectors, is now less than 18 months. Design cycles for equipment and semiconductor components are short and small. Even if a company could design something sophisticated or complex, does it have the time?

The semiconductor industry is in the throes of silicon transition. Whether designers like the transition or not, the users are making the calls. Intel is one company listening and heeding the call with leading-edge microprocessors in multiprocessing systems. Lucent, Texas Instruments, and Analog Devices Inc. are hot on the trail with embedded DSP, embedded microcontrollers, and embedded ASIC and mixed signal in ASSP devices. System-level integration, the enabler of smaller form factor and more feature-rich function, is according to Lucent Microelectronics, "the technical springboard that companies like cellular phone manufacturers need to differentiate their product." As the industry matures or shrinks, depending on one's outlook, the basic packaging infrastructure in place today may not be suitable to address the needs of the very near future.

Figure 1
Chipscale Package Size Comparisons



Source: Xilinx

In today's market, there is no time. More ICs are moving to modules or to self-contained units or cards. Modules are basically "idiot proof." They are easy to plug in anywhere. They plug into a cellular phone or a PC board, and they are present in every new application. The package industry of the future may look very much like a card I/O or an Intel kit.

If the package is indeed the primary barrier to development of many of the high-performance systems beyond 2000, how does today's industry improve or ready its infrastructure to survive the changes and challenges?

Flextronics International Ltd. is one of many companies that is building part of the infrastructure need. Other companies include Fujitsu Microelectronics Inc., IBM, and Flip Chip Technologies L.L.C., as well as most of the foundry companies such as Chartered Semiconductor Manufacturing Pte. Ltd., Taiwan Semiconductor Mfg. Co. (TSMC), and United Microelectronics Corporation.

Through either alliances or shared facilities, or as full turnkey manufacturers, these companies provide all levels of package integration: from wafer level through test and burn-in, through box, pack, and ship to customer types of services. Basically, they have become a one-stop shopping mall for the industry.

Flextronics has expanded its service developments during the last 18 months. It has increased its operational square footage to over 2 million, and as of the first quarter 1998, manufacturing facilities were running at full capacity. From product design to PCB fabrication, materials procurement and inventory management, final system assembly and test, packaging, and distribution, the company obviously fills the need for many customers.

Table 7
Emerging Package Application Opportunities

Products	Companies	Key Product Features	Key Package Features
Palm-Size PCs	Texas Instruments, Casio, Everex, Philips Electronics, 3Com	Voice command and voice recorders, alarms	CSP, MCM, BGA, flip chip
Handheld Portables	Philips Electronics, Sharp, NEC, Psion plc, Ericsson Mobile Computing AB, Hewlett-Packard, Geofox Inc., Casio, Compaq	Color screen, flash memory expansion slots, ROM card slots, PCS phone compatibility, camera card plug-in capability, touch-type keyboard, modem and memory expansion slots	COB, COF, flip chip on flex, CSP, MCM, BGA, TAB, SO
Smart Phones	Nokia Mobile Phones, Samsung Electronics, Alcatel, Philips Consumer, Motorola, Lucent, Hyundai, LG Information & Communication	Portable digital GSM, cellular CDMA, desktop, speech coding, security, PC card slots	Flip chip on flex, COB, CSP, MCM, BGA, TAB, SO
Automotive PC	Intel, Motorola, Microsoft, Chrysler, Daimler-Benz	Windows CE, connector card PC, desktop PC card slots, modem slots	COB, flip chip, CSP, MCM, TAB

Source: Dataquest (June 1998)

Flextronics and others have grown as a result of semiconductor suppliers outsourcing package design, manufacturing, and assembly services. In their own way they have leveraged their skills in materials procurement while reducing cycle time and costs for themselves and their customers. Package proliferation and standards chaos may be with us for quite a long time. The full-service provider, such as Flextronics, is gaining in popularity and may displace many of the small service providers along the way to growth.

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This Dataquest Perspective and others to follow on the subject of packaging replace the annual IC Package Focus Report. Any comments or suggestions may be forwarded directly to the author.

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Perspective

Semiconductors Worldwide

Market Analysis

Worldwide Semiconductor Quarterly Outlook: Spring 1998

Abstract: *Dataquest forecasts for worldwide semiconductor consumption are reviewed and analyzed in the context of the Asian financial crisis, delays in the production transition to 300mm technology, the booming U.S. economy, and trade issues. While the semiconductor industry as a whole appears to be healthy, with positive or recovering growth prospects in all regional markets during the current year, these optimistic forecasts should be tempered with some caution.*

By Junko Matsubara

Mixed Signals from the Industry

The U.S. economy appears to be on an upswing. Unemployment is at a 28-year record low, the stock market is at record highs, inflation is in check, and consumer confidence is responding to the positive conditions. This should translate into higher levels of domestic electronic hardware sales and thus generally benefit the semiconductor industry. Unfortunately, as has happened in the past, the semiconductor industry is not always in complete synchronization with the rest of the U.S. economy. This time the reasons are relatively clear. The semiconductor industry is trade intensive, and Asian markets for both chips and chipmaking equipment are depressed. The high contrast between the economic state of the United States and most of Asia has put some unusual forces into play in Silicon Valley. While some companies are being forced to reduce their workforce by double-digit percentages, other companies, notably Internet service providers, can't get enough new hires to fill all their openings. The shortage of affordable housing suggests that new job openings in the valley still outnumber the jobs being lost to downsizing.

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Despite the outward appearance of prosperity and growth, there are reasons to be concerned. How long will the current conditions last? Will the high-

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growth areas of the Internet lead to a rapid rebound for semiconductor equipment makers? If equipment makers found any signs of a recovery in the short term, it seems unlikely that they would submit their companies to the hardships of workforce reductions. Nevertheless, predicting these markets with the many underlying forces at work is becoming as complex as predicting weather changes, and Dataquest does not use supercomputers for its forecasting. Besides, even with its supercomputers, the U.S. weather service still failed to predict the tornado that touched down recently in the middle of Silicon Valley, for the first time in 50 years.

This Perspective discusses some of the salient issues that will help answer some of these questions. Dataquest forecasts for the five-year growth rate of the major semiconductor markets will also be reviewed.

Company Financials: Not Always the Complete Story

Table 1 shows the year-to-year change in the first quarter sales and gross profit margin for 16 major semiconductor companies. No Asian companies are represented because they do not generally issue quarterly results.

Table 1
Semiconductor Companies' Financial Results, Q1/97 and Q1/98 (Thousands of Dollars)

	Net Sales Q1/97	Net Sales Q1/98	Net Sales Change (%)	Gross Margin Change (%)	Net Income Q1/97	Net Income Q1/98	Net Income Change (%)
Micron Technology	876,200	755,400	-13.8	-22.0	16,565	-48,000	-389.8
Texas Instruments	2,263,000	2,187,000	-3.4	-4.3	129,000	11,000	-91.5
IBM	17,308,000	17,618,000	1.8	-1.5	1,195,000	1,036,000	-13.3
Atmel	252,946	260,392	2.9	-9.1	38,738	17,727	-54.2
Motorola	6,642,000	6,886,000	3.7	-3.9	325,000	180,000	-44.6
Intel	6,488,000	6,001,000	-7.5	-10.3	1,983,000	1,273,000	-35.8
AMD	551,999	540,856	-2.0	-15.2	12,951	-55,872	-531.4
Rockwell	1,899,000	1,941,000	2.2	-4.4	189,000	109,000	-42.3
LSI Logic	308,388	324,850	5.3	-3.1	38,407	30,443	-20.7
Lucent Technologies	5,149,000	6,157,000	19.6	2.1	66,000	23,000	-65.2
VLSI Technology	177,684	141,286	-20.5	-1.9	8,986	3,116	-65.3
SGS-Thomson	944,900	1,005,400	6.4	0.1	90,500	126,301	39.6
National Semiconductor	680,500	650,100	-4.5	-1.2	42,800	22,300	-47.9
Analog Devices	292,063	330,721	13.2	1.7	39,180	44,284	13.0
Applied Materials	835,776	1,307,685	56.5	3.7	27,577	228,893	730.0
Lam Research	233,266	240,018	2.9	19.5	-44,255	-70,064	58.3

Source: Company literature, Dataquest (May 1998)

Based on these figures, it appears that Applied Materials Inc. and Lucent Technologies had the best performance through the first quarter, with strong growth in both sales and gross profit margins. Despite this performance,

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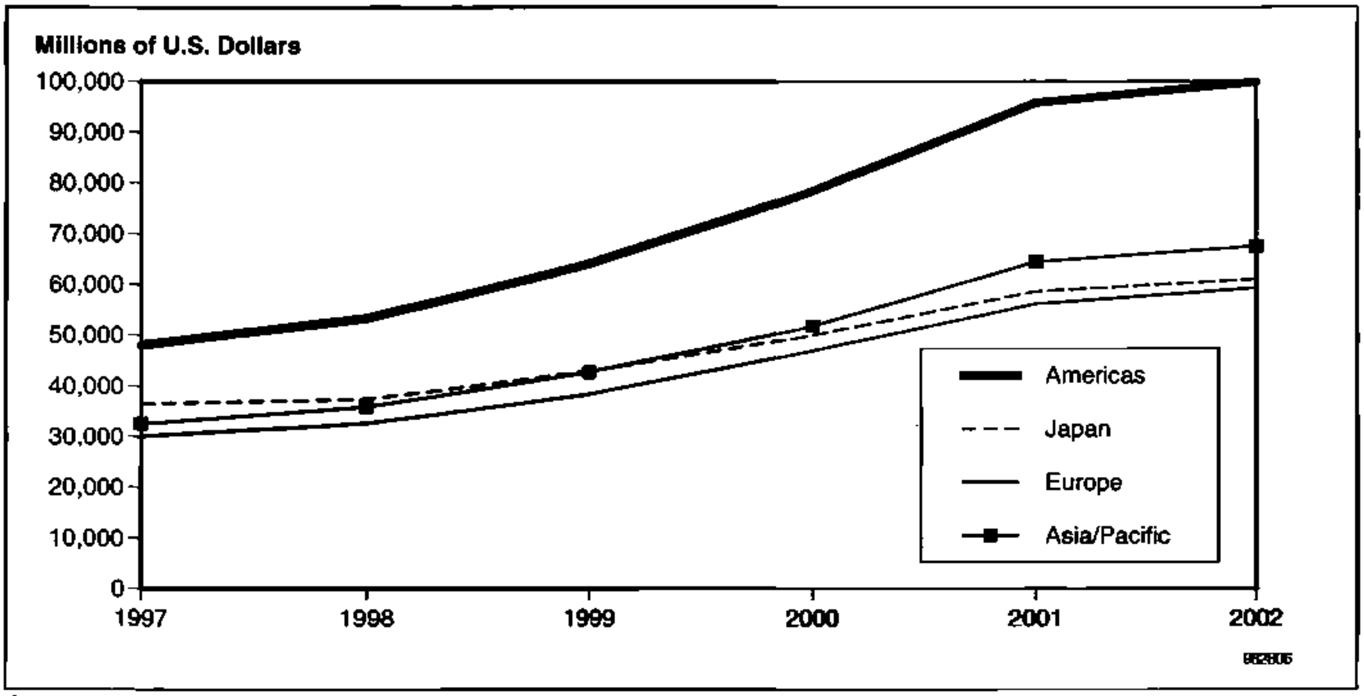
Applied Materials and other equipment supplies are forecasting slower sales in the short term based on canceled or falling order rates. Lam Research Corporation also did well during the fourth quarter, recording the highest increase in growth profit margin of the 16 companies we investigated. However, Lam Research has already taken evasive action in preparation for revenue declines by having several rounds of layoffs. Its troubles are not unique, but rather a direct result of many chip manufacturers' decisions to delay upgrades to the new 300mm wafer-fabrication technology. This has delayed the return on the R&D investments that equipment manufacturers put into developing the new technology.

As Figure 1 shows, Dataquest forecasts that the Japanese, European, and Asia/Pacific regional markets will all be outpaced by the growth of the Americas semiconductor market in the next few years. This will have important implications for equipment manufacturers, which are the most dependent on international sales. For these companies, there will likely be a two-year slowing, followed by a rebound, assuming that Asian manufacturers solve most of their other problems related to their domestic economies.

Figure 1
Semiconductor Consumption Forecast by Region



Source: Dataquest (May 1998)

Among semiconductor vendors, Micron Technology Inc. derives the largest percentage of its revenue from commodity dynamic RAM (DRAM) memories, and it also showed the weakest financial performance in our roundup. The company's performance was indicative of the soft DRAM markets and probably representative of the declining profitability being experienced by both South Korean and Japanese semiconductor vendors. Although Micron remained profitable in the first quarter of 1998, it had only

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a 3 percent gross profit margin, compared to the double-digit profit margins of the other 15 companies shown in the table.

Other DRAM vendors such as Texas Instruments Inc. and IBM fared significantly better, with more than 30 percent gross profit margins, mostly because of their size and diversified product lines. At the time of this writing, there is speculation that TI is preparing to exit the DRAM business by selling its facilities to Micron in exchange for Micron stock. This would serve to insulate TI's financial performance from the fluctuations in the DRAM markets, while still providing it with both an investment in, and future source of, DRAM products. A move like this would allow TI to focus its resources on its digital signal processing (DSP) and logic businesses to better compete with the likes of Motorola and the surging Lucent Technologies. Lucent registered net sales during the first quarter that exceeded even Intel Corporation's. Analog Devices, another major player in DSPs, also did well during the first quarter as one of the highest performing of the smaller semiconductor companies.

The year-to-year change in the first-quarter sales and gross profit margin were down substantially at microprocessor giant Intel and its most visible competitor, Advanced Micro Devices Inc. In Intel's case, the changes in sales and profitability are somewhat misleading. The company still had a 54 percent gross profit margin during the first quarter, the highest among the companies being reviewed. The declines in profitability are the result of the shift in the sweet spot of the PC markets to lower-cost machines. Many buyers are now finding that the performance of "value-line" machines is sufficient to meet their application needs while running on Windows 95. AMD's difficulties with low profitability stemmed more from manufacturing problems than from any flaws in its market or product strategy.

The Asian Financial Crisis

In the many ongoing debates about the impact of the Asian crisis on the U.S. economy, the majority of analysts now seem to speculate that the impact will be minimal. However, the reality of the situation is that no developed country or region can prosper indefinitely without robust trade with other countries. The last recession that the United States experienced in the early 1990s was due, in part, to the trade imbalance. Trading partners successfully exported their products into the U.S. market but failed to appreciate the importance of balancing their exports with a sufficient flow of imports of U.S.-made products into their own home markets. This led to a prolonged period of trade deficits and an unsustainable balance of payments, which eventually culminated in the loss of jobs and a slower economy in the United States. Inevitably, the U.S. recession resulted in a lack of funds to continue purchasing foreign-made imports, which, in turn, put a damper on trade with Asia. This sent Japan, in particular, into an even more severe recession than the one initially experienced by the United States. The circumstances that caused this chain of events could reoccur in the absence of a balanced flow of goods between the United States and its Asian trading partners. The

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widespread decline of the Asian economies offers further substantiation of how dependent these economies are on trade.

The optimistic projections of so many U.S.-based analysts forecast minimal impact on the U.S. economy from the Asian crisis. However, it is important to recognize that these models implicitly depend on the recovery of Asian economies within a certain time frame. The longer the recovery takes to occur in Asia, the greater the impact on the U.S. economy. U.S. analysts have incentives to downplay the impact from Asia because no one wants to be the cause of an investor panic that results in a stock market "adjustment."

Moreover, the claims by many analysts that the U.S. economy is too healthy to be affected by the problems in Asia sound all too similar to the arguments put forth by Japanese analysts in the early 1990s just before the bottom fell out of their economy. Similar to current suggestions about the U.S. economy, those analysts claimed that the Japanese economy was simply too healthy and insulated to be affected by the U.S. recession. After all, Japan had a big trade surplus and lots of money. The problem with their reasoning was that Japan had basically accumulated too much money. The country was so cash rich that its trading partners had depleted their capacity to buy more Japanese products. Less cash meant reduced trade, and the rest is recession history.

Another way to think of the interaction is that if one country continues to export goods to another country without importing a similar amount of goods, the total number of goods available to the combined population is lower, and the standard of living of the combined population is therefore reduced. It doesn't matter whether the country exporting more than it imports does so because it finds no demand in its own markets for foreign goods, or because it genuinely has no funds with which to purchase imports. It is not cash that increases the standard of living of the global population, but total employment and high global productivity.

The trade conditions that now exist between the United States and Asia are similar to those that preceded the last recession in the United States. Americans are increasing their purchases of imported goods, while Asian countries are spending more conservatively, as expected, in these uncertain economic conditions. The result may well be a trade deficit with Asia that continues to expand as long as the Asian economies remain depressed. Consumer confidence in Asia will need to recover before U.S. exporters see a significant rise in demand for their products. While the circumstances for lower exports from the United States to Asia may be a bit different now than those that existed earlier in the decade, the impact on the U.S. economy is potentially the same.

Semiconductor Market Forecast

In semiconductors, Dataquest forecasts that the U.S. consumption rate will easily outpace the consumption growth rates in the other major areas of the world, which includes Europe, Japan, and the Asia/Pacific regions. This is shown in Figure 1 and Table 2.

Table 2
Semiconductor Consumption Forecast by Region (Millions of Dollars)

	1997	1998	1999	2000	2001	2002
Americas	48,086	53,326	64,133	78,388	95,782	99,906
Japan	36,499	37,397	42,943	49,988	58,610	61,093
Europe	30,046	32,627	38,425	46,927	56,152	59,336
Asia/Pacific	32,534	35,899	42,754	51,751	64,483	67,561
Total	**147,165**	**159,249**	**188,255**	**227,054**	**275,027**	**287,896**

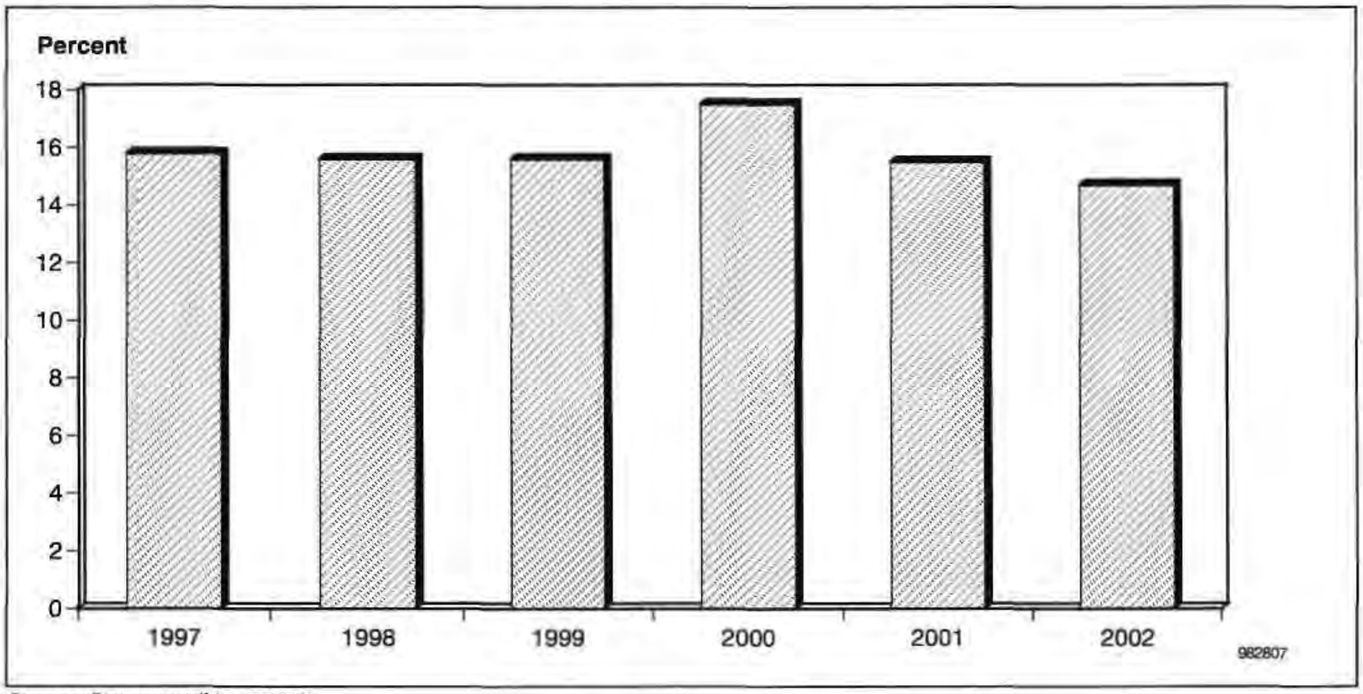
Source: Dataquest (May 1998)

Of the four major regions, Japan was the only one that experienced a contraction of its semiconductor consumption in 1997. Furthermore, Dataquest is anticipating that the Japanese semiconductor consumption will show far lower growth than the rest of the world during 1998, making the consumption curve nearly flat in Japan during the current quarter. The Americas semiconductor consumption level was roughly equal to the Japanese market in 1992, and by next year the Americas market is expected to have more than 1.5 times the semiconductor consumption level of Japan. Thus, the short-term outlook for Japanese system vendors, the consumers of semiconductors, is not encouraging. This escalating disparity in the consumption rates between the United States and all other countries is alarming in itself, even if it is just in the semiconductor sector. It suggests a growing trade imbalance that would naturally lead to economic resistance to further separation of the consumption rates.

Figure 2 shows the Dataquest forecast for the growth rate of worldwide PC shipments in the next five years. Over five years, beginning in 1998, the compound annual growth rate (CAGR) is expected to be 15.8 percent, which is in general agreement with the 14.6 percent CAGR of the worldwide semiconductor market over the same five-year period. A similar consistency exists between the Americas' five-year semiconductor market CAGR, at 15.7 percent, and their PC market CAGR of 14.8 percent for same time period. However, both the Asia/Pacific and Japanese regions have a greater disparity between their PC market CAGRs of 25.3 and 14.4 percent, respectively, and their semiconductor market CAGRs of 15.7 and 10.9 percent, respectively. In both cases, this forecast suggests that the supply of foreign-made PCs will grow at a faster rate than the sale of PCs made by domestic firms, assuming that the growth of the semiconductor markets in these regions is a reasonable gauge of PC production growth.

Although it does seem clear that the Japanese have very different PC-buying practices from their U.S. counterparts, the slowdown of PC sales in Japan is disconcerting. Price barriers, which vanished a few years ago, have begun to reappear, despite the rapid declines in mainstream PC prices on world markets during the past year. A weak yen may be partly to blame, but cannot alone account for the lack of penetration in the Japanese home markets. The Internet is apparently not driving PC sales in Japan to the extent it is in other countries, where sub-$1,000 Internet-ready PCs are the volume leaders. In contrast, mobile computers, particularly mininotebooks, appear to be the PC product leaders in Japan. The average selling price in Japan is closer to $2,000. These facts may confirm the hypothesis that Internet-browsing performance is a primary consideration in determining the suitability for home PC purchases in the West and hence has helped push the sub-$1,000 PC into the mainstream. Since the Internet is less pervasive in Japan, consumers there are not yet using these criteria in their buying decisions. Therefore, Japanese purchasers are more skeptical of the lower-cost machines in the way that U.S. buyers were once wary of some of the first-generation PCs that targeted the home markets.

Figure 2
Worldwide PC Shipment Growth Rate Forecast



Source: Dataquest (May 1998)

Dataquest projections for semiconductor market growth suggest that the annual change in the growth rate of global consumption will remain positive for at least the next few years. The expected deceleration of growth around 2001 would coincide with the end of a silicon growth cycle that began in 1995. If this prediction materializes, historical trends would then show that the so-called silicon cycle would have slowed in frequency, with an average period of four years during the 1980s to a 50 percent-larger, six-plus-year period during the 1990s.

Silicon Valley Stocks: The Internet Frenzy

Components of the Dataquest 100 high-technology stock index are found in Figure 3, which shows the average weekly stock performance of Silicon Valley companies from the semiconductor, equipment, PC, software, and telecommunications industries as separate curves.

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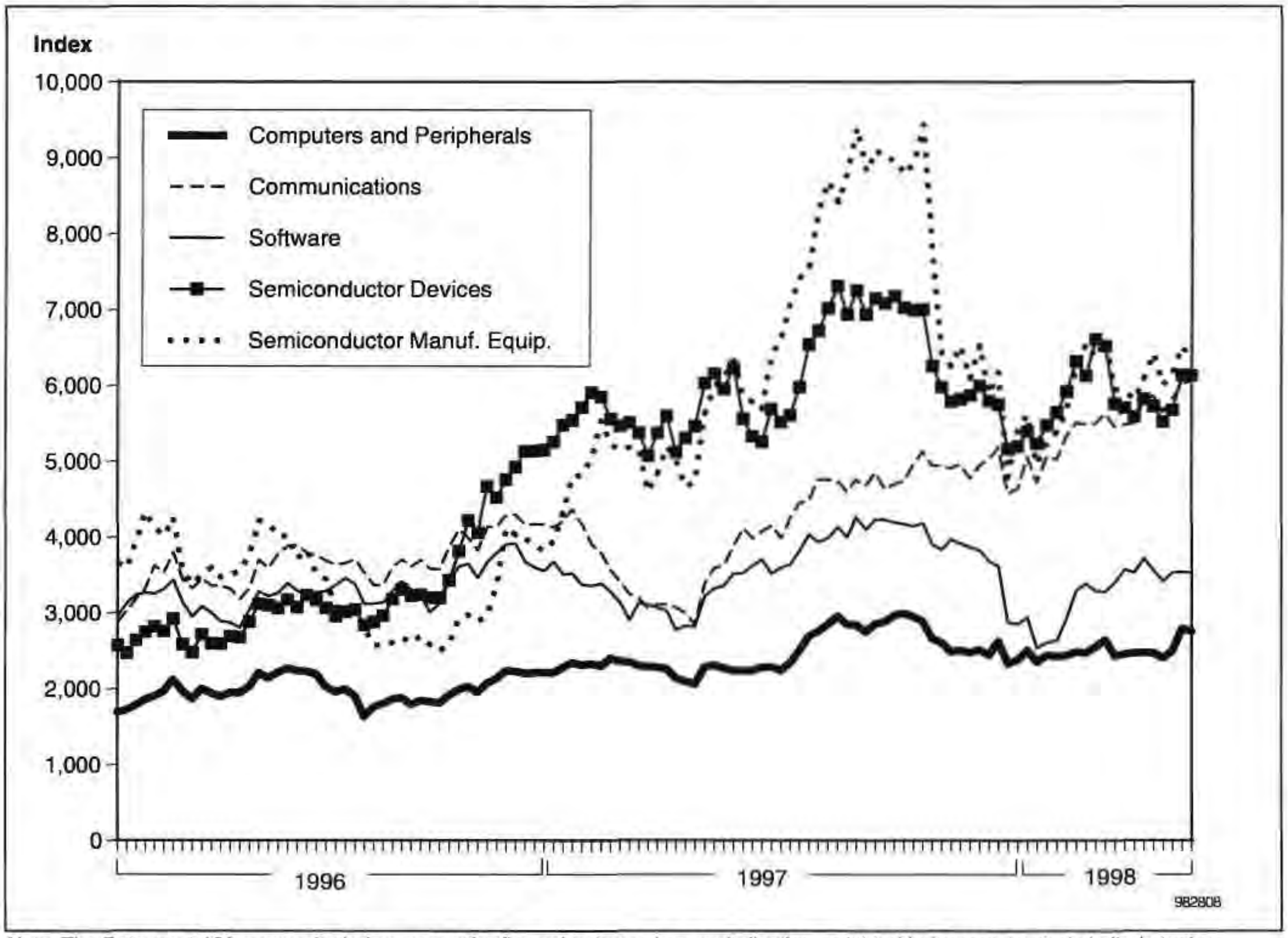
Figure 3
Dataquest 100 Weekly Index, 1996 to Q1/98



Note: The Dataquest 100 composite index, as are the five subindexes, is a capitalization-weighted index constructed similarly to the Standard & Poor's S&P 500 Index. The indexes are set equal to 1,000 in the base period December 31, 1992. A list of companies included in the Dataquest 100 is available on request.
Source: Dataquest (May 1998)

The stock prices of equipment and semiconductors manufacturing companies have shown a distinctly downward trend since the beginning of the fourth quarter of 1997. In contrast, communications companies maintained strong market valuations, mostly because of high investor confidence in the Internet and related industries. Even companies remotely identified as pertaining to networking have enjoyed high market capitalization to earnings ratios. However, the business models of many of the fastest-growing Internet companies, particularly the search engine companies with their now astronomical market valuations, have yet to prove that the large amount of investing that has gone into these companies is justified. Not that long ago, Netscape Communications Corp. was perceived as a high-flying start-up with unlimited promise as a World Wide Web pioneer. Today, the company is still worth billions, but it continues to struggle to identify sources of growth and long-term revenue and, as a consequence, has experienced both layoffs and reorganization. In its latest moves to find itself, Netscape is attempting to capitalize on the current market love affair with search engine companies by boosting its role as a service provider. However, in doing this, Netscape appears to be merely following the investor dollars in a desperate attempt to buoy its stock price.

The Internet is an efficient medium for trade, so it shouldn't be too surprising that there are growing parallels between the business practices of some Internet companies and many of the export-minded Asian electronics giants that have stumbled so badly in recent years. Many would say that the stereotypical Silicon Valley Internet start-up company couldn't be culturally more distinct from traditional Korean or Japanese companies. However, both classes of companies have operated under a common assumption: If you export sufficient quantities of product at any price (at cost in the case of some commodity memories and largely free in the case of services provided by most Internet companies), then prosperity must follow.

Internet investors are buying into this concept in a big way, but one has to wonder whether the earnings potential of some of the most active segments of the Internet industry can justify the large investment levels. Almost the first question any new user on the Internet asks is: Who is paying for this? The standard response is the businesses that advertise on the Internet. But the real answer will depend on the future. Stock investors are paying for a lot of Internet expansion and services with the hope that it will eventually lead to higher levels of commerce on the Internet, and hence greater returns on their investments.

It is certainly true that some companies have already successfully capitalized on the efficiency of the Internet to improve their electronic mail order businesses, such as build-to-order computer manufacturers (Dell Computer Corporation, for example), booksellers, adult entertainment providers, and business-to-business transactions. However, there may also be some businesses that will benefit only minimally from the new medium. These industries may even find that their advertising budgets are better spent on print or TV media than on the Internet. It still has to be determined how the Internet will affect individual buying habits. Right now it is basically a big experiment being fueled and financed by speculative investors. In the meantime, the semiconductor industry is benefiting from the surge of networking and computer hardware investments associated with businesses building up their presence on the Web and from individuals who are purchasing Internet-centric PCs and communications gear.

The important thing to recognize for the semiconductor industry is that if investor confidence in the Internet subsides, the speculative investments that are fueling hardware consumption could quickly vanish. There are definitely many Internet users that are not paying for the services rendered via their own purchasing or consumption habits. In the extreme case of those individuals who are known to be actually addicted to Internet surfing, much of their time spent on the Internet is a loss of productivity that necessarily lowers everyone's standard of living.

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Dataquest Perspective

There are unknowns that may ultimately cause corrections to the semiconductor consumption levels that Dataquest has forecast. Trade issues and regional economic conditions are difficult to incorporate into a forecasting model, but nevertheless may have a significant impact on the eventual market sizes. Moreover, new application drivers and technological advances are always parameters that are difficult to anticipate or quantify. The economic boom in the United States is in stark contrast to the economic gloom of most of Asia, and the difference in prosperity is a bit ominous. It may be the calm before the storm, or it may be that the economic momentum of the United States is so great that the prosperity will simply pull Asia out of its slump by virtue of high demand for Asian products.

It is important for Asian countries to recognize that although raising export levels will boost their employment levels, imports are required to sustain those export levels. The projected acceleration of the U.S. semiconductor consumption rate relative to other parts of the world in the next half decade is somewhat astonishing. It suggests elevated levels of imports to the United States from Asia, without an obvious pattern of growth in Asian consumption levels. In five years, the United States is projected to consume more than one-third of the world's production of semiconductors. This percentage is still below the level achieved by the United States in previous decades, but probably would never have been anticipated just five years ago. At that time, the U.S. and Japanese semiconductor markets were nearly equal in size, and the European and Asia/Pacific markets appeared to be gaining ground on the two leading markets.

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Perspective

Semiconductors Worldwide

Vendor Analysis

Texas Instruments and Its New Analog Thrust

Abstract: *Texas Instruments surpassed SGS-Thomson and became the No. 1 supplier of analog ICs in 1997. The strategic moves and competitive position of Texas Instruments in the analog IC market are reviewed and analyzed in this Perspective.*

By Jim Liang

The Less-Known Story

If we go back in time and look at Texas Instruments Inc. at the beginning of the 1990s, we see a multifaceted company, with business activities scattered in such diverse markets as calculators, DRAMs, notebook PCs, defense, and electronics contract manufacturing. Since then, TI has transformed itself into a well-focused company. Many might say that the focus is digital signal processors (DSPs), given TI's pioneering work and dominant position in the DSP market. However, that is only the better-known story.

The less-known story has to do with TI's analog thrust. Ranked as the No. 9 supplier of analog ICs in 1991, TI overtook SGS-Thomson Microelectronics B.V. and became the No. 1 supplier of analog ICs in 1997, with analog IC revenue exceeding $2 billion. Shown in Figure 1 is TI's analog IC revenue and growth rate history, compared with the growth rate of the overall analog IC market. It is evident that TI has outgrown the total analog IC market every year since 1992. The compound annual growth rate (CAGR) for TI's analog IC revenue from 1991 to 1997 was 30 percent, more than twice the 14 percent growth rate for the total analog IC market. The acquisition of Silicon Systems, which added more than $400 million to TI's analog IC revenue, contributed significantly to TI's analog momentum and propelled TI to the No. 2 position of analog ICs in 1996. However, TI's internal growth has been just as remarkable. Without the SSI acquisition, TI's analog IC revenue grew

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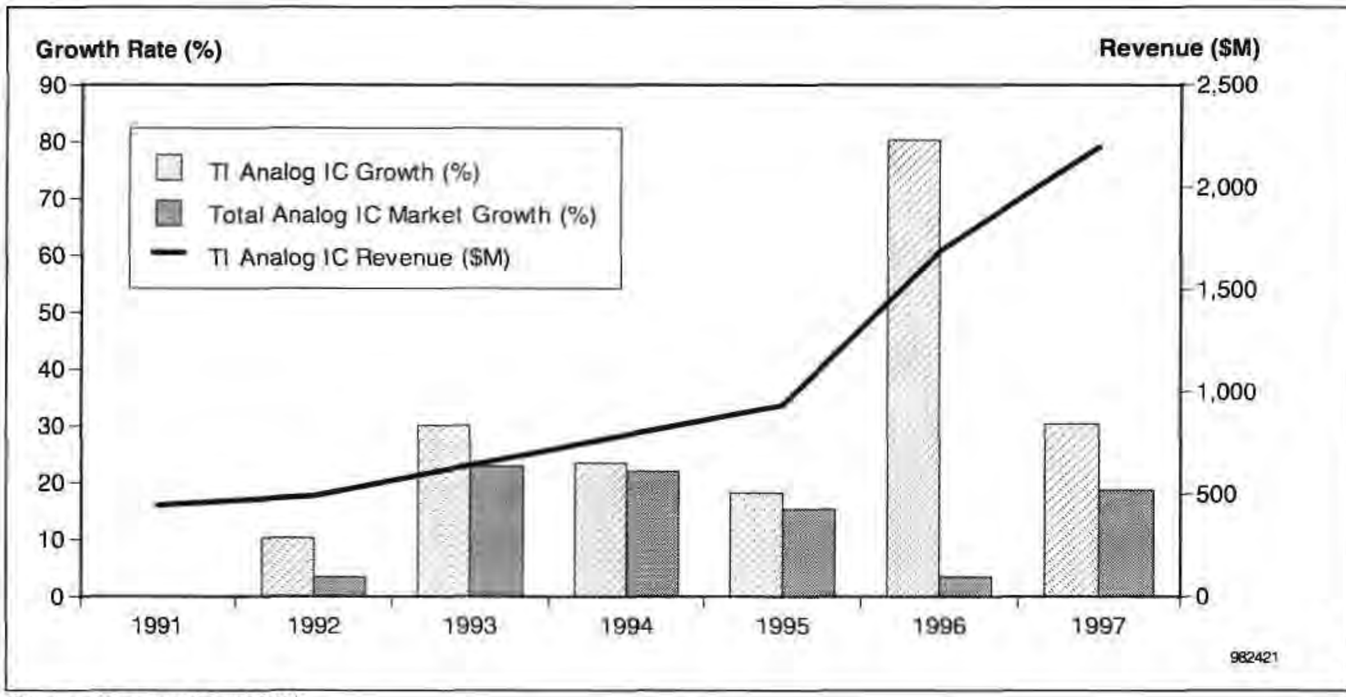
at a CAGR of approximately 25 percent from 1991 to 1997, still significantly higher than the 14 percent growth rate of the overall market.

Figure 1
TI's Analog IC Revenue and Growth Rates Compared with the Total Analog IC Market Growth Rate



Source: Dataquest (May 1998)

Analog ICs include linear ICs (pure analog ICs) and mixed-signal ICs. The mixed-signal IC segment has been growing rapidly. From 1991 to 1997, the mixed-signal IC market grew at a CAGR of 18 percent, which makes mixed-signal ICs one of the fastest-growing segments in the semiconductor market. This rapid growth is mostly the result of the "pull" effect from digital technology. In each digital system, mixed-signal ICs are needed to interface between the real analog world and the digital world. The proliferation of digital technology has expanded the overall market demand for mixed-signal ICs. Digital technology is driving new applications into a more affordable range, which dramatically increases market size.

TI's analog story is indeed about its focus on the mixed-signal IC market. From 1991 to 1997, TI's mixed-signal IC revenue is estimated to have grown at a phenomenal CAGR of 40 percent! Even without the acquisition of SSI, the internal growth is estimated at a solid 31 percent. In comparison, the 1991 to 1997 CAGR for TI's linear ICs was estimated at 14 percent, and about three-quarters of TI's analog IC revenue came from mixed-signal ICs in 1997.

TI's mixed-signal IC growth is a result of its business model, which is tailored toward high-growth end-equipment markets. In 1991, TI put together teams of system, application, marketing, and design experts to focus on high-potential end-equipment markets. In 1992, TI entered the analog baseband market for cell phones. In 1996, TI acquired SSI and became the

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No. 1 supplier to the mass storage market. For a more detailed analysis of TI's current moves in the mass storage IC market, please refer to Dataquest Perspective "TI DSP Also Acts like an MCU for Disk Drives" (MCRO-WW-DP-9805, code # 64438). In 1997, TI introduced the x2 modem chipset, including an analog front end and bus interface circuits. The result of these efforts has been TI's remarkable success in supplying mixed-signal application-specific standard products (ASSPs) to three huge end-equipment markets: disk drives, modems, and cell phones. Today, TI has become a strategic supplier to 3Com Corporation, Ericsson, Nokia, Seagate Technology Inc., Quantum Corporation, and Western Digital Corporation—all dominant OEMs in their respective markets.

The TI story is really about both DSPs and mixed-signal ICs. In fact, DSPs and mixed-signal ICs combine synergistically into what TI calls "Digital Signal Processing Solutions (DSPS)." The TI strategy has been to push for the acceptance and penetration of DSPs, which in turn expands the end market for mixed-signal ICs. DSP, with its low cost and high performance, shifts the market demand higher for end systems with DSPs; this in turn not only expands the demand for DSP itself, but also for the accompanying mixed-signal ICs.

The Weapons

The weapons to succeed in the mixed-signal ASSP market include mixed-signal design talent, mixed-signal process technology, and systems expertise. Having both digital and analog functions on the same chip is a unique challenge; it is difficult to make high-precision analog components using the standard digital submicron CMOS process, which is not optimized for analog circuits. Moreover, the switching in digital circuits generates noise that can interfere with the analog circuits on the same chip. Both specialized design capability and process technologies, such as BiCMOS, are needed to overcome these problems. Because these ICs are designed for specific mass applications, it is crucial to have in-house systems expertise to provide value to major OEMs in these application markets.

Given the synergy between DSPs and mixed-signal ICs, it is beneficial for a vendor to offer both technologies, or better yet, a complete solution that includes both DSPs and mixed-signal ICs.

TI's success came from its development and early deployment of these weapons to grab market share leadership. This is not the end of the story; in fact, this is probably only the beginning. Other significant players have jumped into the game, which brings us to the competition.

The Competition

The three biggest competitors for TI are probably Lucent Technologies, Analog Devices Inc., and Motorola Incorporated. All three have both DSP and mixed-signal technology. In 1996, TI was the No. 1 supplier of both DSPs and mixed-signal ICs. Lucent Technologies was the No. 2 supplier of DSPs and the No. 7 supplier of mixed-signal ICs. Analog Devices was the No. 3 supplier of DSPs and the No. 4 supplier of mixed-signal ICs. Motorola was the No. 4 supplier of DSPs and the No. 6 supplier of mixed-signal ICs.

TI and its competitors have staged significant battles. Lucent Technologies and TI have squared off in 56K modems. TI joined forces with U.S. Robotics Inc. (now part of 3Com), the world's No. 1 manufacturer of modems, and came up with X2 protocol. Lucent Technologies teamed up with Rockwell International Corporation and pushed a protocol called K56flex.

Analog Devices, on the other hand, attacked TI's dominance in supplying chipsets to 3Com's X2-based modems. ADI worked with 3Com and developed the industry's first single-chip solution for X2-based controllerless modems. In this solution, ADI utilized a standard 0.5-micron CMOS process technology to integrate DSP, memory, and analog front end (AFE) on the same chip. Building on its leading sigma-delta data converter and voice codec technologies, ADI was able to successfully integrate the AFE and DSP core without degrading the performance of the analog functions.

As the market for communications and consumer products such as modems, digital cellular phones, digital cameras, and digital video discs gains rapid momentum, so will the drive toward higher speed and reduced size, weight, cost, and power consumption. The ability to provide single-chip, mixed-signal DSP solutions for these products will become a key factor for success in these markets. ADI fired a shot by offering a single-chip modem, and this has significantly raised the bar for competitors.

Motorola has traditionally been strong in supplying semiconductors for the wireless market, given its position as a leading OEM for cell phones. In 1996, Motorola was the No. 1 supplier of wireless baseband semiconductors. TI has been gaining momentum in the wireless markets in recent years and went from the No. 4 supplier of wireless baseband semiconductors in 1995 to No. 2 in 1996. TI has established a dedicated strategic business unit for the wireless market. TI's wireless endeavor so far has been in providing DSPs and mixed-signal baseband solutions. The next move for TI is to become a leading supplier of power management and radio frequency (RF) solutions. TI has already delivered power management and small-signal RF products and is expected to enter the power RF market in 1998.

SWOT Analysis

Table 1 summarizes a strengths, weaknesses, opportunities, and threats (SWOT) analysis of TI's position in the analog and mixed-signal IC market. TI's strengths, as well as weaknesses, come from its business concentration on key mass markets.

Strong competitors with both DSP and mixed-signal technology will certainly pose a threat to TI. However, the biggest threat to TI's continued success in the analog/mixed-signal arena, as it is for other leading suppliers of these ICs, is the potential lack of analog/mixed-signal design talent. It usually takes years to train graduating engineers before they can handle analog and mixed-signal design projects, since design automation is not as prevalent in analog design as in digital design. To some extent, analog design is more of an art than a science, and it takes years for a new designer to get a handle on that "magic." Furthermore, engineering schools today are turning out far fewer analog designers than their digital counterparts. The lack of analog talent will limit the growth potential of analog ICs and make analog technology the bottleneck for digital systems. This in turn will limit the growth potential for the overall market. This threat is more significant to TI, as the market leader needs the most design talent.

Dataquest Perspective

Now that TI's opportunities have been identified, how can TI exploit them and maintain its leadership position? Dataquest offers three recommendations.

First, TI needs to increase the total market for digital signal processing solutions. Since TI has the biggest market share, it is in the company's best interest to expand the total market; an increased total market always benefits the market leader the most. Therefore, TI needs to play a leading role in identifying and enabling new mass markets for DSP solutions. We shall name this strategy "beyond disk drives, modems, and cell phones."

Second, TI needs to work with leading engineering institutions around the world to help to cultivate future analog and mixed-signal design talent. TI already has active programs in place to encourage the education of DSP design at universities, and the same needs to be accomplished for analog and mixed-signal design.

Table 1
SWOT Analysis of TI's Analog/Mixed-Signal Market Position

	Issues
Strengths	Complementary DSP and mixed-signal/analog offerings, and strategic relationship with key OEMs in the three major mass markets: disk drives, modems, and cell phones
Weaknesses	Concentration of business on a few mass markets, with the likelihood of being severely affected if these key markets take a dive; today's hot application markets may become saturated tomorrow
Opportunities	Emerging new mass-markets that require both digital signal processing and mixed-signal technology, and the potential to enter the high-end standard linear IC market
Threats	Attack from strong competitors with both DSP and mixed-signal technology, and the potential lack of analog/mixed-signal design talent to fuel growth

Source: Dataquest (May 1998)

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Finally, TI could launch an offense into the high-end standard linear IC market. Even though the linear IC market has been growing at an unspectacular 11 percent per year, the high-end segment of the linear IC market has been growing at a much faster rate. This is partly because the price erosion in the high-end segment has been less severe than for low-end commodity-type products. Also, the linear IC market has the attractive characteristics of long product life cycles, high gross margins, and relatively stable pricing (as compared with the more cyclical DRAM pricing). The high-end standard linear market is where companies such as Linear Technology Corporation and Maxim Integrated Products Inc. have thrived. Although TI is not yet a leading player in this market, the company's advanced analog process technology and design expertise should allow it to mount a formidable challenge.

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Perspective

Semiconductors Worldwide

Technology Analysis

Evolution of Packaging Technology for SLI ASICs

Abstract: *The low-cost ball grid array package has gained wide acceptance for 0.35-micron system-level integration ASICs. As gate counts reach 500,000 to 1.5 million and system frequency exceeds 100 MHz, a cost-effective package design is critical. To maximize performance of these devices, package designs need to be 200 to 350 pins, with external operating frequencies of 66 MHz to 150 MHz. ASIC vendors are using low-cost BGAs at or below the cost of conventional PQFPs. This has accelerated BGA market growth and the implementation of other new package technologies, such as chip-scale packages and flip-chip attach.*

By Yoshihisa Toyosaki

Evolution of High-Density Attach Technology

Increased use of high-density attach technologies has emerged with new information equipment markets, such as personal digital assistants (PDAs), cellular phone, and mobile computers, and with new consumer electronics markets, such as digital camcorders and digital still cameras. Growth of small-form-factor and handheld equipment designs increased demand earlier than expected for new chip-scale packages (CSPs), ball grid arrays (BGAs), combinations of BGAs with flip chip, as well as direct chip attach (DCA) and known good die (KGD). To house leading-edge packages and KGD printed circuit board (PCB) developments such as surface laminate circuit (SLC), a buildup substrate technique developed by IBM Japan is being widely adopted in numerous applications that require miniaturization. Dataquest believes, however, that there are hurdles to these new package and substrate technologies. Some of the hurdles include a limited number of buildup substrate suppliers, high design costs, and delay in the effort to develop package standards between Japan and the United States for CSPs and BGAs.

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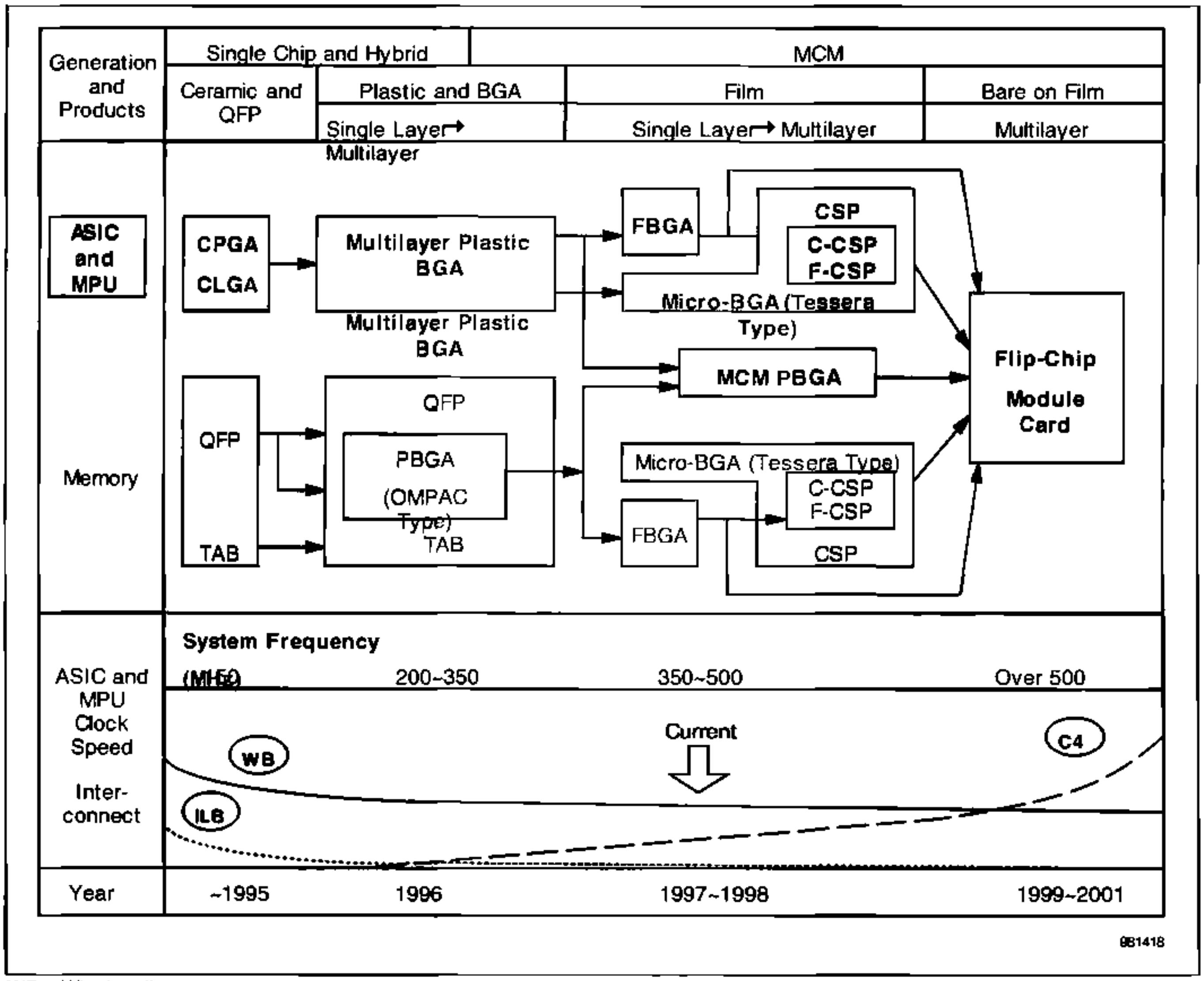
Figure 1 shows a road map for leading-edge packaging technologies to 2001. The evolutionary path is based on the system block frequency required for each generation of MPU, which is closely associated with application-specific ICs (ASICs), and the key technologies required to implement the designs.

Figure 1
Advanced Packaging Road Map

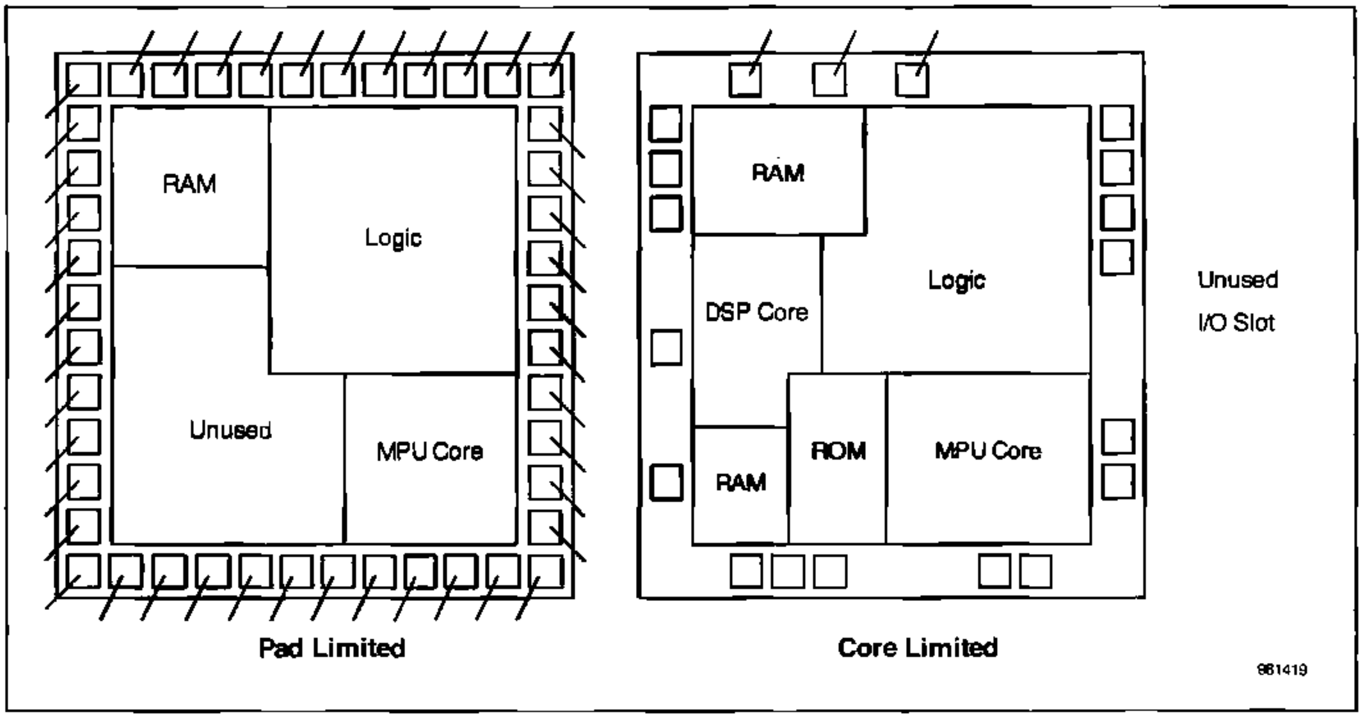


WB = Wire bonding
ILB = Inner lead bonding
C4 = Controlled-collapse chip connection
Source: Dataquest (March 1998)

Pad-Limited and Core-Limited Designs in SLI ASICs

Although finer process technologies lead directly to an increase in gate counts accommodated in the same die size, Dataquest sees a risk of "I/O pad-limited design," where the die size is governed by the number of I/Os in some applications. Interconnect technology varies with package type, but the ability to reduce the I/O pad size required for bonding a die and a package is limited. The area of the die per side (in square millimeters) needed to secure the required I/O counts is a physical limitation resulting in a larger die area than that designed (see Figure 2). This design trend is frequently seen in gate arrays. Previously, "core-limited designs" were common. Applications limited by die size have declined with the pervasiveness of 0.5- to 0.35-micron process technology and commercialization of a 0.25-micron high-density ASIC process technology. Nevertheless, core-limited designs will persist in some applications, such as DVD encoders that require large circuits and switching systems demanding large DRAM capacities (memory space switchlike applications). In particular, Dataquest believes that this need will continue in consumer applications in which single-chip implementation using system-level integration (SLI) ASICs is an important goal.

Figure 2
Situation of Pad-Limited and Core-Limited Designs



Source: Dataquest (March 1998)

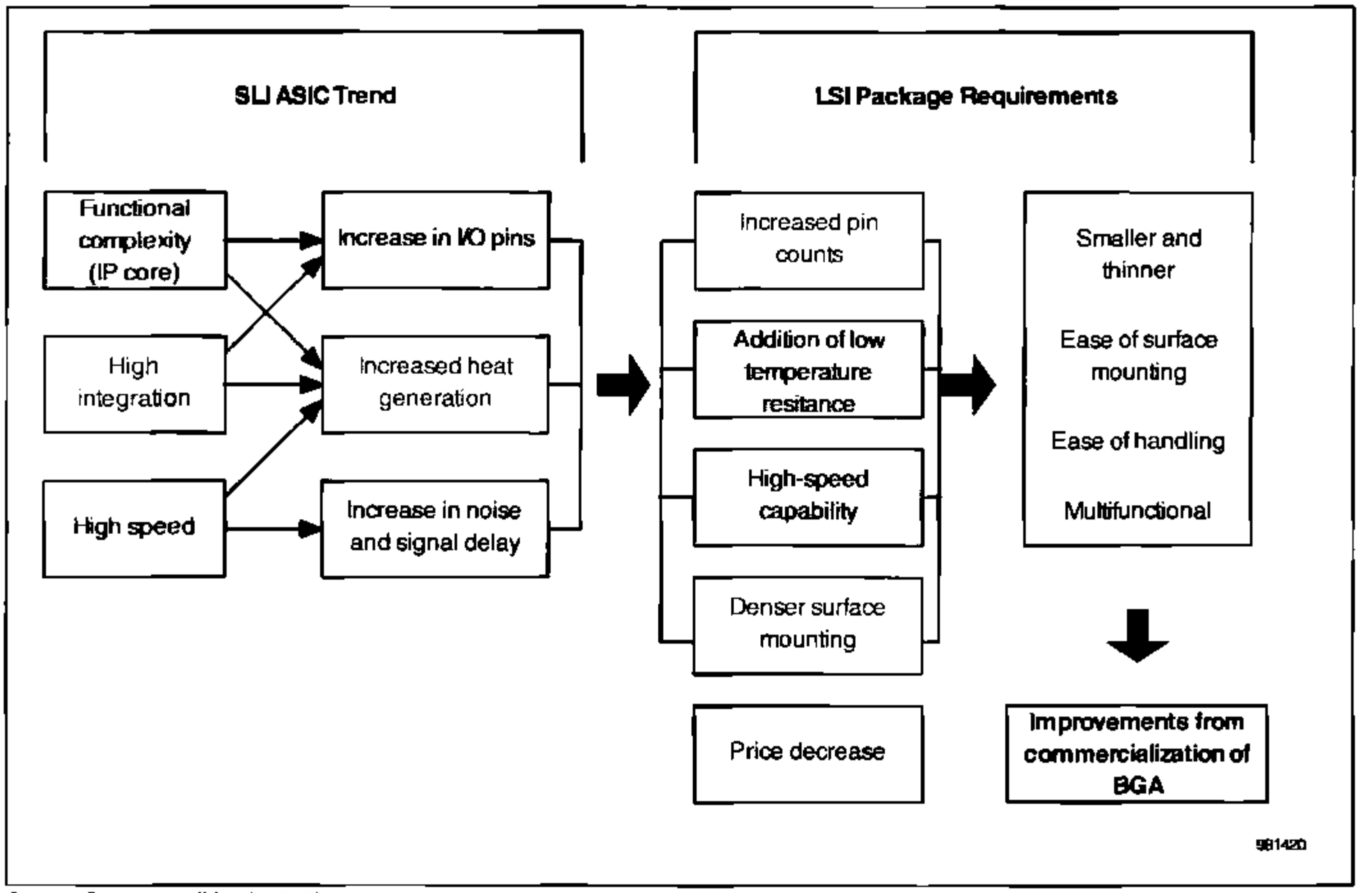
BGA Package and Development Targets

Conventional plastic quad flat packages (PQFPs) are generally limited to 304 pins and 50 MHz by inductance issues. BGA technology raises limitation levels to 750 pins and 200 MHz.

In the plastic ball grid array (PBGA) package structure, the chip surface area contains circuitlike die attach patterns and signal patterns. The chip is mounted by using a die bonder and epoxy-based silver paste. The package is characterized by a single-side resin sealing structure that allows an array of solder balls (I/O and power source) to reach the lower side of the IC, resulting in a wider pitch and enabling a smaller and thinner package. Major characteristics of the low-cost BGA (overmolded plastic pad array, or

OMPAC) developed by Motorola Incorporated, currently the mainstream BGA package design, are shown in Figure 3.

Figure 3
BGA Package for ASICs



Source: Dataquest (March 1998)

Current State of CSP

CSP is a compact package with a size more or less equivalent to the die area. Although many CSP technologies have been developed, most of them have a common feature, which is to provide a dense area array on the underside of a package. Compared to BGAs, CSPs offer better marketability because they occupy a relatively smaller area on a PCB, resulting in a cost advantage, especially for portable applications. Size reduction also leads to improved electrical performance.

Major markets for the CSP include consumer applications such as digital camcorders and portable DVD and communications applications such as modem cards and mobile phones. As designs for these applications face increasingly strict size and cost demands, the CSP must also satisfy other requirements. Emerging applications require relatively small pin counts (176 or fewer as of 1997), and many of these are limited by the height, length, and width of a package. CSP, the smallest package, is primarily used for memory products such as flash and SRAM, as well as for discrete devices. These

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devices have variable die sizes and yet require very small pin counts (50 or fewer). This makes them highly suitable for the chip-size CSPs.

Naturally, there are various problems with CSPs. Obstacles include a higher initial packaging cost and limited wiring patterns on a PCB. These are important design considerations in consumer applications. Higher equipment costs could delay full acceptance of the CSP, but suppliers must meet user demands for package miniaturization and the most cost-effective package solution. Some of the current solutions include the narrow-pitched low quad flat pack (LQFP) as well as the BGA. As the industry's infrastructure improves, CSPs will gradually move into mainstream applications with high pin counts. CSPs are now used in digital camcorders, which use PCBs with six to eight layers with buildup substrates.

The CSP is best suited to applications that require mounting of devices with low pin counts on very small, very dense PCBs. Some of these applications use PCB designs with 176 or fewer pins (see Table 1 and Figure 4). DVD manufacturers set the highest priority on small form factor and light weight, using SLC, a high-cost laminate substrate. This design application enables CSP packaging in an area array pattern. However, CSP is unsuitable for computing and communications applications that use very large PCBs with high pin counts. CSPs used in memory applications are expected to go into volume production late 1998. This will accelerate development of the infrastructure and widen market acceptance for CSP technology.

The CSP design of Sharp Electronics Corporation and Texas Instruments Japan is an extension of existing technologies, rather than a technological breakthrough. The primary goal is to minimize costs and development risks. Technological advances include a ball pitch of less than 1.27mm—for example, 1.0mm, and 0.8mm. The package size will continue to be reduced until the die becomes a limiting factor.

Table 1
Expected Pin Counts in Digital Camcorders by Generation

Digital Camcorder Manufacturer	First Generation	Second Generation	Third Generation
Company A	64 to 144 pins	80 to 144 pins	100 to 120 pins
Company B and Company C	80 to 164 pins	100 to 176 pins	176 to 256 pins
Company D	100 to 160 pins, mainly 144 pins	176 pins	208 to 304 pins, single chip

Source: Dataquest (March 1998)

According to digital camcorder designers, assembly cost for the LQFP package with about 100 pins is around ¥1 per pin. However, the cost of CSP assembly is relatively high because it is in the prevolume production stage (see Figure 5). Major cost adders include higher material costs, assembly yield, and new equipment requirements (including tooling, R&D, and

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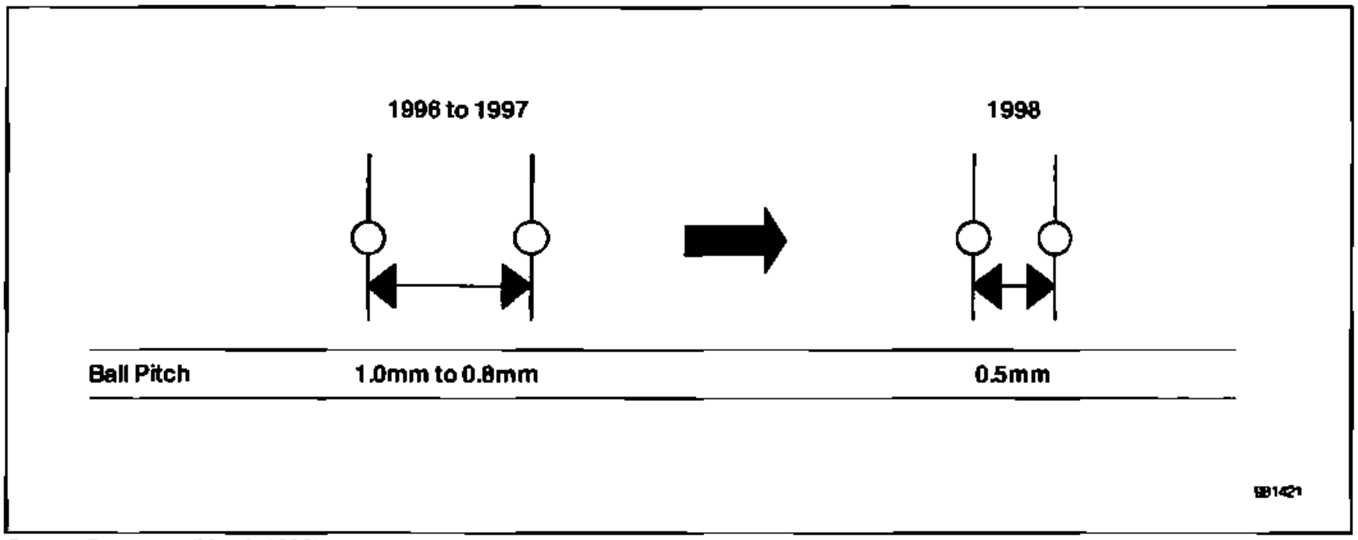
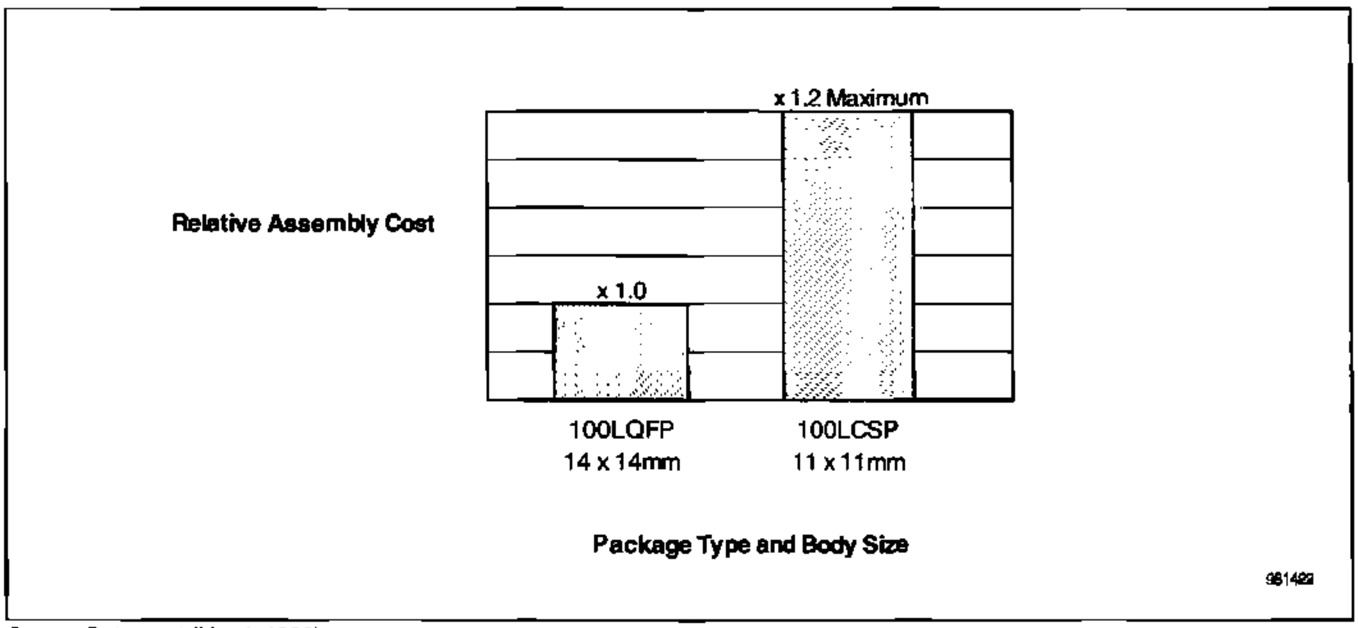
qualification costs). The CSP assembly cost acceptable to digital camcorder users is a maximum of 20 percent higher than the LQFP cost.

Figure 4
Expected Narrowing of Ball Pitch in CSP Package for Digital Camcorder Application



Source: Dataquest (March 1998)

Figure 5
Analysis of CSP Package Cost Demanded by Digital Camcorder Makers



Source: Dataquest (March 1998)

Flip-Chip Technology

Flip-chip technology is being viewed as another advanced attach solution for high-performance and high-pin-count application markets. Yet, there are many issues to be overcome before commercial application of the flip-chip technology to ASICs. Some of these issues are summarized as follows:

- A limited number of designers and engineers who have experience in development and volume production of flip-chip products
- Restriction on package assembly technology using the new flip-chip technology, including internal wiring (often conflicting with package patents held by IBM, Tessera Inc., Matsushita Electrical Industrial Company Ltd., and Hitachi Ltd.)
- Production capacities of suppliers and subcontractors, as well as their business strategies and investment in flip-chip technology
- Additional cost incurred according to structure, varying with package type and design (mask cost and turnaround time)
- Failure analysis requirements attributable to design (circuit and bump, among others)
- Issues related to alpha particles and electric coupling, attributable to design
- CAD systems (to establish layout methods for internal core and I/O cells)
- Wafer sort (high-cost probe guard, long lead times, and customized development because of the nonstandard footprint)
- Establishment of flip-chip technology and package qualification methods

Figure 6 shows flip-chip technology road map trends required for the technology to evolve through each generation and mature at a low cost.

IBM's Controlled Collapse Chip Connection (C4) flip-chip technology, now licensed by many semiconductor suppliers, is widely used in advanced computer and emerging communications handset applications. Major characteristics of flip-chip technology developed by IBM include the following:

- Ease of securing high contact points: Electrical contacts can be placed over the entire surface of a semiconductor device in an array pattern. Although the present basic designs are limited to a 250-micron pitch and a solder ball diameter of 100 microns, further shrinkage is feasible by taking into account the consistency of coefficient of thermal expansion between the device and the substrate and selection of a soldering material.
- Ease of high-performance design: Contacts can be placed on any location over the entire surface of a device. The ability to minimize inductance or impedance leads to electrically advantageous designs.
- Enabling higher integration on the device: By allowing formation of contacts on an active area of a device, the flip-chip design enables finer-geometry design for a die.
- High productivity: High-quality batch bonding by reflow methods facilitates the reworkability of a device.

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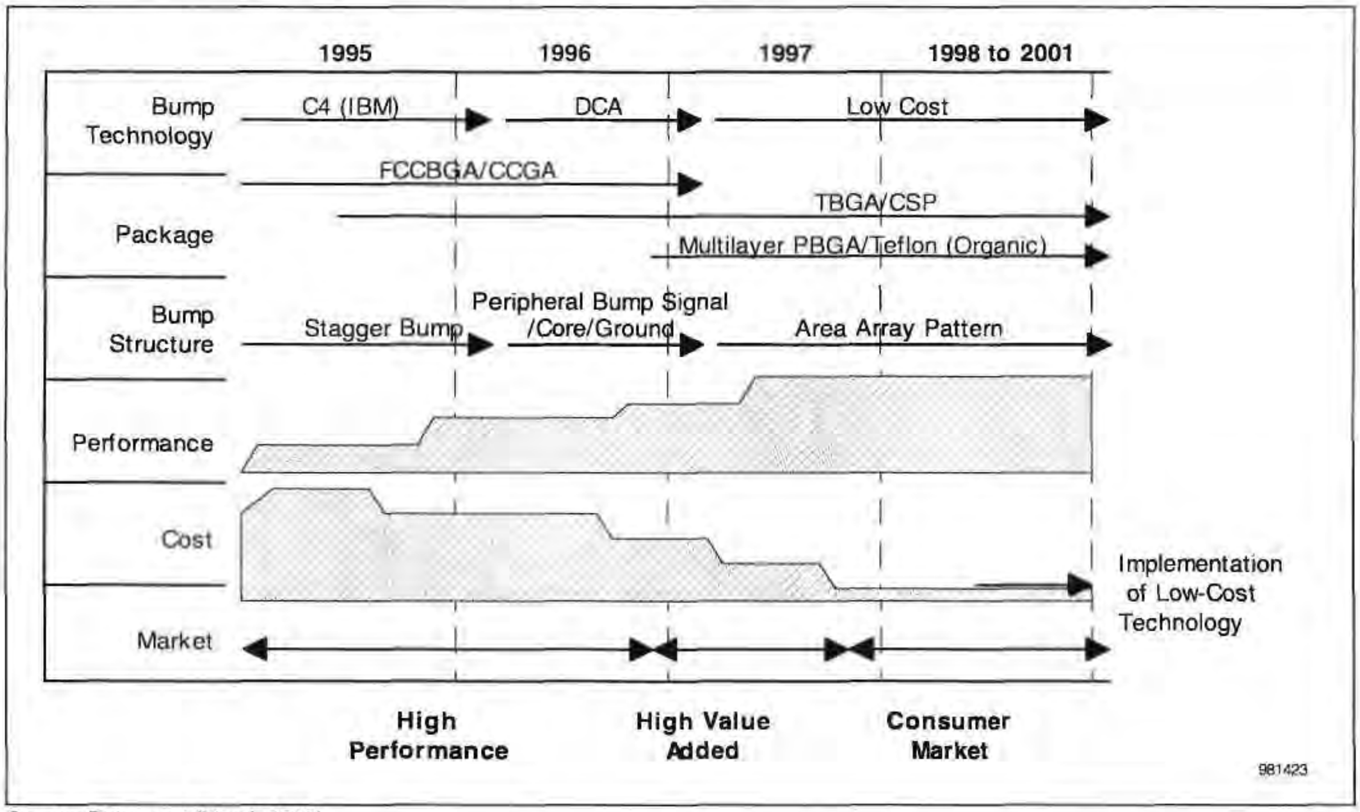
- High reliability: In addition to field-proven highly reliable soldering, the self-alignment effect created by surface tension as the solder melts assures highly precise and reliable bonding of a small form factor.

In spite of the technological challenges of flip chip, leading-edge ASIC companies are stepping up their efforts to commercialize flip-chip technology in order to leverage its advantages, which are being demanded by systems companies.

Figure 6
Evolution of Flip-Chip Technology and Cost Trends



Source: Dataquest (March 1998)

Technical Requirements for ASIC Packages by Market Segment

Tables 2 through 4 show technical requirements for ASIC packages by major applications in each market segment. Table 5 shows market requirements for high-speed I/O, an important factor in package development.

Performance requirements for packages from the system side are shown in Table 6 and rated on a five-point scale. Table 7 shows the relative importance of packaging characteristics for data processing, communications, and consumer applications. Figure 7 illustrates package and mounting technologies for advanced ASIC designs.

Table 2
Packaging Technology Requirements in the Data Processing Market

	Mainframe/ Supercomputer	Server	Workstation	Desktop/ Notebook PC	Personal Digital Assistant
Gate Count/ Memory Integration	400,000-3,000,000	100,000-500,000	200,000-1,500,000	50,000-100,000	2,000-300,000
Performance					
Core	150-300 MHz	66-150 MHz	66-150 MHz	66-100 MHz	1-70 MHz
I/O	150 MHz-1.2 GHz (actual: 800 MHz, serial transmission)	75-500 MHz (600 MHz, serial transmission)	66-500 MHz	66-500 MHz	33 MHz
Source Voltage					
Core	2.5V	≤1V/3.3V	1.8/2.5/3.3V	1.8V/3.3V	2.5V
I/O	≤1V/2.5V/3.3V	≤1V/3.3V/5V	≤1V/3.3V/5V	5V/3.3V	2.5V/3.3V
Pin Count	500-1,600	208-750	208-750	120-400	100-400
Package Requirements	FCBGA, multilayer PBGA	Multilayer PBGA, TBGA	Multilayer PBGA, TBGA	TBGA, PBGA, PQFP	LQFP, CSP

Source: Dataquest (March 1998)

Table 3
Packaging Technology Requirements in the Telecommunications Market

	Transmission	Switch	Networking	Wireless
Gate Count/ Memory Integration	600,000-1,200,000	100,000-400,000	100,000-200,000	2,000-50,000 Baseband
Performance				
Core	155 MHz	50-74 MHz	50 MHz	50-100 MHz
I/O	622 MHz-1.2 GHz	622 MHz-1.2 GHz	300 MHz	150 MHz
Source Voltage				
Core	3.3V	3.3V	3.3V	≤2.5V/3.3V
I/O	1V/3.3V	3.3V	1V/3.3V	≤2.5V/3.3V (1V core required in 2000)
Pin Count	225-527	225-650	100-500	100-225
Package Requirements	FCBGA, multilayer PBGA	Multilayer PBGA, TBGA	PQFP, CSP, PBGA	LQFP, CSP, module integration

Source: Dataquest (March 1998)

Environment of Attach Technology

Traditionally, suppliers have generated revenue by supplying customer-specific designs. However, to achieve high-density mounting at a lower cost, packages having area array terminals on the rear side, such as BGA and CSP, have emerged. Dataquest believes that the future package development should be based on the concept of reducing total system cost.

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Packages and high-density printed circuit boards, including buildup substrates, will be offered by multiple suppliers. Buildup substrates with 100-micron wiring pitch have been introduced for bare die attach, intended for multichip modules (MCMs).

Table 4
Packaging Technology Requirements in the Consumer Market

	Broadcast	DVD	Digital TV	Digital Audio	Digital Video
Gate Count/ Memory Integration	10,000-100,000	50,000-1,000,000	10,000-150,000	10,000-100,000	100,000-1,000,000
Performance					
Core	20-33 MHz	27 MHz	27 MHz	33 MHz	18-25 MHz
I/O	33 MHz	51-81 MHz	33 MHz	33 MHz	25-50 MHz
Source Voltage					
Core	3.3V	2.5V/3.3V	2V/3.3V	2V/3.3V	≤2V/2.5V
I/O	3.3V	2.5V/3.3V	2V/3.3V	2V/3.3V	≤2V/2.5V
Pin Count	100-400	160-208	64-208	100-304	100-304
Package Requirements	PQFP	PQFP, CSP	PQFP	LQFP, CSP	LQFP, CSP

Source: Dataquest (March 1998)

Table 5
Market Requirements for High-Speed I/O

Application	Wide Path I/O	High-Speed Serial I/O
Data Processing		
Supercomputer/Networking	+++	++
Workstation/Server	++	+
Desktop/Notebook PC	+	-
Telecommunications		
Networking	+	-
Transmission	+	+++
Digital Video		
DVD, Digital Camcorder, Digital Still Camera	-	-

+++ = Critical
++ = Very important
+ = Important
- = Not important (no influence)
Source: Dataquest (March 1998)

Table 6
Performance Analysis of Package Technologies

Package Type	I/O Integration Level/Performance	Thermal Characteristics	Electrical Characteristics
Single Layer			
PLCC	5	5	5
PQFP (Copper Lead)	4	4	4
TAB in PQFP	4	4	4
LQFP/TQFP	3	3	3.5
MQUAD	4	1	3.5
TAB (TCP)	2	2-5	3
Two-Layer (Power/Ground Partially Reinforced Type)			
PBGA (OMPAC)	1-2	3	2-3
Two-Layer (Ground/Plain)			
TBGA	1	2-3	1-2
Two or More Layers (Ground/Power Plain)			
Multilayer PBGA	1	1	1
CPGA	2	1	2

Note: Performance evaluation criteria: 5 = highest, 1 = lowest.
Source: Dataquest (March 1998)

Table 7
Performance Analysis of Packaging Technologies

Market Segments/ Applications	Pad Limited	Core Limited	Multipin	Big Die	Electrical Characteristics	Thermal Characteristics	Size
Data Processing							
Mainframe/Supercomputer	+++	-	+++	+	+++	+++	-
Server	++	-	++	-	+	++	-
Workstation	+++	-	++	-	+++	+++	+
Desktop/Notebook PC	++	-	-	-	+	-	+++
Telecommunications							
Transmission	-	++	+	++	+++	+++	-
Networking	+	-	-	-	+	+	+
Consumer							
Digital TV	+	-	+	+	+	+	++
DVD Decoder	-	++	+	+	+	+	+
DVD Encoder	-	+++	+	+++	+	++	+
Digital Camcorder	-	+	-	-	-	+	+++
Home Video Game	+++	+	+	-	+	++	+

+++ = Critical
++ = Very important
+ = Important
- = Not important (no influence)
Source: Dataquest (March 1998)

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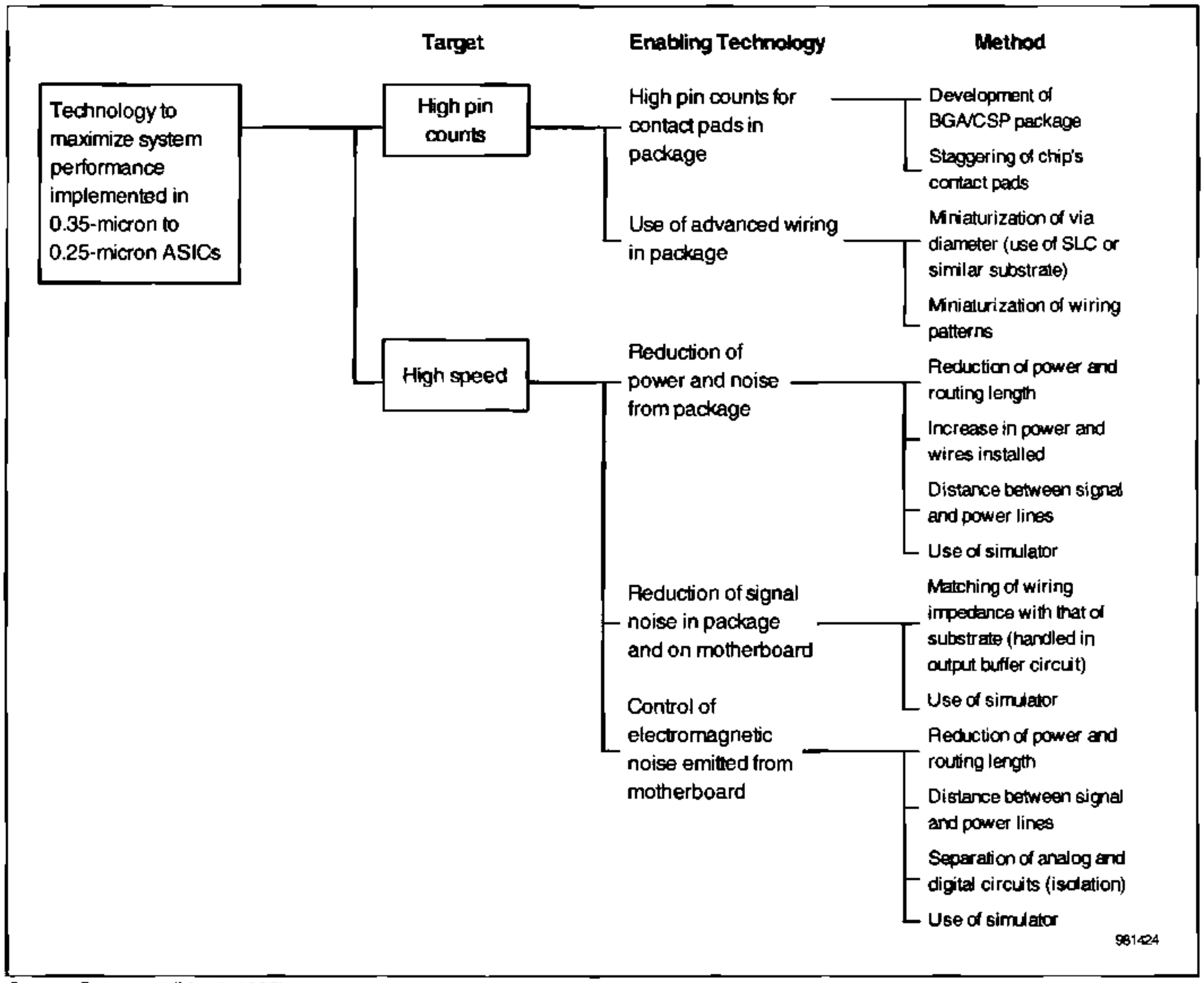
Figure 7
Package and Mounting Technologies for 0.35- to 0.25-Micron ASICs



Source: Dataquest (March 1998)

Technological Challenges for ASIC Packages

Increased function and integration at the system level, as well as miniaturization and lower power consumption, now require higher integration, higher speed, higher pin counts, and enhanced functions from ASIC products. The ASIC package domain has often been relatively neglected, compared to the process, library, and intellectual property core areas. However, system design specifications for ASIC products, packages, and attach technologies are becoming critical. Technical challenges for ASIC process and package designs include the following:

- Accurate analysis of stress produced in the fab process, such as oxidization and diffusion, as well as analysis of electrical characteristics of circuit devices that vary according to the degree of stress

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- Thermal stress related to the complexity of multilayer plastic packages composed of multiple materials. The packaged device goes through many thermal processes, so it must be robust enough to withstand destruction of the composite materials by thermal stress—for example, destruction of a die by thermal stress, destruction of resin by thermal fatigue, and destruction of a passivation film. Also, increased use of smaller and thinner ASIC packages makes destruction by external forces at the time of mold separation and lead forming an important issue.

Given the diverse technological challenges, if the ASIC business is to change from the traditional custom production approach, ASIC vendors will have to establish standard procedures for package design and analysis that go beyond the realm of the traditional single-chip package.

Dataquest Perspective

In 1997, when 0.35-micron process technology became the mainstay, the integration level of LSIs was driven by finer geometries. SLI ASICs, led by cell-based ICs, increased demand for high-performance packages with smaller and thinner form factors and high reliability. This technology development demanded higher pin counts, higher heat emission, electrical characteristics that match the increase in I/O counts, lower power consumption, and higher speed. The traditional QFP and tape automated bonding-based lead frames and films were reaching their limits of pitch, heat emission, and electrical characteristics.

Packages with an external contact pitch of 0.4mm for miniaturization and higher-pin-count system ICs required a finer pattern. To meet higher-performance system requirements, new packages were developed, such as BGA and CSP, and new solder bump techniques progressed rapidly. CSP technology has overcome major obstacles, but many challenges remain for volume commercialization of CSPs.

In theory, direct chip attach to the substrate is the most effective means of maximizing performance of ASIC products. For this reason, many companies have been working with MCM designs. Nevertheless, the supply of bare die, especially for known good die, involves increased technical challenges, reliability issues, and additional test costs.

The development of an optimum ASIC package requires further understanding of system user requirements. ASIC vendors need to further analyze the needs of the entire application market and decide on the applicable technical solution for these products to ensure the optimum package design. Ultimately, this would guarantee a "true" SLI ASIC that would meet the user's needs.

To reduce package cost, ASIC vendors should employ a more flexible strategy, possibly involving an alliance with a subcontractor with a leading-edge package. Such a joint technology effort could be critical in meeting the shorter time to market required by customer cycles.

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Perspective

Semiconductors Worldwide

Event Summary

ISSCC 1998

Abstract: *This Perspective summarizes the 1998 ISSCC that was held in February in San Francisco, California. In this Event Summary, Dataquest briefly relates all significant announcements and comments pertaining to key developments. Further details on technical presentations are available from the Dataquest inquiry service.*

By Jim Liang

Event Background and Overview

This year marked the 45th session of the International Solid-State Circuits Conference (ISSCC), which is sponsored by the Institute of Electrical and Electronics Engineers (IEEE). This is one of the most important conferences of the year for those semiconductor companies and universities around the globe involved in research and development of solid-state circuits. It creates a forum for open discussion among engineers and allows for dissemination of information that may help advance the technology and design concepts within the semiconductor industry.

This year's conference was held February 5 through 7 in San Francisco, California. There were 159 technical papers presented in 25 sessions, eight discussion sessions, six tutorial lectures, and a short course. Forty-eight percent of the papers are from North America, 18 percent from Europe, and 34 percent from Far East. Of these papers, 70 percent are from industry, 18 percent from universities, and 12 percent from industry-university collaborations.

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Discussion Sessions

The following is a listing of the discussion session titles from this year's conference:

- Three Decades of DRAM Development, Debates, and Distinction
- How Much Analog Is Going to Survive on Large Digital Chips?
- Deep Sub-1V, SOI, or Bulk CMOS?
- Will Power Limit Microprocessor Performance?
- Will CMOS Image Sensors Survive Scaling?
- How Will Media Signal Processors Dominate the Next Decade?
- LSI Solutions and Enabling Technologies for Mobile Multimedia Devices in the Year 2002
- Global Communications: the Good, the Bad, and the Ugly

Tutorials

The six tutorials at the 1998 ISSCC were:

- High-Speed SRAM Design
- How a Spread-Spectrum Radio Works
- Op Amp Compensation for Low-Voltage, Mixed-Signal Designs
- FIR-1001: Architectures and Applications
- MEMS for the Circuit Designer
- High-Speed Clocking for Large Digital ICs

Short Course

- xDSL Broadband Communication via Plain Old Telephone Service

Plenary Session

"Global Communications" was the main theme for the 1998 ISSCC. The infrastructure for global communications is broad and includes technologies of voice, data, and video. Papers spanning each of these topics were included in this year's conference. Furthermore, all three papers at the plenary session were devoted to this theme, and they are as follows:

- Challenges in Semiconductor Technology for Multimegabit Network Services
- GSM and Beyond—The Future of the Access Network
- The Global Positioning System: Challenges in Bringing GPS to Mainstream Consumers

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The first paper, from Hitachi Ltd., highlighted the semiconductor technologies currently employed in network systems such as backbone broadband transmission, Asynchronous Transfer Mode (ATM) switching, and mobile communications. The paper then outlined the technology advancements required to realize future multimegabit network services: advanced microfabrication techniques, novel circuit technologies, and sophisticated system-level integration architectures.

The second paper, presented by Alcatel Microelectronics, examined the future of network access and provided a vision of how the competition between wireline and wireless cellular would play out in the future.

The last paper came from SiRF Technology Inc. and was focused on global positioning system (GPS) technology. The paper discussed the history of GPS, its potential applications, and the technological challenges that need to be overcome in order that GPS becomes a mainstream consumer product.

Significant Announcements

Two significant announcements took place at the 1998 ISSCC. The first was the 1-GHz microprocessor announcement from IBM Corporation. In the announcement, IBM said that it successfully demonstrated an "experimental CMOS processor" that runs at speeds up to 1,100 MHz. Its engineers implemented a working subset of a PowerPC microprocessor, using conventional 0.25-micron manufacturing technology. While the pace of microprocessor speed improvement in the past few years has been clearly ahead of the software industry's ability to build more ambitious applications that consume the available computing power, Dataquest expects it is going to be only a matter of time for the applications demand to grow and meet the processor speed capability. For more detailed analysis, please see Dataquest Alert, "To One Gigahertz and Beyond" (PSAM-WW-DA-9804, February 1998).

The second announcement was Alcatel's formation of a new division, Alcatel Microelectronics, to market intellectual property (IP) and system-on-a-chip application-specific standard products for wireline and wireless access solutions worldwide. Alcatel Microelectronics has also joined forces with electronic design automation tool vendor Synopsys Inc. to refine its systems-on-a-chip design environment. In the wireline access arena, Alcatel Microelectronics is aimed at the asymmetric digital subscriber loop modems market, and in the wireless access arena, it is targeting the Global System for Mobile Communications (GSM) solutions market. Alcatel Microelectronics' manufacturing strategy is to support the IP and system-on-a-chip marketing efforts with a hybrid approach: focusing on Alcatel Microelectronics' mixed-signal and radio frequency (RF) BiCMOS manufacturing technology for designs requiring the highest level of analog and digital functionality on a single chip, while utilizing a network of CMOS foundries for lower costs when advanced mixed-signal capabilities are not required. Over time, Alcatel microelectronics plans to contract with low-cost foundries for production of its digital CMOS and to return all the manufacturing capacity to mixed-signal and RF. Dataquest believes that Alcatel's strategic move reflects the

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continuing growth of the telecommunications market, which drives the growth of telecommunications chips. Furthermore, Dataquest believes that Alcatel Microelectronics' shift to mixed-signal and RF manufacturing technology illustrates the growing importance of mixed-signal and RF technology to system-on-a-chip solution providers as the key differentiating factor.

Technical Papers Worth Highlighting

Besides the IBM paper describing the first 1-GHz microprocessor, the following papers caught Dataquest's attention because they represent significant technology breakthroughs:

- "A 480MHz RISC Microprocessor in a 0.12-Micron CMOS Technology with Copper Interconnects," by IBM, about the first microprocessor using copper interconnect technology
- "40Gb/s Analog IC Chipset for Optical Receiver Using SiGe HBTs," by Hitachi Ltd., about a 95-GHz SiGe-based heterojunction bipolar transistor (HBT) used to realize building blocks for 40-Gbps optical links
- "A 128Mb Early Prototype for Gigascale Single-Electron Memories," by Hitachi Ltd., about a 128Mb single-electron memory targeting minimum-bit-cost technology
- "A 200mW 3.3V CMOS color Camera IC Producing 352x288 24b Video at 30Frames/s," by Lucent Technologies, about CMOS sensors for virtual reality and Internet conferencing applications

Analog and Mixed Signal

Analog and mixed-signal ICs are gaining importance in this digital age as getting data to and from the real world becomes the gating factor of digital systems. The reduction in cost and size of digital systems has stimulated market demand, which in turn has driven the growth of analog and mixed-signal ICs. Dataquest projects that analog and mixed-signal ICs will grow at a compounded annual growth rate (CAGR) of 15 percent for the next four years. Reflecting this growing importance, the 1998 ISSCC devoted the following four technical sessions to this topic:

- Oversampling Converters
- Analog-to-Digital Converters (ADCs)
- Analog Techniques
- Amplifiers

Significant advances were reported in the analog technology area, including 400-Msamples/sec 6-bit CMOS analog-to-digital converters from both Texas Instruments and Fujitsu Ltd., a 10-bit 250-Msamples/sec CMOS digital-to-analog converter from Broadcom Corporation, and a 113dB signal-to-noise ratio oversampling digital-to-analog converter utilizing sigma-delta technology from Analog Devices.

Wireless and RF

One of the fastest-growing application segments within the semiconductor industry is wireless communications. The wireless semiconductor market can be partitioned into two major segments, RF semiconductors, which are used in the radio portion of a wireless system, and baseband semiconductors, which include microcontrollers, digital signal processors, microprocessors, memory, power management, and display semiconductors. RF semiconductors such as RF amplifiers, synthesizers, transceivers, receivers, and switches have experienced strong growth in the last few years as a result of the burgeoning wireless communications market, and Dataquest expects this trend to continue into the foreseeable future. At this year's ISSCC, four technical sessions were dedicated to wireless and RF:

- Transceivers and Power Amplifiers
- Wireless Receivers
- Advanced RF Circuits
- Wireless Building Blocks

Among the papers presented at these sessions, Dataquest felt that three were particularly interesting: The first was from Toshiba Corporation, about a single-chip CMOS RF transceiver utilizing standard 0.25-micron CMOS technology; the second was from University of California, Los Angeles regarding a 900-MHz/1.8-GHz CMOS receiver for dual-band applications, and the third was from Stanford University, about a 115mW CMOS GPS receiver implemented in an analog 0.5-micron CMOS technology.

Dataquest Perspective

The remarkable growth of the computer market during the last decade has been the driving force behind the growth of semiconductors. As a result, PC components such as microprocessors, logic, and memory have been the main focus of ISSCC in the past. However, this year's ISSCC has chosen "global communications" as the main theme. This reflects Dataquest's belief that the communication markets will join the computer market as the driving forces behind semiconductor growth for the future.

As a result of this rapid emergence of communications market, mixed-signal ICs and RF ICs will become increasingly important. It will be companies with expertise in mixed-signal and RF design and manufacturing that possess the key weapons to succeed.

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Perspective

Semiconductors Worldwide

Market Analysis

Alliance Activity in 1997: Another Year of Acquisitions

Abstract: *Acquisition was the name of the investment game in 1997. Overall alliance activity was not as robust as in 1996, as Dataquest captured only 289 known or published alliance agreements, in comparison to over 450 listings in 1996. The alliances listed in this document involve all aspects of the global semiconductor industry—components, front-end equipment, materials, foundry, assembly, and end-system equipment.*

By Mary Ann Olsson

Investment for Some, but Takeover for Others

Most electronics companies will remember 1997 as the year of falling DRAM prices, tougher competition, and shrinking design cycle times. In reality, profit margins became everything. To head off the competition and to keep the shareholders at bay, companies bought their way into technology and regional markets through acquisition.

In 1997, as in previous years, agreements between U.S. companies were still the most numerous, as shown in Figure 1. The growth of alliances between U.S. companies and U.S. and European companies was substantial in comparison to previous years. By company, Siemens AG was the most active in forming alliances worldwide. Founded in 1847 by Werner von Siemens, Siemens AG is celebrating its 150th year in business and holds the No. 12 position in semiconductors for 1997.

As shown in Figure 2, investment agreements surpassed license and joint-development agreements in 1997. Table 1 lists all the alliance activities by company and region. The order of appearance in either column A or B is random.

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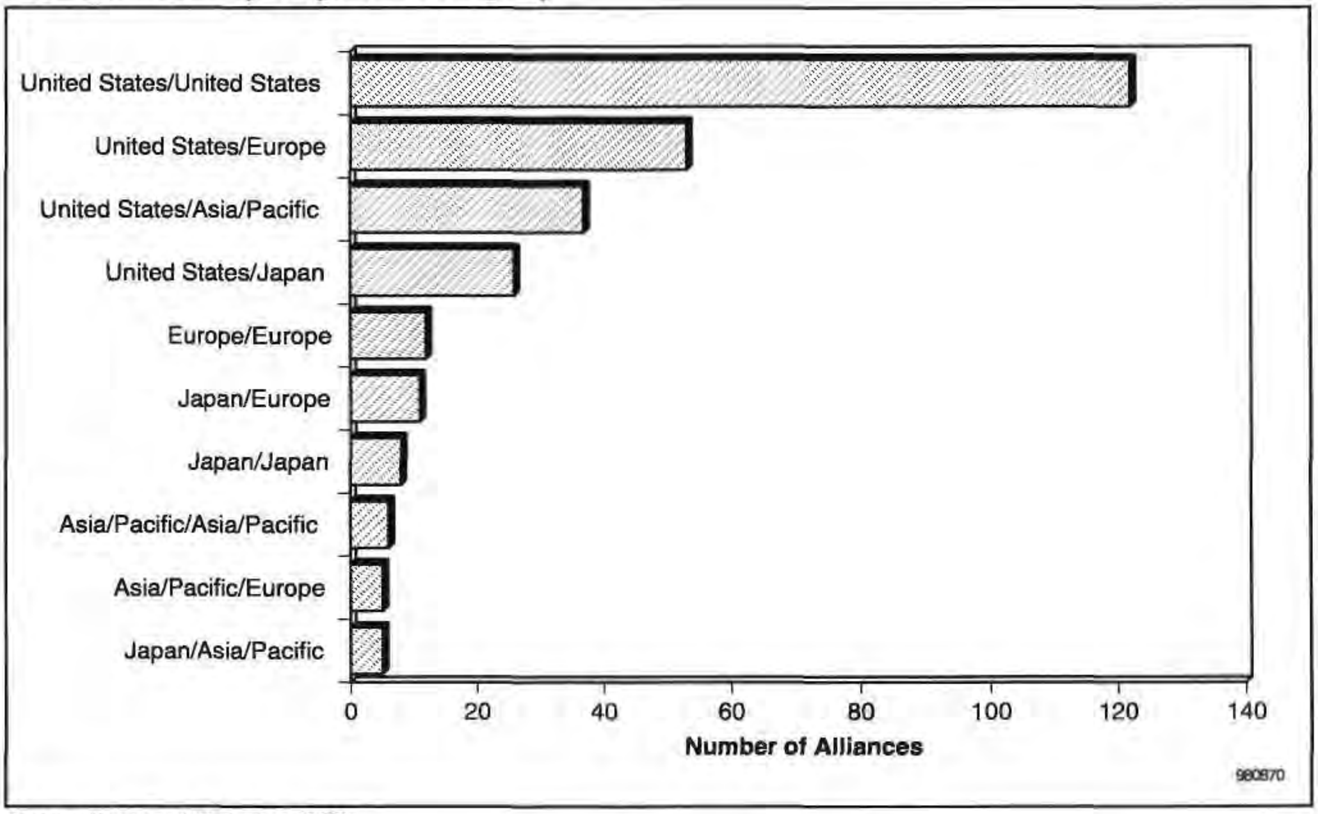
Figure 3 shows alliance activity by product function, contract assembly, front-end equipment and foundry, electronic equipment systems, software, materials, and others. The "others" category includes products that are not included in specific categories currently collected by Dataquest. Figure 4 illustrates the application market selections. Not all the alliances listed in Table 1 are application specific. Each agreement is coded according to a Dataquest classification. Dataquest classifies all of the alliances listed in this table as follows:

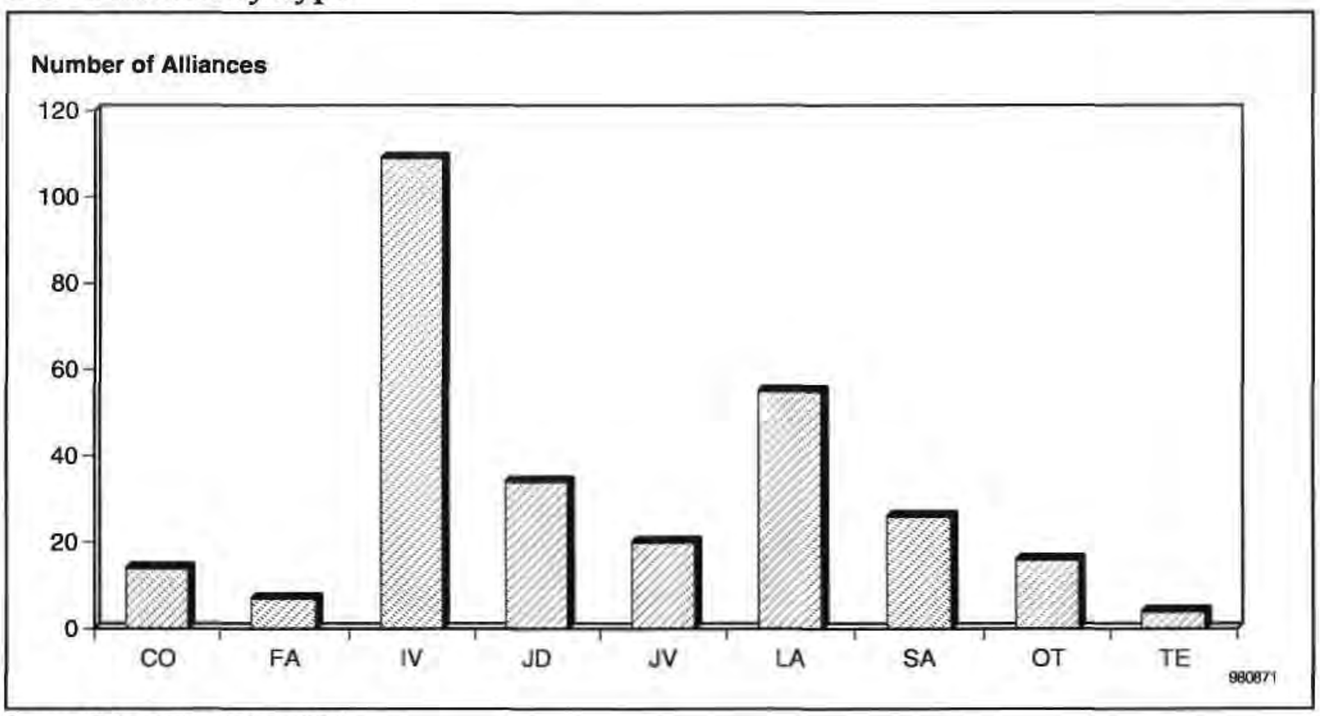
- License agreements (LA): License agreements are defined as legal permission to utilize a company's patents or proprietary technology for a fee or royalty payment. This could also include a cross-licensing agreement where the companies involved have legal permission to another company's patents or proprietary technology.
- Second-source agreements (SS): Second-source agreements allow companies to manufacture a product designed and developed by another company as a second source of supply for customers.
- Sales agreements (SA): Sales agreements provide companies with exclusive or nonexclusive rights to sell the partner's original products to which value is added, in specified markets.
- Fab agreements (FA): Fab agreements involve the use of another company's fabrication facilities to manufacture a product.
- Assembly and test agreements (AT): Assembly and test agreements involve a company's manufactured components and parts that are shipped to another company for assembly and test.
- Technology exchange (TE): Technology exchange involves an exchange of proprietary technologies that may or may not involve a transfer of money.
- Joint venture (JV): Joint ventures involve two or more companies that jointly form a company to develop, manufacture, or market new products.
- Joint development (JD): Joint development agreements are between two or more companies that decide to combine forces and capabilities to develop new products or technology.
- Investment (IV): Investment alliances are made among regional companies or foreign companies for the purposes of gaining access to technology or acquisition of small start-ups or innovative companies.
- Coordination (CO): Coordination of standards are agreements on common or compatible technical standards that would link devices and systems and users of different components, systems, or tools.
- Procurement (PC): Procurement agreements are commitments by companies to purchase certain quantities of specific goods or services over a contracted time.
- Other types (OT): Other types of agreements could include visitation and research participation where researchers visit, observe, and participate in the R&D activities of the allied company. An original equipment manufacturing (OEM) agreement might involve the manufacturing of a product for another company that will label it with its name or logo and will also handle all of the business aspects of that product, such as its marketing and service. Service agreements are those provisions of follow-up service of the product in foreign markets.

Figure 1
1997 Alliances by Regional Company



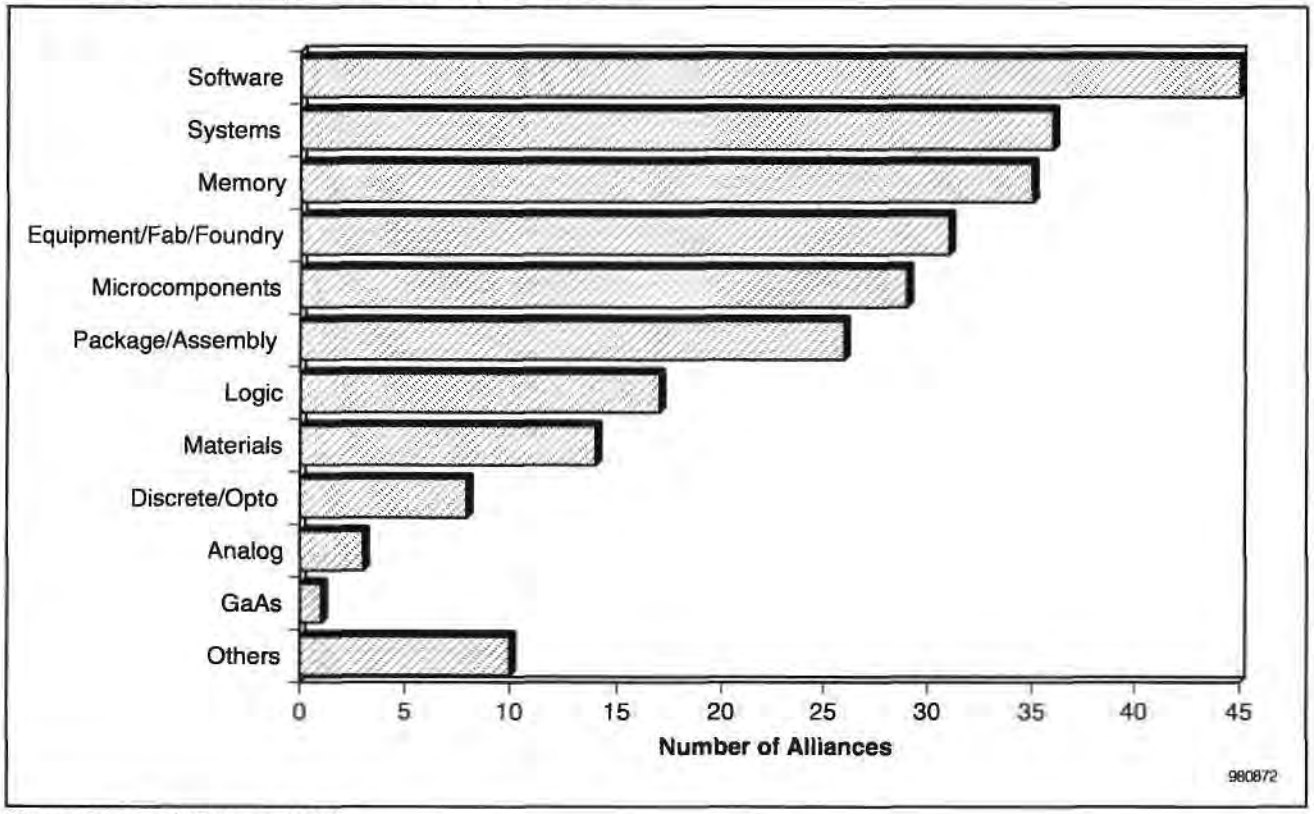
Source: Dataquest (February 1998)

Figure 2
1997 Alliances by Type



Source: Dataquest (February 1998)

Figure 3
Alliance Activity by Product Segment, 1997



Source: Dataquest (February 1998)

Figure 4
Alliance Activity by Application Segment, 1997

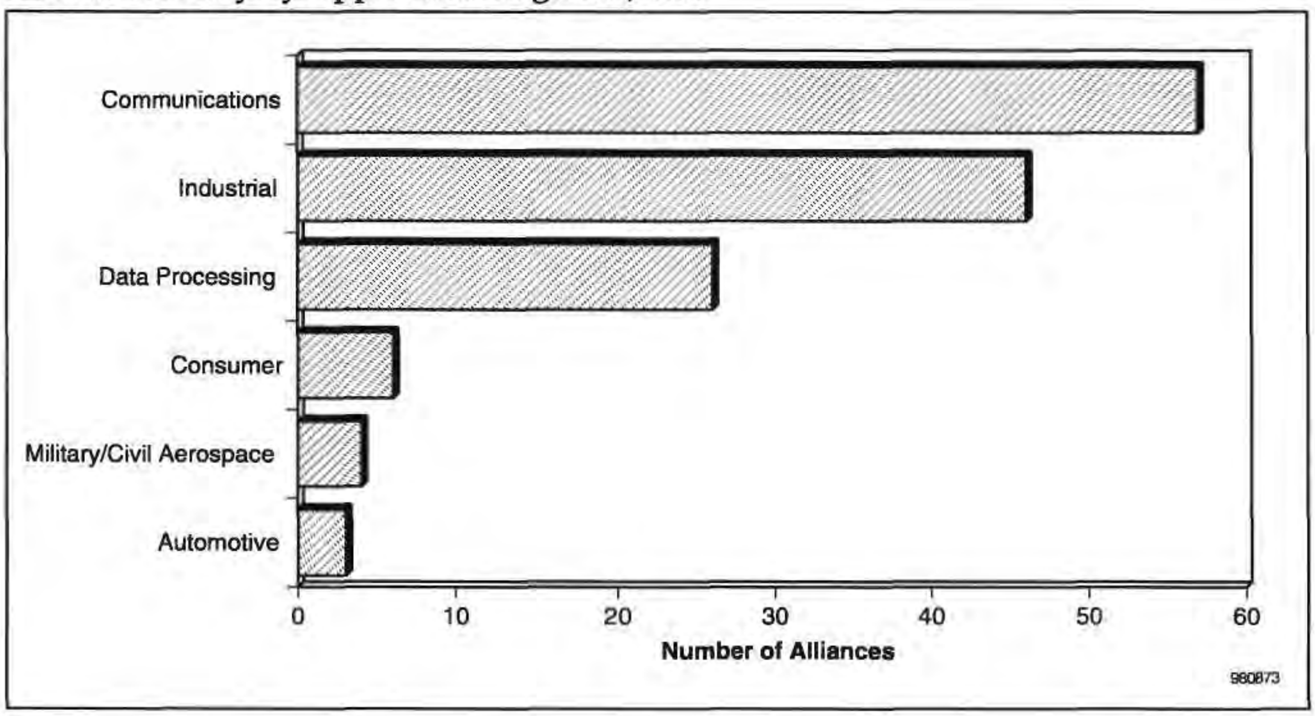


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Figure 4
Alliance Activity by Application Segment, 1997

Source: Dataquest (February 1998)

Table 1
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
SanDisk Corporation	U.S.	Cross-license on flash memory	Sharp Corporation	Japan	Cross-license on flash memory	LA	January
WebTV Networks Inc.	U.S.	Internet TV joint venture, 65% share	Fujitsu Ltd.	Japan	35% share of WebTV joint venture	JV	January
Whitetree Inc.	U.S.	ATM/Ethernet switching solution alliance	General Datacom Inc.	U.S.	ATM/Ethernet switching solution	OT	January
Efficient Networks Inc.	U.S.	ATM/Ethernet switching solution alliance	General Datacom Inc.	U.S.	ATM/Ethernet switching solution	OT	January
QUALCOMM Inc.	U.S.	Equity investment	Unwired Planet Inc.	U.S.	Browser and HDML cellular/PCS network	IV	January
Rockwell Semiconductor	U.S.	License: RISC core for 56K modem	Advanced RISC Machines Ltd.	Europe	License: ARM core technology	LA	January
Ultratech Stepper Inc.	U.S.	Acquisition: terms not disclosed	Lepton Inc.	U.S.	E-beam lithography system	IV	January
Raytheon Company	U.S.	Acquisition: $2.95 billion	Texas Instruments Inc.	U.S.	Military electronics business	IV	January
Synopsys Inc.	U.S.	Acquisition: $430 million	Epic Design Technology	U.S.	Submicron software technology	IV	January
Quickturn Design Systems	U.S.	Acquisition: $55 million	SpeedSim Inc.	U.S.	Cycle-based Verilog simulators	IV	January
Hewlett-Packard Company	U.S.	Joint technology development/product integration	Cisco Systems Inc.	U.S.	Internet hardware/software products	JD	January
NEC Corporation	Japan	Cenju-3 parallel computer	Institut National de Recherche en Informatique et en Automatique	Europe	R&D project on parallel computing	JD	January
Intel Corporation	U.S.	Acquisition: $72 million	Case Technology	Europe	Fast Ethernet hardware	IV	January
Intel Corporation	U.S.	Acquisition: $52 million	Xircom Inc.	U.S.	PC card specialist	IV	January

Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
Information Handling Systems	U.S.	CapsXpert component database	Team Corporation	Canada	EDA bridge product	JD	January
Teleport Communications Group Inc.	U.S.	Acquisition: $65 million	TCG CERFnet.	U.S.	Internet service provider	IV	January
Celestica Inc.	Canada	Acquisition: $180 million	Design to Distribution Ltd. (D2D)	Europe	Contract manufacturer	IV	January
Digital Projection Ltd.	Europe	Acquisition: $10 million investment/management	3i plc	Europe	Large-scale projectors	IV	January
Kohlberg Kravis Roberts & Co.	Europe	Acquisition: $1.5 billion	Amphenol Corporation	U.S.	Connector manufacturer	IV	January
Hitachi Ltd.	Japan	1Gb DRAM development	Texas Instruments Inc.	U.S.	Joint development	JD	January
Mitsubishi Electric Corporation	Japan	1Gb DRAM development	Texas Instruments Inc.	U.S.	Joint development	JD	January
Cascade Communications Inc.	U.S.	Acquisition of Sahara	Sahara Networks	U.S.	Broadband access products	IV	January
Compaq Computer Corporation	U.S.	Codevelop flat-panel monitor displays	Mitsubishi Electric Corporation	Japan	Advanced Display to build displays	JD	January
Honeywell Inc.	U.S.	$561 million acquisition of Measurex	Measurex Corporation	U.S.	Computer-integrated measurement systems	IV	January
Zenith Electronics Corporation	U.S.	Internet television products	Oracle Corporation	U.S.	Internet television products	OT	January
Zenith Electronics Corporation	U.S.	Internet television products	Netscape Communications Corporation	U.S.	Internet television products	OT	January
Raytheon Co.	U.S.	Acquisition of Hughes Defense Operations	General Motors Corporation	U.S.	Sale of Hughes Electronics Corp.	IV	January
3DO Corporation	U.S.	Graphics, audio, video chips for the Internet	Samsung Electronics Co.	Korea	$30 million joint venture	JV	January
Symbios Logic Inc.	U.S.	RISC SCSI I/O processor drivers	Diamond Multimedia Systems Inc.	U.S.	Market PCI ultra-SCSI adapters	OT	January
Taiwan Semiconductor Mfg. Co.	Taiwan	Integrate OakDSPCore into ASIC cell library	DSP Group Inc.	U.S.	License of OakDSPCore technology	LA	January
WaferScale Integration Inc.	U.S.	EPROM technology	Tower Semiconductor Ltd.	Israel	0.6-micron CMOS process	FA	January
Samsung Electronics Company Ltd.	Korea	Nonexclusive rights license	Ramtron International Corporation	U.S.	License: FRAM technology	LA	January

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Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
Bookham Technology Ltd.	Europe	Optical IC product development	Newbridge Networks Inc.	Canada	Active Silicon Optical Circuit technology	JD	January
Avant! Corporation	U.S.	Merger completion	Frontline Design Automation	U.S.	Verilog simulators	IV	January
Geoworks Inc.	U.S.	Acquisition: $30 million	Eden Group	Europe	Real-time operating systems	IV	February
Analog Devices Inc.	U.S.	RF/IF components partner	Zilog Inc.	U.S.	Z-phone components	SA	February
Flextronics International Ltd.	U.S.	Acquisition of Karlskrona manufacturing facility	Ericsson Business Networks AB	Europe	Business communications systems plant	IV	February
SGS-Thomson Microelectronics	Europe	Multiphase license agreement on FRAM technology	Ramtron International Corporation	U.S.	CMOS 64K nonvolatile FRAM memories	LA	February
Advanced RISC Machines Ltd.	Europe	ARM RISC architecture with Java OS	Sun Microsystems Inc.	U.S.	JavaSoft to license Java OS for ARM	LA	February
Motorola Inc.	U.S.	ADSL integration agreement	Marconi S.p.A.	Europe	CopperGold transceiver designs	JD	February
Siemens AG	Europe	Wireless ATM switching	Broadband Networks Inc.	U.S.	Joint investment	IV	February
Newbridge Networks Inc.	Canada	Wireless ATM switching	Broadband Networks Inc.	U.S.	Joint investment	IV	February
Siemens AG	Europe	DSP-Carmel	IC Communications	Israel	DSP for GSM handsets	JV	March
Fujitsu Ltd.	Japan	Unify ultrathin small-outline-USON CSP designs	LG Semicon Co. Ltd.	Korea	Bottom-leaded plastic-BLP CSP design	CO	March
Hewlett-Packard Company	U.S.	Acquisition: Software tools business	Siemens Automotive	Europe	Sale of software operations	IV	March
Hewlett-Packard Company	U.S.	Test/diagnostic services solution	Cosworth Engineering Inc.	Europe	Automotive test/ diagnostic solutions	JV	March
SGS-Thomson Microelectronics	Europe	High-speed driver/ receiver technology	Rambus Inc.	U.S.	License of Rambus technology	LA	March
Rohm Company Ltd.	Japan	PineDSPCore in motor control ICs	DSP Group Inc.	U.S.	License of PineDSPCore and OakDSPCore	LA	March
Motorola Inc.	U.S.	Acquisition of Pilkington's IP and patents	Pilkington Micro-electronics Ltd.	Europe	Programmable logic products	IV	March
Trimble Navigation Ltd.	U.S.	Access to GPS chipset for in-vehicle navigation	Xanavi Informatics Corporation	Japan	GPS in Birdview car navigation	LA	March

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Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
EBV Electronics	Europe	Distributor—subsidiary of Raab Karcher	TEMIC Inc.	Europe	IC and discrete device distribution	SA	March
CNet Technology Inc.	Europe	Joint IC design team	SGS-Thomson	Europe	ICs for digital TV and wireless applications	OT	March
TSMC	Taiwan	Fab and assembly flow agreement	Advanced Semiconductor Engineering Group (ASE)	Taiwan	Fab and assembly flow agreement	FA	March
Olicom Inc.	U.S.	License: LANE software suite	Cisco Systems Inc.	U.S.	Token-ring switch software	LA	March
Network Peripherals Inc.	U.S.	License: LAN switching line	Farallon Communications Inc.	U.S.	Networking license	LA	March
SANYO Electric Company Ltd.	Japan	3-D broadcasting technology development	Nippon Television Network	Japan	3-D broadcasting technology	JD	March
Intel Corporation	U.S.	Multimedia/Internet to PC via satellite	SES	Europe	Satellite specialist: $10 million investment	JV	March
National Semiconductor Corporation	U.S.	Acquisition: $100 million	Mediamatics Inc.	U.S.	MPEG audio/video decoder company	IV	March
CNet Technology Inc.	U.S.	PowerNIC chips	United Microelectronics Corporation	Taiwan	Fast Ethernet products/fab	FA	March
Davicom Semiconductor Inc.	U.S.	DM9101 chips	United Microelectronics Corporation	Taiwan	Fast Ethernet products/fab	FA	March
IBM Corporation	U.S.	Joint hard disk drive controller IC	Mitsubishi Electric Corporation	Japan	MCU/embedded flash memory	JD	March
Philips	Europe	ARM RISC core license	Advanced RISC Machines Ltd.	Europe	License of RISC technology	LA	March
Lattice Semiconductor Corporation	U.S.	$150 million investment	Seiko-Epson Corporation	Japan	8-inch Sakata fab	IV	March
Texas Instruments Inc.	U.S.	DSP architecture enhancement	Spectron Microsystems	U.S.	DSP/BIOS application programming interface	SA	March
Deltec Electronics Corporation	U.S.	Power management software	Compaq Computer Corporation	U.S.	Uninterruptible power supply design	SA	March
Integrated Storage Devices Inc.	U.S.	Acquisition: $5 million	National Semiconductor Corporation	U.S.	CompactSpeech product line	IV	April
Fujitsu Ltd.	Japan	BGA specification agreement	Toshiba Corporation	Japan	Memory BGA configuration spec.	CO	April

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Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
NEC Corporation	Japan	Fab partner $700 million 0.35-micron 8-inch fab	Shanghai Hua Hong Microelectronics	China	Project 909/Chinese govt.: 71% share	FA	April
Hewlett-Packard Company	U.S.	0.35- and 0.25-micron ASICs	Chartered Semiconductor Manufacturing Ltd.	Singapore	Foundry joint venture	JV	April
Abpac Inc.	U.S.	License of Motorola BGA technology	Motorola Inc.	U.S.	BGA Patent Immunity Agreement	LA	April
Tessera Inc.	U.S.	$30 million in funding	AB	Europe	Industrial Holding Company, Sweden	IV	April
Taiwan Semiconductor Mfg. Co.	Taiwan	$14.5 billion fab investment	Taiwan Science-Based Industrial Park	Taiwan	Taiwan government backed project	IV	April
Rockwell International Corporation	U.S.	Acquisition of Hi-Media chipset business, $50 million	ComStream Corporation	U.S.	Broadband communication chipset business	IV	April
DSP Communications Inc.	U.S.	IS-95 baseband processor chipsets for CDMA	Kenwood	Japan	Chipset for CDMA/ analog subscriber terminals	OT	April
NEC Corporation	Japan	Company spin-off from corporation	TeleMidic Ltd.	Japan	MIDI-based network	JV	April
Lam Research Corporation	U.S.	Acquisition: $225 million	OnTrak System Inc.	U.S.	Wafer polish equipment manufacturer	IV	April
Intel Corporation	U.S.	6.75% equity investment	Avid Technology Inc.	U.S.	Audio/video company	IV	April
Intel Corporation	U.S.	Stock investment	Rambus Corporation	U.S.	Intel investment	IV	April
Electroglas Inc.	U.S.	Acquisition: $30 million	Knights Technology	U.S.	Software-yield management	IV	April
Advanced RISC Machines Ltd.	Europe	Acquisition: 45% investment	Palmchip Inc.	U.S.	Mass-storage controller	IV	April
Motorola Inc.	U.S.	Investment	Tao Group Ltd.	Europe	Virtual processor/ Java-like OS	IV	April
Vivid Semiconductor Corporation	U.S.	High-voltage driver ICs	LG Semicon Co. Ltd.	Korea	Five-year license/fab agreement	FA	May
National Scientific Corporation	U.S.	Acquisition of Avalon	Avalon Technology Inc.	U.S.	Hot air soldering equipment	IV	May
Hewlett-Packard Company	U.S.	HP 3070 test systems agreement	TSL America	U.S.	$6 million exclusive agreement	IV	May

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Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
China Aerospace Corporation	China	Joint venture memorandum on network computers	Digital Equipment Corporation	U.S.	Engineering and design resources	JV	May
Motorola Inc.	U.S.	Total Access Communication Systems	Eastern Communications Co.	China	$200 M contract to cellular equipment and services	OT	May
Shin-Etsu Handotai Co. Ltd.	Japan	SOI wafer facility in Japan	Silicon On Insulator Technologies	Europe	SHE partner in SOI wafer technology	JD	May
Kingston Technology Inc.	Taiwan	$100 million investment in Taiwan	Far East Kingston Technology	Taiwan	DRAM module factory in Hsin Chu	IV	May
Cadence Design Systems Inc.	U.S.	Four-year design tools technology agreement	Ericsson	Europe	Design tools for wireless products	TE	May
Ascend Communications Inc.	U.S.	Acquisition of Cascade	Cascade Communications Inc.	U.S.	Communications systems	IV	June
LSI Logic Inc.	U.S.	Single-chip digital terrestrial TV solution	BBC	Europe	LSI CoreWare in L64780 demodulation chip	JD	June
Telemac Corporation	U.S.	Debit Technology in handsets	Philips Consumer Communications	Europe	Telemac technology in cellular handsets	JD	June
Pinnacle Systems Inc.	U.S.	Studio Mixer/SmartCable technology in Fujitsu product	Fujitsu Ltd.	Japan	Computer-based consumer video products	OT	June
Texas Instruments Inc.	U.S.	Ten-year semiconductor cross license patent agreement	Vanguard International Semiconductor Corp.	Taiwan	Cross license of patent technology	LA	June
Texas Instruments Inc.	U.S.	Ten-year semiconductor cross license patent agreement	NEC Corporation	Japan	Cross license of patent technology	LA	June
Cisco Systems Inc.	U.S.	Acquisition of Skystone	Skystone Systems Corporation	Canada	SONET/SDH communications	IV	June
LG Semicon Co. Ltd.	Korea	Codevelop Java processors	Sun Microsystems Inc.	U.S.	LG Semicon to manufacture Java processors	JD	June
Tower Semiconductor Ltd.	Israel	EPROM compiler for customers	Virage Logic Corporation	U.S.	EPROM compiler with BIST for Tower	OT	June
Seiko Epson Corporation	Japan	Joint development of ASIC libraries	Exemplar Logic	U.S.	Leonardo design environment	JD	June

Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
Compaq Computer Corporation	U.S.	Acquisition of Tandem for $3 billion	Tandem Computers Inc.	U.S.	Massively parallel computer systems	IV	June
Lucent Technologies	U.S.	$2.5 billion consumer phone joint venture, 40% share	Philips Electronics N.V.	Europe	Consumer Communications share, 60%	JV	June
Aptix Corporation	U.S.	Resell Altera MAX II Plus software	Altera Corporation	U.S.	Altera PLDs in Aptix products	OT	June
Synplicity Inc.	U.S.	Logic synthesis software to Lattice	Lattice Semiconductor Corporation	U.S.	Software OEM agreement	OT	June
Johnson Matthey plc	Europe	Plastic land grid array license to Kyocera	Kyocera Electronics Inc.	Japan	Kyocera's C4 technology to Johnson Matthey	LA	June
EFTC Corporation	U.S.	Circuit card assemblies for Boeing 777	Honeywell Incorporated	U.S.	Circuit cards to EFTC	JD	June
UNIAX Corporation	U.S.	License on light-emitting polymer (LEP) displays	Cambridge Display Technology Ltd.	Europe	LEP technology	LA	June
Hoechst AG	U.S.	R&D and joint research for UNIAX	Cambridge Display Technology Ltd.	Europe	Light-emitting polymer (LEP) technology	LA	June
Aspect Development Inc.	U.S.	Component/supplier management solutions	Viewlogic Systems Inc.	U.S.	EDA tools license and royalties	JD	June
Oracle Corporation	U.S.	Acquisition: terms not disclosed	Navio Communications Inc.	U.S.	Netscape software subsidiary	IV	June
Gateway 2000 Inc.	U.S.	Acquisition: rights to Amiga platform	Amiga Technologies GmbH	Europe	Amiga computer platform	IV	June
Applied Technology Materials Inc.	U.S.	Acquisition: $78 million	Lawrence Semiconductor	U.S.	Silicon-based thin film	IV	June
AltoCom Inc.	U.S.	License: V.34 modem software	Philips Semiconductors Inc.	Europe	Code in TwoChipPIC controller	LA	June
AltoCom Inc.	U.S.	License: V.34 modem software	Advanced RISC Machines Ltd.	Europe	Software in fixed-point integer processors	LA	June
Microsoft Corporation	U.S.	$80 million R&D research investment	Cambridge University Computer Lab	Europe	Research and venture capital	IV	June
Bay Networks Inc.	U.S.	Acquisition: $155 million	Rapid City Communications Inc.	U.S.	LAN switch start-up	IV	June

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Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
Eastman Kodak Co.	U.S.	Pixel imaging chip development	Motorola Incorporated	U.S.	CMOS process for optical sensor fab	JD	June
Toshiba Corporation	Japan	iReady core to ASIC customers	iReady Corporation	U.S.	Internet tuner core license	LA	June
LSI Logic Corporation	U.S.	Stacked-cell 0.25-micron process	Micron Technology Inc.	U.S.	Stacked-cell embedded-DRAM process	JD	June
Spyrus Inc.	U.S.	Acquisition	Terisa Systems Inc.	U.S.	Security software specialist	IV	June
Toshiba Corporation	Japan	Embedded-DRAM technology	Chartered Semiconductor Mfg. Pte. Ltd.	Singapore	0.35/0.25-micron fab process	LA	June
EFTC Corporation	U.S.	Merger/acquisition for $19.5 million	Circuit Test Inc. (CTI)	U.S.	Quick-turn repair company	IV	July
Tessera	U.S.	MicroBGA license agreement	Hyundai Electronics	Korea	MicroBGA license from Tessera	LA	July
Tessera	U.S.	MicroBGA license agreement	LG Semicon Co. Ltd.	Korea	MicroBGA license from Tessera	LA	July
Tessera	U.S.	MicroBGA license agreement	Samsung Electronics Co.	Korea	MicroBGA license from Tessera	LA	July
Tessera	U.S.	MicroBGA die attach and encapsulation	Dow Corning Corporation	U.S.	Silicone-based products for MicroBGA	JD	July
Tessera	U.S.	MicroBGA package technology	Hitachi Cable Ltd.	Japan	Assemble ICs in Tessera package	LA	July
EFTC Corporation	U.S.	Acquisition of assets.	Allied Signal Inc.	U.S.	Circuit assembly operations	IV	July
Novellus Systems Inc.	U.S.	$150 million assets acquisition	Varian Associates Inc.	U.S.	Sale of thin-film systems unit	IV	July
Sterling Software Inc.	U.S.	Acquisition of TI's application software business	Texas Instruments Inc.	U.S.	$165 million revenue from sale of software	IV	July
Advanced Technology Materials Inc.	U.S.	Acquisition of company—$78 million	Lawrence Semiconductor Laboratories	U.S.	An ATMI Epitronics subsidiary	IV	July
Applied Science and Technology Inc.	U.S.	Acquisition of CPI: $6.35 million	Converter Power Inc. (CPI)	U.S.	Switching power supplies	IV	July

Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
Veeco Instruments Inc.	U.S.	Strategic marketing/ manufacturing agreement	Edwards High Vacuum International	Europe	600T/600D helium mass spec. leak detectors	OT	July
OnTrak Systems Inc.	U.S.	Joint development of Rippey PVA brush technology	Rippey Corporation	U.S.	PVA brush roller technology	JD	July
Amkor/Anam	Korea	Package manufacturing for bumped die	Flip Chip Technologies	U.S.	Flip chip technology and wire bonders	SA	July
Crysteco Inc.	U.S.	Acquisition of Texas facility	Fabico Inc.	U.S.	Epitaxial facility—680,000 wafer capacity	IV	July
Daifuku Co.	Japan	Joint development of 300mm solution/ Daifuku manufacturing	Fluoroware Inc.	U.S.	Unified pod with tool load-port interface	JD	July
Shing Chung Engineering	Taiwan	Trace Analytical Systems joint venture	Trace Analytical	U.S.	High-purity gas monitor systems	JV	July
Macotron Systems	Europe	Availability of linear/ mixed-signal test equipment	TMT Inc.	U.S.	Test equipment availability in Europe	SA	July
Flowmec	Europe	Ultrahigh-purity gas fittings	Sang International	Korea	Distribution agreement in Korea	OT	July
Interuniversities Microelectronics Center (IMEC)	Europe	193nm deep-UV lithography R&D program	ASM Lithography	Europe	IMEC Class 1 clean room facility	OT	July
Cambridge Display Technology Ltd.	Europe	LEP technology for displays	Hoechst Celanese AG	Europe	Technology license agreement	LA	July
Cambridge Display Technology Ltd.	Europe	LEP patents and intellectual property rights	UNIAX Corporation	U.S.	Royalty fees and license agreement	LA	July
United Microelectronics Corporation	Taiwan	$18.5 billion investment: 8-inch/12-inch fabs	Tainan Science-Based Industrial Park	Taiwan	Government-owned project	IV	July
IBM Corporation	U.S.	$25 million research facility in India	Solutions Research Center	India	Indian Institute of Technology	IV	July
Texas Pacific Group	U.S.	Acquisition of Zilog Inc.: $527 million	Zilog Inc.	U.S.	Sale of company to private investment	IV	July
Texas Instruments Inc.	U.S.	License of high-bandwidth memory interface	Rambus Inc.	U.S.	License of technology for DSP/ASICs	LA	July

Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
SanDisk Corporation	U.S.	Cross-license agreement of flash memory products	Hitachi Ltd.	Japan	Cross license of flash memory	LA	July
Eaton Corporation	U.S.	Acquisition of Fusion for $39/share	Fusion Systems Corporation	U.S.	Merger	IV	July
SubMicron Systems Corporation	U.S.	Sale of assets and liabilities of subsidiary	Systems Chemistry Inc.	U.S.	Sale to BOS Group	IV	July
Mentor Graphics Corporation	U.S.	Libraries and IP designs/ tools	Chartered Semiconductor Mfg. Pte. Ltd.	Singapore	Manufacturing process	TE	July
Sony Corporation	Japan	Flat panel display for TVs	Sharp Corporation	Japan	Flat-panel displays	JD	July
Philips Electronics NV	Europe	Joint development of flat-panel display with Sony/ Sharp	Sharp Corporation	Japan	Flat-panel displays	JD	July
Giga-tronics Inc.	U.S.	Acquisition of Viking	Viking Semiconductor Equipment	U.S.	Optical inspection equipment	IV	July
Seagate Technology Inc.	U.S.	Acquisition: $230 million to shareholders	Quinta Corporation	U.S.	Magnetic technology for optical storage	IV	July
Lucent Technologies	U.S.	Acquisition: $1.8 billion	Octel Communications Corporation	U.S.	Voice/e-mail messaging	IV	July
Sun Microsystems Inc.	U.S.	License of Java Bytecode	Siemens AG	Europe	Hardware design to JavaCard	LA	July
3Com Corporation	U.S.	Expand LAN telephony	Siemens AG	Europe	License of 3Com software	SA	July
Integrated Storage Devices Inc.	U.S.	Voice-recording chips based on flash memory	SST Inc.	U.S.	Flash memory technology	SA	July
Integrated Storage Devices Inc.	U.S.	Voice-recording chips based on flash memory	Winbond Corporation	Taiwan	Flash memory technology	SA	July
Sun Microsystems Inc.	U.S.	Acquisition of Integrity Arts	Integrity Arts Inc.	U.S.	Software written in Java for smart cards	IV	August
National Semiconductor Corporation	U.S.	Develop/manufacture liquid crystal on silicon microdisplays	Three-Five Systems Inc.	U.S.	SVGA display technology	SA	August
Samsung Electronics Company Ltd.	Korea	Cross license flash memory patents	SanDisk Corporation	U.S.	Cross license flash memory patents	LA	August
Mentor Graphics Corporation	U.S.	Joint development of customer support package	NEC Corporation	Japan	RISC processor core with Mentor CVE	JD	August

Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
DuPont Photomasks Inc.	U.S.	DPI Reticle Technology Center-joint venture	Advanced Micro Devices Inc.	U.S.	Photomask technology joint venture	JV	August
DuPont Photomasks Inc.	U.S.	DPI Reticle Technology Center-joint venture	Micron Technology Inc.	U.S.	Photomask technology joint venture	JV	August
DuPont Photomasks Inc.	U.S.	DPI Reticle Technology Center-joint venture	Motorola Incorporated	U.S.	Photomask technology joint venture	JV	August
Philips Semiconductors Inc.	Europe	Joint development and manufacture of embedded flash products	Macronix International Company	Taiwan	Embedded flash products development	JD	August
QSound Labs Inc.	U.S.	License of QSurround to AKM Semiconductor	AKM Semiconductor Inc.	Japan	License for its DSP codec products	LA	August
Cadence Design Systems Inc.	U.S.	Joint development of Cadence Spectre simulator	United Microelectronics Corporation	Taiwan	UMC process technologies	JD	August
SanDisk Corporation	U.S.	Cross license of flash memory patents	Toshiba Corporation	Japan	Cross license of flash memory patents	LA	August
Synopsys Inc.	U.S.	IP core characterization for system on a chip	Advanced RISC Machines Ltd.	Europe	EPIC-based analog technology	TE	August
NEC Corporation	Japan	Joint-venture memory/ logic manufacturing	Shanghai Hua Hong Microelectronics Co.	China	NEC/China Ministry of Electronics Industry	JV	August
Intel Corporation	U.S.	Acquisition: $420 million	Chips & Technologies	U.S.	Graphics/video chipset	IV	August
National Semiconductor Corporation	U.S.	Acquisition: $550 million	Cyrix Corporation	U.S.	Microprocessor technology	IV	August
Motorola Inc.	U.S.	Smart card microcontroller chip compatibility	SGS-Thomson	Europe	Smart card and terminal agreement	SA	August
Mitsubishi Corporation	Japan	Oriental International Group joint venture	Dongling Trading	China	27% Mitsubishi investment	IV	August
Oriental International Group	China	51% investment in $12.5 million joint venture	Dongling Trading	China	Electronic machinery/ high-tech products	IV	August
Continental Grain Co.	U.S.	22 percent investment in joint venture	Dongling Trading	China	Electronic machinery/ high-tech products	IV	August
SanDisk Corporation	U.S.	$45 million investment in joint venture	United Silicon Inc.	Taiwan	SanDisk 10 percent equity	JV	August

Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
United Microelectronics Corporation	Taiwan	$800 million fab joint venture	United Silicon Inc.	Taiwan	Joint venture with SanDisk	JV	August
Advanced RISC Machines Ltd.	Europe	License RISC technology	Hyundai Electronics	Korea	License of ARM processor	LA	August
Advanced RISC Machines Ltd.	Europe	License RISC technology	Sony Corporation	Japan	License of ARM processor	LA	August
Aavid Thermal Technologies Inc.	U.S.	Partnership agreement: Aavid's thermal products	Tellurex Corporation	U.S.	Patented Z-MAX thermo-electric coolers	SA	August
Siemens AG	Europe	0.25-micron CMOS 64Mb technology	Rambus Inc.	U.S.	License: memory interface technology	LA	August
General Dynamics Corporation	U.S.	Acquisition: Advanced Technology Systems	Lucent Technologies Inc.	U.S.	Sale of surveillance and signal-processing unit	SA	August
Ambit Design Systems	U.S.	Develop synthesis tools design methodology	Chrysalis Symbolic Design	U.S.	Three-year joint development agreement	JD	August
Fujitsu Microelectronics	Japan	Single-chip ADSL modem	Orckit Communications Ltd.	Israel	0.35-micron two-chip digital/analog design	JD	August
Sun Microsystems Inc.	U.S.	Acquisition: stock and employees	Diba Inc.	U.S.	Software systems for Java platform	IV	August
Allied Signal Inc.	U.S.	Acquisition of Litronic's packaging operations	Litronic Industries Inc.	U.S.	New venture is ASTI	IV	September
Texas Instruments Inc.	U.S.	PicoGate logic device compatibility agreement	Philips Semiconductors Inc.	Europe	PicoGate logic using five-pin SOT package	SA	September
Siliconware Precision Industries Ltd.	Taiwan	Equity investment in Abpac	Abpac Inc.	U.S.	BGA foundry start-up	IV	September
Zi Corporation	Canada	Sublicense Chinese character input technology	Advanced RISC Machines Ltd.	Europe	Zi technology to ARM licensees	LA	September
Hyundai Electronics	Korea	Spin-off of assembly and test division	ChipPAC Inc.	U.S.	Assembly and test spin-off	IV	September
Atmel Corporation	U.S.	emWare technology in 8051 microcontrollers	emWare Inc.	U.S.	Embedded Internet software	SA	September
Samsung Electronics Company	Korea	Cross-license agreement on flash memory patent	SanDisk Corporation	U.S.	Patents cover design and manufacture	LA	September

Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
SubMicron Systems Corporation	U.S.	$3.8 million in payment and royalties for Primaxx	AG Associates	U.S.	Primaxx dry cleaning license	LA	September
NEC Corporation	Japan	Five-year Intelligent Transport System agreement	AT&T	U.S.	NEC's SONET ADM network equipment	SA	September
IBM Corporation	U.S.	Share of technology and joint development	Motorola Inc.	U.S.	PowerPC joint agreement	SA	September
Philips Semiconductors Inc.	Europe	Renew five-year technology agreement	SGS-Thomson	Europe	Codevelop 0.18-micron technology CAD tools	SA	September
Psion Software plc	Europe	EPOC 32 OS license	Philips Consumer Communication	Europe	EPOC in pocket-size data and message products	LA	September
Integrated Device Technology Inc.	U.S.	Coordinated agreement on pinouts/compatibility	Motorola Inc.	U.S.	Zero Bus Transfer (ZBT) SRAMs	SA	September
Integrated Device Technology Inc.	U.S.	Coordinated agreement on pinouts/compatibility	Micron Technology Inc.	U.S.	Zero Bus Transfer (ZBT) SRAMs	SA	September
Microsoft Corporation	U.S.	$45 million common stock purchase for 8% equity	Lernout & Hauspie Speech Products N.V.	Europe	Voice-enabled computing on Windows	SA	September
Frontier Design N.V.	Europe	Acquisition of Mentor's 75% interest	Mentor Graphics Corporation	U.S.	Sale of interest in European Design Center	IV	September
Summit Design Inc.	U.S.	Acquisition: $29 million in stock and cash	Simulation Technology Corporation	U.S.	EDA tools	IV	September
Avant! Corporation	U.S.	Acquisition: $150 million	Technology Modeling Association	U.S.	Process and device simulation tools	IV	September
Tektronix Inc.	U.S.	Acquisition: terms not disclosed	Siemens Communications Test Equipment GmbH	Europe	WAN protocol analyzers and ISDN test equipment	IV	September
Ball Semiconductors Inc.	U.S.	Ball-shaped semiconductor technology	Mitsui High-Tec Inc.	Japan	$26 million partner investment	IV	September
Kopin Corporation	Japan	CyberDisplay products in Motorola systems	Motorola Corporation	U.S.	Cellular phones, pagers, smart-card readers	SA	September
Apple Computer Inc.	U.S.	Acquisition: $100 million in stock	Power Computer Corporation	U.S.	Mac clone business	IV	September
ICG Communications Inc.	U.S.	Acquisition: $283.5 million stock swap	Netcom On-Line Communication Services	U.S.	Switching communications	IV	October
Atmel Corporation	U.S.	0.25-micron 8-inch fab joint venture	Philips	Europe	$850M joint venture	IV	October

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Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
Atmel Corporation	U.S.	Atmel and Philips joint venture in Malaysia	Khazanah Nasional Berhad	Malaysia	Kulim High Technology Park	IV	October
Synopsys Inc.	U.S.	Acquisition: $540 million stock swap	Viewlogic Systems Inc.	U.S.	ASIC design tools	IV	October
Orcad Inc.	U.S.	Acquisition: EDA tools	MicroSim Corporation	U.S.	Spice analog simulation EDA tools	IV	October
Hewlett-Packard Company	U.S.	Acquisition: HP Singapore Vision Operation	Vital Technology Pte. Ltd.	Singapore	IC and PCB assembly inspection systems	IV	October
Intel Corporation	U.S.	Standards specifications agreement	Cisco Systems Inc.	U.S.	Multimedia Cable Network Systems	CO	October
Intel Corporation	U.S.	USB/1394 and videoconferencing standards	@Home Network Inc.	U.S.	Standards agreement	CO	October
TRW Inc.	U.S.	Acquisition of GaAs MCM business	Milliwave Technology Inc.	U.S.	GaAs MCM for wireless communications	IV	October
Raytheon Company	U.S.	Acquisition: $5.1 billion	Hughes Aircraft Company	U.S.	Aircraft business sector	IV	October
Intel Corporation	U.S.	Acquisition: wholly owned subsidiary of Intel	Corollary Inc.	U.S.	High-end computer servers	IV	October
General Semiconductor Inc.	U.S.	Acquisition: $8 million small-signal transistor business	ITT Industries Inc.	U.S.	Discrete semiconductor business	IV	October
VLSI Technology Inc.	U.S.	$120 million equity investment in 0.25-micron fab	Wafer Technology Sendiran Berhad	Malaysia	8-inch fab agreement	FA	October
Lucent Technologies	U.S.	Acquisition: $650 million stock	Livingston Enterprises Inc.	U.S.	RADIUS software/ Portmaster servers	IV	October
Flextronics International Ltd.	U.S.	Acquisition: merger and stock exchange	Neutronics Electronics Holding AG	Europe	Contract equipment manufacturer	IV	October
Silicon Storage Technology Inc.	U.S.	License of SuperFlash process technology	Analog Devices Inc.	U.S.	License and royalty agreement	LA	October
NEC Corporation	Japan	Interoperability standard	SGS-Thomson	Europe	Contactless smart cards and readers	CO	November
NEC Corporation	Japan	Interoperability standard	Motorola Inc.	U.S.	Contactless smart cards and readers	CO	November
Samsung Electronics	Korea	Samsung chips in Staktek technology	Staktek Corporation	U.S.	Stacked memory chip designs	CO	November

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Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
PRI Automation Inc.	U.S.	4.4 million shares/ $170 million transaction	Equipe Technologies Inc.	U.S.	Atmospheric robotics equipment	IV	November
Integrated Silicon Solution Inc.	U.S.	Acquisition: $500,000 cash and stock exchange	Nexcom Technology	U.S.	Flash patents and designs	IV	November
Hitachi Ltd.	Japan	License: 32-bit SH-3 RISC MPU core technology	Seiko Epson	Japan	Hitachi core into ASIC/ ASSPs	LA	November
Siemens AG	Europe	License: 0.25-micron flash license	GateField	Europe	License: ProASIC technology	LA	November
SGS-Thomson Microelectronics B.V.	Europe	SGS chips in set-top box designs	British Sky Broadcasting	Europe	Digital satellite TV service	CO	November
Daewoo Electronics Corporation	Korea	Joint IC design center in Seoul	SGS-Thomson	Europe	Consumer, communications, computer products	JD	November
Integrated Silicon Solution Inc.	U.S.	Flash memory blocks IP license agreements	Rockwell International Corporation	U.S.	Embedded logic products	LA	November
Integrated Silicon Solution Inc.	U.S.	Codevelop 0.35-micron flash memory	Chartered Semiconductor Manufacturing Pte. Ltd.	Singapore	License/development fees/royalties	LA	November
IBM Corporation	U.S.	Memory partnership agreement	Dongbu Group	Korea	64Mb/256Mb DRAM technology	TE	November
Sheldahl Inc.	U.S.	License: ViaThin interconnect substrate	Parlex Corporation	U.S.	Produce ViaThin substrate	LA	November
Ambit Design Systems Inc.	U.S.	Synthesis solution into Toshiba EDA environment	Toshiba	Japan	Develop library support for tools	CO	November
Digital Equipment Corporation	U.S.	Ten-year mutual patent cross-license agreement	Intel Corporation	U.S.	Fab/foundry agreement for DEC	LA	November
ATMI Inc.	U.S.	License of Harvard deposition methodology	Harvard University	U.S.	License: titanium nitride deposition	LA	November
Texas Instruments Inc.	U.S.	Acquisition: $395 million of ADSL specialist	Amati Communications Inc.	U.S.	Asymmetry digital subscriber line	IV	November
Rockwell International Corporation	U.S.	Consumer digital subscriber line collaboration	Northern Telecom Inc.	U.S.	Modem CDSL technology	CO	November
Rockwell International Corporation	U.S.	Promote overlapped PAM transmission	Orckit	Israel	xDSL technology	CO	November

Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
Hitachi Ltd.	Japan	0.25-micron low-power SH-3 RISC MPU	NTT Electronics Corporation	Japan	0.25-micron technology collaboration	CO	November
NEC Corporation	Japan	MIPs 4300 core in consumer products	Philips	Europe	Port MIPs in STB/satellite broadcast	CO	November
Intel Corporation	U.S.	Equity investment.	Cambridge Display Technology	Europe	Light-emitting polymer (LEP) technology	IV	November
Natural MicroSystems Corporation	U.S.	Acquisition: $6.9 million computer telephony add-in boards	ViaDSP Inc.	U.S.	DSP board specialist	IV	November
SGS-Thomson	Europe	IC/IP joint venture: Daewoo ST Semiconductor Co.	Daewoo Electric Co.	Korea	IC joint venture for system equipment	IV	November
Atmel Corporation	U.S.	Acquisition: terms not disclosed	Fincitec Components Oy	Europe	DSP and sigma-delta conversion technology	IV	November
Lucent Technologies	U.S.	Cell library and CAM cores agreement	Natural Microsystems Inc.	U.S.	ASICs based on Lucent technology	SA	December
Texas Instruments Inc.	U.S.	Port JAVA to digital baseband processor	Sun Microsystems Inc.	U.S.	License: embedded/personal JAVA	LA	December
Osicom Technology Inc.	U.S.	Develop embedded RISC processors	Atmel Corporation	U.S.	Web processor development	JD	December
Noise Cancellation Technology Inc.	U.S.	Silicon micromachined microphone technology	Siemens	Europe	License and royalty fees to NCTI	LA	December
Johnson Matthey plc	Europe	License package technology	Kyocera	Japan	License package technology	LA	December
Lucent Technologies	U.S.	Cell library and CAM cores agreement	General DataComm Inc.	U.S.	APEX ATM switches in Lucent systems	CO	December
Seeq Technology Inc.	U.S.	Gigabit Ethernet agreement expanded	Essential Communications Inc.	U.S.	Roadrunner ASIC for PCI bus interface	OT	December
Coryphaeus Software Inc.	U.S.	Development tool kits for TSC	Technology Service Corporation	U.S.	Infrared sensor simulation	JD	December
NEC Corporation	Japan	Russia joint venture in telecom systems: 45% stake	Mitsui & Co.	Japan	10% stake in telecom venture	JV	December

Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
NEC Corporation	Japan	Russia joint venture in telecom systems: 45% stake	Sumitomo Corporation	Japan	10% stake in telecom venture	JV	December
NEC Corporation	Japan	Russia joint venture in telecom systems: 45% stake	Telecominvest	Russia	35% stake in telecom venture	JV	December
IDS Prof. Scheer	Europe	ARIS toolset in future products	Siemens	Europe	ComUnity Framework	SA	December
Silicon Valley Group	U.S.	Acquisition: $39.5 million	Tinsley Laboratories Inc.	U.S.	Precision optics manufacturer	IV	December
MEMC Electronic Materials Inc.	U.S.	Develop 200/300mm plasma wafer-shaping tools	Integrated Process Equipment Corporation	U.S.	Plasma-assisted chemical etch tools	JD	December
Planar Systems Inc.	U.S.	Acquisition: $15 million	Standish Industries Inc.	U.S.	Flat panel LCD manufacturer	IV	December
Rodel Inc.	U.S.	Acquisition: terms not disclosed	Solution Technology Inc.	U.S.	Slurry manufacturer and distributor	IV	December
Aetrium Inc.	U.S.	Acquisition: Handler Division, estimated $4 million revenue	Advantek Inc.	U.S.	Pick and place handler technology	IV	December
Selas Corporation	U.S.	Acquisition: $16.8 million stock	MRL Industries	U.S.	Semiconductor furnace system	IV	December
Comdisco Electronics Group	U.S.	ComIto Equipment Management: 60% interest	Itochu Corporation	Japan	40% interest in fab tools/ leasing joint venture	JV	December
PRI Automation Inc.	U.S.	Acquisition	Interval Logic Corporation	U.S.	Planning/scheduling software	IV	December
Fairchild Semiconductor Corporation	U.S.	Acquisition: $120 million	Raytheon Semiconductor Division	U.S.	Mixed-signal/digital ICs	IV	December
Loughborough Sound Images Ltd.	Europe	DSP board merger	Mizar Inc.	U.S.	DSP board merger	IV	December
Silicon Storage Technology Inc.	U.S.	License: split-gate flash technology	Samsung	Korea	SST license	LA	December
Silicon Storage Technology Inc.	U.S.	License: split-gate flash technology	TSMC	Taiwan	SST license	LA	December

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Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
Intel Corporation	U.S.	Patent cross license agreement	Sun Microsystems Inc.	U.S.	Patent cross license agreement	LA	December
Vishay International Inc.	U.S.	Acquisition: $500 million for TEMIC	TEMIC Semiconductor	Europe	Discrete semiconductor business	IV	December
Vishay International Inc.	U.S.	Acquisition: 65% investment	Lite-On Power Semiconductor	Taiwan	Optoelectronics	IV	December
Nokia Oy	Europe	Acquisition: $120 cash/stock	Ipsilon Network Inc.	U.S.	IP switching technology	IV	December
Lucent Technologies	U.S.	Acquisition: $200 million stock exchange	Prominet Corporation	U.S.	Gigabit Ethernet switch business	IV	December
Mentor Graphics	U.S.	Cross-industry partnership	TSMC	Taiwan	Test chip and core development	SA	December
Synopsys Inc.	U.S.	Cross-industry partnership	TSMC	Taiwan	Test chip and core development	SA	December
SGS-Thomson	Europe	64Mb MPU cores for SuperH family series	Hitachi Ltd.	Japan	0.18-micron CMOS 500-MHz technology	JD	December
Larscom Inc.	U.S.	Acquisition: $32 million stock/cash	NetEdge System Inc.	U.S.	ATM edge switches	IV	December
MINC Inc.	U.S.	Acquisition: FPGA design tools	Synario Design Automation	U.S.	Data I/O division	IV	December

Source: Dataquest (February 1998)

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Perspective

Semiconductors Worldwide

Market Analysis

Alliance Activity in 1997: Another Year of Acquisitions

Abstract: *Acquisition was the name of the investment game in 1997. Overall alliance activity was not as robust as in 1996, as Dataquest captured only 289 known or published alliance agreements, in comparison to over 450 listings in 1996. The alliances listed in this document involve all aspects of the global semiconductor industry—components, front-end equipment, materials, foundry, assembly, and end-system equipment.*
By Mary Ann Olsson

Investment for Some, but Takeover for Others

Most electronics companies will remember 1997 as the year of falling DRAM prices, tougher competition, and shrinking design cycle times. In reality, profit margins became everything. To head off the competition and to keep the shareholders at bay, companies bought their way into technology and regional markets through acquisition.

In 1997, as in previous years, agreements between U.S. companies were still the most numerous, as shown in Figure 1. The growth of alliances between U.S. companies and U.S. and European companies was substantial in comparison to previous years. By company, Siemens AG was the most active in forming alliances worldwide. Founded in 1847 by Werner von Siemens, Siemens AG is celebrating its 150th year in business and holds the No. 12 position in semiconductors for 1997.

As shown in Figure 2, investment agreements surpassed license and joint-development agreements in 1997. Table 1 lists all the alliance activities by company and region. The order of appearance in either column A or B is random.

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Figure 3 shows alliance activity by product function, contract assembly, front-end equipment and foundry, electronic equipment systems, software, materials, and others. The "others" category includes products that are not included in specific categories currently collected by Dataquest. Figure 4 illustrates the application market selections. Not all the alliances listed in Table 1 are application specific. Each agreement is coded according to a Dataquest classification. Dataquest classifies all of the alliances listed in this table as follows:

- License agreements (LA): License agreements are defined as legal permission to utilize a company's patents or proprietary technology for a fee or royalty payment. This could also include a cross-licensing agreement where the companies involved have legal permission to another company's patents or proprietary technology.
- Second-source agreements (SS): Second-source agreements allow companies to manufacture a product designed and developed by another company as a second source of supply for customers.
- Sales agreements (SA): Sales agreements provide companies with exclusive or nonexclusive rights to sell the partner's original products to which value is added, in specified markets.
- Fab agreements (FA): Fab agreements involve the use of another company's fabrication facilities to manufacture a product.
- Assembly and test agreements (AT): Assembly and test agreements involve a company's manufactured components and parts that are shipped to another company for assembly and test.
- Technology exchange (TE): Technology exchange involves an exchange of proprietary technologies that may or may not involve a transfer of money.
- Joint venture (JV): Joint ventures involve two or more companies that jointly form a company to develop, manufacture, or market new products.
- Joint development (JD): Joint development agreements are between two or more companies that decide to combine forces and capabilities to develop new products or technology.
- Investment (IV): Investment alliances are made among regional companies or foreign companies for the purposes of gaining access to technology or acquisition of small start-ups or innovative companies.
- Coordination (CO): Coordination of standards are agreements on common or compatible technical standards that would link devices and systems and users of different components, systems, or tools.
- Procurement (PC): Procurement agreements are commitments by companies to purchase certain quantities of specific goods or services over a contracted time.
- Other types (OT): Other types of agreements could include visitation and research participation where researchers visit, observe, and participate in the R&D activities of the allied company. An original equipment manufacturing (OEM) agreement might involve the manufacturing of a product for another company that will label it with its name or logo and will also handle all of the business aspects of that product, such as its marketing and service. Service agreements are those provisions of follow-up service of the product in foreign markets.

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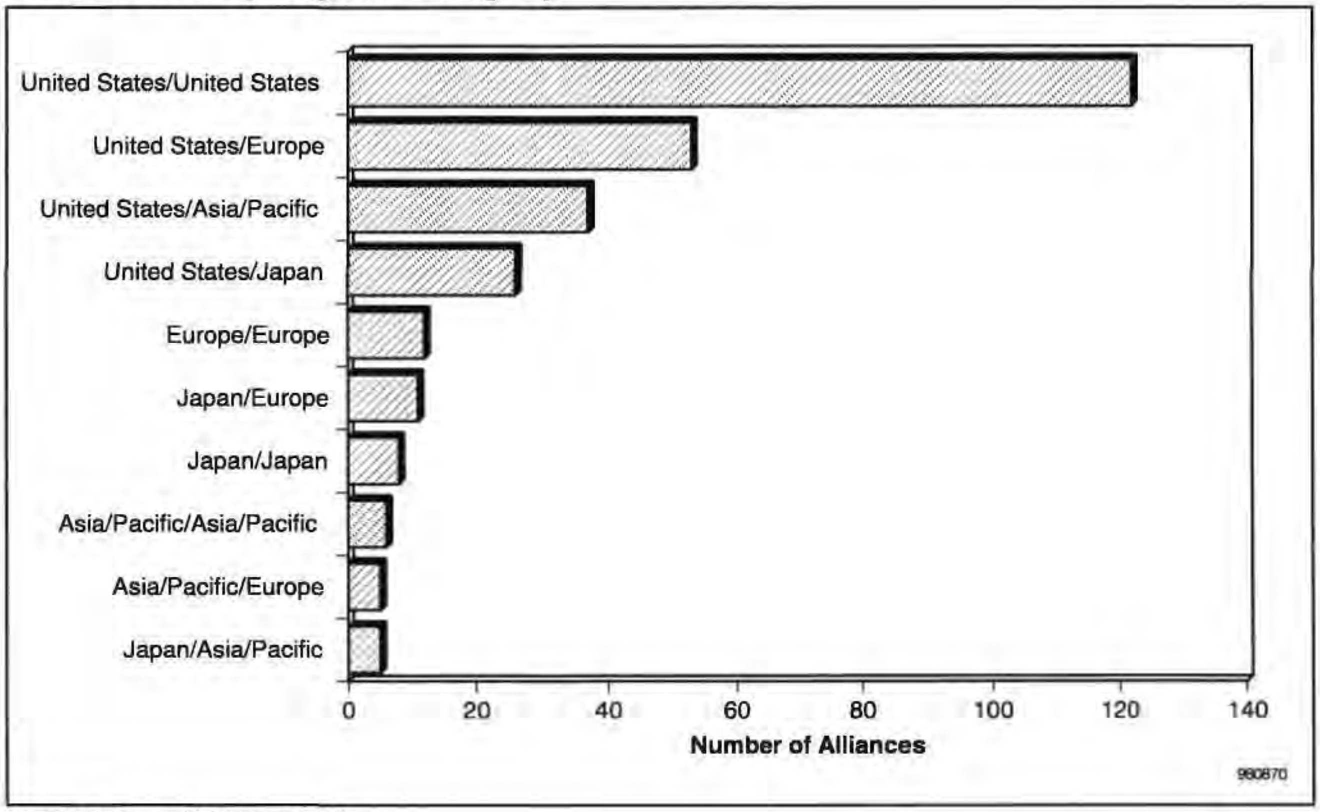
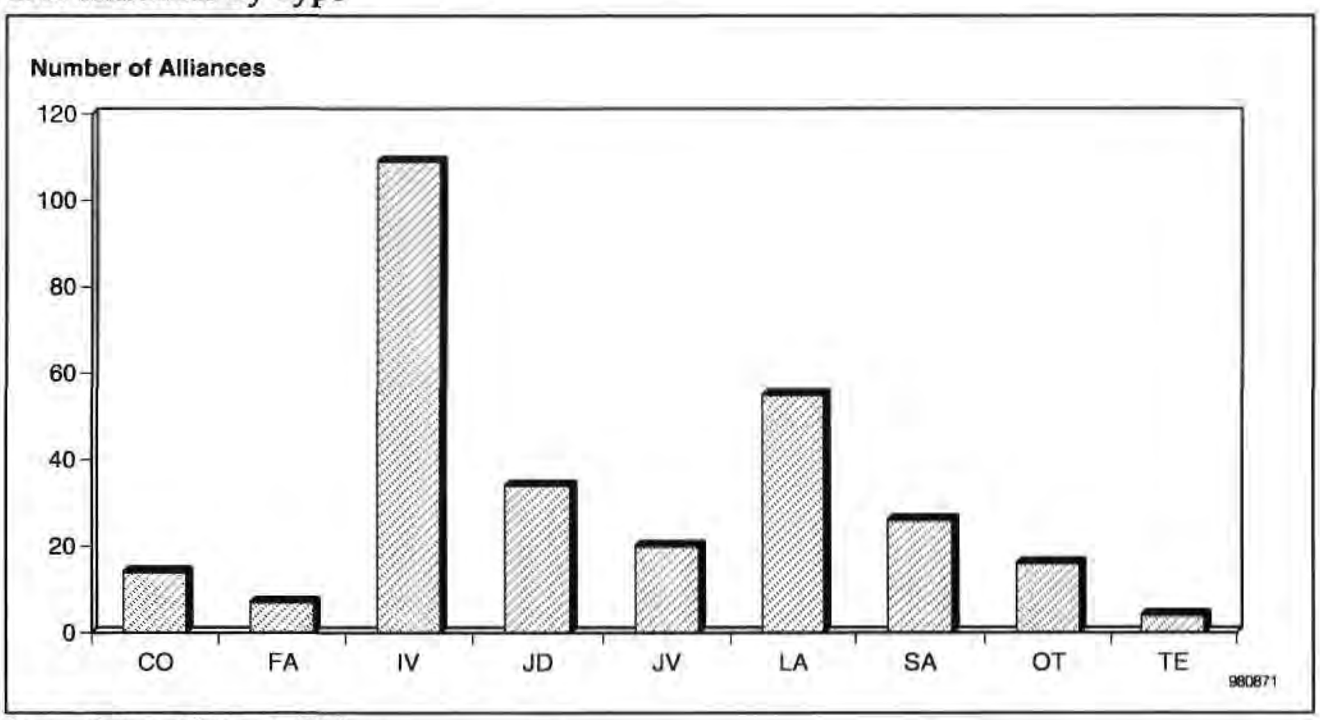
Figure 1
1997 Alliances by Regional Company



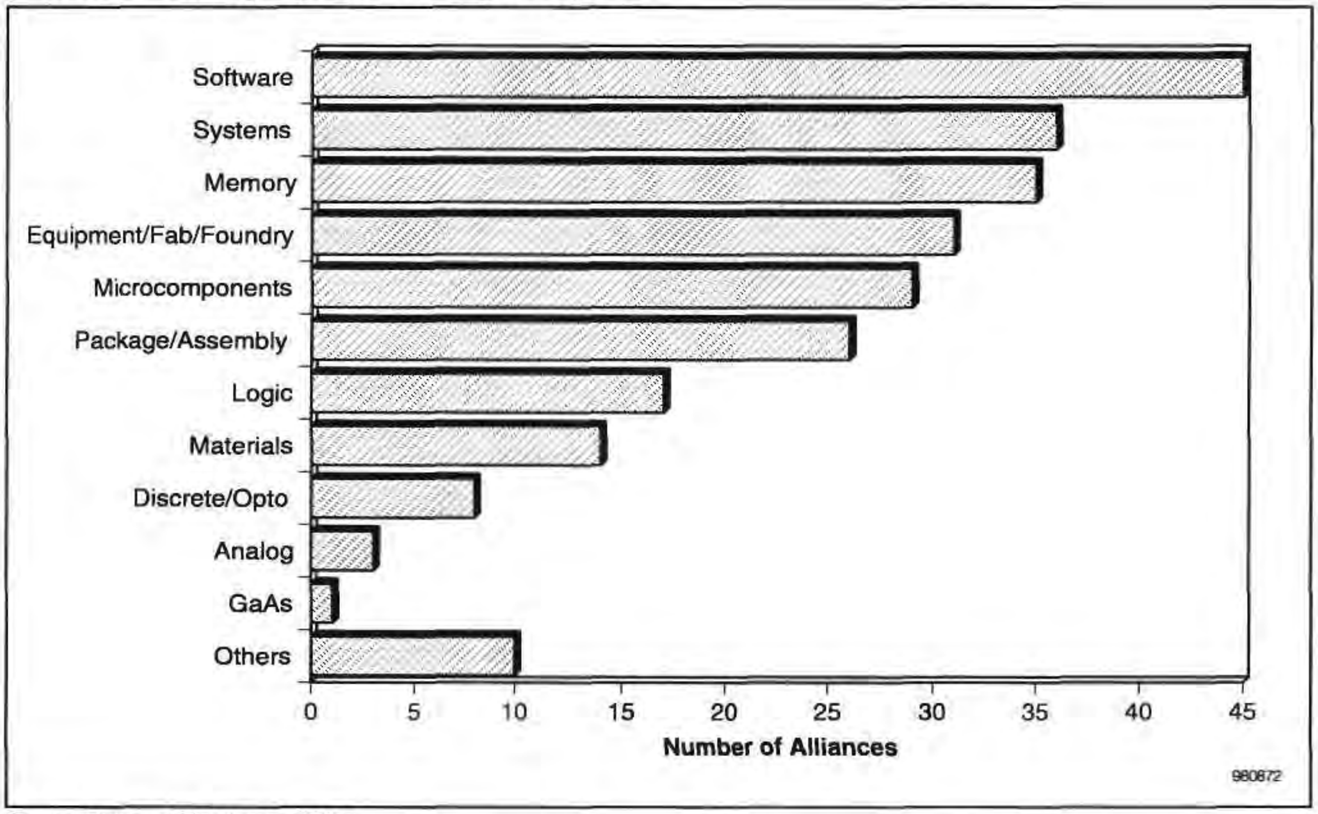
Source: Dataquest (February 1998)

Figure 2
1997 Alliances by Type



Source: Dataquest (February 1998)

Figure 3
Alliance Activity by Product Segment, 1997



Source: Dataquest (February 1998)

Figure 4
Alliance Activity by Application Segment, 1997

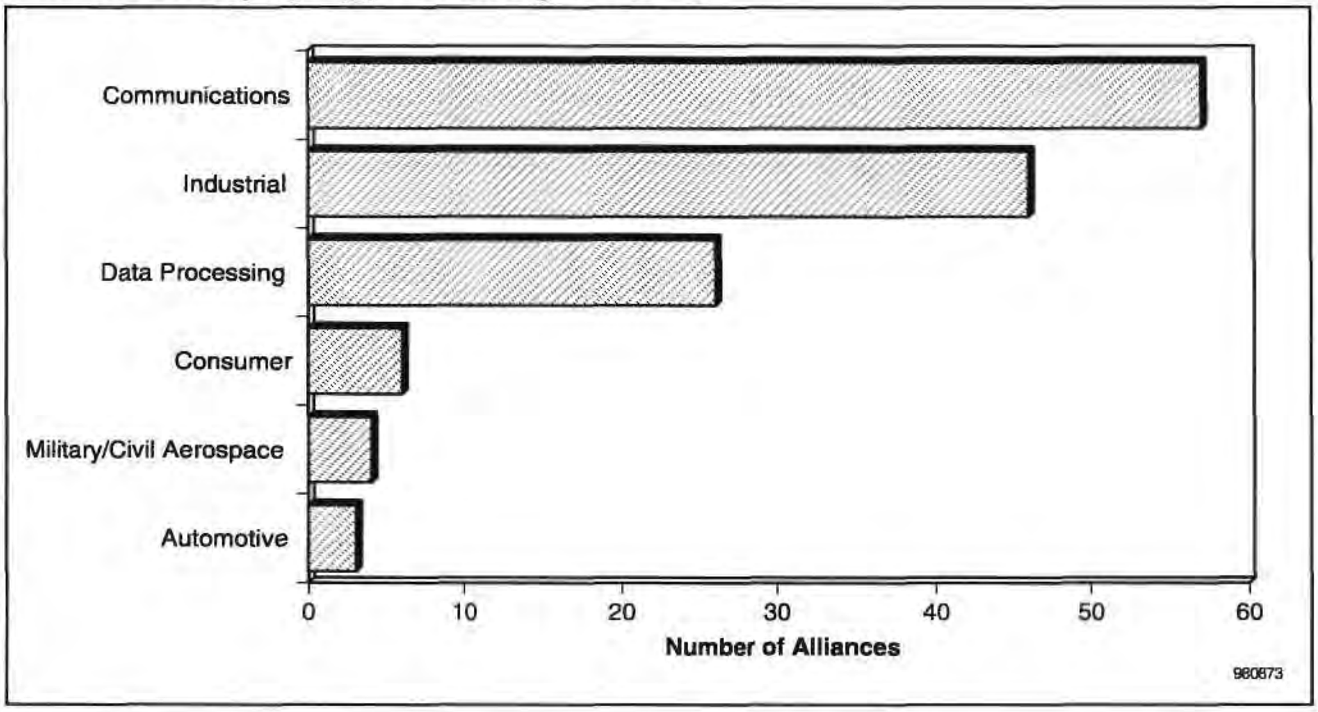


Figure 4
Alliance Activity by Application Segment, 1997

Source: Dataquest (February 1998)

Table 1
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
SanDisk Corporation	U.S.	Cross-license on flash memory	Sharp Corporation	Japan	Cross-license on flash memory	LA	January
WebTV Networks Inc.	U.S.	Internet TV joint venture, 65% share	Fujitsu Ltd.	Japan	35% share of WebTV joint venture	JV	January
Whitetree Inc.	U.S.	ATM/Ethernet switching solution alliance	General Datacom Inc.	U.S.	ATM/Ethernet switching solution	OT	January
Efficient Networks Inc.	U.S.	ATM/Ethernet switching solution alliance	General Datacom Inc.	U.S.	ATM/Ethernet switching solution	OT	January
QUALCOMM Inc.	U.S.	Equity investment	Unwired Planet Inc.	U.S.	Browser and HDML cellular/PCS network	IV	January
Rockwell Semiconductor	U.S.	License: RISC core for 56K modem	Advanced RISC Machines Ltd.	Europe	License: ARM core technology	LA	January
Ultratech Stepper Inc.	U.S.	Acquisition: terms not disclosed	Lepton Inc.	U.S.	E-beam lithography system	IV	January
Raytheon Company	U.S.	Acquisition: $2.95 billion	Texas Instruments Inc.	U.S.	Military electronics business	IV	January
Synopsys Inc.	U.S.	Acquisition: $430 million	Epic Design Technology	U.S.	Submicron software technology	IV	January
Quickturn Design Systems	U.S.	Acquisition: $55 million	SpeedSim Inc.	U.S.	Cycle-based Verilog simulators	IV	January
Hewlett-Packard Company	U.S.	Joint technology development/product integration	Cisco Systems Inc.	U.S.	Internet hardware/software products	JD	January
NEC Corporation	Japan	Cenju-3 parallel computer	Institut National de Recherche en Informatique et en Automatique	Europe	R&D project on parallel computing	JD	January
Intel Corporation	U.S.	Acquisition: $72 million	Case Technology	Europe	Fast Ethernet hardware	IV	January
Intel Corporation	U.S.	Acquisition: $52 million	Xircom Inc.	U.S.	PC card specialist	IV	January

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Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
Information Handling Systems	U.S.	CapsXpert component database	Team Corporation	Canada	EDA bridge product	JD	January
Teleport Communications Group Inc.	U.S.	Acquisition: $65 million	TCG CERFnet.	U.S.	Internet service provider	IV	January
Celestica Inc.	Canada	Acquisition: $180 million	Design to Distribution Ltd. (D2D)	Europe	Contract manufacturer	IV	January
Digital Projection Ltd.	Europe	Acquisition: $10 million investment/management	3i plc	Europe	Large-scale projectors	IV	January
Kohlberg Kravis Roberts & Co.	Europe	Acquisition: $1.5 billion	Amphenol Corporation	U.S.	Connector manufacturer	IV	January
Hitachi Ltd.	Japan	1Gb DRAM development	Texas Instruments Inc.	U.S.	Joint development	JD	January
Mitsubishi Electric Corporation	Japan	1Gb DRAM development	Texas Instruments Inc.	U.S.	Joint development	JD	January
Cascade Communications Inc.	U.S.	Acquisition of Sahara	Sahara Networks	U.S.	Broadband access products	IV	January
Compaq Computer Corporation	U.S.	Codevelop flat-panel monitor displays	Mitsubishi Electric Corporation	Japan	Advanced Display to build displays	JD	January
Honeywell Inc.	U.S.	$561 million acquisition of Measurex	Measurex Corporation	U.S.	Computer-integrated measurement systems	IV	January
Zenith Electronics Corporation	U.S.	Internet television products	Oracle Corporation	U.S.	Internet television products	OT	January
Zenith Electronics Corporation	U.S.	Internet television products	Netscape Communications Corporation	U.S.	Internet television products	OT	January
Raytheon Co.	U.S.	Acquisition of Hughes Defense Operations	General Motors Corporation	U.S.	Sale of Hughes Electronics Corp.	IV	January
3DO Corporation	U.S.	Graphics, audio, video chips for the Internet	Samsung Electronics Co.	Korea	$30 million joint venture	JV	January
Symbios Logic Inc.	U.S.	RISC SCSI I/O processor drivers	Diamond Multimedia Systems Inc.	U.S.	Market PCI ultra-SCSI adapters	OT	January
Taiwan Semiconductor Mfg. Co.	Taiwan	Integrate OakDSPCore into ASIC cell library	DSP Group Inc.	U.S.	License of OakDSPCore technology	LA	January
WaferScale Integration Inc.	U.S.	EPROM technology	Tower Semiconductor Ltd.	Israel	0.6-micron CMOS process	FA	January
Samsung Electronics Company Ltd.	Korea	Nonexclusive rights license	Ramtron International Corporation	U.S.	License: FRAM technology	LA	January

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Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
Bookham Technology Ltd.	Europe	Optical IC product development	Newbridge Networks Inc.	Canada	Active Silicon Optical Circuit technology	JD	January
Avant! Corporation	U.S.	Merger completion	Frontline Design Automation	U.S.	Verilog simulators	IV	January
Geoworks Inc.	U.S.	Acquisition: $30 million	Eden Group	Europe	Real-time operating systems	IV	February
Analog Devices Inc.	U.S.	RF/IF components partner	Zilog Inc.	U.S.	Z-phone components	SA	February
Flextronics International Ltd.	U.S.	Acquisition of Karlskrona manufacturing facility	Ericsson Business Networks AB	Europe	Business communications systems plant	IV	February
SGS-Thomson Microelectronics	Europe	Multiphase license agreement on FRAM technology	Ramtron International Corporation	U.S.	CMOS 64K nonvolatile FRAM memories	LA	February
Advanced RISC Machines Ltd.	Europe	ARM RISC architecture with Java OS	Sun Microsystems Inc.	U.S.	JavaSoft to license Java OS for ARM	LA	February
Motorola Inc.	U.S.	ADSL integration agreement	Marconi S.p.A.	Europe	CopperGold transceiver designs	JD	February
Siemens AG	Europe	Wireless ATM switching	Broadband Networks Inc.	U.S.	Joint investment	IV	February
Newbridge Networks Inc.	Canada	Wireless ATM switching	Broadband Networks Inc.	U.S.	Joint investment	IV	February
Siemens AG	Europe	DSP-Carmel	JC Communications	Israel	DSP for GSM handsets	JV	March
Fujitsu Ltd.	Japan	Unify ultrathin small-outline-USON CSP designs	LG Semicon Co. Ltd.	Korea	Bottom-leaded plastic-BLP CSP design	CO	March
Hewlett-Packard Company	U.S.	Acquisition: Software tools business	Siemens Automotive	Europe	Sale of software operations	IV	March
Hewlett-Packard Company	U.S.	Test/diagnostic services solution	Cosworth Engineering Inc.	Europe	Automotive test/diagnostic solutions	JV	March
SGS-Thomson Microelectronics	Europe	High-speed driver/receiver technology	Rambus Inc.	U.S.	License of Rambus technology	LA	March
Rohm Company Ltd.	Japan	PineDSPCore in motor control ICs	DSP Group Inc.	U.S.	License of PineDSPCore and OakDSPCore	LA	March
Motorola Inc.	U.S.	Acquisition of Pilkington's IP and patents	Pilkington Microelectronics Ltd.	Europe	Programmable logic products	IV	March
Trimble Navigation Ltd.	U.S.	Access to GPS chipset for in-vehicle navigation	Xanavi Informatics Corporation	Japan	GPS in Birdview car navigation	LA	March

Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
EBV Electronics	Europe	Distributor—subsidiary of Raab Karcher	TEMIC Inc.	Europe	IC and discrete device distribution	SA	March
CNet Technology Inc.	Europe	Joint IC design team	SGS-Thomson	Europe	ICs for digital TV and wireless applications	OT	March
TSMC	Taiwan	Fab and assembly flow agreement	Advanced Semiconductor Engineering Group (ASE)	Taiwan	Fab and assembly flow agreement	FA	March
Olicom Inc.	U.S.	License: LANE software suite	Cisco Systems Inc.	U.S.	Token-ring switch software	LA	March
Network Peripherals Inc.	U.S.	License: LAN switching line	Farallon Communications Inc.	U.S.	Networking license	LA	March
SANYO Electric Company Ltd.	Japan	3-D broadcasting technology development	Nippon Television Network	Japan	3-D broadcasting technology	JD	March
Intel Corporation	U.S.	Multimedia/Internet to PC via satellite	SES	Europe	Satellite specialist: $10 million investment	JV	March
National Semiconductor Corporation	U.S.	Acquisition: $100 million	Mediamatics Inc.	U.S.	MPEG audio/video decoder company	IV	March
CNet Technology Inc.	U.S.	PowerNIC chips	United Microelectronics Corporation	Taiwan	Fast Ethernet products/fab	FA	March
Davicom Semiconductor Inc.	U.S.	DM9101 chips	United Microelectronics Corporation	Taiwan	Fast Ethernet products/fab	FA	March
IBM Corporation	U.S.	Joint hard disk drive controller IC	Mitsubishi Electric Corporation	Japan	MCU/embedded flash memory	JD	March
Philips	Europe	ARM RISC core license	Advanced RISC Machines Ltd.	Europe	License of RISC technology	LA	March
Lattice Semiconductor Corporation	U.S.	$150 million investment	Seiko-Epson Corporation	Japan	8-inch Sakata fab	IV	March
Texas Instruments Inc.	U.S.	DSP architecture enhancement	Spectron Microsystems	U.S.	DSP/BIOS application programming interface	SA	March
Deltec Electronics Corporation	U.S.	Power management software	Compaq Computer Corporation	U.S.	Uninterruptible power supply design	SA	March
Integrated Storage Devices Inc.	U.S.	Acquisition: $5 million	National Semiconductor Corporation	U.S.	CompactSpeech product line	IV	April
Fujitsu Ltd.	Japan	BGA specification agreement	Toshiba Corporation	Japan	Memory BGA configuration spec.	CO	April

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Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
NEC Corporation	Japan	Fab partner $700 million 0.35-micron 8-inch fab	Shanghai Hua Hong Microelectronics	China	Project 909/Chinese govt.: 71% share	FA	April
Hewlett-Packard Company	U.S.	0.35- and 0.25-micron ASICs	Chartered Semiconductor Manufacturing Ltd.	Singapore	Foundry joint venture	JV	April
Abpac Inc.	U.S.	License of Motorola BGA technology	Motorola Inc.	U.S.	BGA Patent Immunity Agreement	LA	April
Tessera Inc.	U.S.	$30 million in funding	AB	Europe	Industrial Holding Company, Sweden	IV	April
Taiwan Semiconductor Mfg. Co.	Taiwan	$14.5 billion fab investment	Taiwan Science-Based Industrial Park	Taiwan	Taiwan government backed project	IV	April
Rockwell International Corporation	U.S.	Acquisition of Hi-Media chipset business, $50 million	ComStream Corporation	U.S.	Broadband communication chipset business	IV	April
DSP Communications Inc.	U.S.	IS-95 baseband processor chipsets for CDMA	Kenwood	Japan	Chipset for CDMA/analog subscriber terminals	OT	April
NEC Corporation	Japan	Company spin-off from corporation	TeleMidic Ltd.	Japan	MIDI-based network	JV	April
Lam Research Corporation	U.S.	Acquisition: $225 million	OnTrak System Inc.	U.S.	Wafer polish equipment manufacturer	IV	April
Intel Corporation	U.S.	6.75% equity investment	Avid Technology Inc.	U.S.	Audio/video company	IV	April
Intel Corporation	U.S.	Stock investment	Rambus Corporation	U.S.	Intel investment	IV	April
Electroglas Inc.	U.S.	Acquisition: $30 million	Knights Technology	U.S.	Software-yield management	IV	April
Advanced RISC Machines Ltd.	Europe	Acquisition: 45% investment	Palmchip Inc.	U.S.	Mass-storage controller	IV	April
Motorola Inc.	U.S.	Investment	Tao Group Ltd.	Europe	Virtual processor/Java-like OS	IV	April
Vivid Semiconductor Corporation	U.S.	High-voltage driver ICs	LG Semicon Co. Ltd.	Korea	Five-year license/fab agreement	FA	May
National Scientific Corporation	U.S.	Acquisition of Avalon	Avalon Technology Inc.	U.S.	Hot air soldering equipment	IV	May
Hewlett-Packard Company	U.S.	HP 3070 test systems agreement	TSL America	U.S.	$6 million exclusive agreement	IV	May

Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
China Aerospace Corporation	China	Joint venture memorandum on network computers	Digital Equipment Corporation	U.S.	Engineering and design resources	JV	May
Motorola Inc.	U.S.	Total Access Communication Systems	Eastern Communications Co.	China	$200 M contract to cellular equipment and services	OT	May
Shin-Etsu Handotai Co. Ltd.	Japan	SOI wafer facility in Japan	Silicon On Insulator Technologies	Europe	SHE partner in SOI wafer technology	JD	May
Kingston Technology Inc.	Taiwan	$100 million investment in Taiwan	Far East Kingston Technology	Taiwan	DRAM module factory in Hsin Chu	IV	May
Cadence Design Systems Inc.	U.S.	Four-year design tools technology agreement	Ericsson	Europe	Design tools for wireless products	TE	May
Ascend Communications Inc.	U.S.	Acquisition of Cascade	Cascade Communications Inc.	U.S.	Communications systems	IV	June
LSI Logic Inc.	U.S.	Single-chip digital terrestrial TV solution	BBC	Europe	LSI CoreWare in L64780 demodulation chip	JD	June
Telemac Corporation	U.S.	Debit Technology in handsets	Philips Consumer Communications	Europe	Telemac technology in cellular handsets	JD	June
Pinnacle Systems Inc.	U.S.	Studio Mixer/SmartCable technology in Fujitsu product	Fujitsu Ltd.	Japan	Computer-based consumer video products	OT	June
Texas Instruments Inc.	U.S.	Ten-year semiconductor cross license patent agreement	Vanguard International Semiconductor Corp.	Taiwan	Cross license of patent technology	LA	June
Texas Instruments Inc.	U.S.	Ten-year semiconductor cross license patent agreement	NEC Corporation	Japan	Cross license of patent technology	LA	June
Cisco Systems Inc.	U.S.	Acquisition of Skystone	Skystone Systems Corporation	Canada	SONET/SDH communications	IV	June
LG Semicon Co. Ltd.	Korea	Codevelop Java processors	Sun Microsystems Inc.	U.S.	LG Semicon to manufacture Java processors	JD	June
Tower Semiconductor Ltd.	Israel	EPROM compiler for customers	Virage Logic Corporation	U.S.	EPROM compiler with BIST for Tower	OT	June
Seiko Epson Corporation	Japan	Joint development of ASIC libraries	Exemplar Logic	U.S.	Leonardo design environment	JD	June

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Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
Compaq Computer Corporation	U.S.	Acquisition of Tandem for $3 billion	Tandem Computers Inc.	U.S.	Massively parallel computer systems	IV	June
Lucent Technologies	U.S.	$2.5 billion consumer phone joint venture, 40% share	Philips Electronics N.V.	Europe	Consumer Communications share, 60%	JV	June
Aptix Corporation	U.S.	Resell Altera MAX II Plus software	Altera Corporation	U.S.	Altera PLDs in Aptix products	OT	June
Synplicity Inc.	U.S.	Logic synthesis software to Lattice	Lattice Semiconductor Corporation	U.S.	Software OEM agreement	OT	June
Johnson Matthey plc	Europe	Plastic land grid array license to Kyocera	Kyocera Electronics Inc.	Japan	Kyocera's C4 technology to Johnson Matthey	LA	June
EFTC Corporation	U.S.	Circuit card assemblies for Boeing 777	Honeywell Incorporated	U.S.	Circuit cards to EFTC	JD	June
UNIAX Corporation	U.S.	License on light-emitting polymer (LEP) displays	Cambridge Display Technology Ltd.	Europe	LEP technology	LA	June
Hoechst AG	U.S.	R&D and joint research for UNIAX	Cambridge Display Technology Ltd.	Europe	Light-emitting polymer (LEP) technology	LA	June
Aspect Development Inc.	U.S.	Component/supplier management solutions	Viewlogic Systems Inc.	U.S.	EDA tools license and royalties	JD	June
Oracle Corporation	U.S.	Acquisition: terms not disclosed	Navio Communications Inc.	U.S.	Netscape software subsidiary	IV	June
Gateway 2000 Inc.	U.S.	Acquisition: rights to Amiga platform	Amiga Technologies GmbH	Europe	Amiga computer platform	IV	June
Applied Technology Materials Inc.	U.S.	Acquisition: $78 million	Lawrence Semiconductor	U.S.	Silicon-based thin film	IV	June
AltoCom Inc.	U.S.	License: V.34 modem software	Philips Semiconductors Inc.	Europe	Code in TwoChipPIC controller	LA	June
AltoCom Inc.	U.S.	License: V.34 modem software	Advanced RISC Machines Ltd.	Europe	Software in fixed-point integer processors	LA	June
Microsoft Corporation	U.S.	$80 million R&D research investment	Cambridge University Computer Lab	Europe	Research and venture capital	IV	June
Bay Networks Inc.	U.S.	Acquisition: $155 million	Rapid City Communications Inc.	U.S.	LAN switch start-up	IV	June

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Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
Eastman Kodak Co.	U.S.	Pixel imaging chip development	Motorola Incorporated	U.S.	CMOS process for optical sensor fab	JD	June
Toshiba Corporation	Japan	iReady core to ASIC customers	iReady Corporation	U.S.	Internet tuner core license	LA	June
LSI Logic Corporation	U.S.	Stacked-cell 0.25-micron process	Micron Technology Inc.	U.S.	Stacked-cell embedded-DRAM process	JD	June
Spyrus Inc.	U.S.	Acquisition	Terisa Systems Inc.	U.S.	Security software specialist	IV	June
Toshiba Corporation	Japan	Embedded-DRAM technology	Chartered Semiconductor Mfg. Pte. Ltd.	Singapore	0.35/0.25-micron fab process	LA	June
EFTC Corporation	U.S.	Merger/acquisition for $19.5 million	Circuit Test Inc. (CTI)	U.S.	Quick-turn repair company	IV	July
Tessera	U.S.	MicroBGA license agreement	Hyundai Electronics	Korea	MicroBGA license from Tessera	LA	July
Tessera	U.S.	MicroBGA license agreement	LG Semicon Co. Ltd.	Korea	MicroBGA license from Tessera	LA	July
Tessera	U.S.	MicroBGA license agreement	Samsung Electronics Co.	Korea	MicroBGA license from Tessera	LA	July
Tessera	U.S.	MicroBGA die attach and encapsulation	Dow Corning Corporation	U.S.	Silicone-based products for MicroBGA	JD	July
Tessera	U.S.	MicroBGA package technology	Hitachi Cable Ltd.	Japan	Assemble ICs in Tessera package	LA	July
EFTC Corporation	U.S.	Acquisition of assets.	Allied Signal Inc.	U.S.	Circuit assembly operations	IV	July
Novellus Systems Inc.	U.S.	$150 million assets acquisition	Varian Associates Inc.	U.S.	Sale of thin-film systems unit	IV	July
Sterling Software Inc.	U.S.	Acquisition of TI's application software business	Texas Instruments Inc.	U.S.	$165 million revenue from sale of software	IV	July
Advanced Technology Materials Inc.	U.S.	Acquisition of company—$78 million	Lawrence Semiconductor Laboratories	U.S.	An ATMI Epitronics subsidiary	IV	July
Applied Science and Technology Inc.	U.S.	Acquisition of CPI: $6.35 million	Converter Power Inc. (CPI)	U.S.	Switching power supplies	IV	July

Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
Veeco Instruments Inc.	U.S.	Strategic marketing/ manufacturing agreement	Edwards High Vacuum International	Europe	600T/600D helium mass spec. leak detectors	OT	July
OnTrak Systems Inc.	U.S.	Joint development of Rippey PVA brush technology	Rippey Corporation	U.S.	PVA brush roller technology	JD	July
Amkor/Anam	Korea	Package manufacturing for bumped die	Flip Chip Technologies	U.S.	Flip chip technology and wire bonders	SA	July
Crysteco Inc.	U.S.	Acquisition of Texas facility	Fabico Inc.	U.S.	Epitaxial facility—680,000 wafer capacity	IV	July
Daifuku Co.	Japan	Joint development of 300mm solution/ Daifuku manufacturing	Fluoroware Inc.	U.S.	Unified pod with tool load-port interface	JD	July
Shing Chung Engineering	Taiwan	Trace Analytical Systems joint venture	Trace Analytical	U.S.	High-purity gas monitor systems	JV	July
Macotron Systems	Europe	Availability of linear/ mixed-signal test equipment	TMT Inc.	U.S.	Test equipment availability in Europe	SA	July
Flowmec	Europe	Ultrahigh-purity gas fittings	Sang International	Korea	Distribution agreement in Korea	OT	July
Interuniversities Microelectronics Center (IMEC)	Europe	193nm deep-UV lithography R&D program	ASM Lithography	Europe	IMEC Class 1 clean room facility	OT	July
Cambridge Display Technology Ltd.	Europe	LEP technology for displays	Hoechst Celanese AG	Europe	Technology license agreement	LA	July
Cambridge Display Technology Ltd.	Europe	LEP patents and intellectual property rights	UNIAX Corporation	U.S.	Royalty fees and license agreement	LA	July
United Microelectronics Corporation	Taiwan	$18.5 billion investment: 8-inch/12-inch fabs	Tainan Science-Based Industrial Park	Taiwan	Government-owned project	IV	July
IBM Corporation	U.S.	$25 million research facility in India	Solutions Research Center	India	Indian Institute of Technology	IV	July
Texas Pacific Group	U.S.	Acquisition of Zilog Inc.: $527 million	Zilog Inc.	U.S.	Sale of company to private investment	IV	July
Texas Instruments Inc.	U.S.	License of high-bandwidth memory interface	Rambus Inc.	U.S.	License of technology for DSP/ASICs	LA	July

Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
SanDisk Corporation	U.S.	Cross-license agreement of flash memory products	Hitachi Ltd.	Japan	Cross license of flash memory	LA	July
Eaton Corporation	U.S.	Acquisition of Fusion for $39/share	Fusion Systems Corporation	U.S.	Merger	IV	July
SubMicron Systems Corporation	U.S.	Sale of assets and liabilities of subsidiary	Systems Chemistry Inc.	U.S.	Sale to BOS Group	IV	July
Mentor Graphics Corporation	U.S.	Libraries and IP designs/tools	Chartered Semiconductor Mfg. Pte. Ltd.	Singapore	Manufacturing process	TE	July
Sony Corporation	Japan	Flat panel display for TVs	Sharp Corporation	Japan	Flat-panel displays	JD	July
Philips Electronics NV	Europe	Joint development of flat-panel display with Sony/Sharp	Sharp Corporation	Japan	Flat-panel displays	JD	July
Giga-tronics Inc.	U.S.	Acquisition of Viking	Viking Semiconductor Equipment	U.S.	Optical inspection equipment	IV	July
Seagate Technology Inc.	U.S.	Acquisition: $230 million to shareholders	Quinta Corporation	U.S.	Magnetic technology for optical storage	IV	July
Lucent Technologies	U.S.	Acquisition: $1.8 billion	Octel Communications Corporation	U.S.	Voice/e-mail messaging	IV	July
Sun Microsystems Inc.	U.S.	License of Java Bytecode	Siemens AG	Europe	Hardware design to JavaCard	LA	July
3Com Corporation	U.S.	Expand LAN telephony	Siemens AG	Europe	License of 3Com software	SA	July
Integrated Storage Devices Inc.	U.S.	Voice-recording chips based on flash memory	SST Inc.	U.S.	Flash memory technology	SA	July
Integrated Storage Devices Inc.	U.S.	Voice-recording chips based on flash memory	Winbond Corporation	Taiwan	Flash memory technology	SA	July
Sun Microsystems Inc.	U.S.	Acquisition of Integrity Arts	Integrity Arts Inc.	U.S.	Software written in Java for smart cards	IV	August
National Semiconductor Corporation	U.S.	Develop/manufacture liquid crystal on silicon microdisplays	Three-Five Systems Inc.	U.S.	SVGA display technology	SA	August
Samsung Electronics Company Ltd.	Korea	Cross license flash memory patents	SanDisk Corporation	U.S.	Cross license flash memory patents	LA	August
Mentor Graphics Corporation	U.S.	Joint development of customer support package	NEC Corporation	Japan	RISC processor core with Mentor CVE	JD	August

Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
DuPont Photomasks Inc.	U.S.	DPI Reticle Technology Center-joint venture	Advanced Micro Devices Inc.	U.S.	Photomask technology joint venture	JV	August
DuPont Photomasks Inc.	U.S.	DPI Reticle Technology Center-joint venture	Micron Technology Inc.	U.S.	Photomask technology joint venture	JV	August
DuPont Photomasks Inc.	U.S.	DPI Reticle Technology Center-joint venture	Motorola Incorporated	U.S.	Photomask technology joint venture	JV	August
Philips Semiconductors Inc.	Europe	Joint development and manufacture of embedded flash products	Macronix International Company	Taiwan	Embedded flash products development	JD	August
QSound Labs Inc.	U.S.	License of QSurround to AKM Semiconductor	AKM Semiconductor Inc.	Japan	License for its DSP codec products	LA	August
Cadence Design Systems Inc.	U.S.	Joint development of Cadence Spectre simulator	United Microelectronics Corporation	Taiwan	UMC process technologies	JD	August
SanDisk Corporation	U.S.	Cross license of flash memory patents	Toshiba Corporation	Japan	Cross license of flash memory patents	LA	August
Synopsys Inc.	U.S.	IP core characterization for system on a chip	Advanced RISC Machines Ltd.	Europe	EPIC-based analog technology	TE	August
NEC Corporation	Japan	Joint-venture memory/logic manufacturing	Shanghai Hua Hong Microelectronics Co.	China	NEC/China Ministry of Electronics Industry	JV	August
Intel Corporation	U.S.	Acquisition: $420 million	Chips & Technologies	U.S.	Graphics/video chipset	IV	August
National Semiconductor Corporation	U.S.	Acquisition: $550 million	Cyrix Corporation	U.S.	Microprocessor technology	IV	August
Motorola Inc.	U.S.	Smart card microcontroller chip compatibility	SGS-Thomson	Europe	Smart card and terminal agreement	SA	August
Mitsubishi Corporation	Japan	Oriental International Group joint venture	Dongling Trading	China	27% Mitsubishi investment	IV	August
Oriental International Group	China	51% investment in $12.5 million joint venture	Dongling Trading	China	Electronic machinery/high-tech products	IV	August
Continental Grain Co.	U.S.	22 percent investment in joint venture	Dongling Trading	China	Electronic machinery/high-tech products	IV	August
SanDisk Corporation	U.S.	$45 million investment in joint venture	United Silicon Inc.	Taiwan	SanDisk 10 percent equity	JV	August

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Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
United Microelectronics Corporation	Taiwan	$800 million fab joint venture	United Silicon Inc.	Taiwan	Joint venture with SanDisk	JV	August
Advanced RISC Machines Ltd.	Europe	License RISC technology	Hyundai Electronics	Korea	License of ARM processor	LA	August
Advanced RISC Machines Ltd.	Europe	License RISC technology	Sony Corporation	Japan	License of ARM processor	LA	August
Aavid Thermal Technologies Inc.	U.S.	Partnership agreement: Aavid's thermal products	Tellurex Corporation	U.S.	Patented Z-MAX thermo-electric coolers	SA	August
Siemens AG	Europe	0.25-micron CMOS 64Mb technology	Rambus Inc.	U.S.	License: memory interface technology	LA	August
General Dynamics Corporation	U.S.	Acquisition: Advanced Technology Systems	Lucent Technologies Inc.	U.S.	Sale of surveillance and signal-processing unit	SA	August
Ambit Design Systems	U.S.	Develop synthesis tools design methodology	Chrysalis Symbolic Design	U.S.	Three-year joint development agreement	JD	August
Fujitsu Microelectronics	Japan	Single-chip ADSL modem	Orckit Communications Ltd.	Israel	0.35-micron two-chip digital/analog design	JD	August
Sun Microsystems Inc.	U.S.	Acquisition: stock and employees	Diba Inc.	U.S.	Software systems for Java platform	IV	August
Allied Signal Inc.	U.S.	Acquisition of Litronic's packaging operations	Litronic Industries Inc.	U.S.	New venture is ASTI	IV	September
Texas Instruments Inc.	U.S.	PicoGate logic device compatibility agreement	Philips Semiconductors Inc.	Europe	PicoGate logic using five-pin SOT package	SA	September
Siliconware Precision Industries Ltd.	Taiwan	Equity investment in Abpac	Abpac Inc.	U.S.	BGA foundry start-up	IV	September
Zi Corporation	Canada	Sublicense Chinese character input technology	Advanced RISC Machines Ltd.	Europe	Zi technology to ARM licensees	LA	September
Hyundai Electronics	Korea	Spin-off of assembly and test division	ChipPAC Inc.	U.S.	Assembly and test spin-off	IV	September
Atmel Corporation	U.S.	emWare technology in 8051 microcontrollers	emWare Inc.	U.S.	Embedded Internet software	SA	September
Samsung Electronics Company	Korea	Cross-license agreement on flash memory patent	SanDisk Corporation	U.S.	Patents cover design and manufacture	LA	September

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Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
SubMicron Systems Corporation	U.S.	$3.8 million in payment and royalties for Primaxx	AG Associates	U.S.	Primaxx dry cleaning license	LA	September
NEC Corporation	Japan	Five-year Intelligent Transport System agreement	AT&T	U.S.	NEC's SONET ADM network equipment	SA	September
IBM Corporation	U.S.	Share of technology and joint development	Motorola Inc.	U.S.	PowerPC joint agreement	SA	September
Philips Semiconductors Inc.	Europe	Renew five-year technology agreement	SGS-Thomson	Europe	Codevelop 0.18-micron technology CAD tools	SA	September
Psion Software plc	Europe	EPOC 32 OS license	Philips Consumer Communication	Europe	EPOC in pocket-size data and message products	LA	September
Integrated Device Technology Inc.	U.S.	Coordinated agreement on pinouts/compatibility	Motorola Inc.	U.S.	Zero Bus Transfer (ZBT) SRAMs	SA	September
Integrated Device Technology Inc.	U.S.	Coordinated agreement on pinouts/compatibility	Micron Technology Inc.	U.S.	Zero Bus Transfer (ZBT) SRAMs	SA	September
Microsoft Corporation	U.S.	$45 million common stock purchase for 8% equity	Lernout & Hauspie Speech Products N.V.	Europe	Voice-enabled computing on Windows	SA	September
Frontier Design N.V.	Europe	Acquisition of Mentor's 75% interest	Mentor Graphics Corporation	U.S.	Sale of interest in European Design Center	IV	September
Summit Design Inc.	U.S.	Acquisition: $29 million in stock and cash	Simulation Technology Corporation	U.S.	EDA tools	IV	September
Avant! Corporation	U.S.	Acquisition: $150 million	Technology Modeling Association	U.S.	Process and device simulation tools	IV	September
Tektronix Inc.	U.S.	Acquisition: terms not disclosed	Siemens Communications Test Equipment GmbH	Europe	WAN protocol analyzers and ISDN test equipment	IV	September
Ball Semiconductors Inc.	U.S.	Ball-shaped semiconductor technology	Mitsui High-Tec Inc.	Japan	$26 million partner investment	IV	September
Kopin Corporation	Japan	CyberDisplay products in Motorola systems	Motorola Corporation	U.S.	Cellular phones, pagers, smart-card readers	SA	September
Apple Computer Inc.	U.S.	Acquisition: $100 million in stock	Power Computer Corporation	U.S.	Mac clone business	IV	September
ICG Communications Inc.	U.S.	Acquisition: $283.5 million stock swap	Netcom On-Line Communication Services	U.S.	Switching communications	IV	October
Atmel Corporation	U.S.	0.25-micron 8-inch fab joint venture	Philips	Europe	$850M joint venture	IV	October

Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
Atmel Corporation	U.S.	Atmel and Philips joint venture in Malaysia	Khazanah Nasional Berhad	Malaysia	Kulim High Technology Park	IV	October
Synopsys Inc.	U.S.	Acquisition: $540 million stock swap	Viewlogic Systems Inc.	U.S.	ASIC design tools	IV	October
Orcad Inc.	U.S.	Acquisition: EDA tools	MicroSim Corporation	U.S.	Spice analog simulation EDA tools	IV	October
Hewlett-Packard Company	U.S.	Acquisition: HP Singapore Vision Operation	Vital Technology Pte. Ltd.	Singapore	IC and PCB assembly inspection systems	IV	October
Intel Corporation	U.S.	Standards specifications agreement	Cisco Systems Inc.	U.S.	Multimedia Cable Network Systems	CO	October
Intel Corporation	U.S.	USB/1394 and videoconferencing standards	@Home Network Inc.	U.S.	Standards agreement	CO	October
TRW Inc.	U.S.	Acquisition of GaAs MCM business	Milliwave Technology Inc.	U.S.	GaAs MCM for wireless communications	IV	October
Raytheon Company	U.S.	Acquisition: $5.1 billion	Hughes Aircraft Company	U.S.	Aircraft business sector	IV	October
Intel Corporation	U.S.	Acquisition: wholly owned subsidiary of Intel	Corollary Inc.	U.S.	High-end computer servers	IV	October
General Semiconductor Inc.	U.S.	Acquisition: $8 million small-signal transistor business	ITT Industries Inc.	U.S.	Discrete semiconductor business	IV	October
VLSI Technology Inc.	U.S.	$120 million equity investment in 0.25-micron fab	Wafer Technology Sendiran Berhad	Malaysia	8-inch fab agreement	FA	October
Lucent Technologies	U.S.	Acquisition: $650 million stock	Livingston Enterprises Inc.	U.S.	RADIUS software/ Portmaster servers	IV	October
Flextronics International Ltd.	U.S.	Acquisition: merger and stock exchange	Neutronics Electronics Holding AG	Europe	Contract equipment manufacturer	IV	October
Silicon Storage Technology Inc.	U.S.	License of SuperFlash process technology	Analog Devices Inc.	U.S.	License and royalty agreement	LA	October
NEC Corporation	Japan	Interoperability standard	SGS-Thomson	Europe	Contactless smart cards and readers	CO	November
NEC Corporation	Japan	Interoperability standard	Motorola Inc.	U.S.	Contactless smart cards and readers	CO	November
Samsung Electronics	Korea	Samsung chips in Staktek technology	Staktek Corporation	U.S.	Stacked memory chip designs	CO	November

Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
PRI Automation Inc.	U.S.	4.4 million shares/ $170 million transaction	Equipe Technologies Inc.	U.S.	Atmospheric robotics equipment	IV	November
Integrated Silicon Solution Inc.	U.S.	Acquisition: $500,000 cash and stock exchange	Nexcom Technology	U.S.	Flash patents and designs	IV	November
Hitachi Ltd.	Japan	License: 32-bit SH-3 RISC MPU core technology	Seiko Epson	Japan	Hitachi core into ASIC/ ASSPs	LA	November
Siemens AG	Europe	License: 0.25-micron flash license	GateField	Europe	License: ProASIC technology	LA	November
SGS-Thomson Microelectronics B.V.	Europe	SGS chips in set-top box designs	British Sky Broadcasting	Europe	Digital satellite TV service	CO	November
Daewoo Electronics Corporation	Korea	Joint IC design center in Seoul	SGS-Thomson	Europe	Consumer, communications, computer products	JD	November
Integrated Silicon Solution Inc.	U.S.	Flash memory blocks IP license agreements	Rockwell International Corporation	U.S.	Embedded logic products	LA	November
Integrated Silicon Solution Inc.	U.S.	Codevelop 0.35-micron flash memory	Chartered Semiconductor Manufacturing Pte. Ltd.	Singapore	License/development fees/royalties	LA	November
IBM Corporation	U.S.	Memory partnership agreement	Dongbu Group	Korea	64Mb/256Mb DRAM technology	TE	November
Sheldahl Inc.	U.S.	License: ViaThin interconnect substrate	Parlex Corporation	U.S.	Produce ViaThin substrate	LA	November
Ambit Design Systems Inc.	U.S.	Synthesis solution into Toshiba EDA environment	Toshiba	Japan	Develop library support for tools	CO	November
Digital Equipment Corporation	U.S.	Ten-year mutual patent cross-license agreement	Intel Corporation	U.S.	Fab/foundry agreement for DEC	LA	November
ATMI Inc.	U.S.	License of Harvard deposition methodology	Harvard University	U.S.	License: titanium nitride deposition	LA	November
Texas Instruments Inc.	U.S.	Acquisition: $395 million of ADSL specialist	Amati Communications Inc.	U.S.	Asymmetry digital subscriber line	IV	November
Rockwell International Corporation	U.S.	Consumer digital subscriber line collaboration	Northern Telecom Inc.	U.S.	Modem CDSL technology	CO	November
Rockwell International Corporation	U.S.	Promote overlapped PAM transmission	Orckit	Israel	xDSL technology	CO	November

Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
Hitachi Ltd.	Japan	0.25-micron low-power SH-3 RISC MPU	NTT Electronics Corporation	Japan	0.25-micron technology collaboration	CO	November
NEC Corporation	Japan	MIPs 4300 core in consumer products	Philips	Europe	Port MIPs in STB/satellite broadcast	CO	November
Intel Corporation	U.S.	Equity investment.	Cambridge Display Technology	Europe	Light-emitting polymer (LEP) technology	IV	November
Natural MicroSystems Corporation	U.S.	Acquisition: $6.9 million computer telephony add-in boards	ViaDSP Inc.	U.S.	DSP board specialist	IV	November
SGS-Thomson	Europe	IC/IP joint venture: Daewoo ST Semiconductor Co.	Daewoo Electric Co.	Korea	IC joint venture for system equipment	IV	November
Atmel Corporation	U.S.	Acquisition: terms not disclosed	Fincitec Components Oy	Europe	DSP and sigma-delta conversion technology	IV	November
Lucent Technologies	U.S.	Cell library and CAM cores agreement	Natural Microsystems Inc.	U.S.	ASICs based on Lucent technology	SA	December
Texas Instruments Inc.	U.S.	Port JAVA to digital baseband processor	Sun Microsystems Inc.	U.S.	License: embedded/personal JAVA	LA	December
Osicom Technology Inc.	U.S.	Develop embedded RISC processors	Atmel Corporation	U.S.	Web processor development	JD	December
Noise Cancellation Technology Inc.	U.S.	Silicon micromachined microphone technology	Siemens	Europe	License and royalty fees to NCTI	LA	December
Johnson Matthey plc	Europe	License package technology	Kyocera	Japan	License package technology	LA	December
Lucent Technologies	U.S.	Cell library and CAM cores agreement	General DataComm Inc.	U.S.	APEX ATM switches in Lucent systems	CO	December
Seeq Technology Inc.	U.S.	Gigabit Ethernet agreement expanded	Essential Communications Inc.	U.S.	Roadrunner ASIC for PCI bus interface	OT	December
Coryphaeus Software Inc.	U.S.	Development tool kits for TSC	Technology Service Corporation	U.S.	Infrared sensor simulation	JD	December
NEC Corporation	Japan	Russia joint venture in telecom systems: 45% stake	Mitsui & Co.	Japan	10% stake in telecom venture	JV	December

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Table 1 (Continued)
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Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
NEC Corporation	Japan	Russia joint venture in telecom systems: 45% stake	Sumitomo Corporation	Japan	10% stake in telecom venture	JV	December
NEC Corporation	Japan	Russia joint venture in telecom systems: 45% stake	Telecominvest	Russia	35% stake in telecom venture	JV	December
IDS Prof. Scheer	Europe	ARIS toolset in future products	Siemens	Europe	ComUnity Framework	SA	December
Silicon Valley Group	U.S.	Acquisition: $39.5 million	Tinsley Laboratories Inc.	U.S.	Precision optics manufacturer	IV	December
MEMC Electronic Materials Inc.	U.S.	Develop 200/300mm plasma wafer-shaping tools	Integrated Process Equipment Corporation	U.S.	Plasma-assisted chemical etch tools	JD	December
Planar Systems Inc.	U.S.	Acquisition: $15 million	Standish Industries Inc.	U.S.	Flat panel LCD manufacturer	IV	December
Rodel Inc.	U.S.	Acquisition: terms not disclosed	Solution Technology Inc.	U.S.	Slurry manufacturer and distributor	IV	December
Aetrium Inc.	U.S.	Acquisition: Handler Division, estimated $4 million revenue	Advantek Inc.	U.S.	Pick and place handler technology	IV	December
Selas Corporation	U.S.	Acquisition: $16.8 million stock	MRL Industries	U.S.	Semiconductor furnace system	IV	December
Comdisco Electronics Group	U.S.	ComIto Equipment Management: 60% interest	Itochu Corporation	Japan	40% interest in fab tools/leasing joint venture	JV	December
PRI Automation Inc.	U.S.	Acquisition	Interval Logic Corporation	U.S.	Planning/scheduling software	IV	December
Fairchild Semiconductor Corporation	U.S.	Acquisition: $120 million	Raytheon Semiconductor Division	U.S.	Mixed-signal/digital ICs	IV	December
Loughborough Sound Images Ltd.	Europe	DSP board merger	Mizar Inc.	U.S.	DSP board merger	IV	December
Silicon Storage Technology Inc.	U.S.	License: split-gate flash technology	Samsung	Korea	SST license	LA	December
Silicon Storage Technology Inc.	U.S.	License: split-gate flash technology	TSMC	Taiwan	SST license	LA	December

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Table 1 (Continued)
1997 Worldwide Alliance Activity

Company A	Regional Headquarters	Product/Facility	Company B	Regional Headquarters	Product/Facility	Type	Month
Intel Corporation	U.S.	Patent cross license agreement	Sun Microsystems Inc.	U.S.	Patent cross license agreement	LA	December
Vishay International Inc.	U.S.	Acquisition: $500 million for TEMIC	TEMIC Semiconductor	Europe	Discrete semiconductor business	IV	December
Vishay International Inc.	U.S.	Acquisition: 65% investment	Lite-On Power Semiconductor	Taiwan	Optoelectronics	IV	December
Nokia Oy	Europe	Acquisition: $120 cash/stock	Ipsilon Network Inc.	U.S.	IP switching technology	IV	December
Lucent Technologies	U.S.	Acquisition: $200 million stock exchange	Prominet Corporation	U.S.	Gigabit Ethernet switch business	IV	December
Mentor Graphics	U.S.	Cross-industry partnership	TSMC	Taiwan	Test chip and core development	SA	December
Synopsys Inc.	U.S.	Cross-industry partnership	TSMC	Taiwan	Test chip and core development	SA	December
SGS-Thomson	Europe	64Mb MPU cores for SuperH family series	Hitachi Ltd.	Japan	0.18-micron CMOS 500-MHz technology	JD	December
Larscom Inc.	U.S.	Acquisition: $32 million stock/cash	NetEdge System Inc.	U.S.	ATM edge switches	IV	December
MINC Inc.	U.S.	Acquisition: FPGA design tools	Synario Design Automation	U.S.	Data I/O division	IV	December

Source: Dataquest (February 1998)

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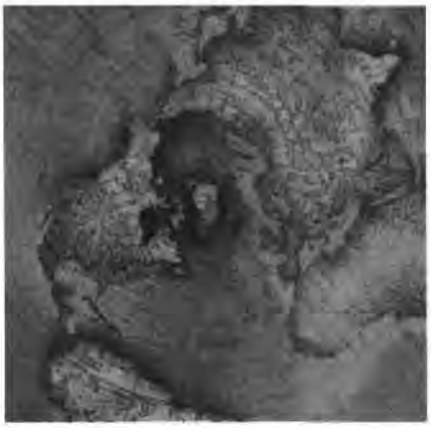

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Worldwide Semiconductor Forecast and Trends, Fall 1998

Market Trends

Program: Semiconductors—Top Views
Product Code: SCND-WW-MT-9802
Publication Date: November 9, 1998
Filing: Top Views

Market Trends

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Chapter 1
Executive Summary

Dataquest forecasts that worldwide semiconductor revenue will decline by 6 percent in 1998, a number that represents a downgrade from our previous expectations for the year. The worldwide semiconductor market should grow by 12 percent in 1999 and total $155 billion. The economic crisis in Asia, including Japan, remains a major concern. For the long term, Europe and the United States will lead the growth. The world market should grow at an 11.5 percent compound annual growth rate (CAGR) for 1997 through 2002, reaching $254 billion in the year 2002.

Objectives

This forecast and market trends information serves the following objectives:

- Near-term planning of worldwide and regional semiconductor manufacturing, sales, and procurement tactics
- Long-term strategic planning of semiconductor product strategy and supply base management
- Capital formation process decision making in debt and equities markets

Forecast Outlook

Worldwide semiconductor revenue will grow by 12 percent in 1999, totaling $155 billion. This growth will follow the unexpected revenue decline of at least 6 percent for 1998. By the year 2002, worldwide semiconductor revenue will total just over $250 billion, which marks an 11.5 percent-plus CAGR for the five-year period from 1997 through 2002.

The industry is now moving toward the end of its third straight year of lackluster performance . The prior expectation had been that the product market would rebound in 1998. The Asian financial crisis and low pricing for DRAMs, cell-based ICs (CBICs), and analog ICs, among other parts, thwarted semiconductor revenue growth this year. Few product segments will achieve more than marginal 1998 revenue growth, and year-end results remain a concern.

The 1999 forecast assumes sluggish demand in Asia, at best, but also stable DRAM pricing. Most product markets will not strengthen until mid-1999, so next year's growth will be concentrated in the second half of 1999. Also, the long-term growth rate is slower than was previously forecast.

Key Growth Metrics

Table 1-1 provides growth rates and revenue totals by product for the period from 1997 to 2002, including the five-year CAGR.

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Table 1-1
Worldwide Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1998 Growth (%)	1999 Growth (%)	2002 Revenue	1992-1997 CAGR (%)
Total Semiconductors	**147,165**	**-5.9**	**11.8**	**253,842**	**11.5**
Total Semiconductors (without DRAM)	**126,421**	**-1.8**	**9.7**	**208,247**	**10.5**
Bipolar Digital	1,239	-10.3	-14.9	604	-13.4
MOS Memory	30,978	-21.0	24.0	64,694	15.9
Dynamic RAM	20,744	-31.2	30.0	45,595	17.1
Static RAM	4,008	9.1	15.5	8,578	16.4
Nonvolatile Memory	5,571	-8.5	16.3	9,432	11.1
Other MOS Memory	655	10.9	11.3	1,089	10.7
MOS Microcomponent	48,945	-1.6	8.9	79,690	10.2
Microprocessor	23,659	3.3	11.2	38,080	10.0
Microcontroller	10,896	-10.8	7.3	17,390	9.8
Microperipheral	10,736	-8.3	0.2	14,530	6.2
Digital Signal Processor	3,654	13.8	19.2	9,690	21.5
MOS Digital Logic	24,757	-4.9	5.7	40,474	10.3
ASIC	16,527	-3.8	8.3	30,540	13.1
Custom IC	1,514	-29.1	-33.9	176	-35.0
MOS Standard Logic	2,266	-6.9	3.2	2,359	0.8
Total Other MOS Logic	4,450	0.4	7.4	7,400	10.7
Analog-Monolithic	21,652	1.7	15.9	40,601	13.4
Total Discrete	**14,255**	**-3.0**	**9.0**	**20,562**	**7.6**
Total Optical Semiconductor	**5,339**	**-1.1**	**5.7**	**7,217**	**6.2**

Source: Dataquest (September 1998)

Semiconductor Forecast with and without DRAM

Figure 1-1 provides a different look at the forecast. The figure shows worldwide semiconductor growth rates for 1997 through 2002 for the total semiconductor market, the DRAM market, and the non-DRAM semiconductor market.

The figure shows somewhat more stable and flatter long-term semiconductor growth when DRAMs are excluded. The figure also highlights the more volatile growth expected for DRAM.

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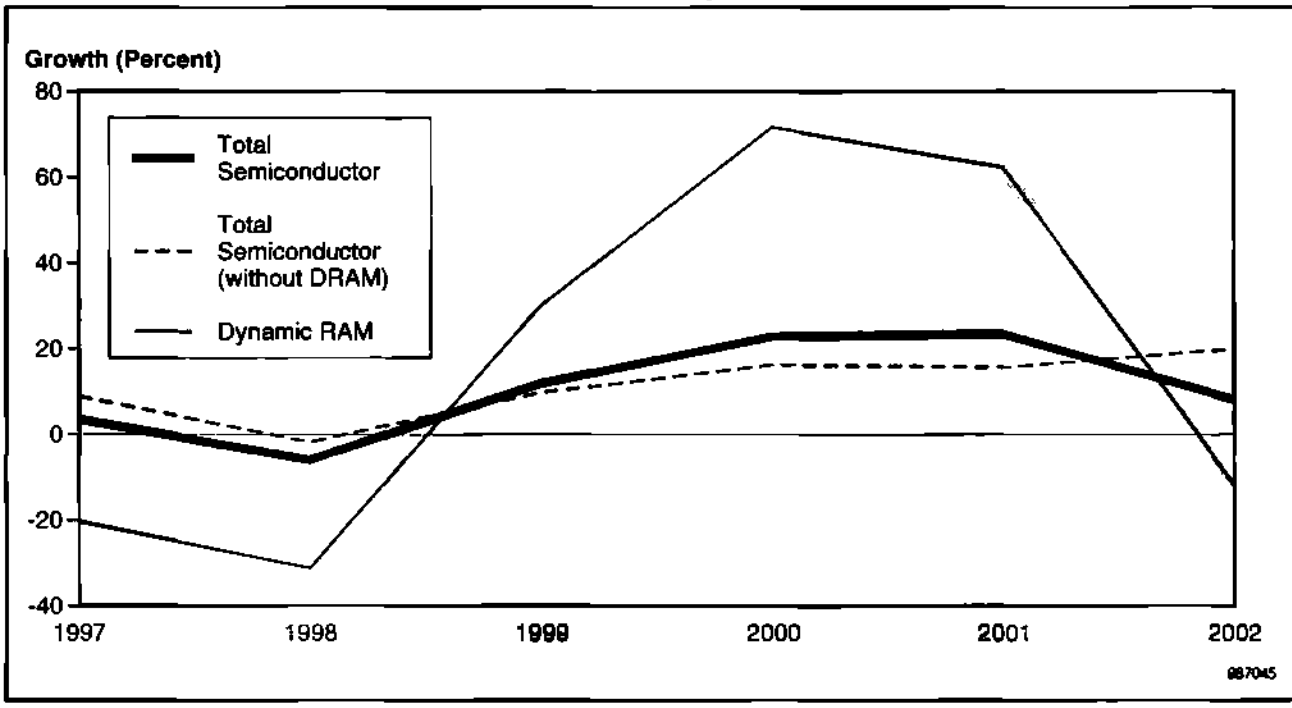
Figure 1-1
Worldwide Semiconductor Forecast, 1997 through 2002



Source: Dataquest (September 1998)

Electronic Production Forecast Analysis

As a first step in the forecast process, Dataquest combined worldwide electronic equipment production numbers for 1997 to 2002 with semiconductor input/output (I/O) analysis. This process generated the following worldwide semiconductor forecast (with the final forecast shown in parentheses):

- 1998: $148 billion for the production-based estimate of semiconductor consumption (versus the final forecast of $138 billion)
- 1999: $165 billion for the production-based estimate of semiconductor consumption (versus the final forecast of $155 billion)
- 2000: $196 billion for the production-based estimate (versus a $190 billion final forecast)
- 2001: $230 billion for the production-based estimate (versus a $235 billion final forecast)
- 2002: $242 billion for the production-based estimate (versus a $254 billion final forecast)

The forecast methodology process uses this information as a central input and "reasonable test" for generating the final semiconductor forecast.

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Forecast Methodology

The worldwide semiconductor revenue forecast consists of an interlinked set of regional product consumption forecasts. A team of product and regional experts generate regional product forecasts. The experts are chosen on the basis of their knowledge of key application trends, unit growth rates, and local economic factors. The team also has expertise on capacity, pricing, and related factors.

Each regional product forecast (for example, the Asia/Pacific digital signal processor [DSP] forecast) is rolled into a single worldwide product forecast. Also, the regional product forecasts (for example, Japanese consumption of DSP, DRAM, and so on) are rolled into a single regional forecast. As noted, the interlinked forecasts ultimately are rolled into the worldwide product forecast.

The basic methodology is as follows:

- Under the aegis of the worldwide product director, a regional product expert provides a "first-pass" regional product consumption forecast to the worldwide product director; for example, the microcontroller (MCU) expert in Japan provides a five-year forecast of MCU consumption in Japan to the worldwide MCU director; the worldwide director compiles the full set of MCU regional forecasts and then reviews the resultant worldwide MCU revenue totals and growth rates.
- Concomitantly, under the aegis of a regional forecast director, the first-pass regional product forecasts are also sent by the regional product experts to the regional forecast director. For example, the MCU expert, the DRAM expert, and so on in Japan also send their Japanese consumption market forecasts to the Japan regional forecast director. The regional forecast director compiles the regional product forecasts into a regional forecast and then reviews the resultant regional revenue totals and growth rates.
- The process remains interactive as the regional product forecasts are fine-tuned. When agreement has been reached on these regional product forecasts, a "proposed" worldwide forecast is reviewed by a team of worldwide and regional product analysts. This process typically requires selective modification to worldwide product forecasts, including regional forecasts. The process includes scrutiny of worldwide growth rates, product growth, regional growth, supply and capacity, pricing, potential forecast accelerators or inhibitors, and related factors.
- By consensus, the final worldwide and regional semiconductor product forecasts are then generated and published from the forecast database.

Perspective

Three straight disappointing years have challenged semiconductor industry confidence. The Asian crisis and its spreading impact outside Asia heighten near-term concern. Recent semiconductor company consolidation resulting from overcapacity contributes to this concern. The next six to nine months mark a critical period as the industry tries to rebound and re-establish revenue vitality.

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This forecast analysis identifies specific assumptions that serve as the basis for the semiconductor product and regional forecasts. The analysis also includes factors that could accelerate or inhibit the forecast rates of growth. Under current economic conditions, the near-term inhibitors are likely to capture attention.

For example, if Japan's economy becomes weaker than expected, then China might revalue its currency in 1999 in order to maintain export competitiveness. In turn, this move could make the Asian crisis deeper and more prolonged than expected—with obviously negative implications for near-term semiconductor demand and pricing. At this point , multiple factors could restrain semiconductor revenue growth during late 1998 and well into 1999.

By contrast, our long-range forecast assumes that semiconductors will retain market vitality and expand over the next five years. For the long term, worldwide information technology (IT) spending should grow at a CAGR of 11 to 12 percent. Semiconductors will have to compete against software and IT services for a share of corporate spending budgets. Even so, semiconductors will win a place in many systems demanded by business and consumer users.

The semiconductor market should grow at a rate similar to the growth in the IT market, partly on the long-term assumption that the DRAM oversupply will continue into 2000. As noted, under current economic conditions, it is easy to overlook factors that could accelerate the forecast rates of growth. For example, it is not early to predict the emergence of the next PC or Internet-based "killer application." Certainly no such application seems to be on the near-term horizon. Although such developments are hard to predict, the forecast analysis recognizes that microprocessor- or DSP-based killer applications could accelerate long-term growth well above the 12 percent rate. Also, the forecast anticipates an eventual but mild DRAM shortage (versus the 1995 experience). Although hard to envisage now, a post-1999 DRAM shortage akin to 1995 would mean accelerated long-term growth.

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Chapter 2
Worldwide Product Forecasts

The tables in this chapter provide the complete five-year forecast by product type for the worldwide semiconductor market. This chapter also provides semiconductor demand expectations for the PC, communications, and consumer application markets.

Worldwide Semiconductor Product Forecast and History

Table 2-1 provides the five-year forecast through 2002 by product type for the worldwide semiconductor market. We term this the "most likely" forecast for each product. This table shows total semiconductor market growth including DRAM and also without DRAM. Table 2-2 shows revenue history by product type for the 1992-1997 period.

The tables show that the worldwide semiconductor market should grow at a 12 percent-plus CAGR during the five-year period from 1997 to 2002. This growth rate contrasts with the much stronger 18 percent CAGR for 1992 to 1997.

Assumptions: Most Likely Forecast, Accelerators, and Inhibitors

The forecasts in this report provide the most likely forecast for that product or region. Each most likely forecast includes a set of assumptions that serve as the basis for the forecast. Near-term assumptions generally refer to the late 1998-to-1999 period, whereas long-term assumptions usually pertain to the post-1999 time frame.

Also, the forecast analysis includes a set of factors that could accelerate the forecast rate of growth plus a set of factors that would inhibit and lower the forecast growth rate.

Assumptions for the Most Likely Forecast

The following are the high-level assumptions for the most likely worldwide forecast:

- Worldwide PC unit shipments will grow about 15 percent per year; however, PC average selling prices (ASPs) will continue to fall. At best, PC revenue will grow annually at a single-digit rate.
- The semiconductor market will continue to confront oversupply; the foundry oversupply will persist for the next 18 months and the DRAM oversupply until mid- or late 2000.
- Despite continuing oversupply, DRAM pricing should stabilize during 1999 following the price collapse of the 1996-to-1998 period.
- The Internet will drive the wired communications chip market in both the near term and the long term; the Internet should mean growth for high-end microprocessors (MPUs) used in computer servers.
- Europe should experience strong growth in PC and digital cellular handset production.

Table 2-1
Worldwide Semiconductor Products, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1997-2002 CAGR (%)
Total Semiconductor	**147,165**	**3.5**	**138,437**	**-5.9**	**154,820**	**11.8**	**190,153**	**22.8**	**234,823**	**23.5**	**253,842**	**8.1**	**11.5**
Total Semiconductor (without DRAM)	**126,421**	**8.9**	**124,161**	**-1.8**	**136,263**	**9.7**	**158,298**	**16.2**	**183,129**	**15.7**	**208,247**	**20**	**10.5**
Bipolar Digital	1,239	-33.0	1,112	-10.3	946	-14.9	835	-11.7	707	-15.3	604	-14.6	-13.4
MOS Memory	30,978	-18.6	24,474	-21.0	30,349	24.0	45,987	51.5	68,765	49.5	64,694	-5.9	15.9
Dynamic RAM	20,744	-20.3	14,276	-31.2	18,557	30.0	31,855	71.7	51,694	62.3	45,595	-11.8	17.1
Static RAM	4,008	-20.2	4,372	9.1	5,050	15.5	6,250	23.8	7,893	26.3	8,578	8.7	16.4
Nonvolatile Memory	5,571	-13.7	5,100	-8.5	5,933	16.3	6,992	17.9	8,193	17.2	9,432	15.1	11.1
Other MOS Memory	655	13.5	726	10.9	809	11.3	889	9.9	984	10.7	1,089	10.6	10.7
MOS Microcomponent	48,945	18.0	48,170	-1.6	52,440	8.9	59,990	14.4	69,280	15.5	79,690	15.0	10.2
Microprocessor	23,659	26.1	24,440	3.3	27,180	11.2	30,300	11.5	33,670	11.1	38,080	13.1	10.0
Microcontroller	10,896	6.4	9,720	-10.8	10,430	7.3	12,350	18.4	14,860	20.3	17,390	17.0	9.8
Microperipheral	10,736	6.5	9,850	-8.3	9,870	0.2	11,070	12.2	12,720	14.9	14,530	14.2	6.2
Digital Signal Processor	3,654	53.0	4,160	13.8	4,960	19.2	6,270	26.4	8,030	28.1	9,690	20.7	21.5
MOS Digital Logic	24,757	9.2	23,551	-4.9	24,900	5.7	29,342	17.8	34,497	17.6	40,474	17.3	10.3
ASICs	16,527	11.7	15,898	-3.8	17,213	8.3	20,895	21.4	25,332	21.2	30,540	20.6	13.1
Custom IC	1,514	-12.2	1,074	-29.1	710	-33.9	480	-32.4	300	-37.4	176	-41.5	-35.0
MOS Standard Logic	2,266	13.7	2,109	-6.9	2,177	3.2	2,305	5.9	2,355	2.2	2,359	0.2	0.8
Total Other MOS Logic	4,450	7.0	4,470	0.4	4,799	7.4	5,661	18.0	6,510	15.0	7,400	13.7	10.7
Analog-Monolithic	21,652	18.7	22,020	1.7	25,532	15.9	30,346	18.9	35,609	17.3	40,601	14.0	13.4
Total Discrete	14,255	5.8	13,829	-3.0	15,073	9.0	17,573	16.6	19,388	10.3	20,562	6.1	7.6
Total Optical Semiconductor	**5,339**	**8.6**	**5,281**	**-1.1**	**5,580**	**5.7**	**6,081**	**9.0**	**6,577**	**8.2**	**7,217**	**9.7**	**6.2**

Source: Dataquest (September 1998)

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Table 2-2
Worldwide Semiconductor Products, Revenue Forecast, 1992 to 1997
(Millions of Dollars)

	1992 Revenue	1992 Growth (%)	1993 Revenue	1993 Growth (%)	1994 Revenue	1994 Growth (%)	1995 Revenue	1995 Growth (%)	1996 Revenue	1996 Growth (%)	1997 Revenue	1997 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	**65,260**	**9.3**	**85,514**	**31.0**	**110,513**	**29.2**	**151,310**	**36.9**	**142,150**	**-6.1**	**147,165**	**3.5**	**17.7**
Total Semiconductor (without DRAM)	**56,495**	**7.2**	**70,933**	**25.6**	**87,247**	**23.0**	**109,061**	**25.0**	**116,138**	**6.5**	**126,421**	**24**	**17.5**
Bipolar Digital	3,193	-12.0	3,079	-3.6	2,912	-5.4	2,455	-15.7	1,849	-24.7	1,239	-33.0	-17.2
MOS Memory	15,308	19.2	23,306	52.2	33,505	43.8	55,287	65.0	38,064	-31.2	30,978	-18.6	15.1
Dynamic RAM	8,765	25.5	14,581	66.4	23,266	59.6	42,249	81.6	26,012	-38.4	20,744	-20.3	18.8
Static RAM	3,038	17.9	3,908	28.6	4,514	15.5	6,265	38.8	5,020	-19.9	4,008	-20.2	5.7
Nonvolatile Memory	3,316	7.2	4,551	37.2	5,407	18.8	6,239	15.4	6,455	3.5	5,571	-13.7	10.9
Other MOS Memory	189	-1.0	266	40.7	318	19.5	534	67.9	577	8.1	655	13.5	28.2
MOS Microcomponent	14,359	22.0	19,947	38.9	26,408	32.4	34,504	30.7	41,469	20.2	48,945	18.0	27.8
Microprocessor	5,501	41.4	8,783	59.7	11,437	30.2	14,269	24.8	18,756	31.4	23,659	26.1	33.9
Microcontroller	4,613	4.2	5,904	28.0	7,517	27.3	10,250	36.4	10,244	-0.1	10,896	6.4	18.8
Microperipheral	3,801	20.4	4,581	20.5	6,424	40.2	8,316	29.5	10,081	21.2	10,736	6.5	23.1
Digital Signal Processor	444	48.5	679	52.9	1,030	51.7	1,669	62.0	2,388	43.1	3,654	53.0	52.4
MOS Digital Logic	10,042	3.5	13,121	30.7	16,108	22.8	20,667	28.3	22,676	9.7	24,757	9.2	19.8
ASICs	5,440	5.0	7,203	32.4	9,008	25.1	12,528	39.1	14,801	18.1	16,527	11.7	24.9
Custom IC	2,013	-5.3	2,367	17.6	2,502	5.7	2,143	-14.3	1,724	-19.6	1,514	-12.2	-5.5
MOS Standard Logic	1,191	19.9	1,501	26.0	1,864	24.2	2,202	18.1	1,993	-9.5	2,266	13.7	13.7
Total Other MOS Logic	1,399	-0.4	2,080	48.7	2,769	33.1	3,821	38.0	4,158	8.8	4,450	7.0	26.0
Analog-Monolithic	10,180	7.0	12,513	22.9	15,263	22.0	17,616	15.4	18,235	3.5	21,652	18.7	16.3
Total Discrete	8,155	1.5	9,083	11.4	10,763	18.5	14,314	33.0	13,474	-5.9	14,255	5.8	11.8
Total Optical Semiconductor	**2,688**	**-4.1**	**3,002**	**11.7**	**3,889**	**29.5**	**4,812**	**23.7**	**4,915**	**2.1**	**5,339**	**8.6**	**14.7**

Source: Dataquest (September 1998)

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- Demand throughout Asia, including Japan, for semiconductor-based products will remain sluggish at best.
- Good growth in consumer electronics in the Americas, especially the United States, will be offset by weaker demand in other world regions.
- The impact on semiconductor demand from broader information technology market trends, such as corporate spending on year 2000 (Y2K) solutions and European Monetary Union (EMU) conversion, remains uncertain.

Potential Accelerators to Growth

Although today's economic conditions cause more concern about market inhibitors, several factors could accelerate worldwide semiconductor revenue growth to a CAGR of more than 11.5 percent.

Strong Emerging Economy Demand for Communications and Consumer Electronics

As noted, the most likely forecast expects sluggish Asian demand for the next several years. Semiconductor growth would accelerate if demand for new communication systems and consumer products proves stronger than expected in the emerging economies of Asia, Eastern Europe, and Latin America.

Faster Adoption of Digital Consumer Electronics

The most likely forecast anticipates the emergence of DVD, digital TV, and other consumer digital systems and appliances. The trend has been "stop and start," with expectations often exceeding market results. If the pace of adoption accelerates, so would semiconductor growth.

Voice Recognition

Voice recognition technology has existed for years but has never quite made a dramatic market impact. The most likely forecast expects voice technology to have growing yet nondramatic impact on semiconductor demand. Accelerated adoption of voice technology by digital users would boost semiconductor growth.

Killer PC and Multimedia Applications

The most likely forecast is not based on the expectation that some amazing killer PC or multimedia application will emerge over the next several years. Even so, it is plausible that in the year 2000 or so, a semiconductor-intensive product will sweep worldwide or regional markets. Internet-based computing, communication, and consumer appliances come to mind. If such an unpredictable killer application emerges, semiconductor growth would accelerate.

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Potential Inhibitors to Semiconductor Growth

As noted, following the 1998 decline, worldwide semiconductor revenue should increase by nearly 12 percent in 1999 and at an 11.5 percent CAGR for the 1997-to-2002 time frame. The following factors could, however, cause slower semiconductor market growth.

Deeper Decline and Slower Recovery in Asia

Although the most likely forecast assumes Asian economic weakness during the 1998-to-1999 period, conditions in Asia could deteriorate even more than expected. In the near term, recession might become depression in many Asian countries, meaning weaker-than-expected 1999 semiconductor demand and pricing. The long-term restructuring of Japan's banking system could have a sharp impact not only on exchange rates but also on Asian trade.

U.S. Economic Downturn

The most likely forecast assumes steady-to-strong American demand for systems that use semiconductors. For example, a U.S. economic downturn, in a ripple effect from Asia, could thwart semiconductor revenue growth.

Fierce Competition That Drives Down ASPs

The semiconductor market will remain highly competitive, and the most likely forecast assumes competitive long-term pricing. The forecast assumes, however, that semiconductor pricing in the near term will be less brutal for vendors than in the recent past. For example, the forecast assumes that factors such as industry consolidation (for example, the Hyundai-LG Semicon "Big Deal" and Micron's purchase of Texas Instruments' memory business) should moderate intense competition and extreme pricing pressure.

Any unexpectedly strong intensification of competition, by contrast, would inhibit post-1998 revenue growth by driving down semiconductor ASPs.

Delay of Access Technologies

The forecast explicitly assumes that the Internet will stimulate near-term growth and then sustain long-term expansion. Long-term semiconductor growth depends on the widespread availability of high-bandwidth technologies like digital modems, digital subscriber line (DSL) service, and the Rambus interface. Delayed access to high-bandwidth technologies would stifle revenue growth.

Semiconductor Demand Outlook by Application Market

As noted, the worldwide electronic equipment production forecast serves as a basis for the semiconductor product forecast.

PCs, wired communications, wireless communications and consumer electronics account for about 70 percent of semiconductor consumption. Trends in these application markets will determine near-term results and generate long-term growth in semiconductor revenue. For the long term, the PC remains the paramount application for compute MPUs and

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DRAMs. Servers will eventually emerge as a key application for compute MPUs. Mobile communications , data communications, and digital consumer electronics, among other applications, should drive DSP, MCU, embedded MPU, and digital application-specific IC (ASIC) growth. Flash memory and EEPROM should also benefit from these trends.

The following sections summarize the outlook for the key semiconductor application markets.

Demand for PC Semiconductors

Table 2-3 provides the most likely forecast for semiconductor demand from PC applications. The PC-related market accounts for about 40 percent of worldwide semiconductor demand.

Table 2-3
Worldwide PC Semiconductor Revenue

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Revenue ($B)	41.79	38.37	44.18	60.65	78.02	76.03	12.7
Annual Growth (%)	NA	-8.2	15.1	37.3	28.6	-2.5	NA

NA = Not applicable
Source: Dataquest (September 1998)

Short-Term Assumptions for the PC Semiconductor Forecast

These assumptions guide the most likely 1998-to-1999 PC semiconductor forecast shown in Table 2-3.

- PC unit growth is expected to remain in the 13 to 17 percent range throughout the forecast period including 1999; by contrast, PC revenue will grow at a single-digit annual rate.
- The United States will continue to be dominated by a replace-and-upgrade cycle but the strong embrace of the sub-$1,000 PC will prompt more consumers to purchase their first home PC, boosting the penetration rate to more than 40 percent.
- The graphics chip market will face pricing pressure even as manufacturers continue to add features. The corporate computing market will continue to be slow to demand 3-D graphics features. Although it is difficult to buy non-3-D products today, the issue is one of corporate users buying down on the value scale rather than buying up.
- The audio market will face increasing competition from integrated designs with sound chips on the motherboard. Price pressure is extreme and will continue for at least one more year.

Long-Term Assumptions for the PC Semiconductor Forecast

These long-term assumptions guide the most likely PC semiconductor forecast shown in Table 2-3.

- PC unit growth will remain in the 13 to 17 percent range throughout the forecast period; however, PC ASPs will continue to fall. At best, PC revenue will grow annually at a single-digit rate.

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- A cyclical upturn in DRAM revenue in 2000 and 2001 will be the primary drivers of overall PC semiconductor revenue growth.
- PC main memory sizes will track historic trends and grow in the range of 40 to 45 percent per year.

Accelerators to the PC Semiconductor Forecast

These assumption factors, if they occur, will accelerate the most likely forecast shown in Table 2-3. The result would be higher growth rates and revenue levels for PC semiconductors than those shown in the table.

- Continued attrition of vendors in key segments, including DRAM and graphics, could reduce competition to levels at which vendors regain the ability to charge substantial price premiums, increasing both semiconductor ASPs and profit margins.
- Sustained PC demand coupled with a leveling-off or increase in PC ASPs would lead to both an increase in dollars spent on semiconductor devices per PC and an overall increase in semiconductor revenue. The increase in semiconductor spending would be driven by device shortages caused by current light capital spending.
- Strengthening in the economies in the Asia/Pacific region and Japan, or increased Western European and U.S. consumption made possible by lower manufacturing costs in these economies, could drive higher consumption.

Inhibitors to the PC Semiconductor Forecast

The occurrence of these assumption factors would inhibit the forecast shown in Table 2-3. The result would be lower growth rates and revenue levels for PC semiconductors than those shown in the table.

- Corporate PC purchasers, stirred by the acceptance of the sub-$1,000 PC price category in the consumer segment, could force OEMs to bring down the mainstream feature set to sub-$1,000 PC and below. This development could severely limit semiconductor revenue as PC OEMs force semiconductor suppliers to take the brunt of the price drops. A similar impact would occur if PC OEMs choose to slow the acceptance of higher-priced leading-edge technologies.
- The transition to Direct Rambus main memory could proceed poorly and delay the introduction of a next-generation memory thus limiting perceived performance gains in the entire PC platform. PC buyers, seeing little compelling evidence of performance improvements from the new technology, might then choose lower-priced alternatives.
- PC growth in the developing Asia/Pacific and Latin American markets could slow because of economic issues stemming from the current financial crises.
- Changes in consumption trends driven by PC buying pattern changes and continued weaknesses in consumer spending could prolong overcapacity through more of the forecast period.

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Demand for Communication Semiconductors

Table 2-4 provides the most likely forecast for semiconductor demand from wired and wireless communication applications

Table 2-4
Worldwide Communications Semiconductor Revenue

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Revenue ($B)	29.93	31.46	34.16	36.72	39.58	42.67	7.4
Annual Growth (%)	NA	5.1	8.6	7.5	7.8	7.8	NA

NA = Not applicable
Source: Dataquest (September 1998)

Assumptions for the Communications Semiconductor Forecast

These assumptions guide the most likely communications semiconductor forecast shown in Table 2-4. The communications market accounts for about 20 percent of worldwide semiconductor demand. This segment includes both wired communications and wireless communications semiconductor applications.

- Wireless communications semiconductors
  - There will be a modest recovery in the Asia/Pacific digital cellular market by the end of 1999.
  - Digital cordless telephones will retain continued popularity beyond 1999.
  - "Third-generation" cellular is not expected to have a significant impact on semiconductor consumption during the 1997-2002 forecast horizon.
- Wired communications semiconductors
  - Driven by Internet bandwidth upgrades, semiconductor consumption by the public infrastructure equipment market will remain strong.
  - Gigabit Ethernet remains a backbone technology during the 1997-to-2002 forecast horizon.
  - Cable modems and xDSL modems are on track for deployment in the 2001/2002 time frame.

Accelerators to the Communications Semiconductors Forecast

These assumption factors, if they occur, will accelerate the forecast shown in Table 2-4. The result would be higher growth rates and revenue levels for communications semiconductors than those shown in the table.

- Adoption rates
  - A dramatic pickup in demand for communications systems in the Middle East, Africa, and India.
  - A substantial uptake of wired and wireless home networking technology.

- Wireless communications semiconductors
  - The rapid adoption of enhanced feature phones, for example, smart phones
  - Significant deployment of 3rd-generation cellular products prior to 2002
  - Unimpeded high growth rates for digital cellular handsets and infrastructure in the Americas and Europe
- Wired communications semiconductors
  - Widespread adoption of Gigabit Ethernet (10/100/1,000-Mbps) to the desktop, especially physical layer devices for copper media
  - Significantly increased Internet bandwidth demand fueled by killer multimedia applications

Inhibitors to the Communications Semiconductors Forecast

These assumption factors, if they occur, will inhibit the forecast shown in Table 2-4. This would mean lower growth rates and revenue levels for communications semiconductors than shown in the table.

- Wireless communications semiconductors
  - A deeper Asian financial crisis with sharper negative impact on Asia/Pacific digital cellular handset and infrastructure deployment.
  - More severe price erosion fueled by fierce competition
  - Price erosion caused by breakthroughs in technologies such as silicon germanium (SiGe)
- Wired communications semiconductors
  - Standardization or implementation delays of next access technologies such as xDSL and cable modems
  - More severe price erosion fueled by fierce competition

Demand for Consumer Electronics Semiconductors

Table 2-5 provides the most likely forecast for semiconductor demand from consumer electronics applications. The consumer electronics market accounts for about 10 percent of worldwide semiconductor demand.

Table 2-5
Worldwide Consumer Electronics Semiconductor Revenue

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Revenue ($B)	23.77	24.86	26.54	28.22	30.46	33.1	6.8
Annual Growth (%)	NA	4.6	6.7	6.4	7.9	8.6	NA

NA = Not applicable
Source: Dataquest (September 1998)

Short-Term Assumptions for the Consumer Semiconductor Forecast

These assumptions guide the most likely 1998-to-1999 consumer electronics semiconductor forecast shown in Table 2-5.

- Growth in Asia/Pacific will be slower than expected; China will remain strong, while the rest of the region will sees slowing growth in gross domestic product or recession.
- Consumer electronics market saturation in Europe and recession in Japan will depress sales growth.
- Demand in the Americas, and especially in the United States, will be much stronger; for example, U.S. video and audio sales will rebound strongly in 1998 while TV sales growth will hit record levels.

Long-Term Assumptions for the Consumer Semiconductor Forecast

These long-term assumptions guide the most likely 1999 consumer electronics semiconductor forecast shown in Table 2-5.

- The Asian economy will recover; China will remain strong, and other countries will return to healthy growth and consumer electronics demand.
- Japan will remain in economic doldrums throughout forecast period.
- The consumer market in the Americas and Europe will gain strength with the popularity of new digital products.

Accelerators to the Consumer Semiconductors Forecast

These assumption factors, if they occur, will accelerate the most likely forecast shown in Table 2-5. The result would be higher growth rates and revenue levels for consumer electronics semiconductors than those shown in the table.

- Acceptance of digital TV (DTV) and digital set-top boxes in the Americas and Europe may be faster than expected; interactive television may explode.
- Asian economies may recover by the end of 1998 or early 1999; strong Asian New Year's sales may boost the market in 1999.
- The U.S. economy may grow faster than expected; Japan's economy may return to strong growth during the forecast period.
- Emerging economies (Africa, the Middle East, and India, for example) may experience a dramatic pickup in demand for consumer goods.

Inhibitors to the Consumer Semiconductors Forecast

These assumption factors, if they occur, will inhibit the forecast shown in Table 2-5. The result would be lower growth rates and revenue levels for consumer electronics semiconductors than those shown in the table.

- The economic downturn may continue in Asia/Pacific and Japan.
- The U.S. economy may weaken, especially because the Americas represent nearly 40 percent of the worldwide consumer electronics market.
- The Asian financial crisis may spread to China, which is a major factor in our most likely growth scenario.
- Digital products may fail; DTV and digital set-top boxes may stall.
- PCs may eat into the market share of video games and television.

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Product Forecasts

The following section identifies the assumptions that serve as the basis for each semiconductor product forecast in Table 2-1. As noted, we characterize Table 2-1 as the most likely forecast for each product. In addition, the following analysis includes assumption factors that could either accelerate or inhibit each product growth forecast.

ASIC, Logic, and SLI Forecast

The forecast in Table 2-1 shows that worldwide logic/ASIC revenue will increase by 6 percent in 1999 and total $25 billion, following a sharp 5 percent decline for 1998. The ASIC market during 1998 experienced the worst percentage revenue change in history. Gate array revenue declined by nearly 20 percent, while revenue from programmable logic devices (PLDs) and CBICs marginally increased. In the long term, worldwide revenue will grow at a 10 percent CAGR and reach $40 billion by 2002. This growth will be fueled in part by the trend toward system-level integration (SLI).

Short-Term Assumptions for the ASIC Forecast

These assumptions guide the most likely 1998-to-1999 logic/ASIC forecast shown in Table 2-1.

- ASIC and logic market growth stalled during 1998 for three main reasons:
  - A general industry slowdown
  - The Asian financial crisis
  - An associated accelerated rate of ASP declines
- Logic markets will remain flat into 1999; there will be no significant increase in ASIC/logic quarterly revenue until the second or third quarter of 1999.
- Other logic—which includes application specific standard products (ASSPs)—should show strong unit growth, but also above-average price declines.
- Custom ICs are rapidly being replaced by ASICs because they offer shorter time to market.
- Standard logic has a small number of suppliers, and the market remains a relatively flat.

Long-Term Assumptions for the ASIC Forecast

These long-term assumptions guide the most likely logic/ASIC forecast, shown in Table 2-1.

- ASIC growth will be driven by CBICs and PLDs at the expense of gate arrays.
- SLI will fuel the growth of the cell-based IC market as MPUs, DRAMs, and other intellectual property (IP) blocks are integrated on-chip.
- Key ASIC/ASSP application market drivers include the following: disk drives, workstations, servers, digital cellular, LAN/WAN, premise and central office switching systems, set-top boxes, video games, digital camcorders, still cameras, and digital TV
- ASICs will be converted to ASSPs as application markets mature.

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Accelerators to the ASIC Forecast

These assumption factors, if they occur, will accelerate the most likely ASIC and logic forecast shown in Table 2-1. The result would be higher growth rates and revenue levels for ASICs than those shown in the table.

- If application demand picks up in the first half of 1999, we could see a 10 percent upside in logic revenue for the 1999.
- In the longer term, if core standards for plug-and-play are put into practice in the next year, we could see more designs go to production in a shorter time period, thus taking up ASIC and ASSP revenue.
- Major consolidation in the industry could ultimately cause pricing to stabilize and increase long-term revenue growth.

Inhibitors to the ASIC Forecast

These assumption factors, if they occur, will inhibit the most likely ASIC and logic forecast shown in Table 2-1. The result would be lower growth rates and revenue levels for ASICs than those shown in the table.

- If near-term pricing aggressively declines because a vast number of suppliers target the same SLI markets, CBIC revenue will grow more slowly than expected.
- The rate at which SLI is adopted may slow.
    - SLI is the fastest-growing part of the logic market and is rapidly becoming the dominant part.
    - The move to SLI could be negatively affected by competitive pricing for other devices such as memory and microcomponents.
    - The move to SLI could be negatively affected by any limitation on the capability to design and produce SLI devices.
- ASIC growth rates would be negatively impacted by a major ramp-up in ASSPs.
- Unexpected changes in the growth of the major ASIC applications of cellular handsets, central office systems, and networking may occur.

Microprocessor Forecast

The forecast in Table 2-1 is that worldwide MPU revenue will increase by 11 percent in 1999 and total $27 billion, following growth of just 3.3 percent in 1998. Long term, worldwide MPU revenue will grow at a 10 percent CAGR and reach $38 billion by 2002.

Although MPUs are best known for compute applications, we provide additional assumptions for the embedded MPU segment.

Short-Term Assumptions for the MPU Forecast

These assumptions guide the most likely 1998-to-1999 MPU forecast shown in Table 2-1.

- Intel's high-end Xeon processors will begin to offset desktop MPU ASP erosion in the second half of 1998, but will not offset such erosion completely until 1999, when Intel offers support for four- and eight-way server configurations.

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- As noted before, annual worldwide PC unit growth will remain in the 13 to 17 percent range for both the near term and the long term. PC ASPs, however, will continue to fall, so that PC revenue will grow annually at a single-digit rate.

Long-Term Assumptions for the MPU Forecast

These long-term assumptions guide the most likely MPU forecast shown in Table 2-1.

- Throughout the forecast period, general-purpose, "PC-like" devices will continue as the dominant mechanism for users to access the Internet and to perform other data processing functions in the home and office.
- As indicated, PC prices and ASPs will continue to trend down, as users see little reason to buy high-performance (and expensive) systems to use with current application software that places few demands on CPU performance.
- In the later years of the forecast period, new software applications and usage paradigms will evolve that will tax the processing power of the much faster processors then available and motivate users to replace older systems. Some of these new applications will expand the market by making computers relevant to users who previously had no need for such devices. Vast increases in communications bandwidth to homes and small office environments will enable many of these applications.

Accelerators to the MPU Forecast

These assumption factors, if they occur, will accelerate the most likely forecast shown in Table 2-1. The result would be higher growth rates and revenue levels for MPUs than those shown in the table.

- System purchasers may conclude—in large numbers—that they can afford to purchase more computing performance at current prices than they realistically need to do their jobs, thus stemming PC and MPU price erosion.
- Our MPU forecast presently does not expect either of the following technological capabilities to be widely deployed during the forecast period:
  - High-bandwidth communications facilities (including cable modems and DSL technology) may achieve critical mass sooner than expected.
  - Corporations may accelerate the conversion to more sophisticated computing environments, both in response to lower prices and to cover Y2K exposure resulting from continued use of mature software systems.
- New usage paradigms, in particular voice-based natural language user interfaces, may reach maturity more rapidly than Dataquest presently expects and facilitate the onset of new applications that tax processor performance.

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Inhibitors to the MPU Forecast

These assumption factors, if they occur, will inhibit the forecast shown in Table 2-1. The result would be lower growth rates and revenue levels for MPUs than those shown in the table.

- PC growth in the developing Asia/Pacific and Latin American markets may slow more than expected because of economic issues stemming from the current financial crises.
- Corporations may defer computer purchases in order to fund software fixes to the Y2K problem.
- Improved communications bandwidth facilities may fail to emerge, as regulators and local exchange carriers continue to debate how such facilities will be funded.
- Technological dislocation may slow market growth—for example, such dislocation might occur should the U.S. government succeed in breaking up Microsoft, Intel, or both on antitrust grounds.

Assumptions for the Most Likely Embedded MPU Forecast

The following assumptions guide the embedded MPU forecast shown:

- Demand remains suitably strong for proven embedded applications such as office equipment, routers and hubs, video games, satellite receivers, and set-top boxes.
- High-performance MPUs have been offered at much lower prices than previously, so that $20 can buy nearly 200 MIPS.
- The attraction for building an ASIC with a deeply embedded MPU core will take away some embedded MPU business.

Accelerators to the Embedded MPU Forecast

These assumption factors, if they occur, will accelerate the most likely MPU forecast shown in Table 2-1. The result would be somewhat higher growth rates and revenue levels than those shown in the table.

- Vendors may develop sufficient peripherals integrated with processors to slow the move to custom solutions in SLI ASICs.
- Windows CE may spur enough developers to consider the platform for their ideas to really uncover a "killer application," and the hardware, software, service, and licenses may all be low-cost.

Inhibitors to the Embedded MPU Forecast

The occurrence of these assumption factors would inhibit the most likely forecast shown in Table 2-1 and result in lower revenue and growth rates.

- Microprocessor core availability in ASICs may become available from so many vendors that the value becomes minimal, lowering ASPs.
- Too many vendors may focus on network applications, so that prices for high-performance MPUs erode.

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Microcontroller Forecast

The forecast in Table 2-1 shows that worldwide MCU revenue will increase by 7 percent in 1999 and total $10.4 billion, following a sharp 11 percent decline for 1998. In the long term, worldwide MCU revenue will grow at a CAGR of 10 percent and reach $17 billion by 2002.

Assumptions for the Most Likely MCU Forecast

These assumptions guide the most likely MCU forecast shown in Table 2-1.

- Prices for MCUs eroded badly during 1998, meaning low 1999 price levels.
- Growth for 16- and 32-bit MCUs will increase more quickly than previously expected.
- More exotic features such as flash memory will be offered at low adders.

Accelerators to the MCU Forecast

These assumption factors, if they occur, will accelerate the most likely MCU forecast shown in Table 2-1. The result would be higher growth rates and revenue levels for MCUs than those shown in the table.

- Vendors may pursue completely new markets in the low end, building the overall base.
- More configurations of existing MCUs may become available with one-time programmable and flash memories.
- Higher-performance 8-bit MCUs may become available, allowing 16-bit MCUs to retain higher prices.
- It may happen that 4-bit MCUs are more rapidly upgraded to slightly more expensive 8-bit MCUs.
- The United States may find a need for smart cards.

Inhibitors to the MCU Forecast

The occurrence of this assumption factor would inhibit the most likely MCU forecast shown in Table 2-1 and result in lower revenue levels and growth rates.

- More former DRAM vendors may get into the microcontroller business, improving margins for themselves but lowering margins overall, without significantly increasing overall market.

DSP Forecast

Table 2-1 shows that worldwide DSP revenue will increase by 19 percent in 1999 and total $5 billion, following 14 percent growth for 1998, which was below expectations. In the long term, worldwide DSP revenue will grow at a 22 percent CAGR and reach $10 billion by 2002.

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Assumptions for the DSP Forecast

These assumptions guide the most likely DSP forecast shown in Table 2-1.

- Demand for cellular phones, modems, and disk drives is no longer increasing as fast as demand for DSPs.
- New architectures of high-performance DSPs reduce the cost-per-function in high-density DSP arrays.
- Digital signal processing can open a host of new applications for mobile and Internet communications and consumer interactivity.

Accelerators to the DSP Forecast

These assumption factors, if they occur, will accelerate the most likely DSP forecast shown in Table 2-1. The result would be higher growth rates and revenue levels than those shown in the table.

- Off-network data communications may continue to be upgraded as cheaply and as easily as the 56K modem allowed, without infrastructure changes or with infrastructure upgrades in lockstep.
- Dedicated DSPs may open significant new human interfaces to microprocessor-based equipment.

Inhibitors to the DSP Forecast

The occurrence of these assumption factors would inhibit the most likely DSP forecast shown in Table 2-1 and result in lower revenue levels and growth rates.

- Software development tools for the exotic DSP architectures may be inadequate for rapid acceptance.
- Microprocessors may be fast enough and well enough supported in digital signal processing techniques to severely reduce the number of applications that require separate DSP chips.

Memory IC Forecast

Table 2-1 shows that worldwide memory IC revenue will increase by 24 percent in 1999 and total $46 billion, following a steep 21 percent decline for 1998. In the long term, worldwide memory revenue will grow at a CAGR of 16 percent and reach $65 billion by 2002.

Short-Term Assumptions for the Memory IC Forecast

These assumptions guide the most likely 1998-to-1999 memory IC forecast shown in Table 2-1.

- Nearly all memory prices will continue to suffer because of an industry overcapacity situation.
- No near-term changes are anticipated in already-existing bit or unit consumption trends.
- The effects of embedded memory on existing markets will be negligible.

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Long-Term Assumptions for the Memory IC Forecast

These long-term assumptions guide the most likely memory IC forecast shown in Table 2-1.

- DRAM consumption will catch up with capacity in 2000, and an undercapacity will occur in 2001, to be corrected in 2002.
- Flash memory will displace EPROM, but other memory markets will continue along their current paths: strong growth for EEPROM, modest growth for mask ROM and SRAM.

Short-Term Accelerators to the Memory IC Forecast

These assumption factors, if they occur, will accelerate the most likely memory IC forecast shown in Table 2-1. The result will be higher growth rates and revenue levels than those shown in the table.

- Market attrition could support price increases.
- Strengthening in the economies in Asia Pacific and Japan, or increased American or European consumption allowed by lower manufacturing costs in these economies, could drive higher consumption.

Long-Term Accelerators to the Memory IC Forecast

The occurrence of these assumption factors would accelerate the most likely memory IC forecast shown in Table 2-1 and result in higher revenue and growth rates.

- The DRAM shortage of 2000-to-2001 could be worse than anticipated, driving costs significantly higher.
- Vendor attrition or unprecedented consumption could exacerbate anticipated long-term shortages, meaning stronger and higher prices.

Short-Term Inhibitors to the Memory IC Forecast

These assumption factors, if they occur, will inhibit the most likely memory IC forecast shown in Table 2-1. The result would be lower growth rates and revenue levels than those shown in the table.

- Worsening of already-miserable market pricing practices could drive negative growth in 1999.
- Lower consumption stemming from depressed economies could cause usage to drop and competition to worsen.

Long-Term Inhibitors to the Memory IC Forecast

The occurrence of these assumption factors would inhibit the most likely memory IC forecast shown in Table 2-1 and result in lower revenue levels and growth rates.

- Changes in consumption trends driven by PC buying pattern changes and continued weaknesses in consumer spending may prolong overcapacity through more of the forecast period.
- DRAM overcapacity may cause manufacturers to invade and destroy all memory markets, causing recovery to be more difficult.

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DRAM Forecast

Table 2-1 shows that worldwide DRAM revenue will increase by 30 percent in 1999 and total $19 billion, following a 31 percent plummet for 1998. In the long term, worldwide DRAM revenue will grow at a 17 percent CAGR and reach $46 billion by 2002.

Short-Term Assumptions for the DRAM Forecast

These assumptions guide the most likely 1998-1999 DRAM forecast shown in Table 2-1.

- Bit growth in the near term will be about average at 66 percent.
- Prices during late 1998 and 1999 will commence to level off, driven partly by the conversion to PC100 and partly by antidumping findings against Hyundai and LG Semicon.
- The current overcapacity will not resolve itself in the near term.

Long-Term Assumptions for the DRAM Forecast

These long-term assumptions guide the "most likely" DRAM forecast shown in Table 2-1.

- DRAM overcapacity will continue until demand meets capacity in 2000.
- The year 2001 will be marked by undercapacity, and the resultant profit cycle will be similar to those of 1980, 1984, and 1989; a repeat of the cycle of 1995 will not occur within our lifetimes.

Short-Term Accelerators to the DRAM Forecast

These assumption factors, if they occur, will accelerate the most likely 1998-to-1999 forecast shown in Table 2-1. The result would be higher growth rates and revenue levels than those shown in the table.

- Closure of significant DRAM fab capacity could have a very strong effect on increasing prices.
- Stronger than expected bit demand might drive spot shortages and combine with firming prices to make 1998 better than expected.

Long-Term Accelerators to the DRAM Forecast

The occurrence of these assumption factors would accelerate the most likely DRAM forecast shown in Table 2-1 and result in higher revenue and growth rates.

- Increases in PC consumption of DRAM over key historical averages could drive an earlier shortage of more important magnitude; historical averages have been 15 percent unit growth for PCs and 45 percent annual increases in system memory size.
- A shakeout in the market, accompanied by complete desertion by more than one major supplier, could reduce competition, making possible higher pricing.

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Short-Term Inhibitors to the DRAM Forecast

These assumption factors, if they occur, will inhibit the 1998-to-1999 DRAM forecast shown in Table 2-1. The result would be lower growth rates and revenue levels than those shown in the table.

- Current below-variable-cost pricing could continue to erode, driving revenue to completely unsustainable levels.
- Current above-average bit growth in 1998 may dwindle down to below average, or 1999 bit growth may counterbalance the high bit growth of 1997 and 1998.

Long-Term Inhibitors to the DRAM Forecast

The occurrence of these assumption factors would inhibit the most likely DRAM forecast shown in Table 2-1 and result in lower revenue levels and growth rates.

- Acceptance of the sub-$1,000 PC may squeeze OEMs to the point that they cannot afford to put more memory into the PC, and per-PC megabyte growth may falter.
- Manufacturing efficiencies may accelerate, allowing today's capacity to exceed demand beyond 2000.

SRAM Forecast

Table 2-1 shows that worldwide SRAM revenue will increase by 16 percent in 1999 and total $5 billion, following a 9 percent increase for 1998. In the long term, worldwide SRAM revenue will grow at a 16 percent CAGR and reach $8.6 billion by 2002.

Short-Term Assumptions for the SRAM Forecast

These assumptions guide the "most likely" 1998-to-1999 SRAM forecast shown in Table 2-1.

- Depressed pricing will continue, despite consolidation of the PC cache market.
- Other end markets will move in a relatively predictable direction; however, the current oversupply will keep prices low.

Long-Term Assumptions for the SRAM Forecast

These long-term assumptions guide the most likely SRAM forecast shown in Table 2-1.

- A foundry overcapacity situation will keep prices from recovering.
- Bit growth, density migration, and speed improvement will continue along trends that have been in place for the past three years.

Short-Term Accelerators to the SRAM Forecast

These assumption factors, if they occur, will accelerate the most likely 1998-to-1999 SRAM forecast shown in Table 2-1. The result would be higher growth rates and revenue levels than those shown in the table.

- Greater consumption of electronics goods, driven by lower manufacturing costs in the troubled Asia/Pacific economies, could increase overall consumption in the western world.

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- Possible adoption of level-three cache memories in Pentium II- and Celeron-based PCs could unleash new growth in the PC cache arena.

Long-Term Accelerators to the SRAM Forecast

The occurrence of these assumption factors would accelerate the most likely forecast shown in Table 2-1 and result in higher revenue and growth rates.

- A recovery in the Japanese economy, and commensurate increases in spending on high-end consumer electronics goods, could drive unpredicted consumption, resulting in higher unit consumption, faster density migration, and less competitive pricing.
- Movement to more complex interfaces such as Zero Bus Turnaround (ZBT), double data rate (DDR), and others could increase ASPs to account for the greater complexity of the part, the increased difficulty of test, and the fact that fewer vendors will be interested in participating in the market, driving competition down and prices up.

Short-Term Inhibitors to the SRAM Forecast

These assumption factors, if they occur, will inhibit the most likely SRAM forecast shown in Table 2-1. The result would be lower growth rates and revenue levels than those shown in the table.

- Further intrusion into the SRAM market by distressed DRAM suppliers could cause SRAM pricing to drop below cost, as in the DRAM market.
- Continuing financial woes in countries that consume large volumes of high-technology products could lead to sales shortfalls, affecting all suppliers that produce subassemblies and components used in these devices.

Long-Term Inhibitors to the SRAM Forecast

The occurrence of these assumption factors would inhibit the most likely SRAM forecast shown in Table 2-1 and result in lower revenue levels and growth rates.

- The adoption of DRAM into traditional SRAM applications could displace a large portion of the SRAM market. This possibility would be enabled by the increasing ease with which a DRAM controller can be added to an ASIC.
- Embedded volatile memory, either DRAM or SRAM, could be used to displace discrete SRAM chips in many applications, competing against discrete devices and displacing their market.

Nonvolatile Memory Forecast

Table 2-1 shows that worldwide nonvolatile revenue will increase by 16 percent in 1999 and total $5.9 billion, following a sharp 9 percent decline for 1998. In the long term, worldwide revenue will grow at a CAGR of 11 percent and reach $9.4 billion by 2002.

Flash memory and EEPROM will drive nonvolatile market growth. For example, EEPROM will surpass the $1 billion level in 1998 and approach $1.9 billion for 2002. This growth would result in an impressive five-year CAGR of 15 percent. Although flash revenue will decline in 1998 because of aggressive pricing, bit shipments continue to zoom. More stable pricing should enable worldwide revenue to grow at an 18 percent CAGR and exceed $6 billion by 2002.

Short-Term Assumptions for the Nonvolatile Memory Forecast

These assumptions guide the most likely 1998-to-1999 nonvolatile memory forecast shown in Table 2-1.

- The flash market will continue to be oversupplied in the near term, and competitive pricing of both flash and EPROM will reflect this oversupply. EEPROM and mask ROM will enjoy stable pricing.
- Flash and EEPROM bit consumption will continue to grow dramatically. ROM will continue to grow modestly, and EPROM will continue to be displaced by cheap flash memory.
- Flash will displace EPROM now that more attractive prices are available.

Long-Term Assumptions for the Nonvolatile Forecast

These long-term assumptions guide the most likely nonvolatile forecast shown in Table 2-1.

- The flash market will grow more from increased usage in new applications; however, it will also displace EPROM to a great extent over the term of the forecast.
- Mask ROM will continue to grow at a rate established before the great video game boom. The recent adoption of the Nintendo 64 system will not dramatically boost ROM sales.
- EEPROM will continue to grow substantially, driven by its use in smart cards, DRAM modules, and microcontroller-based equipment.

Short-Term Accelerators to the Nonvolatile Forecast

These assumption factors, if they occur, will accelerate the most likely nonvolatile forecast shown in Table 2-1. The result would be higher growth rates and revenue levels than those shown in the table.

- Pricing may stabilize because less fab capacity than needed comes on line in the near term.
- Greater consumption of electronics goods driven by lower manufacturing costs in the troubled Asia/Pacific economies could increase overall consumption in the western world.

Long-Term Accelerators to the Nonvolatile Forecast

The occurrence of these assumption factors would accelerate the most likely nonvolatile forecast shown in Table 2-1 and result in higher revenue and growth rates.

- A recovery in the Japanese economy, and commensurate increases in spending on high-end consumer electronics goods, could drive unpredicted consumption, resulting in higher unit consumption, faster density migration, and less competitive pricing.
- The video game market may move wholesale to the use of mask ROMs, driving this market back into prominence.

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Short-Term Inhibitors to the Nonvolatile Forecast

These assumption factors, if they occur, will inhibit the nonvolatile forecast shown in Table 2-1. The result would be lower growth rates and revenue levels than those shown in the table.

- Further intrusion into the nonvolatile memory market by distressed DRAM suppliers could cause flash and mask ROM pricing to drop below cost, as in the DRAM market.
- Continuing financial woes in countries that consume large volumes of high-technology products could lead to sales shortfalls, affecting all suppliers that produce subassemblies and components used in these devices.

Long-Term Inhibitors to the Nonvolatile Forecast

The occurrence of these assumption factors would inhibit the most likely nonvolatile forecast shown in Table 2-1 and result in lower revenue levels and growth rates.

- Overcapacity from DRAM fabs converted for flash use and overinvestment in dedicated flash fabs and flash-capable foundry could prevent flash memory prices from recovering during the forecast window.
- Faltering new markets led by decreased consumption in the ailing Asian economies could stall consumption, leading both to lower usage and more competitive pricing.

Analog IC Forecast

Table 2-1 shows that worldwide analog IC revenue will increase by 16 percent in 1999 and total $26 billion, following disappointing marginal growth for 1998. In the long term, worldwide analog revenue will grow at a CAGR of 13 percent and exceed $40 billion by 2002.

Short-Term Assumptions for the Analog IC Forecast

These assumptions guide the most likely 1998-to-1999 analog IC forecast shown in Table 2-1.

- Demand has been slowing down in PC, communications, consumer, and industrial markets, among others.
- The Asian economic downturn and its rippling effects on the rest of the world are the main reasons for the slowdown in demand.
- A recovering Asian economy and continued growth in the Americas and Europe in 1999, combined with the inventory reduction at analog IC suppliers in 1998, should bring strong growth back to analog ICs in 1999.

Long-Term Assumptions for the Analog IC Forecast

These long-term assumptions guide the most likely analog IC forecast shown in Table 2-1.

- A semiconductor boom cycle starting in 1999 will continue to result in strong growth for analog ICs in 2000 and 2001.
- The year 2002 could see a slowdown in analog IC growth as the semiconductor market enters its next cyclical downturn.

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Short-Term Accelerators to the Analog IC Forecast

These assumption factors, if they occur, will accelerate the most likely analog IC forecast shown in Table 2-1. The result would be higher growth rates and revenue levels for analog IC than those shown in the table.

- Stronger-than-expected recovery in the Asian economies would strengthen analog IC demand.
- Strength in the PC market may continue beyond the seasonally strong fourth quarter of 1998.

Long-Term Accelerators to the Analog IC Forecast

The occurrence of these assumption factors would accelerate the most likely analog IC forecast shown in Table 2-1 and result in higher revenue and growth rates.

- Strong emergence of new digital application markets
- Availability of more analog design talent

Short-Term Inhibitors to the Analog IC Forecast

These assumption factors, if they occur, will inhibit the most likely analog IC forecast shown in Table 2-1. The result would be lower growth rates and revenue levels than those shown in the table.

- Worsening turmoil in the emerging financial markets, triggering global crisis
- Slowdown of economic growth and industrial activities in the United States and Europe

Long-Term Inhibitors to the Analog IC Forecast

The occurrence of these assumption factors would inhibit the most likely analog forecast shown in Table 2-1 and result in lower revenue levels and growth rates.

- The commoditization of technology may cause the semiconductor market to grow significantly more slowly than in the past as a result of the much increased erosion in pricing.
- Cannibalization of the analog IC market may occur because of system-level integration.

Discrete Semiconductor Forecast

Table 2-1 shows that worldwide discrete semiconductor revenue will increase by 9 percent in 1999 and total $15 billion, following an unexpected 3 percent decline for 1998. In the long term, worldwide discrete revenue will grow at a CAGR of 8 percent and reach $20.5 billion by 2002.

Short-Term Assumptions for the Discrete Forecast

These assumptions guide the most likely 1998-to-1999 discrete semiconductor forecast shown in Table 2-1.

- Product price instability across all discrete devices, prevalent through the first half of 1998, has subsided. All discrete product groups are still in a state of ready availability. However, prices are returning to a state of stability.

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- The worldwide discrete market revenue decline of 1998 was a direct result of a steep decline in product revenue for Japan.
- Continued instability in the consumer, data processing, industrial, and automotive sectors indicate a slower-than-normal growth path for discrete devices through the second quarter of 1999.

Long-Term Assumptions for the Discrete Forecast

These long-term assumptions guide the most likely discrete semiconductor forecast shown in Table 2-1.

- The delayed recovery in the semiconductor market may delay some competitor and user decisions to shift to the slowly evolving power discrete (MOSFET and insulated gate bipolar transistor [IGBT]) products. Although large suppliers in the Americas, such as Motorola, have lost product share to some of the European competitors, consolidation of vendor activities and new market entrants may change the balance of supplier share and product activity during the next two years.
- The long-term prospects for growth appear moderate as competitors and users move to power management devices. Consolidation or acquisition of competitors' products appear as developments of change and even more price instability for developing product areas.

Short-Term Accelerators to the Discrete Forecast

These assumption factors, if they occur, will accelerate the most likely discrete semiconductor forecast shown in Table 2-1. The result would be higher growth rates and revenue levels than those shown in the table.

- Stronger-than-expected recovery from Japan, especially in the power MOSFET and IGBT products, could improve the forecast outlook.
- Stronger worldwide demand plus improved pricing for power discretes in the industrial and automotive areas for power management functions could improve the long-term outlook for growth in all regions.

Long-Term Accelerators to the Discrete Forecast

The occurrence of these assumption factors would accelerate the most likely discrete semiconductor forecast shown in Table 2-1 and result in higher revenue and growth rates.

- Growth in demand for wireless communication products will increase demand for multiple discrete products.
- Entrance of new American competitors in the power discrete segment may improve the Americas share of the discrete market.

Short-Term Inhibitors to the Discrete Forecast

These assumption factors, if they occur, will inhibit the most likely discrete semiconductor forecast shown in Table 2-1. The result would be lower growth rates and revenue levels than shown in the table.

- Evidence of a slowdown in the European cellular and automotive markets could damage expected growth of discretes over the forecast period.
- A continued delay in the market's recovery could damage competitors' strength in the American market.

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Long-Term Inhibitors to the Discrete Forecast

The occurrence of these assumption factors would inhibit the most likely discrete semiconductor forecast shown in Table 2-1 and result in lower revenue levels and growth rates.

- The declining market economies anomaly, which could spread into the European and Americas markets, could drive the industry into a recession, which would nullify growth throughout the industry.
- A transition by Americas competitors to ASSPs and embedded cores and transitioning to SLI technology could shrink the dollar volume in the market, driving the competitive field to further consolidation.

Optoelectronic Semiconductor Forecast

Table 2-1 shows that worldwide optoelectronic semiconductor revenue will increase by 6 percent in 1999 and total $5.6 billion. This follows an unexpected 1 percent decline for 1998. Long term, worldwide optoelectronic semiconductor revenue will grow at a 6 percent CAGR and exceed $7 billion by 2002.

Assumptions for the Optoelectronic Forecast

These assumptions guide the most likely 1998-to-1999 optoelectronic semiconductor forecast shown in Table 2-1.

- LEDs and laser diodes are key market drivers (60 percent-plus of revenue).
- LED growth has been moderated from the previous forecast by the general industry slowdown led by the Asian financial crisis.
- The laser diode market has been impacted negatively by the slow consumer markets and positively by the demand for bandwidth in the telecommunications market driven by the Internet.
- PC and wireless handset demand growth will return to higher levels in 1999.

Accelerators to the Optoelectronic Forecast

The occurrence of these assumption factors would accelerate the most likely optoelectronics forecast shown in Table 2-1 and result in higher revenue and growth rates.

- In the near term, successful resolution of the Asian financial crisis, especially in Japan
- In the longer term, acceleration of the automotive industry's switch to the use of LEDs for rear-window brake-light bezels and related applications
- Rapid long-term expansion of the Internet to developing countries

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Short-Term Inhibitors to the Optoelectronic Forecast

These assumption factors, if they occur, will inhibit the most likely optoelectronics forecast shown in Table 2-1. The result would be lower growth rates and revenue levels than those shown in the table.

- In the near term, China may be impacted by the Asian financial crisis.
- In the long term, the U.S. and European economies may experience slower-than-expected growth.

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Chapter 3

Worldwide Semiconductor Product Forecasts by Region

This chapter presents the worldwide total semiconductor forecasts by region.

Worldwide Semiconductor Forecast by Region

The total semiconductor revenue forecast by region—with and without DRAM—and the associated growth rates for the five-year semiconductor forecast are listed in Table 3-1. Chapters 4 through 7 provide top-level perspectives on the regional semiconductor forecasts.

Detailed regional product forecasts are contained in the appendix (Tables A-1 through A-12).

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Table 3-1
Total Semiconductor Consumption by Region, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1997-2002 CAGR (%)
Worldwide	**147,165**	**3.5**	**138,437**	**-5.9**	**154,820**	**11.8**	**190,153**	**22.8**	**234,823**	**23.5**	**253,842**	**8.1**	**11.5**
Americas	48,086	5.3	45,836	-4.7	51,996	13.4	65,134	25.3	80,966	24.3	87,553	8.1	12.7
Japan	36,499	-5.0	30,721	-15.8	32,652	6.3	38,450	17.8	47,108	22.5	50,388	7.0	6.7
Europe	30,046	5.9	30,480	1.4	34,194	12.2	42,043	23.0	50,934	21.1	55,106	8.2	12.9
Asia/Pacific	32,534	9.6	31,400	-3.5	35,978	14.6	44,526	23.8	55,815	25.4	60,795	8.9	13.3

Source: Dataquest (September 1998)

Chapter 4
Americas Forecast

Table 4-1 shows that semiconductor revenue from the Americas (that is, North America and Latin America) will increase by 13 percent in 1999 and total $52 billion, following a sharp 5 percent decline for 1998. Excluding DRAM, the market was flat in 1998 and should grow by 11 percent in 1999. In the long term, regional revenue will grow at a CAGR of 12 percent-plus and reach $88 billion by 2002.

Detailed regional product forecasts are contained in the appendix.

Short-Term Assumptions for the Americas Forecast

These assumptions guide the most likely 1998-to-1999 Americas forecasts shown in Table 4-1 and the appendix tables.

- A dramatic 1998 decline in DRAM revenue in North and Latin America means a decline in the semiconductor market; at best, non-DRAM product revenue in the Americas will be flat for 1998.
- The Americas markets, especially the U.S. market, will avoid recession in 1999, despite the economic chaos that threatens to spread worldwide.
- The market will experience price stability in 1999 and improved demand in all product sectors including DRAM; even so, market strengthening and recovery will not occur until the second half of 1999 or later.

Long-Term Assumptions for the Americas Forecast

These long-term assumptions guide the most likely North and Latin American forecast shown in Table 4-1 and the appendix.

- Although threats of recession for the Americas are on the horizon, barring any further major economic downturn in Japan and especially China (the Americas' largest trading partner), the Americas should avoid economic recession.
- Slower growth in machine tool production for the industrial sector, slower growth in semiconductor units sold to the automotive sector, and flat-to-no-growth in the consumer sector would be harbingers of a downturn spreading into the Americas market.

Short-Term Accelerators to the Americas Forecast

These assumption factors, if they occur, will accelerate the most likely Americas forecast shown in Table 4-1 and the appendix. The result would be higher growth rates and revenue levels than those shown in the tables.

- Robust return to growth in new data processing and communication applications could spur increased demand across all semiconductor product groups.
- Near-term stabilization and strengthening of product prices may boost market revenue.

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Long-Term Accelerators to the Americas Forecast

The occurrence of these assumption factors would accelerate the most likely forecast shown in Table 4-1 and the appendix, resulting in higher revenue and growth rates.

- A return to stronger capital spending and investment is expected in late 1999 for future semiconductor products and technology.
- Increased demand for advanced semiconductor functions into new industrial, consumer, and communications sectors will grow the semiconductor revenue as forecast in the 2001-to-2002 time frame.

Short-Term Inhibitors to the Americas Forecast

These assumption factors, if they occur, will inhibit the forecast shown in Table 4-1 and the appendix. The result would be lower growth rates and revenue levels for the Americas than those shown in the table.

- Y2K fears, whether real or exaggerated, may interrupt revenue growth or the potential for return to growth during the later half of 1999. Investment dollars normally slated for semiconductor R&D may be diverted to other software and hardware business-related operations.
- If the economic downturn spreads to the Americas (and European) regions, a return to growth in 2000 will be delayed. A continued semiconductor market downturn will affect multiple competitors that have been weakened by the industry's lengthening malaise. Weakened company profitability may lead to further consolidation.

Long-Term Inhibitors to the Americas Forecast

The occurrence of these assumption factors would inhibit the most likely Americas forecast shown in Table 4-1 and the appendix, meaning lower revenue levels and growth rates.

- A shift to ASSP ICs and SLI may shrink the long-term value and growth of the semiconductor and electronic equipment industry.
- Industrywide consolidation and economic downturns could shift internal manufacturing to outsourcing of production. As a result, the Americas industry structure would change dramatically. This change would stimulate both the package and assembly industries as well as the foundry business.

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Table 4-1
Americas Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1997-2002 CAGR (%)
Total Semiconductor	**48,086**	**5.3**	**45,836**	**-4.7**	**51,996**	**13.4**	**65,134**	**25.3**	**80,966**	**24.3**	**87,553**	**8.1**	**12.7**
Total Semiconductor (without DRAM)	39,853	13.2	39,925	0.2	44,230	10.8	51,515	16.5	60,026	16.5	68,651	14.4	11.5

Source: Dataquest (September 1998)

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Chapter 5

Japan Forecast

Table 5-1 shows that semiconductor revenue in Japan will increase by 6 percent in 1999 and total $33 billion, following a dramatic 16 percent decline for 1998. Excluding DRAM, the market still declined by 13 percent in 1998 and should grow by just 4 percent in 1999. In the long term, regional revenue will grow at a CAGR of 7 percent-plus and reach $50 billion by 2002; growth is slightly lower when DRAM is excluded.

Detailed regional product forecasts are contained in the appendix.

Note that for 1998, the yen-to-dollar exchange rate (see Chapter 9) is assumed to depreciate by more than 10 percent, lowering revenue in dollar terms.

Short-Term Assumptions for the Japan Forecast

These assumptions guide the most likely 1998-to-1999 Japan forecast shown in Table 5-1 and the appendix.

Following the Japanese recession in 1998, a modest of recovery is expected in 1999.

- Key application equipment shows sluggish production trends highlighted by a 1998 decline in PC shipments into the domestic market.
- Weak pricing trends continue as oversupply in various semiconductor products persists through the first half of 1999. Improvements in pricing and recovery of revenue growth are expected in the second half of 1999.

Long-Term Assumptions for the Japan Forecast

These long-term assumptions guide the most likely Japan forecast shown in Table 5-1 and the appendix.

- Recovery in various aspects of the worldwide economy will increase production of semiconductor application equipment.
- In addition to computers and communication products, digital consumer products will drive the long-term growth of semiconductor demand in Japan;
- The year 2000 Olympic games should increase demand for satellite and terrestrial broadcasting service systems.
- The supply/demand balance changes from oversupply to mild undersupply in the year 2000, resulting in a peak year in 2001 when the market will see stable pricing trends. A mild downturn in pricing trends is expected in the year 2002.

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Short-Term Accelerators to the Japan Forecast

These assumption factors, if they occur, will accelerate the most likely Japan forecast shown in Table 5-1. The result would be higher growth rates and revenue levels than those shown in the table.

- Stronger and more extensive economic recovery may come about in Japan as well as in other Asian countries.
- Among applications, lowered PC prices, and Windows 98 may result in stronger-than-expected demand toward the end of 1998, with the year 1999 in Japan marking the beginning of a recovery.
- Infrastructure construction may be accelerated in 1999 for digital satellite and terrestrial broadcasting systems in expectation of an audio/video system boom for the Olympic games.
- In the DRAM market, the move toward PC100 SDRAM is causing partial undersupply, which may lead to early stabilization of DRAM pricing.
- Increases in shipments of ASSPs for emerging digital consumer products such as MiniDisc, DVD, and digital still cameras may offset, if only partially, the negative growth trends for consumer application ASSPs.

Long-Term Accelerators to the Japan Forecast

The occurrence of these assumption factors would accelerate the most likely Japan forecast shown in Table 5-1 and the appendix, resulting in higher revenue and growth rates.

- Gigabit network backbone construction and cable television infrastructure integration may move forward, generating demand for various multimedia end products.
- Lowering PC selling prices may create stronger domestic demand in Japan, causing stronger PC semiconductor demand
- Digitization of consumer equipment may give the Japanese semiconductor market a chance to leverage on domestic system suppliers, accelerating trends toward SLI.

Short-Term Inhibitors to the Japan Forecast

These assumption factors, if they occur, will inhibit the forecast shown in Table 5-1 and the appendix. The result would be lower growth rates and revenue levels than those shown in the tables.

- Any failure in the recovery of the Japanese and Asian economies will pose an immediate threat to electronics production.
- With the penetration of Personal Digital Cellular reaching more than 30 percent, Japanese production of cellular phones may slow significantly.
- The stabilization of DRAM prices may slow down growth in PC DRAM megabytes, delaying a balancing of supply and demand.

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Long-Term Inhibitors to the Japan Forecast

The occurrence of these assumption factors would inhibit the most likely Japan forecast shown in Table 5-1 and result in lower revenue levels and growth rates.

- If the quality of services cannot be improved because of incoherent and segmented service offerings, the result will be a slowdown in growth of digital consumer, communication, and data processing markets.
- SLI efforts may create excessive competition, dampening revenue growth in SLI ASICs.

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Table 5-1
Japan Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1997-2002 CAGR (%)
Total Semiconductor	**36,499**	**-5.0**	**30,721**	**-15.8**	**32,652**	**6.3**	**38,450**	**17.8**	**47,108**	**22.5**	**50,388**	**7.0**	**6.7**
Total Semiconductor (without DRAM)	32,662	(2.1)	28,275	-13.4	29,496	4.3	33,030	12.0	37,635	13.9	41,967	11.5	5.1

Source: Dataquest (September 1998)

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Chapter 6

Europe, the Middle East, and Africa Forecast

Table 6-1 shows that semiconductor revenue in Europe, Middle East, and Africa will increase by 12 percent in 1999 and total $34 billion (surpassing Japan), following relatively flat 1998 revenue growth. Excluding DRAM, the market will increase by 6 percent in 1998 and should grow by 10 percent in 1999. In the long term, regional revenue will grow at a CAGR of 13 percent and reach $55 billion by 2002; growth is slightly lower when DRAM is excluded.

Detailed regional product forecasts are contained in the appendix.

Assumptions for the Europe, Middle East, and Africa Forecast

These long-term assumptions guide the most likely Europe, Middle East, and Africa forecast shown in Table 6-1 and the appendix tables.

- Two major applications—PCs and digital handsets—will drive regional revenue growth.
- PC memory fit continues to increase at a historic rate; this forecast assumes that impending major technology changes will not slow the rate down.
- Associated with PC memory expectations is the expectation that DRAM ASP fluctuations (in either direction) from assumed ASPs will result in changes in revenue.
- SLI migration will not be delayed because of declining ASPs of the main candidates for integration.

Accelerators to the Europe, Middle East, and Africa Forecast

These assumption factors, if they occur, will accelerate the most likely Europe, Middle East, and Africa forecast shown in Table 6-1 and the appendix. The result would be higher growth rates and revenue levels than those shown in the table.

- The inability of the industry to meet PC100 and Direct Rambus DRAM demand could drive up DRAM pricing in 1999.
- The negative impact from the Asian crisis on digital cellular handset production may be less severe than anticipated.
- Consumers may migrate to digital broadcasting more enthusiastically than forecast, increasing digital set-top box demand.
- The impact of sub-$1,000 PCs may be negated by demand for the higher processing power necessary for new killer PC applications.

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Inhibitors to the Europe, Middle East, and Africa Forecast

The occurrence of these assumption factors would inhibit the most likely Europe, Middle East, and Africa forecast shown in Table 6-1 and the appendix, meaning lower revenue levels and growth rates.

- ASPs may continue to decline as the supply/demand imbalance continues to spread to products not currently affected.
- The industry may fail to regain investment momentum, delaying acceptance of new technologies.
- Pending liberalization of wireline communications may fail to have the expected inpact on central office and infrastructure sales.

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Table 6-1
Europe Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1997-2002 CAGR (%)
Total Semiconductor	**30,046**	**5.9**	**30,480**	**1.4**	**34,194**	**12.2**	**42,043**	**23.0**	**50,934**	**21.1**	**55,106**	**8.2**	**12.9**
Total Semiconductor (without DRAM)	26,014	9.5	27,642	6.3	30,503	10.3	35,373	16.0	40,678	15.0	45,849	12.7	12.0

Source: Dataquest (September 1998)

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Chapter 7
Asia/Pacific Forecast

Table 7-1 shows that semiconductor revenue in Asia/Pacific will increase by 15 percent in 1999 and total $36 billion, following a 4 percent decline for 1998. Excluding DRAM, the market will increase marginally in 1998 and should grow by 13 percent in 1999. In the long term, regional revenue will grow at a 13 percent CAGR and reach $61 billion by 2002. DRAM drives regional revenue, so the non-DRAM growth rate is quite similar.

Detailed regional product forecasts are contained in the appendix.

Short-Term Assumptions for the Most Likely Forecast

These assumptions guide the most likely 1998-to-1999 Asia/Pacific forecast shown in Table 7-1 and the appendix tables.

- The Asia crisis hit semiconductor demand and pricing hard in 1998; Pacific Basin economies should start to recover from the 1998 economic downturn during 1999 (1 percent gross domestic product growth).
- China's economy will grow about 8 percent in 1999.
- The Asia/Pacific semiconductor market is expected to post positive growth in 1999 because of increased electronic equipment production.
- Semiconductor consumption will gradually recover during the second half of 1999.

Long-Term Assumptions for the Asia/Pacific Forecast

These long-term assumptions guide the most likely Asia/Pacific forecast shown in Table 7-1 and the appendix.

- The highest growth rates will come from microcomponents and memory products, as a result of fast-expanding data processing and communications applications.
- Asia/Pacific semiconductor consumption growth will increase rapidly in 2000 and 2001, driven by higher revenue from the memory market. However, the balanced supply/demand situation is expected to tend toward oversupply by 2002.

Short-Term Accelerators to the Asia/Pacific Forecast

These assumption factors, if they occur, will accelerate the most likely Asia/Pacific forecast shown in Table 7-1 and the appendix. The result would be higher growth rates and revenue levels than those shown in the table.

- Communication equipment could generate stronger demand in the region, especially for ASICs, DSPs, ASSPs, and analog ICs.
- In the near term, mobile and wireless communications, plus digital consumer products such as digital set-top-boxes, could become quite strong.

- Strong production growth may occur in this region, especially for Pentium II, DVD, 3D graphics, Windows NT, and Windows 98.

Long-Term Accelerators to the Asia/Pacific Forecast

The occurrence of these assumption factors would accelerate the most likely Asia/Pacific forecast shown in Table 7-1 and the appendix, making possible higher revenue levels and growth rates.

- In the long term, any acceleration in demand from the region's most important semiconductor demand driver, the PC, would accelerate the forecast.
- Electronic equipment manufacturers in Asia/Pacific may gain competitiveness, winning more contract business from PC manufacturers.
- Electronic equipment production from new manufacturing investments, especially in data processing and communications applications, may grow.
- The memory market may recover earlier than expected; ASPs may strengthen because of consolidation in the industry.

Short-Term Inhibitors to the Asia/Pacific Forecast

These assumption factors, if they occur, will inhibit the Asia/Pacific forecast shown in Table 7-1 and the appendix. The result would be lower growth rates and revenue levels than those shown in the table.

- The Asian economic crisis may fail to improve in 1999; for example, Japan's economy may remain in a deep slump, and American and European export markets may exhibit reduced demand.
- Overcapacity in consumer electronics may continue.
- Related to an export slump would be concomitant slowing of local Asia consumption as a result of high unemployment.
- The lack of internal consumption would then probably bring down Asia's economy and ultimately the consumption of chips.

Long-Term Inhibitors to the Asia/Pacific Forecast

The occurrence of these assumption factors would inhibit the most likely Asia/Pacific forecast shown in Table 7-1 and the appendix, causing lower revenue levels and growth rates.

- Semiconductor vendors may lower prices even more steeply in response to intense competition in the high-growth device markets.
- Oversupply in commodity chip markets may occur earlier than 2002.

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Table 7-1
Asia/Pacific Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1997-2002 CAGR (%)
Total Semiconductor	**32,534**	**9.6**	**31,400**	**-3.5**	**35,978**	**14.6**	**44,526**	**23.8**	**55,815**	**25.4**	**60,795**	**8.9**	**13.3**
Total Semiconductor (without DRAM)	27,892	17.2	28,319	1.5	32,034	13.1	38,380	19.8	44,790	16.7	51,780	15.6	13.2

Source: Dataquest (September 1998)

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Chapter 8
Capacity/Supply and Pricing Environment

This section provides a top-level view of the semiconductor supply-side and pricing factors that guided the forecast process.

Capacity and Supply-Side Considerations

Aggressive investment in 0.25-micron technology throughout 1997 has only exacerbated the persistent overcapacity in the industry. Dataquest has been calling for a "W" recovery pattern in capital spending, with the second-phase downturn being caused by the fundamentals of overcapacity and the movement toward financial health eventually winning over the desire for technology. As this second phase now unfolds with very deep spending cuts in 1998, the questions now arise for 1999: Were the cutbacks deep enough to correct the oversupply? When can a sustainable recovery really begin? What will fundamentally bring about recovery?

DRAM Oversupply with Us into 2000, but the End Is in Sight!

We can now say, for the first time in the last several forecast cycles, what we see as the fundamental issue that will bring the next spending boom in the years 2001 to 2002, starting in about the third quarter of 2000. The main fuel for the boom will be the return of DRAM spending, resulting from an undersupply that will emerge.

In DRAM, there has been a net capacity addition in the last two years beyond the requirements for silicon area. Presently, we are estimating the overcapacity in DRAM to be between 20 and 25 percent. The movement of the industry to the more silicon-efficient 64Mb density will sustain the oversupply throughout 1999 into 2000. Our silicon demand model shows that with the forecast 60 to 70 percent bit-growth rate in 1998 and 1999, about 12 to 14 percent less silicon will be required by the end of 1999 than is currently consumed.

However, net supply will be trending down as well over the next 18 months as capital spending cuts have an effect in reducing the rate of supply increase. As time passes, larger linewidth capacity naturally exits the market, and we are estimating that this "attrition" will actually outpace new supply. Also, we expect capacity to actively exit the market, meaning that fabs currently in commission will be closed or mothballed. The exit of capacity could take several forms, including companies exiting the market, consolidation in the industry, and outright mothballing of fabs. Recent examples are the net loss of the TwinStar fab in the United States, which was part of the sale of Texas Instruments' memory business to Micron Technology, and the recent closing of the Siemens fab in the United Kingdom. The situation should set up nicely for a shortage of capacity in the year 2000.

Silicon consumption in the DRAM market accounts for 13 to 16 percent of silicon consumption, and in order to meet the bit demand in 1999, roughly 13 percent less silicon will be required at the end of 1999 compared to the end of 1998, primarily because of the silicon efficiencies generated by the 64Mb density. As the DRAM density transition is completed, sequential silicon demand should accelerate starting in mid-2000, yielding continued double-digit MSI growth rates through early 2002. About 50 percent more silicon will be required to meet the demand of early 2002 when compared to mid-2000. The reduced capital spending pattern of 1998 to 1999 should actually set net capacity in the DRAM area on a downward trend. In 2000, these two trends will meet to produce an undersupply condition.

Foundry Capacity Now in Acute Oversupply: Lower Prices

The foundry market has also made a transition to overcapacity. Unfortunately, the stall in semiconductor demand has made the forecast oversupply much more acute; it is now calculated to be between 30 and 40 percent. Foundry suppliers have reacted to this oversupply condition much faster than DRAM suppliers by cutting back spending heavily for the remainder of 1998. Total spending in 1998 is now estimated at 20 percent growth as a group compared to earlier estimates of 40 percent. We expect 1999 spending in the foundry area to be cut significantly, perhaps 20 to 30 percent below 1998 levels.

The excess foundry capacity that exists today is also technologically mismatched with the current demand, creating a technology glut. The greatest oversupply exists in the leading-edge technology. This observation is confirmed by recent trends in wafer process, where the most severe declines can be seen in 0.35-micron and now in 0.25-micron wafers.

Foundry overcapacity is expected to remain critical throughout most of 2000. Prices for foundry wafers generally are declining at a very rapid rate. Dataquest surveys pricing in this market every four months, and in our most recent survey showed prices declining 10 to 13 percent over four months. The markets for fabless companies, the main customer of foundry, tend to be very competitive. These fabless companies as a result cannot keep the benefits of the lower cost structure and are forced to pass on these cost reductions to the market. For the first time in history, the foundry market is having a major impact on semiconductor pricing in the logic and chipset areas. These assumptions have been factored into our semiconductor forecast for 1999 and 2000.

Dataquest expects some balance to return to the foundry market by 2001, as demand picks up generally and is accelerated by the delay of the movement to 300mm wafers. We expect the foundry industry to benefit from integrated device manufacturers choosing to outsource rather than build a 200mm fab that may have a short lifetime or a 300mm fab before processes are debugged. Therefore, pricing for foundry wafers in the 2001-to-2002 time frame should be firm.

Pricing

Pricing in the current market is very near or, in some cases, below cost levels for selected semiconductor devices. In this environment, price changes have very little space to move lower, while oversupply of most devices continues and demand is not expected to increase appreciably, causing a price hike. The current estimate for near term pricing is that pricing will continue to decline overall at a much slower rate than in the past two years. In some cases, new technology memory not yet in volume production may actually show very short-term increases, but as the tide of oversupply catches up pricing in these areas will also follow the declining trend.

Long-term pricing will follow the cyclical nature of capital spending patterns. The current overcapitalized market is expected to burn off the investments made over the past four years by the end of 1999. Renewed investment after that point will take time to come to market. In the interim, overall demand continues to pressure supply, and without continuous increases in supply, prices will begin to increase in the 2000-to-2001 time frame. By 2002, supply is expected to overshoot demand again, and another cycle of price cutting is expected to begin. It is hoped that investment for the next generation of capital equipment will be in better balance with overall demand levels to prevent the steep price declines that gross oversupply brings.

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Chapter 9
Exchange Rates

We do not forecast exchange rates. The following exchange rate is used for the 1998 forecast:

- Yen: 136.35 per U.S. dollar

The following exchange rate is used for the 1999-to-2002 forecast:

- Yen: 140.79 per U.S. dollar

Table 9-1 shows exchange rates of the yen and European Currency Unit (ECU) versus the U.S. dollar for the period from 1980 to 1997. The appreciation of the dollar against these local currencies is given in the last two columns.

Table 9-1
Exchange Rates

Year	Yen per U.S. Dollar	ECU per U.S. Dollar	U.S. Dollar Growth versus Yen (%)	U.S. Dollar Growth versus ECU (%)
1980	227.00	-	3.6	-
1981	221.00	-	-2.7	-
1982	248.00	-	12.2	-
1983	235.00	-	-5.2	-
1984	237.00	-	0.9	-
1985	238.00	-	0.4	-
1986	167.00	-	-29.8	-
1987	144.00	-	-13.8	-
1988	130.00	0.846	-9.7	-2.5
1989	138.00	0.908	6.2	7.3
1990	144.00	0.788	4.3	-13.2
1991	136.00	0.811	-5.6	2.9
1992	126.45	0.770	-7.0	-5.0
1993	111.20	0.858	-12.1	11.4
1994	101.81	0.840	-8.4	-2.1
1995	93.90	0.774	-7.8	-7.9
1996	108.81	0.800	15.9	3.2
1997	121.10	0.885	11.3	10.6

Source: Dataquest (September 1998)

Appendix A

Regional Forecasts

Tables A-1 through A-4 provide the product forecasts by region. Tables A-5 through A-12 provide the regional forecasts by product and also the 1992-to-1997 history.

Table A-1
Microcomponent Consumption by Region, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1997-2002 CAGR (%)
MOS Microcomponent													
Worldwide	**48,945**	**18.0**	**48,170**	**-1.6**	**52,440**	**8.9**	**59,990**	**14.4**	**69,280**	**15.5**	**79,690**	**15.0**	**10.2**
Americas	17,785	21.9	18,010	1.3	19,780	9.8	22,360	13.0	25,230	12.8	28,700	13.8	10.0
Japan	9,336	6.1	7,640	-18.2	8,110	6.2	9,370	15.5	11,280	20.4	12,820	13.7	6.5
Europe	10,939	17.1	11,470	4.9	12,340	7.6	14,010	13.5	16,070	14.7	18,560	15.5	11.2
Asia/Pacific	10,885	24.5	11,050	1.5	12,210	10.5	14,250	16.7	16,700	17.2	19,610	17.4	12.5
Microprocessor													
Worldwide	**23,659**	**26.1**	**24,440**	**3.3**	**27,180**	**11.2**	**30,300**	**11.5**	**33,670**	**11.1**	**38,080**	**13.1**	**10.0**
Americas	10,626	33.4	11,200	5.4	12,510	11.7	13,870	10.9	15,120	9.0	16,850	11.4	9.7
Japan	2,676	14.7	2,030	-24.1	2,210	8.9	2,540	14.9	3,000	18.1	3,470	15.7	5.3
Europe	5,901	16.6	6,620	12.2	7,210	8.9	7,870	9.2	8,630	9.7	9,730	12.7	10.5
Asia/Pacific	4,456	31.4	4,590	3.0	5,250	14.4	6,020	14.7	6,920	15.0	8,030	16.0	12.5
Microcontroller													
Worldwide	**10,896**	**6.4**	**9,720**	**-10.8**	**10,430**	**7.3**	**12,350**	**18.4**	**14,860**	**20.3**	**17,390**	**17.0**	**9.8**
Americas	2,194	0.6	2,160	-1.5	2,280	5.6	2,690	18.0	3,280	21.9	3,900	18.9	12.2
Japan	4,059	3.3	3,210	-20.9	3,510	9.3	4,050	15.4	4,850	19.8	5,510	13.6	6.3
Europe	2,330	11.9	2,140	-8.2	2,190	2.3	2,620	19.6	3,190	21.8	3,800	19.1	10.3
Asia/Pacific	2,313	12.8	2,210	-4.5	2,450	10.9	2,990	22.0	3,540	18.4	4,180	18.1	12.6
Microperipheral													
Worldwide	**10,736**	**6.5**	**9,850**	**-8.3**	**9,870**	**0.2**	**11,070**	**12.2**	**12,720**	**14.9**	**14,530**	**14.2**	**6.2**
Americas	3,887	6.6	3,390	-12.8	3,480	2.7	3,940	13.2	4,560	15.7	5,240	14.9	6.2
Japan	1,873	-9.2	1,670	-10.8	1,570	-6.0	1,690	7.6	1,850	9.5	2,040	10.3	1.7
Europe	1,661	8.0	1,500	-9.7	1,480	-1.3	1,660	12.2	1,920	15.7	2,170	13.0	5.5
Asia/Pacific	3,315	17.0	3,290	-0.8	3,340	1.5	3,780	13.2	4,390	16.1	5,080	15.7	8.9
Digital Signal Processor													
Worldwide	**3,654**	**53.0**	**4,160**	**13.8**	**4,960**	**19.2**	**6,270**	**26.4**	**8,030**	**28.1**	**9,690**	**20.7**	**21.5**
Americas	1,078	36.1	1,260	16.9	1,510	19.8	1,860	23.2	2,270	22.0	2,710	19.4	20.2
Japan	728	54.9	730	0.3	820	12.3	1,090	32.9	1,580	45.0	1,800	13.9	19.8
Europe	1,047	59.1	1,210	15.6	1,460	20.7	1,860	27.4	2,330	25.3	2,860	22.7	22.3
Asia/Pacific	801	71.2	960	19.9	1,170	21.9	1,460	24.8	1,850	26.7	2,320	25.4	23.7

Source: Dataquest (September 1998)

Table A-2
MOS Memory Consumption by Region, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1997-2002 CAGR (%)
MOS Memory													
Worldwide	**30,978**	**-18.6**	**24,474**	**-21.0**	**30,349**	**24.0**	**45,987**	**51.5**	**68,765**	**49.5**	**64,694**	**-5.9**	**15.9**
Americas	11,898	-18.7	9,672	-18.7	12,078	24.9	18,704	54.9	27,233	45.6	25,809	-5.2	16.8
Japan	6,523	-23.1	5,039	-22.8	6,132	21.7	8,935	45.7	13,627	52.5	13,023	-4.4	14.8
Europe	6,041	-12.7	4,787	-20.8	5,984	25.0	9,420	57.4	13,588	44.2	13,024	-4.1	16.6
Asia/Pacific	6,516	-18.7	4,976	-23.6	6,156	23.7	8,927	45.0	14,317	60.4	12,838	-10.3	14.5
Dynamic RAM													
Worldwide	**20,744**	**-20.3**	**14,276**	**-31.2**	**18,557**	**30.0**	**31,855**	**71.7**	**51,694**	**62.3**	**45,595**	**-11.8**	**17.1**
Americas	8,233	-21.3	5,911	-28.2	7,766	31.4	13,619	75.4	20,941	53.8	18,902	-9.7	18.1
Japan	3,837	-24.1	2,446	-36.3	3,156	29.0	5,420	71.7	9,473	74.8	8,421	-11.1	17.0
Europe	4,032	-12.8	2,838	-29.6	3,691	30.1	6,670	80.7	10,255	53.8	9,257	-9.7	18.1
Asia/Pacific	4,642	-21.0	3,081	-33.6	3,944	28.0	6,146	55.8	11,025	79.4	9,015	-18.2	14.2
Static RAM													
Worldwide	**4,008**	**-20.2**	**4,372**	**9.1**	**5,050**	**15.5**	**6,250**	**23.8**	**7,893**	**26.3**	**8,578**	**8.7**	**16.4**
Americas	1,852	-10.3	2,037	10.0	2,296	12.7	2,726	18.7	3,551	30.3	3,769	6.1	15.3
Japan	911	-26.1	1,002	10.0	1,148	14.6	1,421	23.8	1,794	26.2	1,950	8.7	16.4
Europe	646	-18.9	674	4.3	814	20.8	1,007	23.8	1,272	26.3	1,382	8.7	16.4
Asia/Pacific	599	-35.3	660	10.1	792	20.1	1,096	38.4	1,276	16.4	1,476	15.7	19.8
Nonvolatile Memory													
Worldwide	**5,571**	**-13.7**	**5,100**	**-8.5**	**5,933**	**16.3**	**6,992**	**17.9**	**8,193**	**17.2**	**9,432**	**15.1**	**11.1**
Americas	1,519	-16.5	1,395	-8.2	1,654	18.6	1,972	19.2	2,309	17.1	2,646	14.6	11.7
Japan	1,612	-21.1	1,410	-12.5	1,627	15.4	1,873	15.1	2,115	12.9	2,381	12.6	8.1
Europe	1,216	-14.0	1,112	-8.5	1,298	16.7	1,544	19.0	1,839	19.1	2,140	16.4	12.0
Asia/Pacific	1,224	4.0	1,182	-3.4	1,355	14.6	1,604	18.4	1,930	20.3	2,265	17.4	13.1
Other MOS Memory													
Worldwide	**655**	**13.5**	**726**	**10.9**	**809**	**11.3**	**889**	**9.9**	**984**	**10.7**	**1,089**	**10.6**	**10.7**
Americas	294	-3.0	329	12.1	361	9.6	387	7.3	432	11.6	492	13.7	10.8
Japan	163	6.5	181	11.0	201	11.0	221	10.0	245	10.9	271	10.6	10.7
Europe	147	72.9	163	10.9	182	11.4	200	9.9	221	10.7	244	10.7	10.7
Asia/Pacific	51	41.7	53	3.9	65	22.6	81	24.6	86	6.2	82	-4.7	10.0

Source: Dataquest (September 1998)

Table A-3
Logic Consumption by Region, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1997-2002 CAGR (%)
MOS Digital Logic													
Worldwide	24,757	9.2	23,551	-4.9	24,900	5.7	29,342	17.8	34,497	17.6	40,474	17.3	10.3
Americas	8,525	12.7	8,367	-1.9	9,090	8.6	10,943	20.4	13,145	20.1	15,777	20.0	13.1
Japan	8,164	4.4	7,165	-12.2	7,106	-0.8	7,920	11.5	8,944	12.9	10,021	12.0	4.2
Europe	4,159	5.2	4,128	-0.7	4,455	7.9	5,395	21.1	6,451	19.6	7,717	19.6	13.2
Asia/Pacific	3,909	17.2	3,891	-0.5	4,249	9.2	5,084	19.7	5,958	17.2	6,958	16.8	12.2
ASIC													
Worldwide	16,527	11.7	15,898	-3.8	17,213	8.3	20,895	21.4	25,332	21.2	30,540	20.6	13.1
Americas	7,098	18.6	7,086	-0.2	7,820	10.3	9,553	22.2	11,678	22.2	14,269	22.2	15.0
Japan	4,577	4.0	4,002	-12.6	4,117	2.9	4,745	15.2	5,565	17.3	6,404	15.1	6.9
Europe	3,190	12.9	3,170	-0.6	3,446	8.7	4,290	24.5	5,248	22.3	6,404	22.0	15.0
Asia/Pacific	1,662	4.7	1,640	-1.3	1,830	11.6	2,308	26.1	2,842	23.1	3,463	21.9	15.8
Custom IC													
Worldwide	1,514	-12.2	1,074	-29.1	710	-33.9	480	-32.4	300	-37.4	176	-41.5	-35.0
Americas	223	-26.6	145	-35.0	64	-55.6	38	-40.7	20	-48.8	9	-55.0	-47.6
Japan	795	-5.2	574	-27.8	396	-31.0	267	-32.5	167	-37.4	99	-41.0	-34.1
Europe	71	-47.8	44	-38.0	29	-35.0	20	-30.0	13	-35.0	8	-40.0	-35.7
Asia/Pacific	425	-4.5	311	-26.8	221	-29.0	155	-30.0	100	-35.0	60	-40.0	-32.3
MOS Standard Logic													
Worldwide	2,266	13.7	2,109	-6.9	2,177	3.2	2,305	5.9	2,355	2.2	2,359	0.2	0.8
Americas	684	4.9	636	-7.0	665	4.5	708	6.6	719	1.5	690	-4.0	0.2
Japan	500	11.4	462	-7.6	468	1.2	498	6.6	513	3.0	524	2.0	0.9
Europe	466	11.0	457	-2.0	469	2.6	487	4.0	499	2.5	509	2.0	1.8
Asia/Pacific	616	30.5	554	-10.0	577	4.0	611	6.0	623	2.0	636	2.0	0.6
Total Other MOS Logic													
Worldwide	4,450	7.0	4,470	0.4	4,799	7.4	5,661	18.0	6,510	15.0	7,400	13.7	10.7
Americas	520	-16.7	499	-4.0	542	8.5	643	18.8	728	13.2	809	11.1	9.2
Japan	2,292	7.6	2,127	-7.2	2,125	-0.1	2,410	13.4	2,699	12.0	2,996	11.0	5.5
Europe	432	-24.5	458	6.0	511	11.7	598	16.9	691	15.5	796	15.3	13.0
Asia/Pacific	1,206	45.1	1,386	14.9	1,621	17.0	2,010	24.0	2,392	19.0	2,799	17.0	18.3

Source: Dataquest (September 1998)

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Table A-4
Analog, Discrete and Optical Consumption by Region, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1997-2002 CAGR (%)
Analog-Monolithic													
Worldwide	**21,652**	**18.7**	**22,020**	**1.7**	**25,532**	**15.9**	**30,346**	**18.9**	**35,609**	**17.3**	**40,601**	**14.0**	**13.4**
Americas	5,477	23.8	5,504	0.5	6,506	18.2	7,970	22.5	9,723	22.0	11,328	16.5	15.6
Japan	4,977	8.7	4,298	-13.6	4,522	5.2	4,922	8.8	5,403	9.8	5,951	10.1	3.6
Europe	4,888	17.8	5,750	17.6	6,613	15.0	7,591	14.8	8,548	12.6	9,299	8.8	13.7
Asia/Pacific	6,310	24.1	6,468	2.5	7,891	22.0	9,863	25.0	11,935	21.0	14,023	17.5	17.3
Total Discrete													
Worldwide	**14,255**	**5.8**	**13,829**	**-3.0**	**15,073**	**9.0**	**17,573**	**16.6**	**19,388**	**10.3**	**20,562**	**6.1**	**7.6**
Americas	3,074	5.1	3,000	-2.4	3,245	8.2	3,811	17.4	4,246	11.4	4,500	6.0	7.9
Japan	4,244	-3.7	3,529	-16.8	3,708	5.1	4,062	9.5	4,438	9.3	4,862	9.6	2.8
Europe	3,120	9.6	3,400	9.0	3,820	12.4	4,600	20.4	5,204	13.1	5,400	3.8	11.6
Asia/Pacific	3,817	15.9	3,900	2.2	4,300	10.3	5,100	18.6	5,500	7.8	5,800	5.5	8.7
Total Optical Semiconductor													
Worldwide	5,339	8.6	5,281	-1.1	5,580	5.7	6,081	9.0	6,577	8.2	7,217	9.7	6.2
Americas	970	31.3	980	1.0	1,050	7.1	1,125	7.1	1,200	6.7	1,275	6.3	5.6
Japan	2,725	3.3	2,552	-6.3	2,649	3.8	2,852	7.7	3,081	8.0	3,411	10.7	4.6
Europe	731	-8.5	804	10.0	860	7.0	930	8.1	995	7.0	1,050	5.5	7.5
Asia/Pacific	913	23.5	945	3.5	1,021	8.0	1,174	15.0	1,301	10.8	1,481	13.8	10.2

Source: Dataquest (September 1998)

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Table A-5
Americas Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1997-2002 CAGR (%)
Total Semiconductor	**48,086**	**5.3**	**45,836**	**-4.7**	**51,996**	**13.4**	**65,134**	**25.3**	**80,966**	**24.3**	**87,553**	**8.1**	**12.7**
Total Semiconductor (without DRAM)	**39,853**	**13.2**	**39,925**	**0.2**	**44,230**	**10.8**	**51,515**	**16.5**	**60,026**	**16.5**	**68,651**	**18**	**11.5**
Bipolar Digital	357	-40.2	303	-15.1	247	-18.5	221	-10.5	190	-14.0	164	-13.7	-14.4
MOS Memory	11,898	-18.7	9,672	-18.7	12,078	24.9	18,704	54.9	27,233	45.6	25,809	-5.2	16.8
Dynamic RAM	8,233	-21.3	5,911	-28.2	7,766	31.4	13,619	75.4	20,941	53.8	18,902	-9.7	18.1
Static RAM	1,852	-10.3	2,037	10.0	2,296	12.7	2,726	18.7	3,551	30.3	3,769	6.1	15.3
Nonvolatile Memory	1,519	-16.5	1,395	-8.2	1,654	18.6	1,972	19.2	2,309	17.1	2,646	14.6	11.7
Other MOS Memory	294	-3.0	329	12.1	361	9.6	387	7.3	432	11.6	492	13.7	10.8
MOS Microcomponent	17,785	21.9	18,010	1.3	19,780	9.8	22,360	13.0	25,230	12.8	28,700	13.8	10.0
Microprocessor	10,626	33.4	11,200	5.4	12,510	11.7	13,870	10.9	15,120	9.0	16,850	11.4	9.7
Microcontroller	2,194	0.6	2,160	-1.5	2,280	5.6	2,690	18.0	3,280	21.9	3,900	18.9	12.2
Microperipheral	3,887	6.6	3,390	-12.8	3,480	2.7	3,940	13.2	4,560	15.7	5,240	14.9	6.2
Digital Signal Processor	1,078	36.1	1,260	16.9	1,510	19.8	1,860	23.2	2,270	22.0	2,710	19.4	20.2
MOS Digital Logic	8,525	12.7	8,367	-1.9	9,090	8.6	10,943	20.4	13,145	20.1	15,777	20.0	13.1
ASIC	7,098	18.6	7,086	-0.2	7,820	10.3	9,553	22.2	11,678	22.2	14,269	22.2	15.0
Custom IC	223	-26.6	145	-35.0	64	-55.6	38	-40.7	20	-48.8	9	-55.0	-47.6
MOS Standard Logic	684	4.9	636	-7.0	665	4.5	708	6.6	719	1.5	690	-4.0	0.2
Total Other MOS Logic	520	-16.7	499	-4.0	542	8.5	643	18.8	728	13.2	809	11.1	9.2
Analog-Monolithic	5,477	23.8	5,504	0.5	6,506	18.2	7,970	22.5	9,723	22.0	11,328	16.5	15.6
Total Discrete	3,074	5.1	3,000	-2.4	3,245	8.2	3,811	17.4	4,246	11.4	4,500	6.0	7.9
Total Optical Semiconductor	970	31.3	980	1.0	1,050	7.1	1,125	7.1	1,200	6.7	1,275	6.3	5.6

Source: Dataquest (September 1998)

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Table A-6
Americas Semiconductor Market, Revenue Forecast, 1992 to 1997 (Millions of Dollars)

	1992 Revenue	1992 Growth (%)	1993 Revenue	1993 Growth (%)	1994 Revenue	1994 Growth (%)	1995 Revenue	1995 Growth (%)	1996 Revenue	1996 Growth (%)	1997 Revenue	1997 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	20,426	20.2	27,924	36.7	35,773	28.1	48,343	35.1	45,672	-5.5	48,086	5.3	18.7
Total Semiconductor (without DRAM)	16,871	17.2	22,092	30.9	26,743	21.1	32,604	21.9	35,217	8.0	39,853	27	18.8
Bipolar Digital	1,232	-7.4	1,173	-4.8	967	-17.6	760	-21.4	597	-21.4	357	-40.2	-21.9
MOS Memory	5,707	26.5	8,785	53.9	12,469	41.9	20,480	64.2	14,642	-28.5	11,898	-18.7	15.8
Dynamic RAM	3,555	36.7	5,832	64.1	9,030	54.8	15,739	74.3	10,455	-33.6	8,233	-21.3	18.3
Static RAM	1,107	24.5	1,349	21.9	1,630	20.8	2,509	53.9	2,064	-17.7	1,852	-10.3	10.8
Nonvolatile Memory	924	3.2	1,449	56.8	1,634	12.8	1,951	19.4	1,820	-6.7	1,519	-16.5	10.5
Other MOS Memory	121	-3.2	155	28.1	175	12.9	281	60.6	303	7.8	294	-3.0	19.4
MOS Microcomponent	5,282	34.8	7,620	44.3	9,839	29.1	12,425	26.3	14,587	17.4	17,785	21.9	27.5
Microprocessor	2,674	53.2	4,323	61.7	5,446	26.0	6,800	24.9	7,968	17.2	10,626	33.4	31.8
Microcontroller	938	19.3	1,254	33.7	1,652	31.7	2,048	24.0	2,181	6.5	2,194	0.6	18.5
Microperipheral	1,486	17.4	1,764	18.7	2,320	31.5	2,982	28.5	3,646	22.3	3,887	6.6	21.2
Digital Signal Processor	184	54.6	279	51.6	421	50.9	595	41.3	792	33.1	1,078	36.1	42.4
MOS Digital Logic	3,179	10.8	4,459	40.3	5,422	21.6	6,801	25.4	7,566	11.2	8,525	12.7	21.8
ASIC	2,313	10.6	3,088	33.5	3,846	24.5	5,012	30.3	5,986	19.4	7,098	18.6	25.1
Custom IC	207	5.1	291	40.6	493	69.4	529	7.3	304	-42.5	223	-26.6	1.5
MOS Standard Logic	369	31.3	433	17.3	563	30.0	684	21.5	652	-4.7	684	4.9	13.1
Total Other MOS Logic	290	-3.7	652	124.8	525	-19.5	582	10.9	624	7.2	520	-16.7	12.4
Analog-Monolithic	2,691	12.3	3,304	22.8	3,820	15.6	3,994	4.6	4,425	10.8	5,477	23.8	15.3
Total Discrete	1,603	15.4	1,811	13.0	2,212	22.1	3,027	36.8	2,924	-3.4	3,074	5.1	13.9
Total Optical Semiconductor	423	27.4	484	14.4	697	44.0	625	-10.3	739	18.2	970	31.3	18.1

Source: Dataquest (September 1998)

Table A-7
Japan Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1997-2002 CAGR (%)
Total Semiconductor	**36,499**	**-5.0**	**30,721**	**-15.8**	**32,652**	**6.3**	**38,450**	**17.8**	**47,108**	**22.5**	**50,388**	**7.0**	**6.7**
Total Semiconductor (without DRAM)	**32,662**	**(2.1)**	**28,275**	**-13.4**	**29,496**	**4.3**	**33,030**	**12.0**	**37,635**	**13.9**	**41,967**	**18**	**5.1**
Bipolar Digital	530	-31.2	498	-6.0	425	-14.7	389	-8.5	335	-13.9	300	-10.4	-10.8
MOS Memory	6,523	-23.1	5,039	-22.8	6,132	21.7	8,935	45.7	13,627	52.5	13,023	-4.4	14.8
Dynamic RAM	3,837	-24.1	2,446	-36.3	3,156	29.0	5,420	71.7	9,473	74.8	8,421	-11.1	17.0
Static RAM	911	-26.1	1,002	10.0	1,148	14.6	1,421	23.8	1,794	26.2	1,950	8.7	16.4
Nonvolatile Memory	1,612	-21.1	1,410	-12.5	1,627	15.4	1,873	15.1	2,115	12.9	2,381	12.6	8.1
Other MOS Memory	163	6.5	181	11.0	201	11.0	221	10.0	245	10.9	271	10.6	10.7
MOS Microcomponent	9,336	6.1	7,640	-18.2	8,110	6.2	9,370	15.5	11,280	20.4	12,820	13.7	6.5
Microprocessor	2,676	14.7	2,030	-24.1	2,210	8.9	2,540	14.9	3,000	18.1	3,470	15.7	5.3
Microcontroller	4,059	3.3	3,210	-20.9	3,510	9.3	4,050	15.4	4,850	19.8	5,510	13.6	6.3
Microperipheral	1,873	-9.2	1,670	-10.8	1,570	-6.0	1,690	7.6	1,850	9.5	2,040	10.3	1.7
Digital Signal Processor	728	54.9	730	0.3	820	12.3	1,090	32.9	1,580	45.0	1,800	13.9	19.8
MOS Digital Logic	8,164	4.4	7,165	-12.2	7,106	-0.8	7,920	11.5	8,944	12.9	10,021	12.0	4.2
ASIC	4,577	4.0	4,002	-12.6	4,117	2.9	4,745	15.2	5,565	17.3	6,404	15.1	6.9
Custom IC	795	-5.2	574	-27.8	396	-31.0	267	-32.5	167	-37.4	99	-41.0	-34.1
MOS Standard Logic	500	11.4	462	-7.6	468	1.2	498	6.6	513	3.0	524	2.0	0.9
Total Other MOS Logic	2,292	7.6	2,127	-7.2	2,125	-0.1	2,410	13.4	2,699	12.0	2,996	11.0	5.5
Analog-Monolithic	4,977	8.7	4,298	-13.6	4,522	5.2	4,922	8.8	5,403	9.8	5,951	10.1	3.6
Total Discrete	4,244	-3.7	3,529	-16.8	3,708	5.1	4,062	9.5	4,438	9.3	4,862	9.6	2.8
Total Optical Semiconductor	2,725	3.3	2,552	-6.3	2,649	3.8	2,852	7.7	3,081	8.0	3,411	10.7	4.6

Source: Dataquest (September 1998)

Table A-8
Japan Semiconductor Market, Revenue Forecast, 1992 to 1997 (Millions of Dollars)

	1992 Revenue	1992 Growth (%)	1993 Revenue	1993 Growth (%)	1994 Revenue	1994 Growth (%)	1995 Revenue	1995 Growth (%)	1996 Revenue	1996 Growth (%)	1997 Revenue	1997 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	20,582	-8.5	24,645	19.7	31,008	25.8	42,086	35.7	38,413	-8.7	36,499	-5.0	12.1
Total Semiconductor (without DRAM)	18,782	(8.6)	21,958	16.9	26,996	22.9	33,596	24.4	33,356	-0.7	32,662	19	11.7
Bipolar Digital	1,154	-20.0	1,128	-2.3	1,216	7.8	1,068	-12.2	770	-27.9	530	-31.2	-14.4
MOS Memory	4,037	-4.5	5,570	38.0	7,246	30.1	12,168	67.9	8,487	-30.3	6,523	-23.1	10.1
Dynamic RAM	1,800	-7.6	2,687	49.3	4,012	49.3	8,490	111.6	5,057	-40.4	3,837	-24.1	16.3
Static RAM	1,029	-4.8	1,305	26.8	1,397	7.0	1,446	3.5	1,233	-14.7	911	-26.1	-2.4
Nonvolatile Memory	1,198	1.4	1,538	28.4	1,785	16.1	2,116	18.5	2,044	-3.4	1,612	-21.1	6.1
Other MOS Memory	10	-44.4	40	300.0	52	30.0	116	123.1	153	31.9	163	6.5	74.8
MOS Microcomponent	3,269	-8.7	3,987	22.0	5,603	40.5	7,826	39.7	8,797	12.4	9,336	6.1	23.4
Microprocessor	604	-1.9	835	38.2	1,247	49.3	1,686	35.2	2,334	38.4	2,676	14.7	34.7
Microcontroller	1,913	-12.2	2,284	19.4	2,964	29.8	4,140	39.7	3,930	-5.1	4,059	3.3	16.2
Microperipheral	650	-5.4	749	15.2	1,226	63.7	1,726	40.8	2,063	19.5	1,873	-9.2	23.6
Digital Signal Processor	102	5.2	119	16.7	166	39.5	274	65.1	470	71.5	728	54.9	48.2
MOS Digital Logic	3,837	-5.8	4,711	22.8	5,993	27.2	7,793	30.0	7,821	0.4	8,164	4.4	16.3
ASIC	1,749	-7.7	2,298	31.4	2,893	25.9	4,270	47.6	4,402	3.1	4,577	4.0	21.2
Custom IC	1,285	-3.8	1,477	14.9	1,308	-11.4	979	-25.2	839	-14.3	795	-5.2	-9.2
MOS Standard Logic	315	-7.1	386	22.5	443	14.8	519	17.2	449	-13.5	500	11.4	9.7
Total Other MOS Logic	488	-3.4	560	14.8	1,359	142.7	2,025	49.0	2,131	5.2	2,292	7.6	36.3
Analog-Monolithic	2,902	-6.2	3,278	13.0	4,048	23.5	4,745	17.2	4,577	-3.5	4,977	8.7	11.4
Total Discrete	3,077	-10.3	3,423	11.2	3,916	14.4	4,694	19.9	4,408	-6.1	4,244	-3.7	6.6
Total Optical Semiconductor	1,556	-12.9	1,728	11.1	2,097	21.4	2,768	32.0	2,638	-4.7	2,725	3.3	11.9

Source: Dataquest (September 1998)

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Table A-9
Europe Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1997-2002 CAGR (%)
Total Semiconductor	30,046	5.9	30,480	1.4	34,194	12.2	42,043	23.0	50,934	21.1	55,106	8.2	12.9
Total Semiconductor (without DRAM)	26,014	9.5	27,642	6.3	30,503	10.3	35,373	16.0	40,678	15.0	45,849	18	12.0
Bipolar Digital	168	-31.7	141	-16.1	122	-13.5	97	-20.5	78	-19.6	56	-28.2	-19.7
MOS Memory	6,041	-12.7	4,787	-20.8	5,984	25.0	9,420	57.4	13,588	44.2	13,024	-4.1	16.6
Dynamic RAM	4,032	-12.8	2,838	-29.6	3,691	30.1	6,670	80.7	10,255	53.8	9,257	-9.7	18.1
Static RAM	646	-18.9	674	4.3	814	20.8	1,007	23.8	1,272	26.3	1,382	8.7	16.4
Nonvolatile Memory	1,216	-14.0	1,112	-8.5	1,298	16.7	1,544	19.0	1,839	19.1	2,140	16.4	12.0
Other MOS Memory	147	72.9	163	10.9	182	11.4	200	9.9	221	10.7	244	10.7	10.7
MOS Microcomponent	10,939	17.1	11,470	4.9	12,340	7.6	14,010	13.5	16,070	14.7	18,560	15.5	11.2
Microprocessor	5,901	16.6	6,620	12.2	7,210	8.9	7,870	9.2	8,630	9.7	9,730	12.7	10.5
Microcontroller	2,330	11.9	2,140	-8.2	2,190	2.3	2,620	19.6	3,190	21.8	3,800	19.1	10.3
Microperipheral	1,661	8.0	1,500	-9.7	1,480	-1.3	1,660	12.2	1,920	15.7	2,170	13.0	5.5
Digital Signal Processor	1,047	59.1	1,210	15.6	1,460	20.7	1,860	27.4	2,330	25.3	2,860	22.7	22.3
MOS Digital Logic	4,159	5.2	4,128	-0.7	4,455	7.9	5,395	21.1	6,451	19.6	7,717	19.6	13.2
ASIC	3,190	12.9	3,170	-0.6	3,446	8.7	4,290	24.5	5,248	22.3	6,404	22.0	15.0
Custom IC	71	-47.8	44	-38.0	29	-35.0	20	-30.0	13	-35.0	8	-40.0	-35.7
MOS Standard Logic	466	11.0	457	-2.0	469	2.6	487	4.0	499	2.5	509	2.0	1.8
Total Other MOS Logic	432	-24.5	458	6.0	511	11.7	598	16.9	691	15.5	796	15.3	13.0
Analog-Monolithic	4,888	17.8	5,750	17.6	6,613	15.0	7,591	14.8	8,548	12.6	9,299	8.8	13.7
Total Discrete	3,120	9.6	3,400	9.0	3,820	12.4	4,600	20.4	5,204	13.1	5,400	3.8	11.6
Total Optical Semiconductor	731	-8.5	804	10.0	860	7.0	930	8.1	995	7.0	1,050	5.5	7.5

Source: Dataquest (September 1998)

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Table A-10
Europe Semiconductor Market, Revenue Forecast, 1992 to 1997 (Millions of Dollars)

	1992 Revenue	1992 Growth (%)	1993 Revenue	1993 Growth (%)	1994 Revenue	1994 Growth (%)	1995 Revenue	1995 Growth (%)	1996 Revenue	1996 Growth (%)	1997 Revenue	1997 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	12,218	10.9	15,459	26.5	20,900	35.2	28,416	36.0	28,379	-0.1	30,046	5.9	19.7
Total Semiconductor (without DRAM)	10,661	8.7	12,788	20.0	15,973	24.9	20,529	28.5	23,757	15.7	26,014	19	19.5
Bipolar Digital	426	-12.3	390	-8.5	357	-8.5	306	-14.3	246	-19.6	168	-31.7	-17.0
MOS Memory	2,660	24.9	4,040	51.9	6,574	62.7	10,074	53.2	6,918	-31.3	6,041	-12.7	17.8
Dynamic RAM	1,557	29.2	2,671	71.5	4,927	84.5	7,887	60.1	4,622	-41.4	4,032	-12.8	21.0
Static RAM	458	21.5	525	14.6	620	18.1	921	48.5	797	-13.5	646	-18.9	7.1
Nonvolatile Memory	607	17.6	798	31.5	966	21.1	1,180	22.2	1,414	19.8	1,216	-14.0	14.9
Other MOS Memory	38	22.6	46	21.1	61	32.6	86	41.0	85	-1.2	147	72.9	31.1
MOS Microcomponent	2,723	30.9	4,037	48.3	5,408	34.0	7,000	29.4	9,341	33.4	10,939	17.1	32.1
Microprocessor	1,088	60.5	2,098	92.8	2,775	32.3	3,196	15.2	5,062	58.4	5,901	16.6	40.2
Microcontroller	934	17.8	1,106	18.4	1,431	29.4	2,030	41.9	2,083	2.6	2,330	11.9	20.1
Microperipheral	571	5.7	615	7.7	897	45.9	1,226	36.7	1,538	25.4	1,661	8.0	23.8
Digital Signal Processor	130	85.7	218	67.7	305	39.9	548	79.7	658	20.1	1,047	59.1	51.8
MOS Digital Logic	1,749	6.5	1,936	10.7	2,330	20.4	2,959	27.0	3,953	33.6	4,159	5.2	18.9
ASIC	965	9.8	1,114	15.4	1,369	22.9	1,867	36.4	2,825	51.3	3,190	12.9	27.0
Custom IC	171	1.8	140	-18.1	157	12.1	169	7.6	136	-19.5	71	-47.8	-16.1
MOS Standard Logic	248	18.1	311	25.4	419	34.7	483	15.3	420	-13.0	466	11.0	13.4
Total Other MOS Logic	366	-5.4	378	3.3	390	3.2	446	14.4	572	28.3	432	-24.5	3.4
Analog-Monolithic	2,249	3.0	2,736	21.7	3,370	23.2	4,134	22.7	4,148	0.3	4,888	17.8	16.8
Total Discrete	1,826	-0.1	1,769	-3.1	2,108	19.2	3,118	47.9	2,848	-8.7	3,120	9.6	11.3
Total Optical Semiconductor	434	-10.5	372	-14.3	575	54.6	681	18.4	799	17.3	731	-8.5	11.0

Source: Dataquest (September 1998)

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Table A-11
Asia/Pacific Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1997-2002 CAGR (%)
Total Semiconductor	**32,534**	**9.6**	**31,400**	**-3.5**	**35,978**	**14.6**	**44,526**	**23.8**	**55,815**	**25.4**	**60,795**	**8.9**	**13.3**
Total Semiconductor (without DRAM)	**27,892**	**17.2**	**28,319**	**1.5**	**32,034**	**13.1**	**38,380**	**19.8**	**44,790**	**16.7**	**51,780**	**27**	**13.2**
Bipolar Digital	184	-22.0	170	-7.6	152	-10.6	128	-15.8	104	-18.8	84	-19.2	-14.5
MOS Memory	6,516	-18.7	4,976	-23.6	6,156	23.7	8,927	45.0	14,317	60.4	12,838	-10.3	14.5
Dynamic RAM	4,642	-21.0	3,081	-33.6	3,944	28.0	6,146	55.8	11,025	79.4	9,015	-18.2	14.2
Static RAM	599	-35.3	660	10.1	792	20.1	1,096	38.4	1,276	16.4	1,476	15.7	19.8
Nonvolatile Memory	1,224	4.0	1,182	-3.4	1,355	14.6	1,604	18.4	1,930	20.3	2,265	17.4	13.1
Other MOS Memory	51	41.7	53	3.9	65	22.6	81	24.6	86	6.2	82	-4.7	10.0
MOS Microcomponent	10,885	24.5	11,050	1.5	12,210	10.5	14,250	16.7	16,700	17.2	19,610	17.4	12.5
Microprocessor	4,456	31.4	4,590	3.0	5,250	14.4	6,020	14.7	6,920	15.0	8,030	16.0	12.5
Microcontroller	2,313	12.8	2,210	-4.5	2,450	10.9	2,990	22.0	3,540	18.4	4,180	18.1	12.6
Microperipheral	3,315	17.0	3,290	-0.8	3,340	1.5	3,780	13.2	4,390	16.1	5,080	15.7	8.9
Digital Signal Processing	801	71.2	960	19.9	1,170	21.9	1,460	24.8	1,850	26.7	2,320	25.4	23.7
MOS Digital Logic	3,909	17.2	3,891	-0.5	4,249	9.2	5,084	19.7	5,958	17.2	6,958	16.8	12.2
ASIC	1,662	4.7	1,640	-1.3	1,830	11.6	2,308	26.1	2,842	23.1	3,463	21.9	15.8
Custom IC	425	-4.5	311	-26.8	221	-29.0	155	-30.0	100	-35.0	60	-40.0	-32.3
MOS Standard Logic	616	30.5	554	-10.0	577	4.0	611	6.0	623	2.0	636	2.0	0.6
Total Other MOS Logic	1,206	45.1	1,386	14.9	1,621	17.0	2,010	24.0	2,392	19.0	2,799	17.0	18.3
Analog-Monolithic	6,310	24.1	6,468	2.5	7,891	22.0	9,863	25.0	11,935	21.0	14,023	17.5	17.3
Total Discrete	**3,817**	**15.9**	**3,900**	**2.2**	**4,300**	**10.3**	**5,100**	**18.6**	**5,500**	**7.8**	**5,800**	**5.5**	**8.7**
Total Optical Semiconductor	**913**	**23.5**	**945**	**3.5**	**1,021**	**8.0**	**1,174**	**15.0**	**1,301**	**10.8**	**1,481**	**13.8**	**10.2**

Source: Dataquest (September 1998)

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Table A-12
Asia/Pacific Semiconductor Market, Revenue Forecast, 1992 to 1997 (Millions of Dollars)

	1992 Revenue	1992 Growth (%)	1993 Revenue	1993 Growth (%)	1994 Revenue	1994 Growth (%)	1995 Revenue	1995 Growth (%)	1996 Revenue	1996 Growth (%)	1997 Revenue	1997 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	**12,034**	**30.9**	**17,486**	**45.3**	**22,832**	**30.6**	**32,465**	**42.2**	**29,686**	**-8.6**	**32,534**	**9.6**	**22.0**
Total Semiconductor (without DRAM)	**10,181**	**27.8**	**14,095**	**38.4**	**17,535**	**24.4**	**22,332**	**27.4**	**23,808**	**6.6**	**27,892**	**31**	**22.3**
Bipolar Digital	381	3.3	388	1.8	372	-4.1	321	-13.7	236	-26.5	184	-22.0	-13.5
MOS Memory	2,904	47.1	4,911	69.1	7,216	46.9	12,565	74.1	8,017	-36.2	6,516	-18.7	17.5
Dynamic RAM	1,853	50.9	3,391	83.0	5,297	56.2	10,133	91.3	5,878	-42.0	4,642	-21.0	20.2
Static RAM	444	93.9	729	64.2	867	18.9	1,389	60.2	926	-33.3	599	-35.3	6.2
Nonvolatile Memory	587	17.4	766	30.5	1,022	33.4	992	-2.9	1,177	18.6	1,224	4.0	15.8
Other MOS Memory	20	17.6	25	25.0	30	20.0	51	70.0	36	-29.4	51	41.7	20.6
MOS Microcomponent	3,085	40.4	4,303	39.5	5,558	29.2	7,253	30.5	8,744	20.6	10,885	24.5	28.7
Microprocessor	1,135	33.4	1,527	34.5	1,969	28.9	2,587	31.4	3,392	31.1	4,456	31.4	31.5
Microcontroller	828	23.8	1,260	52.2	1,470	16.7	2,032	38.2	2,050	0.9	2,313	12.8	22.8
Microperipheral	1,094	64.8	1,453	32.8	1,981	36.3	2,382	20.2	2,834	19.0	3,315	17.0	24.8
Digital Signal Processor	28	115.4	63	125.0	138	119.0	252	82.6	468	85.7	801	71.2	95.6
MOS Digital Logic	1,277	14.6	2,015	57.8	2,363	17.3	3,114	31.8	3,336	7.1	3,909	17.2	25.1
ASIC	413	30.7	703	70.2	900	28.0	1,379	53.2	1,588	15.2	1,662	4.7	32.1
Custom IC	350	-17.5	459	31.1	544	18.5	466	-14.3	445	-4.5	425	-4.5	4.0
MOS Standard Logic	259	58.9	371	43.2	439	18.3	516	17.5	472	-8.5	616	30.5	18.9
Total Other MOS Logic	255	20.9	490	92.2	495	1.0	768	55.2	831	8.2	1,206	45.1	36.4
Analog-Monolithic	2,338	26.9	3,195	36.7	4,025	26.0	4,743	17.8	5,085	7.2	6,310	24.1	22.0
Total Discrete	**1,649**	**19.0**	**2,080**	**26.1**	**2,527**	**21.5**	**3,475**	**37.5**	**3,294**	**-5.2**	**3,817**	**15.9**	**18.3**
Total Optical Semiconductor	**275**	**37.5**	**418**	**52.0**	**520**	**24.4**	**738**	**41.9**	**739**	**0.1**	**913**	**23.5**	**27.1**

Source: Dataquest (September 1998)

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Worldwide Semiconductor Forecast and Trends: Spring 1998

Market Trends

Program: Semiconductors—Top Views
Product Code: SCND-WW-MT-9801
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Chapter 1
Executive Summary

Dataquest forecasts that worldwide semiconductor revenue will grow 8.2 percent in 1998, reaching $159 billion. The world market should grow at a 14.4 percent compound average growth rate (CAGR) from 1997 through 2002, reaching $288 billion in 2002.

Objectives

This forecast and market trends information serves the following objectives:

- Near-term planning for worldwide and regional semiconductor manufacturing, sales, and procurement tactics
- Long-term strategic planning for semiconductor product strategy and supply-base management
- Capital formation process decision-making in debt and equities markets

Forecast Highlights and Assumptions

The following are key assumptions and highlights of this forecast:

- Worldwide semiconductor revenue should increase by just over 8 percent in 1998 to a total of $159 billion. This modest recovery—which is a slower 1998 growth rate than originally expected—follows the slight 3.5 percent growth of 1997. The industry faces its third year of lackluster performance. The Asian financial crisis and low dynamic RAM (DRAM) pricing will hamper semiconductor revenue growth this year, although some product segments will achieve robust double-digit growth rates. In 1999, the market should grow by 18 percent to $188 billion. Long-term growth will be somewhat slower than in the previous forecast. By 2002, worldwide semiconductor revenue should total nearly $290 billion, which marks a 14.4 percent CAGR for the five-year period from 1997 through 2002.
- Worldwide PC unit shipments will increase by just over 15 percent in 1998 and exceed 90 million units. PC revenue will grow by just 6.4 percent this year, however, in part because of the emergence of the "sub-$1,000 PC." In the long term, the semiconductor forecast assumes that worldwide PC unit shipments will grow at a 16 percent CAGR for the five-year period and total nearly 170 million units in 2002. PC revenue, however, should grow at a slower 9 percent CAGR because of the decline in PC pricing.
- The semiconductor industry should retain long-term vitality. PCs, communications, and consumer electronics will continue to rank as the most important application markets. The trend toward system-level integration (SLI) bodes well for the industry. The impact of information technology (IT) market challenges such as the year 2000 (Y2K) problem and the European Monetary Union (EMU) remain uncertain. However, the effect of these on the semiconductor market will likely "filter" through their impact on the PC, communications, and related equipment sectors.

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- The Asian crisis means somewhat lower near-term and long-term expectations for Japan and Asia/Pacific. Japan will remain behind the Americas region as the world's second-largest semiconductor consumption market until 2000, when Asia/Pacific should surpass Japan.
- The x86 architecture, as the central processor in the PC, serves as the major driving force for the PC and microprocessor (MPU) markets. As expected, MPU revenue growth will start to moderate following the extremely high growth of the 1992-to-1997 period. For 1998, worldwide MPU revenue should increase by just over 15 percent—and at a 16 percent CAGR for the 1997-to-2002 time frame.
- Microprocessors in embedded applications will continue to fuel the growth of MPUs for a wider array of vendors. For example, growth in video games, communications, and Internet appliances continues to drive the embedded RISC market.
- Digital signal processors (DSPs) rank among the highest-growth semiconductor products. These devices are the centerpiece of communications electronics such as cell phones, modems, and the emerging consumer digital electronics. DSP technology is vital in speeding up the information highway. Worldwide DSP revenue should grow at a 25 percent CAGR for the 1997-to-2002 period.
- Memory IC trends, especially DRAM pricing, serve as a key swing factor in both the near-term and long-term forecasts. In 1998, worldwide memory revenue should grow by a scant 1.4 percent; DRAM revenue will increase by just 1 percent this year.
- There will be a continuing oversupply of DRAM capacity through most of 1999. The long-term forecast, however, explicitly assumes a DRAM capacity shortage by year 2000 and a DRAM revenue surge for 2001. Associated assumptions are excess DRAM capacity by 2002 and a cyclical DRAM revenue downturn that year.
- Cell-based ICs (CBICs) will continue to be a fast-growing logic product and will be the product of choice for system-level integration. By contrast, gate arrays are entering the decline phase of the product life cycle.

Key Growth Metrics

Table 1-1 provides growth by product for the period from 1997 to 2002, including the CAGRs.

Semiconductor Forecast: With and without DRAM

Figure 1-1 provides a different forecast view.

The figure shows the worldwide semiconductor growth rates and revenue totals for 1997 through 2002 for the total semiconductor market, the DRAM market, and the non-DRAM semiconductor market (that is, total semiconductors, excluding DRAM).

Flatter, more stable semiconductor growth is seen when DRAMs are excluded. The figure also highlights the higher, more volatile growth expected for DRAM.

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Table 1-1
Worldwide Semiconductor Growth by Product Type, 1997 and 2002
(Revenue in Millions of Dollars)

	1997 Revenue	1997 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)	1997-2002 CAGR (%)
Total Semiconductor	**147,165**	**3.5**	**287,895**	**4.7**	**17.7**	**14.4**
Total Integrated Circuit	**127,571**	**3.1**	**257,154**	**4.1**	**18.6**	**15.1**
Bipolar Digital	1,239	-33.0	604	-14.6	-17.2	-13.4
MOS Memory	30,978	-18.6	61,202	-20.1	15.1	14.6
Dynamic RAM	20,744	-20.3	40,920	-29.4	18.8	14.6
Static RAM	4,008	-20.2	9,761	3.8	5.7	19.5
Nonvolatile Memory	5,571	-13.7	9,432	15.1	10.9	11.1
EPROM	785	-37.1	225.9	-16.0	-8.9	-22.0
EEPROM	967	-7.9	1,922.9	15.3	17.8	14.7
Flash Memory	2,775	-3.2	6,378.1	19.2	63.3	18.1
Mask ROM	1,044	-19.1	905.1	-0.1	-5.7	-2.8
Other MOS Memory	655	13.5	1,089	10.7	28.2	10.7
MOS Microcomponent	48,945	18.0	103,130	14.9	27.8	16.1
Microprocessor	23,659	26.1	49,650	14.5	33.9	16.0
Microcontroller	10,896	6.4	22,230	14.2	18.8	15.3
Microperipheral	10,736	6.5	19,990	12.2	23.1	13.2
Digital Signal Processor	3,654	53.0	11,260	23.7	52.4	25.2
MOS Digital Logic	24,757	9.2	50,818	18.8	19.8	15.5
ASICs	16,527	11.7	39,789	21.8	24.9	19.2
Custom IC	1,514	-12.2	205	-41.4	-5.5	-33.0
MOS Standard Logic	2,266	13.7	2,805	1.1	13.7	4.4
Total Other MOS Logic	4,450	7.0	8,019	14.7	26.0	12.5
Analog-Monolithic	21,652	18.7	41,400	11.2	16.3	13.8
Total Discrete	14,255	5.8	23,300	10.4	11.8	10.3
Total Optical Semiconductor	5,339	8.6	7,441	8.2	14.7	6.9

Source: Dataquest (May 1998)

Electronic Production Forecast Analysis

As a first step in the forecast process, Dataquest combined worldwide electronic equipment production from 1997 to 2002 with semiconductor input/output (I/O) analysis. This process generated the following worldwide semiconductor forecast (with the final forecast shown in parentheses):

- 1998—$164 billion for the production-based estimate of semiconductor consumption (versus the final forecast of $159 billion)
- 2002—$262 billion for the production-based estimate (versus a $288 billion final forecast)

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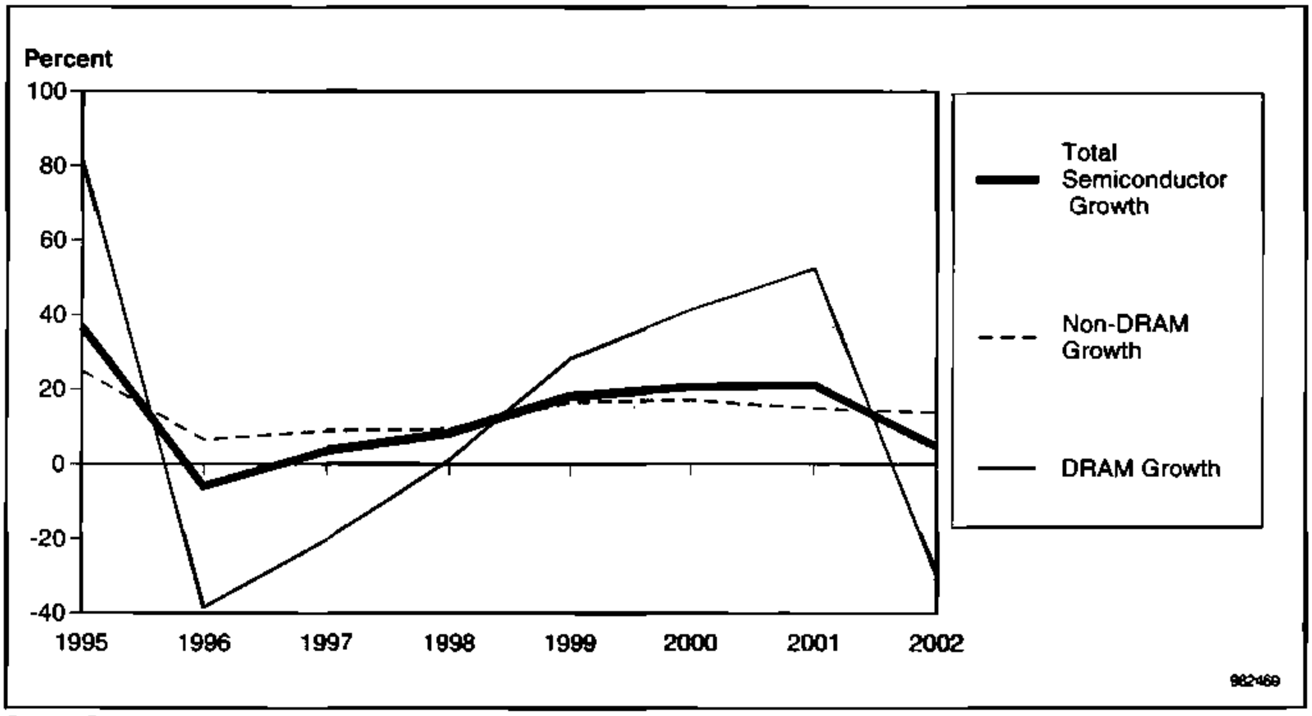
Figure 1-1
Worldwide Semiconductor Forecast



Source: Dataquest (May 1998)

The forecast methodology process uses this information as a central input and "sanity check" for generating the final semiconductor forecast.

Forecast Methodology

The worldwide semiconductor revenue forecast consists of an interlinked set of regional product consumption forecasts. A team of product and regional experts generate regional product forecasts. The experts are chosen on the basis of their expertise, including knowledge of key application trends, unit growth rates, and local economic factors.

Each regional product forecast (for example, the Asia/Pacific DSP forecast) rolls into a single, worldwide product forecast. Also, the totality of regional product forecasts (for example, Japanese consumption of DSP and DRAM, among others) roll into a single regional forecast. As noted, the interlinked forecasts ultimately roll into the worldwide product forecast.

The basic methodology is as follows:

- Under the aegis of the worldwide product director, a regional product expert provides a "first-pass" regional product consumption forecast to the worldwide product director. For example, the microcontroller (MCU) expert in Japan provides a five-year forecast of MCU consumption in Japan to the worldwide MCU director. The worldwide director compiles the full set of MCU regional forecasts and then reviews the resultant worldwide MCU revenue totals and growth rates.

- Concomitantly, under the aegis of a regional forecast director, the "first-pass" regional product forecasts are also sent by the regional product experts to the regional forecast director. For example, the MCU expert in Japan and the DRAM expert, among others, send their Japanese consumption market forecasts to the Japan regional forecast director. The regional forecast director compiles the regional product forecasts into a regional forecast and then reviews the resultant regional revenue totals and growth rates.
- The process remains interactive as the regional product forecasts get fine tuned. When agreement has been reached on these regional product forecasts, a "proposed" worldwide forecast is reviewed by a team of worldwide and regional product analysts. This process typically requires selective modification to worldwide product forecasts, including regional forecasts. This process includes scrutiny of worldwide growth rates, product growth, regional growth, upside/downside potential, and related factors.
- By consensus, the final worldwide and regional semiconductor product forecasts are then generated and published from the forecast database.

The Forecast Range

Market uncertainty means a forecast's results will be either higher or lower than the forecast. For this reason, this section provides a forecast range. Although the Asian crisis certainly tempers semiconductor market expectations, DRAM pricing predominates as the foremost swing factor affecting the semiconductor forecast range.

For the forecast range analysis, Dataquest assumes a set of low-side and high-side DRAM pricing assumptions. We also assume that DRAM bit growth will be quite predictable, despite pricing volatility.

For the low-side scenario, we assume low DRAM pricing. The market price is assumed to be at a "bottom-level," cost-based price, below which antidumping measures would be taken.

By contrast, under the high-side scenario, we assume very high DRAM pricing. Using historic patterns, we assume high markups for the market price, at as much as 1.7 times the cost.

The following summarizes the worldwide semiconductor forecast range for the 1999-through-2002 period, based on the DRAM price low/high assumptions (with the official forecast in parentheses).

Total Worldwide Semiconductor Forecast Range

The worldwide semiconductor forecast range is as follows:

- 1999—$186 billion to $201 billion ($188 billion forecast)
- 2000—$217 billion to $252 billion ($227 billion forecast)
- 2001—$249 billion to $291 billion ($275 billion forecast)
- 2002—$281 billion to $325 billion ($288 billion forecast)

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Perspective

The worldwide IT market totaled $1 trillion for 1997. Inclusion of all telecom services and companies' internal information system (IS) spending would increase the 1997 total to more than $2 trillion. Either way, the IT market is bigger than most countries' gross domestic product.

GartnerGroup has identified the megatrends that will shape the worldwide IT industry for the next five years. The global semiconductor industry, as a key enabling technology for the IT marketplace, will directly benefit from several IT megatrends. These IT megatrends signal long-term vitality for the worldwide semiconductor market:

- Rise of the Internet:
  - 300 million active Internet seats are expected by 2002.
  - Semiconductors will build the infrastructure as well as equip and connect the users.
- Network computing happens—although "network computers" do not:
  - The network computer will fizzle, although it has stimulated interested in fully equipped sub-$1,000 PCs.
  - Networked computing, however, will continue to expand and use semiconductors in that process.
- Bandwidth demand explodes:
  - Bandwidth demand will grow 30 to 40 percent per year.
  - Networking functions will become integrated into semiconductors—although software solutions will be just as important.

Meanwhile, some IT market trends do not favor the semiconductor outlook. For the medium term, concern exists that solutions for the Y2K and EMU problems could divert business spending from PCs and other semiconductor-based products.

In the long term, worldwide IT spending should grow at an 11 to 12 percent CAGR for the 1997-to-2002 period. There will be a dramatic shift toward the added-value software and services segments—meaning lower revenue growth for hardware segments.

To put everything in perspective, however, the worldwide semiconductor forecast looks realistic. The services and emerging software segments will grow at CAGRs of 16 percent or higher over the next five years. By contrast, system hardware revenue will grow at a sub-10 percent CAGR. Driven by the trend toward system-level integration, the semiconductor market should grow at a "sort of intermediate" CAGR of 14 percent.

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Chapter 2
Worldwide Forecast by Product

The tables of this chapter provide the complete five-year forecast by product type and by region for the worldwide semiconductor market.

Worldwide Semiconductor Product Forecast and History

The following tables show semiconductor product growth, both historic and forecast. Table 2-1 provides the five-year forecast through 2002 by product type for the worldwide semiconductor market. Table 2-2 presents the history of product growth for 1992 through 1997.

As noted in the tables, the worldwide semiconductor market should grow at a 14 percent-plus CAGR during the five-year period from 1997 to 2002. This is a realistic growth expectation when compared to the 18 percent CAGR from 1992 to 1997.

Forecast Summary: No Strong Recovery Yet

For many semiconductor companies, 1997 marked a year of modest revenue recovery following the 1996 revenue downturn. Memory segments like DRAM, however, did not recover in terms of revenue growth.

The forecast calls for modest worldwide semiconductor growth in 1998 and stronger growth over the long term. As noted, Dataquest expects the worldwide semiconductor market as measured in revenue to grow at a sub-10 percent rate this year. Our prior expectation for 1998 had been a more robust growth rate.

DRAM and the Asian crisis explain much of this change. For example, worldwide DRAM revenue should remain flat in 1998 at the 1997 level. The prior expectation was for a rebound in DRAM revenue growth this year. DRAM bit growth remains impressive, but excess capacity and low pricing combined with the Asian crisis mean scant DRAM revenue growth for 1998.

1998 Forecast Range

As noted, the worldwide semiconductor forecast calls for just over 8 percent this year. Applications market analysis, however, reveals that the 1998 forecast ranges from a low-side estimate of 3 percent growth to a high-side estimate of slightly over 10 percent growth.

Key Application Markets

PCs, communications, and consumer electronics will account for about 70 percent of semiconductor consumption. Trends in these application markets will determine near-term results and fuel long-term growth in semiconductor revenue. In the long term, the PC remains the paramount application for compute MPU and DRAM. Servers will eventually emerge as a key application for compute MPUs. Mobile communications, data communications, and digital consumer electronics, among other applications, should drive DSP, MCU, embedded MPU, and digital application-specific IC (ASIC) growth. Flash memory and EEPROM should also benefit from these trends.

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Table 2-1
Worldwide Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	147,165	3.5	159,249	8.2	188,256	18.2	227,054	20.6	275,028	21.1	287,895	4.7	14.4
Total Integrated Circuit	127,571	3.1	138,617	8.7	165,531	19.4	201,014	21.4	247,052	22.9	257,154	4.1	15.1
Bipolar Digital	1,239	-33.0	1,112	-10.3	946	-14.9	835	-11.7	707	-15.3	604	-14.6	-13.4
MOS Memory	30,978	-18.6	31,401	1.4	39,743	26.6	53,572	34.8	76,573	42.9	61,202	-20.1	14.6
Dynamic RAM	20,744	-20.3	20,960	1.0	26,897	28.3	38,043	41.4	57,994	52.4	40,920	-29.4	14.6
Static RAM	4,008	-20.2	4,182	4.3	5,694	36.2	7,378	29.6	9,402	27.4	9,761	3.8	19.5
Nonvolatile Memory	5,571	-13.7	5,533	-0.7	6,343	14.6	7,262	14.5	8,193	12.8	9,432	15.1	11.1
EPROM	785	-37.1	527	-32.8	406	-23.0	328	-19.3	269	-17.9	226	-16.0	-22.0
EEPROM	967	-7.9	1,121	15.9	1,305	16.4	1,472	12.8	1,668	13.3	1,923	15.3	14.7
Flash Memory	2,775	-3.2	3,057	10.2	3,710	21.4	4,506	21.5	5,350	18.7	6,378	19.2	18.1
Mask ROM	1,044	-19.1	828	-20.7	922	11.4	956	3.6	906	-5.2	905	-0.1	-2.8
Other MOS Memory	655	13.5	726	10.9	809	11.4	889	9.9	984	10.7	1,089	10.7	10.7
MOS Microcomponent	48,945	18.0	55,530	13.5	65,980	18.8	76,970	16.7	89,750	16.6	103,130	14.9	16.1
Microprocessor	23,659	26.1	27,300	15.4	32,250	18.1	37,440	16.1	43,380	15.9	49,650	14.5	16.0
Microcontroller	10,896	6.4	12,320	13.1	14,270	15.8	16,720	17.2	19,460	16.4	22,230	14.2	15.3
Microperipheral	10,736	6.5	11,300	5.3	13,660	20.9	15,580	14.1	17,810	14.3	19,990	12.2	13.2
Digital Signal Processor	3,654	53.0	4,610	26.2	5,800	25.8	7,230	24.7	9,100	25.9	11,260	23.7	25.2
MOS Digital Logic	24,757	9.2	26,573	7.3	31,084	17.0	37,061	19.2	42,793	15.5	50,818	18.8	15.5
ASICs	16,527	11.7	18,409	11.4	22,330	21.3	27,446	22.9	32,675	19.1	39,789	21.8	19.2
Custom IC	1,514	-12.2	1,164	-23.1	823	-29.4	557	-32.3	349	-37.3	205	-41.4	-33.0
MOS Standard Logic	2,266	13.7	2,373	4.7	2,565	8.1	2,739	6.8	2,775	1.3	2,805	1.1	4.4
Total Other MOS Logic	4,450	7.0	4,626	4.0	5,366	16.0	6,318	17.7	6,993	10.7	8,019	14.7	12.5
Analog-Monolithic	21,652	18.7	24,001	10.8	27,777	15.7	32,577	17.3	37,229	14.3	41,400	11.2	13.8
Total Discrete	14,255	5.8	15,221	6.8	16,934	11.3	19,711	16.4	21,100	7.0	23,300	10.4	10.3
Total Optical Semiconductor	5,339	8.6	5,411	1.3	5,791	7.0	6,329	9.3	6,876	8.6	7,441	8.2	6.9

Source: Dataquest (May 1998)

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Table 2-2
Worldwide Semiconductor Market, Revenue History, 1992 to 1997 (Millions of Dollars)

	1992 Revenue	1992 Growth (%)	1993 Revenue	1993 Growth (%)	1994 Revenue	1994 Growth (%)	1995 Revenue	1995 Growth (%)	1996 Revenue	1996 Growth (%)	1997 Revenue	1997 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	65,260	9.3	85,514	31.0	110,513	29.2	151,310	36.9	142,150	-6.1	147,165	3.5	17.7
Total Integrated Circuit	54,417	11.4	73,429	34.9	95,861	30.5	132,184	37.9	123,761	-6.4	127,571	3.1	18.6
Bipolar Digital	3,193	-12.0	3,079	-3.6	2,912	-5.4	2,455	-15.7	1,849	-24.7	1,239	-33.0	-17.2
MOS Memory	15,308	19.2	23,306	52.2	33,505	43.8	55,287	65.0	38,064	-31.2	30,978	-18.6	15.1
Dynamic RAM	8,765	25.5	14,581	66.4	23,266	59.6	42,249	81.6	26,012	-38.4	20,744	-20.3	18.8
Static RAM	3,038	17.9	3,908	28.6	4,514	15.5	6,265	38.8	5,020	-19.9	4,008	-20.2	5.7
Nonvolatile Memory	3,316	7.2	4,551	37.2	5,407	18.8	6,239	15.4	6,455	3.5	5,571	-13.7	10.9
EPROM	1,253	-7.7	1,460	16.5	1,561	6.9	1,437	-7.9	1,249	-13.1	785	-37.1	-8.9
EEPROM	426	0	561	31.7	746	33.0	793	6.3	1,050	32.4	967	-7.9	17.8
Flash Memory	239	0	746	212.1	884	18.5	1,942	119.7	2,866	47.6	2,775	-3.2	63.3
Mask ROM	1,398	0	1,784	27.6	2,216	24.2	2,067	-6.7	1,290	-37.6	1,044	-19.1	-5.7
Other MOS Memory	189	-1.0	266	40.7	318	19.5	534	67.9	577	8.1	655	13.5	28.2
MOS Microcomponent	14,359	22.0	19,947	38.9	26,408	32.4	34,504	30.7	41,469	20.2	48,945	18.0	27.8
Microprocessor	5,501	41.4	8,783	59.7	11,437	30.2	14,269	24.8	18,756	31.4	23,659	26.1	33.9
Microcontroller	4,613	4.2	5,904	28.0	7,517	27.3	10,250	36.4	10,244	-0.1	10,896	6.4	18.8
Microperipheral	3,801	20.4	4,581	20.5	6,424	40.2	8,316	29.5	10,081	21.2	10,736	6.5	23.1
Digital Signal Processor	444	48.5	679	52.9	1,030	51.7	1,669	62.0	2,388	43.1	3,654	53.0	52.4
MOS Digital Logic	10,042	3.5	13,121	30.7	16,108	22.8	20,667	28.3	22,676	9.7	24,757	9.2	19.8
ASICs	5,440	5.0	7,203	32.4	9,008	25.1	12,528	39.1	14,801	18.1	16,527	11.7	24.9
Custom IC	2,013	-5.3	2,367	17.6	2,502	5.7	2,143	-14.3	1,724	-19.6	1,514	-12.2	-5.5
MOS Standard Logic	1,191	19.9	1,501	26.0	1,864	24.2	2,202	18.1	1,993	-9.5	2,266	13.7	13.7
Total Other MOS Logic	1,399	-0.4	2,080	48.7	2,769	33.1	3,821	38.0	4,158	8.8	4,450	7.0	26.0
Analog-Monolithic	10,180	7.0	12,513	22.9	15,263	22.0	17,616	15.4	18,235	3.5	21,652	18.7	16.3
Total Discrete	8,155	1.5	9,083	11.4	10,763	18.5	14,314	33.0	13,474	-5.9	14,255	5.8	11.8
Total Optical Semiconductor	2,688	-4.1	3,002	11.7	3,889	29.5	4,812	23.7	4,915	2.1	5,339	8.6	14.7

Source: Dataquest (May 1998)

The following section summarizes the 1998 outlook for the three key semiconductor application markets: PCs, communications, and consumer electronics.

The High and Low of PC Semiconductors

Personal computers and workstations consume about one-third of the world's semiconductors and therefore have a tremendous impact on the market growth dynamics. Additionally, these applications consume 75 to 80 percent of all DRAM shipments and are somewhat elastic in terms of semiconductor demand as measured by revenue. This adds volatility to the overall semiconductor demand picture and particularly affects memory pricing trends.

Near-term volatility is minimal because we are already about one-third of the way through 1998, and we have a high level of confidence in our assumptions regarding PC pricing dynamics and the software application base (including operating systems) for PCs. We see minimal upside opportunities for our forecast in the near term unless system demand takes a dramatic uptick. Downside risk for 1998 is 5 percent on a revenue basis.

Long-term trends have greater volatility and hinge on four key "swing" factors. The low-side scenario would involve a 10 percent downward revision for PC semiconductor revenue in 1999 and 15 percent thereafter. Semiconductor spending as a percentage of the factory system average selling price (ASP) cannot be raised, so any dramatic upside opportunity can come only from higher-than-expected unit shipments or a stabilizing trend in factory system ASPs.

The key trends include the following:

- DRAM ASPs—The high-side scenario requires DRAM ASPs, as our memories forecast has DRAM and bit consumption according to the forecast. The low-side scenario has DRAM ASPs 20 percent lower than the target ASPs in the DRAM forecast.
- Consumer spending recovery in Asia—The high-side scenario involves a quicker recovery than Dataquest currently projects. The low-side scenario includes moderate recovery of consumer spending in Asia. The outlook is good for North America and Europe.
- The popularity of sub-$1,000 PCs in business environments—The high-side scenario includes limited acceptance of sub-$1,000 PCs in corporate environments. The low-side scenario has business acceptance of sub-$1,000 mirroring consumer excitement over that category. Falling ASPs for the PC industry cause PC makers to limit their semiconductor spending on a per-PC basis. Unit growth remains strong either way.
- Compelling new applications—The high-side scenario requires new applications to emerge that convince buyers to "buy up." Microsoft's Chrome product in the Windows 2000 operating system is an example. New versions of today's programs will only lead to the low-side scenario. Windows 98 arrives midyear, but it is unlikely to inspire dramatic changes. Windows NT 5.0 will not emerge until 1999.

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The High and Low of Communications Semiconductors

The communications market accounts for about 20 percent of worldwide semiconductor consumption. In the near term, consumption for use in communications equipment on the low side could be 3 to 4 percent lower than the current forecast; on the high side, consumption could be 6 to 7 percent higher than forecast.

The following section summarizes the forecast range across different communications application segments:

- Premise telecom high and low range:
  - 1998 semiconductor consumption forecast ranges from 4 to 5 percent lower to just over 4 percent higher.
  - Downside would be mainly due to pricing pressures and Asian financial crisis.
  - Upside would be driven by 56Kbps modem "churn," acceptance of new wide area network (WAN) systems, and Y2K; the Y2K problem could cause companies to buy new premise telecom systems as their solution (versus a software rewrite).
- Public telecom high and low range:
  - 1998 forecast ranges from 3 percent lower to 3 percent higher.
  - Downside and upside both depend mainly on pricing and uncertainty.
- Mobile communications high and low range:
  - 1998 forecast ranges from 3 percent lower to more than 10 percent higher.
  - Downside would be due to lower demand resulting from the Asian crisis and European saturation.
  - Upside would be due to lack of negative impact from Asia crisis, strong subscriber growth, microcell and picocell infrastructure deployment, and possible strong code division multiple access (CDMA) ramp in the United States.

The High and Low of Consumer Semiconductors

Consumer electronics use about 10 percent of the world's semiconductors. In 1998, the forecast assumes just over a 9 percent worldwide increase of semiconductors for consumer electronics equipment. The following assumptions guide this 1998 forecast:

- Demand for next-generation consumer products will recover from the 1997 lull in demand. These products include digital set-top boxes (STB), digital TV, including high-definition television (HDTV), digital versatile disc (DVD), and 32-bit and 64-bit game players (Nintendo 64 and Sony Playstation).
- Legacy consumer product demand will increase slightly or else remain flat versus 1997. These older applications include color TVs, component stereos, analog audio/video systems, and household appliances.
- Semiconductor price erosion will moderate.
- Asian crisis will have moderate impact on consumer electronics sales.

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Consumer Electronics Low-Side Scenario

For the near term, consumption for use in consumer electronics could on the low side be more than 10 percent lower than the current forecast. At worst, consumption by consumer applications could actually decline this year versus 1997. A similar result occurred in this application market during 1996.

The following assumptions would cause this negative 1998 scenario:

- The Asian crisis has major negative impact on consumer electronics sales.
- Demand for next-generation consumer products continues to fall below expectations.
- Legacy consumer product demand continues to decline.
- Semiconductor price erosion continues.

Consumer Electronics High-Side Scenario

On the high side, consumption could be 1 to 2 percent higher than forecast. The optimistic outlook says that consumer electronics applications can sustain the same near-11 percent consumption growth rate as experienced in the past several years. The following assumptions would cause this optimistic 1998 scenario:

- Fallout from the Asian crisis on consumer electronics demand is contained.
- The rate of demand for next-generation consumer products increases significantly.
- Legacy consumer demand rises slightly.
- Semiconductor price erosion moderates.

As noted, the 1998 forecast range based on applications analysis runs from a low-side estimate of 3 percent growth to a high-side estimate of slightly over 10 percent growth.

Product Forecasts

The following sections highlight trends that guide key product forecasts.

ASIC and Logic Trends and Forecast Assumptions

The worldwide MOS digital logic forecast calls for 7.3 percent growth in 1998. This is slower growth than originally expected. On a regional basis, the 1998 forecasts have been lowered in all regions to varying degrees, with the highest reduction in Japan, followed by Asia/Pacific.

The short-term forecasts on other MOS logic products have also been lowered. Supply exceeds demand for these products, which means downward pricing pressure. Standard logic remains relatively unchanged from our prior forecasts. ASIC product forecasts have been lowered only slightly.

Cell-based ICs, the system-level integration product of choice, will continue as the fastest-growing logic product. Gate arrays, however, are under serious pricing pressure and are entering the decline phase of the life cycle. CBICs are displacing gate arrays from high-end applications as programmable logic devices (PLDs) displace gate arrays on low-end applications. This translates into higher long-term growth in the CBIC and PLD segments and lower growth in gate arrays.

For 1998, the worldwide CBIC market should grow at a 22 percent rate. PLDs are suffering from rapid price erosion and slow demand, so we are forecasting only an 11 percent increase in 1998, the lowest growth rate in history. Gate array revenue will continue to decline and decrease this year by 7 percent. Full-custom ICs are on the most rapid decline, as they are being replaced by cell-based ICs and gate arrays to some degree. The mature standard logic market should increase by 5 percent. Other MOS logic products will grow 4 percent.

Long term, the CBIC market should exceed $30 billion by 2002, with an impressive CAGR of more than 27 percent for 1997 through 2002. PLDs will expand at nearly a 20 percent CAGR and exceed $5 billion by 2002. Other MOS logic products—which include some application-specific standard products—will grow at a respectable near-15 percent CAGR. The standard logic market will grow slowly, while gate arrays will decline.

Microprocessor Trends and Forecast Assumptions

The worldwide microprocessor revenue forecast remains largely consistent with prior expectations. As expected, MPU revenue should increase this year and over the long term, but at a slower rate versus the 1992-to-1997 period. The x86 architecture will continue its domination of the PC market. Business PC demand continues to drive MPU demand. The x86 MPU technology advances still stimulate PC demand from the key "early adopter" repeat buyers.

Key PC market dynamics, however, are changing as of first half 1998. For example, the "sub-$1,000" PC captured consumer market demand during late 1997. Business buyers now show growing interest in low-cost PCs, which means a long-term decline in the PC ASP. A sharp fall in the x86 MPU ASP, however, is not expected. Competition for Intel Corporation from competitors such as Advanced Micro Devices Inc. and National Semiconductor Corporation will not cause an x86 price war.

Why not? Although the price of MPUs for PC desktop applications will decline, the x86 ASP will rise somewhat as MPUs absorb other system functions. Also, Intel is creating workstation- and server-specific versions of x86 products that generate a much higher ASP (more than $500) than devices geared for PC markets. Internet appliances, communications (for example, cellular), and video games will fuel growth in the embedded RISC MPU market.

For 1998, worldwide MPU revenue should increase by 15.4 percent and reach $27 billion. Intel should lead a strong rebound in second-half 1998 in the worldwide MPU market. In 2002, worldwide MPU revenue should reach $50 billion, which represents a 16 percent CAGR for 1997 through 2002. This is a lower long-term MPU growth rate than the 30 percent-plus CAGR for the 1992-through-1997 period; this mirrors the slower long-term pace of PC revenue growth.

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Microcontroller and DSP Trends and Forecast Assumptions

Our forecast continues to assume that non-PC applications such as digital cellular, digital consumer electronics, and data communications will drive demand for MCUs and DSPs, including embedded versions. The following is a summary of these product forecasts:

- DSPs should increase by more than 25 percent in 1998, exceeding $4.5 billion. By 2002, worldwide DSP revenue should surpass $11 billion, which translates into a stellar 25 percent CAGR for 1997 through 2002.
- Sharp price erosion for MCU products means lower 1998 revenue than originally expected. In 1998, worldwide MCU revenue will increase by just over 13 percent and total $12.3 billion. Long term, worldwide MCU revenue will total $22 billion by 2002. The forecast of a 15.3 percent CAGR for the 1997-to-2002 period is lower than previously expected.

Memory IC Trends and Forecast Assumptions

The DRAM market will remain volatile. The DRAM revenue forecast could swing widely for both the near term and the long term because of DRAM price fluctuations. DRAM bit consumption continues in line with our prior projections. This means that unit demand should be strong, although pricing might remain weak. As indicated, the semiconductor forecast assumes a cyclical upturn in 2001. The DRAM market peak in 2001, however, has been moderated to match similar historical peaks.

DRAM prices continue to hug a cost-based price curve, which means low pricing. This stifles the prospect for DRAM revenue growth. Dataquest expects this to remain the case through 1998 and into 1999. These prices are limited on the high side by DRAM oversupply and on the low side by antidumping regulations.

The effects of the current Asian crisis on DRAM prices will be "self-regulating" in that a temporary 1998 price downturn should shift market share to lower-cost producers. After this, the low-cost suppliers' capacity will be utilized, and DRAM prices will recover slightly.

The current overcapacity will continue through 1999 and into 2000. Capital expenditure did not slow in 1997 as we had originally anticipated. To reflect the impact, the DRAM market revenue peak originally expected for 2000 has been pushed out by one year to 2001. (Some manufacturing capacity may eventually exit the DRAM market, but this is not predicted in the current forecast.)

The DRAM high-side revenue forecast for 2002 is $78 billion. This would occur if there were a shortage in this year and bit growth followed its historical rate of 65 percent per year. Our low-side scenario, assuming as severe an overcapacity as we currently face, would be just $34 billion. By contrast, the DRAM bit growth trend has been extremely stable since the early 1980s, despite price fluctuations and the expected positive and negative influences of demand drivers.

The static RAM (SRAM) market is still oversubscribed, but conversion of cellular phones from analog to digital has dramatically increased SRAM usage in these phones. There is a big difference between this market and the

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PC market, the last big SRAM stronghold. Cell phone manufacturers are much more selective about their supplier base; they use parts from top-tier suppliers and shy away from small, fabless companies. We still expect to see attrition in this market. Many companies that thrived in an open market for PC cache chips will shortly be excluded from this previously highly penetrable market and will not be able to participate in the cellular telephone market.

The nonvolatile memory market should see a continuing slow conversion from EPROM toward flash memory. Most of this conversion is happening in new designs and is therefore occurring at the higher densities. The flash memory market has moved from high profitability toward more competitive pricing as many competitors join the fold. However, unit growth remains strong. This new lower pricing has acted to enable the use of flash memory in a diverse array of new applications. Mask ROM has moved away from the "growth hump" that was characteristic of the game cartridge boom and is back on the less-dramatic, pregame growth trend.

Substantial growth should continue in the relatively small EEPROM market, fueled by this technology's use in everything from electronic commerce to microcontroller-based systems, including smart cards. New applications include Universal Serial Bus (USB) interfaces for the PC. The conversion of DRAM modules from single in-line memory modules (SIMMs) to dual in-line memory modules (DIMMs) will also help, as each new DIMM will contain one EEPROM to identify the attributes of the module.

The following summarizes memory IC product outlooks:

- DRAM revenue should increase by a scant 1 percent in 1998 and total $21 billion. By 2002, worldwide DRAM revenue should total $41 billion, which marks a 14.6 percent CAGR for 1997 through 2002.
- SRAM revenue will grow by 4.3 percent in 1998 and total $4.2 billion. In 2002, worldwide SRAM revenue will total nearly $10 billion, which means a 20 percent CAGR for 1997 through 2002.
- Flash memory revenue should increase by 10.2 percent in 1998 and reach the $3 billion level. By 2002, worldwide flash revenue will total nearly $6.4 billion, with an 18 percent CAGR for 1997 through 2002.
- EEPROM revenue will rise by 16 percent in 1998 and exceed the $1.1 billion mark. By 2002, worldwide EEPROM revenue should approach $2 billion, for a near-15 percent CAGR for 1997 through 2002.
- EPROM revenue should decrease by more than 30 percent in 1998, declining to just over $0.5 billion. By 2002, worldwide EPROM revenue will decline to only $0.22 billion.
- Mask ROM revenue will fall by more than 20 percent in 1998, declining to $0.8 billion. By 2002, however, worldwide mask ROM revenue will edge upward to the $0.9 billion level.

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Analog Product Trends and Forecast Assumptions

Worldwide analog IC revenue during 1998 should grow by nearly 11 percent and total $24 billion. The Asian financial crisis should reduce consumer demand in the Asia/Pacific and Japan, which will slow the growth of analog products. By contrast, the analog market expanded by nearly 19 percent in 1997.

Analog IC revenue should grow at a CAGR of 14 percent from 1997 through 2002 and reach $41 billion by 2002. Looking at the long-term trends through 2002, mixed-signal ICs will experience solid growth, driven by application markets such as digital cellular. Also, new emerging applications in the consumer and communications market will contribute to the growth of mixed-signal ICs. In the more traditional, standard linear product area, voltage regulator products will still enjoy strong growth as the demand for smart power continues to grow, especially in the portable markets.

Discrete Product Trends and Forecast Assumptions

Worldwide discrete product revenue should rise in 1998 by nearly 7 percent to $15.2 billion. The discrete product market grew at a similar rate in 1997. The long-term forecast assumes a stable market. We forecast a CAGR of 10 percent in discrete products through 2002, reaching a total of $23 billion.

Regional vendors in the Americas, Europe, and Asia/Pacific are expected to maintain fairly strong growth and a share of the discrete market through the end of the decade. The Americas region's growth will be determined by prowess in the communications, automotive, and industrial sectors in the face of strong competition from Europe.

Optoelectronics Product Trends and Forecast Assumptions

Optoelectronic semiconductors have a number of factors that will affect overall and regional growth rates. Optoelectronic IC revenue should grow only 1.3 percent in 1998 and total $5.4 billion. This market grew by nearly 9 percent in 1997. By 2002, worldwide optoelectronics revenue will total $7.4 billion, which represents a moderate percent 7 percent CAGR for 1997 through 2002.

For the near term, the Asian economic crisis will reduce dollar growth in Japan and the Asia/Pacific region through lower demand or currency effects relative to the dollar. These effects are expected to be most severe in 1998. After this year, this region is expected to resume higher growth rates as worldwide and regional demand for new consumer electronics and personal communications products overcome the effects of the current economic conditions.

For example, long-term acceptance of DVD and multimedia disk consumer electronic products will raise growth rates of laser diodes. More expensive diodes are required for the new, high-capacity players. This long-term growth will benefit Japan and the Asia/Pacific region.

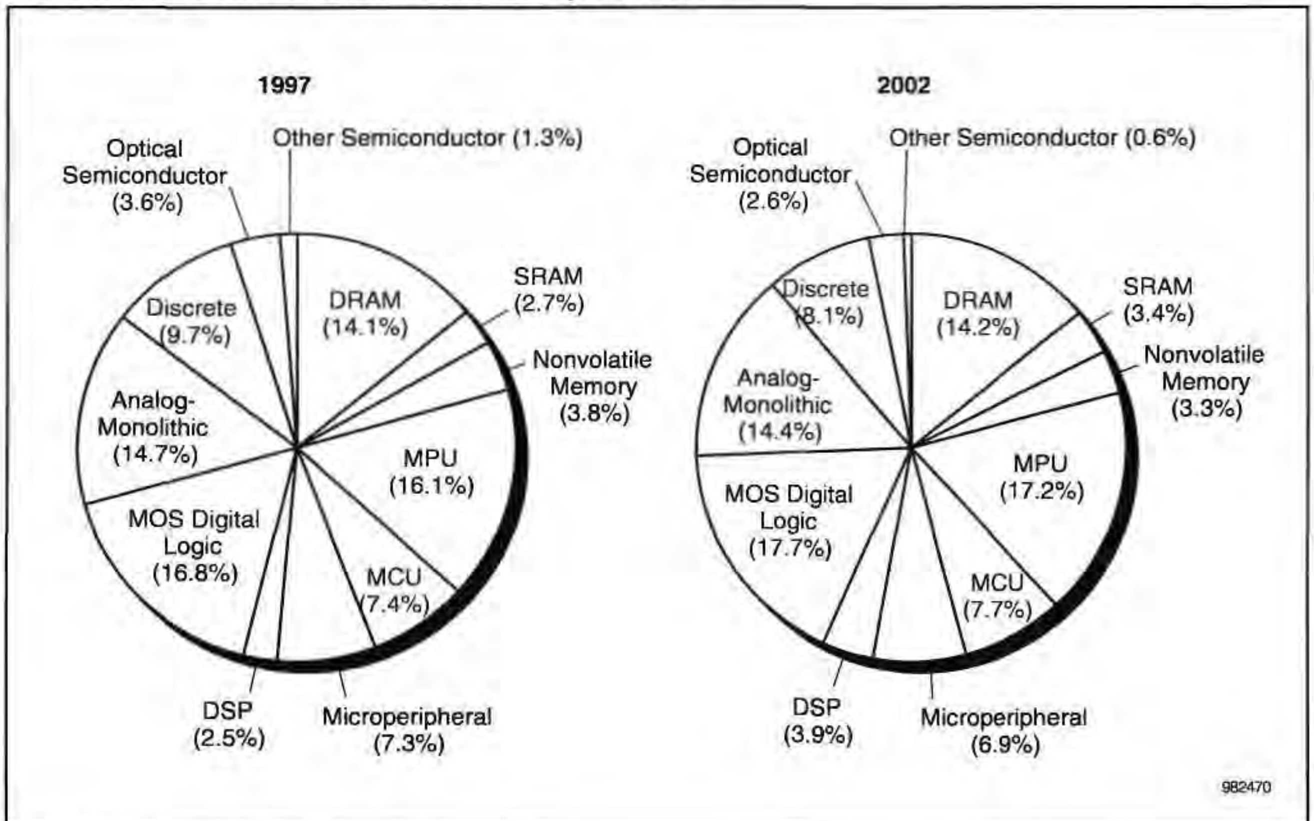
The growth in Japan will be mitigated by movement of production of consumer electronics products to the Asia/Pacific region as volumes increase and prices decrease. Digital cameras will drive demand for charge-coupled devices (CCDs). This will have a positive effect on demand for CCDs in Japan, but it will be insignificant compared to slower CCD growth in camcorder markets for the next five years until prices drop and picture quality improves. CCD demand in digital cameras will not have a large effect on the overall growth rate for CCDs or optoelectronics until the end of the forecast period.

The growth of the Internet also means positive long-term growth in this market. The Internet is creating extensive demand for high-bandwidth optical networks. This factor is particularly important in the United States. It will cause higher growth in laser diodes for fiber-optic modules for 155-Mbps through 10-Gbps fiber-optic networks. This will have a positive effect on growth in Europe as well as the Americas.

A third factor that is positively affecting demand for optoelectronics is automotive electronics. Automobile manufacturers are switching from incandescent lamps to LEDs for the rear braking lights in new car designs. This will give LEDs a positive push in all markets for the next several years as more car models adopt the new technology.

Figure 2-1 shows the impact of these varying rates of growth by product.

Figure 2-1
Worldwide Semiconductor Forecast by Product



Source: Dataquest (May 1998)

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Chapter 3
Worldwide Semiconductor Product Forecasts by Region

This chapter presents the worldwide product forecasts by region.

Worldwide Semiconductor Forecast by Region

The worldwide semiconductor revenue forecast is broken into the four constituent regional forecasts in Figure 3-1. By world region, the forecast calls for the following CAGRs for 1997 to 2002 (regional revenue consumption for 2002 is shown in parentheses):

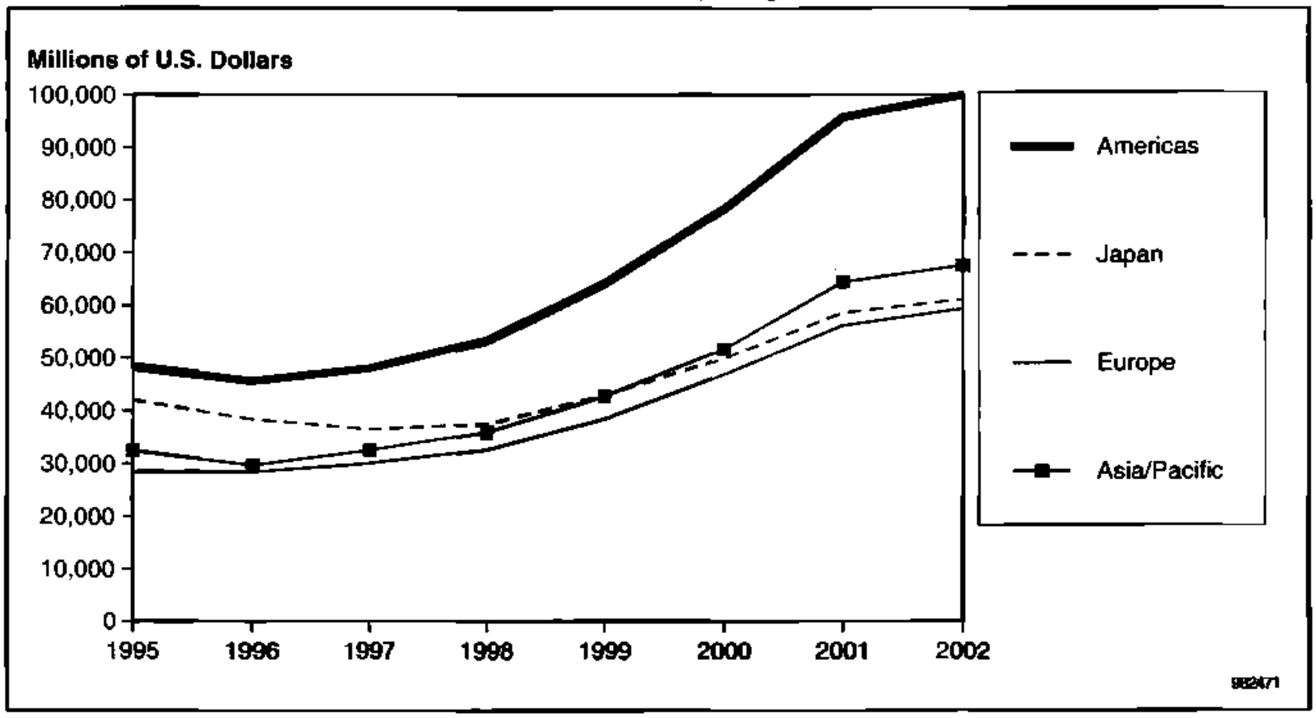
- Americas—15.7 percent CAGR ($100 billion)
- Japan—11 percent CAGR ($61 billion)
- Europe, Middle East, and Africa—14.6 percent CAGR ($59 billion)
- Asia/Pacific—15.7 percent CAGR ($68 billion)

As indicated, the long-term growth rates for Japan and Asia/Pacific have been lowered versus prior expectations.

Table 3-1 shows the regional revenue data and annual growth rates by region for the five-year semiconductor forecast.

The effect of this forecast on total market share by region is provided in Figure 3-2.

Figure 3-1
Worldwide Semiconductor Revenue Forecast by Region



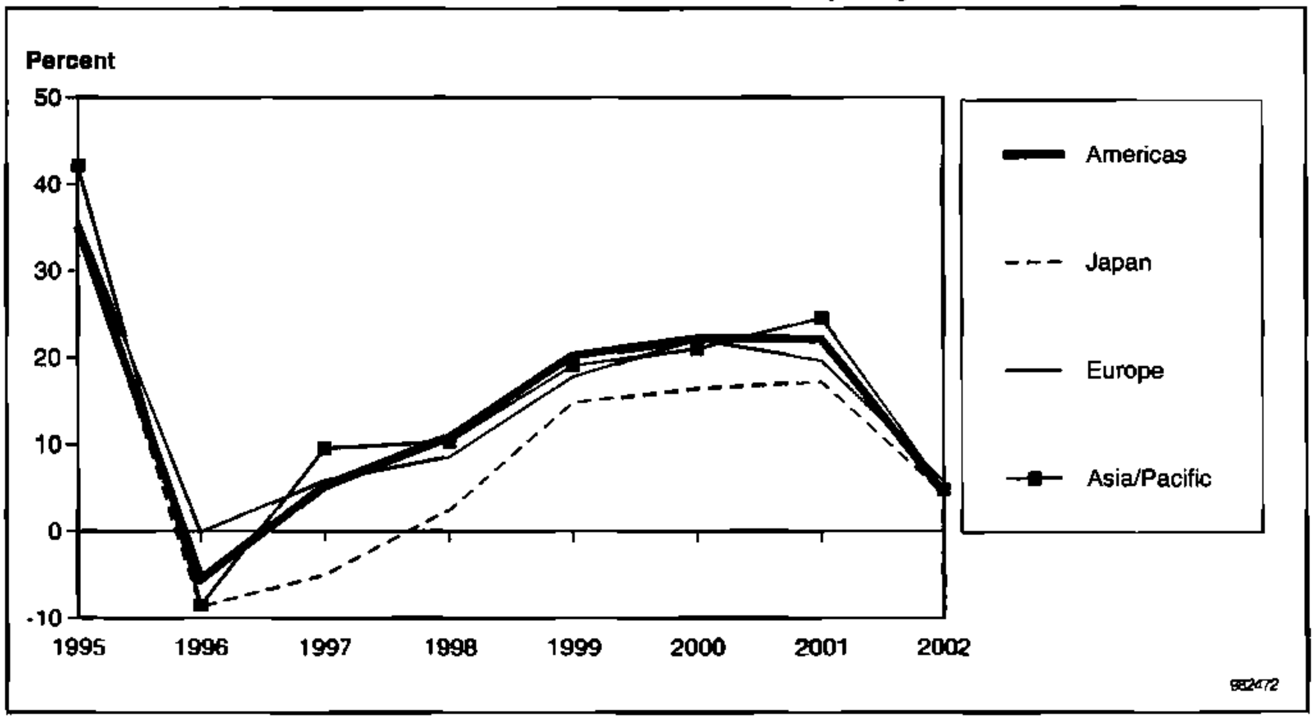
Source: Dataquest (May 1998)

Table 3-1
Total Semiconductor (Including Hybrid) Consumption by Region, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1997-2002 CAGR (%)
Worldwide	**147,165**	**3.5**	**159,249**	**8.2**	**188,256**	**18.2**	**227,054**	**20.6**	**275,028**	**21.1**	**287,895**	**4.7**	**14.4**
Americas	48,086	5.3	53,326	10.9	64,133	20.3	78,388	22.2	95,782	22.2	99,906	4.3	15.7
Japan	36,499	-5.0	37,397	2.5	42,943	14.8	49,988	16.4	58,610	17.2	61,093	4.2	10.9
Europe	30,046	5.9	32,627	8.6	38,425	17.8	46,927	22.1	56,152	19.7	59,335	5.7	14.6
Asia/Pacific	32,534	9.6	35,899	10.3	42,754	19.1	51,751	21.0	64,483	24.6	67,561	4.8	15.7

Source: Dataquest (May 1998)

Figure 3-2
Worldwide Semiconductor Revenue Growth Forecast by Region



Source: Dataquest (May 1998)

Semiconductor Product Forecasts by Region

This section builds on the product and regional analysis of the prior sections by focusing on the individual products and their regional segmentation.

Microcomponent IC Forecast by Region

Table 3-2 shows microcomponent product consumption by region for 1997 to 2002. Microcomponent growth should moderate somewhat to a 16 percent CAGR for 1997 through 2002. The Americas will remain the largest market, by far. Asia/Pacific, driven by MPUs and microperipherals (MPRs), will remain the second-largest regional market. Even so, as noted, the Asian crisis throws a pall over the outlook for Asia/Pacific and Japan consumption.

The large MPU market—$27 billion in 1998 and $32 billion in 1999—will grow at a 16 percent CAGR from 1997 through 2002. For 1998, Americas and Asia/Pacific should achieve the strongest growth rates among the regions. By 2001, each regional MPU market, led by the large Americas market, will exceed $10 billion, except for Japan.

Communications and digital entertainment applications, among others, will drive the DSP market to a 25 percent CAGR for 1997 through 2002. Rapid growth means an $11 billion market by 2002, led by the European and Americas regions.

Table 3-2
Microcomponent Consumption by Region, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)
MOS Microcomponent													
Worldwide	48,945	18.0	55,530	13.5	65,980	18.8	76,970	16.7	89,750	16.6	103,130	14.9	16.1
Americas	17,785	21.9	20,543	15.5	24,270	18.1	28,000	15.4	32,540	16.2	37,070	13.9	15.8
Japan	9,336	6.1	10,040	7.5	12,040	19.9	14,010	16.4	16,010	14.3	18,470	15.4	14.6
Europe	10,939	17.1	12,296	12.4	14,310	16.4	16,700	16.7	19,490	16.7	22,420	15.0	15.4
Asia/Pacific	10,885	24.5	12,651	16.2	15,360	21.4	18,260	18.9	21,710	18.9	25,170	15.9	18.3
Microprocessor													
Worldwide	23,659	26.1	27,300	15.4	32,250	18.1	37,440	16.1	43,380	15.9	49,650	14.5	16.0
Americas	10,626	33.4	12,436	17.0	14,500	16.6	16,600	14.5	19,100	15.1	21,600	13.1	15.2
Japan	2,676	14.7	2,813	5.1	3,420	21.6	4,020	17.5	4,710	17.2	5,550	17.8	15.7
Europe	5,901	16.6	6,702	13.6	7,760	15.8	8,930	15.1	10,200	14.2	11,600	13.7	14.5
Asia/Pacific	4,456	31.4	5,349	20.1	6,570	22.8	7,890	20.1	9,370	18.8	10,900	16.3	19.6
Microcontroller													
Worldwide	10,896	6.4	12,320	13.1	14,270	15.8	16,720	17.2	19,460	16.4	22,230	14.2	15.3
Americas	2,194	0.6	2,790	27.2	3,190	14.3	3,680	15.4	4,390	19.3	5,060	15.3	18.2
Japan	4,059	3.3	4,360	7.4	5,200	19.3	6,040	16.2	6,720	11.3	7,580	12.8	13.3
Europe	2,330	11.9	2,540	9.0	2,820	11.0	3,290	16.7	3,920	19.1	4,510	15.1	14.1
Asia/Pacific	2,313	12.8	2,630	13.7	3,060	16.3	3,710	21.2	4,430	19.4	5,080	14.7	17.0
Microperipheral													
Worldwide	10,736	6.5	11,300	5.3	13,660	20.9	15,580	14.1	17,810	14.3	19,990	12.2	13.2
Americas	3,887	6.6	3,967	2.1	4,870	22.8	5,610	15.2	6,460	15.2	7,310	13.2	13.5
Japan	1,873	-9.2	1,917	2.3	2,200	14.8	2,410	9.5	2,620	8.7	2,850	8.8	8.8
Europe	1,661	8.0	1,755	5.6	2,070	18.0	2,360	14.0	2,720	15.3	3,030	11.4	12.8
Asia/Pacific	3,315	17.0	3,662	10.5	4,520	23.4	5,200	15.0	6,010	15.6	6,800	13.1	15.5
Digital Signal Processor													
Worldwide	3,654	53.0	4,610	26.2	5,800	25.8	7,230	24.7	9,100	25.9	11,260	23.7	25.2
Americas	1,078	36.1	1,350	25.2	1,710	26.7	2,110	23.4	2,590	22.7	3,100	19.7	23.5
Japan	728	54.9	950	30.5	1,220	28.4	1,540	26.2	1,960	27.3	2,490	27.0	27.9
Europe	1,047	59.1	1,300	24.2	1,660	27.7	2,120	27.7	2,650	25.0	3,280	23.8	25.7
Asia/Pacific	801	71.2	1,010	26.1	1,210	19.8	1,460	20.7	1,900	30.1	2,390	25.8	24.4

Source: Dataquest (May 1998)

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MCUs continue to find new embedded homes in every conceivable electronic product, meaning stable long-term growth. The $11 billion MCU market of 1997 will double to $22 billion by 2002. The CAGR for 1997 through 2002 is expected to be 15 percent.

For 1998, Americas shows the strongest growth among the regions; all other 1998 regional forecasts have been lowered. Japan will remain the largest MCU market in the long term, with Americas and Asia/Pacific the fastest growing.

Memory IC Forecast by Region

Table 3-3 shows the memory product consumption forecast by region. Each region will show a double-digit CAGR over the forecast period. In 1998, however, each region shows negligible memory revenue growth.

The Asia/Pacific growth rate will *no longer* outpace other regions' memory growth. The Americas region will remain by far the No. 1 market for DRAM. The Americas region should also ultimately emerge as the leading consumer of nonvolatile memory. Asia/Pacific, Europe, and Japan will be important markets, however, for nonvolatile memory. For example, Europe's consumption will be driven by cellular phones that use EEPROM or flash.

Digital Logic Forecast by Region

Table 3-4 gives the digital logic forecast by region. For 1998, Americas and Europe should show the strongest regional growth. The Asian crisis means lowered expectations for Asia/Pacific and Japan. Japan will continue to rank with Americas as the two largest markets.

The worldwide digital logic markets will achieve a long-term 16 percent growth rate driven by strength in digital cell-based ICs and PLDs. The trend to system-level integration means that many formerly standalone MPUs will instead ship in the form of ASIC cores. By region, 1997-to-2002 CAGRs will range as follows:

- Japan—10 percent
- Asia/Pacific—15 percent
- Europe, Middle East, and Africa—18 percent
- Americas—19 percent

Analog, Discrete, and Optoelectronics by Region

Table 3-5 shows the regional forecasts for analog ICs, discrete semiconductors, and optoelectronic semiconductors. The products tend to be mature, as reflected in their slower, more stable growth rates. Optoelectronics consumption centers in Japan. The market for analog and discrete products has been geographically diversified.

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Table 3-3
MOS Memory Consumption by Region, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)
MOS Memory													
Worldwide	30,978	-18.6	31,401	1.4	39,743	26.6	53,572	34.8	76,573	42.9	61,202	-20.1	14.6
Americas	11,898	-18.7	12,215	2.7	15,733	28.8	21,511	36.7	29,953	39.2	24,108	-19.5	15.2
Japan	6,523	-23.1	6,518	-0.1	8,192	25.7	10,870	32.7	15,224	40.1	12,439	-18.3	13.8
Europe	6,041	-12.7	6,092	0.8	7,718	26.7	10,756	39.4	14,831	37.9	12,127	-18.2	15.0
Asia/Pacific	6,516	-18.7	6,576	0.9	8,100	23.2	10,436	28.8	16,566	58.7	12,527	-24.4	14.0
Dynamic RAM													
Worldwide	20,744	-20.3	20,960	1.0	26,897	28.3	38,043	41.4	57,994	52.4	40,920	-29.4	14.6
Americas	8,233	-21.3	8,427	2.4	11,003	30.6	15,851	44.1	22,982	45.0	16,681	-27.4	15.2
Japan	3,837	-24.1	3,877	1.0	4,975	28.3	7,037	41.4	10,727	52.4	7,569	-29.4	14.6
Europe	4,032	-12.8	4,045	0.3	5,229	29.3	7,763	48.5	11,255	45.0	8,169	-27.4	15.2
Asia/Pacific	11	-21.0	4,611	-0.7	5,690	23.4	7,393	29.9	13,030	76.3	8,500	-34.8	12.9
Static RAM													
Worldwide	4,008	-20.2	4,182	4.3	5,694	36.2	7,378	29.6	9,402	27.4	9,761	3.8	19.5
Americas	1,852	-10.3	1,932	4.3	2,589	34.0	3,218	24.3	4,230	31.4	4,289	1.4	18.3
Japan	911	-26.1	950	4.3	1,294	36.2	1,677	29.6	2,137	27.4	2,219	3.8	19.5
Europe	646	-18.9	674	4.3	918	36.2	1,189	29.6	1,515	27.4	1,573	3.8	19.5
Asia/Pacific	599	-35.3	626	4.4	893	42.7	1,294	44.9	1,520	17.5	1,680	10.5	22.9
Nonvolatile Memory													
Worldwide	5,571	-13.7	5,533	-0.7	6,343	14.6	7,262	14.5	8,193	12.8	9,432	15.1	11.1
Americas	1,519	-16.5	1,527	0.5	1,780	16.5	2,055	15.5	2,309	12.4	2,646	14.6	11.7
Japan	1,612	-21.1	1,510	-6.3	1,721	14.0	1,934	12.4	2,115	9.3	2,381	12.6	8.1
Europe	1,216	-14.0	1,210	-0.5	1,390	14.9	1,604	15.4	1,839	14.6	2,140	16.4	12.0
Asia/Pacific	1,224	4.0	1,286	5.1	1,452	12.9	1,668	14.9	1,930	15.7	2,265	17.4	13.1
Other MOS Memory													
Worldwide	655	13.5	726	10.9	809	11.4	889	9.9	984	10.7	1,089	10.7	10.7
Americas	294	-3.0	329	12.1	361	9.6	387	7.3	432	11.6	492	13.7	10.8
Japan	163	6.5	181	10.9	201	11.4	221	9.9	245	10.7	271	10.7	10.7
Europe	147	72.9	163	10.9	182	11.4	200	9.9	221	10.7	244	10.7	10.7
Asia/Pacific	51	41.7	53	3.9	65	22.6	81	24.6	86	6.2	82	-4.7	10.0

Source: Dataquest (May 1998)

Table 3-4
Digital Logic Consumption by Region, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)
MOS Digital Logic													
Worldwide	24,757	9.2	26,573	7.3	31,084	17.0	37,061	19.2	42,793	15.5	50,818	18.8	15.5
Americas	8,525	12.7	9,484	11.3	11,373	19.9	13,900	22.2	16,465	18.4	19,960	21.2	18.5
Japan	8,164	4.4	8,282	1.5	9,256	11.8	10,492	13.4	11,663	11.2	13,387	14.8	10.4
Europe	4,159	5.2	4,634	11.4	5,515	19.0	6,714	21.7	7,889	17.5	9,531	20.8	18.0
Asia/Pacific	3,909	17.2	4,172	6.7	4,940	18.4	5,955	20.5	6,776	13.8	7,939	17.2	15.2
MOS Digital ASIC													
Worldwide	16,527	11.7	18,409	11.4	22,330	21.3	27,446	22.9	32,675	19.1	39,789	21.8	19.2
Americas	7,098	18.6	8,094	14.0	9,912	22.5	12,296	24.1	14,795	20.3	18,200	23.0	20.7
Japan	4,577	4.0	4,775	4.3	5,580	16.9	6,574	17.8	7,581	15.3	8,935	17.9	14.3
Europe	3,190	12.9	3,647	14.3	4,458	22.2	5,561	24.7	6,674	20.0	8,210	23.0	20.8
Asia/Pacific	11	4.7	1,893	13.9	2,380	25.7	3,015	26.7	3,625	20.2	4,443	22.6	21.7
Custom IC													
Worldwide	1,514	-12.2	1,164	-23.1	823	-29.4	557	-32.3	349	-37.3	205	-41.4	-33.0
Americas	223	-26.6	145	-35.0	64	-55.6	38	-40.7	20	-48.8	9	-55.0	-47.6
Japan	795	-5.2	630	-20.8	466	-26.0	315	-32.5	197	-37.4	116	-41.0	-31.9
Europe	71	-47.8	49	-31.0	37	-25.0	26	-30.0	17	-35.0	10	-40.0	-32.4
Asia/Pacific	425	-4.5	341	-19.8	256	-25.0	179	-30.0	116	-35.0	70	-40.0	-30.3
MOS Standard Logic													
Worldwide	2,266	13.7	2,373	4.7	2,565	8.1	2,739	6.8	2,775	1.3	2,805	1.1	4.4
Americas	684	4.9	705	3.0	761	8.0	811	6.6	823	1.5	815	-1.0	3.6
Japan	500	11.4	513	2.5	549	7.2	586	6.6	588	0.4	599	2.0	3.7
Europe	466	11.0	487	4.4	512	5.2	532	4.0	538	1.0	548	2.0	3.3
Asia/Pacific	616	30.5	670	8.7	743	11.0	810	9.0	826	2.0	843	2.0	6.5
Total Other MOS Logic													
Worldwide	4,450	7.0	4,626	4.0	5,366	16.0	6,318	17.7	6,993	10.7	8,019	14.7	12.5
Americas	520	-16.7	541	4.0	636	17.6	755	18.8	827	9.5	936	13.2	12.5
Japan	2,292	7.6	2,365	3.2	2,661	12.5	3,018	13.4	3,298	9.3	3,737	13.3	10.3
Europe	432	-24.5	451	4.5	509	12.7	595	16.9	660	11.0	763	15.5	12.0
Asia/Pacific	1,206	45.1	1,269	5.2	1,561	23.0	1,951	25.0	2,208	13.2	2,584	17.0	16.5

Source: Dataquest (May 1998)

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Table 3-5
Analog-Monolithic Consumption by Region, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)
Analog-Monolithic													
Worldwide	21,652	18.7	24,001	10.8	27,777	15.7	32,577	17.3	37,229	14.3	41,400	13.3	13.8
Americas	5,477	23.8	6,359	16.1	7,510	18.1	8,877	18.2	10,261	15.6	11,557	12.0	16.1
Japan	4,977	8.7	5,058	1.6	5,509	8.9	6,030	9.5	6,551	8.6	7,033	12.3	7.2
Europe	4,888	17.8	5,350	9.5	6,150	15.0	7,060	14.8	7,950	12.6	8,650	14.4	12.1
Asia/Pacific	6,310	24.1	7,234	14.6	8,608	19.0	10,610	23.3	12,467	17.5	14,160	14.0	17.5
Total Discrete													
Worldwide	14,255	5.8	15,221	6.8	16,934	11.3	19,711	16.4	21,100	7.0	23,300	19.8	10.3
Americas	3,074	5.1	3,400	10.6	3,910	15.0	4,704	20.3	5,098	8.4	5,697	19.3	13.1
Japan	4,244	-3.7	4,361	2.8	4,701	7.8	5,148	9.5	5,522	7.3	5,903	17.5	6.8
Europe	3,120	9.6	3,309	6.1	3,750	13.3	4,670	24.5	4,920	5.4	5,500	20.4	12.0
Asia/Pacific	11	15.9	4,151	8.8	4,573	10.2	5,189	13.5	5,560	7.1	6,200	22.6	10.2
Total Optical Semiconductor													
Worldwide	5,339	8.6	5,411	1.3	5,791	7.0	6,329	9.3	6,876	8.6	7,441	7.5	6.9
Americas	970	31.3	1,022	5.4	1,090	6.7	1,175	7.8	1,275	8.5	1,350	4.4	6.8
Japan	2,725	3.3	2,640	-3.1	2,820	6.8	3,050	8.2	3,305	8.4	3,560	7.8	5.5
Europe	731	-8.5	804	10.0	860	7.0	930	8.1	995	7.0	1,050	8.1	7.5
Asia/Pacific	913	23.5	945	3.5	1,021	8.0	1,174	15.0	1,301	10.8	1,481	8.5	10.2

Source: Dataquest (May 1998)

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Analog IC Forecast by Region

The movement to digital consumer electronics will be evolutionary, which means a stable long-term outlook for the analog IC market. As noted, the Asian crisis, among other factors, means somewhat lowered analog IC consumption expectations for Asia/Pacific and Japan in 1998 and in the long term. Even so, analog ICs historically show more equal distribution among the four regions than other products, and this stabilizes the worldwide outlook. Also, the increasing presence of analog ICs in computer and communications applications should stabilize worldwide growth.

Discrete Device Forecast by Region

Discrete semiconductors have been losing market share because of the relentless integration of components, yet the long-term outlook remains consistent with recent growth rates. For example, the discrete market had just under a 12 percent CAGR during the 1992-to-1997 period. Discrete semiconductors should grow at a somewhat slower but similar 10.3 percent CAGR for 1997 through 2002. The discrete semiconductor market remains viable because power and RF devices are not readily integrated. Power transistors represent about one-third of discrete device revenue and are expected to lead discrete device growth.

Asia/Pacific should ultimately surpass Japan as the world's largest market for discrete semiconductors. Each regional discrete device market—except Japan—should grow at a low double-digit CAGR through 2002.

The growing use of power discrete devices in power control and communications applications in the Americas and Europe indicates regional CAGRs of more than 12 percent in the next five years. The Americas and European markets for discrete semiconductors will remain at relatively the same size.

Optical Semiconductor Forecast by Region

Japan has been and should continue to be the largest regional market, by far, for optical semiconductors. Optoelectronics products are the most dependent of all semiconductor products on consumer entertainment-related applications. A major boom in the DVD application would mean stronger growth than currently projected for this product market (7 percent CAGR for 1997 to 2002). Meanwhile, computer and peripheral applications have an increasing impact on the optical semiconductor market. For example, scanners and copiers use charge-coupled devices (CCDs), CD-ROMs use laser diodes, and optical-fiber data links use semiconductor receivers and transmitters.

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Chapter 4
Americas Forecast by Product Family

Semiconductor Forecast by Region

The semiconductor forecast calls for the Americas region (North America and Latin America) to grow at a 16 percent CAGR for 1997 through 2002. This growth will push the $48 billion market of 1997 to $100 billion by 2002.

The following section identifies the assumptions that guide the forecast.

Dataquest expects the Americas semiconductor market to grow by a moderate 11 percent rate in 1998. Stronger growth should occur during the 1999-to-2001 time frame. As of the first half of 1998, the major North American semiconductor vendors reported slower growth than expected in world markets, including the home region. Some have indicated slowdowns in key application segments such as desktop PCs, cellular handsets, and consumer markets. In the long term, these application markets should expand, which signals strong regional growth in the DSP, flash, and SLI product markets.

PCs will remain a kingpin application in the Americas region for both the near term and the long term. For example, MPU and DRAM product revenue represents over 40 percent of the Americas region's product revenue. For 1998, the Americas MPU market will grow by 17 percent and reach $12 billion. The Americas DRAM market will barely grow in 1998 because of low pricing, despite continuing DRAM bit growth. As indicated, Dataquest expects a rebound in the second half of 1998 in the Americas PC MPU market.

Also, Intel should successfully migrate the x86 architecture to server applications over the long term; this translates into a 15 percent CAGR for MPU revenue in the Americas region.

High-Growth Products

MPUs will remain the largest regional product market. The 1997-to-2002 CAGRs of the fastest-growing semiconductor products in the Americas region are as follows (with 2002 revenue in parentheses):

- DSPs—24 percent CAGR ($3.1 billion)
- ASICs—21 percent CAGR ($18.2 billion)
- SRAM—18 percent ($4.3 billion)
- Flash memory—17 percent ($1.9 billion)
- MPUs—15.2 percent ($21.6 billion)

Tables 4-1 and 4-2 provide details of the Americas semiconductor market.

Figure 4-1 shows the effect of the Americas forecast on the relative consumption by product. The Americas market will remain highly dependent on the health of data processing, especially PCs.

Table 4-1
Americas Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	**48,086**	**5.3**	**53,326**	**10.9**	**64,133**	**20.3**	**78,388**	**22.2**	**95,782**	**22.2**	**99,906**	**4.3**	**15.7**
Total Integrated Circuit	**44,042**	**4.8**	**48,904**	**11.0**	**59,133**	**20.9**	**72,509**	**22.6**	**89,409**	**23.3**	**92,859**	**3.9**	**16.1**
Bipolar Digital	357	-40.2	303	-15.1	247	-18.5	221	-10.5	190	-14.0	164	-13.7	-14.4
MOS Memory	11,898	-18.7	12,215	2.7	15,733	28.8	21,511	36.7	29,953	39.2	24,108	-19.5	15.2
Dynamic RAM	8,233	-21.3	8,427	2.4	11,003	30.6	15,851	44.1	22,982	45.0	16,681	-27.4	15.2
Static RAM	1,852	-10.3	1,932	4.3	2,589	34.0	3,218	24.3	4,230	31.4	4,289	1.4	18.3
Nonvolatile Memory	1,519	-16.5	1,527	0.5	1,780	16.5	2,055	15.5	2,309	12.4	2,646	14.6	11.7
EPROM	220	-43.3	133	-39.3	92	-31.2	65	-28.8	46	-30.2	30	-33.6	-32.7
EEPROM	303	7.4	369	21.7	443	20.1	499	12.6	534	7.0	602	12.8	14.7
Flash Memory	11	-8.9	935	8.0	1,140	21.9	1,382	21.3	1,628	17.8	1,910	17.3	17.2
Mask ROM	309	-34.5	91	-30.9	106	16.9	109	2.7	102	-6.5	103	1.8	-4.6
Other MOS Memory	294	-3.0	329	12.1	361	9.6	387	7.3	432	11.6	492	13.7	10.8
MOS Microcomponent	17,785	21.9	20,543	15.5	24,270	18.1	28,000	15.4	32,540	16.2	37,070	13.9	15.8
Microprocessor	10,626	33.4	12,436	17.0	14,500	16.6	16,600	14.5	19,100	15.1	21,600	13.1	15.2
Microcontroller	2,194	0.6	2,790	27.2	3,190	14.3	3,680	15.4	4,390	19.3	5,060	15.3	18.2
Microperipheral	3,887	6.6	3,967	2.1	4,870	22.8	5,610	15.2	6,460	15.2	7,310	13.2	13.5
Digital Signal Processor	1,078	36.1	1,350	25.2	1,710	26.7	2,110	23.4	2,590	22.7	3,100	19.7	23.5
MOS Digital Logic	8,525	12.7	9,484	11.3	11,373	19.9	13,900	22.2	16,465	18.4	19,960	21.2	18.5
ASICs	7,098	18.6	8,094	14.0	9,912	22.5	12,296	24.1	14,795	20.3	18,200	23.0	20.7
Custom IC	223	-26.6	145	-35.0	64	-55.6	38	-40.7	20	-48.8	9	-55.0	-47.6
MOS Standard Logic	684	4.9	705	3.0	761	8.0	811	6.6	823	1.5	815	-1.0	3.6
Total Other MOS Logic	520	-16.7	541	4.0	636	17.6	755	18.8	827	9.5	936	13.2	12.5
Analog-Monolithic	5,477	23.8	6,359	16.1	7,510	18.1	8,877	18.2	10,261	15.6	11,557	12.6	16.1
Total Discrete	3,074	5.1	3,400	10.6	3,910	15.0	4,704	20.3	5,098	8.4	5,697	11.7	13.1
Total Optical Semiconductor	970	31.3	1,022	5.4	1,090	6.7	1,175	7.8	1,275	8.5	1,350	5.9	6.8

Source: Dataquest (May 1998)

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Table 4-2
Americas Semiconductor Market, Revenue History, 1992-1997 (Millions of Dollars)

	1992 Revenue	1992 Growth (%)	1993 Revenue	1993 Growth (%)	1994 Revenue	1994 Growth (%)	1995 Revenue	1995 Growth (%)	1996 Revenue	1996 Growth (%)	1997 Revenue	1997 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	20,426	20.2	27,924	36.7	35,773	28.1	48,343	35.1	45,672	-5.5	48,086	5.3	18.7
Total Integrated Circuit	18,400	20.5	25,629	39.3	32,864	28.2	44,691	36.0	42,009	-6.0	44,042	4.8	19.1
Bipolar Digital	1,232	-7.4	1,173	-4.8	967	-17.6	760	-21.4	597	-21.4	357	-40.2	-21.9
MOS Memory	5,707	26.5	8,785	53.9	12,469	41.9	20,480	64.2	14,642	-28.5	11,898	-18.7	15.8
Dynamic RAM	3,555	36.7	5,832	64.1	9,030	54.8	15,739	74.3	10,455	-33.6	8,233	-21.3	18.3
Static RAM	1,107	24.5	1,349	21.9	1,630	20.8	2,509	53.9	2,064	-17.7	1,852	-10.3	10.8
Nonvolatile Memory	924	3.2	1,449	56.8	1,634	12.8	1,951	19.4	1,820	-6.7	1,519	-16.5	10.5
EPROM	417	-4.8	489	17.3	527	7.8	419	-20.5	388	-7.4	220	-43.3	-12.0
EEPROM	139	0	178	28.1	233	30.9	290	24.5	282	-2.8	303	7.4	16.9
Flash Memory	11	0	482	232.4	474	-1.7	852	79.7	950	11.5	865	-8.9	42.9
Mask ROM	309	0	300	34.5	400	33.3	390	-2.5	200	-48.7	131	-34.5	-10.1
Other MOS Memory	121	-3.2	155	28.1	175	12.9	281	60.6	303	7.8	294	-3.0	19.4
MOS Microcomponent	5,282	34.8	7,620	44.3	9,839	29.1	12,425	26.3	14,587	17.4	17,785	21.9	27.5
Microprocessor	2,674	53.2	4,323	61.7	5,446	26.0	6,800	24.9	7,968	17.2	10,626	33.4	31.8
Microcontroller	938	19.3	1,254	33.7	1,652	31.7	2,048	24.0	2,181	6.5	2,194	0.6	18.5
Microperipheral	1,486	17.4	1,764	18.7	2,320	31.5	2,982	28.5	3,646	22.3	3,887	6.6	21.2
Digital Signal Processor	184	54.6	279	51.6	421	50.9	595	41.3	792	33.1	1,078	36.1	42.4
MOS Digital Logic	3,179	10.8	4,459	40.3	5,422	21.6	6,801	25.4	7,566	11.2	8,525	12.7	21.8
ASICs	2,313	10.6	3,088	33.5	3,846	24.5	5,012	30.3	5,986	19.4	7,098	18.6	25.1
Custom IC	207	5.1	291	40.6	493	69.4	529	7.3	304	-42.5	223	-26.6	1.5
MOS Standard Logic	369	31.3	433	17.3	563	30.0	684	21.5	652	-4.7	684	4.9	13.1
Total Other MOS Logic	290	-3.7	652	124.8	525	-19.5	582	10.9	624	7.2	520	-16.7	12.4
Analog-Monolithic	2,691	12.3	3,304	22.8	3,820	15.6	3,994	4.6	4,425	10.8	5,477	23.8	15.3
Total Discrete	1,603	15.4	1,811	13.0	2,212	22.1	3,027	36.8	2,924	-3.4	3,074	5.1	13.9
Total Optical Semiconductor	423	27.4	484	14.4	697	44.0	625	-10.3	739	18.2	970	31.3	18.1

Source: Dataquest (May 1998)

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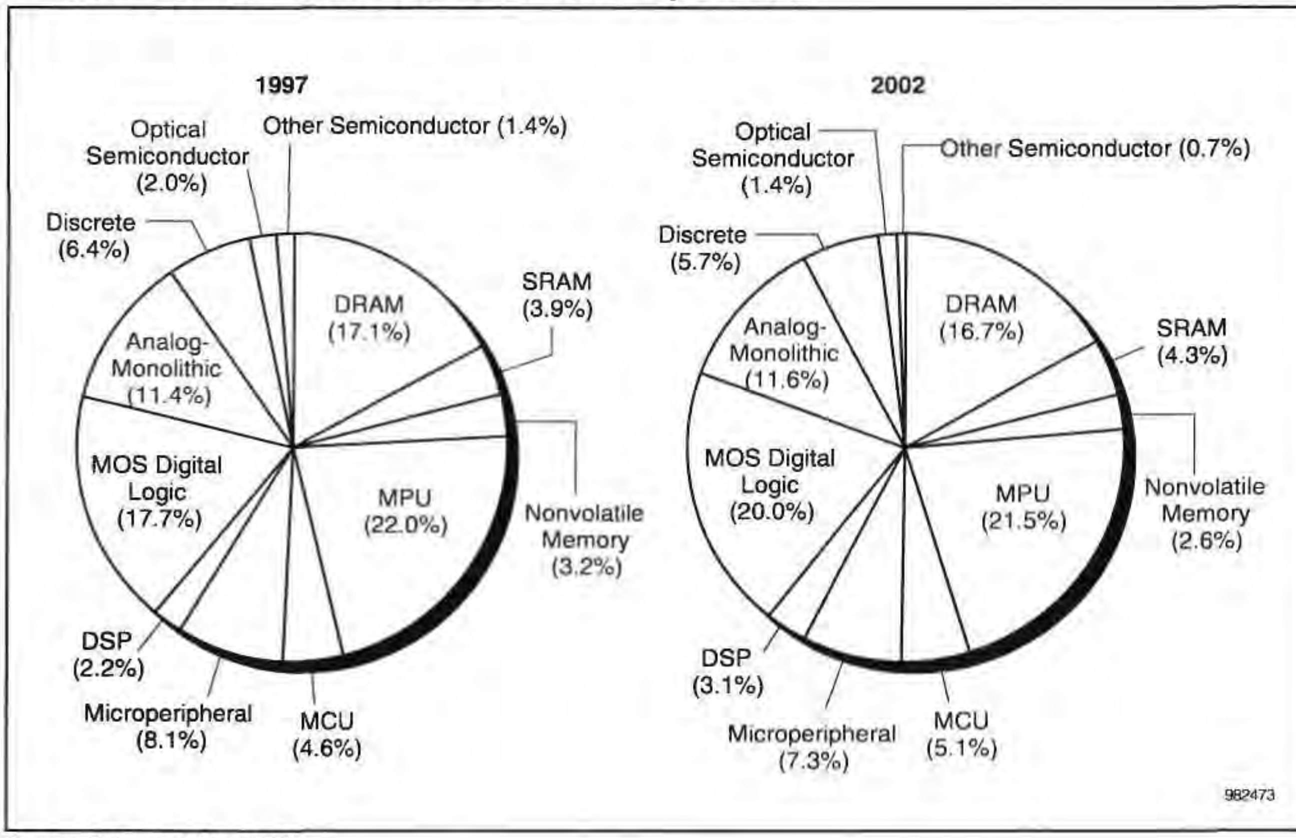
Figure 4-1
Americas Semiconductor Revenue Forecast by Product



Source: Dataquest (May 1998)

Chapter 5
Japanese Forecast by Product Family

Semiconductor Forecast by Region

Dataquest forecasts that the Japanese market will have an 11 percent CAGR for 1997 through 2002. The $37-billion market (in 1997) should reach $60 billion by 2002. This Japanese regional forecast of semiconductor consumption is lower than previously expected. Japan's economy both affects and is affected by the Asian crisis.

The following section identifies the assumptions that guide the forecast.

Market Weakness of Applications

On the demand side, electronic equipment production is expected to show 3 percent growth, which is lower than the fall forecast. This reduction comes from the decelerated domestic economy, as well as the decrease in demand in Asia/Pacific because of the macroeconomic crisis. PC shipments in Japan are experiencing sluggishness or even a decline in some months, and 1998 will see modest single-digit growth. Mobile communications did not slow down as expected in 1997—so the downturn is expected this year.

The CAGR of electronic equipment production for Japan in the years 1997 through 2002 is quite weak—less than 3 percent. Communications and consumer products will remain the leading applications, while industrial will see the highest CAGR over the period. Even with the introduction of all the digitized systems, the consumer category should remain the second-largest. Japan's consumer segment, however, should generate the slowest growth in semiconductor consumption for the coming five years.

Slower Semiconductor Product Growth

Japanese semiconductor consumption in 1998 will increase by just 3 percent in dollars, and at a somewhat higher rate in yen. With major applications slowing down, such as PCs, mobile communications, and audio/video equipment, as well as weak capital spending in most industries, Japanese semiconductor consumption is showing the lowest growth among all regions. In the coming five years, the weak growth in electronic equipment production will limit the growth of semiconductor consumption in Japan. As a result, Japan's 11 percent CAGR is the lowest of all the regions.

DRAM bit prices are declining faster than forecast during 1998 because of prolonged oversupply and the quick ramp-up of 64Mb supply. The shift from extended data out (EDO) to SDRAM may not contribute to DRAM price firming as much as previously expected. The current focus of interest is on the pricing premium of 100-MHz SDRAM, which remains to be secured for the first half of 1998 but will diminish in the second half as vendors increase supply.

Flash memory market will continue to be driven in both the near term and the long term by mobile equipment and IC card applications, such as cellular phones and digital still camera. As major memory suppliers emphasize flash memory in view of sluggish DRAM, the pricing of flash memories will continue to decline, and that will include 16Mb and beyond.

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In the MOS microcomponent area during 1998, the MPU market growth in Japan will slow because of the sluggish Japanese PC market; the MCU market will experience somewhat stronger growth this year.

Four-bit MCUs will continue to enjoy expansion in application areas but will be replaced by 8-bit toward the end of the forecast period. MCUs with embedded flash will expand their market quickly and will lead to the introduction of embedded ferroelectric (FRAM) MCUs. Sixteen-bit MCU applications include emerging digital consumer equipment such as DVD, minidisc (MD), digital TV, and digital VCR. Both 32-bit and 64-bit products will continue to find applications in system-level integration.

DSP including media processors will continue to show the highest growth among microcomponent categories, finding applications in digital cellular, rigid disk drive (RDD), and DVD, utilizing advanced process technology of each generation.

In the ASIC area, system-level integration is becoming the norm for product development as well as applications. This trend is expediting the shift from gate arrays to CBICs and PLDs. In the Japanese market, because the domestic suppliers still put emphasis on gate arrays, this shift is taking place more slowly than in the worldwide market. CBICs in Japan are currently based on 0.35- to 0.25-micron processes, moving to 0.18-micron processes, as microcomponent, memories, and analog become embedded to offer SLI solutions.

Portable equipment applications in Japan are expected to drive low-voltage technologies as well as embedded memories and high-density packaging technologies.

Analog is expected to slow down in 1998 because of sluggish domestic markets for end products including consumer equipment. General-purpose analog such as amps and voltage regulators enjoyed proliferation as emerging new systems were introduced. However, as SLI becomes the norm for optimized system development, independent, general-purpose analog will be embedded in CBICs. RF and power products continue to enjoy sound growth in the forecast period, although 1998 should be a year of slow growth.

Similar market trends are expected for discrete semiconductors in Japan. For example, small signal products, which enjoyed an increase in volume in the past few years, will finally see slow growth as SLI products incorporate more system blocks. Here again, RF and power are the two functions that remain to be covered by independent ("discrete") discrete products, helped by mobile applications and digital consumer equipment. Steady growth is expected in optical semiconductors.

High-Growth Products

The 1997-to-2002 CAGRs of the fastest-growing semiconductor products in the Japanese region are shown here (with 2002 revenue in parentheses):

- DSPs—28 percent ($2.5 billion)
- SRAM—20 percent ($2.2 billion)

- Flash memory—18 percent ($1.5 billion)
- MPUs—16 percent ($5.6 billion)

Tables 5-1 and 5-2 provide details of the Japanese semiconductor market.

Figure 5-1 provides a product comparison for final revenue in the Japanese market.

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Table 5-1
Japanese Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	36,499	-5.0	37,397	2.5	42,943	14.8	49,988	16.4	58,610	17.2	61,093	4.2	10.9
Total Integrated Circuit	29,530	-5.9	30,396	2.9	35,422	16.5	41,790	18.0	49,783	19.1	51,630	3.7	11.8
Bipolar Digital	530	-31.2	498	-6.0	425	-14.7	389	-8.5	335	-13.9	300	-10.4	-10.8
MOS Memory	6,523	-23.1	6,518	-0.1	8,192	25.7	10,870	32.7	15,224	40.1	12,439	-18.3	13.8
Dynamic RAM	3,837	-24.1	3,877	1.0	4,975	28.3	7,037	41.4	10,727	52.4	7,569	-29.4	14.6
Static RAM	911	-26.1	950	4.3	1,294	36.2	1,677	29.6	2,137	27.4	2,219	3.8	19.5
Nonvolatile Memory	1,612	-21.1	1,510	-6.3	1,721	14.0	1,934	12.4	2,115	9.3	2,381	12.6	8.1
EPROM	169	-51.4	114	-32.8	87	-23.0	71	-19.3	58	-17.9	49	-16.0	-22.0
EEPROM	151	-9.6	175	15.9	204	16.4	230	12.8	260	13.3	300	15.3	14.7
Flash Memory	11	-19.0	702	10.2	852	21.4	1,034	21.5	1,228	18.7	1,464	19.2	18.1
Mask ROM	309	-11.8	520	-20.7	579	11.4	600	3.6	568	-5.2	568	-0.1	-2.8
Other MOS Memory	163	6.5	181	10.9	201	11.4	221	9.9	245	10.7	271	10.7	10.7
MOS Microcomponent	9,336	6.1	10,040	7.5	12,040	19.9	14,010	16.4	16,010	14.3	18,470	15.4	14.6
Microprocessor	2,676	14.7	2,813	5.1	3,420	21.6	4,020	17.5	4,710	17.2	5,550	17.8	15.7
Microcontroller	4,059	3.3	4,360	7.4	5,200	19.3	6,040	16.2	6,720	11.3	7,580	12.8	13.3
Microperipheral	1,873	-9.2	1,917	2.3	2,200	14.8	2,410	9.5	2,620	8.7	2,850	8.8	8.8
Digital Signal Processor	728	54.9	950	30.5	1,220	28.4	1,540	26.2	1,960	27.3	2,490	27.0	27.9
MOS Digital Logic	8,164	4.4	8,282	1.5	9,256	11.8	10,492	13.4	11,663	11.2	13,387	14.8	10.4
ASICs	4,577	4.0	4,775	4.3	5,580	16.9	6,574	17.8	7,581	15.3	8,935	17.9	14.3
Custom IC	795	-5.2	630	-20.8	466	-26.0	315	-32.5	197	-37.4	116	-41.0	-31.9
MOS Standard Logic	500	11.4	513	2.5	549	7.2	586	6.6	588	0.4	599	2.0	3.7
Total Other MOS Logic	2,292	7.6	2,365	3.2	2,661	12.5	3,018	13.4	3,298	9.3	3,737	13.3	10.3
Analog-Monolithic	4,977	8.7	5,058	1.6	5,509	8.9	6,030	9.5	6,551	8.6	7,033	7.4	7.2
Total Discrete	4,244	-3.7	4,361	2.8	4,701	7.8	5,148	9.5	5,522	7.3	5,903	6.9	6.8
Total Optical Semiconductor	2,725	3.3	2,640	-3.1	2,820	6.8	3,050	8.2	3,305	8.4	3,560	7.7	5.5

Source: Dataquest (May 1998)

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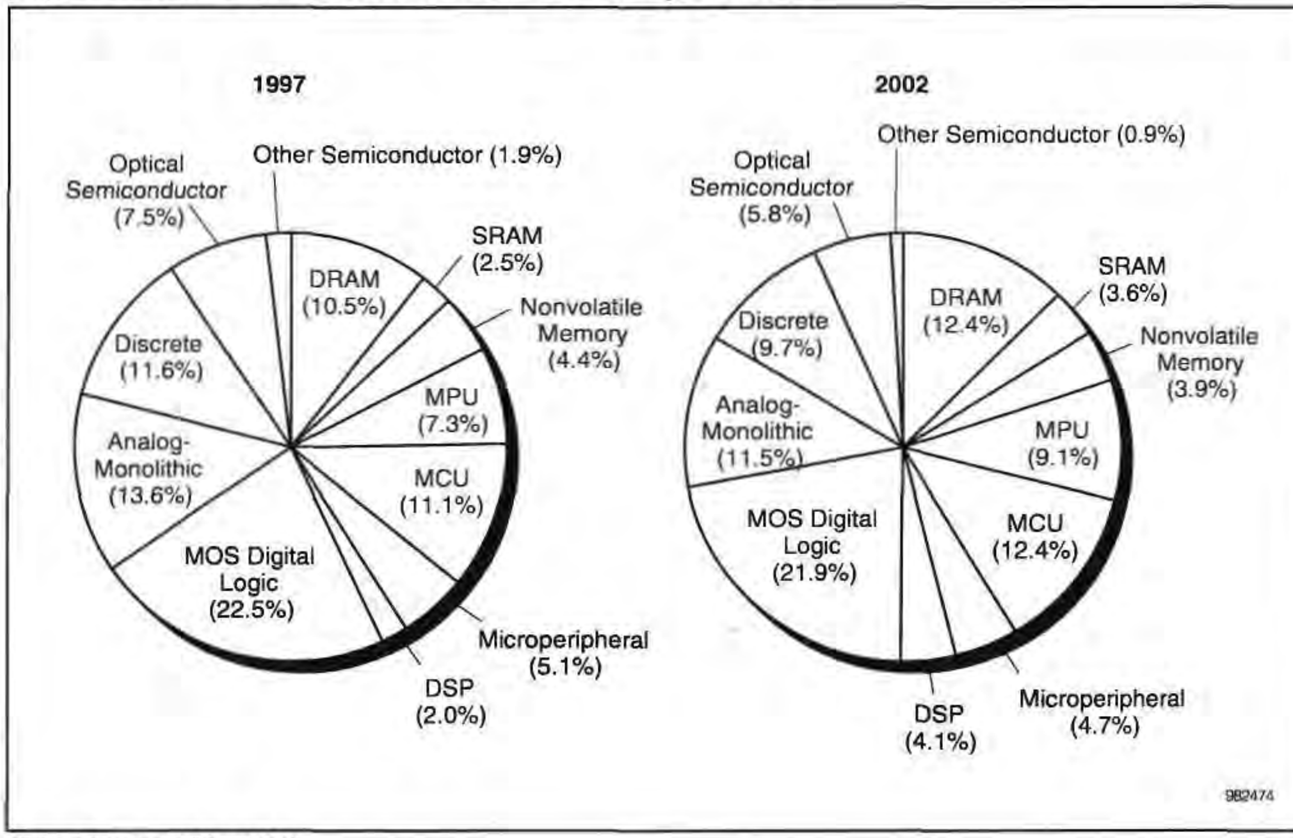
Table 5-2
Japanese Semiconductor Market, Revenue History, 1992-1997 (Millions of Dollars)

	1992 Revenue	1992 Growth (%)	1993 Revenue	1993 Growth (%)	1994 Revenue	1994 Growth (%)	1995 Revenue	1995 Growth (%)	1996 Revenue	1996 Growth (%)	1997 Revenue	1997 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	**20,582**	**-8.5**	**24,645**	**19.7**	**31,008**	**25.8**	**42,086**	**35.7**	**38,413**	**-8.7**	**36,499**	**-5.0**	**12.1**
Total Integrated Circuit	**15,949**	**-7.7**	**19,494**	**22.2**	**24,995**	**28.2**	**34,624**	**38.5**	**31,367**	**-9.4**	**29,530**	**-5.9**	**13.1**
Bipolar Digital	1,154	-20.0	1,128	-2.3	1,216	7.8	1,068	-12.2	770	-27.9	530	-31.2	-14.4
MOS Memory	4,037	-4.5	5,570	38.0	7,246	30.1	12,168	67.9	8,487	-30.3	6,523	-23.1	10.1
Dynamic RAM	1,800	-7.6	2,687	49.3	4,012	49.3	8,490	111.6	5,057	-40.4	3,837	-24.1	16.3
Static RAM	1,029	-4.8	1,305	26.8	1,397	7.0	1,446	3.5	1,233	-14.7	911	-26.1	-2.4
Nonvolatile Memory	1,198	1.4	1,538	28.4	1,785	16.1	2,116	18.5	2,044	-3.4	1,612	-21.1	6.1
EPROM	314	-24.2	377	20.1	396	5.0	439	10.9	348	-20.7	169	-51.4	-11.7
EEPROM	79	0	88	11.4	122	38.6	143	17.2	167	16.8	151	-9.6	13.8
Flash Memory	11	0	34	183.3	120	252.9	361	200.8	786	117.7	637	-19.0	121.3
Mask ROM	309	0	1,039	31.0	1,147	10.4	1,173	2.3	743	-36.7	655	-11.8	-3.8
Other MOS Memory	10	-44.4	40	300.0	52	30.0	116	123.1	153	31.9	163	6.5	74.8
MOS Microcomponent	3,269	-8.7	3,987	22.0	5,603	40.5	7,826	39.7	8,797	12.4	9,336	6.1	23.4
Microprocessor	604	-1.9	835	38.2	1,247	49.3	1,686	35.2	2,334	38.4	2,676	14.7	34.7
Microcontroller	1,913	-12.2	2,284	19.4	2,964	29.8	4,140	39.7	3,930	-5.1	4,059	3.3	16.2
Microperipheral	650	-5.4	749	15.2	1,226	63.7	1,726	40.8	2,063	19.5	1,873	-9.2	23.6
Digital Signal Processor	102	5.2	119	16.7	166	39.5	274	65.1	470	71.5	728	54.9	48.2
MOS Digital Logic	3,837	-5.8	4,711	22.8	5,993	27.2	7,793	30.0	7,821	0.4	8,164	4.4	16.3
ASICs	1,749	-7.7	2,298	31.4	2,893	25.9	4,270	47.6	4,402	3.1	4,577	4.0	21.2
Custom IC	1,285	-3.8	1,477	14.9	1,308	-11.4	979	-25.2	839	-14.3	795	-5.2	-9.2
MOS Standard Logic	315	-7.1	386	22.5	443	14.8	519	17.2	449	-13.5	500	11.4	9.7
Total Other MOS Logic	488	-3.4	560	14.8	1,359	142.7	2,025	49.0	2,131	5.2	2,292	7.6	36.3
Analog-Monolithic	2,902	-6.2	3,278	13.0	4,048	23.5	4,745	17.2	4,577	-3.5	4,977	8.7	11.4
Total Discrete	3,077	-10.3	3,423	11.2	3,916	14.4	4,694	19.9	4,408	-6.1	4,244	-3.7	6.6
Total Optical Semiconductor	1,556	-12.9	1,728	11.1	2,097	21.4	2,768	32.0	2,638	-4.7	2,725	3.3	11.9

Source: Dataquest (May 1998)

Figure 5-1
Japanese Semiconductor Revenue Forecast by Product



Source: Dataquest (May 1998)

Chapter 6
Europe, Middle East, and Africa Forecast by Product Family

Semiconductor Forecast by Region

The forecast calls for the Europe (including Middle East and Africa) market to grow at a 15 percent CAGR for 1997 through 2002. The market should grow by nearly 9 percent in 1998 to a total of $33 billion and reach $60 billion by 2002. The following assumptions guide the forecast with a focus on the near term.

The single most critical factor affecting the 1998 European semiconductor market will be DRAM average selling prices. A "side effect" of DRAM pricing and the excess capacity driving low DRAM pricing is the impact on the European pricing of other semiconductor products.

The prime application driver for Europe is the PC. For the near term, concern about "downside" forecast potential far outweighs upside potential. If European consumption of PCs is less than expected this year, MPU and DRAM revenue growth in the region would become lower than currently projected (about $0.5 billion).

A second major application driver in the European semiconductor market is mobile communications. The negative impact of the Asian crisis has been incorporated into the 1998 European semiconductor forecast. If the Asian crisis proves not as bad as expected, then the near-term European semiconductor forecast gains upside potential ($1.5 billion range).

Wireline communications mark a third key semiconductor application in Europe. France and Germany have started to "liberalize" their networks in 1998, which means increased semiconductor consumption. The European forecast is relatively pessimistic about the impact in this first year of new operators moving into the region. If the pace is faster than expected, then the European semiconductor forecast gains additional near-term upside potential.

Increasing Internet usage means growth in European data communication applications. The Internet now helps drive local European manufacture of switches, hubs, and routers by the major players. The current European semiconductor forecast is based on a conservative estimate of the regional production. The potential of faster growth means upside potential for the European semiconductor market.

By contrast, consumer digital applications create some downside forecast potential The current forecast expects strong growth in the set-top box market. Several pending European regulatory issues, however, might again delay European deployment of STB. This could lower European semiconductor consumption in this segment by about $100 million.

High-Growth Products

The products with the highest CAGRs in Europe over the five-year forecast period are as follows (with 2002 revenue in parentheses):

- DSPs—26 percent ($3.3 billion)
- ASICs—21 percent ($8.2 billion)
- SRAM—20 percent ($1.6 billion)
- Flash memory—17 percent ($1.4 billion)

Tables 6-1 and 6-2 provide details on the European semiconductor market.

Figure 6-1 shows the impact of the five-year forecast by product for the Europe, Middle East, and Africa market over the forecast period.

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Table 6-1
Europe, Middle East, and Africa Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	30,046	5.9	32,627	8.6	38,425	17.8	46,927	22.1	56,152	19.7	59,335	5.7	14.6
Total Integrated Circuit	26,195	5.9	28,514	8.9	33,815	18.6	41,327	22.2	50,237	21.6	52,785	5.1	15.0
Bipolar Digital	168	-31.7	141	-16.1	122	-13.5	97	-20.5	78	-19.6	56	-28.2	-19.7
MOS Memory	6,041	-12.7	6,092	0.8	7,718	26.7	10,756	39.4	14,831	37.9	12,127	-18.2	15.0
Dynamic RAM	4,032	-12.8	4,045	0.3	5,229	29.3	7,763	48.5	11,255	45.0	8,169	-27.4	15.2
Static RAM	646	-18.9	674	4.3	918	36.2	1,189	29.6	1,515	27.4	1,573	3.8	19.5
Nonvolatile Memory	1,216	-14.0	1,210	-0.5	1,390	14.9	1,604	15.4	1,839	14.6	2,140	16.4	12.0
EPROM	191	-32.3	128	-32.8	99	-23.0	80	-19.3	65	-17.9	55	-16.0	-22.0
EEPROM	302	-29.9	350	15.9	407	16.4	460	12.8	521	13.3	601	15.3	14.7
Flash Memory	11	4.5	690	2.9	837	21.4	1,016	21.5	1,207	18.7	1,439	19.2	16.5
Mask ROM	309	-11.7	42	-20.7	47	11.4	49	3.6	46	-5.2	46	-0.1	-2.8
Other MOS Memory	147	72.9	163	10.9	182	11.4	200	9.9	221	10.7	244	10.7	10.7
MOS Microcomponent	10,939	17.1	12,296	12.4	14,310	16.4	16,700	16.7	19,490	16.7	22,420	15.0	15.4
Microprocessor	5,901	16.6	6,702	13.6	7,760	15.8	8,930	15.1	10,200	14.2	11,600	13.7	14.5
Microcontroller	2,330	11.9	2,540	9.0	2,820	11.0	3,290	16.7	3,920	19.1	4,510	15.1	14.1
Microperipheral	1,661	8.0	1,755	5.6	2,070	18.0	2,360	14.0	2,720	15.3	3,030	11.4	12.8
Digital Signal Processor	1,047	59.1	1,300	24.2	1,660	27.7	2,120	27.7	2,650	25.0	3,280	23.8	25.7
MOS Digital Logic	4,159	5.2	4,634	11.4	5,515	19.0	6,714	21.7	7,889	17.5	9,531	20.8	18.0
ASICs	3,190	12.9	3,647	14.3	4,458	22.2	5,561	24.7	6,674	20.0	8,210	23.0	20.8
Custom IC	71	-47.8	49	-31.0	37	-25.0	26	-30.0	17	-35.0	10	-40.0	-32.4
MOS Standard Logic	466	11.0	487	4.4	512	5.2	532	4.0	538	1.0	548	2.0	3.3
Total Other MOS Logic	432	-24.5	451	4.5	509	12.7	595	16.9	660	11.0	763	15.5	12.0
Analog-Monolithic	4,888	17.8	5,350	9.5	6,150	15.0	7,060	14.8	7,950	12.6	8,650	8.8	12.1
Total Discrete	3,120	9.6	3,309	6.1	3,750	13.3	4,670	24.5	4,920	5.4	5,500	11.8	12.0
Total Optical Semiconductor	731	-8.5	804	10.0	860	7.0	930	8.1	995	7.0	1,050	5.5	7.5

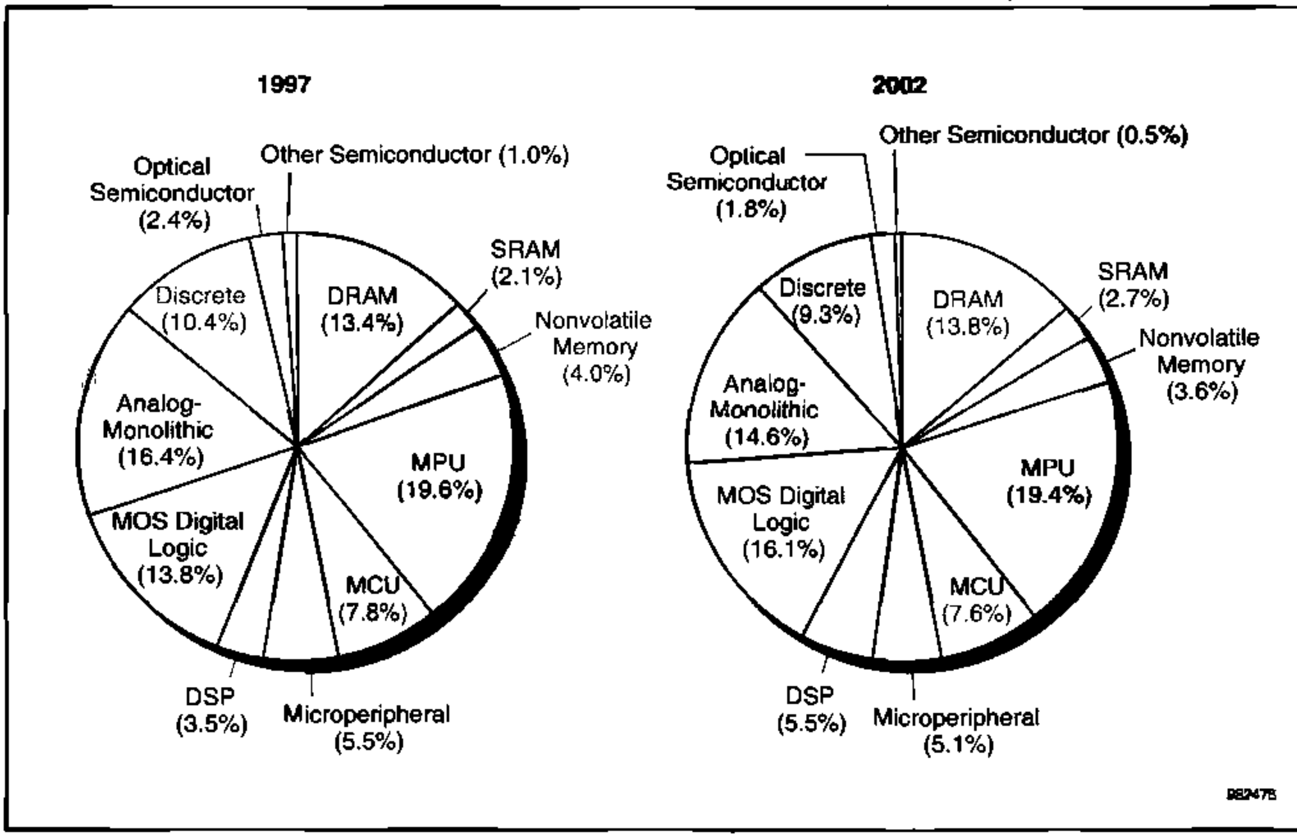
Source: Dataquest (May 1998)

Table 6-2
Europe, Middle East, and Africa Semiconductor Market, Revenue History, 1992 to 1997 (Millions of Dollars)

	1992 Revenue	1992 Growth (%)	1993 Revenue	1993 Growth (%)	1994 Revenue	1994 Growth (%)	1995 Revenue	1995 Growth (%)	1996 Revenue	1996 Growth (%)	1997 Revenue	1997 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	12,218	10.9	15,459	26.5	20,900	35.2	28,416	36.0	28,379	-0.1	30,046	5.9	19.7
Total Integrated Circuit	9,958	14.5	13,318	33.7	18,217	36.8	24,617	35.1	24,732	0.5	26,195	5.9	21.3
Bipolar Digital	426	-12.3	390	-8.5	357	-8.5	306	-14.3	246	-19.6	168	-31.7	-17.0
MOS Memory	2,660	24.9	4,040	51.9	6,574	62.7	10,074	53.2	6,918	-31.3	6,041	-12.7	17.8
Dynamic RAM	1,557	29.2	2,671	71.5	4,927	84.5	7,887	60.1	4,622	-41.4	4,032	-12.8	21.0
Static RAM	458	21.5	525	14.6	620	18.1	921	48.5	797	-13.5	646	-18.9	7.1
Nonvolatile Memory	607	17.6	798	31.5	966	21.1	1,180	22.2	1,414	19.8	1,216	-14.0	14.9
EPROM	293	-3.3	323	10.2	350	8.4	333	-4.9	282	-15.3	191	-32.3	-8.2
EEPROM	170	0	214	25.9	300	40.2	274	-8.7	431	57.3	302	-29.9	12.2
Flash Memory	11	0	181	154.9	206	13.8	483	134.5	641	32.7	670	4.5	56.7
Mask ROM	309	0	80	9.6	110	37.5	90	-18.2	60	-33.3	53	-11.7	-6.2
Other MOS Memory	38	22.6	46	21.1	61	32.6	86	41.0	85	-1.2	147	72.9	31.1
MOS Microcomponent	2,723	30.9	4,037	48.3	5,408	34.0	7,000	29.4	9,341	33.4	10,939	17.1	32.1
Microprocessor	1,088	60.5	2,098	92.8	2,775	32.3	3,196	15.2	5,062	58.4	5,901	16.6	40.2
Microcontroller	934	17.8	1,106	18.4	1,431	29.4	2,030	41.9	2,083	2.6	2,330	11.9	20.1
Microperipheral	571	5.7	615	7.7	897	45.9	1,226	36.7	1,538	25.4	1,661	8.0	23.8
Digital Signal Processor	130	85.7	218	67.7	305	39.9	548	79.7	658	20.1	1,047	59.1	51.8
MOS Digital Logic	1,749	6.5	1,936	10.7	2,330	20.4	2,959	27.0	3,953	33.6	4,159	5.2	18.9
ASICs	965	9.8	1,114	15.4	1,369	22.9	1,867	36.4	2,825	51.3	3,190	12.9	27.0
Custom IC	171	1.8	140	-18.1	157	12.1	169	7.6	136	-19.5	71	-47.8	-16.1
MOS Standard Logic	248	18.1	311	25.4	419	34.7	483	15.3	420	-13.0	466	11.0	13.4
Total Other MOS Logic	366	-5.4	378	3.3	390	3.2	446	14.4	572	28.3	432	-24.5	3.4
Analog-Monolithic	2,249	3.0	2,736	21.7	3,370	23.2	4,134	22.7	4,148	0.3	4,888	17.8	16.8
Total Discrete	1,826	-0.1	1,769	-3.1	2,108	19.2	3,118	47.9	2,848	-8.7	3,120	9.6	11.3
Total Optical Semiconductor	434	-10.5	372	-14.3	575	54.6	681	18.4	799	17.3	731	-8.5	11.0

Source: Dataquest (May 1998)

Figure 6-1
Europe, Middle East, and Africa Semiconductor Revenue Forecast by Product



Source: Dataquest (May 1998)

Chapter 7
Asia/Pacific Forecast by Product Family

Semiconductor Forecast by Region

Dataquest's forecast calls for the Asia/Pacific market to grow at a 16 percent CAGR from 1997 through 2002, which is lower than prior expectations. The market should grow by 10 percent this year to $36 billion and total $68 billion by 2002. The following assumptions guide the forecast.

The financial crisis in the Asia/Pacific region will have varying effects on semiconductor consumption in the region—many negative, but some positive. The effects also differ markedly on an Asian country-by-country basis. For example, growth has decelerated in countries such as Indonesia, Thailand, and the Philippines—but accelerated in China and Taiwan. Taiwan's electronics industry will fare well in this crisis, primarily because a larger percentage of components are supplied locally and because its financial sector is stronger than in the other countries.

All semiconductor vendors watch China. China's electronics equipment production will grow nearly 20 percent this year. China now stands as the largest semiconductor market in Asia/Pacific. China represents a huge consumer of communications and computer equipment, accounting for 25 percent of all personal computers purchased in Asia/Pacific. China's PC unit growth exceeds a 40 percent annual rate.

Although electronics consumption may be lower than previously expected in selected countries, the region as a whole will continue to enjoy the fastest growth rates in the world.

The semiconductor market for PC applications represents more than one-third of all semiconductor consumption and will continue as the key role for semiconductor growth. The Asia/Pacific PC production will maintain steady growth over the forecast period. PC production in Asia/Pacific should total 23 million units in 1998. The PC production growth in this region will be attributed to Pentium II, DVD, 3-D graphics, Windows NT, and Windows 98. Although much of the production is shipped elsewhere in the world, PC unit consumption in the region should increase by more than 20 percent this year and reach 12 million units.

In the long term, Dataquest expects the region's most important semiconductor demand driver, the PC, to sustain solid growth in Asia/Pacific production, with a CAGR of 23 percent over the five-year forecast period. As a result, PC production in Asia/Pacific will exceed 45 million units in 2002. PC motherboard production will also continue in the region.

In terms of regional consumption, PC unit consumption in Asia/Pacific will grow at a 25 percent CAGR for the period and total 30 million units in 2002. PC revenue will grow at a slower, but still impressive, 20 percent CAGR.

Communications equipment will also generate outstanding Asia/Pacific semiconductor growth over the forecast period. This application will support the demand growth for ASICs, DSPs, application-specific standard

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products (ASSPs), and analog ICs. In the near term, most of the Asia/Pacific semiconductor market for communication in 1998 will be driven by mobile and wireless communications. Digital consumer products such as digital set-top-boxes will also begin to make a significant contribution to overall semiconductor demand.

The discrete device and optical semiconductor markets should be lower in 1998 than originally expected because of sluggish consumer equipment production, especially digital consumer applications. However, these markets will continue to achieve steady growth because of the post-1998 recovery in Asia/Pacific production of digital consumer equipment.

High-Growth Products

The following summarizes the CAGRs of the fastest-growing products in the region (with 2002 regional revenue shown in parentheses):

- DSPs—24 percent CAGR ($2.4 billion)
- SRAM—23 percent ($1.7 billion)
- Flash memory—21 percent ($1.6 billion)
- ASICs—22 percent ($4.4 billion)
- MPUs—20 percent ($11 billion)

Tables 7-1 and 7-2 provide details on the Asia/Pacific semiconductor market.

Figure 7-1 compares products in 1997 and 2002.

Table 7-1
Asia/Pacific Semiconductor Market, Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997 Revenue	1997 Growth (%)	1998 Revenue	1998 Growth (%)	1999 Revenue	1999 Growth (%)	2000 Revenue	2000 Growth (%)	2001 Revenue	2001 Growth (%)	2002 Revenue	2002 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	32,534	9.6	35,899	10.3	42,754	19.1	51,751	21.0	64,483	24.6	67,561	4.8	15.7
Total Integrated Circuit	27,804	8.4	30,803	10.8	37,160	20.6	45,388	22.1	57,622	27.0	59,880	3.9	16.6
Bipolar Digital	184	-22.0	170	-7.6	152	-10.6	128	-15.8	104	-18.8	84	-19.2	-14.5
MOS Memory	6,516	-18.7	6,576	0.9	8,100	23.2	10,436	28.8	16,566	58.7	12,527	-24.4	14.0
Dynamic RAM	4,642	-21.0	4,611	-0.7	5,690	23.4	7,393	29.9	13,030	76.3	8,500	-34.8	12.9
Static RAM	599	-35.3	626	4.4	893	42.7	1,294	44.9	1,520	17.5	1,680	10.5	22.9
Nonvolatile Memory	1,224	4.0	1,286	5.1	1,452	12.9	1,668	14.9	1,930	15.7	2,265	17.4	13.1
EPROM	205	-11.3	152	-25.9	128	-15.8	112	-12.5	100	-10.7	92	-8.0	-14.8
EEPROM	211	24.1	227	7.6	251	10.6	284	13.1	353	24.3	420	19.0	14.8
Flash Memory	11	23.3	731	21.2	882	20.7	1,073	21.7	1,287	19.9	1,565	21.6	21.0
Mask ROM	309	-28.6	176	-14.1	191	8.5	199	4.2	190	-4.5	188	-1.1	-1.7
Other MOS Memory	51	41.7	53	3.9	65	22.6	81	24.6	86	6.2	82	-4.7	10.0
MOS Microcomponent	10,885	24.5	12,651	16.2	15,360	21.4	18,260	18.9	21,710	18.9	25,170	15.9	18.3
Microprocessor	4,456	31.4	5,349	20.1	6,570	22.8	7,890	20.1	9,370	18.8	10,900	16.3	19.6
Microcontroller	2,313	12.8	2,630	13.7	3,060	16.3	3,710	21.2	4,430	19.4	5,080	14.7	17.0
Microperipheral	3,315	17.0	3,662	10.5	4,520	23.4	5,200	15.0	6,010	15.6	6,800	13.1	15.5
Digital Signal Processor	801	71.2	1,010	26.1	1,210	19.8	1,460	20.7	1,900	30.1	2,390	25.8	24.4
MOS Digital Logic	3,909	17.2	4,172	6.7	4,940	18.4	5,955	20.5	6,776	13.8	7,939	17.2	15.2
ASICs	1,662	4.7	1,893	13.9	2,380	25.7	3,015	26.7	3,625	20.2	4,443	22.6	21.7
Custom IC	425	-4.5	341	-19.8	256	-25.0	179	-30.0	116	-35.0	70	-40.0	-30.3
MOS Standard Logic	616	30.5	670	8.7	743	11.0	810	9.0	826	2.0	843	2.0	6.5
Total Other MOS Logic	1,206	45.1	1,269	5.2	1,561	23.0	1,951	25.0	2,208	13.2	2,584	17.0	16.5
Analog-Monolithic	6,310	24.1	7,234	14.6	8,608	19.0	10,610	23.3	12,467	17.5	14,160	13.6	17.5
Total Discrete	3,817	15.9	4,151	8.8	4,573	10.2	5,189	13.5	5,560	7.1	6,200	11.5	10.2
Total Optical Semiconductor	913	23.5	945	3.5	1,021	8.0	1,174	15.0	1,301	10.8	1,481	13.8	10.2

Source: Dataquest (May 1998)

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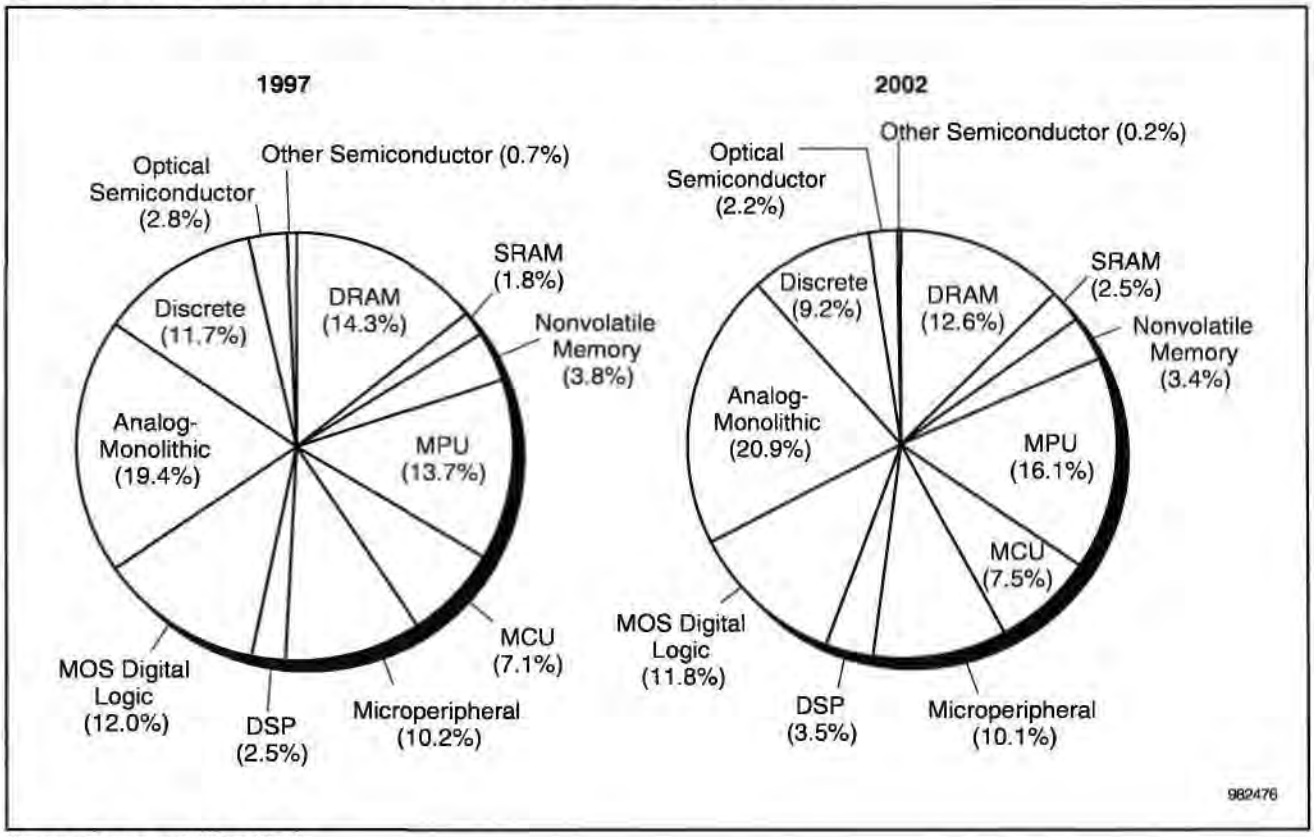
Table 7-2
Asia/Pacific Semiconductor Market, Revenue History, 1992-1997 (Millions of Dollars)

	1992 Revenue	1992 Growth (%)	1993 Revenue	1993 Growth (%)	1994 Revenue	1994 Growth (%)	1995 Revenue	1995 Growth (%)	1996 Revenue	1996 Growth (%)	1997 Revenue	1997 Growth (%)	1992-1997 CAGR (%)
Total Semiconductor	**12,034**	**30.9**	**17,486**	**45.3**	**22,832**	**30.6**	**32,465**	**42.2**	**29,686**	**-8.6**	**32,534**	**9.6**	**22.0**
Total Integrated Circuit	**10,110**	**32.9**	**14,988**	**48.2**	**19,785**	**32.0**	**28,252**	**42.8**	**25,653**	**-9.2**	**27,804**	**8.4**	**22.4**
Bipolar Digital	381	3.3	388	1.8	372	-4.1	321	-13.7	236	-26.5	184	-22.0	-13.5
MOS Memory	2,904	47.1	4,911	69.1	7,216	46.9	12,565	74.1	8,017	-36.2	6,516	-18.7	17.5
Dynamic RAM	1,853	50.9	3,391	83.0	5,297	56.2	10,133	91.3	5,878	-42.0	4,642	-21.0	20.2
Static RAM	444	93.9	729	64.2	867	18.9	1,389	60.2	926	-33.3	599	-35.3	6.2
Nonvolatile Memory	587	17.4	766	30.5	1,022	33.4	992	-2.9	1,177	18.6	1,224	4.0	15.8
EPROM	229	12.8	271	18.3	288	6.3	246	-14.6	231	-6.1	205	-11.3	-2.2
EEPROM	38	0	81	113.2	91	12.3	86	-5.5	170	97.7	211	24.1	40.9
Flash Memory	11	0	49	345.5	84	71.4	246	192.9	489	98.8	603	23.3	122.7
Mask ROM	309	0	365	18.1	559	53.2	414	-25.9	287	-30.7	205	-28.6	-7.9
Other MOS Memory	20	17.6	25	25.0	30	20.0	51	70.0	36	-29.4	51	41.7	20.6
MOS Microcomponent	3,085	40.4	4,303	39.5	5,558	29.2	7,253	30.5	8,744	20.6	10,885	24.5	28.7
Microprocessor	1,135	33.4	1,527	34.5	1,969	28.9	2,587	31.4	3,392	31.1	4,456	31.4	31.5
Microcontroller	828	23.8	1,260	52.2	1,470	16.7	2,032	38.2	2,050	0.9	2,313	12.8	22.8
Microperipheral	1,094	64.8	1,453	32.8	1,981	36.3	2,382	20.2	2,834	19.0	3,315	17.0	24.8
Digital Signal Processor	28	115.4	63	125.0	138	119.0	252	82.6	468	85.7	801	71.2	95.6
MOS Digital Logic	1,277	14.6	2,015	57.8	2,363	17.3	3,114	31.8	3,336	7.1	3,909	17.2	25.1
ASICs	413	30.7	703	70.2	900	28.0	1,379	53.2	1,588	15.2	1,662	4.7	32.1
Custom IC	350	-17.5	459	31.1	544	18.5	466	-14.3	445	-4.5	425	-4.5	4.0
MOS Standard Logic	259	58.9	371	43.2	439	18.3	516	17.5	472	-8.5	616	30.5	18.9
Total Other MOS Logic	255	20.9	490	92.2	495	1.0	768	55.2	831	8.2	1,206	45.1	36.4
Analog-Monolithic	2,338	26.9	3,195	36.7	4,025	26.0	4,743	17.8	5,085	7.2	6,310	24.1	22.0
Total Discrete	1,649	19.0	2,080	26.1	2,527	21.5	3,475	37.5	3,294	-5.2	3,817	15.9	18.3
Total Optical Semiconductor	275	37.5	418	52.0	520	24.4	738	41.9	739	0.1	913	23.5	27.1

Source: Dataquest (May 1998)

Figure 7-1
Asia/Pacific Semiconductor Revenue Forecast by Product



Source: Dataquest (May 1998)

Chapter 8
Exchange Rates

Dataquest does not forecast exchange rates. The following exchange rates are used for the forecast for 1998 through 2002:

- Japan—¥129.73 per U.S. dollar
- European Union—ECU 0.8994 per U.S. dollar

Table 8-1 shows exchange rates of the yen and ECU versus the U.S. dollar for the period from 1980 to 1997. The appreciation of the dollar against these local currencies is given in the last two columns.

Table 8-1
Exchange Rates

Year	Yen per U.S. Dollar	ECU per U.S. Dollar	U.S. Dollar Growth versus Yen (%)	U.S. Dollar Growth versus ECU (%)
1980	227.00	-	3.6	-
1981	221.00	-	-2.7	-
1982	248.00	-	12.2	-
1983	235.00	-	-5.2	-
1984	237.00	-	0.9	-
1985	238.00	-	0.4	-
1986	167.00	-	-29.8	-
1987	144.00	-	-13.8	-
1988	130.00	0.846	-9.7	-2.5
1989	138.00	0.908	6.2	7.3
1990	144.00	0.788	4.3	-13.2
1991	136.00	0.811	-5.6	2.9
1992	126.45	0.770	-7.0	-5.0
1993	111.20	0.858	-12.1	11.4
1994	101.81	0.840	-8.4	-2.1
1995	93.90	0.774	-7.8	-7.9
1996	108.81	0.800	15.9	3.2
1997	121.10	0.885	11.3	10.6

Source: Dataquest (May 1998)

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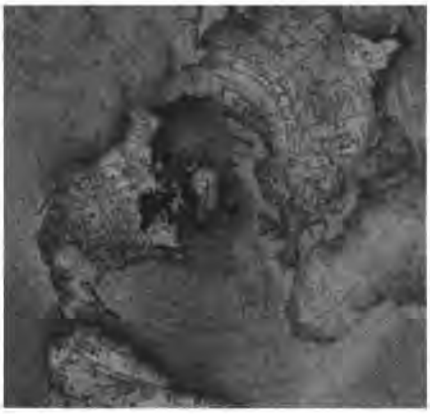

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1998 Semiconductor Market by Product

Market Trends

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MARIA VALENZUELA

Program: Semiconductors Worldwide
Product Code: SEMI-WW-MT-9801
Publication Date: June 29, 1998
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1998 Semiconductor Market by Product

Market Trends

Program: Semiconductors Worldwide
Product Code: SEMI-WW-MT-9801
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Chapter 1
Executive Summary

Two years shy of the year 2000 and a forecast of $227 billion, the semiconductor industry and its vendors stand precariously on the edge of an economic chasm. Will the industry recover in 1999, growing at more than 15 percent? Or will the financial crisis in Asia spread to Japan, pushing recovery into mid-1999? The move to institute 0.25-micron manufacturing capability, coupled with the retooling of fabs to migrate from DRAM to logic, was the main focus of investment in equipment in 1997. At the very high end of performance, companies such as Intel Corporation (300-MHz and above microprocessors), IBM (application-specific ICs, or ASICs, and 64Mb DRAMs), and Lucent Technologies (digital signal processors, or DSPs) are manufacturing products in 0.25- and 0.18-micron technology. Yet 40 percent of silicon is still consumed by discrete and optical semiconductor products for device geometries in the 1.0-to-0.5-micron range. The worldwide average wafer diameter for 1997 was 5.85 inches and for 1998 was 6.06 inches. Yet there are more companies and countries investing in 0.25-micron technology. Overinvestment and aggressive spending patterns plus overcapacity and accelerated die shrinks weakened the growth potential of the worldwide semiconductor market for 1998.

The Asian financial crisis, with its capital and credit constraints, has created tremendous uncertainty, with downside capital spending ramifications. Although capital spending is almost dead in Korea, Taiwan's financial situation is the healthiest in Asia. Taiwanese companies' capital spending is expected to increase about 13 percent in 1998 to $7 billion. U.S. and European regional companies are spending in the low 4 percent range, and Japanese companies will cut spending overall by 8 to 10 percent in yen (14 percent in dollars) over 1997. Overall, Japan's degree of strength or weakness and the effect of the Asian financial situation on the Americas and Europe will determine the ability of the industry to recover in late 1998. Table 1-1 shows the Dataquest's estimate of the future of the electronics industry.

Table 1-1
The Future of the Electronics Industry (Millions of Dollars)

	1997	2002
Silicon Wafers*	7,378	15,459
Wafer Fab Equipment	22,318	42,837
Semiconductors	147,165	287,895
Electronic Equipment	923,819	1,250,000

*Includes prime, test, and monitor wafers
Source: Dataquest (June 1998)

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Industry 1997: Technology and Applications

Data compiled from the more than 170 companies surveyed in 1997 indicated that the semiconductor industry had grown to $147.2 billion, up 3.5 percent from the $142.2 billion market of 1996. Capital spending declined 0.7 percent to $44.7 billion from $45 billion in 1996. Capital spending for 1998 is expected to decline to $43 billion, down 3.7 percent from 1997. The move toward 0.25-micron manufacturing capability, coupled with the retooling of fabs from DRAM to logic, has been the main focus of investment in fab equipment in 1997 and early 1998.

Table 1-2 shows a 10-year span of historical and forecast market share of semiconductor products. The 2002 data is based on Dataquest's spring 1998 forecast. Microcomponents will continue to capture the largest market share of all semiconductor products, based on demand from the data processing application segment—specifically, demand from the PC segment, a volatile equipment market. However, the communications segment, as shown in Table 1-3, will stimulate the growth of all other product categories as demand for components from the wired and wireless application segments expands. Semiconductor distribution in the electronic equipment base for 1997 is forecast in Table 1-4.

Table 1-2
Historical and Forecast Product Share of Semiconductors (Percent)

Product	1987 Market Share	1997 Market Share	2002 Market Share
MOS Memory	16	21	21
Microcomponents	14	33	36
MOS Digital Logic	17	17	18
Analog/Mixed-Signal	17	15	14
Discrete	18	10	8
Optical Semiconductors	5	4	3
Bipolar Digital	13	0	0
Total Semiconductor Revenue ($M)	**37,011**	**147,165**	**287,895**

Total semiconductor revenue does not include hybrid ICs.
Source: Dataquest (June 1998)

Table 1-3
Worldwide Electronic Equipment Forecast, 1997 to 2002 (Millions of Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Data Processing	293,864	324,207	358,338	388,657	425,942	457,574	6.6
Communications	214,190	229,406	239,818	250,530	262,130	276,202	5.2
Industrial	133,514	141,681	151,951	162,633	172,184	181,792	6.4
Consumer	165,636	169,304	176,432	184,620	193,589	204,721	4.3
Military/Civil Aerospace	56,463	58,282	60,441	62,789	65,607	68,870	4.1
Transportation	42,950	46,020	49,704	53,125	56,830	60,412	7.1
Total Electronic Equipment	**906,617**	**968,899**	**1,036,685**	**1,102,354**	**1,176,283**	**1,249,572**	**6.6**

Source: Dataquest (June 1998)

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Table 1-4
Value of Semiconductors Consumed Worldwide by Electronics Product Groups (Millions of Dollars)

	1998	1999	2000	2001	2002
Semiconductors in Data Processing	74,844	85,918	101,272	112,573	121,558
Semiconductors in Communications	34,439	37,917	43,111	46,932	51,178
Semiconductors in Industrial	15,199	18,370	22,710	25,771	27,661
Semiconductors in Consumer	25,613	28,668	33,226	36,398	41,728
Semiconductors in Military/Civil Aerospace	2,721	2,927	3,175	3,394	3,582
Semiconductors in Transportation	7,755	8,572	9,796	10,967	11,928

Source: Dataquest (June 1998)

Regional Suppliers

As shown in Table 1-5, the Americas and Japanese regions supplied 81.7 percent of semiconductors produced and shipped to the world in 1997. At $48.1 billion, the Americas region consumed 32.7 percent of semiconductors in 1997 (see Figure 1-1). Americas vendors also produced $72.3 billion in semiconductors (see Figure 1-2). Japan and Asia/Pacific owe their decline in revenue and product shares to continued drastic price declines in DRAM and to the lack of a substantial increase in DRAM bit growth to offset the lower average selling prices (ASPs).

Americas vendors maintained fairly significant growth in microcomponents, logic, and analog products. Americas vendors control 75.5 percent of microcomponents and increased their market share 21.4 percent from 1996 to 1997. They have a 48.7 percent share of logic, which grew 13.7 percent from 1996 to 1997. Americas vendors' analog share is 45.9 percent, with a 23.9 percent growth from 1996 to 1997. For European vendors, the strongest growth was in analog products. European vendors control 24.9 percent of the analog market and increased their revenue 17.8 percent from 1996 to 1997. The total regional forecast for semiconductors with actual production from 1997 is shown in Table 1-6. The specific product forecast detail for all regions can be found in Chapters 2 through 7.

In the final market share rankings for 1997, Intel led the worldwide semiconductor market. Intel captured 14.8 percent of the total market and led the top five vendors in all regions, as noted in Table 1-7.

Table 1-5
Worldwide Semiconductor Market Supplied, by Region, 1970 to 1997 (Percentage of Total Revenue)

Year	Americas	Japan	Europe, Africa, and Middle East	Asia/Pacific
1970	56.5	27.1	16.1	-
1974	62.3	20.7	16.3	-
1975	63.9	19.3	16.8	-
1976	60.4	24.5	15.1	-
1977	59.6	25.4	15.0	-
1978	55.3	28.4	16.3	-
1979	57.9	25.8	16.3	-
1980	57.2	27.4	15.2	0.2
1981	51.4	35.5	12.9	0.3
1982	51.4	35.3	12.7	0.6
1983	49.0	38.8	11.3	0.9
1984	48.4	39.7	11.0	0.8
1985	45.4	41.7	11.7	1.2
1986	41.5	45.9	11.2	1.4
1987	39.0	48.2	11.0	1.8
1988	36.5	51.0	9.7	2.8
1989	35.9	50.6	9.8	3.7
1990	38.6	46.3	11.2	3.9
1991	38.4	46.4	10.6	4.6
1992	41.3	42.3	10.2	6.2
1993	43.4	40.4	8.9	7.3
1994	41.7	40.5	8.9	8.9
1995	39.7	40.1	8.5	11.8
1996	45.1	35.8	9.6	9.5
1997	49.2	32.5	10.1	8.3

Source: Dataquest (June 1998)

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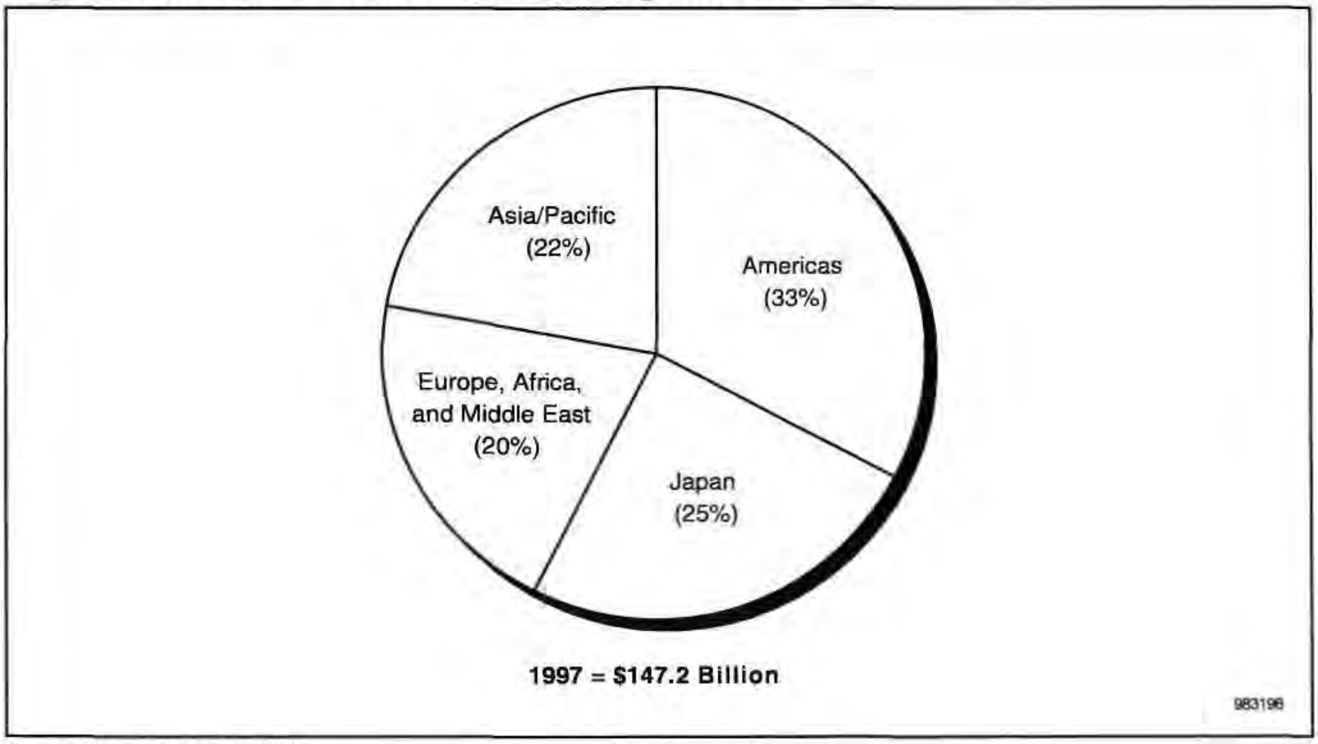
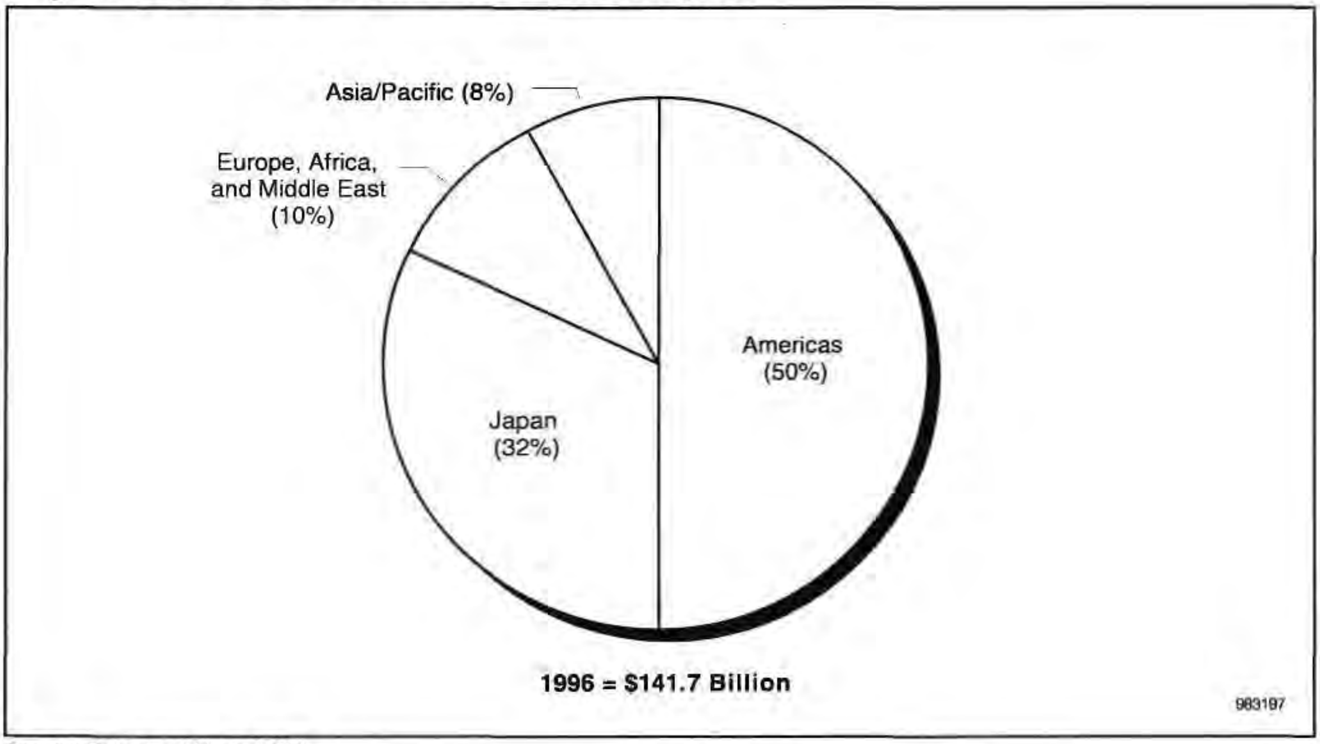
Figure 1-1
Regional Share of Semiconductor Consumption, 1997



Source: Dataquest (June 1998)

Figure 1-2
Regional Share of Semiconductor Production, 1997



Source: Dataquest (June 1998)

Table 1-6
Worldwide Semiconductor Regional Forecast, 1997 to 2002 (Millions of Dollars)

Region	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Worldwide	147,165	159,249	188,256	227,054	275,028	287,895	14.4
Americas	48,086	53,326	64,133	78,388	95,782	99,906	15.7
Japan	36,499	37,397	42,943	49,988	58,610	61,093	10.9
Europe, Africa, and Middle East	30,046	32,627	38,425	46,927	56,152	59,335	14.6
Asia/Pacific	32,534	35,899	42,754	51,751	64,483	67,561	15.7

Source: Dataquest (June 1998)

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Table 1-7
Top Five Vendors of Semiconductors Worldwide by Region, 1997 (Millions of Dollars)

	Worldwide		Americas		Japan		Europe, Africa, and Middle East		Asia/Pacific	
Rank	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue
1	Intel	21,746	Intel	9,621	NEC	5,666	Intel	5,811	Intel	4,077
2	NEC	10,222	Motorola	3,879	Toshiba	3,484	Siemens	2,182	Samsung	1,922
3	Motorola	8,067	IBM	2,679	Hitachi	3,355	Motorola	1,885	Texas Instruments	1,853
4	Texas Instruments	7,352	Texas Instruments	2,202	Fujitsu	2,768	Philips	1,847	Toshiba	1,807
5	Toshiba	7,253	NEC	2,131	Matsushita	2,244	SGS-Thomson	1,777	Motorola	1,682
Top Five Revenue ($M)		54,640		20,512		17,517		13,502		11,341
Top Five Share of Market (%)		37.1		42.6		48.0		44.9		34.8

Source: Dataquest (June 1998)

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Chapter 2
MOS Memory Market

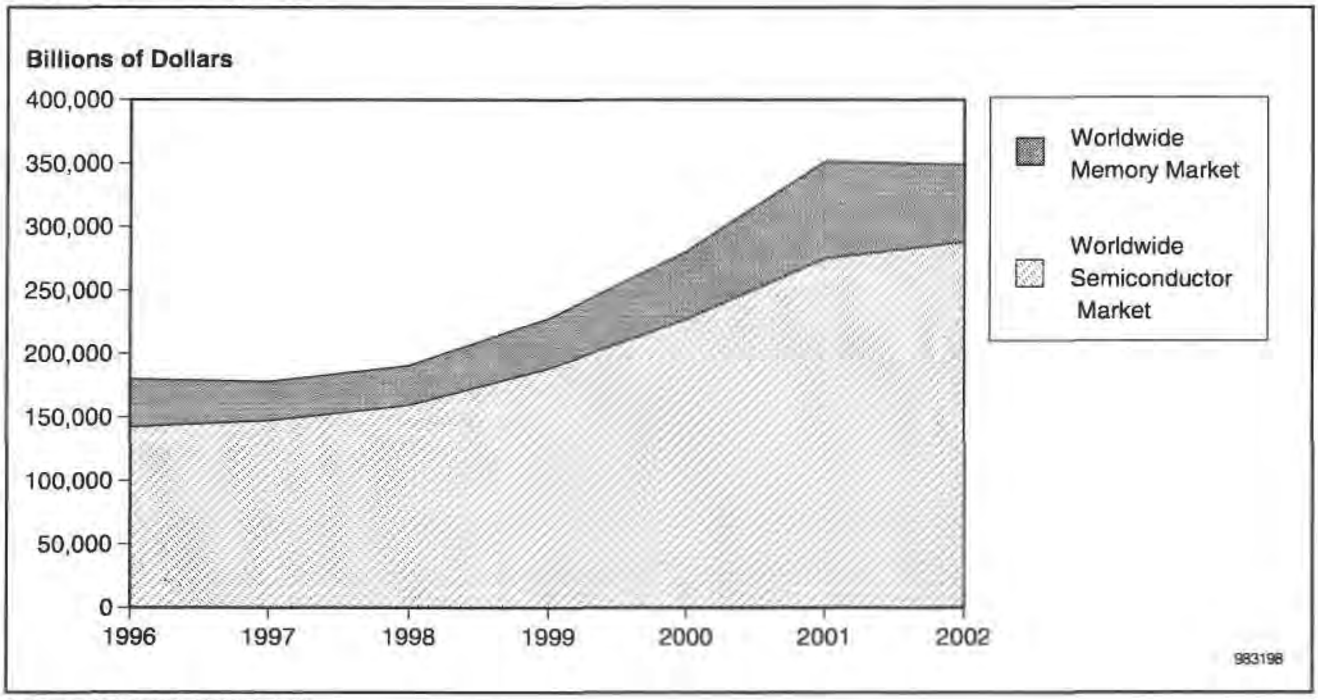
At $30.9 billion, MOS memory revenue represented about 21 percent of worldwide semiconductor revenue in 1997. Figure 2-1 illustrates the growth and size of the memory market in relation to the total semiconductor market for 1997 through the forecast period. Worldwide memory revenue declined 18.6 percent. Overcapacity and continued cuts in DRAM ASPs drastically reduced DRAM vendor company revenue for the second straight year.

DRAM units grew 28.5 percent in 1997 over 1996 as total shipments reached 3.4 billion units. The 16Mb density, at 2.1 billion units shipped, captured the largest share. The overall DRAM ASP declined to $6.05 from $9.69 in 1996. If price declines continue through the first two quarters of 1998, the overall DRAM ASP and total revenue could be pushed well below the $6 ASP and $20.9 billion in revenue forecast for 1998. The average price per megabyte of DRAM in 1997 was $3.85, a 58.8 percent decline from $9.34 in 1996.

Of the SRAM products, unit shipments grew 10.6 percent to 1.2 billion units in 1997. The 256K devices totaled 514.8 million units for a 44 percent share of total SRAM shipments. Although price declines were not as severe in SRAM as in DRAM, the overall ASP declined 23 percent to $3.42 in 1997 from $4.45 in 1996. Factory revenue for SRAMs worldwide totaled $4.0 billion, declining 14.9 percent from 1996.

The nonvolatile memory segments totaled $5.6 billion in 1997. All four product segments (EPROM, flash, ROM, and EEPROM), declined in revenue. EPROM revenue declined 37.1 percent to $785 million in 1997. Flash revenue declined 3.2 percent to $2.7 billion. ROM revenue declined 19.1 percent to $1.0 billion. EEPROM revenue declined 7.9 percent to $967 million.

Figure 2-1
Total Memory Share of Worldwide Semiconductor Market, 1997 to 2002 (Millions of Dollars)



Source: Dataquest (June 1998)

MOS Memory Product Forecast

The MOS memory market data shown in Table 2-1 includes factory revenue and product shares for total MOS memory products shipped to the worldwide market for 1997 through 2002.

Table 2-2 shows the regional shares of consumption and production revenue for MOS memory products. Table 2-3 shows the market share of the top five suppliers worldwide of MOS memory products to each region. Samsung Electronics Company Ltd. continued to dominate the MOS memory market worldwide, as well as the Americas, European, and Asia/Pacific markets. Samsung was also the No. 1 revenue supplier of DRAMs and SRAMs to the world. Table 2-4 shows the top five suppliers' share of worldwide revenue for the specific memory product categories.

Table 2-1
Worldwide MOS Memory Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
DRAM	20,744	20,960	26,897	38,043	57,994	40,920	14.6
DRAM Share of MOS Memory (%)	67.0	66.7	67.7	71.0	75.7	66.8	-
SRAM	4,008	4,182	5,694	7,378	9,402	9,761	19.5
SRAM Share of MOS Memory (%)	12.9	13.3	14.3	13.8	12.3	15.9	-
Nonvolatile	5,571	5,533	6,343	7,262	8,193	9,432	11.1
Nonvolatile Share of MOS Memory (%)	18.0	17.6	15.9	13.6	10.7	15.4	-
Other MOS Memory	655	726	809	889	984	1,089	10.7
Other MOS Memory Share of MOS Memory (%)	2.1	2.3	2.0	1.7	1.3	1.4	-
Total Memory Revenue	30,978	31,401	39,743	53,572	76,573	61,202	14.6
Percentage Change	-18.6	1.4	26.6	34.8	42.9	-20.1	-

Source: Dataquest (June 1998)

Table 2-2
1997 MOS Memory Production versus Consumption (Millions of Dollars)

	Consumption by Region	1997 Growth(%)	Production by Region	Market Share (%)
Americas	11,898	-18.7	8,375	27.0
Japan	6,523	-23.1	11,827	38.2
Europe, Africa, and Middle East	6,041	-12.7	1,621	5.2
Asia/Pacific	6,516	-18.7	9,155	29.6
Total Memory	**30,978**	**-18.6**	**30,978**	**100.0**

Source: Dataquest (June 1998)

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Table 2-3
Top Five Suppliers of MOS Memory by Region, 1997 (Millions of Dollars)

	Worldwide		Americas		Japan		Europe, Africa, and Middle East		Asia/Pacific	
Rank	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue
1	Samsung	4,623	Samsung	1,984	NEC	1,067	Samsung	1,184	Samsung	892
2	NEC	3,215	Micron Technology	1,279	Hitachi	949	Siemens	479	LG Semicon	731
3	Hitachi	2,209	NEC	1,270	Fujitsu	643	NEC	446	Hyundai	697
4	Hyundai	1,931	Hitachi	830	Samsung	563	Texas Instruments	421	NEC	432
5	Micron Technology	1,704	IBM	655	Toshiba	534	Hyundai	408	Siemens	352
Top Five Revenue ($M)		13,682		6,018		3,756		2,938		3,104
Top Five Share of Market (%)		44.2		50.6		57.6		48.6		47.6

Source: Dataquest (June 1998)

Table 2-4
Top Five Suppliers of Specific Memory Products to the World (Millions of Dollars)

	DRAM		SRAM		Nonvolatile		Other MOS Memory	
Rank	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue
1	Samsung	3,897	Samsung	591	Intel	850	IDT	193
2	NEC	2,519	Hitachi	425	Advanced Micro Devices	707	Oki	121
3	Hyundai	1,867	NEC	360	Atmel	670	NEC	100
4	Hitachi	1,710	IBM	350	Sharp	475	Cypress Semiconductor	98
5	Micron Technology	1,649	Toshiba	347	SGS-Thomson	467	Philips	73
Top Five Revenue ($M)		11,642		2,073		3,169		585
Top Five Share of Market (%)		56.1		51.7		56.9		89.4

Source: Dataquest (June 1998)

Chapter 3
MOS Microcomponents

The MOS microcomponent market share of semiconductors was 33.3 percent in 1997, making that the largest segment of semiconductor devices. Dataquest's spring 1998 forecast expects microcomponents to capture 35.8 percent of the estimated $288 billion semiconductor market for 2002. A view of the MOS microcomponent share of the worldwide market forecast is illustrated in Figure 3-1.

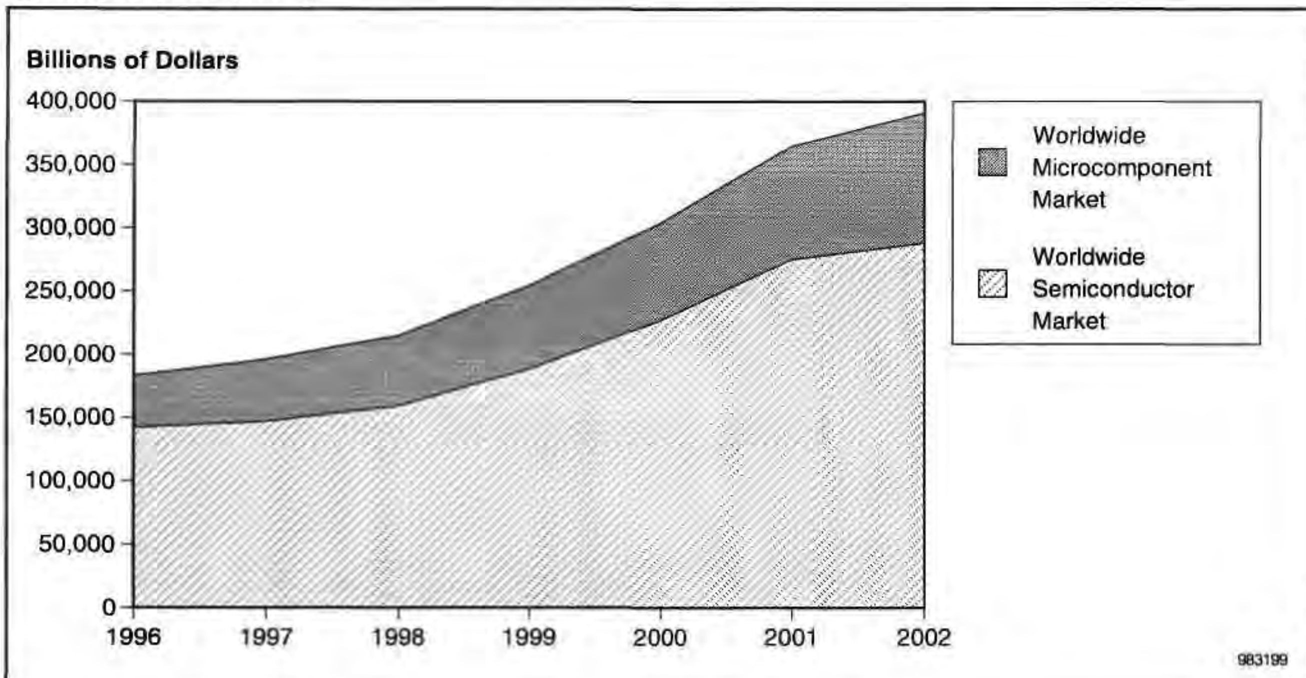
MOS Microcomponent Product Forecast

The MOS microcomponent revenue forecast and market shares for each microcomponent sector are listed in Table 3-1. Microcomponent revenue reached $48,945 million in 1997. This represented an 18 percent increase from 1996. The Americas region remained the largest producer and consumer of the microcomponent products. The 1997 consumption and production data for microcomponents by region is listed in Table 3-2.

Microcomponent Market Share

Table 3-3 shows the top five suppliers' share of MOS microcomponents by region of consumption. Table 3-4 shows the top five suppliers' worldwide share of revenue for the specific MOS microcomponent segments. Further analysis on the markets and suppliers of microcomponents is available from Dataquest's Embedded Microcomponents Worldwide program.

Figure 3-1
MOS Microcomponent Share of Semiconductor Market, 1997 to 2002
(Millions of Dollars)



Source: Dataquest (June 1998)

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Table 3-1
MOS Microcomponent Revenue Forecast, 1997-2002 (Millions of Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Microprocessors	23,659	27,300	32,250	37,440	43,380	49,650	16.0
Microprocessor Share of Microcomponents (%)	48	49	49	49	48	48	-
Microcontrollers	10,896	12,320	14,270	16,720	19,460	22,230	15.3
Microcontroller Share of Microcomponents (%)	22	22	22	22	22	22	-
Microperipherals	10,736	11,300	13,660	15,580	17,810	19,990	13.2
Microperipheral Share of Microcomponents (%)	22	20	21	20	20	19	-
DSPs	3,654	4,610	5,800	7,230	9,100	11,260	25.2
DSP Share of Microcomponents (%)	7	8	9	9	10	11	-
Total Microcomponents	**48,945**	**55,530**	**65,980**	**76,970**	**89,750**	**103,130**	**16.1**

Source: Dataquest (June 1998)

Table 3-2
MOS Microcomponent Consumption versus Production, 1997 (Millions of Dollars)

	Consumption by Region	1997 Growth (%)	Production by Region	Market Share (%)
Americas	17,785	21.9	36,974	75.5
Japan	9,336	6.1	8,817	18.0
Europe, Africa, and Middle East	10,939	17.1	1,899	3.9
Asia/Pacific	10,885	24.5	1,255	2.6
Total	**48,945**	**18.0**	**48,945**	**100.0**

Source: Dataquest (June 1998)

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Table 3-3
Top Five MOS Microcomponent Suppliers by Region, 1997 (Millions of Dollars)

	Worldwide		Americas		Japan		Europe, Africa, and Middle East		Asia/Pacific	
Rank	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue
1	Intel	20,896	Intel	9,284	Intel	2,129	Intel	5,589	Intel	3,894
2	Motorola	3,530	Motorola	1,635	NEC	1,510	Motorola	986	Motorola	685
3	NEC	2,404	Rockwell	659	Hitachi	917	Texas Instruments	554	Toshiba	395
4	Texas Instruments	1,728	Texas Instruments	589	Toshiba	722	SGS-Thomson	387	Texas Instruments	382
5	Hitachi	1,683	IBM	585	Fujitsu	635	Philips	317	United Microelectronics	326
Top Five Revenue ($M)		30,241		12,752		5,913		7,833		5,682
Top Five Share of Market (%)		61.8		71.7		63.3		71.6		52.2

Source: Dataquest (June 1998)

Table 3-4
Top Five Suppliers of Specific MOS Microcomponent Products to the World, 1997 (Millions of Dollars)

	Microprocessor		Microcontroller		Microperipheral		Digital Signal Processor	
Rank	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue
1	Intel	18,893	Motorola	1,781	Intel	1,455	Texas Instruments	1,230
2	Motorola	1,135	NEC	1,483	Rockwell	1,333	Lucent Technologies	888
3	Advanced Micro Devices	722	Hitachi	1,224	National Semiconductor	710	Motorola	378
4	IBM	652	Mitsubishi	884	Cirrus Logic	604	Toshiba	351
5	Sun Microsystems	550	Toshiba	591	S3	437	Analog Devices Inc.	287
Top Five Revenue ($M)		21,952		5,963		4,539		3,134
Top Five Share of Market (%)		92.8		54.7		42.3		85.8

Source: Dataquest (June 1998)

Chapter 4
MOS Logic

The MOS digital logic segment (ASICs, custom ICs, MOS standard logic, and other MOS logic) is the third-largest product segment of the semiconductor market, after memory and microprocessors. Total MOS digital logic revenue grew 9.2 percent and reached $24.7 billion, or a 16.8 percent share of the world semiconductor market in 1997. Figure 4-1 illustrates the logic share of the semiconductor forecast through 2002.

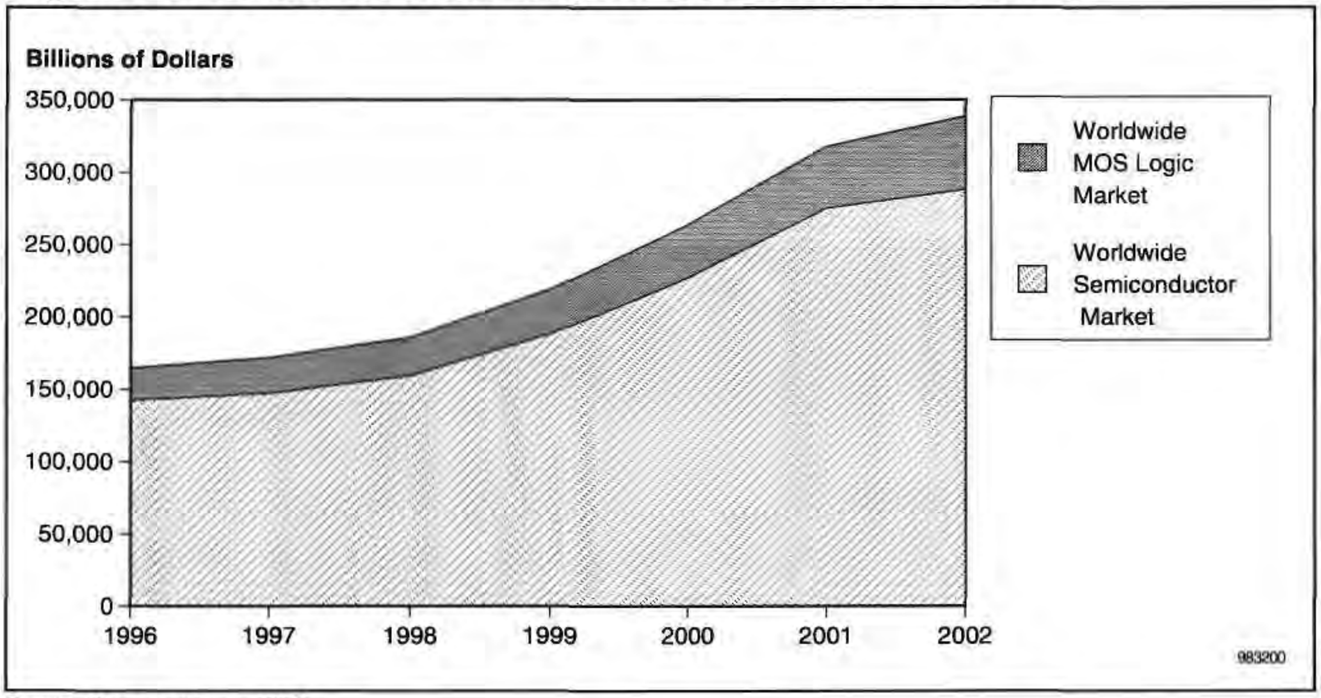
Logic Product Forecast

The digital ASIC group of products—mixed-signal ASICs, cell-based ICs, programmable logic devices (PLDs), linear array ASICs, and gate arrays—representing the bulk of logic revenue, grew 11.7 percent to $16.5 billion. Revenue from custom ICs, MOS standard logic, and other MOS logic products combined represents $8.2 billion or a 33.2 percent share of MOS digital logic. Revenue by segments is shown in Table 4-1. MOS digital logic consumption versus production data by region in 1997 is shown in Table 4-2.

Logic Market Share

Tables 4-3 shows the top five suppliers' total revenue share of MOS logic products by region for 1997.

Figure 4-1
Logic Share of Semiconductor Market, 1997 to 2002 (Millions of Dollars)



Source: Dataquest (June 1998)

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Table 4-1
Logic Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
MOS Digital ASICs	16,527	18,409	22,330	27,446	32,675	39,789	19.2
MOS Digital ASIC Share of Logic (%)	67	69	72	74	76	78	-
Custom ICs	1,514	1,164	823	557	349	205	-33.0
Custom IC Share of Logic (%)	6	4	3	2	1	0	-
MOS Standard Logic	2,266	2,373	2,565	2,739	2,775	2,805	4.4
MOS Standard Logic Share of Logic (%)	9	9	8	7	6	6	-
Other MOS Logic	4,450	4,626	5,366	6,318	6,993	8,019	12.5
Other MOS Logic Share of Logic (%)	18	17	17	17	16	16	-
Total Logic Revenue	**24,757**	**26,573**	**31,084**	**37,061**	**42,793**	**50,818**	**15.5**

Source: Dataquest (June 1998)

Table 4-2
MOS Logic Consumption versus Production, 1997 (Millions of Dollars)

	Consumption by Region	1997 Growth (%)	Production by Region	Market Share (%)
Americas	8,525	12.7	12,065	48.7
Japan	8,164	4.4	9,953	40.2
Europe, Africa, and Middle East	4,159	5.2	2,125	8.6
Asia/Pacific	3,909	17.2	614	2.5
Total	**24,757**	**9.2**	**24,757**	**100.0**

Source: Dataquest (June 1998)

Table 4-3
Top Five Suppliers of MOS Logic by Region, 1997 (Millions of Dollars)

	Worldwide		Americas		Japan		Europe, Africa, and Middle East		Asia/Pacific	
Rank	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue
1	NEC	2,701	IBM	1,439	NEC	1,847	Texas Instruments	358	Lucent Technologies	369
2	IBM	1,598	Lucent Technologies	745	Fujitsu	985	Lucent Technologies	285	Philips	368
3	Texas Instruments	1,552	LSI Logic	569	Toshiba	737	Philips	278	Texas Instruments	352
4	Lucent Technologies	1,486	Motorola	424	Hitachi	540	VLSI Technology	272	Toshiba	269
5	Toshiba	1,467	NEC	424	Sony	478	SGS-Thomson	245	Samsung	222
Top Five Revenue ($M)		8,804		3,601		4,588		1,438		1,580
Top Five Share of Market (%)		35.5		42.2		56.2		34.5		40.4

Source: Dataquest (June 1998)

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Chapter 5

The Analog Market

Analog ICs comprise linear ICs and mixed-signal ICs. Linear ICs, which are completely analog in nature, include amplifiers, comparators, regulators, references, and consumer and automotive ICs. Mixed-signal IC categories include data converters, interface ICs, telecom ICs, and mass-storage ICs. Although linear ICs have been growing at a slower rate, but a steady one, mixed-signal ICs have been growing at a faster rate because of the need to bridge the physical "analog" world with digital electronics. Analog ICs are found in all electronic equipment, even equipment that seems purely digital, such as digital computers. The major uses of analog ICs that will continue their growth are:

- Signal processing—purely analog or pre- and-post-DSP
- Conversion from analog-to-digital and digital-to-analog formats
- Providing regulated power supplies for electronics
- Providing drive to communication links and devices; providing signal conditioning for the receiving end
- Radio frequency (RF) communications

Figure 5-1 illustrates the analog share of the worldwide semiconductor market through 2002.

Analog Product Forecast

Worldwide analog semiconductor revenue grew 18.7 percent in 1997 to $21.7 billion. Dataquest projects analog IC revenue to grow at a compound annual growth rate (CAGR) of 13.8 percent between 1998 and 2002 and reach $41.4 billion by 2002. For 1998, Dataquest expects the analog IC revenue to grow 10.8 percent. In the long term, to 2002, mixed-signal ICs will experience solid growth, driven by application markets such as digital cellular. Also, emerging applications in the consumer and communications markets will contribute to the growth of mixed-signal ICs. In the more traditional standard linear product area, voltage regulator products will continue to enjoy strong growth as the demand for smart power continues to grow, especially in the portable applications. Table 5-1 shows the analog forecast for the world and each region. Table 5-2 shows analog production versus consumption for each region.

Analog Market Share

Texas Instruments Inc. overtook SGS-Thomson Microelectronics B.V. and became the No. 1 analog IC supplier in 1997. Table 5-3 shows the top five vendors of analog by region. Table 5-4 shows the top five analog vendors by specific analog product categories.

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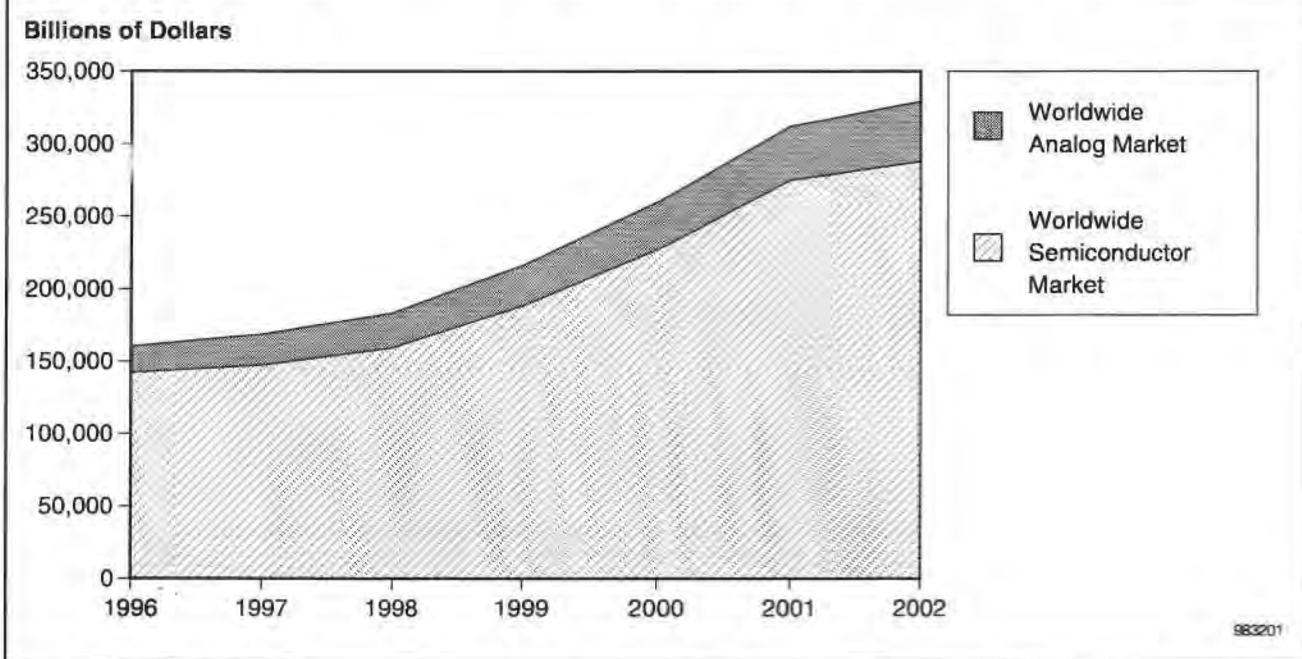
Figure 5-1
Total Analog Share of Semiconductor Market, 1997 to 2002 (Millions of Dollars)



Source: Dataquest (June 1998)

Table 5-1
Worldwide and Regional Analog Forecast, 1998 to 2002 (Millions of Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Americas	5,477	6,359	7,510	8,877	10,261	11,557	16.1
Japan	4,977	5,058	5,509	6,030	6,551	7,033	7.2
Europe, Africa, and Middle East	4,888	5,350	6,150	7,060	7,950	8,650	12.1
Asia/Pacific	6,310	7,234	8,608	10,610	12,467	14,160	17.5
Total	**21,652**	**24,001**	**27,777**	**32,577**	**37,229**	**41,400**	**13.8**

Source: Dataquest (June 1998)

Table 5-2
Analog Consumption versus Production, 1997 (Millions of Dollars)

	Consumption by Region	Growth (%) 1996-1997	Production by Region	Market Share (%)
Americas	5,477	23.8	9,929	45.9
Japan	4,977	8.7	5,800	26.8
Europe, Africa, and Middle East	4,888	17.8	5,390	24.9
Asia/Pacific	6,310	24.1	533	2.5
Total	**21,652**	**18.7**	**21,652**	**100.0**

Source: Dataquest (June 1998)

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Table 5-3
Top Five Suppliers of Analog by Region, 1997 (Millions of Dollars)

	Worldwide		Americas		Japan		Europe, Africa, and Middle East		Asia/Pacific	
Rank	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue
1	Texas Instruments	2,195	Motorola	600	Texas Instruments	548	Siemens	845	Texas Instruments	748
2	SGS-Thomson	1,891	Texas Instruments	534	Toshiba	460	Philips	671	SGS-Thomson	682
3	Philips	1,717	Analog Devices	487	Matsushita	410	SGS-Thomson	659	Philips	612
4	Motorola	1,418	National Semiconductor	464	NEC	397	Texas Instruments	365	Toshiba	442
5	National Semiconductor	1,358	SGS-Thomson	457	SANYO	363	National Semiconductor	346	SANYO	402
Top Five Revenue ($M)		8,579		2,542		2,178		2,886		2,886
Top Five Share of Market (%)		39.6		46.4		43.8		59.0		45.7

Source: Dataquest (June 1998)

Table 5-4
Top Five Suppliers of Specific Analog Products to the World (Millions of Dollars)

	Amplifier/ Comparator		Voltage Regulator/ Reference		Data Converter/ Switch/Multiplexer		Interface IC		Telecom IC		Disk Drive IC		Consumer/ Automotive IC	
Rank	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue
1	National Semiconductor	249	National Semiconductor	363	Analog Devices	416	Texas Instruments	449	Siemens	801	Texas Instruments	714	Philips	1,200
2	Analog Devices	243	Linear Technology	207	Texas Instruments	231	National Semiconductor	163	Motorola	631	SGS-Thomson	476	Toshiba	709
3	Texas Instruments	186	Texas Instruments	204	Maxim	109	Maxim	110	SGS-Thomson	543	Cirrus Logic	140	SGS-Thomson	643
4	NEC	142	Motorola	172	Rockwell	97	Toshiba	100	Philips	298	Philips	136	SANYO	588
5	SGS-Thomson	129	Maxim	104	Cirrus Logic	95	Allegro Microsystems	77	Texas Instruments	262	Analog Devices	119	Sony	375
Top Five Revenue ($M)		949		1,050		945		899		2,535		1,585		3,515
Top Five Share of Market (%)		51.5		49.0		63.6		70.2		54.8		67.9		51.4

Source: Dataquest (June 1998)

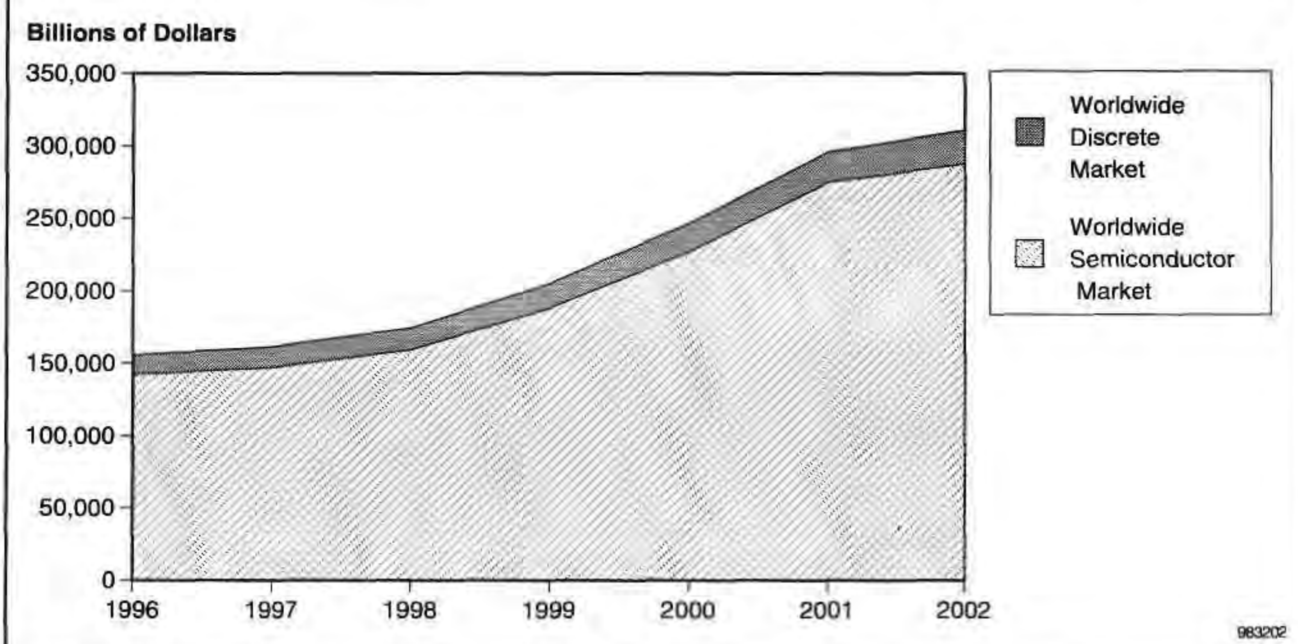
Chapter 6
Discrete Semiconductor Market

The term "discrete" refers to a packaged semiconductor device having a single "device," an electrical functional component such as a diode, transistor, or thyristor. These devices, unlike ICs, must be combined with other components to provide a basic electrical function such as amplification, switching, or latching. Discrete devices represent the ancient ancestral root of the IC business. Despite their age, discrete semiconductors, especially in the power transistor segment, continue to grow. The long-range forecast share of discrete products in relation to worldwide semiconductors is shown in Figure 6-1.

Discrete Product Forecast

Discrete products grew 5.8 percent to $14.3 billion in 1997 and represented 9.7 percent of the total semiconductor market. As noted in Table 6-1, a normal pattern of growth, around 10 percent, is expected in the period from 1999 through 2002. The 1997 consumption and production data for discretes by region is listed in Table 6-2.

Figure 6-1
Total Discrete Share of Semiconductor Market, 1997 to 2002
(Millions of Dollars)



Source: Dataquest (June 1998)

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Table 6-1
Worldwide Discrete Revenue Forecast, 1997 to 2002 (Millions of Dollars)

	1997	1998	1999	2000	2001	2002
Transistors	8,653	9,437	10,838	12,812	13,650	15,145
Small-Signal Transistors	3,129	3,209	3,251	3,203	3,140	3,483
Power Transistors	5,524	6,228	7,586	9,609	10,511	11,662
Bipolar Power Transistors	2,489	1,993	1,972	1,922	1,787	1,982
MOS Transistors	2,440	3,363	4,173	5,285	5,886	6,531
IGBTs	595	872	1,441	2,402	2,838	3,149
Diodes	4,054	4,414	4,742	5,322	5,670	6,291
Small-Signal Diodes	1,550	1,654	1,700	1,680	1,640	1,640
Power Diodes	2,504	2,760	3,042	3,642	4,030	4,651
Thyristors	972	913	847	986	1,050	1,165
Other Discretes	576	457	508	591	630	699
Total Discretes	**14,255**	**15,221**	**16,934**	**19,711**	**21,100**	**23,300**

Source: Dataquest (June 1998)

Table 6-2
1997 Discrete Production versus Consumption (Millions of Dollars)

	Consumption by Region	1997 Growth (%)	Production by Region	Market Share (%)
Americas	3,074	5.1	3,391	23.8
Japan	4,244	-3.7	7,187	50.4
Europe, Africa, and Middle East	3,120	9.6	3,102	21.8
Asia/Pacific	3,817	15.9	575	4.0
Total	**14,255**	**5.8**	**14,255**	**100.0**

Source: Dataquest (June 1998)

Discrete Market Share

Motorola Incorporated maintained control of the No. 1 position in discrete with a 10.8 percent share of the total market, in spite of a 12.0 percent decline in revenue from $1.7 billion in 1995 to $1.5 billion in 1996. Besieged by capacity demands but limited in capacity through the first half of 1997, Motorola's strategic plan is to expand its fab capacity for discretes. Motorola has made investments in two European facilities (4- and 6-inch) for added capacity. The top five suppliers by region and specific discrete products are shown in Tables 6-3 and 6-4.

Table 6-3
Top Five Suppliers of Discrete Products by Region, 1997 (Millions of Dollars)

	Worldwide		Americas		Japan		Europe, Africa, and Middle East		Asia/Pacific	
Rank	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue
1	Toshiba	1,484	Motorola	783	Toshiba	740	Philips	497	Toshiba	454
2	Motorola	1,446	International Rectifier	231	NEC	604	Siemens	373	Rohm	335
3	Philips	1,024	Philips	216	Hitachi	489	Motorola	302	Motorola	297
4	Hitachi	949	Fujitsu	164	Matsushita	392	SGS-Thomson	283	Philips	295
5	NEC	885	Toshiba	149	Rohm	345	Hitachi	161	Samsung	295
Top Five Revenue ($M)		5,788		1,543		2,570		1,616		1,676
Top Five Share of Market (%)		40.6		50.2		60.6		51.8		43.9

Source: Dataquest (June 1998)

Table 6-4
Top Five Suppliers of Specific Discrete Products to the World, 1997 (Millions of Dollars)

	Small-Signal Transistors		Power Transistors						Diodes				Thyristors		Other Discretes	
			Bipolar		MOS		IGBT		Small-Signal		Power					
Rank	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue
1	Rohm	423	Motorola	377	IR	329	Toshiba	122	Hitachi	249	General Instrument	370	Toshiba	160	Philips	121
2	NEC	361	Toshiba	210	Toshiba	309	Mitsubishi	103	Rohm	192	Sanken	217	SGS-Thomson	109	Siemens	68
3	Toshiba	349	Fujitsu	197	Motorola	240	Siemens	71	Motorola	184	Motorola	215	Mitsubishi	105	Hitachi	52
4	Motorola	293	NEC	179	Philips	202	Powerex	49	Philips	158	Shindengen Elec.	187	Teccor Electronics	92	NEC	49
5	Philips	274	Sanken	177	TEMIC	164	Hitachi	47	Matsushita	147	Toshiba	167	Siemens	72	Motorola	46
Top Five Revenue ($M)		1,700		1,140		1,244		392		930		1,156		538		336
Top Five Share of Market (%)		54.3		45.8		51.0		65.9		60.0		46.2		55.3		58.3

Source: Dataquest (June 1998)

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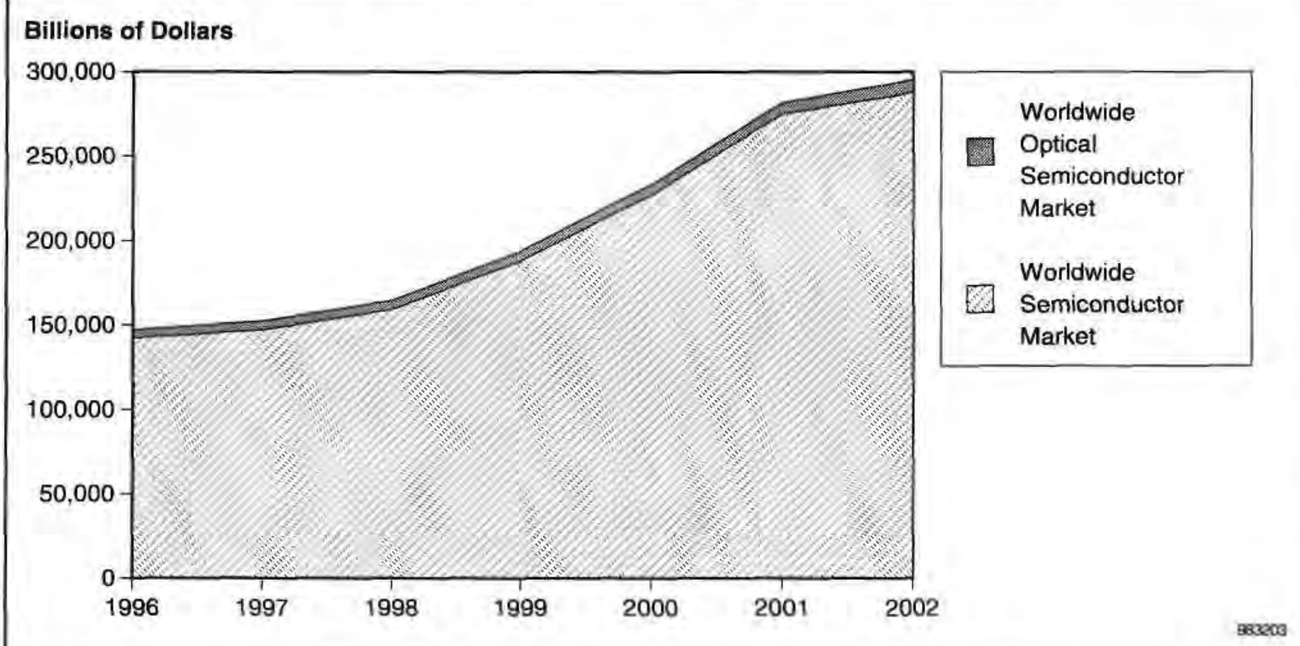
Chapter 7
Optoelectronics

Optoelectronic products represent the interface between light energy and electrical currents. Dataquest does not follow the total optoelectronics market, only the semiconductor optoelectronics sector. Nonsemiconductor products that are not covered are LCDs, CRTs, plasma displays, ceramic sensors, phototubes, or any optoelectronic product not fabricated on semiconductor material with semiconductor processing techniques. Because of this limited viewpoint, it may be more appropriate to discuss this segment as "optical semiconductors" rather than as optoelectronics. Figure 7-1 illustrates the growth of optical semiconductors in relation to the worldwide semiconductor market.

Optical Product Forecast

Optical semiconductor revenue reached $5.3 billion in 1997, an 8.6 percent increase over $4.9 billion in 1996. Applications for wired and wireless telecom, DVD, and digital cameras will be the major consumers of optical semiconductors such as lasers, charge-coupled devices (CCDs), and infrared (IR) products. Optical semiconductors are forecast to reach $7.4 billion by 2002. Table 7-1 shows the regional forecast for optical products, and Table 7-2 shows consumption versus production by region.

Figure 7-1
Total Optical Share of Worldwide Semiconductors



Source: Dataquest (June 1998)

Table 7-1
Worldwide Optical Product Forecast, 1997 to 2002 (Millions of Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Worldwide Total	5,339	5,411	5,791	6,329	6,876	7441	6.9
Americas	970	1,022	1,090	1,175	1,275	1,350	6.8
Japan	2,725	2,640	2,820	3,050	3,305	3,560	5.5
Europe, Africa, and Middle East	731	804	860	930	995	1,050	7.5
Asia/Pacific	913	945	1,021	1,174	1,301	1,481	10.2

Source: Dataquest (June 1998)

Table 7-2
Optical Production versus Consumption, 1997 (Millions of Dollars)

	Consumption by Region	Growth (%) 1996-1997	Production by Region	Market Share (%)
Americas	970	31.3	996	18.7
Japan	2,725	3.3	3,756	70.3
Europe, Africa, and Middle East	731	-8.5	555	10.4
Asia/Pacific	913	23.5	32	0.6
Total	**5,339**	**8.6**	**5,339**	**100.0**

Source: Dataquest (June 1998)

Optical Product Market Share

Desktop video digital cameras and camcorders, scanners, and LCD clusters for automotive communications and avoidance systems are just of the few application segments that drove regional and product-related revenue growth for the top five companies listed in Tables 7-3 and 7-4. Later in the forecast period, the wireless communications sector, optical scanners, surveillance/monitoring, wireless video, and robotics are expected to drive optical semiconductor product growth.

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Table 7-3
Top Five Suppliers of Optical Semiconductor Products by Region, 1997 (Millions of Dollars)

	Worldwide		Americas		Japan		Europe, Africa, and Middle East		Asia/Pacific	
Rank	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue
1	Sharp	715	Lucent Technologies	205	Sharp	522	Hewlett-Packard	166	Sharp	173
2	Hewlett-Packard	433	Hewlett-Packard	192	Matsushita	369	Siemens	161	Rohm	111
3	Toshiba	429	Siemens	173	Sony	348	TEMIC	56	NEC	92
4	Sony	394	Optek	36	Toshiba	265	Toshiba	54	Toshiba	90
5	Matsushita	388	Toshiba	34	Rohm	219	Lucent Technologies	38	Sony	44
Top Five Revenue ($M)		2,359		640		1,723		475		510
Top Five Share of Market (%)		44.2		66.0		63.2		65.0		55.9

Source: Dataquest (June 1998)

Table 7-4
Top Five Suppliers of Specific Optical Semiconductor Products to the World, 1997 (Millions of Dollars)

	LED Lamp/Display		Coupler		CCD		Laser Diode		Photosensor	
Rank	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue	Company	Revenue
1	Hewlett-Packard	293	Sharp	159	Sony	253	Lucent Technologies	273	Sharp	135
2	Toshiba	176	Hewlett-Packard	140	Matsushita	142	Rohm	174	Rohm	38
3	Siemens	172	Toshiba	105	Toshiba	114	Sharp	159	NEC	30
4	Matsushita	170	Siemens	93	NEC	77	Fujitsu	155	Optek	26
5	Rohm	145	NEC	46	Sharp	55	NEC	145	Toshiba	15
Top Five Revenue ($M)		956		543		641		645		244
Top Five Share of Market (%)		52.4		74.0		82.1		62.4		75.8

Source: Dataquest (June 1998)

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Appendix A
Product Definitions

Memory

The bipolar memory product category includes emitter-coupled logic (ECL) and transistor/transistor logic (TTL) random-access memory (RAM), and ECL/TTL programmable read only memory (PROM), first in/first out (FIFO) memory, and last in/last out (LIFO) memory.

The MOS memory product category is organized by volatile, nonvolatile, and specialty devices. Detailed definitions of all memory products are as follows:

- DRAM includes dynamic RAM, multiport DRAM (M-DRAM), video DRAM (V-DRAM), and new architecture DRAMs (NADs). NADs include Rambus, cache, enhanced, and synchronous DRAMs. These are volatile memories, and addressing is multiplexed. DRAMs have memory cells consisting of a single transistor and require regular externally cycled memory cell refreshes.
- SRAM includes static RAM, multiport-SRAM (M-SRAM), battery backed-up SRAM (BB-SRAM), and pseudo-SRAM (P-SRAM). SRAMs have memory cells consisting of a minimum of four transistors (P-SRAMs have memory cells consisting of a single transistor and are similar to DRAMs). SRAMs do not require externally cycled memory cell refreshes. Addressing is not multiplexed (except in the case of P-SRAM).
- The erasable programmable read-only memory (EPROM) product includes ultraviolet EPROM (UV EPROM) and one-time programmable ROM (OTP ROM). EPROMs have memory cells consisting of a single transistor and do not require any memory cell refreshes.
- Read-only memory (ROM) is often referred to as mask ROM because it is programmed by the manufacturer to a user specification using a mask step. ROMs are programmed in hardware rather than software.
- Electronically erasable programmable read-only memory (EEPROM) includes serial (S-EEPROM) and parallel (P-EEPROM) EEPROM and electrically alterable ROM (EAROM). EEPROMs have memory cells consisting of a minimum of two transistors and do not require memory cell refreshes. This product classification also includes nonvolatile RAM (NV-RAM), also known as shadow RAM. These products are a combination of SRAM and EEPROM technologies in each memory cell. The EEPROM functions as a shadow backup for the SRAM when power is lost.
- Flash memory includes products designated as flash EPROM/EEPROM that incorporate either 5V or 12V programming supplies and one-transistor (1T) or two-transistor (2T) memory cells with electrical programming and fast bulk/chip erase. These devices are considered nonvolatile memories.

- Other MOS memory accounts all other products not accounted for in the preceding MOS memory categories. Other MOS memory includes content-addressable memory (CAM), cache-tag RAM, first in, first out (FIFO) memory, last in, last out (LIFO) memory, and ferroelectric memory.

Microcomponent

The microprocessor (MPU), microcontroller (MCU), and digital signal processor (DSP) products of MOS microcomponents are similar in that they are designed to operate by program, fetching and running preprogrammed instructions (found either in software or firmware) to provide the desired logic function. The microperipheral (MPR) category differs in that its primary function is to provide specialized support to a host MPU, MCU, or DSP. The definitions for the four categories are as follows:

- A microprocessor IC includes an instruction decoder, arithmetic logic unit (ALU), registers, and additional logic. It may also contain instruction, data, or unified caches, memory management systems, and auxiliary ALUs for floating-point operations. An MPU's functions are determined by fetching and executing instructions and manipulating data held in registers, internal cache, or external memory.
- A microcontroller IC is designed for a standalone operation that includes a programmable processing unit, program memory, read/write data memory, and some input/output capability. The processing unit contains an instruction decoder, ALU, registers, and additional logic. The MCU's functions are determined by fetching and executing instructions and manipulating data held in on-chip program and data memory (not including cache memories).
- A microperipheral IC serves as a logical support function to an MPU in a system. This definition includes MPRs that comprise more than one device, such as PC or core logic chipsets.
- A digital signal processor IC includes a high-speed arithmetic unit (typically a multiplier-accumulator unit) designed to perform complex mathematical operations, such as Fourier transforms, manipulating digital representations of analog signals in real time. Most DSP functions, such as the multiply-and-accumulate function, are completed in single instruction clock.

Logic

Logic is an electronic function where bits (one and zeros) are processed. This bit processing is defined by hardwiring, mask programming, or field programming. Microcomponents and memory ICs are logic ICs, but they are logic ICs that are either dedicated to a function (such as microperipherals and memory ICs) or are software programmable (such as microprocessors and microcontrollers). Logic ICs also include customer-specific logic ICs.

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The logic IC category includes application-specific ICs, or ASICs (gate arrays, programmable logic devices, cell-based ICs, full-custom ICs), standard logic ICs, and other logic ICs. ASICs are all IC products customized for a single user. ASIC products are a combination of digital, mixed-signal, and analog products. Customized ICs purchased by more than one user become standard products and are no longer counted as ASICs.

- Programmable logic devices (PLDs) are defined as ICs programmed after assembly. Memory devices such as PROMs and ROMs are not included in this market segment.
- Gate arrays are ICs that contain a configuration of uncommitted elements. They are customized by interconnecting these elements with one or more routing layers. Included in this category are generic or custom base wafers, which include embedded functions such as SRAM.
- Cell-based ICs (CBICs) are ICs customized by using a full set of masks and using automated place and route.
- Full-custom ICs are ASICs customized using a full set of masks and using manual place and route.

Analog

Monolithic analog ICs fall loosely into two categories—linear ICs or mixed-signal ICs. Dataquest defines linear ICs as those that are purely analog (having no digital data path or control functions). Linear products include amplifiers, comparators, references/regulators, special linear functions, and consumer-specific functions. Dataquest defines a mixed-signal IC as an IC that has both analog and digital input/output pins, a condition that requires both digital and analog functions on chip and both digital and analog interfaces externally. Mixed-signal IC categories include data converters, interface ICs, mass-storage ICs, mixed-signal ASICs, and telecommunications ICs.

Discrete

Diodes

A diode is a basic two-layer, single-junction device. It is essentially a two-pin device that offers a high impedance to current flow in one direction and a low impedance to current flow in the other. Diodes have no additional means of controlling current flow. The primary types of diodes are signal diodes, power diodes or rectifiers, Schottky barrier diodes, and zener diodes. Signal diodes are diodes with a forward current of less than 100 milliamperes (0.1 amperes).

Transistors

Transistors are three-terminal devices in which two of the terminals provide the normal current path and the third represents the controlling electrode. This control electrode allows the transistor to amplify signals (analog mode) or to operate as a current switch (digital mode). The two main types of transistors are bipolar transistors and field-effect transistors (FETs). Bipolar transistors have a base electrode that allows a small current

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to control a larger current between the emitter and collector electrodes. The FET differs in that a voltage at the gate electrode controls current flow between the source and drain electrodes. The FET, a voltage-controlled device, requires no power at its controlling gate.

Small-signal transistors control relatively small currents (less than 1 ampere) and dissipate less than 1 watt of power. Also, they are confined to operating voltages below 100 volts. They are used as amplifiers and low-power switches in industrial and consumer electronics. Small-signal transistors show limited growth potential because of the continued integration of high-speed transistors.

Power transistors are devices that can control 1 ampere or more of current, can dissipate 1 or more watts of power, or are capable of operating with voltages exceeding 100 volts. Power transistors are used in applications such as switch-mode power supplies, power inverters, regulators, and motor controls. Power transistor applications have been dominated by bipolar devices. In the past decade, however, the power MOSFET device has become prevalent in applications involving high-speed switching. In power-switching applications, the range above 1,000 volts is still dominated by the bipolar power transistor, but power MOSFETs have become competitive in the 100-to-600-volt range. The insulated-gate-bipolar transistor (IGBT) is a recent arrival that offers the low drive current of the MOSFET with the low saturation voltage of the bipolar transistor.

Thyristors

Thyristors consist of a four-layer slice of silicon. The device is characterized by a self-latching switch effect. Once a thyristor has been triggered into conducting current, it will continue to conduct current until the main current falls to zero. Large amounts of power can be controlled with very little gate power.

The name thyristor is used in a generic sense to include silicon-controlled rectifiers (SCRs), triacs, and diacs. A modification of the SCR—the gate turnoff SCR (GTO)—can be turned off with a negative voltage applied to the gate terminal. A newer variation using MOS technology is the MOS-controlled thyristor. There are three principal thyristor market segments: consumer, commercial, and heavy industrial. Triacs are the fastest-growing part of the thyristor segment because of the demand for AC control in appliances. The microwave oven is a very large consumer of triacs in current ratings up to 40 amperes. Hair dryers are large consumers of small SCRs.

Other Discrete Devices

This category accounts for other types of products not specifically characterized in the preceding paragraphs. These devices include microwave diodes, varactor tuning diodes, and tunnel diodes.

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Optical Semiconductors

Photosensors

Photosensors or detectors are individual optical sensing devices using photodiodes or phototransistors. In these devices, the impinging light creates a current flow. The photodiode is more linear in its light-to-current relationship than a phototransistor and switches faster than a phototransistor. The phototransistor, either a junction field-effect transistor (JFET) or bipolar device, offers the advantage of current amplification.

Phototransistors are used as sensors in facsimile and photocopier machines. Photodiodes are used in CD players and in remote control devices for VCRs and other consumer products. Photodiodes are also important in optical data communications. Consumer products and the proliferation of optical communications are fueling the significant growth for these photodiode sensors.

CCD Sensors and MOS Arrays

The two main semiconductor image sensors are MOS arrays and charge-coupled devices (CCDs). Both of these devices use photodiodes as the light sensor. The MOS array is addressed in an x-y format like a memory device. The CCD provides a serial data transfer of the analog signal. The CCD image sensor consists of a PN photodiode array, a CCD analog shift register, and an output circuit. Light enters the photodiode array generating electron-hole pairs. The photo-generated carriers (electrons) are stored within diodes of the array as signal-charge packets. When a designated voltage is applied to the shift gate, the stored charge packets are transferred to the CCD shift register, instantly and in parallel.

CCD image sensors are employed in numerous applications. Linear CCDs are used in facsimile machines, scanners, and electronic copiers. Area CCD applications include camcorders, monitoring systems, robots, and electronic still cameras.

LED Lamps and Displays

LED lamps and displays are based on the light-emitting diode. This device is a pinhead-size PN junction formed from combinations of gallium, arsenic, and phosphorus. Light emission is the result of hole-electron recombinations that take place near the junction of the p-doped and n-doped regions. As the electrons in the n region of the diode travel through the area near the junction, they recombine with a hole, releasing a photon with energy within the band of visible light. The wavelength or color of the emitted light is determined by energy released during recombination.

The most common materials used to manufacture LEDs are gallium arsenide phosphide (GaAsP), which emits light in the 650-nanometer red-light region of the visible spectrum, and gallium phosphide (GaP), which can, with appropriate doping, be made to emit light in the 565-nanometer green region. Mixing GaAsP and GaP in various substrate combinations can result in various color variations, including orange-red, amber, yellow, or bright green. Blue LEDs have been difficult to achieve but are being developed. The blue color is crucial for the construction of a full-color LED display.

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Light from LEDs is proportional to current, and altering the drive current modulates the light output. The electrical requirements needed to operate an LED are current from 0.5 to 20 milliamperes and voltage from 1.6 to 2 volts.

Individual LED dice may be bonded to metal lead frames or substrates of ceramic or fiberglass-epoxy laminate to form discrete numerical modules or multidigit displays. Seven separate dice are used to form a discrete seven-segment display module—an eighth die is used for the decimal point. Each of the seven dice illuminates a segment, or bar, used to form numbers from 1 to 10 and the letters A through F.

As indicators and displays, Dataquest believes that visible LEDs have entered the maturity stage. They are found as indicating lights on every type of electronic equipment. Although they have lost significant markets to liquid crystal displays (LCDs) in numeric and x-y displays, they can still be found in applications where their monochrome, active light emission is more desirable than LCDs.

New application areas are emerging to keep LEDs a growth product. One new growth area for LEDs involves the use of linear LED array printheads. These devices can provide high resolution and high speed in laser printers, facsimile machines, and other printers where light is used to create an image that is transferred to paper. The LED printed competes with laser diodes and thermal printheads in printer applications. Another growing application is the use of high-brightness LEDs in automotive signaling and braking lights.

Optocouplers

Optocouplers or optoisolators consist of an LED separated from a photodetector by a transparent, insulating, dielectric layer and mounted in an opaque package. A current in the LED causes light radiation to travel across the dielectric material to the photodetector, which, in turn, modulates a current at the output relative to the detected light. Because the input and output circuits are separated by an electrical insulator, these devices provide signal isolation. Signal isolation is important in noisy industrial environments, in medical sensing, and in isolating power-control devices from the low-voltage control circuitry.

The coupler may be used in a linear mode, where output current will be a linear function of the input signal, or in a pulsed mode, where the device is merely pulsed on or off (to pass digital bits). A modified optocoupler is the optointerrupter, in which an open space between the LED and the photodetector allows an outside vane or slotted disk to interrupt the light, effectively detecting motion, position, or optically encoded signals. These sensors are used as data encoders in computer peripheral equipment and as position sensors or limit detectors for motor controls.

The current transfer ratio (CTR) is used to rate the efficiency of the coupler. Therefore, it is important to match the radiation wavelength of the LED to the absorption band of the detector. A considerable variety of couplers is available. Although diode couplers offer higher speed, transistor couplers (to 250 kHz) have higher sensitivity. Photo-Darlington couplers are available for high transfer ratios and increased current with speeds up to

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25 kHz. The phototriac driver output coupler provides high-voltage (line-voltage) isolation protection for logic-triggering circuits.

Optocouplers are used in high-performance solid-state relays, position sensors, optical encoders, and voltage isolators for connecting logic circuits to power devices.

Laser Diodes

Semiconductor lasers are categorized according to their oscillation wavelength into the 1.55-, 1.30-, 0.85-, and 0.78-micron bands. The 1.55-micron band is the laser that is believed to have the greatest potential for use as a light source in long-distance optical communications. Currently, however, this wavelength is used only in a very few measuring instruments for optical communications. Semiconductor lasers of the 1.30-micron and 0.85-micron bands are being widely used for optical communications. The 1.30-micron band laser is used in long distance optical communications and is expected to have high growth potential. Semiconductor lasers of the 0.78-micron band are widely used in CD players, optical video disks, and laser printers. Shorter-wavelength laser diodes are starting to replace other laser types in bar-code scanners and offer the potential of increasing the storage capability of optical memories.

Other Optoelectronics

This subcategory includes solar cells, optical thermopiles, and other exotic optical semiconductor products. Photovoltaic cells, or solar cells, are used in widely divergent applications, ranging from sun-powered consumer products to self-powered terrestrial communications links, as well as in powering satellite communications. Solar cells in the consumer environment are expected to show relatively low growth because they have been largely confined to calculator applications. Growth may hinge on whether solar cell-powered portable data processing products are made available.

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SEMICONDUCTORS JAPAN

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Dataquest Perspectives: These research newsletters provide analysis and commentary on key technologies, companies, products, market opportunities, events, user and distribution trends, and strategic issues in the industry. Topical in nature, these documents provide timely information and advice to help you stay ahead of your competition.
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Japanese Semiconductor Consumption by Application Market: Five-year revenue forecasts of the semiconductor-value composition of various categories of electronic equipment, derived by applying I/O ratios to the equipment production forecast estimates. ***Q2 and Q4 1998***

Japanese Electronic Equipment Production Forecast: Five-year forecasts for six categories and 21 subcategories of electronic equipment, providing a demand-side view of the Japanese semiconductor market. ***Q2 and Q4 1998***

Japanese Wafer Fabrication Facilities: Pilot and production fab lines by company, location, fab name, products produced, process technology, minimum linewidth, wafer diameter, and estimated wafer capacity. ***Q4 1998***

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SEMICONDUCTORS JAPAN

Dataquest's Semiconductors Japan program provides quantitative and qualitative information on the products, markets, technologies, and companies driving the Japanese semiconductor industry. This program provides a comprehensive view of all aspects of the industry, including manufacturing and consumption by application market.

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Key semiconductor issues covered throughout the year in our publications and briefings will include:

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- How will digitization of consumer equipment contribute to Japanese semiconductor consumption?
- Who among the users are increasing semiconductor purchase in Japan?
- Will the wafer industry benefit from SLI?
- Will the soft DRAM market continue to persist in the Japanese market?
- Will the arrival of SLI pose an opportunity or a threat to Japanese semiconductor companies?
- Will Japanese semiconductor companies lead in the race for 300 mm wafer fab construction?
- Is foundry going to be an alternative in Japanese companies' strategies?
- Will Japanese companies increase capital spending within Japan, or overseas?

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- Worldwide consumption forecasts by region

Perspective

Semiconductors Japan
Market Analysis

Restructuring Goes On at Japanese Semiconductor Fabs

Abstract: *In 1998, industry reorganization has emerged as a trend against the backdrop of an unprecedented downturn in the worldwide semiconductor industry. A variety of factors, including the protracted semiconductor slowdown, weakening profits, changing dynamics for product-specific markets, and system-level integration (SLI) efforts, are forcing chip makers to reconsider their businesses. In this Perspective, Dataquest reviews fab construction trends among the Japanese manufacturers based on the results of Dataquest's fall 1998 semiconductor fab survey. Please note that we are still in the process of finalizing the results of this survey on a global basis, and therefore, our final release of data may vary slightly from what is presented in this Perspective.*
By Yoshihiro Shimada

Overview of 1998 Fab Survey

Three main observations were made from the results of the 1998 fab survey of Japanese semiconductor manufacturers. They are as follows:

- There are no announced plans for building new fabs.
- DRAM fabs are being substantially reorganized.
- Overseas fabs are being substantially reorganized.

Some of these moves have already been announced by chip makers. Moreover, these results are reasonably predictable considering the current state of supply and demand and the earnings environment. However, a comparison with past low points in the market cycle indicates that more significant steps are being taken this time around.

The survey results for Japanese manufacturers are shown in Figures 1 and 2. Note that the numbers provide a comparison with the situation at the end of 1997.

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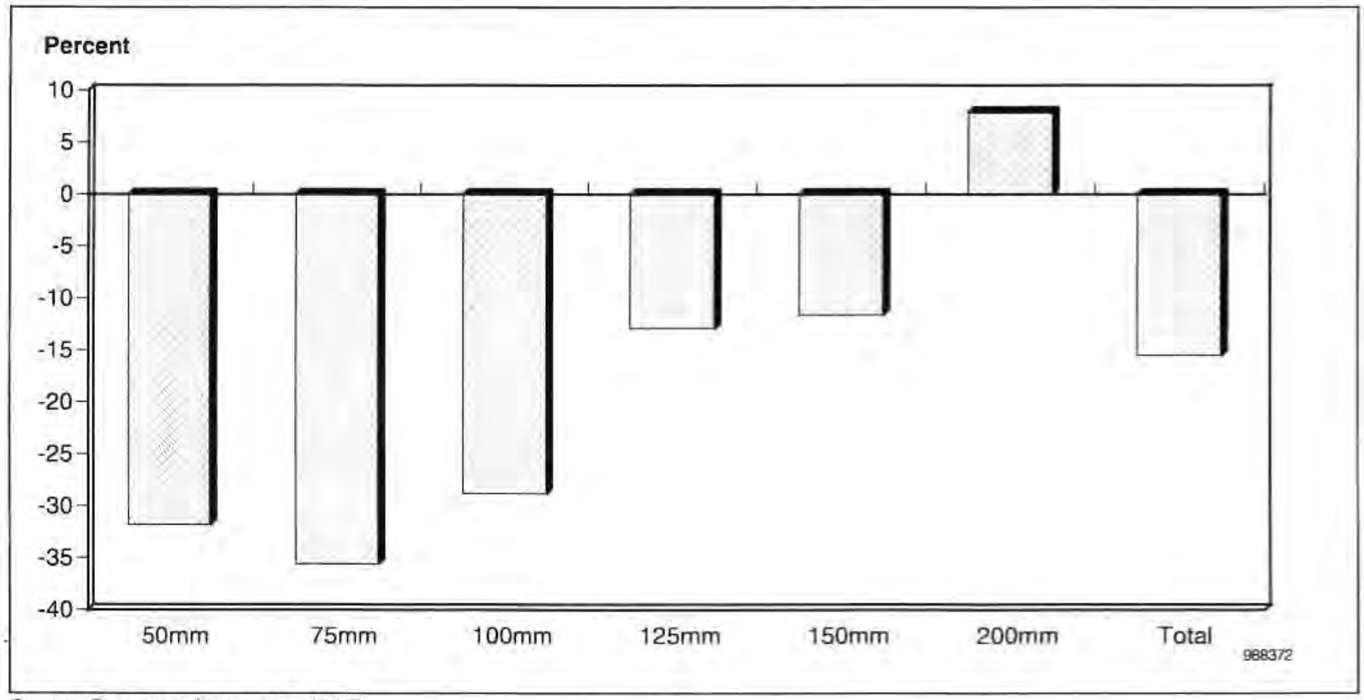
The key points are listed below:

- Among the wafer processing capacity categories, the 50mm to 100mm segments contracted substantially, the 125mm and 150mm segments contracted slightly, and the 200mm segment rose.
- The 0.35-micron process is becoming the mainstay design rule for MOS digital.
- There are 0.25-micron fabs being launched.
- Some chip makers have 300mm fab pilot line plans, but volume production line plans are undetermined.

Figure 1
1998 Japanese Manufacturers' Wafer Processing Capacity by Wafer Size (Change over the Previous Year)



Source: Dataquest (December 1998)

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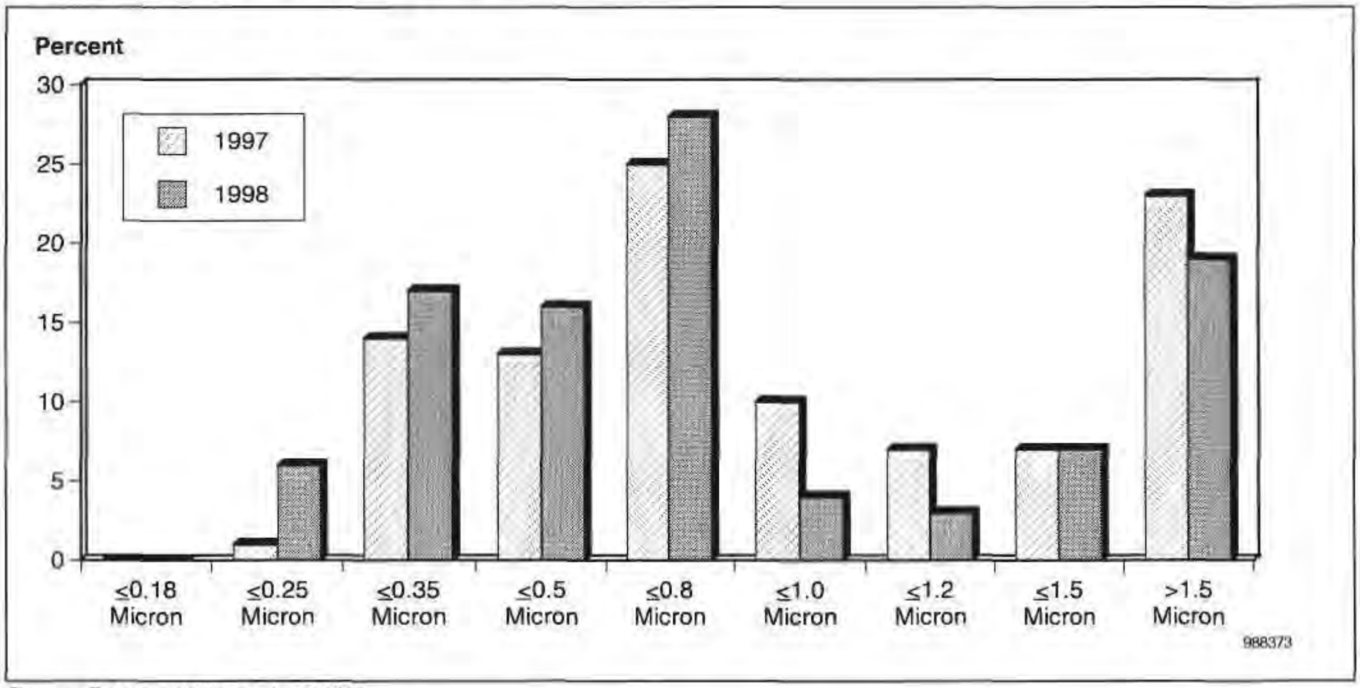
Figure 2
Japanese Manufacturers' Production Capacity by Operating Minimum Geometry (Change over the Previous Year)



Source: Dataquest (December 1998)

Figure 3 shows the state of DRAM production capacity by memory size for Japanese chip makers. The 200mm fabs designed primarily for DRAMs began operation in 1994 and continued to be built to keep up with the sharp increases in semiconductor demand from the PC boom. Facility launches were equally harried, with only six months between the start of volume production and escalation to maximum equipment output levels. Unable to apply the brakes to this rapid expansion of wafer processing capacity, new facility launches continued even after the DRAM market conditions reversed their course from the end of 1995. However, by 1997, new fab construction had ended, and no new line launches were reported for 1998.

Chip shrink techniques, which have gained rapid acceptance by chip makers as a way of improving profitability, dramatically increase the number of devices obtained from a fixed amount of wafer processing capacity and have worked against the dissolution of excess production capacity. Even though this makes it possible to achieve production capacity expansion while delaying the construction of new 200mm fabs, Dataquest expects continued investment in 200mm fabs by the semiconductor industry as a whole; this is because investment in 64Mb-and-later-generation, high-speed DRAM facilities is being given priority, and the useful life of 200mm fabs is being extended by a move to push back the timing of a switch to 300mm fabs. The question is whether Japanese chip makers will make these investments on their own or whether they will utilize resources outside of their own operations.

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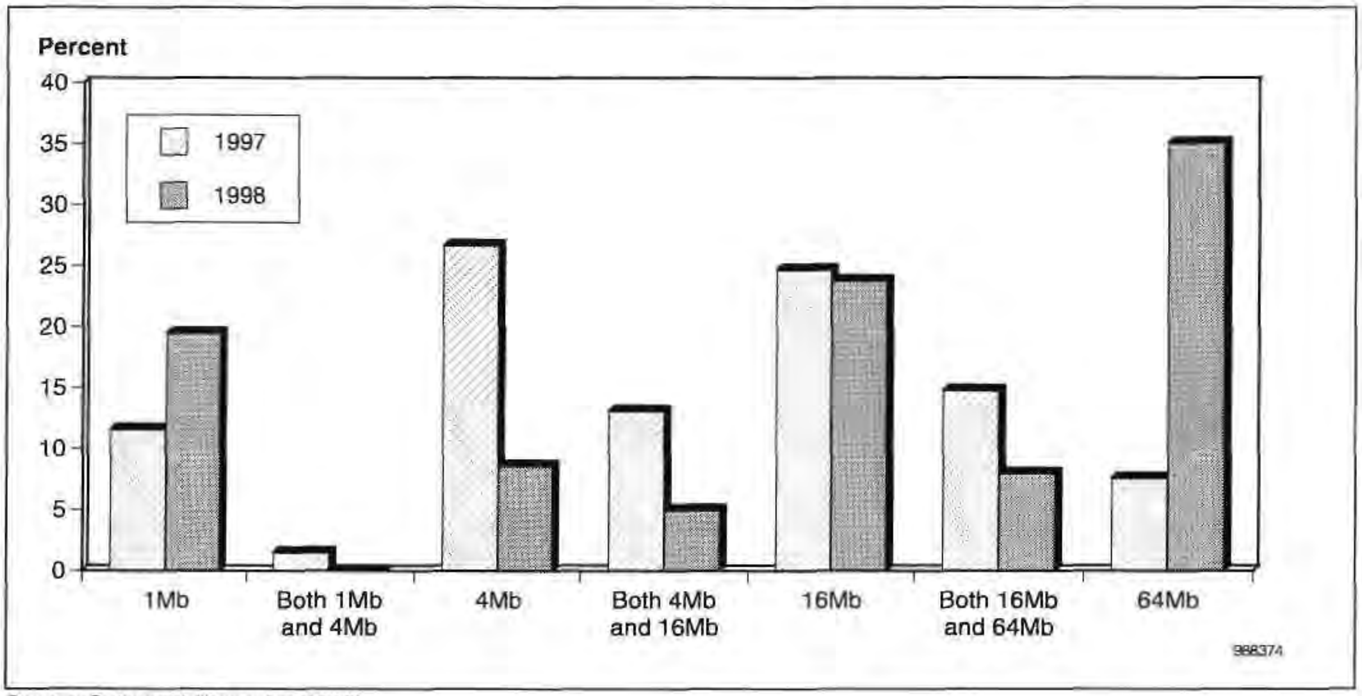
Figure 3
Japanese Manufacturers' DRAM Production Capacity by Memory Size



Source: Dataquest (December 1998)

Despite the shift for MOS digital devices to 200mm fabs, 150mm fab facilities are relatively stable with support from the shift by analog 100mm and 125mm fabs. Dataquest's wafer consumption forecast expects just a slight decline in worldwide 150mm wafer consumption, and we believe that 1998 fab trends are in line with this forecast. 100mm and 125mm fabs were operating through the mid-1990s to fill analog and discrete device demand, but the transition to larger-diameter wafers began with the wafer shortages experienced during the 1994-to-1995 time period. Meanwhile, even though investments to expand fab capacity for MOS digital devices are on hold, investments in fabs to satisfy analog device requirements have continued. Specifically, these investments are aimed at responding to high-growth products such as mixed-signal ICs, power devices, and high-frequency devices, as well as to growing demand for linear ICs, which contain standard analog devices.

Trends by Product Type

Reviewing the situation by product type, it is evident that the number of DRAM-dedicated fabs has dropped sharply. Even when adding fabs that combine DRAMs with other devices, it is clear that the DRAM presence is declining. We believe this is happening for the following reasons:

- Even though volume demand is strong, chip shrink techniques enable production volume increases without expanding wafer processing capacity.

- Chip maker fab investments are being reduced by utilizing external resources such as foundries and OEMs.
- Acceleration of the chip shrink trend is making older-generation fabs outdated and unable to compete.
- There is already adequate capacity for other device types that might be used as a conversion alternative or for facility sharing.

As things currently stand, the primary focus in DRAM capacity strategies is on increasing production volumes through chip shrink techniques, and new investments are dominated by facility upgrades to accomplish this. Therefore, DRAM fab investments in 1998 are dedicated mainly to 0.18-micron design rule capabilities, moving forward with greater precision. Leading chip makers expect to have prototypes using the 0.18-micron process at the end of this year and intend to embark on volume production in 1999.

Logic fabs are also increasing design rule precision to 0.25 micron, and investments in 0.18-micron facilities are beginning to be made for system-level integration (SLI) devices. Looking at process technology line widths, logic fabs have caught up with DRAM fabs at the 0.25-micron mark. Furthermore, the facility investment burden for logic fabs is rising in order to introduce planar technology required for multilayer logic devices and process integration to deal with embedded memory and analog function elements.

This survey has confirmed the development of two distinct types of logic fabs. One is an application-specific standard products (ASSP)-oriented fab, and the other is a microcontroller (MCU)- and ASIC-oriented fab. For the former type, the main focus is on reducing costs by enhancing productivity, and for the latter type, productivity improvements are being accomplished by stabilizing yields with process integration. Considering the product technology and production technique, the expression "microcomponent core ASIC" can be applied.

These product-specific trends are creating clear distinctions among the fab construction investments of Japanese chip makers. Naturally, the restrictions on capital spending resources vary by company, and differences in earnings structures also produce differences in capital investment approaches. However, capital spending investments ultimately are guided by product strategies. Dataquest expects to see differences in the capital-to-application capital spending investment stances having a significant impact on the positioning of Japan's chip makers.

Capital Investments

Dataquest is currently in the process of conducting a survey on capital investments by chip makers, and it appears that changes in capital investment levels are linked to the fab survey results. We will report on the details in a separate document, but the gist of it is that leading chip makers are significantly reducing their investment levels.

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The reductions in capital investments during 1998 are most prominent in the area of production-expansion investments primarily for DRAMs. Taking a slightly different angle, the downward trend is steepest for overseas plants (see Table 1). During the DRAM boom, chip makers moved aggressively to establish new overseas plants. However, under the current DRAM recession conditions, the impetus to secure overseas production capacity has subsided considerably as chip makers focused on improving the operating rates at domestic plants and on reducing the foreign exchange risk from yen depreciation. Also, because the chip makers are giving priority to the introduction of chip shrink techniques at domestic plants, in cases where the overseas plants are joint ventures or where production items are jointly developed, Dataquest believes that overseas plants will have considerable trouble staying competitive.

Table 1
Japanese Manufacturers' Overseas Plant Trends

Company Name	Fab Name	Date of Change	Prior to the Change	After the Change
Oki Electric	Oregon	September 1998	Back-end fab in operation	Back-end fab closed
Hitachi (joint venture with TI)	TwinStar	March 1998	16Mb DRAM	Hitachi's share sold to TI (afterward, TI sold the whole share to Micron Technology)
Hitachi	Irving	June 1998	4Mb DRAM, MCU	Fab closed
Fujitsu	Dahrum	December 1998	16Mb DRAM	Fab closed
Matsushita Electronic Industries	Matsushita Semiconductors America (MASCA)	December 1998	New 64Mb fab, suspension of 4Mb fab, continuation of 4/8-bit MCU fab	Operations halted
Mitsubishi Electric	Aachen	Early 1999	16Mb DRAM	Product types changed (embedded DRAM, SRAM, flash memory)
Mitsubishi Electric	Raleigh	March 1998	4Mb DRAM	Wafer fab stopped, packaging continued
Mitsubishi Electric	Raleigh	November 1998	Discrete assembly and test, memory module assembly	Packaging stopped (capabilities moved to Nagano packaging facility)

Source: Dataquest (December 1998)

At overseas plants where older-generation DRAM fabs are being converted to logic and analog device operations, it is becoming increasingly difficult to offer the functionality that customers demand as logic products rely more and more on advanced technologies. The value of these facilities has largely vanished as the benefits of supplying products that use existing technologies at a low cost and free of foreign exchange risk have diminished. Further, countries and regional governments that showed an active interest in attracting semiconductor plants with preferential measures during the strong

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years are not wooing additional investments; this is because a larger number of plants require infrastructure upgrades, and tax revenue is down from the poor earnings performance.

Under these circumstances, there has been a string of overseas plant closures and freezes on additional investments. These appear to be appropriate business decisions for the current situation. However, a longer-term view shows a pattern of extremes in Japanese chip makers' overseas investments, with extremely aggressive investment during the good years and retreat and withdrawal strategies during the bad years. In fact, the passive posture of the Japanese chip makers in the early 1990s, following the rise in overseas plant openings in the latter half of the 1980s, can be cited as a factor in their slow start in the semiconductor boom, which materialized initially in the overseas markets. If the overseas plant strategies of Japanese chip makers are on the retreat merely as a by-product of a cutback in total capital investment levels, these companies run the same risk once again of missing future opportunities.

Dataquest's spring survey forecast a 20 percent reduction in capital investments by Japanese chip makers in 1998 compared to the previous year, but it appears that the actual rate of decline will exceed this level. This larger-than-expected decline in capital investments is a combination of large-scale cutbacks through the postponement of new fab investments and microadjustments to existing fab upgrade and production-expansion investments. The relative share of investment funds going to the packaging process is rising as new test equipment is introduced to handle the growing diversity in package types and higher device speeds. However, chip makers are working to reduce gross unit levels, the basis for determining investment amounts, by enhancing yields and thereby avoiding an excessive rise in investment costs, as has happened with the fab process.

The motivation to limit capital investment is twofold: restrictions on investment resources and a move to stem excess supply capacity. However, the real question is whether chip makers have lost a sense of direction in the industry's so-called focus on "system LSIs." Not only are chip makers unable to determine what facilities are necessary, how to best link products and technology development, and other key strategic points, but they also appear to be having trouble defining an appropriate road map for their own fab operations. This suggests that once economic conditions recover, the chip makers will simply re-start the supply capacity expansion approach to competition.

A less simplistic readying of supply capacity requires a well-reasoned capital investment strategy, which includes the following:

- A strategic narrowing of business areas based on systematic marketing
- A narrowing of production items for company fabs and the selective use of external resources
- Development of a company structure that utilizes external resources

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At the same time, these strategies also involve the following risks:

- Trouble commercializing products if appropriate customers cannot be secured, even if the application-specific narrowing of products is performed in advance at the development stage through systematic marketing
- The need to develop a structure for assessing and minimizing the costs of utilizing external resources

Japanese chip makers are currently in the process of cautiously, but steadily, expanding production consignment to outside companies. However, in cases where the consignments are not for integrated production from the fab to final testing, it is necessary to develop know-how to avoid overlapping tests and understand how to utilize foundry services.

It is difficult to define clear income levels for custom logic production, which cannot assume the high yield levels of classic memory device production. Also, real operating rates are falling because of multiple-lot and mixed-lot production. Thus, facility plans must be worked out using lower yield and operating rate assumptions. This is reminiscent of the generational shift in DRAM production when facilities were allocated on the basis of low yield rates, but yields surprised everyone by rising sharply and then combined with chip shrink techniques to cause excess supply.

Although increasingly complex business management is required for SLI opportunities, given our outlook that restrictions on investment resources will continue, chip makers will be forced to make decisions from the perspective of their total semiconductor business rather than planning capital investments at the individual product or business unit level.

Dataquest Perspective

Far from the initial expectation for a recovery in the world semiconductor market in 1998, conditions worsened, and the overall market contracted, making this a year of serious challenges for chip makers. Meanwhile, the 1999 outlook foresees a return to a path of recovery, and high growth at 20 percent annual levels is expected again in 2000 and 2001. However, this growth pace is just an average for the total semiconductor market. Dataquest expects to see the market split into two segments: chip makers who achieve high growth rates and those who only receive a minor boost. There are two reasons for this departure of fortunes. From the demand side, there are signs that the market is moving from system diversity to integrated systems, and the success of chip makers enjoying the benefits of the SLI era, which hinges on system support, depends largely on whether they can secure suitable customers. On the supply side, investment strategies currently crippled with a variety of restrictions will define the course of chip makers' potential capacities.

Price stabilization is revisiting the DRAM market, beginning with PC100 specification, high-speed devices, and talk of long-term agreements (LTAs) has returned after a long interlude. Meanwhile, in 1999, leading chip makers

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will prepare 0.15-micron facilities and gear themselves up for the next phase of market growth. Dataquest believes that under these circumstances, semiconductor companies' capital investments require both bold and refined judgment, which ensures that an overall balance in the business and appropriate investment timing are maintained.

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Perspective

Semiconductors Japan

Market Analysis

Silicon Wafer Market in Transition: Moderate Growth Is Expected for the Japanese Market

Abstract: *The silicon wafer market seemed to be in a stage of recovery during the first quarter of 1997. However, the market is staggering again, partly because of the sluggishness of the device market late in 1997 and partly because of reduced wafer consumption caused by the accelerated pace of chip shrinkage in DRAM production. Now, two more forces, the expected changes in regional wafer consumption patterns in the future and a delay in migration to the 300mm wafer process, are working against a market that faces significant changes and turning points. This Perspective analyzes the current state of the Japanese wafer market as well as Japanese suppliers and offers a future outlook for the market.*
By Takashi Ogawa and Clark Fuhs

World Trends in Silicon Wafer Consumption

According to Dataquest's survey, worldwide consumption of silicon wafers in 1997 increased 7 percent from the previous year to 4,014 million square inches (MSI). This is the result of some recovery seen between late 1996 and early 1997, which was partially offset by a decline that began late in the second half of 1997. At present, the market is losing the momentum that was gained from the temporary recovery. Among the major factors causing the downturn, chip shrinkage is particularly noteworthy. It was accelerated by DRAM suppliers that desperately needed to improve profitability under pressure from the market slump, resulting in a significant drop in wafer consumption.

During the 1Mb and 4Mb DRAM era, the rate of chip shrinkage between the first and final versions was estimated to be in the range of 50 to 60 percent. Since last year, however, DRAM suppliers have accelerated the pace, and 60 to 70 percent reduction has already been achieved in shrink versions of 16Mb

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DRAM. For 64Mb DRAM, for which volume shipments began only last year, shrink versions have been developed over a shorter period of time by using the deep ultraviolet (DUV) technology. As a result, even under the optimistic scenario where bit growth is assumed to reach 60 to 70 percent between mid-1997 through the end of 1998, wafer consumption for DRAM production will remain almost unchanged on a quarterly basis.

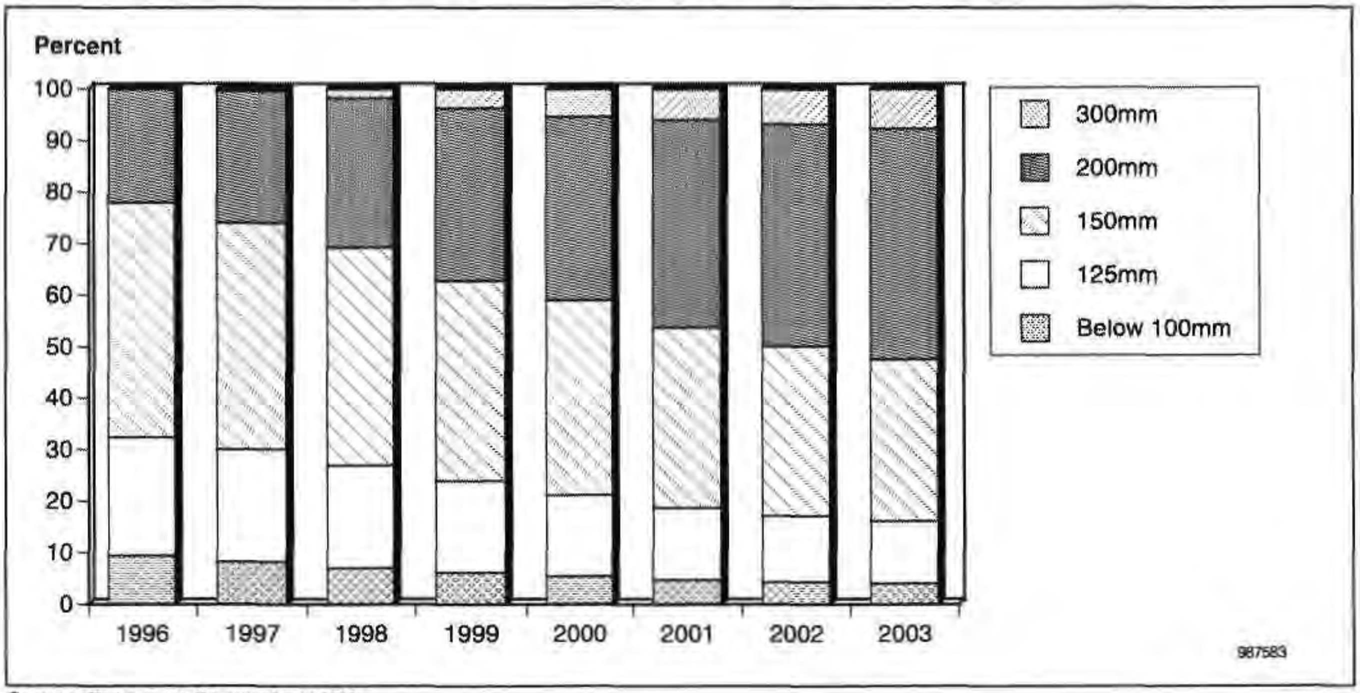
Given the effect of the rapid pace of chip shrinkage and the slack device market as a whole, wafer consumption in 1998 is expected to expand at a meager 3 percent to 4,113 MSI, according to Dataquest's July forecast. Furthermore, if device demand continues to wither beyond the current forecast, the wafer market will likely experience negative growth. It is expected to make a rebound in 1999 when the device market will show a modest recovery, but full-fledged recovery will have to wait until 2000 as the crossover of DRAM generations (on a unit basis) is completed. The market will then record two-digit growth in 2000 and 2001. Dataquest predicts that silicon wafer consumption will expand at a compound annual growth rate (CAGR) of 9 percent between 1997 and 2003, reaching 6,825 MSI in 2003.

Japanese Trends in Silicon Wafer Consumption

In 1997, silicon wafer consumption in the Japanese market grew 2 percent to 1,527 MSI, reflecting its sensitivity to DRAM market conditions. Again, the sluggish DRAM market and the accelerated pace of chip shrinkage will continue to suppress wafer consumption in 1998. Although Dataquest expects, as of June 1998, that 1998 consumption will remain unchanged from 1997's growth rate of 2 percent, silicon wafer consumption may experience negative growth, depending on an actual recovery of DRAM demand in the second half of 1998. Recovery will occur in 2000 or afterward, accompanied by the revival of the DRAM market. In 2000, wafer consumption in Japan will reach 1,887 MSI, a 12 percent increase over consumption in 1999.

One of the notable characteristics of the Japanese wafer market is a high percentage of smaller-diameter wafers (150mm or less). This is evidenced by the 1997 distribution of water consumption by diameter: 75mm wafers accounting for 0.6 percent of total consumption in the market (on a wafer-area basis), 100mm accounting for 7.7 percent, 125mm accounting for 21.8 percent, 150mm accounting for 43.9 percent, and 200mm accounting for 25.6 percent (see Figure 1). Because Japanese semiconductor manufacturers have curtailed their capital spending in reaction to the murky market conditions in the past few years, the resulting modification or delay in the planned installation of 200mm fab lines will further delay the shift from 150mm to 200mm fabs in terms of percentage share of wafer consumption. In fact, if this trend of cautious investment continues to prevail in the industry, 200mm wafers will not become the mainstay of the Japanese market until 2001—a sharp contrast to the world market, where they will take over 150mm wafers in 1998.

Figure 1
Silicon Wafer Consumption by Wafer Size in Japan, 1996 to 2003

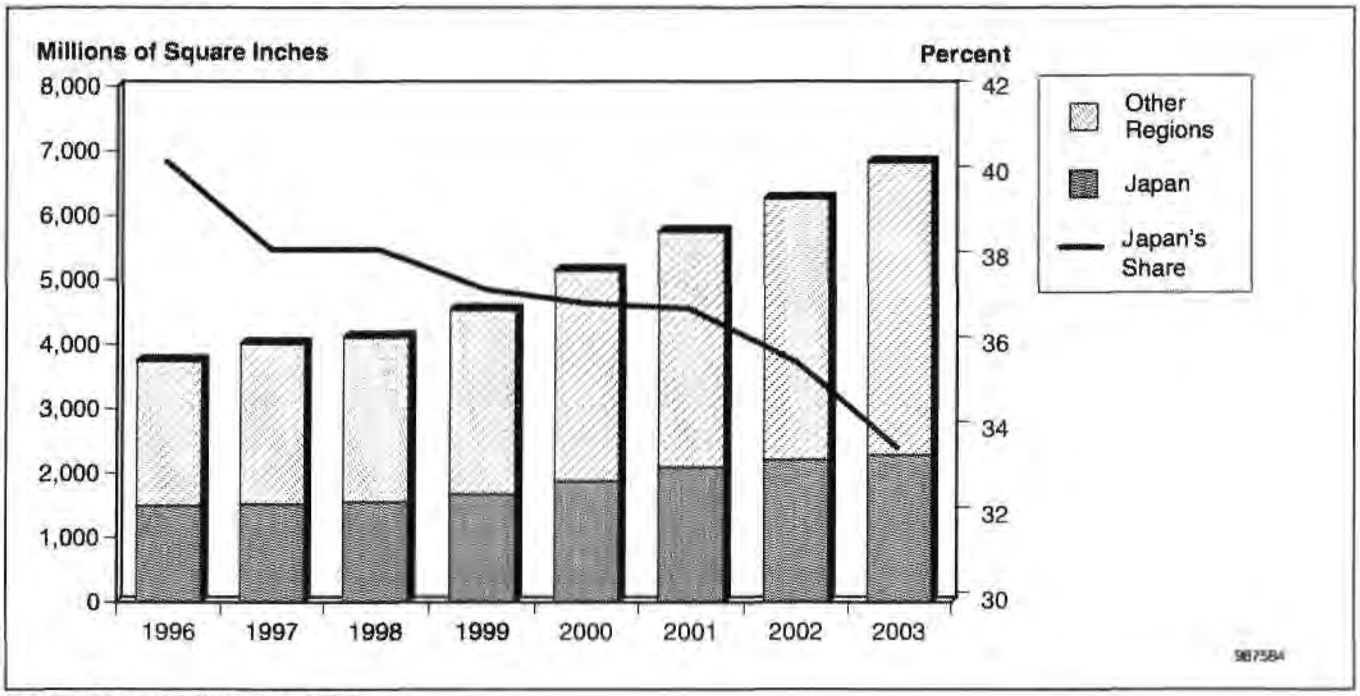


Source: Dataquest (November 1998)

Another important trend is the rapid growth of epitaxial wafer demand for 64Mb DRAM production, which is breaking away from the historical trend, where the Japanese market typically has been a relatively small consumer of epitaxial wafers, primarily using them for discrete and bipolar devices. According to Dataquest's survey, epitaxial wafer consumption for DRAM production (including R&D) jumped from 7.2 MSI to 56 MSI in 1997. Then, after a slowdown anticipated in 1998 because of the DRAM recession, it will grow at a CAGR of 13 percent between 1997 and 2003, amounting to 475 MSI in 2003. Thus, Japan will become the second-fastest-growing market for epitaxial wafers, following the Asia/Pacific market.

In the long run, growth in total wafer consumption in the Japanese market will turn into moderate growth for two reasons: continued investment cutbacks by Japanese semiconductor companies whose business is still highly DRAM-dependent and a decreased reliance on domestic production by Japanese companies as a result of increased procurement from foreign manufacturers through alliances. Dataquest predicts that the Japanese market will record a CAGR of 7 percent between 1997 and 2003, the lowest among four regions (Europe, Asia/Pacific, the Americas, and Japan), and it will lose share in the world wafer market in terms of consumption (see Figure 2).

Figure 2
Silicon Wafer Consumption Forecast, 1996 to 2003



Source: Dataquest (November 1998)

Japanese Silicon Wafer Manufacturers: 1997 Market Review

Table 1 summarizes the world market share of Japanese silicon wafer suppliers in 1997 (on a revenue basis), and Table 2 lists their product focus. Share distribution in the world market has remained virtually unchanged during the past decade. In the world market, Shin-Etsu Handotai Co. Ltd. has maintained the leading position with a market share of 24 to 26 percent, and the next five companies, including non-Japanese, have generally stayed within the share range between 10 percent and 12 percent. Japanese companies control a dominant share in the world market. In 1997, they held a combined share of 63.8 percent, while U.S. companies held 15.5 percent, European companies held 13.3 percent, and Asia/Pacific companies held 7.4 percent. In particular, Japanese companies nearly monopolize the Japanese market with an outstanding 90.8 percent share.

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Table 1
Japanese Silicon Wafer Makers' Market Share and Revenue in 1997

Maker	Revenue ($B)	Market Share (%)	Market Share Gain or Loss (%)
Shin-Etsu	1.65	23.4	-0.3
Sumitomo Sitix	0.96	13.5	0.7
Mitsubishi Materials	0.75	10.6	1.3
Komatsu Electronic Metals	0.61	8.7	-0.2
Toshiba Ceramics	0.35	4.9	-0.8
NSC Electron	0.16	2.3	0.2

Source: Dataquest (November 1998)

Table 2
Japanese Silicon Wafer Makers' Product Focus in 1997

Maker	DRAM	CMOS Logic Epitaxial	Power/Discrete Epitaxial
Shin-Etsu	X	Emerging	-
Sumitomo Sitix	-	X	X
Mitsubishi Materials	-	X	X
Komatsu Electronic Metals	Small	-	X
Toshiba Ceramics	X	-	X
NSC Electron	X	-	-

Note: The "X" indicates the products that each company makes.
Source: Dataquest (November 1998)

Shin-Etsu, controlling the dominant share, is a key supplier of silicon wafers to DRAM manufacturers, together with MEMC Electronic Materials Inc. (MEMC). Because Shin-Etsu gains most of its revenue from 200mm wafers in the DRAM market, it was directly hit by the slow market in 1997, which was accompanied by wafer price erosion, and its market share fell slightly (0.3 percentage points) from the previous year. Sumitomo Sitix Corporation, which recently merged with Sumitomo Metal Industries Ltd., is a major player in the epitaxial wafer market for CMOS logic applications. It is also a major supplier to Intel Corporation and maintains first place in the U.S. epitaxial market with a 22.7 percent share. The company is now boosting share in the power and discrete IC market.

Mitsubishi Material Silicon Corporation (MSIL) is another important supplier in the epitaxial wafer market for power and discrete devices. Although the market is still small, together with sales in epitaxial wafers for DRAM, MSIL registered strong growth in the Americas market in 1997, a 19.1 percent increase over the previous year, and increased its share by 1.3 percentage points. In the future, the company expects business expansion in the epitaxial wafer market for CMOS logic applications, to follow in the footsteps of Shin-Etsu. Komatsu Electronic Metals Co. Ltd. is a secondary supplier to the DRAM market and the major supplier in the power/discrete device segment. In 1997, it demonstrated healthy annual growth of 19 percent in the epitaxial

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market but lost revenue in the polished wafer market by 13.6 percent, resulting in a 0.2 percentage point decline in its overall market share.

Toshiba Ceramics Co. Ltd. supplies epitaxial wafers for power and discrete devices and DRAM wafers, but the latter is limited to several customers, as is also the case with NSC Electron Corporation. Toshiba Ceramics now is focusing on hydrogen annealed, low-defect wafers and steadily is improving product quality in an attempt to expand its share. Finally, Showa Denko KK announced that it would withdraw from the silicon market entirely in fiscal year 1998.

Global Trends in 200mm Wafer Consumption

In 1997, world consumption of 200mm wafers grew 26 percent to 1,485 MSI. In 1998, however, consumption inevitably will be affected by increased cases of phased-down or postponed construction of 200mm fab lines and a slowdown in consumption by the DRAM industry because of the chip shrinkage boom. In June 1998, Dataquest predicted that the 200mm wafer market would expand at a CAGR of 17 percent between 1997 and 2003, reaching 3,824 MSI in 2003 (see Figure 3). However, because the average monthly shipments during the first half of 1998 remained at around 2.6 million wafers, the short-term results may fall below the forecast. Given the many uncertainties about new fab construction plans—which are heavily dependent on the general economy, the timing of the much-awaited DRAM market recovery, and the development of shrink versions—consistent analysis and vigilant watching are essential. Dataquest expects that essentially all of the reduced levels of wafer consumption for 1998 will take place in the 200mm wafer segment.

It is also important to note that test wafer consumption is experiencing a significant decline, reflecting the maturing of production technology and the increased demand for cost reduction. In particular, consumption of 200mm test wafers in the Asia/Pacific region in 1997 decreased by around 30 MSI compared to the previous year. It is expected to decline further during the forecast period, and as a result, the test/process wafer ratio will change from 1:3 in 1998 (worldwide average) to 1:5 in 2003.

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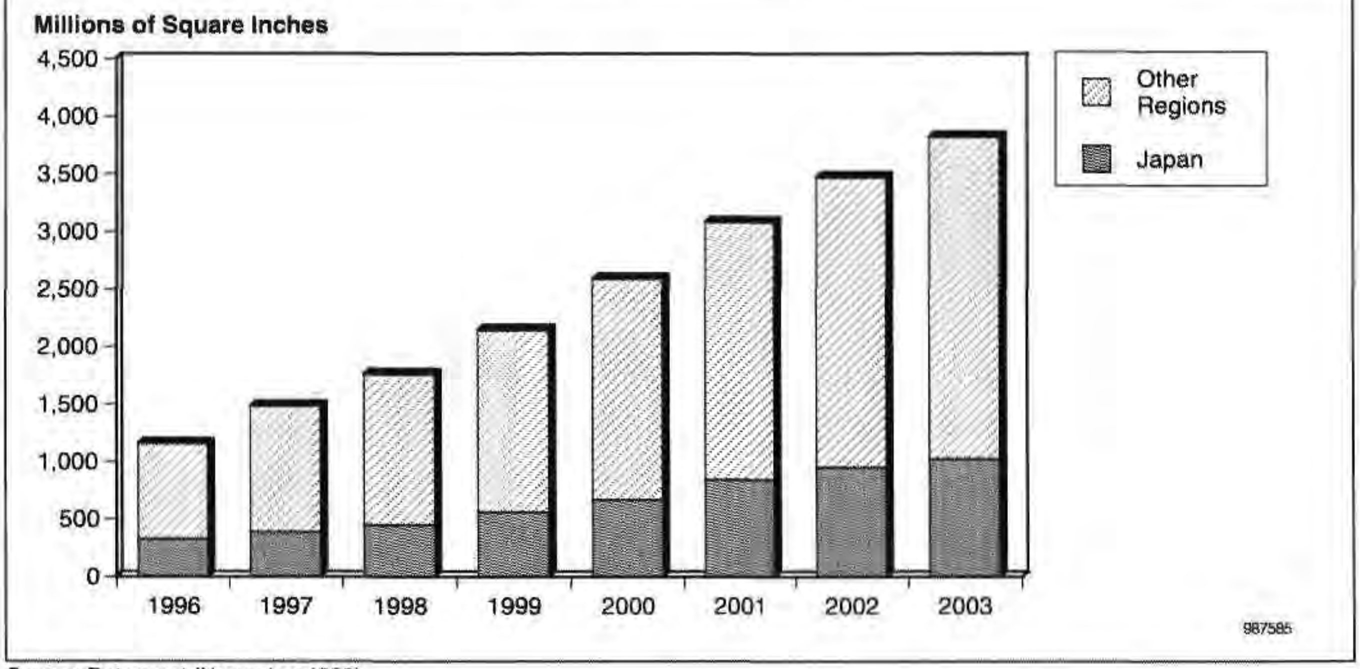
Figure 3
200mm Silicon Wafer Consumption Forecast, 1996 to 2003



Source: Dataquest (November 1998)

Japanese Trends in 200mm Wafer Consumption

In 1997, around 391 MSI of 200mm wafers were consumed in Japan, accounting for 26 percent of the world total; epitaxial wafers represented 26 percent of those (23 percent in the world market). Because demand for 200mm wafers in the Japanese market primarily comes from the DRAM industry, it will be adversely affected in the short run by the sluggish DRAM market and the increased efficiency in wafer use because of chip shrinkage. Dataquest's June forecast expected recovery in the second half of 1998 and double-digit annual growth, but the apparent delay in recovery will likely cause 200mm wafer consumption in Japan to remain flat or record negative growth compared to consumption in 1997. One exception is the demand for epitaxial wafers, which grows steadily because it is driven by demand for 64Mb DRAM production. As a result, epitaxial wafers will account for 30 percent of 200mm wafer consumption in the first half of 1998. In the long run, 200mm wafer consumption in the Japanese market will expand at a CAGR of 17.5 percent between 1997 and 2003.

300mm Wafer Trends and Fab Activity

Technological development efforts to commercialize the 300mm wafer are undertaken through two consortiums—Semiconductor Leading Edge of Technologies (SELETE) and International 300mm Initiative (I300I)—which have produced a number of achievements and deliverables. Nevertheless, semiconductor companies are forced to cut back investments in 300mm wafer production in order to weather the unfavorable business environment—a grave, but logical consequence of the persistent slump in the device market. Dataquest believes that most of the movement toward 300mm fab construction will be postponed further by another year.

According to Dataquest's fab equipment market forecast, the share of semiconductor equipment for 300mm processes will grow to 2.4 percent in 1998 as the market for R&D and pilot production purposes emerges; it then will grow to 7.0 percent in 1999 and 9.0 percent in 2000, reaching a small peak. Then, after a temporary setback, the market for volume production will ramp up, and 300mm process equipment will boost its share to over 20 percent by 2003. It is assumed that eight to 11 pilot fab lines will be operating by the end of 2001, followed by volume production in 2002, with a substantial wafer volume ramp-up during 2004 and 2005.

In addition to the unfavorable investment climate, 300mm fab plans seem to have lost their impetus because most semiconductor manufacturers are still struggling to find the business case (viability) for the 300mm process in the changing semiconductor market environment. In particular, many Japanese semiconductor companies are striving to cultivate new market opportunities, such as system-level integration (SLI), in an attempt to become less dependent on the DRAM business; it is difficult for them to find proper positioning for the 300mm process technology in future business strategies. On the other hand, the 300mm process seems to be one possible choice for companies that have product offerings in the established monopolistic markets and that can find technical advantages from the new process. Dataquest believes that Intel, IBM, and Siemens AG will likely become early adopters of the 300mm process.

Historically, silicon wafer consumption has experienced the crossover of generations at an interval of six to seven years (on a wafer-area basis). The life cycle of 200mm wafers is expected to be much longer: probably ten to 11 years. The previous crossover occurred in 1998 when 200mm wafers took over 150mm products in terms of volume consumed. At that time, 300mm wafers accounted for less than 1 percent of total silicon wafers consumed and were mainly used for testing purposes related to the development of transportation systems (see Figure 4). The share will grow slowly to reach 9 percent in 2003, which would be almost the sixth year of the historical life cycle. This will be equivalent to 5.6 million wafers.

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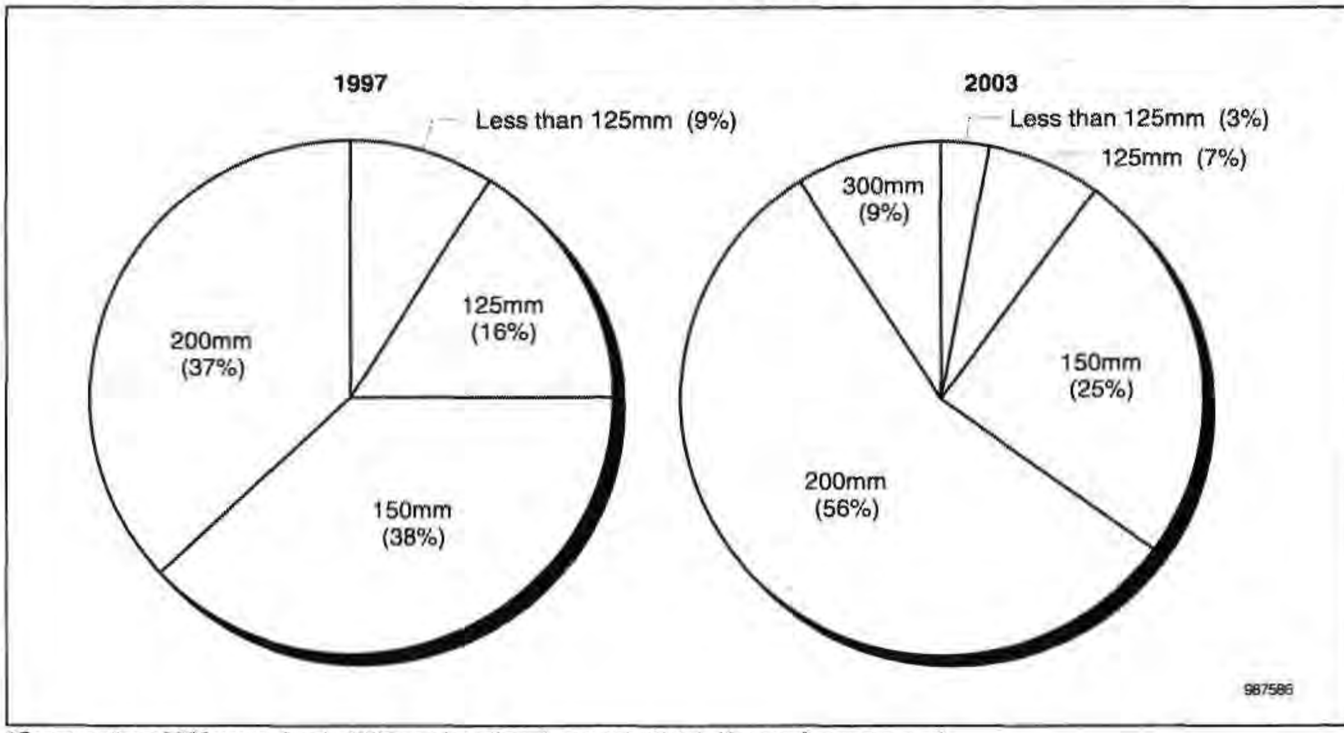
Figure 4
Worldwide Silicon Wafer Consumption Forecast by Wafer Size, 1997 versus 2003

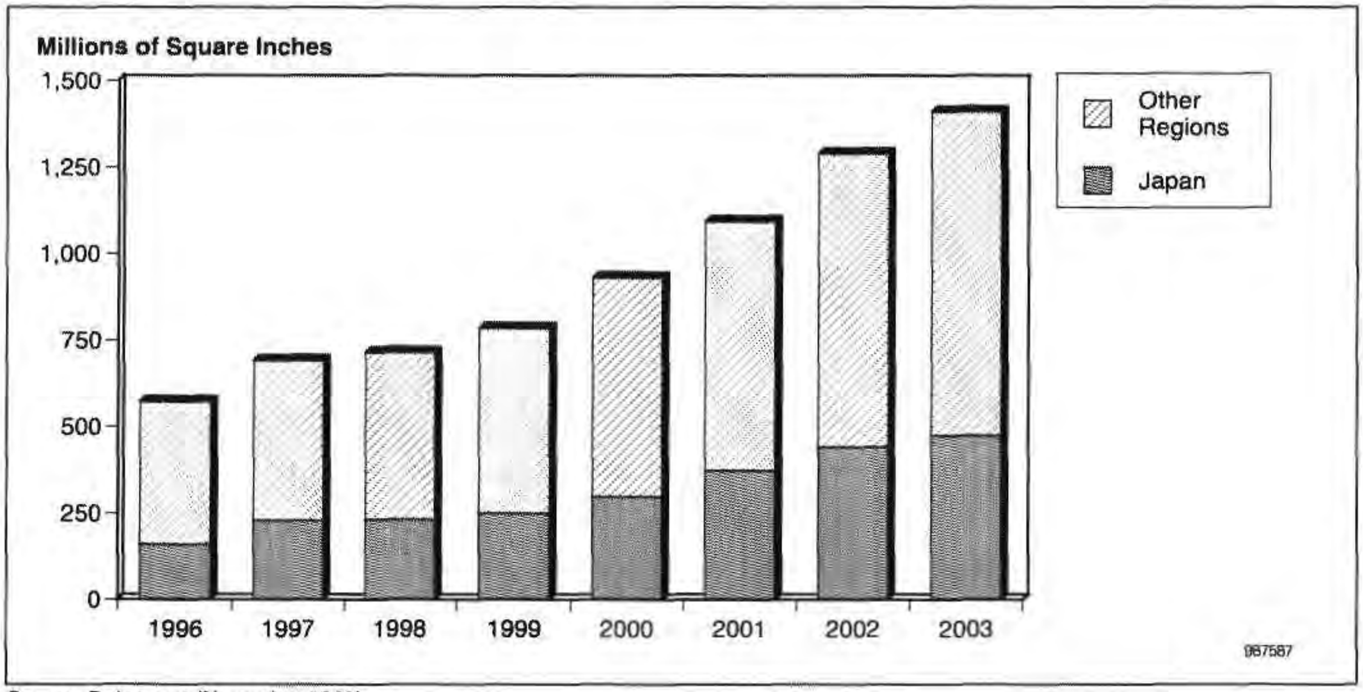


*Consumption of 300mm wafers in 1997 was less than 1 percent of total silicon wafers consumed.
Source: Dataquest (November 1998)

Epitaxial Wafer Consumption Trends

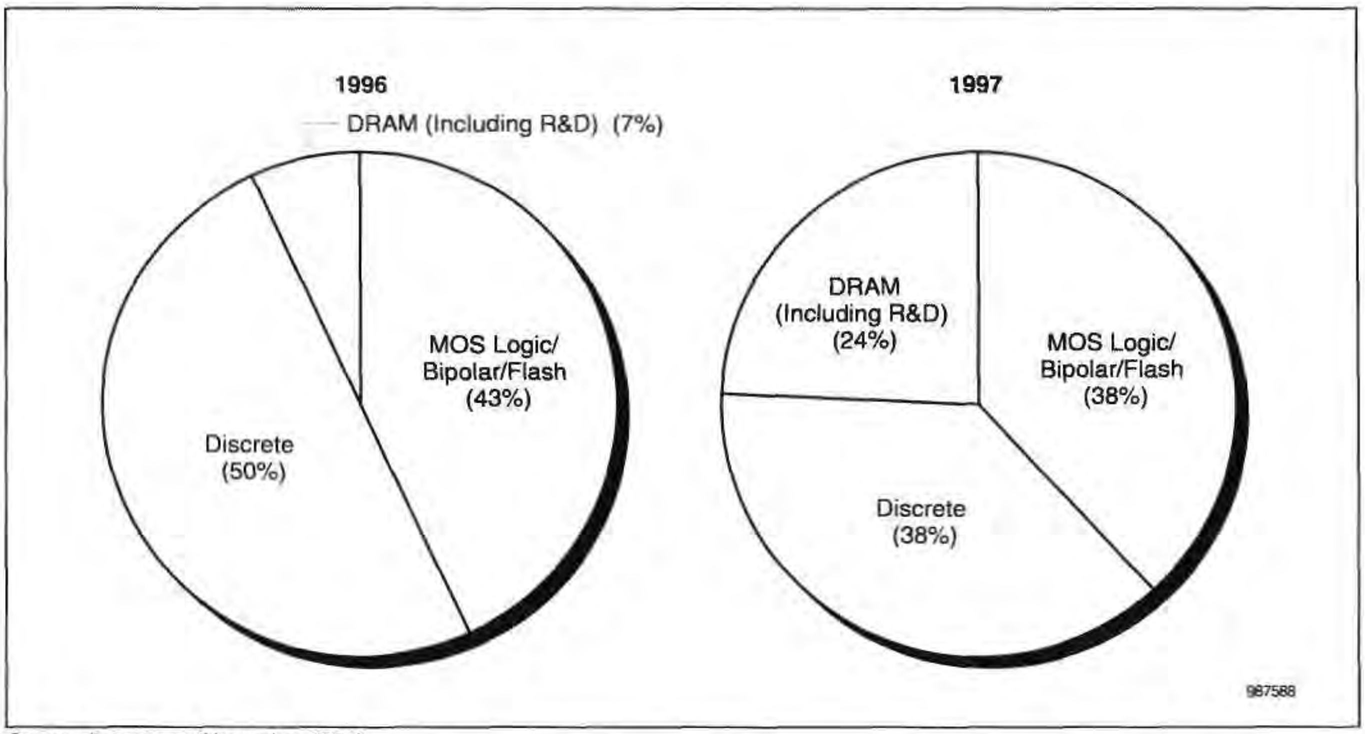
Worldwide epitaxial wafer consumption (merchandise sales only) in 1997 surged 21 percent to 693 MSI, far exceeding polished wafer consumption, which remained at a 5 percent growth rate. In particular, the Japanese market registered an impressive 42 percent growth rate to 230 MSI in 1997 (see Figure 5). In 1997, the breakdown of the world market by application was logic/bipolar/flash memory with 61.6 percent, discrete with 25.4 percent, and DRAM with 13.0 percent. (DRAM applications jumped from 3.0 percent in 1996.) The breakdown was far more conspicuous in 1997 in the Japanese market where the DRAM market still plays a major role: Logic/bipolar/flash memory represented 38.1 percent, discrete represented 37.6 percent, and DRAM represented 24.3 percent (see Figure 6).

Figure 5
Epitaxial Wafer Consumption Forecast, 1996 to 2003



Source: Dataquest (November 1998)

Figure 6
Epitaxial Wafer Consumption by Application in Japan, 1996 versus 1997



Source: Dataquest (November 1998)

Epitaxial demand for DRAM production has risen sharply since the end of 1996 because epitaxial wafers are an effective means of preventing grown-in defects, such as crystal-originated particles (COPs), on silicon wafers. These defects are known to cause a variety of device defects in 0.3-micron-or-finer processes, such as abnormal electric fields below the gate, the poor separation of features, and increased current leakage, depending on the actual position of the COPs.

Meanwhile, other factors that influence epitaxial demand have loomed over the past year. First of all, the persistent DRAM recession forces manufacturers to accelerate the development of shrink versions in a desperate attempt to reduce production costs by improving per-wafer yields. This suppresses wafer consumption while DRAM shipments increase in volume. Second, epitaxial technology was the first to receive industry attention due to its high levels of perfection and reliability. Also, the development of competing technologies—hydrogen annealed wafers and low-COP-type CZ wafers—has progressed steadily with improved performance, so that DRAM suppliers need to be cautious in their choice of wafer technology in consideration of price trends as well as technological advancement.

Nevertheless, Dataquest predicts that epitaxial wafer demand for DRAM production will grow firmly in the medium term at a CAGR of 30 percent between 1997 and 2003. Volume demand will reach 428 MSI in 2003, of which 46 percent will be consumed in Japan. This will fuel epitaxial demand, to achieve a CAGR of 13 percent during the same period, totaling 1,411 MSI in 2003. Similarly, consumption in the Japanese market will grow at an annual rate of 13 percent, bolstered by DRAM demand, and will amount to 475 MSI in 2003, of which the DRAM industry will consume a lofty 42 percent.

Dataquest Perspective

The silicon wafer market is about to experience some significant changes and turning points. The accelerated pace of process miniaturization since 1997, driven by the proliferation of DUV technology, has brought a wave of changes to the silicon wafer market. In particular, this has created a dilemma for the wafer industry because consumption does not grow side by side with increased DRAM shipments. The move is expected to prevail in the medium term, making it necessary for the industry to interpret the market trends on the basis of new criteria to reflect the future evolution of submicron processes (that is, its impact on wafer consumption). A regional consumption pattern will also change. In the past, most of the wafers produced in Japan were consumed locally to meet the gigantic appetite of the fast-growing DRAM industry. In the future, however, domestic consumption will slow down because of increased offshore production and the use of overseas foundries in the form of joint ventures, not to mention the sluggish DRAM market. As a result, domestic consumption market share will drop appreciably.

At the same time, the introduction of a larger-wafer generation will follow a new pattern. The delay in the commercialization of 300mm processes will break the historical pattern, and 200mm wafers will maintain the longest life

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cycle among past generations since the start of product standardization by the Semiconductor Equipment and Materials Industry (SEMI). This means that the wafer industry will face difficulty in relying on its traditional strategy for market expansion, under which it has used larger wafers as a source of value add. In addition to the structural changes in factors affecting profitability, the industry is required to continue capital investment in 300mm wafers. Various moves have recently surfaced as clear signs of response to the situation—for example, the announcement that Showa Denko KK planned to pull out from the market and the merger between Sumitomo Sitix and Sumitomo Metal Industries, which was partly motivated by the need for strengthening the financial base to meet increasing R&D investment. Because wafer manufacturers are facing the same situation as that of chip makers and semiconductor equipment manufacturers, such moves are expected to intensify in order to spread investment risks and boost market share.

Regional wafer consumption trends largely reflect regional device market and production trends. In the Japanese markets that remain in a stage of moderate growth, wafer consumption seems to signify the stagnate semiconductor industry, which is still groping in the dark to find new market opportunities as alternatives to the sluggish DRAM market. Although the need to make a livelihood will likely force Japanese companies to rely on the DRAM business for the time being, there is no doubt that any new direction that they find will have important bearing on the future of the Japanese wafer market. In fact, Dataquest believes that the move for change by the semiconductor industry will not be felt directly by the wafer industry until 2003.

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Perspective

Semiconductors Japan

Market Analysis

Fall 1998 Forecast: Japanese Electronic Equipment Production and Semiconductor Market

Abstract: *Dataquest has brought down its forecast of the semiconductor market in Japan. Economic difficulties both in Japan and other parts of the world, including Asia/Pacific and the Americas, are hurting Japanese electronic equipment production, causing semiconductor consumption to remain below the 1997 level. Persistent oversupply is also a culprit, bringing revenue down even where unit demand is sound. From 1997 to 2002, the Japanese semiconductor market will experience only modest growth, with a 6.7 percent compound annual growth rate (CAGR). However, there will be changes and challenges in each product market, including product transitions in DRAM and an accelerated move toward system-level integration (SLI) ASIC. There are also a number of possible drivers to this semiconductor market forecast, as well as restraints, and the key for resuming growth lies in the overall recovery of Japanese electronics production in various categories, specifically leveraging on infrastructure development.*

By Yoshihiro Shimada, Motoya Ohgami, Masahiro Suzuki, and Yoshihisa Toyosaki

Overview of Electronic Equipment Production in Japan

Japan's economic slump is becoming increasingly severe, with practically no sign of a recovery. This is most starkly seen in the outlook for negative gross domestic product (GDP) growth. Although yen depreciation has improved the profitability of exports, Japan's export markets are drying up. Asian economies, a major destination for Japanese exports, are embroiled in the Asian financial crisis (AFC), and even the United States, Japan's other key trading partner, has begun to show signs of weakening since mid-1998. This economic environment has spelled trouble for Japan's electronic equipment production.

Electronic equipment production in Japan in 1997 rose by 9.7 percent against the previous year on a yen basis, but the real slowdown has taken hold since

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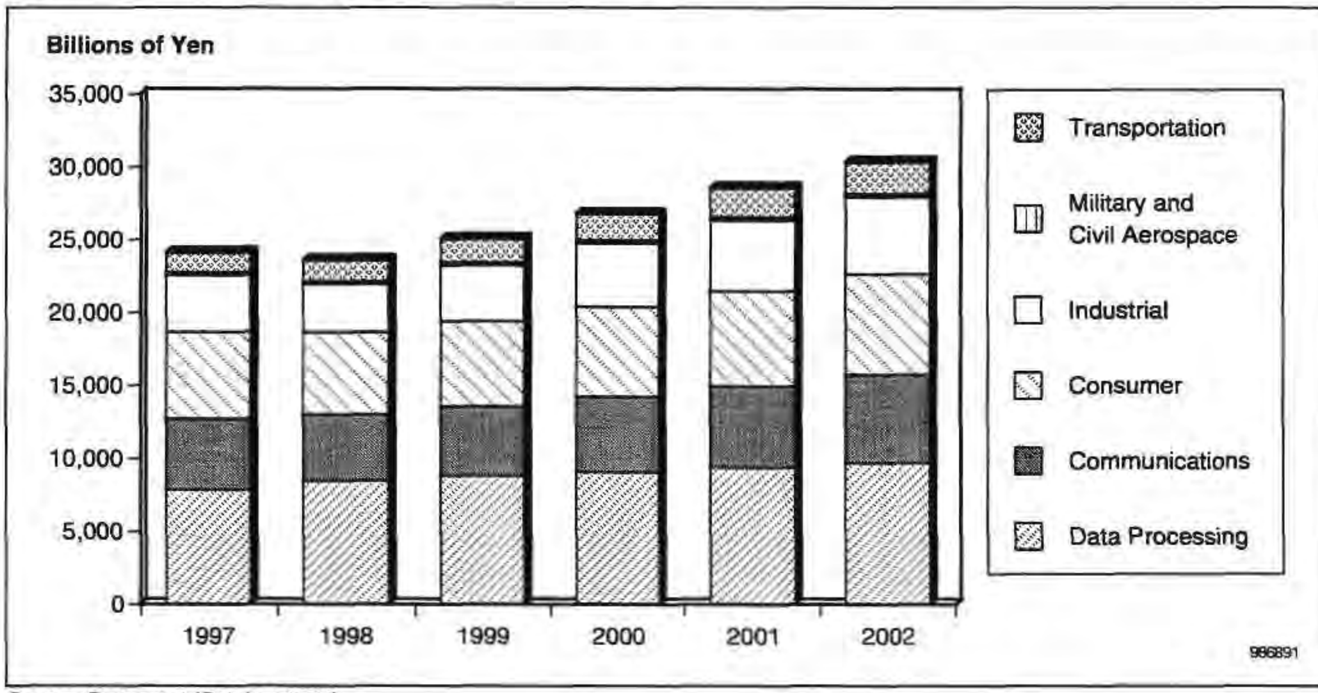
spring 1998. In our spring forecast, Dataquest estimated 3.1 percent growth in Japan's electronic equipment production for 1998. Based on the production results for the first half of 1998, which show a substantial decline in PC and other key electronic equipment production, Dataquest determined that it is necessary to adjust our outlook for 1998 downward. Dataquest expects electronic equipment production in Japan to achieve ¥23,579 billion in revenue in 1998, a 2.1 percent decline since 1997, and to maintain a compound annual growth rate (CAGR) of 4.7 percent during the 1997 to 2002 period (see Figure 1).

Figure 1
Japanese Electronic Equipment Production Forecast



Source: Dataquest (October 1998)

Slumping PC Market and EDP Equipment Production

With the release of Windows 98 delayed until July, PC shipments from January through June suffered a sharp turn for the worst, off 11.9 percent from 1997's shipments to 1.67 million units. Following the release of Windows 98, however, the market is rebounding, fueled primarily by individual demand. Hope is limited for an expansion of demand for PCs used by businesses, which account for nearly 70 percent of the domestic PC market, because of cutbacks in corporate capital spending in response to financial difficulties, including loans. At the same time, client/server systems are picking up as companies move to purchase computer systems to support the introduction of business applications such as enterprise resource planning (ERP) and supply chain management.

In the area of universal serial bus (USB)-compatible peripheral devices, designed to capitalize on the new Windows 98 USB feature, a steady stream of keyboards, mouse units, and other medium- and low-speed equipment is being marketed. Therefore, Dataquest is expecting increased demand not

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only for new PCs but also for peripheral devices. With the popularity of sub-$1,000 PCs, storage devices such as CD-ROMs, DVD-ROMs, and rigid disk drives (RDDs) are faced with rather difficult price metrics. As a result, CD-ROM drives continue to be primarily available in a 40x speed mode, while 2.5-inch-and-smaller RDDs are becoming the mainstream for thin, high-capacity notebook computers. From the perspective of added value, desktop computers are offering high-speed rotation at 7,200 rpm and faster. Dataquest expects scanners and printers to continue enjoying healthy demand in the input/output (I/O) device segment in Japan.

Dataquest estimates that data processing equipment production in Japan will increase by 7.7 percent, compared to 1997 production, to ¥8,462 billion in 1998. The CAGR for the 1997 to 2002 period is set at 4.4 percent.

A Breather for Communications Electronic Equipment Production

The total number of wireless phone subscribers including those subscribing to personal handyphone systems (PHSs) has surpassed 40 million, but new subscriber growth for personal digital cellular (PDC), the primary domestic digital cellular phone service, is slowing. In contrast to the steady pace of new subscriber growth for PDC service at 700,000 to 800,000 new subscribers per month, PHS, pager, and other service contracts continue their downward slide. Replacement demand for home phone terminals has been reinvigorated by the start of number display service. Nonetheless, the number of new contracts for fixed telephone service is declining as an increasing number of users are opting for mobile phones to satisfy their telephone requirements. In November 1998, regulatory changes are planned that will allow phone service rates to be set or changed through a reporting system rather than requiring permission in advance. Dataquest expects that this will increase the variety of low-cost services offered.

Investment in communications infrastructure in 1998 is tailing off following the completion of the digitization of all telephone office switching systems by the end of 1997. While demand for LAN and WAN systems is strong, the benefits are being discounted by sharply lower hub and router prices. In fact, the Japanese market is now considered to be more price-attractive than other Asian markets—even Taiwan, where Japanese companies used to go for a deal. Dataquest believes that demand for LAN-related equipment will expand at an annual rate of around 20 percent for the next few years.

Communications electronic equipment production in Japan is expected to decrease to ¥4,559 billion in 1998, which is 6.5 percent lower than production in 1997. The CAGR for 1997 to 2002 is forecast to be 4.3 percent.

Digital Systems—A Bright Spot for Domestic Consumer Equipment Production

Japan's consumer equipment market for audiovisual equipment is rapidly being digitized. In the audio equipment area, mini-disc (MD) shipments are posting solid gains. MD functionality is no longer only a portable phenomenon and can be found as a standard capability in minicomponent systems. As a result, its growth is expanding into all sectors, including replacement demand. Meanwhile, in the video equipment market, DV-C shipments are sharply increasing. On a domestic shipment basis, DV-Cs account for 70 percent of all video camera volume, surpassing analog video cameras.

The digital still camera (DSC) market is discovering two distinct segments: a high-pixel-density version with over 1 million pixels and an economy version. With more than 30 companies participating in this market, excessive competition is a concern. Demand is also expanding in overseas markets for application as a simple image input device for Internet home page creation. However, this opportunity is being challenged by the expense of DSC compared to the recent emergence of flatbed-style scanners, which are selling in the ¥20,000 range. DVD player revenue growth is expected to exceed 100 percent in 1998, compared to 1997, but shipment volumes are still small. The conditions for further expansion of this market are in place as consumer prices for a stationary system are down to around ¥30,000, and DVD software offerings are being enhanced.

Domestic production in existing TV and VCR markets improved in 1998, spurred by the Nagano Olympics and World Cup Soccer, major sporting events that had a positive effect on the sales of wide-screen TVs. Upcoming opportunities in this market include receiver equipment for earth-based wave digital broadcasts and broadcasting satellite (BS) digital broadcasts scheduled to begin in 2000. Given these developments, Dataquest expects continued growth in demand for wide-screen TVs with high-image quality and multiple functions. In contrast, Dataquest expects negative growth for air conditioners, refrigerators, other consumer appliances, and VCRs.

Dataquest estimates that the value of consumer equipment production in Japan will be ¥5,624 billion in 1998, a 5.3 percent decrease from 1997 production. The CAGR is forecast to be 3.1 percent from 1997 to 2002.

Trends for Other Electronic Equipment Production in Japan

With the worsening economic situation, capital investments in manufacturing have substantially dropped off. Facility operating rates are also lower, and temporary operation halts have been introduced in some cases. The production of production-related and machining equipment is down across the board for the first half of 1998, with negative annual growth of 20 percent or more. Meanwhile, the necessity of monitoring equipment and other security applications in the safety and security alarm markets is expected to grow. For all industrial electronic equipment, Dataquest expects a 1998 production value of ¥3,316 billion, a 15.0 percent decline from 1997 production. A CAGR of 6.3 percent is forecast for the 1997 to 2002 period.

Although the number of new vehicles registered in Japan's domestic car market recorded a double-digit decline from 1997 in the first half of 1998, sales of car navigation sets continued posting steady growth. This market received a boost from the start of the Vehicle Information and Communication System (VICS) transportation information service, and currently more than 600,000 car navigation systems with VICS functionality have been shipped. There are also plans for evolving this system into an all-around information service with more sophisticated capabilities than

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Intelligent Transport Systems (ITS). The value of transportation electronic equipment production in Japan is expected to be ¥1,428 billion in 1998, a 7.9 percent increase from 1997 production. The CAGR from 1997 to 2002 is forecast to be 10.4 percent.

The 1998 Semiconductor Market Disappoints

In a forecast update issued in July, Dataquest put forth a scenario of 1.4 percent growth in the 1998 worldwide market, compared to the same market in 1997. However, the market has continued to lose ground, and there is little doubt that even this scenario is no longer attainable. The following points can be cited as causes of this market's decline:

- Continuing downward slide in DRAM prices—Chip shrinking and other efforts to secure supplier-side profits are backfiring on the elimination of oversupply.
- Growing AFC impact—The AFC has spread on a worldwide scale and is causing an economic slowdown in the United States and other regions.
- Oversupply is spreading to the entire semiconductor market—Market conditions began weakening for microcomponents and logic devices late last year, and this trend has extended to analog and discrete devices. Foundry demand is also rapidly declining.
- Oversupply of electronic equipment—Production adjustments are starting for electronic equipment, and either demand for semiconductor volume is temporarily falling, or the pace of growth is slowing.

Eliminating Excess Supply Capacity

When setting forecasts for the semiconductor market, Dataquest formulates a supply/demand scenario and uses this as the basis for analyzing semiconductor consumption trends. The scenario adopted for this market forecast is outlined as follows:

- Shortages of PC100-specification DRAMs are already occurring, and facility investment cutbacks, factory closings, and other efforts to adjust supply capacity for the entire DRAM segment have started. In light of these circumstances, Dataquest believes that the DRAM supply/demand will balance in mid- to late-2000.
- A restoration of the supply/demand balance for the overall semiconductor market is expected to occur approximately one to two quarters after the DRAM supply/demand balance recovers.
- As a result, there will be a slight shortage in the semiconductor market in 2000, and market conditions will recover. The positive market conditions will continue through 2001, and this will prompt a reinstatement of capital investment.
- Supply capacity will expand because of the increasing capital investments, and another excess supply situation will occur in 2002. Affected by a mild worsening of market conditions, the peak in market

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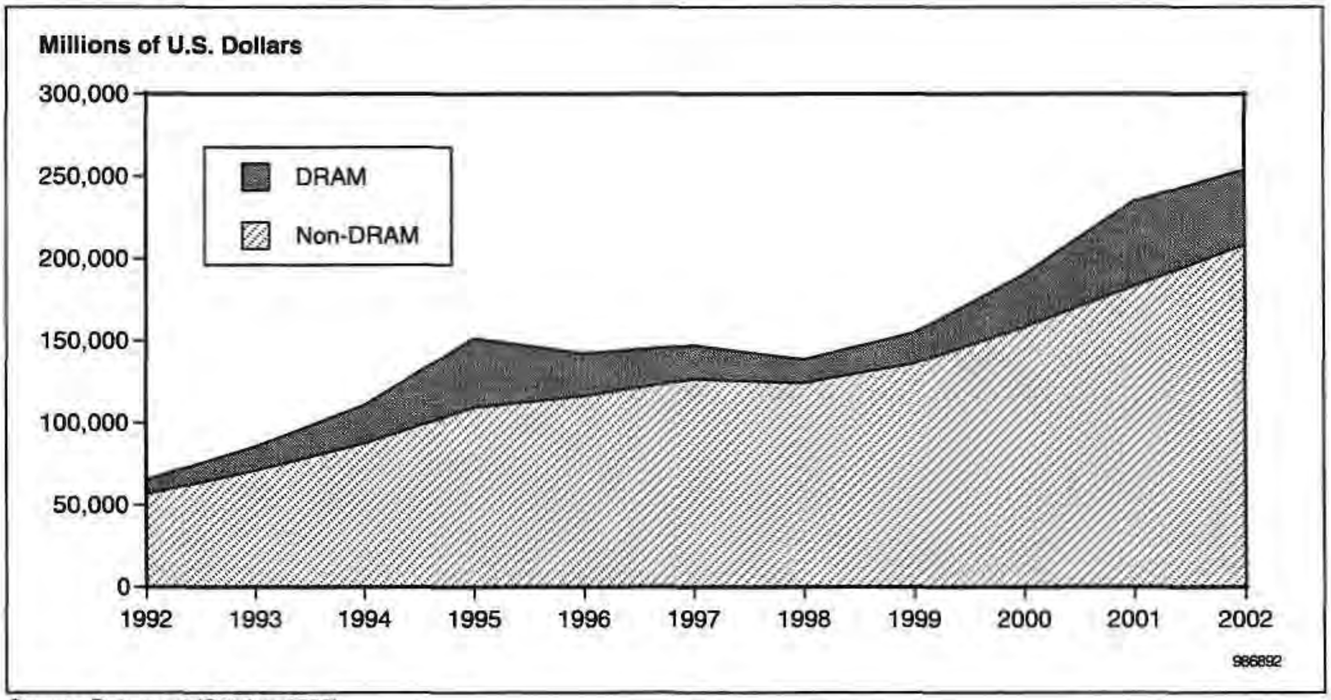
growth rates is expected to occur in 2001. Furthermore, negative growth is only expected for the DRAM segment. The rest of the semiconductor market will continue growing.

The main culprit behind the semiconductor market slump since the end of 1995 has been excess supply capacity. Since 1997, however, the market sentiment has shifted, and slowing demand has emerged as the key factor dragging the market. The phase during which adjustments of supply capacity had a significant impact on semiconductor market trends is approaching an end, and the primary question is whether demand can continue expanding. This is the scenario on which the current Dataquest forecast is based. Accordingly, in 1998, Dataquest expects a 5.9 percent decline for worldwide market growth and a 15.8 percent decline for Japan's market growth, compared to 1997. The main points of this forecast are as follows:

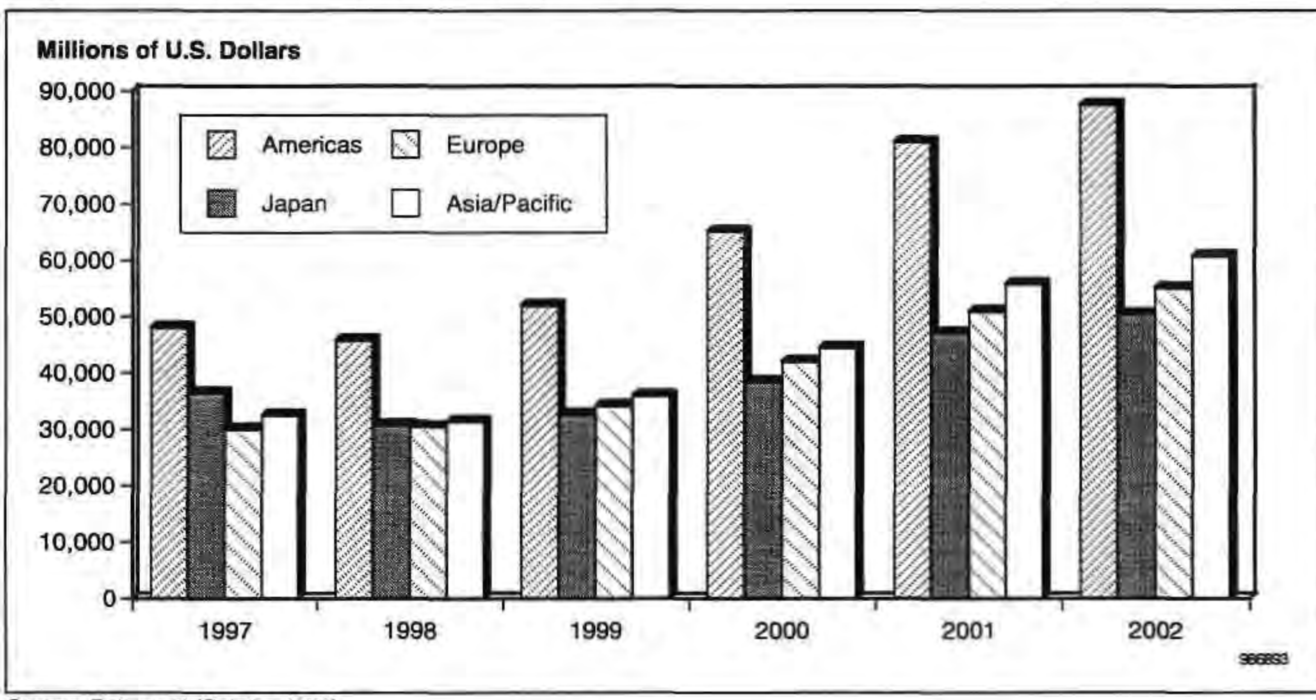
- 1998
  - The worldwide semiconductor market will again post negative growth (see Figure 2).
  - The DRAM market, following three consecutive years of negative growth, will contract to one-third of the historical peak reached in 1995.
  - The "non-DRAM" category, which previously managed to experience positive growth despite negative growth in the overall market, will also record negative growth this year.
  - The Japanese market, affected by yen depreciation, is turning in the weakest results and will be surpassed by the Asia/Pacific market (see Figure 3).
  - The only region likely to record positive growth in 1998, compared to 1997, is the European market.
- 1999 and later
  - The worldwide market in 1999 will begin to recover with double-digit growth.
  - Growth rates will be highest in the Americas and lowest in Japan. As a result, the Japanese market will be surpassed by Europe and will become the smallest of the four regional markets.
  - The supply/demand balance is expected to improve in 1999, and positive market conditions will be enjoyed in 2000 and 2001.
  - A mild adjustment period will occur in 2002 with DRAM revenue falling to negative growth and overall semiconductor market growth slowing to the single-digit level.

Figure 2
Worldwide Semiconductor Market Forecast



Source: Dataquest (October 1998)

Figure 3
Regional Semiconductor Market Forecast



Source: Dataquest (October 1998)

Drivers and Restraints

Dataquest's market forecasts are based on the "most likely scenario," as described previously. However, actual market trends will change depending on the manner in which various factors move, either upward or downward. The main elements that could affect market trends for the current forecast are the following:

- Drivers
  - Short-term (1998 to 1999)
    - Improvement in domestic economic trends (personal consumption trends and capital investment)
    - Early recovery of the Asian economies
    - Future Olympic demand and progress in audiovisual-related infrastructure projects
    - Stabilization of DRAM prices
  - Long-term (2000 to 2002)
    - Recovery in the domestic economy
    - Progress in infrastructure projects that link the digital consumer, communications, and data processing segments, and related increases in domestic electronic equipment production
- Restraints
  - Short-term (1998 to 1999)
    - Continuing economic weakness in the Asian and Japanese economies
    - Sluggish replacement demand as the level of mobile communications equipment dissemination rises
    - DRAM price stabilization limiting the pace of megabyte demand expansion
  - Long-term (2000 to 2002)
    - Delays in information communications infrastructure development
    - Falling prices because of intensified competition in system-level integration (SLI)

The forecast for growth of electronic equipment production in Japan is the lowest of the four regions. Likewise, the 6.7 percent dollar-based CAGR for Japan's semiconductor market for the 1997 to 2002 period is also the weakest (see Figure 4). Although from past experience Dataquest knows that growth in Japan's semiconductor market is accelerated during periods of yen strength, Dataquest's market forecast is based on a constant exchange rate in future years (see Figure 5).

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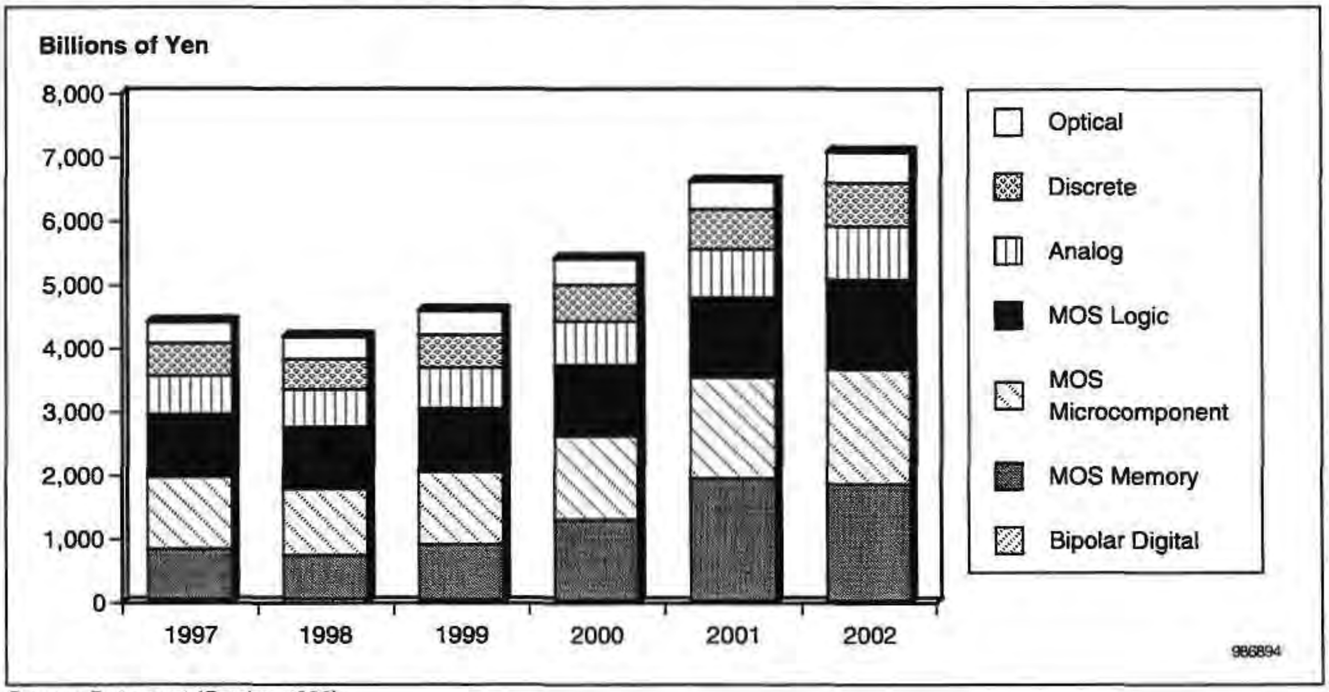
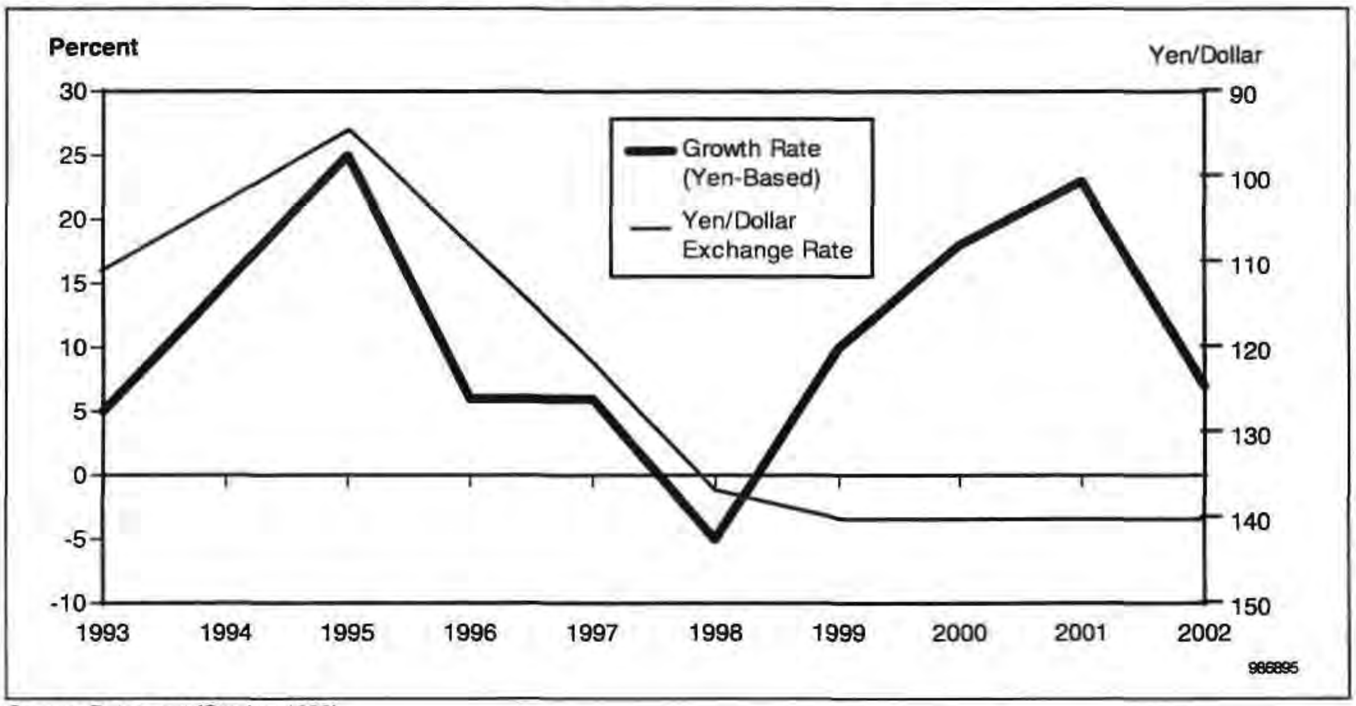
Figure 4
Japanese Semiconductor Market Forecast



Source: Dataquest (October 1998)

Figure 5
Japanese Semiconductor Market Growth and Exchange Rate



Source: Dataquest (October 1998)

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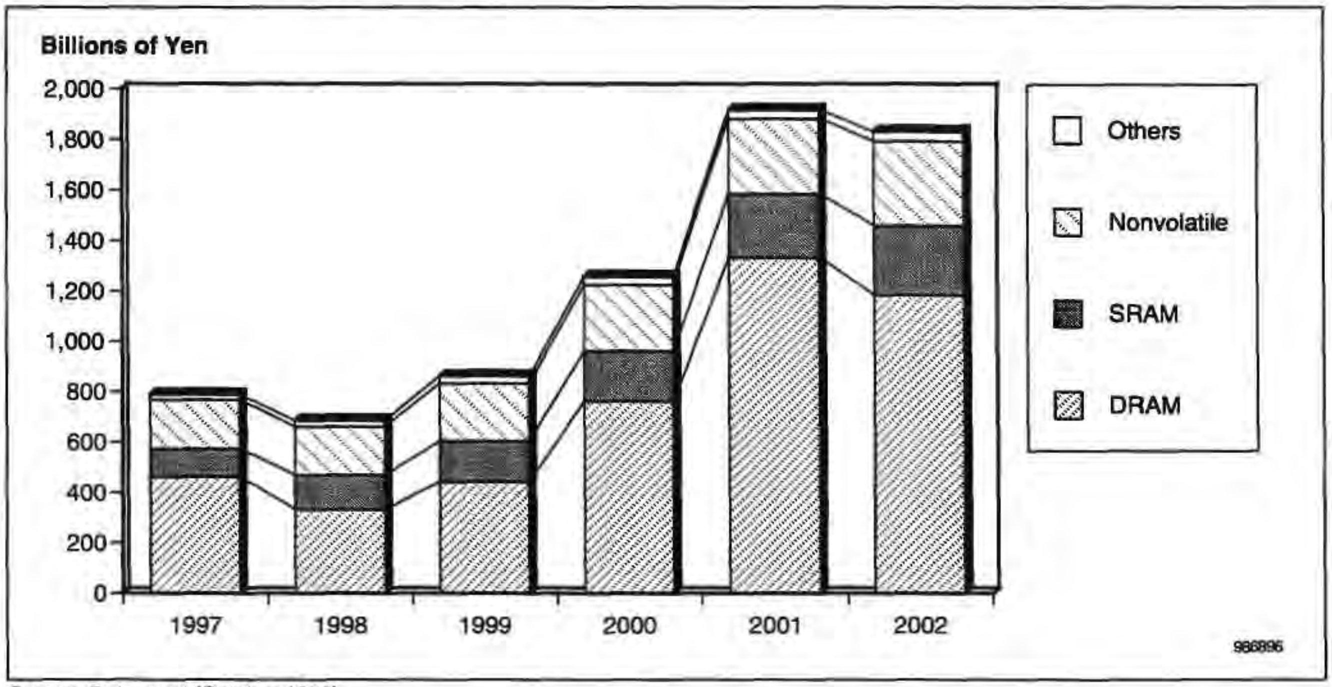
MOS Memory Market in Japan

Dataquest expects the MOS memory market in Japan to decline 13 percent (22.8 percent on a U.S. dollar basis) in 1998, compared to 1997 (see Figure 6). This represents a hefty downward adjustment of 20.0 points from the spring forecast. The primary factor behind this forecast revision is the rapid pace of DRAM price deterioration, which has been much faster than originally thought because of excess supply capacity, a similar pattern to what is happening in the worldwide MOS memory market. In the spring forecast, Dataquest stated that the activities of Korean manufacturers in 1998 would significantly affect DRAM prices and that plummeting 16Mb DRAM prices would also affect 64Mb DRAM prices. In fact, these worries have become a reality over the course of this year. Shipments of 16Mb DRAMs by Korean manufacturers in the first half of 1998 at levels far exceeding demand triggered a downward price slide for not only 16Mb DRAMs but also 64Mb DRAMs. In the 1998 MOS market, static RAM (SRAM) and other MOS memory devices will compensate for the negative DRAM factor.

Figure 6
Japanese MOS Memory Market Forecast



Source: Dataquest (October 1998)

From 1999 onward, Dataquest again expects the MOS memory market in Japan to follow the worldwide market trend, in which the DRAM and nonvolatile memory segments return to positive growth while solid SRAM performance continues. A full-scale expansion of the market will not happen until 2000, and this phase will peak in 2001 with a drop back to negative growth in 2002. The outlook also follows the worldwide market cycle. Dataquest believes that the dip in 2002 will occur when the colossal DRAM market takes a downturn from the negative effect of a generational transition from 64Mb to 256Mb memory devices. Japan's MOS memory market CAGR

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for the 1997 to 2002 period is forecast to be 18.3 percent, a 2.9-point upward revision from the spring forecast's projected CAGR.

DRAM Market in Japan

On a product basis, Dataquest is forecasting a 28.2 percent decline in Japan's DRAM market in 1998 (36.3 percent on a U.S. dollar basis) compared to 1997. This is a sizable downward adjustment of our spring forecast. Just as in worldwide market forecasts, the dramatic reductions in DRAM prices at a pace way beyond original expectations are forcing lower forecasts. Even though DRAM-makers have taken steps to reduce capital investment plans, they also have adopted a strategy of maintaining shipment volumes at a certain level through the introduction of reduced-size chip technology and OEM procurement from Taiwanese manufacturers, while keeping capital investment budgets to a minimum. Moreover, DRAM-makers already have sufficient production capacity with existing 16Mb DRAM facilities, and it is this product area (16Mb DRAMs) that can be blamed for the DRAM price slide.

However, Dataquest sees the shift in PC DRAM demand from the 66-MHz type to the 100-MHz type picking up speed in the latter half of 1998 and believes that this will require more advanced production facilities. In 1999 and thereafter, DRAM-makers will need 0.2-micron-level production facilities to keep up with high-speed DRAM demand. Capital investments in 1998 and 1999 will be vital for maintaining production capacities based on such advanced facilities at a certain level. The implementation of finer process technology is moving forward at a faster pace than it did previously. Dataquest expects this trend to continue, and therefore, Dataquest foresees DRAM-makers having to shoulder an even heavier capital investment burden.

Dataquest's positive growth forecast for 1999 is based on an assumption that production capacity using advanced facilities will be introduced in balance with demand. Dataquest expects the DRAM market in Japan to enter a phase of full recovery in 2000, with a peak reached in 2001. Thereafter, in 2002, the market will be revisited by negative growth. Dataquest forecasts a CAGR of 20.6 percent for the 1997 to 2002 period.

Nonvolatile Memory Market in Japan

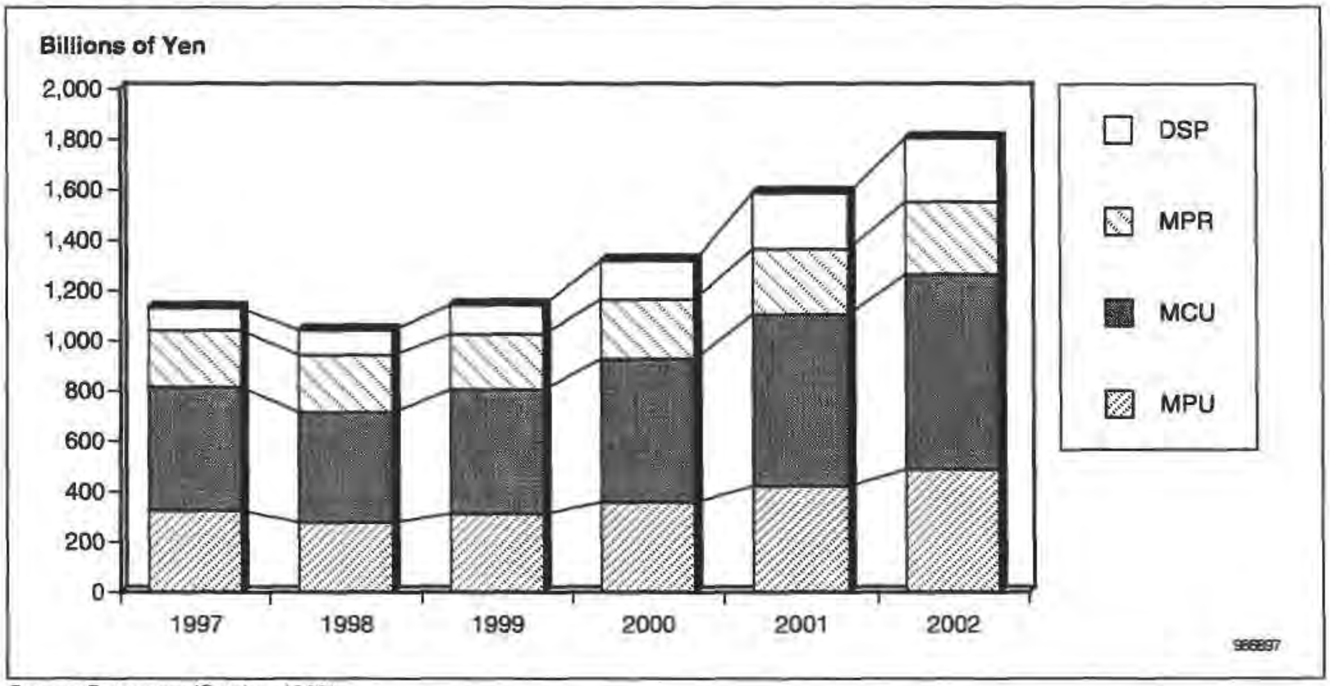
Dataquest's forecast for the nonvolatile memory market in Japan is a 1.5 percent decline (12.5 percent on a U.S. dollar basis) in 1998 compared to 1997. This represents a 1.8-point downward adjustment from the spring forecast. Dataquest's decision to lower the forecast was prompted by a change in the flash memory outlook from positive growth to slight negative growth. Over the next few years leading up to 2002, Dataquest expects that flash memory and EEPROM will turn in positive-growth performances, but it is worth emphasizing that the real driver in the nonvolatile memory market is flash memory. Dataquest is sticking to its view that the EEPROM market will shrink and the mask ROM market will be flat.

Portable equipment such as mobile phones is the primary application fueling growth in the flash memory market. Japan's semiconductor makers, in particular, rely heavily on mobile phones. In contrast, U.S. semiconductor makers depend on the communications equipment application. While the flash memory market currently is led by NOR-type devices, Japan's top semiconductor makers are making a move into the large-capacity flash memory arena in 1998. The main application for large-capacity flash memory is DSCs; however, this market is still rather small. The success of developing new market opportunities will be the primary determining factor for flash memory market expansion.

MOS Microcomponent Market in Japan

Dataquest has revised its 1998 forecast for the MOS microcomponent market substantially downward, compared to the previous forecast, to a 7.9 percent decline (18.2 percent on a U.S. dollar basis) since 1997. During the 1997 to 2002 period, a CAGR of 9.8 percent is expected (see Figure 7). Dataquest expects Japan's MPU market to record negative growth in 1998 because of weak demand in the domestic PC market and sliding MPU prices. Meanwhile, the microcontroller (MCU) segment, which accounts for the largest share of Japan's microcomponent market, is still posting higher shipment volumes, but revenue growth is being diluted by the decline in product prices. Feeling the effect of the disorder in the Asian economies caused by the AFC, Japanese makers' shipments of low-bit MCUs to the Asian market are experiencing even tougher circumstances than those of Asian competitors. Another factor hampering market growth is the stringent cost reduction demands of Asian system manufacturers.

Figure 7
Japanese MOS Microcomponent Market Forecast



Source: Dataquest (October 1998)

Looking at MCU market trends by product type, although the range of applications for 4-bit products has greatly broadened, this market entered a mature phase in 1997 from a growth perspective, and prices are falling. Revenue performance for 4-bit products is taking the brunt of slowing demand for portable game machines, a major market driver until last year. Meanwhile, Dataquest expects stable growth opportunities for 8-bit products, with the upper-layer compatibility shift from 4-bit products and growing demand for more complicated system control.

Although there is a possibility of 16-bit products experiencing a slight decline from the correlation between existing application shipments and unit prices, the first half of 1998 recorded high annual growth, benefiting primarily from strong demand for air conditioners caused by the strange weather. In other areas, as well, including VCRs, RDDs, telephones, digital mobile phones, CD-ROMs, printers, DSCs, automotive equipment, analog camcorders, and pachinko game machines, shipments are posting steady gains. On the technology front, a shift from mask ROM to flash technology is taking place, and the added value that this technology can deliver is expected to win 8-bit application business.

The main applications for 32-bit-and-higher MCUs, including 64-bit MCUs, are DSCs, DV-Cs, DVD players (including ROM), car navigation systems, next-generation home game machines, printers, digital mobile phones, and smart cards. Dataquest expects that demand for lower-power consumption features and cost reduction in the digital mobile phone category will drive a transition from 16-bit MCUs to higher-bit MCUs. Sharply higher growth is expected in the higher-bit MCU market, primarily in applications such as digital consumer equipment and mobile communications equipment, shored up by requirements for systems with sophisticated digital signal processing and advances in SLI technology. From 1999 onward, DVD player demand is expected to rise dramatically, mainly in the U.S. market, and Dataquest expects that this will also contribute to growth for higher-bit MCU products.

Demand for flash MCUs is showing steady growth in 1998. Applications driving the 8-bit, 16-bit, and 32-bit flash MCU market are memory cards, CD-ROMs, DVD-ROMs, RDDs, and automotive equipment. Also, Dataquest expects that custom LSIs, which combine an embedded ARM core with a flash core, will open up entirely new opportunities in the portable game machine market. Digital signal processors (DSPs) are finding demand in inverter-control and servo-control application areas, in addition to the existing market for mobile communications equipment.

MOS Digital Logic Market in Japan

Dataquest's forecast for the MOS digital logic market in Japan is a 1.2 percent (12.2 percent on a U.S. dollar basis) decline in 1998 compared to 1997. A CAGR of 7.4 percent is forecast for the 1997 to 2002 period (see Figure 8).

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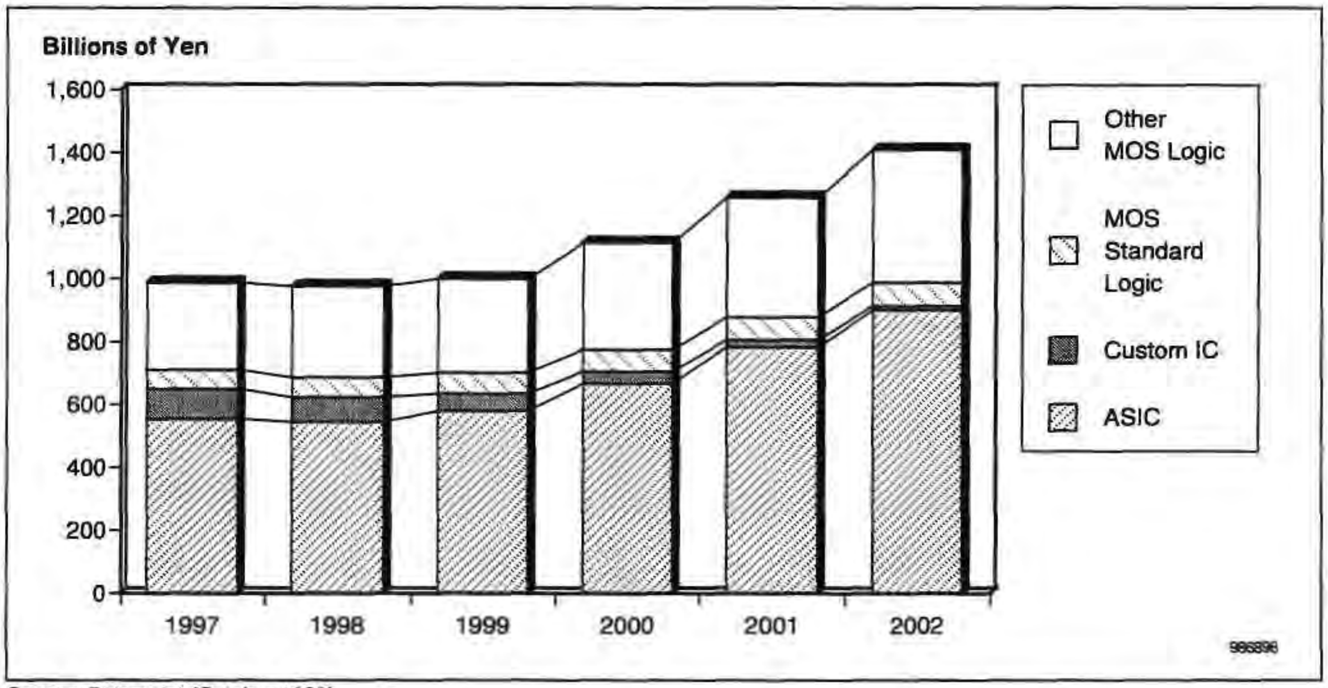
Figure 8
Japanese MOS Logic Market Forecast



Source: Dataquest (October 1998)

Japanese chipmakers excel in the gate array segment of the ASIC market and have shown impressive growth while Americas chipmakers have vanished from the top of the rankings for this segment. Essentially, while the Americas chipmakers are strategically focused on the SLI business and are staging a withdrawal from the gate array market, the Japanese chipmakers are stepping up to the plate in this segment and are winning orders from markets around the world that have been left open. Dataquest believes that this trend will continue.

The programmable logic device (PLD) market in Japan still has not demonstrated the expansion taking place in the Americas market. This is primarily because of internal system customer requirements that a stable supply of gate arrays and extensive support be provided. Chipmakers in Japan and the Americas are clearly operating in different business environments. In Japan, chipmakers are part of a vertically integrated organization that is dedicated to generating profits as a whole. This contrasts starkly with the situation in the Americas, where companies are divided into independent entities or independent business groups and have a mandate to return profitable results. The approach of Japanese chipmakers to the ASIC business is escalating the weakness of the market in Japan. A similar trend is observed across the full spectrum of logic products.

Although today ASIC and application-specific standard product (ASSP) devices incorporate nearly all of the functions offered by standard logic devices, Dataquest still anticipates demand for logic devices that satisfy special applications such as one-gate CMOS, ultrahigh-speed CMOS, and low-amplitude signal logic. Dataquest also believes that strong future demand exists for LCD drivers, grouped in the "other logic" category, from the proliferation of portable systems with built-in LCD panels and flat panel display (FPD)-related products.

Dataquest Perspective

When the semiconductor market fell short of previous-year results in 1996, there was a pervasive recognition that this was the first negative growth in a decade. At the same time, while acknowledging that the market was in an adjustment phase, expectations were that once the adjustment was completed, the market would recover to a growth trajectory again. What has happened instead is that market conditions have not improved and are heading for a second dip in results. The DRAM market has contracted back to the level it was at before its last burst of growth, and joining this is negative growth for all other non-DRAM semiconductor products. The CAGR for the 1997 to 2002 period for the worldwide market is forecast to be 11.5 percent, indicating a long-term trend during which the semiconductor market will enjoy double-digit, stable growth, but not at the feverish pace of past years.

The semiconductor industry in Japan is in the process of transitioning supply capacity from DRAMs to other products as a response to the sharp cycles in market conditions characteristic of the DRAM segment. In fact, logic product offerings have been bolstered with each DRAM downturn. However, recent trends clearly underline the ineffectiveness of this approach for dealing with future market circumstances.

It is apparent from the domestic market's slip into the position of being the smallest of the four regional markets worldwide that Japanese chipmakers must make every effort to strengthen their approach to overseas markets. In doing so, the Japanese market cannot be the model for conceiving business strategies. This effort must be firmly rooted in applications and customer trends enjoying success in these overseas markets. From this perspective, Dataquest believes that the limits have been reached in the conventional approach, which treats the Asia/Pacific market as merely a site for the offshore operations of Japanese electronic equipment makers and puts this region in the same category as semiconductor business in Japan.

From a perspective of product evolution, the importance of SLI and other system-oriented products is growing. Success in this field requires further integration of product functions and manufacturing processes. The prolonged weakening of market conditions is increasing the losses incurred by Japan's semiconductor industry as a whole and thereby is limiting the resources available for expanding the scale of operations. However, Japan's chipmakers should consider the process of building an infrastructure to support system products as an opportunity to implement much-needed efficiencies. Dataquest sees growth in alliances and intellectual property business in the product design and development field. Meanwhile, foundry business is gaining force in the manufacturing area. Finally, for sales and customer support, alliances are being formed to ensure the proper response to application trends in regions throughout the world, and distributors with a global presence are accelerating their activities.

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In a situation where mild semiconductor market growth is expected for the next few years, the focus has returned to the demand side. Given this current market outlook, Dataquest believes that the future evolution of the semiconductor industry hinges on the extent to which efficient resource use can be accomplished in all aspects of the semiconductor business.

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Perspective

Semiconductors Japan

Technology Analysis

CSP: Next-Generation High-Density Packaging Technology

Abstract: *Low-cost chip scale package (CSP) technology has entered a full-growth stage as the package for system-level integration (SLI) ASICs and memory, including flash memories and static RAMs (SRAMs) in the 0.25- to 0.35-micron arena. A major driver is the increased demand for more compact and lighter systems by mobile communications equipment and digital consumer equipment, which form fast-growing markets. This Perspective analyzes CSP technology, which holds the key to the successful implementation of device miniaturization.*
By Yoshihisa Toyosaki

Evolution of High-Density Mounting Packaging Technology

With the rapid growth of the information and communications equipment markets, such as personal digital assistants (PDAs), digital cellular phones, mobile computing devices, and subnotebook PCs, and with the swift expansion of digital consumer equipment markets, including digital video camcorders (DV-Cs), digital still cameras (DSCs), and portable digital video disk (DVD) players, packaging technology for high-density mounting is becoming a technological and commercial focal point. For IC packaging, leading-edge technologies such as chip scale package (CSP) and ball grid array (BGA) have been accepted by a number of applications at a faster pace than previously forecast. In the near future, flip chip (FC), direct chip attach (DCA), and known good die (KGD) are expected to follow suit as emerging technologies.

These leading-edge IC packaging technologies—as well as printed circuit boards (PCBs) accommodating multiple chips that represent buildup substrates, such as surface laminate circuits (SLCs)—are being widely used in a range of volume applications that demand system miniaturization, and new materials appear to be expanding into sizable markets. There are various issues to be addressed, however. First, buildup substrate suppliers continue

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to be limited in number, keeping board costs at lofty levels. Also, the reliability of the materials for IC packaging still needs to be improved. Finally, there are differences in CSP package standards between the United States and Japan.

What Is CSP?

CSP is highly compact IC packaging, which almost equates to a die area. Many CSPs use terminals of a dense area array type on their rear side. CSP is considered to be the same as BGA, but it is not. CSP occupies a smaller area on the PCB (to reduce cost) and helps implement a variety of mobile applications. Also, its ability to reduce the IC package size leads to the improvement of electrical performance. Its market potential is being carefully examined by system manufacturers.

At present, volume markets using CSP are divided into digital consumer equipment, including DV-Cs and portable DVD players, and communications equipment, including digital cellular phones and pagers. Other promising markets are hard disk drives (HDDs), PC cards including modem cards, PDAs, DSCs, and portable audio equipment. These application markets are demanding system size and cost reduction, which can also be satisfied by CSP. These systems have relatively small pin counts (176 or fewer, as of 1998), and many of them are restricted in package height in addition to width and depth. At present, the CSP with the smallest form factor is primarily used to accommodate memories such as flash, static RAM (SRAM), and Rambus DRAM (RDRAM). These devices are relatively large in chip size with 50 or fewer pins, making them highly suitable for the package that is slightly larger than the die.

There are various obstacles to a wider market acceptance of CSP. One of them is establishing a small package with a narrow terminal pitch width. This increases the initial packaging cost, which is an important element of digital consumer equipment, and limits wiring patterns on the PCB. More precisely, to avoid "pin-out" in the area array type package with a narrow terminal pitch, a highly dense PCB needs to be used to secure a certain degree of freedom in the wiring pattern. Partly because the PCB industry must invest in costly equipment to meet the density requirements at a low cost for major applications, the cost issue related to CSP equipment is primarily governed by the PCB cost. As a result, Dataquest believes that an industrywide use of "true" CSP will take some more time.

Nevertheless, the industry must address package miniaturization requirements demanded by system manufacturers, which entails the development of an optimum solution to meet a specific cost target. The solution should include low-profile/thin quad flat package (L/TQFP) and BGA. In due course, the industry is expected to improve the ability to provide a matured technological infrastructure and will offer CSP with higher pin counts, which increasingly will be consumed by volume applications. In fact, system-level integration (SLI) ASICs in CSP are adopted in many DV-Cs, where buildup substrates consisting of an average of six to eight layers are used in PCBs.

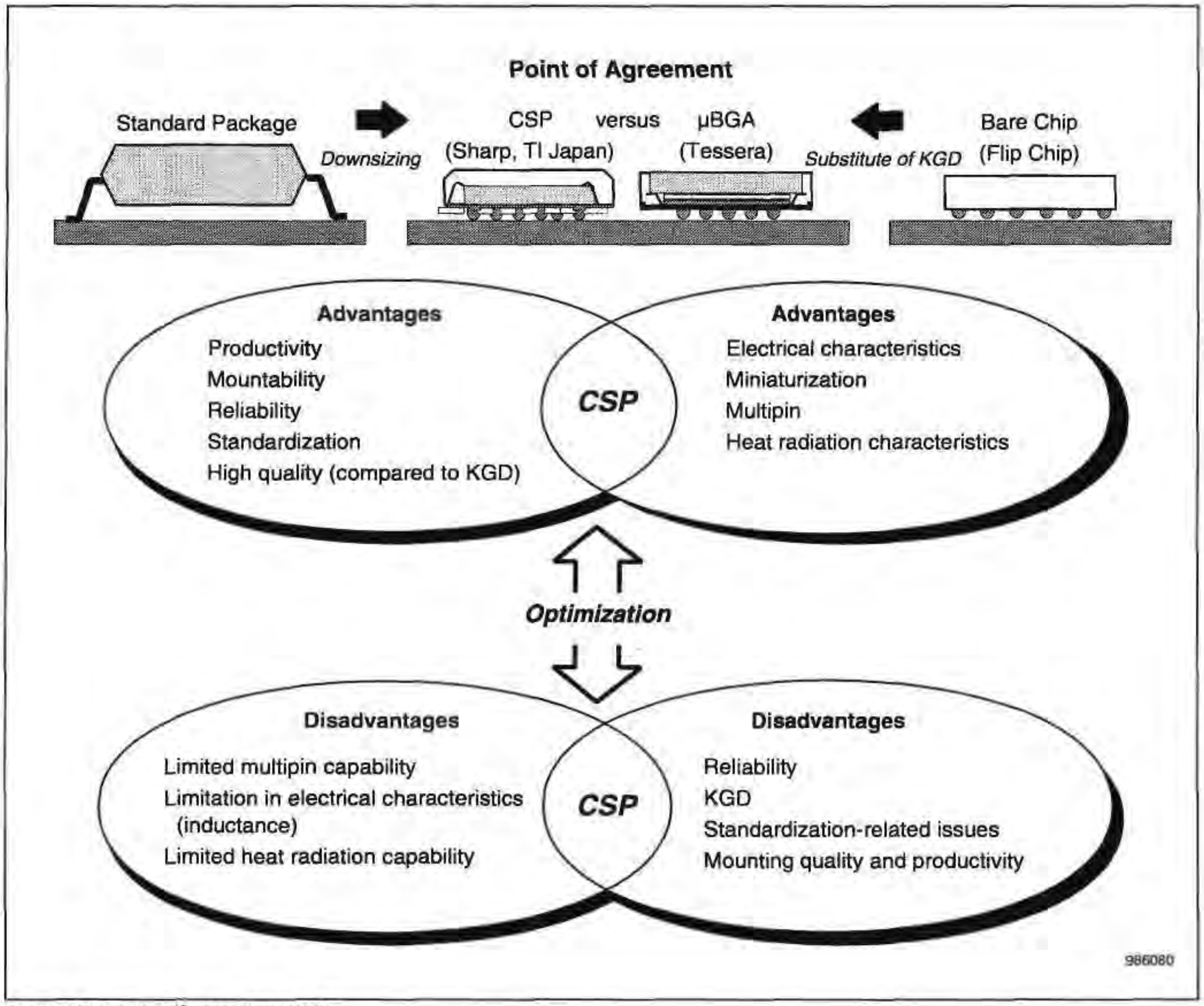
Devices most suitable for CSP are those having a very large area of logic circuits compared to pin counts, namely "core-limited design," where an inner core is limited. This type of circuit design requires a relatively large die area to accommodate balls in the interconnection area, so that the ball terminal pitch can approach a standard grid arrangement. As for applications, CSP is optimum for those that must mount low-pin-count devices on a very small and highly dense PCB. These applications usually use 176 or fewer pin packages. For digital cellular phone and DV-C manufacturers, size and weight reduction of system products are of supreme importance; it is justifiable for them to use very costly SLC boards. In fact, SLC boards permit CSP to be used in the area array layout. In contrast, CSP is not suitable for computing or transmission/telecommunications applications that require high-pin-count packages.

The full-featured CSP, which increasingly is used for memory devices, is ready for volume production in 1998. This serves as the buildup of the technological infrastructure and will spur demand. At this point, chip makers and their subcontractors will provide "true" CSP technology. CSP technologies implemented by Sharp and Texas Instruments Japan are not technological breakthroughs, but they will build on top of proven technologies; their main goal is to minimize cost and risk. Technological advancement will occur in the reduction of ball pitch to less than 1.27mm, namely 1.0mm and 0.8mm. IC package size will continue to shrink until the chip itself becomes a limiting factor, because the improved infrastructure for PCB production and assembly will enable a smaller terminal pitch (the 0.5mm pitch used in DV-C, for example).

Current Status of CSP

Currently available chip packages are mostly shrink versions of existing packages—the results of gradual efforts. A typical example is seen in modified plastic BGA (PBGA) and L/TQFP versions with a 1.27mm or smaller ball pitch. CSP, having the same or a similar pin count, is smaller and lighter than these modified versions. In this sense, CSP can be defined as a low-cost, low-pin-count solution. The industry defines CSP as a package that does not exceed 120 percent of the chip area. The development of CSP was started around 1990, and a large number of semiconductor suppliers are currently working with diverse structures in their R&D efforts. From the density point of view, CSP is positioned midway between existing standard packages and FC, with technical issues to be cleared accordingly (see Figure 1). Given the industrywide trend toward increasingly high-density mounting, CSP is expected to provide a feasible solution for a wide range of applications; however, it is difficult to forecast when exactly it will win which share of which market.

Figure 1
Advantages and Disadvantages of CSP



Source: Dataquest (September 1998)

CSP is undoubtedly a focal point of the PCB industry. Overall, the volume market for true CSP will be a bit slower than expected because of the immature technological infrastructure. Meanwhile, CSP technology capable of satisfying diverse applications will enable package miniaturization at the lowest cost. The CSP-enabled package size will be free from chip size limitation and can be reduced to address a wide range of terminal counts, required by system manufacturers according to a ball pitch allowed by wiring patterns on a PC. Regardless of the package type and name, the industry's goal is to supply small packages in volume and at low cost, as required by system companies.

Major Features and Advantages of CSP

The proliferation of CSP is driven by size and cost. In particular, applications subject to strict limitations in terms of size and weight will find the solution highly attractive. As the continued miniaturization of devices ends up in bare chips—the minimum practicable package size is no package—CSP will be compared to bare chips and KGD in addition to existing packages. CSP implementation methods commercially adopted in the industry are basically divided into chip-on-board (COB)—derived from wire bonding technology—and FC-on-board (FCOB)—derived from FC technology.

In terms of size, CSP is much smaller than standard packages and is larger than bare chips. A major advantage of package miniaturization, in addition to its space-saving, is its reduction of the accumulation of electricity and heat. CSP is a surface-mounting package and is mainly of area array type. As a result, its terminal pitch is more narrow than that of current BGA packages and wider than that of FC.

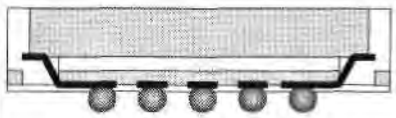
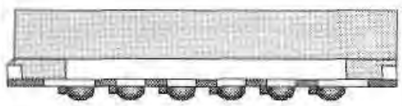
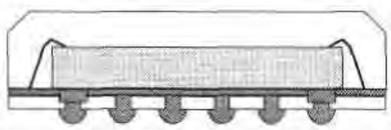
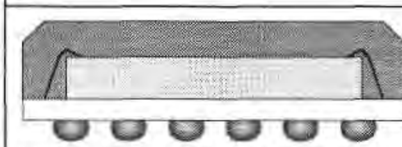
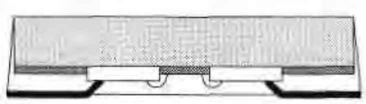
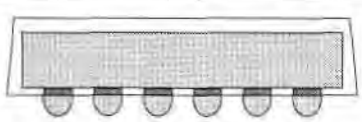
Figure 2 shows CSP structures developed by leading vendors. A few of them have already implemented CSP for ASICs and other devices. As for CSP used in the SLI ASIC business, Dataquest believes that the Sharp/Texas Instruments Japan type (a tape type that can be implemented at low cost by using existing equipment) and the Matsushita/Kyocera type (alumina ceramic) will become the mainstay for mobile communications equipment and digital consumer equipment with low system operation frequency. At present, other technologies still have yet to reach a volume production stage. Commercialization depends on several factors, including cost, technical feasibility, and infrastructure development.

In fact, applications suitable for CSP vary with each technology. For instance, the area array type is suitable for applications with a relatively high pin count (50 pins or more) designed by ASIC vendors because of a large terminal pitch. Table 1 compares specifications of the packaging technologies. Compared to bare chips (including KGD), CSP has the advantages that are usually available in packages. In terms of external appearance and terminal shape, CSP is a standard contact device, and it can help simplify the subsequent mounting of parts in the following respects:

- Ability to standardize sockets for cost reduction and simplified testing
- Ability to simplify PCB design regardless of chip design change or generation shift (silicon respin) by offering the same package solution (for bare chip, PCB design modification is often required)
- Ability to allow any semiconductor suppliers to reduce the mounting cost, as demanded by system companies, by standardizing packages' external appearance and terminal shape

It should be noted that system companies that adopted CSP at an earlier time intend to use it as a differentiating factor and to provide their own solutions before standards are established.

Figure 2
CSP Structures of Leading Manufacturers

Package Type	Sectional View	Manufacturer
Tape Type (TCP Base)		Intel, AMD, Hitachi, Samsung, Sony, LG Semicon, Hyundai (Tessera, Shinko, Amkor-Anam, Mitsui High-Tech)
		NEC, Samsung
		Sharp, TI Japan, NEC, Mitsubishi Electric, Fujitsu, Rohm, Toshiba, Oki, LSI Logic
PCB Type		Sony
Ceramic Type (Substrate)		Matsushita Electric/Electronics, Toshiba, Kyocera
		Fujitsu, Toshiba
Leadframe Type		Fujitsu
Interposerless Type		Mitsubishi Electric

986081

Note: All companies listed here have developed CSP for ASIC production.
Source: Dataquest (September 1998)

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Table 1
Comparison of Specifications by Packaging Technology

Item	Current	CSP	Flip Chip (Including KGD)
Package Total Width	PQFP: 28mm PBGA: 23mm LQFP: 20mm	8mm to 12mm (x1.2 chip size)	5mm to 10mm (chip size)
Height	PQFP: 3.3 to 3.5mm PBGA: 2.2mm LQFP: 1.0 to 1.4mm	0.5mm to 2.0mm	0.6mm
Terminal Width	PQFP: 0.5 to 0.8mm PBGA: 1.27mm LQFP: 0.4mm to 0.5mm	0.5mm to 1.27mm	0.25mm to 1.0mm
Testing Method	Standard socket	Development of socket axis	Establishment of bare chip testing technique
Footprint	Standard	Standard footprint	Establishment of bare chip testing technique
Cost	PQFP: Low PBGA: Medium LQFP: Medium	Originally high (lower with volume production)	High cost to meet diverse pin count
Electrical Characteristics	PQFP: Low PBGA: Medium LQFP: Low	Medium	High performance

Note: Data on low-cost packages covers those with 144 to 176 pins.
Source: Dataquest (September 1998)

CSP Technology and Competitive Analysis

Diverse CSP technologies that are under development are all categorized by chip scale and include area array and peripheral packages. These technologies use substrates, flex inserters, wafer-level reallocation, and overmolding for interconnections to the PCB. Table 2 lists selected CSP technologies currently owned by vendors. Table 3 ranks currently offered CSP packages according to their estimated volume production costs. Note that the list ranks the packages that are similar to low-cost LQFP, which is already commercialized with a sufficient technological infrastructure. Sandia National Laboratories' technology is not included because it is closer to reallocated FC than to CSP.

Table 2
CSP Technologies under Development

Manufacturer	Terminal Structure	Interconnection/Substrate
Tessera	A	Tape inserter, TAB bonding, solder balls
TI MicroStar	A	Tape inserter, wire bonding, solder balls
Matsushita Electric/Electronics	A	Mounting of flip chip to ceramic LGA, underfill
Motorola SLICC	A	Mounting of flip chip to laminated substrate, underfill
NEC	A	Tape inserter, thermo-compression bonding, solder balls
Mitsubishi Electric	A	Reallocation to solder pads, transfer molding, ball bonding to pads
Sandia National Laboratories	A	Reallocation of polyimide to gold or solder balls
GE	A	Flex bonding to Si and bump formation using bear holes, development of HDI
Hitachi Densen	A	Derivative of leadframe technology arranging metal posts in perimeter, overmolding
IBM	A	Flip chip bonding to ceramic mini-BGA with cap, eutectic crystal solder balls
Nitto Denko	A	Tape inserter, thermo-compression bonding, solder balls
Toshiba	A	Flip chip bonding to ceramic LGA, underfill
Sharp	A	Wire bonding to flex substrate, molding
Hitachi Densen	P	Leadframe by small J lead, overmolding
ChipScale	P	Wafer reallocation to silicon post, expoxi-resin encapsulation to active face
Rohm	P	Flip TCP, resin sealing of die front side
Fujitsu	P	Die-size leadframe LOC, formation of LGA by one side overmolding
LG Semicon	P	Small leadframe, formation of LGA by overmolding
ShellCase	P	Sealing of Si between two glass plates, metallization of end contact

A = Array terminal layout
P = Peripheral terminal layout
Source: Dataquest (September 1998)

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Table 3
Current State of CSP Packaging Development and Volume Production

Manufacturer	Volume Production Cost	Maturity Level	Advantage/Disadvantage
Matsushita Electric/Electronics	Low	Commercialized	Flip chip (SBB), ceramic substrate (mainly for captive users)
NEC	Low	Using two systems of sample level	Advantages/disadvantages vary with methods. The NEC system is similar to the one in Figure 1.
Fujitsu	Low	Prototype	TSOP's derivative technology
Kyocera	Low	Commercialized	Land-type ceramic substrate/PCB (supplied to semiconductor suppliers, SBB technology applied for partial connection)
Hitachi Densen (P)	Low	Commercialized	QFP's derivative technology
Nitto Denko	Medium to low (future)	Commercialized	Additional cost because of bold bonding on tape
Motorola SLICC	Medium	Sample level	Flip chip, for PowerPC
Mitsubishi Electric	Medium	Development level	Cost increase because of multistage process
Hitachi Densen (A)	Medium	Development level	Cost increase because of multistage "post" leadframe, no standard substrate assembly
Tessera	High to medium (future)	Partially commercialized	Equity participation by Amkor-Anam and a few licensing agreements have accelerated CSP development and capital investment; this is expected to result in cost reduction in the near future.
GE	High	Development level	Scrap cost increase because of the initial die mounting process
IBM	High	Development level	Flip chip, ceramic substrate
Toshiba	High	Development level	Flip chip, ceramic substrate

SBB = Stud bump bonding technology
P = Peripheral structure
A = Array structure
Source: Dataquest (September 1998)

Major factors affecting the CSP cost are the substrate cost, assembly techniques (FC and wire bonding technology, for example), the number of process steps, and yield. On the other hand, the price is ultimately governed by the level of market penetration. No technology can achieve the lowest possible cost unless it follows learning curves determined by very large volume production. Dataquest sees that any CSP technology involves a certain risk until official standards are established to depict a "technological winner."

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An Analysis of Alternative Technologies

The introduction of CSP technology is hindered by interindustrial barriers that increase the initial cost. To meet short-term design requirements for cost and size, LSI Logic and other vendors propose the small form factor package (SFP)—mini-BGA—technology as a temporary substitute for CSP. This solution includes LQFP and BGA with a small terminal pitch. Table 4 compares existing products using these alternative technologies. It should be noted that the size difference between each IC package and the chip varies greatly among them. For instance, the large core-limited design allows a more efficient use of the package, so that the name "chip scale package" is not appropriate.

Table 4
Comparison of Existing Packages and Mini-BGA

Package Item	LQFP	PBGA	1mm BGA/SFP
Package Total Width	7mm to 28mm	23mm to 35mm	15mm
Package's Relative Size (Compared to Chip Size)	2.5 to 28 times	3.7 to 25 times	3 to 10 times
Height	1.0mm to 1.4mm	2.3mm	1.6mm
Package's Relative Cost in 1997 (Compared to PQFP)	1.2 times	1.5 times	1.5 times
Terminal Width	0.4mm to 0.5mm	1.27mm to 1.8mm	1mm to 0.8mm
Pin Count	44 to 208	169 to 456	100 to 176

Source: Dataquest (September 1998)

Because the package size is primarily governed by size requirements for the system and PCB, it is more appropriate to standardize the package size relative to an available area on the PCB rather than the chip area. In the future, as the CSP cost declines and capabilities related to PCB production and assembly improve, the high-density, area array package will be promoted. The possible evolution of these technologies is analyzed by taking the example of LSI Logic: how the company will implement SFP technology for the 100-to-200-pin markets (see Figure 3).

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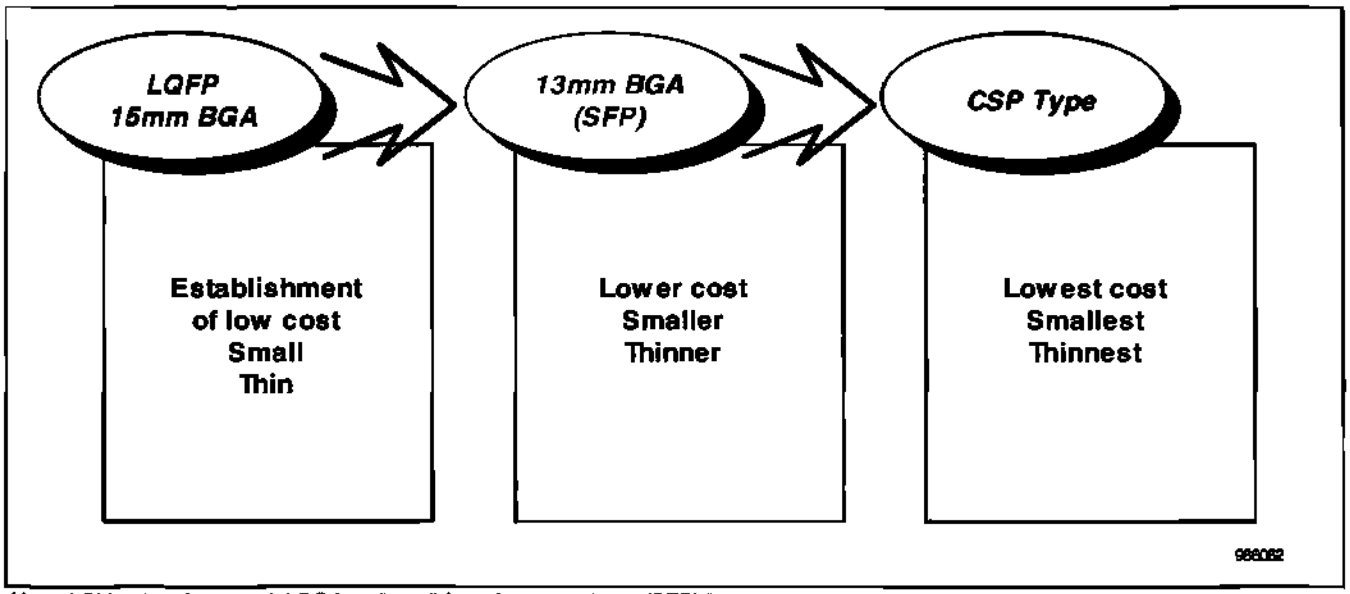
Figure 3
SFP to CSP Road Map at LSI Logic



Note: LSI Logic refers to mini-BGA as "small form factor package (SFP)."
Source: Dataquest (September 1998)

Not all of the currently available CSP-alternative technologies, such as COB, FCOB, chip-on-flex (COF), and LQFP, are suitable for the ASIC market. They basically consist of many bare chip technologies and several types of packages. Many ASIC suppliers have not weighed bare chip sales, because there are pros and cons on the use of the bare chip. The bare chip can be less costly than packaged devices if all the tests are eliminated; however, it must sacrifice many of the advantages offered by the package solution, while suffering the following drawbacks:

- Testing—Testing techniques on the bare chip still have to be matured.
- Standardization—Chip design changes or the commercialization of a new-generation chip often lead to various changes in external appearance and pad shape. Unless a standard package to absorb such changes is used, the PCB needs to be reconfigured and then tested.
- Risk and reliability related to handling—Without physical protection provided by the package, the bare chip can be damaged by various causes, including corrosion and a mechanical or physical shock. Also, the production process to mount bare chips to systems, similar to a semiconductor assembly line, is required.
- Exchange of chips (rework)—The exchange of chips is more difficult for the bare chip than for CSP.

Barriers to Commercial Implementation of CSP

Major obstacles to the commercial implementation of CSP are an immature technological infrastructure and high equipment costs. The major technical issue facing CSP is how to maintain the terminal pitch and array required to

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implement cost-effective interconnection patterns at a PCB level. The infrastructure refers to the technological capabilities of the PCB industry in supporting assembly and testing operations. In particular, infrastructure development should address the following areas:

- Standard lead and package shapes to support compatibility
- Test socket connection
- Testing process
- Standard tapes and reels
- Assemblies handling equipment
- Visual aid systems for assembly
- Assembly process and thermal distribution, including adequate soldering materials and their geometries

These areas require extensive development efforts, and the use of a standard BGA is considered to be the first step toward the development of CSP.

Also, the total system cost poses a major challenge. Following the learning curve for volume production, the CSP package cost will fall to a very low level because small amounts of materials are used and existing assembly techniques can be used with some modifications. On the other hand, the PCB cost as the basis of the above technologies, particularly Tessera's BGA, is much higher than the cost of standard PCBs.

Figure 4 lists routing issues related to small-pitch, area array packages. As shown in this figure, the escape route is established in one layer, representing the worst case. In a small 7 x 7 array, the maximum number of traces escaping between two balls in the array is three. Generally, the required routing density is proportional to the number of ball rows; the routing issue becomes more serious as the array becomes larger. In practice, the required routing density is secured by using a multilayer PCB. Basic rules related to the PCB are governed by the terminal pitch of the package array, the number of balls, and the size of the capture pads. The PCB's cost impacts vary with markets and are generally determined by PCB size and the number of CSP devices mounted on it.

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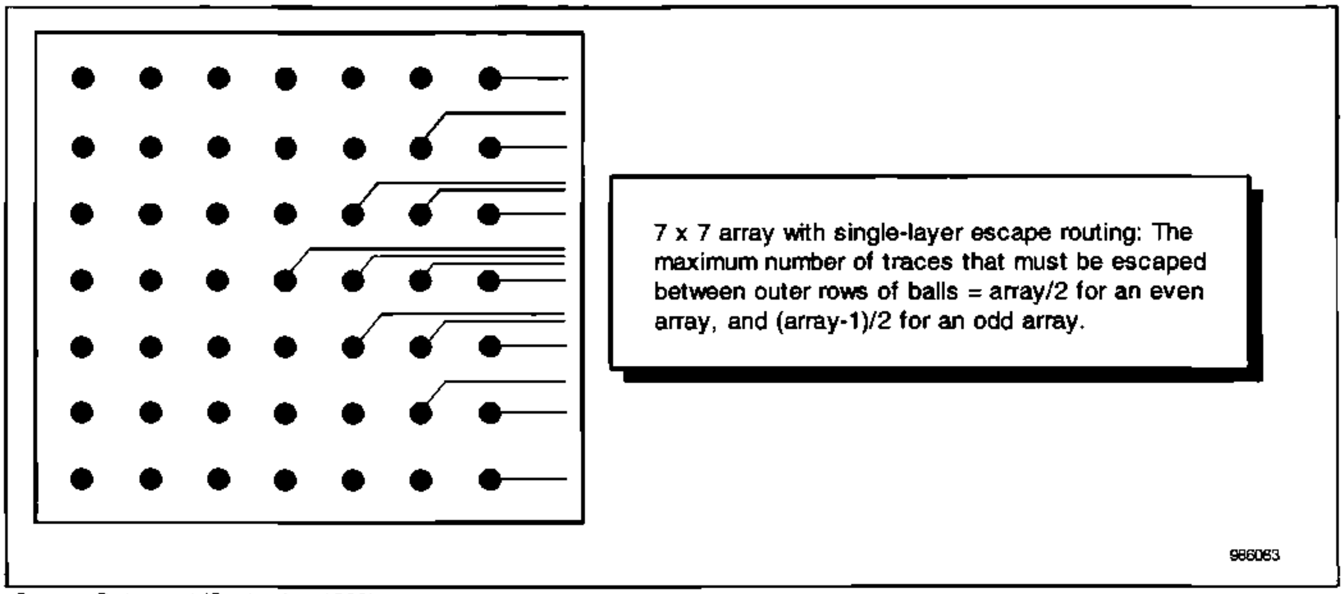
Figure 4
Routing Rule in Area Array Layout



Source: Dataquest (September 1998)

Dataquest Perspective

In the conventional ASIC process development, each manufacturer has established its basic process and packaging technology that are then incorporated into products. Also, in many cases, the memory process, such as DRAM, has been adapted to the ASIC process as a technology driver. Historically, Japanese semiconductor companies have developed products on the basis of "the supply-side logic" and have palmed them off to system companies. This reflects that the product development process lacks the marketing concept—efforts to grasp and serve market needs. In recent years, Americas ASIC suppliers seem to have established a clear competitive edge over Japanese competitors. The difference comes from not only a technology gap in the basic process and packaging but also the lack of market analysis and marketing strategy to address users' needs on the Japanese side.

Because the ASIC industry has already entered the SLI ASIC age, where large-scale LSI development efforts are required, it has become imperative for ASIC suppliers to respond effectively to the needs of application users. Future challenges for establishing the product concept of SLI ASIC include optimizing application requirements by semiconductor technologies, including packaging, process, libraries, and IP core. Dataquest believes that CSP will be one of the critical factors for success.

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Perspective

Semiconductors Japan

Market Analysis

A Comparative Analysis of Wafer Fab Equipment Markets in 1997: The Japanese Market Was Down 23 Percent

Abstract: *In 1997, the worldwide wafer fab equipment market declined 7 percent from the year before to $20.2 billion. The regional breakdown showed mixed results, however. While the Americas and Taiwan maintained double-digit growth, Europe, Japan, and Asia/Pacific (excluding Taiwan) recorded negative growth. From the first quarter through the third quarter, leading-edge equipment, led by excimer laser and equipment used for MPU and logic production, expanded and bolstered growth of the entire market. In the fourth quarter, however, a lingering slump in the DRAM market put a drag on market growth because of capacity expansion, resulting in negative growth on an annual basis.*
By Takashi Ogawa

1997 World Market Trends

In 1997, the wafer fab equipment market recorded negative growth for the first time since 1992 with a 7 percent decrease from 1996. Of $20.2 billion, the Americas accounted for $6.7 billion and maintained a double-digit growth of 15 percent. In contrast, the Japanese market decreased by 23 percent (to $5 billion), Asia/Pacific decreased by 7 percent (to $6 billion), and Europe decreased by 15 percent (to $2.4 billion). Within the Asia/Pacific market, Korea plunged 37 percent (to $1.9 billion), whereas Taiwan expanded 30 percent (to $3.3 billion). The polarized results between regions as well as individual markets (see Figure 1) seem to reflect their semiconductor product mix. Japan and Korea, which are heavily dependent on DRAM, showed sharp declines, while the Americas maintained firm growth, fueled by the expansion of the MPU, ASIC, and logic markets. Taiwan benefited from the booming foundry business, which was increasing capacity.

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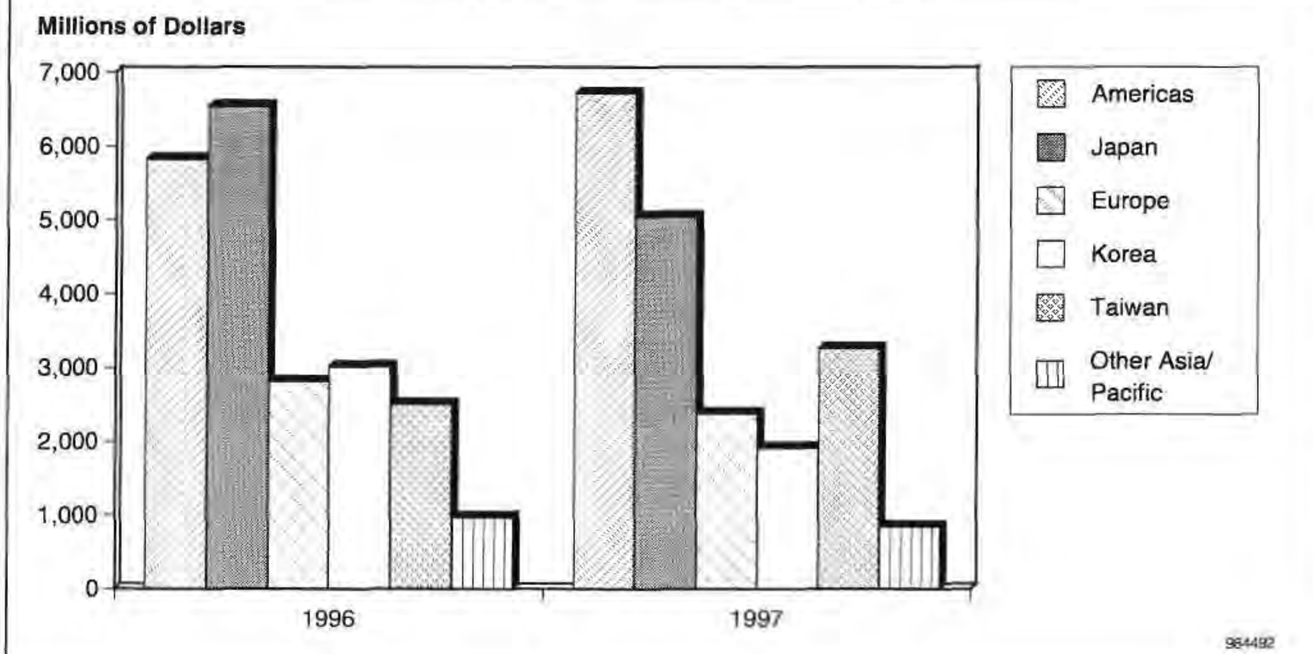
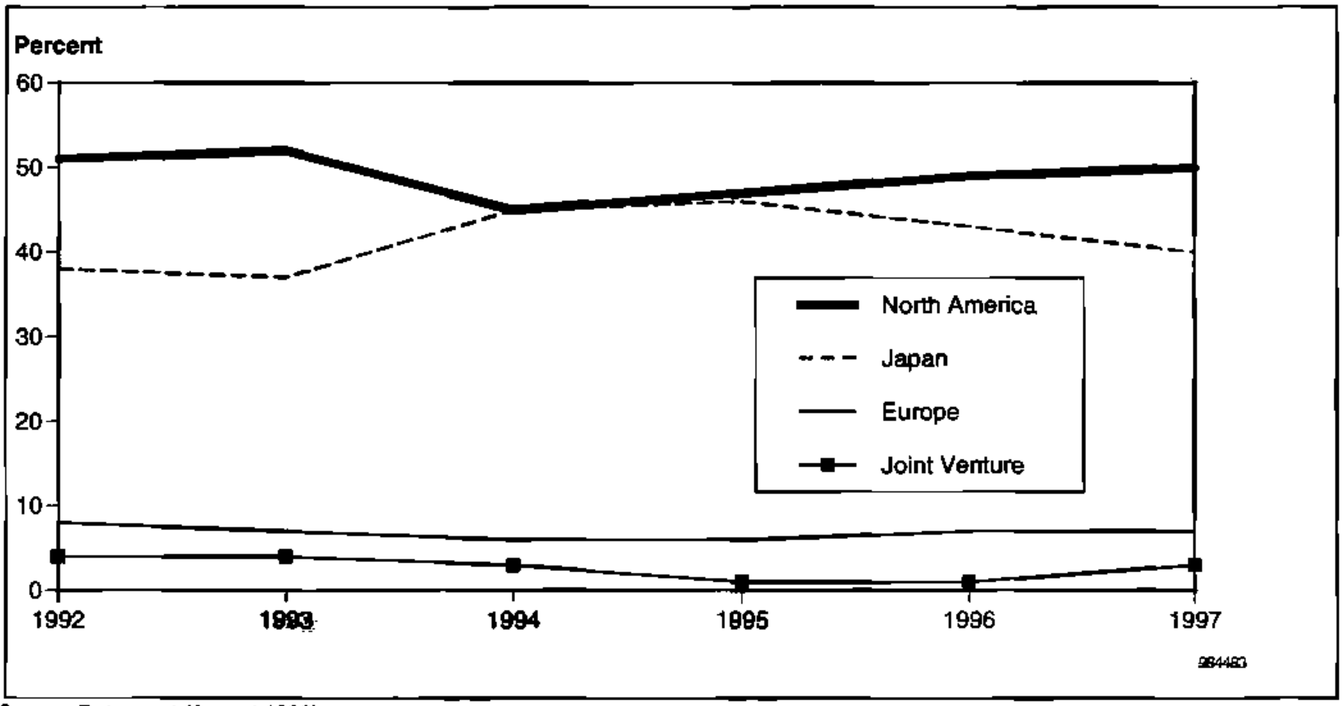
Figure 1
Wafer Fab Equipment Market Trends by Region



Source: Dataquest (August 1998)

The market breakdown by segment also showed mixed results. Major winners were leading-edge equipment markets, including excimer steppers, chemical mechanical polishing (CMP), rapid thermal processing (RTP), and high-density plasma chemical vapor deposition (CVD). On the other hand, the segments relying on capacity expansion, such as auto wet stations and diffusion equipment, suffered a defeat. By ownership, North American companies increased their share to 50 percent, widening a lead over Japanese competitors, whose share declined to 40 percent. This shift was mainly because U.S. companies had a stronger lead in the logic-oriented technologies, which grew relative to the DRAM-oriented equipment segments. Also, the Japanese companies were weaker than average in 1997. European companies maintained their share of 7 percent with their strength in the lithography segment (see Figure 2).

Figure 2
Recent Trends in Wafer Fab Equipment Market Share by Ownership



Source: Dataquest (August 1998)

1997 Japanese Market Trends

After Korea, in terms of losses, the Japanese fab equipment market suffered a major decline of 23 percent. Notably, as shown in Table 1, all of the categories recorded double-digit negative growth. Resist processing equipment plummeted 44 percent to $256 million, ion implantation equipment was down 41 percent to $202 million, and RTP and diffusion equipment declined 29 percent to $208 million. The major downturns reflect the direct impact of curtailed capital spending by Japanese semiconductor companies because of the sluggish DRAM market. As a result, the Japanese market's world share dropped from 30 percent in 1996 to 25 percent, a sharp contrast to the Americas market, which increased its share from 27 percent to 33 percent.

Table 1
Breakdown of Wafer Fab Equipment Market in 1997

Equipment	Japan's Revenue ($M)	Worldwide Revenue ($M)	Japan's Market Share (%)	Japan's Growth Rate (%)
Lithography	1,058.5	3,904.2	27	-14
Resist Processing	255.5	1,205.9	21	-44
Etching, Cleaning, and Planarization	1,285.4	5,194.8	25	-23
Deposition	1,186.1	4,551.5	26	-21
RTP and Diffusion	207.7	805.9	26	-29
Ion Implantation	202.3	912.2	22	-41
Process Control	570.7	2,212.9	26	-14
Manufacturing and Control	196.1	1,056.1	19	-28
Others	84.2	327.6	26	-21
Total	**5,046.5**	**20,171.0**	**25**	**-23**

Source: Dataquest (August 1998)

The breakdown by ownership reveals a similar pattern. Japanese companies lost revenue by 13 percent to $7.9 billion, compared to moderate performances of North American companies (down 1 percent) and European companies (up 1 percent). Of Japanese companies' total revenue, lithography equipment accounted for 31 percent, and resist processing accounted for 11 percent, indicating a continued dominance of exposure technology in terms of revenue. In contrast, North American companies, which are strong in the MPU and logic (including ASIC) markets, earned 59 percent of the revenue from equipment related to interconnection technology, such as etching, cleaning, and planarization and deposition.

The following sections analyze major trends, reflecting the Japanese fab equipment market and manufacturers by the type of equipment.

Steppers

Steppers form a major element of wafer fab equipment investment. In 1997, the world stepper market remained almost flat from the previous year, totaling $3.6 billion. The Japanese market dropped 16 percent to $938 million. Notably, while shipment revenue (on a dollar basis) maintained more or less the previous year's level, unit shipments declined from 1,321 to 1,043. This reflects the fact that the shipment of conventional i-line steppers declined significantly because of cutbacks in capital spending for capacity expansion, whereas sales of higher-priced krypton-fluoride (KrF) excimer laser steppers grew considerably because of the commercial rollout of 0.25-micron technology. Dataquest's survey indicates that unit shipments of excimer steppers surged from about 8 percent in 1996 to 30 percent in 1997.

The breakdown by region and technology indicates that the Americas and European markets previously held high shares of deep ultraviolet (DUV) stepper shipments, but in 1997, unit shipments to the Japanese and Korean

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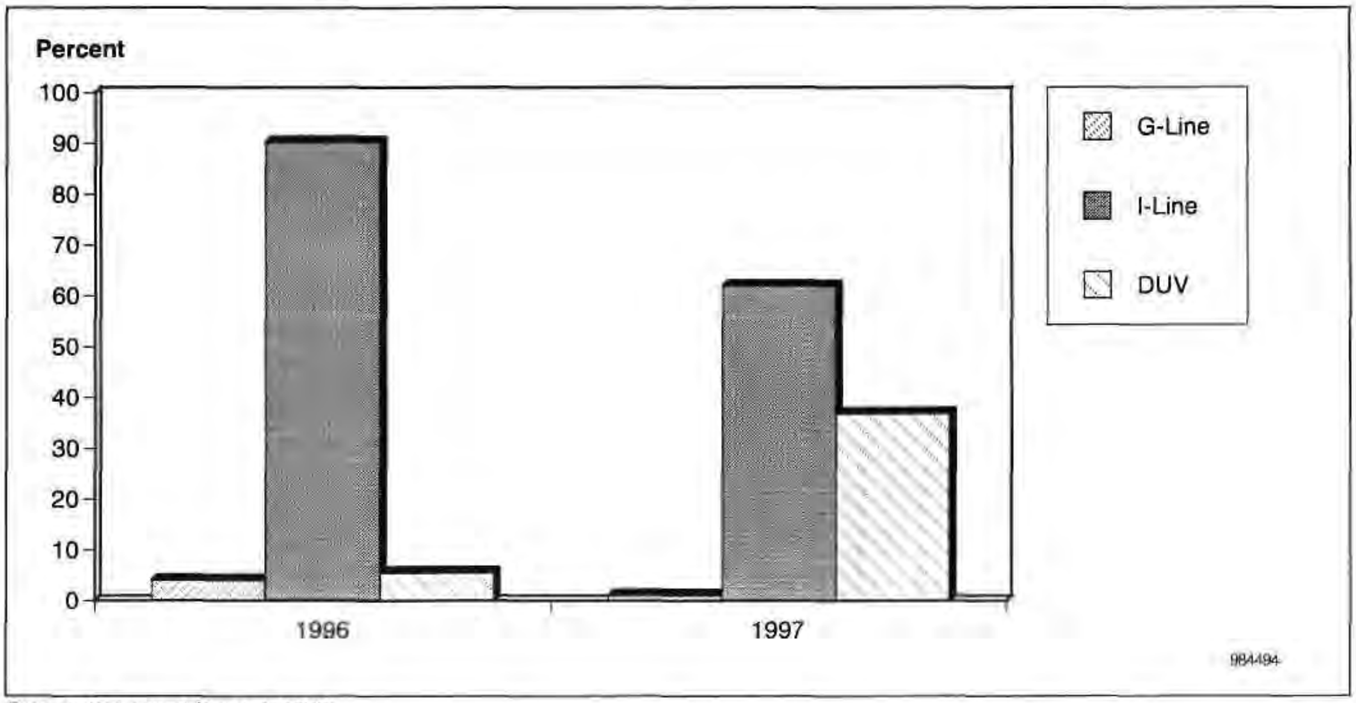
markets grew rapidly as 0.25-micron technology was introduced to 64Mb DRAM production (Figure 3). The increased use of excimer steppers for volume production has affected each vendor's share as well; while no significant change was seen in unit shipment ranking, companies that dominated the excimer stepper segment on a revenue basis increased their shares. Following Nikon Corporation, which maintained first place with a 43 percent share in 1997 (47 percent in 1996), ASM Lithography Holding N.V. advanced to second place by expanding its share from 20 percent to 25 percent and replaced Canon Inc., whose share dropped from 25 percent to 23 percent. In the second-tier group, Silicon Valley Group Inc. raised its share from 4 percent to 7 percent.

Figure 3
Recent Trends in Stepper Shipments to the Japanese Market by Technology (Units)



Source: Dataquest (August 1998)

Auto Wet Stations

The world auto wet station market totaled $954 million in 1997, an 18 percent decrease from the previous year. The highest rates of decline were seen in Europe (down 43 percent) and Korea (down 25 percent). The Japanese market also experienced a 17 percent decrease, totaling $247 million. All of these regions were adversely affected by a major setback in capacity expansion investment, particularly in the DRAM area.

The market shares by company underwent some reshuffling. While Dainippon Screen Corporation continued to hold the leading position with a 20 percent share, Sugai Corporation advanced from fourth to second place (13.3 percent), and Tokyo Electron Ltd. fell from second to third place (12.6 percent), followed by Kaijo Corp. (from fifth to fourth) and STEAG

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MicroTech Inc. Japanese companies command a combined share of around 70 percent of the market. Interestingly, different companies have established dominant positions in different regions. Dainippon takes a lead in the Americas, Japan, and Korea; Kaijo takes a lead in Taiwan; Tokyo Electron takes a lead in other countries in Asia/Pacific; and STEAG MicroTech takes a lead in Europe. While there is no global winner, Sugai and Sankyo Engineering Company Ltd. are moving toward a merger, and the new company is expected to emulate Dainippon's 1997 market share. Much more consolidation is expected in the market.

Resist Processing

The resist processing market was by no means immune to the sluggish capital spending triggered by the DRAM recession. As a result, the worldwide resist processing market declined 28 percent in 1997 to $1.2 billion. The momentum of the equipment for DUV lithography, market-driven by the proliferation of excimer steppers, was dwarfed by a major decline in the conventional equipment segment. The Korean market was hit hardest, and value shipments decreased 45 percent to $105 million, followed by the Japanese market, which dropped 44 percent to $256 million. Again, high dependency on the DRAM business was a determinant factor.

As for vendor ranking, Tokyo Electron dominated the market (59 percent share), followed by SVG (15 percent) and Dainippon (13 percent). Fairchild Technologies GmbH was the only company reporting high growth (50 percent increase over the previous year) and advanced to fifth place by winning a 4 percent share. Its significantly increased presence in the Korean market served as a major impetus for this.

The DUV equipment market is expected to grow consistently with expansion of the excimer stepper market. Vendors are vying for higher performance by focusing on several areas: the controllability of atmosphere inside equipment by means of chemical filters and increased durability of the filters, accurate temperature control in the oven, and the reduction of footprint for the 300mm wafer process.

Dry Etching

In 1997, the worldwide dry etching market declined 13 percent from the previous year to $3.0 billion. Segment-wise, the low-density plasma etching equipment market was down 26 percent to $1.6 billion, while the high-density segment reported an impressive 9 percent increase to $1.4 billion. High-density plasma etching equipment has gained popularity with the pervasiveness of the 0.25-micron process, on account of profile characteristics accompanying the pattern's high-aspect ratio, selectivity, and adaptability to pattern shape. It has now reached a market size similar to that of low-density plasma etching equipment.

Regionally, the high-density plasma etching markets in the Americas and Taiwan recorded high growth, 62 percent and 61 percent over the previous year, respectively, whereas the Japanese market plunged 17 percent to $333 million. As for each company's share in the high-density plasma etching markets, Applied Materials Inc. boosted revenue by 208 percent to hold a 27 percent share and get closer to the leader, Lam Research Corporation (43 percent). Hitachi Ltd. came in third. Applied Materials increased sales in the Americas, European, and Japanese markets.

Chemical Mechanical Polishing

Compared to the dreary condition of the wafer fab equipment market, which recorded a 7 percent decline, the worldwide CMP market grew 75 percent in 1997 to $518 million. In addition to the traditional strongholds in the Americas and Europe, the CMP market underwent rapid expansion in Asia/Pacific, particularly in Taiwan (up 352 percent) and Korea (up 303 percent). In all of the regions, CMP technology expanded its applications from the production of leading-edge logic devices to DRAMs. The Japanese market grew 56 percent to $134 million. As a result, regional shares changed to 41 percent for the Americas, 26 percent for Japan, 10 percent for Europe, and 23 percent for Asia/Pacific, with the Japanese and Asia/Pacific markets ahead of the European market.

In terms of system configuration, integrated CMP equipment that incorporates post-cleaning equipment has expanded its market, a 227 percent increase over 1996, to total $179 million and a 35 percent share. In particular, the Japanese market accounted for 53 percent of the entire segment.

Each company's share showed notable changes as well. IPEC/Planar managed to hold the No. 1 position, although its share dropped to 26 percent, and Ebara Corporation came in second by boosting its share to 22 percent. Applied Materials also gained a 15 percent share and followed SpeedFam Corporation, which was in third place (21.5 percent). Japanese companies together registered a considerable gain from 36 percent to 49 percent. With more Japanese companies (for example, Mitsubishi Materials Corporation, Tokyo Seimitsu Co. Ltd., and Sony Corporation) looking for market share, coupled with expanded applications (such as shallow trench isolation and the dual damascene process), the market should become more competitive.

Chemical Vapor Deposition

In 1997, the worldwide vertical- and horizontal-tube CVD system market totaled $603 million, down 24 percent from a year ago. Two markets recorded healthy growth: the Americas with 22 percent and Taiwan with 18 percent. On the other hand, the Korean and European markets declined sharply, with 64 percent and 47 percent, respectively. Similarly, the Japanese market recorded a negative growth of 25 percent, totaling $190 million. The regional disparity clearly reflects the different conditions of individual device markets.

The distinctive patterns in different segments are more pronounced in the nontube CVD system market. Low-pressure CVD (LPCVD) and

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atmospheric/subatmospheric CVD (APCVD/SACVD) maintained the same revenue levels as the previous year, as bolstered by the first growth of the markets in Taiwan, the Americas, and Europe. In these markets, primary film demand comes from logic-oriented products such as blanket tungsten and gap-fill dielectric depositions. The worldwide nontube CVD market grew 6 percent to $610 million, and the worldwide APCVD/SACVD market was up 1 percent to reach $657 million. In contrast, the Japanese market recorded double-digit negative growth in the both segments—the nontube CVD market totaling $180 million, and the APCVD/SACVD market totaling $138 million—as these markets depended on the DRAM-sensitive films of tungsten silicide and higher-temperature deposited dielectric materials.

In the plasma CVD market, the low-density segment reported a 13 percent decline to $609 million, while the high-density segment recorded an outstanding gain of 88 percent, totaling $202 million. Strong market expansion was seen across the regions: The Americas grew 77 percent, Europe grew 144 percent, and Asia/Pacific grew 144 percent. The Japanese market also grew 10 percent to $12 million.

In the future, further market expansion is expected in the 0.25-micron-and-finer processes where high-density plasma CVD systems expand applications such as dielectric layers below metal films and trench isolation, in addition to the formation of dielectric layers between metal films. Leading the high-density plasma CVD market is Novellus Systems Inc., which managed to maintain first place with a 49 percent share, closely followed by Applied Materials, which increased revenue by 246 percent to gain a 48 percent share. Thus, the market is almost equally divided between the two vendors.

Silicon Epitaxial Reactors

The worldwide silicon epitaxial reactor market recorded a 25 percent growth in 1996 that was driven by DRAM demand; this turned into a negative growth of 13 percent in 1997, totaling $226 million. While it grew somewhat in the first half of 1997, it seemed to cool down in the second half. A major cause was the delay or cutback in the expansion of 200mm wafer production capacities by silicon wafer manufacturers because of the sluggish DRAM market and the lackluster outlook for wafer demand as a result of accelerated chip shrinkage. The falloff from investment in power/discrete capacity was another major cause. Regionally, the Japanese market recorded a 20 percent growth ($99 million), while other regions suffered declines: the Americas by 26 percent ($79 million), Europe by 26 percent ($39 million), and Asia/Pacific by 50 percent ($9 million). This reflects the continuous efforts of Japanese companies to explore the DRAM market as design rules fall below 0.3 micron.

In the world of 0.3-micron-or-finer linewidth, it is well known that crystal defects such as crystal-originated particles (COPs) impede yield in DRAM production. DRAM suppliers take varied approaches, which primarily reflect the maturity and economics of their processes. At present, most Japanese companies address the issue by using epitaxial wafers. At the same time, some continue to use CZ wafers (wafers created using the Czochralski

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Method), adopt hydrogen-annealed wafers (Hi wafers), or consider low-COP CZ wafers.

In terms of share by company, Applied Materials continued to lead the market by holding a 57 percent share, followed by ASM International N.V. (24 percent), whose position also did not change. In third place, however, Concept Systems Design was replaced by Moore Epitaxial Inc. with a 12 percent share.

Rapid Thermal Processing

In 1997, the worldwide RTP equipment market grew strongly at 49 percent and reached $273 million. Double-digit growth was recorded in all of the regions except Europe. The Americas market was up 60 percent (totaling $106 million), Japan was up 69 percent ($69 million), and Asia/Pacific was up 69 percent ($71 million), while Europe was down 19 percent ($28 million). Entering the 0.25-micron age that requires ever finer and thinner devices, precise temperature control in the thermal treatment process becomes increasingly critical, and RTP finds new applications in ion implantation and annealing of source drains, silicide formation, and the formation of gate oxide films.

In terms of vendor ranking, Applied Materials, in first place, recorded a 139 percent increase in revenue to $162 million and gained a 59 percent share. While the company boosted sales in all of the regions, major contributions came from the Japanese market, where its sales skyrocketed by 1,640 percent over the previous year and its share grew to 58 percent. As a result, Dainippon slid from the top position in 1996, and its share plummeted to 17 percent in Japan. In the worldwide market, STEAG AST Elektronik maintained second place with a share of 18 percent. AG Associates came in fourth with a 15 percent share. Future technological challenges in the market include uniform temperature control, the improvement in temperature reproducibility because of variation in wafers' emissivity, and the improvement in the maintainability and reduction of running costs associated with the use of 300mm wafers. Various vendors are establishing volume production capabilities.

Ion Implantation

The ion implanter market is one of the markets primarily governed by individual device market trends and new fab construction. In 1997, the worldwide ion implanter market declined 18 percent to $912 million. Regionally, the Americas and Taiwan reported double-digit growth, whereas other regions suffered negative growth in double digits. Looking at individual segments, high-current ion implanters used in the source drain process and medium-current ion implanters used in the field threshold voltage control process recorded negative growth of 27 percent and 23 percent, respectively, to reflect new fab investment cutbacks by most companies, except for those in the Americas and Taiwan. On the other hand, the high-energy ion implanter market (used for the formation of barrier

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layers and retrograde wells) recorded a 12 percent growth. A regional breakdown, however, unveils mixed results. While the DRAM-dependent Japanese and Korean markets declined 8 percent and 47 percent, respectively, the Americas and European markets reported appreciable growth of 59 percent and 31 percent, respectively, because they rely on logic processes where high-energy ion implantation expands applications. Overall, the Japanese market declined in all of the segments, resulting in a 41 percent decrease and $202 million.

Share by company has remained unchanged for the top three vendors: Eaton Corporation (45 percent), Varian Associates Inc. (30 percent), and Applied Materials (13 percent). However, because Varian acquired the ion implanter division of Genus Incorporated and vendors are introducing products with wider applications, market reshuffling is expected among the segments.

CD-SEM

In 1997, the worldwide critical dimension scanning electron microscope (CD-SEM) market decreased 1 percent to $327 million. Again, a regional breakdown shows polarized results. Two markets recorded strong growth: the Americas (up 21 percent) and Taiwan (up 46 percent). Two markets suffered declines: Korea (down 50 percent) and Japan (down 16 percent and totaling $79 million). The wafer testing and inspection systems industry went through major consolidations between 1996 and 1997, including the merger of KLA Instrument with Tencor Instrument and the market entry of Applied Materials. These moves have already affected market share. Hitachi continued to dominate the 1997 market with a 60 percent share, followed by KLA-Tencor Corporation (18 percent) and Applied Materials (13 percent). In the future, performance improvement efforts will focus on measurement accuracy and reproducibility at low acceleration voltage and on higher throughput. Recently, the need has arisen to implement defect analysis capabilities and evaluation capabilities in the form of data processing utilities through a graphical execution manager (GEM) interface.

Manufacturing Automation and Control

This year, Dataquest newly defined a segment in the factory automation equipment market, called semiconductor manufacturing automation and control (SMAC), for a full-scale market study. The SMAC market is further divided into automation software systems covering system integration and similar functions, transport and storage automation covering wafer handling and transportation, lithography management systems, transition environmental control systems such as standard mechanical interface (SMIF), and process environmental control systems such as cluster tool platforms.

Generally, the SMAC market is expected to be directly affected by fab investment, which was clearly seen in 1997. The entire market showed a slight increase of 2 percent to $1,209 million. Regionally, three markets showed firm growth: The Americas grew 10 percent, Europe grew 36 percent, and Taiwan grew 19 percent. The Korean and Japanese markets, on the other

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hand, declined 22 percent and 23 percent, respectively. Again, the market contrasts are evidence of the impacts of major cutbacks in DRAM-related capital spending on some markets. However, in the Japanese market, to which total shipments in 1997 amounted to $237 million, the transition and process environmental control segments registered positive growth, albeit a small size, and systems adaptive to the next-generation production environment, including SMIF and cluster tool platforms, showed some signs of market expansion.

In terms of share by company, Japanese and North American manufacturers dominate the market, controlling 30 percent and 64 percent, respectively. North American companies hold high shares in Taiwan, other Asia/Pacific countries, and Europe, in addition to their home ground. On the other hand, Japanese companies take the lead in the Japanese and Korean markets. In the 1997 market share ranking, PRI Automation came first with a 15 percent share, followed by Daifuku Company Ltd. (14 percent), Asyst Technologies Inc., and Digital Equipment Corporation. Among the Japanese companies, Shinko Electric Company Ltd. ranked sixth (6 percent).

Equipment Vendor Ranking

Table 2 lists the top ten semiconductor equipment manufacturers in 1997. Clearly, Japanese companies decreased their revenue, whereas U.S. companies recorded firm growth. While no change is seen in the top three, KLA-Tencor ranked fourth because of the merger, and Canon fell from fifth to seventh place because of slow sales in the stepper market. In contrast, ASML maintained sixth position by gaining share in the excimer stepper market and boosting revenue by 21 percent. SVG was also driven by increased revenue from excimer steppers and achieved ninth place. On the other hand, Dainippon stepped down from seventh to tenth place because of the slump in the resist processing and auto wet station markets.

Table 2
Semiconductor Equipment Vendor Ranking

1996 Rank	1997 Rank	Vendor	1996 Revenue ($M)	1997 Revenue ($M)	1997 Growth (%)	1996 Market Share	1997 Market Share
1	1	Applied Materials	3,350.5	3,669.3	9.5	15.9	18.7
2	2	Tokyo Electron	2,591.2	2,145.1	-17.2	12.3	10.9
3	3	Nikon	1,721.2	1,565.2	-9.1	8.2	8.0
-	4	KLA-Tencor	-	1,027.2	-	-	5.2
4	5	Lam Research	1,091.9	915.6	-16.1	5.2	4.7
6	6	ASML	726.0	875.9	20.6	3.5	4.5
5	7	Canon	956.0	862	-9.8	4.5	4.4
8	8	Hitachi	631.9	609.2	-3.6	3.0	3.1
10	9	SVG	551.2	560.6	1.7	2.6	2.9
7	10	Dainippon	648.1	500.8	-22.7	3.1	2.6

Source: Dataquest (August 1998)

The wave of consolidation in 1997—including the mergers, acquisition of divisions, and alliances—seems to have subsided in 1998. Nevertheless, Sugai and Sankyo Engineering plan to merge for the sake of survival in the auto wet station market to form a new company, SES, and Varian has announced the acquisition of the ion implanter division of Genus. Thus, market reorganization is expected to continue through mergers or acquisitions, and market share in various segments will change accordingly.

Dataquest Perspective

The 1997 fab equipment market trends can be summarized in several ways. Generally, the Japanese and Korean markets contracted dramatically as they relied heavily on DRAM investment, and, therefore, equipment companies selling their products primarily in these two markets suffered significant revenue loss. In contrast, the Americas market, whose lifeblood lies in logic (including ASICs) and MPUs, and Taiwan, where foundry investment is rampant, enjoyed expansion, and equipment manufacturers holding share in these markets recorded healthy growth. Thus, the fab equipment market in 1997 was directly linked to the local characteristics of device production, which resulted in a notable regional gap.

Parallel to the widening regional disparity, technology-driven market expansion continues, as seen in 1996. Figure 4 lists segments that recorded high growth in 1997. While the fab equipment market recorded a negative growth of 7 percent, several segments related to 0.25-micron and later process technologies, led by excimer steppers, grew strongly. While the entire market is expected to remain sluggish for another year or two, these high-end segments that hold the key to the commercialization of leading-edge process technology—particularly, sputtering equipment that forms copper interconnections (seed layers) and the formation of electroplated films—will follow a path of solid growth.

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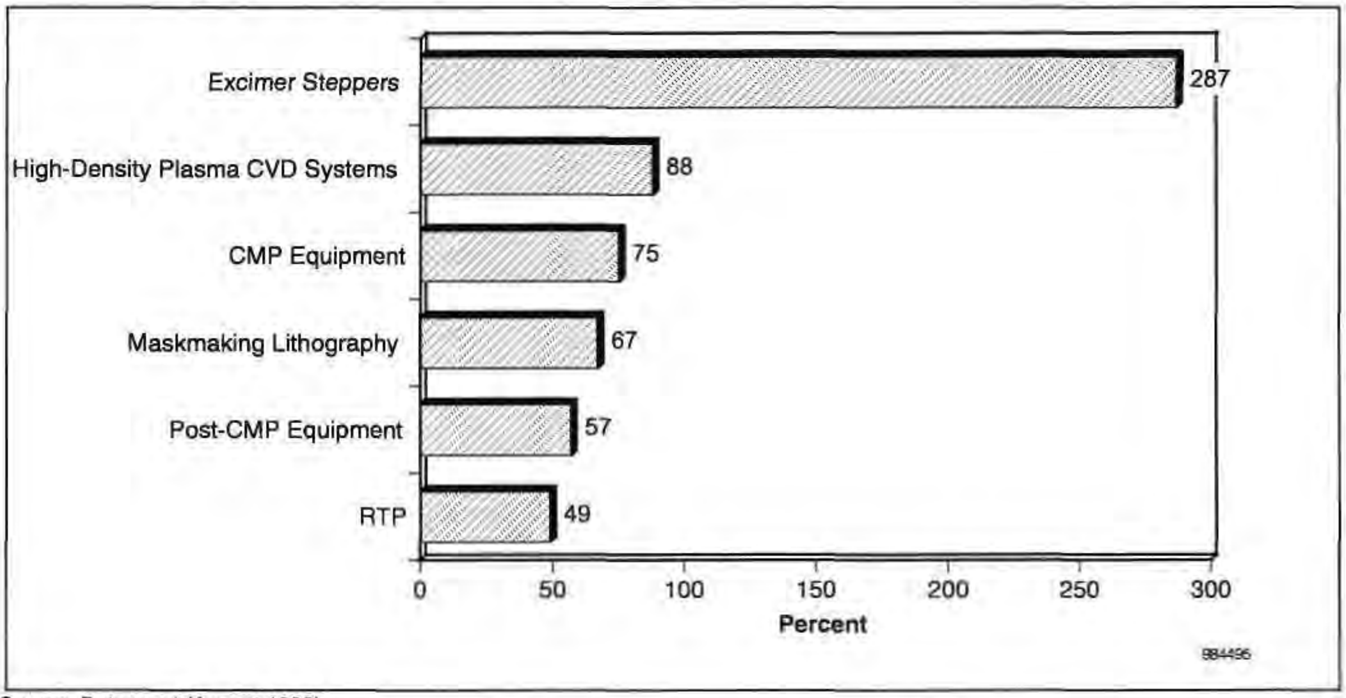
Figure 4
Fast-Growing Segments in 1997 (Worldwide)



Source: Dataquest (August 1998)

In the future, regional equipment market trends will further be differentiated according to the development of leading-edge technology and according to their local device markets and growth patterns. At present, Japanese semiconductor companies are struggling to pursue and nurture high-value-added businesses, such as system-level integration (SLI). In the short run, however, they still have to depend upon DRAM. Dataquest predicts that the DRAM market will make a sufficient recovery after the end of 1999, allowing suppliers to resume full-scale capacity expansion. In the meantime, the Japanese wafer fab equipment market will have to rely on leading-edge equipment such as excimer steppers, CMP, RTP, and high-density plasma CVD as market drivers.

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Perspective

Semiconductors Japan
Market Analysis

Time to Think about the Marketability of 128Mb DRAM

Abstract: *Traditionally, DRAM has quadrupled its integration level. In 1998, however, the grand tradition has been broken with the introduction of 128Mb DRAM. The industry considered the development of 32Mb DRAM in 1996 to be a bridge between 16Mb and 64Mb DRAM, although the 32Mb DRAM failed to materialize as marketable, generic DRAM. Likewise, many view the newly rolled-out 128Mb as a short-lived stopgap between 64Mb and 256Mb DRAM. Whether the quadrupling pattern will continue to dominate or the industry will undergo a paradigm shift in DRAM evolution where the doubling becomes the norm is a critical issue for both DRAM users and suppliers in their product development. This Perspective analyzes 128Mb DRAM from the marketability point of view and examines differentiating factors for 64Mb, 128Mb, and 256Mb DRAM with opportunities for market segmentation.*

By Masahiro Suzuki

Market Forecast for 128Mb DRAM

In 1998, the DRAM market is in transition from 16Mb to 64Mb, the demand for which has yet to ramp up. However, some leading Japanese and Korean DRAM vendors have unveiled the start of volume production of 128Mb products, which is to take place at the end of this year, and other companies seem to be following suit. To add complexity or choice, some Japanese and Korean suppliers have announced commercial shipments of 256Mb DRAM, starting in early 1999. If these plans proceed according to schedule, 64Mb will become the mainstay in the 1998 DRAM market, and three generations of leading-edge DRAM—64Mb, 128Mb, and 256Mb—will coexist in 1999.

In making forecasts for various device markets, Dataquest refers to past trends and demand forecasts for electronics. In our extensive database, however, there is no comparable case like this one—three generations of leading-edge devices competing in the same market. It is therefore important

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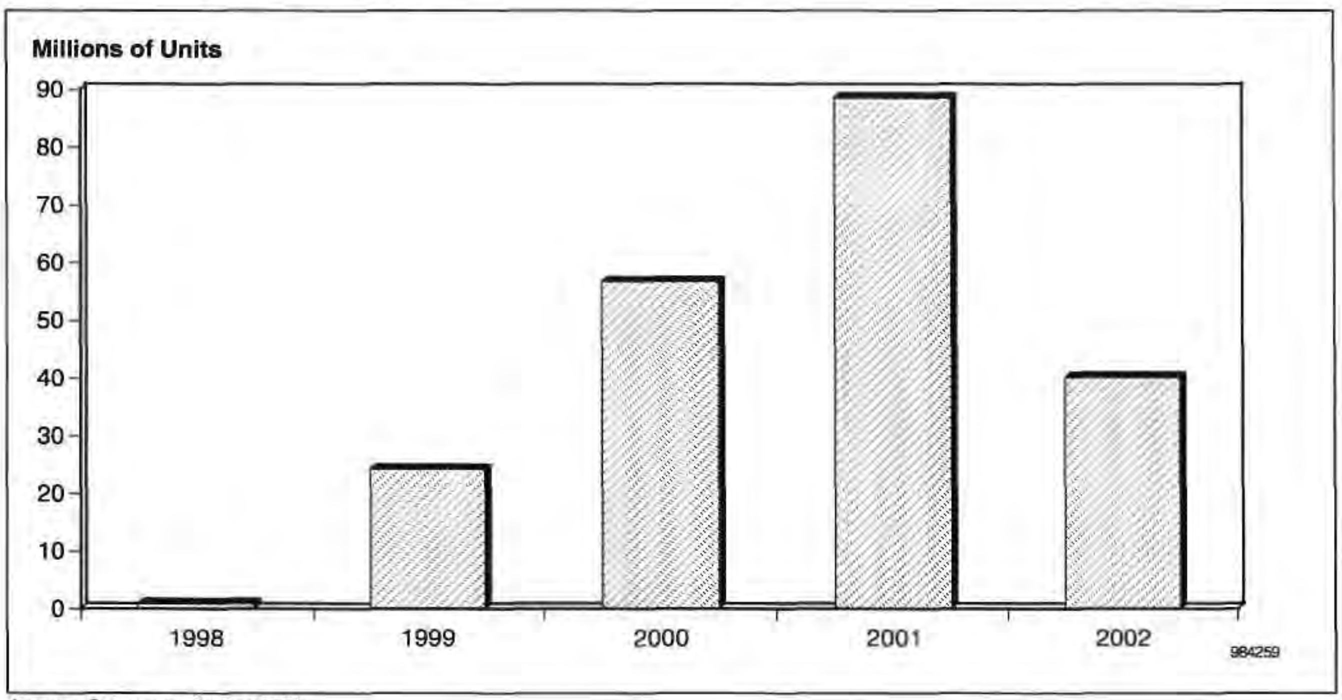
to analyze the 128Mb DRAM market in our May 1998 forecast by focusing on the demand-side, system vendors and their products.

Figure 1 shows unit shipment forecasts for 128Mb DRAM between 1998 and 2002. Note that the 1998 shipments are rather limited, around 900,000, as the forerunners are expected to start up volume production in the third quarter of 1998. To encapsulate the 128Mb chip in the 400-mill package required by DRAM users, semiconductor companies must use the leading-edge production process of 0.23-micron or finer, the capacity of which will inevitably be limited in 1998.

In 1999, other leading vendors will enter the market, and unit shipments will grow steadily. The market is expected to peak in 2001 and then plummet in 2002 to one-half the level of 2001, under the assumption that volume production of the 256Mb version will start to trigger the bit price crossover with 64Mb in that year. Some believe that 128Mb will be further short-lived as volume production of 256Mb ramps up earlier than expected. However, if this happens and 256Mb starts to replace 128Mb at an earlier time, suppliers will face price erosion of the leading-edge device, which will make it difficult for them to reap major investment and secure sufficient profitability for the DRAM business.

Figure 1
Total 128Mb Unit Demand



Source: Dataquest (July 1998)

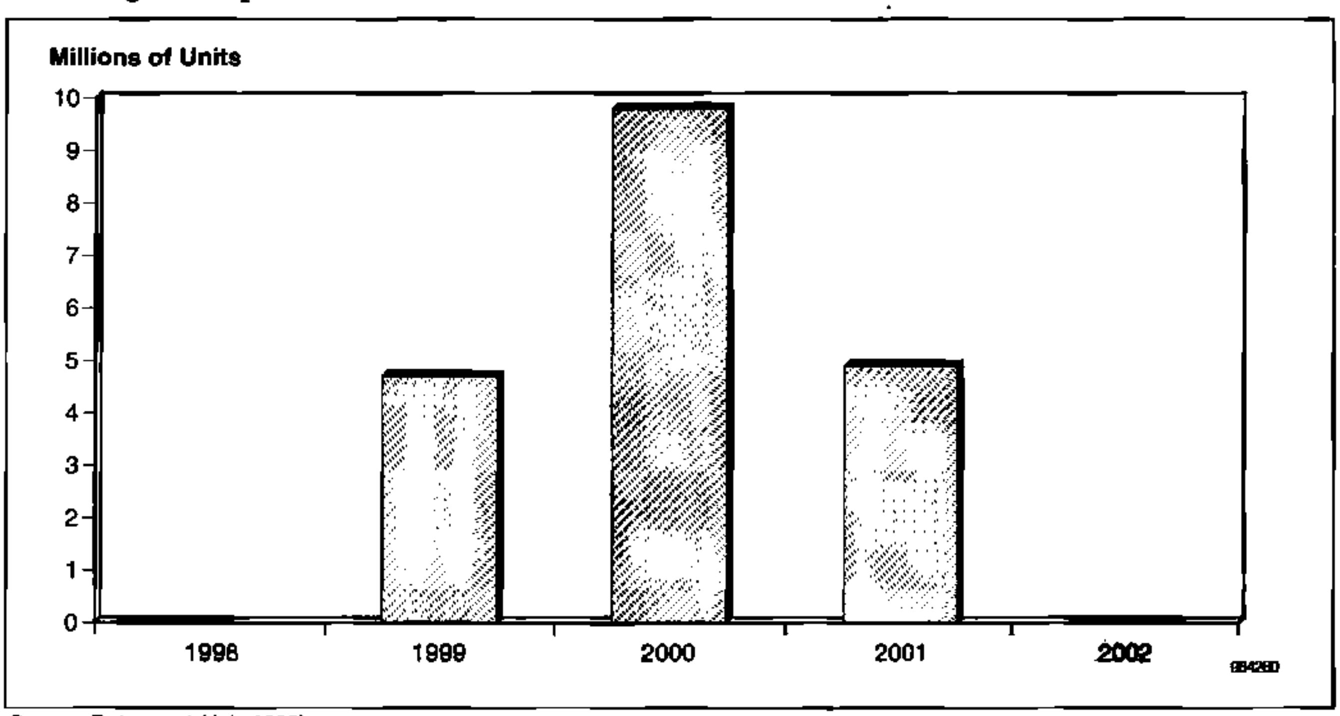
Demand Forecast for 128Mb DRAM

Major target applications for 128Mb DRAM include midrange computers, workstations, PC servers, and high-end notebook PCs. Generally, high-end computers require a larger main memory, which consumes DRAMs of larger capacity, resulting in a higher price premium. On the other hand, semiconductor companies are focusing their efforts on the development of 128Mb synchronous DRAMs (SDRAMs). Generally, when SDRAMs are packaged in a buffer-type dual inline memory module (DIMM), the number of slots available on the motherboard is limited to eight. Thus, supercomputers and mainframes, which require a very large main memory, tend to use extended data out (EDO)-type DRAMs rather than SDRAMs by maximizing performance through the interleave approach.

Midrange Computers

Midrange computers are classified as one class above workstations and thus have relatively large main memory requirements. 128Mb DRAMs will be an attractive choice for low-end machines with a smaller memory size, but they will soon be replaced with 256Mb DRAMs according to the price decline. As a result, 128Mb DRAM demand in the midrange market will reach its peak level in 2000 (see Figure 2).

Figure 2
Midrange Computers: 128Mb Unit Demand



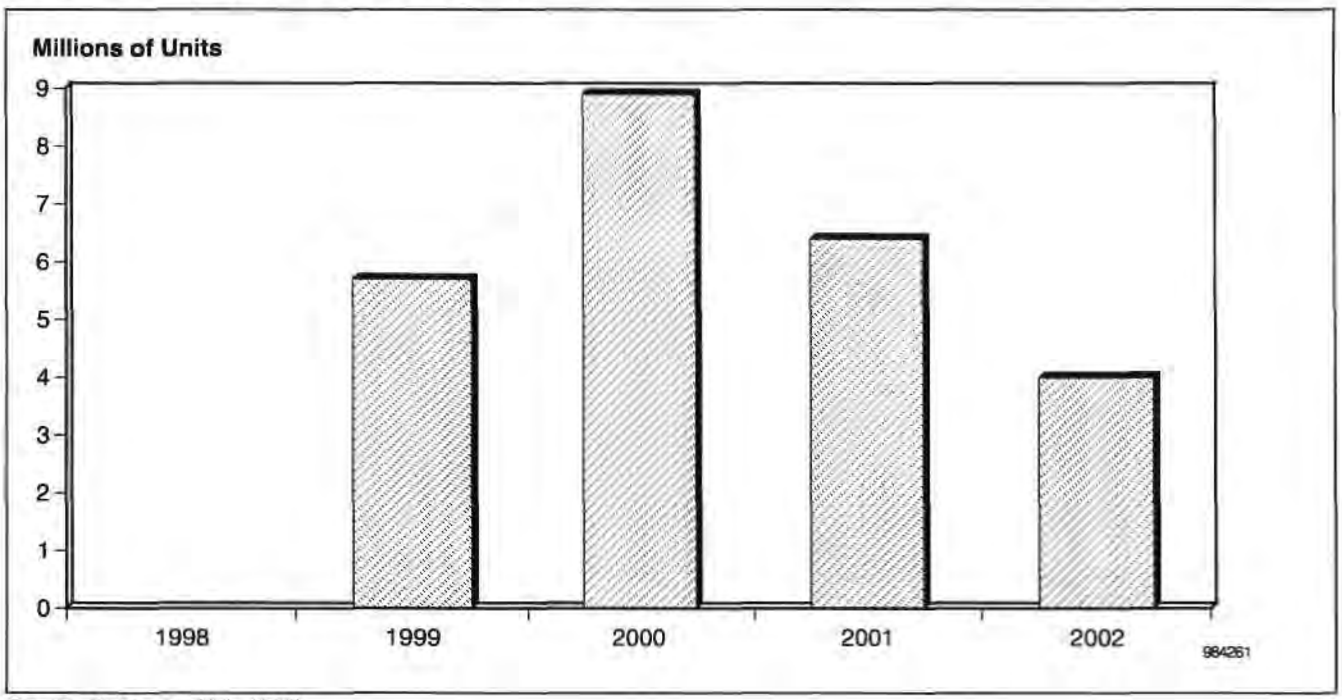
Source: Dataquest (July 1998)

Workstations

This is the segment where replacement of 128Mb by 256Mb is not certain. When the market is divided into three parts—high-end, midlevel, and low-end—the replacement process will be sure to occur in the high-end segment. On the other hand, in midlevel and low-end machines, it will be conditional to the 256Mb price, which must decline to a level triggering the crossover. Furthermore, the low-end segment should be preceded by the proliferation of 128Mb products as their bit price becomes closer to that of 64Mb products.

Interestingly, high-end workstations account for less than 1 percent of the total annual unit shipments, whereas low-end machines represent more than 70 percent. This means that unless the 256Mb price falls significantly, the rate of replacement is not likely to accelerate. In the low-end segment, the 256Mb nonbuffered DIMM will be mainly used for cost saving. In contrast, high-end machines with large memory will demand the buffer DIMM version. The main memory size of 1GB seems to be a threshold. Dataquest predicts that demand for 128Mb DRAM in the workstation market will peak in 2000 and then will gradually be replaced by 256Mb DRAM with a declining price (see Figure 3).

Figure 3
Workstations: 128Mb Unit Demand

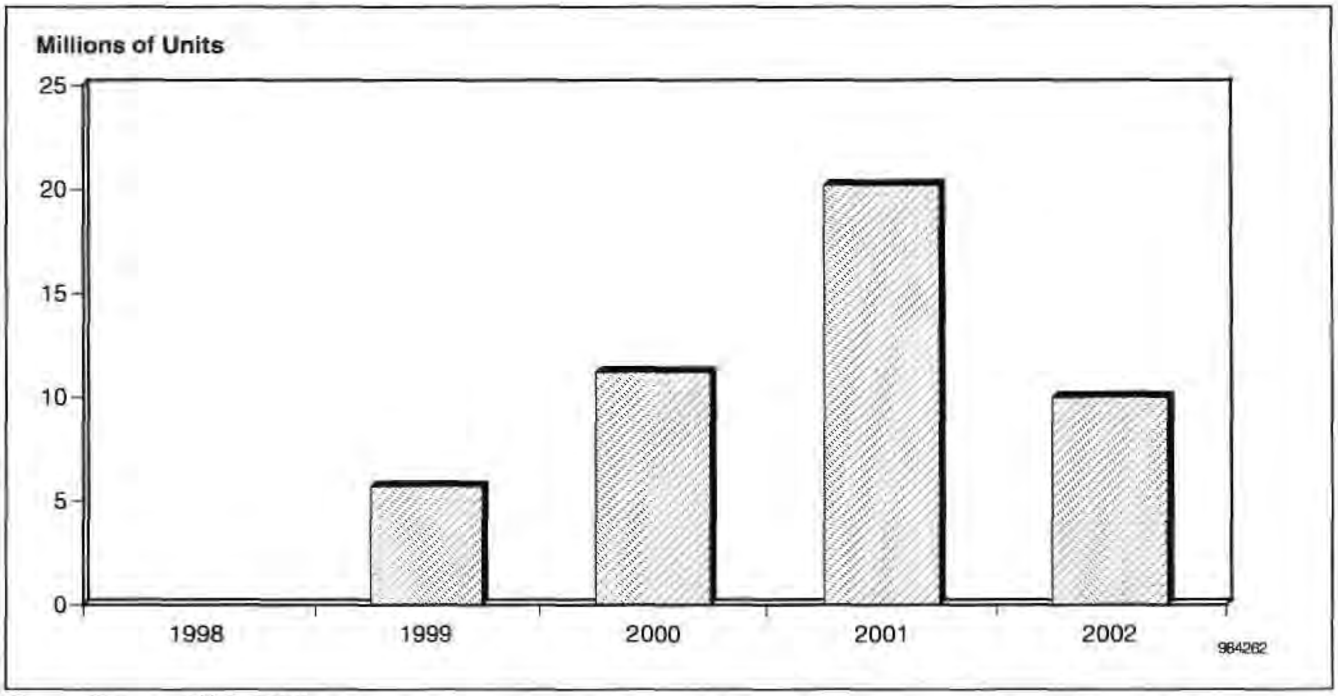


Source: Dataquest (July 1998)

PC Servers

As also seen in the low-end workstation segment, PC servers will become a major application market for 128Mb DRAM that can replace 64Mb DRAM if a parity is reached for the bit price. Between 1998 and 1999, unit demand for 128Mb will expand so much that it will prompt DRAM suppliers to launch strategic pricing for market share. Again, PC servers will opt for the nonbuffered DIMM type. Market demand for 128Mb will reach the highest level in 2001 (see Figure 4), during which time 128Mb will still keep price competitiveness against 256Mb on a bit-price basis.

Figure 4
PC Servers: 128Mb Unit Demand



Source: Dataquest (July 1998)

Notebook PCs

The seemingly relentless drive for a thin form factor makes the packing of parts into less space an increasingly critical issue. The use of 64Mb DRAMs in high-end notebook PCs in early 1997 is evidence that vendors can afford to select costly, large-capacity DRAMs if main memory is to be expanded. The 64MB main memory will increasingly become a standard feature of 1998 models with the release of Windows 98. 128Mb DRAMs will be able to easily configure a thin 64Mb module by allowing four units to be mounted on the single side of the small-outline DIMM (SODIMM). Dataquest believes that high-end models will start to incorporate 128Mb DRAMs in the second half of 1998. The 128Mb price is expected to enter a downward path in 1999, pushing the pervasiveness of notebook PCs. Demand in the notebook PC market will reach its peak in 2001 (see Figure 5).

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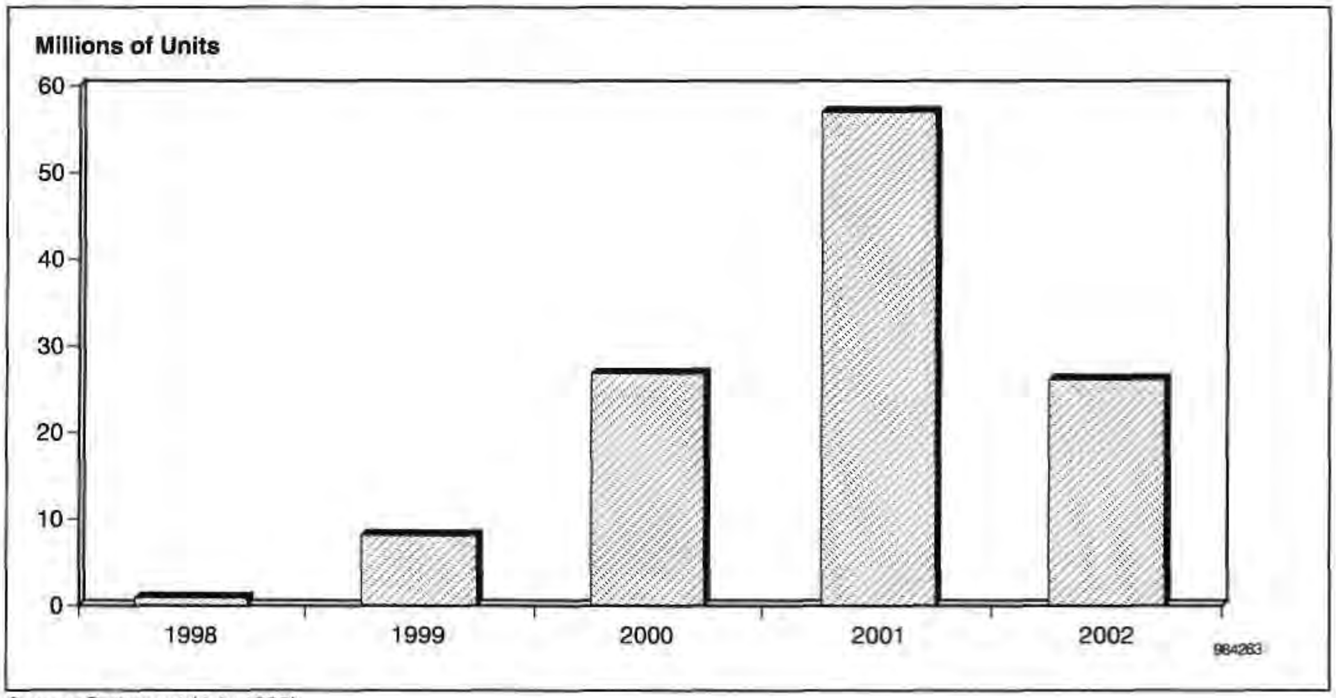
Figure 5
Notebook PCs: 128Mb Unit Demand



Source: Dataquest (July 1998)

As demand forecast for 128Mb DRAM in four major target applications indicates, actual market acceptance is governed by price levels and the timing of model changes in each segment. Another factor is the generation shift from 64Mb to 256Mb, which is expected to occur in 2002. Once the bit price crossover takes place between 64Mb and 256Mb products, it will entail accelerated replacement of 128Mb DRAM by 256Mb DRAM. Table 1 lists 128Mb DRAM shipment schedules of eight leading DRAM suppliers in Japan and Korea.

Table 1
128Mb DRAM Shipment Schedules of Leading Suppliers in Japan and Korea

	Hitachi	NEC	Samsung	Toshiba	Hyundai	LG Semicon	Mitsubishi	Fujitsu
Samples	Q1/98	Apr 98	Q2/98	Q3/98	Q3/98	Q3/98	Q4/98	H1/99
Volume Production	Q2/98	Aug 98	Q3/98	Q4/98	Q4/98	Q4/98	Q1/99	H1/99

Source: Dataquest (July 1998)

Dataquest Perspective

In 1998, the previous hype about 128Mb DRAM is beginning to subside among leading Japanese and Korean DRAM suppliers, as they can afford less and less R&D expenditure. At present, the highest priority is given to the development of a 64Mb shrink chip, for which leading-edge fabrication processes are starting up at an accelerated pace. The next priorities will be

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the 64Mb version that is adaptive to column address strobe (CAS) Latency 2 for PC100, which will take up much time toward the end of 1998, and the next-generation high-speed DRAM in 1999. Future development points to cost reduction, high speed, and large capacity. In particular, the first two areas are already subject to intensive competition. Under these situations, 128Mb DRAM, which is doomed to serve as a stopgap between 64Mb and 256Mb, inevitably lags behind in the R&D priority list.

128Mb DRAMs come in two types: the stack type to integrate two 64Mb chips into one package and the single-chip type. The stack type, already marketed by a Japanese manufacturer, is more costly than the single-chip version. Also, the use of two chips doubles input capacitance, which results in larger dynamic power loss because of charge/discharge with the switching operation, making it unsuitable for notebook PCs. Korean suppliers, originally working on the stack type, are now focusing on the single-chip version. Dataquest believes that the single chip will become the mainstay in the 128Mb segment.

Because there is a limited number of Japanese and Korean DRAM suppliers who can start volume production in 1998, the forerunners will be able to maintain leadership in the 128Mb pricing. The use in PC servers is spurred when the bit price of 128Mb becomes 1.5 to two times that of 64Mb. Dataquest expects that the total shipments of 128Mb DRAMs will reach 24.2 million units in 1999, which translates to a moderate number of 2 million per month. Thus, the initial target is set for midrange computers, workstations, PC servers, and notebook PCs; the market can be sufficiently served by the three forerunners. However, as shown in Table 1, more entrants are expected, and oversupply is highly likely in 1999.

In conclusion, the general impact of 128Mb products on the entire DRAM market can be described by two possible scenarios:

- Scenario 1: When the bit price of 128Mb DRAM constantly exceeds that of 64Mb DRAM, target markets for 64Mb, 128Mb, and 256Mb become highly distinctive: 128Mb for midrange computers, workstations, PC servers, and notebook PCs; and 64Mb for supercomputers, mainframes, and PCs. Then, once 256Mb DRAM is introduced, migration will start from the high-end segments. In this case, DRAM suppliers, particularly the three forerunners, will be able to reap profits from the business.
- Scenario 2: Generally, the semiconductor business relies on volume production for profitability. However, unless semiconductor companies listed in Table 1 discipline themselves in curtailing their output, a supply glut is hard to avoid, and price erosion will follow. The question is how far the price will decline. As the bit price of 128Mb becomes closer to that of 64Mb, desktop PC manufacturers will be enticed to use it, which will push the 64Mb price downward to trigger the price decline cycle between the two products. In this case, manufacturers having volume production capabilities of both 64Mb and 128Mb on the 0.23-micron-or-finer process will be able to have a cost advantage in 128Mb fabrication, if the production yield is more or less the same for the two products. In other words, 128Mb DRAM will be a lucrative product for companies that have

a competitive edge in leading-edge process technology. On the other hand, those without it will have to suffer a blow.

Dataquest believes that the significance of 128Mb DRAM is found not only in the fact that it breaks from the traditional quadrupling but that this device will determine the profitability of DRAM suppliers entangled in persistent excess capacity.

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Perspective

Semiconductors Japan
Market Analysis

A Changing Landscape for the Japanese Foundry Business

Abstract: *This Perspective analyzes foundry business trends for Japanese semiconductor companies on the basis of Dataquest's latest foundry shipments survey results. The prolonged recession of the Japanese semiconductor market increases the capital investment burden, and alliances are needed to build the ability to produce system LSIs—the wave of the future. In the changing environment, foundry business plays a much different, increasingly active role in the industry. Foundry business is gaining new meaning for Japanese semiconductor manufacturers, which are becoming foundry users themselves rather than foundry providers as in the past.*
By Yoshihiro Shimada

Start of Dataquest's Official Foundry Survey

Dataquest has been tracking semiconductor companies' brand shipment revenue trends in the annual market share survey. In 1997, we added a new item, foundry shipments and purchase, covering gross revenue from foundry business, as well as users and technology trends. Since foundry demand is continuously on the rise, the new survey focus is designed to shed light on this demand from the foundry company's perspectives and analyze the overall impact of foundry business on the semiconductor industry.

Most Japanese semiconductor companies have their own fabs and are generally referred to as integrated device manufacturers (IDMs). Japanese IDMs characteristically ramped new fabs producing the most advanced DRAMs, and as new fabs with more advanced technology are built, the old fabs are converted to produce other devices, including MOS logic, MOS microcomponents, and later, even analog. This has been regarded as the most efficient method of fab utilization and has actually been the most typical method. This traditional conversion cycle, however, has been changing recently. Instead of converting DRAM fabs to production of other

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devices, companies are required to build new fabs with logic capabilities. The change is partially driven by the notable success of dedicated foundry providers led by Taiwan Semiconductor Manufacturing Company (TSMC), together with the high profitability they have demonstrated.

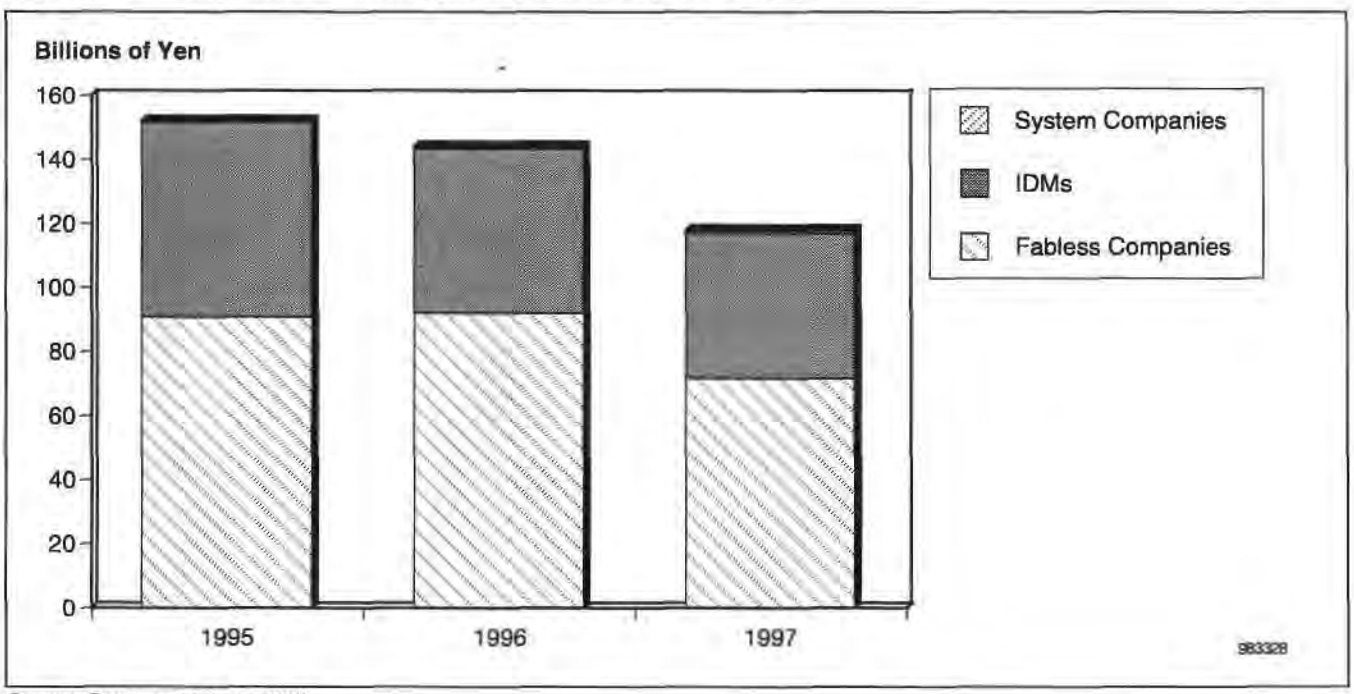
Foundry production as referred to throughout this Perspective includes the OEM production observed among Japanese and Korean companies.

Declining Foundry Shipments from Japan

In the 1997 semiconductor brand shipments ranking, Japanese companies again lost share in the worldwide market. At the same time, their total foundry shipments declined while the worldwide foundry market was expanding (see Figure 1). This makes a sharp contrast to the increasing commitment by Japanese semiconductor companies to foundry business. To put it simply, their decision came long after that of their competitors, especially dedicated foundry providers in Taiwan, who established technical leadership and developed close relationships with U.S. fabless companies.

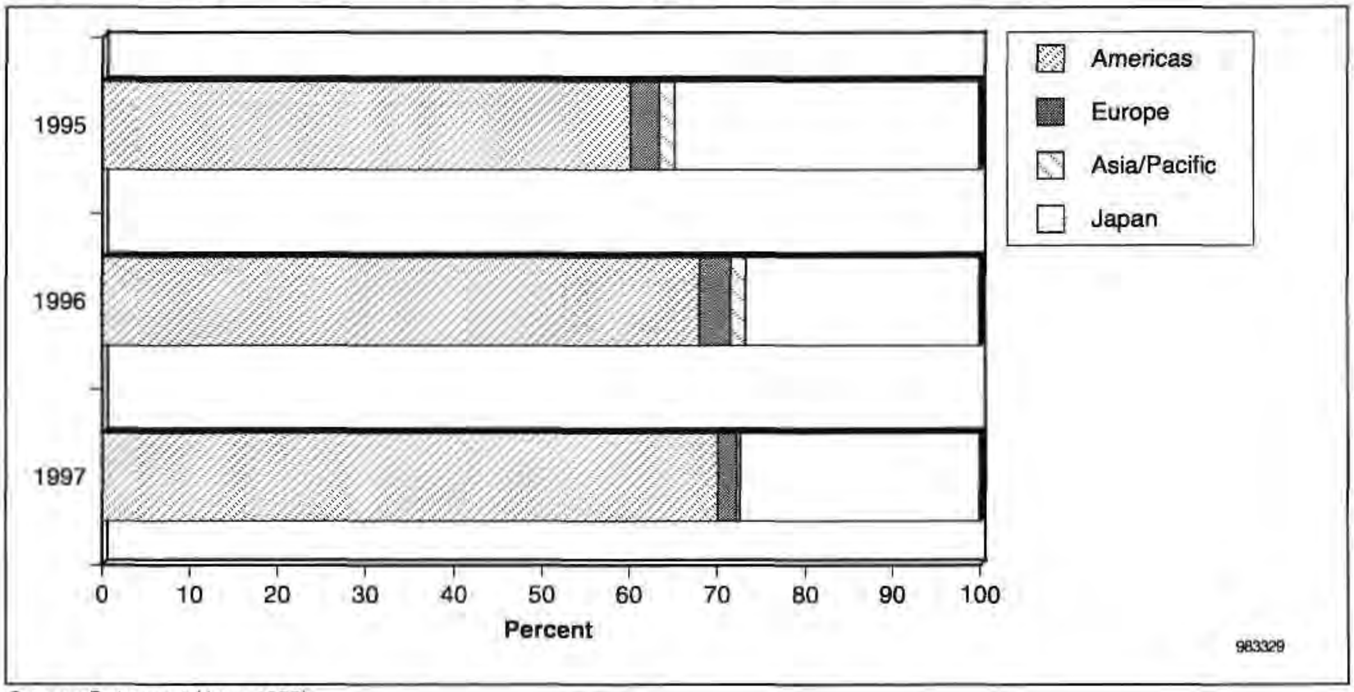
A major destination of foundry shipments by Japanese companies is the Americas market, which accounts for 70 percent of the total (see Figure 2). While the share of the Americas region has been on the rise since 1995, the absolute figure shows slight declines. This reduction in shipments comes mainly from reduced foundry business with U.S. fabless companies. At the same time, the value of shipments to the Japanese market has been declining, which reflects not only sluggish foundry contracts among Japanese companies, but also a decline in domestic delivery to foreign foundry users.

Figure 1
Japanese Companies' Foundry Shipments by User Type



Source: Dataquest (June 1998)

Figure 2
Japanese Companies' Foundry Shipments by Destination



Source: Dataquest (June 1998)

The downward trends are clearly evident in an analysis of revenue by product. The market share of logic and microcomponents, which accounts for a major portion of foundry shipments to Americas fabless companies, has dropped significantly compared to two years ago (see Figure 3). Instead, flash memory foundry has increased, with shipments from Japanese companies such as Sharp Electronics Corporation and SANYO Electric Company Ltd. to U.S. partners.

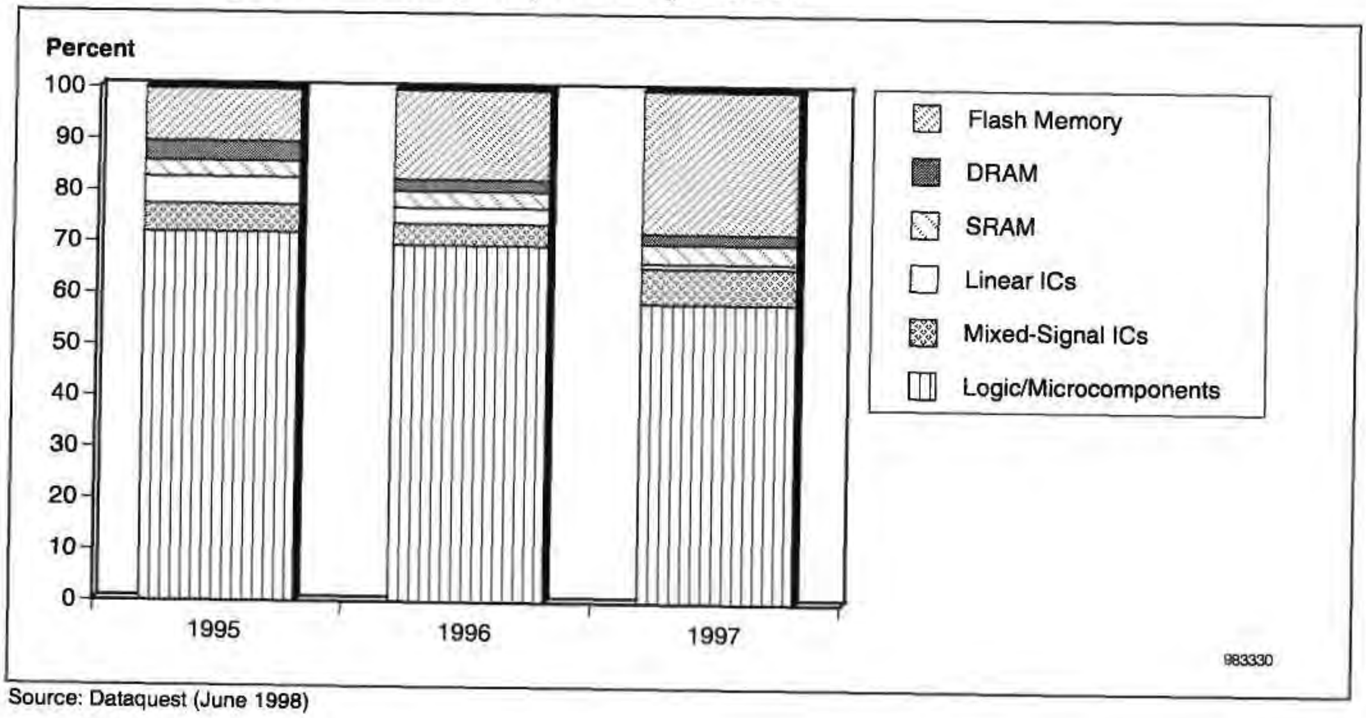
Technology trends are visible in the change in share by wafer size, down for 150mm and up for 200mm (see Figure 4). The major reasons for these changes include the following, given that 200mm fabs:

- Account for a large chunk of excess capacity because they were built during the previous boom
- Need to be operated to their capacity to vie effectively for the increasingly competitive foundry business
- Are more advanced than their 150mm counterparts in terms of design rule

The third point is substantiated by the fact that 0.5-to-0.8-micron processes using 150mm wafers lost share, while 0.5-micron or finer processes, which can be translated to 200mm fab technology, have gained sharply (see Figure 5). Finally, products with one to two metal layers lost share, while three-layer designs grew to 17 percent of the total in 1997. No contract has been won for four or more layers (see Figure 6).

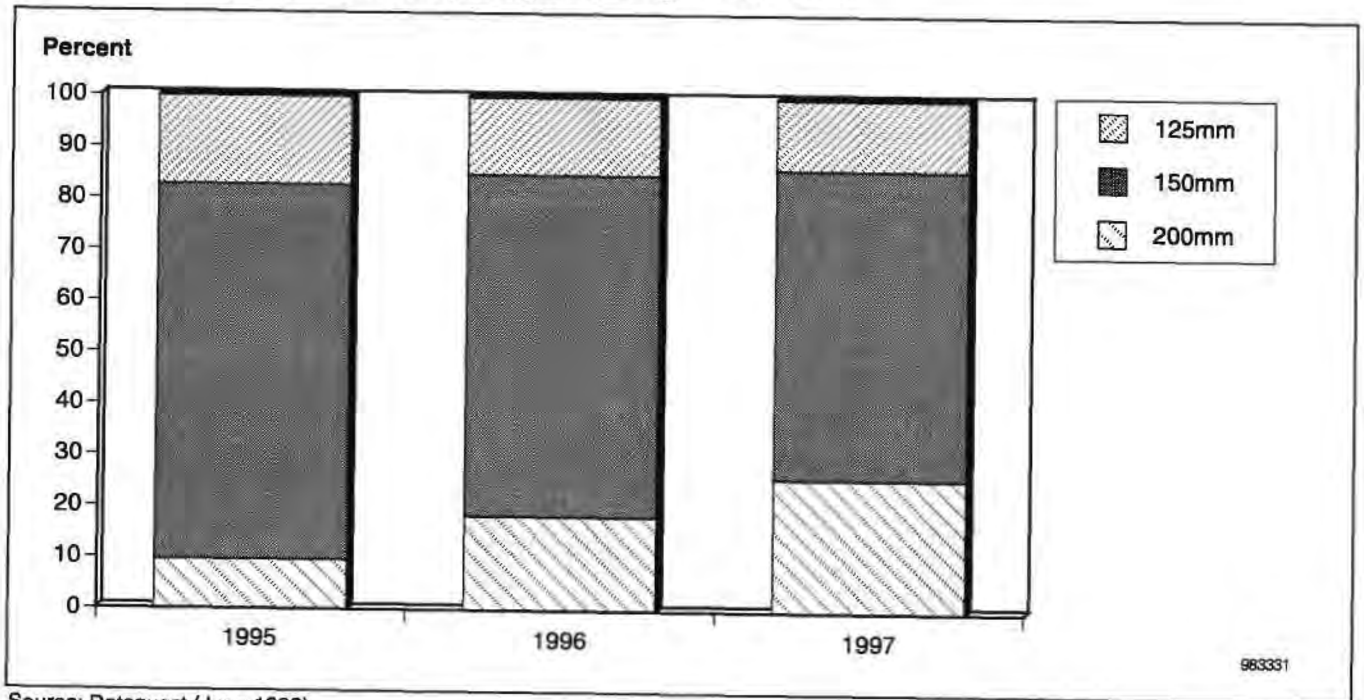
These technology trends suggest that Japanese foundries are focusing on higher capacity utilization for 200mm fabs, while they still have to establish capabilities to support U.S. fabless companies.

Figure 3
Japanese Companies' Foundry Shipments by Product



Source: Dataquest (June 1998)

Figure 4
Japanese Companies' Foundry Shipments by Wafer Size



Source: Dataquest (June 1998)

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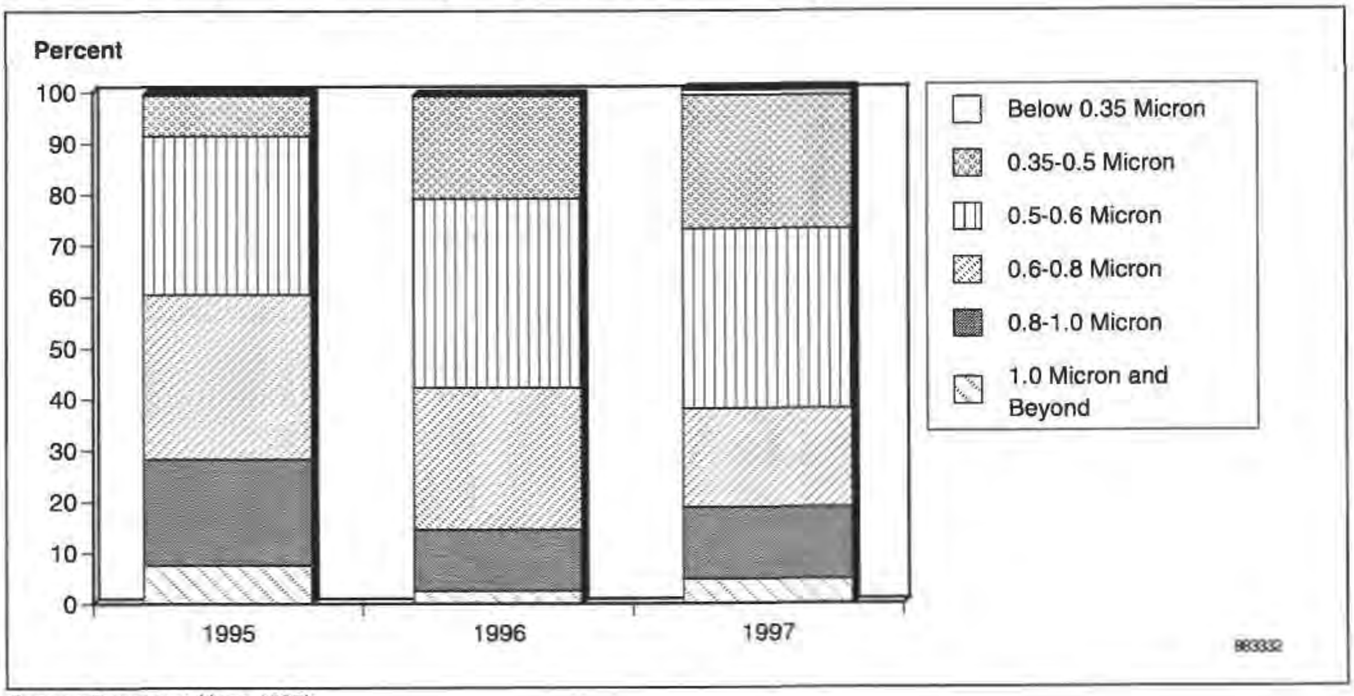
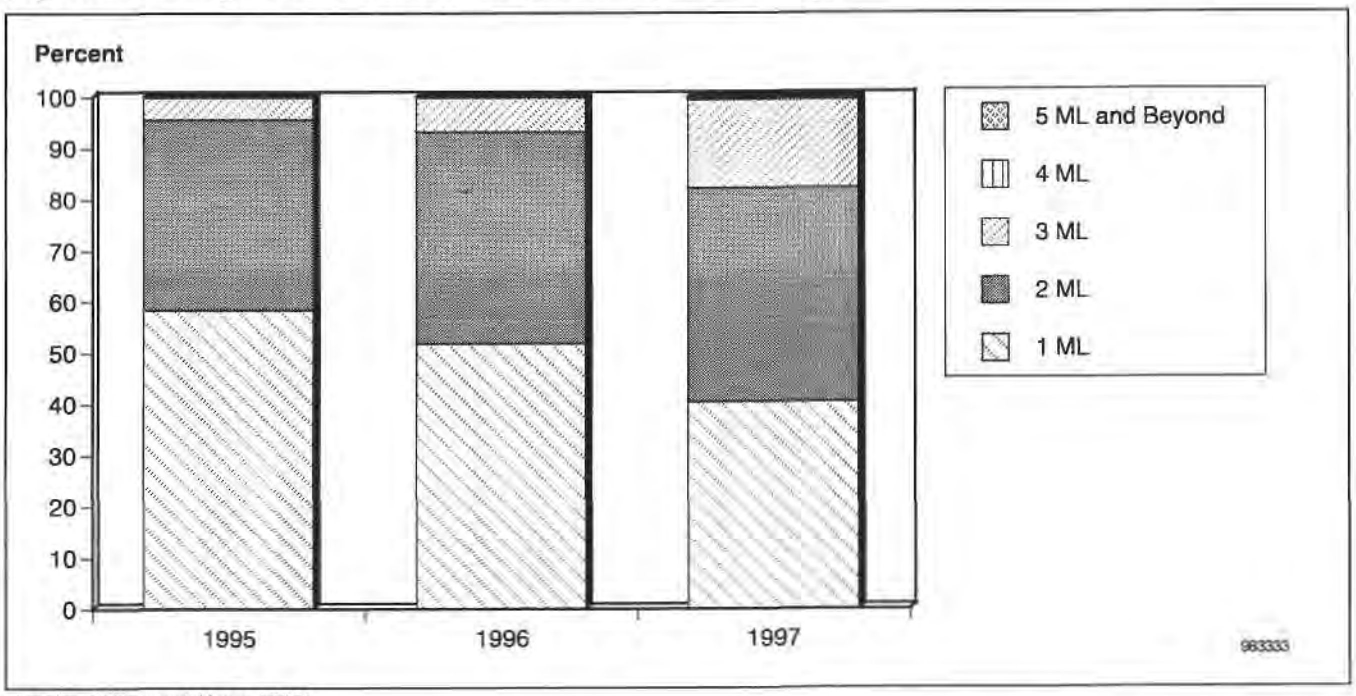
Figure 5
Japanese Companies' Foundry Shipments by Geometry



Source: Dataquest (June 1998)

Figure 6
Japanese Companies' Foundry Shipments by Metal Layer



Source: Dataquest (June 1998)

Foundry Orders on the Rise

Showing a clear contrast to declining foundry shipments, foundry orders by Japanese companies have been increasing steadily, although their worldwide share is still fairly small. While Japanese IDMs have not yet utilized their DRAM capacity fully, their logic fabs are not meeting customer demand, either in volume capacity or in technological capability. Rather than converting memory fabs to logic, which requires additional capital spending, Japanese IDMs are trying to leverage the low production cost of dedicated foundry providers. Alliances and foundry deals involving Japanese companies can be classified into the following models.

Evolution from Joint Development to Foundry Production

Primary examples are Sharp, producing flash memory for Intel Corporation, and Hitachi Ltd. and Mitsubishi Corporation, which share development and production efforts for their own brands of flash products. The intent is to reduce the R&D burdens on circuit design, process technology development, and product planning, while optimizing a production system where partners are responsible for production resources that they can provide with a comparative advantage.

Generally, the manufacture of a product developed by a partner leaves a foundry (an OEM) with relatively little value added. Still, the foundry provider can benefit by gaining experience with a product that it would be difficult to develop or market on its own, not to mention the infusion of new technology, which may enable it to develop proprietary products. This type of partnership can be mutually beneficial as long as each partner has a key technology to license. By sharing the development process from the outset, the production process can be made more reliable. At the same time, it allows the partners to maximize flexibility and efficiency in marketing their own products.

Capacity Supplementation

Traditionally, Japanese companies have seen foundry contracts as a means of using their excess capacities and keeping fabs highly utilized. In particular, when companies are hit by recession just as fabs invested in during a booming market come on line, foundry use is considered to be the "last resort" to avoid idling capacities. Companies often accept orders that are far below the ordinary break-even point for brand shipments.

Foundry deals in the form of such capacity supplementation are typically limited to a specific period, especially in the case of an IDM, that is, until the IDM's own fab is ready for start-up. In the case of an OEM deal, foundry production may be a temporary relief for the customer until it has the ability to develop and manufacture its own products. On the other hand, the OEM may rely on the foundry deal as a strategic instrument that effectively prevents the manufacturer from making inroads into the market.

At present, Japanese companies that order foundry production to supplement their capacities are primarily doing so in the DRAM field, such as Hitachi/LG Semicon, Fujitsu/TSMC, and Toshiba/Winbond Electronics.

The Hitachi/LG Semicon deal is unique in that the two companies—major players in the DRAM market with their own established brands—have entered an alliance in the form of a joint production arrangement. Hitachi also maintains a long-term relationship with Texas Instruments Inc. and operates diverse DRAM processes. This framework allows Hitachi to disperse burdens and risks related to product development and manufacture, but at the same time, Hitachi has presumably been loaded with the management of those diversified masks and processes. For LG Semicon Co. Ltd., the alliance is intended to ensure a jump-start of its new business thrust by leveraging technology and production capacities.

The other two deals differ from that of Hitachi and LG Semicon. TSMC and Winbond Electronics Corporation do not intend the first step of entering the DRAM market for foundries. The decision by TSMC to start a DRAM foundry with Fujitsu seems to represent a point of confluence for TSMC's strategy to establish "0.35-micron and beyond DRAM cell" technology, which was included in its technology road map. On the other hand, Fujitsu intends to disperse risks related to capital spending. These two companies' strategies match, which has led to their foundry deal. The Toshiba/Winbond alliance, which follows a similar pattern to the TSMC case, is characterized as part of their broader partnership, including LCDs.

Strategic Alliance

The Toshiba/Motorola alliance has served as a model for a constructive relationship between Japanese and U.S. semiconductor industries facing much-publicized trade friction. This broad-based, long-term (seven-year) relationship embraced a number of models and paved the way for a myriad of subsequent alliances. Among these were joint product development initiatives uniting the strengths of the partners, committed assistance in increased access to the Japanese market, wafer fab production at a joint venture (for instance, Tohoku Semiconductor), and factory-based collaboration in production efforts.

Nevertheless, the relationship seems to have matured to a stage requiring redefinition as the Japanese semiconductor market is losing its attractiveness in the global context and semiconductor production in the country is waning in terms of comparative advantage. The Hitachi/TI alliance faces a similar situation. Under the long-term relationship, the two companies chose a U.S. joint venture rather than a foundry contract. However, the joint venture was discontinued this March. In this sense, foundry is becoming a less desirable option for IDMs, which have traditionally used it as part of a strategic alliance. Foundry business itself increasingly makes sense on the basis of its flexible, low-cost production.

Evolution from Joint Production

Mitsubishi Electric Corporation has established Powerchip Semiconductor Corporation with UMAX Group of Taiwan to reduce financial burdens from capital spending, use the Taiwan semiconductor industry and its increasingly credible resources, and explore a new DRAM user (since UMAX is a PC motherboard manufacturer). The deal includes a new attempt to reduce the workload for marketing efforts through the joint venture, as opposed to the traditional approach that foundries are solely responsible for production. Powerchip is authorized to ship its own products in excess of a certain production level under its own brand. If this happens, shipments to Mitsubishi Electric will be on a partial foundry basis that goes beyond the traditional, narrow definition.

The Powerchip case relied on UMAX's high expectations for profits from the booming DRAM business as well as Mitsubishi's expectation of securing users for its products. In this sense, this type of alliance cannot be positioned as a general model. Nevertheless, it certainly suggests one of the feasible directions for the industry, which is seeking a way to reduce capital investment requirements by leveraging the technological prowess of each company.

This categorization seems to depict, among other things, the versatile roles of Taiwan companies. Backed by rich financial resources, they have successfully developed semiconductor production into the broad relationships shown here. Japanese PC manufacturers have accelerated procurement from Taiwan companies on an OEM basis since the mid-1990s. The viability of these complementary roles is based on the fact that semiconductor companies in the two countries are both primarily vertically integrated electronics manufacturers. This long-term relationship seems to lay the foundation for diverse alliances in semiconductor production and can serve as the core of a strategy.

Dataquest Perspective

Japanese semiconductor companies largely assume foundry business to be less than profitable, which clearly reflects the "opportunistic" nature of the Japanese foundry business model. Foundry business is forced to assume this less-than-exalted position for several reasons. First, obsolete fabs, rather than leading-edge ones, are used for foundry. Second, the primary purpose of foundry production lies in maximizing utilization. Finally, foundry production is considered a part of complementary or diverse alliances between IDMs. However, with the emergence of TSMC, which has proven the high profitability of the dedicated foundry business, Japanese companies are looking for opportunities to improve the profitability of their own foundry contracts. Many are expecting foundry deals to fill a growing gap between demand and supply capacity stemming from the prolonged recession of the semiconductor market. However, this expectation is no longer feasible, as evidenced by declining foundry revenue. Clearly, the tide has turned. The foundry market continues to establish itself by offering lucrative opportunities for specialized manufacturers. It cannot be viewed as the last resort for IDMs to replenish idling capacities.

Dr. Morris Chang of TSMC, in his recent speech at Dataquest's Semiconductor Conference 98, stated, "It is not correct to think of foundry as a manufacturing issue. Rather, foundry is a service business, and without that notion, you cannot be successful in the business." Foundry service as a reliable and viable business becomes feasible only when there is no need for

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the manufacturer to adjust a process conflict with its own products, which strongly suggests the need for the specialized company.

For dedicated foundry providers, Japanese semiconductor companies can be primary customers because of their broad product lines and business structure, which require ever-growing capital spending. The benefits they offer, that is, elimination of the need for capital investment, including broad process development and optimization toward volume production, are highly attractive for Japanese companies. Not many Japanese companies, however, have a clear, corporatewide foundry strategy; only a handful of them are prepared to deploy foundry business by keeping the optimum balance with brand businesses. What Japanese companies need is to establish core competence in the semiconductor business, which entails a redefinition of "strategic domains" in many cases. Dataquest believes that it is increasingly becoming a critical management issue for Japanese companies to utilize foundry providers (especially Taiwanese companies) effectively as an integral part of the redefinition process.

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Perspective

Semiconductors Japan

Dataquest Predicts

Spring 1998 Forecast: Japanese Electronic Equipment Production and Semiconductor Market

Abstract: *Dataquest's spring forecast shows downward adjustments for electronic equipment production and the semiconductor market in Japan and worldwide, reflecting a clear slowdown in the electronics industry following the end of the PC boom. In the long run, however, growth of the industry will continue, along with expansion of the semiconductor market. When will we see the market bottom out from the present recession, and in what form will this occur? In particular, will the DRAM market reach its bottom this year? Will system LSI become the key to market recovery? With a focus on Japan, this Perspective analyzes electronics production and semiconductor consumption trends up to 2002, on the basis of Dataquest's latest forecast. Unless otherwise specified, world market data is indicated in U.S. dollars, and Japan market data is in yen (exchange rates: ¥121.10/$1.00 in 1997 and ¥129.73/$1.00 from 1998 through 2002).*

By Yoshihiro Shimada, Motoya Ohgami, Masahiro Suzuki, and Yoshihisa Toyosaki

Electronic Equipment Production in Japan

The Japanese economy in 1997, after a temporary surge in domestic demand prior to the consumption tax hike in April, was beleaguered by turmoil in the financial system, a decline in consumer expenditure, and a slowdown in capital spending, which was amplified by the Asian financial crisis toward the year-end. Against the backlash, electronic equipment production showed stronger growth than expected, 7.8 percent over 1996, reaching ¥23,715 billion. Cellular phones contributed greatly as fueled by a series of price cuts and the shift in demand from personal handy phone (PHS) models. Electronic data processing (EDP) equipment also outgrew the forecast, despite a slowdown in domestic PC shipments, and consumer equipment added some momentum that came from video game systems and digital equipment.

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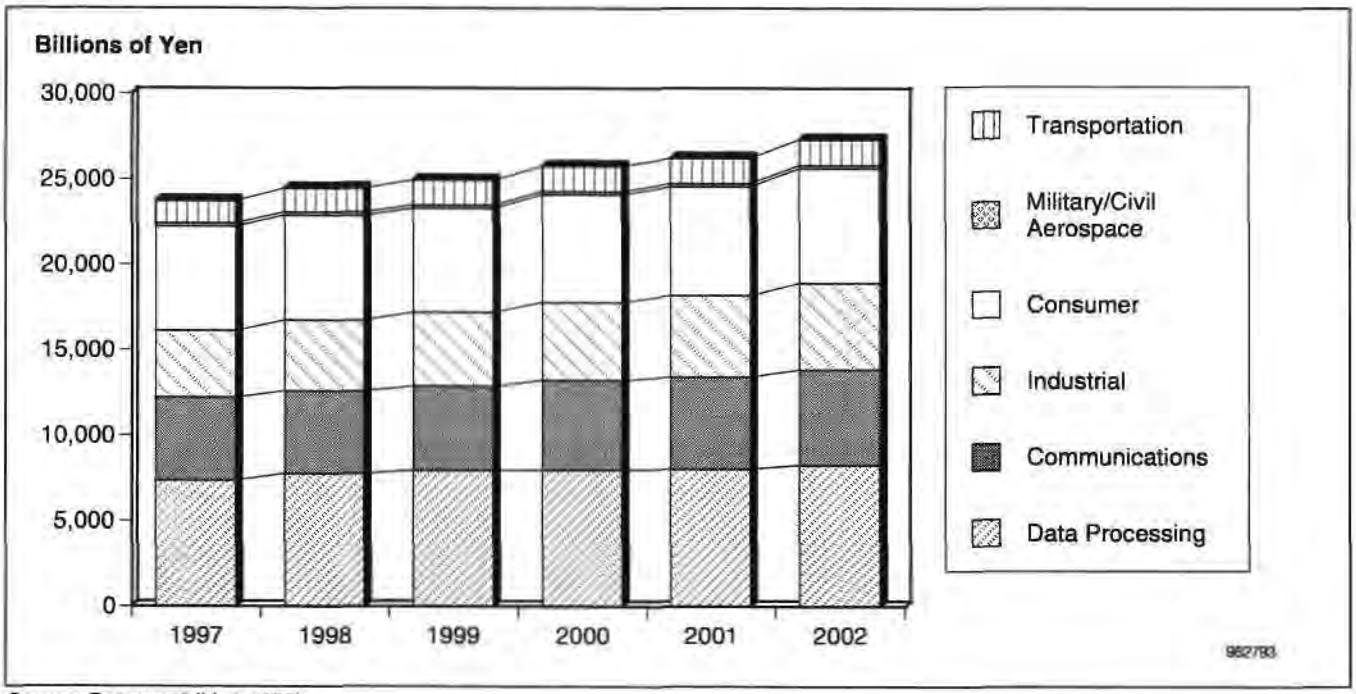
In 1998, communications equipment will no longer serve as a major impetus, as the cellular phone market reaches a high level of penetration and digitization of backbone networks completes its first round. Thus, Dataquest predicts that electronic equipment production in Japan will grow at a moderate 3.1 percent to ¥24,459 billion, down 1.5 percentage points from the fall forecast. Similarly, the compound annual growth rate (CAGR) between 1997 and 2002 will settle at 2.8 percent (see Figure 1).

Future growth opportunities must come from a surge in PC demand stimulated by introduction of low-cost models, and increased implementations of plug-and-play interfaces such as Universal Serial Bus (USB) and Institute of Electrical and Electronics Engineers (IEEE) 1394. While Windows 98 will not have much impact on the PC market, evolution of PCs to a new platform for WebTV and other media-mix services will hold the key to growth of demand for personal equipment.

The following section provides a detailed analysis of electronic equipment production in Japan, by major segment.

Figure 1
Japanese Electronic Equipment Production Forecast



Source: Dataquest (May 1998)

EDP Equipment

In 1997, EDP equipment production in Japan soared 8.3 percent to ¥7,380 billion (see Figure 2). While PC shipments to the domestic market slowed down to less than 5 percent on a unit basis, the price decline spurred the purchase of peripherals such as printers and display units. Also, storage devices led by high-speed optical disk drives, for example, 32x CD-ROM drives and DVD-ROM drives, enjoyed strong growth. The segment is expected to drive the market in the forecast range.

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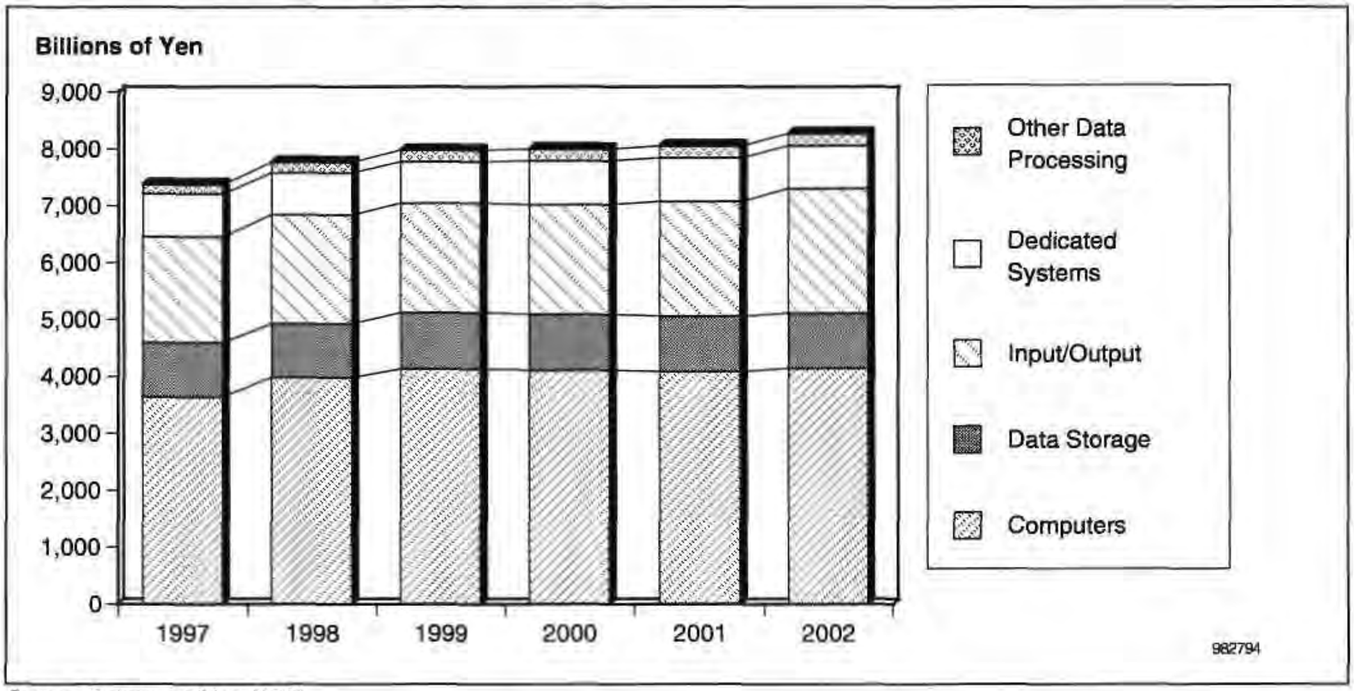
Figure 2
Japanese Data Processing Production Forecast



Source: Dataquest (May 1998)

IT investment will continue to be a major driver in 1998 while Japanese financial institutions are exposed to global competition as a result of the "Big Bang," which urges them to strengthen information systems. Therefore, more than compensating for the general economic slump, computers will drive EDP equipment production, growing 5.3 percent in 1998 with a CAGR of 2.3 percent during the next five years. Gradual recovery of the Japanese economy will continue to fuel EDP equipment production after 1998, which should exceed ¥8 trillion in 2001.

Communications Equipment

Communications equipment production in 1997 jumped 19.8 percent to ¥4,844 billion (see Figure 3). A prime driver was mobile communications equipment; subscribers grew much faster than expected, recording a net increase of 10 million in 1997. While PHS production decelerated at 7 million units, the market is expected to expand as its focus shifts from personal to office use.

Nevertheless, the penetration of mobile phones combining PHS and cellular phones has surpassed 50 percent, and continuation of previous high growth will become inevitably difficult. Meanwhile, digitization of infrastructure facilities by Nippon Telegraph and Telephone (NTT) was completed by the end of 1997. These factors will consequently put a brake on communications equipment production, which will turn into negative growth of 0.2 percent. On the other hand, network equipment, including LANs, will experience healthy growth at a CAGR of 15 percent or above. All in all, communications equipment production will grow at a CAGR of 2.9 percent between 1997 and 2002.

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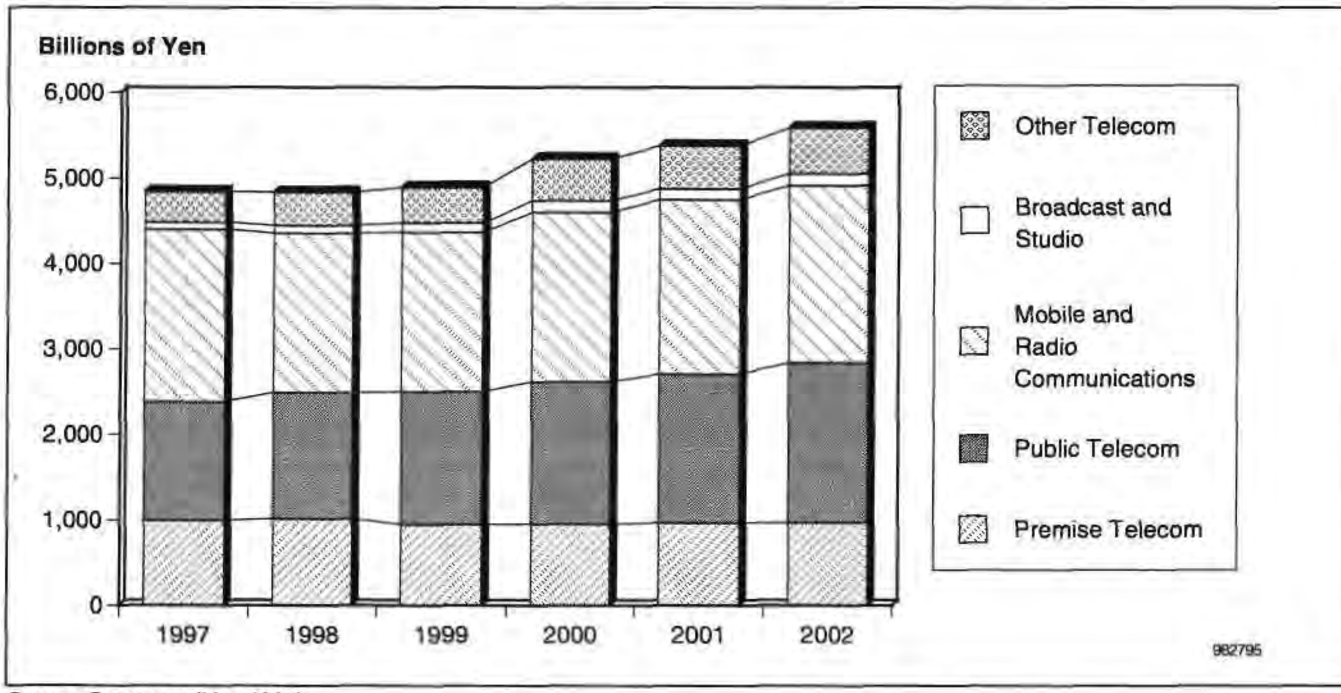
Figure 3
Japanese Communications Equipment Production Forecast



Source: Dataquest (May 1998)

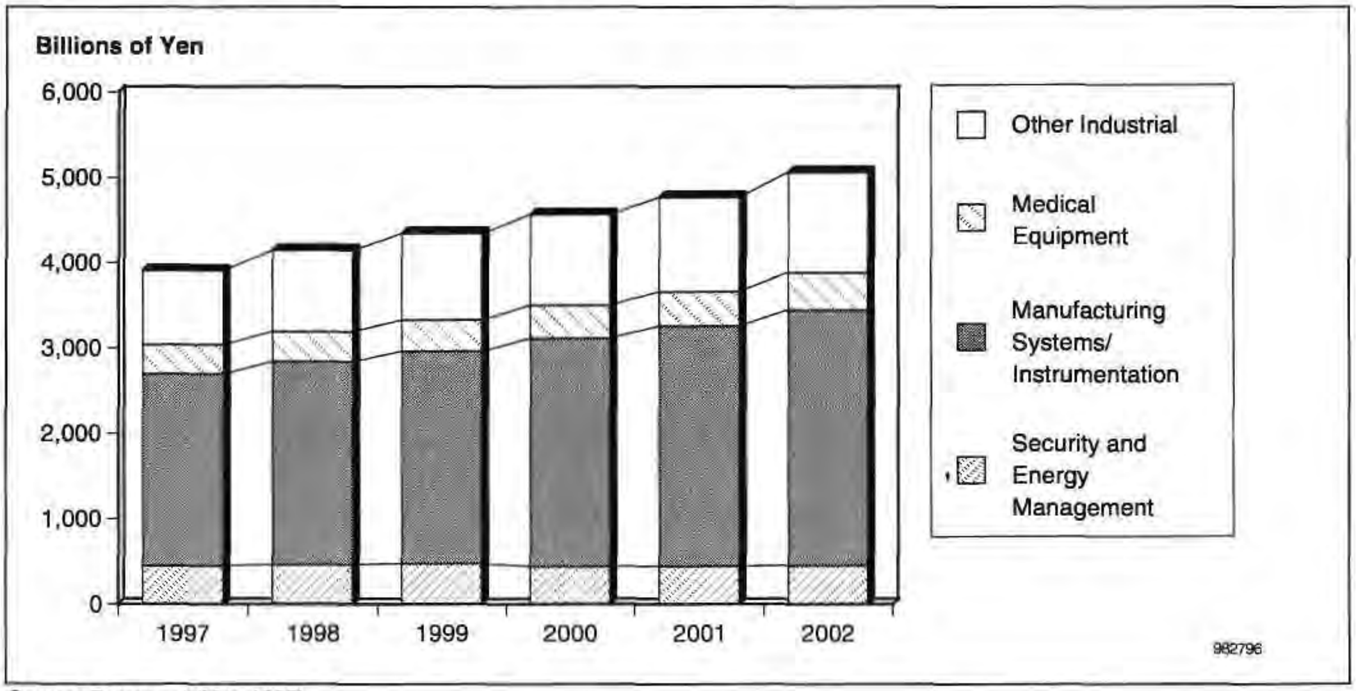
Industrial Equipment

Industrial equipment production in 1997 was up 7.2 percent, totaling ¥3,908 billion (see Figure 4). Of the total, manufacturing systems and instruments recorded the highest growth rate of 14.9 percent. As the wave of relocation of production sites to Asia/Pacific countries subsides, the focal point of the market will shift to computerization and sophistication for value addition and further automation. In particular, medical equipment will show strong growth, with increasing demand for advanced systems to meet the needs of the aging society, resulting in the CAGR of 5.2 percent between 1997 and 2002. Overall, Dataquest predicts a CAGR of 5.3 percent, the highest among the six segments.

Consumer Equipment

Consumer equipment production recorded a 1.3 percent increase in 1997, reaching ¥6,098 billion (see Figure 5). In the video equipment segment, where TVs and VCRs sold in the domestic market are mostly made overseas, it was the replacement demand for wide-screen TVs produced at domestic sites that contributed greatly. In the digital consumer equipment market, digital video cameras (DV-Cs) recorded notable growth, and unit shipments up to the end of 1997 were estimated at slightly below 1 million. The DV-C will become pervasive quickly, driven by price declines and improved availability of key components. Similarly, digital still cameras (DSCs) will ramp up rapidly as they can be easily connected to PCs or TVs via a flash memory card or IEEE 1394 interface. On the other hand, commercialization of digital TVs will have to wait until after 2000 as infrastructure construction has been delayed.

Figure 4
Japanese Industrial Equipment Production Forecast



Source: Dataquest (May 1998)

The current recession will hit household appliance production directly, leading to negative growth in 1998. Video game systems will continue to be a fierce battlefield for a 32-bit hegemony, but production will remain mostly unchanged in 1998, until the next-generation products are introduced in 1999. Dataquest predicts that consumer equipment production as a whole will grow at a CAGR of 1.9 percent between 1997 and 2002.

Japanese Semiconductor Market

In 1997, the Japanese semiconductor market recorded negative growth on a dollar basis, becoming the only market to shrink among the four world regions. Although the yen depreciation diluted the dollar-based figure, the fact remains that the Japanese market is the weakest of the four regions. While electronic equipment production grew faster than previously forecast, semiconductor consumption was sluggish. This indicates that a major source of growth in electronics production came from the segments with little semiconductor content. Also, PC shipment lost momentum in Japan, exerting negative impact on consumption of a variety of semiconductor products, including memory, microprocessors (MPUs), and logic.

The Japanese semiconductor market in 1998 will grow at 9.8 percent (2.5 percent on a dollar basis), down from the fall forecast (see Figure 6). While this reflects the anticipated slowdown in electronic equipment production and the hovering market conditions for DRAMs, a recovery is expected in the second half, leading to double-digit growth. Nevertheless, the CAGR

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between 1997 and 2002 will be the lowest among the four regions, at 12.4 percent (10.9 percent on a dollar basis).

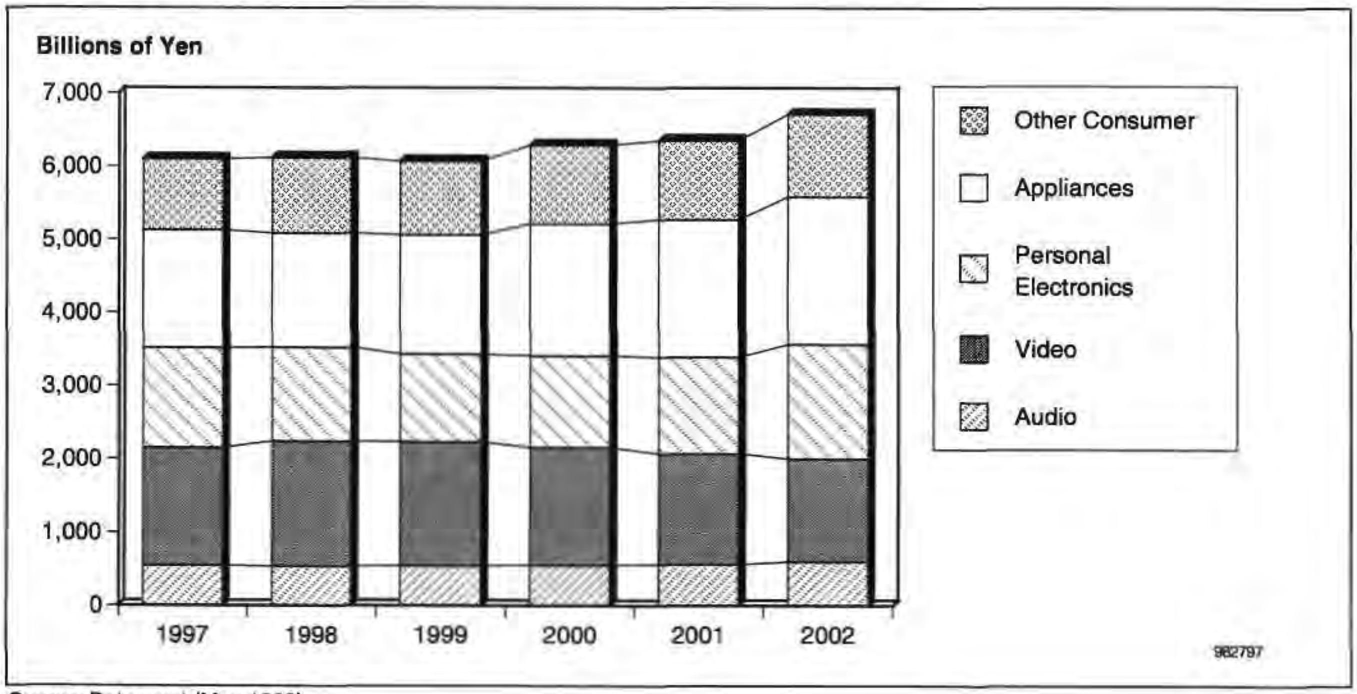
The following section analyzes the future outlook for the Japanese semiconductor market by device.

MOS Memory

In 1997, the Japanese MOS memory market suffered a 14.5 percent decline (23.1 percent on a dollar basis) (see Figure 7). Dataquest predicts that the 1998 market will grow 7.0 percent (a 0.1 percent decrease on a dollar basis), which represents a downward adjustment of 6 percentage points compared to the fall forecast. Again, DRAM price decline because of supply glut is the major culprit. While increased 16Mb production by U.S. companies triggered the price fall in 1997, the aggressive moves of Korean suppliers will dictate DRAM prices. At present, 16Mb prices continue to fall below $3 on the spot market, which pulls 64Mb prices downward.

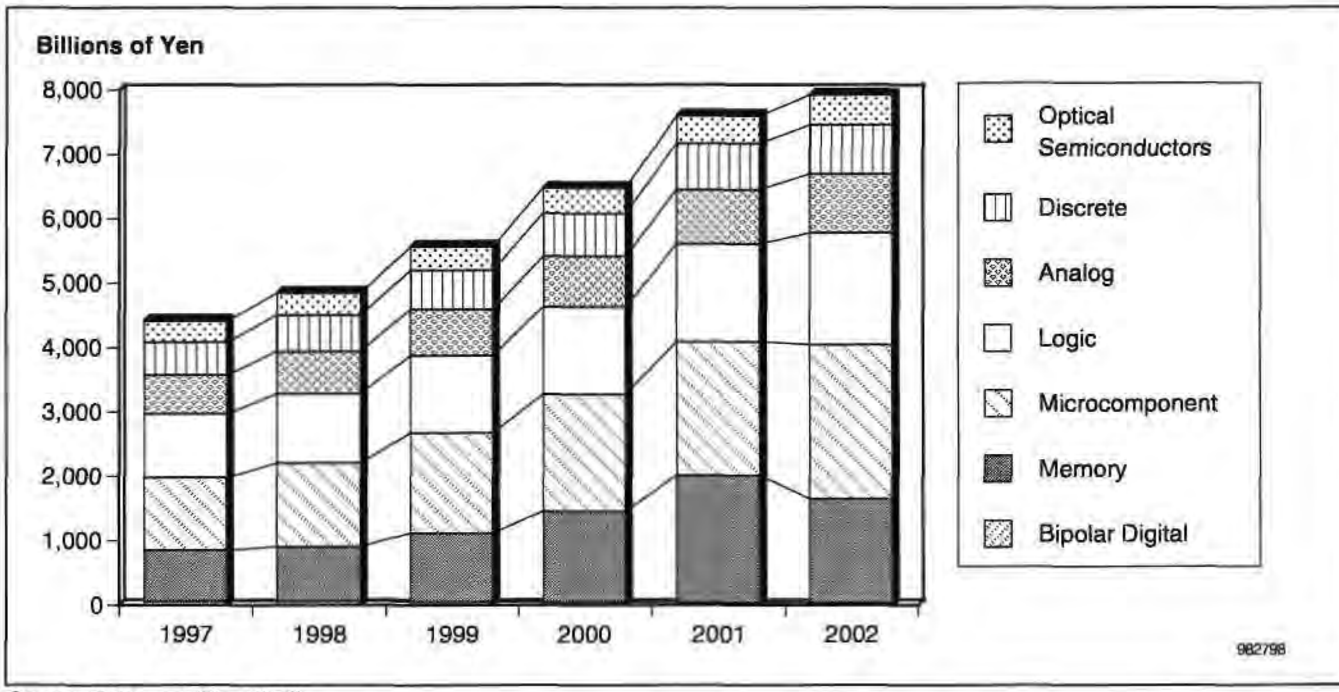
The Japanese MOS memory market in 1998 will be driven by SRAM, EEPROM, and flash memory. In particular, after 1999, the DRAM market will expand at an accelerated pace, while SRAM and nonvolatile memory markets will maintain healthy growth. In 2002, however, the DRAM market will experience negative growth as the generation crossover from 64Mb to 256Mb occurs. Dataquest predicts that the market's CAGR between 1997 and 2002 will be 15.4 percent (13.8 percent on a dollar basis).

Figure 5
Japanese Consumer Equipment Production Forecast



Source: Dataquest (May 1998)

Figure 6
Japanese Semiconductor Consumption Forecast



Source: Dataquest (May 1998)

While the fall forecast assumed that DRAM companies would curtail capital spending in 1998, they are currently moving to minimize the rate of investment cutbacks where possible. In particular, Korean companies are considering maintaining capital spending as close as possible to the 1997 level (on a won basis), despite the DRAM recession and the pain from the AFC. Dataquest pointed out in the fall forecast that a major reduction of 64Mb-production capacity would be required to regain revenue growth in 1998. However, DRAM companies are not reducing capital spending as much as expected, which necessitated the downward adjustment of the DRAM market growth forecast.

In 1998, a major event in the DRAM market will be a full-blown shift from extended data out (EDO) to synchronous DRAM (SDRAM). During the first half of 1998, 100-MHz SDRAMs for PC100 will keep a price premium against 66-MHz versions, which will significantly narrow in the second half as DRAM companies roll out 0.25-micron fab lines. After 1999, the Japanese DRAM market will be driven by better-managed capacity expansion by DRAM suppliers, recording a CAGR of 16.1 percent (14.6 percent on a dollar basis) between 1997 and 2002.

The Japanese nonvolatile memory market will be up slightly 0.3 percent (6.3 percent down on a dollar basis) in 1998 because of double-digit declines in EPROM and mask ROM, which will more than offset the 20 percent growth of EEPROM and flash segments. The CAGR between 1997 and 2002 will be 9.6 percent, as the market will be driven by EEPROM and flash memory.

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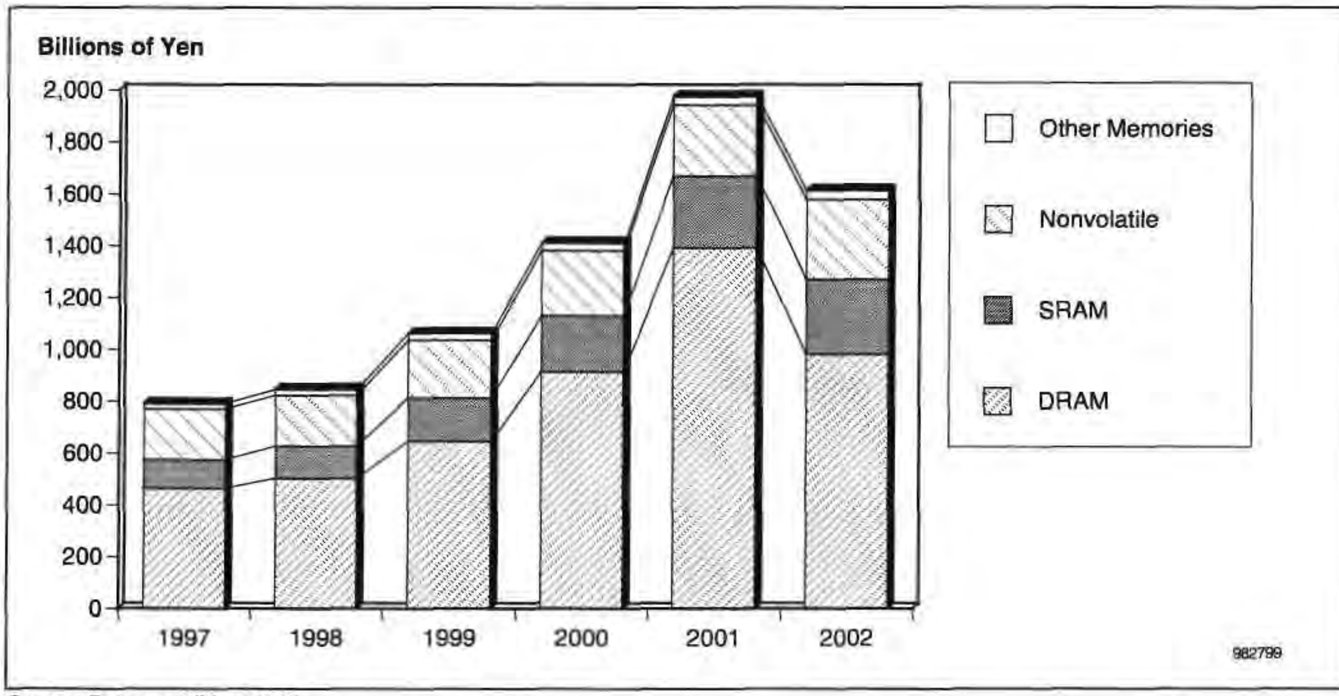
Figure 7
Japanese Memory Consumption Forecast



Source: Dataquest (May 1998)

The Japanese flash memory market recorded negative growth of 9.8 percent in 1997, but it is expected to resume growth in 1998. Major applications include mobile communications equipment, led by cellular phones as well as IC cards. In particular, smart phones are expected to ramp up early in Europe, becoming an important consumer of flash memory. This is expected to a have a positive impact on the Japanese mobile communications and flash memory market.

In the MOS memory market, Japanese semiconductor companies still strive to become less dependent on DRAM business. Large suppliers will increasingly shift their strategic focus to flash memory. The 1997 flash market saw price declines in 8Mb-or-less products. Dataquest expects that the move will spread to 16Mb-or-larger segments in 1998 and after.

MOS Microcomponents

The Japanese MOS microcomponent market will expand 15.2 percent (7.5 percent on a dollar basis) in 1998 (see Figure 8). The CAGR between 1997 and 2002 will be 16.2 percent (14.6 percent on a dollar basis) with firm growth expected for each year.

The Japanese MPU market in 1998 will fail to meet the previously forecast level because of the slowdown in the PC market. The market should grow at 12.6 percent (5.1 percent on a dollar basis). The market will see a wider variety of products besides Intel's X86 families (Pentium with MMX technology, PentiumPro, and MMX Pentium II). Products will include non-Intel, high-speed MPUs, MPUs for low-cost PCs, and MPUs designed for

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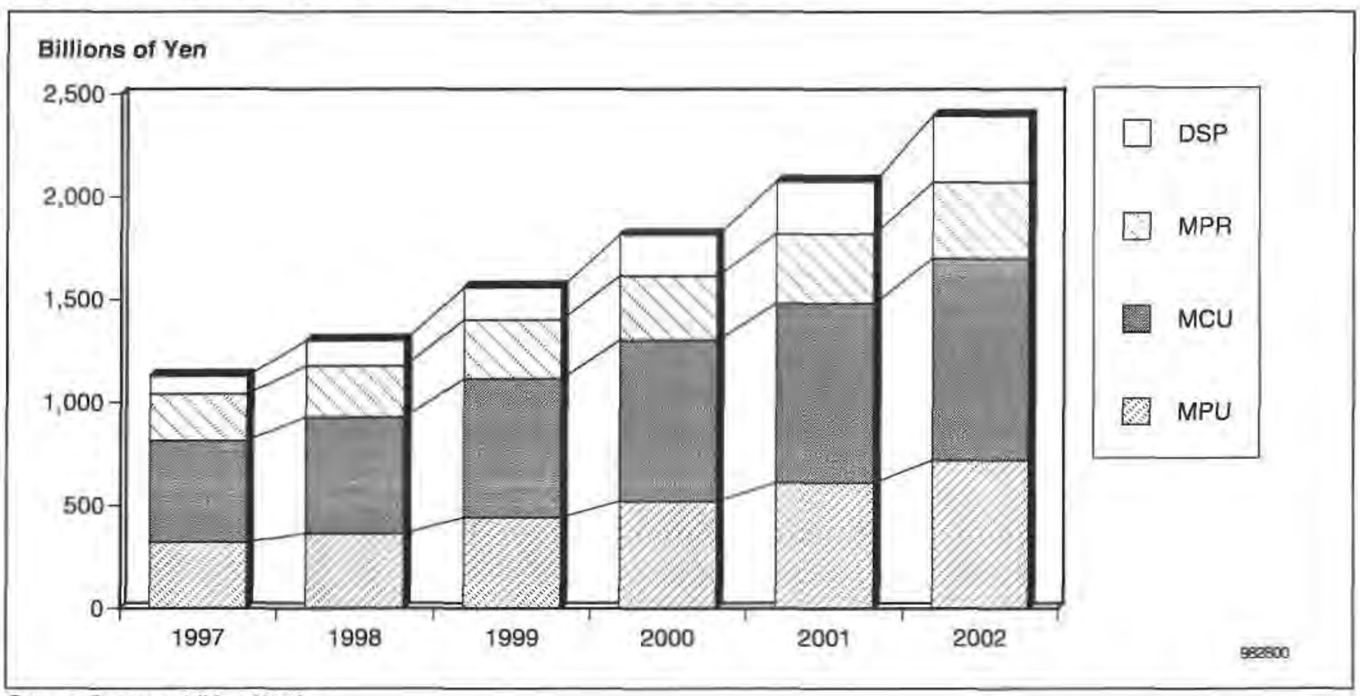
portable applications, including mobile computing (embedded MIPS, SH, Strong ARM), for example, Tillamook, Mobile Pentium II, and Windows CE2.0.

Microcontrollers (MCUs), the largest of the Japanese microcomponent segments, are expected to surge 15.1 percent (7.4 percent on a dollar basis) in 1998. They are incorporated into a variety of electronic equipment. Low-bit versions are embedded into household appliances for system control purposes, many of which are implemented on a 4-bit or 8-bit basis. Japanese companies still hold a dominant share in the 4-bit segment.

Four-bit MCUs are used in diverse products ranging from toys to analog cordless telephones, and companies are still exploring new applications. Nevertheless, the market size will grow only moderately, partly because of the weakening demand from portable game systems, which have been a major driver, and partly because of increased migration to 8-bit products. In particular, revenue growth will be minimal because of low prices, although unit growth may continue.

On the other hand, the 8-bit MCU market will enjoy strong growth as a result of upgrading from 4-bit applications and the need to address the increasing complexity of system control. Development of MCUs embedding flash-memory technology is under way, and the competition has heated up among U.S., European, and Japanese companies for market share.

Figure 8
Japanese Microcomponent Consumption Forecast



Source: Dataquest (May 1998)

In 1997, 8-bit MCUs were used in most electronic equipment, including the following range of products:

- Video and audio equipment
- Computer-related equipment, including keyboards and display units
- Communications equipment, including analog cordless telephones and digital portable telephones
- Antilock braking systems (ABSs)
- *Pachinko* game systems
- Household appliances

Applications expected to emerge in 1998 and afterward include smart cards, minidisc (MD) players, USB controllers (8-bit basis), and MCUs incorporating Infrared Data Association (IrDA) communications features. Encouraged by potential demand for contact/noncontact IC cards, semiconductor companies will opt for alliances to consolidate technological resources and vie for industrial standards. Finally, MCUs integrating ferroelectric memory technology will be introduced to the noncontact IC card market to invigorate the 8-bit MCU market.

Sixteen-bit MCUs, on the other hand, will be increasingly used for digital processing applications, particularly digital cellular phones, PHS phones, hard disk drives (HDDs), and CD-ROM drives. Applications expected in 1998 and afterward include DVD, fixed and on-board audio MD players, and DV-C. Again, flash memory technology will be increasingly incorporated to address system requirements in terms of flexibility, and semiconductor companies will focus on enhancement of their offerings.

As for 32-bit and 64-bit MCUs, system-level integration (SLI) based on ASIC technology will become the mainstay. Promising applications that will be developed after 1998 by using a leading-edge process and an embedded MPU include vehicle information and communication system (VICS)-based car navigation systems incorporating DVD-ROM drives, next-generation home/portable video game systems, and set-top boxes (STBs). Sixteen-, 32-, and 64-bit MCUs will enjoy strong growth next to 8-bit products, driven by price declines resulting from SLI, the emergence of digital consumer equipment, and digitization of systems. Dataquest expects solid profitability.

In 1997, rapid growth was seen in the flash MCU market. Major applications include memory cards for video game systems, CD-ROM drives, and HDDs, spurring consumption of 8- and 16-bit MCUs. As for multibit, embedded MPU (MCU) architectures, ARM will be rapidly accepted in 1998 and afterward. Diverse architectures offered by vendors (MIPS, M Core, SH, SPARC, PowerPC, and X86) will be optimized for different applications according to their SLI strategy.

In 1998, the Japanese microperipherals (MPR) market is expected to grow 9.6 percent over the previous year (2.3 percent on a dollar basis). A variety of PC peripherals based on PC98 standards will become pervasive, and different application-specific standard product (ASSP) segments (chipset, USB, IEEE 1394, and MPACT1/2) will grow in relation to different applications.

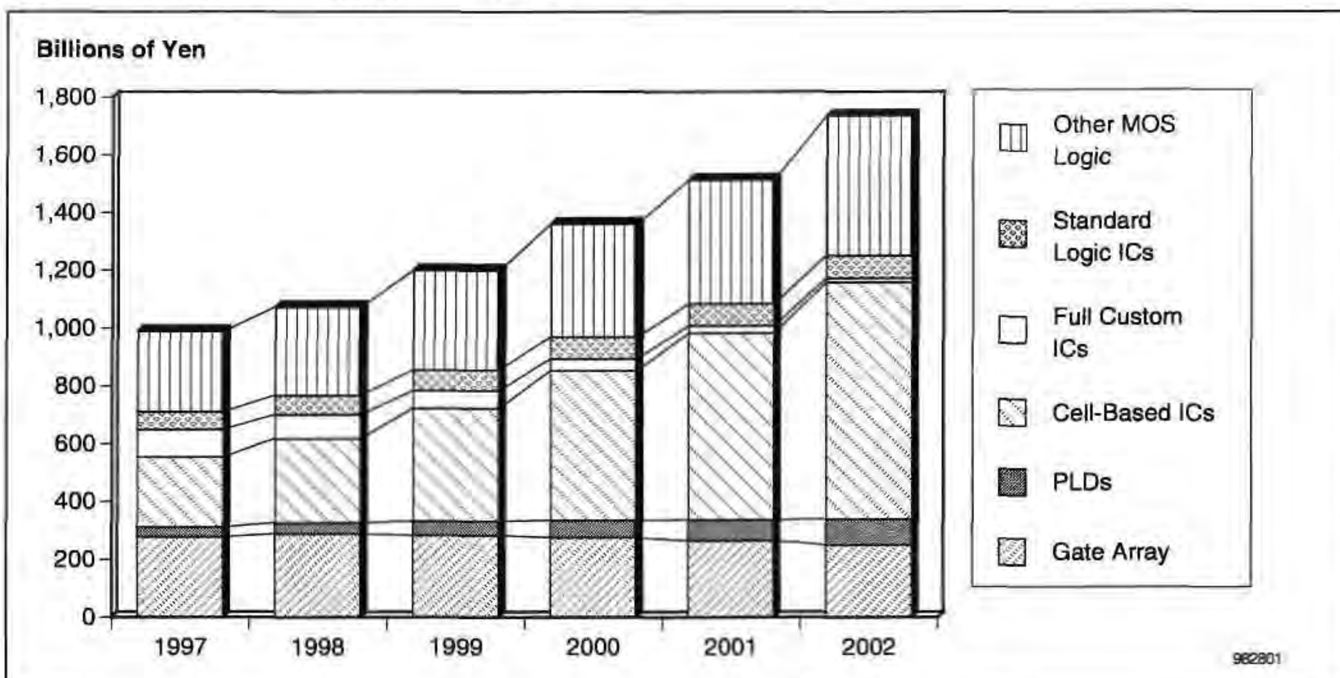
The Japanese digital signal processor (DSP) market will continue strong growth of 39.8 percent (30.5 percent on a dollar basis) in 1998. With the increasingly shortened development cycle for system products, DSPs and media processors will undoubtedly become core technologies as they offer flexibility in development of digital consumer equipment with the ability to reconfigure themselves by replacing middleware/microcode. By 2002, 0.18-to-0.12 micron processes will be commercialized. As a result, the DSP market will grow strongly at a CAGR of 29.7 percent (27.9 percent on a dollar basis) between 1997 and 2002.

Finally, embedded DSPs are increasingly incorporated into servo controllers for CD and MD players as well as codec processing for cellular phones. Generic DSPs including media processors are primarily used in high-speed analog modems (56Kbps) for PCs and sound source processing. New applications emerging in 1998 and afterward include digital cellular phones, which use a single chip integrating a 16/32 bit MCU and DSP, HDD controllers containing DSP/MCU and DRAM for buffer memory, and high-speed disk drives such as DVD-ROM/RAM, incorporating partial response maximum likelihood (PRML) technology and DSP.

Logic/ASICs

In 1998, the Japanese total logic market will grow 8.7 percent (1.5 percent on a dollar basis). The total ASIC market will expand 11.8 percent (4.3 percent on a dollar basis) (see Figure 9).

Figure 9
Japanese Logic Consumption Forecast



Source: Dataquest (May 1998)

In 1997, high-performance systems, as seen in digital consumer equipment, were implemented to incorporate multiple, large-scale circuits by using intellectual property (IP) core and leading electronic design automation (EDA) tools. We also saw a rapid increase in volume production of ASSPs and SLI ASIC products in single-chip implementation by using a highly integrated ASIC process and SLI technologies. A future challenge lies in reducing the cycle time for system development to minimize turnaround time (TAT) and R&D investment, reduce development-related risks, and support early LSI implementation.

Traditionally, the "core-limited design" issue, derived from large-scale internal cores, was a major obstacle in designing ASICs. Recently, however, as the ASIC process reached submicron levels, the shrink ratio of the internal core has been improved. This, in turn, has resulted in an increase in the "I/O pad-limited design," where I/O pads set the limit rather than cores. Also, flexibility in ASIC design to result in small-lot production adversely affects the profitability of business.

Many leading ASIC vendors in the Americas region started to de-emphasize gate array business by 1997. This move is favorable for the programmable logic device (PLD) market and accelerates the collapse of the U.S. gate array market. Technically, PLDs have already integrated 250,000 to 500,000 gates on a commercial basis by using process technology based on 0.25-micron, five-layer interconnect, and shallow trench structure. Dataquest believes that 1 million gates will be integrated by using a 0.18-micron process technology by 2000.

In 1998, the Japanese PLD market will show a strong growth of 15.6 percent (7.9 percent on a dollar basis). In Japan, the gate array business still dominates because of high captive demand. Nevertheless, as SLI will lead ASIC business in the future, the Japanese PLD market will grow to an appreciable size compared to the Americas market. Dataquest expects that the market will register the second-highest growth rate, following cell-based ICs (CBICs), with a CAGR of 21.3 percent between 1997 and 2002.

The Japanese CBIC market (including mixed signal) will grow 20.7 percent (12.7 percent on a dollar basis) in 1998. The ramp-up of 0.35- to 0.25-micron process manufacturing and the increasing need for design optimization in various applications have been driving the market for CBICs, which are regarded as the key infrastructure factor in SLI technologies such as embedded MPUs/DSPs, IP core, embedded memories, and mixed-signal designs. At the same time, the establishment of CBIC technology has caused the custom IC market to shrink rapidly, resulting in the negative CAGR of 15.2 percent (20.8 percent on a dollar basis) between 1997 and 2002.

At present, standard logic features such as small-scale integration (SSI), middle-scale integration (MSI), and large-scale integration (LSI) are mostly incorporated into ASICs, but demand for standard logic still exists in the area of super high-speed CMOS- or BiCMOS-based standard logic, such as CMOS-based one-gate logic products and wide bus products. Thus, the Japanese standard logic market will continue to grow steadily at a CAGR of 5.1 percent (3.7 percent on a dollar basis).

Finally, LCD drivers classified as other MOS logic will be driven by increased market acceptance of LCD-equipped systems as well as exploration of new application markets. As a result, the Japanese market's CAGR will be 11.8 percent (10.3 percent on a dollar basis) during the five-year period.

In 1998, ASIC suppliers announced a number of next-generation 0.18-micron processes, and some of them in Japan and the United States started volume production. Also development efforts are under way to commercialize a "unified process" that represents a "dream process integration." Dataquest believes that portable applications in the Japanese market will contribute to technological progress in the areas of ultralow operating voltage below 1.0V, embedded flash memory, mixed-signal designs, and high-density packages such as chip-scale packaging (CSP) and direct chip attach (DCA), thereby driving the SLI ASIC market.

Other Devices

The outlook for analog, discrete, and opto markets has been adjusted downward from the previous forecast. It should be noted that the analog market was partially affected by reclassification of linear array and mixed signal ASICs (although small in size) into total ASICs.

Dataquest sees that strong demand growth for analog ICs in the past few years has caused the industry to hold unduly high expectations. With the rapid progress of system diversification, accompanied by LSI implementations over several generations, demand for analog ICs and discrete devices experiences a momentum surge. Nevertheless, expansion of mixed-signal analog IC markets will ultimately lead to CBICs absorbing analog functions, so that suppliers tend to overestimate long-term demand by extrapolating the recent high-growth trends. Also, sluggish electronics production causes demand for generic analog devices to slow down.

In the first quarter of 1998, suppliers do not seem to be accelerating analog capacity, partly because of heavy constraints on investment resources. If supply capacity expands abruptly, prices will plummet to result in unit growth without revenue growth. Given this cap for capacity expansion, Dataquest believes that it is difficult for the Japanese analog market to continue double-digit growth.

Dataquest Perspective

After the rapid progress of production site relocation to the Asia/Pacific countries, electronic equipment production in Japan has increasingly depended on the domestic market by building high-value-added production capacities. Given the economic slump and curtailed personal spending in response to the gloomy outlook, digital consumer equipment incorporating advanced technologies fails to create a market opportunity, despite its great potential. Thus, strong growth of electronics production hinges highly on whether the ongoing attempt to reinvigorate domestic consumption can spur demand for new digital consumer equipment and personal information equipment.

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The slack state of electronic equipment production is directly reflected in softened semiconductor demand. At present, Japanese semiconductor companies sell about 50 percent of their products to the domestic market, even though Japan is expected to show the weakest growth trends in the forecast range years. If slow growth persists, overseas strategies cannot help being affected seriously. If the foreign exchange rate does not change significantly, and manufacturers opt to site production capacities near their markets, the increasing weight of overseas markets will cause Japanese companies to boost overseas production. Manufacturers lacking distribution channels other than Japan and the Asia/Pacific region will not be able to survive under the traditional strategy. This may create a dramatic change in the industrial landscape, including semiconductor equipment and materials.

The industry seems to expect a paradigm based on a new market driver: the development of digital consumer equipment by offering SLI-based solutions. Before that, it must answer a question raised in relation to the development of 300mm wafer fabs: "Will there be a market large enough to absorb the explosive growth of supply capacity?" Unless the industry finds an answer, it cannot rely on the domestic market as it has in the past. While Japanese companies have to streamline their business from nontechnological perspectives, such as the introduction of supply chain management, they may have to redefine their global operations and business structure. Dataquest believes that the industry's future lies in its ability to determine whether the redefined business structure serves the overall interest of maintaining business efficiency and whether it can adapt to the change derived from the redefinition process.

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Perspective

Semiconductors Japan
Market Analysis

The Present and Future of the Japanese Semiconductor Equipment Industry

Abstract: *The Japanese semiconductor device industry thrived on its DRAM business, but it is now being threatened by the Korean and Taiwanese competitors. The prosperity of the device industry led to the eminence of the wafer fab equipment industry. Today, Japanese equipment suppliers share the world market equally with U.S. competitors, with different industry structures that reflect the characteristics of the device industries of the two countries. This Perspective discusses the position of the Japanese wafer fab equipment industry on the basis of the two clearly distinguishable semiconductor markets and discusses opportunities and issues facing the industry.*
By Takashi Ogawa

The Japanese Semiconductor Equipment Industry Is Prosperous

According to Dataquest's survey, the world wafer fab equipment market in 1996 reached $21.68 billion, of which Japanese companies earned $8.75 billion and held a 40 percent share. Figure 1 shows the total semiconductor revenue of Japanese companies between 1982 and 1996, together with revenue from DRAM and wafer fab equipment. During that period, Japanese companies' semiconductor revenue recorded a compound annual growth rate (CAGR) of 17.4 percent. As is already widely known, Japanese companies earn a higher percentage of their semiconductor revenue from DRAM sales (the DRAM ratio) than U.S. companies. In 1996, the average DRAM ratio among U.S. chipmakers was 7 percent, while that of Japanese companies was a lofty 23 percent. This is closely associated with the development history of the Japanese device industry, which is equated with the DRAM business that has recorded such phenomenal success.

Dataquest
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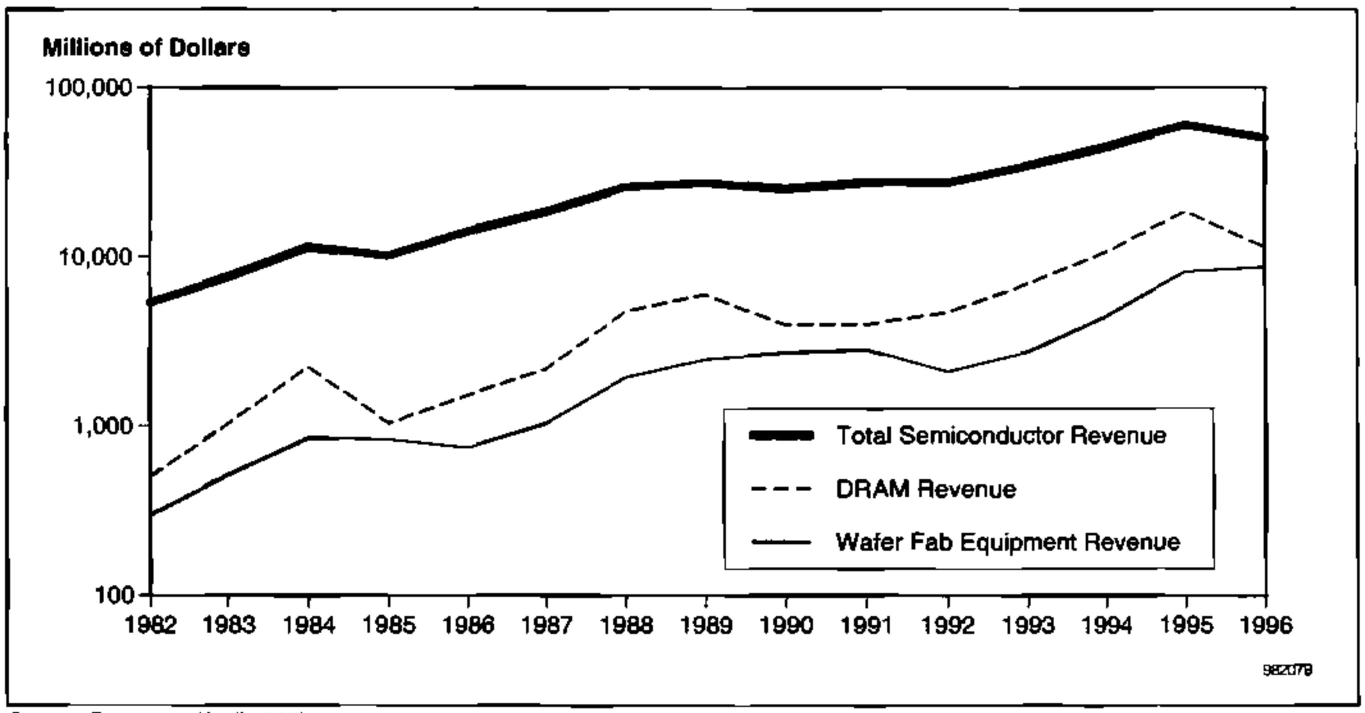
Between 1982 and 1996, the Japanese DRAM industry maintained strong growth at a CAGR of 25 percent. The growth path virtually synchronized with growth in sales of wafer fab equipment supplied by Japanese companies, which grew 30 times from $298 million to $8.75 billion during the period, at a CAGR of 27 percent. Semiconductor manufacturing technologies share common ground with device process technologies, so the emergence of a new process technology or the enhancement of existing technology spurs the birth of new production technology and equipment. Adoption of the new technology then leads to the emergence of a market.

Analyzing the history of semiconductor device development reveals a complementary relationship between wafer fab equipment technologies and device process technologies; both served to support the remarkable growth of the semiconductor industry. In other words, the device market and the equipment market have been evolving in closely related patterns that reflect their specific characteristics.

Figure 1
Changes in Japanese Companies' Semiconductor and Wafer Fab Equipment Revenue, 1982 to 1996



Source: Dataquest (April 1998)

Why Is the Japanese Wafer Fab Equipment Market the Way It Is?

In Japan, semiconductor production technology has evolved in close association with development of DRAM process technology. In the 1970s, Japan, under a near-national consensus to develop the semiconductor industry as a strategic sector, established several consortia, such as the VLSI Technology Research Association, which aimed to develop key process technologies. The industry used these projects to build a technological

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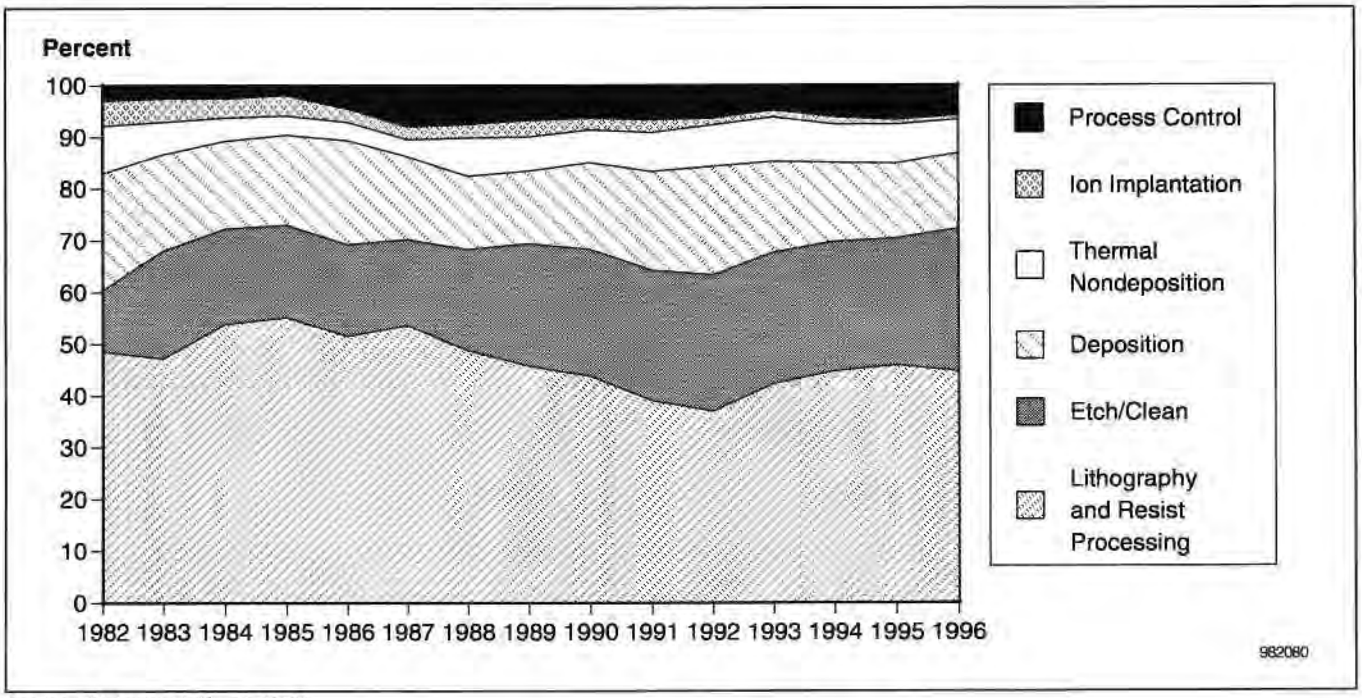
infrastructure in key areas such as exposure, deposition, and wafer fabrication. In the development process, a number of semiconductor equipment makers worked together with device makers. As they entered the nascent market, industrial leaders such as Nikon Corporation, Canon Inc., Kokusai Electric Co. Ltd., and Ulvac Japan Ltd. prepared themselves for success. More important, certain characteristics emerged and cemented the market. Figure 2 shows a breakdown of wafer fab equipment revenue by Japanese companies between 1982 and 1996 by segment.

Figure 2
Changes in Japanese Companies' Wafer Fab Equipment Revenue, by Segment, 1982 to 1996



Source: Dataquest (April 1998)

Lithography and resist processing equipment has consistently held a very high share, around 45 percent, except for some turmoil during downward phases of the silicon cycles. Of the DRAM process technologies, lithography equipment, led by steppers and developers, constitutes a critical element. To survive in the highly competitive and volatile DRAM market, manufacturers must keep up with a relentless cost-cutting race, boosting integration levels through chip shrinkage, adoption of increasingly fine design rules, and increasing the number of die from each wafer. Japanese semiconductor manufacturers, armed with superb production technologies, centered on lithography. Through joint development initiatives and quality control practices, they gained share in the worldwide DRAM market until the 1980s. Explosive device market growth has, in turn, spurred the equipment market. Japanese makers virtually monopolized the lithography and resist processing equipment market. This was during the time when the market was highly skewed toward lithography, and the resist processing segment was born.

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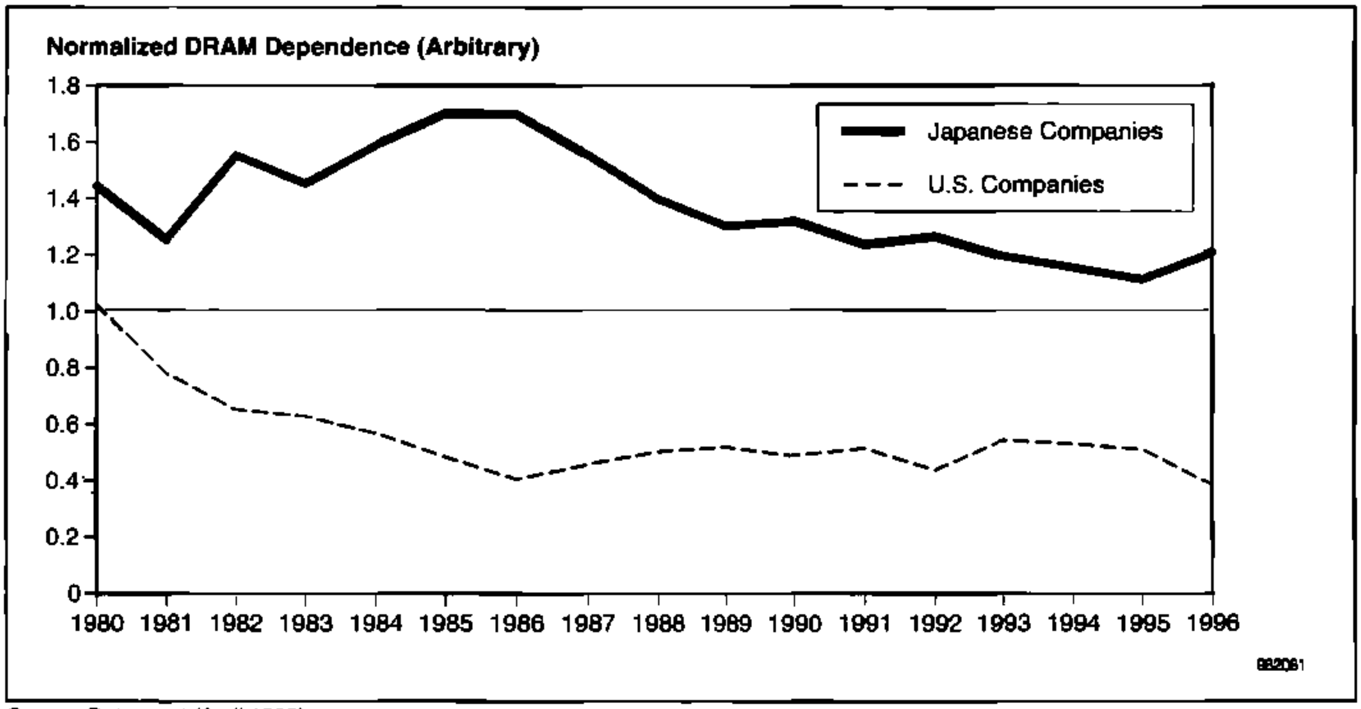
Figure 3 shows normalized DRAM dependence in semiconductor revenue. "Normalized" means that the worldwide average of DRAM dependence is standardized as 1.0. After 1986, Japanese companies gradually decreased their dependence on DRAM; however, their ratio remains at 1.2, higher than the worldwide standard of 1.0. Meanwhile, Japanese equipment makers, which have grown under the umbrella of the device makers, are pursuing global business deployment strategies, including targeting Korean chipmakers, but the market structure originally shaped by the DRAM industry during the dawn of the market has shown little change.

Figure 3
Changes in Normalized DRAM Dependence in Semiconductor Revenue, 1980 to 1996

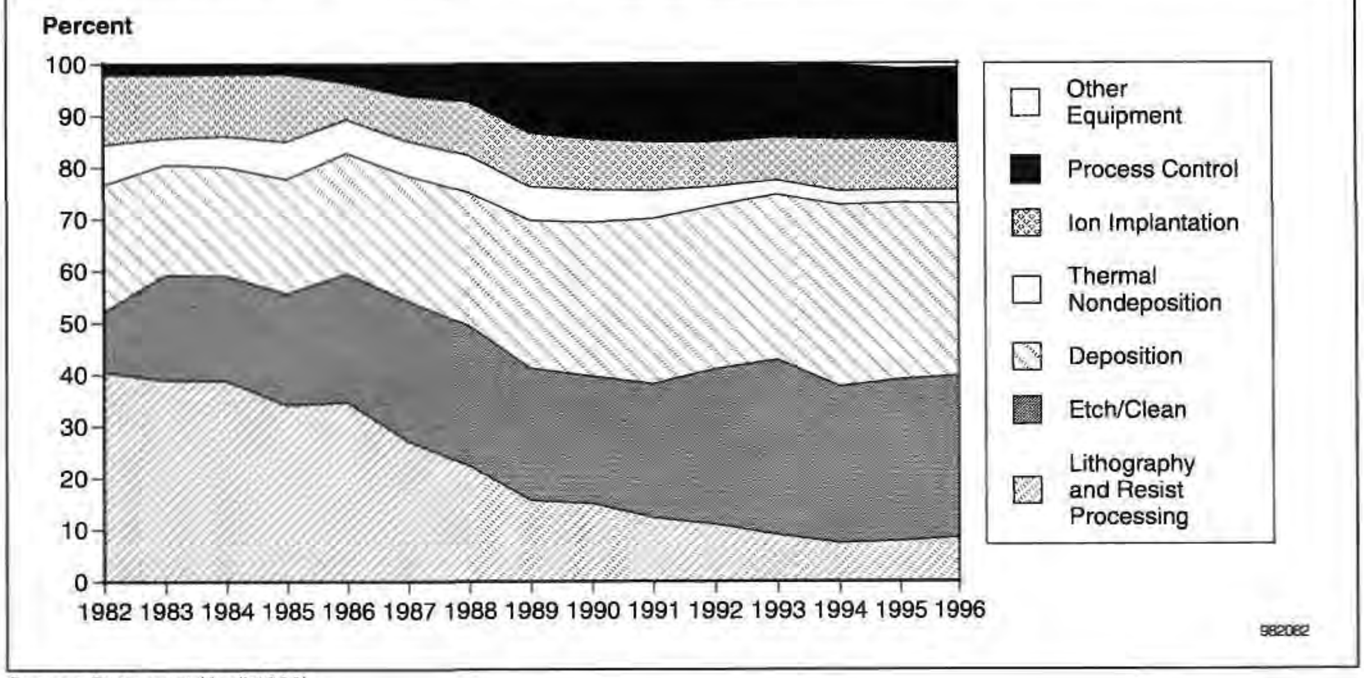


Source: Dataquest (April 1998)

The U.S. Wafer Fab Equipment Industry

The wafer fab equipment market in the United States has also shown distinctive characteristics. In 1996, the wafer fab equipment revenue of U.S. companies totaled $9.73 billion. The world market was more or less divided between U.S. companies and Japanese companies. The U.S. market's CAGR from 1982 through 1996 was 21 percent, about in parity with the Japanese market. Figure 4 shows a breakdown of revenue for U.S. equipment manufacturers between 1982 and 1996 by segment, which reveals a noticeable change. In 1982, lithography and resist processing equipment accounted for about 40 percent of the U.S. equipment market. The share dropped sharply, to 8.5 percent, in 1996. In contrast, the share of the deposition and etch/clean segments grew steadily, from 24.4 percent to 33.3 percent and from 11.7 percent to 31.2 percent, respectively, during the period. In 1996, the combined share of the two segments amounted to 65 percent. Clearly, the U.S. equipment market transformed itself from a structure centered on lithography and resist processing to one centered on deposition and etch/clean during this period. Again, this structural change reflects the evolution of the U.S. device industry.

Figure 4
Changes in U.S. Companies' Wafer Fab Equipment Revenue by Segment, 1982 to 1996



Source: Dataquest (April 1998)

In the U.S. semiconductor industry, DRAM served as a starting point and springboard for prosperity. Before 1980, U.S. semiconductor companies wielded the power in the DRAM market. According to a Dataquest survey, they controlled more than 40 percent of the market before 1980. At that time, they relied on domestic suppliers for wafer fab equipment, including lithography and other key technologies. In fact, the stepper market was dominated by U.S. companies until the mid-1980s, including such companies as GCA, Perkin-Elmer Corporation, and American Semiconductor Equipment Technology, with a combined share exceeding 50 percent. Thus, the U.S. fab process equipment market was originally dominated by lithography and resist processing segments. However, U.S. companies faced aggressive competition and lost share to Japanese DRAM manufacturers. At the same time that the market landscape changed, Nikon and Canon made inroads into the stepper market, and U.S. companies were driven out or lost substantial share.

Intel Corporation, which withdrew from the DRAM market, established new turf, the microprocessor market. Following this bellwether, the U.S. semiconductor industry successfully converted its structure to microcontroller (MCU) and application-specific IC (ASIC) production. In the process, it adopted the consortium approach seen in Japan in the 1970s; the SEMATECH consortium was born in 1987. This initiative focused originally

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on developing device processes, but this was later replaced by efforts to strengthen semiconductor manufacturing technology.

It is important to understand what the strategic shift in the U.S. semiconductor device industry has meant for the equipment industry. Although DRAMs demand state-of-the-art lithography technologies and have acted as a technology driver for device miniaturization, production of ASICs and MPUs calls for technology to form multiple layers for interconnection, including metallization and formation of contact holes. This entails refinement of deposition, etching, and planarization technologies. The United States maintained an advanced technological base in this field, particularly within the military and aerospace industries, and semiconductor equipment companies capitalized on this and expanded their share of these segments through vigorous R&D efforts.

Comparing of Figure 4 with Figure 3 shows that, as DRAM dependence dropped, starting in the early 1980s, U.S. market share from the lithography and resist processing segment declined as well, in contrast to the rise in share of the deposition and etch/clean segments. In 1996, these two segments held a combined share of more than 60 percent. Clearly, the U.S. semiconductor equipment market has completed a structural transformation, moving from the original market focus in response to the changing device market.

Another Strategic Shift?

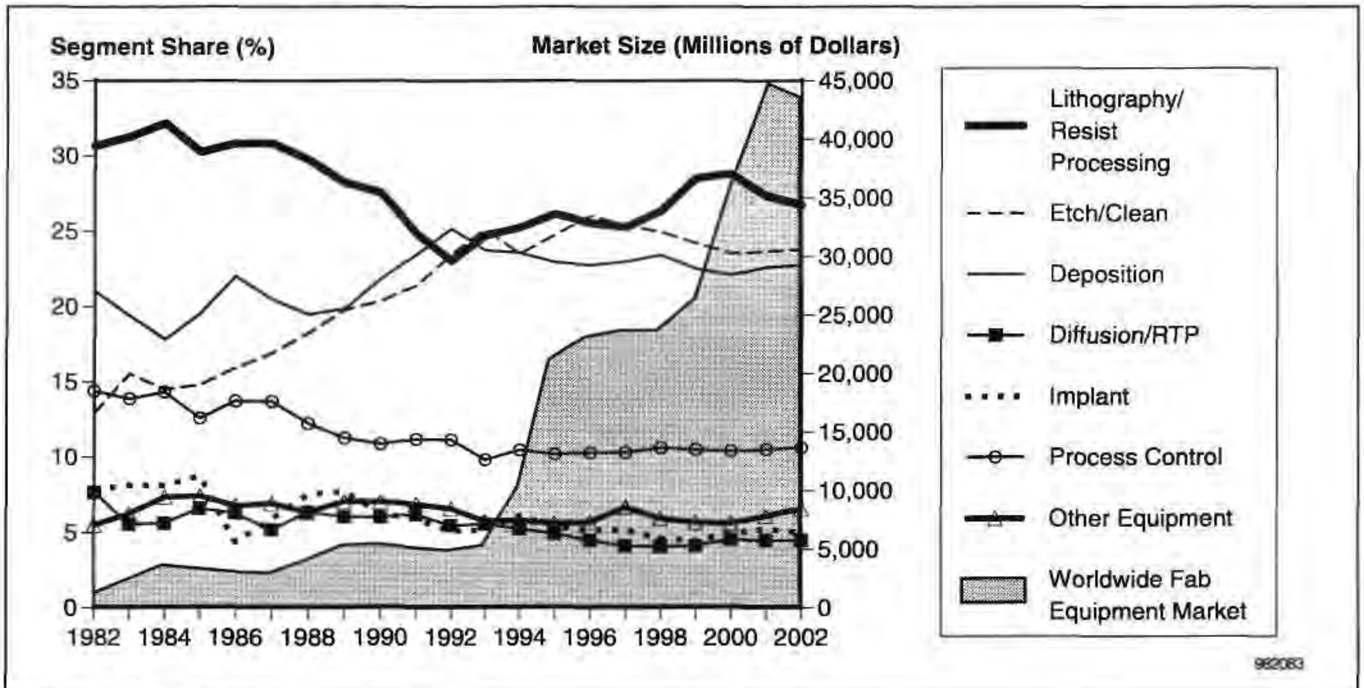
It is reasonable to ask how the semiconductor device market will evolve to understand how the equipment market will evolve. Dataquest predicts that the world semiconductor market will grow at a CAGR of 16 percent between 1996 and 2001, reaching $300 billion in 2001. The DRAM market's CAGR will be 19 percent for the same period, and in 1999, it will achieve major growth, reaching $620 billion in 2001. The DRAM market's share of the total semiconductor market will grow slowly in the next few years and will ramp up in 1999. As a result, DRAM market share is expected to go from 14 percent in 1997 to 16 percent in 1998, to 19 percent in 1999, and to 25 percent in 2000. How will this trend be reflected in the fab process equipment market? Figure 5 summarizes the changes in the world equipment market size and in the percentage breakdown by segment between 1982 and 2002. In short, the semiconductor equipment market is expected to expand at a CAGR of 12 percent up to 2002, when the total market will reach $43 billion. The change in segment composition reveals the following two trends:

- Lithography/resist processing segment will take an increasing share because of the shift to deep-UV laser-based technologies.
- Three markets, lithography/resist processing, deposition, and etch/clean, will polarize.

Year 1 for excimer technology at volume production levels was clearly 1997. According to the results of Dataquest's preliminary surveys, the excimer equipment market in 1997 grew at 240 percent over the previous year. As 0.25-micron or finer processes are adopted for ASICs as well as for DRAMs, deep-UV equipment will become a driver for expansion of the lithography and resist processing equipment market. Because the unit price of the krypton-fluoride (KrF) excimer equipment is higher than that of traditional i-line products (about 70 percent higher at present), the deep-UV segment will gain share, with deep-UV applications expanding after 1998. Therefore, in the lithography and resist processing equipment market, in which Japanese companies have been showing dominance, the ability to gain share in the excimer market will hold the key to success. In fact, the landscape is already changing with the emergence of ASM Lithography.

The lithography and resist processing segment's share eroded gradually from the late 1980s through the early 1990s, while the deposition and etch/clean segments expanded share. In the future, the three segments will divide the market nearly equally. In other words, the deposition and etch/clean market size will increase to approach that of the lithography/resist processing market. Also, new technologies , including the use of such new materials as copper in interconnection and the addition of metal layers, will make deposition and etching technologies more prominent in the ASIC market. Moreover, in DRAM technology, which has traditionally been driven by lithography, mainstream technologies for ASIC/MCU production such as chemical mechanical polishing (CMP) are increasingly being adopted for stack-structured 64Mb and higher devices using 0.25-micron design rules. Again, the deposition and etch/clean segments will be critical in the equipment market.

Figure 5
Trends in the Wafer Fab Equipment Market and in Segment Share, 1982 to 2002

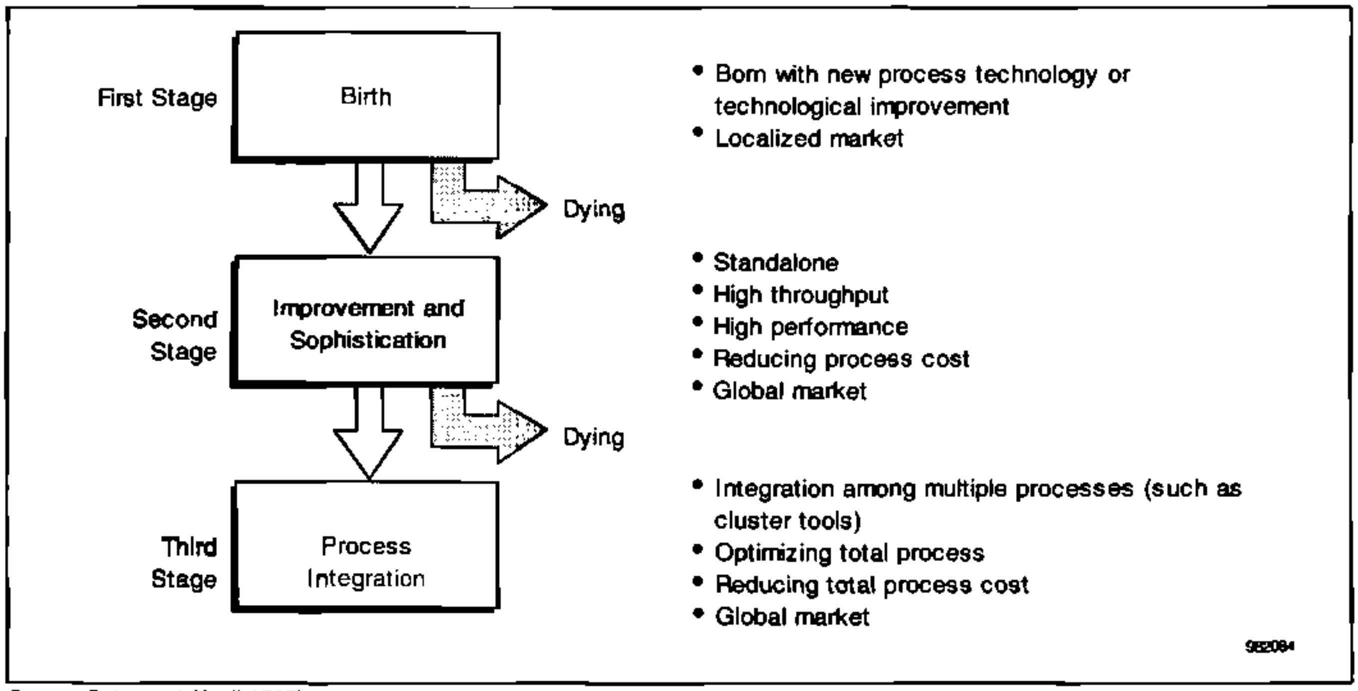


Source: Dataquest (April 1998)

Moving to Process Integration

In addition to market changes, wafer fab equipment is about to enter a new era. Figure 6 shows a conceptual view of the evolution of wafer fab equipment. As discussed earlier, most equipment has been developed for a particular semiconductor process technology. As a new process technology comes on stream, it is incorporated into equipment that will be marketed widely later. At this first stage, the market is still localized; that is, the technology is used by a handful of manufacturers, or the market is limited to a specific country or industrial area.

Figure 6
Development of Semiconductor Manufacturing Equipment



Source: Dataquest (April 1998)

Eventually, the process technology and its advantages become widely recognized, and the equipment is widely accepted, expanding the market. At this level, the market becomes global and attracts new customers. Competition increases, and equipment manufacturers are busy developing variants that extract maximum performance by improving throughput and yield and by reducing process costs, as well as enhancing the original process technology. Now the market is at the second level. Most equipment that incorporates field-proven process technology and has entered the world market is considered to be in this stage.

What's next, then? In the next stage, multiple processes are integrated and a new development concept pursues maximum performance. More precisely, cluster tools and other equipment will be adopted to integrate various process steps, and equipment manufacturers will be required to help optimize performance, including costs. This concept has already been proposed by a U.S. manufacturer. At this stage, equipment vendors must

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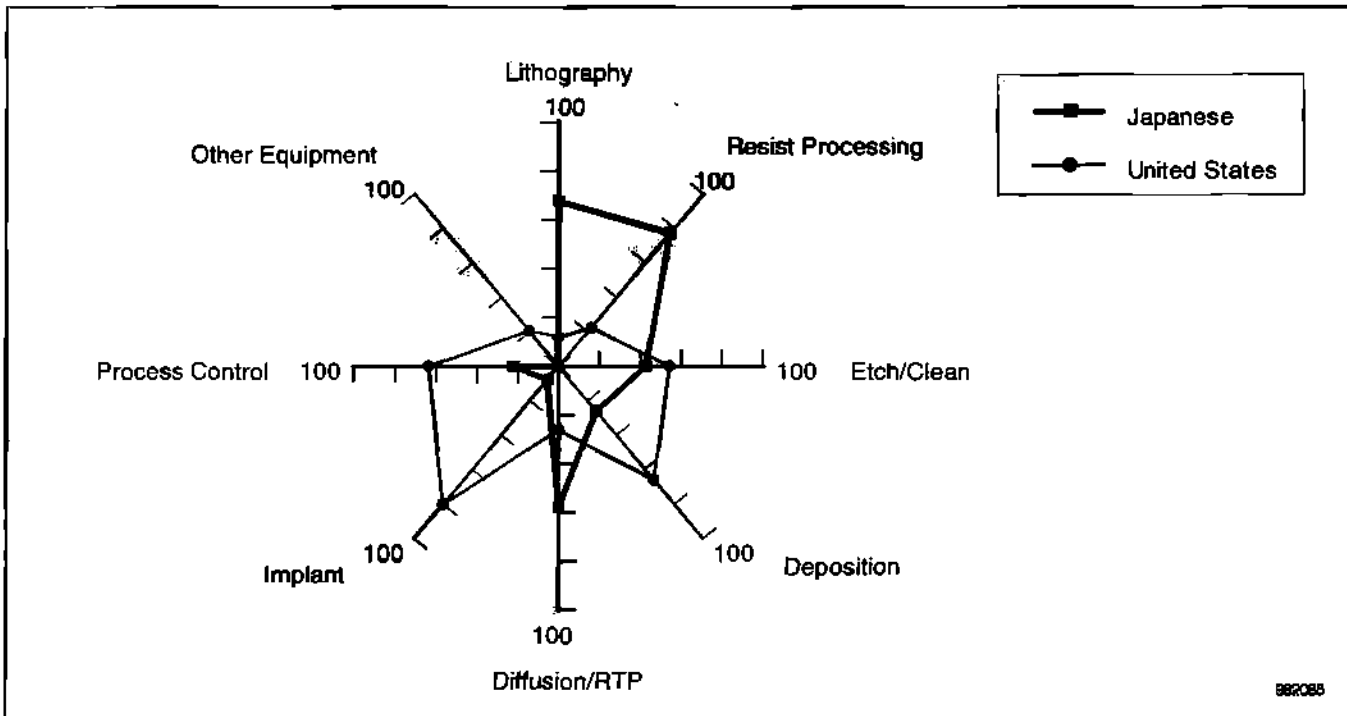
provide know-how related to process conditions, in addition to upgrading hardware technology, such as improving the reliability of existing equipment. In fact, the ability to provide such expertise will increasingly become a key factor in the success of semiconductor equipment makers, which will be required to address "software aspects" of market needs—they will need to cover the entire semiconductor production process.

Dataquest Perspective

Figure 7 shows the share of Japanese and U.S. companies in the semiconductor equipment market by segment. As noted earlier, Japanese companies dominate the lithography and resist processing segment, which has been nurtured in the DRAM market, but they are weak in other segments of the market, except for diffusion and rapid thermal processing (RTP). If market share reflects strength, including technological and management capabilities, then the lopsided share structure of the Japanese wafer fab equipment industry suggests unbalanced allocation of abilities and resources.

Figure 7
Comparison of Wafer Fab Equipment Market Share of Japanese and U.S. Companies by Segment, 1996



Source: Dataquest (April 1998)

A similar pattern is found in the diffusion/RTP segment, in which Japanese companies hold a high share of traditional diffusion equipment. They are being overwhelmed by U.S. companies in the RTP area, which is considered to be essential in advanced control of the thermal process. Given the technological significance and market potential of the deposition and

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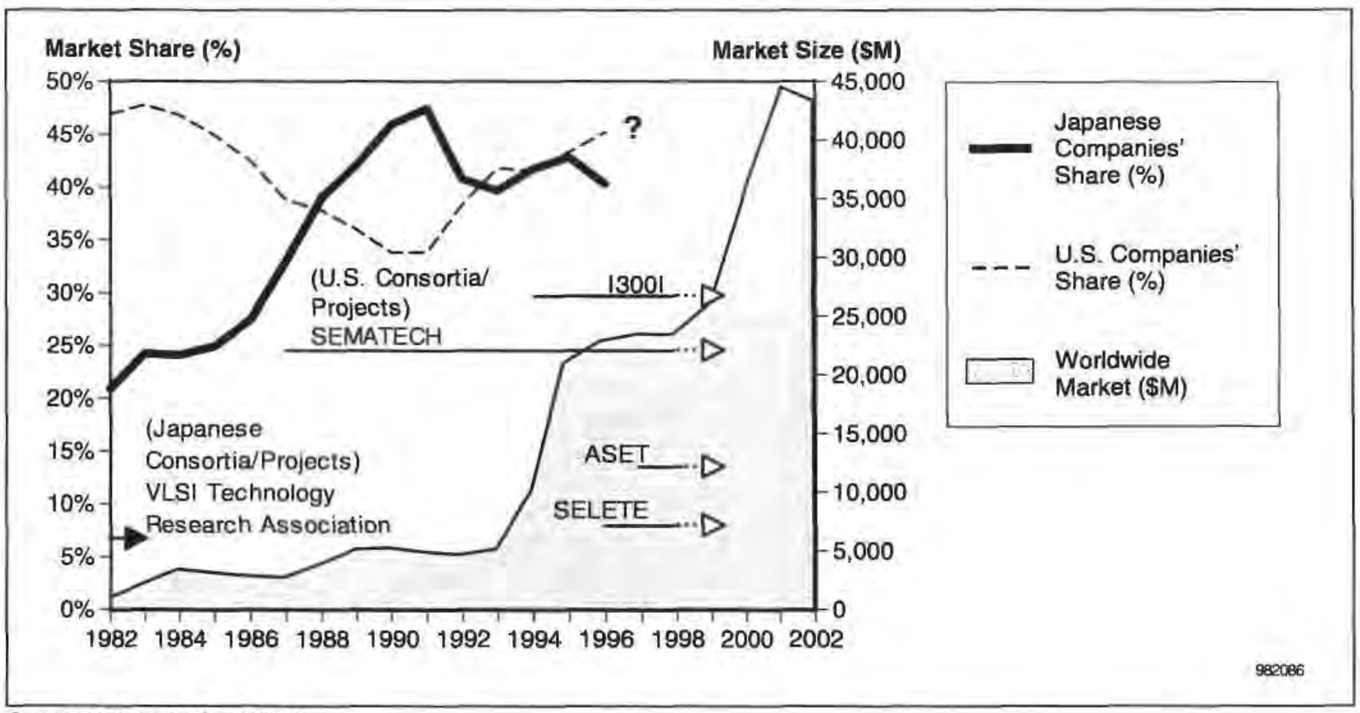
etch/clean segments, the Japanese wafer fab equipment industry needs to refocus on these areas. At the same time, the irreversible move toward process integration will require a broad range of technical capabilities and know-how in a variety of segments. The prosperity of the Japanese wafer fab equipment industry will hinge on its ability to foster companies or consortia that can offer such capabilities, including cost reduction.

It is very important for semiconductor equipment vendors and device makers to work together in developing new process technologies, which lead to new equipment and market opportunities. In retrospect, national projects and consortia have been the most effective means of producing results for the wafer fab equipment industries in both Japan and the United States.

Figure 8 shows the changes in market share of Japanese and U.S. wafer fab equipment companies and the progress of joint development projects in the two countries. Market share positions reversed five to six years after the start of a joint development project in either country. These projects have developed tangible technologies that have helped strengthen the equipment industries and have produced measurable results. In fact, the enhancement of key technologies has proven to play a critical role in periods when a major technology change occurs.

Figure 8
Semiconductor Technology Development, Wafer Fab Equipment Market Size and Share, 1982 to 2002



Source: Dataquest (April 1998)

Today, the industry is in the midst of technology change as various novel technologies, including deep UV and 300mm wafer processing, are about to enter a commercial stage. It is a technology change that will significantly alter the market's structure, and the winners of the race will become the next-generation market leaders. The Japanese wafer fab equipment industry is aware of the imminent change and seems to be determined to meet the challenge by initiating joint development projects—Semiconductor Leading-Edge Technology (SELETE) and Association of Super-Advanced Electronics Technologies (ASET). Dataquest believes that the time has come for Japanese equipment companies to make concerted efforts to refine and enhance key technologies by setting aside their own interests, just as they did in the 1970s—which remains the best course of action to ensure the industry's growth.

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Perspective

Semiconductors Japan

Market Analysis

Analyzing the 1998 DRAM Market

Abstract: *The DRAM market has been plagued by oversupply since 1996, and there are no clear signs of its moving toward a balance. The persistent glut has been squeezing profits for DRAM suppliers, who must relentlessly restructure their DRAM business. Predicting the timing of the market recovery has become urgent. This Perspective analyzes the 1998 DRAM market, focusing on synchronous DRAMs, which are expected to become central in the market. The DRAM shipment and demand data used in this Perspective is based on Dataquest's DRAM supply/ demand quarterly statistics survey in December 1997.*
By Masahiro Suzuki

The General Outlook for the DRAM Market in 1998

The 1998 Japanese DRAM market will be characterized by three distinct trends: increased 64Mb production, 16Mb production cutbacks led by Japanese companies, and rapidly growing share of synchronous DRAMs (SDRAMs).

First, 1998 will be a year of a generation shift from 16Mb to 64Mb. Volume production of 64Mb, led by Samsung Electronics Company Ltd. and NEC Corporation, is steadily on the rise, with other leading suppliers having started commercial production from the second half of 1997. As of February 1998, both 16Mb and 64Mb products were in oversupply, except for 100-MHz, 64Mb SDRAMs, of which a slight shortage is being felt. Dataquest estimates that DRAM demand measured by total bits will reach about 7.5 billion megabytes in 1998, while total supply will amount to 7.7 billion megabytes, resulting in a sufficiency ratio (supply/demand ratio) of around 102. Dataquest believes that, even if DRAM suppliers curtail capital spending significantly, the glut will prevail in 1998.

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Meanwhile, 1998 will see another major shift, an accelerated technology shift from EDO DRAMs to SDRAMs. SDRAM emerged in the third quarter of 1997, when it was rapidly adopted in 16Mb products. Nevertheless, development of 64Mb SDRAMs, particularly PC-100 versions, is somewhat behind schedule. PC-100-enabled and 100-MHz versions will therefore be in slightly tight supply during the first and second quarters. A stable supply of PC-100 versions can be expected in the third quarter of 1998.

DRAM Demand in 1998

The total DRAM demand forecast for 1998, about 7.5 billion megabytes, translates to 3,760 million 16Mb DRAMs, representing a 56 percent increase over 1997. The major driver continues to be PCs, with shipments expected to surge 16.7 percent in 1998, reaching 98.4 million units. At the same time, the average system memory size of PCs will grow to 56.3MB (including the aftermarket). Two factors are important here: The market environment will still work against DRAM prices, which are unlikely to rise rapidly in 1998, and the release of Windows 98 and NT 5.0 will prompt a further increase in system memory size.

Meanwhile, the use of SDRAMs on PCs has accelerated since the third quarter of 1997, and SDRAMs are increasingly outpacing EDO DRAMs in share of design wins. This trend is expected to continue throughout this year. It should be noted that the adoption of SDRAMs for notebook PCs is a bit slower than for desktops, mainly because current SDRAMs consume more power than EDO products. In fact, SDRAMs consume much less power than LCD backlighting and mechanical components, but notebook suppliers continue to use power-saving versions of SDRAMs. DRAM companies are apparently being slow to develop low-power 64Mb SDRAMs.

DRAM Demand Outlook by Integration Level

Figures 1, 2, and 3 show Dataquest's worldwide supply and demand forecast for 4Mb, 16Mb, and 64Mb DRAMs, respectively. Note that a sufficiency ratio of over 100 represents a market glut.

4Mb DRAM

Major systems consuming 4Mb DRAMs include PCs, rigid disk drives (RDDs), printers, facsimile machines, network routers, set-top boxes, and video game systems. Note that total consumption has entered a declining trend. One exception is 4Mb, which is now replacing 1Mb in RDDs. Similarly, the supply of 4Mb DRAMs is on the decline, as shown in Figure 1; unit shipments in 1998 are expected to plunge 45 percent to 472 million from 859 million in 1997. The shipment forecast data for leading manufacturers indicates that most of them will proceed with production cutbacks throughout 1998. In particular, leading suppliers have already switched to order production. The sufficiency ratio will be at about 100 throughout 1998, meaning that the market will be near balance this year. One variant scenario would be further acceleration of production cutbacks by major suppliers, which would spur second-tier companies to boost their production.

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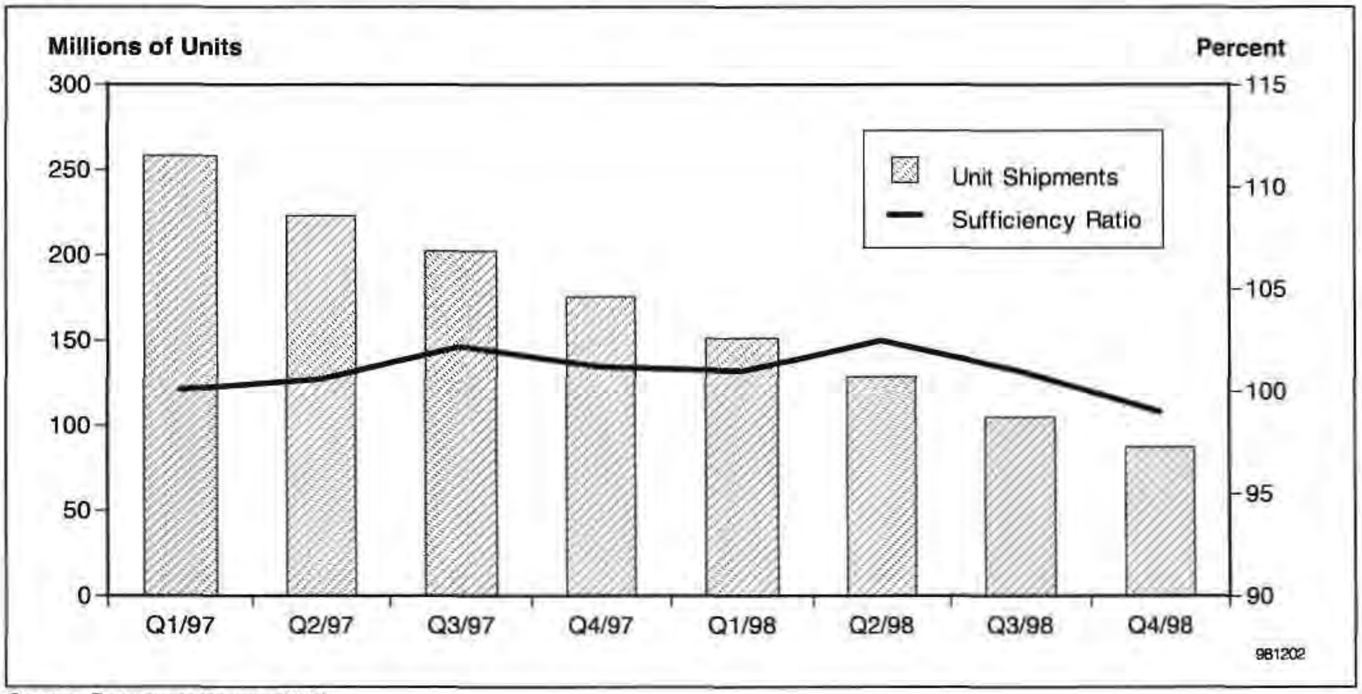
Figure 1
Supply/Demand Forecast for 4Mb DRAMs



Source: Dataquest (March 1998)

16Mb DRAM

Major application markets for 16Mb DRAMs, in addition to PCs, include printers, network routers, DVD players, set-top boxes, and video game systems. Of these, laser printers are the largest consumer. Supply was on the rise in 1997 but flattening in 1998 (see Figure 2). Total shipments of 16Mb DRAMs in 1998 will reach 2,128 million, a 10 percent increase from 1,982 million in 1997.

Analysis of shipment trends by individual manufacturers indicates that leading Japanese and Korean suppliers have already launched production cutbacks. Leading DRAM companies have changed the plans made in mid-1997 and now plan to make the actual cutbacks one or two quarters earlier, to the third or fourth quarter of 1997. However, second-tier companies will generally increase their production throughout 1998, which reflects their delay in developing 64Mb products. Depending on price trends, they may boost 4Mb production while curtailing 16Mb output.

Conspicuous 16Mb DRAM players in the 1998 market are Micron Technology Inc., Texas Instruments Inc., Siemens AG, and Nan Ya Technology Corporation. All of them plan to continue to expand production in 1998. Micron has announced plans to boost 16Mb production while it has the ability to expand 64Mb production. Micron's annual 16Mb shipments reached 224 million units in 1997, ranked second in the world next to the 244 million units shipped by Samsung Electronics. Micron plans a further increase to 416 million units in 1998. Nevertheless, Dataquest believes that Micron will cut back 16Mb capacity and ramp up 64Mb production once

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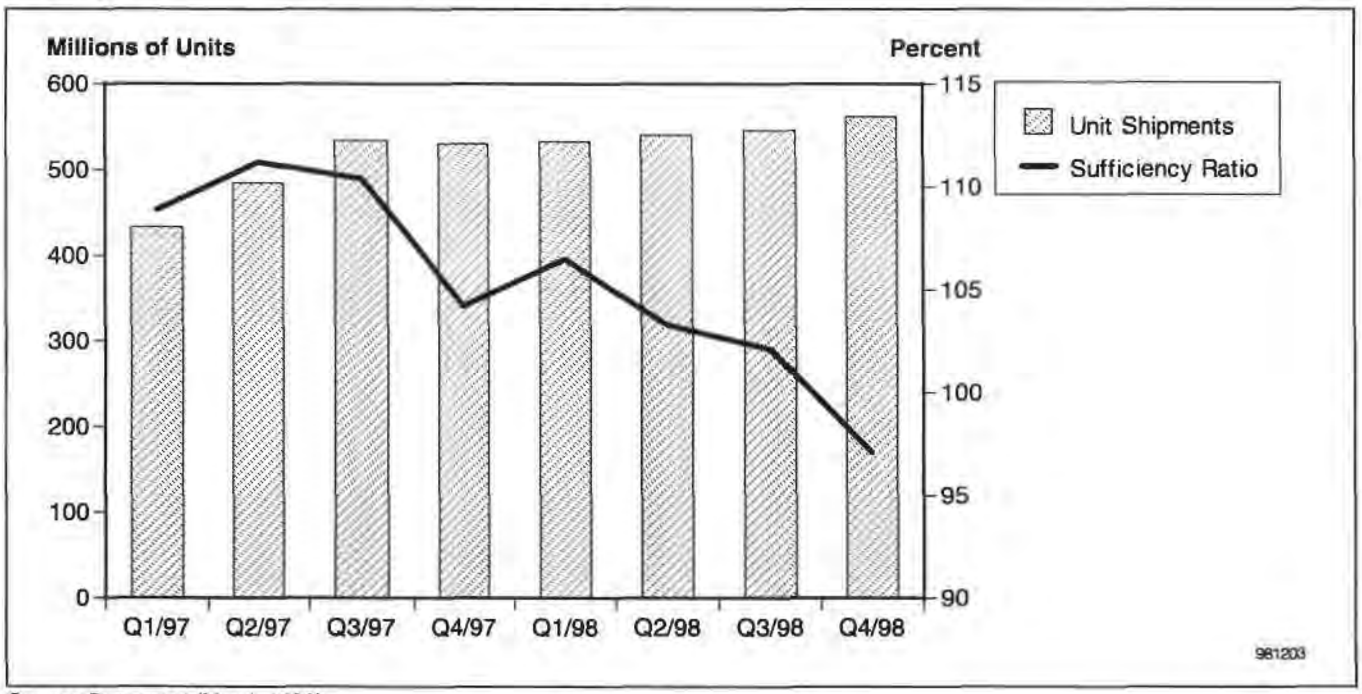
64Mb DRAMs begin proliferating in desktop PCs. In that case, the total supply in 1998 might be reduced from 2,128 million.

TI follows Micron in a major production expansion plan. The company's 16Mb shipments in 1997 totaled 205 million units, ranked No. 3, next to Micron, and it is expected to churn out 278 million units in 1998. However, Siemens and Nan Ya, although they plan to increase production, will ship a combined total of 243 million units in 1998, far below TI's shipments. Thus, Micron and TI will have major clout in the 16Mb market in 1998.

As shown in Figure 2, the oversupply will remain pervasive in the 1998 market if these companies act on their plans to increase production, which will compensate for the production cutbacks planned by other companies. One note of caution—a temporary shortage is possible if so many suppliers cut back production so quickly. More important, Micron's move needs to be watched because it plays a key role in the group intending to boost production. The company may adjust the production ratio between 16Mb and 64Mb according to 64Mb demand. By doing so, it would be a decisive factor in supply and demand trends in 1998.

Figure 2
Supply/Demand Forecast for 16Mb DRAMs



Source: Dataquest (March 1998)

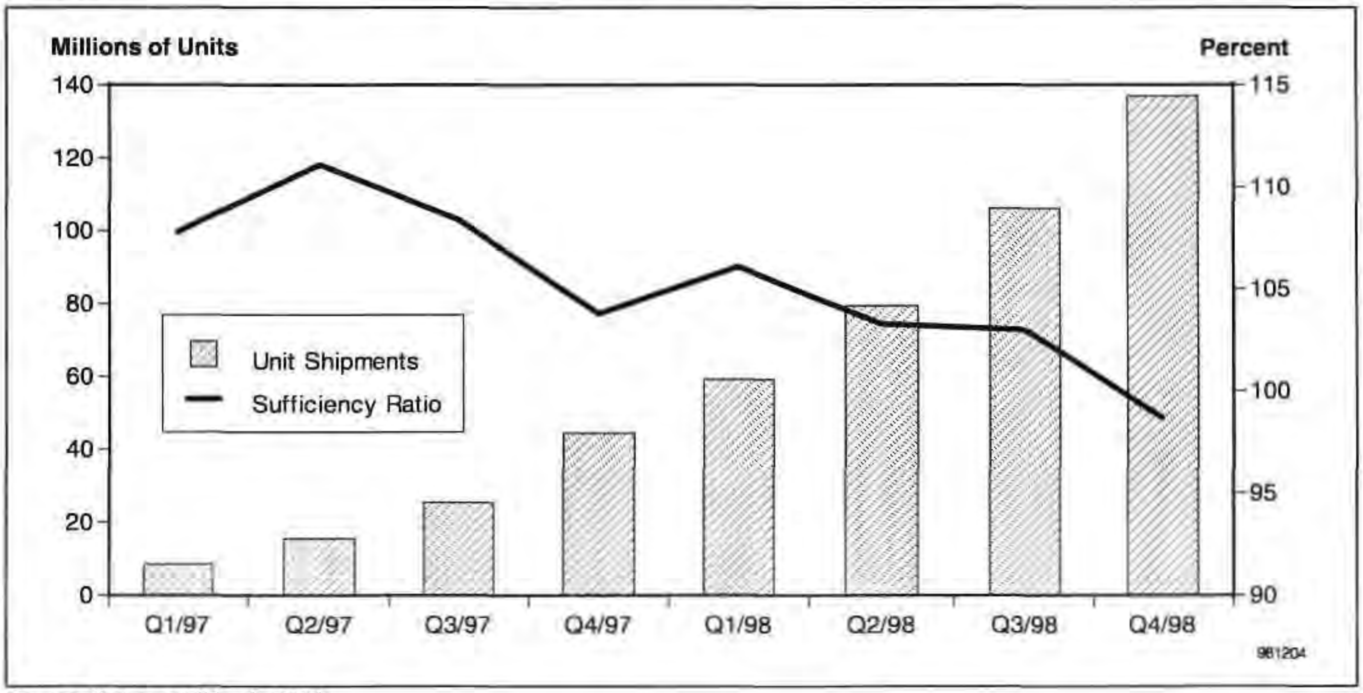
64Mb DRAM

Again, PCs and other higher-end computers are a major consumer of 64Mb DRAMs. In fact, computer main memory seems to be the only application requiring 8MB capacity in the memory device. In addition to PCs, workstations, with a relatively short product cycle, are fast adopting high-integration DRAMs. In 1997, major demand came from workstations in the first half and from some notebook PCs in the second half.

In 1998, 64Mb DRAMs will make inroads into desktop PCs to replace 16Mb products. As shown in Figure 3, 64Mb production will ramp up steadily, and oversupply will be seen in 1998. Korean and Japanese DRAM suppliers have been forced since 1996 to curtail capacity expansions in the wake of the recession. However, Dataquest believes that their cutbacks alone will not lead to the long-awaited balance unless other DRAM companies follow suit by substantially reducing capital spending.

Samsung Electronics shipped an estimated 32 million units in 1997 and will ship 79 million units in 1998. NEC followed Samsung with 21 million units in 1997 and 63 million units in 1998. Micron, however, in 1997 produced 2.8 million units and plans production of 10 million units this year, although the company will likely adjust its plans when 64Mb demand ramps up.

Figure 3
Supply/Demand Forecast for 64Mb DRAMs



Source: Dataquest (March 1998)

Shipment Trends and Forecast by DRAM Type

Figures 4 and 5 show shipment trends and the forecast for 16Mb and 64Mb DRAMs, respectively. (The category "next-generation DRAM" refers to Rambus DRAMs, or RDRAMs).

For 16Mb, the shift to SDRAMs has accelerated since the third quarter of 1997. In 1997, Intel released the 430TX and the 440LX for supporting SDRAMs. The increase in SDRAM shipments coincided with Intel's release of the 440LX in the third quarter. Nevertheless, it is well known that replacement of EDO with 66-MHz SDRAM does not improve the performance of the memory system. Thus, the increasing use of SDRAMs

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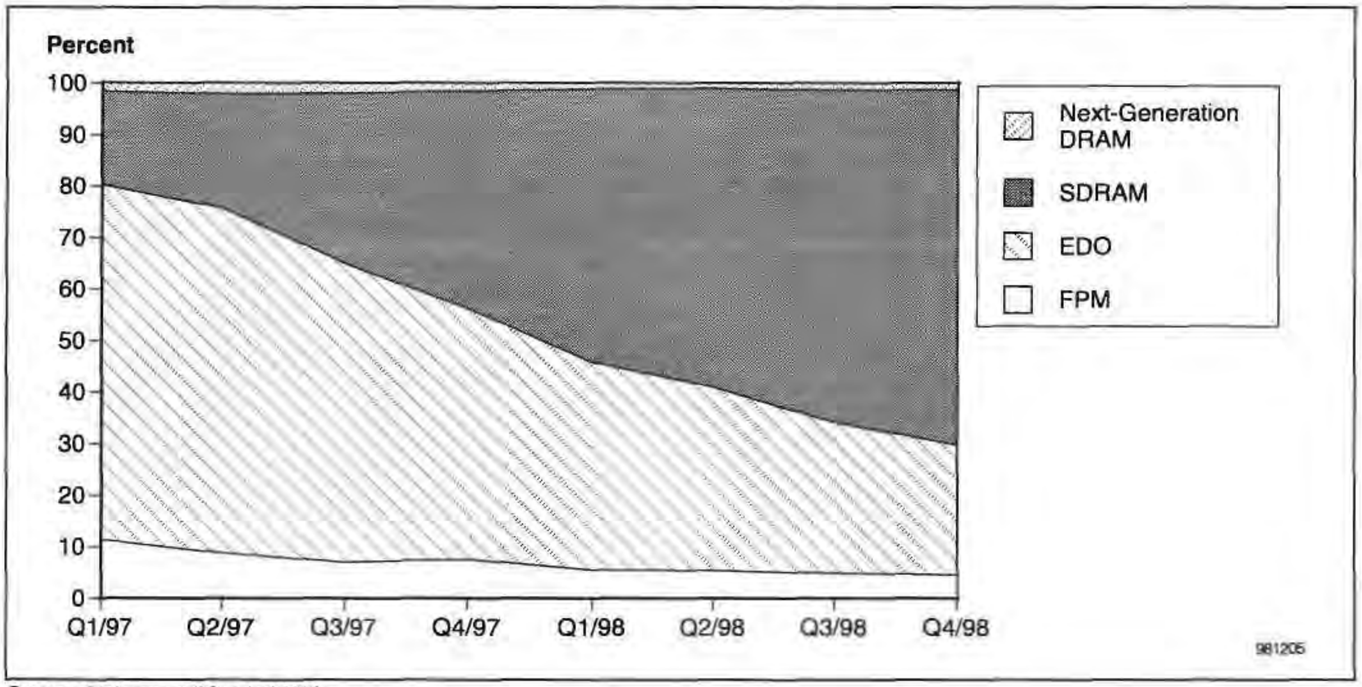
seems to reflect the intention of systems companies to gain know-how about use of the future mainstream device by adopting early. SDRAM shows little difference in price over EDO DRAMs, and using it as a replacement early reduces the kinds of products that require inventory control as early as possible.

Figure 4
Breakdown of 16Mb DRAM Shipments by Device Type



Source: Dataquest (March 1998)

Figure 5 shows that the shift to 64Mb SDRAMs will speed up during the first quarter of 1998. A major driving force is Intel's 440BX, a chipset supporting 100-MHz SDRAMs slated for release in the first quarter. At present, 64Mb SDRAMs are primarily 66 MHz, and 100-MHz versions are available from only a few vendors. For SDRAMs to operate at a system clock speed of 100 MHz on PC motherboards, they must operate at 100 MHz as they are mounted on the dual in-line memory module (DIMM), which is equivalent to a speed of 125 MHz for an SDRAM device alone. (Note that 100-MHz SDRAMs are usually used at the system clock frequency of 66 MHz.) Volume production of 125-MHz SDRAMs requires a 0.25-micron type of process technology.

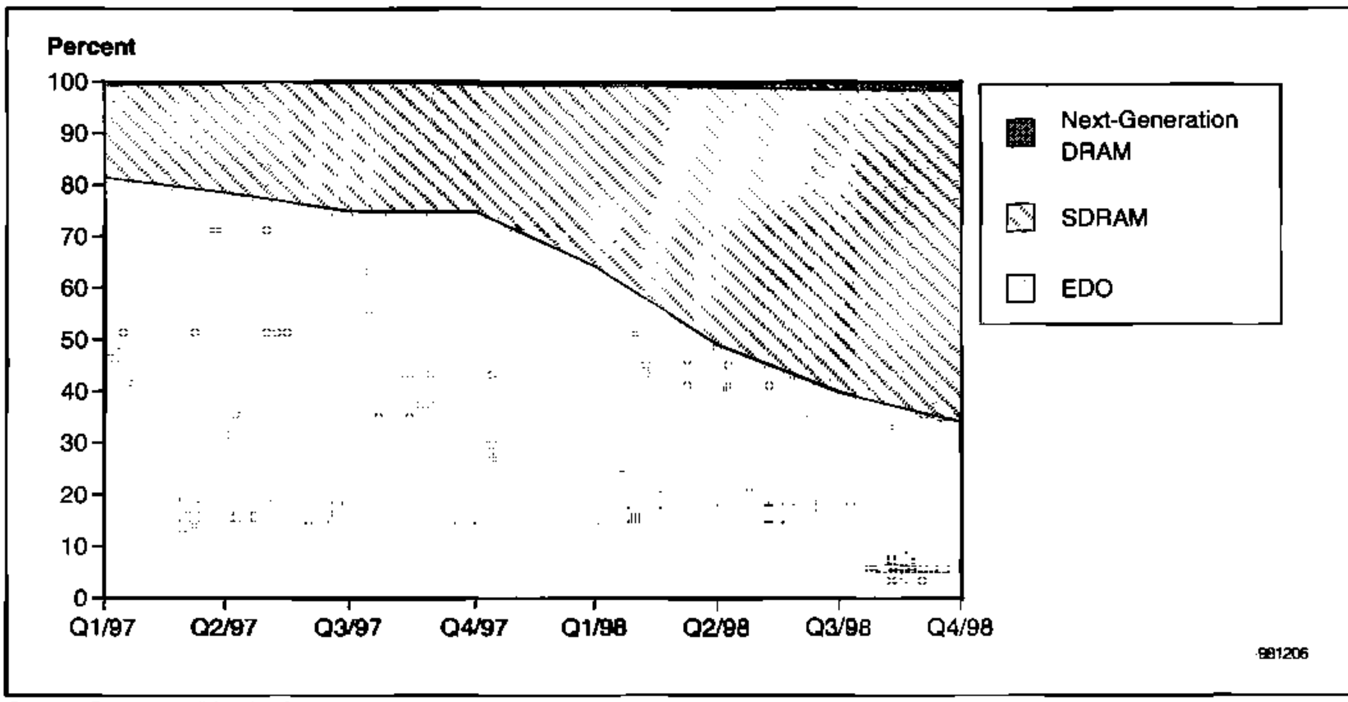
Dataquest Perspective

The Japanese DRAM market in 1998 will be still characterized by oversupply, judging by analysis of total bid-based supply and demand as well as of supply capacities of DRAM suppliers and their likely changes. One exception is 125-MHz 64Mb products, which may face some shortages, accompanied by price premiums. The 125-MHz versions will be required for the 440BX, which operates at a clock frequency of 100 MHz, as well as for 350-MHz

Pentium II or later MPUs. If volume production of these MPUs is substantially delayed, DRAM suppliers will focus on building up 0.25-micron process capacities, and a shortage of the 125-MHz products will become less likely.

Many development challenges are waiting for DRAM companies. In addition to the traditional race for higher integration, they are expected to commercialize high-speed SDRAMs, low-power SDRAMs, and next-generation DRAMs, including RDRAMs, double-data-rate (DDR) DRAMs, and SLDRAMs. In particular, next-generation products, for which specifications have still not been finalized (except for RDRAMs), have a long way to go. Dataquest believes that the most important challenge for DRAM makers is to identify which device type will become mainstream and to allocate their resources effectively to allow timely introduction of suitable products to the market.

Figure 5
Breakdown of 64Mb DRAM Shipments by Type



Source: Dataquest (March 1998)

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Perspective

Semiconductors Japan

Market Analysis

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The Impact of the Asian Financial Crisis on Japanese Semiconductor Companies

Abstract: *The impact of the Asian financial crisis is beginning to be felt on a wider basis. The loss in GDP in the areas hit by the crisis has started to affect local demand for goods, including electronics, affecting both exports to those countries and local production. This Perspective analyses the impact of the crisis on Japanese electronic equipment production and Japanese semiconductor suppliers and offers possible scenarios.*
By Yoshihiro Shimada

The Asian Financial Crisis

The arrival of the Asian financial crisis in 1997 shook Asia/Pacific countries, including Thailand, Korea, Indonesia, Malaysia, Philippines, Singapore, and Hong Kong. The crisis is a financial phenomenon, but its widespread impact is beginning to be felt in the overall economies of those countries.

In Korea, as in Japan in the early 1990s, production of low-end model shifted to Association of Southeast Asian Nations (ASEAN) countries because of their lower costs, and the domestic production remaining in Korea showed a profile similar to domestic production in Japan. The yen depreciation that preceded the Asian financial crisis, however, strengthened Japanese exports of consumer equipment, and production of that equipment in Korea was adversely affected. Semiconductors had already become a major contributor to nationwide exports in Korea, but weak pricing over the past two years or so has hurt Korean exports and the country's foreign exchange reserves. At the same time, rapid expansion of DRAM production capacity required vast capital spending, but most manufacturing equipment and manufacturing materials had to be imported. This is one of the most serious impacts of the Asian financial crisis for Korean semiconductor companies.

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In countries such as Singapore, Malaysia, Thailand, and Indonesia, the production shift from Japan, the United States, and Europe has contributed to a rapid growth in electronic equipment production. Because products have been exported back to those advanced countries, as well as to other regional markets, the economies of those countries have benefited, on the whole. This scheme, however, made those countries heavily dependent on imports as more manufacturing equipment and materials were required, making them vulnerable to the effects of the financial crisis.

Hong Kong, too, has been exposed to the Asian financial crisis, and a financial blow has been unavoidable. In Hong Kong, a large portion of imported semiconductors are re-exported to other parts of the mainland China, and the impact of the crisis must be measured in relation to equipment production sites supported by imported semiconductors. The Chinese government has been making every effort to maintain the value of renminbi, but if the currency should be hit directly by the Asian financial crisis, the impact could be felt throughout the whole Asia/Pacific region.

Taiwan has seen only a minimum impact and has proven its excellence in managing industries and finance. Major industries such as PCs, peripherals, and semiconductors are still growing fast in Taiwan, and Dataquest expects Taiwan to remain comparatively unaffected by the Asian financial crisis.

As the Asian financial crisis's adverse impact widens, Japanese export of industrial equipment is starting to show a decrease. Asia/Pacific countries have been forced to scale down utilization of production sites for equipment to be marketed within Asia/Pacific, and Japanese companies have been no exception.

Impact of the Crisis on Japanese Electronics Production in Asia/Pacific

Dataquest is conducting in the first quarter of 1998 a detailed survey of 1997 semiconductor revenue. The final results are scheduled to be released in the second quarter of 1998, but a preliminary look at Japanese companies has already shown that 1997 revenue has been influenced by the crisis. It should be noted, however, that a discrepancy between company plans and actual revenue in Asia/Pacific does not necessarily come from the Asian financial crisis alone —some equipment had been plunged into a painful correction when oversupply followed a period of robust production.

In the first half of 1997, consumer equipment production in Asia/Pacific on the whole saw recovery from an extended slump that started in mid-1995. There were doubts about PC peripherals' continued production growth, but an adjustment phase had not started yet.

By mid-1997, the winds of change had started to blow. Video CD players, which had enjoyed a sudden increase in production because of a rapid rise in demand from mainland China, began to show sluggishness, and production plummeted. CD players, portable audio equipment, rigid disk drives, and CD-ROMs also saw a decrease in production.

So far in 1998, there has been no clear sign that production levels of this equipment are recovering, and semiconductor orders for those applications continue to be slow.

The Impact on Japanese Semiconductor Companies

The impact of the Asian financial crisis on semiconductor companies is not necessarily negative. The following factors need to be considered:

- Demand side
  - Negative—Reduction in orders from Asia/Pacific users
  - Negative—Price pressure from users
  - Positive—Increase in orders because of improved competitiveness of electronic equipment manufactured in Asia/Pacific
- Supply side
  - Negative—Asia/Pacific semiconductor companies' drive to export
  - Positive—Improvement in short-term semiconductor supply and demand because of production constraints stemming from difficulties in importing materials
  - Positive—Improvement in long-term supply and demand because of limited capital spending by Asia/Pacific semiconductor companies

In this analysis, Dataquest attempts to estimate the impact of the Asian financial crisis on Japanese companies' revenue, using metrics such as revenue by country and semiconductor revenue share of local users in Asia/Pacific.

Naturally, actual problems that semiconductor vendors face will be affected also by the application involved and, eventually, each user. This analysis, however, attempts to show trends in the impact of the crisis on semiconductor orders. Dataquest classifies Asia/Pacific into the following five countries or areas: Korea, Taiwan, China/Hong Kong, Singapore, and Rest of Asia/Pacific (ROA). In this analysis, it is assumed that the higher the revenue in Korea, Singapore, and ROA and the higher the ratio of local users, the higher the risks in semiconductor orders.

Although there has been industry input into these estimates, this analysis is not based on a rigorous survey, and therefore Dataquest chooses to avoid using specific company names. Metrics have, however, been estimated based on each company's characteristics as perceived by Dataquest. The companies analyzed are the top 11 Japanese companies included in the ranking of the top 30 worldwide Asia/Pacific companies: NEC Corporation, Toshiba Corporation, Hitachi Ltd., Fujitsu Ltd., Mitsubishi Corporation, Matsushita Electric Industrial Co. Ltd., SANYO Electric Company Ltd., Sharp Electronics Corporation, Sony Corporation, Sanken Electric Company Ltd., and Rohm Company Ltd.

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These 11 Japanese companies combined hold a 33 percent share of the revenue of the top 30 companies in Asia/Pacific (see Table 1), and their sales into Korea, Singapore, and ROA together account for 60 percent of their total revenue in Asia/Pacific (see Figure 1). In Korea, most of the sales come from business with local users, while in Singapore and ROA, the major portion of their revenue comes from Japanese users or Americas and European users. Among those 11 companies, consumer applications-oriented companies tend to show higher dependence on local users, but they also benefit from their internal user divisions' Asia/Pacific production sites. For those 11 Japanese companies combined, 55 percent of the revenue comes from local users in Asia/Pacific (see Figure 2).

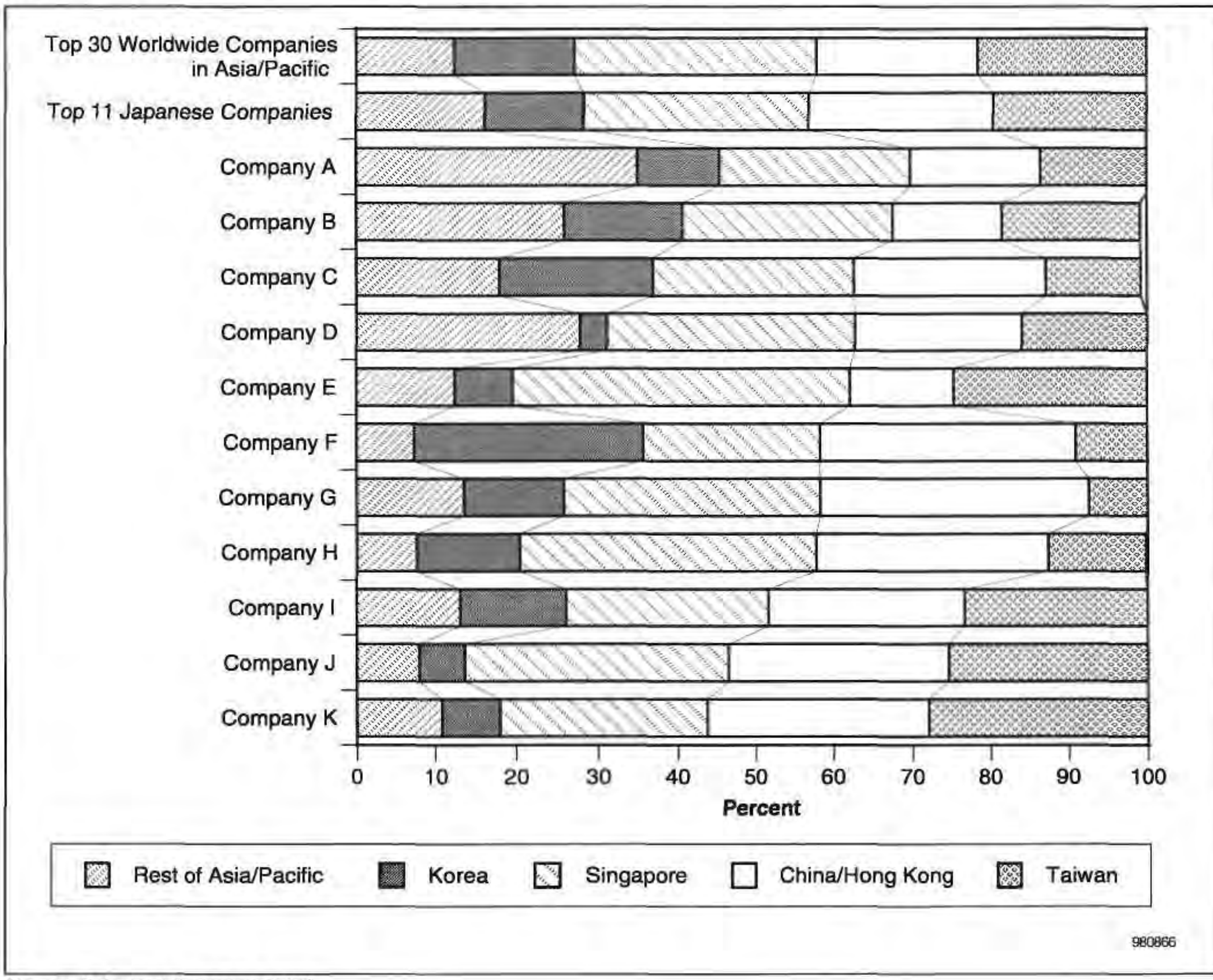
Figure 3 shows the results of estimating the risks that Japanese companies face in semiconductor orders because of the crisis. The first risk scenario is for Korea, Singapore, and ROA combined, and the second risk scenario is for Korea and ROA only. There are some companies whose sales to local users are significantly high but whose risks from the Asian financial crisis are small. Those companies' users are associated with either Japanese, Americas, or European electronics vendors. DRAM companies show similar trends. On the other hand, there are companies whose risks may be high not only because of the Asian financial crisis but also because of sluggishness in certain application markets worldwide. Japanese companies' semiconductor sales in Asia/Pacific are generally characterized by high dependence on Japanese users.

Table 1
Revenue of Selected Japanese Semiconductor Companies in Asia/Pacific, 1996 (Millions of Dollars)

1996 Rank	Company	1996 Revenue	Percentage of Top 30 Companies' Revenue
3	Toshiba	1,804	7.3
7	NEC	1,283	5.2
9	Hitachi	1,169	4.7
11	SANYO	913	3.7
13	Mitsubishi	729	3.0
15	Matsushita	500	2.0
16	Fujitsu	476	1.9
17	Rohm	471	1.9
20	Sharp	406	1.6
23	Sony	286	1.2
29	Sanken	215	0.9
	Top 11 Japanese Companies	**8,252**	**33.4**
	Top 30 Worldwide Companies in Asia/Pacific	**24,699**	**100.0**

Source: Dataquest (February 1998)

Figure 1
Japanese Companies' Sales into Major Countries in Asia/Pacific

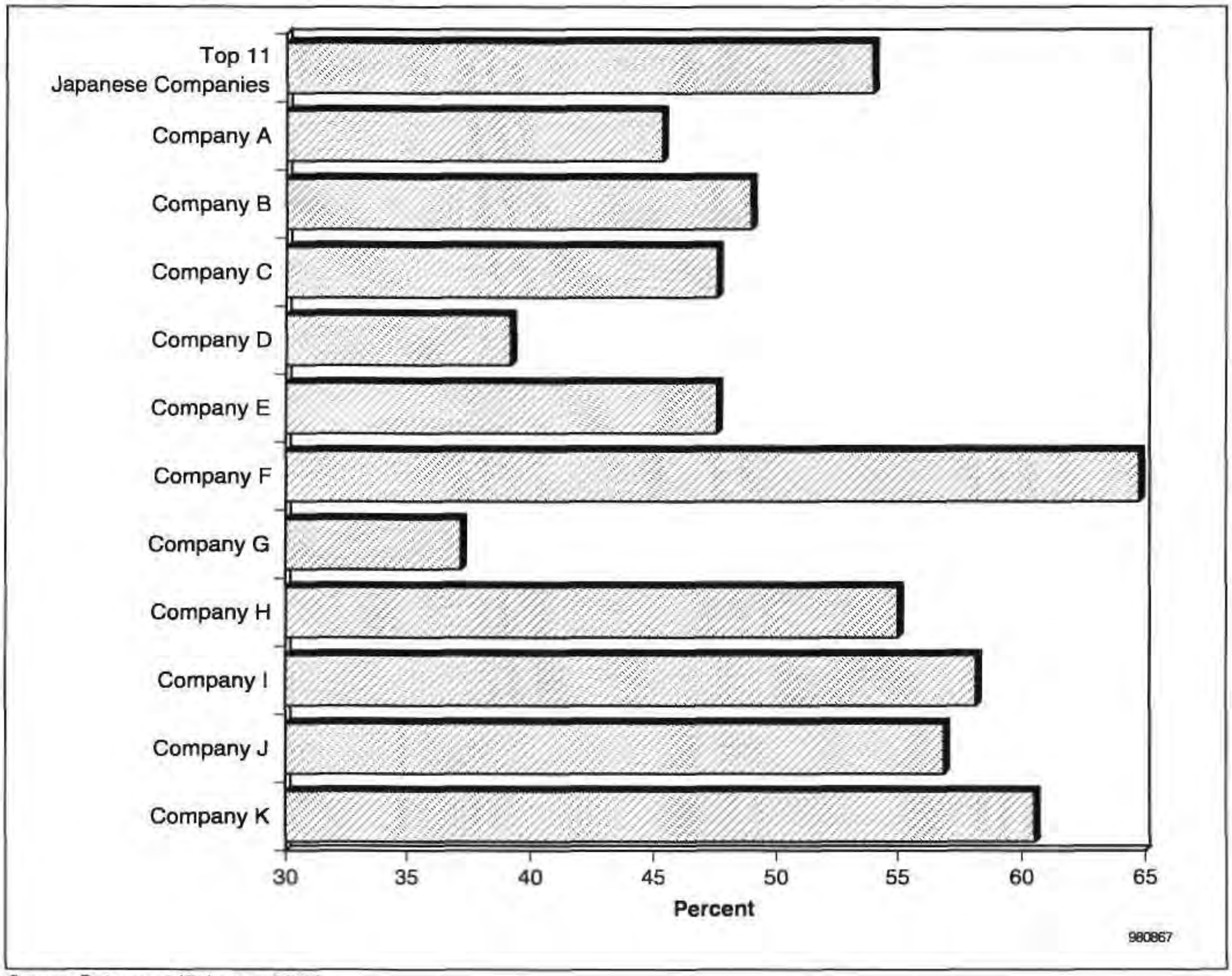


Source: Dataquest (February 1998)

One trend shown in this estimate of risk is that the element of risk added by the Asian financial crisis increases as the total revenue in the crisis-hit areas increases, but at a certain point, the crisis-based risk saturates. This again reflects low dependency on purely local users.

True, semiconductor orders from Asia/Pacific had started to decline even in 1997, and companies with a stronger emphasis on the Korean market were exposed to direct and immediate losses in orders. Dataquest has not heard of any Japanese companies officially attributing lower sales forecasts in Asia/Pacific solely to the Asian financial crisis.

Figure 2
Japanese Companies' Sales to Local Users



Source: Dataquest (February 1998)

This analysis has focused on semiconductor orders and revenue, and manufacturing issues have intentionally been put aside. There has been no immediate change to Japanese companies' wafer fab plans in Asia/Pacific. Test and assembly, or back-end, operations also remain unaffected, because most of the materials are still imported from Japan and the only visible change would come from labor costs.

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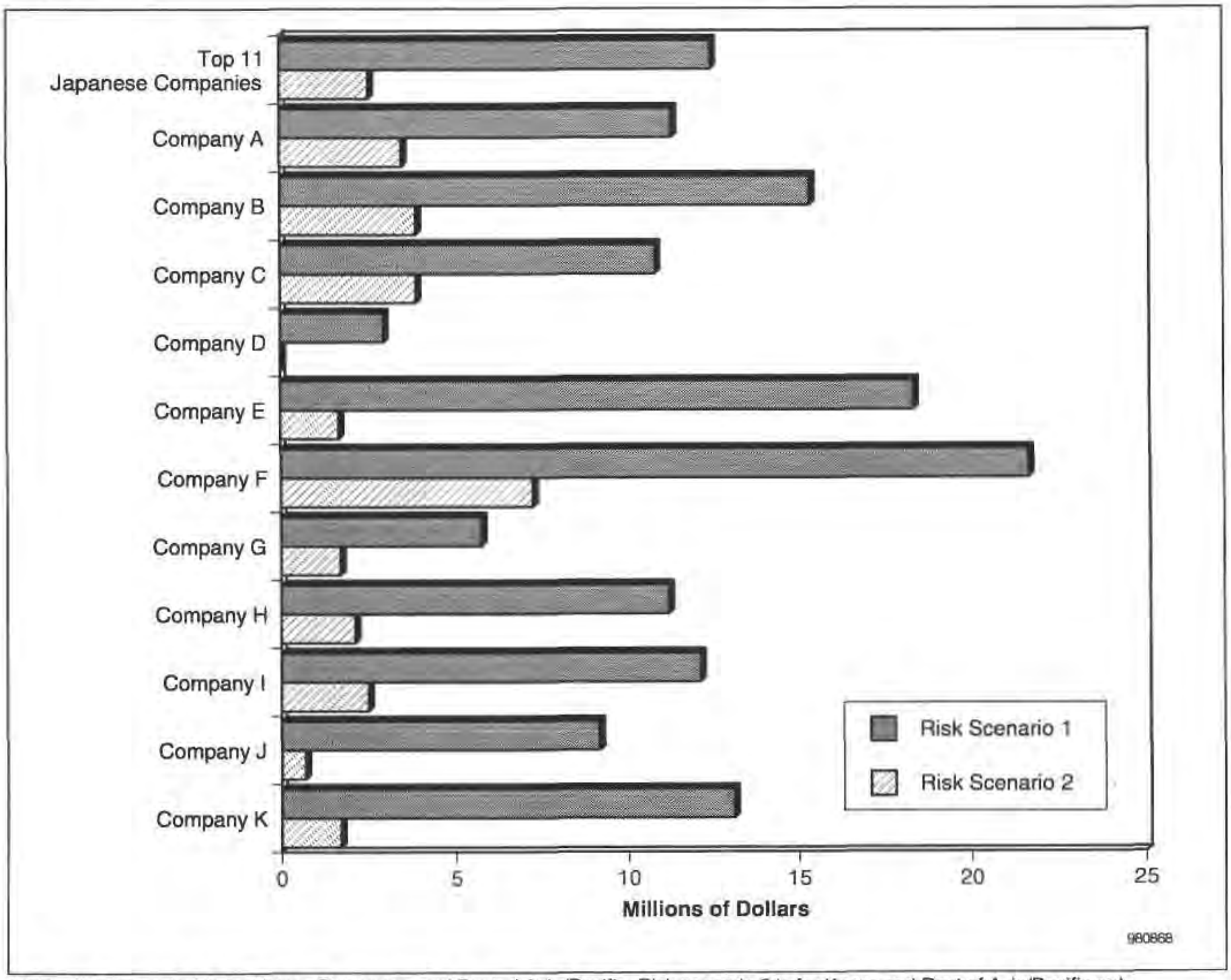
Figure 3
Impact of the Asian Financial Crisis Japanese Companies' Sales into Major Countries in Asia/Pacific



Note: Risk scenario 1 is for Korea, Singapore, and Rest of Asia/Pacific; Risk scenario 2 is for Korea and Rest of Asia/Pacific only.
Source: Dataquest (February 1998)

Possible Scenarios

The future impact of the Asian financial crisis should be measured and analyzed from several aspects, including time frame, origin of demand (whether domestic or export) for application equipment, production of equipment in Asia/Pacific or in other parts of the world, high-end models versus low-end models, availability of semiconductor materials and manufacturing equipment, and semiconductor capital spending.

In the short term, confusion in orders is unavoidable as suppliers and users try to reach new terms of trade incorporating lower exchange rates for local currencies. Local users are putting pressure on local semiconductor sales

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offices to decrease prices, while prices of imported devices now translate into higher value in local currencies.

In the mid- to long term, after new terms of trade have been settled on, Asia/Pacific countries will see changes in their basic economic structures in terms of electronic product categories as Japanese electronics companies rearrange production sites to take advantage of lower costs. Lower exchange rates will also encourage foreign companies to acquire local companies, and the increase in direct investment will contribute to re-establishing and renewing manufacturing facilities in the region.

In terms of demand for electronics manufactured in Asia/Pacific, domestic demand-oriented production will suffer an immediate and direct loss while export demand remains strong. Because overall demand for electronics in Americas and Europe seems to remain firm, the key factor here would be demand in Japan and China.

Lower exchange rates for local currencies will improve the export competitiveness of electronics produced in Asia/Pacific countries, but this could happen at the expense of production in other parts of the world. There is a possibility that some electronics equipment could see lower prices in export markets, and that may increase demand for those products. Whether electronics production in Asia/Pacific increases or decreases affects industrial equipment companies in Japan, because they have benefited from the Japanese electronics companies' production shift, which brought manufacturing equipment to those new sites. One other factor to be considered in electronics manufacturing is the possible shift in product class—in the past few years, ASEAN countries have shifted to middle-range products from low-end models, while China, with its low labor costs, took up production of low-end products. Depreciation of currencies in the ASEAN countries could enable them to resume production of low-end models, especially when they are motivated to increase exports to acquire foreign currency reserves.

Industrial equipment and manufacturing equipment are the areas hit hard by the Asian financial crisis because local companies find imported equipment too expensive. Along with the impact on the purchase of imported materials, this may motivate Asia/Pacific countries to secure industry autonomy.

Dataquest Perspective

The Asian financial crisis in its early stages was a set of financial phenomena. It should be noted that in countries whose gross domestic product (GDP) was not already damaged, economic fundamentals were not necessarily ailing, but the impact of the crisis is already being felt in various industries both inside and outside Asia/Pacific.

It should also be noted that, in Japan, the bursting of the bubble economy several years ago and the yen appreciation that followed continue to drag the Japanese economy down. If the effects of the crisis are managed poorly, there

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could be similar aftereffects in Asia/Pacific countries; if better managed, those countries' economies and industries could become more efficient.

One important factor that this Perspective has not covered is the impact of the Asian financial crisis on semiconductor production by Asia/Pacific companies and Japanese semiconductor companies' reactions to it. Although there is a general expectation in semiconductor industry circles that the crisis will bring the supply and demand into equilibrium sooner than predicted, the actual effects are yet to be seen. If the Asian financial crisis proves to provide an effective adjustment period, electronics industries may find it an opportunity instead.

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Perspective

Semiconductors Japan
Market Analysis

A First Look at 1997 Semiconductor Market Share from the Japanese Perspective

Abstract: *Dataquest has conducted phase one of the annual market share survey for the worldwide top 20 and regional top 10 semiconductor company rankings. This Perspective analyzes the Japanese ranking trends observed in the 1997 survey, trends related to Japanese companies in foreign markets, and the top 10 topics of conversation in the semiconductor industry, from the Japanese perspective.*
By Yoshihiro Shimada

Scope of Survey

Dataquest's annual 1997 market share survey was conducted in November and early December 1997, and the results were published in an earlier Perspective ("Intel, NEC, and Motorola Remain atop the Worldwide Semiconductor Market," SCND-WW-DP-9706, January 1998). We limited our information request to total worldwide semiconductor revenue plus revenue in four regions. We structured the survey to capture the top 20 worldwide plus the top 10 in each region. We did not survey every company worldwide, which explains why the published tables do not have a market total or "other companies" category. Also, we did not survey at detailed product levels.

The Top 10 in the Japanese Market

In the 1997 spring forecast, the Japanese market was expected to show clear signs of recovery by growing at an annual rate of more than 10 percent. By the time Dataquest started work on the fall forecast, this initial expectation had started to look too optimistic. The fall forecasts states that the Japanese

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market will grow annually only 9.5 percent on a yen basis, and 1.0 percent on a dollar basis. As mentioned, total market trends will be analyzed in the detailed survey to come, but the qualitative information obtained in this semiconductor revenue survey suggests deteriorating revenue trends, basically because of weak pricing of products such as DRAM and application-specific ICs (ASICs). Production of application equipment showed a slowdown in some areas, such as PCs, peripherals, and consumer equipment. Putting aside the shift of demand from PHS to cellular phones, mobile communications, on the whole, was the only area in which the industry outpaced initial forecasts that predicted weak or negative growth.

In such a market, the top 10 rankings of semiconductor shipments into Japan changed little during 1997 (see Table 1). Hitachi Ltd. suffered a major loss in revenue because of its high ratio of DRAM to total semiconductor revenue, but managed to maintain its No. 2 position. The only change in ranking was between Intel Corporation and Mitsubishi Corporation. Mitsubishi, with the second-highest DRAM ratio of major Japanese companies, recorded a contraction, while Intel's revenue continued to grow, even though Japanese PC markets turned sluggish in the second half of the year.

Japanese Companies in Foreign Markets

Table 2 shows Japanese companies in the worldwide top 20 ranking. NEC Corporation leads Japanese companies at No. 2 in the worldwide rankings. Hitachi's revenue exceeded Toshiba Corporation's in 1996, but its lead did not last long. Other than that, because revenue changes were comparatively small for most companies, the rankings among Japanese companies did not change much.

Table 1
Revenue of Top 10 Companies Worldwide from Shipments of Semiconductors to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Growth (%) 1996-1997
1	1	NEC	5,756	5,830	1.3
2	2	Hitachi	4,252	3,749	-11.8
3	3	Toshiba	3,838	3,562	-7.2
4	4	Fujitsu	2,645	2,912	10.1
5	5	Matsushita	2,268	2,340	3.2
7	6	Intel	2,028	2,211	9.0
6	7	Mitsubishi	2,147	2,101	-2.1
8	8	Texas Instruments	1,634	1,640	0.4
9	9	Sharp	1,561	1,511	-3.2
10	10	Sony	1,386	1,392	0.4

Source: Dataquest (January 1998)

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Table 2
Revenue of Japanese Semiconductor Companies in the Worldwide Top 20 Ranking (Millions of U.S. Dollars)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Growth (%) 1996-1997
2	2	NEC	10,428	10,656	2.2
5	5	Toshiba	8,065	7,507	-6.9
4	6	Hitachi	8,071	6,523	-19.2
8	8	Fujitsu	4,427	4,872	10.1
11	10	Mitsubishi	4,100	4,097	-0.1
14	14	Matsushita	3,003	3,055	1.7
15	16	SANYO	2,491	2,577	3.5
19	20	Sharp	2,124	2,059	-3.1

Source: Dataquest (January 1998)

In the Americas region, three Japanese companies were listed among the top 10. NEC, with flat growth, gave way to Texas Instruments Inc. to become No. 4, while Toshiba and Hitachi switched places. In a market in which weak DRAM pricing eroded revenue, Japanese companies as well as Korean companies suffered two-digit reductions in total semiconductor revenue.

In the European market, only two Japanese companies made their way into top 10, NEC and Fujitsu. NEC maintained its No. 8 position, while Fujitsu jumped into No. 9.

In the Asia/Pacific region, three Japanese companies, again, appeared in the top 10 ranking. In this region, Toshiba has traditionally been strong, but it gave way to Texas Instruments and became No. 4. NEC, with comparatively strong growth of 7.9 percent over 1996, maintained its No. 7 position. The third Japanese company was SANYO, which has also had advantages in the Asia/Pacific region. SANYO's historical strength has been in consumer applications, and it was a beneficiary of the recovery in consumer equipment production in this region. None of these three Japanese companies' revenue showed any significant or immediate impact of Asia's financial crisis for 1997.

Starting in January 1998, Dataquest will conduct a detailed survey of all semiconductor companies' 1997 product revenue plus memory unit shipments and microprocessor (MPU), microcontroller (MCU), and digital signal processor (DSP) unit shipments. We will release that detailed information during the second quarter of 1998. Those detailed results will provide information on companies that enjoyed product successes in 1997 that are not listed in this document's tables.

The 10 Most Popular Topics in 1997 from the Japanese Perspective

Dataquest has put together a list of the top 10 news in the 1997 semiconductor industry from the perspective of the Japanese semiconductor

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industry, based on interviews with Dataquest's contacts in the industry, as well as from various Dataquest analysts' input.

Table 3 lists 10 ubiquitous topics of industry conversation. The top three topics, characteristically, centered around DRAMs. DRAM consumption was expected to resume a recovery path, but the actual trends betrayed this expectation. Although the shift from 16Mb to 64Mb started to make substantial progress and overall bit demand was more than steady, the delay in the shift from extended data out (EDO) to synchronous DRAM (SDRAM), weak pricing trends, and the PC slowdown in Japan and Asia/Pacific brought revenue growth down.

Micron Technology Inc. became the third most frequent topic. Micron Technology increased production and shipments of 16Mb DRAM while Japanese and Korean companies were seeking ways to stabilize the supply/demand balance. Its production trends and pricing and the profit Micron secured in 1997 revealed a totally new strategy in the DRAM business. True, Micron has been known for its unique strategy, but the fact that the company has finally become the top producer of 16Mb DRAM was a shock to many in industry circles—especially Japanese industry circles.

PC shipment trends were the fourth most frequent topic of discussion. In 1997, the Japanese PC market started to show sluggishness, and peripherals such as CD-ROMs finally started to show signs of production constraint. There is some indication that 1997 PC market trends can be characterized by language—in two-byte language regions such as Japan and Asia/Pacific, PC shipment growth weakened. This stems from the fact that, with PC penetration becoming high, additional demand for PCs lies in the growth of networking. In two-byte language areas, where English is not necessarily spoken as a native language, access to cyberspace is limited while Web sites in the native language may appear to be less attractive than those in English, especially those with American origins. Needless to say, the turbulence in Asian economies is playing a role, too.

Table 3
The 10 Ubiquitous Topics, from a Japanese Perspective

Rank	Topic
1	Contraction in the DRAM market for the second consecutive year
2	Continued fall of DRAM prices
3	Micron Technology's production increase and marketing strategy
4	Winds of change in the regional PC markets
5	Sluggishness in equipment production and semiconductor consumption in Asia/Pacific
6	Construction of quarter-micron fabs
7	Increase in flash memory market players
8	Visibility of Taiwanese manufacturers in the DRAM business
9	Disappointment in worldwide semiconductor consumption growth
10	Continued sound growth in mobile communications applications

Source: Dataquest (January 1998)

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The Asian financial crisis ranked fifth as a topic. In 1997, the real impact was yet to come and influenced Japan very little. Japanese equipment companies with production sites in Asia/Pacific maintained their levels of production, especially in cases where products were destined to be shipped out of the region. Currently, the strongest interest lies in assessing the magnitude of the impact of the crisis on Korean semiconductor companies' capital spending. A major impact is anticipated, however, on various aspects of electronics industry in 1998.

The construction of quarter-micron fabs and their production starts is one of the few positive topics. Contrary to the initial expectation of improvements in profits, quarter-micron fab output was immediately exposed to harsh pricing competition, both in memories and in logic areas.

Flash memories drew interest as a substitute for DRAM in filling fabs as the fast-growing digital still camera market diversified the applications. MCUs with flash memory have also started to show strong growth. With prices lower than originally planned, flash MCUs are finding their markets quickly.

Ranked eighth is Taiwanese companies' penetration into the DRAM market. Over several generations, the winners in the DRAM business have shifted first from American companies to Japanese companies, then to Korean companies. Now the focus of interest is the question of whether Taiwanese companies will become the next leaders in the DRAM market. Taiwanese companies have already started to produce 64Mb DRAMs to seriously penetrate into the DRAM market, which they initially planned to with 16Mb. Whether their product and technology transfers with foreign partners can contribute to the success of Taiwanese companies is yet to be determined.

Ninth on the list is the disappointment in worldwide semiconductor market growth. The industry expected 1997 to be the year of recovery, but the signs of recovery ended up being very modest. In fact, it became the year when applications that had driven the semiconductor market for the past several years failed to bring about strong demand. Although Dataquest's fall forecast was lower than the spring forecast, actual market trends toward the end of the year suggest even further reductions in growth rates.

Last comes a topic in the communications. While the emphasis of the worldwide semiconductor market is shifting from standalone PCs to communications-related applications such as networks and mobile phones, the Japanese electronics industry is still dwelling on PCs and peripherals. Network-related equipment is yet to come into focus, but mobile phones have come to be recognized as one driver of semiconductor demand. In fact, at the beginning of the year, a slowdown in the production of mobile phones was expected, especially for PHS. It is true that PHS subscriptions suffered contraction in the last few months of 1997, but cellular phones remained steady.

Outside the top 10 are other topics, including:

- Applications: Windows 97/98, CD-ROM production, Windows CE machines, and cyberpets

- Semiconductors: SDRAM, embedded memories, Pentium MMX and Pentium II, clone chips, media processors, and analog ICs
- Manufacturing: fab construction trends, Korean companies' capital spending, and 300mm fab technology and construction

A pleasant surprise was seen among analog companies. As electronic equipment production rose on a worldwide basis, it was only natural for demand for analog ICs to grow steadily. But this is an area in which capital spending and engineering staffing have been underestimated, and the actual growth in demand for analog took companies by surprise. Lack of capital spending brought tight supply, even allocation in some cases, as well as constraint in product development because of the lack of analog engineers. This is expected to continue for some years, but the industry is trying to evaluate the actual demand that remains for independent analog devices, as opposed to analog functions incorporated into system-level integration (SLI) ASICs.

Topics of 300mm fab technology kept conversation going throughout the year and will continue to in the coming several years. The collaboration agreement between the International 300mm Wafer Initiative (I300I) and SELETE groups is expected to bring efficiency into the scheme through global standardization, but actual technology development and fab construction are dependent on each company. Semiconductor companies must face issues such as the cost comparison between 300mm and 200mm technologies, technology and equipment development, the long-term semiconductor supply/demand outlook, and semiconductor companies' product development.

Dataquest Perspective

The results of Dataquest's 1997 market share survey show a sharp contrast between strengthening American and European vendors and weakening Japanese and Korean companies.

This, however, does not result solely from a difference in their emphasis on DRAM but also from a difference in their successful systems-oriented marketing and product development. Even among major Japanese and Korean companies, there are companies that have managed to minimize the negative impact of the DRAM price drops by expanding nonmemory MOS digital products, such as microcomponents and logic. Even in DRAM, which has long been considered a typical commodity product category, a systems orientation can be seen, including development of SDRAM and certain companies' marketing efforts focused on PC companies and memory module companies.

The 1997 Japanese market share results, as well as the top 10 topics of interest to the semiconductor industry from a Japanese perspective, seem to pose one question: Has the Japanese semiconductor industry really become global, selective, and diversified? In 1998, systems-oriented product

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Chapter 1
Executive Summary

Scope of This Report

This Market Trends report analyzes the following trends in Japan from 1997 through 2002:

- Electronic equipment production market trends
- Semiconductor market trends
- Semiconductor companies' capital spending trends

Chapter 1 sets the stage for the analysis in this booklet. Chapter 2 discusses electronic equipment production trends, focusing on four major categories: electronic data processing (EDP), communications, industrial, and consumer. Chapter 3 covers the overall semiconductor market trends in Japan, analyzing 1997 market share results and forecasting the market for five years to come. Chapters 4 through 7 discuss detailed product market trends for MOS memories; MOS microcomponents; MOS logic; and analog, discrete, and optical semiconductors, respectively. Those chapters also cover 1997 market share results and forecast market trends for 1998 through 2002. Chapter 8 sheds light on the Japanese semiconductor industry, focusing on the capital spending trends of the Japan-based semiconductor companies during 1997 and 1998.

Research Methodology and Definitions

This Market Trends report follows standard Dataquest market share and forecasting methodologies, but several points may need to be noted.

Numbers are expressed in Japanese yen to make the analysis of time series trends free from fluctuations in the yen/dollar exchange rate. Where necessary, numbers on a dollar basis are mentioned, using the exchange rates shown in Table 1-1.

Table 1-1
Yen-per-Dollar Exchange Rate, 1992 to 1998

Year	Yen (¥)
1992	126.45
1993	111.20
1994	101.81
1995	93.90
1996	108.81
1997	121.10
Preliminary 1998	129.73

Source: Dataquest (August 1998)

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The preliminary 1998 exchange rate estimate incorporated in this report uses actual exchange rates through December 1997 and assumes that the December rate applies to all future months. For the years 1999 through 2002, the preliminary 1998 exchange rate is assumed to apply.

Dataquest has made some minor changes to the product definitions in the 1997 market share survey and analysis and is considering a major shift to a new set of definitions in the future; these future changes will be in conjunction with those made in 1997, aiming at the best analysis of system-oriented market trends.

The following are the changes that have been made:

- The hybrid ICs category has been erased from 1997 revenue. Revenue from the shipment of hybrid ICs is counted on the basis of component chips produced by the same vendor in the product categories that those chips belong to, such as analog and discrete. 1996 revenue remains as it was.
- Linear array revenue has been moved from analog to ASIC in 1997 revenue, while 1996 revenue remains the same. Mixed-signal ASIC revenue has also been moved from analog to ASIC, both in 1996 and 1997 revenue. As a result of those changes, analog and ASIC revenue in 1996 is different from previously published numbers for vendors of those products. Also, as a result, the ASIC category is now called "Total ASIC," and what was formerly called "MOS Digital Logic" is now called "Total Logic."

These changes do not appear explicitly in this book, because it describes top-line trends for each product category, but for any comparison of 1997 trends—as well as future trends—with the past trends, including 1996 and before, these changes may need to be noted in some cases.

Major points discussed in this document include the following:

- Japanese electronics production is forecast to grow 3.0 percent in 1998, and the compound annual growth rate (CAGR) for the coming five years will be 2.8 percent. These growth rates have been brought down from the level previously forecast, and Japan still needs to identify strong drivers of electronics production.
- The Japanese semiconductor market is forecast to grow 9.8 percent in 1998, and the CAGR for the coming five years will be 12.4 percent. In a downside scenario, however, 1998 growth could go down to 1.5 percent. The lack of a strong electronics driver is affecting semiconductor consumption in Japan, and the prolonged oversupply in various semiconductor products is affecting pricing trends negatively.
- Japanese semiconductor companies' capital spending in 1998 will see a major drop from the previous year. Reduction in spending is mostly seen in memories, and Japanese companies are placing more emphasis on preparing supply capacity for advanced logic products to serve SLI markets.

- The Japanese semiconductor market is forecast to grow at the slowest pace among the four regional markets worldwide. Along with prolonged weakness in the DRAM market and the acceleration of the SLI move, the changes in regional market size and application trends will force domestic vendors to restructure their operation toward improved support of global customers. Whether digital consumer applications can revive the Japanese market, and whether it is the Japanese vendors or overseas vendors that benefit from emerging applications, depend on each company's efforts to restructure semiconductor operation and transform from commodity vendor to system-level integrator.

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Chapter 2
Japanese Electronic Equipment Production Trends

The Japanese economy in 1997, after a temporary surge in domestic demand prior to the consumption tax hike in April, was beleaguered by turmoil in the financial system, a decline in consumer expenditure, and a slowdown in capital spending. The economic hardship was amplified by the Asian financial crisis (AFC) toward the year-end.

In 1997, against all the backlash in the Japanese economy and in Asia/ Pacific, electronic equipment production showed stronger growth than expected: 7.8 percent over 1996, reaching ¥23,715 billion (see Tables 2-1 and 2-2). Cellular phones contributed greatly, fueled by a series of price cuts and the shift in demand from personal handy phone (PHS) models. EDP equipment also outgrew the forecast, despite a slowdown in domestic PC shipments, and consumer equipment added some momentum that came from video game systems and digital equipment.

In 1998, communications equipment will no longer serve as a major impetus, as the cellular phone market reaches a high level of penetration and the digitization of backbone networks completes its first round. Thus, Dataquest predicts that electronic equipment production in Japan will grow a moderate 3.0 percent to ¥24,425 billion, down 1.6 percentage points from the fall forecast. Similarly, the CAGR between 1997 and 2002 will settle at 2.8 percent.

Future growth opportunities must come from a surge in PC demand stimulated by the introduction of low-cost models and increased implementations of plug-and-play interfaces, such as universal serial bus (USB) and Institute of Electrical and Electronics Engineers (IEEE) 1394. While Windows 98 will not have much of an impact on the PC market, the evolution of PCs to a new platform for WebTV and other media-mix services will hold the key to growth in demand for personal equipment.

The following section provides a detailed analysis of electronic equipment production in Japan for the four major categories, namely, EDP, communications, industrial, and consumer.

Table 2-1
Japanese Electronic Equipment Production History and Forecast, 1992 to 2002 (Billions of Yen)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	1997-2002 CAGR (%)
Electronic Equipment	**21,154.7**	**19,363.3**	**19,382.3**	**19,814.8**	**22,000.7**	**23,715.2**	**24,425.0**	**24,900.9**	**25,725.4**	**26,201.2**	**27,280.4**	**2.8**
Data Processing	6,206.5	5,645.2	5,752.6	5,913.4	6,811.7	7,379.9	7,759.1	7,969.8	7,989.4	8,046.1	8,264.7	2.3
Communications	2,829.3	2,803.9	2,889.2	2,985.0	4,042.2	4,844.2	4,829.8	4,887.3	5,221.2	5,373.7	5,581.4	2.9
Industrial	3,190.2	2,948.7	2,948.3	3,342.6	3,647.5	3,908.4	4,140.0	4,339.0	4,560.0	4,763.0	5,057.0	5.3
Consumer	7,387.2	6,477.2	6,365.8	6,134.3	6,018.5	6,097.6	6,109.8	6,059.8	6,281.5	6,345.7	6,701.9	1.9
Military/Civil Aerospace	211.8	207.4	202.8	199.6	197.4	195.0	192.4	189.8	187.2	185.0	182.6	-1.3
Transportation	1,329.7	1,280.9	1,223.6	1,239.9	1,283.4	1,290.1	1,393.9	1,455.2	1,486.2	1,487.7	1,492.7	3.0
Exchange Rate (Yen/U.S.$1)	126.45	111.20	101.81	93.90	108.81	121.10	129.73	129.73	129.73	129.73	129.73	-

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (August 1998)

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Table 2-2
Japanese Electronic Equipment Production History and Forecast, 1992 to 2002
(Yen-Based Percentage Change over Preceding Year)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Electronic Equipment	**-12.5**	**-8.5**	**0.1**	**2.2**	**11.0**	**7.8**	**3.0**	**1.9**	**3.3**	**1.8**	**4.1**
Data Processing	-9.6	-9.0	1.9	2.8	15.2	8.3	5.1	2.7	0.2	0.7	2.7
Communications	-9.0	-0.9	3.0	3.3	35.4	19.8	-0.3	1.2	6.8	2.9	3.9
Industrial	-18.7	-7.6	0	13.4	9.1	7.2	5.9	4.8	5.1	4.5	6.2
Consumer	-15.1	-12.3	-1.7	-3.6	-1.9	1.3	0.2	-0.8	3.7	1.0	5.6
Military/Civil Aerospace	-2.1	-2.1	-2.2	-1.6	-1.1	-1.2	-1.3	-1.4	-1.4	-1.2	-1.3
Transportation	-2.7	-3.7	-4.5	1.3	3.5	0.5	8.0	4.4	2.1	0.1	0.3

Source: Dataquest (August 1998)

EDP Equipment

In 1997, EDP equipment production in Japan soared 8.3 percent to ¥7,380 billion. While PC shipments to the domestic market slowed down to less than 5 percent growth on a unit basis, the price decline spurred the purchase of peripherals such as printers and display units. Also, storage devices led by high-speed optical disk drives—32x CD-ROM drives and DVD-ROM drives, for example—enjoyed strong growth. This segment is expected to drive the market during the forecast period.

IT investment will continue to be a major driver in 1998 while Japanese financial institutions are exposed to global competition as a result of the "Big Bang," which urges them to strengthen information systems. Therefore, more than compensating for the general economic slump, computers will drive EDP equipment production, growing 5.1 percent in 1998 with a CAGR of 2.3 percent during the next five years. The gradual recovery of the Japanese economy will continue to fuel EDP equipment production after 1998, which should exceed ¥8 trillion in 2001.

Communications Equipment

Communications equipment production in 1997 jumped 19.8 percent to ¥4,844 billion. A prime driver was mobile communications equipment; subscribers grew much faster than expected, recording a net increase of 10 million in 1997. While PHS production decelerated at 7 million units, the market is expected to expand as its focus shifts from personal to office use.

Nevertheless, the penetration of mobile phones combining PHS and cellular phones has surpassed 50 percent, and the continuation of the previous high growth will become inevitably difficult. Meanwhile, the digitization of infrastructure facilities by Nippon Telegraph and Telephone Corporation (NTT) was completed by the end of 1997. These factors will consequently put a brake on communications equipment production, turning into a negative growth of 0.3 percent. On the other hand, network equipment, including LANs, will experience healthy growth at a CAGR of 15 percent or above. All in all, communications equipment production will grow at a CAGR of 2.9 percent between 1997 and 2002.

Industrial Equipment

Industrial equipment production in 1997 was up 7.2 percent, totaling ¥3,908 billion. Of the total, manufacturing systems and instruments recorded the highest growth rate, with 14.9 percent. As the wave of production site relocation to Asia/Pacific countries subsides, the focal point of the market will shift to computerization and sophistication for adding value and further automation. In particular, medical equipment will exhibit strong growth, with the increasing demand for advanced systems to meet the needs of an aging society, resulting in a CAGR of 5.2 percent between 1997 and 2002. Overall, Dataquest predicts a CAGR of 5.3 percent, the highest among the six segments: data processing, communications, industrial, consumer, military/civil aerospace, and transportation.

Consumer Equipment

Consumer equipment production recorded a 1.3 percent increase in 1997, reaching ¥6,098 billion. In the video equipment segment, where TVs and VCRs sold in the domestic market are mostly made overseas, the replacement demand for wide-screen TVs produced at domestic sites contributed greatly. In the digital consumer equipment market, digital video cameras (DV-Cs) recorded notable growth, and unit shipments up to the end of 1997 were estimated at slightly below 1 million. The DV-C quickly will become pervasive, driven by price declines and the improved availability of key components. Similarly, digital still cameras (DSCs) will ramp up rapidly because they can be easily connected to PCs or TVs via a flash memory card or IEEE 1394 interface. On the other hand, the commercialization of digital TVs will have to wait until after 2000 because infrastructure construction has been delayed.

The current recession will hit household appliance production directly, leading to negative growth in 1998. Video game systems will continue to be a fierce battlefield for a 32-bit hegemony, but production will remain mostly unchanged in 1998, until the next-generation products are introduced in 1999. Dataquest predicts that consumer equipment production as a whole will grow at a CAGR of 1.9 percent between 1997 and 2002.

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Chapter 3
Overall Japanese Semiconductor Market Trends

1997 Market Share

Market Trends

In 1997, the Japanese semiconductor market recorded a growth rate of 5.7 percent over the previous year on a yen basis, which was the only negative growth rate on a dollar basis among the four regional markets in the world. As discussed in the previous chapter, the production of electronics equipment in 1997 grew faster than what was forecast, but this growth was not directly translated into faster growth in semiconductor consumption. The difference in trends was caused by two factors: An increase in electronics production took place in categories with lower semiconductor contents, such as industrial equipment, and the price erosion of semiconductor devices betrayed the increase on a unit basis. Also, PC shipments lost momentum in Japan, exerting a negative impact on the consumption of a variety of semiconductor products, including memories, microprocessors (MPUs), and logic.

As a result, the Japanese semiconductor market has become less than one-fourth of the worldwide market for the first time since 1980. It is still the second-largest regional market following the Americas, but both European and Asia/Pacific markets are close behind. In fact, there were months within 1997 when the Japanese semiconductor market fell behind those two markets.

Affecting this is the sluggishness in the domestic market as well as the fast growth in other regions, especially in the Americas and Europe. Semiconductor procurement to support Japanese electronics companies' Asian production sites has moved to each site or to international purchasing offices (IPOs) outside of Japan, and the yen depreciation observed in 1997 did not reverse the trend.

Ranking Trends

The Japanese semiconductor market is characteristically led by domestic vendors, but their market share has been on a constant decline. In 1997, non-Japanese companies together had 26.4 percent of the Japanese market, and Americas companies alone had a more than 20 percent share, while Asia/Pacific companies lost share because of the weak DRAM market. European companies hold a meager 1.5 percent share but are increasing visibility by focusing on selected product areas for the target applications of digital consumer and automotive. Needless to say, the decline of the Japanese companies' combined market share was largely caused by the DRAM price fall, but it should be noted that non-Japanese companies no longer need strong side support in penetrating the Japanese market. Successful non-Japanese companies have come to enjoy close ties with Japanese system companies with their expertise in system-oriented devices in the areas of microcomponents, logic, and analog.

NEC Corporation continued to lead the Japanese market in 1997 (see Table 3-1). While many other major domestic vendors suffered from sluggishness in various product areas, NEC managed to secure positive growth in all of the major product areas except for memories—ranging from microcomponent, logic, analog, discrete, and optical—on a yen basis. Dataquest estimates that utilization at NEC's fabs remained higher than at those of most other Japanese vendors, helping it to maintain a comparatively healthy income profile. Toshiba Corporation and Hitachi Ltd. switched places in 1997. While Toshiba became the beneficiary of design wins in the digital consumer, mobile communications, and mass storage applications, Hitachi could not fully enjoy the fruit from the increased number of design wins for its proprietary architecture microcomponent product lines. Fujitsu Ltd. and Matsushita Electronics Corporation remained at the same positions of No. 4 and No. 5, respectively. Fujitsu increased market share, with contributions from digital consumer and mass storage applications. Matsushita Electronics also benefited from those two application areas, having system manufacturing companies inside the corporate group. Although PC shipments slowed, Intel Corporation still enjoyed a sound growth of over 20 percent and became No. 6, replacing Mitsubishi Electric Corporation.

Among the non-Japanese companies that gained market share in 1997, LSI Logic Corporation, Analog Devices Inc., Macronix International Company Ltd., and Lucent Technologies stand out with their high growth rates. The growth of LSI Logic was a result of the design wins of its SLI ASIC product line in digital consumer applications, while Lucent took advantage of its communications expertise. Analog Devices was a beneficiary of healthy analog market trends, and Macronix benefited from the mask ROM business, from which Japanese companies are exiting.

Forecast through 2002

The Japanese semiconductor market in 1998 will grow at 9.8 percent (2.5 percent on a dollar basis), down from the fall forecast (see Tables 3-2 and 3-3). This reflects the anticipated slowdown in electronic equipment production and the hovering market conditions for DRAMs, and it also exemplifies the expectation for a recovery in the second half. Underlying assumptions include a mild DRAM price decline, the small direct impact of AFC, and the firming up of the PC market with the introduction of Windows 98. With this growth, however, the Japanese market will lose its share in the worldwide market, while the other three regional markets will gain share.

The CAGR between 1997 and 2002 is forecast to be 12.4 percent, or 10.9 percent on a dollar basis, which is the lowest among the four regions, making the Japanese market the smallest, with a 20 percent share in the worldwide market. With the electronics production CAGR at 2.8 percent, this slow increase in semiconductor consumption is unavoidable, but the long-term trends will pose a major challenge to Japanese vendors.

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Table 3-1
1997 Japanese Market Share Ranking: Total Semiconductor (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	NEC	626.3	686.2	9.6	15.5
3	2	Toshiba	417.6	421.9	1.0	9.5
2	3	Hitachi	462.7	406.3	-12.2	9.2
4	4	Fujitsu	287.8	335.2	16.5	7.6
5	5	Matsushita Electronics	246.8	271.7	10.1	6.1
7	6	Intel	220.7	270.9	22.8	6.1
6	7	Mitsubishi Electric	233.6	245.8	5.2	5.6
8	8	TI	177.8	187.6	5.5	4.2
9	9	Sharp	169.9	180.6	6.3	4.1
10	10	Sony	150.8	165.8	9.9	3.8
11	11	SANYO	135.9	156.5	15.1	3.5
12	12	Rohm	114.1	117.2	2.7	2.7
14	13	Motorola	72.7	75.2	3.5	1.7
13	14	Samsung	89.1	71.3	-20.0	1.6
15	15	Oki	63.0	68.2	8.2	1.5
19	16	LSI	29.9	44.4	48.5	1.0
16	17	Rockwell	48.5	42.1	-13.2	1.0
17	18	Sanken	38.3	36.6	-4.5	0.8
18	19	Fuji Electric	34.8	31.4	-9.9	0.7
20	20	National	27.6	27.5	-0.5	0.6
23	21	SGS-Thomson*	24.8	26.0	4.9	0.6
21	22	HEC	26.5	25.7	-3.3	0.6
29	23	Analog Devices	17.5	23.5	34.1	0.5
31	24	Macronix	16.0	23.0	43.9	0.5
33	25	Lucent	14.8	22.5	52.2	0.5
28	26	Philips Semiconductors	18.7	22.0	17.8	0.5
22	27	LG Semicon	26.4	21.2	-19.8	0.5
26	28	AMD	19.3	19.4	0.6	0.4
27	29	Shindengen Electric	18.8	19.0	1.0	0.4
25	30	Yamaha	20.6	18.5	-9.9	0.4
34	31	Ricoh	14.8	17.1	15.4	0.4
32	32	IBM	15.5	16.0	3.5	0.4
127	33	Stanley Electric	0	15.5	NA	0.4
36	34	New JRC	13.1	15.4	17.8	0.3
35	35	Cirrus Logic	14.5	14.2	-2.1	0.3
37	36	Altera	10.3	13.8	33.6	0.3
30	37	Seiko	17.2	13.7	-20.4	0.3
24	38	Atmel	22.7	13.1	-42.5	0.3

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Table 3-1 (Continued)
1997 Japanese Market Share Ranking: Total Semiconductor (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
46	39	Chips & Technologies	6.0	10.9	82.1	0.2
69	40	Sun	2.2	9.1	317.4	0.2
		All Others	212.1	218.1	2.8	4.9
		Americas Companies	845.1	949.9	12.4	21.5
		Japanese Companies	3,109.2	3,252.1	4.6	73.6
		European Companies	55.2	66.6	20.7	1.5
		Asia/Pacific Companies	170.2	151.4	-11.0	3.4
		Total Market	**4,179.7**	**4,420.0**	**5.7**	**100.0**

NA = Not available
* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

Table 3-2
Japanese Semiconductor Market History and Forecast, 1992 to 2002 (Billions of Yen)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Total Semiconductor*	**2,602.2**	**2,740.5**	**3,156.9**	**3,959.4**	**4,179.7**	**4,420.0**	**4,851.5**	**5,571.0**	**6,485.0**	**7,603.5**	**7,925.5**	**12.4**
Total Integrated Circuit (Excluding Hybrid)	1,921.5	2,076.5	2,454.2	3,162.6	3,313.5	3,576.1	3,943.3	4,595.3	5,421.5	6,458.4	6,697.9	13.4
Total Bipolar Digital	145.9	125.4	123.8	100.6	83.8	64.2	64.6	55.1	50.5	43.5	38.9	-9.5
MOS Memory	510.5	619.4	737.7	1,150.9	923.5	789.9	845.6	1,062.8	1,410.1	1,975.0	1,613.8	15.4
MOS Microcomponent	413.4	443.4	570.4	735.2	957.2	1,130.6	1,302.4	1,561.9	1,817.5	2,077.0	2,396.1	16.2
MOS Digital Logic	484.7	523.9	610.1	730.5	851.0	988.7	1,074.5	1,200.8	1,361.1	1,513.1	1,736.7	11.9
Analog-Monolithic	367.1	364.5	412.1	445.4	498.0	602.7	656.2	714.7	782.3	849.9	912.4	8.6
Total Discrete	389.1	380.6	398.7	439.6	479.6	513.9	565.8	609.9	667.9	716.4	765.8	8.3
Total Optical Semiconductor	196.8	192.2	213.5	259.9	287.0	330.0	342.5	365.8	395.7	428.8	461.8	7.0
Exchange Rate (Yen/U.S.$1)	126.5	111.2	101.8	93.9	108.8	121.1	129.7	129.7	129.7	129.7	129.7	-

*"Total Semiconductor" includes hybrid ICs up to the year 1996, while the "Hybrid IC" category has been eliminated for years 1997 and beyond. Only semiconductor contents of hybrid ICs are counted for years 1997 and beyond.
Notes: Columns may not add to totals shown because of rounding.
Source: Dataquest (August 1998)

Table 3-3
Japanese Semiconductor Market History and Forecast, 1992 to 2002 (Yen-Based Percentage Growth over Preceding Year)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Total Semiconductor (Excluding Hybrid)	**-14.9**	**5.3**	**15.2**	**25.4**	**5.6**	**5.7**	**9.8**	**14.8**	**16.4**	**17.2**	**4.2**
Total Integrated Circuit (Excluding Hybrid)	-13.9	8.1	18.2	28.9	4.8	7.9	10.3	16.5	18.0	19.1	3.7
Total Bipolar Digital	-25.6	-14.1	-1.3	-18.7	-16.7	-23.4	0.7	-14.7	-8.5	-13.9	-10.4
MOS Memory	-11.2	21.3	19.1	56.0	-19.8	-14.5	7.0	25.7	32.7	40.1	-18.3
MOS Microcomponent	-14.4	6.5	28.6	28.9	30.2	18.1	15.2	19.9	16.4	14.3	15.4
MOS Digital Logic	-12.5	8.1	16.5	19.7	16.5	16.2	8.7	11.8	13.4	11.2	14.8
Analog-Monolithic	-12.8	-0.7	13.1	8.1	11.8	21.0	8.9	8.9	9.5	8.6	7.4
Total Discrete	-16.6	-2.2	4.8	10.3	9.1	7.2	10.1	7.8	9.5	7.3	6.9
Total Optical Semiconductor	-19.0	-2.3	11.1	21.7	10.4	15.0	3.8	6.8	8.2	8.4	7.7

Source: Dataquest (August 1998)

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After Dataquest put together the spring forecast and announced the results in April, several major changes in the electronics industry and semiconductor market have been observed. In view of those factors, Dataquest has added another scenario to the forecast, a downside of the trends described earlier.

In this scenario, worldwide electronics production, which was forecast to show 6.9 percent annual growth in 1997, is assumed at 4.4 percent, or slightly above. Affecting this scenario is the slowdown in unit production in several electronics categories, which have suffered oversupply and reduced unit demand caused by the AFC as well as downturn in the factory average selling price for various electronic equipment.

On the other hand, price erosion in the semiconductor market accelerated, not only in DRAMs but also in various product categories, including flash memory, MPUs, and ASIC; this gloomy wave has come to affect analog and discrete devices that have enjoyed healthy markets even after MOS digital products fell victim to the oversupply-ridden market.

Incorporating these factors, the new scenario sees the worldwide semiconductor market growth this year decreasing to 1.4 percent, a sharp drop from the 8.2 percent scenario in the spring forecast. In Japan, this scenario can be translated into a growth of 1.5 percent, as opposed to the 9.8 percent growth discussed above. A detailed scenario will be illustrated in Dataquest's fall forecast.

Challenge to the Vendors

Once, the Japanese semiconductor vendors grew to enjoy the largest market share in the worldwide market by focusing on two factors: DRAM and consumer applications in the domestic market. The sales into the domestic market represented over 80 percent of Japanese vendors' worldwide revenue in the 1980s, but in 1997, this decreased to 56 percent. As discussed in the long-term forecast, however, the Japanese application markets are not likely to offer major drivers for semiconductor consumption growth.

With this demand-side outlook, vendors that have focused on the Japanese market are facing two major challenges:

- Emphasize and strengthen application-oriented marketing to identify growth segments
- Increase support capability for overseas customers

In fact, not only the consumption of semiconductors, but also the system design, has begun to show signs of overseas shift. This shift is inevitable when the localization of the system is required to best serve local markets, but another factor that is prompting this shift in design capability is the realization of limitations in engineering resources, not only within Japan but on a worldwide basis as well.

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At the same time, with the DRAM market forecast to remain at around 15 percent of total semiconductors, Japanese companies need to accelerate the shift of business focus on other product areas. Already, the realization of SLI trends has prompted Japanese companies to initiate the restructuring of their businesses in all aspects of semiconductor operations, ranging from customer support and product design to process development and manufacturing capital spending. This "SLI Shift" also requires marketing power reinforcement.

With reduced profits because of weak pricing trends, major players in the Japanese market face the challenge of making all those changes with minimal resources. It is not sufficient to assume that Japanese semiconductor vendors can automatically benefit from the digital consumer just because the development and production of digital consumer equipment are taking place in the backyard. The efforts to best capture the SLI trends and reform the semiconductor operation will enable them to enjoy a reasonable share and profits in the semiconductor business.

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Chapter 4
Japanese MOS Memory Market Trends

1997 Market Share

Market Trends

In 1997, the Japanese MOS memory market recorded negative growth of 14.5 percent over the previous year. On a dollar basis, the decline reached 23.1 percent, worse than that of the world market, which registered an 18.6 percent decrease. The major factor for the MOS memory decline was the relentless erosion of DRAM prices, which hit the Japanese market hard, and Japanese companies relying on the domestic market were severely damaged. As a result, the world share of the Japanese market declined slightly, from 22.3 percent in 1996 to 21.1 percent in 1997.

A breakdown of the 1997 Japanese market by device indicates major slumps in the DRAM and static RAM (SRAM) segments, which shrunk by 15.6 percent and 17.8 percent, respectively. While the two devices grew in unit shipments, price declines caused the overall market decline on a value basis. In particular, the DRAM market has been suffering a supply glut and is still experiencing a seemingly unstoppable price erosion. The sluggish DRAM market affected SRAM prices that continued to plummet. The nonvolatile memory market was not immune to the dreary market conditions, recording a 12.2 percent decrease in 1997. Clearly, the entire memory market is satiated with excess supply capacities. Even flash memory, one of the few big hopes in the market, reported a negative growth of 9.8 percent on a value basis, although unit shipments grew strongly, as bolstered by cellular phone demand. In the 1997 flash memory market, prices of 8Mb-or-smaller products dropped sharply, to bring the entire market down. In 1998, as Japanese companies are expected to shift part of their production capacity to flash-with-view to reduce dependency on DRAMs, 16Mb flash will likely be a target for another round of price decline.

Ranking Trends

In the 1997 Japanese MOS memory market, NEC ranked first with a 16.4 percent share (see Tables 4-1 through 4-4). The company managed to keep revenue downturns at a single-digit level (7.7 percent) among leading semiconductor companies that heavily rely on the DRAM business. Hitachi held second place, just as it did in 1996, even though it reported a 14.8 percent decline. Fujitsu was the only company in the top five that recorded an increase (8.6 percent); it advanced from fifth to third place. The major contributing factor was the strong growth of 16Mb flash sales, up 53.7 percent from 1996. In contrast, Toshiba fell from third to fifth place as its revenue from flash memory declined 75.7 percent.

Table 4-1
1997 Japanese Market Share Ranking: MOS Memory (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	NEC	139.9	129.2	-7.7	16.4
2	2	Hitachi	134.8	114.9	-14.8	14.5
5	3	Fujitsu	71.7	77.9	8.6	9.9
4	4	Samsung	85.7	68.2	-20.5	8.6
3	5	Toshiba	92.4	64.7	-30.0	8.2
7	6	Mitsubishi Electric	51.2	50.3	-1.9	6.4
6	7	Sharp	57.8	46.9	-18.9	5.9
8	8	TI	42.2	27.9	-34.0	3.5
14	9	Matsushita Electronics	16.2	26.3	62.1	3.3
9	10	HEC	26.5	25.7	-3.3	3.3
10	11	LG Semicon	25.8	20.5	-20.6	2.6
12	12	Oki	20.1	20.1	-0.1	2.5
15	13	Macronix	15.3	19.0	23.9	2.4
16	14	Intel	13.3	13.1	-1.5	1.7
11	15	Atmel	22.5	12.4	-45.2	1.6
13	16	SANYO	19.6	12.0	-38.8	1.5
19	17	IBM	10.3	10.7	3.1	1.3
18	18	SGS-Thomson*	10.4	9.1	-13.1	1.1
22	19	IDT	5.7	4.6	-18.7	0.6
17	20	Sony	13.2	4.2	-67.8	0.5
20	21	Motorola	7.1	3.5	-50.3	0.4
21	22	AMD	6.1	3.4	-44.4	0.4
29	23	Cypress	2.4	3.3	36.6	0.4
31	24	Xicor	2.4	3.3	36.6	0.4
27	25	Rohm	2.6	2.7	2.0	0.3
23	26	Mosel Vitelic	4.5	2.4	-45.7	0.3
32	27	Silicon Storage Technology	2.0	2.1	5.1	0.3
24	28	Nippon Steel	3.9	1.8	-53.6	0.2
25	29	Micron	3.5	1.8	-47.8	0.2
61	30	Fairchild	0	1.8	NA	0.2
35	31	Catalyst	0.8	1.3	74.9	0.2
40	32	Ricoh	0.3	1.0	196.8	0.1
33	33	Seiko	1.1	0.8	-22.1	0.1
41	34	Alliance	0.2	0.7	233.9	0.1
37	35	Siemens	0.5	0.5	-11.0	0.1
38	36	Winbond	0.5	0.5	-11.0	0.1
36	37	Vanguard	0.8	0.4	-52.3	0

Table 4-1 (Continued)
1997 Japanese Market Share Ranking: MOS Memory (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
121	38	Philips Semiconductors	0	0.2	NA	0
28	39	UMC	2.6	0.1	-95.4	0
34	40	WaferScale	1.0	0.1	-87.6	0
		All Others	6.4	0.8	-86.8	0.1
		Americas Companies	125.1	89.9	-28.2	11.4
		Japanese Companies	625.4	553.3	-11.5	70.0
		European Companies	11.0	9.9	-9.6	1.3
		Asia/Pacific Companies	161.9	136.8	-15.5	17.3
		Total Market	**923.5**	**789.9**	**-14.5**	**100.0**

NA = Not Available
* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

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Table 4-2
1997 Japanese Market Share Ranking: DRAM (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
2	1	NEC	83.3	83.6	0.3	18.0
1	2	Hitachi	96.6	81.5	-15.7	17.5
3	3	Samsung	70.8	53.6	-24.3	11.5
4	4	Toshiba	65.1	44.9	-31.0	9.7
5	5	Fujitsu	43.1	39.8	-7.5	8.6
6	6	Mitsubishi Electric	38.3	36.9	-3.6	7.9
10	7	Matsushita Electronics	15.2	25.9	70.1	5.6
9	8	HEC	24.9	24.6	-1.3	5.3
7	9	TI	36.0	20.6	-42.8	4.4
8	10	LG Semicon	25.0	19.9	-20.6	4.3
13	11	Oki	9.7	9.9	2.5	2.1
12	12	IBM	9.9	7.3	-26.6	1.6
11	13	SANYO	13.4	5.9	-55.7	1.3
14	14	Mosel Vitelic	4.4	2.4	-44.4	0.5
17	15	Sharp	3.2	1.9	-38.6	0.4
15	16	Nippon Steel	3.9	1.8	-53.6	0.4
16	17	Micron	3.3	1.8	-44.4	0.4
18	18	Motorola	2.5	0.7	-71.0	0.2
20	19	Siemens	0.5	0.5	-11.0	0.1
19	20	Vanguard	0.8	0.4	-52.3	0.1
27	21	Alliance	0	0.4	NA	0.1
21	22	Sony	0.3	0.2	-25.8	0.1
		All Others	-	-	-	-
		Americas Companies	51.7	30.8	-40.5	6.6
		Japanese Companies	372.1	332.5	-10.6	71.6
		European Companies	0.5	0.5	-11.0	0.1
		Asia/Pacific Companies	125.9	100.9	-19.9	21.7
		Total Market	**550.3**	**464.7**	**-15.6**	**100.0**

NA = Not available
Source: Dataquest (August 1998)

Table 4-3
1997 Japanese Market Share Ranking: SRAM (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Hitachi	29.6	27.4	-7.5	24.8
2	2	NEC	26.0	15.1	-41.8	13.7
3	3	Toshiba	15.0	15.0	0	13.6
5	4	Mitsubishi Electric	10.7	10.1	-5.7	9.1
7	5	Samsung	7.2	8.1	13.0	7.4
6	6	Sharp	9.0	7.3	-19.5	6.6
8	7	Fujitsu	5.8	6.7	15.5	6.0
4	8	Sony	12.8	4.0	-68.9	3.6
18	9	IBM	0.4	3.4	679.1	3.1
9	10	Motorola	4.5	2.8	-37.6	2.5
10	11	SANYO	2.8	2.2	-22.9	2.0
12	12	Cypress	1.5	1.9	27.2	1.8
13	13	Rohm	1.3	1.3	2.0	1.2
15	14	IDT	1.0	1.2	23.7	1.1
11	15	HEC	1.6	1.1	-33.2	1.0
14	16	Seiko	1.1	0.8	-22.1	0.8
16	17	LG Semicon	0.8	0.6	-20.5	0.5
21	18	Winbond	0.4	0.4	-16.5	0.3
23	19	Alliance	0.2	0.4	66.9	0.3
17	20	TI	0.5	0.2	-55.5	0.2
20	21	Oki	0.4	0.1	-72.2	0.1
106	22	Ricoh	0	0.1	NA	0.1
118	23	TEMIC	0	0.1	NA	0.1
19	24	Matsushita Electronics	0.4	0	-100.0	0
22	25	SGS-Thomson*	0.3	0	-100.0	0
24	26	ISSI	0.2	0	-100.0	0
25	27	Micron	0.2	0	-100.0	0
26	28	AMD	0.1	0	-100.0	0
27	29	Mosel Vitelic	0.1	0	-100.0	0
		All Others	-	-	-	-
		Americas Companies	8.7	9.9	14.1	9.0
		Japanese Companies	115.0	90.1	-21.7	81.7
		European Companies	0.3	0.1	-62.9	0.1
		Asia/Pacific Companies	10.1	10.2	0.5	9.2
		Total Market	**134.2**	**110.3**	**-17.8**	**100.0**

NA = Not available
* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

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Table 4-4
1997 Japanese Market Share Ranking: Flash Memory (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Fujitsu	19.2	29.4	53.7	38.1
4	2	Intel	13.3	13.1	-1.5	17.0
3	3	Sharp	15.8	8.5	-46.3	11.0
2	4	Atmel	16.2	7.4	-54.4	9.6
7	5	SANYO	2.6	3.4	29.8	4.4
14	6	Mitsubishi Electric	0.5	2.8	412.0	3.6
6	7	AMD	3.0	2.3	-24.5	3.0
10	8	Samsung	1.6	2.3	41.0	3.0
9	9	Silicon Storage Technology	2.0	2.1	5.1	2.7
5	10	Toshiba	6.0	1.5	-75.7	1.9
16	11	Hitachi	0.2	1.3	512.1	1.7
8	12	NEC	2.3	1.0	-57.6	1.3
12	13	TI	0.7	1.0	48.4	1.3
13	14	Matsushita Electronics	0.5	0.4	-33.2	0.5
11	15	SGS-Thomson*	0.9	0.2	-72.2	0.3
15	16	Macronix	0.5	0.2	-55.5	0.3
17	17	Catalyst	0.1	0.1	11.3	0.2
38	18	Fairchild	0	0.1	NA	0.2
99	19	Oki	0	0.1	NA	0.2
18	20	ISSI	0.1	0	-100.0	0
		All Others	-	-	-	-
		Americas Companies	35.4	26.0	-26.4	33.8
		Japanese Companies	47.1	48.3	2.6	62.6
		European Companies	0.9	0.2	-72.2	0.3
		Asia/Pacific Companies	2.2	2.5	16.9	3.3
		Total Market	**85.5**	**77.1**	**-9.8**	**100.0**

NA = Not available
* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

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MOS Memory Forecast through 2002

Dataquest predicts that the 1998 market will grow 7.0 percent (an 0.1 percent decrease on a dollar basis), which represents a downward adjustment of 6 percentage points compared to the fall forecast (see Tables 4-5 and 4-6). Again, DRAM price decline because of supply glut is the major culprit. While increased 16Mb production by U.S. companies triggered the price fall in 1997, the aggressive moves of Korean suppliers will dictate DRAM prices. At present, 16Mb prices continue to fall below $3 on the spot market, which pulls 64Mb prices downward.

The Japanese MOS memory market in 1998 will be driven by SRAM, EEPROM, and flash memory. In particular, after 1999, the DRAM market will expand at an accelerated pace, while the SRAM and nonvolatile memory markets will maintain healthy growth. In 2002, however, the DRAM market will experience negative growth as the generation crossover from 64Mb to 256Mb occurs. Dataquest predicts that the market's CAGR between 1997 and 2002 will be 15.4 percent (13.8 percent on a dollar basis).

While the fall forecast assumed that DRAM companies would curtail capital spending in 1998, these companies are currently moving to minimize the rate of investment cutbacks where possible. In particular, Korean companies are considering maintaining capital spending as close as possible to the 1997 level (on a won basis), despite the DRAM recession and pain from the AFC. Dataquest pointed out in the fall forecast that a major reduction of 64Mb production capacity would be required to regain revenue growth in 1998. However, DRAM companies are not reducing capital spending as much as expected, which necessitated the downward adjustment of the DRAM market growth forecast.

In 1998, a major event in the DRAM market will be a full-blown shift from extended data out (EDO) to synchronous DRAM (SDRAM). During the first half of 1998, 100-MHz SDRAMs for PC100 will keep a price premium against the 66-MHz versions, which will significantly narrow in the second half of 1998 as DRAM companies roll out 0.25-micron fab lines. After 1999, the Japanese DRAM market will be driven by better-managed capacity expansion by DRAM suppliers, recording a CAGR of 16.1 percent (14.6 percent on a dollar basis) between 1997 and 2002.

The Japanese nonvolatile memory market will be up slightly 0.3 percent (6.3 percent down on a dollar basis) in 1998 because of double-digit declines in EPROM and mask ROM, which will more than offset the 20 percent growth of the EEPROM and flash segments. The CAGR between 1997 and 2002 will be 9.6 percent, as the market will be driven by EEPROM and flash memory.

The Japanese flash memory market recorded negative growth of 9.8 percent in 1997, but it is expected to resume growth in 1998. Major applications include mobile communications equipment, led by cellular phones, as well as IC cards. In particular, smart phones are expected to ramp up early in Europe, becoming an important consumer of flash memory. This is expected to have a positive impact on the Japanese mobile communications and flash memory markets.

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Table 4-5
1997 Japanese MOS Memory Market History and Forecast, 1992 to 2002 (Billions of Yen)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
MOS Memory	510.5	619.4	737.7	1,150.9	923.5	789.9	845.6	1,062.8	1,410.1	1,975.0	1,613.8	15.4
DRAM	227.6	298.8	408.5	805.9	550.3	464.7	503.0	645.4	912.9	1,391.6	981.9	16.1
SRAM	130.1	145.1	142.2	135.4	134.2	110.3	123.3	167.9	217.6	277.2	287.8	21.1
Nonvolatile Memory	151.5	171.0	181.7	198.7	222.4	195.2	195.9	223.3	251.0	274.3	308.9	9.6
Other MOS Memory	1.3	4.4	5.3	10.9	16.6	19.7	23.4	26.1	28.7	31.8	35.2	12.2
Exchange Rate (Yen/U.S.$1)	126.5	111.2	101.8	93.9	108.8	121.1	129.7	129.7	129.7	129.7	129.7	-

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (August 1998)

Table 4-6
Japanese MOS Memory Market History and Forecast, 1992 to 2002 (Yen-Based Percentage Growth over Preceding Year)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
MOS Memory	-11.2	21.3	19.1	56.0	-19.8	-14.5	7.0	25.7	32.7	40.1	-18.3
DRAM	-14.1	31.3	36.7	97.3	-31.7	-15.6	8.2	28.3	41.4	52.4	-29.4
SRAM	-11.5	11.5	-2.0	-4.8	-0.9	-17.8	11.8	36.2	29.6	27.4	3.8
Nonvolatile Memory	-5.7	12.9	6.3	9.4	11.9	-12.2	0.3	14.0	12.4	9.3	12.6
Other MOS Memory	-45.8	238.5	20.5	105.7	52.3	18.9	18.8	11.4	9.9	10.7	10.7

Source: Dataquest (August 1998)

In the MOS memory market, Japanese semiconductor companies still strive to become less dependent on DRAM business. Large suppliers will increasingly shift their strategic focus to flash memory. The 1997 flash market saw price declines in 8Mb-or-less products. Dataquest expects that the move will spread to the 16Mb-or-larger segments in 1998 and after.

Challenge to the Vendors

To analyze the current state of memory vendors, they should be divided according to their DRAM dependency. This analysis focuses on DRAM-dependent companies. At present, DRAM vendors continue to be beleaguered by serious oversupply conditions with a deteriorating profitability that shows no signs of improvement. Cutthroat competition among vendors accelerates the race for next-generation process technology and higher integration, requiring them to engage in an endurance contest to keep high capital spending. As a result, three generations of leading-edge devices—64Mb, 128Mb, and 256Mb—will coexist in 1999.

Up until 1995, the rapid advance of process technology drove the commercial development of smaller DRAM chips by applying a linear shrink approach. At present, however, cost reduction becomes a primary reason for shrinking the chip size, while the same processing technology is applied. This means that the present supply glut is a combination of excess capacities—as the aftermath of the previous capital spending spree—and an increased number of chips taken from each wafer because of the advance of shrink technology.

Needless to say, the DRAM supply capacity must be cut down drastically to bring the market back to parity. However, a reduction of production capacity would be a hard blow to Korean companies and some U.S. manufacturers that heavily depend upon the DRAM business. Compared to them, Japanese DRAM vendors are less dependent and have alternative products to offer. It is thus a reasonable option for them to convert DRAM capacities to other devices on a continuous basis. Although the large-scale production shift will adversely affect prices of other products, such as flash, it makes better sense than desperately insisting on DRAM production under the present no-win situation. While reducing DRAM capacities, even on a temporary basis, it is desirable for them to continue R&D efforts on finer process technology. Because the DRAM market is increasingly driven by higher integration and faster speeds, vendors that lead in design rules are beginning to enjoy early profits. Dataquest predicts that the current oversupply condition will continue until the end of 1999. Vendors should cut down their own DRAM capacities in consideration of capital spending by the end of the century, allowing them to establish leading-edge process technology.

Chapter 5
Japanese MOS Microcomponent Market Trends

1997 Market Share

Market Trends

In 1997, the Japanese microcomponent market saw a sound 18.1 percent growth over the previous year (6.1 percent on a dollar basis). The major source of the increase was in the MPU and microcontroller (MCU) markets, both of which recorded two-digit growth rates.

PCs drove the MPU market, and the introduction of clone MPUs compatible with Pentium MMX helped the formation of the low-end PC and subnote PC markets. MCUs were boosted by the expansion of digital consumer equipment production, mobile communications equipment, and mass storage devices. In the emerging markets, such as the digital consumer and next-generation markets, ECU/euro areas consumed value-added 32-bit MCUs, which contributed to MCU vendors' profits. The Japanese digital signal processing (DSP) market shows a trend different from other regional markets because of Japanese application markets and the Japanese vendors' strategic technology. Notably, in mobile communications and in mass storage, Japanese system manufacturers tend to use semiconductor products developed by internal semiconductor divisions. This tendency has limited the penetration of foreign-made DSPs into the equipment and has created Japanese proprietary trends.

Ranking Trends

Intel increased its share to 22.8 percent, securing the No. 1 position in the Japanese MOS microcomponent market, as well as in other regional markets in 1997 (see Tables 5-1 through 5-5).

Following Intel was NEC, which led the worldwide MCU market as the No. 2 vendor, with a wide MCU product offering ranging from 4-bit to 64-bit. Its growth came mainly from 8-bit, proprietary 32-bit with proprietary architecture, and 64-bit million of instructions per second (MIPS) MCUs.

Ranked No. 3 was Hitachi, which lost market share in 1997 in spite of two-digit growth. Its growth in the previous year was boosted by 32-bit MCUs and MPUs used in video game applications. As its share in that application lowered in 1997, it penetrated into other applications, such as mass storage devices, but it could not make up the loss in other applications fast enough.

Toshiba, ranked No. 4, also grew in two digits, helped by mass storage and mobile communications applications. Fujitsu, with the contribution of 16-bit MCUs in mobile communications and 32-bit MCUs in storage and digital VCR applications, grew at an astonishing 49 percent, to be ranked at No. 5, surpassing Mitsubishi Electric. Mitsubishi Electric has traditionally been strong in VCR applications, and its revenue grew at a sound 13 percent, helped by 16-bit MCUs in storage applications and 32-bit proprietary MCUs with embedded DRAM for digital VCRs.

Table 5-1
1997 Japanese Market Share Ranking: MOS Microcomponent (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Intel	207.4	257.8	24.3	22.8
2	2	NEC	149.4	182.9	22.4	16.2
3	3	Hitachi	100.0	111.0	11.1	9.8
4	4	Toshiba	77.9	87.4	12.2	7.7
6	5	Fujitsu	51.7	76.9	48.8	6.8
5	6	Mitsubishi Electric	66.9	75.7	13.1	6.7
7	7	Matsushita Electronics	51.4	49.5	-3.6	4.4
8	8	Rockwell	43.5	37.7	-13.5	3.3
9	9	Motorola	26.3	27.1	3.0	2.4
10	10	TI	21.0	24.6	17.1	2.2
11	11	Sony	16.8	17.2	2.6	1.5
12	12	Sharp	13.9	16.8	20.9	1.5
16	13	SANYO	7.1	15.1	114.0	1.3
14	14	Oki	9.6	11.7	22.7	1.0
26	15	Lucent	3.8	11.7	208.4	1.0
13	16	Cirrus Logic	13.6	11.4	-16.3	1.0
19	17	Chips & Technologies	6.0	10.9	82.1	1.0
32	18	Sun	2.2	9.1	317.4	0.8
15	19	Oak	9.2	8.4	-9.7	0.7
17	20	Ricoh	6.9	8.4	21.9	0.7
22	21	AMD	4.7	7.5	60.5	0.7
18	22	Adaptec	6.0	6.9	15.3	0.6
20	23	Yamaha	6.0	6.7	11.3	0.6
25	24	National	4.1	6.2	49.4	0.5
28	25	Analog Devices	3.4	5.0	47.2	0.4
29	26	Digital	3.3	5.0	52.1	0.4
33	27	SGS-Thomson*	2.0	3.8	91.7	0.3
21	28	Trident	4.9	3.6	-25.8	0.3
30	29	QLogic	2.6	3.0	15.9	0.3
45	30	Symbios	0.7	2.5	289.5	0.2
41	31	ATI	1.1	2.4	122.6	0.2
36	32	Seiko	1.6	2.1	26.1	0.2
24	33	Philips Semiconductors	4.6	1.9	-57.6	0.2
34	34	C-Cube	1.7	1.9	11.3	0.2
38	35	DSP Group	1.4	1.6	11.3	0.1
23	36	Rohm	4.6	1.5	-68.2	0.1
27	37	LSI	3.8	1.5	-61.8	0.1
50	38	Microchip	0.4	1.5	233.9	0.1

Table 5-1 (Continued)
1997 Japanese Market Share Ranking: MOS Microcomponent (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
35	39	VLSI	1.6	1.3	-18.4	0.1
37	40	IDT	1.4	1.3	-5.8	0.1
		All Others	12.8	12.1	-5.7	1.1
		Americas Companies	383.8	458.2	19.4	40.5
		Japanese Companies	565.1	664.7	17.6	58.8
		European Companies	7.0	6.3	-9.6	0.6
		Asia/Pacific Companies	1.4	1.3	-5.8	0.1
		Total Market	**957.2**	**1,130.6**	**18.1**	**100.0**

* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

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Table 5-2
1997 Japanese Market Share Ranking: MOS Microprocessor (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Intel	187.7	239.4	27.6	73.9
2	2	NEC	16.9	29.3	73.8	9.0
3	3	Hitachi	14.4	14.4	0.3	4.4
9	4	Sun	2.2	9.1	317.4	2.8
4	5	Motorola	7.7	8.2	6.6	2.5
5	6	Toshiba	5.0	6.5	30.7	2.0
7	7	Digital	2.9	4.6	56.6	1.4
10	8	Fujitsu	1.6	4.1	152.3	1.3
6	9	AMD	4.7	2.7	-43.1	0.8
11	10	Sharp	1.5	2.4	59.0	0.7
12	11	IDT	1.4	1.3	-5.8	0.4
18	12	National	0.2	0.8	289.5	0.3
17	13	Mitsubishi Electric	0.3	0.5	48.4	0.1
19	14	Oki	0.2	0.2	11.3	0.1
15	15	TI	0.9	0.1	-86.1	0
16	16	Zilog	0.9	0.1	-86.1	0
22	17	VLSI	0.1	0.1	11.3	0
8	18	LSI	2.7	0	-100.0	0
13	19	Cyrix	1.2	0	-100.0	0
14	20	Matsushita Electronics	1.1	0	-100.0	0
20	21	SGS-Thomson*	0.2	0	-100.0	0
21	22	Chips & Technologies	0.1	0	-100.0	0
		All Others	-	-	-	-
		Americas Companies	212.7	266.5	25.3	82.2
		Japanese Companies	41.0	57.5	40.2	17.8
		European Companies	0.2	0	-100.0	0
		Asia/Pacific Companies	0	0	-	0
		Total Market	**254.0**	**324.1**	**27.6**	**100.0**

* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

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Table 5-3
1997 Japanese Market Share Ranking: MOS Microcontroller (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	NEC	106.9	119.4	11.7	24.3
2	2	Hitachi	72.8	83.8	15.1	17.0
3	3	Mitsubishi Electric	64.6	72.5	12.2	14.8
6	4	Fujitsu	30.6	45.5	48.9	9.3
5	5	Toshiba	33.5	38.6	15.3	7.9
4	6	Matsushita Electronics	39.5	38.0	-3.7	7.7
7	7	Sony	16.8	17.2	2.6	3.5
8	8	Motorola	15.5	15.6	1.1	3.2
12	9	SANYO	6.1	13.9	128.6	2.8
9	10	Sharp	10.9	12.8	18.0	2.6
10	11	Oki	7.8	7.6	-2.6	1.6
11	12	Intel	6.1	5.9	-2.6	1.2
13	13	Ricoh	5.9	5.9	1.0	1.2
15	14	TI	2.1	2.9	40.6	0.6
17	15	SGS-Thomson*	1.5	2.5	66.9	0.5
26	16	AMD	0	2.5	-	0.5
16	17	Seiko	1.6	2.1	26.1	0.4
19	18	Microchip	0.4	1.5	233.9	0.3
14	19	Rohm	3.4	1.0	-71.3	0.2
18	20	Philips Semiconductors	1.0	0.6	-38.2	0.1
20	21	Dallas	0.3	0.4	11.3	0.1
21	22	Siemens	0.3	0.4	11.3	0.1
22	23	Zilog	0.1	0.2	122.6	0
113	24	TEMIC	0	0.1	-	0
115	25	Acer	0	0.1	-	0
116	26	LG Semicon	0	0.1	-	0
123	27	Samsung	0	0.1	-	0
		All Others	-	-	-	-
		Americas Companies	24.5	29.1	18.7	5.9
		Japanese Companies	400.3	458.5	14.5	93.3
		European Companies	2.8	3.6	28.4	0.7
		Asia/Pacific Companies	0	0.4	-	0.1
		Total Market	**427.6**	**491.5**	**14.9**	**100.0**

* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

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Table 5-4
1997 Japanese Market Share Ranking: MOS Microperipheral (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Rockwell	43.5	37.7	-13.5	16.6
4	2	Fujitsu	16.8	23.5	40.2	10.4
3	3	NEC	20.0	22.8	13.7	10.0
2	4	Toshiba	31.2	19.3	-38.3	8.5
6	5	Intel	13.6	12.5	-8.3	5.5
7	6	Hitachi	12.1	11.9	-1.7	5.2
5	7	Cirrus Logic	13.6	11.4	-16.3	5.0
11	8	Chips & Technologies	5.9	10.9	85.5	4.8
8	9	Oak	9.2	8.4	-9.7	3.7
9	10	Adaptec	6.0	6.9	15.3	3.0
10	11	Yamaha	6.0	6.7	11.3	2.9
13	12	National	3.9	5.3	36.0	2.3
12	13	Trident	4.9	3.6	-25.8	1.6
23	14	TI	1.2	3.4	183.3	1.5
24	15	Oki	1.2	3.4	183.3	1.5
16	16	QLogic	2.6	3.0	15.9	1.3
34	17	Symbios	0.7	2.5	289.5	1.1
27	18	ATI	1.1	2.4	122.6	1.1
29	19	Ricoh	1.0	2.4	147.3	1.1
52	20	AMD	0	2.3	-	1.0
14	21	Matsushita Electronics	3.8	2.2	-42.8	1.0
17	22	Motorola	2.5	1.9	-22.6	0.9
19	23	C-Cube	1.7	1.9	11.3	0.9
21	24	Sharp	1.5	1.6	3.3	0.7
22	25	DSP Group	1.4	1.6	11.3	0.7
18	26	Mitsubishi Electric	2.0	1.5	-25.8	0.6
26	27	LSI	1.1	1.5	33.6	0.6
15	28	Philips Semiconductors	3.6	1.2	-66.3	0.5
20	29	VLSI	1.5	1.2	-20.5	0.5
45	30	SGS-Thomson*	0.2	1.2	456.5	0.5
30	31	Dallas	0.9	1.0	11.3	0.4
33	32	IBM	0.7	1.0	48.4	0.4
35	33	OPTi	0.7	1.0	48.4	0.4
36	34	SMSC	0.5	0.6	11.3	0.3
44	35	WaferScale	0.2	0.6	178.2	0.3
25	36	Rohm	1.2	0.5	-59.5	0.2
37	37	Acer	0.5	0.5	-11.0	0.2
38	38	Zoran	0.4	0.5	11.3	0.2

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Table 5-4 (Continued)
1997 Japanese Market Share Ranking: MOS Microperipheral (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
39	39	Digital	0.3	0.4	11.3	0.2
40	40	Fuji Electric	0.3	0.4	11.3	0.2
		All Others	4.9	4.6	-6.0	2.0
		Americas Companies	121.1	126.1	4.1	55.6
		Japanese Companies	98.1	97.4	-0.8	42.9
		European Companies	3.8	2.4	-36.4	1.1
		Asia/Pacific Companies	1.4	1.0	-31.5	0.4
		Total Market	**224.5**	**226.8**	**1.0**	**100.0**

* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

Table 5-5
1997 Japanese Market Share Ranking: Programmable DSP (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
2	1	Toshiba	8.2	23.0	181.9	26.1
1	2	TI	16.9	18.2	7.7	20.6
5	3	Lucent	3.8	11.7	208.4	13.3
4	4	NEC	5.7	11.4	101.2	12.9
3	5	Matsushita Electronics	7.0	9.3	33.9	10.6
6	6	Analog Devices	3.4	5.0	47.2	5.6
7	7	Fujitsu	2.7	3.8	38.0	4.3
10	8	Motorola	0.7	1.3	104.0	1.5
8	9	SANYO	1.0	1.2	23.7	1.4
94	10	Mitsubishi Electric	0	1.2	-	1.4
9	11	Hitachi	0.8	1.0	27.2	1.1
12	12	Oki	0.3	0.5	48.4	0.5
11	13	Zilog	0.7	0.2	-62.9	0.3
13	14	Zoran	0.1	0.1	11.3	0.1
14	15	GEC Plessey	0.1	0.1	11.3	0.1
110	16	Philips Semiconductors	0	0.1	-	0.1
		All Others	0	0	-	0
		Americas Companies	25.5	36.6	43.6	41.5
		Japanese Companies	25.6	51.3	100.8	58.2
		European Companies	0.1	0.2	122.6	0.3
		Asia/Pacific Companies	0	0	-	0
		Total Market	**51.1**	**88.2**	**72.4**	**100.0**

Source: Dataquest (August 1998)

MOS Microcomponent Forecast through 2002

The Japanese MOS microcomponent market will expand 15.2 percent (7.5 percent on a dollar basis) in 1998. The CAGR between 1997 and 2002 will be 16.2 percent (14.6 percent on a dollar basis), with firm growth expected for each year (see Tables 5-6 and 5-7).

The Japanese MPU market in 1998 will fail to meet the previous forecast level because of the slowdown in the PC market. The market should grow at 12.6 percent (5.1 percent on a dollar basis). The market will see a wider variety of products besides Intel's X86 families (Pentium with MMX technology, Pentium Pro, and MMX Pentium II). Products will include non-Intel, high-speed MPUs; MPUs for low-cost PCs; and MPUs designed for portable applications, including mobile computing (embedded MIPS, SH, and StrongARM)—for example, Tillamook, Mobile Pentium II, and Windows CE2.0.

Table 5-6
Japanese MOS Microcomponent Market History and Forecast, 1992 to 2002 (Billions of Yen)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
MOS Microcomponent	413.4	443.4	570.4	735.2	957.2	1,130.6	1,302.4	1,561.9	1,817.5	2,077.0	2,396.1	16.2
Microprocessor	76.4	92.9	127.0	158.7	254.0	324.1	364.9	443.7	521.5	611.0	720.0	17.3
Microcontroller	241.9	248.8	301.8	388.7	427.6	491.5	565.6	674.6	783.6	871.8	983.4	14.9
Microperipheral	82.2	88.5	124.8	162.1	224.5	226.8	248.7	285.4	312.6	339.9	369.7	10.3
DSP	12.9	13.2	16.9	25.7	51.1	88.2	123.2	158.3	199.8	254.3	323.0	29.7
Exchange Rate (Yen/U.S.$1)	126.5	111.2	101.8	93.9	108.8	121.1	129.7	129.7	129.7	129.7	129.7	-

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (August 1998)

Table 5-7
Japanese MOS Microcomponent Market History and Forecast, 1992 to 2002 (Yen-Based Percentage Growth over Preceding Year)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
MOS Microcomponent	-15.1	7.3	28.6	28.9	30.2	18.1	15.2	19.9	16.4	14.3	15.4
Microprocessor	-8.8	21.6	36.7	25.0	60.0	27.6	12.6	21.6	17.5	17.2	17.8
Microcontroller	-18.4	2.9	21.3	28.8	10.0	14.9	15.1	19.3	16.2	11.3	12.8
Microperipheral	-12.0	7.7	41.0	29.9	38.5	1.0	9.6	14.8	9.5	8.7	8.8
DSP	-2.3	2.3	28.0	52.1	99.0	72.4	39.8	28.4	26.2	27.3	27.0

Source: Dataquest (August 1998)

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MCUs, the largest of the Japanese microcomponent segments, are expected to surge 15.1 percent (7.4 percent on a dollar basis) in 1998. They are incorporated into a variety of electronic equipment. Low-bit versions are embedded into household appliances for system control purposes, many of which are implemented on a 4-bit or 8-bit basis. Japanese companies still hold a dominant share in the 4-bit segment.

Four-bit MCUs are used in diverse products, ranging from toys to analog cordless telephones, and companies are still exploring new applications. Nevertheless, the market size will grow only moderately, partly because of the weakening demand from portable game systems, which have been a major driver, and partly because of the increased migration to 8-bit products. In particular, revenue growth will be minimal because of low prices, although unit growth may continue.

On the other hand, the 8-bit MCU market will enjoy strong growth as a result of upgrading from 4-bit applications and the need to address the increasing complexity of system control. The development of MCUs embedding flash memory technology is under way, and the competition has heated up among U.S., European, and Japanese companies for market share.

In 1997, 8-bit MCUs were used in most electronic equipment, including the following range of products:

- Video and audio equipment
- Computer-related equipment, including keyboards and display units
- Communications equipment, including analog cordless telephones and digital portable telephones
- Antilock braking systems (ABSs)
- Pachinko game systems
- Household appliances

Applications expected to emerge in 1998 and afterward include: smart cards, minidisc (MD) players, USB controllers (8-bit basis), and MCUs incorporating Infrared Data Association (IrDA) communications features. Encouraged by potential demand for contact/noncontact IC cards, semiconductor companies will opt for alliances to consolidate technological resources and vie for industrial standards. Finally, MCUs integrating ferroelectric memory technology will be introduced to the noncontact IC card market to invigorate the 8-bit MCU market.

Sixteen-bit MCUs, on the other hand, will be increasingly used for digital processing applications, particularly digital cellular phones, PHSs, hard disk drives (HDDs), and CD-ROM drives. Applications expected in 1998 and afterward include DVD, fixed and on-board audio MD players, and DV-C. Again, flash memory technology will be increasingly incorporated to address system requirements in terms of flexibility, and semiconductor companies will focus on enhancing their offerings.

As for 32-bit and 64-bit MCUs, SLI based on ASIC technology will become the mainstay. Promising applications that will be developed after 1998 by using a leading-edge process and an embedded MPU include: vehicle information and communication system (VICS)-based car navigation systems incorporating DVD-ROM drives, next-generation home/portable video game systems, and set-top boxes (STBs). Sixteen-, 32-, and 64-bit MCUs will enjoy strong growth next to 8-bit products, driven by price declines resulting from SLI, the emergence of digital consumer equipment, and the digitization of systems. Dataquest expects solid profitability.

In 1997, rapid growth was seen in the flash MCU market. Major applications include memory cards for video game systems, CD-ROM drives, and HDDs, spurring consumption of 8- and 16-bit MCUs. As for multibit, embedded MPU (MCU) architectures, ARM will be rapidly accepted in 1998 and afterward. Diverse architectures offered by vendors (MIPS, M Core, SH, SPARC, PowerPC, and X86) will be optimized for different applications according to their SLI strategy.

In 1998, the Japanese microperipheral (MPR) market is expected to grow 9.6 percent over the previous year (2.3 percent on a dollar basis). A variety of PC peripherals based on PC98 standards will become pervasive, and different application-specific standard product (ASSP) segments (chipset, USB, IEEE 1394, and MPACT1/2) will grow in relation to different applications.

The Japanese DSP market will continue a strong growth of 39.8 percent (30.5 percent on a dollar basis) in 1998. With the increasingly shortened development cycle for system products, DSPs and media processors will undoubtedly become core technologies because they offer flexibility in the development of digital consumer equipment with the ability to reconfigure themselves by replacing middleware/microcode. By 2002, 0.18- to 0.12-micron processes will be commercialized. As a result, the DSP market will grow strongly at a CAGR of 29.7 percent (27.9 percent on a dollar basis) between 1997 and 2002.

Finally, embedded DSPs are increasingly incorporated into servo controllers for CD and MD players as well as codec processing for cellular phones. Generic DSPs, including media processors, are primarily used in high-speed analog modems (56-Kbps) for PCs and sound source processing. New applications emerging in 1998 and afterward include digital cellular phones, which use a single chip integrating a 16/32-bit MCU and DSP; HDD controllers containing DSP/MCU and DRAM for buffer memory; and high-speed disk drives such as DVD-ROM/RAM, incorporating partial response maximum likelihood (PRML) technology and DSP.

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Challenge to the Vendors

In order to meet technology requirements from a wide range of applications, 32-bit MPUs with embedded RISC have been rapidly expanding their market since 1996. Major applications include mobile equipment, such as cellular phones and personal digital assistants (PDAs); digital video systems, such as digital camcorders (DVC) and digital still cameras; and systems that require real-time graphical processing, such as in-car navigation and video game machines.

It is difficult to accomplish the real-time processing of large volumes of data such as graphic and/or sound in multimedia systems without high-performance MPUs. DSPs are one solution, but they could increase the number of large-scale integrators (LSIs), which poses a threat to overall system cost and/or size. This can be solved with an embedded RISC MPU solution with multimedia processing by middleware, which enables system makers to save cost and circuit board space.

User needs for graphical user interface (GUI) increases in MPU-driven systems and for high-performance embedded MPUs will be growing, expanding demand for embedded MPUs with advanced SLI ASIC technology, such as MIPS, ARM, SH, SPARC, V853(E), M32R/D, and Shark.

Complex-instruction-set computing (CISC) MPUs that can be represented by x86 architecture have expanded their market mainly in PC applications. Currently, this segment of the market is served with products that are developed and manufactured with 0.25-micron process technology, aiming at production efficiency, cost competitiveness, and high performance, such as high frequency and low-power dissipation. System makers can take advantage of existing resources such as development technology and environment.

Thus, progress in SLI ASIC technology, electronic design automation (EDA) technology, and the development of high-performance 32-bit and 64-bit RISC embedded MPUs and 32-bit CISC MPUs are enabling system companies to develop new systems and subsystems, enjoying benefits in specification optimization, shortening turnaround time, and lowering system cost.

In the microcomponent market, SLI has arrived. No longer are system designers using standalone microcomponents such as MPU, MCU, and DSP; rather, they are increasing their dependency on SLI LSIs. This trend has made the choice, alliance, and development of architecture ever more important in meeting requirements in applications.

These trends are also making the border obscure between ASIC and microcomponent, forcing microcomponent vendors to incorporate various factors, such as supply support, technology support, development environment, and future marketability, when planning microcomponent business for processor architecture. This planning should include the understanding of system technologies so that the architecture can best support system memory, cost management, system size optimization, power, and noise management.

Achieving those technology targets alone cannot bring success in the MPU/MCU or DSP business. Microcomponent vendors will be required to focus more on factors such as technology support, risk evaluation, marketability and launch timing, business opportunity evaluation, and cost of ownership (COO) evaluation. Also included is marketing power, which previously may not have been a strength, especially for Japanese microcomponent vendors. Dataquest believes that those factors are the key to choosing processors in optimizing systems.

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Chapter 6

Japanese Total Logic Market Trends

1997 Market Share

Market Trends

In 1997, the Japanese total logic market grew at 16.2 percent over the previous year (4.4 percent on a dollar basis), while the total ASIC market showed a solid growth of 15.7 percent, driven by cell-based ICs (CBICs), including mixed-signal ASICs. This sound growth in total ASICs is supported by the SLI market expansion, where CBIC technology is the key for developing ASIC and ASSP products that can meet competitive cost targets.

The Japanese ASIC market has followed its own trends, and 1997 was no exception. The worldwide ASIC market saw the following three changes:

- LSI Logic slipped from No. 2 to No. 4 in the total ASIC market.
- IBM and Lucent moved up to No. 2 and No. 3, respectively.
- Programmable logic device (PLD) makers made it to the top 10, but Xilinx Incorporated gave way to Altera Corporation, which has become the top PLD vendor.

These worldwide trends are clearly seen in the Americas market; however, in 1997, Japanese ASIC vendors were not affected. In Japan, where ASIC market growth depends on limited applications in digital consumer equipment and mobile communications, these trends can hardly be observed.

Japanese vendors in the ASIC market are very unique in that they continue to grow in the gate array market, where Americas companies are disappearing from top rankings. Americas companies are choosing to de-emphasize gate arrays so that they can focus on SLI business, while Japanese vendors are filling the void in the market, resulting in their positive growth in gate array revenue in 1997.

In the longer run, however, this trend will turn out to be a burden rather than a market opportunity, because Japanese companies will have to allocate their resources in process technology development, library development, designing power, and profitability to this low-growth segment of the ASIC market.

The PLD market in Japan has not grown to be a major segment as it is in the Americas market. A major cause of this is the persistent demand among system makers for gate array products in supply and in technology support. Japanese ASIC companies are at the same time vertically integrated companies, where overall corporate-level profit comes before profits in product segments such as semiconductors, while at Americas companies, profit maximization as well as the independence of each business unit is clearly defined.

As a result, in an effort to meet domestic customer requirements, small to medium-size designs, which could be optimized with PLDs, are still developed with gate arrays, limiting the growth of the PLD market. Gradually, however, this inefficient design practice is being improved in areas such as communications infrastructure systems, which helped the PLD market in Japan in 1998 to show a sound growth of 15.6 percent over the previous year.

Ranking Trends

As the determinant factor in the total logic market, ASICs played a key role in ranking trends (see Tables 6-1 through 6-5). In the 1997 Japanese ASIC market, NEC ranked No. 1, capturing one-quarter of the market. NEC is actually the worldwide leader in ASICs, having strength in a wide range of applications, including industrial, communications, consumer, and data processing. In the Japanese market, it was the consumer area that contributed to NEC's two-digit growth.

Following NEC was Fujitsu, also with a more than 20 percent market share, which it increased by revenue growth in digital consumer and communications applications. The third company in Japan was Hitachi, which grew in the number of designs, leveraging on its SLI strategy based on SH architecture, but was not free from the competitive pricing trends. LSI Logic ranked at No. 4, growing an overwhelming 64.6 percent over the previous year. LSI Logic leads the SLI trends, and in Japan, its growth comes from successes in ASSP and ASIC business in digital consumer applications, as well as custom LSI for video game machines based on a MIPS architecture embedded MPU core. Ranked as No. 5, Toshiba dropped one notch, recording a negative two-digit growth—the only negative growth among the top 10 Japanese companies.

Total Logic Forecast through 2002

In 1998, the Japanese total logic market will grow 8.7 percent (1.5 percent on a dollar basis). The total ASIC market will expand 11.8 percent, or 4.3 percent on a dollar basis (see Tables 6-6 and 6-7).

In 1997, high-performance systems, as seen in digital consumer equipment, were implemented to incorporate multiple, large-scale circuits by using intellectual property (IP) core and leading EDA tools. We also saw a rapid increase in the volume production of ASSPs and SLI ASIC products in single-chip implementation by using a highly integrated ASIC process and SLI technologies. A future challenge lies in reducing the cycle time for system development to minimize turnaround time and R&D investment, reduce development-related risks, and support early LSI implementation.

Traditionally, the "core-limited design" issue, derived from large-scale internal cores, was a major obstacle in designing ASICs. Recently, however, as the ASIC process reached submicron levels, the shrink ratio of the internal core has been improved. This, in turn, has resulted in an increase in the "input/output (I/O) pad-limited design," where I/O pads set the limit rather than cores. Also, flexibility in the ASIC design, resulting in small-lot production, adversely affects the profitability of business.

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Table 6-1
1997 Japanese Market Share Ranking: MOS Digital Logic (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	NEC	185.8	223.7	20.4	22.6
2	2	Fujitsu	101.4	119.3	17.6	12.1
3	3	Toshiba	81.2	89.3	10.0	9.0
4	4	Hitachi	67.1	65.4	-2.6	6.6
7	5	Sony	42.0	57.9	37.8	5.9
5	6	Matsushita Electronics	52.3	53.2	1.6	5.4
6	7	TI	51.1	52.7	3.0	5.3
8	8	Sharp	40.3	45.7	13.4	4.6
9	9	LSI	26.1	43.0	64.6	4.3
12	10	SANYO	21.3	35.4	65.8	3.6
11	11	Mitsubishi Electric	24.3	29.9	23.3	3.0
10	12	Oki	25.5	28.8	13.2	2.9
14	13	Rohm	13.8	14.2	2.5	1.4
17	14	Altera	10.3	13.8	33.6	1.4
16	15	Motorola	11.9	12.7	7.2	1.3
13	16	Yamaha	14.1	11.6	-17.8	1.2
18	17	Lucent	10.3	10.5	1.9	1.1
15	18	Seiko	13.5	9.7	-28.2	1.0
21	19	Xilinx	6.0	7.4	23.4	0.7
19	20	AMD	6.5	4.8	-25.8	0.5
23	21	Lattice	4.4	4.8	11.3	0.5
22	22	IBM	4.5	4.4	-2.3	0.4
20	23	VLSI	6.0	4.2	-29.2	0.4
42	24	Macronix	0.4	4.0	818.2	0.4
68	25	Fairchild	0	3.5	NA	0.4
25	26	Philips Semiconductors	3.5	3.1	-9.6	0.3
27	27	Fuji Electric	2.7	2.7	-2.1	0.3
28	28	Samsung	1.8	2.7	44.0	0.3
36	29	Cypress	0.8	2.7	249.8	0.3
24	30	Ricoh	3.9	2.4	-38.2	0.2
29	31	Actel	1.6	1.7	3.9	0.2
31	32	New JRC	1.0	1.5	48.4	0.1
53	33	Micronas	0.1	1.5	1,235.5	0.1
26	34	National	3.2	1.2	-61.6	0.1
30	35	Dallas	1.0	1.2	23.7	0.1
87	36	QuickLogic	0	1.2	NA	0.1
32	37	HP	0.9	1.1	25.2	0.1
33	38	Integrated Circuit Systems	0.9	1.1	25.2	0.1

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Table 6-1 (Continued)
1997 Japanese Market Share Ranking: MOS Digital Logic (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
34	39	IDT	0.9	1.1	25.2	0.1
41	40	SGS-Thomson*	0.4	1.0	122.6	0.1
		All Others	8.2	12.8	57.3	1.3
		Americas Companies	150.0	178.9	19.2	18.1
		Japanese Companies	693.7	795.4	14.7	80.5
		European Companies	4.6	7.0	53.7	0.7
		Asia/Pacific Companies	2.7	7.4	171.6	0.7
		Total Market	**851.0**	**988.7**	**16.2**	**100.0**

NA = Not available
* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

Table 6-2
1997 Japanese Market Share Ranking: Total ASIC (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	NEC	116.3	136.6	17.4	24.6
2	2	Fujitsu	100.2	117.7	17.5	21.2
3	3	Hitachi	42.8	46.1	7.9	8.3
5	4	LSI	26.1	43.0	64.6	7.8
4	5	Toshiba	41.1	34.4	-16.4	6.2
6	6	TI	25.8	26.6	3.3	4.8
7	7	Matsushita Electronics	23.0	23.1	0.7	4.2
8	8	Mitsubishi Electric	12.4	16.0	28.9	2.9
9	9	Altera	10.3	13.8	33.6	2.5
11	10	Sharp	9.9	12.0	21.1	2.2
10	11	Lucent	10.3	10.5	1.9	1.9
15	12	Seiko	6.0	8.0	33.6	1.4
14	13	Xilinx	6.0	7.4	23.4	1.3
22	14	SANYO	2.5	6.9	175.8	1.2
12	15	Oki	6.6	4.8	-27.0	0.9
17	16	Lattice	4.4	4.8	11.3	0.9
16	17	IBM	4.5	4.4	-2.3	0.8
13	18	VLSI	6.0	4.2	-29.2	0.8
20	19	Motorola	3.4	4.1	22.1	0.7
18	20	Rohm	3.8	4.0	4.9	0.7
38	21	Macronix	0.2	4.0	1,736.4	0.7
19	22	AMD	3.6	3.5	-2.2	0.6
24	23	Sony	1.3	2.5	94.8	0.5
23	24	Actel	1.6	1.7	3.9	0.3
80	25	QuickLogic	0	1.2	NA	0.2
25	26	National	1.2	1.1	-8.9	0.2
26	27	HP	0.9	1.1	25.2	0.2
27	28	Integrated Circuit Systems	0.8	1.0	27.2	0.2
32	29	Samsung	0.5	1.0	78.1	0.2
28	30	Yamaha	0.8	0.8	11.3	0.2
31	31	GEC Plessey	0.5	0.8	55.8	0.2
33	32	SGS-Thomson*	0.3	0.8	159.7	0.2
21	33	Ricoh	3.3	0.6	-81.5	0.1
30	34	Symbios	0.5	0.6	11.3	0.1
115	35	TEMIC	0	0.6	NA	0.1
29	36	Cypress	0.7	0.4	-44.4	0.1
36	37	Exar	0.2	0.4	66.9	0.1
37	38	Gould/AMI	0.2	0.4	66.9	0.1

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Table 6-2 (Continued)
1997 Japanese Market Share Ranking: Total ASIC (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
42	39	Raytheon	0.1	0.4	233.9	0.1
34	40	Analog Devices	0.2	0.2	11.3	0
		All Others	0.7	2.5	289.5	0.5
		Americas Companies	107.3	133.2	24.2	24.0
		Japanese Companies	370.0	413.7	11.8	74.6
		European Companies	1.0	2.4	147.3	0.4
		Asia/Pacific Companies	0.8	5.0	551.9	0.9
		Total Market	**479.0**	**554.3**	**15.7**	**100.0**

NA = Not available
* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

Table 6-3
1997 Japanese Market Share Ranking: Total Gate Array (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Fujitsu	69.1	78.0	12.9	28.0
2	2	NEC	65.8	74.6	13.3	26.8
3	3	Hitachi	33.3	35.5	6.6	12.7
4	4	Toshiba	22.3	20.3	-8.8	7.3
5	5	Mitsubishi Electric	10.2	13.1	27.9	4.7
6	6	Matsushita Electronics	8.8	9.2	4.4	3.3
7	7	TI	8.7	7.1	-17.9	2.6
10	8	Seiko	5.1	6.9	35.0	2.5
9	9	Sharp	5.8	6.5	13.4	2.3
14	10	SANYO	2.0	4.6	135.0	1.7
12	11	Oki	3.2	3.8	19.0	1.3
21	12	Macronix	0.2	3.8	1,625.1	1.3
8	13	LSI	6.0	3.3	-45.4	1.2
11	14	Motorola	3.4	2.8	-17.4	1.0
17	15	Sony	1.3	2.5	94.8	0.9
13	16	Rohm	2.1	2.2	5.4	0.8
15	17	IBM	1.4	0.8	-40.1	0.3
18	18	Samsung	0.4	0.7	66.9	0.3
16	19	Ricoh	1.3	0.5	-62.9	0.2
19	20	Gould/AMI	0.2	0.4	66.9	0.1
20	21	Yamaha	0.2	0.2	11.3	0.1
24	22	GEC Plessey	0.1	0.2	122.6	0.1
77	23	Raytheon	0	0.2	NA	0.1
22	24	Chip Express	0.1	0.1	11.3	0
23	25	National	0.1	0.1	11.3	0
45	26	Exar	0	0.1	NA	0
48	27	GENNUM	0	0.1	NA	0
		All Others	0	0.6	NA	0.2
		Americas Companies	19.9	15.7	-20.9	5.7
		Japanese Companies	230.5	257.9	11.9	92.6
		European Companies	0.1	0.2	122.6	0.1
		Asia/Pacific Companies	0.7	4.5	586.3	1.6
		Total Market	**251.1**	**278.4**	**10.9**	**100.0**

NA = Not available
Source: Dataquest (August 1998)

Table 6-4
1997 Japanese Market Share Ranking: PLD (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Altera	10.3	13.8	33.6	40.7
2	2	Xilinx	6.0	7.4	23.4	21.8
3	3	Lattice	4.4	4.8	11.3	14.3
4	4	AMD	3.6	3.5	-2.2	10.4
5	5	Actel	1.6	1.7	3.9	5.0
61	6	QuickLogic	0	1.2	NA	3.6
7	7	Lucent	0.5	0.6	11.3	1.8
6	8	Cypress	0.7	0.4	-44.4	1.1
8	9	Toshiba	0.2	0.1	-44.4	0.4
9	10	Atmel	0.1	0.1	11.3	0.4
11	11	TI	0.1	0.1	11.3	0.4
12	12	Ricoh	0.1	0.1	11.3	0.4
10	13	International CMOS Technology	0.1	0	-100.0	0
		All Others	-	-	-	-
		Americas Companies	27.4	33.7	22.8	99.3
		Japanese Companies	0.3	0.2	-25.8	0.7
		European Companies	0	0	-	0
		Asia/Pacific Companies	0	0	-	0
		Total Market	**27.7**	**33.9**	**22.2**	**100.0**

NA = Not available
Source: Dataquest (August 1998)

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Table 6-5
1997 Japanese Market Share Ranking: Cell-Based IC (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	NEC	50.5	62.0	22.8	25.6
2	2	Fujitsu	31.1	39.7	27.6	16.4
3	3	LSI	20.1	39.7	97.3	16.4
5	4	TI	17.0	19.4	14.1	8.0
4	5	Toshiba	18.6	13.9	-25.2	5.8
6	6	Matsushita Electronics	14.1	13.9	-1.5	5.8
8	7	Hitachi	9.5	10.7	12.6	4.4
7	8	Lucent	9.8	9.9	1.4	4.1
10	9	Sharp	4.1	5.4	31.8	2.3
9	10	VLSI	6.0	4.2	-29.2	1.8
12	11	IBM	3.0	3.5	15.3	1.5
13	12	Mitsubishi Electric	2.2	2.9	33.6	1.2
21	13	SANYO	0.5	2.3	322.9	1.0
15	14	Rohm	1.7	1.8	4.3	0.8
72	15	Motorola	0	1.3	NA	0.6
11	16	Oki	3.5	1.1	-68.7	0.5
17	17	HP	0.9	1.1	25.2	0.5
18	18	Seiko	0.9	1.1	25.2	0.5
16	19	National	1.1	1.0	-11.0	0.4
19	20	Integrated Circuit Systems	0.8	1.0	27.2	0.4
24	21	SGS-Thomson*	0.3	0.8	159.7	0.4
20	22	Symbios	0.5	0.6	11.3	0.3
22	23	Yamaha	0.5	0.6	11.3	0.3
23	24	GEC Plessey	0.4	0.6	39.1	0.3
114	25	TEMIC	0	0.6	NA	0.3
25	26	Analog Devices	0.2	0.2	11.3	0.1
26	27	Exar	0.2	0.2	11.3	0.1
28	28	Harris	0.1	0.2	122.6	0.1
31	29	Samsung	0.1	0.2	122.6	0.1
122	30	Macronix	0	0.2	NA	0.1
27	31	Atmel	0.1	0.1	11.3	0.1
29	32	Raytheon	0.1	0.1	11.3	0.1
30	33	Micronas	0.1	0.1	11.3	0.1
14	34	Ricoh	1.8	0	-100.0	0
		All Others	0	1.1	NA	0.5
		Americas Companies	60.0	83.8	39.8	34.6
		Japanese Companies	139.2	155.5	11.7	64.3
		European Companies	0.9	2.2	150.4	0.9
		Asia/Pacific Companies	0.1	0.5	345.2	0.2
		Total Market	**200.1**	**242.0**	**20.9**	**100.0**

NA = Not available
* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

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Table 6-6
1997 Japanese MOS Logic Market History and Forecast, 1992 to 2002 (Billions of Yen)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
MOS Digital Logic	**484.7**	**523.9**	**610.1**	**730.5**	**851.0**	**988.7**	**1,074.5**	**1,200.8**	**1,361.1**	**1,513.1**	**1,736.7**	**11.9**
Total ASIC	383.1	418.7	426.7	491.7	479.0	554.3	619.5	723.9	852.9	983.4	1,159.1	15.9
MOS Gate Array	152.9	166.2	187.2	235.9	251.1	278.4	288.2	284.1	276.3	264.9	250.3	-2.1
MOS CBIC	59.9	77.1	93.5	143.9	200.1	242.0	292.1	391.5	517.1	646.3	819.7	27.6
MOS PLD	7.8	11.1	12.8	19.9	27.7	33.9	39.2	48.2	59.5	72.3	89.1	21.3
Custom IC	162.5	164.2	133.2	92.0	91.3	96.3	81.7	60.4	40.8	25.5	15.1	-31.0
MOS Standard Logic	39.8	42.9	45.1	48.7	48.9	60.5	66.5	71.3	76.0	76.2	77.8	5.1
Total Other MOS Logic	61.7	62.3	138.4	190.1	231.9	277.6	306.9	345.2	391.5	427.9	484.8	11.8

Notes: Columns may not add to totals shown because of rounding.
From 1992 through 1995, the definition of Total ASIC includes MOS Gate Array, MOS CBIC, MOS PLD, and Custom IC. From 1996 on, the definition no longer includes Custom IC.
Source: Dataquest (August 1998)

Table 6-7
Japanese MOS Logic Market History and Forecast, 1992 to 2002 (Yen-Based Percentage Growth over Preceding Year)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
MOS Digital Logic	**-12.5**	**8.1**	**16.5**	**19.7**	**16.5**	**16.2**	**8.7**	**11.8**	**13.4**	**11.2**	**14.8**
Total ASIC	-12.8	9.2	1.9	15.2	-2.6	15.7	11.8	16.9	17.8	15.3	17.9
MOS Gate Array	-15.1	11.0	12.6	26.0	6.5	10.9	3.5	-1.4	-2.8	-4.1	-5.5
MOS CBIC	-11.4	21.2	21.3	53.9	39.1	20.9	20.7	34.1	32.1	25.0	26.8
MOS PLD	-21.4	42.3	15.3	55.5	39.4	22.2	15.6	22.9	23.6	21.4	23.2
Custom IC	-10.6	1.0	-18.9	-30.9	-0.8	5.5	-15.2	-26.0	-32.5	-37.4	-41.0
MOS Standard Logic	-13.6	7.8	5.1	8.1	0.2	23.9	9.8	7.2	6.6	0.4	2.0
Total Other MOS Logic	-10.2	0.9	122.2	37.4	21.9	19.7	10.6	12.5	13.4	9.3	13.3

Source: Dataquest (August 1998)

By 1997, many leading ASIC vendors in the Americas region had started to de-emphasize the gate array business. This move is favorable for the PLD market and is accelerating the collapse of the U.S. gate array market. Technically, PLDs have already integrated 250,000 to 500,000 gates on a commercial basis by using process technology based on 0.25-micron, five-layer interconnect and shallow trench structure. Dataquest believes that 1 million gates will be integrated by using an 0.18-micron process technology by 2000.

In 1998, the Japanese PLD market will show a strong growth of 15.6 percent (7.9 percent on a dollar basis). In Japan, the gate array business still dominates because of high captive demand. Nevertheless, because SLI will lead ASIC business in the future, the Japanese PLD market will grow to an appreciable size compared to the Americas market. Dataquest expects that the market will register the second-highest growth rate, following CBICs, with a CAGR of 21.3 percent between 1997 and 2002.

The Japanese CBIC market (including mixed-signal) will grow 20.7 percent (12.7 percent on a dollar basis) in 1998. The ramp-up of 0.35-to-0.25-micron process manufacturing and the increasing need for design optimization in various applications have been driving the market for CBICs, which are regarded as the key infrastructure factors in SLI technologies such as embedded MPUs/DSPs, IP core, embedded memories, and mixed-signal designs. At the same time, the establishment of CBIC technology has caused the custom IC market to shrink rapidly, resulting in a negative CAGR of 31.0 percent (31.9 percent on a dollar basis) between 1997 and 2002.

Among other logic products, standard logic features such as small-scale integration (SSI), middle-scale integration (MSI), and LSI are mostly incorporated into ASICs, but demand for standard logic still exists in the area of super-high-speed CMOS- or BiCMOS-based standard logic, such as CMOS-based one-gate logic products and wide bus products. Thus, the Japanese standard logic market will continue to grow steadily at a CAGR of 5.1 percent (3.7 percent on a dollar basis).

Finally, LCD drivers will be driven by increased market acceptance of LCD-equipped systems as well as by the exploration of new application markets. As a result, the Japanese market's CAGR for the "Total other MOS Logic" category is expected to be 11.8 percent (10.3 percent on a dollar basis) during the five-year period.

In 1998, ASIC suppliers announced a number of next-generation 0.18-micron processes, and some of them in Japan and the United States started volume production. Also, development efforts are under way to commercialize a "unified process" that represents a "dream process integration." Dataquest believes that portable applications in the Japanese market will contribute to technological progress in the areas of ultra-low operating voltage below 1.0V, embedded flash memory, mixed-signal designs, and high-density packages, such as chip-scale packaging (CSP) and direct chip attach (DCA), thereby driving the SLI ASIC market.

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Challenge to the Vendors

Traditional ASICs were mainly single-function products that integrated glue logic. With the introduction of a new business model in 1990 based on intellectual property cores, the whole ASIC industry has been moving toward SLI, and ASIC vendors have been in the process of restructuring their businesses. Japanese companies are no exception.

In this new ASIC business model, vendors first prepare a large number of IP cores, based on each vendor's own research, either developed internally or acquired from the outside. Then, in the development environment of IP cores, description languages such as Verilog Hardware Description Language (Verilog-HDL) and VHSIC HDL Roger's Interface Language (VHDL-RIL), for standardization, enable vendors to provide the appropriate set of IP cores at the request of ASIC users, which enables the design of a large, complex system with a short turnaround time. This SLI business model is advantageous to users because they can develop and market their new systems with minimum investment and risk, and within a short range of time. For ASIC vendors, users' recognition of IP cores as value-added will help differentiate them from competitors. In the ASIC business, where differentiation has been difficult, this SLI move is expected to help improve profitability.

In putting system-level functions on a single chip, traditional ASIC process technology is not sufficient. Also required are an understanding of requirements from each target application and the most advanced EDA, IP core development environment, and analog/mixed-signal technologies for designing embedded MPUs. Those are the key factors for ASIC vendors to be successful in the SLI business.

In this sense, the Virtual Socket Interface (VSI) Alliance, in which worldwide semiconductor vendors as well as system makers and EDA vendors participate, will standardize IP cores, establish their distribution system, and dramatically change the ASIC industry.

In the current market, continuing DRAM oversupply and pricing weakness have prompted semiconductor companies to shift emphasis from memories to logic, resulting in a crowded market in the latter half of 1997. This supply/demand situation has caused the price fall of logic products, and expectations about the profitability of the SLI business are being questioned. The needs for embedded DRAM and flash are increasing from the application side, and, leveraging on profitable applications such as graphics and mobile equipment, embedded memories will contribute to the market growth of SLI ASIC.

Another factor that poses challenges to vendors is the development of process technology. The main technology has shifted from 0.5 micron to 0.35 micron, and now it is shifting toward 0.25 micron and 0.18 micron concurrently. This trend may cause Japanese ASIC vendors currently investing in 0.25-micron process technology and manufacturing capacity to lose competitiveness.

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The semiconductor industry has observed silicon cycles many times, but in this round, ASIC technology progress, in centering on graphics, data processing, and communications, may change the market positioning for various ASIC vendors. Americas companies have enjoyed high market share, leveraging on embedded MPU and DSP core technology. Korean companies are aiming to catch up with the forerunners by focusing on DRAM as a technology driver. Taiwanese companies have established a business model of dedicated foundry, supporting fabless companies. Japanese companies have an advantage in overall SLI technology, with their embedded technology and IP cores, based on MCU business experience. The SLI ASIC market will be more competitive with all of these vendors, and all SLI companies will be required to equip themselves with the necessary ASIC technologies, an understanding of various technical requirements for each target application, and a strategic analysis of competitors.

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Chapter 7
Japanese Analog IC, Discrete Device, and Optical Semiconductor Market Trends

1997 Market Share

Market Trends

In 1997, the Japanese market saw healthy growth for analog, discrete, and optical semiconductor products. Among those, the analog market recorded a more than 20 percent increase over the previous year for the first time in the 1990s. Contributing to this strong growth were factors such as strong unit demand because of improved electronics production, stable pricing trends, and an increase in mixed-signal products with higher average selling prices than conventional linear products.

At a time when new systems are emerging, system designers resort to discrete function chips, such as general-purpose analog ICs and discrete semiconductor devices, until system designs become stable and circuits become integrated into larger devices, including ASSP and ASIC. The year 1997, which can be marked when the shift to digital consumer systems becomes a solid move, was another example of this trend. The increase in demand for analog and discrete semiconductor products has been observed since 1995, but the acceleration in 1997 was more than the industry expected, and the tightened supply/demand balance helped to keep the prices stable, contributing to profits for vendors.

Major contributions came from segments such as telecom analog, disk-drive analog, special-function analog, and power-management analog products. Among discrete semiconductor products, it was power transistors—not only the emerging isolated gate bipolar transistors (IGBTs) but also MOS field-effect transistors (FETs) and even bipolar transistors—that marked two-digit growth over the previous year. The increase in those products was supported by PC and peripheral equipment as well as mobile communications applications. The driver for the growth in optical semiconductors in Japan was the laser diode, whose consumption was pumped by optical storage devices and audio players such as CD-ROM drive and MD players.

Ranking Trends

In the 1997 Japanese analog market, Texas Instruments Inc. continued to lead while all the rest of the top 10 companies were domestic vendors (see Table 7-1). However, other Americas and European vendors, too, increased their sales rapidly, and as a result, the combined share of non-Japanese vendors has become one-third of the market. TI's revenue growth came both from general-purpose products and ASSPs such as disk drive and automotive. Toshiba, ranked No. 2, also enjoyed growth in general-purpose product revenue as well as an increase in applications in consumer and automotive. Matsushita Electronics switched places with NEC, helped by increases in telecom and disk drives. SANYO Electric Company Ltd. and Sony remained in their respective positions of the previous year, although they recorded growth rates that were higher than the market average.

Table 7-1
1997 Japanese Market Share Ranking: Analog-Monolithic (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	TI	48.0	66.4	38.3	11.0
2	2	Toshiba	47.4	55.7	17.4	9.2
4	3	Matsushita Electronics	42.0	49.7	18.2	8.2
3	4	NEC	45.6	48.1	5.5	8.0
5	5	SANYO	37.5	44.0	17.1	7.3
6	6	Sony	33.2	41.1	23.7	6.8
9	7	Mitsubishi Electric	25.2	33.9	34.3	5.6
8	8	Fujitsu	25.5	30.6	20.3	5.1
10	9	Rohm	24.5	30.6	25.1	5.1
7	10	Hitachi	27.7	23.7	-14.5	3.9
11	11	National	14.3	18.6	30.8	3.1
13	12	Analog Devices	13.3	18.3	37.8	3.0
12	13	Motorola	14.0	16.8	19.9	2.8
16	14	Philips Semiconductors	8.9	14.5	62.9	2.4
15	15	New JRC	10.9	13.2	21.3	2.2
14	16	SGS-Thomson*	11.1	11.3	1.5	1.9
17	17	Sharp	7.1	8.0	13.0	1.3
18	18	Maxim	6.4	7.9	22.6	1.3
19	19	Burr-Brown	5.3	6.1	13.6	1.0
23	20	Ricoh	3.7	5.3	44.0	0.9
21	21	Linear Technology	4.4	5.1	16.9	0.8
113	22	Sanken	0	4.6	NA	0.8
20	23	Rockwell	5.0	4.5	-10.5	0.7
22	24	Allegro MicroSystems	3.9	3.8	-4.2	0.6
27	25	Siemens	2.0	3.1	60.8	0.5
34	26	AMD	1.1	3.1	189.4	0.5
37	27	Cirrus Logic	0.9	2.8	220.0	0.5
26	28	Harris	2.0	2.2	11.3	0.4
28	29	Oki	1.8	1.9	4.7	0.3
35	30	IR	1.1	1.6	44.7	0.3
39	31	Elantec	0.8	1.6	106.7	0.3
31	32	Fuji Electric	1.3	1.5	11.3	0.2
32	33	GEC Plessey	1.3	1.5	11.3	0.2
38	34	TEMIC	0.9	1.5	66.9	0.2
41	35	KEC	0.8	1.3	74.9	0.2
24	36	VTC	2.7	1.2	-55.5	0.2
30	37	Raytheon	1.3	1.2	-7.3	0.2
33	38	Exar	1.2	1.2	1.2	0.2

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Table 7-1 (Continued)
1997 Japanese Market Share Ranking: Analog-Monolithic (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
56	39	Semtech	0.1	1.2	1,012.9	0.2
36	40	Seiko	1.0	1.1	11.3	0.2
		All Others	12.9	13.1	1.0	2.2
		Americas Companies	130.7	169.7	29.8	28.1
		Japanese Companies	340.5	398.9	17.2	66.2
		European Companies	24.3	32.1	32.3	5.3
		Asia/Pacific Companies	2.6	2.1	-21.2	0.3
		Total Market	**498.0**	**602.7**	**21.0**	**100.0**

NA = Not available
* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

The Japanese discrete and optical semiconductor markets have traditionally been dominated by domestic vendors, and 1997 was no exception.

In the 1997 Japanese discrete semiconductor market, Toshiba maintained the lead by growing faster than the market, leveraging on its coverage in all three power transistor areas (see Table 7-2). NEC replaced Hitachi as the No. 2 vendor in Japan, showing two-digit growth rates in most of the product areas except for thyristors. Companies such as Rohm Company Ltd., Mitsubishi Electric, and SANYO kept their respective positionings, but they have a marked difference in product coverage—Rohm benefits from bipolar, SANYO from MOSFET, and Matsushita Electronics from both bipolar and MOS.

In the optical semiconductor market in Japan, Sharp Electronics Corporation widened the lead by growing at 24 percent (see Table 7-3). Contributions came from a wide range of segments, including couplers, charge-coupled devices (CCDs), and laser diodes. Companies following Sharp maintained their respective positions, with Rohm and SANYO each showing over 20 percent growth and both benefiting from the demand increase for laser diodes. Included in the survey from 1997 is Stanley Electric, which jumped in at No. 8 with its focused product coverage of LED lamps and displays.

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Table 7-2
1997 Japanese Market Share Ranking: Discrete (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Toshiba	80.1	89.6	11.9	17.4
3	2	NEC	62.7	73.1	16.7	14.2
2	3	Hitachi	75.2	59.2	-21.2	11.5
4	4	Matsushita Electronics	41.7	47.5	13.9	9.2
5	5	Rohm	40.5	41.8	3.2	8.1
6	6	Mitsubishi Electric	37.0	38.6	4.4	7.5
7	7	SANYO	29.4	34.3	16.7	6.7
9	8	Sanken	19.7	28.3	43.9	5.5
8	9	Fuji Electric	28.5	26.9	-5.7	5.2
10	10	Shindengen Electric	17.1	19.0	11.3	3.7
11	11	Fujitsu	8.1	9.3	15.8	1.8
12	12	Motorola	7.9	7.8	-2.4	1.5
13	13	IR	5.5	5.2	-6.2	1.0
15	14	General Semiconductor	3.3	3.5	7.6	0.7
14	15	Sony	3.4	3.3	-3.1	0.6
17	16	TEMIC	2.9	3.1	7.2	0.6
25	17	KEC	0.8	2.5	233.9	0.5
18	18	Powerex	2.0	1.9	-1.1	0.4
20	19	Philips Semiconductors	1.2	1.9	61.9	0.4
19	20	Oki	1.2	1.5	21.4	0.3
22	21	National	0.9	1.5	66.9	0.3
56	22	Fairchild	0	1.3	NA	0.3
24	23	Siemens	0.9	1.2	39.1	0.2
21	24	HP	0.9	1.0	11.3	0.2
23	25	SGS-Thomson*	0.9	1.0	11.3	0.2
29	26	Teccor Electronics	0.2	0.5	122.6	0.1
26	27	New JRC	0.3	0.4	11.3	0.1
28	28	Supertex	0.2	0.2	11.3	0
32	29	Zetex	0.1	0.2	122.6	0
31	30	Microsemi	0.1	0.1	11.3	0
33	31	Samsung	0.1	0.1	11.3	0
59	32	Harris	0	0.1	NA	0
114	33	Ericsson	0	0.1	NA	0
115	34	GEC Plessey	0	0.1	NA	0
116	35	Micronas	0	0.1	NA	0
16	36	Toko	3.0	0	-100.0	0

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Table 7-2 (Continued)
1997 Japanese Market Share Ranking: Discrete (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
27	37	ITT	0.2	0	-100.0	0
30	38	eupec	0.2	0	-100.0	0
		All Others	3.6	7.5	109.1	1.5
		Americas Companies	21.2	23.1	9.0	4.5
		Japanese Companies	451.1	480.0	6.4	93.4
		European Companies	6.4	8.1	26.4	1.6
		Asia/Pacific Companies	0.9	2.7	206.1	0.5
		Total Market	**479.6**	**513.9**	**7.2**	**100.0**

NA = Not available
* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

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Table 7-3
1997 Japanese Market Share Ranking: Optical Semiconductor (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Sharp	50.8	63.2	24.4	19.2
2	2	Matsushita Electronics	41.7	44.7	7.2	13.5
3	3	Sony	36.8	42.1	14.6	12.8
4	4	Toshiba	29.5	32.1	8.8	9.7
5	5	Rohm	22.1	26.5	20.1	8.0
6	6	NEC	22.0	22.0	0.3	6.7
7	7	SANYO	12.6	15.7	24.7	4.8
108	8	Stanley Electric	0	15.5	NA	4.7
8	9	Fujitsu	12.3	15.1	23.1	4.6
9	10	Mitsubishi Electric	9.6	15.1	58.1	4.6
10	11	Hitachi	7.9	7.0	-11.6	2.1
11	12	HP	5.4	5.8	6.8	1.8
12	13	TI	4.4	5.2	19.6	1.6
14	14	Oki	2.9	3.8	27.8	1.1
13	15	Sanken	3.9	3.6	-7.3	1.1
16	16	Siemens	0.8	1.7	122.6	0.5
20	17	TEMIC	0.4	1.2	178.2	0.4
19	18	KEC	0.5	0.6	11.3	0.2
15	19	Mitel	0.8	0.2	-68.2	0.1
17	20	Lucent	0.7	0.2	-62.9	0.1
21	21	Motorola	0.1	0.1	11.3	0
18	22	New JRC	0.5	0	-100.0	0
		All Others	21.3	8.2	-61.4	2.5
		Americas Companies	11.3	11.6	2.7	3.5
		Japanese Companies	274.0	314.9	14.9	95.4
		European Companies	1.2	2.9	142.8	0.9
		Asia/Pacific Companies	0.5	0.6	11.3	0.2
		Total Market	**287.0**	**330.0**	**15.0**	**100.0**

NA = Not available
Source: Dataquest (August 1998)

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Analog IC, Discrete Device, and Optical Semiconductor Forecast through 2002

The outlook for the analog, discrete, and optical semiconductor markets has been adjusted downward from the previous forecast. It should be noted that the analog market was partially affected by the reclassification of linear array and mixed-signal ASICs (although small in size) into total ASICs.

The strong demand growth for analog ICs in the past few years has caused the industry to hold unduly high expectations. With the rapid progress of system diversification, accompanied by LSI implementations over several generations, demand for analog ICs and discrete devices has been experiencing a surge in momentum (see Tables 7-4 and 7-5). Nevertheless, the expansion of mixed-signal analog IC markets will ultimately lead to CBICs absorbing analog functions, so that suppliers will tend to overestimate long-term demand by extrapolating the recent high-growth trends. Also, sluggish electronics production causes demand for generic analog devices to slow down.

In the first quarter of 1998, suppliers do not seem to be accelerating analog capacity, partly because of heavy constraints on investment resources. If supply capacity expands abruptly, prices will plummet, resulting in unit growth without revenue growth. Given this cap for capacity expansion, Dataquest believes that it will be difficult for the Japanese analog market to continue double-digit growth. (In the downside scenario mentioned in Chapter 2, analog price erosion has been incorporated into the Japanese market growth.)

Challenge to the Vendors

Japanese analog vendors have enjoyed two advantages in the domestic market: IC demand and system technology from Japan-based consumer electronics makers. Now that even Japan-based consumer companies have shifted a large portion of their equipment production overseas and non-Japanese markets are growing much faster, Japanese analog vendors can no longer expect the same pattern. Also, the system technology required in digital consumer applications derives from basic technologies developed by non-Japanese system makers in the Americas and European markets. As system-oriented semiconductor suppliers, Japanese analog companies need to strengthen their design support capability in markets outside of Japan, focusing on target applications in each region.

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Table 7-4
1997 Japanese Analog, Discrete, and Optical Markets—History and Forecast, 1992 to 2002 (Billions of Yen)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Analog-Monolithic	367.1	364.5	412.1	445.4	498.0	602.7	656.2	714.7	782.3	849.9	912.4	8.6
Discrete	389.1	380.6	398.7	439.6	479.6	513.9	565.8	609.9	667.9	716.4	765.8	8.3
Optical	196.8	192.2	213.5	259.9	287.0	330.0	342.5	365.8	395.7	428.8	461.8	7.0
Exchange Rate (Yen/U.S.$1)	126.5	111.2	101.8	93.9	108.8	121.1	129.7	129.7	129.7	129.7	129.7	-

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (August 1998)

Table 7-5
Japanese Analog, Discrete, and Optical Markets—History and Forecast, 1992 to 2002 (Yen-Based Percentage Growth over Preceding Year)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Analog-Monolithic	-12.8	-0.7	13.1	8.1	11.8	21.0	8.9	8.9	9.5	8.6	7.4
Discrete	-16.6	-2.2	4.8	10.3	9.1	7.2	10.1	7.8	9.5	7.3	6.9
Optical	-19.0	-2.3	11.1	21.7	10.4	15.0	3.8	6.8	8.2	8.4	7.7

Source: Dataquest (August 1998)

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Chapter 8
Japanese Companies' Capital Spending Trends

Overall Spending Trends

In 1997, capital spending in Japan saw a decline over the previous year, for the first time since 1992 (see Table 8-1). This was caused mainly by the Japanese companies, whose worldwide spending shrank by 1.7 percent. The outlook for 1998 is even gloomier because the capital expenditure in Japan is expected to be cut by 30 percent on a dollar basis—the largest reduction among all four regions. In the section below, the spending trends of Japanese companies are analyzed, as Japanese companies represent the majority of spending in Japan.

The regional distribution of Japanese companies' spending this year shows a clear preference: Domestic investment declines by one-third, while spending in the Americas and Europe is being reduced by one-half. The only region to show an increase is Asia/Pacific. This does not actually mean that Japanese companies on the whole are focusing on that region. Rather, the increase comes from a large commitment by NEC to the Shanghai joint venture.

During the boom years, Japanese companies took an aggressive approach to high-growth markets overseas by increasing the supply capacity near the markets, just like they did in the past boom years, and, just like they did after the past boom years, they are reducing overseas spending again. This trend can be attributed first to a big reduction in funds caused by lessened profits or increased loss from the semiconductor business in recent years. Realizing the need to focus on next-generation investments, Japanese companies have given up on the idea of enforcing local supply capacity. The second reason can be found in exchange rate trends, where the Japanese yen has depreciated to the level it saw about seven years ago when Japanese companies were less motivated to produce outside of Japan.

Spending trends by product also show a sharp contrast. Investment into memories is to be cut by one-third, while the microcomponent and logic segments combined show a much milder reduction of 7.6 percent. As a result, memories' share of Japanese companies' capital spending is to be surpassed by those two other categories for the first time since DRAM has become a major segment of business for Japanese semiconductor companies. The focus on microcomponent and logic clearly shows their determination to pursue SLI trends. Analog and discrete, two major product categories that represent a large portion of the profits, are given ample share in the investment this year. This, however, poses a threat to the near-future supply/demand of those categories, because the progress of SLI may imply a reduced rate of growth in demand—not reduced demand—for analog and discrete products.

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Table 8-1
Semiconductor Capital Spending of Top 20 Japanese Companies (Billions of Yen)

	1991	1992	1993	1994	1995	1996	1997	1998
Fuji Electric	15.1	15.0	6.8	5.2	7.7	11.5	11.8	10.1
Fujitsu	95.6	71.3	77.9	109.2	149.5	137.5	174.8	107.4
Hitachi	88.4	65.0	86.3	98.8	140.6	139.8	122.9	86.8
Matsushita Electronics	62.9	25.3	18.8	52.3	79.5	103.8	90.0	65.1
Mitsubishi Electric	90.4	60.0	50.0	68.8	105.0	100.0	91.3	57.9
NEC	102.3	77.5	77.5	113.8	188.7	195.0	177.7	173.6
New JRC	4.8	4.2	1.7	1.6	3.8	3.5	2.9	3.4
Nippon Steel	19.5	12.0	9.5	8.6	9.6	7.8	6.8	4.8
Oki	43.2	25.8	13.9	32.0	46.2	47.4	35.6	18.4
Ricoh	5.0	3.5	2.8	3.7	4.0	4.0	5.0	3.9
Rohm	24.2	14.0	25.9	35.2	52.7	42.2	40.8	49.1
Sanken	6.2	4.4	4.2	4.1	6.1	7.7	7.5	12.4
SANYO	40.4	35.5	38.6	36.3	60.8	60.5	52.6	50.2
Seiko	13.9	9.0	7.0	9.3	10.0	42.3	45.8	25.3
Sharp	33.3	30.0	30.0	34.5	38.0	71.2	63.8	47.0
Shindengen Electric	4.5	5.0	5.0	5.0	4.6	5.6	5.4	5.3
Sony	70.7	47.5	40.0	40.0	42.2	48.3	63.3	60.3
Stanley Electric	NA	NA	NA	NA	NA	NA	0.3	0.5
Toshiba	107.3	85.0	80.0	95.0	152.5	155.0	165.5	142.3
Yamaha	3.5	2.3	2.8	4.5	6.9	7.1	6.4	10.9
Total	**831.2**	**592.3**	**578.7**	**757.9**	**1,108.4**	**1,190.2**	**1,169.9**	**934.6**

NA = Not available
Source: Dataquest (August 1998)

Looking at facilities, the expenditure in property and land is being cut in half, while wafer fab equipment spending is to be reduced by 20 percent, and back-end facilities show only a 6 percent reduction. In view of the continuing overcapacity in the market, Japanese companies are discouraged about increasing overall supply capacity; once again they are carefully filling the shells that they build during the boom years. Most of the wafer fab equipment is aimed at upgrades to 0.25-micron technology, while in a limited number of cases, investments in deep submicron fab equipment are included. The efforts in 300mm wafer technology have been slowed for several reasons, including reduced overall spending, technology/equipment problems, and a market condition of prolonged overcapacity. The ultimate question for semiconductor manufacturers in pursuit of large wafer technology is whether they will really need production capacity of that magnitude. Not many companies can fully enjoy the increased efficiency in production of commodity products including DRAMs, but not many companies are ready to offer SLI products that can utilize 300mm wafer fab capacity. Shifting product preference is seen in back-end investment trends, where the focus on microcomponent and logic requires additional equipment for the interconnect/metal layer.

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In the past down-cycle years, Japanese companies sought to increase foundry shipment to improve fab utilization. Ever since the emergence of dedicated foundry providers equipped with advanced logic technology, however, that "opportunistic foundry shipment" practice has become a less easy choice. Dedicated foundries are well prepared to cope with fabless companies' requirements. Foundry providers in Taiwan have a strong tie with the U.S. semiconductor industry, and the tie—especially with fabless companies—has brought them ample orders, taking away business opportunities from other companies. Thus, the decrease in foundry shipments has been another reason for Japanese companies' reduction in additional supply capacity.

The current weak revenue and pricing trends, and consequential dwindling profits, hardly justify strong spending in manufacturing equipment. The question then lies in deciding how much spending is the appropriate amount. There has been a general, empirical belief in the industry that capital spending of over 20 percent of revenue is not necessarily a safe practice unless a company has good reasons to do so and understands the financial risks involved. Looking at Japanese companies' spending, this criterion seems to apply to larger suppliers, while medium-size companies have spent over 20 percent of their revenue, and companies with specific product orientation in discrete and optical areas have spent characteristically less than 15 percent of their revenue. Noteworthy is the ratio for NEC, the largest semiconductor supplier and capital spender among Japanese companies, which is less than 15 percent. Taking into consideration that NEC tends to construct its own proprietary fabs with the exception of recent two cases in China, NEC's investment efficiency is strikingly high among Japanese companies. With the exception of NEC, however, major Japanese companies have started to seek alliances in outsourcing manufacturing at a pace never seen before. This is causing a restructuring of the Japanese semiconductor industry, and Dataquest believes that this is an unavoidable step for Japanese companies to regain strength in the semiconductor business.

Taking into consideration the current trends toward SLI, as well as prolonged DRAM oversupply, it is not likely that Japanese companies will resume a high pace of spending in manufacturing capacity. Even 300mm wafer production has dropped from the list of top priorities, while some companies have not given up technology development and pilot production. Some Japanese companies are facing the ultimate question of whether to make or buy in some product areas where investment efficiency cannot easily be achieved, given their own product portfolio and large amount of expenditure. Dataquest believes that semiconductor vendors that make the bold but required decision to refocus their business, with ample consideration of and emphasis on SLI, will come out shining beyond the current turmoil in the semiconductor industry.

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Market Statistics

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Japanese Fab Database

Market Statistics

Program: Semiconductors Japan
Product Code: SEMI-JA-MS-9806
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Chapter 1
Japanese Fab Database

Background and Methodology

This report contains the Japanese portion of Dataquest's wafer fab database. The records in these tables are fabs located in the Japan region. The Semiconductor Equipment, Materials, and Manufacturing Worldwide (SEMM) program conducts extensive annual surveys, complemented with quarterly secondary research to maintain this database. Published once a year, this document represents Dataquest's best insights and estimates into the end-market of semiconductor equipment.

The tables in this report cover planned and existing merchant, captive, and foundry fab lines. A fab line is a series of equipment to do front-end (from initial oxide through wafer probe) semiconductor manufacturing. Occasionally, two or more separate product-specific fab lines or wafer sizes operate in a single clean room or physical plant. In this situation, Dataquest divides the clean room as separate fab lines if the company dedicates equipment to each wafer size or product line. If a company installs substantially different equipment during an expansion (for example, equipment to increase its maximum wafer diameter), again Dataquest divides the clean room and creates two entries into the database. Therefore, a company may operate many fab lines at one location.

Worldwide Geographic Region Definitions and Regional Roll-Ups

Americas

Includes Central America (all nations), Canada, Mexico, United States, Puerto Rico, and South America (all nations).

Japan

Japan is the only single-country region.

Europe, Africa, and Middle East

Includes Africa (all nations), Albania, Andorra, Armenia, Azerbaijan, Belarus, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Gibraltar, Hungary, Iceland, Israel, Italy, Kazakhstan, Kyrgyzstan, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Middle East (all nations), Moldova, Monaco, Netherlands, Norway, Poland, Romania, Russia, San Marino, Scandinavia, Slovakia, Spain, Sweden, Sweden, Switzerland, Tajikistan, Turkey, Turkmenistan, Ukraine, United Kingdom, Uzbekistan, Vatican City, and all nations within the former Yugoslavia.

Asia/Pacific

Includes Australia, Bangladesh, Cambodia, China, Hong Kong, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, New Zealand, Pakistan, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, and Vietnam.

Field Definitions

The Company field indicates the operator of the fab line. For contract manufacturers that trade capacity for capital investment in the fab, Dataquest lists the contract manufacturer. For incorporated joint ventures, Dataquest lists either the incorporated entity or the major investors, separated with slashes.

The City field displays the most detailed location information. This reference is usually a city or town, but could be an often-used district name (for example, Science Park in the city of Hsinchu, Taiwan). If this field lists a district, Dataquest will list the city in the State or Province field. In some cases, a reference to a state or province will be included in the City or District field to create a unique identifier for this location.

The Prefecture field denotes the second most detailed location. This reference is usually a state (for the United States), province (for Canada and many European and Asian countries), or a prefecture (for Japan). For countries within the United Kingdom, Dataquest lists the country name (for example, "Scotland") in this field so Dataquest can list the descriptor "U.K." in the Country field.

The Country field indicates the broadest location identifier in this report. This reference is usually a country, except in the case of the United Kingdom (see "State or Province" above). Because Japan is a single-country region, there is no regional qualifier for fabs in Japan.

The Fab Name field provides a reference to a particular fab or fab line to distinguish it from other fabs or lines owned by that company. Although Dataquest makes every attempt to match the nomenclature used by the company, occasionally some additional qualifiers (for example, "Phase 1") will appear to provide insight to the facility's history or organization.

The Products field lists the products manufactured at this site. The listings generally fall into five product groups, with the following nomenclature and definitions (when warranted):

- MOS memory
  - DRAM: Dynamic RAM
  - EEPROM: Electrically erasable PROM
  - EPROM: Ultraviolet erasable PROM
  - FERRAM: Ferroelectric RAM
  - FIFO: First-in/first-out memory
  - Flash: Flash memory
  - Mem: Memory
  - NV Mem: Nonvolatile memory (ROM, PROM, EPROM, EEPROM, and FERRAM)
  - PROM: Programmable ROM
  - RAM: Random-access memory

- ROM: Read-only memory
- SGRAM: Synchronous graphics RAM
- Sp Mem: Other specialty memory (such as dual-port, shift-register, or color lookup)
- SRAM: Static RAM
- VRAM: Video RAM

■ MOS microcomponent/digital logic

- Array: Gate array
- ASIC: Application-specific IC
- ASSP: Application-specific standard product
- Bit: Bit slice (subset of MPU functions)
- CBIC: Cell-based IC
- Custom: Full-custom IC (single user)
- DSP: Digital signal processor
- FPGA: Field-programmable gate array
- LISP: 32-bit list instruction set processor for AI
- Logic: Standard logic
- LSI: Large-scale integration
- MCU: Microcontroller unit
- MixSig ASIC: Mixed-signal ASIC
- MPR: Microperipheral
- MPRCom: MPR digital communication (ISDN, LAN, UART, or modem)
- MPU: Microprocessor unit
- PLD: Programmable logic device
- RISC: Reduced-instruction-set computation 32-bit MPU
- Telecom: Telecommunications chip

■ Power/discrete/analog (including bipolar power)

- A/D D/A: Analog-to-digital, digital-to-analog converter
- Automotive: Dedicated to automobile applications
- CODEC: Coder/decoder
- Diode
- Discrete
- FET: Field-effect transistor
- GTO: Gate turn-off thyristor
- HEMT: High-electron-mobility transistor
- IGBT: Insulated-gate bipolar transistor

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- Interface: Interface IC
- Linear: Linear/analog device
- MDiode: Microwave diode
- MESFET: Metal semiconductor field-effect transistor
- MFET: Microwave field-effect transistor
- Modem: Modulator/demodulator
- MMIC: Monolithic Microwave IC
- MOSFET: MOS-based field-effect transistor
- Op Amp: Operational amplifier
- Pwr IC: Power IC
- Pwr Tran: Power transistor
- Rectifier
- Reg: Voltage regulator
- RF: Radio frequency
- SCR: Schottky rectifier
- Sensor
- Smart Pwr: Smart power
- SST: Small-signal transistor
- Switches: Switching device
- Thyristor
- Tran: Transistor
- Zener Diode

- Optoelectronic
  - CCD: Charge-coupled device (imaging)
  - Coupler: Photocoupler
  - IED: Infrared-emitting diode
  - Image Sensor
  - Laser: Semiconductor laser or laser IC
  - LED: Light-emitting diode
  - Opto: Optoelectronic
  - PDiode: Photo diode
  - PTran: Photo transistor
  - SAW: Surface acoustic wave device
  - SIT Image Sensor: Static induction transistor image sensor

- Bipolar Digital and Other Devices (includes all digital ICs using a bipolar process)
  - Darlington
  - Micromachining sensors
  - MilStd: Military Standard Logic
  - RadHard: Radiation hardened

The Process Technology field indicates each fab's use of five major types of processes. The process grouping is as follows:

- P/CMOS: P-channel metal-oxide semiconductor (PMOS) or complementary metal-oxide semiconductor (CMOS)
- NMOS: N-channel metal-oxide semiconductor (NMOS)
- BiCMOS: Bipolar and CMOS combined on a chip
- Bipolar
- III-V: Gallium arsenide and other compound semiconductor processes

The Estimated Minimum Geometry is the smallest linewidth feature size, measured in microns, attainable in production volume.

The Wafer Diameter represents the maximum wafer size that the fab or fab line can process. Wafer diameters, although expressed colloquially in inches, conform to metric specifications. For wafers greater than 3 inches in diameter, expression in inches becomes inaccurate. When calculating square inches, Dataquest uses the following approximations:

- Stated diameter of 4 inches (100mm) = Approximate diameter of 3.938 inches
- Stated diameter of 5 inches (125mm) = Approximate diameter of 4.922 inches
- Stated diameter of 6 inches (150mm) = Approximate diameter of 5.906 inches
- Stated diameter of 8 inches (200mm) = Approximate diameter of 7.87 inches
- Stated diameter of 12 inches (300 mm) = Approximate diameter of 11.84 inches.

The Year and Quarter of Initial Production displays the year (and quarter, if available) in which this line, having completed all qualifications, began manufacturing in production volumes. The format for this reference is "year.quarter" (for example, 1994.3 translates to the third calendar quarter of 1994).

The Initial Monthly Wafer Starts field indicates the initial monthly volume of production wafer throughput.

The Estimated Maximum Monthly Wafer Starts field contains the equipment-limited wafer start capacity per four-week period. Only the throughput of the installed equipment and the process complexity limits the maximum starts. Dataquest does not consider current staffing or the number of shifts operating in determining this metric.

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The Fab Type field shows the types of semiconductor manufacturing performed at this location. The fab types include the following:

- "F" indicates that this is a production-based fab.
- "R" indicates a semiconductor R&D and/or trial production facility.
- "P" means that this location produces a pilot line.
- "T" means that this location performs assembly or testing.
- "N" indicates that this location performs foundry production, or contract manufacturing.
- "VD" means that this location performs VHDL design.
- "PD" means that this location performs IC place and route design.

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Chapter 2
Market Statistics Tables

Tables 2-1 and 2-2 provide information on fabs located in the Japan region.

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Table 2-1
Japan's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Aishin Seiki	Hekinan-Shi	Aichi	Japan	Shinkawa	Automotive	-	2.20	75	1990.0	4,700	15,700	F
Aishin Seiki	Handa-Shi	Aichi	Japan	Handa	Automotive	-	1.00	150	1991.0	5,700	19,100	F
Asahi Kasei Micro Systems	Atsugi-Shi	Kanagawa	Japan	-	Tran Custom	NMOS	1.60	125	1987.0	1,400	4,000	FRN
Asahi Kasei Micro Systems	Nobeoka-Shi	Miyazaki	Japan	-	SRAM Full Custom Other MOS Logic	PCMOS	0.80	150	1993.3	1,500	6,000	FT
Canon	Hiratsuka-Shi	Kanagawa	Japan	-	Amorphous Image Sensors	III-V	1.70	75	1986.0	3,800	11,000	F
Canon	Hiratsuka-Shi	Kanagawa	Japan	-	ASIC	PCMOS	0.35	150	1988.0	700	3,000	F
Canon Denshi	Chichibu-Shi	Saitama	Japan	-	CCD	-	3.00	125	1984.0	1,700	5,000	F
Casio	Hachioji-Shi	Tokyo	Japan	-	ASIC	-	1.20	100	1985.0	2,700	11,000	FT
Fuji Electric	Matsumoto-Shi	Nagano	Japan	-	Custom ASSP	-	2.00	100	1981.0	4,500	15,000	F
Fuji Electric	Matsumoto-Shi	Nagano	Japan	-	Diode Pwr Tran MOSFET	-	6.00	100	1985.0	17,500	50,000	F
Fuji Electric	Matsumoto-Shi	Nagano	Japan	-	Custom ASSP	-	0.80	150	1990.0	700	3,000	F
Fuji Electric	Matsumoto-Shi	Nagano	Japan	-	MOSFET IGBT High-Voltage Diode	-	3.00	125	1995.0	10,500	30,000	F
Fuji Electric	Matsumoto-Shi	Nagano	Japan	-	IGBT Power MOSFET	-	1.60	200	1998.3	6,600	19,100	F
Fuji Film Microdevice	Kurokawa-Gun	Miyagi	Japan	-	CCD Converter Full Custom	PCMOS	1.00	150	1992.0	1,000	3,000	F
Fuji Xerox	Suzuka-Shi	Mie	Japan	-	Pwr ICs Image Sensor Log	PCMOS	3.00	125	1986.0	1,000	3,000	F
Fujitsu	Isawa-Gun	Iwate	Japan	No. 2	8-bit/16-bit MCU	PCMOS	0.80	125	1982.0	11,200	20,000	F
Fujitsu	Isawa-Gun	Iwate	Japan	No. 3	8-bit/17-bit MCU	PCMOS	0.50	150	1984.0	12,500	50,000	F
Fujitsu	Kuwana-Gun	Mie	Japan	No. 1	Arrays	PCMOS	0.25	150	1984.0	2,500	15,000	F
Fujitsu	Aizu Wakamatsu-Shi	Fukushima	Japan	Bldg. No. 1-1	Bipolar	-	0.60	125	1985.0	2,500	12,000	F
Fujitsu	Aizu Wakamatsu-Shi	Fukushima	Japan	Bldg. No. 1-2	Arrays CBIC 32-bit MCU	PCMOS	0.70	150	1985.0	5,000	20,000	FN
Fujitsu	Kawasaki-Shi	Kanagawa	Japan	-	R&D	PCMOS	0.13	150	1988.0	1,700	5,000	FRVD
Fujitsu	Aizu Wakamatsu-Shi	Fukushima	Japan	Bldg. No. 2-1	Arrays Logic CBIC MPU	PCMOS	0.35	150	1990.2	8,700	15,000	FN
Fujitsu	Isawa-Gun	Iwate	Japan	No. 4-1	16Mb DRAM SGRAM	PCMOS	0.42	150	1990.3	10,000	20,000	F
Fujitsu	Kuwana-Gun	Mie	Japan	No. 3 Phase 1	MPU	PCMOS	0.25	150	1991.0	3,700	5,000	F
Fujitsu	Kuwana-Gun	Mie	Japan	No. 3 Phase 2	R&D	PCMOS	0.18	200	1994.0	200	10,000	F
Fujitsu	Isawa-Gun	Iwate	Japan	No. 4-2	64Mb DRAM	PCMOS	0.32	200	1995.0	10,000	25,000	F
Fujitsu	Aizu Wakamatsu-Shi	Fukushima	Japan	Bldg. No. 2-2	Arrays Logic CBIC MPU	-	0.35	200	1996.0		20,000	F
Fujitsu	Kuwana-Gun	Mie	Japan	No. 2	R&D	PCMOS	0.18	150	1998.0	2,500	10,000	F
Fujitsu-Advanced Micro Devices (FASL)	Aizu Wakamatsu-Shi	Fukushima	Japan	Fab 1	4Mb 8Mb 16Mb Flash	PCMOS	0.25	200	1994.0	10,000	25,000	F
Fujitsu-Advanced Micro Devices (FASL)	Aizu Wakamatsu-Shi	Fukushima	Japan	Fab 2 Phase 2	16Mb Flash	PCMOS	0.35	200	1999.0	5,000	25,000	F
Fujitsu-Advanced Micro Devices (FASL)	Aizu Wakamatsu-Shi	Fukushima	Japan	Fab 2	16Mb 64Mb Flash	PCMOS	0.23	200	1998.2	5,000	25,000	F
Fujitsu-Quantum Device	Nakakoma-Gun	Yamanashi	Japan	No.1	FET Opto HEMT	III-V	1.50	100	1985.0	4,500	4,000	F
Fujitsu-Quantum Device	Nakakoma-Gun	Yamanashi	Japan	No.2	HEMT ASIC MMIC	III-V	0.25	100	1991.0	4,500	4,000	F

Table 2-1 (Continued)
Japan's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Genesys Technology	Nishiwaki-Shi		Japan	-	-	-	1.20	150	1992.0	8,500	19,000	F
Hamamatsu Photonics	Hamamatsu-Shi	Shizuoka	Japan	-	Opto	-	1.70	75	1987.0	5,200	15,000	FR
Hitachi	Nakano-Shi	Nagano	Japan	Nakano	Laser Hybrid	III-V	1.50	75	1980.0	5,200	15,000	FT
Hitachi	Hitachi-Shi	Ibaraki	Japan		Pwr GTO Thyristors Ttl	Bipolar	3.00	125	1983.0	5,200	15,000	F
Hitachi	Nakakoma-Gun	Yamanashi	Japan	K4-1F	MPU Logic	PCMOS	1.30	125	1983.0	7,500	30,000	F
Hitachi	Hitachinaka-Shi	Ibaraki	Japan	N1-1F	MCU	PCMOS	0.60	150	1983.0	7,500	18,000	F
Hitachi	Takasaki-Shi	Gunma	Japan	Honkan	Discrete Analog	-	1.30	125	1986.0	5,200	60,000	F
Hitachi	Ome-Shi	Tokyo	Japan	D5-1	MPU Memory CBIC	PCMOS	0.18	200	1987.0	1,200	5,000	FR
Hitachi	Takasaki-Shi	Gunma	Japan	TM3	Discrete Analog	-	0.80	125	1988.0	4,500	7,500	F
Hitachi	Chitose-Shi	Hokkaido	Japan	Chitose 2-1F	MCU	PCMOS	0.60	150	1988.0	3,700	15,000	F
Hitachi	Nakakoma-Gun	Yamanashi	Japan	K4-2F	MPU Logic	PCMOS	0.60	125	1988.0	5,000	20,000	F
Hitachi	Goshogawara-Shi	Aomori	Japan	5M-2F	MCU	PCMOS	0.35	150	1988.0	4,000	16,000	F
Hitachi	Nakakoma-Gun	Yamanashi	Japan	K4-3F	MCU SRAM	PCMOS	0.60	150	1989.0	3,500	16,000	F
Hitachi	Takasaki-Shi	Gunma	Japan	T	Discrete Analog	BiCMOS	0.60	150	1992.0	7,000	15,000	F
Hitachi	Hitachinaka-Shi	Ibaraki	Japan	N2-1F	64Mb DRAM MPU	PCMOS	0.18	200	1994.4	10,000	15,000	F
Hitachi	Goshogawara-Shi	Aomori	Japan	5M-1F	MCU	PCMOS	0.80	150	1995.0	4,200	17,000	F
Hitachi	Nakakoma-Gun	Yamanashi	Japan	K2-2F	Flash SRAM	PCMOS	0.35	200	1995.0	5,000	10,000	F
Hitachi	Hitachinaka-Shi	Ibaraki	Japan	N2-2F	64Mb DRAM	PCMOS	0.25	200	1996.0	10,000	15,000	F
Hitachi	Hitachinaka-Shi	Ibaraki	Japan	N2-3F	64Mb DRAM	PCMOS	0.25	200	1996.0	10,000	15,000	F
Hitachi	Hitachinaka-Shi	Ibaraki	Japan	N1-2F	MCU Logic	PCMOS	0.80	150	1996.0	10,000	18,000	F
Hitachi	Hitachinaka-Shi	Ibaraki	Japan	N1-2F	MCU Logic	PCMOS	0.80	150	1996.0	10,000	18,000	F
Honda	Haga-Gun	Tochigi	Japan	Tochigi Lab	Engine Control Sensors MMIC	PCMOS	2.00	75	1990.0	3,800	11,000	F
IBM Microelectronics	Yasu-Gun	Shiga	Japan	-	Array MPU ROM	PCMOS	1.00	125	1986.0	7,500	30,000	F
IBM Microelectronics	Yasu-Gun	Shiga	Japan	-	64Mb DRAM pDSP	PCMOS	0.35	200	1990.0	6,000	15,000	F
Iwatsu	Hachioji-Shi	Tokyo	Japan	-		PCMOS	1.50	125	1986.0	2,100	6,000	F
JVC	Yokosuka-Shi	Kanagawa	Japan	-	1Kb Arrays DSP Custom	PCMOS	3.00	75	1983.0	2,700	9,000	F
Kawasaki Steel	Utsunomiya-Shi	Tochigi	Japan	-	256Kb SRAM CBIC Arrays	PCMOS	0.25	150	1991.0	2,200	9,000	FN
Kobe Steel (KTI)	Nishiwaki-Shi	Hyogo	Japan	KTI Fab 1	16Mb DRAM ASIC	PCMOS	0.50	150	1992.2	12,500	25,000	FT
Kobe Steel (KTI)	Nishiwaki-Shi	Hyogo	Japan	KTI Fab 2	16Mb 64Mb DRAM ASIC	PCMOS	0.35	200	1996.4	8,500	25,000	F
Kodenshi	Uji-Shi		Japan	Plant 3	Opto Discrete	-	0.80	125	1995.2	2,400	7,000	FT
Konica	Nishi-Shinjuku	Tokyo	Japan	Lab	Opto	-	2.20	75	1984.0	2,400	7,000	FR
Kyocera	Kansai-Shi	Kyoto	Japan	-	-	-	0.65	150	1992.2	8,500	19,000	FR
Kyoto Semiconductor	Kyoto-Shi	Niigata	Japan	-	LED Tran Image Sensor	III-V	1.40	100	1985.0	4,400	12,700	F
LSI Logic	Tsukuba-Shi	Ibaraki	Japan	Tsukuba Fab 2	ASIC CBIC MPU MPR SRAM	-	0.60	150	1993.0	2,000	8,000	FN
Matsushita	Arai-Shi	Niigata	Japan	Fab A	Analog Discrete	Bipolar	6.00	100	1967.0	15,000	30,000	F
Matsushita	Hioki-Gun	Kagoshima	Japan	-	Opto LED Laser	-	3.00	51	1974.0	300	1,000	F
Matsushita	Nagaokakyo-Shi	Kyoto	Japan	C	Discrete (Power)	Bipolar	10.00	100	1980.0	6,300	15,000	F

Table 2-1 (Continued)
Japan's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Matsushita	Hioki-Gun	Kagoshima	Japan	Fab A	Analog	-	2.00	100	1980.0	8,400	28,000	F
Matsushita	Nagaokakyo-Shi	Kyoto	Japan	V	Discrete	-	2.00	100	1982.0	6,600	10,000	F
Matsushita	Arai-Shi	Niigata	Japan	Fab B	MCU Logic ASSP Analog	-	1.50	125	1982.0	4,200	14,000	F
Matsushita	Utsunomiya-Shi	Tochigi	Japan	-	Discrete (Ss Tr Varicap)	NMOS	5.00	100	1983.0	3,500	10,000	FT
Matsushita	Arai-Shi	Niigata	Japan	Fab C-1	Analog	-	2.00	125	1984.0	2,100	5,000	FT
Matsushita	Arai-Shi	Niigata	Japan	Fab C-2	CCD MixSig ICs	-	0.60	125	1984.0	2,400	7,000	FT
Matsushita	Arai-Shi	Niigata	Japan	Fab D-1	Analog	Bipolar	1.80	100	1985.0	6,600	11,000	F
Matsushita	Uozu-Shi	Toyama	Japan	Fab A	Discrete	-	1.50	125	1985.0	8,500	25,000	F
Matsushita	Arai-Shi	Niigata	Japan	Fab D-2	Analog	-	1.50	125	1985.0	5,400	13,000	F
Matsushita	Uozu-Shi	Toyama	Japan	Fab C-1	MPU MCU Logic ASSP	PCMOS	0.80	150	1987.0	6,700	27,000	F
Matsushita	Uozu-Shi	Toyama	Japan	Fab C-2	MCU	PCMOS	0.50	150	1990.0	6,000	20,000	F
Matsushita	Kyoto-Shi	Kyoto	Japan	Kyoto R&D	DRAM MCU Logic	PCMOS	0.25	200	1991.0	200	500	FTR
Matsushita	Uozu-Shi	Toyama	Japan	Fab B	MCU DSP Logic ASSP	PCMOS	0.60	150	1991.0	5,000	20,000	F
Matsushita	Kadoma-Shi	Osaka	Japan	S/C R6	16Mb DRAM 64-bit MPU 64Mb DRAM	PCMOS	0.35	150	1991.1	200	500	FTR
Matsushita	Tonami-Shi	Toyama	Japan	Fab A/B	MCU ASIC Other Memory	PCMOS	0.35	150	1994.0	5,000	15,000	F
Matsushita	Tonami-Shi	Toyama	Japan	Fab C	MCU	PCMOS	0.35	200	1996.4	5,000	20,000	F
Meidensha	Numazu-Shi	Shizuoka	Japan	-	GTO Thyristor	-	4.00	125	1985.0	2,400	7,000	F
Mitsubishi	Kikuchi-Gun	Kumamoto	Japan	B-2F	ASIC MOSFET	PCMOS	1.00	100	1975.0	7,500	30,000	F
Mitsubishi	Fukuoka-Shi	Fukuoka	Japan	No. 1	Pwr Tran Diode Bip	-	3.00	100	1976.0	11,900	34,000	FT
Mitsubishi	Kikuchi-Gun	Kumamoto	Japan	B-1F	OTP MCU	PCMOS	1.00	125	1977.0	9,000	30,000	F
Mitsubishi	Kikuchi-Gun	Kumamoto	Japan	C-2F	MCU SRAM	PCMOS	1.30	125	1981.0	7,000	28,000	F
Mitsubishi	Kikuchi-Gun	Kumamoto	Japan	C-1F	Fast SRAM MCU	-	0.80	125	1982.0	12,500	25,000	F
Mitsubishi	Fukuoka-Shi	Fukuoka	Japan	No. 2	Bipolar Linear A/D D/A Discrete	-	1.50	125	1984.0	14,700	42,000	F
Mitsubishi	Saijo-Shi	Ehime	Japan	SB	MCU	PCMOS	0.90	125	1984.3	19,500	39,000	F
Mitsubishi	Saijo-Shi	Ehime	Japan	SC	MCU	PCMOS	0.80	125	1985.7	10,000	50,000	F
Mitsubishi	Kami-Gun	Kochi	Japan	TA2	8-bit 16-bit 32-bit MCU ASIC	PCMOS	0.50	150	1987.0	15,000	30,000	FT
Mitsubishi	Kami-Gun	Kochi	Japan	TA1	1Mb SRAM ASSP MCU	PCMOS	0.50	150	1989.0	15,000	30,000	F
Mitsubishi	Saijo-Shi	Ehime	Japan	SA-2A	Flash MCU 4Mb SRAM	PCMOS	0.40	150	1991.8	7,000	20,000	F
Mitsubishi	Itami-Shi	Hyogo	Japan	ULSI	64Mb 256Mb DRAM ASIC Flash	PCMOS	0.18	200	1993.0	5,000	10,000	FR
Mitsubishi	Saijo-Shi	Ehime	Japan	SA-2B	eRAM ASIC	PCMOS	0.35	200	1993.1	8,000	16,000	F
Mitsubishi	Kikuchi-Gun	Kumamoto	Japan	D-1F	64Mb DRAM	PCMOS	0.25	150	1996.0	5,000	18,000	F
Mitsubishi	Saijo-Shi	Ehime	Japan	SA-1F	eRAM	PCMOS	0.25	200	1997.0	10,000	15,000	FT
Mitsubishi	Itami-Shi	Hyogo	Japan	E2	Analog Discrete Opto	-	0.8	75				F
Mitsubishi	Itami-Shi	Hyogo	Japan	E3	Analog Discrete Opto	-	0.8	100				F
Mitsubishi	Itami-Shi	Hyogo	Japan	E2	Analog Discrete Opto	-	0.8	75				F
Mitsubishi	Itami-Shi	Hyogo	Japan	E3	Analog Discrete Opto	-	0.8	100				F
Mitsumi	Atsugi-Shi	Kanagawa	Japan	-	Log Discrete	Bipolar	2.00	100	1984.0	10,500	30,000	FT

Table 2-1 (Continued)
Japan's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Mitsumi	Atsugi-Shi	Kanagawa	Japan	-	Logic Power	-	0.80	200	1997.3	7,800	19,700	FT
Moririca Electronics	Yokohama-Shi	Kanagawa	Japan	-	Opto	III-V	1.40	100	1983.0	4,400	12,700	F
Motorola	Aizu Wakamatsu-Shi	Fukushima	Japan	MOS 7	Discrete Logic Analog	-	1.80	100	1972.0	17,500	50,000	FT
Motorola	Fukuyama		Japan	Phenitec	Discrete Power Logic	-	1.00	125	1986.0	4,000	50,000	FJ.V.
Motorola	Yama-Gun	Fukushima	Japan	MOS 7A	Logic Analog	-	0.80	150	1994.0	5,000	25,000	FTR
Murata Manufacturing	Yasu-Gun	Shiga	Japan	Yasu	FET MMIC	III-V	0.80	150	1993.0	5,000	14,400	FR
NEC	Tsuruoka-Shi	Yamagata	Japan	Tsuruoka Works 1	Bipolar Logic Linear Discrete	Bipolar	1.00	100	1976.0	6,000	20,000	FT
NEC	Kumamoto-Shi	Kumamoto	Japan	Dif-5	Logic MCU Other MOS	-	0.80	150	1978.0	10,000	15,000	F
NEC	Otsu-Shi	Shiga	Japan	Dif-1	Pwr Tran Linear	Bipolar	2.00	100	1978.0	8,700	25,000	FT
NEC	Otsu-Shi	Shiga	Japan	Dif-2	MCU LCD Driver	-	0.80	150	1981.0	8,000	30,000	F
NEC	Kumamoto-Shi	Kumamoto	Japan	Dif-4	MCU ASIC	PCMOS	0.80	150	1983.0	7,500	20,000	F
NEC	Otsu-Shi	Shiga	Japan	Dif-3	SRAM 4Mb DRAM Micro ASIC	-	0.50	150	1983.0	4,200	20,000	F
NEC	Kumamoto-Shi	Kumamoto	Japan	Dif-6	MPU	-	0.80	150	1987.0	7,500	30,000	F
NEC	Sagamihara-Shi	Kanagawa	Japan	G-1	16Mb DRAM ASIC MPU 4Mb ROM	-	0.80	150	1988.0	2,500	10,000	FTR
NEC	Kumamoto-Shi	Kumamoto	Japan	Dif-7	MCU ASSP Logic	-	0.50	150	1988.0	7,500	30,000	F
NEC	Otsu-Shi	Shiga	Japan	GaAs	Diode Opto FET	III-V	3.00	75	1988.0	700	5,000	F
NEC	Asa-Gun	Yamaguchi	Japan	Dif-1	SRAM MPU FLASH	-	0.50	150	1988.0	11,200	35,000	FT
NEC	Otsu-Shi	Shiga	Japan	Dif-4	16-bit MCU LCD Driver ASIC	PCMOS	0.25	150	1989.0	10,000	22,000	FT
NEC	Higashi Hiroshima-Shi	Hiroshima	Japan	Dif-1	ASIC MCU Other Memory	PCMOS	0.35	150	1990.4	7,500	60,000	FT
NEC	Tsuruoka-Shi	Yamagata	Japan	Tsuruoka Works 2	Logic Linear MPU ASIC	Bipolar	0.70	125	1993.0	10,000	20,000	F
NEC	Asa-Gun	Yamaguchi	Japan	Dif-2 (Bldg.C)	ASIC	PCMOS	0.35	150	1993.0	22,500	35,000	FT
NEC	Kumamoto-Shi	Kumamoto	Japan	Dif-8	16Mb DRAM 4Mb SRAM RISC ASIC	PCMOS	0.27	200	1994.0	15,000	60,000	F
NEC	Kamigori	Hyogo	Japan	-	-	-	0.50	200	1997.1	7,800	19,700	F
NEC	Higashi Hiroshima-Shi	Hiroshima	Japan	Dif-2	64Mb DRAM ASIC	-	0.25	200	1997.2	11,500	23,000	F
New Japan Radio	Kamifukuoka-Shi	Saitama	Japan	Fab 1	Analog Op Amp Opto	Bipolar	4.00	100	1977.0	7,300	17,000	FTR
New Japan Radio	Kamifukuoka-Shi	Saitama	Japan	Fab 2	Analog A/D D/A	Bipolar	2.50	100	1981.0	10,500	35,000	FTRN
New Japan Radio	Kamifukuoka-Shi	Saitama	Japan	Gaas	Analog Discrete Opto	-	0.50	100	1984.0	200	700	FTRN
New Japan Radio	Kamifukuoka-Shi	Saitama	Japan	Fab 3	Logic Analog MCU	-	0.80	125	1986.0	5,700	21,000	FTRN
Nippon Precision Circuits	Nasu-Gun	Tochigi	Japan	Bldg S	Logic Linear A/D D/A Modem	PCMOS	1.60	100	1984.0	4,500	15,000	F
Nippon Precision Circuits	Nasu-Gun	Tochigi	Japan	Bldg H	A/D D/A DSP Logic ASSP	PCMOS	2.00	150	1990.0	6,000	10,000	F
Nippon Silicon	-	-	Japan	-	16Mb DRAM	-	0.60	150	1990.0	9,800	19,700	FR
Nippon Steel Semiconductor	Tateyama-Shi	Chiba	Japan	M3	16Mb DRAM (will close)	PCMOS	0.40	150	1990.0	10,000	20,000	FT
Nippon Steel Semiconductor	Sagamihara-Shi	Kanagawa	Japan	Electronics Lab	ASIC 16Mb 64Mb DRAM	-	0.35	150	1991.4	200	500	FVDPD
Nippon Steel Semiconductor	Tateyama-Shi	Chiba	Japan	N1	16Mb (64Mb) DRAM (will close)	PCMOS	0.35	200	1996.3	7,000	10,000	FT
Nippondenso	Kariya-Shi	Aichi	Japan	Bldg. 1	Logic Custom MCU Opto	-	1.50	125	1987.0	700	2,000	F
Nippondenso	Nukata-Gun	Aichi	Japan	705	MCU Custom	-	1.50	125	1993.4	2,500	10,000	FT

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Table 2-1 (Continued)
Japan's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Nissan	Yokosuka-Shi	Kanagawa	Japan	R&D Center	MCU Custom	PCMOS	2.00	125	1987.0	100	500	FT
NKK	Ayase-Shi	Kanagawa	Japan	Phase 1	256Kb 1Mb 4Mb SRAM Flash MROM RISC MPU ASIC	PCMOS	0.50	200	1992.0	1,500	6,000	F
Oki	Miyazaki-Gun	Miyazaki	Japan	M1	Micro Logic	-	2.00	100	1981.0	15,000	55,000	FTN
Oki	Miyazaki-Gun	Miyazaki	Japan	M2	1Mb DRAM 4MB MROM LOGIC	-	0.00	125	1984.0	21,000	65,000	FTN
Oki	Hachioji-Shi	Tokyo	Japan	V3	Micro Gate Array ROM Flash Bipolar	-	0.35	150	1985.0	500	2,000	FTRVD PD
Oki	Kurokawa-Gun	Miyagi	Japan	S1	4Mb DRAM VRAM 1Mb SRAM 16M MROM Logic	PCMOS	0.45	150	1988.0	15,000	32,500	FTN
Oki	Miyazaki-Gun	Miyazaki	Japan	M3	4Mb 16Mb DRAM Logic	PCMOS	0.40	150	1991.0	15,000	35,000	FT
Oki	Hachioji-Shi	Tokyo	Japan	U1	16Mb 64Mb 256Mb DRAM Micro Logic Flash	PCMOS	0.18	150	1992.0	500	2,500	FRVDPD
Oki	Kurokawa-Gun	Miyagi	Japan	S2	16Mb 64Mb DRAM System LSI ASIC	PCMOS	0.22	200	1996.1	5,000	16,500	FTN
Olympus	Kamiina-Gun	Nagano	Japan	S/C Technology Centre	SIT Image Sensor	PCMOS	3.00	125	1986.0	1,700	5,000	F
Olympus	Hachioji-Shi	Tokyo	Japan	-	IC	-	1.40	100	1987.0	4,400	12,700	F
Omron	Kouka-Gun	Shiga	Japan	-	Opto Image Sensor	-	2.20	100	1975.0	7,000	20,000	F
Omron	Kouka-Gun	Shiga	Japan	-	Opto Image Sensor	-	3.00	100	1987.0	300	1,000	FT
Origin Electric	Oyama-Shi	Tochigi	Japan	-	Tran Diode Discrete	Bipolar	2.20	100	1983.0	5,900	17,000	FT
Pioneer Video	Kofu-Shi	Yamanashi	Japan	-	MPR ASIC Analog	PCMOS	0.80	125	1985.0	2,400	8,000	FT
Ricoh	Ikeda-Shi	Osaka	Japan	Fab 1	GaAs CBIC Voltage Regulators	-	1.50	150	1982.0	1,200	5,000	FVDPDN
Ricoh	Ikeda-Shi	Osaka	Japan	Fab 2	8-bit MCU GaAs CBIC	PCMOS	0.80	100	1986.0	1,200	5,000	FVDPDN
Ricoh	Kato-Gun	Hyogo	Japan	Fab 3	16-bit MCU GaAs CBIC	PCMOS	1.50	150	1990.0	3,000	12,000	FVDPDN
Rohm	Kyoto		Japan	Fab line 1	MCU Bipolar	-	0.35	200	1990.0			FRVD
Sanken	Niiza-Shi	Saitama	Japan	Niiza	Diode	Bipolar	2.20	100	1970.0	15,000	22,000	F
Sanken	Higashine-Shi	Yamagata	Japan	Yamagata Sanken	Pwr Tran Diode IC	-	1.50	125	1981.4	10,000	97,000	F
Sanken	Nihonmatsu-Shi	Fukushima	Japan	Fukushima Sanken	LED	III-V	0.80	75	1991.0	700	2,000	F
SANYO	Oura-Gun	Gunma	Japan	Bip 1	Analog	Bipolar	3.00	51	1967.0	20,000	50,000	FN
SANYO	Oura-Gun	Gunma	Japan	Tr 1	Tran (SST Pw.T)	Bipolar	1.00	100	1972.0	10,500	30,000	FN
SANYO	Oura-Gun	Gunma	Japan	Tr 2	Tran SST Power	Bipolar	2.00	100	1980.0	21,000	80,000	FN
SANYO	Oura-Gun	Gunma	Japan	Bip 2	Analog	Bipolar	3.00	75	1981.0	13,500	50,000	FN
SANYO	Tottori-Shi	Tottori	Japan	Tottori	LED Laser Diode	-	2.00	75	1983.0	14,000	35,000	FN
SANYO	Oura-Gun	Gunma	Japan	MOS 2	Logic ASSP MCU	PCMOS	1.20	125	1984.0	11,000	22,000	FRN
SANYO	Ojiya-Shi	Niigata	Japan	A 1	4-bit 8-bit MCU DSP Logic (ASSP)	PCMOS	0.80	125	1985.0	17,500	35,000	FTN
SANYO	Anpachi-Gun	Gifu	Japan	VL3	SRAM EEPROM Disk Drive ICs Custom CCD nROM	PCMOS	0.35	125	1986.0	10,500	32,000	FRN
SANYO	Ojiya-Shi	Niigata	Japan	B 2	Analog	-	1.20	125	1987.0	30,000	44,000	FTN
SANYO	Ojiya-Shi	Niigata	Japan	B 1	EEPROM Flash Logic ASSP 8-bit MCU 1Mb DRAM	PCMOS	0.50	150	1989.0	14,000	28,000	FTN

Table 2-1 (Continued)
Japan's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
SANYO	Oura-Gun	Gunma	Japan	Bip 3	Analog	Bipolar	1.20	100	1991.0	12,000	40,000	FN
SANYO	Anpachi-Gun	Gifu	Japan	Tr-G1	MOSFET	PCMOS	0.80	100	1991.0	6,000	5,000	FN
SANYO	Ojiya-Shi	Niigata	Japan	C 2	DRAM Logic SRAM Flash	PCMOS	0.50	150	1994.0	12,500	20,000	FTN
SANYO	Ojiya-Shi	Niigata	Japan	C1	Flash MCU	-	0.35	200	1998.0	10,000	15,000	FTN
SANYO	Anpachi-Gun	Gifu	Japan	Tr-G2	MOSFET	PCMOS	0.80	125			15,000	F
SANYO	Oura-Gun	Gunma	Japan	Tr 3	RF Tran Compound	Bipolar	2.00	75			500	F
Seiko Epson	Suwa-Gun	Nagano	Japan	Bldg. B	Arrays CBIC SRAM EEPROM	-	2.50	100	1981.0	12,500	50,000	FN
Seiko Epson	Suwa-Gun	Nagano	Japan	Bldg. A	Arrays 256Kb SRAM EPROM	PCMOS	1.50	125	1985.0	8,700	35,000	FN
Seiko Epson	Suwa-Gun	Nagano	Japan	Bldg. D	1Mb SRAM ASIC	-	0.80	150	1989.0	5,000	25,000	F
Seiko Epson	Sakata-Shi	Yamagata	Japan	Bldg 3	FPGA PLD CBIC	-	0.65	150	1991.0	5,000	20,000	FN
Seiko Epson	Sakata-Shi	Yamagata	Japan	-	ICs SRAM Telecom ICs PLDs FPGAs ASICsDRAMembDRAM	-	0.25	200	1997.4	5,000	20,000	F
Seiko Instruments	Matsudo-Shi	Chiba	Japan	-	SRAM Arrays CBIC EEPROM	PCMOS	0.80	150	1987.0	700	3,000	FN
Sharp	Tenri-Shi	Nara	Japan	Tenri	Analog LCD Driver	-	1.20	125	1977.0	7,500	25,000	F
Sharp	Tenri-Shi	Nara	Japan	Factory 3	SRAM MROM MCU ASIC LCD Driver	-	0.80	125	1980.0	6,600	22,000	FTN
Sharp	Kita Katsuragi-Gun	Nara	Japan	-	Optocoupler	III-V	1.60	75	1981.0	8,700	25,000	FTN
Sharp	Fukuyama-Shi	Hiroshima	Japan	Factory 1	MCU Arrays CBIC LCD Driver	PCMOS	0.80	150	1985.0	7,500	35,000	F
Sharp	Fukuyama-Shi	Hiroshima	Japan	Factory 1B	MCU Arrays CBIC LCD Driver	PCMOS	0.80	150	1985.0	7,500	30,000	F
Sharp	Yamato Koriyama-Shi	Nara	Japan	-	Laser LED Opto	III-V	1.70	75	1987.0	7,700	22,000	FT
Sharp	Fukuyama-Shi	Hiroshima	Japan	Factory 2	16Mb MROM 256kSRAM Opto	PCMOS	0.60	150	1989.0	20,000	40,000	FTN
Sharp	Fukuyama-Shi	Hiroshima	Japan	Factory 3	Flash 32Mb MROM SRAM Opto DRAM Logic	PCMOS	0.35	200	1993.0	15,000	25,000	FN
Shimadzu	Atsugi-Shi	Kanagawa	Japan	Atsugi	Laser Diode	III-V	1.40	100	1985.0	4,400	12,700	FT
Shindengen	Honjo-Shi	Akita	Japan	Ohura -1	Diode Thyristor	Bipolar	10.00	51	1972.0	35,000	100,000	F
Shindengen	Honjo-Shi	Akita	Japan	Ohura -2	Diode Thyristor	Bipolar	10.00	51	1983.0	21,000	60,000	FT
Shindengen	Higashine-Shi	Yamagata	Japan	Bldg. 1	Tran	-	10.00	75	1985.0	10,000	15,000	F
Shindengen	Higashine-Shi	Yamagata	Japan	Bldg. 2	MOSFET	-	10.00	75	1987.0	6,700	25,000	F
Shindengen	Hanno-Shi	Saitama	Japan	R&D Center	Pwr MOSFET Hybrid	NMOS, Bipolar	5.00	100	1989.0	300	1,000	FTVDPD
Shindengen	Hanno-Shi	Saitama	Japan	Trial	Pwr MOSFET Hybrid	NMOS, Bipolar	5.00	100	1991.0	300	1,000	FT
Shindengen	Higashine-Shi	Yamagata	Japan	Bldg. 3	Power Tran	-	10.00	100	1993.0	5,000	7,000	F
Sony	Kokubu-Shi	Kagoshima	Japan	-	CCD	NMOS	0.60	125	1973.0	7,000	20,000	F
Sony	Kokubu-Shi	Kagoshima	Japan	No. 2 Phase1	Discrete	Bipolar	3.00	100	1975.0	30,000	20,000	F
Sony	Kokubu-Shi	Kagoshima	Japan	No. 2 Phase2	Linear A/D D/A	Bipolar	2.00	125	1976.0	25,000	20,000	F
Sony	Kokubu-Shi	Kagoshima	Japan	No. 4	SRAM MCU	-	1.30	125	1978.0	14,000	28,000	FT
Sony	Atsugi-Shi	Kanagawa	Japan	-	Linear	Bipolar	2.00	100	1983.0	100	400	FT
Sony	Atsugi-Shi	Kanagawa	Japan	-	FET Laser CCD HEMT	III-V	2.00	75	1988.0	100	500	FT
Sony	Isahaya-Shi	Nagasaki	Japan	2G	CCD 256Kb SRAM 1Mb SRAM	PCMOS	0.80	150	1989.4	5,900	17,000	F

Table 2-1 (Continued)
Japan's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Sony	Isahaya-Shi	Nagasaki	Japan	3G	1Mb SRAM 4Mb VRAM CCD Logic	PCMOS	0.50	150	1991.1	8,700	25,000	F
Sony	Kokubu-Shi	Kagoshima	Japan	No. 6	Logic Memory MCU Linear	-	0.80	150	1992.0	7,500	15,000	FT
Sony	Isahaya-Shi	Nagasaki	Japan	4G	Logic	-	0.35	150	1997.0	2,500	10,000	F
Sony	Kokubu-Shi	Kagoshima	Japan	-	Logic	-	0.35	200	1997.0	2,500	10,000	F
Stanley	Hadano-Shi	Kanagawa	Japan	-	Laser LED	III-V	1.60	100	1986.0	3,500	10,000	F
Stanley	Yamagata		Japan	-	LED	III-V	1.20	150	1993.0	5,000	14,400	F
Sumitomo Metal Industries	Amagasaki-Shi	Hyogo	Japan	-	4Mb DRAM Arrays	-	0.80	150	1991.0	300	300	F
Texas Instruments	Hayami-Gun	Oita	Japan	Hiji 1	Logic Linear GaAs	Bipolar	1.00	125	1974.0	2,000	8,000	F
Texas Instruments	Inashiki-Gun	Ibaragi	Japan	Miho 5	ASSP ASIC MPU DSP CBIC	NMOS	1.00	125	1982.0	7,200	29,000	FT
Texas Instruments	Hatogaya-Shi	Saitama	Japan	Hato	Analog LCD Driver ASSP	-	1.00	125	1982.0	5,300	17,700	FT
Texas Instruments	Inashiki-Gun	Ibaragi	Japan	Miho 6	1Mb 4Mb DRAM ASSP MPU	-	0.80	150	1988.0	3,700	15,000	FT
Texas Instruments	Hayami-Gun	Oita	Japan	Hiji 8	Logic	-	0.80	150	1990.0	5,000	10,000	F
Tokin	Sendai-Shi	Miyagi	Japan	-	Power SIT	Bipolar	1.70	75	1984.0	3,500	10,000	F
Toko	Iruma-Gun	Saitama	Japan	-	-	NMOS	3.00	125	1990.0	5,200	15,000	F
Toko	Iruma-Gun	Saitama	Japan	-	A/D D/A Telecom Diode	Bipolar	3.50	125	1990.0	7,000	20,000	FT
Toshiba	Kawasaki-Shi	Kanagawa	Japan	Bldg.108 D-1	Pwr Tran Lin	-	2.00	125	1970.0	5,200	15,000	F
Toshiba	Kimitsu-Shi	Chiba	Japan	Phase 1 & 2	Diode Rectifier Thyristor	Bipolar	4.00	100	1970.0	15,400	44,000	FT
Toshiba	Himeji-Shi	Hyogo	Japan	No.2	Tran Diode FET	-	0.35	150	1982.0	10,500	30,000	FT
Toshiba	Kitakami-Shi	Iwate	Japan	Bldg.101, D-1	CCD ASIC MPU MCU MROM	PCMOS	0.60	125	1984.0	10,000	40,000	FT
Toshiba	Kita Kyushu-Shi	Fukuoka	Japan	Kubik 1	Bipolar Analog Opto	-	1.50	100	1986.0	12,600	45,000	F
Toshiba	Kitakami-Shi	Iwate	Japan	Bldg.101, D-2	CCD ASIC MPU MCU MROM	PCMOS	0.60	125	1986.0	14,000	40,000	F
Toshiba	Oita-Shi	Oita	Japan	C-Cubed 1	MCU Logic	-	0.60	125	1986.0	8,200	33,000	F
Toshiba	Oita-Shi	Oita	Japan	C-Cubed 2	MCU Logic	PCMOS	0.60	125	1987.0	8,000	32,000	F
Toshiba	Kita Kyushu-Shi	Fukuoka	Japan	Kubik 2	Bipolar Analog	-	1.20	125	1988.0	9,000	20,000	FN
Toshiba	Kitakami-Shi	Iwate	Japan	Bldg.102, D-3	ASIC	PCMOS	0.60	150	1989.0	3,700	15,000	F
Toshiba	Oita-Shi	Oita	Japan	C-Cubed 3	MCU Logic SRAM Flash	PCMOS	0.40	150	1989.0	8,000	32,000	F
Toshiba	Himeji-Shi	Hyogo	Japan	No.1	Pwr FET Tran Diode	-	2.00	125	1990.0	15,700	45,000	FT
Toshiba	Kawasaki-Shi	Kanagawa	Japan	Bldg.108 D-2	16Mb 64Mb DRAM Flash MPU Logic	PCMOS	0.35	200	1990.0	600	1,300	F
Toshiba	Kitakami-Shi	Iwate	Japan	Bldg.102, D-4	EPROM MROM MPU ASIC	PCMOS	0.40	150	1991.0	3,700	15,000	F
Toshiba	Oita-Shi	Oita	Japan	C-Cubed 4	Embedded DRAM Flash	PCMOS	0.25	200	1991.0	20,000	40,000	F
Toshiba	Nomi-Gun	Ishikawa	Japan	-	Pwr Tran	Bipolar	2.00	125	1992.0	10,500	30,000	FT
Toshiba	Kita Kyushu-Shi	Fukuoka	Japan	Kubik 3	Analog	-	0.60	150	1993.0	9,000	30,000	F
Toshiba	Kitakami-Shi	Iwate	Japan	Bldg.106, D-5	EPROM MROM MPU ASIC	-	0.40	150	1993.0	6,000	24,000	F
Toshiba	Yokkaichi-Shi	Mie	Japan	Y-Cubed, No. 1-Mod 1	SRAM Flash	PCMOS	0.45	200	1993.0	5,000	10,000	F
Toshiba	Yokkaichi-Shi	Mie	Japan	Y-Cubed, No. 1-Mod 2	SRAM Flash	PCMOS	0.20	200	1994.0	10,000	25,000	F

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Table 2-1 (Continued)
Japan's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Toshiba	Yokkaichi-Shi	Mie	Japan	Y-Cubed, No. 2	64Mb 128Mb 256Mb DRAM	PCMOS	0.18	200	1996.3	14,000	28,000	F
Toshiba	Oita-Shi	Oita	Japan	C-Cubed 5	Embedded DRAM MCU MPR Logic	-	0.25	200	1997.4	12,500	25,000	F
Toshiba-Motorola (Tohoku)	Sendai-Shi	Miyagi	Japan	Tohoku Step 1	ASIC MPU MCU	PCMOS	0.80	150	1988.0	1,800	7,500	FT
Toshiba-Motorola (Tohoku)	Sendai-Shi	Miyagi	Japan	Tohoku Step 1	ASIC MPU MCU	PCMOS	0.80	150	1988.0	1,800	7,500	FT
Toshiba-Motorola (Tohoku)	Sendai-Shi	Miyagi	Japan	Tohoku Step 2	ASIC MPU MCU	-	0.60	150	1991.0	2,500	10,000	F
Toshiba-Motorola (Tohoku)	Sendai-Shi	Miyagi	Japan	Tohoku Step 2	ASIC MPU MCU	-	0.60	150	1991.0	2,500	10,000	F
Toshiba-Motorola (Tohoku)	Sendai-Shi	Miyagi	Japan	Tohoku Step 3	ASIC MPU MCU	PCMOS	0.35	200	1995.2	7,500	15,000	F
Toshiba-Motorola (Tohoku)	Sendai-Shi	Miyagi	Japan	Tohoku Step 3	ASIC MPU MCU	PCMOS	0.35	200	1995.2	7,500	15,000	F
Toyoda Group	Kariya-Shi	Aichi	Japan	Higashi Kariya	ASIC	PCMOS	0.80	125	1990.0	4,400	17,800	F
Toyoda Group	Obu-Shi	Aichi	Japan	Kyowa	Power Tran	Bipolar	2.20	100	1990.2	6,100	17,600	FT
Toyoda Group	Inazawa-Shi	Aichi	Japan	Technology Center	LED	III-V	25.00	51	1993.0	11,600	33,200	F
Toyota Motor	Toyota-Shi	Aichi	Japan	Me	MCU Pwr ICs Custom	-	2.00	125	1990.0	100	500	FT
UMC Group	Tateyama-Shi	Chiba	Japan	M3	16Mb DRAM	PCMOS	0.40	150	1990.0	10,000	20,000	FT
Unizon	Itami-Shi	Hyogo	Japan	-	Zener Diode Reg Arrays	Bipolar	1.20	125	1984.0	3,500	10,000	F
Yamaha	Toyooka-Mura	Shizuoka	Japan	Building 11	ASIC MPR	PCMOS	0.35	150	1990.10	5,000	6,000	FRVDPD
Yamaha	Aira-Gun	Kagoshima	Japan	Fab 2	ROM CBIC ASSP	PCMOS	0.50	150	1996.10	2,500	5,000	FTN
Yamaha	Hamamatsu-Shi	Shizuoka	Japan	Tenryu	ASIC ASSP	PCMOS	0.25	200	1998.6	1,700	7,000	F
Yokogawa Imt	Kamiina-Gun	Nagano	Japan	-	Tran Diode Opto Analog	-	3.00	100	1988.0	2,400	7,000	FT

Source: Dataquest (December 1998)

Table 2-2
Japan's Future Pilot and Production Fab Lines (Including Fabs Beginning Operation during 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Fuji Electric	Matsumoto-Shi	Nagano	Japan	IGBT Power MOSFET	-	-	1.60	200	1998.3	6,600	19,100	F
Fujitsu	Kuwana-Gun	Mie	Japan	R&D	No. 2	PCMOS	0.18	150	1998.0	2,500	10,000	F
Fujitsu	Aizu Wakamatsu-Shi	Pukushima	Japan	Logic Memory	Bldg. No. 3-1 300mm		0.18	300	2001.0	7,500	15,000	F
Fujitsu-Advanced Micro Devices (FASL)	Aizu Wakamatsu-Shi	Fukushima	Japan	16Mb 64Mb Flash	Fab 2	PCMOS	0.23	200	1998.2	5,000	25,000	F
Fujitsu-Advanced Micro Devices (FASL)	Aizu Wakamatsu-Shi	Fukushima	Japan	16Mb Flash	Fab 2 Phase 2	PCMOS	0.25	200	1999.0	4,300	12,500	F
Hitachi	Hitachinaka-Shi	Ibaraki	Japan	64Mb 256Mb DRAM	N3-2F	-	0.18	200	2000.0	5,000	30,000	F
Kawasaki Steel	Utsunomiya-Shi	Tochigi	Japan	SOC ASICs for Telecom and Consumer Electronics	Phase 2	PCMOS	0.18	150	2001.0	1,000	4,000	F
Kawasaki Steel	Utsunomiya-Shi	Tochigi	Japan	SOC ASICs for Telecom and Consumer Electronics	-	PCMOS	0.18	150	2001.0	1,000	4,000	F
Matsushita	Arai-Shi	Niigata	Japan	Memory Logic	-	-	0.18	200	2001.0	3,000	5,000	F
NEC	Sagamihara-Shi	Kanagawa	Japan	-	UC	-	0.18	200	2000.0	1,700	5,000	F
Rohm	-	-	Japan	16Mb ROM ASIC MCU Telecom ICs	Fab Line 2	-	0.25	200	1999.3	-	-	FTR
SANYO	Ojiya-Shi	Niigata	Japan	Flash MCU	C1	-	0.35	200	1998.0	10,000	15,000	FTN
Yamaha	Hamamatsu-Shi	Shizuoka	Japan	ASIC ASSP	Tenryu	PCMOS	0.25	200	1998.6	1,700	7,000	F

Source: Dataquest (December 1998)

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Japanese Electronic Equipment Production Forecast, Fall 1998

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Chapter 1

Japanese Electronic Equipment Production Forecast

Introduction

Electronic equipment production is an important determinant of semiconductor market activity. This is true because semiconductor demand is derived, in part, from the underlying demand for the systems that use semiconductors. That is, the demand for semiconductors is a positive (or increasing) function of the demand for electronic systems. Therefore, forecasting electronic systems production is an essential component of assessing expected semiconductor market activity.

This document contains tables detailing the fall 1998 electronic equipment production forecast. Japanese production is estimated for the years 1992 to 2002. Production tables contain both historical data and forecasts. In most tables, historical data begins with 1992 and ends with 1997, while forecast data provides estimates for 1998 through 2002. The tables detail the type of production data by application market.

Definitions and Conventions

The objective of analyzing electronic systems production activity is to estimate the important implications for semiconductor consumption. In this document, the value of production is estimated as factory revenue. Dataquest defines factory revenue as the exchange value of the commodity transaction between the original equipment manufacturer and the point of entry into distribution. In the case of a direct sale that involves no distribution, as is the case with military systems, factory revenue is equal to the final user cost, net of sales taxes.

Production is the value-adding process by which the factors of production (labor and capital) and material input are transformed into the goods and services that are desired for consumption and investment. As such, production can span both time and geography. For example, a Japanese color television company may minimize its cost of production by manufacturing its products (that is, consuming chips) in Asian countries. Dataquest would estimate this as Asia/Pacific production, because we are interested in that portion of the production process that relates specifically to semiconductor consumption.

Electronic equipment is divided into the following six semiconductor application markets and is further divided into the designated segments:

- Data processing
  - Computers
  - Data storage
  - Input/output
  - Dedicated systems
  - Other data processing

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- Communications
  - Premise telecom
  - Public telecom
  - Mobile and radio equipment
  - Broadcast and studio
  - Other communications
- Industrial
  - Security/energy management
  - Manufacturing systems/instrumentation
  - Medical equipment
  - Other industrial
- Consumer
  - Audio
  - Video
  - Personal electronics
  - Appliances
  - Other consumer
- Military/civil aerospace
- Transportation

Data Sources

The historical information presented in the production data has been consolidated from a variety of sources, each of which focuses on a specific part of the market. These sources include the following:

- Japanese production statistics compiled and published by the Ministry of International Trade and Industry (MITI)
- Estimates presented by knowledgeable and reliable industry spokespersons
- Published information on products and prices

Valuation of Production

Japanese production is expressed in Japanese yen and translated into U.S. dollars. To make the tables in this document useful in comparing different regions, it is necessary to express all values in a common currency, and Dataquest chose the U.S. dollar for convenience. However, the choice of the U.S. dollar or any other currency brings with it some problems that require the readers' careful consideration in interpreting the data.

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Exchange rates are an example of this. When forecasting electronic equipment production, it is important to ensure consistency and continuity. The preliminary 1998 exchange rate estimate is based on actual monthly exchange rates through July 1998, and we assume that the July rate applies for all the future months in 1998. For the years 1999 through 2002, we maintain exchange rates at constant 1999 calendar-year values. This prevents any inconsistencies in the conversion of growth projections and currency fluctuations. The estimates in this Market Statistics report are generated primarily on a yen basis and then are converted to U.S. dollars.

Japanese Electronic Equipment Production Definitions

Data Processing Equipment

Defined as computers, data storage, input/output devices, dedicated systems, and other data processing, as follows:

- Computers include supercomputers, mainframe computers, midrange computers, entry-level servers, workstations, PCs, motherboards, and handheld computers.
- Data storage includes rigid disk drives, removable disk drives, optical disk drives, tape drives, and other data storage.
- Input/output includes all equipment that transfers data between the CPU and a peripheral device, such as printers, monitors, and other input/output devices.
- Dedicated systems include dedicated data processing systems such as copiers, personal organizers, chip cards, and other systems.
- Other data processing includes sound/audio, digital, and graphics accelerator boards. This category also includes the value of aftermarket sales of single in-line memory modules (SIMMs) and dual in-line memory modules (DIMMs).

Communications Equipment

Defined as premise telecom, public telecom, mobile and radio communications, broadcast and studio, and other communications, as follows:

- Premise telecom includes telecommunications equipment on private premises such as image and test communications equipment, data communications equipment (WAN/LAN and remote access), premise voice systems, and desktop terminals (telephones excluding mobile handsets).
- Public telecom includes key equipment involved in the public switching and transmission markets.
- Mobile and radio communications includes cellular/broadband personal communications services (PCS)/enhanced special mobile radio (ESMR) handsets, pagers, and mobile communications infrastructure, among others.
- Broadcast and studio includes audio, video, and other broadcast and studio equipment.
- Other communications includes other communications equipment not counted elsewhere, such as intercommunications systems.

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Industrial Equipment

Defined as security/energy management, manufacturing systems/instruments, medical equipment, and other industrial systems, as follows:

- Security and energy management includes alarm systems and energy management.
- Manufacturing systems/instrumentation includes semiconductor production equipment, control and process control equipment, control and processing display equipment, and robots. This category also includes automatic test equipment (ATE) semiconductor equipment, nuclear electronics, and other test and measurement equipment.
- Medical equipment includes diagnostic, therapeutic, patient monitoring and measuring systems, surgical support equipment, and irradiation equipment.
- Other industrial includes vending machines, automatic service equipment, commercial clothes-washing equipment, teaching machines and aids, particle accelerator electronic equipment, electron microscopes, and scientific equipment not counted elsewhere.

Consumer Equipment

Defined as audio, video, personal electronics, appliances, and other consumer equipment, as follows:

- Audio includes consumer audio equipment.
- Video includes consumer video equipment.
- Personal electronics includes video games, cameras, electronic watches, clocks, and toys.
- Appliances include consumer appliances.
- Other consumer includes automatic garage door openers, electronic tape measures, electronic tire gauges, and other consumer equipment not counted elsewhere.

Military/Civil Aerospace Equipment

Defined as radar/sonar/reconnaissance, missile/space, navigation, electronic warfare, aircraft flight systems, and command/control systems.

Transportation Equipment

Defined as entertainment, vehicle/body control, driver information, power train, and safety and convenience electronics.

Project Analyst: Motoya Ohgami

Chapter 2
Market Statistics Tables

Tables 2-1 through 2-24 contain statistics for Japanese electronic equipment production. Tables 2-1 through 2-6 contain historical data and forecasts for six semiconductor application markets divided into major segments. Tables 2-7 through 2-24 show more detailed forecasts for each application market.

Table 2-1
Japanese Electronic Equipment Production History (Factory Revenue in Billions of Yen)

Segment	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Data Processing							
Computers	2,248	2,026	2,100	2,523	3,450	3,781	11.0
Data Storage	1,302	1,181	1,177	873	859	1169	-2.1
Input/Output	1,577	1,409	1,491	1,520	1,549	1,989	4.7
Dedicated Systems	999	925	839	819	750	753	-5.5
Other Data Processing	82	104	146	179	250	163	14.7
Total	**6,207**	**5,645**	**5,753**	**5,913**	**6,858**	**7,855**	**4.8**
Communications							
Premise Telecommunications	952	899	844	806	869	1,008	1.2
Public Telecommunications	732	816	832	892	1,142	1,384	13.6
Mobile and Radio Equipment	908	880	976	991	1,612	2,039	17.6
Broadcast and Studio	100	78	90	70	92	84	-3.4
Other Communications	137	132	148	226	332	360	21.3
Total	**2,829**	**2,804**	**2,889**	**2,985**	**4,048**	**4,875**	**11.5**
Industrial							
Security/Energy Management	586	522	530	559	542	448	-5.2
Manufacturing Systems/Instrumentation	1,657	1,483	1,434	1,736	1,958	2,245	6.3
Medical Equipment	318	315	287	307	340	342	1.5
Other Industrial	629	629	698	741	808	868	6.7
Total	**3,190**	**2,949**	**2,948**	**3,343**	**3,648**	**3,903**	**4.1**
Consumer							
Audio	932	774	722	602	512	597	-8.5
Video	2,371	2,008	1,840	1,528	1,354	1,434	-9.6
Personal Electronics	1,445	1,280	1,263	1,281	1,315	1,332	-1.6
Appliances	1,699	1,495	1,615	1,753	1,758	1,605	-1.1
Other Consumer	940	920	927	970	978	969	0.6
Total	**7,387**	**6,477**	**6,366**	**6,134**	**5,916**	**5,936**	**-4.3**
Military/Civil Aerospace	**212**	**207**	**203**	**200**	**197**	**195**	**-1.7**
Transportation	**1,330**	**1,281**	**1,224**	**1,240**	**1,283**	**1,323**	**-0.1**
Total Electronics Industry	**21,155**	**19,363**	**19,382**	**19,815**	**21,950**	**24,088**	**2.6**

Source: Dataquest (November 1998)

Table 2-2
Japanese Electronic Equipment Production Forecast (Factory Revenue in Billions of Yen)

Segment	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Data Processing							
Computers	3,781	4,403	4,661	4,678	4,617	4,660	4.3
Data Storage	1,169	1,231	1,244	1,327	1,410	1,375	3.3
Input/Output	1,989	1,985	1,968	2,010	2,123	2,238	2.4
Dedicated Systems	753	699	786	886	1,024	1,174	9.3
Other Data Processing	163	145	165	189	233	289	12.1
Total	**7,855**	**8,462**	**8,824**	**9,090**	**9,408**	**9,736**	**4.4**
Communications							
Premise Telecommunications	1,008	1,033	1,107	1,183	1,242	1,323	5.6
Public Telecommunications	1,384	1,223	1,363	1,528	1,716	1,883	6.3
Mobile and Radio Equipment	2,039	1,924	1,873	1,958	2,064	2,209	1.6
Broadcast and Studio	84	82	93	107	126	144	11.4
Other Communications	360	298	331	378	421	458	4.9
Total	**4,875**	**4,559**	**4,766**	**5,154**	**5,569**	**6,017**	**4.3**
Industrial							
Security/Energy Management	448	420	468	524	597	654	7.9
Manufacturing Systems/Instrumentation	2,245	1,840	2,143	2,407	2,658	2,875	5.1
Medical Equipment	342	321	347	389	436	496	7.7
Other Industrial	868	735	863	1,021	1,155	1,271	7.9
Total	**3,903**	**3,316**	**3,821**	**4,341**	**4,846**	**5,296**	**6.3**
Consumer							
Audio	597	564	602	638	676	723	3.9
Video	1,434	1,584	1,544	1,465	1,356	1,265	-2.5
Personal Electronics	1,332	1,262	1,231	1,304	1,404	1,603	3.8
Appliances	1,605	1,408	1,554	1,758	1,913	2,008	4.6
Other Consumer	969	807	903	1,012	1,168	1,304	6.1
Total	**5,936**	**5,624**	**5,834**	**6,177**	**6,518**	**6,903**	**3.1**
Military/Civil Aerospace	**195**	**190**	**214**	**235**	**230**	**230**	**3.4**
Transportation	**1,323**	**1,428**	**1,608**	**1,792**	**1,999**	**2,173**	**10.4**
Total Electronics Industry	**24,088**	**23,580**	**25,067**	**26,789**	**28,569**	**30,355**	**4.7**

Source: Dataquest (November 1998)

Table 2-3
Japanese Electronic Equipment Production History
(Factory Revenue in Millions of Dollars)

Segment	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Data Processing							
Computers	17,775	18,223	20,625	26,868	31,710	31,225	11.9
Data Storage	10,295	10,623	11,562	9,293	7,893	9,650	-1.3
Input/Output	12,467	12,667	14,646	16,187	14,234	16,421	5.7
Dedicated Systems	7,900	8,317	8,241	8,722	6,895	6,217	-4.7
Other Data Processing	645	935	1,430	1,906	2,298	1,346	15.9
Total	**49,083**	**50,766**	**56,503**	**62,976**	**63,030**	**64,860**	**5.7**
Communications							
Premise Telecommunications	7,531	8,085	8,286	8,585	7,986	8,326	2.0
Public Telecommunications	5,786	7,335	8,168	9,499	10,497	11,431	14.6
Mobile and Radio Equipment	7,183	7,914	9,583	10,558	14,819	16,834	18.6
Broadcast and Studio	788	699	888	743	847	694	-2.5
Other Communications	1,087	1,183	1,454	2,403	3,052	2,973	22.3
Total	**22,375**	**25,215**	**28,378**	**31,789**	**37,202**	**40,257**	**12.5**
Industrial							
Security/Energy Management	4,636	4,697	5,205	5,952	4,982	3,699	-4.4
Manufacturing Systems/ Instrumentation	13,106	13,337	14,080	18,491	17,993	18,539	7.2
Medical Equipment	2,515	2,831	2,814	3,265	3,122	2,827	2.4
Other Industrial	4,972	5,652	6,860	7,889	7,426	7,168	7.6
Total	**25,229**	**26,517**	**28,959**	**35,597**	**33,523**	**32,233**	**5.0**
Consumer							
Audio	7,373	6,959	7,087	6,409	4,702	4,929	-7.7
Video	18,754	18,060	18,072	16,270	12,440	11,839	-8.8
Personal Electronics	11,426	11,514	12,403	13,647	12,088	10,999	-0.8
Appliances	13,437	13,444	15,863	18,670	16,156	13,254	-0.3
Other Consumer	7,431	8,271	9,101	10,332	8,984	8,002	1.5
Total	**58,420**	**58,248**	**62,526**	**65,328**	**54,369**	**49,022**	**-3.4**
Military/Civil Aerospace	**1,675**	**1,865**	**1,992**	**2,126**	**1,814**	**1,610**	**-0.8**
Transportation	**10,516**	**11,519**	**12,018**	**13,204**	**11,795**	**10,925**	**0.8**
Total Electronics Industry	**167,297**	**174,130**	**190,377**	**211,020**	**201,735**	**198,907**	**3.5**
Exchange Rate (Yen/U.S.$)	126.45	111.20	101.81	93.90	108.81	121.10	-

Source: Dataquest (November 1998)

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Table 2-4
Japanese Electronic Equipment Production Forecast
(Factory Revenue in Millions of Dollars)

Segment	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Data Processing							
Computers	31,225	32,293	33,107	33,223	32,793	33,097	1.2
Data Storage	9,650	9,026	8,833	9,429	10,016	9,764	0.2
Input/Output	16,421	14,555	13,978	14,274	15,081	15,899	-0.6
Dedicated Systems	6,217	5,127	5,583	6,293	7,273	8,339	6.0
Other Data Processing	1,346	1,063	1,172	1,342	1,655	2,053	8.8
Total	**64,860**	**62,064**	**62,672**	**64,561**	**66,819**	**69,151**	**1.3**
Communications							
Premise Telecommunications	8,326	7,574	7,861	8,400	8,821	9,396	2.4
Public Telecommunications	11,431	8,973	9,679	10,853	12,189	13,374	3.2
Mobile and Radio Equipment	16,834	14,107	13,303	13,910	14,663	15,691	-1.4
Broadcast and Studio	694	601	661	760	895	1,023	8.1
Other Communications	2,973	2,184	2,351	2,685	2,990	3,253	1.8
Total	**40,257**	**33,440**	**33,855**	**36,608**	**39,558**	**42,737**	**1.2**
Industrial							
Security/Energy Management	3,699	3,080	3,324	3,722	4,240	4,645	4.7
Manufacturing Systems/ Instrumentation	18,539	13,495	15,221	17,096	18,879	20,420	2.0
Medical Equipment	2,827	2,354	2,465	2,763	3,097	3,523	4.5
Other Industrial	7,168	5,391	6,130	7,252	8,204	9,028	4.7
Total	**32,233**	**24,320**	**27,140**	**30,833**	**34,420**	**37,616**	**3.1**
Consumer							
Audio	4,929	4,133	4,275	4,531	4,804	5,138	0.8
Video	11,839	11,615	10,968	10,407	9,633	8,982	-5.4
Personal Electronics	10,999	9,256	8,745	9,264	9,972	11,388	0.7
Appliances	13,254	10,326	11,038	12,487	13,588	14,262	1.5
Other Consumer	8,002	5,919	6,414	7,188	8,296	9,262	3.0
Total	**49,022**	**41,249**	**41,440**	**43,876**	**46,292**	**49,032**	**0**
Military/Civil Aerospace	**1,610**	**1,393**	**1,520**	**1,669**	**1,634**	**1,634**	**0.3**
Transportation	**10,925**	**10,474**	**11,419**	**12,726**	**14,198**	**15,434**	**7.2**
Total Electronics Industry	**198,907**	**172,940**	**178,045**	**190,273**	**202,921**	**215,605**	**1.6**
Exchange Rate (Yen/U.S.$)	121.10	136.35	140.79	140.79	140.79	140.79	-

Source: Dataquest (November 1998)

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Table 2-5
Japanese Electronic Equipment Production History
(Yen-Based Annual Growth; Percent)

Segment	1992	1993	1994	1995	1996	1997
Data Processing						
Computers	-11.6	-9.8	3.6	20.1	36.8	9.6
Data Storage	-4.7	-9.3	-0.4	-25.9	-1.6	36.1
Input/Output	-13.0	-10.7	5.9	1.9	1.9	28.4
Dedicated Systems	-7.0	-7.4	-9.3	-2.4	-8.4	0.4
Other Data Processing	22.2	27.5	40.0	22.9	39.7	-34.8
Total	**-9.6**	**-9.0**	**1.9**	**2.8**	**16.0**	**14.5**
Communications						
Premise Telecommunications	-9.5	-5.6	-6.2	-4.4	7.8	16.0
Public Telecommunications	-11.4	11.5	2.0	7.3	28.0	21.2
Mobile and Radio Equipment	-3.3	-3.1	10.9	1.6	62.7	26.4
Broadcast and Studio	0.6	-22.0	16.3	-22.8	31.4	-8.7
Other Communications	-28.3	-4.3	12.5	52.4	46.9	8.4
Total	**-9.0**	**-0.9**	**3.0**	**3.3**	**35.6**	**20.4**
Industrial						
Security/Energy Management	-10.9	-10.9	1.5	5.5	-3.0	-17.3
Manufacturing Systems/Instrumentation	-25.1	-10.5	-3.3	21.1	12.8	14.7
Medical Equipment	-2.5	-1.0	-9.0	7.0	10.7	0.6
Other Industrial	-13.7	0	11.1	6.1	9.0	7.4
Total	**-18.7**	**-7.6**	**0**	**13.4**	**9.1**	**7.0**
Consumer						
Audio	-17.1	-17.0	-6.8	-16.6	-15.0	16.6
Video	-22.1	-15.3	-8.4	-17.0	-11.4	5.9
Personal Electronics	-4.0	-11.4	-1.4	1.5	2.7	1.3
Appliances	-14.0	-12.0	8.0	8.6	0.3	-8.7
Other Consumer	-10.3	-2.1	0.8	4.7	0.8	-0.9
Total	**-15.1**	**-12.3**	**-1.7**	**-3.6**	**-3.6**	**0.4**
Military/Civil Aerospace	**-2.1**	**-2.1**	**-2.2**	**-1.6**	**-1.5**	**-1.0**
Transportation	**-2.7**	**-3.7**	**-4.5**	**1.3**	**3.5**	**3.1**
Total Electronics Industry	**-12.5**	**-8.5**	**0.1**	**2.2**	**10.8**	**9.7**

Source: Dataquest (November 1998)

Table 2-6
Japanese Electronic Equipment Production Forecast
(Yen-Based Annual Growth; Percent)

Segment	1997	1998	1999	2000	2001	2002
Data Processing						
Computers	9.6	16.4	5.9	0.4	-1.3	0.9
Data Storage	36.1	5.3	1.0	6.7	6.2	-2.5
Input/Output	28.4	-0.2	-0.8	2.1	5.7	5.4
Dedicated Systems	0.4	-7.2	12.4	12.7	15.6	14.6
Other Data Processing	-34.8	-11.0	13.8	14.5	23.3	24.0
Total	**14.5**	7.7	**4.3**	**3.0**	**3.5**	**3.5**
Communications						
Premise Telecommunications	16.0	2.4	7.2	6.9	5.0	6.5
Public Telecommunications	21.2	-11.6	11.4	12.1	12.3	9.7
Mobile and Radio Equipment	26.4	-5.6	-2.6	4.6	5.4	7.0
Broadcast and Studio	-8.7	-2.4	13.4	15.1	17.8	14.3
Other Communications	8.4	-17.3	11.1	14.2	11.4	8.8
Total	**20.4**	**-6.5**	**4.5**	**8.1**	**8.1**	**8.0**
Industrial						
Security/Energy Management	-17.3	-6.3	11.4	12.0	13.9	9.5
Manufacturing Systems/Instrumentation	14.7	-18.0	16.5	12.3	10.4	8.2
Medical Equipment	0.6	-6.2	8.1	12.1	12.1	13.8
Other Industrial	7.4	-15.3	17.4	18.3	13.1	10.0
Total	**7.0**	**-15.0**	**15.2**	**13.6**	**11.6**	**9.3**
Consumer						
Audio	16.6	-5.6	6.8	6.0	6.0	7.0
Video	5.9	10.5	-2.5	-5.1	-7.4	-6.8
Personal Electronics	1.3	-5.2	-2.4	5.9	7.6	14.2
Appliances	-8.7	-12.3	10.4	13.1	8.8	5.0
Other Consumer	-0.9	-16.7	11.9	12.1	15.4	11.6
Total	**0.4**	**-5.3**	3.7	**5.9**	**5.5**	**5.9**
Military/Civil Aerospace	**-1.0**	**-2.6**	**12.6**	**9.8**	**-2.1**	**0**
Transportation	**3.1**	**7.9**	**12.6**	**11.4**	**11.6**	**8.7**
Total Electronics Industry	**9.7**	**-2.1**	**6.3**	**6.9**	**6.6**	**6.3**

Source: Dataquest (November 1998)

Table 2-7
Japanese Electronic Equipment Production Forecast—Data Processing (Factory Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Computers							
Mainframe/Supercomputers	846	968	1,032	929	786	651	-5.1
Midrange Computers	284	341	367	392	410	423	8.3
Workstations	192	202	196	193	189	180	-1.3
PCs	2,323	2,742	2,907	2,993	3,059	3,227	6.8
Motherboards	137	150	158	170	172	179	5.4
Total	**3,781**	**4,403**	**4,661**	**4,678**	**4,617**	**4,660**	**4.3**
Data Storage							
Rigid Disk Drives	705	684	665	661	668	613	-2.8
Optical Disk Drives	268	265	234	237	244	249	-1.5
Removable Magnetic Storage	195	281	345	430	498	513	21.3
Total	**1,169**	**1,231**	**1,244**	**1,327**	**1,410**	**1,375**	**3.3**
Input/Output							
Page Printers	284	308	329	334	356	373	5.6
Serial Printers	515	542	478	420	375	345	-7.7
Monitors	487	481	441	439	435	434	-2.3
Other Input/Output	703	653	720	817	957	1,086	9.1
Total	**1,989**	**1,985**	**1,968**	**2,010**	**2,123**	**2,238**	**2.4**
Dedicated Systems	**753**	**699**	**786**	**886**	**1,024**	**1,174**	**9.3**
Other Data Processing	**163**	**145**	**165**	**189**	**233**	**289**	**12.1**
Data Processing Total	**7,855**	**8,462**	**8,824**	**9,090**	**9,408**	**9,736**	**4.4**

Source: Dataquest (November 1998)

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Table 2-8
Japanese Electronic Equipment Production Forecast—Data Processing (Factory Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Computers							
Mainframe/Supercomputers	6,986	7,100	7,332	6,601	5,580	4,625	-7.9
Midrange Computers	2,345	2,505	2,608	2,783	2,915	3,003	5.1
Workstations	1,582	1,480	1,393	1,374	1,346	1,278	-4.2
PCs	19,179	20,110	20,648	21,261	21,728	22,922	3.6
Motherboards	1,133	1,098	1,125	1,205	1,225	1,269	2.3
Total	**31,225**	**32,293**	**33,107**	**33,223**	**32,793**	**33,097**	**1.2**
Data Storage							
Rigid Disk Drives	5,825	5,015	4,721	4,692	4,743	4,355	-5.7
Optical Disk Drives	2,214	1,947	1,659	1,685	1,735	1,768	-4.4
Removable Magnetic Storage	1,611	2,064	2,453	3,052	3,538	3,641	17.7
Total	**9,650**	**9,026**	**8,833**	**9,429**	**10,016**	**9,764**	**0.2**
Input/Output							
Page Printers	2,342	2,262	2,334	2,370	2,529	2,651	2.5
Serial Printers	4,251	3,974	3,398	2,980	2,663	2,452	-10.4
Monitors	4,023	3,530	3,131	3,120	3,092	3,082	-5.2
Other Input/Output	5,805	4,789	5,114	5,803	6,797	7,714	5.8
Total	**16,421**	**14,555**	**13,978**	**14,274**	**15,081**	**15,899**	**-0.6**
Dedicated Systems	**6,217**	**5,127**	**5,583**	**6,293**	**7,273**	**8,339**	**6.0**
Other Data Processing	**1,346**	**1,063**	**1,172**	**1,342**	**1,655**	**2,053**	**8.8**
Data Processing Total	**64,860**	**62,064**	**62,672**	**64,561**	**66,819**	**69,151**	**1.3**
Exchange Rate (Yen/U.S.$)	121.10	136.35	140.79	140.79	140.79	140.79	-

Source: Dataquest (November 1998)

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Table 2-9
Japanese Electronic Equipment Production Forecast—Data Processing (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Computers						
Mainframe/Supercomputers	12.3	14.4	6.6	-10.0	-15.5	-17.1
Midrange Computers	0.9	20.2	7.5	6.7	4.8	3.0
Workstations	-3.5	5.3	-2.8	-1.4	-2.0	-5.1
PCs	11.3	18.1	6.0	3.0	2.2	5.5
Motherboards	6.1	9.2	5.8	7.1	1.6	3.7
Total	**14.5**	**7.7**	**4.3**	**3.0**	**3.5**	**3.5**
Data Storage						
Rigid Disk Drives	16.8	-3.1	-2.8	-0.6	1.1	-8.2
Optical Disk Drives	81.7	-1.0	-12.0	1.6	3.0	1.9
Removable Magnetic Storage	81.7	44.2	22.7	24.5	15.9	2.9
Total	**36.1**	**5.3**	**1.0**	**6.7**	**6.2**	**-2.5**
Input/Output						
Page Printers	2.1	8.8	6.5	1.5	6.7	4.8
Serial Printers	84.4	5.3	-11.7	-12.3	-10.6	-7.9
Monitors	22.2	-1.2	-8.4	-0.3	-0.9	-0.3
Other Input/Output	18.5	-7.1	10.3	13.5	17.1	13.5
Total	**28.4**	**-0.2**	**-0.8**	**2.1**	**5.7**	**5.4**
Dedicated Systems	**0.4**	**-7.2**	**12.4**	**12.7**	**15.6**	**14.6**
Other Data Processing	**-34.8**	**-11.0**	**13.8**	**14.5**	**23.3**	**24.0**
Data Processing Total	**14.5**	**7.7**	**4.3**	**3.0**	**3.5**	**3.5**

Source: Dataquest (November 1998)

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Table 2-10
Japanese Electronic Equipment Production Forecast—Communications (Factory Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Premise Telecommunications							
LAN Cards	34	61	72	82	74	79	18.3
Premise Line Cards	35	42	43	45	45	46	5.8
Answering Machines	6	6	6	6	6	6	1.3
Fax	310	327	354	360	361	366	3.4
Modems	5	5	4	4	4	4	-4.6
Corded Telephones	31	31	28	26	23	21	-7.4
Analog Cordless	58	67	61	56	52	46	-4.5
Digital Cordless	49	42	42	42	41	41	-3.3
Other Premise Telecom	481	451	495	561	637	713	8.2
Total	**1,008**	**1,033**	**1,107**	**1,183**	**1,242**	**1,323**	**5.6**
Public Telecommunications							
Central Office Line Cards	60	68	74	77	82	84	6.8
Other Public Telecom	1,324	1,155	1,289	1,451	1,634	1,799	6.3
Total	**1,384**	**1,223**	**1,363**	**1,528**	**1,716**	**1,883**	**6.3**
Mobile and Radio Equipment							
Analog Cellular	32	-	-	-	-	-	-100.0
Digital Cellular	865	612	477	431	364	343	-16.9
Pagers	57	50	41	36	30	28	-13.5
Mobile Communications Infrastructure	849	1,004	1,104	1,248	1,435	1,607	13.6
Other Mobile Communications	235	258	251	244	236	231	-0.3
Total	**2,039**	**1,924**	**1,873**	**1,958**	**2,064**	**2,209**	**1.6**
Broadcast and Studio	**84**	**82**	**93**	**107**	**126**	**144**	**11.4**
Other Communications Equipment	**360**	**297.8**	**331**	**378**	**421**	**458**	**4.9**
Communications Total	**4,875**	**4,559**	**4,766**	**5,154**	**5,569**	**6,017**	**4.3**

Source: Dataquest (November 1998)

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Table 2-11
Japanese Electronic Equipment Production Forecast—Communications (Factory Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Premise Telecommunications							
LAN Cards	282	447	513	585	522	563	14.8
Premise Line Cards	288	310	306	321	320	329	2.7
Answering Machines	49	46	42	41	43	45	-1.7
Fax	2,559	2,395	2,518	2,558	2,563	2,599	0.3
Modems	39	34	30	29	28	26	-7.5
Corded Telephones	255	230	202	184	165	149	-10.2
Analog Cordless	480	494	437	398	367	328	-7.3
Digital Cordless	402	309	298	299	289	292	-6.2
Other Premise Telecom	3,972	3,308	3,516	3,985	4,524	5,064	5.0
Total	**8,326**	**7,574**	**7,861**	**8,400**	**8,821**	**9,396**	**2.4**
Public Telecommunications							
Central Office Line Cards	498	502	524	547	583	596	3.7
Other Public Telecom	10,933	8,471	9,155	10,306	11,606	12,778	3.2
Total	**11,431**	**8,973**	**9,679**	**10,853**	**12,189**	**13,374**	**3.2**
Mobile and Radio Equipment							
Analog Cellular	267	-	-	-	-	-	-100.0
Digital Cellular	7,144	4,485	3,386	3,059	2,582	2,437	-19.4
Pagers	472	366	294	254	213	196	-16.1
Mobile Communications Infrastructure	7,012	7,363	7,844	8,863	10,193	11,416	10.2
Other Mobile Communications	1,939	1,893	1,780	1,733	1,675	1,642	-3.3
Total	**16,834**	**14,107**	**13,303**	**13,910**	**14,663**	**15,691**	**-1.4**
Broadcast and Studio	**694**	**601**	**661**	**760**	**895**	**1,023**	**8.1**
Other Communications Equipment	**2,973**	**2,184**	**2,351**	**2,685**	**2,990**	**3,253**	**1.8**
Communications Total	**40,257**	**33,440**	**33,855**	**36,608**	**39,558**	**42,737**	**1.2**
Exchange Rate (Yen/U.S.$)	121.10	136.35	140.79	140.79	140.79	140.79	-

Source: Dataquest (November 1998)

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Table 2-12
Japanese Electronic Equipment Production Forecast—Communications (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Premise Telecommunications						
LAN Cards	115.1	78.6	18.5	14.0	-10.8	7.8
Premise Line Cards	16.7	21.3	1.8	5.0	-0.2	2.7
Answering Machines	6.9	6.5	-6.8	-1.3	4.4	4.6
Fax	9.1	5.4	8.5	1.6	0.2	1.4
Modems	-6.1	-0.8	-9.3	-3.0	-5.3	-4.5
Corded Telephones	-16.8	1.4	-9.0	-9.2	-10.4	-9.4
Analog Cordless	21.2	15.9	-8.8	-8.7	-7.9	-10.6
Digital Cordless	-32.9	-13.4	-0.4	0.2	-3.3	1.1
Other Premise Telecom	29.6	-6.2	9.8	13.3	13.5	11.9
Total	**16.0**	**2.4**	**7.2**	**6.9**	**5.0**	**6.5**
Public Telecommunications						
Central Office Line Cards	19.9	13.5	7.8	4.3	6.6	2.3
Other Public Telecom	21.3	-12.8	11.6	12.6	12.6	10.1
Total	**21.2**	**-11.6**	**11.4**	**12.1**	**12.3**	**9.7**
Mobile and Radio Equipment						
Analog Cellular	-77.5	-100.0	-	-	-	-
Digital Cellular	41.0	-29.3	-22.1	-9.6	-15.6	-5.6
Pagers	-10.7	-12.7	-17.2	-13.6	-16.2	-7.8
Mobile Communications Infrastructure	48.7	18.2	10.0	13.0	15.0	12.0
Other Mobile Communications	6.8	9.9	-2.9	-2.6	-3.3	-2.0
Total	**26.4**	**-5.6**	**-2.6**	**4.6**	**5.4**	**7.0**
Broadcast and Studio	**-8.9**	**-2.4**	**13.4**	**15.1**	**17.8**	**14.3**
Other Communications Equipment	**8.4**	**-17.3**	**11.1**	**14.2**	**11.4**	**8.8**
Communications Total	**20.4**	**-6.5**	**4.5**	**8.1**	**8.1**	**8.0**

Source: Dataquest (November 1998)

Table 2-13
Japanese Electronic Equipment Production Forecast—Industrial (Factory Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Security/Energy Management	448	420	468	524	597	654	7.9
Manufacturing Systems/Instrumentation	2,245	1,840	2,143	2,407	2,658	2,875	5.1
Medical Equipment	342	321	347	389	436	496	7.7
Other Industrial Equipment	868	735	863	1,021	1,155	1,271	7.9
Industrial Total	**3,903**	**3,316**	**3,821**	**4,341**	**4,846**	**5,296**	**6.3**

Source: Dataquest (November 1998)

Table 2-14
Japanese Electronic Equipment Production Forecast—Industrial (Factory Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Security/Energy Management	3,699	3,080	3,324	3,722	4,240	4,645	4.7
Manufacturing Systems/Instrumentation	18,539	13,495	15,221	17,096	18,879	20,420	2.0
Medical Equipment	2,827	2,354	2,465	2,763	3,097	3,523	4.5
Other Industrial Equipment	7,168	5,391	6,130	7,252	8,204	9,028	4.7
Industrial Total	**32,233**	**24,320**	**27,140**	**30,833**	**34,420**	**37,616**	**3.1**
Exchange Rate (Yen/U.S.$)	121.10	136.35	140.79	140.79	140.79	140.79	-

Source: Dataquest (November 1998)

Table 2-15
Japanese Electronic Equipment Production Forecast—Industrial (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Security/Energy Management	-17.4	-6.3	11.4	12.0	13.9	9.5
Manufacturing Systems/Instrumentation	14.7	-18.0	16.5	12.3	10.4	8.2
Medical Equipment	0.8	-6.2	8.1	12.1	12.1	13.8
Other Industrial Equipment	7.4	-15.3	17.4	18.3	13.1	10.0
Industrial Total	**7.0**	**-15.0**	**15.2**	**13.6**	**11.6**	**9.3**

Source: Dataquest (November 1998)

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Table 2-16
Japanese Electronic Equipment Production Forecast—Consumer (Factory Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Audio							
Personal/Portable Stereos	144	155	146	140	131	127	-2.4
Other Audio	453	409	456	498	545	596	5.6
Total	**597**	**564**	**602**	**638**	**676**	**723**	**3.9**
Video							
Color TVs	469	496	505	479	442	412	-2.5
VCRs	254	265	247	240	225	212	-3.6
Analog Camcorders	434	387	308	232	142	82	-28.3
Digital Camcorders	233	391	428	434	456	460	14.5
DVDs	8	17	24	41	47	52	44.3
Analog Set-Top Boxes	3	3	2	2	2	2	-12.1
Digital Set-Top Boxes	32	26	30	37	41	44	6.9
Total	**1,434**	**1,584**	**1,544**	**1,465**	**1,356**	**1,265**	**-2.5**
Personal Electronics							
Digital Still Cameras	55	97	114	116	114	118	16.5
Video Game Controllers	351	279	158	133	125	186	-11.9
Other Personal Electronics	926	887	959	1,055	1,165	1,299	7.0
Total	**1,332**	**1,262**	**1,231**	**1,304**	**1,404**	**1,603**	**3.8**
Appliances	**1,605**	**1,408**	**1,554**	**1,758**	**1,913**	**2,008**	**4.6**
Other Consumer Equipment	**969**	**807**	**903**	**1,012**	**1,168**	**1,304**	**6.1**
Consumer Total	**5,936**	**5,624**	**5,834**	**6,177**	**6,518**	**6,903**	**3.1**

Source: Dataquest (November 1998)

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Table 2-17
Japanese Electronic Equipment Production Forecast—Consumer
(Factory Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Audio							
Personal/Portable Stereos	1,188	1,133	1,036	994	933	905	-5.3
Other Audio	3,741	3,000	3,239	3,537	3,871	4,233	2.5
Total	**4,929**	**4,133**	**4,275**	**4,531**	**4,804**	**5,138**	**0.8**
Video							
Color TVs	3,870	3,635	3,584	3,402	3,142	2,930	-5.4
VCRs	2,098	1,943	1,755	1,701	1,599	1,505	-6.4
Analog Camcorders	3,587	2,835	2,189	1,649	1,011	584	-30.4
Digital Camcorders	1,927	2,866	3,041	3,085	3,240	3,265	11.1
DVDs	69	123	169	294	335	371	40.0
Analog Set-Top Boxes	26	21	17	14	12	12	-14.7
Digital Set-Top Boxes	262	192	212	261	295	314	3.7
Total	**11,839**	**11,615**	**10,968**	**10,407**	**9,633**	**8,982**	**-5.4**
Personal Electronics							
Digital Still Cameras	455	708	812	823	811	840	13.1
Video Game Controllers	2,898	2,043	1,122	948	885	1,321	-14.5
Other Personal Electronics	7,647	6,505	6,812	7,493	8,275	9,227	3.8
Total	**10,999**	**9,256**	**8,745**	**9,264**	**9,972**	**11,388**	**0.7**
Appliances	**13,254**	**10,326**	**11,038**	**12,487**	**13,588**	**14,262**	**1.5**
Other Consumer Equipment	**8,002**	**5,919**	**6,414**	**7,188**	**8,296**	**9,262**	**3.0**
Consumer Total	**49,022**	**41,249**	**41,440**	**43,876**	**46,292**	**49,032**	**0**
Exchange Rate (Yen/U.S.$)	121.10	136.35	140.79	140.79	140.79	140.79	-

Source: Dataquest (November 1998)

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Table 2-18
Japanese Electronic Equipment Production Forecast—Consumer (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Audio						
Personal/Portable Stereos	24.5	7.4	-5.6	-4.1	-6.1	-3.0
Other Audio	14.4	-9.7	11.5	9.2	9.4	9.4
Total	**16.7**	**-5.6**	**6.8**	**6.0**	**6.0**	**7.0**
Video						
Color TVs	-2.6	5.8	1.8	-5.1	-7.6	-6.8
VCRs	-2.3	4.2	-6.7	-3.1	-6.0	-5.9
Analog Camcorders	4.4	-11.0	-20.3	-24.7	-38.7	-42.2
Digital Camcorders	45.8	67.5	9.6	1.4	5.0	0.8
DVDs	130.3	101.0	41.6	73.9	14.0	10.9
Analog Set-Top Boxes	-11.2	-8.9	-16.1	-17.3	-13.3	-4.2
Digital Set-Top Boxes	9.3	-17.2	13.9	22.8	13.0	6.7
Total	**5.9**	**10.5**	**-2.5**	**-5.1**	**-7.4**	**-6.8**
Personal Electronics						
Digital Still Cameras	111.2	75.3	18.5	1.3	-1.4	3.5
Video Game Controllers	20.4	-20.6	-43.3	-15.5	-6.6	49.2
Other Personal Electronics	-7.2	-4.2	8.1	10.0	10.4	11.5
Total	**1.3**	**-5.2**	**-2.4**	**5.9**	**7.6**	**14.2**
Appliances	**-8.7**	**-12.3**	**10.4**	**13.1**	**8.8**	**5.0**
Other Consumer Equipment	**-0.9**	**-16.7**	**11.9**	**12.1**	**15.4**	**11.6**
Consumer Total	**0.4**	**-5.3**	**3.7**	**5.9**	**5.5**	**5.9**

Source: Dataquest (November 1998)

Table 2-19
Japanese Electronic Equipment Production Forecast—Military/Civil Aerospace (Factory Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Military/Civil Aerospace	195	190	214	235	230	230	3.4

Source: Dataquest (November 1998)

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Table 2-20
Japanese Electronic Equipment Production Forecast—Military/Civil Aerospace (Factory Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Military/Civil Aerospace	1,610	1,393	1,520	1,669	1,634	1,634	0.3
Exchange Rate (Yen/U.S.$)	121.10	136.35	140.79	140.79	140.79	140.79	-

Source: Dataquest (November 1998)

Table 2-21
Japanese Electronic Equipment Production Forecast—Military/Civil Aerospace (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Military/Civil Aerospace	-1.2	-2.6	12.6	9.8	-2.1	0

Source: Dataquest (November 1998)

Table 2-22
Japanese Electronic Equipment Production Forecast—Transportation (Factory Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Auto Stereo	215	229	222	228	223	212	-0.3
Auto ECU	221	268	289	301	309	311	7.1
Antilock Braking System	74	88	94	99	101	107	7.6
Airbags	50	63	65	67	69	70	7.0
Automotive Navigation Systems	156	205	336	442	573	672	33.9
Other Automotive	607	575	602	654	724	801	5.7
Transportation Total	**1,323**	**1,428**	**1,608**	**1,792**	**1,999**	**2,173**	**10.4**

Source: Dataquest (November 1998)

Table 2-23
Japanese Electronic Equipment Production Forecast—Transportation (Factory Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Auto Stereo	1,774	1,683	1,576	1,618	1,583	1,506	-3.2
Auto ECU	1,823	1,967	2,051	2,139	2,196	2,209	3.9
Antilock Braking System	614	642	664	702	719	763	4.4
Airbags	412	462	465	479	487	498	3.8
Automotive Navigation Systems	1,290	1,503	2,387	3,143	4,071	4,770	29.9
Other Automotive	5,012	4,217	4,276	4,645	5,142	5,689	2.6
Transportation Total	**10,925**	**10,474**	**11,419**	**12,726**	**14,198**	**15,434**	**7.2**
Exchange Rate (Yen/U.S.$)	121.10	136.35	140.79	140.79	140.79	140.79	-

Source: Dataquest (November 1998)

Table 2-24
Japanese Electronic Equipment Production Forecast—Transportation (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Auto Stereo	2.7	6.8	-3.3	2.7	-2.1	-4.9
Auto ECU	18.4	21.5	7.7	4.3	2.7	0.6
Antilock Braking System	34.9	17.8	6.7	5.8	2.3	6.1
Airbags	29.8	26.1	3.9	3.1	1.7	2.2
Automotive Navigation Systems	6.9	31.2	64	31.7	29.5	17.2
Other Automotive	-6.3	-5.3	4.7	8.6	10.7	10.6
Transportation Total	**3.1**	**7.9**	**12.6**	**11.4**	**11.6**	**8.7**

Source: Dataquest (November 1998)

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Japanese Semiconductor Consumption Forecast by Electronics Application, Fall 1998

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Preface

Dataquest's *Japanese Semiconductor Consumption Forecast by Electronics Application, Fall 1998* is a revised and reformatted version of our long-standing semiannual semiconductor consumption by electronics application market forecast. We have made several changes to this publication in an effort to make it more relevant and meaningful; we have also included a new category of information that shows unit production trends for selected systems. Major changes include:

- Categorization changes to secure consistency with electronic equipment production forecasts
- Addition of high-volume electronic equipment unit production forecast data for 40 major systems

Dataquest has directed its semiconductor applications research toward better understanding the dynamics of production and semiconductor use across individual electronic systems. We have developed forecast models capable of tracking production and estimating total semiconductor consumption for some 40 different individual electronic systems, shown in full scale for the first time in this report.

Project Analyst: Motoya Ohgami

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Chapter 1
Introduction and Discussion

Introduction

This document contains Dataquest's forecast of Japanese semiconductor consumption by electronics application, 1997 to 2002, based both on U.S. dollars and Japanese yen. It also contains our forecast of worldwide semiconductor consumption by broad categories over the same period. This is the second of two semiannual forecasts. This forecast reflects changes since this spring in Dataquest's view of semiconductor consumption by electronic equipment worldwide and in Japan. It incorporates changes suggested by Dataquest's recently updated forecasts of electronic equipment production and semiconductor shipments.

The tables in this document present data intended to answer the following questions:

- What is the estimated semiconductor consumption of various categories of electronic equipment?
- What is the estimated semiconductor consumption of the key individual electronic systems that make up these broad categories?

The estimates offered in this document are intended to provide very general answers to these questions. They are meant as a broad guide to semiconductor consumption by electronic equipment production in Japan. The most detailed information about estimated semiconductor consumption by individual electronic systems is available in the last chapter of this document.

The semiconductor consumption forecasts presented here complement Dataquest's recently updated forecasts of electronic equipment production and semiconductor shipments. Updated Japanese electronic equipment forecasts can be found in the Market Statistics report *Japanese Electronic Equipment Production Forecast, Fall 1998* (November 1998). Our updated semiconductor forecast is found in the Market Trends report *Worldwide Semiconductor Forecast ~~and Trends, Fall 1998~~* ~~(November~~ 1998). Additional regional and semiconductor device details for this forecast can also be requested through Dataquest's inquiry service.

The tables in this document are organized as follows:

- Tables 2-1 and 2-2 summarize the worldwide semiconductor consumption forecast and compare it to the worldwide semiconductor shipments forecast.
- Tables 2-3 and 2-4 summarize the Japanese semiconductor consumption forecast on a dollar basis and compare it to the Japanese semiconductor shipments forecast.
- Tables 2-5 to 2-12 detail Japanese semiconductor consumption by individual electronic system, grouped by equipment type, on a dollar basis.

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- Tables 2-13 and 2-14 summarize the Japanese semiconductor consumption forecast on a yen basis and compare it to the Japanese semiconductor shipments forecast.
- Tables 2-15 to 2-22 detail Japanese semiconductor consumption by individual electronic system, grouped by equipment type, on a yen basis.
- Tables 3-1 to 3-40 present unit production and semiconductor consumption forecasts in Japan for 40 major electronic systems.
- Figures 3-1 to 3-40 show Japan's share of the worldwide unit production for 40 major electronic systems for 1997 and 2002.

Segmentation of Semiconductor Applications

Dataquest forecasts semiconductor consumption by end-use electronic application. We divide electronic applications into six broad groups in accordance with our segmentation of electronic equipment production. These groups are, in turn, disaggregated into more narrow electronic systems categories, as follows:

- Data processing
  - Computers
  - Data storage
  - Input/output devices
  - Dedicated systems
  - Other data processing
- Communications
  - Premise telecommunications
  - Public telecommunications
  - Mobile communications
  - Broadcast and studio equipment
  - Other communications
- Industrial
  - Security and energy management systems
  - Manufacturing systems and instruments
  - Medical equipment
  - Other industrial equipment
- Consumer
  - Audio
  - Video
  - Personal electronics
  - Appliances
  - Other consumer equipment

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- Military/civil aerospace
- Transportation

As part of the forecast process, Dataquest develops forecasts for about 40 individual electronic systems within these various categories and subcategories. These include the following:

- Data processing
  - Mainframes/supercomputers (computers)
  - Midrange computers (computers)
  - Workstations (computers)
  - PCs (computers)
  - Motherboards (computers)
  - Rigid disk drives (data storage)
  - Optical disk drives (data storage)
  - Removable magnetic storage (data storage)
  - Page printers (input/output)
  - Serial printers (input/output)
  - Monitors (input/output)
- Communications
  - LAN cards (premise telecommunications)
  - Premise line cards (premise telecommunications)
  - Answering machines (premise telecommunications)
  - Fax machines (premise telecommunications)
  - Modems (premise telecommunications)
  - Corded telephones (premise telecommunications)
  - Analog cordless phones (premise telecommunications)
  - Digital cordless phones (premise telecommunications)
  - Central office line cards (public telecommunications)
  - Analog cellular phones (mobile telecommunications)
  - Digital cellular phones (mobile telecommunications)
  - Pagers (mobile telecommunications)
  - Mobile telecommunications infrastructure (mobile telecommunications)
  - Other mobile telecommunications products (mobile telecommunications)

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- Consumer
  - Personal/portable stereos (audio)
  - Color TVs (video)
  - VCRs (video)
  - Analog camcorders (video)
  - Digital camcorders (video)
  - DVDs (video)
  - Analog set-top boxes (video)
  - Digital set-top boxes (video)
  - Digital still cameras (personal electronics)
  - Video game controllers (personal electronics)
- Transportation
  - Automotive stereos
  - Automotive engine control units (ECUs)
  - Antilock braking systems
  - Air bags
  - Automotive navigation systems

Geographic Segmentation

Dataquest's worldwide electronic equipment production forecast is aggregated from individual forecasts for four principal geographic regions:

- Americas
- Japan
- Europe, Middle East, and Africa
- Asia/Pacific

Exchange Rates

Dataquest's worldwide electronic equipment forecast aggregates data from many countries, each of which uses a currency that has a different and fluctuating exchange rate relative to the U.S. dollar. Because we compile our worldwide forecast from individual regional forecasts, we use the U.S. dollar as a common currency for comparisons and aggregation. As a rule, Dataquest calculates forecasts in local currencies and then converts them to U.S. dollars using projected average annual exchange rates. Dataquest does not forecast exchange rates per se. Instead, we calculate projected average annual exchange rates from current exchange rates. Our projections are based on estimates of the latest available monthly exchange rate at the time the forecast is developed. These rates are based on monthly exchange rates observed through July 1998. Additional information about historical exchange rates and Dataquest's method of calculating future average exchange rates may be requested through Dataquest's client inquiry service.

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Forecast Methodology

When discussing semiconductor consumption, it is critical to remember that semiconductors are not end products consumed for their own sake. They are intermediate products used as inputs for electronic end products that are eventually consumed by individuals and businesses for the utility they provide. Implicit in the concept of semiconductor consumption is the notion that the electronic end products in which semiconductors will be incorporated or consumed can be specified. A semiconductor forecast that does not or cannot specify this is not a forecast of semiconductor consumption. At best, it is merely a forecast of semiconductor shipments.

Dataquest's semiconductor consumption by electronic application forecast grew out of the recognition that a truly complete semiconductor forecast must specify the electronic end uses of semiconductors. However, specifying semiconductor end uses has proved far more difficult than recognizing that it must be done. Although it appears possible to specify semiconductor consumption by the variety of electronics produced, there are simply too many different types of semiconductor devices consumed in too large a variety of electronic products. As a result, semiconductor consumption must invariably be estimated. This can be done in any number of ways. Before this forecast, Dataquest used a mathematical model to estimate semiconductor consumption by various electronic end uses. Taking Dataquest's electronic equipment production and semiconductor shipments forecasts as inputs, this model allocated estimated semiconductor shipments across forecast electronics production subject to various assumptions about the semiconductor content of electronic products. The model also imposed several balancing conditions intended to guarantee that estimated semiconductor shipments were completely allocated across all forecast electronics production.

The model applied a top-down approach to estimating semiconductor consumption. In effect, it calculated estimates of semiconductor consumption by compelling agreement between the details of the electronics production forecast and the semiconductor shipments forecast. As a result, the estimates of semiconductor consumption were more an artifact of a mathematical process than truly independent estimates of semiconductor consumption. Although the model offered considerable flexibility, it was nonetheless limited by the validity of its semiconductor content assumptions and the balancing requirement that semiconductor consumption equal semiconductor shipments. Despite its potential drawbacks, the model provided the best estimates we could offer, given a paucity of knowledge about semiconductor applications in specific electronic systems.

Over the last several years, Dataquest's semiconductor applications research has been concentrated on the study of semiconductor use in specific individual electronic systems. We have successfully developed models to track and forecast the production and semiconductor consumption of some 40 different individual electronic systems. These include PCs and PC motherboards, rigid disk drives, LAN cards and modems, digital cellular phones, digital set-top boxes, and automotive navigation systems, among others. The electronic systems encompassed by our models account for about one-half of all electronics production and nearly two-thirds of estimated semiconductor consumption.

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These models have allowed us not only to codify our knowledge about individual electronic systems but also to approach the task of estimating semiconductor consumption using a bottom-up forecast method. This method was used for the forecast and will be used for future forecasts. The method essentially involves building a forecast of semiconductor consumption for all electronics production by leveraging estimates of semiconductor consumption for individual electronic systems. Dataquest uses individual systems estimates as a forecast base and augments this with estimates of semiconductor consumption for other electronic equipment categories not tracked individually. Precisely because the method uses well-researched knowledge about individual electronics systems that dominate semiconductor consumption, Dataquest believes it is capable of providing far better forecasts of semiconductor consumption than our former top-down method, especially for electronic equipment categories such as computers, where individual systems forecasts account for virtually the entire category. The results of this analysis are shown in Chapter 3.

Forecast Highlights

Dataquest estimates that worldwide semiconductor consumption will decrease by 0.2 percent in 1998 to about $148.0 billion. Dataquest expects approximately two-thirds of this growth will come about because of growth in worldwide electronics production, which is now forecast to grow 2.2 percent in 1998 to about $935.8 billion. The remainder will be the result of expected growth in the average semiconductor content of electronics, which we forecast will increase to about 15.8 percent of electronics factory value. Longer-term, we estimate worldwide semiconductor consumption will average 10.3 percent annual growth through 2002. This should raise worldwide semiconductor consumption to about $241.6 billion by 2002. Dataquest expects slightly over half of the longer-term growth in worldwide semiconductor consumption to come about because of growth in worldwide electronics production, which we are now forecasting to average 6.1 percent annual growth through 2002. Once again, remaining growth in semiconductor consumption will be the result of increases in the average semiconductor content of electronics. We now expect average semiconductor content will rise to about 19.7 percent of electronics factory value by 2002.

We are now forecasting Japanese semiconductor consumption will decrease by 10.4 percent in 1998. This compares to anticipated growth rates of 3.8 percent for Asia/Pacific and 5.0 percent for Europe, the Middle East, and Africa. In the long term, Japanese consumption is expected to average just 4.6 percent annual growth between 1997 and 2002, as opposed to 13.9 percent for Asia/Pacific and 10.2 percent for Europe, the Middle East, and Africa. (Note: All of our forecasts are valued in U.S. dollars and thus reflect projected exchange rate movements in addition to expected changes in semiconductor consumption expressed in local currencies.) Underlying these marked differences in long-term growth are equally marked differences in expected sources of growth.

There is a strong desire among suppliers to believe that semiconductor shipments, and with them semiconductor revenue, can continue to post high rates of long-term growth. However, this desire needs to be tempered with the recognition that long-term shipments growth is only possible so

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long as electronics makers are able to profitably increase semiconductor consumption, either by expanding electronics production or increasing semiconductor content. A number of fundamental changes are taking place in several key electronics markets that will limit the future ability of electronics makers to profitably increase semiconductor consumption. Semiconductor suppliers would be well advised to acknowledge these emerging limits because failure to do so will only intensify competition and further imperil both future shipment and revenue growth in Japan.

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Chapter 2

Worldwide and Japanese Semiconductor Consumption Forecasts

Tables 2-1 through 2-22 present Dataquest's forecast of worldwide and Japanese semiconductor consumption by electronics application.

Table 2-1
Value of Semiconductors Consumed Worldwide by Electronic Product Group, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
All Electronic Products	**148,293**	**147,951**	**165,368**	**196,390**	**229,875**	**241,605**
Data Processing Products	**71,174**	**69,312**	**80,338**	**103,376**	**127,647**	**130,236**
Computers	50,005	47,211	54,744	73,208	92,455	91,212
Data Storage	8,631	9,418	11,159	12,888	14,405	16,379
Input/Output	6,898	7,061	7,655	8,656	10,043	10,906
Dedicated Systems	2,720	2,728	3,445	4,558	5,751	6,364
Other Data Processing	2,921	2,895	3,334	4,066	4,993	5,375
Communications Products	**30,035**	**31,407**	**33,992**	**36,811**	**39,960**	**43,071**
Premise Telecommunications	11,401	12,181	13,346	13,927	15,016	15,844
Public Telecommunications	4,561	4,402	4,912	5,279	5,707	6,075
Mobile Communications	11,458	12,149	12,694	14,050	15,091	16,658
Broadcast and Studio	900	952	1,092	1,297	1,574	1,763
Other Communications	1,716	1,722	1,947	2,259	2,572	2,732
Industrial Products	**13,095**	**12,721**	**14,150**	**15,960**	**17,882**	**19,771**
Security/Energy Management	1,332	1,383	1,550	1,783	2,075	2,320
Manufacturing Systems/Instruments	8,226	7,778	8,629	9,765	10,955	12,125
Medical Equipment	1,413	1,473	1,613	1,744	1,900	2,085
Other Industrial	2,124	2,088	2,359	2,667	2,952	3,240
Consumer Products	**23,737**	**23,622**	**24,948**	**26,962**	**29,533**	**31,905**
Audio	3,933	3,692	3,976	4,455	4,923	5,075
Video	9,913	10,425	11,110	11,537	11,965	12,365
Personal Electronics	6,079	5,959	6,129	6,699	7,522	8,977
Appliances	2,825	2,678	2,818	3,234	3,876	4,159
Other Consumer	987	867	915	1,037	1,247	1,329
Military/Civil Aerospace Products	**2,597**	**2,624**	**2,756**	**2,934**	**3,130**	**3,376**
Transportation Products	**7,654**	**8,264**	**9,185**	**10,346**	**11,723**	**13,246**
Semiconductor Shipments	**147,165**	**138,437**	**154,820**	**190,153**	**234,823**	**253,842**
Exchange Rate (Yen/U.S.$)	**121.10**	**136.35**	**140.79**	**140.79**	**140.79**	**140.79**

Source: Dataquest (November 1998)

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Table 2-2
Growth in the Value of Semiconductors Consumed Worldwide by Electronic Product Group, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
All Electronic Products	3.6	-0.2	11.8	18.8	17.1	5.1	10.3
Data Processing Products	**-2.0**	**-2.6**	**15.9**	**28.7**	**23.5**	**2.0**	**12.8**
Computers	-6.5	-5.6	16.0	33.7	26.3	-1.3	12.8
Data Storage	21.8	9.1	18.5	15.5	11.8	13.7	13.7
Input/Output	6.5	2.4	8.4	13.1	16.0	8.6	9.6
Dedicated Systems	-8.0	0.3	26.3	32.3	26.2	10.7	18.5
Other Data Processing	10.4	-0.9	15.1	22.0	22.8	7.6	13.0
Communications Products	**16.5**	**4.6**	**8.2**	**8.3**	**8.6**	**7.8**	**7.5**
Premise Telecommunications	8.3	6.8	9.6	4.3	7.8	5.5	6.8
Public Telecommunications	10.7	-3.5	11.6	7.5	8.1	6.4	5.9
Mobile Communications	34.1	6.0	4.5	10.7	7.4	10.4	7.8
Broadcast and Studio	3.3	5.8	14.7	18.7	21.4	12.0	14.4
Other Communications	-0.4	0.4	13.1	16.0	13.8	6.2	9.7
Industrial Products	**4.6**	**-2.9**	**11.2**	**12.8**	**12.0**	**10.6**	**8.6**
Security/Energy Management	0.9	3.9	12.1	15.1	16.3	11.9	11.7
Manufacturing Systems/Instruments	5.1	-5.4	10.9	13.2	12.2	10.7	8.1
Medical Equipment	2.3	4.2	9.5	8.2	8.9	9.7	8.1
Other Industrial	7.2	-1.7	13.0	13.1	10.7	9.7	8.8
Consumer Products	**6.1**	**-0.5**	**5.6**	**8.1**	**9.5**	**8.0**	**6.1**
Audio	-0.5	-6.1	7.7	12	10.5	3.1	5.2
Video	4.0	5.2	6.6	3.8	3.7	3.3	4.5
Personal Electronics	25.7	-2.0	2.8	9.3	12.3	19.3	8.1
Appliances	-5.6	-5.2	5.2	14.8	19.9	7.3	8.0
Other Consumer	-7.2	-12.2	5.5	13.4	20.2	6.5	6.1
Military/Civil Aerospace Products	**0.5**	**1.0**	**5.0**	**6.5**	**6.7**	**7.9**	**5.4**
Transportation Products	**5.1**	**8.0**	**11.1**	**12.6**	**13.3**	**13.0**	**11.6**
Semiconductor Shipments	**3.5**	**-5.9**	**11.8**	**22.8**	**23.5**	**8.1**	**11.5**

Source: Dataquest (November 1998)

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Table 2-3
Value of Semiconductors Consumed in Japan by Electronic Product Group, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
All Electronic Products	**35,321**	**31,639**	**32,767**	**36,717**	**41,123**	**44,194**
Data Processing Products	**12,758**	**12,207**	**12,549**	**14,537**	**17,014**	**17,637**
Computers	7,778	7,441	7,196	8,204	9,663	9,450
Data Storage	1,865	2,012	2,189	2,490	2,683	2,857
Input/Output	1,849	1,664	1,701	1,797	2,021	2,113
Dedicated Systems	799	695	911	1,256	1,683	2,013
Other Data Processing	467	395	552	790	964	1,204
Communications Products	**6,846**	**5,622**	**5,779**	**6,271**	**6,817**	**7,371**
Premise Telecommunications	2,095	1,868	1,899	1,973	2,073	2,171
Public Telecommunications	1,749	1,441	1,725	2,027	2,372	2,652
Mobile Communications	2,574	1,959	1,728	1,753	1,748	1,833
Broadcast and Studio	120	110	134	162	202	237
Other Communications	308	243	293	355	423	478
Industrial Products	**3,941**	**2,990**	**3,440**	**4,029**	**4,626**	**5,233**
Security/Energy Management	285	238	257	291	340	387
Manufacturing Systems/Instruments	2,849	2,112	2,470	2,909	3,319	3,721
Medical Equipment	265	225	240	276	325	389
Other Industrial	542	414	472	553	641	736
Consumer Products	**9,284**	**8,393**	**8,337**	**8,853**	**9,323**	**10,220**
Audio	1,392	1,218	1,299	1,433	1,556	1,588
Video	2,591	2,547	2,469	2,342	2,161	2,016
Personal Electronics	4,062	3,679	3,562	3,956	4,348	5,382
Appliances	783	615	655	734	811	785
Other Consumer	456	334	353	388	448	450
Military/Civil Aerospace Products	**311**	**278**	**310**	**351**	**346**	**362**
Transportation Products	**2,180**	**2,149**	**2,351**	**2,676**	**2,996**	**3,370**
Semiconductor Shipments	**36,499**	**30,721**	**32,652**	**38,450**	**47,108**	**50,388**
Exchange Rate (Yen/U.S.$)	**121.10**	**136.35**	**140.79**	**140.79**	**140.79**	**140.79**

Source: Dataquest (November 1998)

 ©1998 Dataquest

Table 2-4
Growth in the Value of Semiconductors Consumed in Japan by Electronic Product Group, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
All Electronic Products	**3.0**	**-10.4**	**3.6**	**12.1**	**12.0**	**7.5**	**8.8**
Data Processing Products	**-3.5**	**-4.3**	**2.8**	**15.8**	**17.0**	**3.7**	**6.7**
Computers	-7.6	-4.3	-3.3	14.0	17.8	-2.2	4.0
Data Storage	37.6	7.9	8.8	13.7	7.8	6.5	8.9
Input/Output	4.3	-10.0	2.2	5.7	12.4	4.5	2.7
Dedicated Systems	-8.3	-13.0	31.0	37.9	34.0	19.6	20.3
Other Data Processing	-41.7	-15.4	39.7	43.1	22.1	24.9	20.9
Communications Products	**8.2**	**-17.9**	**2.8**	**8.5**	**8.7**	**8.1**	**1.5**
Premise Telecommunications	1.3	-10.8	1.6	3.9	5.0	4.8	0.7
Public Telecommunications	17.5	-17.6	19.7	17.6	17.0	11.8	8.7
Mobile Communications	9.6	-23.9	-11.8	1.4	-0.3	4.9	-6.6
Broadcast and Studio	-12.0	-8.0	21.8	20.7	24.8	17.2	14.6
Other Communications	7.2	-21.0	20.4	21.2	18.9	13.0	9.1
Industrial Products	**3.7**	**-24.1**	**15.1**	**17.1**	**14.8**	**13.1**	**5.8**
Security and Energy Management	-18.0	-16.3	8.0	13.1	16.9	13.7	6.3
Manufacturing Systems/Instruments	6.7	-25.9	17.0	17.8	14.1	12.1	5.5
Medical Equipment	-1.6	-15.2	6.7	14.8	17.9	19.6	7.9
Other Industrial	5.4	-23.6	14.0	17.1	15.9	14.7	6.3
Consumer Products	**11.3**	**-9.6**	**-0.7**	**6.2**	**5.3**	**9.6**	**1.9**
Audio	3.1	-12.5	6.6	10.4	8.6	2.1	2.7
Video	-2.0	-1.7	-3.1	-5.1	-7.7	-6.7	-4.9
Personal Electronics	43.1	-9.4	-3.2	11.0	9.9	23.8	5.8
Appliances	-19.2	-21.4	6.4	12.2	10.4	-3.2	0
Other Consumer	-15.6	-26.8	5.6	10.0	15.6	0.5	-0.2
Military/Civil Aerospace Products	**-8.7**	**-10.8**	**11.4**	**13.3**	**-1.3**	**4.6**	**3.1**
Transportation Products	**-3.7**	**-1.4**	**9.4**	**13.8**	**12.0**	**12.5**	**9.1**
Semiconductor Shipments	**-5.0**	**-15.8**	**6.3**	**17.8**	**22.5**	**7.0**	**6.7**

Source: Dataquest (November 1998)

Table 2-5
Value of Semiconductors Consumed in Japan by Individual Data Processing Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Mainframe/Supercomputers (Computers)	594	718	711	697	625	505
Midrange Computers (Computers)	496	555	519	608	685	748
Workstations (Computers)	358	330	331	368	410	427
PCs (Computers)	5,784	5,352	5,166	6,014	7,330	7,196
Motherboards (Computers)	545	486	470	516	613	575
Rigid Disk Drives (Data Storage)	724	650	610	626	640	678
Optical Disk Drives (Data Storage)	787	873	928	1,023	1,048	1,112
Removable Magnetic Storage (Data Storage)	354	489	652	841	995	1,067
Page Printers (Input/Output)	516	487	507	522	558	579
Serial Printers (Input/Output)	564	556	515	488	486	460
Monitors (Input/Output)	122	125	116	129	145	150
Other Data Processing Products	1,913	1,585	2,025	2,704	3,480	4,142
All Data Processing Products	**12,758**	**12,207**	**12,549**	**14,537**	**17,014**	**17,637**
Exchange Rate (Yen/U.S.$)	**121.10**	**136.35**	**140.79**	**140.79**	**140.79**	**140.79**

Source: Dataquest (November 1998)

Table 2-6
Growth in the Value of Semiconductors Consumed in Japan by Individual Data Processing Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Mainframe/Supercomputers (Computers)	6.4	20.8	-1.0	-1.9	-10.3	-19.3	-3.2
Midrange Computers (Computers)	-12.8	11.8	-6.5	17.3	12.6	9.2	8.5
Workstations (Computers)	-19.6	-7.8	0.2	11.5	11.2	4.3	3.6
PCs (Computers)	-9.4	-7.5	-3.5	16.4	21.9	-1.8	4.5
Motherboards (Computers)	17.7	-10.8	-3.3	9.6	18.9	-6.3	1.0
Rigid Disk Drives (Data Storage)	7.4	-10.3	-6.1	2.7	2.3	5.9	-1.3
Optical Disk Drives (Data Storage)	75.8	10.9	6.2	10.3	2.4	6.1	7.1
Removable Magnetic Storage (Data Storage)	51.6	38.4	33.3	28.9	18.4	7.2	24.7
Page Printers (Input/Output)	-9.4	-5.6	4.1	2.9	6.8	3.7	2.3
Serial Printers (Input/Output)	28.0	-1.4	-7.4	-5.2	-0.5	-5.4	-4.0
Monitors (Input/Output)	21.9	2.9	-7.2	10.7	12.4	3.8	4.3
Other Data Processing Products	-18.1	-17.2	27.8	33.5	28.7	19.0	16.7
All Data Processing Products	**-4.7**	**-4.3**	**2.8**	**15.8**	**17.0**	**3.7**	**6.7**

Source: Dataquest (November 1998)

Table 2-7
Value of Semiconductors Consumed in Japan by Individual Communications Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
LAN Cards (Premise Telecommunications)	43	67	74	83	76	73
Premise Line Cards (Premise Telecommunications)	42	42	41	44	40	42
Answering Machines (Premise Telecommunications)	6	5	5	5	6	6
Fax Machines (Premise Telecommunications)	528	498	510	512	510	505
Modems (Premise Telecommunications)	7	6	6	6	6	5
Corded Telephones (Premise Telecommunications)	29	26	23	22	20	19
Analog Cordless Phones (Premise Telecommunications)	219	226	193	184	172	156
Digital Cordless Phones (Premise Telecommunications)	232	181	175	176	173	174
Central Office Line Cards (Public Telecommunications)	86	79	85	91	91	95
Analog Cellular Phones (Mobile Telecommunications)	25	-	-	-	-	-
Digital Cellular Phones (Mobile Telecommunications)	1,728	1,127	876	815	708	691
Pagers (Mobile Telecommunications)	88	68	54	47	40	37
Mobile Telecommunications Infrastructure (Mobile Telecommunications)	512	545	588	682	795	902
Other Mobile Telecommunications (Mobile Telecommunications)	221	220	210	208	204	204
Other Communications Products	3,080	2,532	2,940	3,396	3,976	4,462
All Communications Products	**6,846**	**5,622**	**5,779**	**6,271**	**6,817**	**7,371**
Exchange Rate (Yen/U.S.$)	**121.10**	**136.35**	**140.79**	**140.79**	**140.79**	**140.79**

Source: Dataquest (November 1998)

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Table 2-8
Growth in the Value of Semiconductors Consumed in Japan by Individual Communications Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
LAN Cards (Premise Telecommunications)	96.1	55.5	10.9	12.8	-9.1	-3.2	11.3
Premise Line Cards (Premise Telecommunications)	4.2	0.4	-3.2	6.3	-8.2	4.0	-0.3
Answering Machines (Premise Telecommunications)	1.1	-18.9	-10.6	17.1	14.9	4.6	0.4
Fax Machines (Premise Telecommunications)	17.4	-5.6	2.4	0.3	-0.4	-0.8	-0.9
Modems (Premise Telecommunications)	-18.8	-1.3	-2.3	-2.7	-9.1	-4.5	-4.0
Corded Telephones (Premise Telecommunications)	-23.2	-7.8	-11.4	-6.8	-6.0	-5.0	-7.4
Analog Cordless Phones (Premise Telecommunications)	-4.6	2.9	-14.7	-4.5	-6.6	-9.1	-6.6
Digital Cordless Phones (Premise Telecommunications)	-35.8	-22.3	-3.4	0.8	-1.7	0.3	-5.7
Central Office Line Cards (Public Telecommunications)	5.6	-8.2	7.5	7.0	-0.3	5.0	2.0
Analog Cellular Phones (Mobile Telecommunications)	-79.9	-100.0	-	-	-	-	-100.0
Digital Cellular Phones (Mobile Telecommunications)	14.8	-34.8	-22.3	-6.9	-13.2	-2.5	-16.8
Pagers (Mobile Telecommunications)	-25.6	-22.7	-20.0	-13.2	-14.7	-7.2	-15.7
Mobile Telecommunications Infrastructure (Mobile Telecommunications)	37.3	6.4	8.0	16.0	16.5	13.4	12.0
Other Mobile Telecommunications (Mobile Telecommunications)	-2.3	-0.7	-4.3	-0.9	-1.7	-0.4	-1.6
Other Communications Products	12.3	-17.8	16.1	15.5	17.1	12.2	7.7
All Communications Products	**8.2**	**-17.9**	**2.8**	**8.5**	**8.7**	**8.1**	**1.5**

Source: Dataquest (November 1998)

Table 2-9
Value of Semiconductors Consumed in Japan by Individual Consumer Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Personal/Portable Stereos (Audio)	195	206	187	177	164	155
Color TVs (Video)	616	598	625	625	570	537
VCRs (Video)	510	474	448	429	407	383
Analog Camcorders (Video)	876	690	560	409	248	143
Digital Camcorders (Video)	458	659	700	710	743	750
DVDs (Video)	20	26	35	60	73	77
Analog Set-Top Boxes (Video)	12	9	6	5	4	4
Digital Set-Top Boxes (Video)	100	90	95	104	115	121
Digital Still Cameras (Personal Electronics)	289	309	345	351	340	362
Video Game Controllers (Personal Electronics)	1,794	1,275	711	592	542	810
Other Consumer Products	4,415	4,057	4,626	5,390	6,116	6,879
All Consumer Products	**9,284**	**8,393**	**8,337**	**8,853**	**9,323**	**10,220**
Exchange Rate (Yen/U.S.$)	**121.10**	**136.35**	**140.79**	**140.79**	**140.79**	**140.79**

Source: Dataquest (November 1998)

Table 2-10
Growth in the Value of Semiconductors Consumed in Japan by Individual Consumer Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Personal/Portable Stereos (Audio)	12.5	5.8	-9.3	-5.0	-7.6	-5.7	-4.5
Color TVs (Video)	0.7	-2.8	4.4	0	-8.8	-5.8	-2.7
VCRs (Video)	-20.6	-7.0	-5.5	-4.3	-5.0	-5.8	-5.5
Analog Camcorders (Video)	-5.6	-21.2	-18.9	-26.9	-39.3	-42.4	-30.4
Digital Camcorders (Video)	35.4	44.0	6.2	1.4	4.7	1.0	10.4
DVDs (Video)	111.7	30.5	33.5	71.0	21.5	5.5	30.7
Analog Set-Top Boxes (Video)	-22.9	-25.1	-27.0	-18.8	-15.0	-2.4	-18.1
Digital Set-Top Boxes (Video)	-0.6	-10.4	5.5	10.0	10.7	4.8	3.8
Digital Still Cameras (Personal Electronics)	83.3	7.0	11.6	1.9	-3.0	6.2	4.6
Video Game Controllers (Personal Electronics)	14.4	-29.0	-44.2	-16.7	-8.6	49.4	-14.7
Other Consumer Products	16.2	-8.1	14.0	16.5	13.5	12.5	9.3
All Consumer Products	**15.9**	**0.8**	**10.1**	**18.3**	**7.7**	**24.7**	**1.9**

Source: Dataquest (November 1998)

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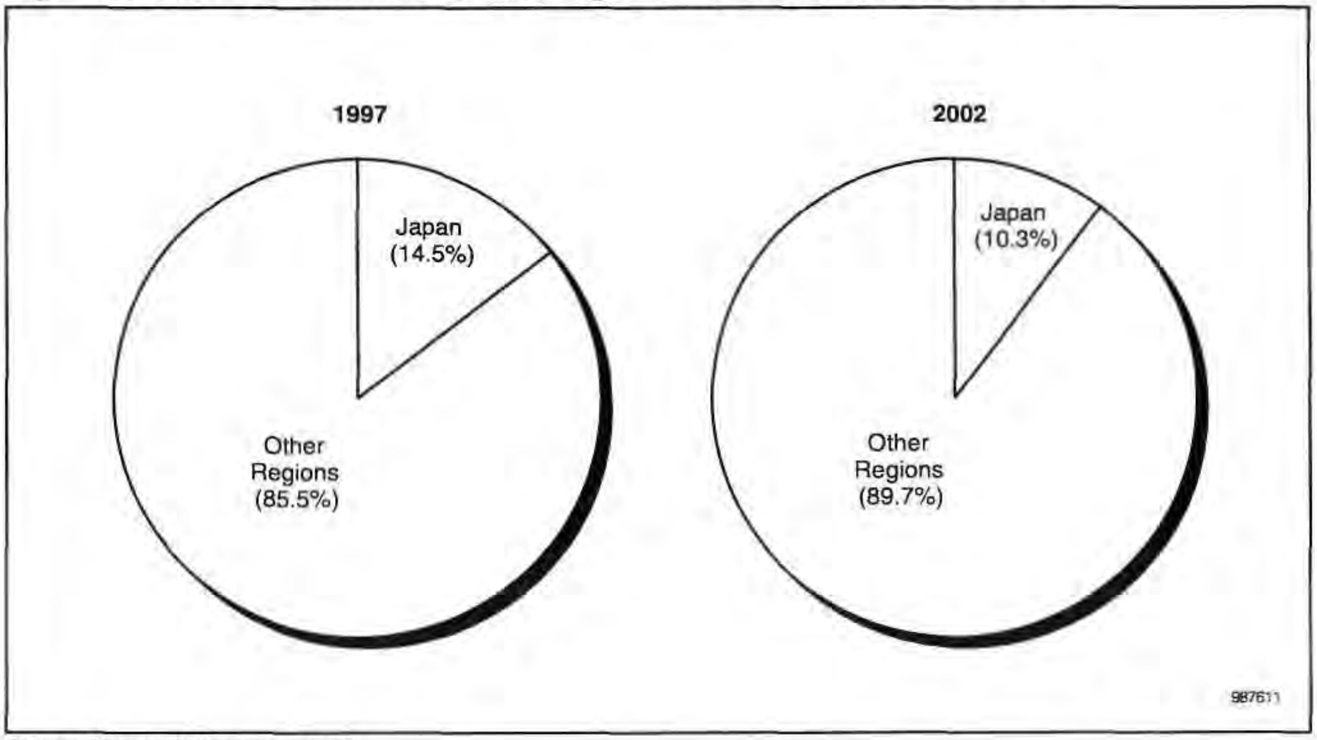
Table 3-6
Production and Semiconductor Consumption Forecast for Rigid Disk Drives in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	18,635	17,889	18,783	20,661	21,838	24,506	5.6
Factory ASP (U.S.$)	312.6	275.0	254.6	230.0	220.0	180.0	-10.5
Factory Revenue (U.S.$M)	5,825	4,919	4,782	4,752	4,804	4,411	-5.4
Semiconductor Content (U.S.$)	38.9	36.3	32.5	30.3	29.3	27.7	-6.6
Semiconductor TAM (U.S.$M)	724	650	610	626	640	678	-1.3

Source: Dataquest (November 1998)

Figure 3-6
Japanese Unit Production Trends for Rigid Disk Drives, 1997 versus 2002



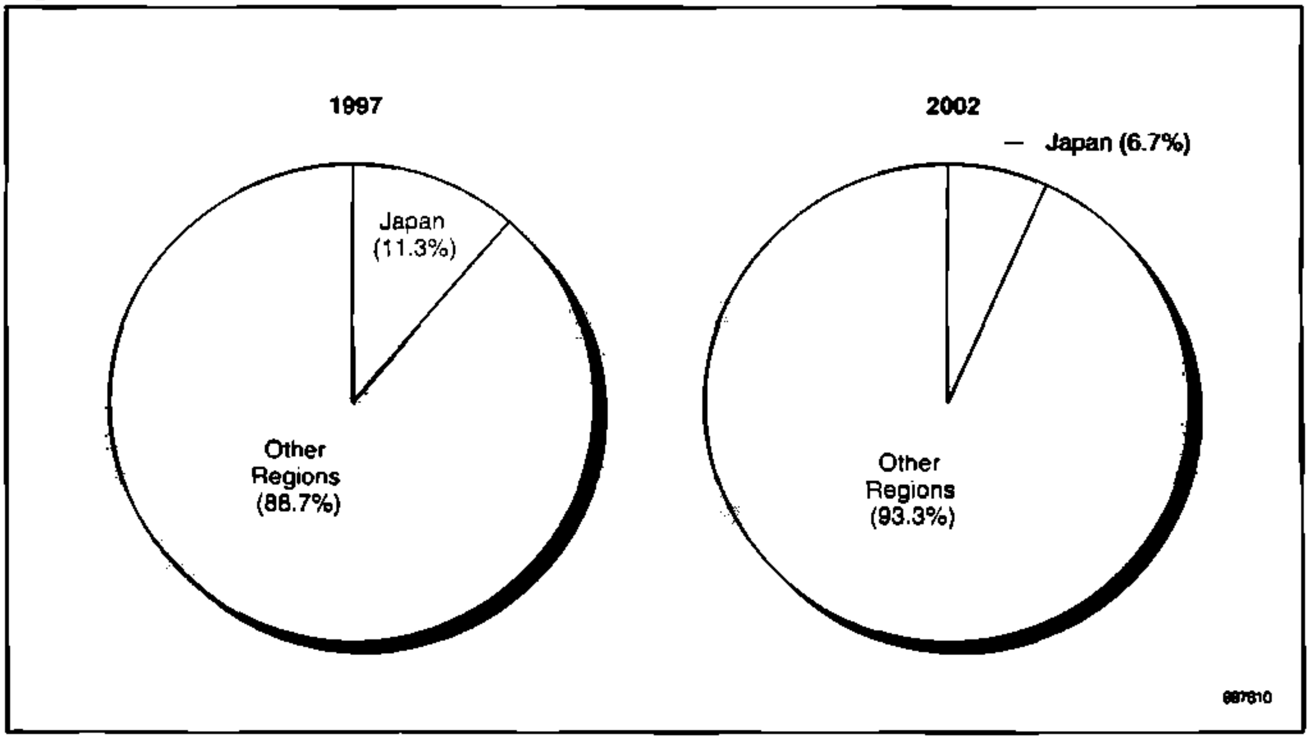
Source: Dataquest (November 1998)

Table 3-5
Production and Semiconductor Consumption Forecast for Motherboards in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	10,818	10,493	11,258	12,248	12,569	13,105	3.9
Factory ASP (U.S.$)	104.70	102.68	101.25	99.69	98.68	98.11	-1.3
Factory Revenue (U.S.$M)	1,133	1,077	1,140	1,221	1,240	1,286	2.6
Semiconductor Content (U.S.$)	50.4	46.3	41.8	42.1	48.8	43.8	-2.8
Semiconductor TAM (U.S.$M)	545	486	470	516	613	575	1.0

Source: Dataquest (November 1998)

Figure 3-5
Japanese Unit Production Trends for Motherboards, 1997 versus 2002



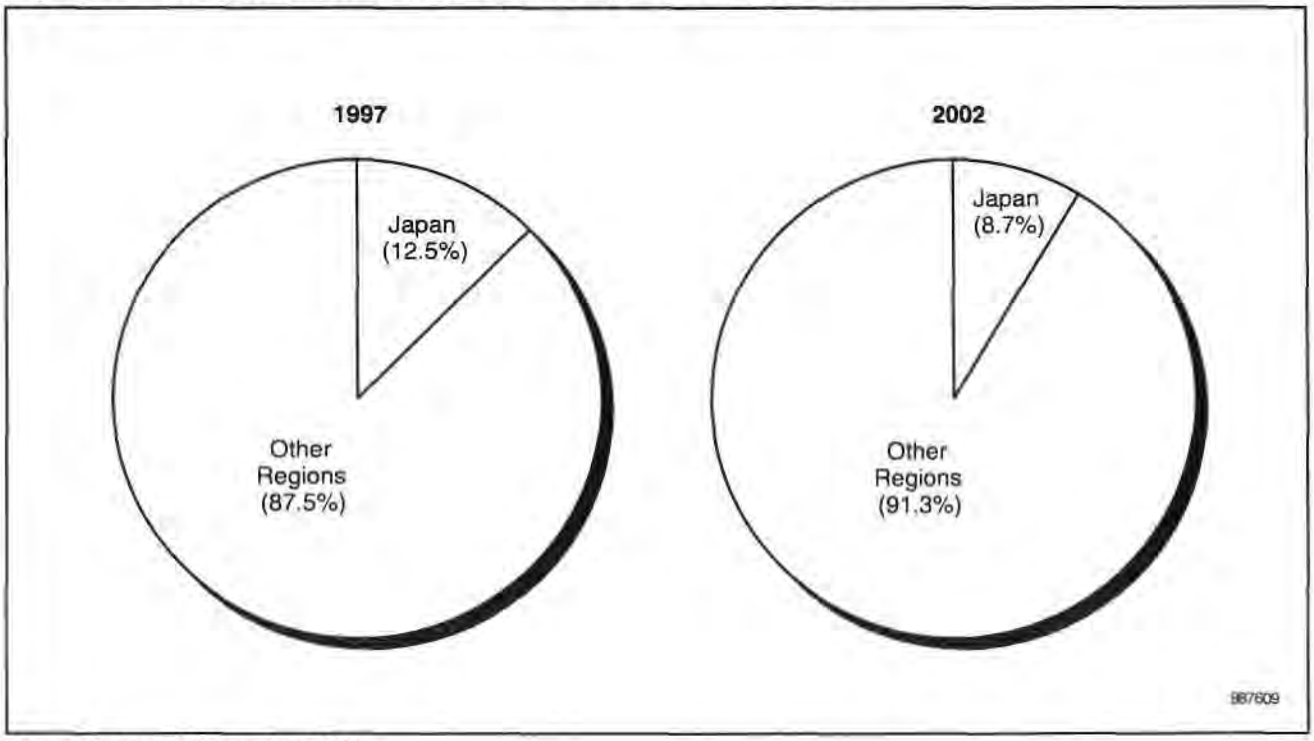
Source: Dataquest (November 1998)

Table 3-4
Production and Semiconductor Consumption Forecast for PCs in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	10,084	10,640	11,710	12,750	13,560	14,520	7.6
Factory ASP (U.S.$)	1,902.0	1,854.0	1,786.0	1,689.0	1,623.0	1,599.0	-3.4
Factory Revenue (U.S.$M)	19,179	19,727	20,914	21,535	22,008	23,217	3.9
Semiconductor Content (U.S.$)	573.6	503.0	441.1	471.7	540.6	495.6	-2.9
Semiconductor TAM (U.S.$M)	5,784	5,352	5,166	6,014	7,330	7,196	4.5

Source: Dataquest (November 1998)

Figure 3-4
Japanese Unit Production Trends for PCs, 1997 versus 2002



Source: Dataquest (November 1998)

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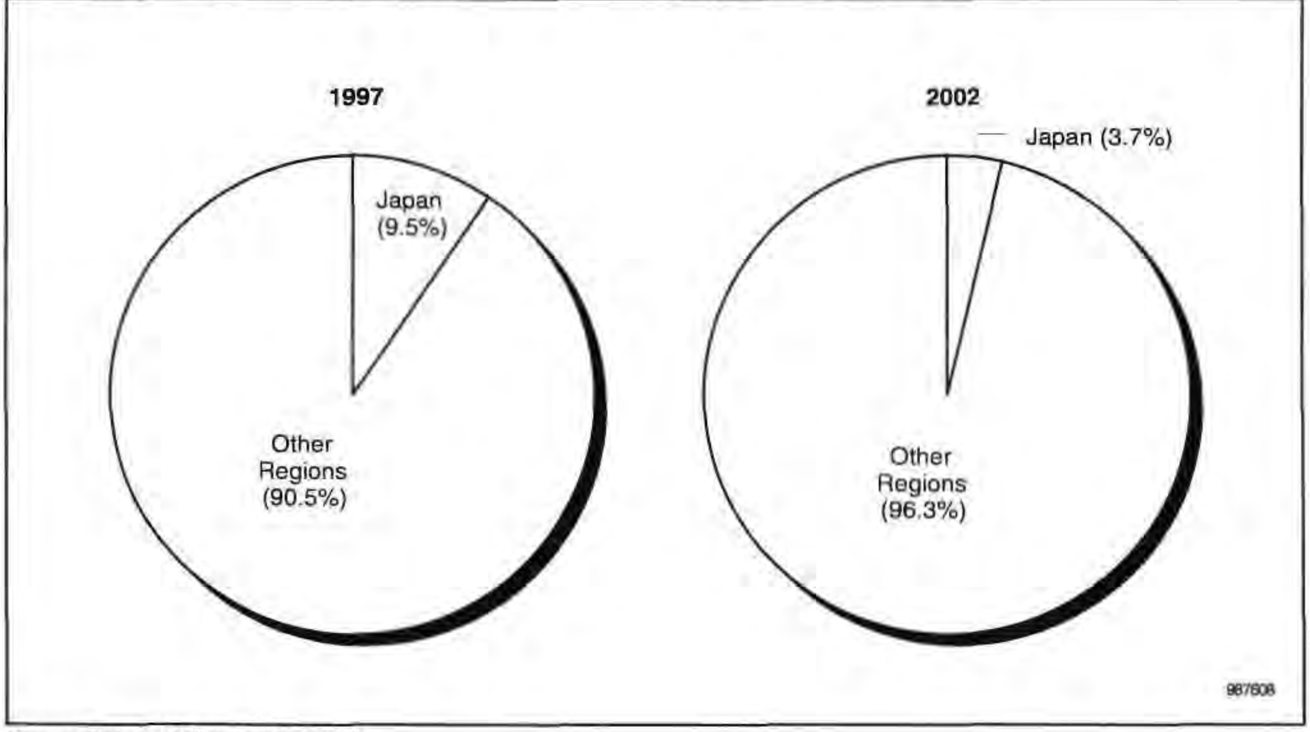
Table 3-3
Production and Semiconductor Consumption Forecast for Workstations in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	97	104	112	119	126	133	6.6
Factory ASP (U.S.$)	16,323.0	14,000.0	12,600.0	11,718.0	10,780.6	9,702.5	-9.9
Factory Revenue (U.S.$M)	1,582	1,452	1,411	1,391	1,363	1,294	-3.9
Semiconductor Content (U.S.$)	3,690.8	3,179.6	2,950.7	3,103.4	3,240.4	3,202.8	-2.8
Semiconductor TAM (U.S.$M)	358	330	331	368	410	427	3.6

Source: Dataquest (November 1998)

Figure 3-3
Japanese Unit Production Trends for Workstations, 1997 versus 2002



Source: Dataquest (November 1998)

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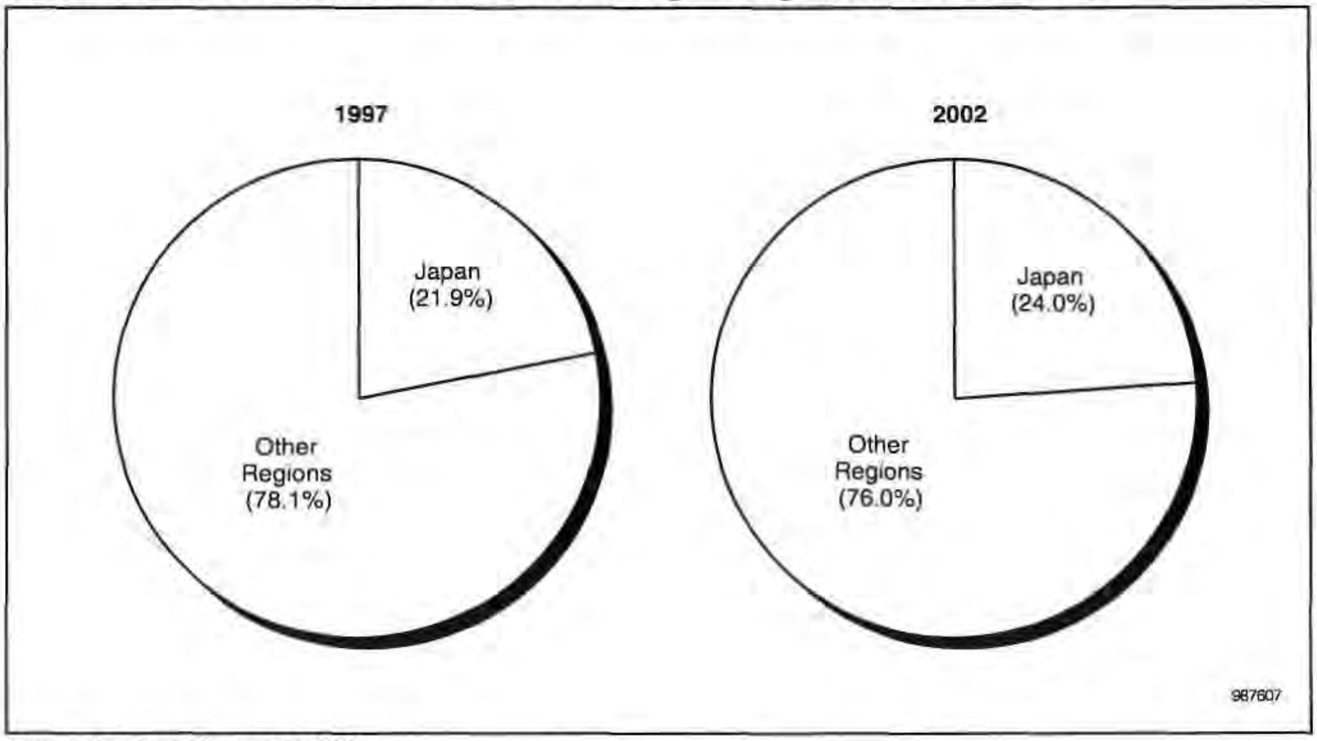
Table 3-2
Production and Semiconductor Consumption Forecast for Midrange Computers in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	148	160	179	197	213	230	9.2
Factory ASP (U.S.$)	15,855.8	15,380.2	14,765.0	14,322.0	13,892.4	13,250.0	-3.5
Factory Revenue (U.S.$M)	2,345	2,457	2,642	2,819	2,953	3,041	5.3
Semiconductor Content (U.S.$)	3,355.6	3,473.0	2,898.8	3,090.0	3,222.5	3,256.9	-0.6
Semiconductor TAM (U.S.$M)	496	555	519	608	685	748	8.5

Source: Dataquest (November 1998)

Figure 3-2
Japanese Unit Production Trends for Midrange Computers, 1997 versus 2002



Source: Dataquest (November 1998)

Chapter 3
High-Volume Electronic Equipment Unit Production and Semiconductor Consumption Forecast in Japan

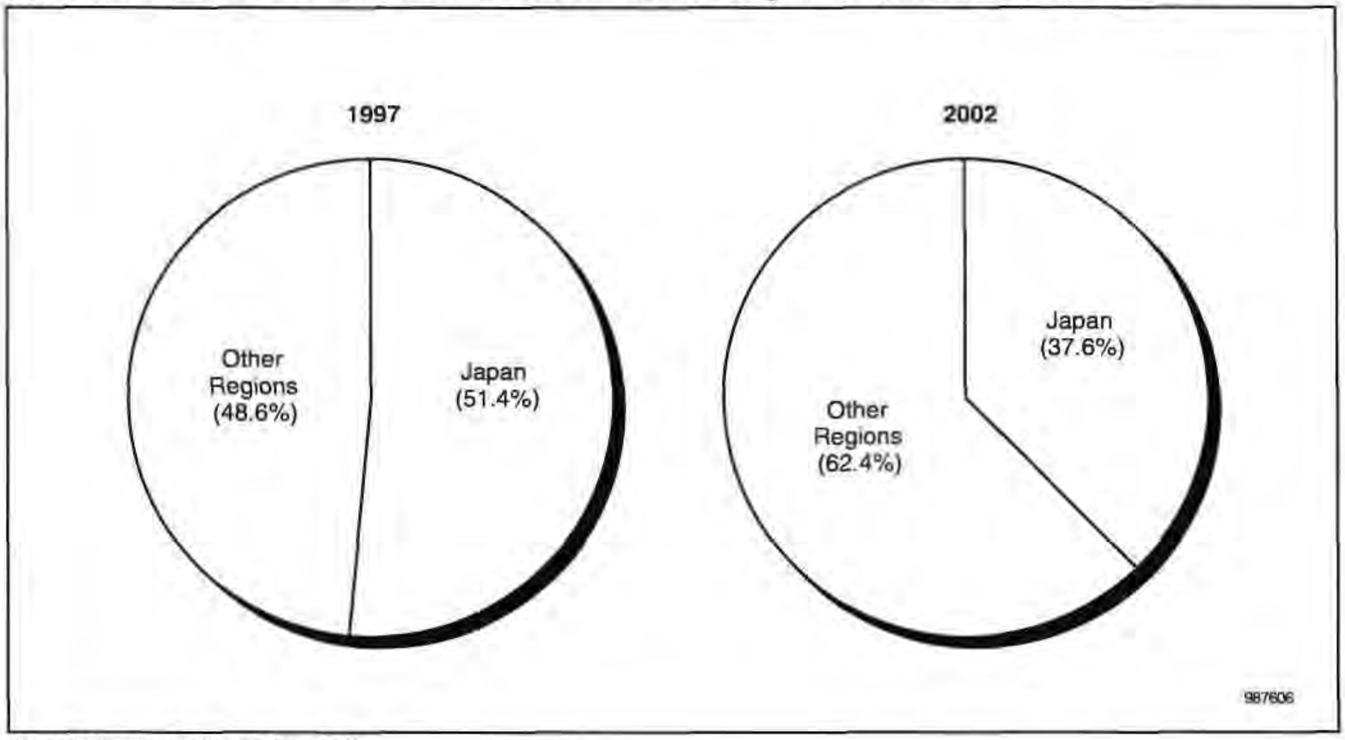
Tables 3-1 through 3-40 present Dataquest's forecast of electronic equipment unit production and semiconductor consumption for 40 major electronic systems. Figures 3-1 through 3-40 show the trends of Japan's share in production volume for 40 major electronic systems, 1997 versus 2002, in comparison with other regions.

Table 3-1
Production and Semiconductor Consumption Forecast for Mainframe/Supercomputers in Japan, 1997-2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	6	6	7	7	7	7	0.4
Factory ASP (U.S.$)	1,094,482.8	1,092,693.4	1,109,650.0	1,023,923.2	860,876.3	718,060.4	-8.1
Factory Revenue (U.S.$M)	6,986	6,964	7,426	6,686	5,652	4,685	-7.7
Semiconductor Content (U.S.$)	93,132.6	112,659.3	106,211.1	106,784.0	95,217.5	77,332.4	-3.6
Semiconductor TAM (U.S.$M)	594	718	711	697	625	505	-3.2

Source: Dataquest (November 1998)

Figure 3-1
Japanese Unit Production Trends for Mainframe/Supercomputers, 1997 versus 2002



Source: Dataquest (November 1998)

Table 2-21
Value of Semiconductors Consumed in Japan by Individual Transportation Product, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
Automotive Stereos	25	28	28	31	31	31
Automotive Engine Control Units (ECUs)	64	77	80	83	84	85
Antilock Braking Systems	16	19	21	23	25	26
Air Bags	13	17	19	20	21	23
Automotive Navigation Systems	31	41	63	86	113	142
Other Transportation Products	116	110	120	134	148	167
All Transportation Products	**264**	**293**	**331**	**377**	**422**	**474**

Source: Dataquest (November 1998)

Table 2-22
Growth in the Value of Semiconductors Consumed in Japan by Individual Transportation Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Automotive Stereos	6.3	14.9	-1.0	10.8	-0.5	1.5	4.9
Automotive Engine Control Units (ECUs)	18.0	21.1	4.3	2.9	1.8	1.1	6.0
Antilock Braking Systems	32.6	21.8	11.3	6.8	9.6	6.8	11.1
Air Bags	36.6	31.8	11.9	5.8	5.2	5.9	11.7
Automotive Navigation Systems	34.2	32.2	50.9	37.3	31.3	25.5	35.2
Other Transportation Products	-7.0	-4.9	8.8	12.1	10.2	13.2	7.6
All Transportation Products	**7.2**	**11.0**	**13.0**	**13.8**	**12.0**	**12.5**	**12.4**

Source: Dataquest (November 1998)

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Table 2-19
Value of Semiconductors Consumed in Japan by Individual Consumer Product, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
Personal/Portable Stereos (Audio)	24	28	26	25	23	22
Color TVs (Video)	75	82	88	88	80	76
VCRs (Video)	62	65	63	60	57	54
Analog Camcorders (Video)	106	94	79	58	35	20
Digital Camcorders (Video)	55	90	99	100	105	106
DVDs (Video)	2	4	5	8	10	11
Analog Set-Top Boxes (Video)	1	1	1	1	1	1
Digital Set-Top Boxes (Video)	12	12	13	15	16	17
Digital Still Cameras (Personal Electronics)	35	42	49	49	48	51
Video Game Controllers (Personal Electronics)	217	174	100	83	76	114
Other Consumer Products	535	553	651	759	861	968
All Consumer Products	**1,124**	**1,144**	**1,174**	**1,246**	**1,313**	**1,439**

Source: Dataquest (November 1998)

Table 2-20
Growth in the Value of Semiconductors Consumed in Japan by Individual Consumer Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Personal/Portable Stereos (Audio)	25.3	19.1	-6.4	-5.0	-7.6	-5.7	-1.6
Color TVs (Video)	12.1	9.4	7.8	0	-8.8	-5.8	0.3
VCRs (Video)	-11.7	4.7	-2.4	-4.3	-5.0	-5.8	-2.7
Analog Camcorders (Video)	5.1	-11.3	-16.2	-26.9	-39.3	-42.4	-28.3
Digital Camcorders (Video)	50.6	62.2	9.6	1.4	4.7	1.0	13.8
DVDs (Video)	135.6	46.9	37.8	71.0	21.5	5.5	34.7
Analog Set-Top Boxes (Video)	-14.1	-15.6	-24.7	-18.8	-15.0	-2.4	-15.6
Digital Set-Top Boxes (Video)	10.6	0.9	8.9	10.0	10.7	4.8	7.0
Digital Still Cameras (Personal Electronics)	104.1	20.5	15.2	1.9	-3.0	6.2	7.8
Video Game Controllers (Personal Electronics)	27.3	-20.0	-42.4	-16.7	-8.6	49.4	-12.1
Other Consumer Products	29.3	3.5	17.7	16.5	13.5	12.5	12.6
All Consumer Products	**23.9**	**1.8**	**2.6**	**6.2**	**5.3**	**9.6**	**5.1**

Source: Dataquest (November 1998)

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Table 2-18
Growth in the Value of Semiconductors Consumed in Japan by Individual Communications Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
LAN Cards (Premise Telecommunications)	118.3	75.0	14.5	12.8	-9.1	-3.2	14.7
Premise Line Cards (Premise Telecommunications)	16.0	13.1	0	6.3	-8.2	4.0	2.8
Answering Machines (Premise Telecommunications)	12.5	-8.7	-7.7	17.1	14.9	4.6	3.5
Fax Machines (Premise Telecommunications)	30.7	6.3	5.8	0.3	-0.4	-0.8	2.2
Modems (Premise Telecommunications)	-9.7	11.1	0.9	-2.7	-9.1	-4.5	-1.1
Corded Telephones (Premise Telecommunications)	-14.5	3.8	-8.5	-6.8	-6.0	-5.0	-4.6
Analog Cordless Phones (Premise Telecommunications)	6.2	15.9	-12.0	-4.5	-6.6	-9.1	-3.7
Digital Cordless Phones (Premise Telecommunications)	-28.5	-12.5	-0.2	0.8	-1.7	0.3	-2.8
Central Office Line Cards (Public Telecommunications)	17.5	3.4	11.0	7.0	-0.3	5.0	5.1
Analog Cellular Phones (Mobile Telecommunications)	-77.6	-100.0	-	-	-	-	-100.0
Digital Cellular Phones (Mobile Telecommunications)	27.8	-26.6	-19.8	-6.9	-13.2	-2.5	-14.2
Pagers (Mobile Telecommunications)	-17.2	-13.0	-17.4	-13.2	-14.7	-7.2	-13.2
Mobile Telecommunications Infrastructure (Mobile Telecommunications)	52.8	19.8	11.5	16.0	16.5	13.4	15.4
Other Mobile Telecommunications (Mobile Telecommunications)	8.7	11.8	-1.2	-0.9	-1.7	-0.4	1.4
Other Communications Products	25.0	-7.4	19.9	15.5	17.1	12.2	11.0
All Communications Products	**20.4**	**-7.5**	**6.1**	**8.5**	**8.7**	**8.1**	**4.6**

Source: Dataquest (November 1998)

Table 2-17
Value of Semiconductors Consumed in Japan by Individual Communications Product, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
LAN Cards (Premise Telecommunications)	5	9	10	12	11	10
Premise Line Cards (Premise Telecommunications)	5	6	6	6	6	6
Answering Machines (Premise Telecommunications)	1	1	1	1	1	1
Fax Machines (Premise Telecommunications)	64	68	72	72	72	71
Modems (Premise Telecommunications)	1	1	1	1	1	1
Corded Telephones (Premise Telecommunications)	3	4	3	3	3	3
Analog Cordless Phones (Premise Telecommunications)	27	31	27	26	24	22
Digital Cordless Phones (Premise Telecommunications)	28	25	25	25	24	24
Central Office Line Cards (Public Telecommunications)	10	11	12	13	13	13
Analog Cellular Phones (Mobile Telecommunications)	3	-	-	-	-	-
Digital Cellular Phones (Mobile Telecommunications)	209	154	123	115	100	97
Pagers (Mobile Telecommunications)	11	9	8	7	6	5
Mobile Telecommunications Infrastructure (Mobile Telecommunications)	62	74	83	96	112	127
Other Mobile Telecommunications (Mobile Telecommunications)	27	30	30	29	29	29
Other Communications Products	373	345	414	478	560	628
All Communications Products	**829**	**767**	**814**	**883**	**960**	**1,038**

Source: Dataquest (November 1998)

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Table 2-15
Value of Semiconductors Consumed in Japan by Individual Data Processing Product, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
Mainframe/Supercomputers (Computers)	72	98	100	98	88	71
Midrange Computers (Computers)	60	76	73	86	96	105
Workstations (Computers)	43	45	47	52	58	60
PCs (Computers)	700	730	727	847	1,032	1,013
Motherboards (Computers)	66	66	66	73	86	81
Rigid Disk Drives (Data Storage)	88	89	86	88	90	95
Optical Disk Drives (Data Storage)	95	119	131	144	148	157
Removable Magnetic Storage (Data Storage)	43	67	92	118	140	150
Page Printers (Input/Output)	63	66	71	74	79	81
Serial Printers (Input/Output)	68	76	73	69	68	65
Monitors (Input/Output)	15	17	16	18	20	21
Other Data Processing Products	232	216	285	381	490	583
All Data Processing Products	**1,545**	**1,664**	**1,767**	**2,047**	**2,395**	**2,483**

Source: Dataquest (November 1998)

Table 2-16
Growth in the Value of Semiconductors Consumed in Japan by Individual Data Processing Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Mainframe/Supercomputers (Computers)	18.4	36.0	2.2	-1.9	-10.3	-19.3	-0.3
Midrange Computers (Computers)	-3.0	25.9	-3.5	17.3	12.6	9.2	11.9
Workstations (Computers)	-10.5	3.8	3.5	11.5	11.2	4.3	6.8
PCs (Computers)	0.8	4.2	-0.3	16.4	21.9	-1.8	7.7
Motherboards (Computers)	31.0	0.4	-0.1	9.6	18.9	-6.3	4.1
Rigid Disk Drives (Data Storage)	19.6	1.0	-3.1	2.7	2.3	5.9	1.7
Optical Disk Drives (Data Storage)	95.6	24.9	9.7	10.3	2.4	6.1	10.4
Removable Magnetic Storage (Data Storage)	68.7	55.8	37.6	28.9	18.4	7.2	28.5
Page Printers (Input/Output)	0.8	6.3	7.5	2.9	6.8	3.7	5.4
Serial Printers (Input/Output)	42.5	11.0	-4.4	-5.2	-0.5	-5.4	-1.1
Monitors (Input/Output)	35.7	15.9	-4.2	10.7	12.4	3.8	7.5
Other Data Processing Products	-8.8	-6.7	31.9	33.5	28.7	19.0	20.3
All Data Processing Products	**6.0**	**12.1**	**9.9**	**9.5**	**3.8**	**4.4**	**10.0**

Source: Dataquest (November 1998)

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Table 2-14
Growth in the Value of Semiconductors Consumed in Japan by Electronic Product Group, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
All Electronic Products	**14.6**	**0.9**	**6.9**	**12.1**	**12**	**7.5**	**7.8**
Data Processing Products	**7.4**	**7.7**	**6.1**	**15.8**	**17.0**	**3.7**	**10.0**
Computers	2.8	7.7	-0.1	14.0	17.8	-2.2	7.2
Data Storage	53.2	21.5	12.4	13.7	7.8	6.5	12.2
Input/Output	16.1	1.3	5.6	5.7	12.4	4.5	5.8
Dedicated Systems	2.1	-2.0	35.2	37.9	34.0	19.6	24.0
Other Data Processing	-35.1	-4.8	44.2	43.1	22.1	24.9	24.6
Communications Products	**20.4**	**-7.5**	**6.1**	**8.5**	**8.7**	**8.1**	**4.6**
Premise Telecommunications	12.8	0.4	5.0	3.9	5.0	4.8	3.8
Public Telecommunications	30.7	-7.3	23.6	17.6	17.0	11.8	12.0
Mobile Communications	22.0	-14.3	-8.9	1.4	-0.3	4.9	-3.7
Broadcast and Studio	-2.0	3.6	25.8	20.7	24.8	17.2	18.1
Other Communications	19.3	-11.1	24.3	21.2	18.9	13.0	12.5
Industrial Products	**15.4**	**-14.6**	**18.8**	**17.1**	**14.8**	**13.1**	9.1
Security and Energy Management	-8.8	-5.7	11.5	13.1	16.9	13.7	9.6
Manufacturing Systems/Instruments	18.8	-16.5	20.8	17.8	14.1	12.1	8.7
Medical Equipment	9.6	-4.5	10.2	14.8	17.9	19.6	11.2
Other Industrial	17.3	-14.0	17.7	17.1	15.9	14.7	9.5
Consumer Products	**23.9**	**1.8**	**2.6**	**6.2**	**5.3**	**9.6**	**5.1**
Audio	14.7	-1.5	10.1	10.4	8.6	2.1	5.8
Video	9.0	10.7	0.1	-5.1	-7.7	-6.7	-2.0
Personal Electronics	59.2	2.0	0	11.0	9.9	23.8	9.0
Appliances	-10.0	-11.6	9.8	12.2	10.4	-3.2	3.1
Other Consumer	-6.0	-17.5	9.1	10.0	15.6	0.5	2.8
Military/Civil Aerospace Products	**1.6**	**0.5**	**15.1**	**13.3**	**-1.3**	**4.6**	**6.2**
Transportation Products	**7.2**	**11.0**	**13.0**	**13.8**	**12.0**	**12.5**	**12.4**
Semiconductor Shipments	**-5.0**	**-5.2**	**9.7**	**17.8**	**22.5**	**7.0**	**9.9**

Source: Dataquest (November 1998)

Table 2-13
Value of Semiconductors Consumed in Japan by Electronic Product Group, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
All Electronic Products	**4,277**	**4,314**	**4,613**	**5,169**	**5,790**	**6,222**
Data Processing Products	**1,545**	**1,664**	**1,767**	**2,047**	**2,395**	**2,483**
Computers	942	1,015	1,013	1,155	1,360	1,330
Data Storage	226	274	308	351	378	402
Input/Output	224	227	239	253	285	297
Dedicated Systems	97	95	128	177	237	283
Other Data Processing	57	54	78	111	136	170
Communications Products	**829**	**767**	**814**	**883**	**960**	**1,038**
Premise Telecommunications	254	255	267	278	292	306
Public Telecommunications	212	196	243	285	334	373
Mobile Communications	312	267	243	247	246	258
Broadcast and Studio	15	15	19	23	29	33
Other Communications	37	33	41	50	59	67
Industrial Products	**477**	**408**	**484**	**567**	**651**	**737**
Security/Energy Management	34	32	36	41	48	54
Manufacturing Systems/Instruments	345	288	348	410	467	524
Medical Equipment	32	31	34	39	46	55
Other Industrial	66	57	67	78	90	104
Consumer Products	**1,124**	**1,144**	**1,174**	**1,246**	**1,313**	**1,439**
Audio	169	166	183	202	219	224
Video	314	347	348	330	304	284
Personal Electronics	492	502	502	557	612	758
Appliances	95	84	92	103	114	110
Other Consumer	55	45	50	55	63	63
Military/Civil Aerospace Products	**38**	**38**	**44**	**49**	**49**	**51**
Transportation Products	**264**	**293**	**331**	**377**	**422**	**474**
Semiconductor Shipments	**4,420**	**4,189**	**4,597**	**5,413**	**6,632**	**7,094**

Source: Dataquest (November 1998)

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Table 2-11
Value of Semiconductors Consumed in Japan by Individual Transportation Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Automotive Stereos	203	207	199	220	219	222
Automotive ECUs	526	565	571	588	598	605
Antilock Braking Systems	129	140	151	161	176	188
Air Bags	107	125	136	144	151	160
Automotive Navigation Systems	259	304	445	611	802	1,006
Other Transportation Products	956	807	850	953	1,050	1,189
All Transportation Products	**2,180**	**2,149**	**2,351**	**2,676**	**2,996**	**3,370**
Exchange Rate (Yen/U.S.$)	**121.10**	**136.35**	**140.79**	**140.79**	**140.79**	**140.79**

Source: Dataquest (November 1998)

Table 2-12
Growth in the Value of Semiconductors Consumed in Japan by Individual Transportation Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Automotive Stereos	-4.5	2.1	-4.1	10.8	-0.5	1.5	1.8
Automotive ECUs	6.0	7.5	1.0	2.9	1.8	1.1	2.8
Antilock Braking Systems	19.2	8.2	7.8	6.8	9.6	6.8	7.8
Air Bags	22.7	17.0	8.3	5.8	5.2	5.9	8.4
Automotive Navigation Systems	20.5	17.4	46.2	37.3	31.3	25.5	31.2
Other Transportation Products	-16.4	-15.6	5.4	12.1	10.2	13.2	4.5
All Transportation Products	**-3.7**	**-1.4**	**9.4**	**13.8**	**12.0**	**12.5**	**9.1**

Source: Dataquest (November 1998)

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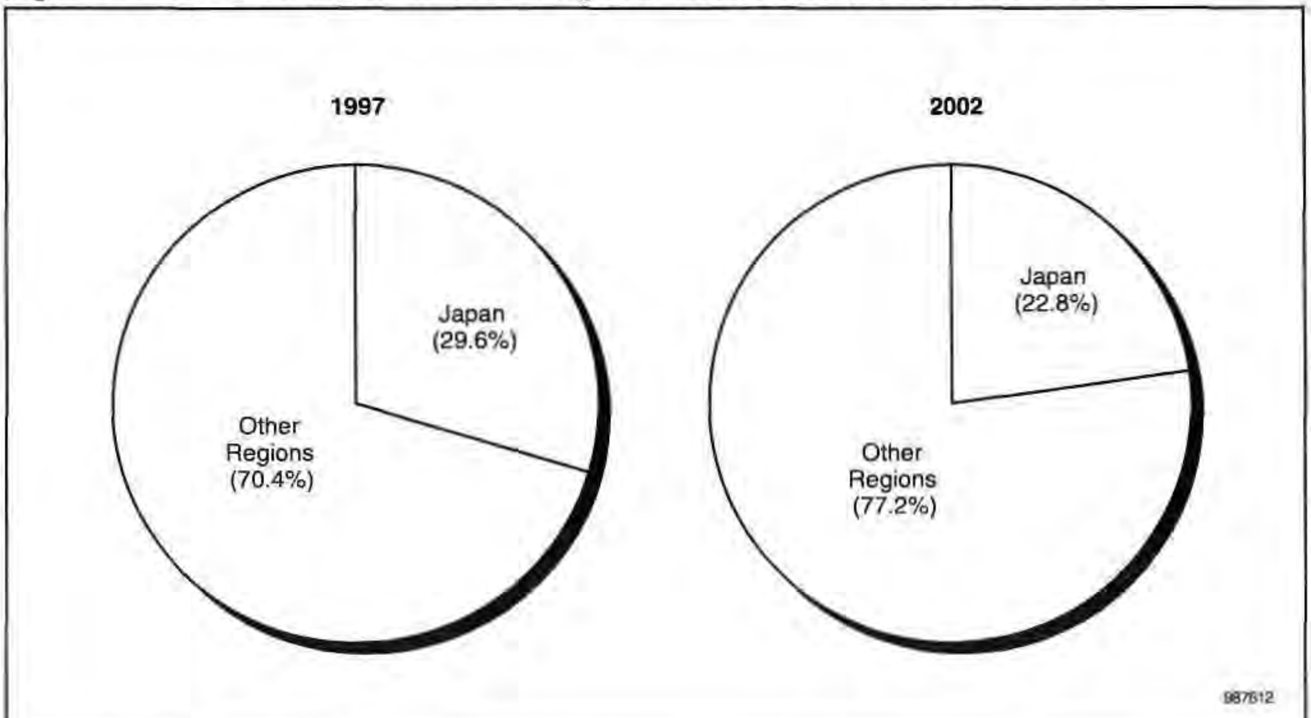
Table 3-7
Production and Semiconductor Consumption Forecast for Optical Disk Drives in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	25,599	31,069	36,198	40,973	45,175	50,464	14.5
Factory ASP (U.S.$)	86.5	61.5	46.4	41.6	38.9	35.5	-16.3
Factory Revenue (U.S.$M)	2,214	1,910	1,680	1,706	1,757	1,791	-4.2
Semiconductor Content (U.S.$)	30.8	28.1	25.6	25.0	23.2	22.0	-6.5
Semiconductor TAM (U.S.$M)	787	873	928	1,023	1,048	1,112	7.1

Source: Dataquest (November 1998)

Figure 3-7
Japanese Unit Production Trends for Optical Disk Drives, 1997 versus 2002



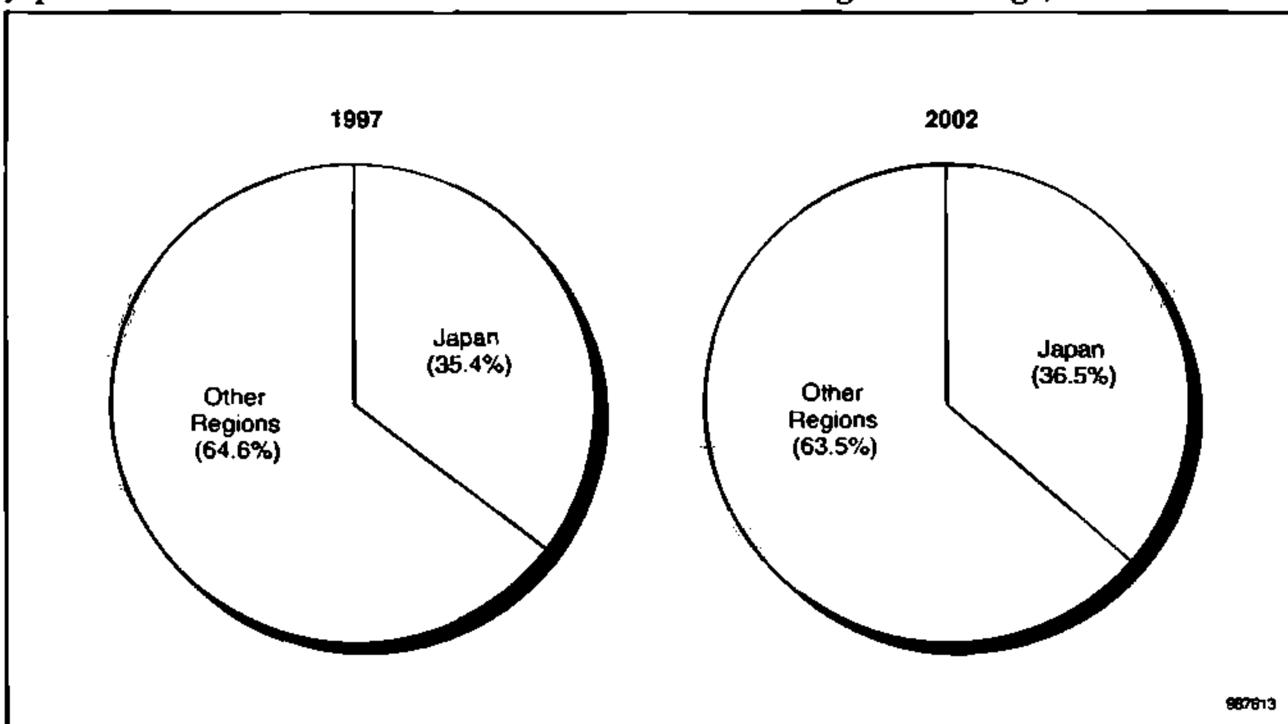
Source: Dataquest (November 1998)

Table 3-8
Production and Semiconductor Consumption Forecast for Removable Magnetic Storage in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	NA	NA	NA	NA	NA	NA	NA
Factory ASP (U.S.$)	NA	NA	NA	NA	NA	NA	NA
Factory Revenue (U.S.$M)	1,611	2,024	2,484	3,092	3,584	3,687	18.0
Semiconductor Content (U.S.$)	NA	NA	NA	NA	NA	NA	NA
Semiconductor TAM (U.S.$M)	131	142	168	188	215	227	11.6

NA = Not available or not applicable
Note: Semiconductor TAM figures are derived from regional estimation.
Source: Dataquest (November 1998)

Figure 3-8
Japanese Revenue Production Trends for Removable Magnetic Storage, 1997 versus 2002



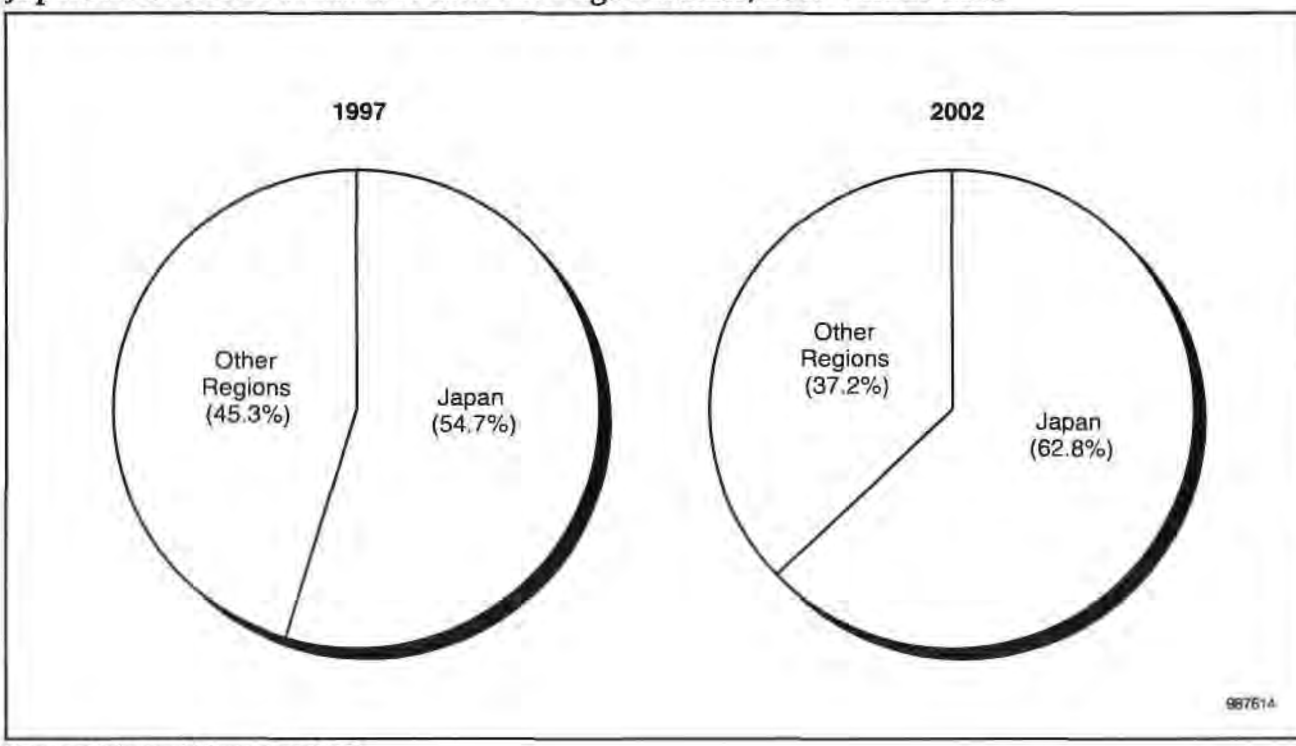
Source: Dataquest (November 1998)

Table 3-9
Production and Semiconductor Consumption Forecast for Page Printers in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	5,204	5,412	6,061	6,667	7,534	8,137	9.4
Factory ASP (U.S.$)	450.0	410.0	390.0	360.0	340.0	330.0	-6.0
Factory Revenue (U.S.$M)	2,342	2,219	2,364	2,400	2,562	2,685	2.8
Semiconductor Content (U.S.$)	99.2	90.1	83.7	78.3	74.0	71.1	-6.4
Semiconductor TAM (U.S.$M)	516	487	507	522	558	579	2.3

Source: Dataquest (November 1998)

Figure 3-9
Japanese Unit Production Trends for Page Printers, 1997 versus 2002



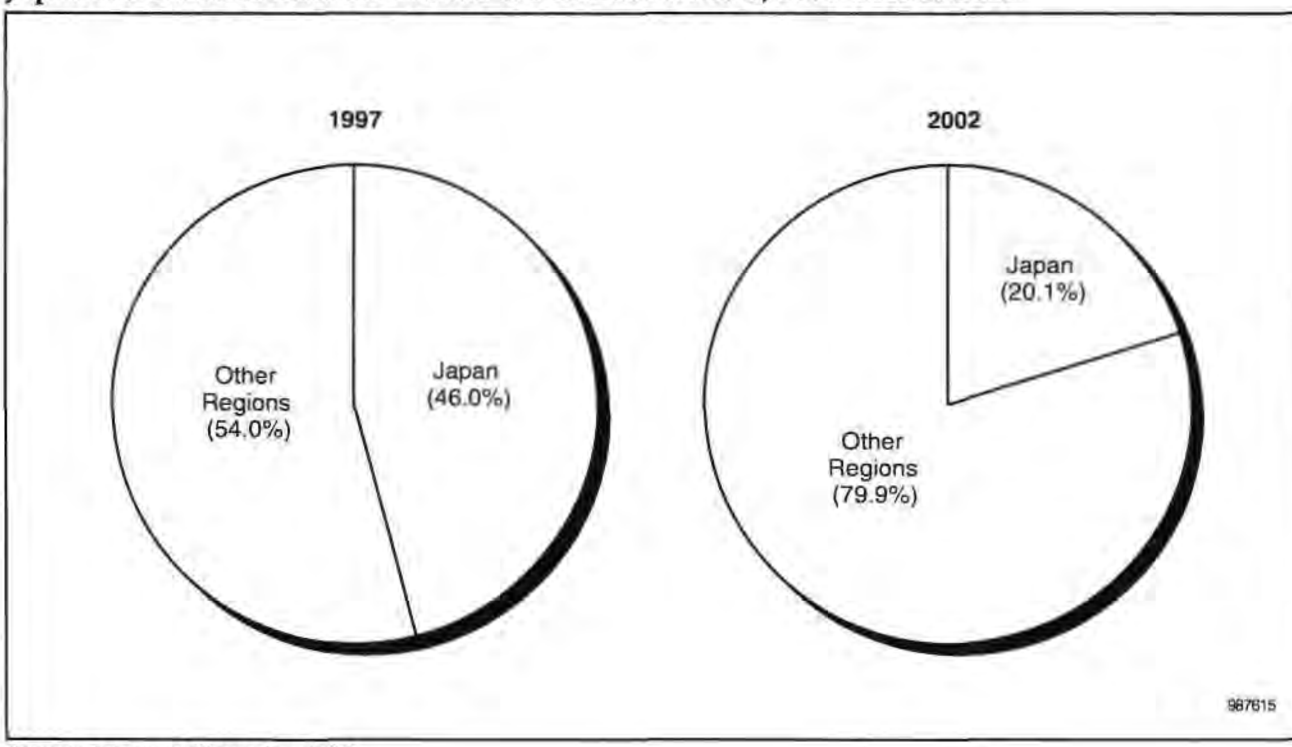
Source: Dataquest (November 1998)

Table 3-10
Production and Semiconductor Consumption Forecast for Serial Printers in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	18,403	17,483	16,084	14,798	13,762	13,074	-6.6
Factory ASP (U.S.$)	231.0	223.0	214.0	204.0	196.0	190.0	-3.8
Factory Revenue (U.S.$M)	4,251	3,899	3,442	3,019	2,697	2,484	-10.2
Semiconductor Content (U.S.$)	30.7	31.8	32.0	33.0	35.3	35.2	2.8
Semiconductor TAM (U.S.$M)	564	556	515	488	486	460	-4.0

Source: Dataquest (November 1998)

Figure 3-10
Japanese Unit Production Trends for Serial Printers, 1997 versus 2002



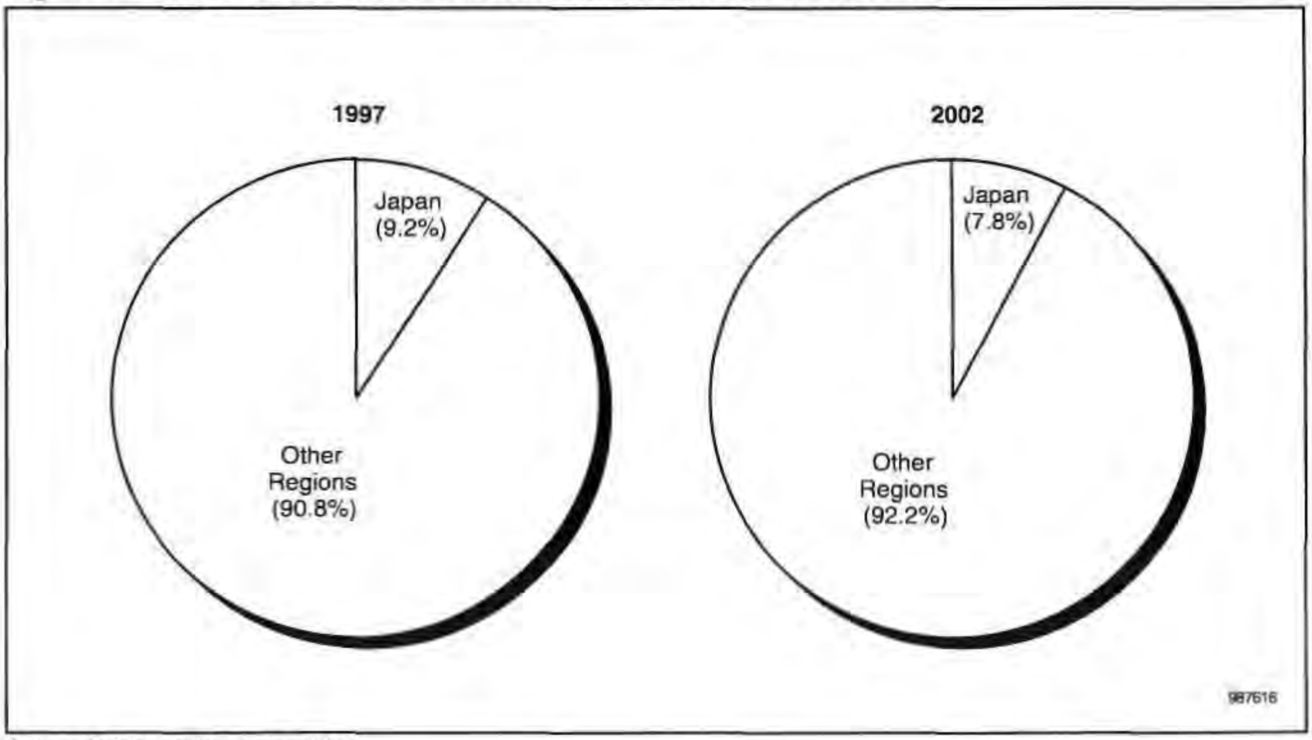
Source: Dataquest (November 1998)

Table 3-11
Production and Semiconductor Consumption Forecast for Monitors in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	7,159	7,228	7,359	8,146	9,157	10,134	7.2
Factory ASP (U.S.$)	562.0	479.0	431.0	388.0	342.0	308.0	-11.3
Factory Revenue (U.S.$M)	4,023	3,462	3,172	3,161	3,132	3,121	-5.0
Semiconductor Content (U.S.$)	17.0	17.0	16.0	16.0	16.0	15.0	-2.5
Semiconductor TAM (U.S.$M)	122	123	118	130	147	152	4.5

Source: Dataquest (November 1998)

Figure 3-11
Japanese Unit Production Trends for Monitors, 1997 versus 2002



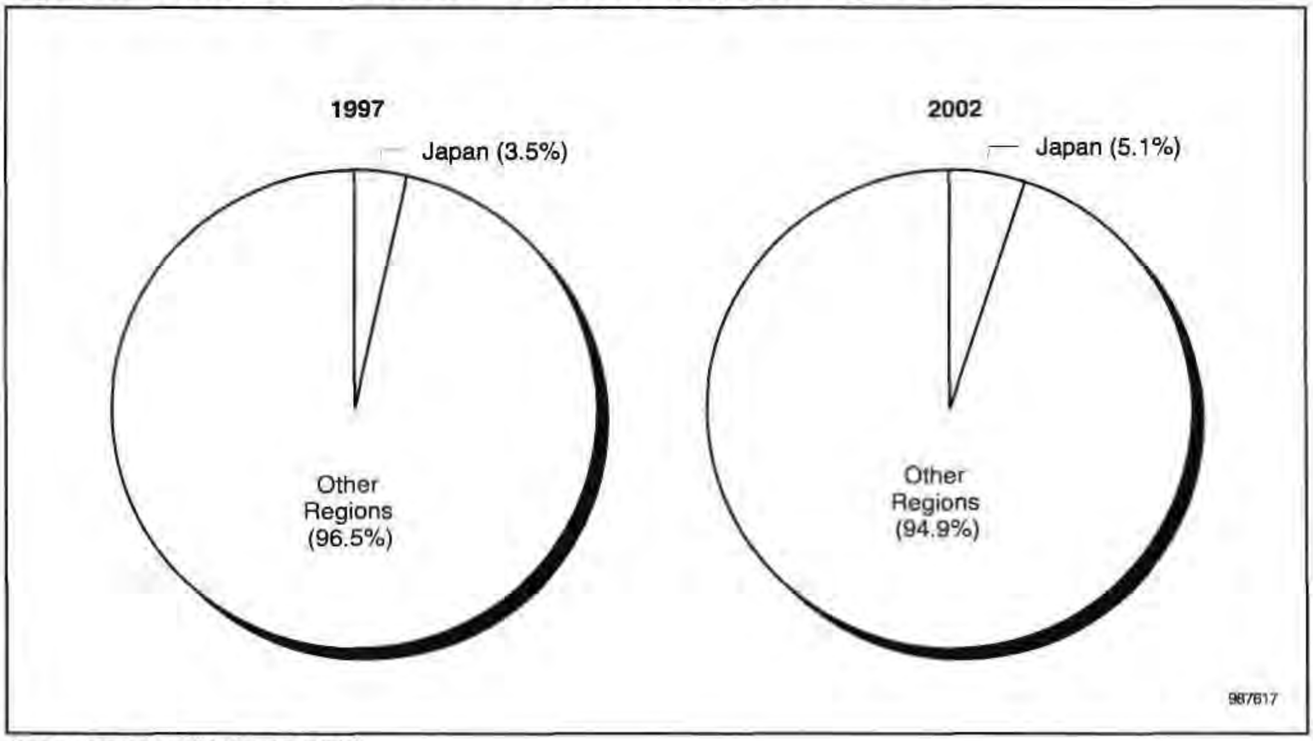
Source: Dataquest (November 1998)

Table 3-12
Production and Semiconductor Consumption Forecast for LAN Cards in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	1,932	3,083	3,731	4,301	4,144	4,620	19.0
Factory ASP (U.S.$)	145.9	142.4	139.3	137.9	127.6	123.4	-3.3
Factory Revenue (U.S.$M)	282	439	520	593	529	570	15.1
Semiconductor Content (U.S.$)	22.2	21.2	20.0	19.6	18.5	16.1	-6.2
Semiconductor TAM (U.S.$M)	43	65	75	84	77	74	11.6

Source: Dataquest (November 1998)

Figure 3-12
Japanese Unit Production Trends for LAN Cards, 1997 versus 2002



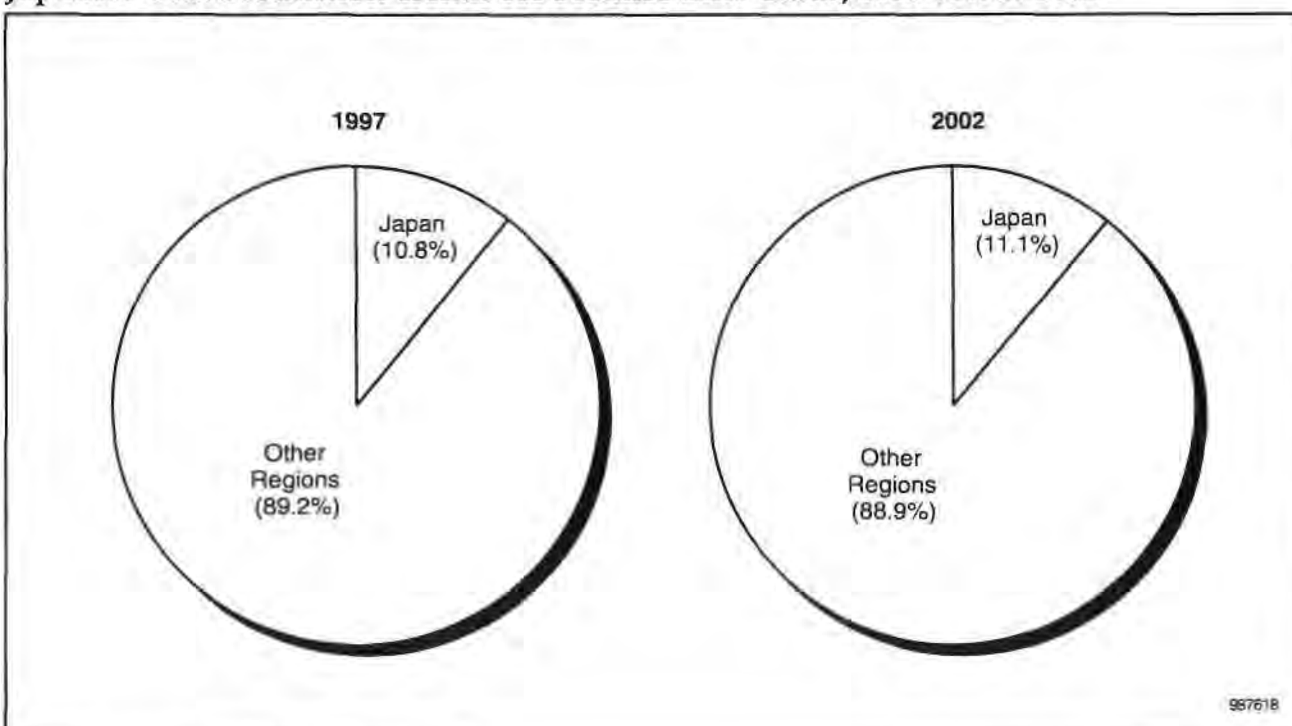
Source: Dataquest (November 1998)

Table 3-13
Production and Semiconductor Consumption Forecast for Premise Line Cards in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	3,561	3,691	3,775	4,012	4,053	4,214	3.4
Factory ASP (U.S.$)	80.8	82.4	82.0	81.0	80.0	79.0	-0.4
Factory Revenue (U.S.$M)	288	304	310	325	324	333	3.0
Semiconductor Content (U.S.$)	11.8	11.3	11.0	11.0	10.0	10.0	-3.3
Semiconductor TAM (U.S.$M)	42	42	42	44	41	42	0

Source: Dataquest (November 1998)

Figure 3-13
Japanese Unit Production Trends for Premise Line Cards, 1997 versus 2002



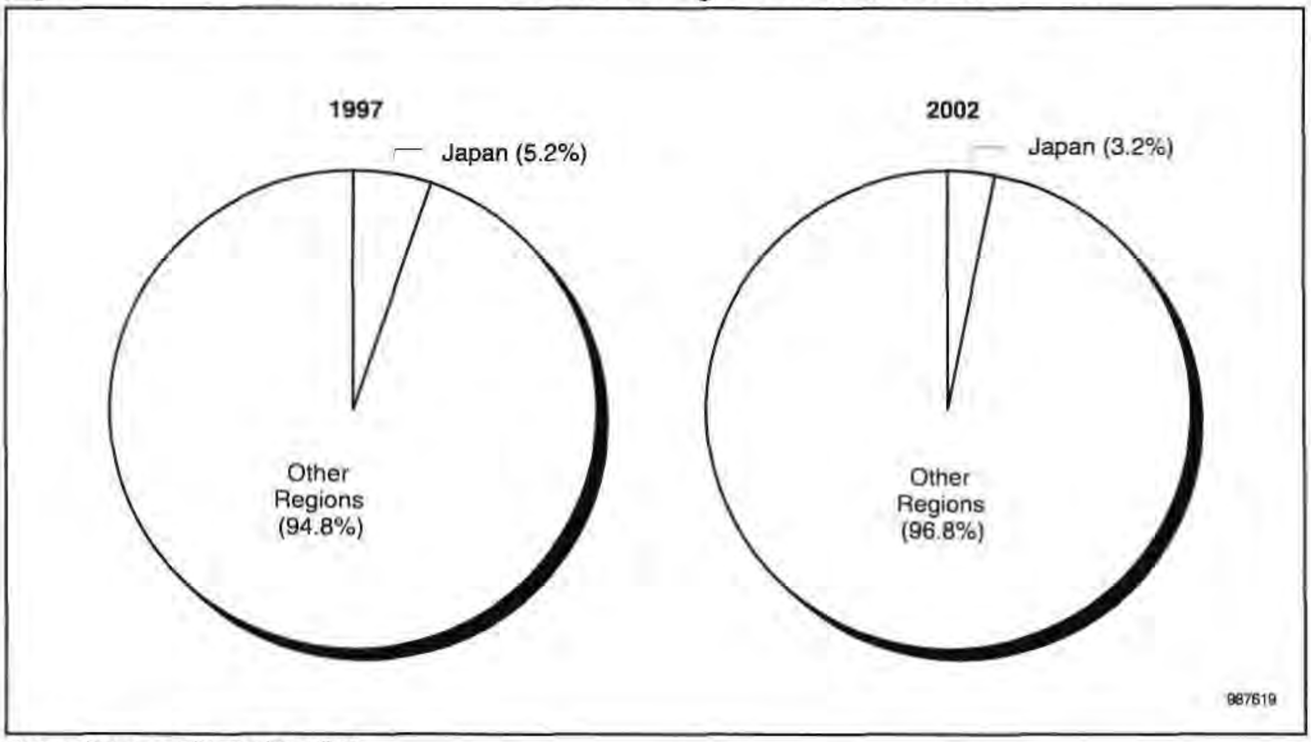
Source: Dataquest (November 1998)

Table 3-14
Production and Semiconductor Consumption Forecast for Answering Machines in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	1,357	1,311	1,217	1,140	1,092	1,087	-4.3
Factory ASP (U.S.$)	36.1	34.7	34.8	36.7	40.0	42.0	3.0
Factory Revenue (U.S.$M)	49	45	42	42	44	46	-1.4
Semiconductor Content (U.S.$)	4.6	3.8	3.8	4.7	5.6	5.9	5.2
Semiconductor TAM (U.S.$M)	6	5	5	5	6	6	0.6

Source: Dataquest (November 1998)

Figure 3-14
Japanese Unit Production Trends for Answering Machines, 1997 versus 2002



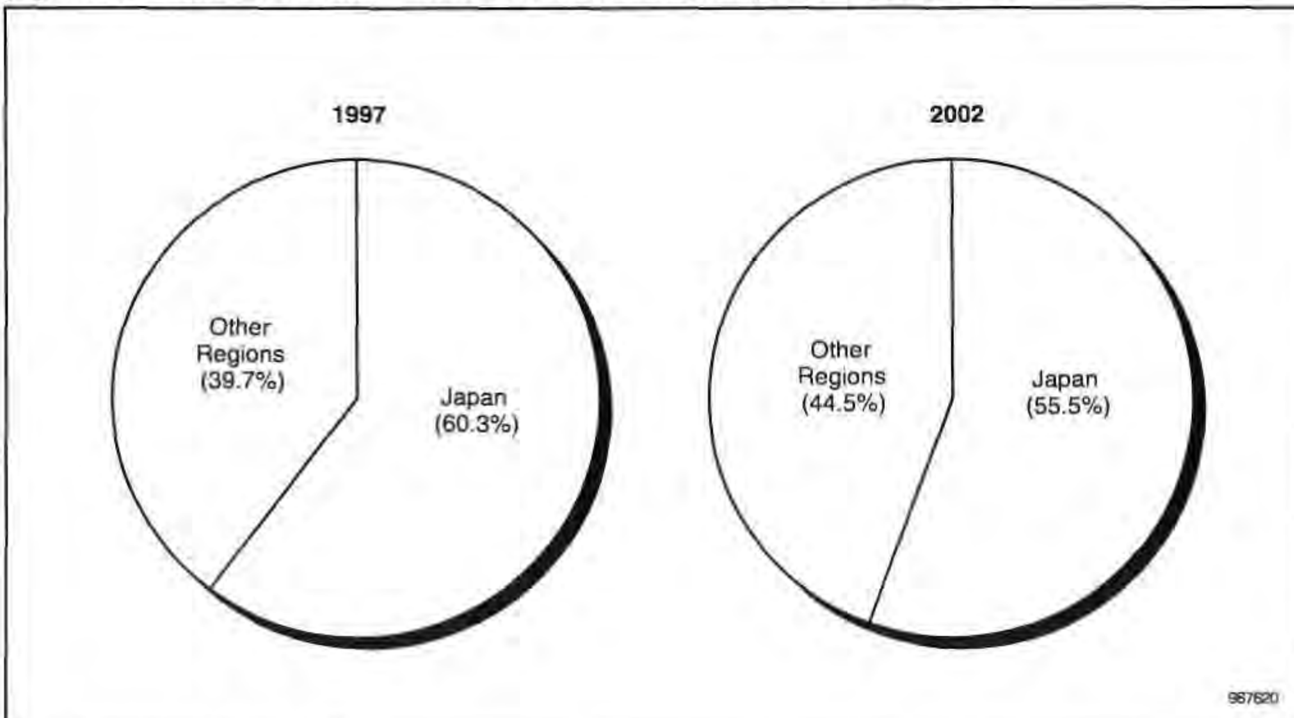
Source: Dataquest (November 1998)

Table 3-15
Production and Semiconductor Consumption Forecast for Fax Machines in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	6,595	6,266	6,892	7,099	7,170	7,313	2.1
Factory ASP (U.S.$)	388.0	375.0	370.0	365.0	362.0	360.0	-1.5
Factory Revenue (U.S.$M)	2,559	2,350	2,550	2,591	2,596	2,633	0.6
Semiconductor Content (U.S.$)	80.0	78.0	75.0	73.0	72.0	70.0	-2.6
Semiconductor TAM (U.S.$M)	528	489	517	518	516	512	-0.6

Source: Dataquest (November 1998)

Figure 3-15
Japanese Unit Production Trends for Fax Machines, 1997 versus 2002



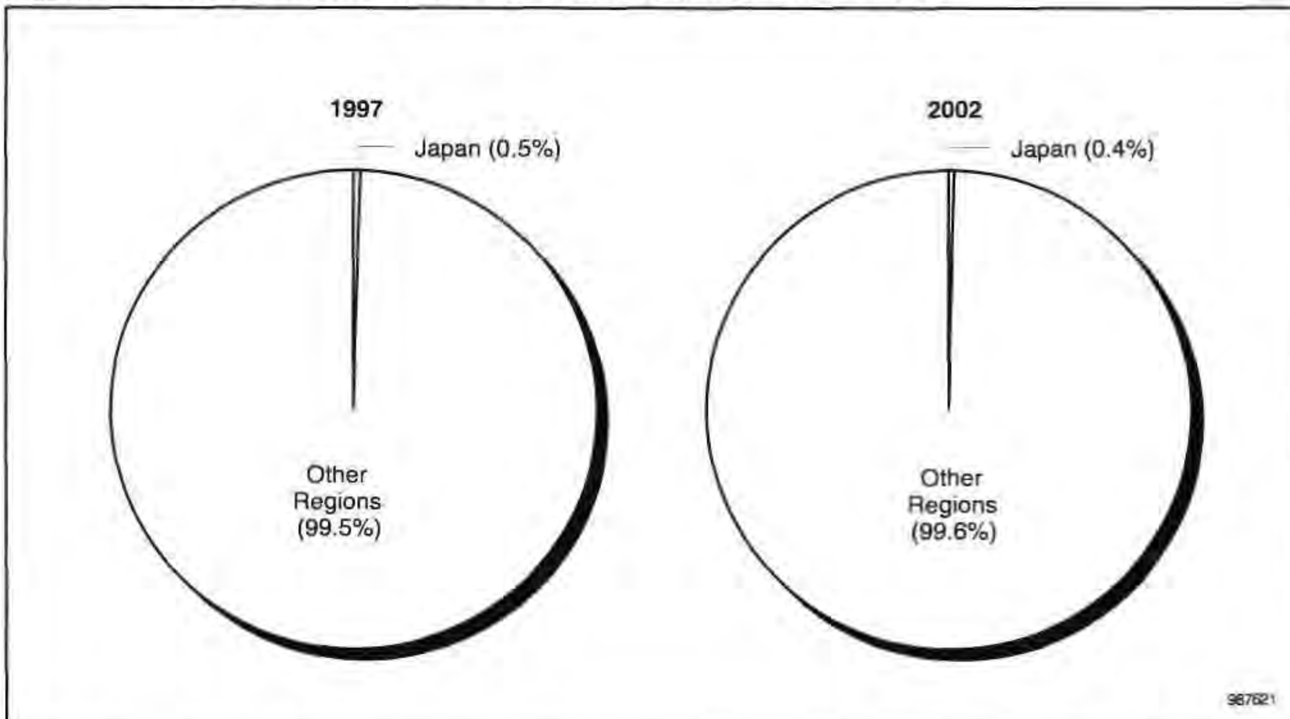
Source: Dataquest (November 1998)

Table 3-16
Production and Semiconductor Consumption Forecast for Modems in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	217	225	235	247	255	268	4.3
Factory ASP (U.S.$)	180.0	150.0	130.0	120.0	110.0	100.0	-11.1
Factory Revenue (U.S.$M)	39	34	31	30	28	27	-7.2
Semiconductor Content (U.S.$)	30.0	28.0	27.0	25.0	22.0	20.0	-7.8
Semiconductor TAM (U.S.$M)	7	6	6	6	6	5	-3.8

Source: Dataquest (November 1998)

Figure 3-16
Japanese Unit Production Trends for Modems, 1997 versus 2002



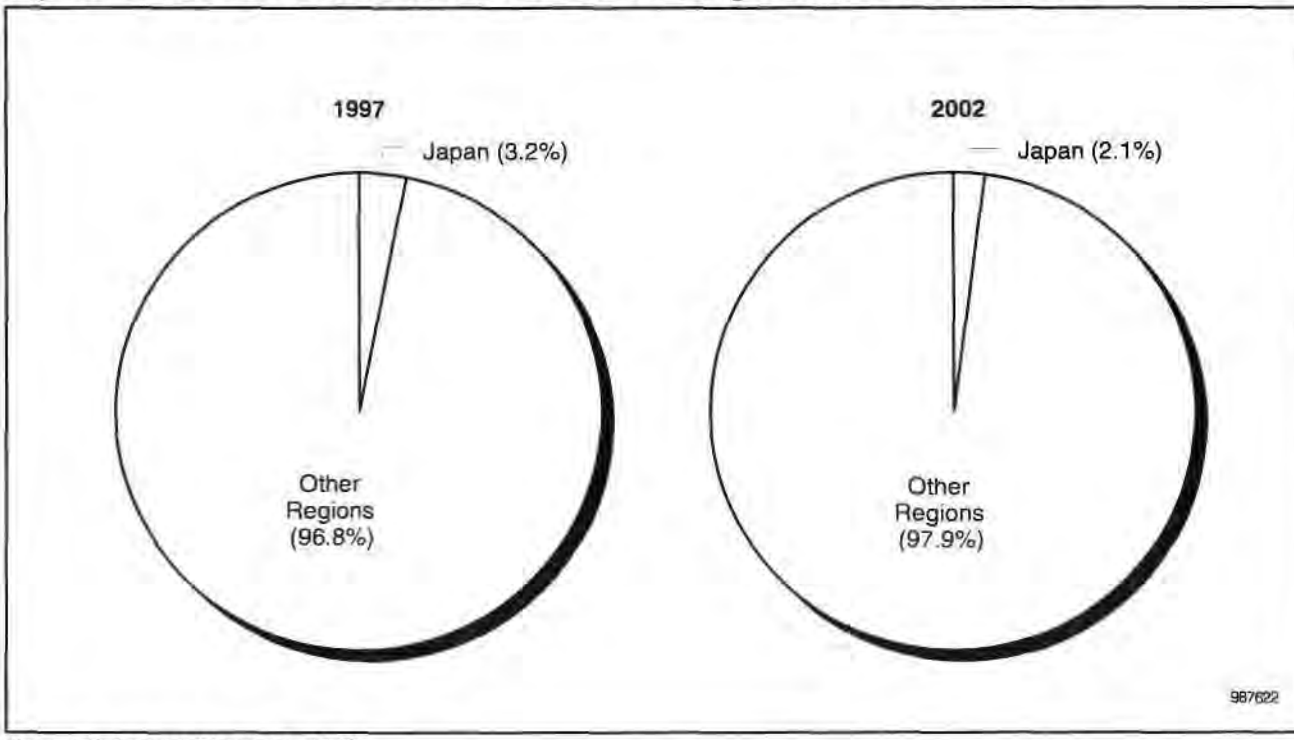
Source: Dataquest (November 1998)

Table 3-17
Production and Semiconductor Consumption Forecast for Corded Telephones in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	5,096	4,790	4,551	4,323	4,064	3,861	-5.4
Factory ASP (U.S.$)	50.0	47.0	45.0	43.0	41.0	39.1	-4.8
Factory Revenue (U.S.$M)	255	225	205	186	167	151	-9.9
Semiconductor Content (U.S.$)	5.6	5.4	5.2	5.1	5.1	5.1	-1.9
Semiconductor TAM (U.S.$M)	29	26	24	22	21	20	-7.2

Source: Dataquest (November 1998)

Figure 3-17
Japanese Unit Production Trends for Corded Telephones, 1997 versus 2002



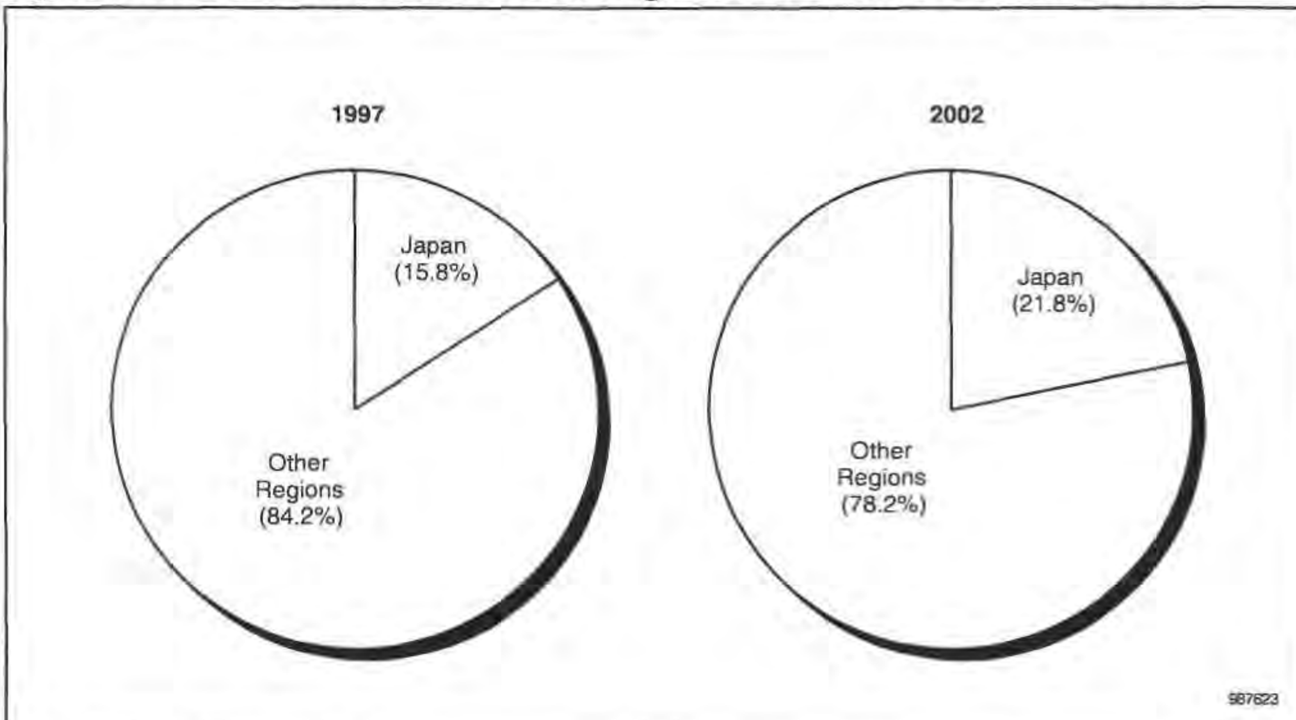
Source: Dataquest (November 1998)

Table 3-18
Production and Semiconductor Consumption Forecast for Analog Cordless Phones in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	6,857	6,924	6,502	6,208	5,996	5,448	-4.5
Factory ASP (U.S.$)	70.0	70.0	68.0	65.0	62.0	61.0	-2.7
Factory Revenue (U.S.$M)	480	485	442	404	372	332	-7.1
Semiconductor Content (U.S.$)	32.0	32.0	30.0	30.0	29.0	29.0	-1.9
Semiconductor TAM (U.S.$M)	219	222	195	186	174	158	-6.4

Source: Dataquest (November 1998)

Figure 3-18
Japanese Unit Production Trends for Analog Cordless Phones, 1997 versus 2002



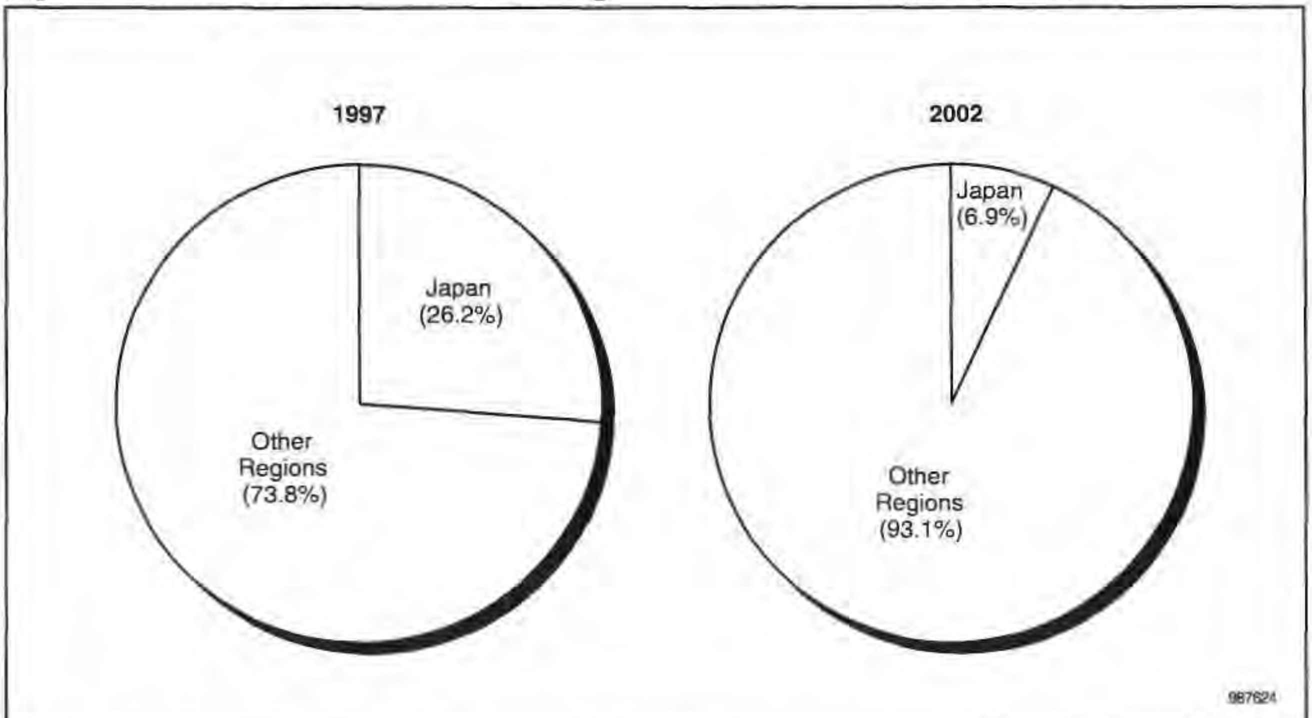
Source: Dataquest (November 1998)

Table 3-19
Production and Semiconductor Consumption Forecast for Digital Cordless Phones in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	3,686	3,137	3,424	3,808	4,091	4,605	4.6
Factory ASP (U.S.$)	109.1	96.7	88.2	79.5	71.5	64.2	-10.1
Factory Revenue (U.S.$M)	402	303	302	303	293	296	-6.0
Semiconductor Content (U.S.$)	63.1	56.5	51.6	46.8	42.8	38.2	-9.6
Semiconductor TAM (U.S.$M)	232	177	177	178	175	176	-5.4

Source: Dataquest (November 1998)

Figure 3-19
Japanese Unit Production Trends for Digital Cordless Phones, 1997 versus 2002



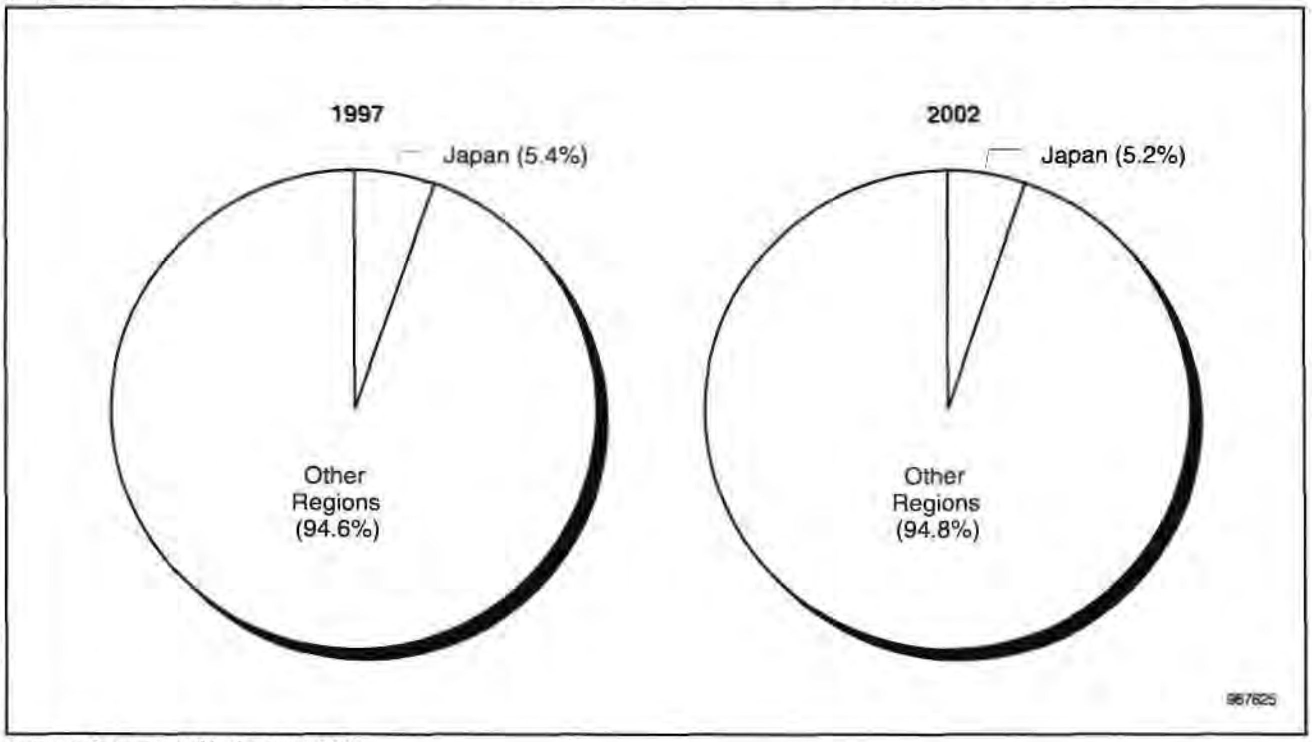
Source: Dataquest (November 1998)

Table 3-20
Production and Semiconductor Consumption Forecast for Central Office Line Cards in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	6,162	5,977	6,634	7,099	7,667	8,050	5.5
Factory ASP (U.S.$)	80.8	82.4	80.0	78.0	77.0	75.0	-1.5
Factory Revenue (U.S.$M)	498	492	531	554	590	604	3.9
Semiconductor Content (U.S.$)	14.0	13.0	13.0	13.0	12.0	12.0	-3.0
Semiconductor TAM (U.S.$M)	86	78	86	92	92	97	2.3

Source: Dataquest (November 1998)

Figure 3-20
Japanese Unit Production Trends for Central Office Line Cards, 1997 versus 2002



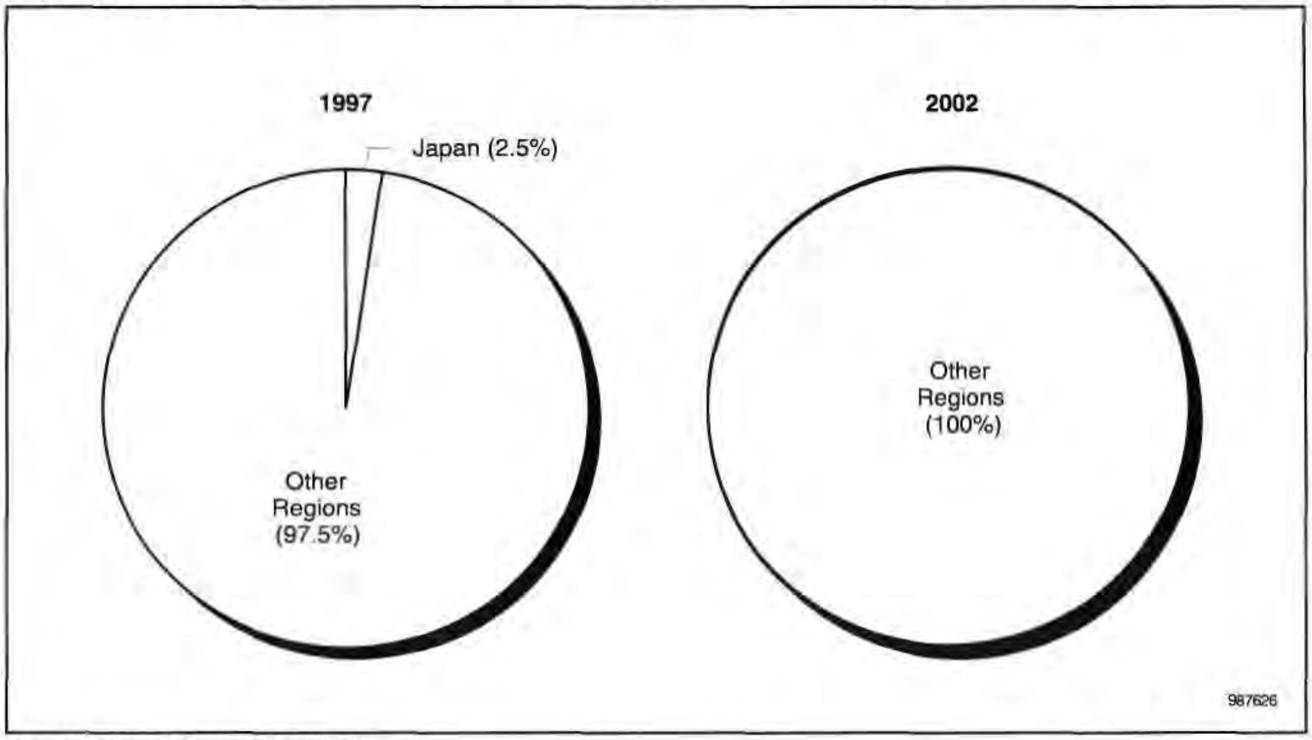
Source: Dataquest (November 1998)

Table 3-21
Production and Semiconductor Consumption Forecast for Analog Cellular Phones in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	620	-	-	-	-	-	-100.0
Factory ASP (U.S.$)	430	-	-	-	-	-	-100.0
Factory Revenue (U.S.$M)	267	-	-	-	-	-	-100.0
Semiconductor Content (U.S.$)	41	-	-	-	-	-	-100.0
Semiconductor TAM (U.S.$M)	25	-	-	-	-	-	-100.0

Source: Dataquest (November 1998)

Figure 3-21
Japanese Unit Production Trends for Analog Cellular Phones, 1997 versus 2002



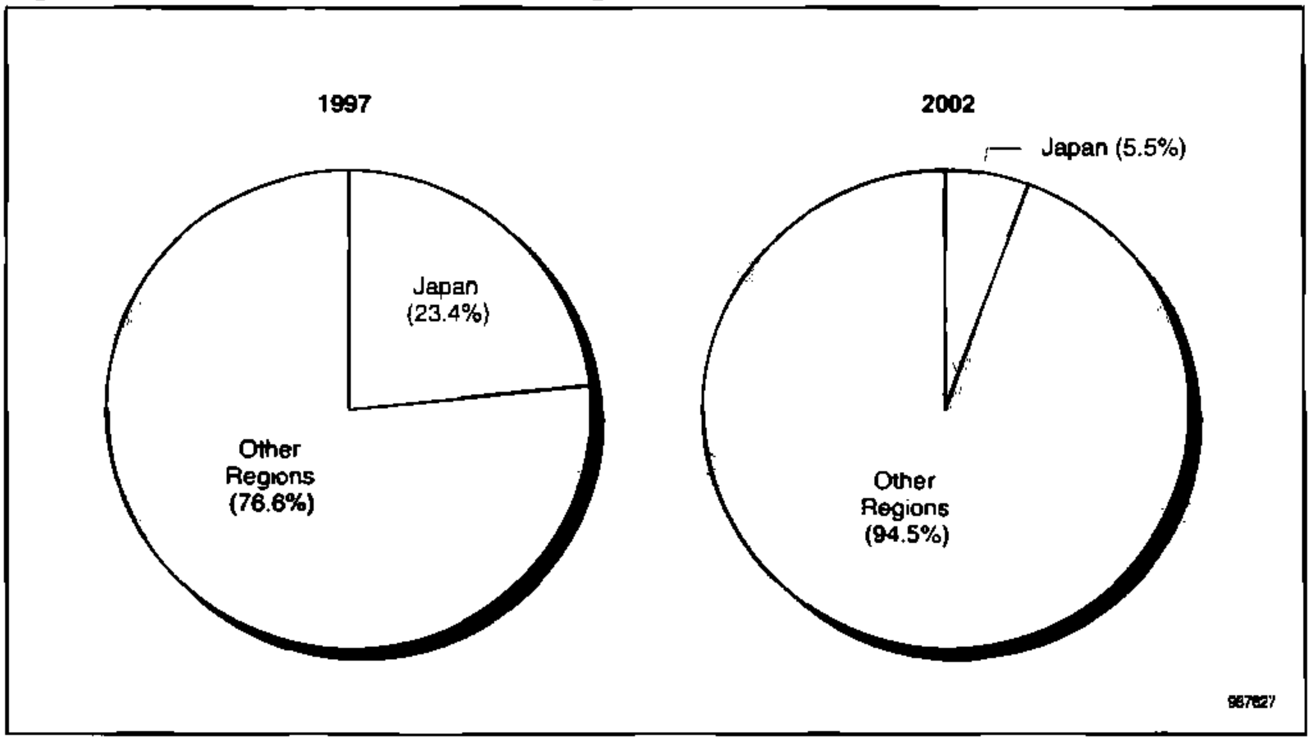
Source: Dataquest (November 1998)

Table 3-22
Production and Semiconductor Consumption Forecast for Digital Cellular Phones in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	23,045	18,525	17,150	17,700	17,075	17,325	-5.5
Factory ASP (U.S.$)	310.0	237.5	200.0	175.1	153.2	142.5	-14.4
Factory Revenue (U.S.$M)	7,144	4,400	3,429	3,099	2,615	2,469	-19.1
Semiconductor Content (U.S.$)	75.0	59.7	51.7	46.7	42.0	40.4	-11.6
Semiconductor TAM (U.S.$M)	1,728	1,106	887	826	717	700	-16.5

Source: Dataquest (November 1998)

Figure 3-22
Japanese Unit Production Trends for Digital Cellular Phones, 1997 versus 2002



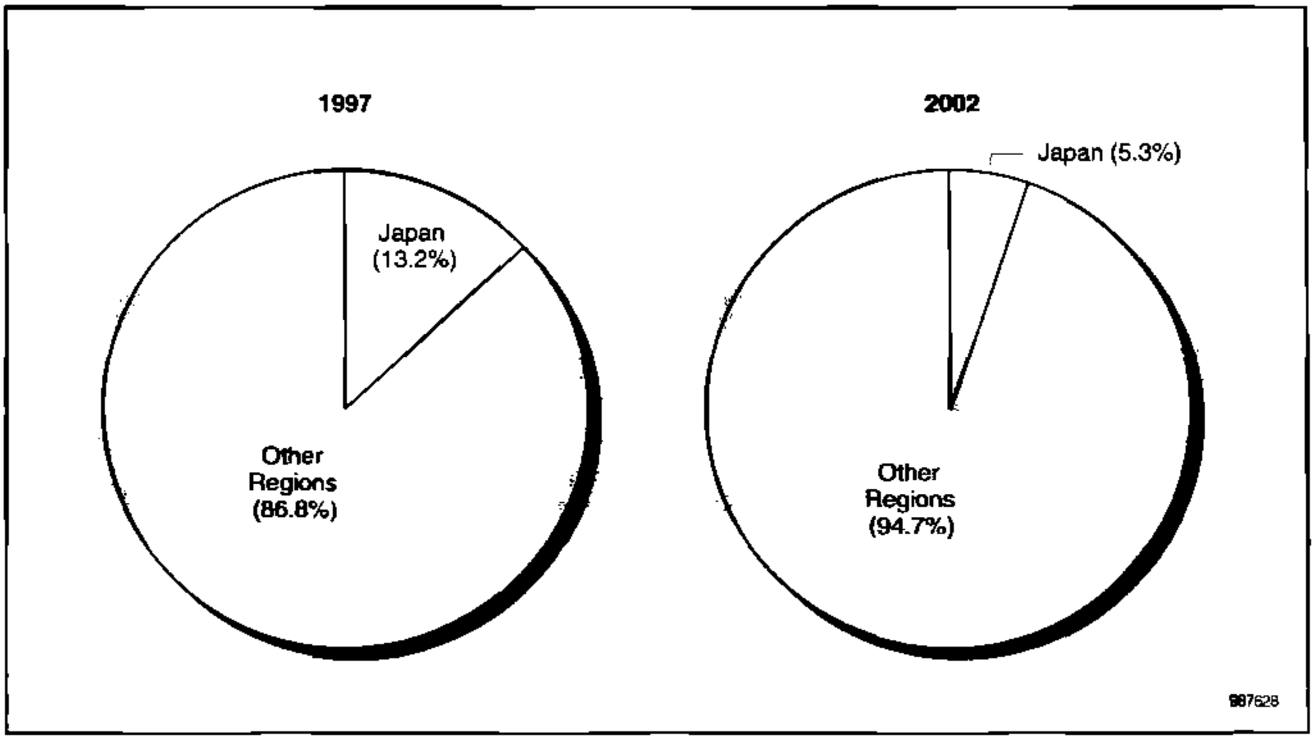
Source: Dataquest (November 1998)

Table 3-23
Production and Semiconductor Consumption Forecast for Pagers in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	5,761	4,608	3,917	3,525	3,173	3,014	-12.1
Factory ASP (U.S.$)	82	78	76	73	68	66	-4.2
Factory Revenue (U.S.$M)	472	359	298	257	216	199	-15.9
Semiconductor Content (U.S.$)	15.2	14.4	14.0	13.5	12.8	12.5	-3.8
Semiconductor TAM (U.S.$M)	88	66	55	48	41	38	-15.5

Source: Dataquest (November 1998)

Figure 3-23
Japanese Unit Production Trends for Pagers, 1997 versus 2002



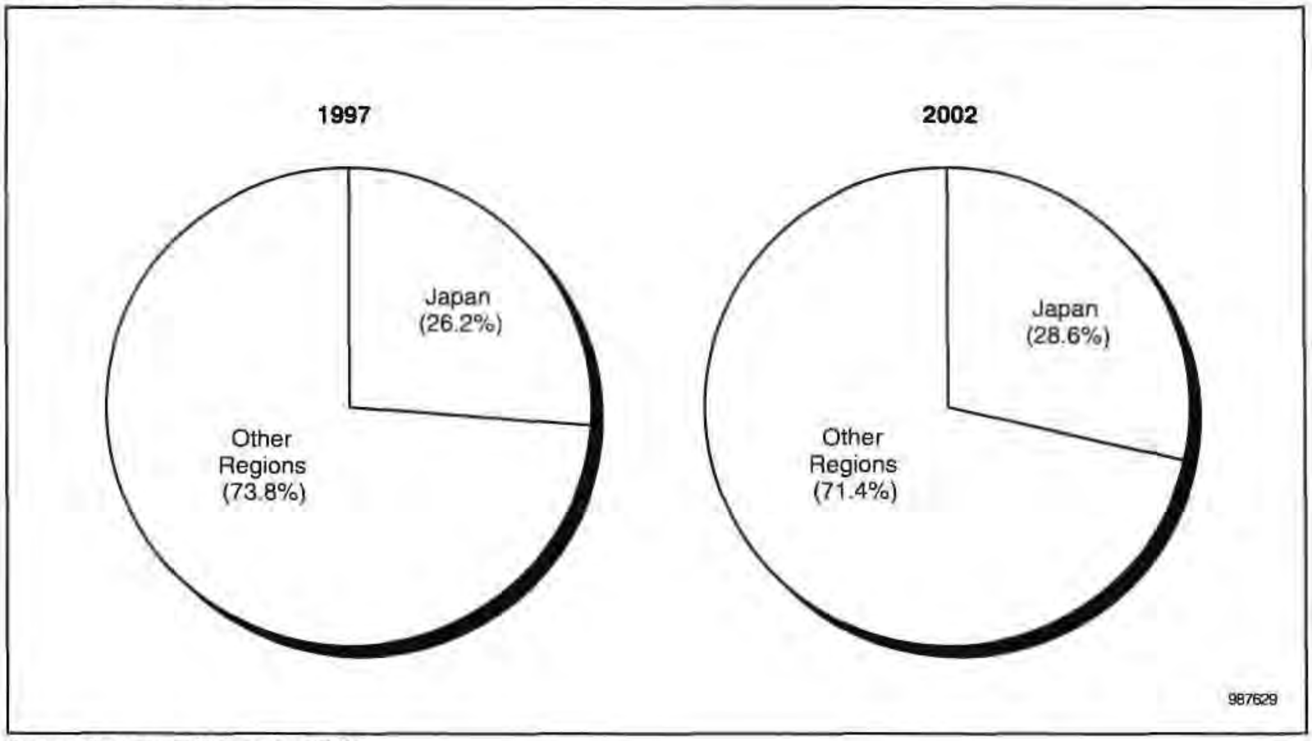
Source: Dataquest (November 1998)

Table 3-24
Production and Semiconductor Consumption Forecast for Mobile Telecommunications Infrastructure in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	NA	NA	NA	NA	NA	NA	NA
Factory ASP (U.S.$)	NA	NA	NA	NA	NA	NA	NA
Factory Revenue (U.S.$M)	7,012	7,222	7,945	8,977	10,324	11,563	10.5
Semiconductor Content (U.S.$)	NA	NA	NA	NA	NA	NA	NA
Semiconductor TAM (U.S.$M)	512	534	596	691	805	913	12.3

NA = Not available or not applicable
Source: Dataquest (November 1998)

Figure 3-24
Japanese Revenue Production Trends for Mobile Telecommunications Infrastructure, 1997 versus 2002



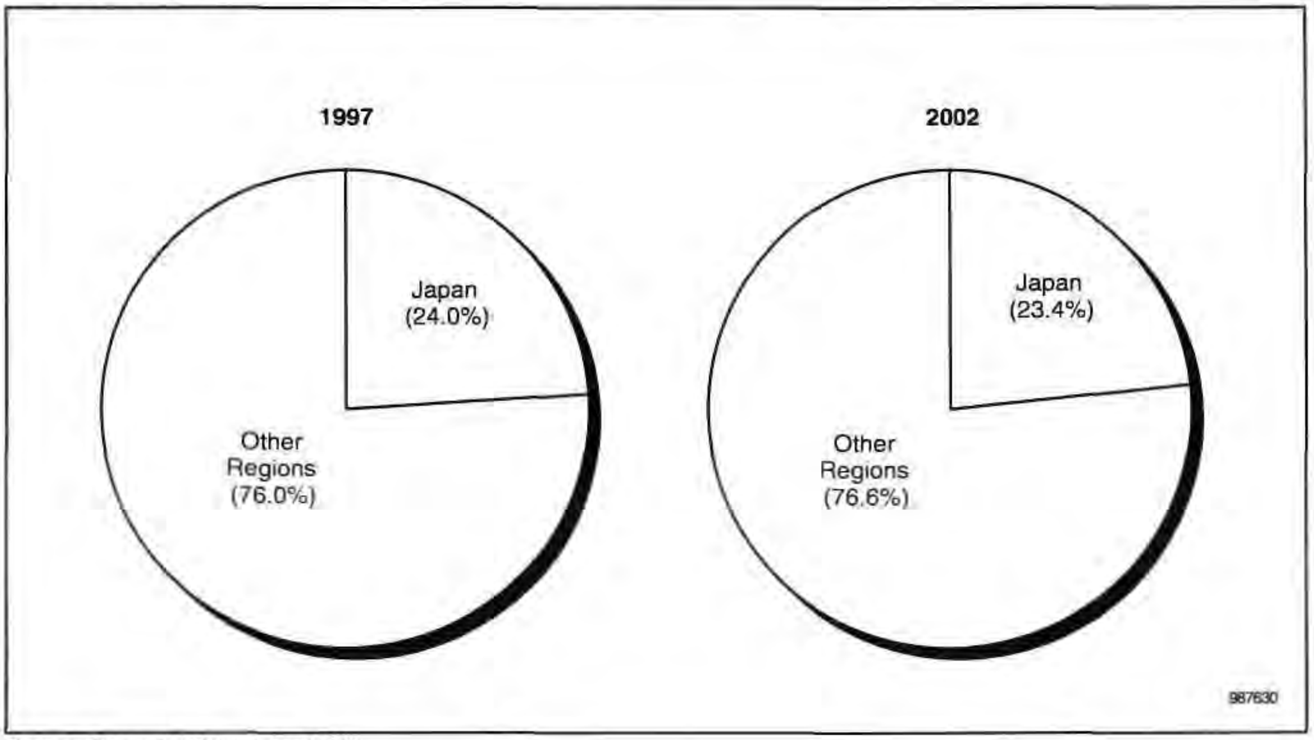
Source: Dataquest (November 1998)

Table 3-25
Production and Semiconductor Consumption Forecast for Other Mobile Telecommunications in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	NA	NA	NA	NA	NA	NA	NA
Factory ASP (U.S.$)	NA	NA	NA	NA	NA	NA	NA
Factory Revenue (U.S.$M)	1,939	1,857	1,803	1,756	1,697	1,663	-3.0
Semiconductor Content (U.S.$)	NA	NA	NA	NA	NA	NA	NA
Semiconductor TAM (U.S.$M)	221	215	213	211	207	206	-1.4

NA = Not available or not applicable
Source: Dataquest (November 1998)

Figure 3-25
Japanese Revenue Production Trends for Other Mobile Telecommunications, 1997 versus 2002



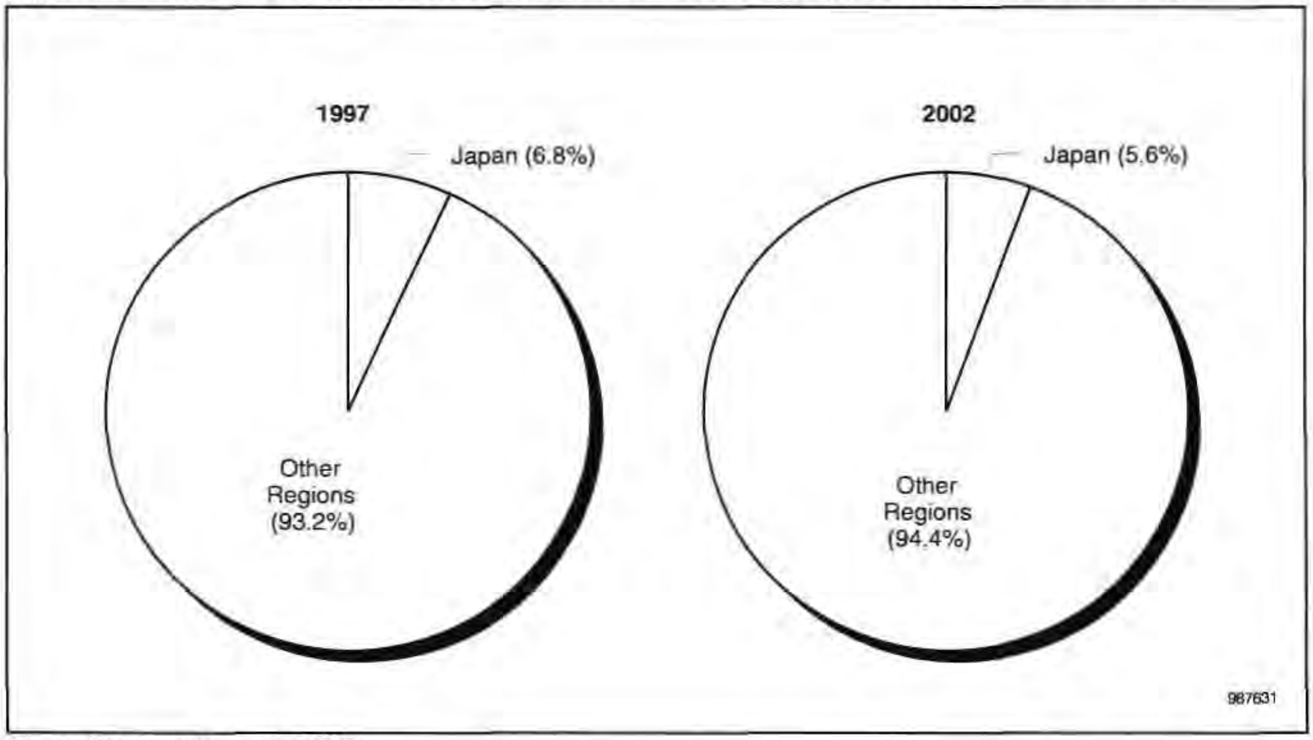
Source: Dataquest (November 1998)

Table 3-26
Production and Semiconductor Consumption Forecast for Personal/Portable Stereos in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	9,565	10,521	10,134	9,931	9,435	9,199	-0.8
Factory ASP (U.S.$)	124.2	105.7	103.6	101.4	100.1	99.6	-4.3
Factory Revenue (U.S.$M)	1,188	1,112	1,050	1,007	945	917	-5.1
Semiconductor Content (U.S.$)	20.4	19.2	18.7	18.1	17.6	17.0	-3.5
Semiconductor TAM (U.S.$M)	195	202	189	180	166	157	-4.3

Source: Dataquest (November 1998)

Figure 3-26
Japanese Unit Production Trends for Personal/Portable Stereos, 1997 versus 2002



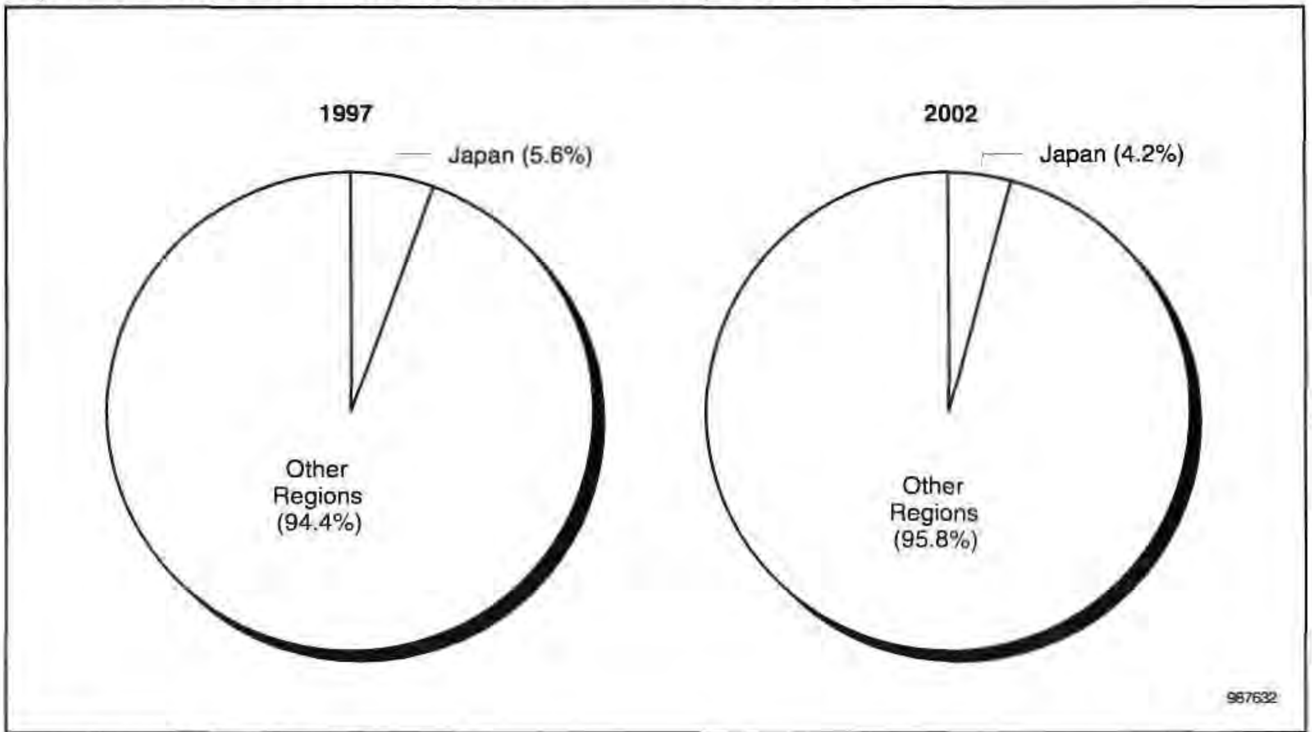
Source: Dataquest (November 1998)

Table 3-27
Production and Semiconductor Consumption Forecast for Color TVs in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	6,683	6,482	6,806	6,666	6,399	6,207	-1.5
Factory ASP (U.S.$)	579.0	550.1	533.4	517.0	497.4	478.1	-3.8
Factory Revenue (U.S.$M)	3,870	3,566	3,630	3,446	3,183	2,968	-5.2
Semiconductor Content (U.S.$)	92.1	90.6	93.0	95.0	90.3	87.6	-1.0
Semiconductor TAM (U.S.$M)	616	587	633	633	578	544	-2.4

Source: Dataquest (November 1998)

Figure 3-27
Japanese Unit Production Trends for Color TVs, 1997 versus 2002



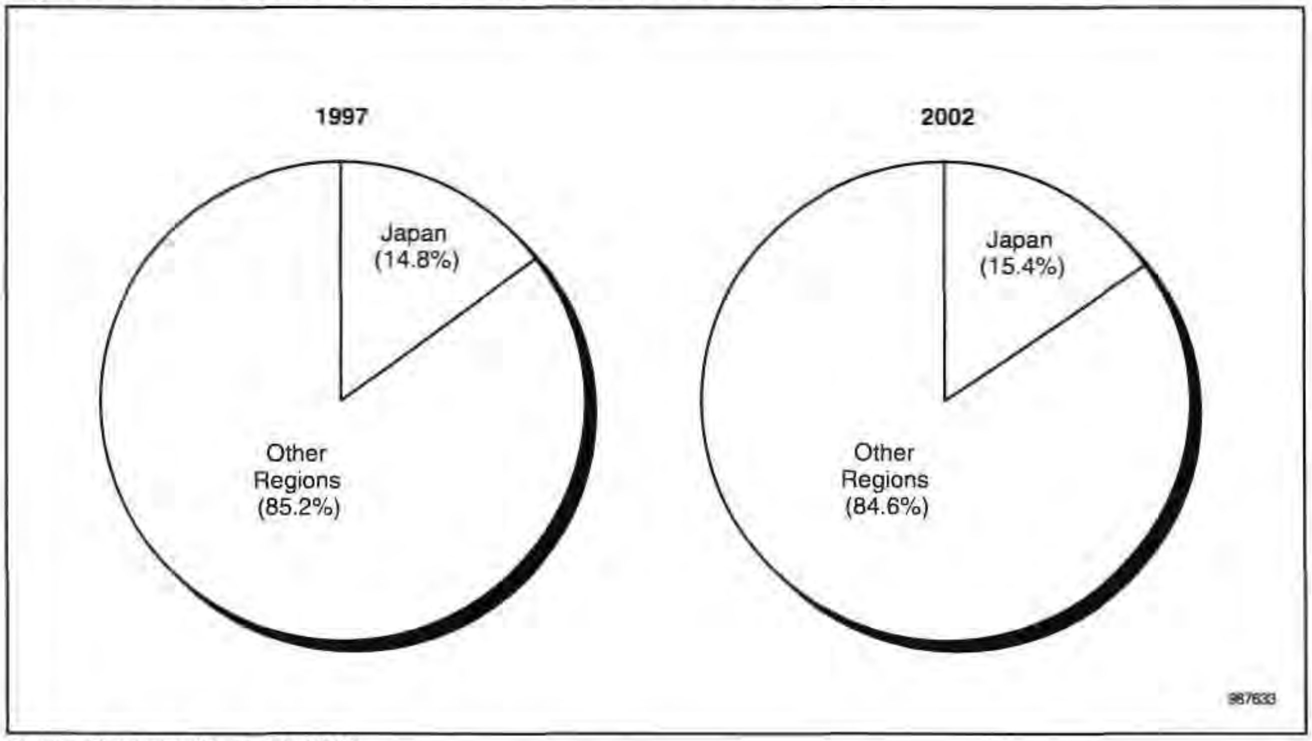
Source: Dataquest (November 1998)

Table 3-28
Production and Semiconductor Consumption Forecast for VCRs in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	9,202	9,017	8,952	8,737	8,388	8,136	-2.4
Factory ASP (U.S.$)	228.1	211.4	198.6	197.2	193.1	187.4	-3.9
Factory Revenue (U.S.$M)	2,098	1,906	1,778	1,723	1,620	1,524	-6.2
Semiconductor Content (U.S.$)	55.4	51.6	50.7	49.7	49.1	47.7	-2.9
Semiconductor TAM (U.S.$M)	510	465	454	434	412	388	-5.3

Source: Dataquest (November 1998)

Figure 3-28
Japanese Unit Production Trends for VCRs, 1997 versus 2002



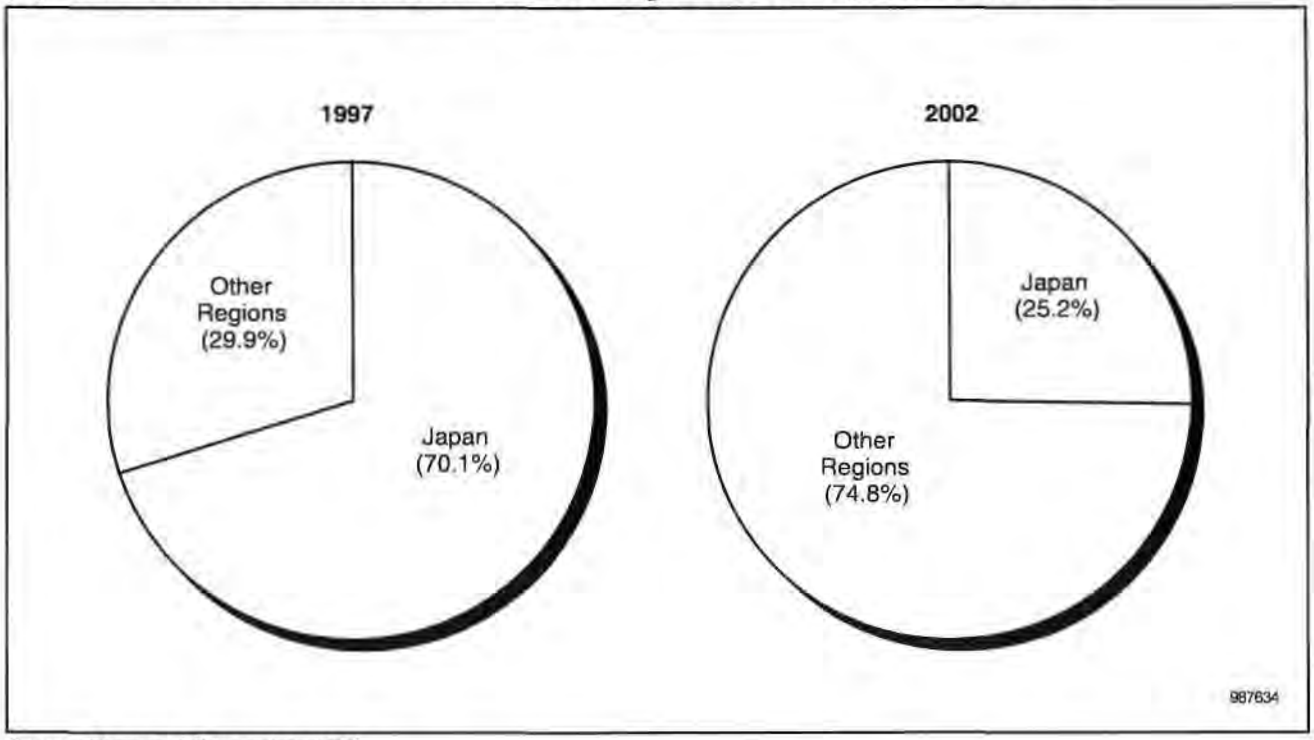
Source: Dataquest (November 1998)

Table 3-29
Production and Semiconductor Consumption Forecast for Analog Camcorders in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	7,426	6,045	5,156	3,948	2,467	1,450	-27.9
Factory ASP (U.S.$)	483	460	430	423	415	408	-3.3
Factory Revenue (U.S.$M)	3,587	2,781	2,217	1,670	1,024	592	-30.3
Semiconductor Content (U.S.$)	118	112	110	105	102	100	-3.3
Semiconductor TAM (U.S.$M)	876	677	567	415	252	145	-30.2

Source: Dataquest (November 1998)

Figure 3-29
Japanese Unit Production Trends for Analog Camcorders, 1997 versus 2002



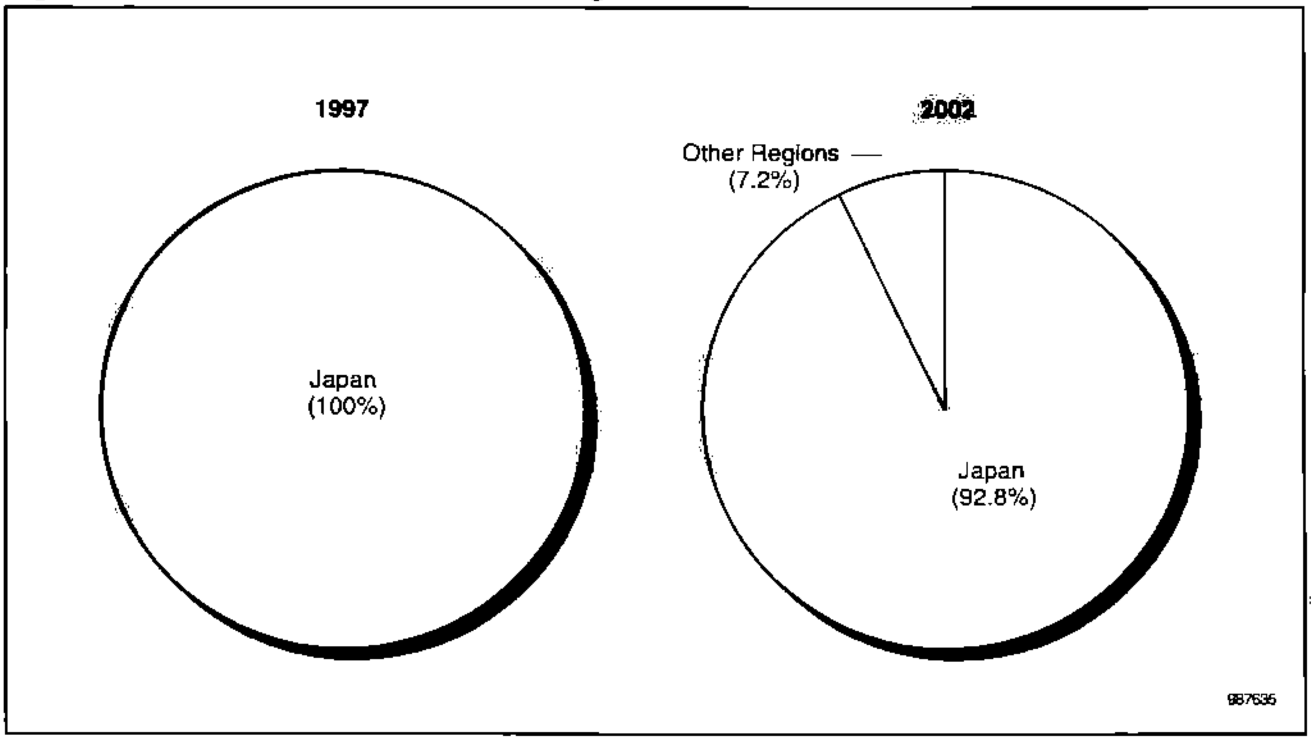
Source: Dataquest (November 1998)

Table 3-30
Production and Semiconductor Consumption Forecast for Digital Camcorders in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	1,578	2,840	3,977	5,170	6,203	7,134	35.2
Factory ASP (U.S.$)	1,221.0	989.6	774.7	604.5	529.0	463.6	-17.6
Factory Revenue (U.S.$M)	1,927	2,811	3,080	3,125	3,281	3,307	11.4
Semiconductor Content (U.S.$)	290.0	227.6	178.3	139.0	121.3	106.5	-18.1
Semiconductor TAM (U.S.$M)	458	647	709	719	753	760	10.7

Source: Dataquest (November 1998)

Figure 3-30
Japanese Unit Production Trends for Digital Camcorders, 1997 versus 2002



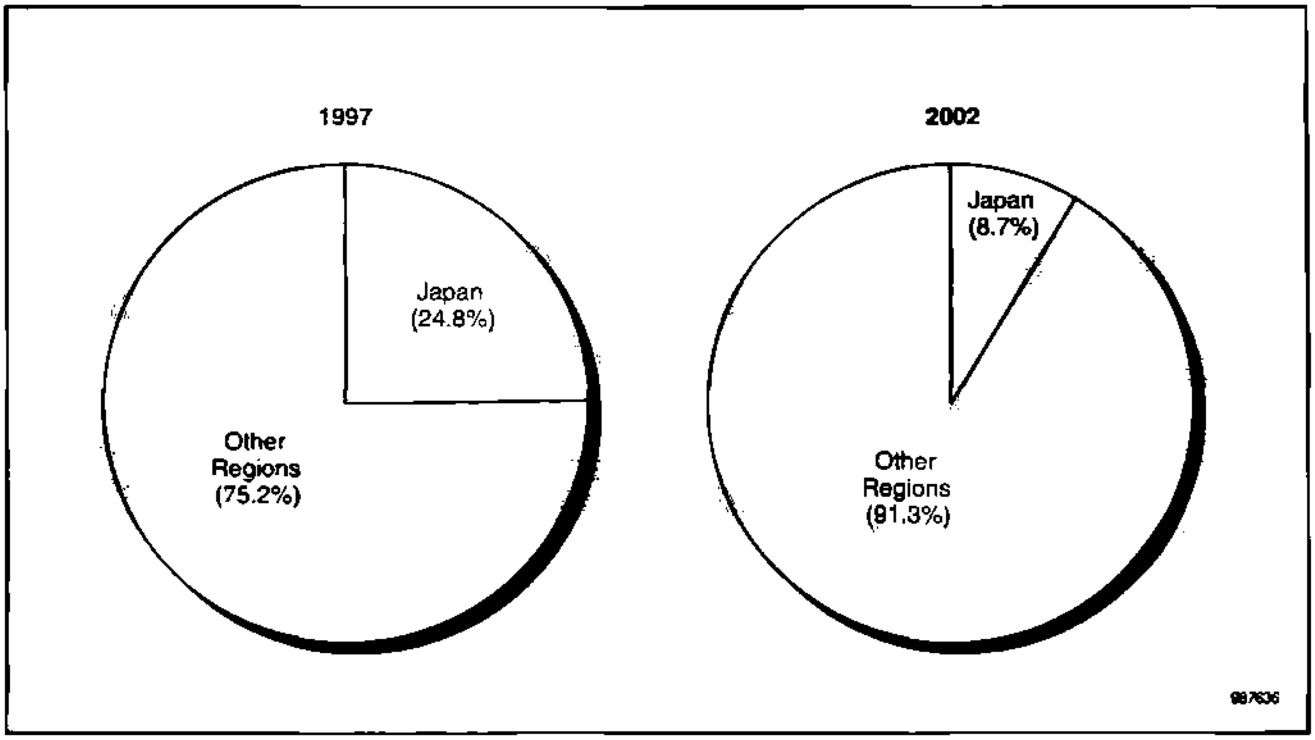
Source: Dataquest (November 1998)

Table 3-31
Production and Semiconductor Consumption Forecast for DVDs in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	175	403	725	1,525	1,915	2,350	68.1
Factory ASP (U.S.$)	394	300	236	195	177	160	-16.5
Factory Revenue (U.S.$M)	69	121	171	297	339	376	40.4
Semiconductor Content (U.S.$)	115.0	64.0	49.0	39.8	38.5	33.1	-22.0
Semiconductor TAM (U.S.$M)	20	26	36	61	74	78	31.0

Source: Dataquest (November 1998)

Figure 3-31
Japanese Unit Production Trends for DVDs, 1997 versus 2002



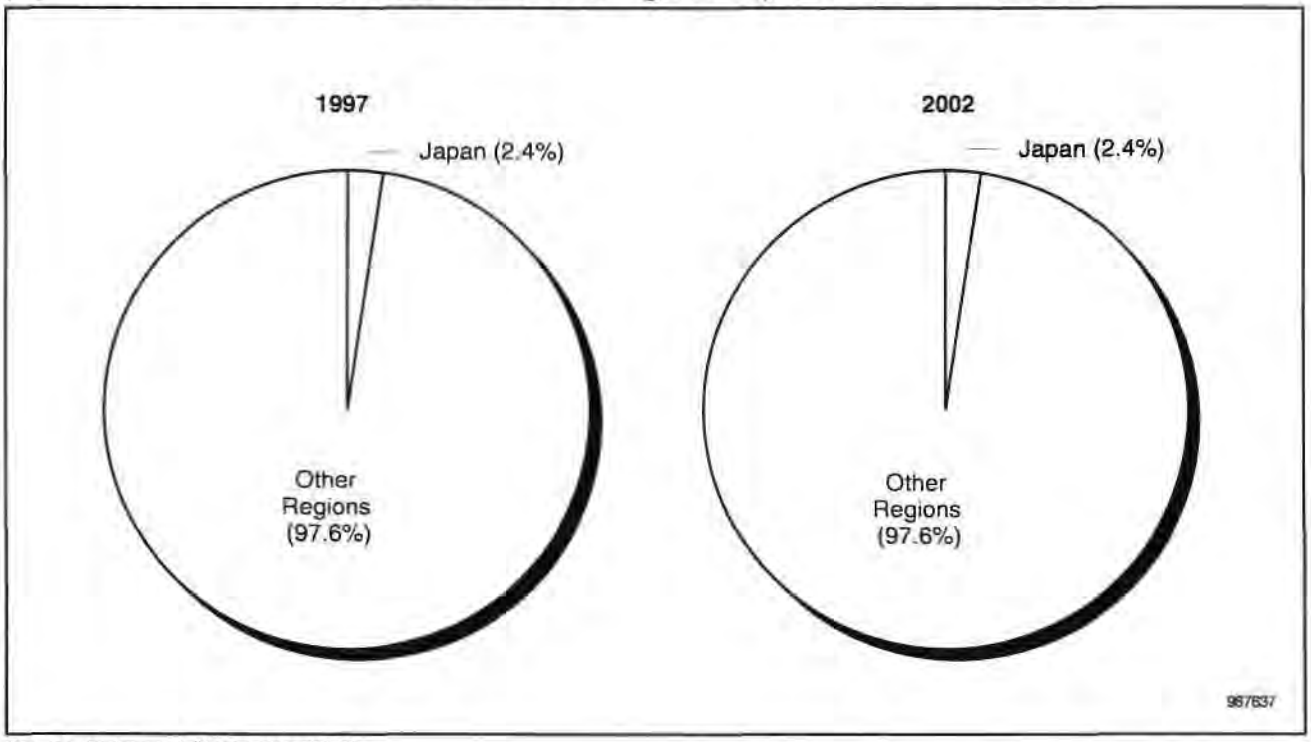
Source: Dataquest (November 1998)

Table 3-32
Production and Semiconductor Consumption Forecast for Analog Set-Top Boxes in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	269	218	183	153	134	127	-13.9
Factory ASP (U.S.$)	98	96	96	95	94	95	-0.6
Factory Revenue (U.S.$M)	26	21	18	15	13	12	-14.5
Semiconductor Content (U.S.$)	43	39	35	34	33	34	-4.6
Semiconductor TAM (U.S.$M)	12	9	6	5	4	4	-17.9

Source: Dataquest (November 1998)

Figure 3-32
Japanese Unit Production Trends for Analog Set-Top Boxes, 1997 versus 2002



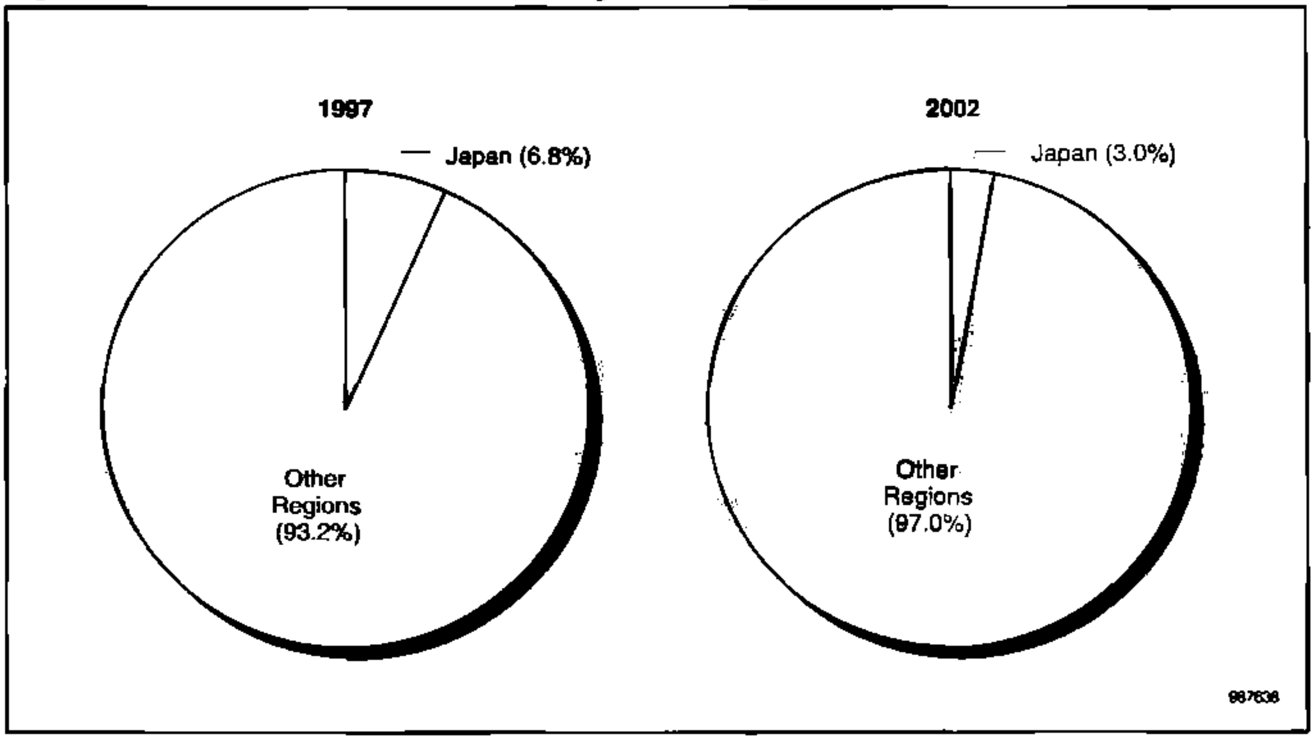
Source: Dataquest (November 1998)

Table 3-33
Production and Semiconductor Consumption Forecast for Digital Set-Top Boxes in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	557	629	768	960	1,113	1,225	17.1
Factory ASP (U.S.$)	470	300	280	275	268	260	-11.2
Factory Revenue (U.S.$M)	262	189	215	264	298	318	4.0
Semiconductor Content (U.S.$)	180	140	125	110	105	100	-11.1
Semiconductor TAM (U.S.$M)	100	88	96	106	117	122	4.1

Source: Dataquest (November 1998)

Figure 3-33
Japanese Unit Production Trends for Digital Set-Top Boxes, 1997 versus 2002



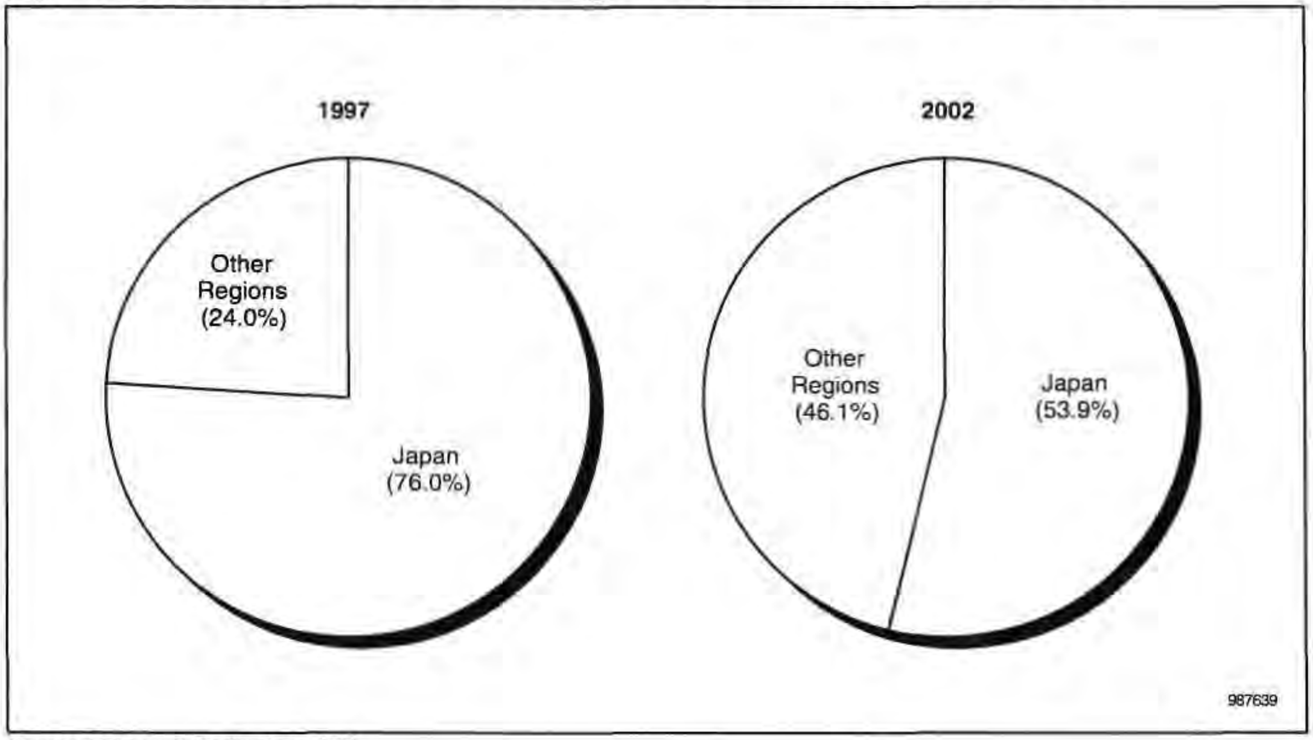
Source: Dataquest (November 1998)

Table 3-34
Production and Semiconductor Consumption Forecast for Digital Still Cameras in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	1,756	2,985	3,987	4,385	4,583	5,041	23.5
Factory ASP (U.S.$)	259.0	232.7	206.4	190.0	179.4	168.8	-8.2
Factory Revenue (U.S.$M)	455	695	823	833	822	851	13.4
Semiconductor Content (U.S.$)	164.4	101.5	87.6	81.1	75.3	72.7	-15.1
Semiconductor TAM (U.S.$M)	289	303	349	356	345	366	4.9

Source: Dataquest (November 1998)

Figure 3-34
Japanese Unit Production Trends for Digital Still Cameras, 1997 versus 2002



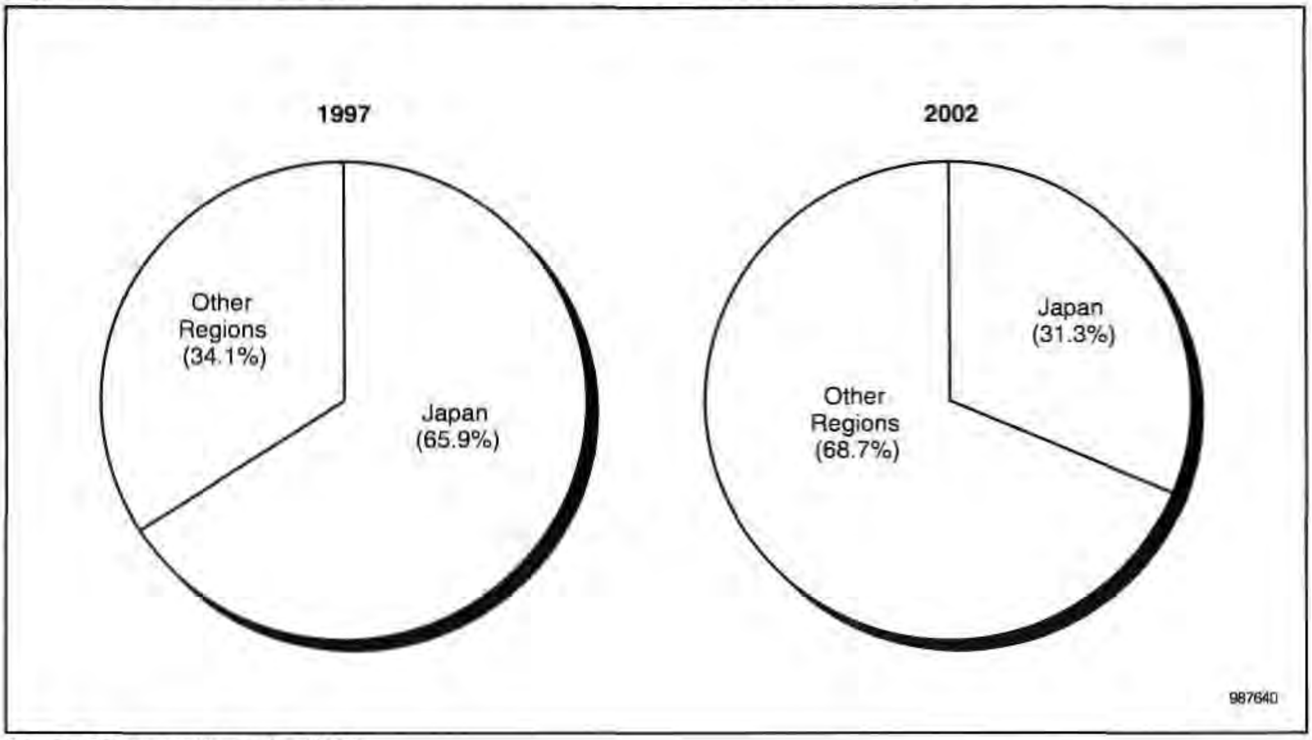
Source: Dataquest (November 1998)

Table 3-35
Production and Semiconductor Consumption Forecast for Video Game Controllers in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	19,190	15,065	8,000	6,000	5,900	10,000	-12.2
Factory ASP (U.S.$)	151	133	142	160	152	134	-2.4
Factory Revenue (U.S.$M)	2,898	2,004	1,136	960	897	1,338	-14.3
Semiconductor Content (U.S.$)	94	83	90	100	93	82	-2.6
Semiconductor TAM (U.S.$M)	1,794	1,250	720	600	549	820	-14.5

Source: Dataquest (November 1998)

Figure 3-35
Japanese Unit Production Trends for Video Game Controllers, 1997 versus 2002



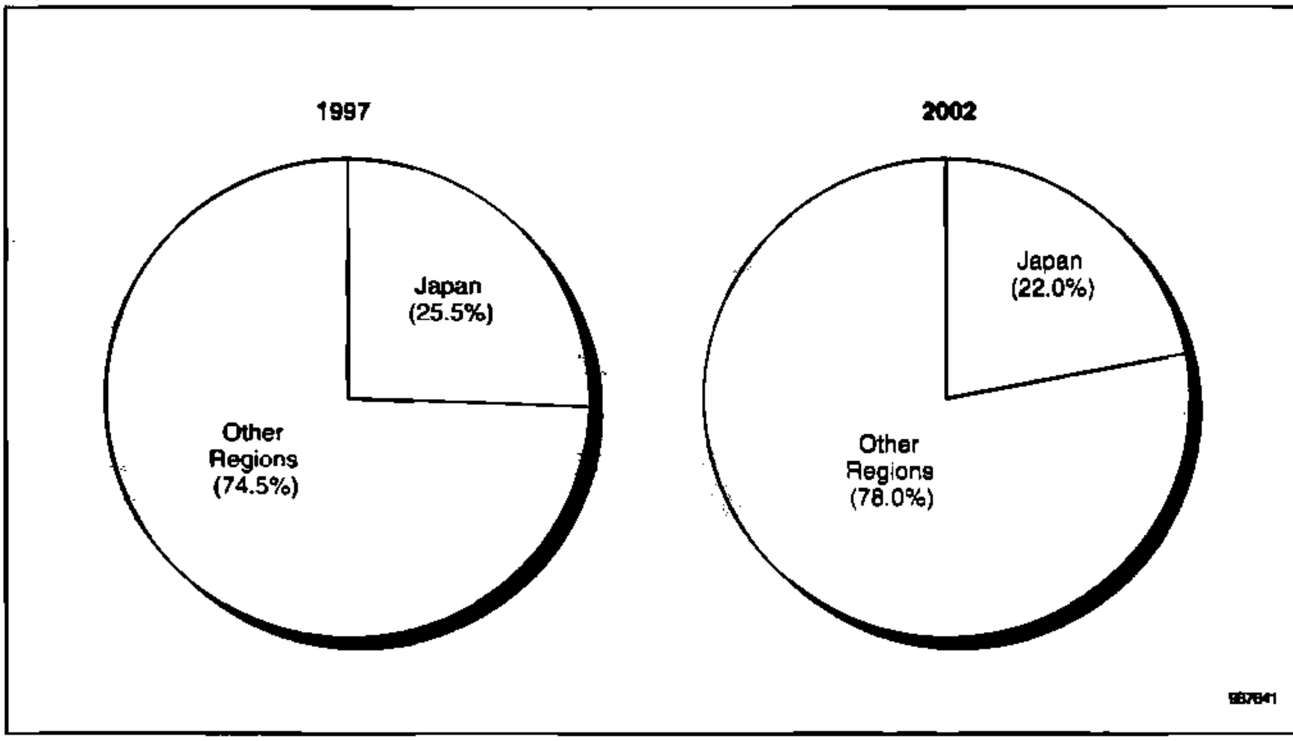
Source: Dataquest (November 1998)

Table 3-36
Production and Semiconductor Consumption Forecast for Automotive Stereos in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	13,336	12,696	12,567	13,109	13,038	12,500	-1.3
Factory ASP (U.S.$)	133	130	127	125	123	122	-1.7
Factory Revenue (U.S.$M)	1,774	1,650	1,596	1,639	1,604	1,525	-3.0
Semiconductor Content (U.S.$)	15.2	16.0	16.0	17.0	17.0	18.0	3.4
Semiconductor TAM (U.S.$M)	203	203	201	223	222	225	2.1

Source: Dataquest (November 1998)

Figure 3-36
Japanese Unit Production Trends for Automotive Stereos, 1997 versus 2002



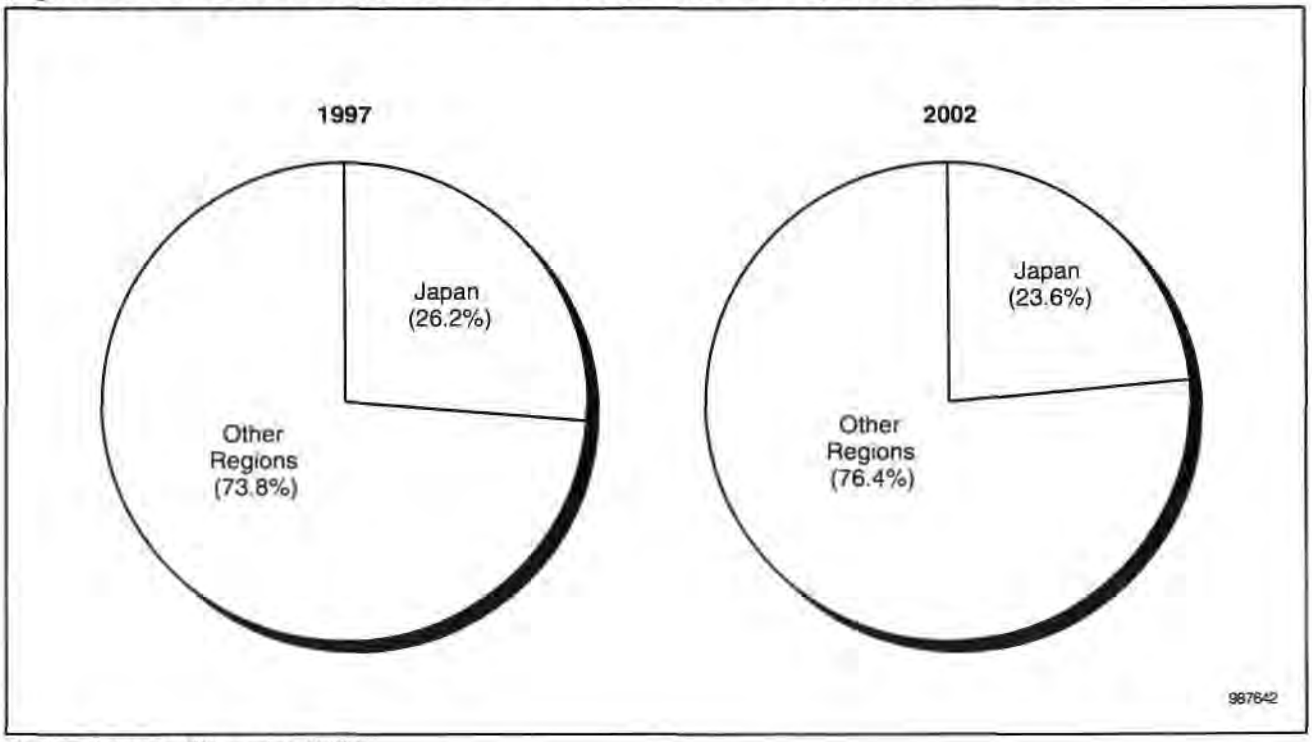
Source: Dataquest (November 1998)

Table 3-37
Production and Semiconductor Consumption Forecast for Automotive ECUs in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	11,184	11,553	11,805	12,045	12,367	12,500	2.2
Factory ASP (U.S.$)	163.0	167.0	176.0	179.8	179.8	179.0	1.9
Factory Revenue (U.S.$M)	1,823	1,929	2,078	2,166	2,224	2,238	4.2
Semiconductor Content (U.S.$)	47.0	48.0	49.0	49.4	49.0	49.0	0.8
Semiconductor TAM (U.S.$M)	526	555	578	595	606	613	3.1

Source: Dataquest (November 1998)

Figure 3-37
Japanese Unit Production Trends for Automotive ECUs, 1997 versus 2002



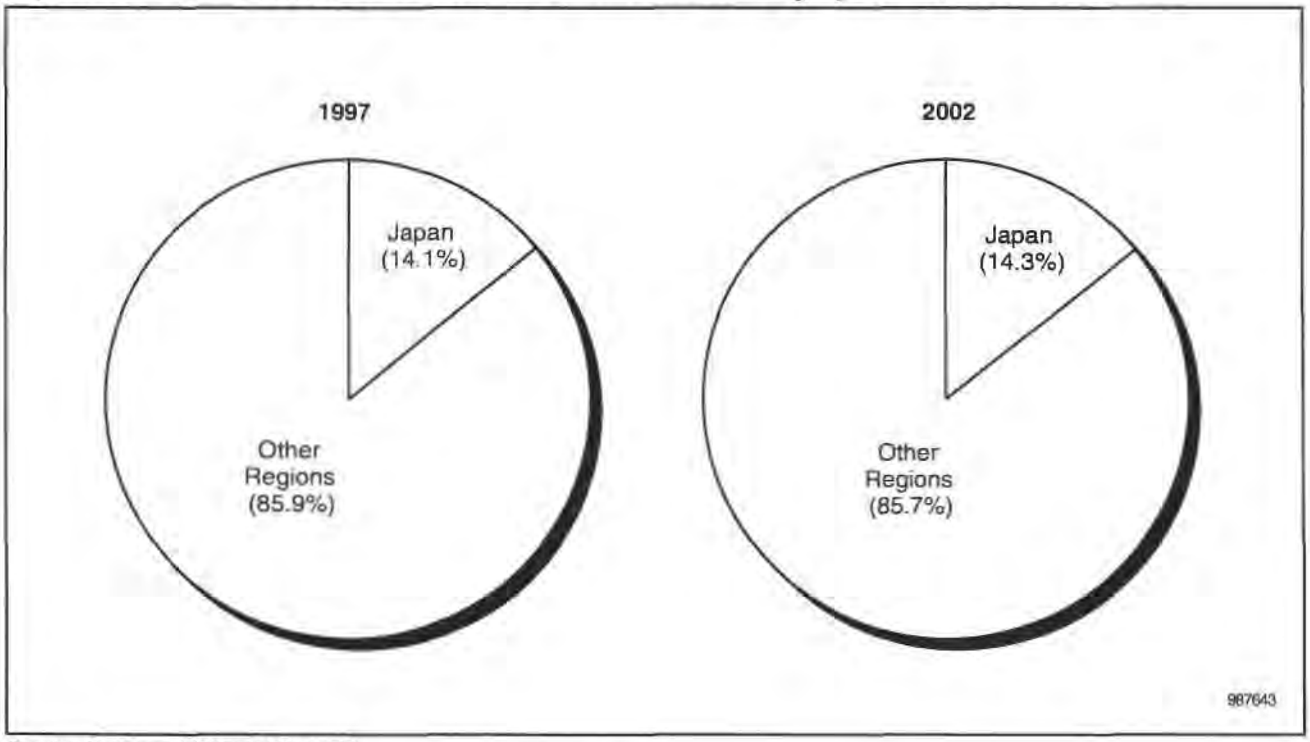
Source: Dataquest (November 1998)

Table 3-38
Production and Semiconductor Consumption Forecast for Antilock Braking Systems in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	3,148	3,425	3,911	4,286	4,697	5,150	10.3
Factory ASP (U.S.$)	195	184	172	166	155	150	-5.1
Factory Revenue (U.S.$M)	614	630	673	711	728	773	4.7
Semiconductor Content (U.S.$)	41	40	39	38	38	37	-2.0
Semiconductor TAM (U.S.$M)	129	137	153	163	178	191	8.1

Source: Dataquest (November 1998)

Figure 3-38
Japanese Unit Production Trends for Antilock Braking Systems, 1997 versus 2002



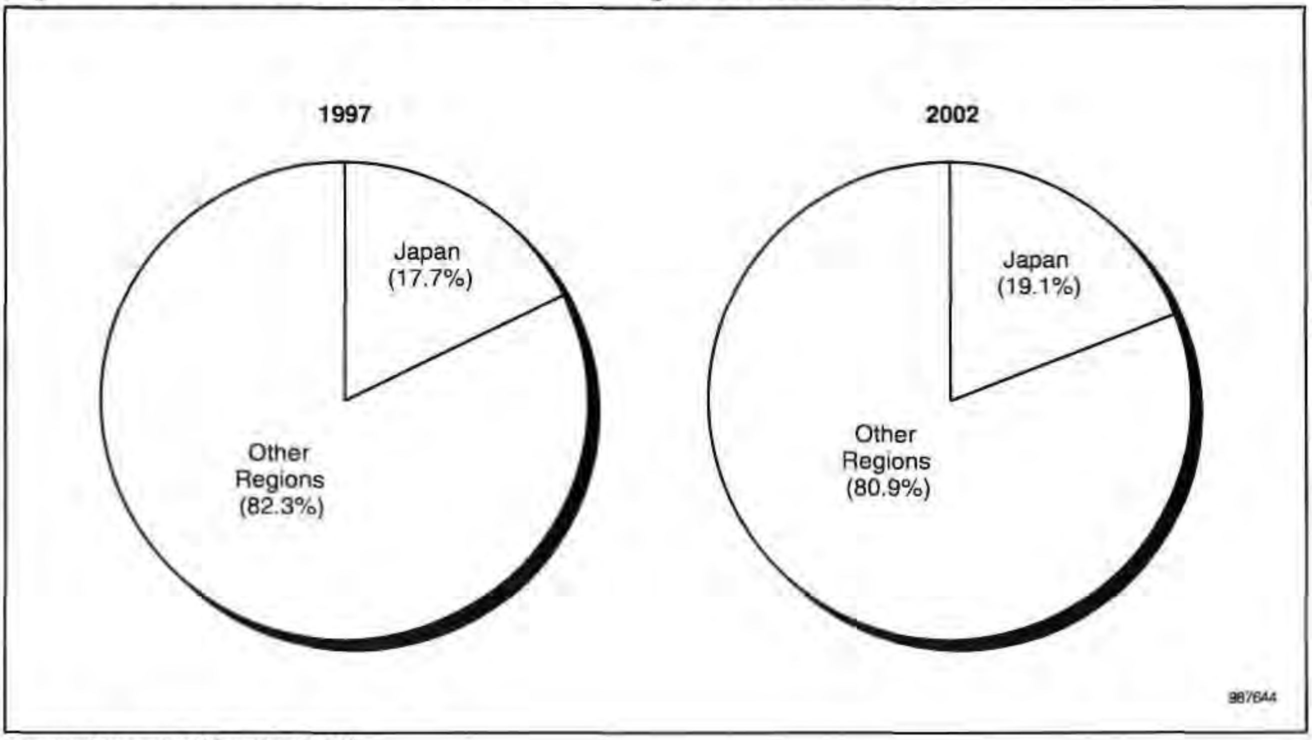
Source: Dataquest (November 1998)

Table 3-39
Production and Semiconductor Consumption Forecast for Air Bags in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	5,355	6,472	7,240	8,083	8,500	9,000	10.9
Factory ASP (U.S.$)	77	70	65	60	58	56	-6.2
Factory Revenue (U.S.$M)	412	453	471	485	493	504	4.1
Semiconductor Content (U.S.$)	20	19	19	18	18	18	-2.1
Semiconductor TAM (U.S.$M)	107	123	138	145	153	162	8.6

Source: Dataquest (November 1998)

Figure 3-39
Japanese Unit Production Trends for Air Bags, 1997 versus 2002



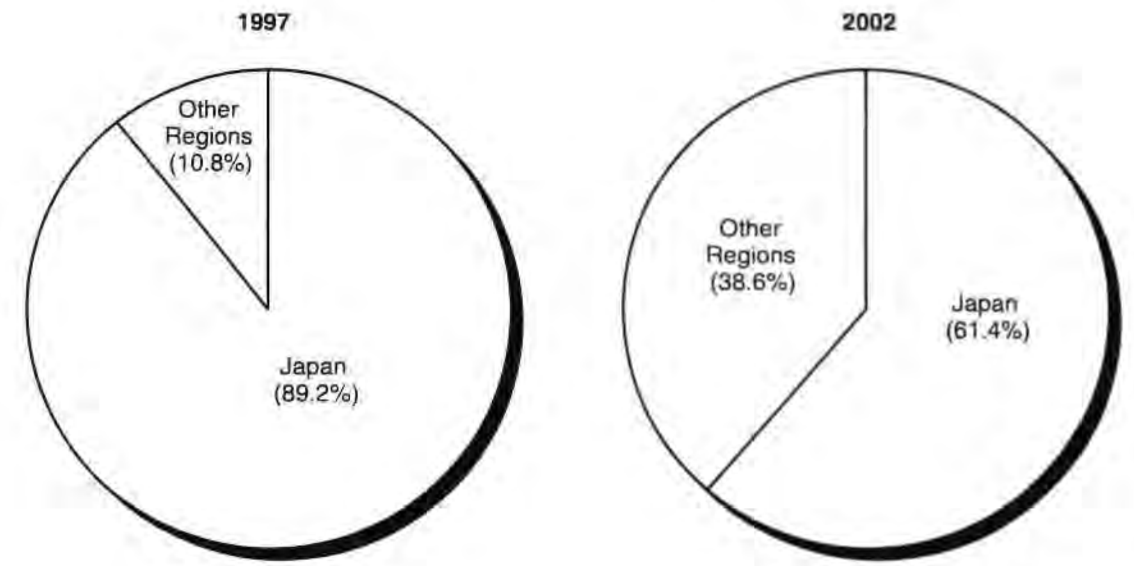
Source: Dataquest (November 1998)

Table 3-40
Production and Semiconductor Consumption Forecast for Automotive Navigation Systems in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	1,352	1,787	2,985	4,239	5,807	7,549	41.1
Factory ASP (U.S.$)	954	825	810	751	710	640	-7.7
Factory Revenue (U.S.$M)	1,290	1,474	2,418	3,183	4,123	4,831	30.2
Semiconductor Content (U.S.$)	191.7	167.0	150.9	145.9	139.8	135.0	-6.8
Semiconductor TAM (U.S.$M)	259	298	450	619	812	1,019	31.5

Source: Dataquest (November 1998)

Figure 3-40
Japanese Unit Production Trends for Automotive Navigation Systems, 1997 versus 2002



Source: Dataquest (November 1998)

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Japanese Semiconductor Consumption Forecast by Electronics Application, Spring 1998

Market Statistics

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Program: Semiconductors Japan
Product Code: SEMI-JA-MS-9803
Publication Date: July 6, 1998
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Preface

Dataquest's *Japanese Semiconductor Consumption Forecast by Electronics Application, Spring 1998* is a revised and reformatted version of our long-standing semiannual semiconductor consumption by electronics application market forecast. We have made several changes to this publication in an effort to make it more relevant and meaningful, as well as more consistent with Dataquest's other research of semiconductor applications in electronic systems. Three major changes include:

- We are publishing only forecast data.
- We have increased the electronic systems detail reported in our forecast of total semiconductor consumption while eliminating the forecasts of specific semiconductor device consumption offered in previous reports.
- Dataquest's estimate of semiconductor consumption no longer equals the value of forecast semiconductor shipments.

The decision to publish only forecast data is significant. This decision stemmed from several considerations. On one hand, we have found that clients are generally far more interested in a forecast of semiconductor consumption than in estimates of past consumption. Given this and given that our estimates of historical consumption are always available to those who desire them through Dataquest's client inquiry services, Dataquest believes readers lose little from our decision to publish only forecast data. More important, we are in the midst of instituting an important and fundamental change in our forecast methodology. Data limitations severely restrict our ability to extend this method back into history. Rather than undertake the effort required to publish historical data consistent with the dictates and conventions of our new forecast method, we have decided to publish only forecast data.

The third change is admittedly quite significant and is related to the methodology change mentioned. Put succinctly, this forecast marks Dataquest's move away from a decidedly top-down method of estimating semiconductor consumption toward a bottom-up forecast approach, motivated by several factors. First, our forecast should more explicitly reflect the knowledge that Dataquest has rapidly been acquiring about semiconductor applications among individual electronic systems. For several years, Dataquest has directed its semiconductor applications research toward better understanding the dynamics of production and semiconductor use across individual electronic systems. We have developed forecast models capable of tracking production and estimating total semiconductor consumption for some 40 different individual electronic systems.

Dataquest believes these models are now sufficiently developed to use them as the backbone of our forecast of semiconductor consumption. Indeed, Dataquest believes that by leveraging the bottom-level knowledge provided by these models, we can provide far more accurate forecasts than ever before. Using these models as the basis for our forecast also allows us to report total semiconductor consumption for individual electronic systems, something that many clients have been requesting.

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Unfortunately, we are still in the process of developing semiconductor device detail for many of our individual systems models. Rather than perpetuate old ways, we have opted to forgo publishing consumption forecasts of specific semiconductor devices, at least until our individual systems models are complete enough to let us generate forecasts consistent with our new methodology.

Second, Dataquest is seeking to eliminate our dependence on an assumption-sensitive mathematical model for our estimates of semiconductor consumption. Past forecasts of semiconductor consumption were created using a top-down mathematical model. Using Dataquest's forecasts of electronic equipment production and semiconductor shipments as inputs, this model generated estimates of semiconductor consumption by mathematically matching estimated semiconductor shipments to our forecast of electronics production based on a variety of assumptions about the semiconductor content of the various electronics product categories. Thus, our semiconductor consumption estimates were more by-products of a mathematical process than true estimates of consumption. In its defense, the model was extraordinarily flexible and allowed us to create very reasonable estimates of semiconductor consumption for broad categories of electronic products. Nonetheless, its results were highly sensitive to the semiconductor content assumptions needed to drive the model. Moreover, it offered little opportunity to incorporate our growing insights into the semiconductor consumption of individual electronics systems.

Above all, we are hoping to establish a truly separate and independent forecast of semiconductor consumption that can be compared and contrasted to Dataquest's long-standing semiconductor shipments forecast. One important feature of our now-discarded mathematical forecast model was its insistence that estimated semiconductor consumption always equal forecast semiconductor shipments. Putting aside its validity, this insistence essentially robbed our semiconductor consumption forecast of any independent insight into the dynamics of the semiconductor market in the future. By forsaking this insistence, Dataquest is not only able to provide an independent view of future semiconductor developments but also a view that can and should be compared to Dataquest's well-established semiconductor shipments forecast. Our hope is that readers will find contrasting views of the semiconductor market helpful in their efforts to divine its future.

As always, Dataquest welcomes readers' comments and would greatly appreciate any suggestions about improving our research.

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Chapter 1

Introduction and Discussion

Introduction

This document contains Dataquest's forecast of Japanese semiconductor consumption by electronics application, 1997 to 2002, based both on U.S. dollars and Japanese yen. It also contains our forecast of worldwide semiconductor consumption by broad categories over the same period. This is the first of two semiannual forecasts; the second will be published this coming fall. This first forecast reflects changes since last fall in Dataquest's view of semiconductor consumption by electronic equipment worldwide and in Japan. It incorporates changes suggested by Dataquest's recently updated forecasts of electronic equipment production and semiconductor shipments.

Long-time readers will note significant changes in the focus and format of this forecast, compared to previous forecasts. This document reports only a forecast for 1997 to 2002. More significantly, we have greatly expanded the electronic systems detail supporting our forecast of total semiconductor consumption, and we have eliminated our forecasts of semiconductor device consumption by electronic application. These changes are related to a fundamental change in our forecast methodology. Dataquest's previous semiconductor consumption forecasts were a top-down mathematical reconciliation of updated electronic equipment production and semiconductor shipment forecasts. The forecast in this document represents an effort to independently estimate from the bottom up the semiconductor consumption generated by Dataquest's forecast of electronics production. Dataquest no longer attempts to specify how forecast semiconductor shipments will distribute themselves across electronics applications. Instead, the forecast separately estimates semiconductor consumption by electronic systems, unconstrained by the requirement that semiconductor consumption equal semiconductor shipments. It leaves open the possibility that estimated semiconductor consumption may differ from estimated semiconductor shipments. Unfortunately, this document is not the appropriate forum for discussing the consequences of the semiconductor demand/supply imbalance implied by persistent differences between estimated semiconductor consumption and estimated semiconductor shipments. That task will be left for other Dataquest publications.

The tables in this document present data intended to answer the following questions:

- What is the estimated semiconductor consumption of various broad categories of electronic equipment?
- What is the estimated semiconductor consumption of the key individual electronic systems that make up these broad categories?

The estimates offered in this document are intended to provide very general answers to these questions. They are meant as a broad guide to semiconductor consumption by electronic equipment production in Japan. More detailed information about estimated semiconductor consumption by individual electronic systems is available in other Dataquest documents.

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The semiconductor consumption forecasts presented here complement Dataquest's recently updated forecasts of electronic equipment production and semiconductor shipments. Updated Japanese electronic equipment forecasts can be found in *Japanese Electronic Equipment Production Forecast, Spring 1998* (SEMI-JA-MS-9802, June 1998). Our updated semiconductor shipments forecast is found in *Worldwide Semiconductor Five-Year Forecast Trends: Spring 1998* (SCND-WW-MT-9801, June 1998). Additional regional and semiconductor device detail for this forecast can also be requested through Dataquest's inquiry service.

The tables in this document are organized as follows:

- Tables 2-1 and 2-2 summarize the worldwide semiconductor consumption forecast and compare it to the worldwide semiconductor shipments forecast.
- Tables 2-3 and 2-4 summarize the Japanese semiconductor consumption forecast on a dollar basis and compare it to the Japanese semiconductor shipments forecast.
- Tables 2-5 to 2-12 detail Japanese semiconductor consumption by individual electronic system, grouped by equipment type, on a dollar basis.
- Tables 2-13 and 2-14 summarize the Japanese semiconductor consumption forecast on a yen basis and compare it to the Japanese semiconductor shipments forecast.
- Tables 2-15 to 2-22 detail Japanese semiconductor consumption by individual electronic system, grouped by equipment type, on a yen basis.

Segmentation of Semiconductor Applications

Dataquest forecasts semiconductor consumption by end-use electronic application. We divide electronic applications into six broad groups in accordance with our segmentation of electronic equipment production. These groups are, in turn, disaggregated into narrower electronic systems categories, as follows:

- Data processing
  - Computers
  - Data storage
  - Input/output devices
  - Other data processing
- Communications
  - Premise telecommunications
  - Public telecommunications
  - Mobile communications
  - Broadcast and studio equipment
  - Other communications

- Industrial
  - Security and energy management systems
  - Manufacturing systems and instruments
  - Medical equipment
  - Other industrial equipment
- Consumer
  - Audio
  - Video
  - Personal electronics
  - Appliances
  - Other consumer equipment
- Military/civil aerospace
- Transportation

As part of the forecast process, Dataquest develops forecasts for about 40 individual electronic systems within these various categories and subcategories. These include:

- Data processing
  - Mainframes/supercomputers (computers)
  - Midrange computers (computers)
  - Workstations (computers)
  - PCs (computers)
  - PC motherboards (computers)
  - Rigid disk drives (data storage)
  - Optical disk drives (data storage)
  - Removable magnetic storage (data storage)
  - Page printers (input/output)
  - Serial printers (input/output)
  - Monitors (input/output)
- Communications
  - LAN cards (premise telecommunications)
  - Premise line cards (premise telecommunications)
  - Answering machines (premise telecommunications)
  - Fax machines (premise telecommunications)
  - Modems (premise telecommunications)
  - Corded telephones (premise telecommunications)
  - Analog cordless phones (premise telecommunications)
  - Digital cordless phones (premise telecommunications)

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- Central office line cards (public telecommunications)
- Analog cellular phones (mobile telecommunications)
- Digital cellular phones (mobile telecommunications)
- Pagers (mobile telecommunications)
- Mobile telecommunications infrastructure (mobile telecommunications)
- Other mobile telecommunications products (mobile telecommunications)

- Consumer
  - Personal/portable stereos (audio)
  - Color TVs (video)
  - VCRs (video)
  - Analog camcorders (video)
  - Digital camcorders (video)
  - DVD (video)
  - Analog set-top boxes (video)
  - Digital set-top boxes (video)
  - Digital still cameras (personal electronics)
  - Video game controllers (personal electronics)
  - Video game cartridges (personal electronics)
- Transportation
  - Automotive stereos
  - Automotive engine control units (ECUs)
  - Antilock braking systems
  - Air bags
  - Automotive navigation systems

Geographic Segmentation

Dataquest's worldwide electronic equipment production forecast is aggregated from individual forecasts for four principal geographic regions:

- Americas
- Japan
- Europe, Middle East, and Africa
- Asia/Pacific

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Exchange Rates

Dataquest's worldwide electronic equipment forecast aggregates data from many countries, each of which uses a currency that has a different and fluctuating exchange rate relative to the U.S. dollar. Because we compile our worldwide forecast from individual regional forecasts, we use the U.S. dollar as a common currency for comparisons and aggregation. As a rule, Dataquest calculates forecasts in local currencies and then converts them to U.S. dollars using projected average annual exchange rates. Dataquest does not forecast exchange rates per se. Instead, we calculate projected average annual exchange rates from current exchange rates. Our projections are based on estimates of the latest available monthly exchange rate at the time the forecast is developed. These rates are based on monthly exchange rates observed through February 1998. Additional information about historical exchange rates and Dataquest's method of calculating future average exchange rates may be requested through Dataquest's client inquiry service.

Forecast Methodology

When discussing semiconductor consumption, it is critical to remember that semiconductors are not end products consumed for their own sake. They are intermediate products used as inputs for electronic end products that are eventually consumed by individuals and businesses for the utility they provide. Implicit in the concept of semiconductor consumption is the notion that the electronic end products in which semiconductors will be incorporated or consumed can be specified. A semiconductor forecast that does not or cannot specify this is not a forecast of semiconductor consumption. At best, it is merely a forecast of semiconductor shipments.

Dataquest's semiconductor consumption by electronic application forecast grew out of the recognition that a truly complete semiconductor forecast must specify the electronic end uses of semiconductors. However, specifying semiconductor end uses has proved far more difficult than recognizing that it must be done. Although it appears possible to specify semiconductor consumption by the variety of electronics produced, there are simply too many different types of semiconductor devices consumed in too large a variety of electronic products. As a result, semiconductor consumption must invariably be estimated. This can be done in any number of ways. Before this forecast, Dataquest used a mathematical model to estimate semiconductor consumption by various electronic end uses. Taking Dataquest's electronic equipment production and semiconductor shipments forecasts as inputs, this model allocated estimated semiconductor shipments across forecast electronics production subject to various assumptions about the semiconductor content of electronic products. The model also imposed several balancing conditions intended to guarantee that estimated semiconductor shipments were completely allocated across all forecast electronics production.

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The model applied a top-down approach to estimating semiconductor consumption. In effect, it calculated estimates of semiconductor consumption by compelling agreement between the details of the electronics production forecast and the semiconductor shipments forecast. As a result, the estimates of semiconductor consumption were more an artifact of a mathematical process than truly independent estimates of semiconductor consumption. Although the model offered considerable flexibility, it was nonetheless limited by the validity of its semiconductor content assumptions and the balancing requirement that semiconductor consumption equal semiconductor shipments. Despite its potential drawbacks, the model provided the best estimates we could offer, given a paucity of knowledge about semiconductor applications in specific electronic systems.

Over last several years, Dataquest's semiconductor applications research has been concentrated on the study of semiconductor use in specific individual electronic systems. We have successfully developed models to track and forecast the production and semiconductor consumption of some 40 different individual electronic systems. These include PCs and PC motherboards, rigid disk drives, LAN cards and modems, digital cellular phones, digital set-top boxes, and automotive navigation systems, among others. The electronic systems encompassed by our models account for about one-half of all electronics production and nearly two-thirds of estimated semiconductor consumption.

These models have not only allowed us to codify our knowledge about individual electronic systems but also to approach the task of estimating semiconductor consumption using a bottom-up forecast method. This method was used for the forecast and will be used for future forecasts. The method essentially involves building a forecast of semiconductor consumption for all electronics production by leveraging estimates of semiconductor consumption for individual electronic systems. Dataquest uses individual systems estimates as a forecast base and augments this with estimates of semiconductor consumption for other electronic equipment categories not tracked individually. Precisely because the method uses well-researched knowledge about individual electronics systems that dominate semiconductor consumption, Dataquest believes it is capable of providing far better forecasts of semiconductor consumption than our former top-down method, especially for electronic equipment categories such as computers, where individual systems forecasts account for virtually the entire category.

This change to a new method has a number of consequences. Dataquest has, at least temporarily, eliminated forecasts of specific semiconductor device consumption by electronic application. Although informative, these forecasts were largely an artifact of our old top-down method. Recent research indicates that these forecasts were especially sensitive to the assumptions and balancing conditions of our top-down method. We are still in the process of developing semiconductor device detail for many of the individual systems forecasts that now serve as the basis for our new bottom-up method.

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Consequently, our systems forecasts have yet to reach the point at which they can be leveraged to provide reasonable consumption forecasts for specific semiconductor devices. We hope to reinstate device consumption forecasts as soon as possible according to this bottom-up method. In the meantime, we trust that readers will find the added electronics system detail we can now offer in our forecast adequate compensation.

More important, Dataquest no longer insists that estimated semiconductor consumption equal the forecast of semiconductor shipments. In truth, our long-standing insistence that consumption estimates equal shipment estimates was more a matter of mathematical necessity than a reflection of market realities. There are several reasons why semiconductor consumption as we estimate it may differ from a forecast of semiconductor shipments. First, there can be significant slippage between semiconductor shipments and semiconductor consumption by electronics producers over short periods because of changes in the semiconductor inventories held by electronic producers. Electronics producers naturally adjust their semiconductor inventories in response to expected changes in their level of production. Although just-in-time practices are reducing producers' inventories, the continued existence of inventories means semiconductor shipments and consumption may differ.

Second, not all semiconductor shipments are consumed by electronics producers manufacturing new electronics. Some find their way into so-called "aftermarkets" where they are eventually "consumed" by existing electronics. Dataquest excludes aftermarket activity from the estimates of semiconductor consumption. Aftermarket consumption is virtually impossible to track and, in any event, appears to be small relative to the consumption generated by electronics producers. Finally, Dataquest's estimates of both electronics production and semiconductor consumption no doubt suffer from errors of omission. We know our estimates probably exclude at least some current semiconductor applications and certainly exclude more than a few applications that cannot be anticipated now. We have good reason to believe these omissions are minor. Still, they represent yet another reason why estimated semiconductor consumption may differ from forecast semiconductor shipments.

It nonetheless seems reasonable to expect that estimated semiconductor consumption and forecast semiconductor shipments will closely parallel one another, especially over the long term. As already noted, semiconductors are first and foremost intermediate inputs to the production of electronics. Growth in semiconductor shipments is ultimately fueled by growth in the semiconductor consumption generated by electronics production. Growth in the semiconductor consumption of electronics producers is, in turn, fueled by growth in both the volume and semiconductor content of electronics production. In the end, all growth in semiconductor shipments can be attributed to growth in one or the other of these key consumption drivers. Estimation errors aside, persistent differences between estimated semiconductor consumption growth and forecast semiconductor shipment growth prefigure a demand/supply imbalance in the semiconductor market.

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In the past, Dataquest's top-down method obscured potential semiconductor market imbalances by assuming that estimated semiconductor consumption must equal forecast semiconductor shipments. The beauty of the bottom-up method is that we can offer important insights into the future of the semiconductor market. We realize that separate forecasts of semiconductor consumption and semiconductor shipments have the potential to create confusion. However, Dataquest believes that separate forecasts may actually help clarify semiconductor market movements by revealing potential market imbalances.

Forecast Highlights

Dataquest estimates that worldwide semiconductor consumption will increase by 10.7 percent in 1998 to about $160.6 billion. Dataquest expects approximately two-thirds of this growth will come about because of growth in worldwide electronics production, which is now forecast to grow 6.9 percent in 1998 to about $968.9 billion. The remainder will be the result of expected growth in the average semiconductor content of electronics, which we forecast will increase to about 16.6 percent of electronics factory value. Longer-term, we estimate worldwide semiconductor consumption will average 12.2 percent annual growth through 2002. This should raise worldwide semiconductor consumption to about $257.6 billion by 2002. Dataquest expects slightly over half of the longer-term growth in worldwide semiconductor consumption to come about because of growth in worldwide electronics production, which we are now forecasting to average 6.6 percent annual growth through 2002. Once again, remaining growth in semiconductor consumption will be the result of increases in the average semiconductor content of electronics. We now expect average semiconductor content will rise to about 20.6 percent of electronics factory value by 2002.

Japan currently ranks as the world's second-leading regional consumer of semiconductors. Asia/Pacific, in turn, ranks third just ahead of our Europe, Middle East, and Africa region. Dataquest expects at least one if not two significant changes in this ranking as time progresses. It now looks very probable that Asia/Pacific will overtake Japan as the world's No. 2 regional consumer of semiconductors by 2002. An additional possibility is that Europe, Middle East, and Africa will also overtake Japan before the end of the forecast period, placing Japan last among the regions as a semiconductor consumer. These changes appear inherent in the markedly different consumption growth rates anticipated for each region. We are now forecasting Japanese semiconductor consumption will grow just 1.9 percent in 1998. This compares to anticipated growth rates of 17.6 percent for Asia/Pacific and 10.6 percent for Europe, Middle East, and Africa. Longer-term, Japanese consumption is expected to average just 8.8 percent annual growth between 1997 and 2002 as opposed to 16.3 percent for Asia/Pacific and 12.8 percent for Europe, Middle East, and Africa. (Note: All our forecasts are valued in U.S. dollars and thus reflect projected exchange rate movements in addition to expected changes in semiconductor consumption expressed in local currencies.) Underlying these marked differences in long-term growth are equally marked differences in expected sources of growth.

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About 80 percent of Japan's longer-term consumption growth is forecast to come from increases in semiconductor content. In contrast, just over 70 percent of Asia/Pacific's longer-term consumption growth is expected to come from growing electronics production. For Europe, Middle East, and Africa, consumption growth will come from a more equally balanced combination of production growth and increased semiconductor content.

We need to note that our regional forecasts, especially for Japan and Asia/Pacific, are considerably more tentative than usual. Ongoing economic and political events in Japan and Asia/Pacific, some quite dramatic, have introduced significant uncertainty into our forecasts. In particular, Dataquest believes there is much greater potential for downward deviations from our forecasts than in the past. Readers should keep this in mind when using and interpreting our results.

As discussed earlier, this forecast represents an effort to independently forecast semiconductor consumption, free of the assumption that semiconductor consumption must always and everywhere equal semiconductor shipments. At least for the near-term, our semiconductor consumption forecasts generally agrees with our recently published forecast of semiconductor shipments. According to the latter, semiconductor supplier shipments are expected to increase 8.2 percent in 1998 to about $159.2 billion. This compares quite well to our forecast of a 10.7 percent increase in semiconductor consumption to about $160.6 billion for 1998. Given that the downside risks of ongoing turmoil in Japan and Asia/Pacific threaten our forecast, we would not be surprised to see semiconductor consumption growth move into even closer agreement with the growth currently expected for semiconductor shipments as 1998 progresses. In fact, there is a significant chance that both semiconductor consumption and semiconductor shipments growth will fall well below 8 percent before the year is out because of continuing troubles in Japan and Asia/Pacific.

Longer-term, there is significant disagreement between our two forecasts. According to Dataquest's semiconductor shipments forecast, semiconductor shipments are expected to average 14.4 percent annual growth through 2002. If realized, that would raise the value of semiconductor shipments to $287.9 billion by 2002. Recall that semiconductor consumption is forecast to average 12.2 percent annual growth through the forecast period so that it reaches $257.6 billion by 2002. As noted earlier, semiconductor consumption may reasonably differ from semiconductor shipments on several accounts. But even after due consideration of these factors, the $30.3 billion difference between our forecasts for semiconductor consumption and semiconductor shipments appears excessive. The difference suggests there is likely to be a sizable oversupply of semiconductors around 2002. We would especially urge semiconductor suppliers to consider this a distinct possibility and to ponder its consequences.

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There is a strong desire among suppliers to believe that semiconductor shipments, and with them semiconductor revenue, can continue to post high rates of long-term growth. But this desire needs to be tempered with the recognition that long-term shipments growth is only possible so long as electronics makers are able to profitably increase semiconductor consumption, either by expanding electronics production or increasing semiconductor content. A number of fundamental changes are taking place in several key electronics markets that will limit the future ability of electronics makers to profitably increase semiconductor consumption. Semiconductor suppliers would be well advised to acknowledge these emerging limits since failure to do so will only intensify competition and further imperil both future shipment and revenue growth in Japan.

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Chapter 2
Worldwide and Japanese Semiconductor Consumption Forecasts

Tables 2-1 through 2-22 present Dataquest's forecast of worldwide and Japanese semiconductor consumption by electronics application.

Table 2-1
Value of Semiconductors Consumed Worldwide by Electronic Product Group, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
All Electronic Products	**145,027**	**160,571**	**182,372**	**213,290**	**236,035**	**257,634**
Data Processing Products	66,869	74,844	85,918	101,272	112,573	121,558
Computers	49,321	54,994	62,787	73,087	81,574	88,060
Data Storage	6,810	7,935	8,890	10,404	11,588	12,969
Input/Output	6,446	6,987	8,001	9,476	10,140	10,761
Other Data Processing	4,292	4,928	6,240	8,305	9,271	9,769
Communications Products	31,353	34,439	37,917	43,111	46,932	51,178
Premise Telecommunications	11,692	13,008	13,845	15,530	16,976	17,934
Public Telecommunications	4,581	4,994	5,906	7,063	7,871	9,181
Mobile Communications	12,586	13,560	14,668	16,070	17,120	18,528
Broadcast and Studio	894	1,057	1,340	1,758	2,006	2,285
Other Communications	1,600	1,820	2,158	2,690	2,960	3,249
Industrial Products	13,122	15,199	18,370	22,710	25,771	27,661
Security/Energy Management	1,320	1,542	1,857	2,241	2,620	2,835
Manufacturing System/Instruments	8,258	9,522	11,505	14,419	16,265	17,483
Medical Equipment	1,434	1,667	1,992	2,383	2,698	2,879
Other Industrial	2,110	2,468	3,016	3,667	4,188	4,464
Consumer Products	23,843	25,613	28,668	33,226	36,398	41,728
Audio	3,857	4,107	4,825	6,034	6,381	6,867
Video	9,923	10,774	11,917	12,770	13,887	14,877
Personal Electronics	5,997	6,421	7,045	8,497	9,583	12,771
Appliances	2,619	2,746	3,116	3,687	4,068	4,509
Other Consumer	1,447	1,564	1,765	2,239	2,479	2,704
Military/Civil Aerospace Products	2,676	2,721	2,927	3,175	3,394	3,582
Transportation Products	7,165	7,755	8,572	9,796	10,967	11,928
Semiconductor Shipments	**147,165**	**159,249**	**188,256**	**227,054**	**275,028**	**287,895**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73

Source: Dataquest (June 1998)

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Table 2-2
Growth in the Value of Semiconductors Consumed Worldwide by Electronic Product Group, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
All Electronic Products	**-0.5**	**8.1**	**12.8**	**26.8**	**10.7**	**9.1**	**12.2**
Data Processing Products	-3.5	11.9	14.8	17.9	11.2	8.0	12.7
Computers	-5.5	11.5	14.2	16.4	11.6	8.0	12.3
Data Storage	9.2	16.5	12.0	17.0	11.4	11.9	13.7
Input/Output	3.1	8.4	14.5	18.4	7.0	6.1	10.8
Other Data Processing	-7.3	14.8	26.6	33.1	11.6	5.4	17.9
Communications Products	15.0	9.8	10.1	13.7	8.9	9.0	10.3
Premise Telecommunications	5.1	11.3	6.4	12.2	9.3	5.6	8.9
Public Telecommunications	8.9	9.0	18.3	19.6	11.4	16.7	14.9
Mobile Communications	32.8	7.7	8.2	9.6	6.5	8.2	8.0
Broadcast and Studio	7.8	18.2	26.8	31.2	14.1	13.9	20.6
Other Communications	-1.8	13.7	18.6	24.6	10.1	9.8	15.2
Industrial Products	4.7	15.8	20.9	23.6	13.5	7.3	16.1
Security/Energy Management	-0.3	16.9	20.4	20.7	16.9	8.2	16.5
Manufacturing System/Instruments	5.4	15.3	20.8	25.3	12.8	7.5	16.2
Medical Equipment	2.5	16.3	19.4	19.6	13.2	6.7	15.0
Other Industrial	7.1	17.0	22.2	21.6	14.2	6.6	16.2
Consumer Products	8.4	7.4	11.9	15.9	9.5	14.6	11.8
Audio	0.4	6.5	17.5	25.1	5.7	7.6	12.2
Video	3.8	8.6	10.6	7.2	8.7	7.1	8.4
Personal Electronics	32.9	7.1	9.7	20.6	12.8	33.3	16.3
Appliances	-0.2	4.9	13.5	18.3	10.3	10.8	11.5
Other Consumer	-0.5	8.1	12.8	26.8	10.7	9.1	13.3
Military/Civil Aerospace Products	0.5	1.7	7.6	8.5	6.9	5.5	6.0
Transportation Products	2.6	8.2	10.5	14.3	11.9	8.8	10.7
Semiconductor Shipments	**3.9**	**8.2**	**18.2**	**20.6**	**21.1**	**4.7**	**14.4**

Source: Dataquest (June 1998)

Table 2-3
Value of Semiconductors Consumed in Japan by Electronic Product Group, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
All Electronic Products	**36,742**	**37,438**	**41,390**	**47,414**	**50,132**	**55,932**
Data Processing Products	13,357	14,002	15,393	16,860	17,498	18,260
Computers	8,520	9,133	9,721	10,458	10,947	11,493
Data Storage	1,737	1,730	2,040	2,097	2,115	2,141
Input/Output	1,746	1,658	1,788	1,915	2,010	2,100
Other Data Processing	1,354	1,481	1,843	2,390	2,425	2,526
Communications Products	7,132	6,798	7,245	8,307	8,752	9,372
Premise Telecommunications	2,041	1,976	1,911	2,016	2,083	2,136
Public Telecommunications	1,748	1,895	2,328	2,944	3,247	3,699
Mobile Communications	2,915	2,447	2,381	2,458	2,465	2,429
Broadcast and Studio	120	132	189	275	272	319
Other Communications	308	348	436	615	685	788
Industrial Products	3,948	4,228	5,139	6,460	7,077	7,934
Security/Energy Management	285	296	340	365	384	410
Manufacturing System/Instruments	2,855	3,054	3,744	4,826	5,311	5,948
Medical Equipment	265	277	330	410	454	531
Other Industrial	542	601	724	858	928	1,046
Consumer Products	9,886	9,970	10,972	12,979	13,983	17,433
Audio	1,507	1,535	1,802	2,204	2,411	2,822
Video	2,828	2,820	2,843	2,705	2,497	2,287
Personal Electronics	4,168	4,223	4,735	6,062	6,880	9,845
Appliances	874	856	1,013	1,301	1,444	1,659
Other Consumer	508	535	578	708	752	820
Military/Civil Aerospace Products	311	294	301	313	311	316
Transportation Products	2,108	2,147	2,340	2,495	2,511	2,617
Semiconductor Shipments	**36,499**	**37,397**	**42,943**	**49,988**	**58,610**	**61,093**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73

Source: Dataquest (June 1998)

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Table 2-4
Growth in the Value of Semiconductors Consumed in Japan by Electronic Product Group, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
All Electronic Products	3.3	1.9	10.6	14.6	5.7	11.6	8.8
Data Processing Products	-4.7	4.8	9.9	9.5	3.8	4.4	6.5
Computers	-2.4	7.2	6.4	7.6	4.7	5.0	6.2
Data Storage	-7.7	-0.4	17.9	2.8	0.9	1.2	4.3
Input/Output	0.4	-5.1	7.9	7.1	5.0	4.5	3.8
Other Data Processing	-19.1	9.4	24.4	29.7	1.5	4.1	13.3
Communications Products	7.8	-4.7	6.6	14.7	5.3	7.1	5.6
Premise Telecommunications	-2.1	-3.2	-3.3	5.5	3.3	2.5	0.9
Public Telecommunications	17.4	8.4	22.9	26.5	10.3	13.9	16.2
Mobile Communications	11.2	-16.1	-2.7	3.2	0.3	-1.4	-3.6
Broadcast and Studio	-12.0	10.6	42.4	45.6	-0.8	17.2	21.7
Other Communications	7.1	13.0	25.4	40.8	11.4	15.0	20.7
Industrial Products	3.9	7.1	21.6	25.7	9.6	12.1	15.0
Security and Energy Management	-18.0	3.9	15.0	7.3	5.1	6.8	7.6
Manufacturing System/Instruments	6.9	7.0	22.6	28.9	10.0	12.0	15.8
Medical Equipment	-1.6	4.3	19.2	24.2	10.7	16.9	14.8
Other Industrial	5.4	10.7	20.6	18.5	8.2	12.7	14.0
Consumer Products	15.9	0.8	10.1	18.3	7.7	24.7	12.0
Audio	8.7	1.9	17.4	22.3	9.4	17.0	13.4
Video	0.1	-0.3	0.8	-4.9	-7.7	-8.4	-4.2
Personal Electronics	48.3	1.3	12.1	28.0	13.5	43.1	18.8
Appliances	-9.8	-2.1	18.4	28.4	10.9	15.0	13.7
Other Consumer	-5.8	5.3	7.9	22.6	6.1	9.1	10.0
Military/Civil Aerospace Products	-8.7	-5.6	2.5	3.9	-0.6	1.6	0.3
Transportation Products	-6.9	1.9	9.0	6.6	0.7	4.2	4.4
Semiconductor Shipments	**-5.4**	**2.5**	**14.8**	**16.4**	**17.2**	**4.2**	**10.9**

Source: Dataquest (June 1998)

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Table 2-5
Value of Semiconductors Consumed in Japan by Individual Data Processing Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Mainframe/Supercomputers (Computers)	560	599	535	452	353	311
Midrange Computers (Computers)	667	705	618	674	723	721
Workstations (Computers)	383	304	282	304	305	271
PCs (Computers)	6,120	6,650	7,319	7,969	8,475	9,075
Motherboards (Computers)	790	875	968	1,059	1,091	1,115
Rigid Disk Drives (Data Storage)	952	781	697	719	673	658
Optical Disk Drives (Data Storage)	569	704	1,011	984	1,008	979
Removable Magnetic Storage (Data Storage)	216	245	332	394	435	504
Page Printers (Input/Output)	540	484	519	540	551	559
Serial Printers (Input/Output)	394	355	359	356	353	339
Monitors (Input/Output)	122	120	118	119	126	140
Other Data Processing Products	2,045	2,180	2,635	3,291	3,406	3,589
All Data Processing Products	**13,357**	**14,002**	**15,393**	**16,860**	**17,498**	**18,260**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73

Source: Dataquest (June 1998)

Table 2-6
Growth in the Value of Semiconductors Consumed in Japan by Individual Data Processing Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Mainframe/Supercomputers (Computers)	-4.6	7.0	-10.7	-15.5	-21.9	-11.9	-11.1
Midrange Computers (Computers)	-1.8	5.6	-12.3	9.0	7.4	-0.4	1.5
Workstations (Computers)	-14.1	-20.5	-7.5	7.9	0.2	-11.0	-6.7
PCs (Computers)	-4.1	8.7	10.1	8.9	6.4	7.1	8.2
Motherboards (Computers)	25.0	10.8	10.6	9.5	3.0	2.2	7.1
Rigid Disk Drives (Data Storage)	-19.3	-18.0	-10.7	3.1	-6.4	-2.1	-7.1
Optical Disk Drives (Data Storage)	21.3	23.9	43.5	-2.6	2.4	-2.9	11.5
Removable Magnetic Storage (Data Storage)	-7.5	13.4	35.5	18.6	10.5	15.9	18.5
Page Printers (Input/Output)	-10.0	-10.3	7.3	4.0	2.0	1.4	0.7
Serial Printers (Input/Output)	4.3	-9.9	1.3	-0.9	-0.9	-4.0	-3.0
Monitors (Input/Output)	21.9	-1.7	-1.6	0.8	6.2	11.0	2.8
Other Data Processing Products	-12.4	6.6	20.9	24.9	3.5	5.4	11.9
All Data Processing Products	**-4.7**	**4.8**	**9.9**	**9.5**	**3.8**	**4.4**	**6.5**

Source: Dataquest (June 1998)

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Table 2-7
Value of Semiconductors Consumed in Japan by Individual Communications Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
LAN Cards (Premise Telecommunications)	37	54	64	74	82	83
Premise Line Cards (Premise Telecommunications)	39	37	38	44	42	42
Answering Machines (Premise Telecommunications)	6	4	4	5	6	7
Fax Machines (Premise Telecommunications)	438	449	488	545	577	622
Modems (Premise Telecommunications)	7	7	7	8	9	9
Corded Telephones (Premise Telecommunications)	40	31	33	36	38	38
Analog Cordless (Premise Telecommunications)	254	235	215	199	186	163
Digital Cordless (Premise Telecommunications)	232	177	177	178	175	176
Central Office Line Cards (Public Telecommunications)	86	82	83	83	77	77
Analog Cellular (Mobile Telecommunications)	25	0	0	0	0	0
Digital Cellular (Mobile Telecommunications)	1,728	1,259	1,084	1,001	918	792
Pagers (Mobile Telecommunications)	101	89	86	80	74	69
Mobile Telecommunications Infrastructure (Mobile Telecommunications)	841	902	1,021	1,191	1,294	1,395
Other Mobile Telecommunications (Mobile Telecommunications)	219	196	190	185	179	174
Other Communications Products	3,078	3,275	3,756	4,677	5,096	5,726
All Communications Products	**7,132**	**6,798**	**7,245**	**8,307**	**8,752**	**9,372**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73

Source: Dataquest (June 1998)

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Table 2-8
Growth in the Value of Semiconductors Consumed in Japan by Individual Communications Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
LAN Cards (Premise Telecommunications)	67.8	47.3	17.3	17.1	9.7	1.0	17.5
Premise Line Cards (Premise Telecommunications)	-3.8	-6.0	4.9	15.1	-5.5	-0.2	1.4
Answering Machines (Premise Telecommunications)	-4.2	-29.0	-4.1	26.7	21.1	6.6	2.2
Fax Machines (Premise Telecommunications)	-5.2	2.5	8.5	11.6	5.9	7.9	7.3
Modems (Premise Telecommunications)	-12.6	-1.0	3.4	13.8	6.3	2.1	4.8
Corded Telephones (Premise Telecommunications)	-1.9	-22.7	5.8	10.9	4.8	1.8	-0.7
Analog Cordless (Premise Telecommunications)	10.3	-7.2	-8.9	-7.4	-6.4	-12.1	-8.4
Digital Cordless (Premise Telecommunications)	-35.8	-23.8	-0.2	0.8	-1.7	0.3	-5.4
Central Office Line Cards (Public Telecommunications)	5.6	-5.2	1.1	0.5	-7.1	-0.5	-2.3
Analog Cellular (Mobile Telecommunications)	-79.9	NM	NM	NM	NM	NM	NM
Digital Cellular (Mobile Telecommunications)	14.8	-27.1	-13.9	-7.6	-8.3	-13.7	-14.4
Pagers (Mobile Telecommunications)	-14.3	-11.5	-3.9	-6.8	-8.0	-6.8	-7.4
Mobile Telecommunications Infrastructure (Mobile Telecommunications)	33.6	7.2	13.2	16.6	8.6	7.8	10.6
Other Mobile Telecommunications (Mobile Telecommunications)	-9.7	-10.5	-2.9	-2.6	-3.3	-3.0	-4.5
Other Communications Products	12.2	6.4	14.7	24.5	9.0	12.4	13.2
All Communications Products	**7.8**	**-4.7**	**6.6**	**14.7**	**5.3**	**7.1**	**5.6**

NM = Not meaningful
Source: Dataquest (June 1998)

Table 2-9
Value of Semiconductors Consumed in Japan by Individual Consumer Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Personal/Portable Stereos (Audio)	171	154	161	165	160	158
Color TVs (Video)	794	775	770	777	769	784
VCRs (Video)	566	475	453	435	279	231
Analog Camcorders (Video)	876	701	588	438	271	155
Digital Camcorders (Video)	458	685	814	769	849	798
DVD (Video)	22	40	64	119	154	171
Analog Set-Top Boxes (Video)	12	9	6	5	4	4
Digital Set-Top Boxes (Video)	100	136	148	162	170	143
Digital Still Cameras (Personal Electronics)	234	349	336	289	316	424
Video Game Controllers (Personal Electronics)	1,727	1,169	680	540	472	609
Video Game Cartridges (Personal Electronics)	54	27	14	8	6	4
Other Consumer Products	4,872	5,450	6,937	9,273	10,532	13,951
All Consumer Products	**9,886**	**9,970**	**10,972**	**12,979**	**13,983**	**17,433**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73

Source: Dataquest (June 1998)

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Table 2-10
Growth in the Value of Semiconductors Consumed in Japan by Individual Consumer Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Personal/Portable Stereos (Audio)	-18.4	-9.8	4.7	2.4	-3.1	-1.4	-1.6
Color TVs (Video)	0.5	-2.5	-0.6	0.9	-1.0	2.0	-0.3
VCRs (Video)	-11.8	-16.2	-4.5	-4.0	-35.9	-17.0	-16.4
Analog Camcorders (Video)	-5.6	-20.0	-16.2	-25.4	-38.1	-42.8	-29.3
Digital Camcorders (Video)	35.4	49.7	18.8	-5.6	10.5	-6.1	11.8
DVD (Video)	126.8	86.8	58.9	85.7	29.9	11.0	51.4
Analog Set-Top Boxes (Video)	-22.9	-26.5	-24.7	-18.8	-15.0	-2.4	-17.9
Digital Set-Top Boxes (Video)	-0.6	35.3	8.8	9.7	5.1	-15.9	7.4
Digital Still Cameras (Personal Electronics)	48.7	49.3	-3.9	-14.0	9.6	34.0	12.6
Video Game Controllers (Personal Electronics)	12.1	-32.3	-41.8	-20.6	-12.6	29.1	-18.8
Video Game Cartridges (Personal Electronics)	-67.2	-49.9	-46.3	-44.7	-28.6	-26.9	-40.0
Other Consumer Products	34.0	11.9	27.3	33.7	13.6	32.5	23.4
All Consumer Products	**15.9**	**0.8**	**10.1**	**18.3**	**7.7**	**24.7**	**12.0**

Source: Dataquest (June 1998)

Table 2-11
Value of Semiconductors Consumed in Japan by Individual Transportation Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Automotive Stereos	188	157	163	184	175	179
Automotive ECUs	486	490	536	597	613	627
Antilock Braking Systems	119	121	141	163	184	197
Air Bags	99	109	127	146	164	174
Automotive Navigation Systems	260	377	489	561	623	750
Other Transportation Products	956	894	884	843	752	690
All Transportation Products	**2,108**	**2,147**	**2,340**	**2,495**	**2,511**	**2,617**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73

Source: Dataquest (June 1998)

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Table 2-12
Growth in the Value of Semiconductors Consumed in Japan by Individual Transportation Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Automotive Stereos	-11.9	-16.3	3.8	13.0	-5.0	2.3	-0.9
Automotive ECUs	-2.2	0.7	9.4	11.4	2.6	2.3	5.2
Antilock Braking Systems	10.0	1.3	16.8	15.6	12.8	6.7	10.5
Air Bags	13.2	9.6	17.3	14.5	12.3	5.9	11.9
Automotive Navigation Systems	20.7	45.4	29.5	14.8	11.1	20.4	23.7
Other Transportation Products	-16.4	-6.5	-1.1	-4.6	-10.8	-8.1	-6.3
All Transportation Products	**-6.9**	**1.9**	**9.0**	**6.6**	**0.7**	**4.2**	**4.4**

Source: Dataquest (June 1998)

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Table 2-13
Value of Semiconductors Consumed in Japan by Electronic Product Group, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
All Electronic Products	**4,449**	**4,850**	**5,362**	**6,143**	**6,495**	**7,246**
Data Processing Products	1,617	1,814	1,994	2,184	2,267	2,366
Computers	1,032	1,183	1,259	1,355	1,418	1,489
Data Storage	210	224	264	272	274	277
Input/Output	211	215	232	248	260	272
Other Data Processing	164	192	239	310	315	328
Communications Products	864	881	939	1,076	1,134	1,214
Premise Telecommunications	247	256	248	261	270	277
Public Telecommunications	212	245	302	381	421	479
Mobile Communications	353	317	309	318	319	315
Broadcast and Studio	15	17	24	36	35	41
Other Communications	37	45	57	80	89	102
Industrial Products	478	548	666	837	917	1,028
Security/Energy Management	34	38	44	47	50	53
Manufacturing System/Instruments	346	396	485	625	688	771
Medical Equipment	32	36	43	53	59	69
Other Industrial	66	78	94	111	120	136
Consumer Products	1,197	1,292	1,421	1,681	1,811	2,258
Audio	183	199	233	285	312	366
Video	342	365	368	350	324	296
Personal Electronics	505	547	613	785	891	1,275
Appliances	106	111	131	169	187	215
Other Consumer	62	69	75	92	97	106
Military/Civil Aerospace Products	38	38	39	41	40	41
Transportation Products	255	278	303	323	325	339
Semiconductor Shipments	**4,420**	**4,852**	**5,571**	**6,485**	**7,604**	**7,926**

Source: Dataquest (June 1998)

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Table 2-14
Growth in the Value of Semiconductors Consumed in Japan by Electronic Product Group, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
All Electronic Products	**14.9**	**9.0**	**10.6**	**14.6**	**5.7**	**11.6**	**10.2**
Data Processing Products	6.0	12.1	9.9	9.5	3.8	4.4	7.9
Computers	8.6	14.8	6.4	7.6	4.7	5.0	7.6
Data Storage	2.7	6.7	17.9	2.8	0.9	1.2	5.7
Input/Output	11.8	1.7	7.9	7.1	5.0	4.5	5.2
Other Data Processing	-10.0	17.2	24.4	29.7	1.5	4.1	14.9
Communications Products	19.9	2.0	6.6	14.7	5.3	7.1	7.0
Premise Telecommunications	9.0	3.6	-3.3	5.5	3.3	2.5	2.3
Public Telecommunications	30.6	16.0	22.9	26.5	10.3	13.9	17.8
Mobile Communications	23.8	-10.2	-2.7	3.2	0.3	-1.4	-2.3
Broadcast and Studio	-2.1	18.3	42.4	45.6	-0.8	17.2	23.3
Other Communications	19.2	20.9	25.4	40.8	11.4	15.0	22.3
Industrial Products	15.6	14.6	21.6	25.7	9.6	12.1	16.5
Security and Energy Management	-8.8	11.2	15.0	7.3	5.1	6.8	9.0
Manufacturing System/Instruments	19.0	14.4	22.6	28.9	10.0	12.0	17.4
Medical Equipment	9.6	11.6	19.2	24.2	10.7	16.9	16.4
Other Industrial	17.3	18.5	20.6	18.5	8.2	12.7	15.6
Consumer Products	29.0	7.9	10.1	18.3	7.7	24.7	13.5
Audio	20.9	9.0	17.4	22.3	9.4	17.0	14.9
Video	11.5	6.7	0.8	-4.9	-7.7	-8.4	-2.9
Personal Electronics	65.1	8.4	12.1	28.0	13.5	43.1	20.4
Appliances	0.4	4.7	18.4	28.4	10.9	15.0	15.2
Other Consumer	4.9	12.7	7.9	22.6	6.1	9.1	11.5
Military/Civil Aerospace Products	1.6	1.0	2.5	3.9	-0.6	1.6	1.7
Transportation Products	3.6	9.0	9.0	6.6	0.7	4.2	5.8
Semiconductor Shipments	**5.7**	**9.8**	**14.8**	**16.4**	**17.2**	**4.2**	**12.4**

Source: Dataquest (June 1998)

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Table 2-15
Value of Semiconductors Consumed in Japan by Individual Data Processing Product, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
Mainframe/Supercomputers (Computers)	68	78	69	59	46	40
Midrange Computers (Computers)	81	91	80	87	94	93
Workstations (Computers)	46	39	37	39	39	35
PCs (Computers)	741	862	948	1,032	1,098	1,176
Motherboards (Computers)	96	113	125	137	141	144
Rigid Disk Drives (Data Storage)	115	101	90	93	87	85
Optical Disk Drives (Data Storage)	69	91	131	128	131	127
Removable Magnetic Storage (Data Storage)	26	32	43	51	56	65
Page Printers (Input/Output)	65	63	67	70	71	72
Serial Printers (Input/Output)	48	46	47	46	46	44
Monitors (Input/Output)	15	16	15	15	16	18
Other Data Processing Products	248	282	341	426	441	465
All Data Processing Products	**1,617**	**1,814**	**1,994**	**2,184**	**2,267**	**2,366**

Source: Dataquest (June 1998)

Table 2-16
Growth in the Value of Semiconductors Consumed in Japan by Individual Data Processing Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Mainframe/Supercomputers (Computers)	6.1	14.5	-10.7	-15.5	-21.9	-11.9	-9.9
Midrange Computers (Computers)	9.3	13.0	-12.3	9.0	7.4	-0.4	2.9
Workstations (Computers)	-4.4	-15.0	-7.5	7.9	0.2	-11.0	-5.4
PCs (Computers)	6.7	16.2	10.1	8.9	6.4	7.1	9.7
Motherboards (Computers)	39.1	18.5	10.6	9.5	3.0	2.2	8.6
Rigid Disk Drives (Data Storage)	-10.2	-12.3	-10.7	3.1	-6.4	-2.1	-5.9
Optical Disk Drives (Data Storage)	35.1	32.5	43.5	-2.6	2.4	-2.9	13.0
Removable Magnetic Storage (Data Storage)	3.0	21.4	35.5	18.6	10.5	15.9	20.1
Page Printers (Input/Output)	0.2	-4.0	7.3	4.0	2.0	1.4	2.1
Serial Printers (Input/Output)	16.1	-3.6	1.3	-0.9	-0.9	-4.0	-1.6
Monitors (Input/Output)	35.7	5.2	-1.6	0.8	6.2	11.0	4.2
Other Data Processing Products	-2.5	14.1	20.9	24.9	3.5	5.4	13.4
All Data Processing Products	**6.0**	**12.1**	**9.9**	**9.5**	**3.8**	**4.4**	7.9

Source: Dataquest (June 1998)

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Table 2-17
Value of Semiconductors Consumed in Japan by Individual Communications Product, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
LAN Cards (Premise Telecommunications)	4	7	8	10	11	11
Premise Line Cards (Premise Telecommunications)	5	5	5	6	5	5
Answering Machines (Premise Telecommunications)	1	1	1	1	1	1
Fax Machines (Premise Telecommunications)	53	58	63	71	75	81
Modems (Premise Telecommunications)	1	1	1	1	1	1
Corded Telephones (Premise Telecommunications)	5	4	4	5	5	5
Analog Cordless Phones (Premise Telecommunications)	31	30	28	26	24	21
Digital Cordless Phones (Premise Telecommunications)	28	23	23	23	23	23
Central Office Line Cards (Public Telecommunications)	10	11	11	11	10	10
Analog Cellular Phones (Mobile Telecommunications)	3	0	0	0	0	0
Digital Cellular Phones (Mobile Telecommunications)	209	163	140	130	119	103
Pagers (Mobile Telecommunications)	12	12	11	10	10	9
Mobile Telecommunications Infrastructure (Mobile Telecommunications)	102	117	132	154	168	181
Other Mobile Telecommunications (Mobile Telecommunications)	27	25	25	24	23	23
Other Communications Products	373	424	487	606	660	742
All Communications Products	**864**	**881**	**939**	**1,076**	**1,134**	**1,214**

Source: Dataquest (June 1998)

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Table 2-18
Growth in the Value of Semiconductors Consumed in Japan by Individual Communications Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
LAN Cards (Premise Telecommunications)	86.7	57.6	17.3	17.1	9.7	1.0	19.1
Premise Line Cards (Premise Telecommunications)	7.0	0.6	4.9	15.1	-5.5	-0.2	2.8
Answering Machines (Premise Telecommunications)	6.6	-24.0	-4.1	26.7	21.1	6.6	3.6
Fax Machines (Premise Telecommunications)	5.5	9.7	8.5	11.6	5.9	7.9	8.7
Modems (Premise Telecommunications)	-2.8	5.9	3.4	13.8	6.3	2.1	6.2
Corded Telephones (Premise Telecommunications)	9.2	-17.3	5.8	10.9	4.8	1.8	0.7
Analog Cordless Phones (Premise Telecommunications)	22.8	-0.7	-8.9	-7.4	-6.4	-12.1	-7.2
Digital Cordless Phones (Premise Telecommunications)	-28.5	-18.5	-0.2	0.8	-1.7	0.3	-4.2
Central Office Line Cards (Public Telecommunications)	17.5	1.4	1.1	0.5	-7.1	-0.5	-1.0
Analog Cellular Phones (Mobile Telecommunications)	-77.6	NM	NM	NM	NM	NM	NM
Digital Cellular Phones (Mobile Telecommunications)	27.8	-22.1	-13.9	-7.6	-8.3	-13.7	-13.3
Pagers (Mobile Telecommunications)	-4.6	-5.3	-3.9	-6.8	-8.0	-6.8	-6.2
Mobile Telecommunications Infrastructure (Mobile Telecommunications)	48.7	14.7	13.2	16.6	8.6	7.8	12.1
Other Mobile Telecommunications (Mobile Telecommunications)	0.5	-4.2	-2.9	-2.6	-3.3	-3.0	-3.2
Other Communications Products	24.9	13.8	14.7	24.5	9.0	12.4	14.8
All Communications Products	**19.9**	**2.0**	**6.6**	**14.7**	**5.3**	**7.1**	**7.0**

NM = Not meaningful
Source: Dataquest (June 1998)

Table 2-19
Value of Semiconductors Consumed in Japan by Individual Consumer Product, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
Personal/Portable Stereos (Audio)	21	20	21	21	21	20
Color TVs (Video)	96	100	100	101	100	102
VCRs (Video)	69	61	59	56	36	30
Analog Camcorders (Video)	106	91	76	57	35	20
Digital Camcorders (Video)	55	89	105	100	110	103
DVD (Video)	3	5	8	15	20	22
Analog Set-Top Boxes (Video)	1	1	1	1	1	1
Digital Set-Top Boxes (Video)	12	18	19	21	22	19
Digital Still Cameras (Personal Electronics)	28	45	43	37	41	55
Video Game Controllers (Personal Electronics)	209	151	88	70	61	79
Video Game Cartridges (Personal Electronics)	7	3	2	1	1	1
Other Consumer Products	590	706	899	1,201	1,364	1,807
All Consumer Products	**1,197**	**1,292**	**1,421**	**1,681**	**1,811**	**2,258**

Source: Dataquest (June 1998)

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Table 2-20
Growth in the Value of Semiconductors Consumed in Japan by Individual Consumer Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Personal/Portable Stereos (Audio)	-9.2	-3.6	4.7	2.4	-3.1	-1.4	-0.2
Color TVs (Video)	11.8	4.3	-0.6	0.9	-1.0	2.0	1.1
VCRs (Video)	-1.8	-10.3	-4.5	-4.0	-35.9	-17.0	-15.3
Analog Camcorders (Video)	5.1	-14.4	-16.2	-25.4	-38.1	-42.8	-28.3
Digital Camcorders (Video)	50.6	60.2	18.8	-5.6	10.5	-6.1	13.3
DVD (Video)	152.4	99.9	58.9	85.7	29.9	11.0	53.4
Analog Set-Top Boxes (Video)	-14.1	-21.4	-24.7	-18.8	-15.0	-2.4	-16.8
Digital Set-Top Boxes (Video)	10.6	44.8	8.8	9.7	5.1	-15.9	8.8
Digital Still Cameras (Personal Electronics)	65.5	59.7	-3.9	-14.0	9.6	34.0	14.1
Video Game Controllers (Personal Electronics)	24.8	-27.6	-41.8	-20.6	-12.6	29.1	-17.7
Video Game Cartridges (Personal Electronics)	-63.5	-46.4	-46.3	-44.7	-28.6	-26.9	-39.2
Other Consumer Products	49.2	19.7	27.3	33.7	13.6	32.5	25.1
All Consumer Products	**29.0**	**7.9**	**10.1**	**18.3**	**7.7**	**24.7**	**13.5**

Source: Dataquest (June 1998)

Table 2-21
Value of Semiconductors Consumed in Japan by Individual Transportation Product, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
Automotive Stereos	23	20	21	24	23	23
Automotive Engine Control Units	59	63	69	77	79	81
Antilock Braking Systems	14	16	18	21	24	25
Air Bags	12	14	17	19	21	22
Automotive Navigation Systems	31	49	63	73	81	97
Other Transportation Products	116	116	114	109	97	89
All Transportation Products	**255**	**278**	**303**	**323**	**325**	**339**

Source: Dataquest (June 1998)

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Table 2-22
Growth in the Value of Semiconductors Consumed in Japan by Individual Transportation Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Automotive Stereos	-1.9	-10.5	3.8	13.0	-5.0	2.3	0.4
Automotive Engine Control Units	8.9	7.8	9.4	11.4	2.6	2.3	6.6
Antilock Braking Systems	22.4	8.4	16.8	15.6	12.8	6.7	12.0
Air Bags	26.0	17.3	17.3	14.5	12.3	5.9	13.4
Automotive Navigation Systems	34.3	55.5	29.5	14.8	11.1	20.4	25.3
Other Transportation Products	-7.0	0	-1.1	-4.6	-10.8	-8.1	-5.0
All Transportation Products	**3.6**	**9.0**	**9.0**	**6.6**	**0.7**	**4.2**	**5.8**

Source: Dataquest (June 1998)

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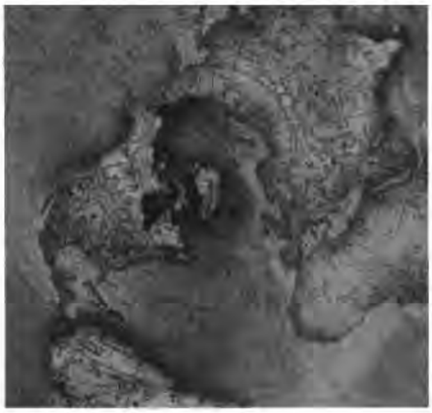

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Japanese Electronic Equipment Production Forecast, Spring 1998

Market Statistics

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Chapter 1
Japanese Electronic Equipment Production Forecast

Introduction

Electronic equipment production is an important determinant of semiconductor market activity. This is true because semiconductor demand is derived, in part, from the underlying demand for the systems that use semiconductors. That is, the demand for semiconductors is a positive (or increasing) function of the demand for electronic systems. Therefore, forecasting electronic systems production is an essential component of assessing expected semiconductor market activity.

This document contains tables detailing the spring 1998 electronic equipment production forecast. Japanese production is estimated for the years 1992 to 2002. Production tables contain both historical data and forecasts. In most tables, historical data begins with 1992 and ends with 1997, while forecast data provides estimates for 1998 through 2002. The tables detail the type of production data by application market.

Definitions and Conventions

The objective of analyzing electronic systems production activity is to estimate the important implications for semiconductor consumption. Therefore, generalized economic concepts such as production and consumption are tailored to isolate these implications.

The value of production is estimated as factory revenue. Dataquest defines factory revenue as the exchange value of the commodity transaction between the original equipment manufacturer and the point of entry into distribution. In the case of a direct sale that involves no distribution, as is the case with military systems, factory revenue is equal to the final user cost, net of sales taxes.

Production is the value-adding process by which the factors of production (labor and capital) and material input are transformed into the goods and services that are desired for consumption and investment. As such, production can span both time and geography. For example, a Japanese color television company may minimize its cost of production by manufacturing its products (that is, consuming chips) in Asian countries. Dataquest would estimate this as Asia/Pacific production, because we are interested in that portion of the production process that relates specifically to semiconductor consumption. Production would be valued as the exchange value of the transaction between the Japanese company's Asian operations (which is factory revenue) and the European distributor or final user.

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Electronic equipment is divided into the following six semiconductor application markets and is further divided into the designated segments. Japanese production is further divided into specific types of equipment systems.

- Data processing
  - Computers
  - Data storage
  - Input/output
  - Dedicated systems
  - Other data processing
- Communications
  - Premise telecom
  - Public telecom
  - Mobile and radio communications
  - Broadcast and studio
  - Other telecom
- Industrial
  - Security and energy management
  - Manufacturing systems/instrumentation
  - Medical equipment
  - Other industrial
- Consumer
  - Audio
  - Video
  - Personal electronics
  - Appliances
  - Other consumer
- Military and civil aerospace
- Transportation
  - Entertainment
  - Control unit
  - Safety and convenience

Data Sources

The historical information presented in the production data has been consolidated from a variety of sources, each of which focuses on a specific part of the market. These sources include the following:

- Japanese production statistics compiled and published by the Ministry of International Trade and Industry (MITI)

- Estimates presented by knowledgeable and reliable industry spokespersons
- Published product literature and prices

Dataquest believes that the estimates presented here are the most accurate and meaningful generally available today.

Valuation of Production

Japanese production is expressed in Japanese yen and translated into U.S. dollars. To make the worldwide tables in this document useful in comparing different regions, it is necessary to express all values in a common currency, and Dataquest chose the U.S. dollar for convenience. However, the choice of the U.S. dollar or any other currency brings with it some problems that require the readers' careful consideration in interpreting the data, as follows:

- Inflation and deflation—No adjustment has been made in the historical or forecast data to account for the effects of past inflation or deflation or for possible future inflation or deflation. Production is expressed in current dollars (that is, dollars that include the effects of inflation and changes in exchange rates).
- Exchange rates—When forecasting electronic equipment production, it is important to ensure consistency and continuity so that we maintain exchange rates at constant 1998 calendar year values. This prevents any inconsistencies in the conversion of growth projections and currency fluctuations. The estimates in this Market Statistics report are generated primarily on a yen basis and then converted to U.S. dollars. The preliminary 1998 exchange rate estimate is based on actual exchange rates through December 1997, and we assume that the December rate applies for all the future months.

Japanese Electronic Equipment Production Definitions

Data Processing Equipment

Defined as computers, data storage, terminals, input/output, dedicated systems, and other data processing, as follows:

- Computers include general-use computers, office-use computers, personal-use computers, and control-use computers.
- Data storage includes rigid disk drives, flexible disk drives, other drives, and other data storage.
- Input/output includes printers, display units, other input/output units, general-use terminals, terminals for special use, and terminals for supporting systems.
- Dedicated systems include calculators, cash registers, copying machines, typewriters, word processors, and other dedicated equipment.
- Other data processing includes PC cards, single in-line memory modules (SIMMs), and other data processing equipment.

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Communications Equipment

Defined as premise telecom, public telecom, mobile and radio communications, broadcast and studio, and other communications, as follows:

- Premise telecom includes telephones (standard, multifunction, cordless, PHS, and others), applied telephone, facsimile, PBX telephone systems, key telephone systems, and modems.
- Public telecom includes carrier transmission equipment and central office switching.
- Mobile and radio communications includes radio communications (radio base station equipment, mobile radio equipment, and mobile communications equipment) and applied radio equipment.
- Broadcast and studio includes all electronic equipment used to make information public by means of radio and television.
- Other communications includes communications control units and other communications equipment.

Industrial Equipment

Defined as security and energy management, instrumentation, manufacturing systems, medical equipment, and other industrial equipment, as follows:

- Security and energy management includes alarm systems (intrusion detection and fire detection) and energy management (air conditioners for industrial use).
- Manufacturing systems/instrumentation includes NC machines, robotics, ultrasonic applied equipment, metering units, measuring instruments, industrial meters, and other instrumentation equipment such as analyzers.
- Medical equipment includes X-ray systems, measuring systems, and other medical equipment such as radioisotope equipment.
- Other industrial includes vending machines, automatic service equipment, commercial-type washers, electron microscopes, ultrasonic equipment, and all other industrial equipment not accounted for in the preceding segments.

Consumer Equipment

Defined as audio equipment, video equipment, personal electronics, appliances, and other consumer equipment, as follows:

- Audio includes audio amplifiers, digital audio disc (DAD) players, radios, stereo sets, tape recorders, headphone stereos, musical instruments, and other audio equipment (tuners and turntables).
- Video includes video cassette recorders (VCRs), video cameras, DVD players, color televisions, and LCD televisions.
- Personal electronics includes cameras, clocks, electronic toys, watches, and game systems and software.
- Appliances include air conditioners for home use, microwave ovens, refrigerators, and washers and dryers.

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- Other consumer includes gas heaters, gas fan heaters, oil fan heaters, electric heaters, fans, electric water heaters, gas water heaters, oil water heaters, electric pots, rice cooker and rice jar combinations, gas rice cookers, sewing machines, electric irons, vacuum cleaners, and other consumer equipment.

Military/Civil Aerospace Equipment

Defined as electronic systems for defense agencies, such as communications equipment and instrumentation.

Transportation Equipment

Defined as in-car entertainment systems, control units and safety and convenience electronics.

- In-car entertainment includes FM/AM radios, radio-cassette combination systems, and car stereo cassette units.
- Control units include electronics control equipment for engine, body, and powertrain.
- Safety and convenience includes in-car equipment for safety and convenience, such as car air conditioners.

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Chapter 2
Market Statistics Tables

Tables 2-1 through 2-42 contain statistics for Japanese electronic equipment production.

Table 2-1
Japanese Electronic Equipment Production History (Vendor Revenue in Billions of Yen)

Segment	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Data Processing							
Computers	2,248	2,026	2,100	2,523	3,352	3,643	10.1
Data Storage	1,302	1,181	1,177	873	867	959	-5.9
Input/Output	1,577	1,409	1,491	1,520	1,593	1,862	3.4
Dedicated Systems	999	925	839	819	750	753	-5.5
Other Data Processing	82	104	146	179	250	163	14.8
Total	**6,207**	**5,645**	**5,753**	**5,913**	**6,812**	**7,380**	**3.5**
Communications							
Premise Telecommunications	952	899	844	806	875	998	0.9
Public Telecommunications	732	816	832	892	1,142	1,384	13.6
Mobile and Radio Equipment	908	880	976	991	1,601	2,018	17.3
Broadcast and Studio	100	78	90	70	92	84	-3.3
Other Communications	137	132	148	226	332	360	21.2
Total	**2,829**	**2,804**	**2,889**	**2,985**	**4,042**	**4,844**	**11.4**
Industrial							
Security/Energy Management	586	522	530	559	542	448	-5.2
Manufacturing Systems/Instrumentation	1,657	1,483	1,434	1,736	1,958	2,250	6.3
Medical Equipment	318	315	287	307	340	342	1.5
Other Industrial	629	629	698	741	808	868	6.7
Total	**3,190**	**2,949**	**2,948**	**3,343**	**3,648**	**3,908**	**4.1**
Consumer							
Audio	932	774	722	602	512	551	-10.0
Video	2,371	2,008	1,840	1,528	1,455	1,605	-7.5
Personal Electronics	1,445	1,280	1,263	1,281	1,316	1,368	-1.1
Appliances	1,699	1,495	1,615	1,753	1,758	1,605	-1.1
Other Consumer	940	920	927	970	978	969	0.6
Total	**7,387**	**6,477**	**6,366**	**6,134**	**6,019**	**6,098**	**-3.8**
Military/Civil Aerospace	**212**	**207**	**203**	**200**	**197**	**195**	**-1.6**
Transportation	**1,330**	**1,281**	**1,224**	**1,240**	**1,283**	**1,290**	**-0.6**
Total Electronics Industry	**21,155**	**19,363**	**19,382**	**19,815**	**22,001**	**23,715**	**2.3**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

Table 2-2
Japanese Electronic Equipment Production Forecast (Vendor Revenue in Billions of Yen)

Segment	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Data Processing							
Computers	3,643	3,979	4,128	4,104	4,081	4,139	2.6
Data Storage	959	945	993	986	974	969	0.2
Input/Output	1,862	1,910	1,924	1,925	2,016	2,196	3.4
Dedicated Systems	753	740	725	770	765	745	-0.2
Other Data Processing	163	185	199	204	210	215	5.7
Total	**7,380**	**7,759**	**7,970**	**7,989**	**8,046**	**8,265**	**2.3**
Communications							
Premise Telecommunications	998	1,014	947	950	966	971	-0.5
Public Telecommunications	1,384	1,472	1,552	1,662	1,738	1,867	6.2
Mobile and Radio Equipment	2,018	1,864	1,863	1,987	2,042	2,072	0.5
Broadcast and Studio	84	90	110	135	125	137	10.3
Other Communications	360	389	415	487	503	534	8.2
Total	**4,844**	**4,830**	**4,887**	**5,221**	**5,374**	**5,581**	**2.9**
Industrial							
Security/Energy Management	448	465	474	440	445	451	0.1
Manufacturing Systems/Instrumentation	2,250	2,373	2,487	2,673	2,811	2,990	5.9
Medical Equipment	342	352	365	387	402	440	5.1
Other Industrial	868	950	1,013	1,060	1,105	1,176	6.3
Total	**3,908**	**4,140**	**4,339**	**4,560**	**4,763**	**5,057**	**5.3**
Consumer							
Audio	551	537	542	550	564	601	1.8
Video	1,605	1,701	1,689	1,607	1,508	1,402	-2.7
Personal Electronics	1,368	1,283	1,201	1,251	1,320	1,561	2.7
Appliances	1,605	1,558	1,627	1,803	1,875	2,013	4.6
Other Consumer	969	1,031	1,001	1,070	1,078	1,125	3.0
Total	**6,098**	**6,110**	**6,060**	**6,281**	**6,346**	**6,702**	**1.9**
Military/Civil Aerospace	**195**	**192**	**190**	**187**	**185**	**183**	**-1.3**
Transportation	**1,290**	**1,394**	**1,455**	**1,486**	**1,488**	**1,493**	**3.0**
Total Electronics Industry	**23,715**	**24,425**	**24,901**	**25,725**	**26,201**	**27,280**	**2.8**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-3
Japanese Electronic Equipment Production History (Vendor Revenue in Millions of Dollars)

Segment	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Data Processing							
Computers	17,775	18,223	20,625	26,868	30,805	30,083	11.1
Data Storage	10,295	10,623	11,562	9,293	7,965	7,915	-5.1
Input/Output	12,467	12,667	14,646	16,187	14,642	15,379	4.3
Dedicated Systems	7,900	8,317	8,241	8,722	6,895	6,217	-4.7
Other Data Processing	645	935	1,430	1,906	2,298	1,346	15.8
Total	**49,083**	**50,766**	**56,503**	**62,976**	**62,605**	**60,940**	**4.4**
Communications							
Premise Telecommunications	7,531	8,085	8,286	8,585	8,039	8,244	1.8
Public Telecommunications	5,786	7,335	8,168	9,499	10,497	11,431	14.6
Mobile and Radio Equipment	7,183	7,914	9,583	10,558	14,716	16,661	18.3
Broadcast and Studio	788	699	888	743	847	694	-2.5
Other Communications	1,087	1,183	1,454	2,403	3,052	2,973	22.3
Total	**22,375**	**25,215**	**28,378**	**31,789**	**37,151**	**40,002**	**12.3**
Industrial							
Security/Energy Management	4,636	4,697	5,205	5,952	4,982	3,699	-4.4
Manufacturing Systems/ Instrumentation	13,106	13,337	14,080	18,491	17,993	18,580	7.2
Medical Equipment	2,515	2,831	2,814	3,265	3,122	2,827	2.4
Other Industrial	4,972	5,652	6,860	7,889	7,426	7,168	7.6
Total	**25,229**	**26,517**	**28,959**	**35,597**	**33,523**	**32,274**	**5.0**
Consumer							
Audio	7,373	6,959	7,087	6,409	4,702	4,549	-9.2
Video	18,754	18,060	18,072	16,270	13,377	13,255	-6.7
Personal Electronics	11,426	11,514	12,403	13,647	12,097	11,293	-0.2
Appliances	13,437	13,444	15,863	18,670	16,156	13,254	-0.3
Other Consumer	7,431	8,271	9,101	10,332	8,984	8,002	1.5
Total	**58,420**	**58,248**	**62,526**	**65,328**	**55,315**	**50,352**	**-2.9**
Military/Civil Aerospace	**1,675**	**1,865**	**1,992**	**2,126**	**1,814**	**1,610**	**-0.8**
Transportation	**10,516**	**11,519**	**12,018**	**13,204**	**11,795**	**10,653**	**0.3**
Total Electronics Industry	**167,297**	**174,130**	**190,377**	**211,020**	**202,203**	**195,832**	**3.2**
Exchange Rate (Yen/U.S.$)	126.45	111.20	101.81	93.90	108.81	121.10	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-4
Japanese Electronic Equipment Production Forecast (Vendor Revenue in Millions of Dollars)

Segment	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Data Processing							
Computers	30,083	30,675	31,822	31,635	31,459	31,906	1.2
Data Storage	7,915	7,285	7,658	7,602	7,509	7,473	-1.1
Input/Output	15,379	14,719	14,831	14,839	15,538	16,928	1.9
Dedicated Systems	6,217	5,704	5,589	5,935	5,897	5,743	-1.6
Other Data Processing	1,346	1,426	1,534	1,572	1,619	1,657	4.2
Total	**60,940**	**59,810**	**61,434**	**61,584**	**62,022**	**63,707**	**0.9**
Communications							
Premise Telecommunications	8,244	7,818	7,299	7,325	7,446	7,487	-1.9
Public Telecommunications	11,431	11,348	11,963	12,808	13,399	14,395	4.7
Mobile and Radio Equipment	16,661	14,372	14,364	15,319	15,737	15,969	-0.8
Broadcast and Studio	694	694	848	1,041	964	1,056	8.8
Other Communications	2,973	2,999	3,199	3,754	3,877	4,116	6.7
Total	**40,002**	**37,230**	**37,673**	**40,247**	**41,423**	**43,023**	**1.5**
Industrial							
Security/Energy Management	3,699	3,584	3,654	3,392	3,430	3,476	-1.2
Manufacturing Systems/ Instrumentation	18,580	18,292	19,171	20,604	21,668	23,048	4.4
Medical Equipment	2,827	2,713	2,814	2,983	3,099	3,392	3.7
Other Industrial	7,168	7,323	7,809	8,171	8,518	9,065	4.8
Total	**32,274**	**31,912**	**33,446**	**35,150**	**36,715**	**38,981**	**3.8**
Consumer							
Audio	4,549	4,142	4,174	4,243	4,351	4,634	0.4
Video	13,255	13,110	13,022	12,387	11,626	10,804	-4.0
Personal Electronics	11,293	9,892	9,258	9,642	10,176	12,035	1.3
Appliances	13,254	12,010	12,541	13,898	14,453	15,517	3.2
Other Consumer	8,002	7,943	7,716	8,249	8,310	8,672	1.6
Total	**50,352**	**47,096**	**46,711**	**48,420**	**48,915**	**51,661**	**0.5**
Military/Civil Aerospace	**1,610**	**1,483**	**1,463**	**1,443**	**1,426**	**1,408**	**-2.7**
Transportation	**10,653**	**10,745**	**11,217**	**11,456**	**11,468**	**11,507**	**1.6**
Total Electronics Industry	**195,832**	**188,276**	**191,944**	**198,300**	**201,967**	**210,286**	**1.4**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-5
Japanese Electronic Equipment Production History (Yen-Based Annual Growth; Percent)

Segment	1992	1993	1994	1995	1996	1997
Data Processing						
Computers	-11.6	-9.8	3.6	20.1	32.9	8.7
Data Storage	-4.7	-9.3	-0.4	-25.9	-0.7	10.6
Input/Output	-13.0	-10.7	5.9	1.9	4.8	16.9
Dedicated Systems	-7.0	-7.4	-9.3	-2.4	-8.4	0.4
Other Data Processing	22.2	27.5	40.0	22.9	39.7	-34.8
Total	**-9.6**	**-9.0**	**1.9**	**2.8**	**15.2**	**8.3**
Communications						
Premise Telecommunications	-9.5	-5.6	-6.2	-4.4	8.5	14.1
Public Telecommunications	-11.4	11.5	2.0	7.3	28.0	21.2
Mobile and Radio Equipment	-3.3	-3.1	10.9	1.6	61.5	26.0
Broadcast and Studio	0.6	-22.0	16.3	-22.8	32.1	-8.9
Other Communications	-28.3	-4.3	12.5	52.4	47.2	8.4
Total	**-9.0**	**-0.9**	**3.0**	**3.3**	**35.4**	**19.8**
Industrial						
Security/Energy Management	-10.9	-10.9	1.5	5.5	-3.0	-17.4
Manufacturing Systems/Instrumentation	-25.1	-10.5	-3.3	21.1	12.8	14.9
Medical Equipment	-2.5	-1.0	-9.0	7.0	10.8	0.8
Other Industrial	-13.7	0.0	11.1	6.1	9.1	7.4
Total	**-18.7**	**-7.6**	**0**	**13.4**	**9.1**	**7.2**
Consumer						
Audio	-17.1	-17.0	-6.8	-16.6	-15.0	7.7
Video	-22.1	-15.3	-8.4	-17.0	-4.7	10.3
Personal Electronics	-4.0	-11.4	-1.4	1.5	2.7	3.9
Appliances	-14.0	-12.0	8.0	8.6	0.3	-8.7
Other Consumer	-10.3	-2.1	0.8	4.7	0.8	-0.9
Total	**-15.1**	**-12.3**	**-1.7**	**-3.6**	**-1.9**	**1.3**
Military/Civil Aerospace	**-2.1**	**-2.1**	**-2.2**	**-1.6**	**-1.1**	**-1.2**
Transportation	**-2.7**	**-3.7**	**-4.5**	**1.3**	**3.5**	**0.5**
Total Electronics Industry	**-12.5**	**-8.5**	**0.1**	**2.2**	**11.0**	**7.8**

Source: MITI, Dataquest (May 1998)

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Table 2-6
Japanese Electronic Equipment Production Forecast (Yen-Based Annual Growth; Percent)

Segment	1997	1998	1999	2000	2001	2002
Data Processing						
Computers	8.7	9.2	3.7	-0.6	-0.6	1.4
Data Storage	10.6	-1.4	5.1	-0.7	-1.2	-0.5
Input/Output	16.9	2.5	0.8	0.1	4.7	8.9
Dedicated Systems	0.4	-1.7	-2.0	6.2	-0.6	-2.6
Other Data Processing	-34.8	13.5	7.6	2.5	2.9	2.4
Total	**8.3**	**5.1**	**2.7**	**0.2**	**0.7**	**2.7**
Communications						
Premise Telecommunications	14.1	1.6	-6.6	0.3	1.7	0.5
Public Telecommunications	21.2	6.3	5.4	7.1	4.6	7.4
Mobile and Radio Equipment	26.0	-7.6	-0.1	6.6	2.7	1.5
Broadcast and Studio	-8.9	7.1	22.2	22.7	-7.4	9.6
Other Communications	8.4	8.1	6.7	17.3	3.3	6.2
Total	**19.8**	**-0.3**	**1.2**	**6.8**	**2.9**	**3.9**
Industrial						
Security/Energy Management	-17.4	3.8	1.9	-7.2	1.1	1.3
Manufacturing Systems/Instrumentation	14.9	5.5	4.8	7.5	5.2	6.4
Medical Equipment	0.8	2.8	3.7	6.0	3.9	9.5
Other Industrial	7.4	9.4	6.6	4.6	4.2	6.4
Total	**7.2**	**5.9**	**4.8**	**5.1**	**4.5**	**6.2**
Consumer						
Audio	7.7	-2.5	0.8	1.6	2.5	6.5
Video	10.3	6.0	-0.7	-4.9	-6.1	-7.1
Personal Electronics	3.9	-6.2	-6.4	4.2	5.5	18.3
Appliances	-8.7	-2.9	4.4	10.8	4.0	7.4
Other Consumer	-0.9	6.3	-2.9	6.9	0.7	4.4
Total	**1.3**	**0.2**	**-0.8**	**3.7**	**1.0**	**5.6**
Military/Civil Aerospace	**-1.2**	**-1.3**	**-1.4**	**-1.4**	**-1.2**	**-1.3**
Transportation	**0.5**	**8.0**	**4.4**	**2.1**	**0.1**	**0.3**
Total Electronics Industry	**7.8**	**3.0**	**1.9**	**3.3**	**1.8**	**4.1**

Source: MITI, Dataquest (May 1998)

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Table 2-7
Japanese Electronic Equipment Production History—Data Processing (Vendor Revenue in Billions of Yen)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Computers							
General Use	932	758	730	664	731	763	-3.9
Office Use	287	222	219	209	198	250	-2.7
Personal Use	897	890	978	1,313	2,088	2,270	20.4
Control Use	132	157	173	338	335	360	22.3
Total	**2,248**	**2,026**	**2,100**	**2,523**	**3,352**	**3,643**	**10.1**
Data Storage							
Rigid Disk Drives	880	793	793	543	534	540	-9.3
Flexible Disk Drives	135	95	58	33	27	29	-26.4
Other Drives	249	246	261	213	205	240	-0.7
Other Data Storage	38	46	66	84	101	150	31.5
Total	**1,302**	**1,181**	**1,177**	**873**	**867**	**959**	**-5.9**
Input/Output							
Printers	657	584	584	641	676	780	3.5
Display Units	236	239	316	443	503	580	19.7
Other Units	48	37	36	8	12	12	-24.1
Terminals General Use	282	252	236	107	70	90	-20.4
Terminals Special Use	329	284	307	310	328	393	3.6
Terminal Supporting Systems	25	13	12	12	4	7	-22.3
Total	**1,577**	**1,409**	**1,491**	**1,520**	**1,593**	**1,862**	**3.4**
Dedicated Systems							
Calculators	92	78	49	30	29	29	-20.7
Cash Registers	96	79	65	65	69	72	-5.6
Copying Machines	553	523	533	550	546	547	-0.2
Typewriters	19	13	7	3	2	2	-39.7
Word Processors	239	231	185	169	104	103	-15.5
Other Dedicated Systems	0	0	1	1	1	0	20.4
Total	**999**	**925**	**839**	**819**	**750**	**753**	**-5.5**
Other Data Processing	**82**	**104**	**146**	**179**	**250**	**163**	**14.8**
Data Processing Total	**6,207**	**5,645**	**5,753**	**5,913**	**6,812**	**7,380**	**3.5**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-8
Japanese Electronic Equipment Production Forecast—Data Processing (Vendor Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Computers							
General Use	763	816	827	860	870	869	2.6
Office Use	250	328	332	335	331	341	6.4
Personal Use	2,270	2,405	2,484	2,460	2,433	2,480	1.8
Control Use	360	430	485	449	447	449	4.5
Total	**3,643**	**3,979**	**4,128**	**4,104**	**4,081**	**4,139**	**2.6**
Data Storage							
Rigid Disk Drives	540	560	534	534	492	478	-2.4
Flexible Disk Drives	29	25	8	5	3	2	-41.4
Other Drives	240	235	273	240	251	239	-0.1
Other Data Storage	150	125	178	207	228	250	10.8
Total	**959**	**945**	**993**	**986**	**974**	**969**	**0.2**
Input/Output							
Printers	780	790	795	785	632	680	-2.7
Display Units	580	618	622	629	730	776	6.0
Other Units	12	10	11	10	8	7	-10.2
Terminals General Use	90	92	90	84	72	70	-4.9
Terminals Special Use	393	395	401	413	571	660	10.9
Terminal Supporting Systems	7	5	5	4	3	3	-18.0
Total	**1,862**	**1,910**	**1,924**	**1,925**	**2,016**	**2,196**	**3.4**
Dedicated Systems							
Calculators	29	24	23	22	21	18	-9.1
Cash Registers	72	86	90	115	118	115	9.8
Copying Machines	547	549	552	580	578	570	0.8
Typewriters	2	2	2	2	2	3	10.8
Word Processors	103	79	58	51	45	39	-17.7
Other Dedicated Systems	0	0	0	0	0	0	-0.3
Total	**753**	**740**	**725**	**770**	**765**	**745**	**-0.2**
Other Data Processing	**163**	**185**	**199**	**204**	**210**	**215**	**5.7**
Data Processing Total	**7,380**	**7,759**	**7,970**	**7,989**	**8,046**	**8,265**	**2.3**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-9
Japanese Electronic Equipment Production History—Data Processing (Vendor Revenue in Millions of Dollars)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Computers							
General Use	7,367	6,817	7,170	7,071	6,718	6,301	-3.1
Office Use	2,272	1,992	2,148	2,220	1,820	2,064	-1.9
Personal Use	7,094	8,000	9,606	13,986	19,190	18,745	21.5
Control Use	1,042	1,413	1,699	3,595	3,079	2,973	23.3
Total	**17,775**	**18,223**	**20,625**	**26,868**	**30,805**	**30,083**	**11.1**
Data Storage							
Rigid Disk Drives	6,959	7,134	7,785	5,781	4,904	4,459	-8.5
Flexible Disk Drives	1,065	855	569	351	244	239	-25.8
Other Drives	1,968	2,216	2,560	2,268	1,884	1,982	0.1
Other Data Storage	302	416	646	890	932	1,239	32.6
Total	**10,295**	**10,623**	**11,562**	**9,293**	**7,965**	**7,915**	**-5.1**
Input/Output							
Printers	5,197	5,248	5,740	6,822	6,209	6,441	4.4
Display Units	1,863	2,147	3,101	4,717	4,627	4,789	20.8
Other Units	376	331	352	87	108	99	-23.4
Terminals General Use	2,230	2,265	2,320	1,134	642	743	-19.7
Terminals Special Use	2,604	2,553	3,017	3,300	3,018	3,245	4.5
Terminal Supporting Systems	195	121	115	127	32	58	-21.6
Total	**12,467**	**12,667**	**14,646**	**16,187**	**14,642**	**15,379**	**4.3**
Dedicated Systems							
Calculators	729	702	477	319	267	239	-20.0
Cash Registers	758	709	634	691	633	595	-4.7
Copying Machines	4,371	4,707	5,235	5,862	5,022	4,517	0.7
Typewriters	149	116	66	36	16	12	-39.2
Word Processors	1,892	2,078	1,821	1,804	951	851	-14.8
Other Dedicated Systems	1	3	6	7	5	3	21.5
Total	**7,900**	**8,317**	**8,241**	**8,722**	**6,895**	**6,217**	**-4.7**
Other Data Processing	**645**	**935**	**1,430**	**1,906**	**2,298**	**1,346**	**15.8**
Data Processing Total	**49,083**	**50,766**	**56,503**	**62,976**	**62,605**	**60,940**	**4.4**
Exchange Rate (Yen/U.S.$)	126.45	111.20	101.81	93.90	108.81	121.10	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-10
Japanese Electronic Equipment Production Forecast—Data Processing (Vendor Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Computers							
General Use	6,301	6,290	6,375	6,629	6,706	6,699	1.2
Office Use	2,064	2,528	2,559	2,582	2,551	2,629	5.0
Personal Use	18,745	18,539	19,147	18,962	18,754	19,117	0.4
Control Use	2,973	3,315	3,739	3,461	3,446	3,461	3.1
Total	**30,083**	**30,675**	**31,722**	**31,635**	**31,459**	**31,906**	**1.2**
Data Storage							
Rigid Disk Drives	4,459	4,317	4,116	4,116	3,792	3,685	-3.7
Flexible Disk Drives	239	193	62	39	23	15	-42.2
Other Drives	1,982	1,811	2,104	1,850	1,935	1,842	-1.4
Other Data Storage	1,239	964	1,372	1,596	1,757	1,927	9.2
Total	**7,915**	**7,285**	**7,658**	**7,602**	**7,509**	**7,473**	**-1.1**
Input/Output							
Printers	6,441	6,090	6,128	6,051	4,872	5,242	-4.0
Display Units	4,789	4,761	4,795	4,849	5,627	5,982	4.5
Other Units	99	77	85	77	62	54	-11.4
Terminals General Use	743	709	694	647	554	540	-6.2
Terminals Special Use	3,245	3,045	3,091	3,184	4,402	5,087	9.4
Terminal Supporting Systems	58	39	39	31	21	20	-19.1
Total	**15,379**	**14,719**	**14,831**	**14,839**	**15,538**	**16,925**	**1.9**
Dedicated Systems							
Calculators	239	185	176	170	162	139	-10.3
Cash Registers	595	661	694	886	910	886	8.3
Copying Machines	4,517	4,232	4,255	4,471	4,455	4,394	-0.6
Typewriters	12	13	14	15	16	19	9.2
Word Processors	851	610	447	393	347	301	-18.8
Other Dedicated Systems	3	4	4	3	3	3	-1.7
Total	**6,217**	**5,704**	**5,589**	**5,935**	**5,897**	**5,743**	**-1.6**
Other Data Processing	**1,346**	**1,426**	**1,534**	**1,572**	**1,619**	**1,657**	**4.2**
Data Processing Total	**60,940**	**59,810**	**61,434**	**61,584**	**62,022**	**63,707**	**0.9**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-11
Japanese Electronic Equipment Production History—Data Processing (Yen-Based Annual Growth; Percent)

Equipment Type	1992	1993	1994	1995	1996	1997
Computers						
General Use	-28.3	-18.6	-3.7	-9.0	10.1	4.4
Office Use	-0.5	-22.9	-1.3	-4.7	-5.0	26.3
Personal Use	7.9	-0.8	9.9	34.3	59.0	8.7
Control Use	6.0	19.3	10.1	95.1	-0.8	7.5
Total	**-11.6**	**-9.8**	**3.6**	**20.1**	**32.9**	**8.7**
Data Storage						
Rigid Disk Drives	-2.2	-9.9	-0.1	-31.5	-1.7	1.2
Flexible Disk Drives	-15.5	-29.4	-39.1	-43.0	-19.4	9.0
Other Drives	-9.1	-1.0	5.8	-18.3	-3.8	17.1
Other Data Storage	14.4	21.2	42.1	27.1	21.3	47.9
Total	**-4.7**	**-9.3**	**-0.4**	**-25.9**	**-0.7**	**10.6**
Input/Output						
Printers	-5.9	-11.2	0.1	9.6	5.5	15.5
Display Units	-2.2	1.4	32.2	40.3	13.7	15.2
Other Units	-25.2	-22.7	-2.7	-77.1	42.7	2.6
Terminals General Use	-32.5	-10.7	-6.2	-54.9	-34.4	28.8
Terminals Special Use	-10.7	-13.8	8.2	0.9	6.0	19.7
Terminal Supporting Systems	11.3	-45.7	-12.7	1.7	-70.6	100.0
Total	**-13.0**	**-10.7**	**5.9**	**1.9**	**4.8**	**16.9**
Dedicated Systems						
Calculators	-20.9	-15.3	-37.8	-38.3	-3.3	0
Cash Registers	-5.5	-17.7	-18.1	0.6	6.2	4.5
Copying Machines	0.4	-5.3	1.8	3.3	-0.7	0.1
Typewriters	-34.3	-31.4	-48.1	-49.3	-50.0	-11.8
Word Processors	-13.6	-3.4	-19.8	-8.6	-38.9	-0.5
Other Dedicated Systems	51.9	124.1	61.6	22.4	-24.7	-24.1
Total	**-7.0**	**-7.4**	**-9.3**	**-2.4**	**-8.4**	**0.4**
Other Data Processing	**22.2**	**27.5**	**40.0**	**22.9**	**39.7**	**-34.8**
Data Processing Total	**-9.6**	**-9.0**	**1.9**	**2.8**	**15.2**	**8.3**

Source: MITI, Dataquest (May 1998)

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Table 2-12
Japanese Electronic Equipment Production Forecast—Data Processing (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Computers						
General Use	4.4	6.9	1.3	4.0	1.2	-0.1
Office Use	26.3	31.2	1.2	0.9	-1.2	3.0
Personal Use	8.7	5.9	3.3	-1.0	-1.1	1.9
Control Use	7.5	19.4	12.8	-7.4	-0.4	0.4
Total	**8.7**	**9.2**	**3.7**	**-0.6**	**-0.6**	**1.4**
Data Storage						
Rigid Disk Drives	1.2	3.7	-4.6	0	-7.9	-2.8
Flexible Disk Drives	9.0	-13.8	-68.0	-37.5	-40.0	-33.3
Other Drives	17.1	-2.1	16.2	-12.1	4.6	-4.8
Other Data Storage	47.9	-16.7	42.4	16.3	10.1	9.6
Total	**10.6**	**-1.4**	**5.1**	**-0.7**	**-1.2**	**-0.5**
Input/Output						
Printers	15.5	1.3	0.6	-1.3	-19.5	7.6
Display Units	15.2	6.5	0.7	1.1	16.1	6.3
Other Units	2.6	-16.7	10.0	-9.1	-20.0	-12.5
Terminals General Use	28.8	2.2	-2.2	-6.7	-14.4	-2.5
Terminals Special Use	19.7	0.5	1.5	3.0	38.3	15.6
Terminal Supporting Systems	100.0	-28.6	0	-20.0	-32.5	-3.7
Total	**16.9**	**2.5**	**0.8**	**0.1**	**4.7**	**8.9**
Dedicated Systems						
Calculators	0	-17.2	-5.0	-3.5	-4.5	-14.3
Cash Registers	4.5	19.0	5.0	27.8	2.6	-2.5
Copying Machines	0.1	0.4	0.5	5.1	-0.3	-1.4
Typewriters	-11.8	13.3	5.9	5.6	10.5	19.0
Word Processors	-0.5	-23.2	-26.7	-12.1	-11.8	-13.3
Other Dedicated Systems	-24.1	21.5	-3.9	-5.6	-5.9	-5.1
Total	**0.4**	**-1.7**	**-2.0**	**6.2**	**-0.6**	**-2.6**
Other Data Processing	**-34.8**	**13.5**	**7.6**	**2.5**	**2.9**	**2.4**
Data Processing Total	**8.3**	**5.1**	**2.7**	**0.2**	**0.7**	**2.7**

Source: MITI, Dataquest (May 1998)

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Table 2-13
Japanese Electronic Equipment Production History—Communications (Vendor Revenue in Billions of Yen)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Premise Telecommunications							
Telephones	321	294	252	223	252	268	-0.5
Standard	31	25	18	17	10	12	-17.3
Multifunction	33	27	27	17	16	15	-14.7
Cordless	224	219	184	176	207	219	-0.5
Others	32	23	23	13	18	22	-7.3
Applied Telephones	36	33	36	46	48	52	7.7
Facsimiles	391	355	312	290	290	350	-2.2
PBX Telephone Systems	87	83	102	113	142	180	15.6
Key Telephone Systems	95	104	106	92	93	98	0.5
Modems	22	30	35	41	52	50	17.4
Total	**952**	**899**	**844**	**806**	**875**	**998**	**0.9**
Public Telecommunications							
Carrier Transmission	413	474	483	568	753	824	14.8
Central Office Switches	319	342	348	324	390	560	11.9
Total	**732**	**816**	**832**	**892**	**1,142**	**1,384**	**13.6**
Mobile and Radio							
Radio Communications	735	697	811	823	1,419	1,810	19.7
Radio Base Station Equipment	279	236	229	272	471	595	16.3
Mobile Radio Equipment	386	405	500	515	923	1,180	25.0
Mobile Communications Equipment	70	57	82	37	25	35	-12.8
Applied Radio Equipment	219	225	202	168	183	208	-1.0
Total	**908**	**880**	**976**	**991**	**1,601**	**2,018**	**17.3**
Broadcast and Studio	**100**	**78**	**90**	**70**	**92**	**84**	**-3.3**
Other Communications Equipment	**137**	**132**	**148**	**226**	**332**	**360**	**21.2**
Communications Total	**2,829**	**2,804**	**2,889**	**2,985**	**4,042**	**4,844**	**11.4**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

Table 2-14
Japanese Electronic Equipment Production Forecast—Communications (Vendor Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Premise Telecommunications							
Telephones	268	377	347	346	355	358	5.9
Standard	12	10	8	7	7	6	-12.7
Multifunction	15	19	21	20	21	21	6.6
Cordless	219	322	290	291	294	296	6.2
Others	22	26	29	28	33	35	9.7
Applied Telephones	52	42	40	41	47	49	-1.1
Facsimiles	350	303	270	268	264	255	-6.1
PBX Telephone Systems	180	149	146	152	159	166	-1.6
Key Telephone Systems	98	98	99	101	101	105	1.4
Modems	50	46	45	42	40	38	-5.4
Total	**998**	**1,014**	**947**	**950**	**966**	**971**	**-0.6**
Public Telecommunications							
Carrier Transmission	824	943	1,004	1,075	1,115	1,210	8.0
Central Office Switches	560	529	548	587	623	657	3.2
Total	**1,384**	**1,472**	**1,552**	**1,662**	**1,738**	**1,867**	**6.2**
Mobile and Radio							
Radio Communications	1,810	1,670	1,683	1,805	1,873	1,912	1.1
Radio Base Station Equipment	595	605	758	940	1,020	1,125	13.6
Mobile Radio Equipment	1,180	1,038	896	835	822	754	-8.6
Mobile Communications Equipment	35	27	29	30	31	33	-1.3
Applied Radio Equipment	208	193	180	182	169	161	-5.0
Total	**2,018**	**1,864**	**1,863**	**1,987**	**2,042**	**2,072**	**0.5**
Broadcast and Studio	**84**	**90**	**110**	**135**	**125**	**137**	**10.3**
Other Communications Equipment	**360**	**389**	**415**	**487**	**503**	**534**	**8.2**
Communications Total	**4,844**	**4,830**	**4,887**	**5,221**	**5,374**	**5,581**	**2.9**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

Table 2-15
Japanese Electronic Equipment Production History—Communications (Vendor Revenue in Millions of Dollars)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Premise Telecommunications							
Telephones	2,536	2,645	2,474	2,378	2,316	2,213	0.3
Standard	245	223	172	185	95	99	-16.6
Multifunction	263	239	267	176	148	124	-14.0
Cordless	1,774	1,972	1,805	1,875	1,902	1,808	0.4
Others	254	210	230	142	167	182	-6.5
Applied Telephones	284	293	357	486	438	429	8.6
Facsimiles	3,088	3,194	3,066	3,092	2,662	2,890	-1.3
PBX Telephone Systems	689	750	1,002	1,208	1,302	1,486	16.6
Key Telephone Systems	754	932	1,040	976	855	809	1.4
Modems	177	268	343	437	475	413	18.4
Total	**7,531**	**8,085**	**8,286**	**8,585**	**8,039**	**8,244**	**1.8**
Public Telecommunications							
Carrier Transmission	3,265	4,263	4,746	6,050	6,916	6,804	15.8
Central Office Switches	2,522	3,071	3,421	3,449	3,581	4,624	12.9
Total	**5,786**	**7,335**	**8,168**	**9,499**	**10,497**	**11,431**	**14.6**
Mobile and Radio							
Radio Communications	5,813	6,272	7,963	8,769	13,036	14,946	20.8
Radio Base Station Equipment	2,208	2,121	2,245	2,894	4,329	4,913	17.3
Mobile Radio Equipment	3,054	3,638	4,914	5,480	8,483	9,744	26.1
Mobile Communications Equipment	550	512	803	395	225	289	-12.1
Applied Radio Equipment	1,730	2,019	1,986	1,788	1,681	1,718	-0.1
Total	**7,183**	**7,914**	**9,583**	**10,558**	**14,716**	**16,661**	**18.3**
Broadcast and Studio	**788**	**699**	**888**	**743**	**847**	**694**	**-2.5**
Other Communications Equipment	**1,087**	**1,183**	**1,454**	**2,403**	**3,052**	**2,973**	**22.3**
Communications Total	**22,375**	**25,215**	**28,378**	**31,789**	**37,151**	**40,002**	**12.3**
Exchange Rate (Yen/U.S.$)	126.45	111.20	101.81	93.90	108.81	121.10	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-16
Japanese Electronic Equipment Production Forecast—Communications (Vendor Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Premise Telecommunications							
Telephones	2,213	2,902	2,678	2,669	2,733	2,757	4.5
Standard	99	77	58	55	50	47	-13.9
Multifunction	124	146	162	154	163	159	5.1
Cordless	1,808	2,482	2,235	2,243	2,266	2,282	4.8
Others	182	197	223	216	254	270	8.2
Applied Telephones	429	321	308	316	363	379	-2.5
Facsimiles	2,890	2,336	2,081	2,062	2,037	1,966	-7.4
PBX Telephone Systems	1,486	1,147	1,125	1,172	1,226	1,280	-3.0
Key Telephone Systems	809	758	763	779	779	809	0
Modems	413	352	344	325	306	291	-6.7
Total	**8,244**	**7,817**	**7,300**	**7,322**	**7,443**	**7,482**	**-1.9**
Public Telecommunications							
Carrier Transmission	6,804	7,269	7,739	8,286	8,595	9,327	6.5
Central Office Switches	4,624	4,080	4,221	4,526	4,802	5,064	1.8
Total	**11,431**	**11,349**	**11,960**	**12,813**	**13,397**	**14,391**	**4.7**
Mobile and Radio							
Radio Communications	14,946	12,876	12,972	13,914	14,441	14,737	-0.3
Radio Base Station Equipment	4,913	4,664	5,843	7,246	7,862	8,672	12.0
Mobile Radio Equipment	9,744	8,001	6,907	6,436	6,336	5,812	-9.8
Mobile Communications Equipment	289	211	222	232	242	253	-2.6
Applied Radio Equipment	1,718	1,491	1,387	1,403	1,300	1,238	-6.3
Total	**16,661**	**14,367**	**14,359**	**15,317**	**15,740**	**15,975**	**-0.8**
Broadcast and Studio	**694**	**694**	**850**	**1,041**	**964**	**1,056**	**8.8**
Other Communications Equipment	**2,973**	**2,999**	**3,199**	**3,754**	**3,877**	**4,116**	**6.7**
Communications Total	**40,002**	**37,231**	**37,671**	**40,245**	**41,424**	**43,020**	**1.5**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

Table 2-17
Japanese Electronic Equipment Production History—Communications (Yen-Based Annual Growth; Percent)

Equipment Type	1992	1993	1994	1995	1996	1997
Premise Telecommunications						
Telephones	-12.1	-8.3	-14.3	-11.4	12.9	6.3
Standard	19.2	-20.0	-29.4	-0.6	-40.8	16.5
Multifunction	-7.2	-20.1	2.3	-39.3	-2.4	-6.8
Cordless	-4.0	-2.2	-16.2	-4.2	17.5	5.8
Others	-53.5	-27.1	0	-43.2	36.8	20.9
Applied Telephones	-10.9	-9.2	11.3	25.6	4.6	9.0
Facsimiles	-6.3	-9.0	-12.1	-7.0	-0.2	20.9
PBX Telephone Systems	-9.5	-4.2	22.3	11.2	25.0	27.0
Key Telephone Systems	-0.2	8.6	2.2	-13.5	1.5	5.4
Modems	-42.3	33.0	17.1	17.5	26.1	-3.3
Total	**-9.5**	**-5.6**	**-6.2**	**-4.5**	**8.7**	**14.0**
Public Telecommunications						
Carrier Transmission	-11.9	14.8	1.9	17.6	32.5	9.5
Central Office Switches	-10.6	7.1	2.0	-7.0	20.3	43.7
Total	**-11.4**	**11.5**	**2.0**	**7.3**	**28.0**	**21.2**
Mobile and Radio						
Radio Communications	-7.8	-5.1	16.2	1.6	72.3	27.6
Radio Base Station Equipment	-1.8	-15.5	-3.1	18.9	73.4	26.3
Mobile Radio Equipment	-10.0	4.8	23.7	2.9	79.4	27.8
Mobile Communications Equipment	-17.2	-18.2	43.8	-54.6	-34.0	42.9
Applied Radio Equipment	9.8	2.6	-9.9	-17.0	8.9	13.7
Total	**-3.3**	**-3.1**	**10.9**	**1.6**	**61.5**	**26.0**
Broadcast and Studio	**0.6**	**-22.0**	**16.3**	**-22.8**	**32.1**	**-8.9**
Other Communications Equipment	**-28.3**	**-4.3**	**12.5**	**52.4**	**47.2**	**8.4**
Communications Total	**-9.0**	**-0.9**	**3.0**	**3.3**	**35.4**	**19.8**

Source: MITI, Dataquest (May 1998)

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Table 2-18
Japanese Electronic Equipment Production Forecast—Communications (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Premise Telecommunications						
Telephones	6.5	40.5	-7.7	-0.3	2.4	0.9
Standard	16.5	-16.7	-25.0	-4.0	-9.7	-6.2
Multifunction	-6.8	26.7	10.5	-4.8	5.5	-2.4
Cordless	5.8	47.0	-9.9	0.3	1.0	0.7
Others	20.9	15.9	13.3	-3.1	17.9	6.1
Applied Telephones	9.0	-19.8	-4.1	2.5	14.9	4.5
Facsimiles	20.9	-13.4	-10.9	-0.9	-1.2	-3.5
PBX Telephone Systems	27.0	-17.3	-1.9	4.1	4.6	4.4
Key Telephone Systems	5.4	0.4	0.6	2.0	0	4.0
Modems	-3.3	-8.6	-2.4	-5.4	-5.9	-4.8
Total	**14.0**	**1.6**	**-6.6**	**0.3**	**1.7**	**0.5**
Public Telecommunications						
Carrier Transmission	9.5	14.4	6.5	7.1	3.7	8.5
Central Office Switches	43.7	-5.5	3.5	7.2	6.1	5.5
Total	**21.2**	**6.4**	**5.4**	**7.1**	**4.6**	**7.4**
Mobile and Radio						
Radio Communications	27.6	-7.7	0.7	7.3	3.8	2.0
Radio Base Station Equipment	26.3	1.7	25.3	24.0	8.5	10.3
Mobile Radio Equipment	27.8	-12.0	-13.7	-6.8	-1.6	-8.3
Mobile Communications Equipment	42.9	-21.7	5.1	4.5	4.3	4.5
Applied Radio Equipment	13.7	-7.0	-6.9	1.1	-7.4	-4.7
Total	**26.0**	**-7.6**	**-0.1**	**6.7**	**2.8**	**1.5**
Broadcast and Studio	**-8.9**	**7.1**	**22.6**	**22.4**	**-7.4**	**9.6**
Other Communications Equipment	**8.4**	**8.1**	**6.7**	**17.3**	**3.3**	**6.2**
Communications Total	**19.8**	**-0.3**	**1.2**	**6.8**	**2.9**	**3.9**

Source: MITI, Dataquest (May 1998)

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Table 2-19
Japanese Electronic Equipment Production History—Industrial (Vendor Revenue in Billions of Yen)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Security/Energy Management							
Alarm Systems	144	132	129	126	113	98	-7.4
Energy Management	442	390	401	433	430	350	-4.6
Total	**586**	**522**	**530**	**559**	**542**	**448**	**-5.2**
Manufacturing Systems/Instrumentation							
NC Machines	657	491	451	595	726	801	4.0
Robotics	207	192	207	262	267	355	11.4
Ultrasonic Applied Equipment	15	20	19	29	26	29	14.9
Metering Units	42	39	42	45	46	48	2.6
Measuring Instruments	238	238	275	375	414	450	13.6
Industrial Meters	317	328	259	263	292	350	2.0
Others	182	174	180	167	186	217	3.6
Total	**1,657**	**1,483**	**1,434**	**1,736**	**1,958**	**2,250**	**6.3**
Medical Equipment							
X-Ray Systems	163	159	141	152	175	177	1.6
Measuring Systems	62	58	52	59	60	61	-0.4
Others	93	98	94	96	104	104	2.4
Total	**318**	**315**	**287**	**307**	**340**	**342**	**1.5**
Other Industrial Equipment							
Vending Machines	252	237	232	231	240	260	0.7
Automatic Service Equipment	31	30	26	20	13	12	-17.4
Commercial-Type Washing Machines	15	13	13	15	17	15	0.3
Electron Microscope	32	36	36	43	56	60	13.6
Ultrasonic Equipment	74	71	90	77	81	90	4.1
Others	226	241	301	354	402	431	13.8
Total	**629**	**629**	**698**	**741**	**808**	**868**	**6.7**
Industrial Total	**3,190**	**2,949**	**2,948**	**3,343**	**3,648**	**3,908**	**4.1**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-20
Japanese Electronic Equipment Production Forecast—Industrial (Vendor Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Security/Energy Management							
Alarm Systems	98	103	105	95	100	105	1.4
Energy Management	350	362	369	345	345	346	-0.2
Total	**448**	**465**	**474**	**440**	**445**	**451**	**0.1**
Manufacturing Systems/Instrumentation							
NC Machines	801	836	921	1,020	1,065	1,085	6.3
Robotics	355	358	357	392	386	402	2.5
Ultrasonic Applied Equipment	29	26	27	27	26	25	-2.9
Metering Units	48	47	48	49	50	52	1.5
Measuring Instruments	450	480	520	575	636	682	8.7
Industrial Meters	350	400	384	371	410	470	6.1
Others	217	226	230	239	239	275	4.9
Total	**2,250**	**2,373**	**2,487**	**2,673**	**2,811**	**2,990**	**5.9**
Medical Equipment							
X-Ray Systems	177	190	198	210	215	235	5.8
Measuring Systems	61	60	62	59	58	69	2.5
Others	104	102	105	118	129	136	5.5
Total	**342**	**352**	**365**	**387**	**402**	**440**	**5.2**
Other Industrial Equipment							
Vending Machines	260	280	290	267	263	274	1.1
Automatic Service Equipment	12	13	15	17	19	21	11.9
Commercial-Type Washing Machines	15	18	18	19	21	22	7.6
Electron Microscope	60	55	50	40	36	34	-10.7
Ultrasonic Equipment	90	114	120	128	152	177	14.5
Others	431	470	520	589	615	648	8.5
Total	**868**	**950**	**1,013**	**1,060**	**1,105**	**1,176**	**6.3**
Industrial Total	**3,908**	**4,140**	**4,339**	**4,560**	**4,763**	**5,057**	**5.3**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-21
Japanese Electronic Equipment Production History—Industrial (Vendor Revenue in Millions of Dollars)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Security/Energy Management							
Alarm Systems	1,139	1,187	1,271	1,341	1,034	809	-6.6
Energy Management	3,496	3,510	3,934	4,611	3,947	2,890	-3.7
Total	**4,636**	**4,697**	**5,205**	**5,952**	**4,982**	**3,699**	**-4.4**
Manufacturing Systems/Instrumentation							
NC Machines	5,199	4,418	4,434	6,337	6,673	6,614	4.9
Robotics	1,633	1,729	2,031	2,790	2,453	2,931	12.4
Ultrasonic Applied Equipment	115	176	183	309	241	239	15.9
Metering Units	334	351	411	478	425	396	3.5
Measuring Instruments	1,879	2,143	2,702	3,991	3,805	3,716	14.6
Industrial Meters	2,505	2,951	2,545	2,801	2,684	2,890	2.9
Others	1,439	1,567	1,772	1,782	1,708	1,792	4.5
Total	**13,106**	**13,337**	**14,080**	**18,491**	**17,993**	**18,580**	**7.2**
Medical Equipment							
X-Ray Systems	1,291	1,427	1,380	1,620	1,609	1,462	2.5
Measuring Systems	491	519	512	623	553	504	0.5
Others	732	883	921	1,021	958	859	3.3
Total	**2,515**	**2,831**	**2,814**	**3,265**	**3,122**	**2,827**	**2.4**
Other Industrial Equipment							
Vending Machines	1,990	2,132	2,281	2,464	2,201	2,147	1.5
Automatic Service Equipment	247	273	258	212	115	99	-16.7
Commercial-Type Washing Machines	117	116	123	160	158	124	1.1
Electron Microscope	251	319	355	460	514	495	14.6
Ultrasonic Equipment	582	640	885	824	747	743	5.0
Others	1,784	2,169	2,956	3,767	3,690	3,559	14.8
Total	**4,972**	**5,652**	**6,860**	**7,889**	**7,426**	**7,168**	**7.6**
Industrial Total	**25,229**	**26,517**	**28,959**	**35,597**	**33,523**	**32,274**	**5.0**
Exchange Rate (Yen/U.S.$)	126.45	111.20	101.81	93.90	108.81	121.10	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-22
Japanese Electronic Equipment Production Forecast—Industrial (Vendor Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Security/Energy Management							
Alarm Systems	809	795	809	732	771	809	0
Energy Management	2,890	2,790	2,844	2,659	2,659	2,667	-1.6
Total	**3,699**	**3,584**	**3,654**	**3,392**	**3,430**	**3,476**	**-1.2**
Manufacturing Systems/Instrumentation							
NC Machines	6,614	6,444	7,099	7,862	8,209	8,364	4.8
Robotics	2,931	2,760	2,752	3,022	2,974	3,095	1.1
Ultrasonic Applied Equipment	239	200	208	208	200	193	-4.3
Metering Units	396	358	371	379	388	398	0.1
Measuring Instruments	3,716	3,700	4,008	4,432	4,902	5,256	7.2
Industrial Meters	2,890	3,083	2,960	2,860	3,157	3,623	4.6
Others	1,792	1,742	1,773	1,842	1,839	2,120	3.4
Total	**18,580**	**18,288**	**19,171**	**20,606**	**21,670**	**23,047**	**4.4**
Medical Equipment							
X-Ray Systems	1,462	1,465	1,526	1,619	1,657	1,811	4.4
Measuring Systems	504	462	478	455	447	532	1.1
Others	859	786	809	910	994	1,048	4.1
Total	**2,827**	**2,713**	**2,814**	**2,983**	**3,099**	**3,392**	**3.7**
Other Industrial Equipment							
Vending Machines	2,147	2,158	2,235	2,058	2,025	2,112	-0.3
Automatic Service Equipment	99	100	116	130	144	163	10.4
Commercial-Type Washing Machines	124	138	140	150	158	166	6.1
Electron Microscope	495	424	385	309	280	263	-11.9
Ultrasonic Equipment	743	879	925	988	1,171	1,367	13.0
Others	3,559	3,623	4,008	4,537	4,741	4,995	7.0
Total	**7,168**	**7,322**	**7,810**	**8,172**	**8,518**	**9,067**	**4.8**
Industrial Total	**32,274**	**31,912**	**33,446**	**35,150**	**36,715**	**38,981**	**3.8**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

Table 2-23
Japanese Electronic Equipment Production History—Industrial (Yen-Based Annual Growth; Percent)

Equipment Type	1992	1993	1994	1995	1996	1997
Security/Energy Management						
Alarm Systems	-4.5	-8.3	-2.0	-2.7	-10.6	-12.9
Energy Management	-12.8	-11.7	2.6	8.1	-0.8	-18.5
Total	**-10.9**	**-10.9**	**1.5**	**5.5**	**-3.0**	**-17.4**
Manufacturing Systems/Instrumentation						
NC Machines	-33.4	-25.3	-8.1	31.8	22.0	10.3
Robotics	-28.5	-6.9	7.5	26.7	1.9	33.0
Ultrasonic Applied Equipment	-19.9	35.2	-5.1	55.9	-9.7	10.7
Metering Units	-11.3	-7.6	7.2	7.4	2.9	3.9
Measuring Instruments	-30.1	0.3	15.4	36.2	10.5	8.7
Industrial Meters	-5.3	3.6	-21.0	1.5	11.0	19.9
Others	-7.8	-4.2	3.5	-7.3	11.1	16.7
Total	**-25.1**	**-10.5**	**-3.3**	**21.1**	**12.8**	**14.9**
Medical Equipment						
X-Ray Systems	2.0	-2.8	-11.5	8.3	15.1	1.1
Measuring Systems	6.0	-7.1	-9.7	12.3	2.9	1.3
Others	-13.8	6.2	-4.5	2.2	8.7	-0.2
Total	**-2.5**	**-1.0**	**-9.0**	**7.0**	**10.8**	**0.7**
Other Industrial Equipment						
Vending Machines	-10.4	-5.8	-2.1	-0.3	3.5	8.6
Automatic Service Equipment	5.8	-2.6	-13.5	-24.3	-37.2	-4.0
Commercial-Type Washing Machines	-6.3	-12.8	-3.1	20.0	14.7	-12.8
Electron Microscope	-10.7	12.0	1.7	19.7	29.4	7.3
Ultrasonic Equipment	-12.1	-3.3	26.5	-14.1	5.0	10.7
Others	-20.3	6.9	24.8	17.5	13.5	7.3
Total	**-13.7**	**0**	**11.1**	**6.1**	**9.1**	**7.4**
Industrial Total	**-18.7**	**-7.6**	**0**	**13.4**	**9.1**	**7.1**

Source: MITI, Dataquest (May 1998)

Table 2-24
Japanese Electronic Equipment Production Forecast—Industrial (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Security/Energy Management						
Alarm Systems	-12.9	5.2	1.8	-9.5	5.3	5.0
Energy Management	-18.5	3.4	1.9	-6.5	0	0.3
Total	**-17.4**	**3.8**	**1.9**	**-7.2**	**1.1**	**1.3**
Manufacturing Systems/Instrumentation						
NC Machines	10.3	4.4	10.2	10.7	4.4	1.9
Robotics	33.0	0.8	-0.3	9.8	-1.6	4.1
Ultrasonic Applied Equipment	10.7	-10.3	3.8	0	-3.7	-3.8
Metering Units	3.9	-3.1	3.4	2.3	2.2	2.6
Measuring Instruments	8.7	6.7	8.3	10.6	10.6	7.2
Industrial Meters	19.9	14.3	-4.0	-3.4	10.4	14.8
Others	16.7	4.1	1.8	3.9	-0.2	15.3
Total	**14.9**	**5.4**	**4.8**	**7.5**	**5.2**	**6.4**
Medical Equipment						
X-Ray Systems	1.1	7.3	4.2	6.1	2.4	9.3
Measuring Systems	1.3	-1.6	3.3	-4.8	-1.7	19.0
Others	-0.2	-1.9	2.9	12.4	9.3	5.4
Total	**0.7**	**2.9**	**3.7**	**6.0**	**3.9**	**9.5**
Other Industrial Equipment						
Vending Machines	8.6	7.7	3.6	-7.9	-1.6	4.3
Automatic Service Equipment	-4.0	8.3	15.4	12.7	10.7	12.8
Commercial-Type Washing Machines	-12.8	19.3	1.7	6.6	5.7	5.4
Electron Microscope	7.3	-8.3	-9.1	-19.8	-9.5	-6.1
Ultrasonic Equipment	10.7	26.7	5.3	6.8	18.5	16.8
Others	7.3	9.0	10.6	13.2	4.5	5.4
Total	**7.4**	**9.4**	**6.7**	**4.6**	**4.2**	**6.4**
Industrial Total	**7.1**	**5.9**	**4.8**	**5.1**	**4.5**	**6.2**

Source: MITI, Dataquest (May 1998)

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Table 2-25
Japanese Electronic Equipment Production History—Consumer (Vendor Revenue in Billions of Yen)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Audio							
Audio Amplifiers	97	92	86	66	45	44	-14.6
DAD Players	210	187	210	207	210	230	1.9
Radios	27	26	21	21	8	7	-23.9
Stereos	171	132	112	72	48	67	-17.1
Tape Recorders	180	135	113	67	40	30	-30.1
Headphone Stereos	74	65	47	45	46	50	-7.6
Musical Instruments	153	121	118	110	105	108	-6.7
Other Audio Equipment	20	15	14	15	10	15	-5.9
Total	**932**	**774**	**722**	**602**	**512**	**551**	**-10.0**
Video							
VCRs	782	598	542	341	298	258	-19.9
Video Cameras	614	498	454	443	462	649	1.1
Video Disc Players	129	135	116	89	49	25	-28.0
Color TVs	811	749	699	612	583	590	-6.2
LCD TVs	35	28	29	32	31	33	-1.2
DVD Recorder	0	4	5	11	33	50	NM
Total	**2,371**	**2,008**	**1,840**	**1,528**	**1,455**	**1,605**	**-7.5**
Personal Electronics							
Cameras	283	228	202	183	191	195	-7.2
Clocks	82	68	55	48	43	41	-13.0
Electronic Toys	548	506	543	596	660	710	5.3
Watches	262	231	187	173	161	165	-8.9
Game Software	269	248	276	281	261	257	-0.9
Total	**1,445**	**1,280**	**1,263**	**1,281**	**1,316**	**1,368**	**-1.1**
Appliances							
Air Conditioners	896	702	785	936	943	850	-1.0
Microwave Ovens	139	129	113	110	107	105	-5.4
Refrigerators	440	441	496	493	497	450	0.4
Washers and Dryers	224	223	221	214	210	200	-2.3
Total	**1,699**	**1,495**	**1,615**	**1,753**	**1,758**	**1,605**	**-1.1**
Other Consumer Equipment	**940**	**920**	**927**	**970**	**978**	**969**	**0.6**
Consumer Total	**7,387**	**6,477**	**6,366**	**6,134**	**6,019**	**6,098**	**-3.8**

Note: Columns may not add to totals shown because of rounding.
NM = Not meaningful
Source: MITI, Dataquest (May 1998)

Table 2-26
Japanese Electronic Equipment Production Forecast—Consumer (Vendor Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Audio							
Audio Amplifiers	44	41	37	34	31	29	-8.0
DAD Players	230	233	239	253	265	285	4.4
Radios	7	6	4	3	2	3	-18.6
Stereos	67	47	46	46	48	48	-6.5
Tape Recorders	30	29	26	22	17	16	-11.8
Headphone Stereos	50	53	55	55	55	62	4.2
Musical Instruments	108	118	124	129	137	152	7.1
Other Audio Equipment	15	11	11	8	9	7	-15.4
Total	**551**	**537**	**542**	**550**	**564**	**601**	**1.7**
Video							
VCRs	258	252	235	223	152	117	-14.7
Video Cameras	649	697	538	442	350	194	-21.5
Video Disc Players	25	20	18	15	10	10	-16.7
Color TVs	590	620	632	612	608	605	0.5
LCD TVs	33	32	34	36	38	41	4.3
DVD Recorder	50	80	232	279	350	435	54.1
Total	**1,605**	**1,701**	**1,689**	**1,607**	**1,508**	**1,402**	**-2.7**
Personal Electronics							
Cameras	195	198	217	220	243	270	6.7
Clocks	41	39	36	33	32	31	-5.4
Electronic Toys	710	721	730	800	850	1,064	8.4
Watches	165	148	142	138	135	136	-3.8
Game Software	257	178	77	60	60	60	-25.2
Total	**1,368**	**1,283**	**1,201**	**1,251**	**1,320**	**1,561**	**2.7**
Appliances							
Air Conditioners	850	883	900	950	981	1,022	3.8
Microwave Ovens	105	95	105	111	112	115	1.8
Refrigerators	450	430	440	550	580	650	7.6
Washers and Dryers	200	150	182	192	202	226	2.4
Total	**1,605**	**1,558**	**1,627**	**1,803**	**1,875**	**2,013**	**4.6**
Other Consumer Equipment	**969**	**1,031**	**1,001**	**1,070**	**1,078**	**1,125**	**3.0**
Consumer Total	**6,098**	**6,110**	**6,060**	**6,281**	**6,346**	**6,702**	**1.9**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-27
Japanese Electronic Equipment Production History—Consumer (Vendor Revenue in Millions of Dollars)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Audio							
Audio Amplifiers	767	828	849	700	414	363	-13.9
DAD Players	1,659	1,682	2,067	2,200	1,930	1,899	2.7
Radios	217	234	204	227	74	58	-23.2
Stereos	1,351	1,189	1,097	761	440	553	-16.3
Tape Recorders	1,420	1,210	1,111	714	368	248	-29.5
Headphone Stereos	588	587	461	480	423	413	-6.8
Musical Instruments	1,208	1,092	1,158	1,171	965	892	-5.9
Other Audio Equipment	161	133	138	155	92	124	-5.1
Total	**7,373**	**6,959**	**7,087**	**6,409**	**4,702**	**4,549**	**-9.2**
Video							
VCRs	6,183	5,379	5,320	3,628	2,736	2,130	-19.2
Video Cameras	4,853	4,482	4,457	4,720	4,242	5,359	2.0
Video Disc Players	1,023	1,212	1,138	946	453	206	-27.4
Color TVs	6,415	6,737	6,870	6,514	5,354	4,872	-5.4
LCD TVs	278	247	285	339	286	273	-0.4
DVD Recorder	0	35	47	117	299	413	NM
Total	**18,754**	**18,060**	**18,072**	**16,270**	**13,377**	**13,255**	**-6.7**
Personal Electronics							
Cameras	2,240	2,047	1,984	1,947	1,755	1,610	-6.4
Clocks	650	612	544	513	396	339	-12.2
Electronic Toys	4,330	4,548	5,330	6,350	6,061	5,863	6.3
Watches	2,074	2,074	1,832	1,845	1,482	1,363	-8.1
Game Software	2,130	2,234	2,713	2,990	2,397	2,122	-0.1
Total	**11,426**	**11,514**	**12,403**	**13,647**	**12,097**	**11,293**	**-0.2**
Appliances							
Air Conditioners	7,083	6,310	7,712	9,967	8,669	7,019	-0.2
Microwave Ovens	1,096	1,156	1,106	1,175	987	867	-4.6
Refrigerators	3,481	3,967	4,875	5,249	4,569	3,716	1.3
Washers and Dryers	1,775	2,009	2,169	2,278	1,927	1,652	-1.4
Total	**13,437**	**13,444**	**15,863**	**18,670**	**16,156**	**13,254**	**-0.3**
Other Consumer Equipment	**7,431**	**8,271**	**9,101**	**10,332**	**8,984**	**8,002**	**1.5**
Consumer Total	**58,420**	**58,248**	**62,526**	**65,328**	**55,315**	**50,352**	**-2.9**
Exchange Rate (Yen/U.S.$)	126.45	111.20	101.81	93.90	108.81	121.10	-

Note: Columns may not add to totals shown because of rounding.
NM = Not meaningful
Source: MITI, Dataquest (May 1998)

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Table 2-28
Japanese Electronic Equipment Production Forecast—Consumer (Vendor Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Audio							
Audio Amplifiers	363	316	285	262	239	224	-9.3
DAD Players	1,899	1,796	1,842	1,950	2,043	2,197	3.0
Radios	58	43	33	24	15	19	-19.7
Stereos	553	362	355	355	370	370	-7.7
Tape Recorders	248	224	200	166	131	123	-13.0
Headphone Stereos	413	409	424	424	424	474	2.8
Musical Instruments	892	908	954	997	1,057	1,172	5.6
Other Audio Equipment	124	83	85	62	69	50	-16.6
Total	**4,549**	**4,142**	**4,178**	**4,243**	**4,351**	**4,634**	**0.4**
Video							
VCRs	2,130	1,944	1,811	1,719	1,172	901	-15.8
Video Cameras	5,359	5,373	4,147	3,407	2,698	1,495	-22.5
Video Disc Players	206	154	139	116	77	77	-17.9
Color TVs	4,872	4,779	4,873	4,717	4,687	4,664	-0.9
LCD TVs	273	244	264	278	291	314	2.9
DVD Recorder	413	617	1,788	2,151	2,698	3,353	52.0
Total	**13,255**	**13,110**	**13,022**	**12,387**	**11,626**	**10,804**	**-4.0**
Personal Electronics							
Cameras	1,610	1,527	1,669	1,696	1,873	2,081	5.3
Clocks	339	297	274	257	245	239	-6.7
Electronic Toys	5,863	5,555	5,627	6,167	6,552	8,202	6.9
Watches	1,363	1,142	1,095	1,062	1,043	1,047	-5.1
Game Software	2,122	1,372	594	462	462	462	-26.3
Total	**11,293**	**9,892**	**9,258**	**9,644**	**10,176**	**12,035**	**1.3**
Appliances							
Air Conditioners	7,019	6,806	6,937	7,323	7,562	7,878	2.3
Microwave Ovens	867	732	809	855	864	886	0.4
Refrigerators	3,716	3,315	3,392	4,240	4,471	5,010	6.2
Washers and Dryers	1,652	1,156	1,403	1,480	1,557	1,740	1.0
Total	**13,254**	**12,010**	**12,541**	**13,898**	**14,453**	**15,517**	**3.2**
Other Consumer Equipment	**8,002**	**7,943**	**7,716**	**8,249**	**8,310**	**8,672**	**1.6**
Consumer Total	**50,352**	**47,098**	**46,711**	**48,420**	**48,915**	**51,661**	**0.5**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-29
Japanese Electronic Equipment Production History—Consumer (Yen-Based Annual Growth; Percent)

Equipment Type	1992	1993	1994	1995	1996	1997
Audio						
Audio Amplifiers	-15.6	-5.1	-6.2	-24.0	-31.5	-2.2
DAD Players	0.2	-10.9	12.5	-1.8	1.6	9.5
Radios	-24.5	-5.1	-20.0	2.4	-62.0	-13.6
Stereos	-21.9	-22.6	-15.5	-36.0	-33.0	39.9
Tape Recorders	-23.4	-25.1	-16.0	-40.8	-40.3	-25.0
Headphone Stereos	-27.6	-12.1	-28.2	-3.8	2.0	8.7
Musical Instruments	-13.1	-20.5	-2.9	-6.7	-4.5	2.9
Other Audio Equipment	-37.2	-27.1	-5.4	4.3	-31.5	50.0
Total	**-17.1**	**-17.0**	**-6.8**	**-16.6**	**-14.9**	**7.6**
Video						
VCRs	-24.8	-23.5	-9.5	-37.1	-12.6	-13.3
Video Cameras	-33.5	-18.8	-8.9	-2.3	4.2	40.6
Video Disc Players	-5.5	4.2	-14.0	-23.4	-44.5	-49.3
Color TVs	-10.9	-7.6	-6.6	-12.5	-4.8	1.3
LCD TVs	-0.6	-21.7	5.5	9.7	-2.2	6.1
DVD Recorder	NM	NM	23.1	129.2	195.5	53.8
Total	**-22.1**	**-15.3**	**-8.4**	**-17.0**	**-4.7**	**10.3**
Personal Electronics						
Cameras	-17.7	-19.6	-11.2	-9.5	4.5	2.1
Clocks	-10.7	-17.3	-18.5	-13.0	-10.6	-4.9
Electronic Toys	7.8	-7.6	7.3	9.9	10.6	7.7
Watches	-17.2	-12.1	-19.1	-7.1	-6.9	2.3
Game Software	10.4	-7.8	11.2	1.7	-7.1	-1.5
Total	**-4.0**	**-11.4**	**-1.4**	**1.5**	**2.7**	**4.0**
Appliances						
Air Conditioners	-19.2	-21.7	11.9	19.2	0.8	-9.9
Microwave Ovens	-7.8	-7.2	-12.4	-2.0	-2.6	-2.2
Refrigerators	-9.2	0.2	12.5	-0.7	0.9	-9.5
Washers and Dryers	-3.4	-0.4	-1.2	-3.1	-2.0	-4.6
Total	**-14.0**	**-12.0**	**8.0**	**8.6**	**0.3**	**-8.7**
Other Consumer Equipment	**-10.3**	**-2.1**	**0.8**	**4.7**	**0.8**	**-0.9**
Consumer Total	**-15.1**	**-12.3**	**-1.7**	**-3.6**	**-1.9**	**1.3**

NM = Not meaningful
Source: MITI, Dataquest (May 1998)

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Table 2-30
Japanese Electronic Equipment Production Forecast—Consumer (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Audio						
Audio Amplifiers	-2.2	-6.8	-9.8	-8.1	-8.8	-6.5
DAD Players	9.5	1.3	2.6	5.9	4.7	7.5
Radios	-13.6	-20.0	-23.2	-27.9	-35.5	25.0
Stereos	39.9	-29.9	-2.1	0	4.3	0
Tape Recorders	-25.0	-3.3	-10.3	-16.9	-21.3	-5.9
Headphone Stereos	8.7	6.0	3.8	0	0.0	11.8
Musical Instruments	2.9	9.1	5.0	4.5	6.0	10.9
Other Audio Equipment	50.0	-28.0	1.9	-26.4	11.1	-27.8
Total	**7.6**	**-2.5**	**0.9**	**1.5**	**2.5**	**6.5**
Video						
VCRs	-13.3	-2.3	-6.8	-5.1	-31.8	-23.1
Video Cameras	40.6	7.4	-22.8	-17.8	-20.8	-44.6
Video Disc Players	-49.3	-20.0	-10.0	-16.7	-33.3	0
Color TVs	1.3	5.1	2.0	-3.2	-0.7	-0.5
LCD TVs	6.1	-3.9	8.2	5.2	4.7	7.9
DVD Recorder	53.8	60.0	190.0	20.3	25.4	24.3
Total	**10.3**	**6.0**	**-0.7**	**-4.9**	**-6.2**	**-7.0**
Personal Electronics						
Cameras	2.1	1.6	9.3	1.6	10.5	11.1
Clocks	-4.9	-6.1	-7.8	-6.2	-4.5	-2.5
Electronic Toys	7.7	1.5	1.3	9.6	6.3	25.2
Watches	2.3	-10.2	-4.1	-3.0	-1.8	0.4
Game Software	-1.5	-30.7	-56.7	-22.1	0	0.0
Total	**4.0**	**-6.2**	**-6.4**	**4.2**	**5.5**	**18.2**
Appliances						
Air Conditioners	-9.9	3.9	1.9	5.6	3.3	4.2
Microwave Ovens	-2.2	-9.5	10.5	5.6	1.1	2.6
Refrigerators	-9.5	-4.4	2.3	25.0	5.5	12.1
Washers and Dryers	-4.6	-25.0	21.3	5.5	5.2	11.7
Total	**-8.7**	**-2.9**	**4.4**	**10.8**	**4.0**	**7.3**
Other Consumer Equipment	**-0.9**	**6.4**	**-2.9**	**6.9**	**0.7**	**4.4**
Consumer Total	**1.3**	**0.2**	**-0.8**	**3.6**	**1.0**	**5.6**

Source: MITI, Dataquest (May 1998)

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Table 2-31
Japanese Electronic Equipment Production History—Military/Civil Aerospace (Vendor Revenue in Billions of Yen)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Military/Civil Aerospace	212	207	203	200	197	195	-1.6

Source: Dataquest (May 1998)

Table 2-32
Japanese Electronic Equipment Production Forecast—Military/Civil Aerospace (Vendor Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Military/Civil Aerospace	195	192	190	187	185	183	-1.3

Source: Dataquest (May 1998)

Table 2-33
Japanese Electronic Equipment Production History—Military/Civil Aerospace (Vendor Revenue in Millions of Dollars)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Military/Civil Aerospace	1,675	1,865	1,992	2,126	1,814	1,610	-0.8
Exchange Rate (Yen/U.S.$)	126.45	111.20	101.81	93.90	108.81	121.10	-

Source: Dataquest (May 1998)

Table 2-34
Japanese Electronic Equipment Production Forecast—Military/Civil Aerospace (Vendor Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Military/Civil Aerospace	1,610	1,480	1,465	1,441	1,426	1,411	-2.6
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73	-

Source: Dataquest (May 1998)

Table 2-35
Japanese Electronic Equipment Production History—Military/Civil Aerospace (Yen-Based Annual Growth; Percent)

Equipment Type	1992	1993	1994	1995	1996	1997
Military/Civil Aerospace	-2.1	-2.1	-2.2	-1.6	-1.1	-1.2

Source: Dataquest (May 1998)

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Table 2-36
Japanese Electronic Equipment Production Forecast—Military/Civil Aerospace (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Military/Civil Aerospace	-1.2	-1.5	-1.0	-1.6	-1.1	-1.1

Source: Dataquest (May 1998)

Table 2-37
Japanese Electronic Equipment Production History—Transportation (Vendor Revenue in Billions of Yen)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Entertainment	370	363	346	339	339	340	-1.7
Control Units	357	339	322	341	351	353	-0.2
Driver Information Systems	18	17	22	43	74	80	35.5
Safety and Convenience	586	561	534	518	520	517	-2.5
Transportation Total	**1,330**	**1,281**	**1,224**	**1,240**	**1,283**	**1,290**	**-0.6**

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1998)

Table 2-38
Japanese Electronic Equipment Production Forecast—Transportation (Vendor Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Entertainment	340	335	325	320	306	302	-2.3
Control Units	353	384	398	409	415	416	3.3
Driver Information Systems	80	115	140	145	152	160	14.9
Safety and Convenience	517	560	592	611	615	615	3.5
Transportation Total	**1,290**	**1,394**	**1,455**	**1,486**	**1,488**	**1,493**	**3.0**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-39
Japanese Electronic Equipment Production History—Transportation (Vendor Revenue in Millions of Dollars)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Entertainment	2,925	3,268	3,396	3,607	3,112	2,808	-0.8
Control Units	2,820	3,051	3,162	3,630	3,223	2,915	0.7
Driver Information Systems	138	153	220	454	681	661	36.7
Safety and Convenience	4,630	5,046	5,240	5,512	4,777	4,269	-1.6
Transportation Total	**10,516**	**11,519**	**12,018**	**13,204**	**11,795**	**10,653**	**0.3**
Exchange Rate (Yen/U.S.$)	126.45	111.20	101.81	93.90	108.81	121.10	-

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1998)

Table 2-40
Japanese Electronic Equipment Production Forecast—Transportation (Vendor Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Entertainment	2,808	2,582	2,505	2,469	2,359	2,328	-3.7
Control Units	2,915	2,960	3,068	3,154	3,199	3,207	1.9
Driver Information Systems	661	886	1,079	1,118	1,172	1,233	13.3
Safety and Convenience	4,269	4,317	4,563	4,710	4,741	4,741	2.1
Transportation Total	**10,653**	**10,745**	**11,217**	**11,456**	**11,468**	**11,507**	**1.6**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

Table 2-41
Japanese Electronic Equipment Production History—Transportation (Yen-Based Annual Growth; Percent)

Equipment Type	1992	1993	1994	1995	1996	1997
Entertainment	-7.0	-1.8	-4.9	-2.0	0	0.4
Control Units	2.8	-4.9	-5.1	5.9	2.9	0.7
Driver Information Systems	47.1	-2.9	31.8	90.2	73.9	8.0
Safety and Convenience	-4.0	-4.2	-4.9	-3.0	0.4	-0.5
Transportation Total	**-2.7**	**-3.7**	**-4.5**	**1.3**	**3.5**	**0.5**

Source: MITI, Dataquest (May 1998)

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Table 2-42
Japanese Electronic Equipment Production Forecast—Transportation (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Entertainment	0.4	-1.5	-3.0	-1.4	-4.5	-1.3
Control Units	0.7	8.8	3.6	2.8	1.4	0.2
Driver Information Systems	8.0	43.8	21.7	3.6	4.8	5.3
Safety and Convenience	-0.5	8.3	5.7	3.2	0.7	0
Transportation Total	**0.5**	**8.1**	**4.4**	**2.1**	**0.2**	**0.3**

Source: MITI, Dataquest (May 1998)

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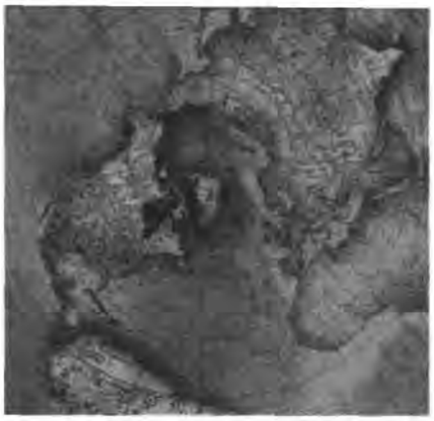

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Final 1997 Japanese Semiconductor Market Share

Market Statistics

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Final 1997 Japanese Semiconductor Market Share

Market Statistics

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Chapter 1

Final 1997 Japanese Semiconductor Market Share

Introduction

This document contains detailed information on Dataquest's view of the semiconductor market. Included in this document are the following:

- 1995-1997 market share estimates
- 1996-1997 market share rankings

Worldwide market share estimates combine data from many countries, each of which has a different and fluctuating exchange rate. Estimates of non-U.S. market consumption or revenue are based on the average exchange rate for the given year. Refer to the section titled "Exchange Rates" for more information regarding these average rates. As a rule, Dataquest's estimates are calculated in local currencies and then converted to U.S. dollars.

More detailed data on this market may be requested through Dataquest's client inquiry service. Qualitative analysis of this data is provided in the Dataquest Perspectives.

Segmentation and Definitions

A detailed explanation of device segmentation and related definitions is contained in the Semiconductor Market Definitions Guide (SCND-WW-GU-9801).

Market Share Methodology

Dataquest uses both primary and secondary sources to produce market statistics data. In the fourth quarter of each year, Dataquest surveys all major participants within each industry. Selected companies are resurveyed during the first quarter of the following year to verify final annual results. This primary research is supplemented with additional primary research and secondary research to verify market size, shipment totals, and pricing information. Sources of data used by Dataquest include the following:

- Information published by major industry participants
- Estimates made by knowledgeable and reliable industry spokespersons
- Government data or trade association data (such as WSTS, MITI, and U.S. DOC)
- Published product literature and price lists
- Interviews with knowledgeable manufacturers, distributors, and users
- Relevant economic data
- Information and data from online and CD-ROM data banks
- Articles in both the general and trade press

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- Reports from financial analysts
- End-user surveys

Dataquest believes that the estimates presented in this document are the most accurate and meaningful statistics available.

Despite the care taken in gathering, analyzing, and categorizing the data in a meaningful way, careful attention must be paid to the definitions and assumptions used herein when interpreting the estimates presented in this document. Various companies, government agencies, and trade associations may use slightly different definitions of product categories and regional groupings, or they may include different companies in their summaries. These differences should be kept in mind when making comparisons between data and numbers provided by Dataquest and those provided by other sources.

Notes on Market Share

In the process of conducting data collection and preparing market statistics information, Dataquest will sometimes consolidate or revise a particular company, model, series, or industry's numbers. In this section, we explain any such changes contained within this document for your reference.

Notes to Market Share Tables

1. Cyrix was acquired by National Semiconductor in 1997.

2. National Semiconductor divested itself of Fairchild in 1997.

3. National Semiconductor's 1997 revenue includes all of Cyrix's 1997 revenue and part of Fairchild's calendar first quarter revenue.

4. Power Innovations was formed through the acquisition of the Power Semiconductor interests of Texas Instruments.

5. Melexis was formerly known as Elex.

6. Micronas acquired ITT in 1997.

7. The following companies were added to the market share database in 1997:

- Fairchild
- Vitesse
- TriQuint
- Power Innovations
- Robert Bosch
- Stanley

8. Toko is now tracked in other Japanese companies.

9. IBM's 1996 revenue was restated in 1997.

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Exchange Rates

Dataquest uses an average annual exchange rate in converting revenue to U.S. dollar amounts. Table 1-1 outlines these rates for 1995 through 1997.

Table 1-1
Exchange Rates

	1995	1996	1997
Japan (Yen/U.S.$)	93.90	108.81	121.10
France (Franc/U.S.$)	4.97	5.12	5.84
Germany (Deutsche Mark/U.S.$)	1.43	1.50	1.73
United Kingdom (U.S.$/Pound Sterling)	1.59	1.56	1.64

Source: Dataquest (April 1998)

Project Analyst: Kevin McClure

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Chapter 2
Market Share Tables

Tables 2-1 through 2-10 show each company's vendor revenue by technology category. Tables 2-11 through 2-20 show the top companies' vendor revenue by technology category.

Table 2-1
Each Company's Vendor Revenue from Shipments of Total Semiconductors to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**42,073**	**38,413**	**36,499**	**100.0**	**100.0**	**100.0**
Americas Companies	**7,571**	**7,767**	**7,844**	**18.0**	**20.2**	**21.5**
ACC Microelectronics	1	1	1	0	0	0
Actel	12	15	14	0	0	0
Adaptec	18	55	57	0	0.1	0.2
Advanced Micro Devices	189	177	160	0.4	0.5	0.4
Allegro MicroSystems	26	36	31	0	0	0
Alliance Semiconductor	6	2	6	0	0	0
Altera	80	95	114	0.2	0.2	0.3
Analog Devices	170	161	194	0.4	0.4	0.5
ATI Technologies	0	10	20	0	0	0
Atmel	89	209	108	0.2	0.5	0.3
Burr-Brown	56	66	50	0.1	0.2	0.1
C-Cube	0	16	16	0	0	0
Catalyst	7	7	11	0	0	0
Chip Express	0	1	1	0	0	0
Chips & Technologies	53	55	90	0.1	0.1	0.2
Cirrus Logic	158	133	117	0.4	0.3	0.3
Cypress Semiconductor	38	38	49	0	0	0.1
Dallas Semiconductor	20	24	25	0	0	0
Digital	0	30	41	0	0	0.1
DSP Group	13	13	13	0	0	0
Elantec	4	8	13	0	0	0
ESS	0	0	15	0	0	0
Exar	25	13	13	0	0	0
Fairchild	0	0	55	0	0	0.2
General Semiconductor	37	30	29	0	0	0
Gennum	4	4	4	0	0	0
Gould AMI	2	2	3	0	0	0
Harris Semiconductor	37	22	22	0	0	0
Hewlett-Packard	31	66	65	0	0.2	0.2
Honeywell	1	1	1	0	0	0

Table 2-1 (Continued)
Each Company's Vendor Revenue from Shipments of Total Semiconductors to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
IBM	539	142	132	1.3	0.4	0.4
IMP	2	0	0	0	0	0
Integrated Circuit Systems	10	11	12	0	0	0
Integrated Device Technology	58	73	58	0.1	0.2	0.2
Integrated Silicon Solution	6	4	0	0	0	0
Intel	1,351	2,028	2,237	3.2	5.3	6.1
International CMOS Technology	1	1	0	0	0	0
International Rectifier	61	61	56	0.1	0.2	0.2
ISD	0	0	9	0	0	0
Lattice	18	40	40	0	0.1	0.1
Level One Communications	0	4	4	0	0	0
Linear Technology	32	40	42	0	0.1	0.1
Linfinity	1	1	1	0	0	0
Logic Devices	1	1	1	0	0	0
LSI Logic	250	275	367	0.6	0.7	1.0
Lucent Technologies	60	136	186	0.1	0.4	0.5
Maxim	29	59	65	0	0.2	0.2
Micrel	3	5	0	0	0	0
Micro Linear	1	1	1	0	0	0
Microchip Technology	31	31	12	0	0	0
Micron Technology	56	32	15	0.1	0	0
Microsemi	1	1	1	0	0	0
Mitel	6	14	10	0	0	0
Motorola	919	668	621	2.2	1.7	1.7
National Semiconductor	231	254	227	0.5	0.7	0.6
Oak Technology	35	85	69	0	0.2	0.2
OPTi	5	6	8	0	0	0
PMC Sierra Semiconductor	5	5	5	0	0	0
Powerex	18	18	16	0	0	0
Q Logic	23	24	25	0	0	0
Quality Semiconductor	0	5	5	0	0	0
QuickLogic	0	0	10	0	0	0
Ramtron	4	0	0	0	0	0
Raytheon	13	13	13	0	0	0
Rockwell	298	446	348	0.7	1.2	1.0
S3	5	8	2	0	0	0
Seeq Technology	0	1	1	0	0	0
Semtech	1	1	10	0	0	0

Table 2-1 (Continued)
Each Company's Vendor Revenue from Shipments of Total Semiconductors to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Silicon Storage Technology	0	18	17	0	0	0
Standard Microsystems	5	5	5	0	0	0
Sun Microsystems	0	20	75	0	0	0.2
Supertex	10	9	9	0	0	0
Symbios	13	11	26	0	0	0
Teccor Electronics	2	2	4	0	0	0
TelCom	3	3	5	0	0	0
Texas Instruments	1,992	1,634	1,549	4.7	4.3	4.2
Trident Microsystems	23	45	30	0	0.1	0
Unitrode	2	4	4	0	0	0
Vitesse	0	0	11	0	0	0
VLSI Technology	39	70	46	0	0.2	0.1
VTC	19	25	10	0	0	0
WaferScale Integration	8	11	6	0	0	0
Xicor	23	22	27	0	0	0
Xilinx	52	55	61	0.1	0.1	0.2
Zilog	19	22	7	0	0	0
Zoran	0	5	5	0	0	0
Japanese Companies	**31,804**	**28,575**	**26,855**	**75.6**	**74.4**	**73.6**
Fuji Electric	374	320	259	0.9	0.8	0.7
Fujitsu	3,091	2,645	2,768	7.3	6.9	7.6
Hitachi	4,390	4,252	3,355	10.4	11.1	9.2
Matsushita	2,582	2,268	2,244	6.1	5.9	6.1
Mitsubishi	2,540	2,147	2,030	6.0	5.6	5.6
NEC	5,584	5,756	5,666	13.3	15.0	15.5
New JRC	154	120	127	0.4	0.3	0.3
Nippon Steel Semiconductor	206	36	15	0.5	0	0
Oki	753	579	563	1.8	1.5	1.5
Ricoh	187	136	141	0.4	0.4	0.4
Rohm	1,188	1,049	968	2.8	2.7	2.7
Sanken	449	352	302	1.1	0.9	0.8
SANYO	1,352	1,249	1,292	3.2	3.3	3.5
Seiko Epson	194	158	113	0.5	0.4	0.3
Sharp	1,820	1,561	1,491	4.3	4.1	4.1
Shindengen Electric	212	173	157	0.5	0.5	0.4
Sony	1,589	1,386	1,369	3.8	3.6	3.8
Stanley	129	0	128	0.3	0	0.4
Toshiba	4,518	3,838	3,484	10.7	10	9.5

Table 2-1 (Continued)
Each Company's Vendor Revenue from Shipments of Total Semiconductors to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Yamaha	235	189	153	0.6	0.5	0.4
Other Japanese Companies	192	307	230	0.5	0.8	0.6
European Companies	**412**	**507**	**550**	**1.0**	**1.3**	**1.5**
Austria Mikro Systeme	1	0	0	0	0	0
Ericsson	1	1	3	0	0	0
Eupec	0	2	0	0	0	0
GEC Plessey	24	20	21	0	0	0
Micronas	1	1	13	0	0	0
Philips	142	172	182	0.3	0.4	0.5
SGS-Thomson	157	228	215	0.4	0.6	0.6
Siemens	44	41	57	0.1	0.1	0.2
TEMIC	38	39	55	0	0.1	0.2
Zetex	0	1	2	0	0	0
Other European Companies	2	2	2	0	0	0
Asia/Pacific Companies	**2,286**	**1,564**	**1,250**	**5.4**	**4.1**	**3.4**
Acer	0	5	5	0	0	0
Holtek	0	0	2	0	0	0
Hualon Microelectronics Corp.	0	2	2	0	0	0
Hyundai	345	244	212	0.8	0.6	0.6
Korean Electronic Co.	18	19	37	0	0	0.1
LG Semicon	395	243	175	0.9	0.6	0.5
Macronix	110	147	190	0.3	0.4	0.5
Mosel Vitelic	112	41	24	0.3	0.1	0
Samsung	1,276	819	589	3.0	2.1	1.6
Silicon Integrated Systems	0	1	0	0	0	0
United Microelectronics	26	27	4	0	0	0
Vanguard	0	7	3	0	0	0
VIA	0	1	0	0	0	0
Winbond Electronics	4	8	7	0	0	0

Source: Dataquest (April 1998)

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Table 2-2
Each Company's Vendor Revenue from Shipments of Total ICs to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**34,611**	**31,367**	**29,530**	**100.0**	**100.0**	**100.0**
Americas Companies	**7,299**	**7,468**	**7,557**	**21.1**	**23.8**	**25.6**
ACC Microelectronics	1	1	1	0	0	0
Actel	12	15	14	0	0	0
Adaptec	18	55	57	0	0.2	0.2
Advanced Micro Devices	189	177	160	0.5	0.6	0.5
Allegro MicroSystems	26	36	31	0	0.1	0.1
Alliance Semiconductor	6	2	6	0	0	0
Altera	80	95	114	0.2	0.3	0.4
Analog Devices	170	161	194	0.5	0.5	0.7
ATI Technologies	0	10	20	0	0	0
Atmel	89	209	108	0.3	0.7	0.4
Burr-Brown	56	66	50	0.2	0.2	0.2
C-Cube	0	16	16	0	0	0
Catalyst	7	7	11	0	0	0
Chip Express	0	1	1	0	0	0
Chips & Technologies	53	55	90	0.2	0.2	0.3
Cirrus Logic	158	133	117	0.5	0.4	0.4
Cypress Semiconductor	38	38	49	0.1	0.1	0.2
Dallas Semiconductor	20	24	25	0	0	0
Digital	0	30	41	0	0	0.1
DSP Group	13	13	13	0	0	0
Elantec	4	8	13	0	0	0
ESS	0	0	15	0	0	0
Exar	25	13	13	0	0	0
Fairchild	0	0	44	0	0	0.1
Gennum	4	4	4	0	0	0
Gould AMI	2	2	3	0	0	0
Harris Semiconductor	37	22	21	0.1	0	0
Hewlett-Packard	6	8	9	0	0	0
Honeywell	1	1	1	0	0	0
IBM	539	142	132	1.6	0.5	0.4
IMP	2	0	0	0	0	0
Integrated Circuit Systems	10	11	12	0	0	0
Integrated Device Technology	58	73	58	0.2	0.2	0.2
Integrated Silicon Solution	6	4	0	0	0	0
Intel	1,351	2,028	2,237	3.9	6.5	7.6
International CMOS Technology	1	1	0	0	0	0

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Table 2-2 (Continued)
Each Company's Vendor Revenue from Shipments of Total ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
International Rectifier	7	10	13	0	0	0
ISD	0	0	9	0	0	0
Lattice	18	40	40	0	0.1	0.1
Level One Communications	0	4	4	0	0	0
Linear Technology	32	40	42	0	0.1	0.1
Linfinity	1	1	1	0	0	0
Logic Devices	1	1	1	0	0	0
LSI Logic	250	275	367	0.7	0.9	1.2
Lucent Technologies	55	130	184	0.2	0.4	0.6
Maxim	29	59	65	0	0.2	0.2
Micrel	3	5	0	0	0	0
Micro Linear	1	1	1	0	0	0
Microchip Technology	31	31	12	0	0	0
Micron Technology	56	32	15	0.2	0.1	0
Mitel	6	7	8	0	0	0
Motorola	851	594	556	2.5	1.9	1.9
National Semiconductor	230	246	215	0.7	0.8	0.7
Oak Technology	35	85	69	0.1	0.3	0.2
OPTi	5	6	8	0	0	0
PMC Sierra Semiconductor	5	5	5	0	0	0
Q Logic	23	24	25	0	0	0
Quality Semiconductor	0	5	5	0	0	0
QuickLogic	0	0	10	0	0	0
Ramtron	4	0	0	0	0	0
Raytheon	13	13	13	0	0	0
Rockwell	298	446	348	0.9	1.4	1.2
S3	5	8	2	0	0	0
Seeq Technology	0	1	1	0	0	0
Semtech	1	1	10	0	0	0
Silicon Storage Technology	0	18	17	0	0	0
Standard Microsystems	5	5	5	0	0	0
Sun Microsystems	0	20	75	0	0	0.3
Supertex	8	7	7	0	0	0
Symbios	13	11	26	0	0	0
TelCom	3	3	5	0	0	0
Texas Instruments	1,957	1,594	1,506	5.7	5.1	5.1
Trident Microsystems	23	45	30	0	0.1	0.1
Unitrode	2	4	4	0	0	0

Table 2-2 (Continued)
Each Company's Vendor Revenue from Shipments of Total ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Vitesse	0	0	11	0	0	0
VLSI Technology	39	70	46	0.1	0.2	0.2
VTC	19	25	10	0	0	0
WaferScale Integration	8	11	6	0	0	0
Xicor	23	22	27	0	0	0
Xilinx	52	55	61	0.2	0.2	0.2
Zilog	19	22	7	0	0	0
Zoran	0	5	5	0	0	0
Japanese Companies	**24,694**	**21,911**	**20,291**	**71.3**	**69.9**	**68.7**
Fuji Electric	68	58	37	0.2	0.2	0.1
Fujitsu	2,912	2,458	2,566	8.4	7.8	8.7
Hitachi	3,700	3,488	2,808	10.7	11.1	9.5
Matsushita	1,712	1,502	1,483	4.9	4.8	5.0
Mitsubishi	2,082	1,719	1,586	6.0	5.5	5.4
NEC	4,828	4,978	4,880	13.9	15.9	16.5
New JRC	143	112	124	0.4	0.4	0.4
Nippon Steel Semiconductor	206	36	15	0.6	0.1	0
Oki	714	541	520	2.1	1.7	1.8
Ricoh	187	136	141	0.5	0.4	0.5
Rohm	562	474	404	1.6	1.5	1.4
Sanken	162	135	38	0.5	0.4	0.1
SANYO	946	863	879	2.7	2.8	3.0
Seiko Epson	194	158	113	0.6	0.5	0.4
Sharp	1,333	1,094	969	3.9	3.5	3.3
Shindengen Electric	24	16	0	0	0	0
Sony	1,202	1,017	994	3.5	3.2	3.4
Toshiba	3,355	2,831	2,479	9.7	9.0	8.4
Yamaha	235	189	153	0.7	0.6	0.5
Other Japanese Companies	99	80	102	0.3	0.3	0.3
European Companies	**347**	**437**	**459**	**1.0**	**1.4**	**1.6**
Austria Mikro Systeme	1	0	0	0	0	0
Ericsson	1	1	2	0	0	0
GEC Plessey	24	20	20	0	0	0
Micronas	1	1	12	0	0	0
Philips	126	161	166	0.4	0.5	0.6
SGS-Thomson	151	220	207	0.4	0.7	0.7
Siemens	30	26	33	0	0	0.1
TEMIC	12	8	19	0	0	0

Table 2-2 (Continued)
Each Company's Vendor Revenue from Shipments of Total ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Asia/Pacific Companies	**2,271**	**1,551**	**1,223**	**6.6**	**4.9**	**4.1**
Acer	0	5	5	0	0	0
Holtek	0	0	2	0	0	0
Hualon Microelectronics Corp.	0	2	2	0	0	0
Hyundai	345	244	212	1.0	0.8	0.7
Korean Electronic Co.	5	7	11	0	0	0
LG Semicon	395	243	175	1.1	0.8	0.6
Macronix	110	147	190	0.3	0.5	0.6
Mosel Vitelic	112	41	24	0.3	0.1	0
Samsung	1,274	818	588	3.7	2.6	2.0
Silicon Integrated Systems	0	1	0	0	0	0
United Microelectronics	26	27	4	0	0	0
Vanguard	0	7	3	0	0	0
VIA	0	1	0	0	0	0
Winbond Electronics	4	8	7	0	0	0

Source: Dataquest (April 1998)

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Table 2-3
Each Company's Vendor Revenue from Shipments of Bipolar Digital to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**1,068**	**770**	**530**	**100.0**	**100.0**	**100.0**
Americas Companies	**287**	**185**	**153**	**26.9**	**24.0**	**28.9**
Advanced Micro Devices	16	8	4	1.5	1.0	0.8
Motorola	82	49	59	7.7	6.4	11.1
National Semiconductor	35	26	0	3.3	3.4	0
Texas Instruments	154	102	90	14.4	13.2	17.0
Japanese Companies	**771**	**577**	**371**	**72.2**	**74.9**	**70.0**
Fujitsu	155	64	50	14.5	8.3	9.4
Hitachi	336	360	206	31.5	46.8	38.9
Matsushita	22	14	8	2.1	1.8	1.5
Mitsubishi	30	19	19	2.8	2.5	3.6
NEC	87	68	59	8.1	8.8	11.1
Oki	36	4	3	3.4	0.5	0.6
Toshiba	105	48	26	9.8	6.2	4.9
European Companies	**8**	**7**	**2**	**0.7**	**0.9**	**0.4**
GEC Plessey	2	2	0	0.2	0.3	0
Philips	6	5	2	0.6	0.6	0.4
Asia/Pacific Companies	**2**	**1**	**4**	**0.2**	**0.1**	**0.8**
LG Semicon	2	1	0	0.2	0.1	0
Mosel Vitelic	0	0	4	0	0	0.8

Source: Dataquest (April 1998)

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Table 2-4
Each Company's Vendor Revenue from Shipments of MOS Digital ICs to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**27,774**	**25,105**	**24,023**	**100.0**	**100.0**	**100.0**
Americas Companies	**5,927**	**6,056**	**6,003**	**21.3**	**24.1**	**25.0**
ACC Microelectronics	1	1	1	0	0	0
Actel	12	15	14	0	0	0
Adaptec	18	55	57	0	0.2	0.2
Advanced Micro Devices	162	159	130	0.6	0.6	0.5
Alliance Semiconductor	6	2	6	0	0	0
Altera	80	95	114	0.3	0.4	0.5
Analog Devices	13	33	43	0	0.1	0.2
ATI Technologies	0	10	20	0	0	0
Atmel	89	209	108	0.3	0.8	0.4
C-Cube	0	16	16	0	0	0
Catalyst	7	7	11	0	0	0
Chip Express	0	1	1	0	0	0
Chips & Technologies	53	55	90	0.2	0.2	0.4
Cirrus Logic	155	125	94	0.6	0.5	0.4
Cypress Semiconductor	38	38	49	0.1	0.2	0.2
Dallas Semiconductor	20	20	21	0	0	0
Digital	0	30	41	0	0.1	0.2
DSP Group	13	13	13	0	0	0
ESS	0	0	15	0	0	0
Exar	0	2	3	0	0	0
Fairchild	0	0	44	0	0	0.2
Gennum	0	0	1	0	0	0
Gould AMI	2	2	3	0	0	0
Harris Semiconductor	6	4	3	0	0	0
Hewlett-Packard	6	8	9	0	0	0
IBM	539	142	132	1.9	0.6	0.5
IMP	1	0	0	0	0	0
Integrated Circuit Systems	5	8	9	0	0	0
Integrated Device Technology	58	73	58	0.2	0.3	0.2
Integrated Silicon Solution	6	4	0	0	0	0
Intel	1,351	2,028	2,237	4.9	8.1	9.3
International CMOS Technology	1	1	0	0	0	0
ISD	0	0	9	0	0	0
Lattice	18	40	40	0	0.2	0.2
Logic Devices	1	1	1	0	0	0
LSI Logic	250	275	367	0.9	1.1	1.5

Table 2-4 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Digital ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Lucent Technologies	47	130	184	0.2	0.5	0.8
Micrel	1	1	0	0	0	0
Microchip Technology	31	31	12	0.1	0.1	0
Micron Technology	56	32	15	0.2	0.1	0
Motorola	585	416	358	2.1	1.7	1.5
National Semiconductor	96	89	61	0.3	0.4	0.3
Oak Technology	35	85	69	0.1	0.3	0.3
OPTi	5	6	8	0	0	0
PMC Sierra Semiconductor	4	2	2	0	0	0
Q Logic	23	24	25	0	0	0.1
Quality Semiconductor	0	5	5	0	0	0
QuickLogic	0	0	10	0	0	0
Ramtron	4	0	0	0	0	0
Raytheon	0	1	3	0	0	0
Rockwell	298	400	311	1.1	1.6	1.3
S3	5	8	2	0	0	0
Silicon Storage Technology	0	18	17	0	0	0
Standard Microsystems	5	5	5	0	0	0
Sun Microsystems	0	20	75	0	0	0.3
Symbios	13	11	26	0	0	0.1
Texas Instruments	1,556	1,051	868	5.6	4.2	3.6
Trident Microsystems	23	45	30	0	0.2	0.1
Vitesse	0	0	5	0	0	0
VLSI Technology	39	70	46	0.1	0.3	0.2
WaferScale Integration	8	11	6	0	0	0
Xicor	23	22	27	0	0	0.1
Xilinx	52	55	61	0.2	0.2	0.3
Zilog	19	22	7	0	0	0
Zoran	0	5	5	0	0	0
Japanese Companies	**19,433**	**17,316**	**16,626**	**70.0**	**69.0**	**69.2**
Fuji Electric	32	28	25	0.1	0.1	0.1
Fujitsu	2,398	2,066	2,263	8.6	8.2	9.4
Hitachi	3,019	2,775	2,406	10.9	11.1	10
Matsushita	1,235	1,102	1,065	4.4	4.4	4.4
Mitsubishi	1,611	1,309	1,287	5.8	5.2	5.4
NEC	4,175	4,367	4,424	15.0	17.4	18.4
New JRC	26	12	15	0	0	0
Nippon Steel Semiconductor	206	36	15	0.7	0.1	0

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Table 2-4 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Digital ICs to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Oki	638	507	501	2.3	2.0	2.1
Ricoh	154	102	97	0.6	0.4	0.4
Rohm	231	193	151	0.8	0.8	0.6
SANYO	456	441	516	1.6	1.8	2.1
Seiko Epson	182	149	104	0.7	0.6	0.4
Sharp	1,258	1,029	903	4.5	4.1	3.8
Sony	794	661	655	2.9	2.6	2.7
Toshiba	2,734	2,311	1,993	9.8	9.2	8.3
Yamaha	231	186	152	0.8	0.7	0.6
Other Japanese Companies	53	42	54	0.2	0.2	0.2
European Companies	**165**	**207**	**192**	**0.6**	**0.8**	**0.8**
GEC Plessey	5	6	8	0	0	0
Micronas	0	1	12	0	0	0
Philips	45	74	44	0.2	0.3	0.2
SGS-Thomson	102	118	114	0.4	0.5	0.5
Siemens	12	8	7	0	0	0
TEMIC	0	0	7	0	0	0
Asia/Pacific Companies	**2,249**	**1,526**	**1,202**	**8.1**	**6.1**	**5.0**
Acer	0	5	5	0	0	0
Holtek	0	0	2	0	0	0
Hualon Microelectronics Corp.	0	2	2	0	0	0
Hyundai	345	244	212	1.2	1.0	0.9
LG Semicon	391	239	172	1.4	1.0	0.7
Macronix	110	147	190	0.4	0.6	0.8
Mosel Vitelic	112	41	20	0.4	0.2	0
Samsung	1,262	805	586	4.5	3.2	2.4
Silicon Integrated Systems	0	1	0	0	0	0
United Microelectronics	26	27	4	0	0.1	0
Vanguard	0	7	3	0	0	0
VIA	0	1	0	0	0	0
Winbond Electronics	3	7	6	0	0	0

Source: Dataquest (April 1998)

Table 2-5
Each Company's Vendor Revenue from Shipments of MOS Memory to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**12,168**	**8,487**	**6,523**	**100.0**	**100.0**	**100.0**
Americas Companies	**1,907**	**1,150**	**742**	**15.7**	**13.6**	**11.4**
Advanced Micro Devices	50	56	28	0.4	0.7	0.4
Alliance Semiconductor	6	2	6	0	0	0
Atmel	87	207	102	0.7	2.4	1.6
Catalyst	7	7	11	0	0	0.2
Cypress Semiconductor	25	22	27	0.2	0.3	0.4
Dallas Semiconductor	3	0	0	0	0	0
Fairchild	0	0	15	0	0	0.2
IBM	428	95	88	3.5	1.1	1.3
Integrated Device Technology	41	52	38	0.3	0.6	0.6
Integrated Silicon Solution	6	4	0	0	0	0
Intel	68	122	108	0.6	1.4	1.7
Microchip Technology	28	27	0	0.2	0.3	0
Micron Technology	56	32	15	0.5	0.4	0.2
Motorola	142	65	29	1.2	0.8	0.4
National Semiconductor	35	22	0	0.3	0.3	0
Ramtron	4	0	0	0	0	0
Silicon Storage Technology	0	18	17	0	0.2	0.3
Texas Instruments	893	388	230	7.3	4.6	3.5
WaferScale Integration	5	9	1	0	0.1	0
Xicor	23	22	27	0.2	0.3	0.4
Japanese Companies	**7,933**	**5,748**	**4,569**	**65.2**	**67.7**	**70.0**
Fujitsu	967	659	643	7.9	7.8	9.9
Hitachi	1,702	1,239	949	14.0	14.6	14.5
Matsushita	245	149	217	2.0	1.8	3.3
Mitsubishi	701	471	415	5.8	5.5	6.4
NEC	1,392	1,286	1,067	11.4	15.2	16.4
Nippon Steel Semiconductor	206	36	15	1.7	0.4	0.2
Oki	248	185	166	2.0	2.2	2.5
Ricoh	6	3	8	0	0	0.1
Rohm	30	24	22	0.2	0.3	0.3
SANYO	143	180	99	1.2	2.1	1.5
Seiko Epson	20	10	7	0.2	0.1	0.1
Sharp	697	531	387	5.7	6.3	5.9
Sony	192	121	35	1.6	1.4	0.5
Toshiba	1,381	849	534	11.3	10.0	8.2
Yamaha	1	1	1	0	0	0
Other Japanese Companies	2	4	4	0	0	0

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Table 2-5 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Memory to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
European Companies	**102**	**101**	**82**	**0.8**	**1.2**	**1.3**
Philips	0	0	2	0	0	0
SGS-Thomson	93	96	75	0.8	1.1	1.1
Siemens	9	5	4	0	0	0
TEMIC	0	0	1	0	0	0
Asia/Pacific Companies	**2,226**	**1,488**	**1,130**	**18.3**	**17.5**	**17.3**
Hualon Microelectronics Corp.	0	1	1	0	0	0
Hyundai	345	244	212	2.8	2.9	3.3
LG Semicon	389	237	169	3.2	2.8	2.6
Macronix	110	141	157	0.9	1.7	2.4
Mosel Vitelic	112	41	20	0.9	0.5	0.3
Samsung	1,242	788	563	10.2	9.3	8.6
United Microelectronics	26	24	1	0.2	0.3	0
Vanguard	0	7	3	0	0	0
Winbond Electronics	2	5	4	0	0	0

Source: Dataquest (April 1998)

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Table 2-6
Each Company's Vendor Revenue from Shipments of MOS Microcomponents to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**7,826**	**8,797**	**9,336**	**100.0**	**100.0**	**100.0**
Americas Companies	**2,675**	**3,527**	**3,784**	**34.2**	**40.1**	**40.5**
ACC Microelectronics	1	1	1	0	0	0
Adaptec	18	55	57	0.2	0.6	0.6
Advanced Micro Devices	72	43	62	0.9	0.5	0.7
Analog Devices	13	31	41	0.2	0.4	0.4
ATI Technologies	0	10	20	0	0.1	0.2
C-Cube	0	16	16	0	0.2	0.2
Chips & Technologies	53	55	90	0.7	0.6	1.0
Cirrus Logic	155	125	94	2.0	1.4	1.0
Cypress Semiconductor	7	9	0	0	0.1	0
Dallas Semiconductor	3	11	11	0	0.1	0.1
Digital	0	30	41	0	0.3	0.4
DSP Group	13	13	13	0.2	0.1	0.1
ESS	0	0	15	0	0	0.2
Harris Semiconductor	4	0	0	0	0	0
IBM	18	6	8	0.2	0	0
Integrated Device Technology	9	13	11	0.1	0.1	0.1
Intel	1,283	1,906	2,129	16.4	21.7	22.8
LSI Logic	30	35	12	0.4	0.4	0.1
Lucent Technologies	36	35	97	0.5	0.4	1.0
Microchip Technology	3	4	12	0	0	0.1
Motorola	260	242	224	3.3	2.8	2.4
National Semiconductor	37	38	51	0.5	0.4	0.5
Oak Technology	35	85	69	0.4	1.0	0.7
OPTi	5	6	8	0	0	0
PMC Sierra Semiconductor	4	2	2	0	0	0
Q Logic	23	24	25	0.3	0.3	0.3
Rockwell	298	400	311	3.8	4.5	3.3
S3	5	8	2	0	0	0
Standard Microsystems	5	5	5	0	0	0
Sun Microsystems	0	20	75	0	0.2	0.8
Symbios	8	6	21	0.1	0	0.2
Texas Instruments	136	193	203	1.7	2.2	2.2
Trident Microsystems	23	45	30	0.3	0.5	0.3
VLSI Technology	17	15	11	0.2	0.2	0.1
WaferScale Integration	3	2	5	0	0	0
Zilog	19	22	7	0.2	0.3	0
Zoran	0	5	5	0	0	0

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Table 2-6 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Microcomponents to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Japanese Companies	**5,118**	**5,193**	**5,489**	**65.4**	**59.0**	**58.8**
Fuji Electric	3	3	3	0	0	0
Fujitsu	458	475	635	5.9	5.4	6.8
Hitachi	818	919	917	10.5	10.4	9.8
Matsushita	488	472	409	6.2	5.4	4.4
Mitsubishi	676	615	625	8.6	7.0	6.7
NEC	1,353	1,373	1,510	17.3	15.6	16.2
New JRC	2	3	3	0	0	0
Oki	110	88	97	1.4	1.0	1.0
Ricoh	59	63	69	0.8	0.7	0.7
Rohm	47	42	12	0.6	0.5	0.1
SANYO	69	65	125	0.9	0.7	1.3
Seiko Epson	19	15	17	0.2	0.2	0.2
Sharp	154	128	139	2.0	1.5	1.5
Sony	186	154	142	2.4	1.8	1.5
Toshiba	556	716	722	7.1	8.1	7.7
Yamaha	110	55	55	1.4	0.6	0.6
Other Japanese Companies	10	7	9	0.1	0	0
European Companies	**30**	**64**	**52**	**0.4**	**0.7**	**0.6**
GEC Plessey	1	1	1	0	0	0
Philips	17	42	16	0.2	0.5	0.2
SGS-Thomson	9	18	31	0.1	0.2	0.3
Siemens	3	3	3	0	0	0
TEMIC	0	0	1	0	0	0
Asia/Pacific Companies	**3**	**13**	**11**	**0**	**0.1**	**0.1**
Acer	0	5	5	0	0	0
LG Semicon	0	0	1	0	0	0
Macronix	0	2	0	0	0	0
Samsung	2	0	1	0	0	0
Silicon Integrated Systems	0	1	0	0	0	0
United Microelectronics	0	3	3	0	0	0
VIA	0	1	0	0	0	0
Winbond Electronics	1	1	1	0	0	0

Source: Dataquest (April 1998)

Table 2-7
Each Company's Vendor Revenue from Shipments of MOS Digital Logic to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**7,780**	**7,821**	**8,164**	**100.0**	**100.0**	**100.0**
Americas Companies	**1,345**	**1,379**	**1,477**	**17.3**	**17.6**	**18.1**
Actel	12	15	14	0.2	0.2	0.2
Advanced Micro Devices	40	60	40	0.5	0.8	0.5
Altera	80	95	114	1.0	1.2	1.4
Analog Devices	0	2	2	0	0	0
Atmel	2	2	6	0	0	0
Chip Express	0	1	1	0	0	0
Cypress Semiconductor	6	7	22	0	0	0.3
Dallas Semiconductor	14	9	10	0.2	0.1	0.1
Exar	0	2	3	0	0	0
Fairchild	0	0	29	0	0	0.4
Gennum	0	0	1	0	0	0
Gould AMI	2	2	3	0	0	0
Harris Semiconductor	2	4	3	0	0	0
Hewlett-Packard	6	8	9	0	0.1	0.1
IBM	93	41	36	1.2	0.5	0.4
IMP	1	0	0	0	0	0
Integrated Circuit Systems	5	8	9	0	0.1	0.1
Integrated Device Technology	8	8	9	0.1	0.1	0.1
International CMOS Technology	1	1	0	0	0	0
ISD	0	0	9	0	0	0.1
Lattice	18	40	40	0.2	0.5	0.5
Logic Devices	1	1	1	0	0	0
LSI Logic	220	240	355	2.8	3.1	4.3
Lucent Technologies	11	95	87	0.1	1.2	1.1
Micrel	1	1	0	0	0	0
Motorola	183	109	105	2.4	1.4	1.3
National Semiconductor	24	29	10	0.3	0.4	0.1
Quality Semiconductor	0	5	5	0	0	0
QuickLogic	0	0	10	0	0	0.1
Raytheon	0	1	3	0	0	0
Symbios	5	5	5	0	0	0
Texas Instruments	527	470	435	6.8	6.0	5.3
Vitesse	0	0	5	0	0	0
VLSI Technology	22	55	35	0.3	0.7	0.4
Xilinx	52	55	61	0.7	0.7	0.7

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Table 2-7
Each Company's Vendor Revenue from Shipments of MOS Digital Logic to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Japanese Companies	**6,382**	**6,375**	**6,568**	**82.0**	**81.5**	**80.5**
Fuji Electric	29	25	22	0.4	0.3	0.3
Fujitsu	973	932	985	12.5	11.9	12.1
Hitachi	499	617	540	6.4	7.9	6.6
Matsushita	502	481	439	6.5	6.2	5.4
Mitsubishi	234	223	247	3.0	2.9	3.0
NEC	1,430	1,708	1,847	18.4	21.8	22.6
New JRC	24	9	12	0.3	0.1	0.1
Oki	280	234	238	3.6	3.0	2.9
Ricoh	89	36	20	1.1	0.5	0.2
Rohm	154	127	117	2.0	1.6	1.4
SANYO	244	196	292	3.1	2.5	3.6
Seiko Epson	143	124	80	1.8	1.6	1.0
Sharp	407	370	377	5.2	4.7	4.6
Sony	416	386	478	5.3	4.9	5.9
Toshiba	797	746	737	10.2	9.5	9.0
Yamaha	120	130	96	1.5	1.7	1.2
Other Japanese Companies	41	31	41	0.5	0.4	0.5
European Companies	**33**	**42**	**58**	**0.4**	**0.5**	**0.7**
GEC Plessey	4	5	7	0	0	0
Micronas	0	1	12	0	0	0.1
Philips	28	32	26	0.4	0.4	0.3
SGS-Thomson	0	4	8	0	0	0
TEMIC	0	0	5	0	0	0
Asia/Pacific Companies	**20**	**25**	**61**	**0.3**	**0.3**	**0.7**
Holtek	0	0	2	0	0	0
Hualon Microelectronics Corp.	0	1	1	0	0	0
LG Semicon	2	2	2	0	0	0
Macronix	0	4	33	0	0	0.4
Samsung	18	17	22	0.2	0.2	0.3
Winbond Electronics	0	1	1	0	0	0

Source: Dataquest (April 1998)

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Table 2-8
Each Company's Vendor Revenue from Shipments of Analog-Monolithic to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**4,745**	**4,577**	**4,977**	**100.0**	**100.0**	**100.0**
Americas Companies	**1,053**	**1,201**	**1,401**	**22.2**	**26.2**	**28.1**
Advanced Micro Devices	11	10	26	0.2	0.2	0.5
Allegro MicroSystems	26	36	31	0.5	0.8	0.6
Analog Devices	148	122	151	3.1	2.7	3.0
Burr-Brown	36	49	50	0.8	1.1	1.0
Cirrus Logic	3	8	23	0	0.2	0.5
Dallas Semiconductor	0	4	4	0	0	0
Elantec	4	7	13	0	0.2	0.3
Exar	25	11	10	0.5	0.2	0.2
Gennum	4	4	3	0	0	0
Harris Semiconductor	31	18	18	0.7	0.4	0.4
Honeywell	1	1	1	0	0	0
IMP	1	0	0	0	0	0
Integrated Circuit Systems	5	3	3	0.1	0	0
International Rectifier	7	10	13	0.1	0.2	0.3
Level One Communications	0	4	4	0	0	0
Linear Technology	32	40	42	0.7	0.9	0.8
Linfinity	1	1	1	0	0	0
Lucent Technologies	8	0	0	0.2	0	0
Maxim	29	59	65	0.6	1.3	1.3
Micrel	2	4	0	0	0	0
Micro Linear	1	1	1	0	0	0
Mitel	5	6	8	0.1	0.1	0.2
Motorola	184	129	139	3.9	2.8	2.8
National Semiconductor	98	131	154	2.1	2.9	3.1
PMC Sierra Semiconductor	1	3	3	0	0	0
Raytheon	13	12	10	0.3	0.3	0.2
Rockwell	0	46	37	0	1.0	0.7
Seeq Technology	0	1	1	0	0	0
Semtech	1	1	10	0	0	0.2
Supertex	8	7	7	0.2	0.2	0.1
TelCom	3	3	5	0	0	0.1
Texas Instruments	247	441	548	5.2	9.6	11.0
Unitrode	2	4	4	0	0	0
Vitesse	0	0	6	0	0	0.1
VTC	19	25	10	0.4	0.5	0.2

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Table 2-8 (Continued)
Each Company's Vendor Revenue from Shipments of Analog-Monolithic to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Japanese Companies	**3,498**	**3,129**	**3,294**	**73.7**	**68.4**	**66.2**
Fuji Electric	16	12	12	0.3	0.3	0.2
Fujitsu	255	234	253	5.4	5.1	5.1
Hitachi	230	255	196	4.8	5.6	3.9
Matsushita	455	386	410	9.6	8.4	8.2
Mitsubishi	274	232	280	5.8	5.1	5.6
NEC	437	419	397	9.2	9.2	8.0
New JRC	117	100	109	2.5	2.2	2.2
Oki	27	17	16	0.6	0.4	0.3
Ricoh	33	34	44	0.7	0.7	0.9
Rohm	271	225	253	5.7	4.9	5.1
Sanken	0	0	38	0	0	0.8
SANYO	406	345	363	8.6	7.5	7.3
Seiko Epson	12	9	9	0.3	0.2	0.2
Sharp	75	65	66	1.6	1.4	1.3
Sony	382	305	339	8.1	6.7	6.8
Toshiba	442	436	460	9.3	9.5	9.2
Yamaha	4	3	1	0	0	0
Other Japanese Companies	36	30	48	0.8	0.7	1.0
European Companies	**174**	**223**	**265**	**3.7**	**4.9**	**5.3**
Austria Mikro Systeme	1	0	0	0	0	0
Ericsson	1	1	2	0	0	0
GEC Plessey	17	12	12	0.4	0.3	0.2
Micronas	1	0	0	0	0	0
Philips	75	82	120	1.6	1.8	2.4
SGS-Thomson	49	102	93	1.0	2.2	1.9
Siemens	18	18	26	0.4	0.4	0.5
TEMIC	12	8	12	0.3	0.2	0.2
Asia/Pacific Companies	**20**	**24**	**17**	**0.4**	**0.5**	**0.3**
Korean Electronic Co.	5	7	11	0.1	0.2	0.2
LG Semicon	2	3	3	0	0	0
Samsung	12	13	2	0.3	0.3	0
Winbond Electronics	1	1	1	0	0	0

Source: Dataquest (April 1998)

Table 2-9
Each Company's Vendor Revenue from Shipments of Total Discrete to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**4,694**	**4,408**	**4,244**	**100.0**	**100.0**	**100.0**
Americas Companies	**214**	**195**	**191**	**4.6**	**4.4**	**4.5**
Fairchild	0	0	11	0	0	0.3
General Semiconductor	37	30	29	0.8	0.7	0.7
Harris Semiconductor	0	0	1	0	0	0
Hewlett-Packard	7	8	8	0.1	0.2	0.2
International Rectifier	54	51	43	1.2	1.2	1.0
Microsemi	1	1	1	0	0	0
Motorola	68	73	64	1.4	1.7	1.5
National Semiconductor	1	8	12	0	0.2	0.3
Powerex	18	18	16	0.4	0.4	0.4
Supertex	2	2	2	0	0	0
Teccor Electronics	2	2	4	0	0	0
Japanese Companies	**4,420**	**4,146**	**3,964**	**94.2**	**94.1**	**93.4**
Fuji Electric	306	262	222	6.5	5.9	5.2
Fujitsu	49	74	77	1.0	1.7	1.8
Hitachi	641	691	489	13.7	15.7	11.5
Matsushita	445	383	392	9.5	8.7	9.2
Mitsubishi	366	340	319	7.8	7.7	7.5
NEC	597	576	604	12.7	13.1	14.2
New JRC	2	3	3	0	0	0
Oki	12	11	12	0.3	0.2	0.3
Rohm	428	372	345	9.1	8.4	8.1
Sanken	239	181	234	5.1	4.1	5.5
SANYO	279	270	283	5.9	6.1	6.7
Shindengen Electric	188	157	157	4.0	3.6	3.7
Sony	39	31	27	0.8	0.7	0.6
Toshiba	764	736	740	16.3	16.7	17.4
Other Japanese Companies	30	31	60	0.6	0.7	1.4
European Companies	**49**	**59**	**67**	**1.0**	**1.3**	**1.6**
Ericsson	0	0	1	0	0	0
Eupec	0	2	0	0	0	0
GEC Plessey	0	0	1	0	0	0
Micronas	0	0	1	0	0	0
Philips	16	11	16	0.3	0.2	0.4
SGS-Thomson	6	8	8	0.1	0.2	0.2
Siemens	4	8	10	0	0.2	0.2

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Table 2-9 (Continued)
Each Company's Vendor Revenue from Shipments of Total Discrete to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
TEMIC	21	27	26	0.4	0.6	0.6
Zetex	0	1	2	0	0	0
Other European Companies	2	2	2	0	0	0
Asia/Pacific Companies	**11**	**8**	**22**	**0.2**	**0.2**	**0.5**
Korean Electronic Co.	9	7	21	0.2	0.2	0.5
Samsung	2	1	1	0	0	0

Source: Dataquest (April 1998)

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Table 2-10
Each Company's Vendor Revenue from Shipments of Total Optical Semiconductors to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**2,768**	**2,638**	**2,725**	**100.0**	**100.0**	**100.0**
Americas Companies	**58**	**104**	**96**	**2.1**	**3.9**	**3.5**
Hewlett-Packard	18	50	48	0.7	1.9	1.8
Lucent Technologies	5	6	2	0.2	0.2	0
Mitel	0	7	2	0	0.3	0
Motorola	0	1	1	0	0	0
Texas Instruments	35	40	43	1.3	1.5	1.6
Japanese Companies	**2,690**	**2,518**	**2,600**	**97.2**	**95.5**	**95.4**
Fujitsu	130	113	125	4.7	4.3	4.6
Hitachi	49	73	58	1.8	2.8	2.1
Matsushita	425	383	369	15.4	14.5	13.5
Mitsubishi	92	88	125	3.3	3.3	4.6
NEC	159	202	182	5.7	7.7	6.7
New JRC	9	5	0	0.3	0.2	0
Oki	27	27	31	1.0	1.0	1.1
Rohm	198	203	219	7.2	7.7	8.0
Sanken	48	36	30	1.7	1.4	1.1
SANYO	127	116	130	4.6	4.4	4.8
Sharp	487	467	522	17.6	17.7	19.2
Sony	348	338	348	12.6	12.8	12.8
Stanley	129	0	128	4.7	0	4.7
Toshiba	399	271	265	14.4	10.3	9.7
Other Japanese Companies	63	196	68	2.3	7.4	2.5
European Companies	**16**	**11**	**24**	**0.6**	**0.4**	**0.9**
Siemens	10	7	14	0.4	0.3	0.5
TEMIC	5	4	10	0.2	0.2	0.4
Asia/Pacific Companies	**4**	**5**	**5**	**0.1**	**0.2**	**0.2**
Korean Electronic Co.	4	5	5	0.1	0.2	0.2

Source: Dataquest (April 1998)

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Table 2-11
Top 40 Total Market Vendor Revenue from Shipments of Total Semiconductors to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	NEC	5,756	5,666	-1.6	15.5
3	2	Toshiba	3,838	3,484	-9.2	9.5
2	3	Hitachi	4,252	3,355	-21.1	9.2
4	4	Fujitsu	2,645	2,768	4.7	7.6
5	5	Matsushita	2,268	2,244	-1.1	6.1
7	6	Intel	2,028	2,237	10.3	6.1
6	7	Mitsubishi	2,147	2,030	-5.4	5.6
8	8	Texas Instruments	1,634	1,549	-5.2	4.2
9	9	Sharp	1,561	1,491	-4.5	4.1
10	10	Sony	1,386	1,369	-1.2	3.8
11	11	SANYO	1,249	1,292	3.4	3.5
12	12	Rohm	1,049	968	-7.7	2.7
14	13	Motorola	668	621	-7.0	1.7
13	14	Samsung	819	589	-28.1	1.6
15	15	Oki	579	563	-2.8	1.5
19	16	LSI Logic	275	367	33.5	1.0
16	17	Rockwell	446	348	-22.0	1.0
17	18	Sanken	352	302	-14.2	0.8
18	19	Fuji Electric	320	259	-19.1	0.7
20	20	National Semiconductor	254	227	-10.6	0.6
23	21	SGS-Thomson	228	215	-5.7	0.6
21	22	Hyundai	244	212	-13.1	0.6
29	23	Analog Devices	161	194	20.5	0.5
31	24	Macronix	147	190	29.3	0.5
33	25	Lucent Technologies	136	186	36.8	0.5
28	26	Philips	172	182	5.8	0.5
22	27	LG Semicon	243	175	-28.0	0.5
26	28	Advanced Micro Devices	177	160	-9.6	0.4
27	29	Shindengen Electric	173	157	-9.2	0.4
25	30	Yamaha	189	153	-19.0	0.4
34	31	Ricoh	136	141	3.7	0.4
32	32	IBM	142	132	-7.0	0.4
NA	33	Stanley	0	128	NA	0.4
36	34	New JRC	120	127	5.8	0.3
35	35	Cirrus Logic	133	117	-12.0	0.3
37	36	Altera	95	114	20.0	0.3
30	37	Seiko Epson	158	113	-28.5	0.3

Table 2-11 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of Total Semiconductors to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
24	38	Atmel	209	108	-48.3	0.3
46	39	Chips & Technologies	55	90	63.6	0.2
69	40	Sun Microsystems	20	75	275.0	0.2
		All Others	1,949	1,801	-7.6	4.9
		Americas Companies	**7,767**	**7,844**	**1.0**	**21.5**
		Japanese Companies	**28,575**	**26,855**	**-6.0**	**73.6**
		European Companies	**507**	**550**	**8.5**	**1.5**
		Asia/Pacific Companies	**1,564**	**1,250**	**-20.1**	**3.4**
		Total Market	**38,413**	**36,499**	**-5.0**	**100.0**

NA = Not available
Source: Dataquest (April 1998)

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Table 2-12
Top 40 Total Market Vendor Revenue from Shipments of Total ICs to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	NEC	4,978	4,880	-2.0	16.5
2	2	Hitachi	3,488	2,808	-19.5	9.5
4	3	Fujitsu	2,458	2,566	4.4	8.7
3	4	Toshiba	2,831	2,479	-12.4	8.4
5	5	Intel	2,028	2,237	10.3	7.6
6	6	Mitsubishi	1,719	1,586	-7.7	5.4
7	7	Texas Instruments	1,594	1,506	-5.5	5.1
8	8	Matsushita	1,502	1,483	-1.3	5.0
10	9	Sony	1,017	994	-2.3	3.4
9	10	Sharp	1,094	969	-11.4	3.3
11	11	SANYO	863	879	1.9	3.0
12	12	Samsung	818	588	-28.1	2.0
13	13	Motorola	594	556	-6.4	1.9
14	14	Oki	541	520	-3.9	1.8
15	15	Rohm	474	404	-14.8	1.4
17	16	LSI Logic	275	367	33.5	1.2
16	17	Rockwell	446	348	-22.0	1.2
18	18	National Semiconductor	246	215	-12.6	0.7
19	19	Hyundai	244	212	-13.1	0.7
21	20	SGS-Thomson	220	207	-5.9	0.7
25	21	Analog Devices	161	194	20.5	0.7
28	22	Macronix	147	190	29.3	0.6
33	23	Lucent Technologies	130	184	41.5	0.6
20	24	LG Semicon	243	175	-28.0	0.6
26	25	Philips	161	166	3.1	0.6
24	26	Advanced Micro Devices	177	160	-9.6	0.5
23	27	Yamaha	189	153	-19.0	0.5
30	28	Ricoh	136	141	3.7	0.5
29	29	IBM	142	132	-7.0	0.4
34	30	New JRC	112	124	10.7	0.4
32	31	Cirrus Logic	133	117	-12.0	0.4
35	32	Altera	95	114	20.0	0.4
27	33	Seiko Epson	158	113	-28.5	0.4
22	34	Atmel	209	108	-48.3	0.4
42	35	Chips & Technologies	55	90	63.6	0.3
64	36	Sun Microsystems	20	75	275.0	0.3
36	37	Oak Technology	85	69	-18.8	0.2

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Table 2-12 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of Total ICs to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
40	38	Maxim	59	65	10.2	0.2
43	39	Xilinx	55	61	10.9	0.2
37	40	Integrated Device Technology	73	58	-20.5	0.2
		All Others	1,397	1,237	-11.5	4.2
		Americas Companies	**7,468**	**7,557**	**1.2**	**25.6**
		Japanese Companies	**21,911**	**20,291**	**-7.4**	**68.7**
		European Companies	**437**	**459**	**5.0**	**1.6**
		Asia/Pacific Companies	**1,551**	**1,223**	**-21.1**	**4.1**
		Total Market	**31,367**	**29,530**	**-5.9**	**100.0**

Source: Dataquest (April 1998)

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Table 2-13
Top 15 Total Market Vendor Revenue from Shipments of Bipolar Digital to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Hitachi	360	206	-42.8	38.9
2	2	Texas Instruments	102	90	-11.8	17.0
3	3	NEC	68	59	-13.2	11.1
5	4	Motorola	49	59	20.4	11.1
4	5	Fujitsu	64	50	-21.9	9.4
6	6	Toshiba	48	26	-45.8	4.9
8	7	Mitsubishi	19	19	0	3.6
9	8	Matsushita	14	8	-42.9	1.5
10	9	Advanced Micro Devices	8	4	-50.0	0.8
NA	10	Mosel Vitelic	0	4	NA	0.8
12	11	Oki	4	3	-25.0	0.6
11	12	Philips	5	2	-60.0	0.4
7	13	National Semiconductor	26	0	-100.0	0
13	14	GEC Plessey	2	0	-100.0	0
14	15	LG Semicon	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	**185**	**153**	**-17.3**	**28.9**
		Japanese Companies	**577**	**371**	**-35.7**	**70.0**
		European Companies	**7**	**2**	**-71.4**	**0.4**
		Asia/Pacific Companies	**1**	**4**	**300.0**	**0.8**
		Total Market	**770**	**530**	**-31.2**	**100.0**

NA = Not available
Source: Dataquest (April 1998)

Table 2-14
Top 40 Total Market Vendor Revenue from Shipments of MOS Digital ICs to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	NEC	4,367	4,424	1.3	18.4
2	2	Hitachi	2,775	2,406	-13.3	10.0
4	3	Fujitsu	2,066	2,263	9.5	9.4
5	4	Intel	2,028	2,237	10.3	9.3
3	5	Toshiba	2,311	1,993	-13.8	8.3
6	6	Mitsubishi	1,309	1,287	-1.7	5.4
7	7	Matsushita	1,102	1,065	-3.4	4.4
9	8	Sharp	1,029	903	-12.2	3.8
8	9	Texas Instruments	1,051	868	-17.4	3.6
11	10	Sony	661	655	-0.9	2.7
10	11	Samsung	805	586	-27.2	2.4
13	12	SANYO	441	516	17.0	2.1
12	13	Oki	507	501	-1.2	2.1
16	14	LSI Logic	275	367	33.5	1.5
14	15	Motorola	416	358	-13.9	1.5
15	16	Rockwell	400	311	-22.3	1.3
17	17	Hyundai	244	212	-13.1	0.9
24	18	Macronix	147	190	29.3	0.8
26	19	Lucent Technologies	130	184	41.5	0.8
18	20	LG Semicon	239	172	-28.0	0.7
21	21	Yamaha	186	152	-18.3	0.6
20	22	Rohm	193	151	-21.8	0.6
25	23	IBM	142	132	-7.0	0.5
22	24	Advanced Micro Devices	159	130	-18.2	0.5
28	25	SGS-Thomson	118	114	-3.4	0.5
30	26	Altera	95	114	20.0	0.5
19	27	Atmel	209	108	-48.3	0.4
23	28	Seiko Epson	149	104	-30.2	0.4
29	29	Ricoh	102	97	-4.9	0.4
27	30	Cirrus Logic	125	94	-24.8	0.4
36	31	Chips & Technologies	55	90	63.6	0.4
53	32	Sun Microsystems	20	75	275.0	0.3
32	33	Oak Technology	85	69	-18.8	0.3
31	34	National Semiconductor	89	61	-31.5	0.3
37	35	Xilinx	55	61	10.9	0.3
34	36	Integrated Device Technology	73	58	-20.5	0.2
38	37	Adaptec	55	57	3.6	0.2

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Table 2-14 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of MOS Digital ICs to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
42	38	Cypress Semiconductor	38	49	28.9	0.2
35	39	VLSI Technology	70	46	-34.3	0.2
33	40	Philips	74	44	-40.5	0.2
		All Others	710	719	1.3	3.0
		Americas Companies	**6,056**	**6,003**	**-0.9**	**25.0**
		Japanese Companies	**17,316**	**16,626**	**-4.0**	**69.2**
		European Companies	**207**	**192**	**-7.2**	**0.8**
		Asia/Pacific Companies	**1,526**	**1,202**	**-21.2**	**5.0**
		Total Market	**25,105**	**24,023**	**-4.3**	**100.0**

Source: Dataquest (April 1998)

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Table 2-15
Top 40 Total Market Vendor Revenue from Shipments of MOS Memory to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	NEC	1,286	1,067	-17.0	16.4
2	2	Hitachi	1,239	949	-23.4	14.5
5	3	Fujitsu	659	643	-2.4	9.9
4	4	Samsung	788	563	-28.6	8.6
3	5	Toshiba	849	534	-37.1	8.2
7	6	Mitsubishi	471	415	-11.9	6.4
6	7	Sharp	531	387	-27.1	5.9
8	8	Texas Instruments	388	230	-40.7	3.5
14	9	Matsushita	149	217	45.6	3.3
9	10	Hyundai	244	212	-13.1	3.3
10	11	LG Semicon	237	169	-28.7	2.6
12	12	Oki	185	166	-10.3	2.5
15	13	Macronix	141	157	11.3	2.4
16	14	Intel	122	108	-11.5	1.7
11	15	Atmel	207	102	-50.7	1.6
13	16	SANYO	180	99	-45.0	1.5
19	17	IBM	95	88	-7.4	1.3
18	18	SGS-Thomson	96	75	-21.9	1.1
22	19	Integrated Device Technology	52	38	-26.9	0.6
17	20	Sony	121	35	-71.1	0.5
20	21	Motorola	65	29	-55.4	0.4
21	22	Advanced Micro Devices	56	28	-50.0	0.4
30	23	Cypress Semiconductor	22	27	22.7	0.4
31	24	Xicor	22	27	22.7	0.4
27	25	Rohm	24	22	-8.3	0.3
23	26	Mosel Vitelic	41	20	-51.2	0.3
32	27	Silicon Storage Technology	18	17	-5.6	0.3
24	28	Nippon Steel Semiconductor	36	15	-58.3	0.2
25	29	Micron Technology	32	15	-53.1	0.2
NA	30	Fairchild	0	15	NA	0.2
35	31	Catalyst	7	11	57.1	0.2
40	32	Ricoh	3	8	166.7	0.1
33	33	Seiko Epson	10	7	-30.0	0.1
41	34	Alliance Semiconductor	2	6	200.0	0
37	35	Siemens	5	4	-20.0	0
38	36	Winbond Electronics	5	4	-20.0	0
36	37	Vanguard	7	3	-57.1	0

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Table 2-15 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of MOS Memory to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
NA	38	Philips	0	2	NA	0
28	39	United Microelectronics	24	1	-95.8	0
34	40	WaferScale Integration	9	1	-88.9	0
		All Others	59	7	-88.1	0.1
		Americas Companies	**1,150**	**742**	**-35.5**	**11.4**
		Japanese Companies	**5,748**	**4,569**	**-20.5**	**70.0**
		European Companies	**101**	**82**	**-18.8**	**1.3**
		Asia/Pacific Companies	**1,488**	**1,130**	**-24.1**	**17.3**
		Total Market	**8,487**	**6,523**	**-23.1**	**100.0**

NA = Not available
Source: Dataquest (April 1998)

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Table 2-16
Top 40 Total Market Vendor Revenue from Shipments of MOS Microcomponents to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Intel	1,906	2,129	11.7	22.8
2	2	NEC	1,373	1,510	10.0	16.2
3	3	Hitachi	919	917	-0.2	9.8
4	4	Toshiba	716	722	0.8	7.7
6	5	Fujitsu	475	635	33.7	6.8
5	6	Mitsubishi	615	625	1.6	6.7
7	7	Matsushita	472	409	-13.3	4.4
8	8	Rockwell	400	311	-22.3	3.3
9	9	Motorola	242	224	-7.4	2.4
10	10	Texas Instruments	193	203	5.2	2.2
11	11	Sony	154	142	-7.8	1.5
12	12	Sharp	128	139	8.6	1.5
16	13	SANYO	65	125	92.3	1.3
14	14	Oki	88	97	10.2	1.0
27	15	Lucent Technologies	35	97	177.1	1.0
13	16	Cirrus Logic	125	94	-24.8	1.0
19	17	Chips & Technologies	55	90	63.6	1.0
32	18	Sun Microsystems	20	75	275.0	0.8
15	19	Oak Technology	85	69	-18.8	0.7
17	20	Ricoh	63	69	9.5	0.7
22	21	Advanced Micro Devices	43	62	44.2	0.7
20	22	Adaptec	55	57	3.6	0.6
18	23	Yamaha	55	55	0	0.6
25	24	National Semiconductor	38	51	34.2	0.5
28	25	Analog Devices	31	41	32.3	0.4
29	26	Digital	30	41	36.7	0.4
33	27	SGS-Thomson	18	31	72.2	0.3
21	28	Trident Microsystems	45	30	-33.3	0.3
30	29	Q Logic	24	25	4.2	0.3
45	30	Symbios	6	21	250.0	0.2
41	31	ATI Technologies	10	20	100.0	0.2
35	32	Seiko Epson	15	17	13.3	0.2
24	33	Philips	42	16	-61.9	0.2
34	34	C-Cube	16	16	0	0.2
NA	35	ESS	0	15	NA	0.2
38	36	DSP Group	13	13	0	0.1
23	37	Rohm	42	12	-71.4	0.1

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Table 2-16 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of MOS Microcomponents to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
26	38	LSI Logic	35	12	-65.7	0.1
50	39	Microchip Technology	4	12	200.0	0.1
36	40	VLSI Technology	15	11	-26.7	0.1
		All Others	131	96	-26.7	1.0
		Americas Companies	**3,527**	**3,784**	**7.3**	**40.5**
		Japanese Companies	**5,193**	**5,489**	**5.7**	**58.8**
		European Companies	**64**	**52**	**-18.8**	**0.6**
		Asia/Pacific Companies	**13**	**11**	**-15.4**	**0.1**
		Total Market	**8,797**	**9,336**	**6.1**	**100.0**

NA = Not available
Source: Dataquest (April 1998)

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Table 2-17
Top 40 Total Market Vendor Revenue from Shipments of MOS Digital Logic to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	NEC	1,708	1,847	8.1	22.6
2	2	Fujitsu	932	985	5.7	12.1
3	3	Toshiba	746	737	-1.2	9.0
4	4	Hitachi	617	540	-12.5	6.6
7	5	Sony	386	478	23.8	5.9
5	6	Matsushita	481	439	-8.7	5.4
6	7	Texas Instruments	470	435	-7.4	5.3
8	8	Sharp	370	377	1.9	4.6
9	9	LSI Logic	240	355	47.9	4.3
12	10	SANYO	196	292	49.0	3.6
11	11	Mitsubishi	223	247	10.8	3.0
10	12	Oki	234	238	1.7	2.9
14	13	Rohm	127	117	-7.9	1.4
18	14	Altera	95	114	20.0	1.4
16	15	Motorola	109	105	-3.7	1.3
13	16	Yamaha	130	96	-26.2	1.2
17	17	Lucent Technologies	95	87	-8.4	1.1
15	18	Seiko Epson	124	80	-35.5	1.0
21	19	Xilinx	55	61	10.9	0.7
19	20	Advanced Micro Devices	60	40	-33.3	0.5
23	21	Lattice	40	40	0	0.5
22	22	IBM	41	36	-12.2	0.4
20	23	VLSI Technology	55	35	-36.4	0.4
41	24	Macronix	4	33	725.0	0.4
NA	25	Fairchild	0	29	NA	0.4
25	26	Philips	32	26	-18.8	0.3
27	27	Fuji Electric	25	22	-12.0	0.3
28	28	Samsung	17	22	29.4	0.3
36	29	Cypress Semiconductor	7	22	214.3	0.3
24	30	Ricoh	36	20	-44.4	0.2
29	31	Actel	15	14	-6.7	0.2
31	32	New JRC	9	12	33.3	0.1
50	33	Micronas	1	12	1,100.0	0.1
26	34	National Semiconductor	29	10	-65.5	0.1
30	35	Dallas Semiconductor	9	10	11.1	0.1
NA	36	QuickLogic	0	10	NA	0.1
32	37	Integrated Device Technology	8	9	12.5	0.1

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Table 2-17 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of MOS Digital Logic to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
33	38	Integrated Circuit Systems	8	9	12.5	0.1
34	39	Hewlett-Packard	8	9	12.5	0.1
NA	40	ISD	0	9	NA	0.1
		All Others	79	105	32.9	1.3
		Americas Companies	**1,379**	**1,477**	**7.1**	**18.1**
		Japanese Companies	**6,375**	**6,568**	**3.0**	**80.5**
		European Companies	**42**	**58**	**38.1**	**0.7**
		Asia/Pacific Companies	**25**	**61**	**144.0**	**0.7**
		Total Market	**7,821**	**8,164**	**4.4**	**100.0**

NA = Not available
Source: Dataquest (April 1998)

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Table 2-18
Top 40 Total Market Vendor Revenue from Shipments of Analog-Monolithic to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Texas Instruments	441	548	24.3	11.0
2	2	Toshiba	436	460	5.5	9.2
4	3	Matsushita	386	410	6.2	8.2
3	4	NEC	419	397	-5.3	8.0
5	5	SANYO	345	363	5.2	7.3
6	6	Sony	305	339	11.1	6.8
9	7	Mitsubishi	232	280	20.7	5.6
8	8	Fujitsu	234	253	8.1	5.1
10	9	Rohm	225	253	12.4	5.1
7	10	Hitachi	255	196	-23.1	3.9
11	11	National Semiconductor	131	154	17.6	3.1
13	12	Analog Devices	122	151	23.8	3.0
12	13	Motorola	129	139	7.8	2.8
16	14	Philips	82	120	46.3	2.4
15	15	New JRC	100	109	9.0	2.2
14	16	SGS-Thomson	102	93	-8.8	1.9
17	17	Sharp	65	66	1.5	1.3
18	18	Maxim	59	65	10.2	1.3
19	19	Burr-Brown	49	50	2.0	1.0
23	20	Ricoh	34	44	29.4	0.9
21	21	Linear Technology	40	42	5.0	0.8
NA	22	Sanken	0	38	NA	0.8
20	23	Rockwell	46	37	-19.6	0.7
22	24	Allegro MicroSystems	36	31	-13.9	0.6
27	25	Siemens	18	26	44.4	0.5
34	26	Advanced Micro Devices	10	26	160.0	0.5
38	27	Cirrus Logic	8	23	187.5	0.5
26	28	Harris Semiconductor	18	18	0	0.4
28	29	Oki	17	16	-5.9	0.3
35	30	International Rectifier	10	13	30.0	0.3
39	31	Elantec	7	13	85.7	0.3
30	32	Fuji Electric	12	12	0	0.2
31	33	GEC Plessey	12	12	0	0.2
37	34	TEMIC	8	12	50.0	0.2
40	35	Korean Electronic Co.	7	11	57.1	0.2
24	36	VTC	25	10	-60.0	0.2
32	37	Raytheon	12	10	-16.7	0.2

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Table 2-18 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of Analog-Monolithic to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
33	38	Exar	11	10	-9.1	0.2
54	39	Semtech	1	10	900.0	0.2
36	40	Seiko Epson	9	9	0	0.2
		All Others	119	108	-9.2	2.2
		Americas Companies	**1,201**	**1,401**	**16.7**	**28.1**
		Japanese Companies	**3,129**	**3,294**	**5.3**	**66.2**
		European Companies	**223**	**265**	**18.8**	**5.3**
		Asia/Pacific Companies	**24**	**17**	**-29.2**	**0.3**
		Total Market	**4,577**	**4,977**	**8.7**	**100.0**

NA = Not available
Source: Dataquest (April 1998)

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Table 2-19
Top 38 Total Market Vendor Revenue from Shipments of Total Discrete to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Toshiba	736	740	0.5	17.4
3	2	NEC	576	604	4.9	14.2
2	3	Hitachi	691	489	-29.2	11.5
4	4	Matsushita	383	392	2.3	9.2
5	5	Rohm	372	345	-7.3	8.1
6	6	Mitsubishi	340	319	-6.2	7.5
7	7	SANYO	270	283	4.8	6.7
9	8	Sanken	181	234	29.3	5.5
8	9	Fuji Electric	262	222	-15.3	5.2
10	10	Shindengen Electric	157	157	0	3.7
11	11	Fujitsu	74	77	4.1	1.8
12	12	Motorola	73	64	-12.3	1.5
13	13	International Rectifier	51	43	-15.7	1.0
15	14	General Semiconductor	30	29	-3.3	0.7
14	15	Sony	31	27	-12.9	0.6
17	16	TEMIC	27	26	-3.7	0.6
25	17	Korean Electronic Co.	7	21	200.0	0.5
18	18	Powerex	18	16	-11.1	0.4
19	19	Philips	11	16	45.5	0.4
20	20	Oki	11	12	9.1	0.3
21	21	National Semiconductor	8	12	50.0	0.3
NA	22	Fairchild	0	11	NA	0.3
23	23	Siemens	8	10	25.0	0.2
22	24	SGS-Thomson	8	8	0	0.2
24	25	Hewlett-Packard	8	8	0	0.2
29	26	Teccor Electronics	2	4	100.0	0
26	27	New JRC	3	3	0	0
27	28	Supertex	2	2	0	0
32	29	Zetex	1	2	100.0	0
31	30	Samsung	1	1	0	0
33	31	Microsemi	1	1	0	0
NA	32	Harris Semiconductor	0	1	NA	0
NA	33	GEC Plessey	0	1	NA	0
NA	34	Ericsson	0	1	NA	0
NA	35	Micronas	0	1	NA	0
16	36	TOKO	28	0	-100.0	0

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Table 2-19 (Continued)
Top 38 Total Market Vendor Revenue from Shipments of Total Discrete to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
28	37	ITT	2	0	-100.0	0
30	38	Eupec	2	0	-100.0	0
		All Others	33	62	87.9	1.5
		Americas Companies	**195**	**191**	**-2.1**	**4.5**
		Japanese Companies	**4,146**	**3,964**	**-4.4**	**93.4**
		European Companies	**59**	**67**	**13.6**	**1.6**
		Asia/Pacific Companies	**8**	**22**	**175.0**	**0.5**
		Total Market	**4,408**	**4,244**	**-3.7**	**100.0**

NA = Not available
Source: Dataquest (April 1998)

Table 2-20
Top 22 Total Market Vendor Revenue from Shipments of Total Optical Semiconductors to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Sharp	467	522	11.8	19.2
2	2	Matsushita	383	369	-3.7	13.5
3	3	Sony	338	348	3.0	12.8
4	4	Toshiba	271	265	-2.2	9.7
5	5	Rohm	203	219	7.9	8.0
6	6	NEC	202	182	-9.9	6.7
7	7	SANYO	116	130	12.1	4.8
NA	8	Stanley	0	128	NA	4.7
8	9	Fujitsu	113	125	10.6	4.6
9	10	Mitsubishi	88	125	42.0	4.6
10	11	Hitachi	73	58	-20.5	2.1
11	12	Hewlett-Packard	50	48	-4.0	1.8
12	13	Texas Instruments	40	43	7.5	1.6
14	14	Oki	27	31	14.8	1.1
13	15	Sanken	36	30	-16.7	1.1
15	16	Siemens	7	14	100.0	0.5
20	17	TEMIC	4	10	150.0	0.4
18	18	Korean Electronic Co.	5	5	0	0.2
16	19	Mitel	7	2	-71.4	0
17	20	Lucent Technologies	6	2	-66.7	0
21	21	Motorola	1	1	0	0
19	22	New JRC	5	0	-100.0	0
		All Others	196	68	-65.3	2.5
		Americas Companies	**104**	**96**	**-7.7**	**3.5**
		Japanese Companies	**2,518**	**2,600**	**3.3**	**95.4**
		European Companies	**11**	**24**	**118.2**	**0.9**
		Asia/Pacific Companies	**5**	**5**	**0**	**0.2**
		Total Market	**2,638**	**2,725**	**3.3**	**100.0**

NA = Not available
Source: Dataquest (April 1998)

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Japanese Semiconductor User Trends, 1997

Focus Report

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Chapter 1
Executive Summary

Scope of This Report

This report analyzes the following Japanese semiconductor user trends in 1997:

- Overall electronic equipment production and semiconductor consumption trends in Japan
- Electronics production trends of 22 major Japanese semiconductor users
- Semiconductor purchasing trends of each of the 22 companies

Chapter 2 discusses electronic equipment production trends, focusing on four major categories: data processing, communications, industrial, and consumer. Chapter 3 analyzes semiconductor purchasing trends in 1997 for the 22 top-ranking semiconductor users as a group. Chapter 4 discusses the company profile of each semiconductor user, noting major electronic products by category as well as semiconductor purchasing trends, and ends with a "Dataquest Perspective" section.

Research Methodology and Definitions

This Focus Report analyzes the results of Dataquest's recent survey of Japanese semiconductor users. To arrive at the estimates in this report, Dataquest conducted extensive research into semiconductor purchasing practices in the Japanese market. Also incorporated into the estimation is public information on each semiconductor-user company, regarding both electronic equipment production trends as well as semiconductor usage. Based on primary information, Dataquest has estimated the semiconductor purchasing trends of major Japanese companies for 1996 and 1997. All numbers are shown in Japanese yen unless otherwise stated.

The definitions used in this report are as follows:

- Semiconductor consumption—This refers to the number of semiconductors actually used in electronic systems manufactured by user companies.
- Semiconductor purchasing—This refers to the number of semiconductors purchased by user companies. Regional semiconductor consumption discussed in this report refers to the number of semiconductors booked and billed in each region, based on user location.
- Data processing—This is defined as computer systems, data storage, input/output devices, dedicated systems, and other data processing equipment.
- Industrial—This is defined as security/energy management systems, manufacturing systems/instruments, medical equipment, and other industrial equipment.

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- Communications—This is defined as premise telecom equipment, public telecom equipment, mobile communications equipment, broadcast and studio equipment, and other telecom equipment.
- Consumer—This is defined as audio equipment, video equipment, personal electronics, appliances, and other consumer equipment.
- Military and civil aerospace—This is defined as military and civil aerospace electronic equipment.
- Transportation—This is defined as in-car entertainment, body control electronics, power train systems, and safety and convenience systems.

Highlights of the Report

The major points discussed in this document include the following:

- In 1997, while electronics equipment production in Japan grew 7.8 percent, semiconductor consumption in Japan recorded modest growth of 5.7 percent.
- The 22 top-ranking Japanese electronics companies together increased semiconductor purchasing by 2.4 percent in 1997. Individually, however, some leading companies, such as Hitachi and Mitsubishi Electric, decreased their semiconductor purchasing.
- Comparatively strong growth (more than 8 percent) in semiconductor purchasing was seen in the communications category; this was mainly due to a rise in the unit production of that type of equipment, including digital cellular phones and other wireless communications systems.
- Modest growth (approximately 4 percent) in semiconductor purchasing was seen in the data processing category; this was mainly due to an increase in the unit production of computer peripherals and dedicated systems.
- Several products in the consumer category, such as the digital video camera (DV-C) and digital still camera (DSC), recorded strong growth in production, but semiconductor purchasing of consumer equipment was down by 2.4 percent in 1997.
- While production of automotive navigation systems was growing rapidly, semiconductor purchasing trends in the transportation category declined by 1.6 percent in 1997; this was mainly due to sluggish sales and decreases in price.

Project Analyst: Motoya Ohgami, Yoshihiro Shimada, and Hiroyuki Shimizu

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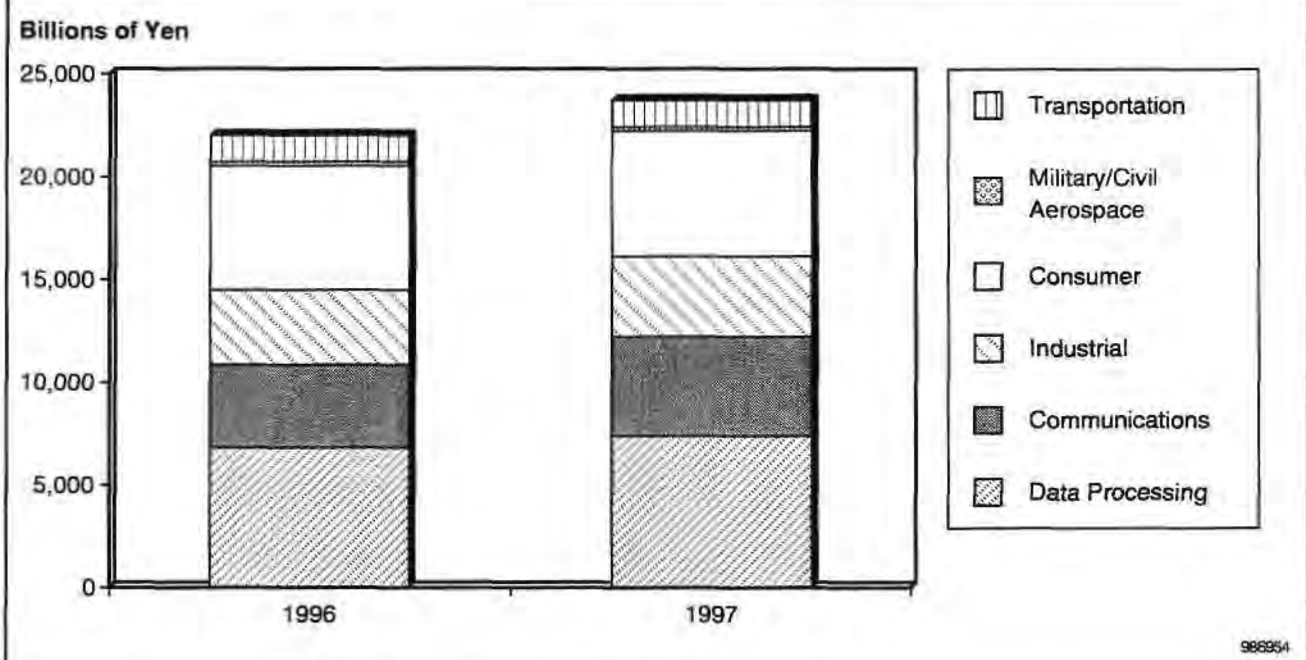
Chapter 2
Japanese Electronic Equipment Production and Semiconductor Consumption

In 1997, after a temporary surge in domestic demand prior to the consumption tax hike in April, the Japanese economy was beleaguered by turmoil in the financial system, a decline in consumer expenditure, and a slowdown in capital spending. The economic hardship was amplified by the Asian financial crisis (AFC) toward the year-end.

In 1997, against all of the economic backlash in Japan as well as in Asia/Pacific, electronic equipment production showed stronger growth than expected: 7.8 percent over 1996, reaching ¥23,715 billion (see Figure 2-1 and Table 2-1). Cellular phones contributed greatly, fueled by a series of price cuts and the shift in demand from personal handyphone systems (PHSs). Data processing equipment also outgrew the forecast, despite a slowdown in domestic PC shipments, and consumer equipment added some momentum, which came from video game systems and digital equipment.

The following section provides detailed analysis of electronic equipment production in Japan for the four major categories: data processing, communications, industrial, and consumer.

Figure 2-1
Japanese Electronic Equipment Production, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

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Table 2-1
Japanese Electronic Equipment Production by Application, 1996-1997 (Billions of Yen)

Application	1996	1997
Data Processing	6,811.7	7,379.9
Communications	4,042.2	4,844.2
Industrial	3,647.5	3,908.4
Consumer	6,018.5	6,097.8
Military/Civil Aerospace	197.4	195.0
Transportation	1,283.4	1,290.1
Total Electronic Equipment	**22,000.7**	**23,715.4**

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (October 1998)

Data Processing Equipment

In 1997, data processing equipment production revenue in Japan soared 8.3 percent to ¥7,380 billion (see Figure 2-2). While PC shipments to the domestic market slowed down to less than 5 percent on a unit basis, the price decline spurred the purchase of peripherals such as printers and display units. Also, storage devices led by high-speed optical disc drives—24x-to-32x CD-ROM and CD-R drives and newly introduced DVD-ROM drives, for example—enjoyed strong growth. This segment is expected to drive the market during the forecast period.

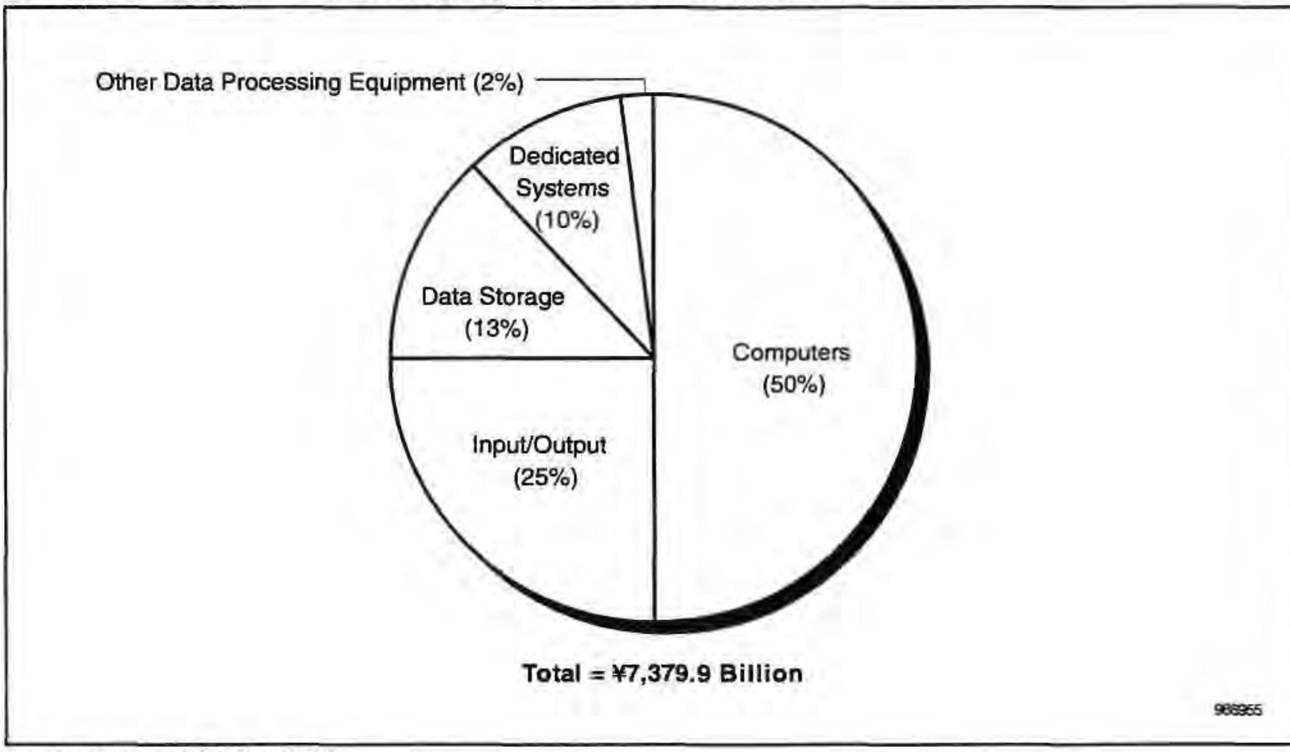
These trends affected various system vendors in this category, such as Canon and Seiko Epson, which are very well known for computer peripheral products such as printers. NEC, Toshiba, and SANYO decreased their semiconductor purchasing mostly because of price cuts and sluggish production. Fujitsu and Matsushita Kotobuki increased their semiconductor purchasing, owing much to the production increase of hard disk drives (HDDs) and CD-ROMs.

Communications Equipment

In 1997, communications equipment production revenue jumped 19.8 percent to ¥4,844 billion (see Figure 2-3). A prime driver was mobile communications equipment; subscribers grew much faster than expected, recording a net increase of 10 million in 1997. While PHS production decelerated by 7 million units in 1997, the market is expected to expand and shift its focus from personal to office use. Nevertheless, the penetration of mobile phones combining PHS and personal digital cellular (PDC) phones has surpassed 30 percent in Japan, and continuation of the previous high growth in domestic demand has become inevitably difficult. Meanwhile, the digitization of infrastructure facilities by Nippon Telegraph and Telephone (NTT) was completed at the end of 1997. This can be translated into the end of robust growth in infrastructure equipment production.

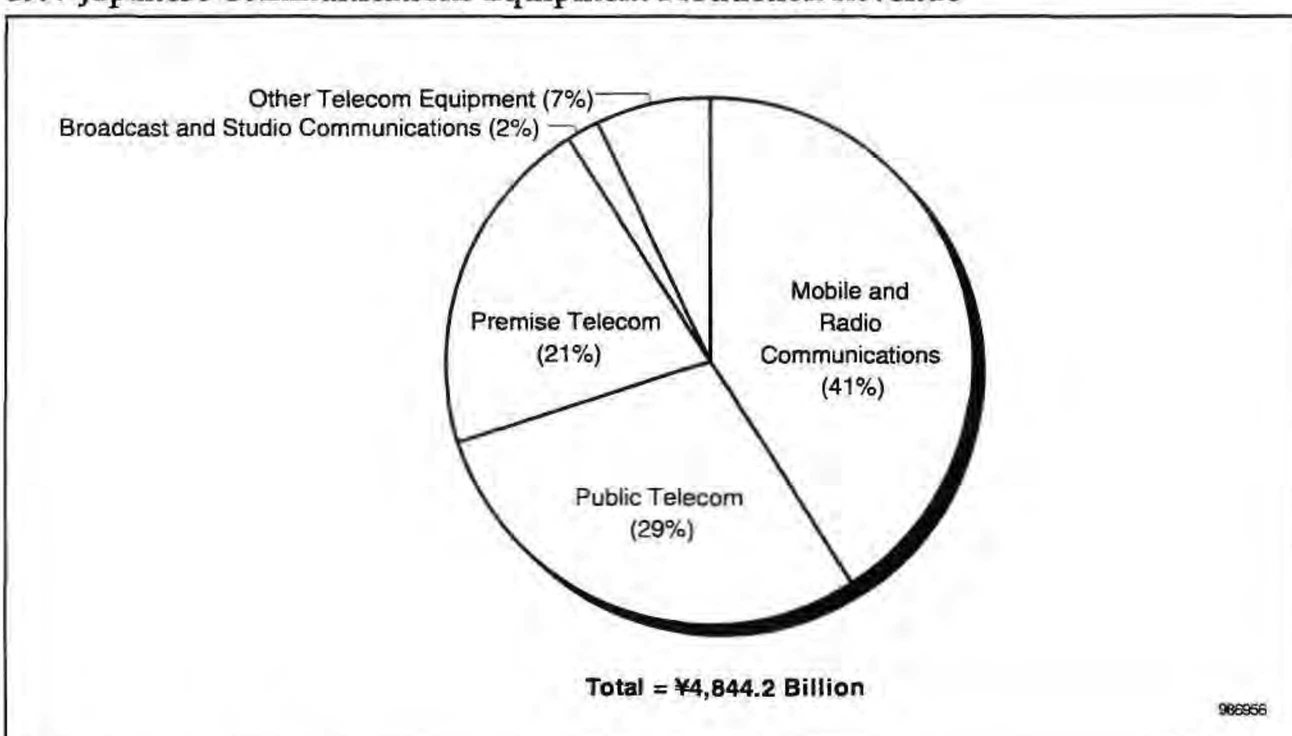
These trends affected system vendors in this category, such as Matsushita Communication, NEC, and Mitsubishi Electric—the top three vendors in the domestic market for digital cellular phones.

Figure 2-2
1997 Japanese Data Processing Equipment Production Revenue



Source: Dataquest (October 1998)

Figure 2-3
1997 Japanese Communications Equipment Production Revenue



Source: Dataquest (October 1998)

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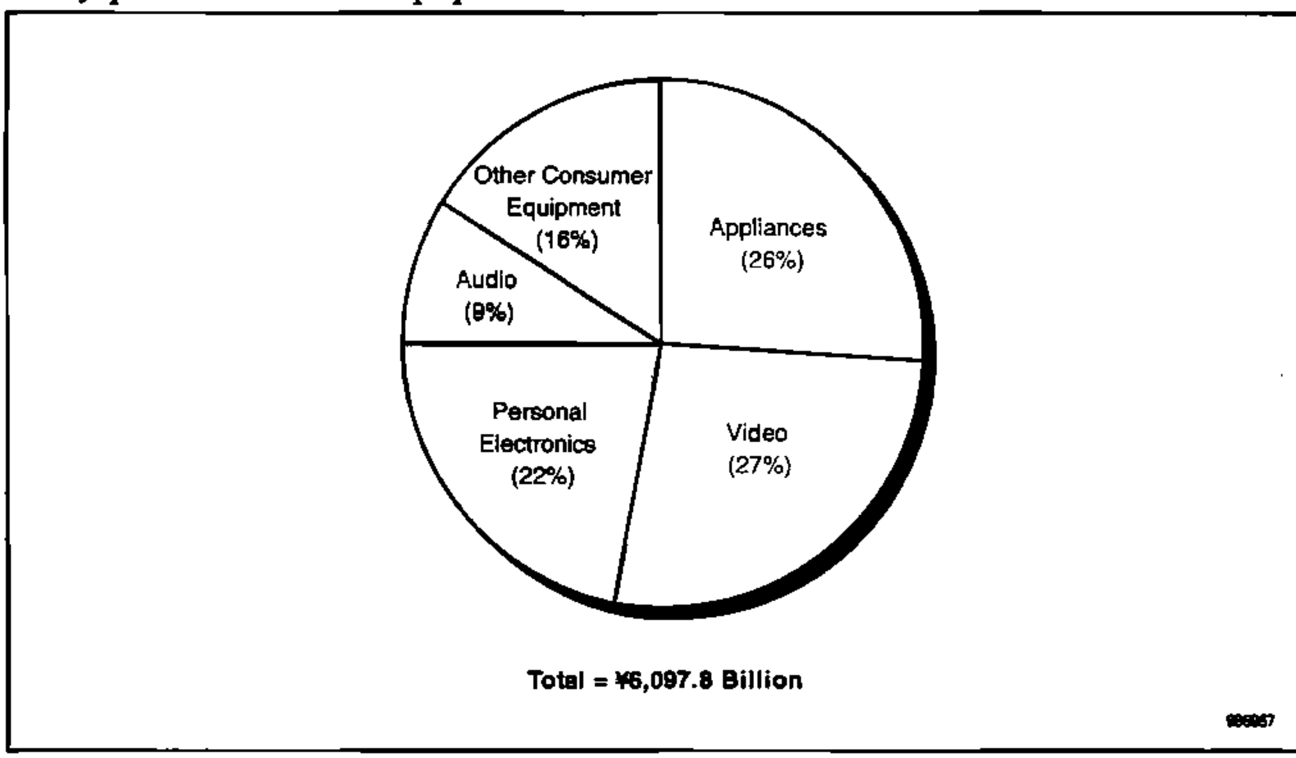
Consumer Equipment

Consumer equipment production revenue recorded a 1.3 percent increase in 1997, reaching ¥6,098 billion (see Figure 2-4). In the video equipment segment, where TVs and VCRs sold in the domestic market are made mostly overseas, replacement demand for wide-screen TVs produced at domestic sites contributed greatly. In the digital consumer equipment market, DV-Cs recorded notable growth, and unit shipments at the end of 1997 were estimated at slightly below 1 million. The DV-C quickly will become pervasive, driven by price declines and the improved availability of key components. Similarly, DSCs will ramp up rapidly because they can be easily connected to PCs or TVs via a flash memory card or standard serial interface. In the audio equipment segment, a sudden rise in demand for minidiscs (MDs) has spurred the introduction of various systems equipped with MD drives. TV games continued to expand the market, helped by price cuts.

These trends affected system vendors in this category, such as Victor Company of Japan, Sony, and Nintendo.

Figure 2-4
1997 Japanese Consumer Equipment Production Revenue



Source: Dataquest (October 1998)

Industrial Equipment

Industrial equipment production revenue in 1997 was up 7.2 percent, totaling ¥3,908 billion (see Figure 2-5). Among the segments in this category, manufacturing systems and instruments recorded the highest growth rate, with 14.9 percent. As the wave of production site relocation to Asia/Pacific countries subsides, the focal point of the market will shift to computerization and sophistication for adding value and further automation for new products.

These trends affected system vendors in this category, such as Hitachi, Toshiba, and Mitsubishi Electric; these big companies did not contribute much to the growth of semiconductor purchasing in this category in 1997.

Semiconductor Market

Thus, even in the year when the overall gross domestic product (GDP) in Japan recorded negative growth, electronics production increased fairly well. This gain in electronics production, however, did not mean as robust of an increase in semiconductor purchasing in Japan.

In 1997, the Japanese semiconductor market recorded a growth rate of 5.7 percent over the previous year—the only negative growth rate on a dollar basis among the four regional markets in the world: the Americas, Europe, Asia/Pacific, and Japan. The difference in trends between electronics production and semiconductor consumption was caused by two factors: An increase in electronics production took place in categories with lower semiconductor contents, such as industrial equipment, and the price erosion of semiconductor devices betrayed the increase on a unit basis. Also, PC shipments lost momentum in Japan, exerting a negative impact on the consumption of a variety of semiconductor products, including memories, microprocessors (MPUs), and logic.

As a result, the Japanese semiconductor market has become less than one-fourth of the worldwide market for the first time since 1980. It is still the second-largest regional market following the Americas, but both European and Asia/Pacific markets are close behind. In fact, there were months within 1997 when the Japanese semiconductor market fell behind those two markets.

Affecting this is the sluggishness in the domestic market as well as the fast growth in other regions, especially in the Americas and Europe. Semiconductor procurement to support Japanese electronics companies' Asian production sites has moved to each site or to international purchasing offices (IPOs) outside Japan, and the yen depreciation observed in 1997 did not reverse the trend.

Japanese semiconductor consumption by application category in 1997 is given in Figure 2-6.

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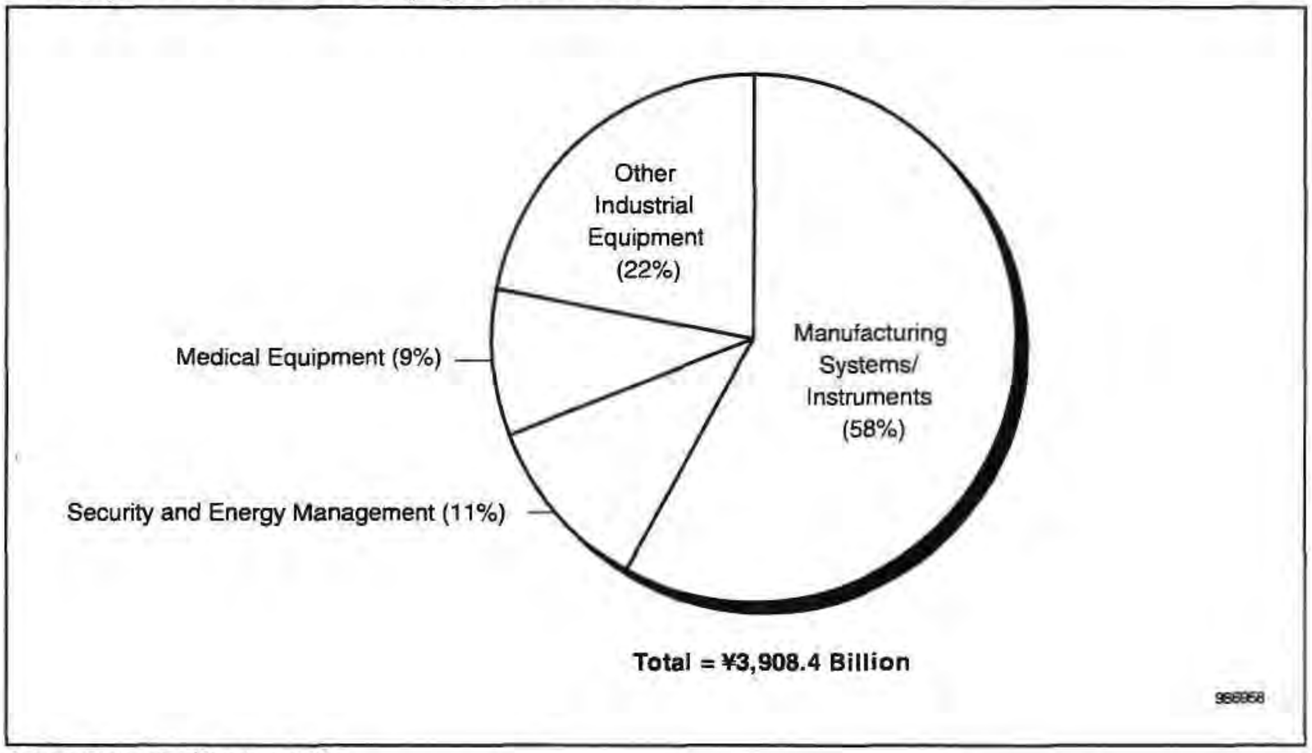
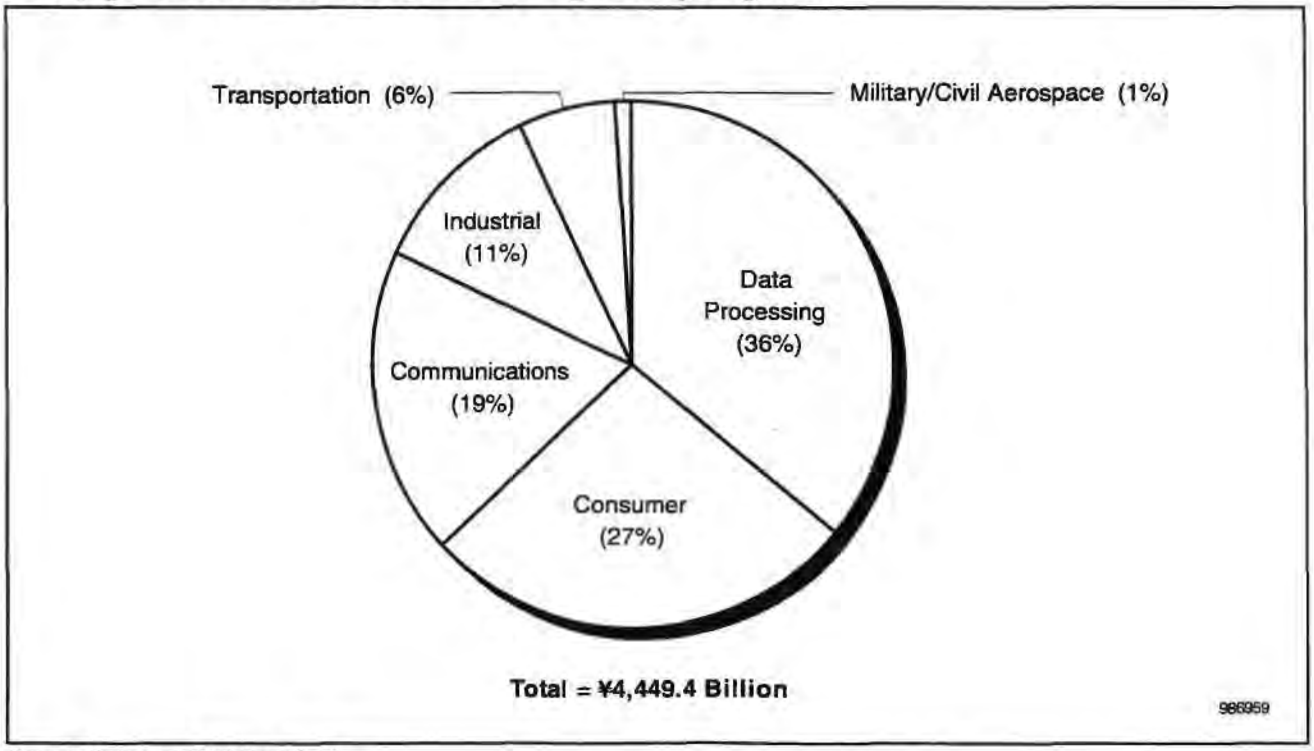
Figure 2-5
1997 Japanese Industrial Equipment Production Revenue



Source: Dataquest (October 1998)

Figure 2-6
1997 Japanese Semiconductor Consumption by Segment



Source: Dataquest (October 1998)

Chapter 3
Japanese Semiconductor User Trends by Application

This chapter analyzes Japanese semiconductor consumption by application categories, focusing on the 22 top-ranking companies.

It should be noted that the semiconductor purchasing estimated in this report was measured as the amount of semiconductors booked and billed within Japan, regardless of where the bought semiconductors were actually mounted to circuit boards and systems. This implies that if the Japanese electronics companies analyzed here chose to buy semiconductors in Japan and then send them to their overseas production sites, that amount is still included in the semiconductor purchasing in Japan. Therefore, the semiconductor purchasing in this report may not equal semiconductor consumption in the true sense of the word. In Dataquest's methodology, however, even that portion of semiconductor purchasing is regarded as part of the "consumption," measured as the semiconductor companies' aggregated shipments into the Japanese market.

Table 3-1 and Figure 3-1 show the ranking of 22 major semiconductor-user companies based on their semiconductor purchasing trends in 1997. The top three users were NEC, Sony, and Fujitsu. The development of systems targeted at the domestic market tends to be conducted within Japan. The tendency is clearer in areas such as communications, where the differences in each country's format are so conspicuous—to the level of being incompatible with each other—that system development needs to be done within the country or region of its use. On the other hand, consumer electronics have been developed in Japan to be shipped to export markets, resulting in a large number of developed and produced systems.

Data Processing

In this category, there are several products that contribute to the growth of semiconductor purchasing; they are mainly PC peripherals such as printers, monitors, digital copy systems, multifunctional dedicated machines, and optical disc storage, such as CD-ROM/R/RW and DVD players. Table 3-2 and Figure 3-2 show semiconductor purchase ranking in the data processing equipment area. Fujitsu, NEC, and Toshiba have sizable amounts of computer business, resulting in large purchase numbers. Canon follows the top three companies with its expertise in copiers and computer peripherals.

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Table 3-1
Japanese Semiconductor Purchase Ranking of All Electronic Equipment, 1996-1997 (Billions of Yen)

1997 Rank	Company	1996	1997	Change (%)
1	NEC	291.9	297.0	1.8
2	Sony	238.4	264.9	11.1
3	Fujitsu	202.4	211.1	4.3
4	Toshiba	205.7	198.8	-3.3
5	Matsushita Electric	178.6	181.0	1.4
6	Hitachi	176.8	171.5	-3.0
7	Canon	120.0	132.3	10.2
8	Mitsubishi Electric	136.8	131.6	-3.8
9	Nintendo	91.3	92.6	1.4
10	Denso	74.3	73.0	-1.9
11	Matsushita Communication	56.2	61.2	9.0
12	Sharp	59.7	59.9	0.3
13	Matsushita Kotobuki	51.0	58.1	13.9
14	SANYO	59.8	55.6	-7.1
15	SEGA	63.0	52.3	-16.9
16	Ricoh	46.6	50.4	8.3
17	Victor	41.2	44.2	7.2
18	Seiko Epson	32.9	38.9	18.4
19	Pioneer Electronic	36.9	38.3	3.7
20	Oki	26.0	26.4	1.6
21	Casio	21.4	23.2	8.3
22	Kyushu Matsushita	20.0	22.3	11.1
	Total	**2,230.7**	**2,284.4**	**2.4**

Source: Dataquest (October 1998)

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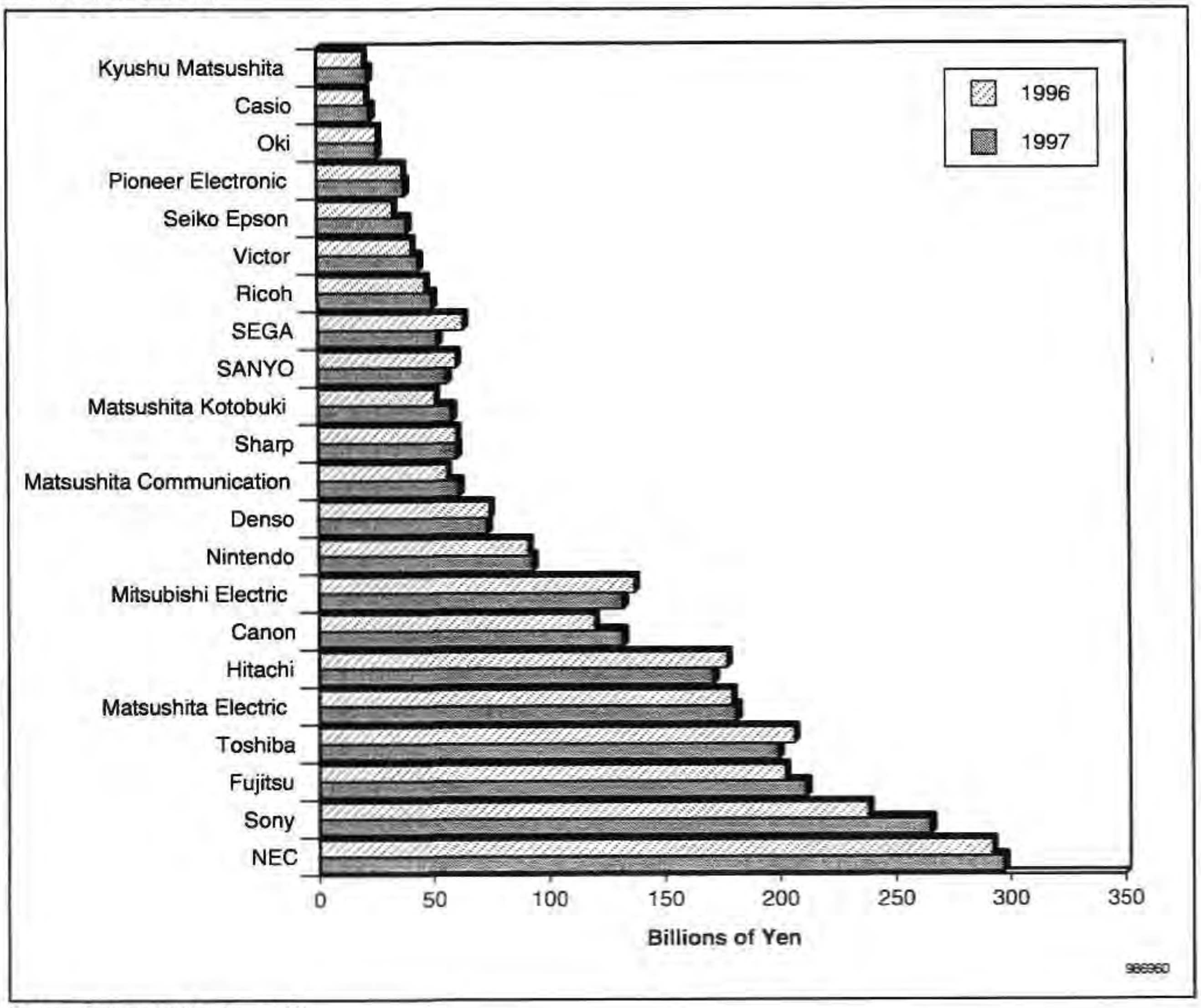
Figure 3-1
Japanese Semiconductor Purchase Ranking of All Electronic Equipment, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

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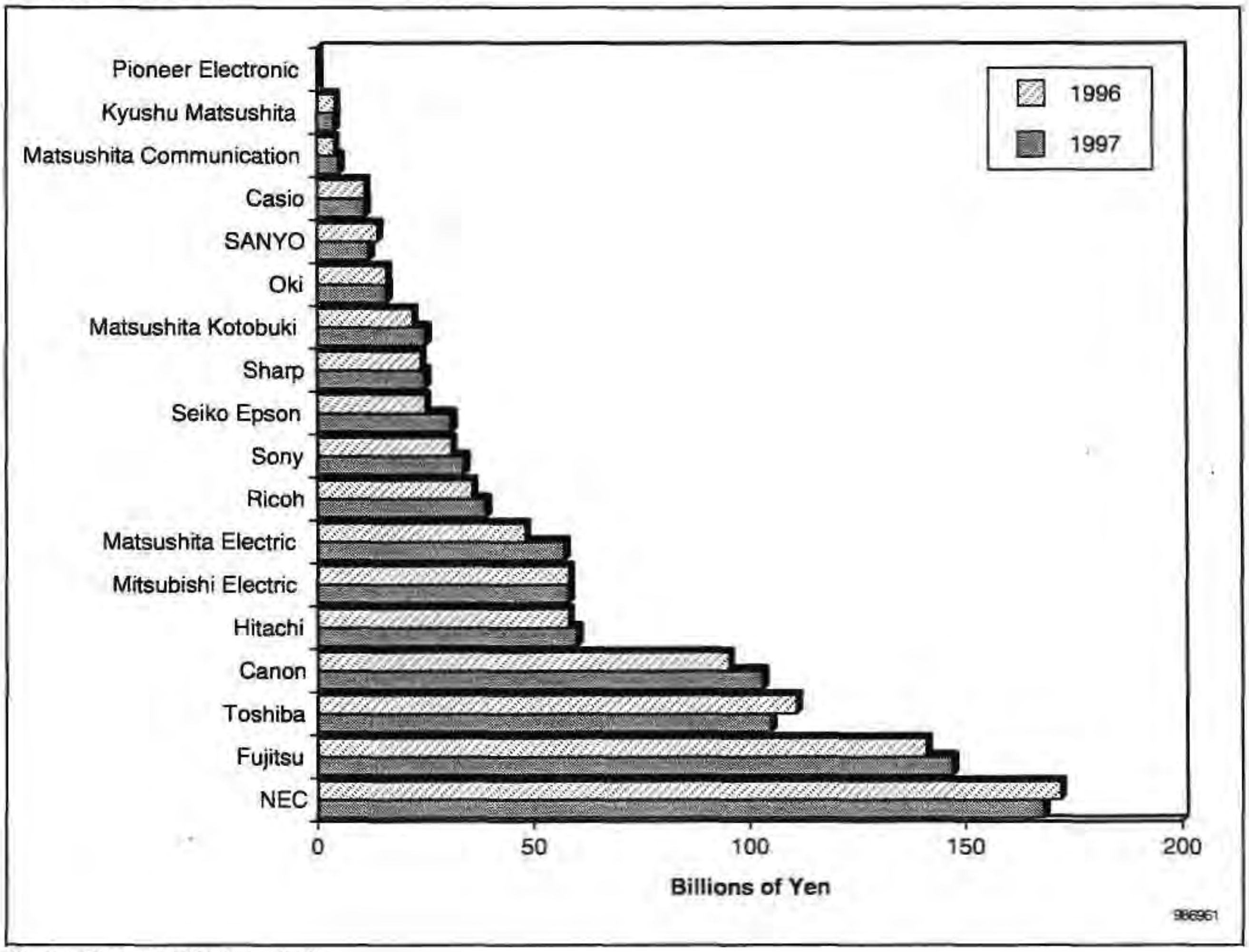
Table 3-2
Japanese Semiconductor Purchase Ranking of Data Processing Equipment, 1996-1997 (Billions of Yen)

1997 Rank	Company	1996	1997	Change (%)
1	NEC	171.9	167.5	-2.6
2	Fujitsu	141.2	146.7	3.9
3	Toshiba	110.6	105.2	-4.9
4	Canon	94.5	103.3	9.3
5	Hitachi	57.5	59.7	3.8
6	Mitsubishi Electric	57.8	57.6	-0.3
7	Matsushita Electric	48.0	56.5	17.7
8	Ricoh	36.1	39.4	9.1
9	Sony	31.4	34.0	8.3
10	Seiko Epson	24.8	31.1	25.4
11	Sharp	23.8	25.3	6.3
12	Matsushita Kotobuki	21.7	25.0	15.2
13	Oki	15.6	16.3	4.5
14	SANYO	13.6	11.6	-14.7
15	Casio	11.4	11.1	-2.6
16	Matsushita Communication	4.5	4.9	8.9
17	Kyushu Matsushita	3.7	4.3	16.2
18	Pioneer Electronic	0.1	0.1	0
	Total	**868.3**	**899.7**	**3.6**

Source: Dataquest (October 1998)

Figure 3-2
Japanese Semiconductor Purchase Ranking of Data Processing Equipment, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Communications

In the communications area, wireless communications and LAN/WAN equipment, including hubs, switches, and routers, are increasing in production volume, consuming an increasing portion of the semiconductors shipped worldwide. In Japan, the rapid growth in digital cellular phones helped vendors of both handsets and base stations. This contributed to increases in semiconductor consumption at companies such as Matsushita Electric, Sony, Toshiba, and Denso, some of which may not have been giants in the communications area but are growing fairly well in production. Table 3-3 and Figure 3-3 show the Japanese semiconductor purchase ranking of communications equipment.

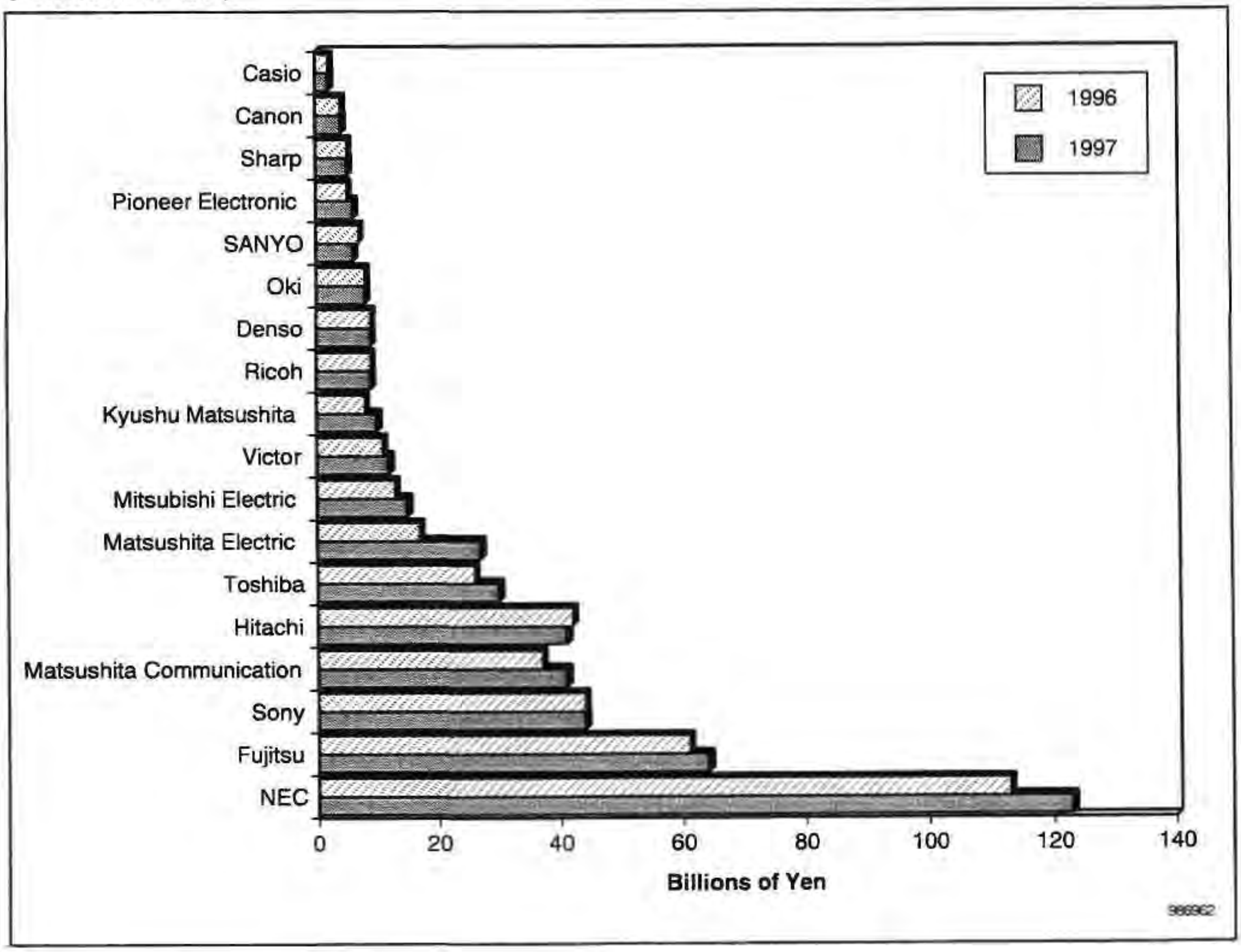
Table 3-3
Japanese Semiconductor Purchase Ranking of Communications Equipment, 1996-1997 (Billions of Yen)

1997 Rank	Company	1996	1997	Change (%)
1	NEC	113.1	122.8	8.6
2	Fujitsu	61.2	64.4	5.2
3	Sony	43.6	44.1	1.1
4	Matsushita Communication	37.3	41.3	10.7
5	Hitachi	42.5	41.0	-3.5
6	Toshiba	26.3	29.9	13.7
7	Matsushita Electric	16.9	27.4	62.1
8	Mitsubishi Electric	13.3	15.5	16.5
9	Victor	11.4	12.2	7.0
10	Kyushu Matsushita	8.4	9.5	13.1
11	Ricoh	8.6	8.9	3.5
12	Denso	9.0	8.8	-2.2
13	Oki	8.5	7.9	-7.1
14	SANYO	7.0	6.3	-10.0
15	Pioneer Electronic	4.8	6.0	25.0
16	Sharp	4.6	4.9	6.5
17	Canon	3.8	4.5	18.4
18	Casio	1.8	1.9	5.6
	Total	**421.9**	**457.3**	**8.4**

Source: Dataquest (October 1998)

 ©1998 Dataquest

Figure 3-3
Japanese Semiconductor Purchase Ranking of Communications Equipment, 1996-1997 (Billions of Yen)



 ©1998 Dataquest

Consumer

In the consumer equipment area, Sony, Nintendo, and Matsushita Electric lead other companies by far. In the sluggish domestic market, MD has been showing an accelerating growth, pulling demand for other audio systems as well. Other digital consumer equipment, such as digital camcorders and DSCs, grew, too, and contributed to the semiconductor purchasing of those vendors. Table 3-4 and Figure 3-4 show the Japanese semiconductor purchase ranking of consumer equipment.

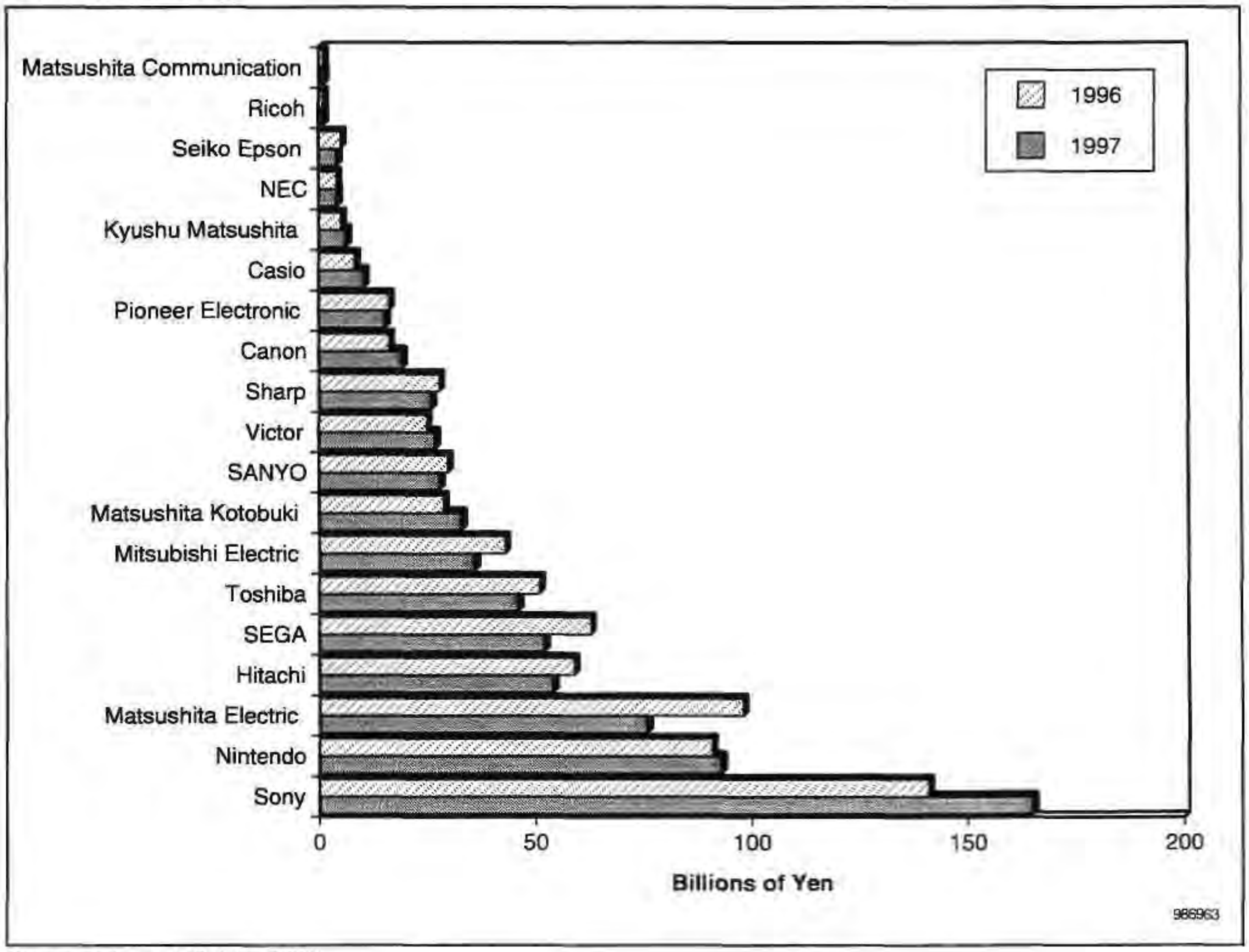
Table 3-4
Japanese Semiconductor Purchase Ranking of Consumer Equipment, 1996-1997 (Billions of Yen)

1997 Rank	Company	1996	1997	Change (%)
1	Sony	140.7	165.1	17.3
2	Nintendo	91.3	92.6	1.4
3	Matsushita Electric	98.2	75.8	-22.8
4	Hitachi	58.8	53.9	-8.3
5	SEGA	63.0	52.3	-16.9
6	Toshiba	51.4	46.2	-10.1
7	Mitsubishi Electric	43.3	36.3	-16.2
8	Matsushita Kotobuki	29.3	33.1	13.0
9	SANYO	29.7	28.3	-4.5
10	Victor	24.7	26.7	8.2
11	Sharp	28.2	26.4	-6.4
12	Canon	16.1	18.9	17.5
13	Pioneer Electronic	16.3	15.2	-7.3
14	Casio	8.2	10.3	24.6
15	Kyushu Matsushita	5.0	5.6	13.7
16	NEC	4.3	4.2	-2.5
17	Seiko Epson	4.6	4.1	-10.8
18	Ricoh	1.2	1.4	21.0
19	Matsushita Communication	0.7	0.9	29.7
	Total	**714.8**	**697.3**	**-2.5**

Source: Dataquest (October 1998)

 ©1998 Dataquest

Figure 3-4
Japanese Semiconductor Purchase Ranking of Consumer Equipment, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

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Industrial

Overall capital expenditure in the Japanese industry declined in 1997, and manufacturing systems and instruments showed growth that was positive but smaller than that of the previous year. A drop in housing and building construction also hurt security and energy management equipment. The onset of the AFC brought down the demand for infrastructure-related equipment for Asian countries. Leading semiconductor users in this area are Toshiba, Matsushita Electric, SANYO, Mitsubishi Electric, and Hitachi. Table 3-5 and Figure 3-5 show the Japanese semiconductor purchase ranking of industrial equipment.

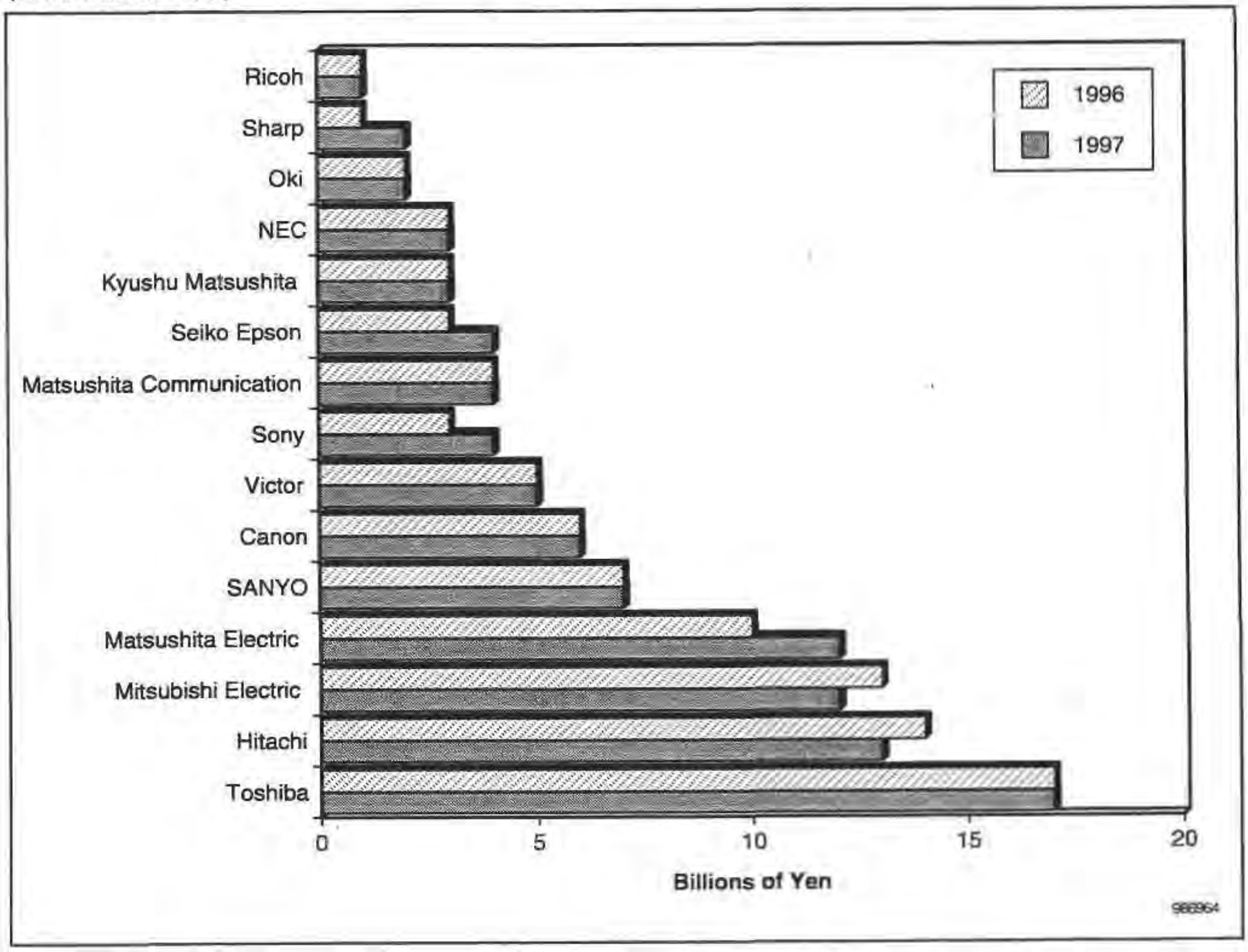
Table 3-5
Japanese Semiconductor Purchase Ranking of Industrial Equipment, 1996-1997 (Billions of Yen)

1997 Rank	Company	1996	1997	Change (%)
1	Toshiba	17.4	17.5	0.6
2	Hitachi	14.0	13.0	-7.1
3	Mitsubishi Electric	12.5	12.4	-0.8
4	Matsushita Electric	10.0	11.7	17.0
5	SANYO	7.2	7.4	2.8
6	Canon	5.6	5.6	0
7	Victor	5.1	5.4	5.9
8	Sony	3.4	3.9	14.7
9	Matsushita Communication	3.7	3.8	2.7
10	Seiko Epson	3.5	3.7	5.7
11	Kyushu Matsushita	2.9	2.8	-3.4
12	NEC	2.6	2.5	-3.8
13	Oki	1.8	2.0	11.1
14	Sharp	1.4	1.5	7.1
15	Ricoh	0.7	0.6	-14.3
	Total	**91.8**	**93.8**	**2.2**

Source: Dataquest (October 1998)

 ©1998 Dataquest

Figure 3-5
Japanese Semiconductor Purchase Ranking of Industrial Equipment, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

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Transportation

Domestic car sales in 1997 declined by around 5 percent. However, automotive equipment production saw a slight increase in all areas except car audio/video systems. Navigation system production, especially, continued to grow very rapidly. This trend benefited the semiconductor purchasing of companies such as Sony, Pioneer Electronic, and Matsushita Electric. The production of automobiles was becoming sluggish, which affected semiconductor demand in equipment in power train and body control, such as electronic control units (ECUs) and antilock brake systems (ABSs). Table 3-6 and Figure 3-6 show the Japanese semiconductor purchase ranking of transportation equipment.

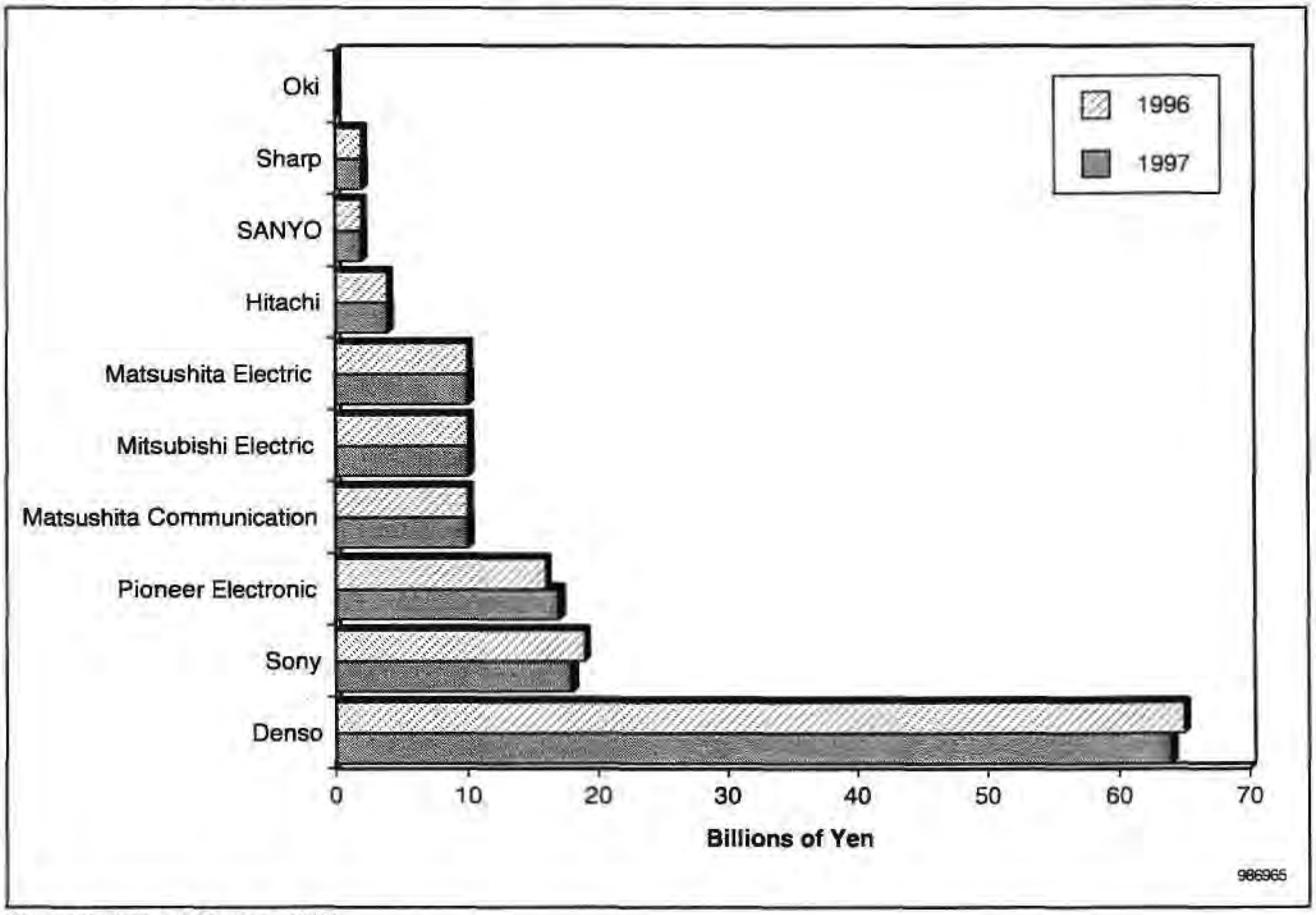
Table 3-6
Japanese Semiconductor Purchase Ranking of Transportation Equipment, 1996-1997 (Billions of Yen)

1997 Rank	Company	1996	1997	Change (%)
1	Denso	65.4	64.2	-1.8
2	Sony	19.2	17.9	-6.8
3	Pioneer Electronic	15.7	17.0	8.3
4	Matsushita Communication	10.1	10.4	3.0
5	Matsushita Electric	9.9	9.9	0
6	Mitsubishi Electric	9.9	9.9	0
7	Hitachi	4.0	3.9	-2.5
8	SANYO	2.4	1.9	-20.8
9	Sharp	1.7	1.8	5.9
10	Oki	0.2	0.2	0
	Total	**138.5**	**137.1**	**-1.0**

Source: Dataquest (October 1998)

 ©1998 Dataquest

Figure 3-6
Japanese Semiconductor Purchase Ranking of Transportation Equipment, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Chapter 4

Japanese Semiconductor User Profiles

This section analyzes each of the major Japanese electronics companies as semiconductor users.

Canon Inc.

Canon is the world's leading manufacturer of cameras, and in the area of dedicated business systems, Canon's copier has a sizable share in the worldwide market. Also, Canon's coverage includes a lot of optical equipment; semiconductor manufacturing equipment, such as steppers; and computer peripherals, such as printers. About 40 percent of Canon's products are shipped to various export markets. Its domestic sales grew in segments such as computer peripherals; multifunctional products such as copiers, fax machines, and printers; and handy terminals.

Canon's production sites are concentrated in Japan and so is its semiconductor usage. In digital camcorders and cameras, Canon has made every effort to differentiate its products by incorporating ASICs with proprietary system function designs.

Table 4-1 shows Canon's major electronic products. Figures 4-1 through 4-3 show Canon's equipment production and semiconductor purchase trends. Computer peripherals, such as printers and scanners, and dedicated business equipment have large shares in Canon's semiconductor purchasing.

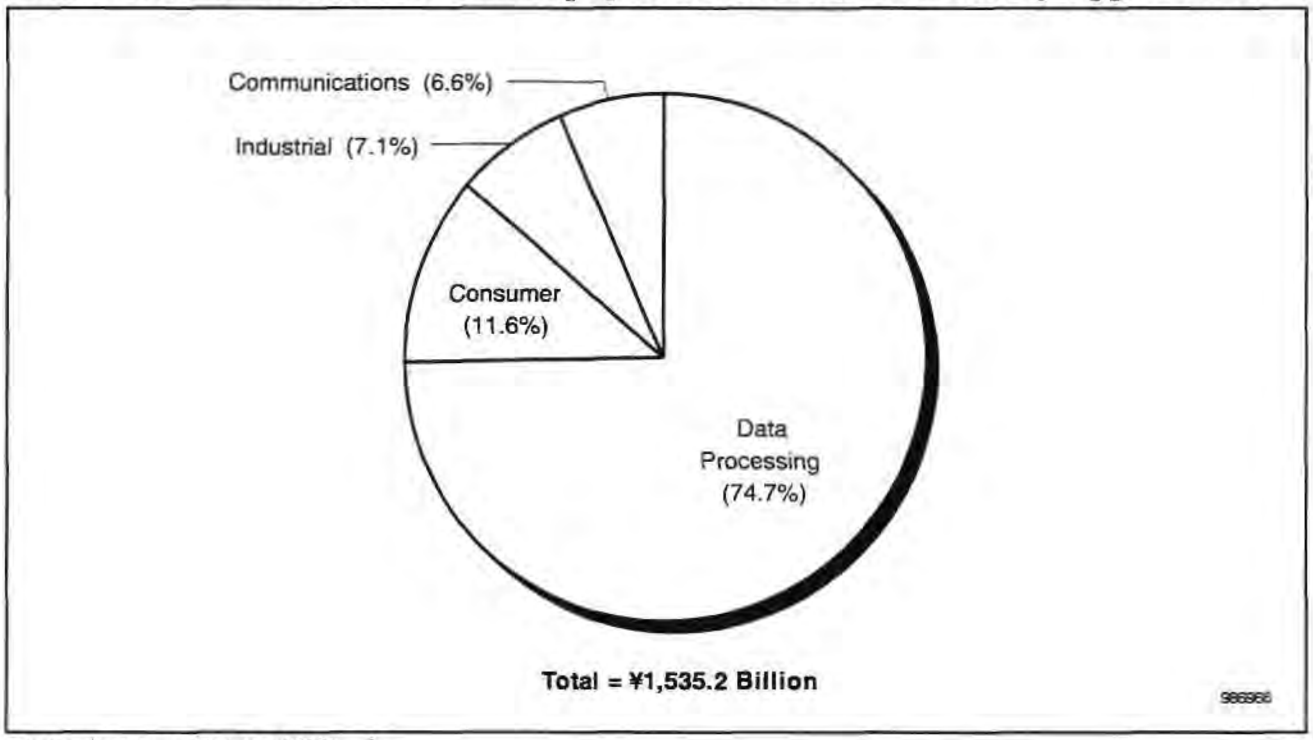
Table 4-1
Canon's Major Electronic Products

Application	Products
Data Processing	PCs, midrange computers, flexible disk drives, terminals, laser beam printers, other printers, word processors, calculators, copiers
Communications	Multifunction phones, fax machines
Consumer	Camcorders, cameras, digital still cameras
Industrial	Manufacturing systems, test and measuring equipment

Source: Dataquest (October 1998)

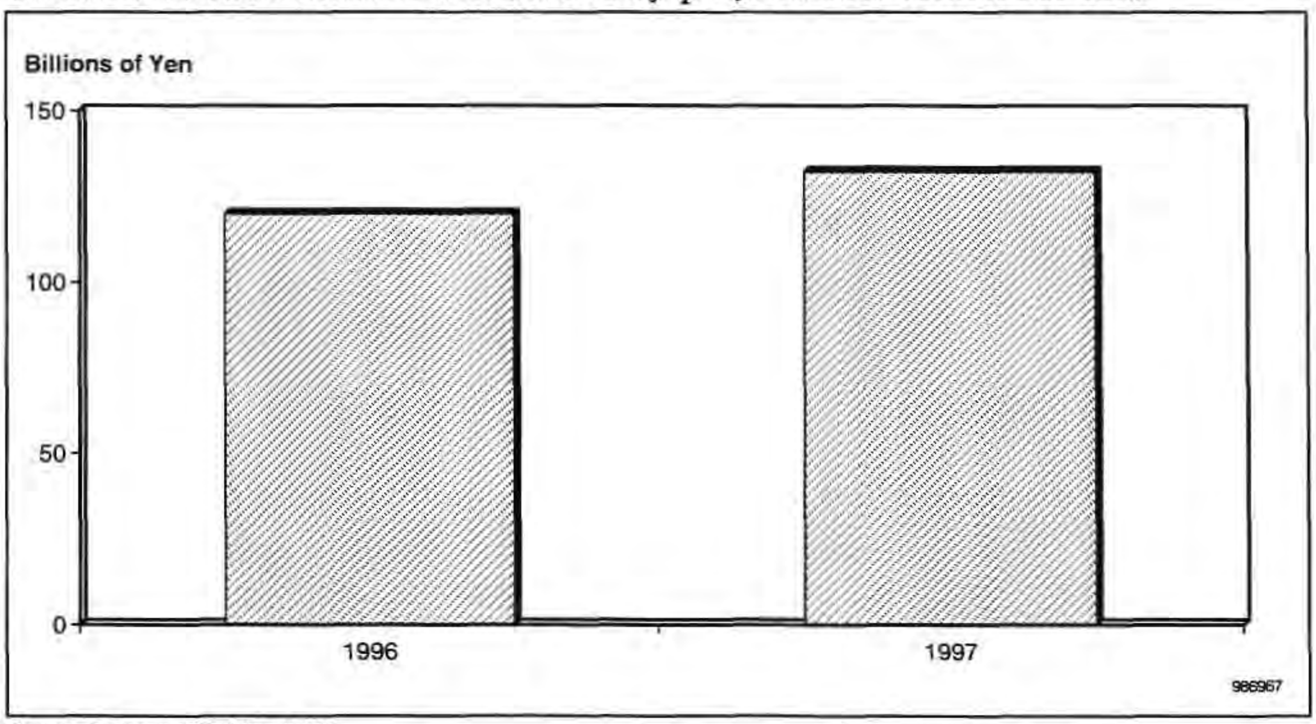
 ©1998 Dataquest

Figure 4-1
Canon's 1997 Worldwide Electronic Equipment Production Revenue by Application



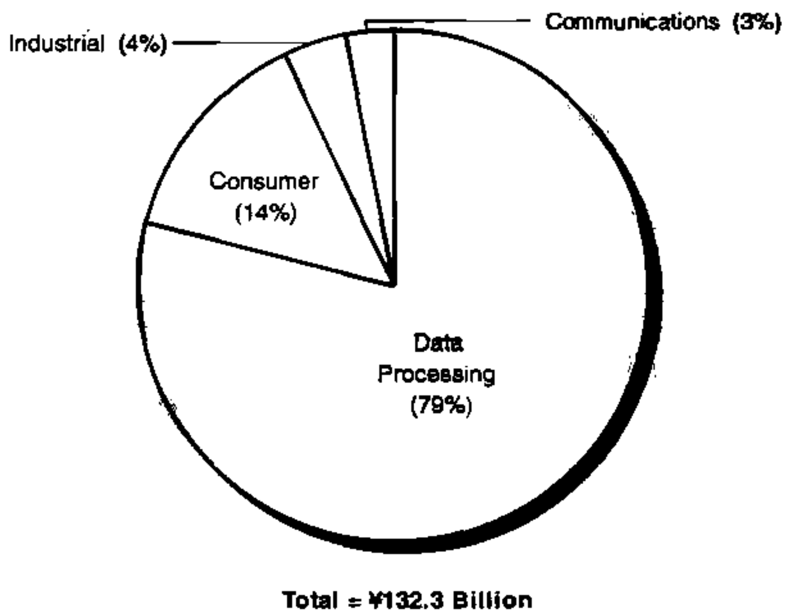
Source: Dataquest (October 1998)

Figure 4-2
Canon's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-3
Canon's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Casio Computer Company Ltd.

Casio was founded to develop and market purely electric calculators applying relays used in telephone exchange systems. Later, Casio diversified its product line to include desktop and portable calculators, electric watches and clocks, LCD TVs, DSCs, and electronic musical instruments. Consumer equipment production was responsible for 52 percent of Casio's revenue, of which a large portion came from the sales of watches/clocks. Another 41 percent came from the sales of data processing equipment, including calculators, handheld computers, and peripherals. Sales of data processing equipment grew in the private-use markets, but business-use products saw a decline in sales because of a drop in unit shipments as well as in selling prices. Exports grew to represent 40 percent of the total sales. Semiconductor purchasing experienced a mild decrease, which was partly influenced by the price cuts of semiconductor devices used in data processing equipment.

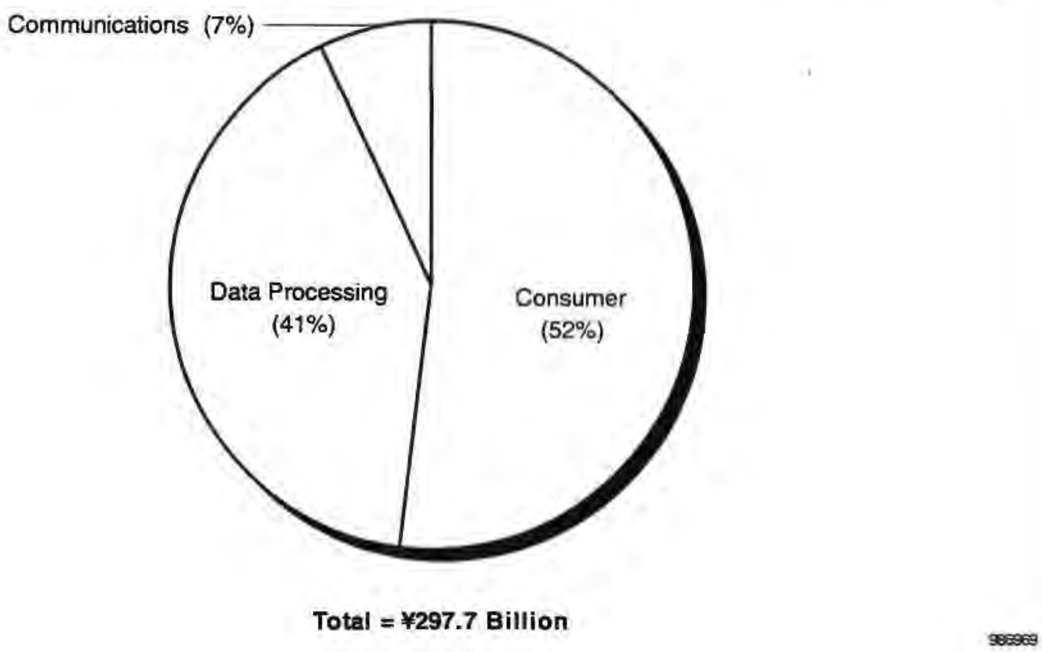
Table 4-2 shows Casio's major electronic products. Figures 4-4 through 4-6 show Casio's equipment production and semiconductor purchase trends.

Table 4-2
Casio's Major Electronic Products

Application	Products
Data Processing	PCs, word processors, organizers, printers
Communications	PHSs
Consumer	Digital still cameras, TVs, watches

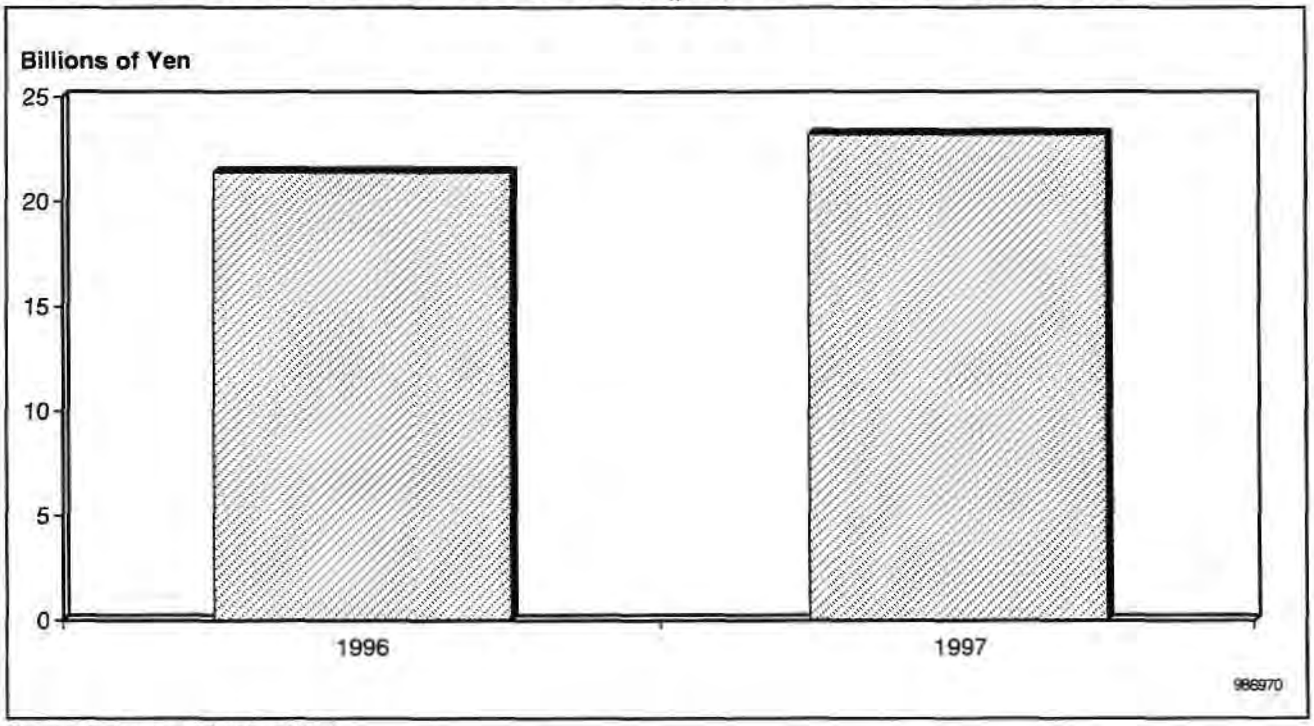
Source: Dataquest (October 1998)

Figure 4-4
Casio's 1997 Worldwide Electronic Equipment Production Revenue by Application



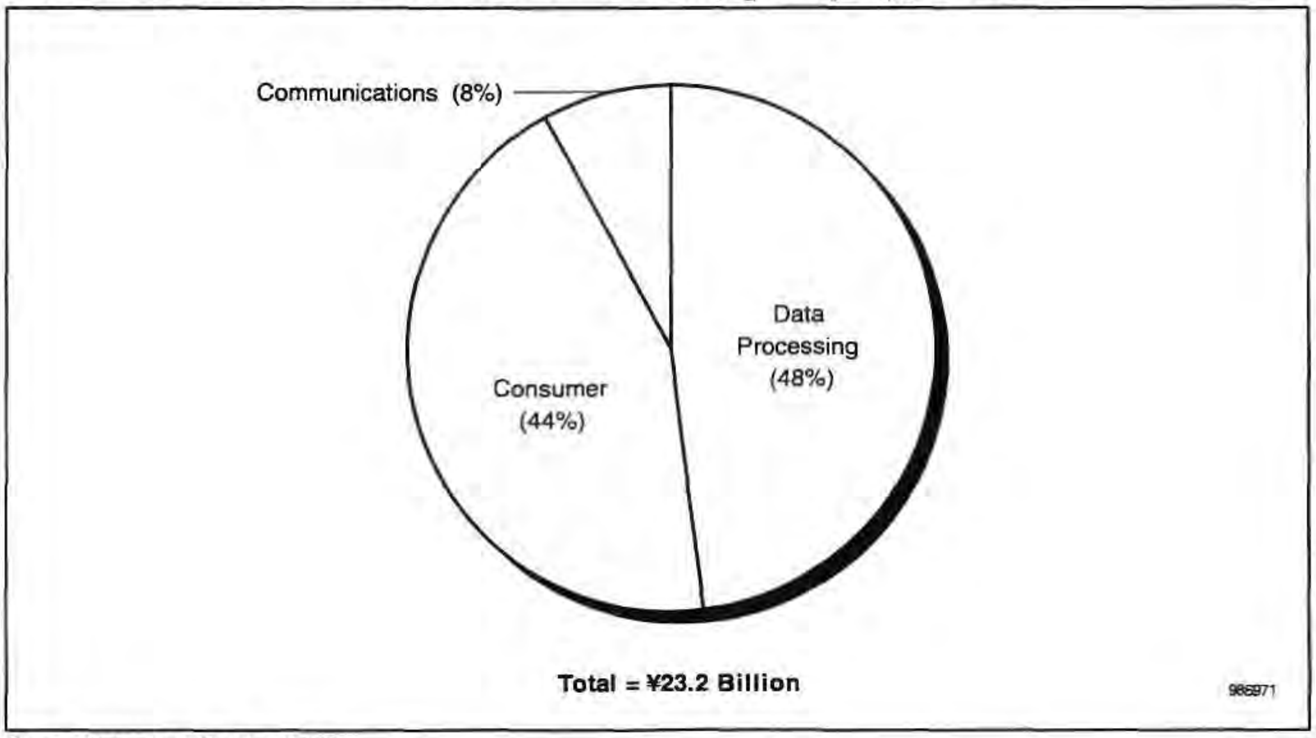
Source: Dataquest (October 1998)

Figure 4-5
Casio's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-6
Casio's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Denso Corporation

Car air conditioners represent one-third of Denso's revenue, having the largest share among all product lines. Another one-third is accounted for by all other automotive electronics. Although Denso is expanding its product lines to areas such as communications and appliances, sales in those areas are still comparatively small. Although car production still holds the key for Denso's overall production, the company has sought a wider customer base among worldwide car manufacturers, which has helped Denso's revenue growth to show steady trends. Semiconductor purchasing has amounted to about ¥73 billion, and 88 percent of this is for transportation equipment.

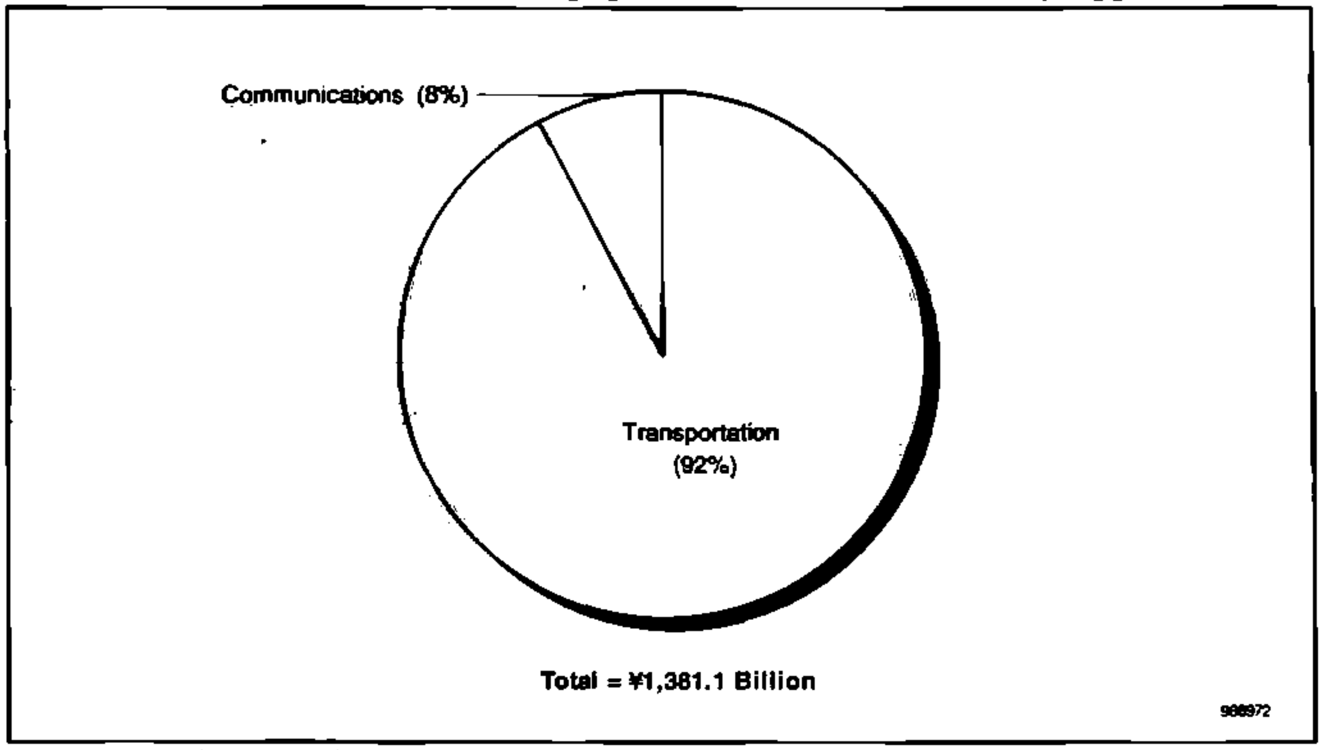
Table 4-3 shows Denso's major electronic products. Figures 4-7 through 4-9 show Denso's equipment production and semiconductor purchase trends.

Table 4-3
Denso's Major Electronic Products

Application	Products
Communications	Cellular phones
Transportation	Navigation systems, car stereos, auto ECUs, other automotive products

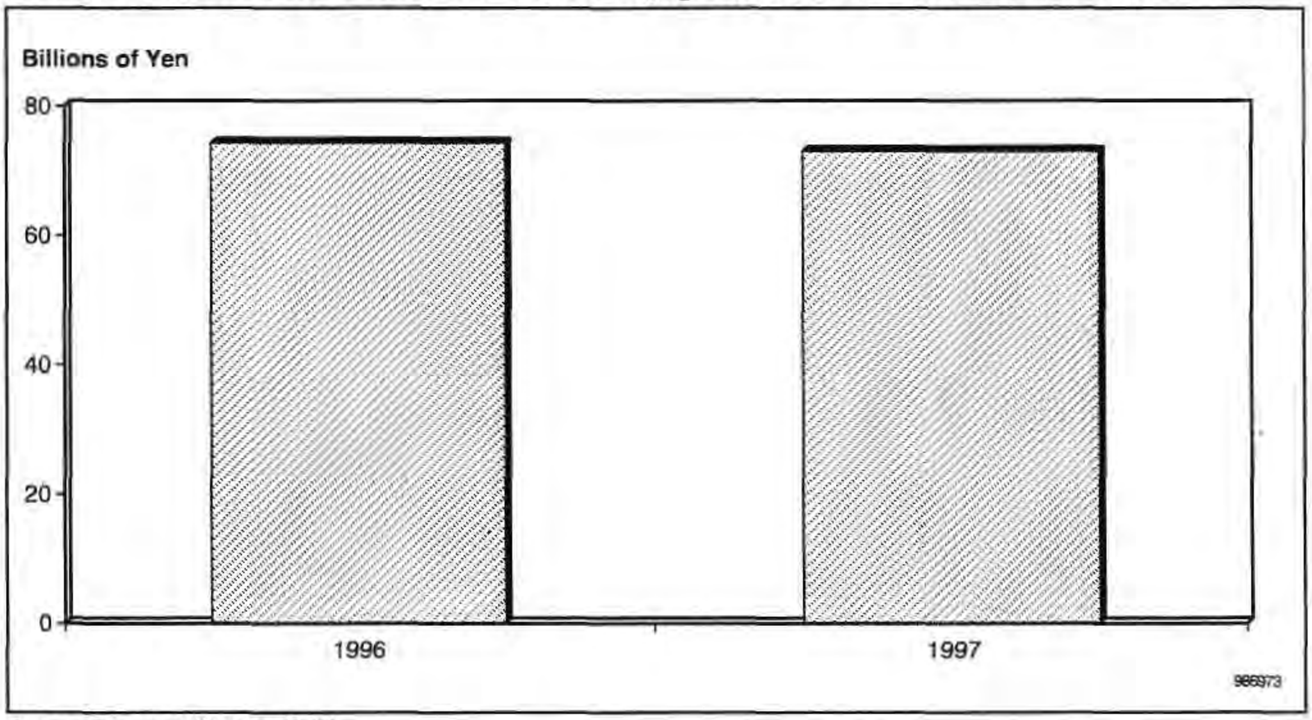
Source: Dataquest (October 1998)

Figure 4-7
Denso's 1997 Worldwide Electronic Equipment Production Revenue by Application



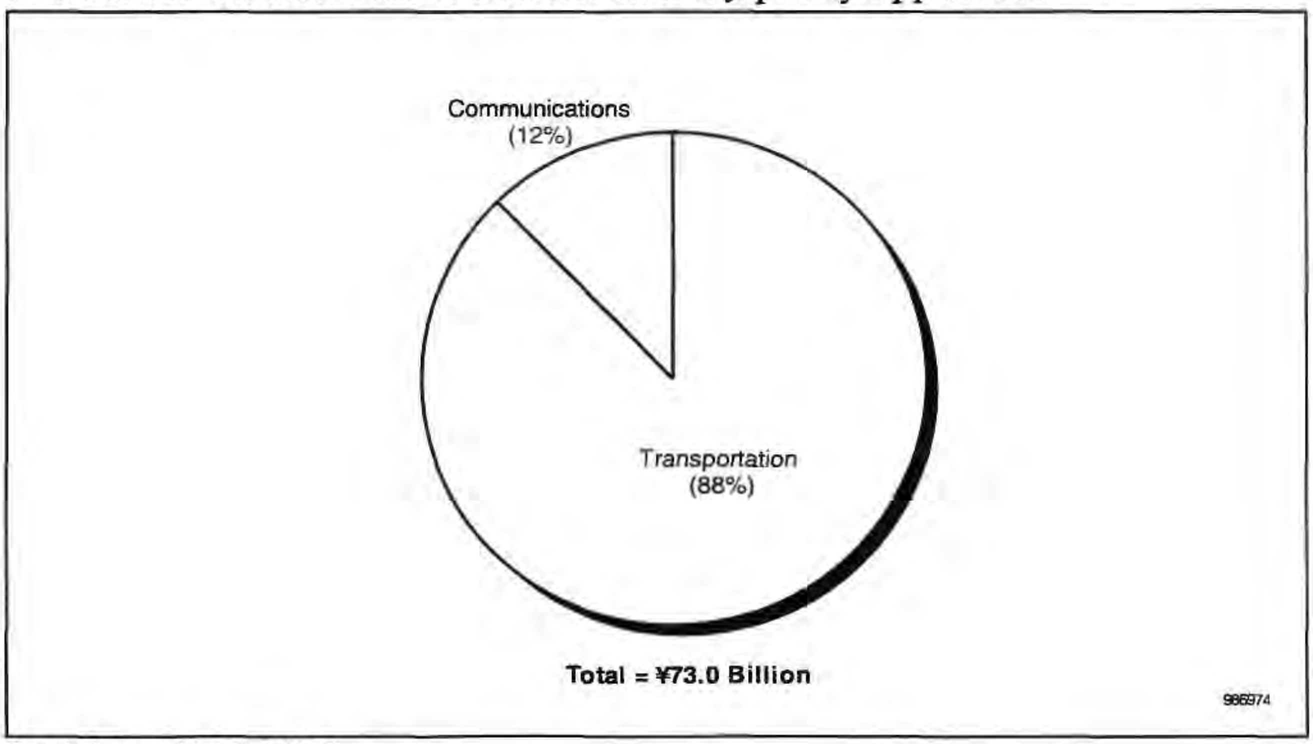
Source: Dataquest (October 1998)

Figure 4-8
Denso's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-9
Denso's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Fujitsu Ltd.

Fujitsu has traditionally been dependent on the domestic market. In 1997, however, while its domestic sales grew—helped by sound market share gains in PCs—its sales of data processing and communications equipment in the Americas and Europe grew rapidly, too, contributing to a decline in dependence on the Japanese market. About 70 percent of its semiconductor purchases are in the data processing area, while the communications segment is increasing its share because of increases in infrastructure business in mobile communications handsets and base stations.

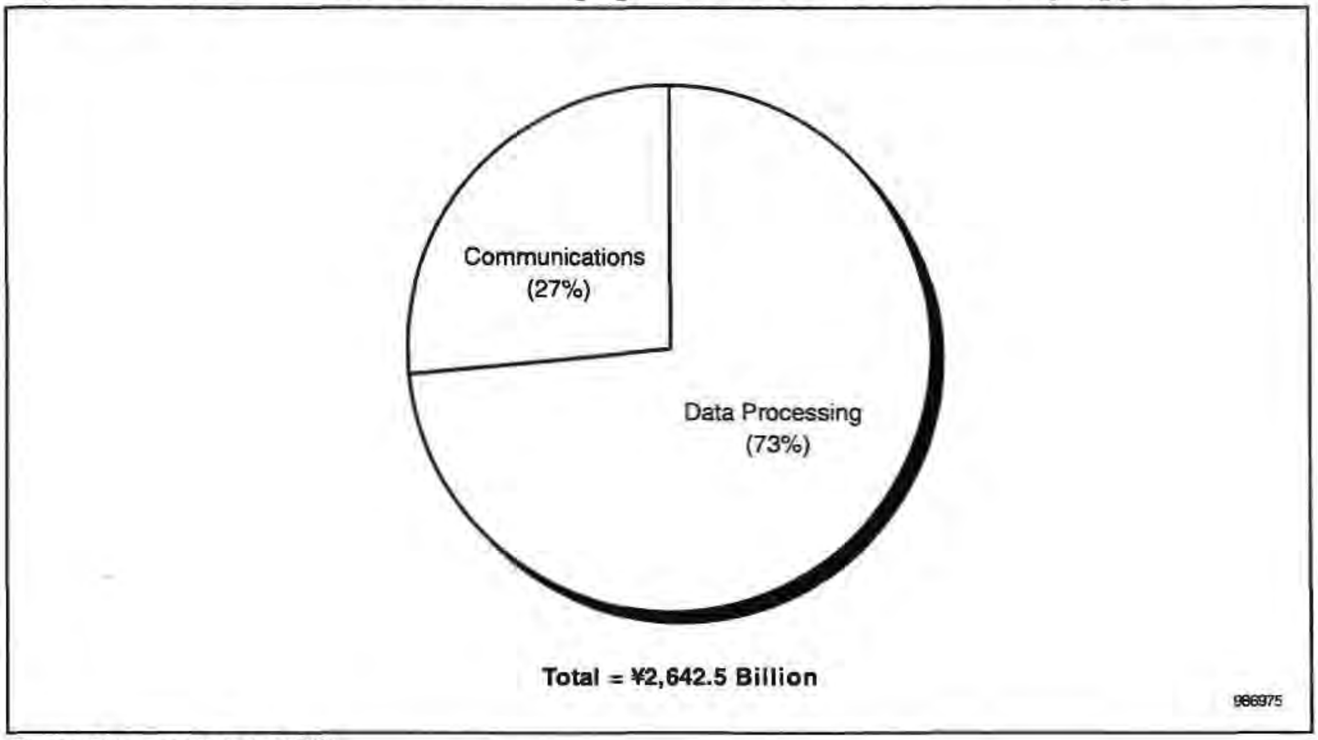
Table 4-4 shows Fujitsu's major electronic products. Figures 4-10 through 4-12 show Fujitsu's equipment production and semiconductor purchase trends.

Table 4-4
Fujitsu's Major Electronic Products

Application	Products
Data Processing	PCs, workstations, mainframe computers, midrange computers, rigid disk drives, displays, terminals, laser beam printers, other printers, word processors
Communications	Corded phones, cordless phones, multifunction phones, cellular phones, pagers, fax machines, modems, PBX equipment, transmission equipment, broadcast equipment

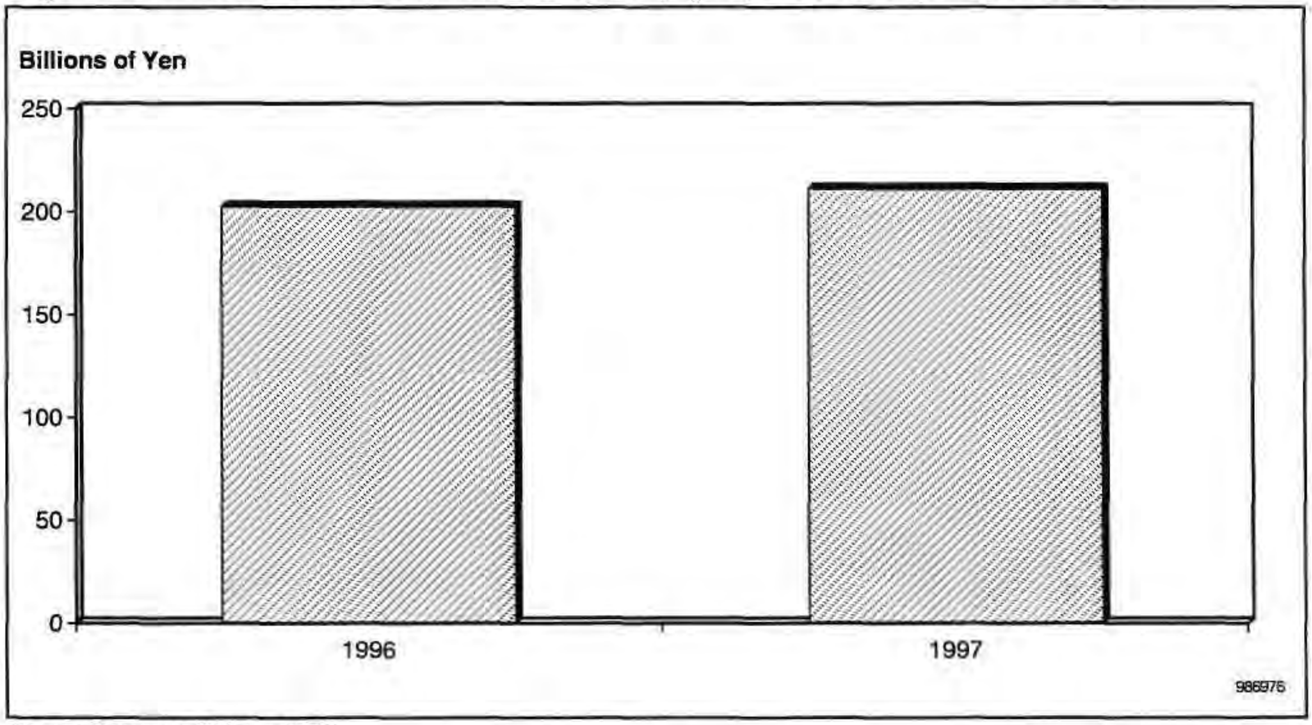
Source: Dataquest (October 1998)

Figure 4-10
Fujitsu's 1997 Worldwide Electronic Equipment Production Revenue by Application



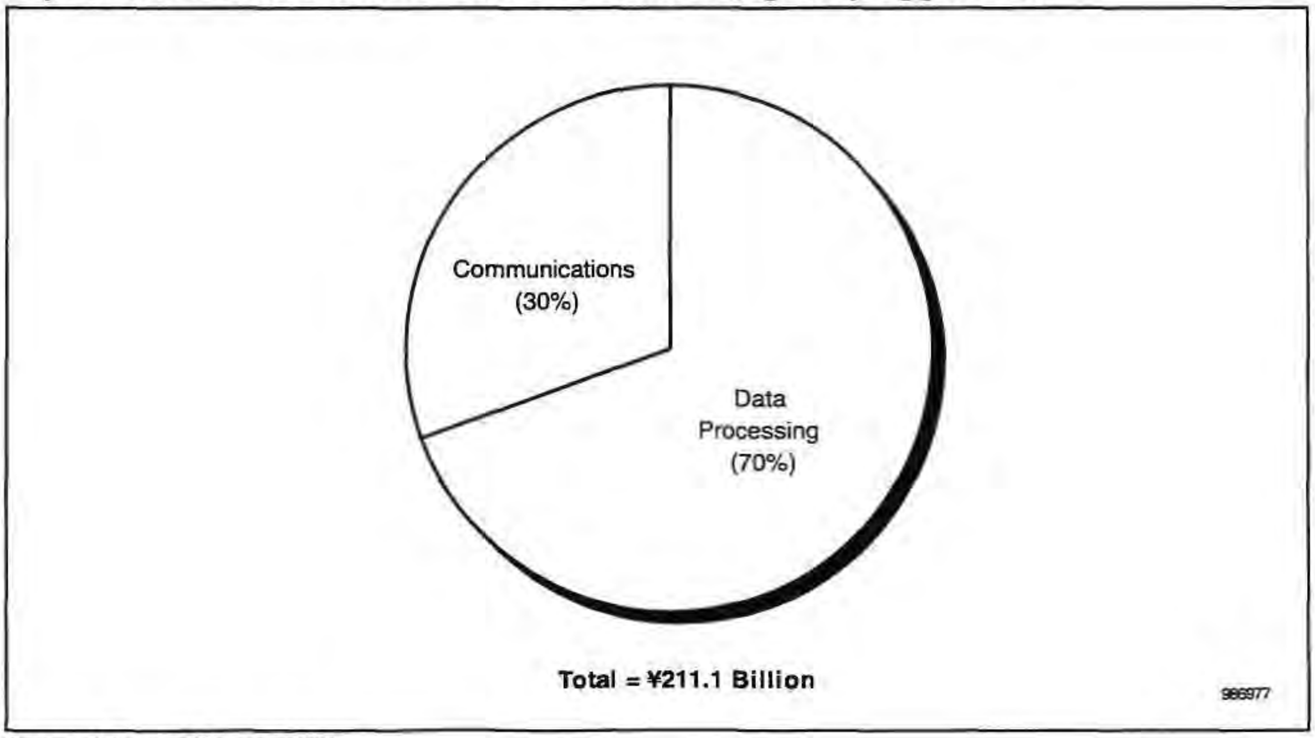
Source: Dataquest (October 1998)

Figure 4-11
Fujitsu's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-12
Fujitsu's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Hitachi Ltd.

Hitachi is a typical Japanese "general electric" company, having its basis on heavy-industry electric equipment and having a wide range of product offerings. Computers and communications are contributing to corporate profits. Data processing and communications products have large shares of semiconductor purchasing.

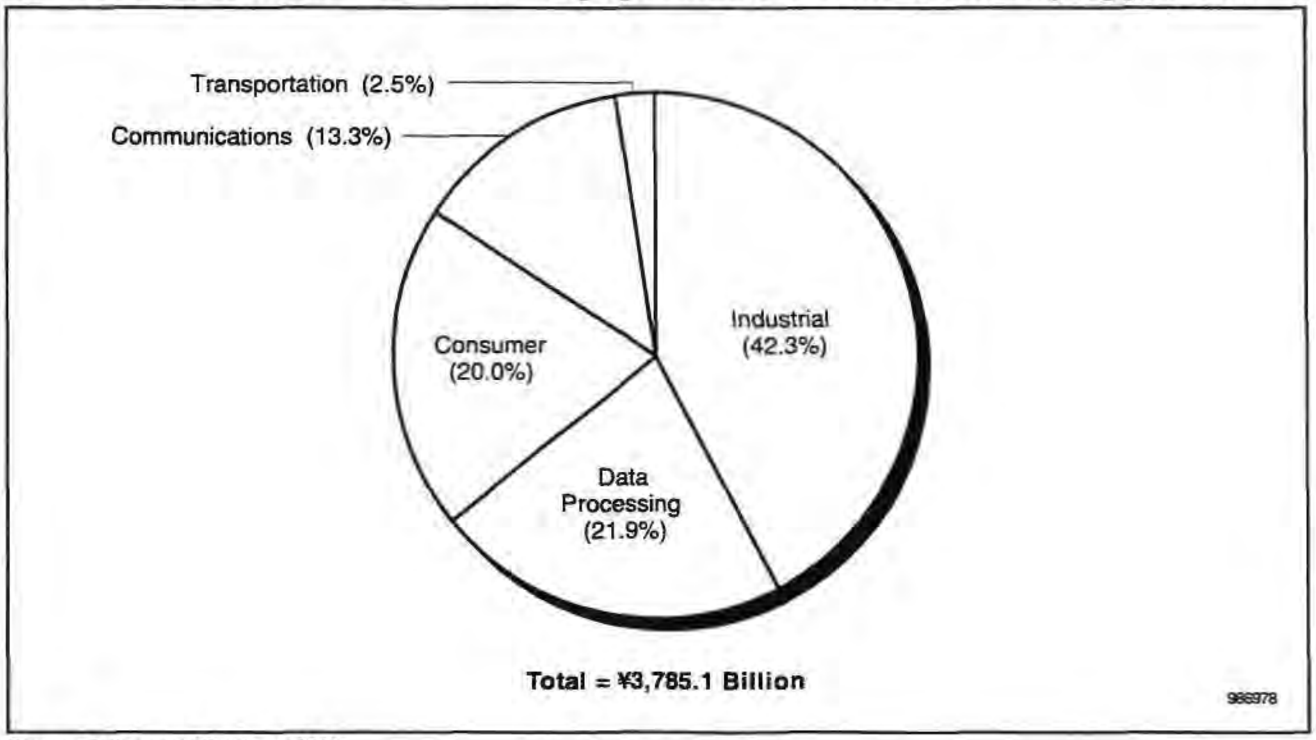
Table 4-5 shows Hitachi's major electronic products. Figures 4-13 through 4-15 show Hitachi's equipment production and semiconductor purchase trends.

Table 4-5
Hitachi's Major Electronic Products

Application	Products
Data Processing	PCs, workstations, mainframe computers, midrange computers, flexible disk drives, rigid disk drives, displays, terminals, laser beam printers, other printers, word processors, copiers
Communications	Corded phones, cordless phones, cellular phones, multifunction, faxes, modems, PBX equipment, transmission equipment, broadcast equipment
Consumer	TVs, set-top boxes, VCRs, camcorders, CD players, appliances
Industrial	Manufacturing systems, test and measuring equipment, medical equipment

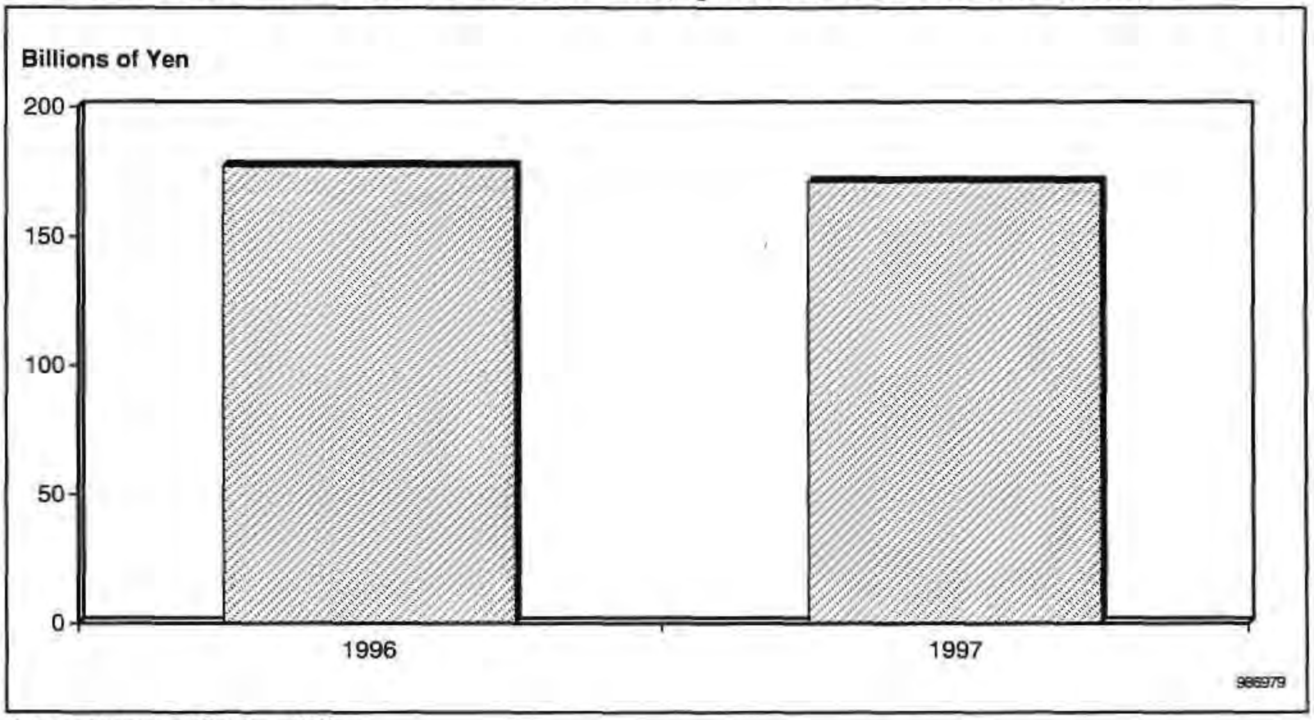
Source: Dataquest (October 1998)

Figure 4-13
Hitachi's 1997 Worldwide Electronic Equipment Production Revenue by Application



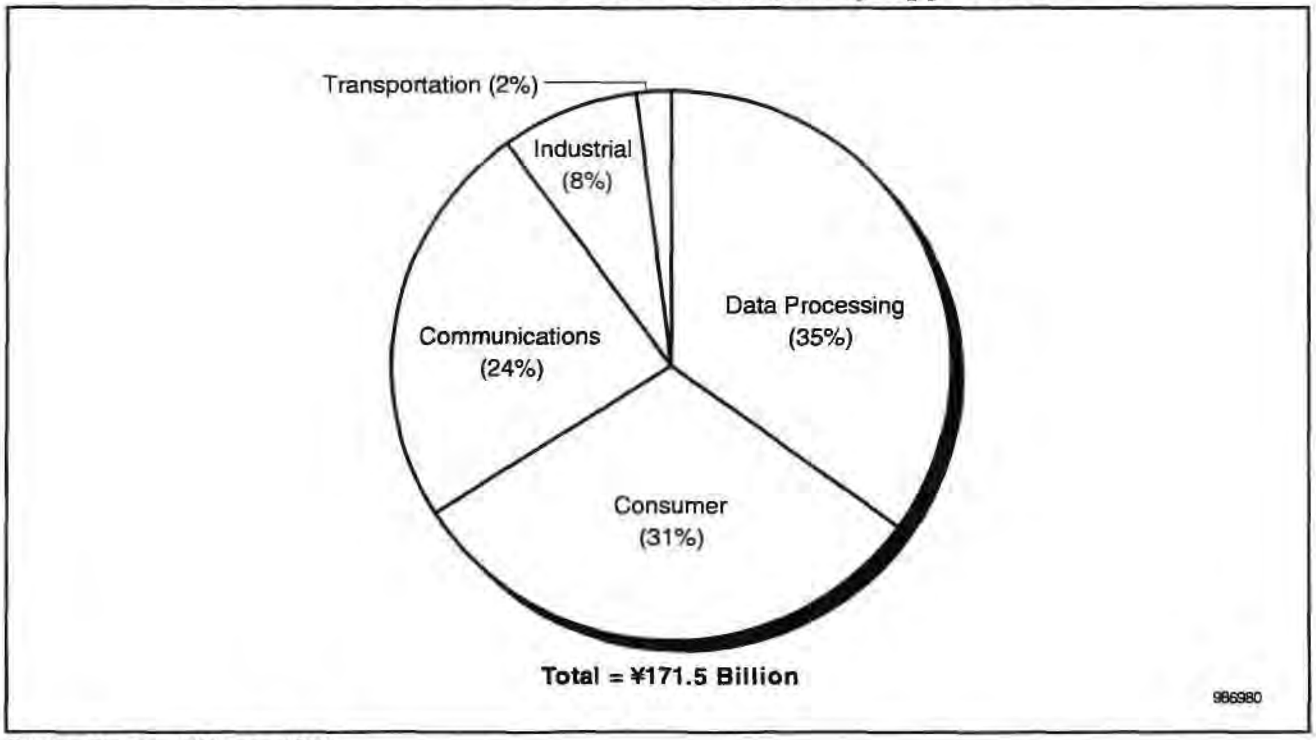
Source: Dataquest (October 1998)

Figure 4-14
Hitachi's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-15
Hitachi's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Kyushu Matsushita Electric Co. Ltd.

Kyushu Matsushita has focused on the data processing, communications, and industrial areas, including factory automation (FA) equipment. One-half of its products are exported, while cordless phones are increasing in production targeted at both the domestic and overseas markets. In the FA area, the company has a wide coverage, including chip mounters. The majority of its semiconductor purchasing is in communications and peripheral equipment for export markets.

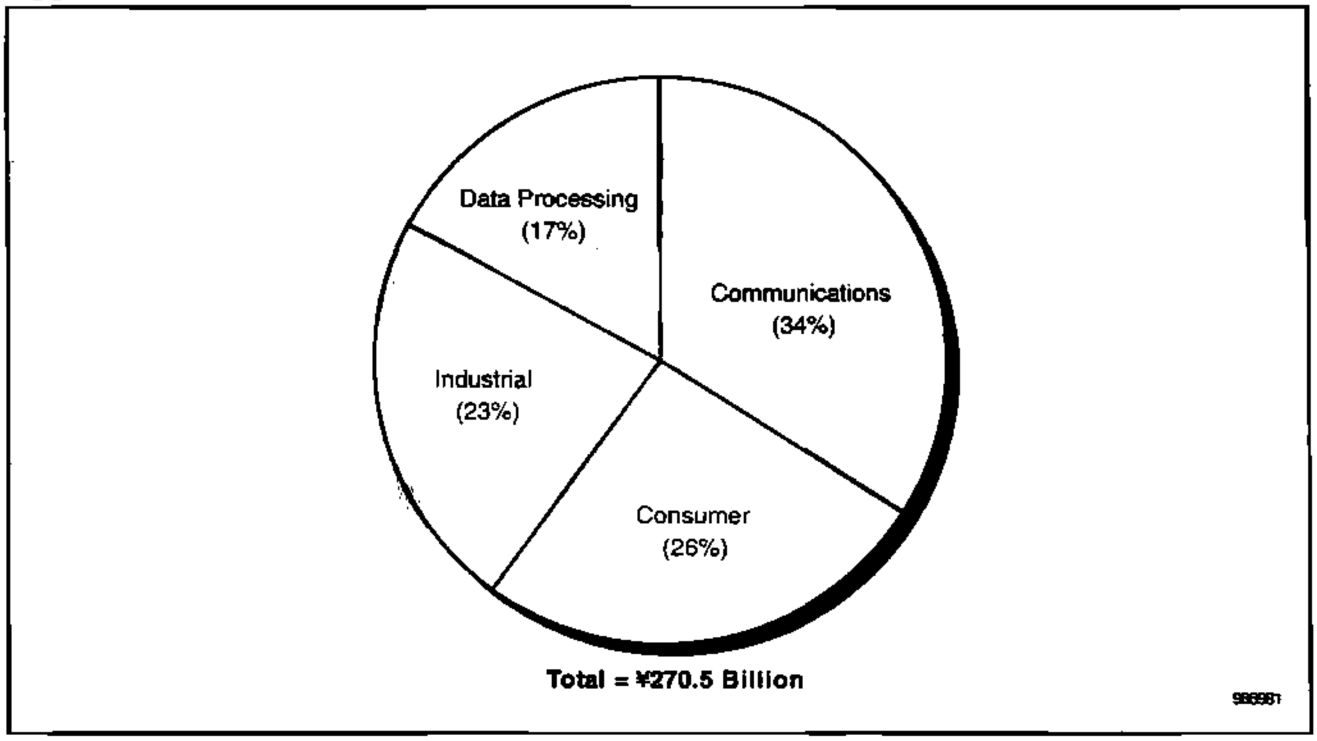
Table 4-6 shows Kyushu Matsushita's major electronic products. Figures 4-16 through 4-18 show Kyushu Matsushita's equipment production and semiconductor purchase trends.

Table 4-6
Kyushu Matsushita's Major Electronic Products

Application	Products
Data Processing	Laser beam printers, word processors
Communications	Corded phones, cordless phones, PHSs, fax machines
Transportation	Navigation equipment

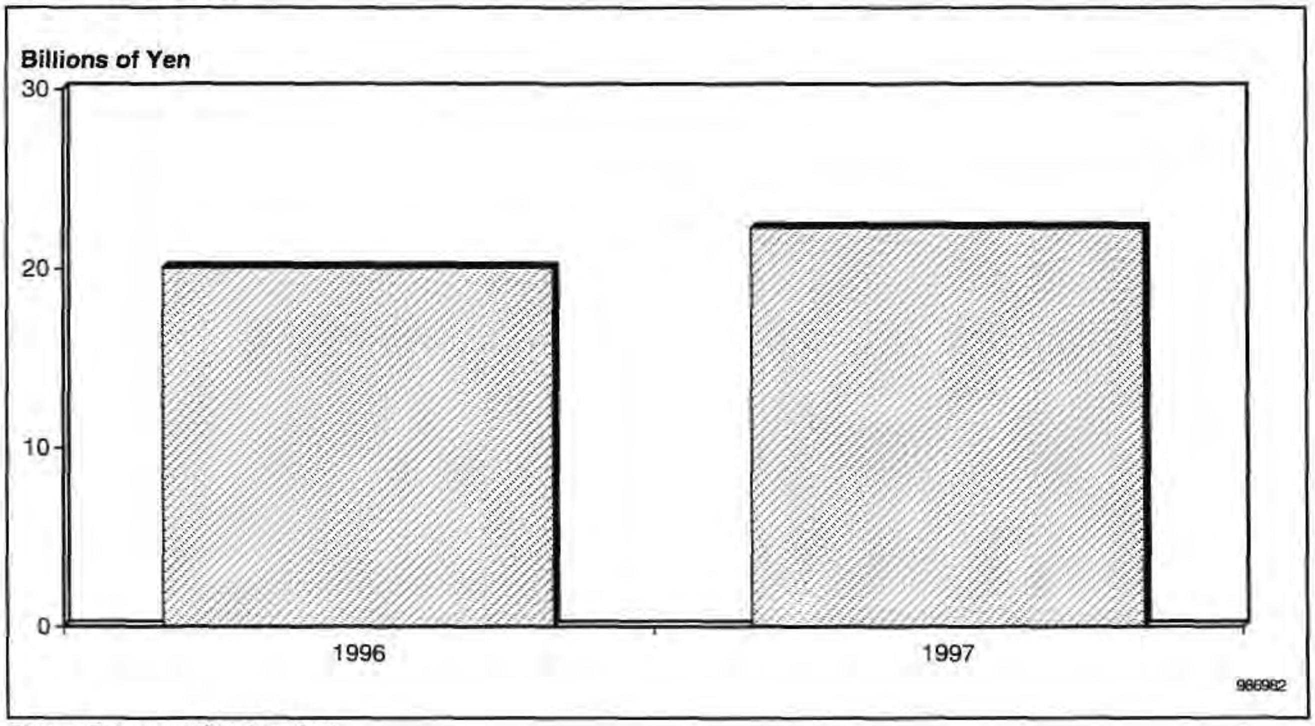
Source: Dataquest (October 1998)

Figure 4-16
Kyushu Matsushita's 1997 Worldwide Electronic Equipment Production Revenue by Application



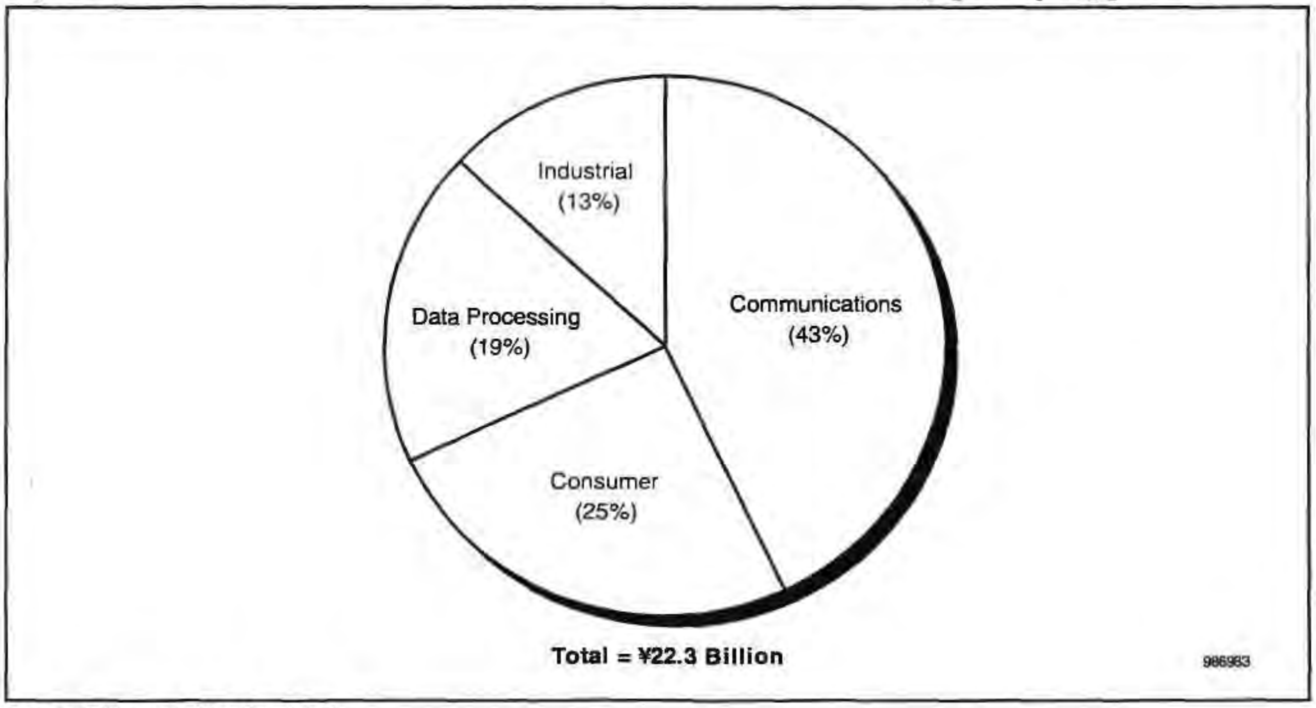
Source: Dataquest (October 1998)

Figure 4-17
Kyushu Matsushita's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-18
Kyushu Matsushita's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Matsushita Electric Industrial Company Ltd.

Matsushita Electric had a difficult year in 1997. In the consumer area, audio/video equipment experienced steady sales, helped by MD and digital video equipment, while the sales of appliances such as air conditioners and refrigerators decreased. On the other hand, communications equipment experienced an increase in revenue. Contributing to that growth were fax machines, cordless phones, PDCs, and broadcasting equipment that grew with increasing sales of the new digital video format (DVCPRO) products. The majority of Matsushita's semiconductor purchasing is in consumer applications, while the highest growth rate in its semiconductor purchasing was recorded in communications.

Table 4-7 shows Matsushita Electric's major electronic products. Figures 4-19 through 4-21 show Matsushita Electric's equipment production and semiconductor purchase trends.

Table 4-7
Matsushita Electric's Major Electronic Products

Application	Products
Data Processing	PCs, workstations, displays, terminals, printers, word processors, DVD-ROM/RAMs, CD-ROMs
Communications	Cordless phones, broadcasting equipment, fax machines
Consumer	TVs, set-top boxes, VCRs, camcorders, CD players, appliances, DVD players, minidiscs, digital video cameras, digital still cameras
Industrial	Manufacturing systems, test and measuring equipment
Transportation	Navigation systems, car stereos

Source: Dataquest (October 1998)

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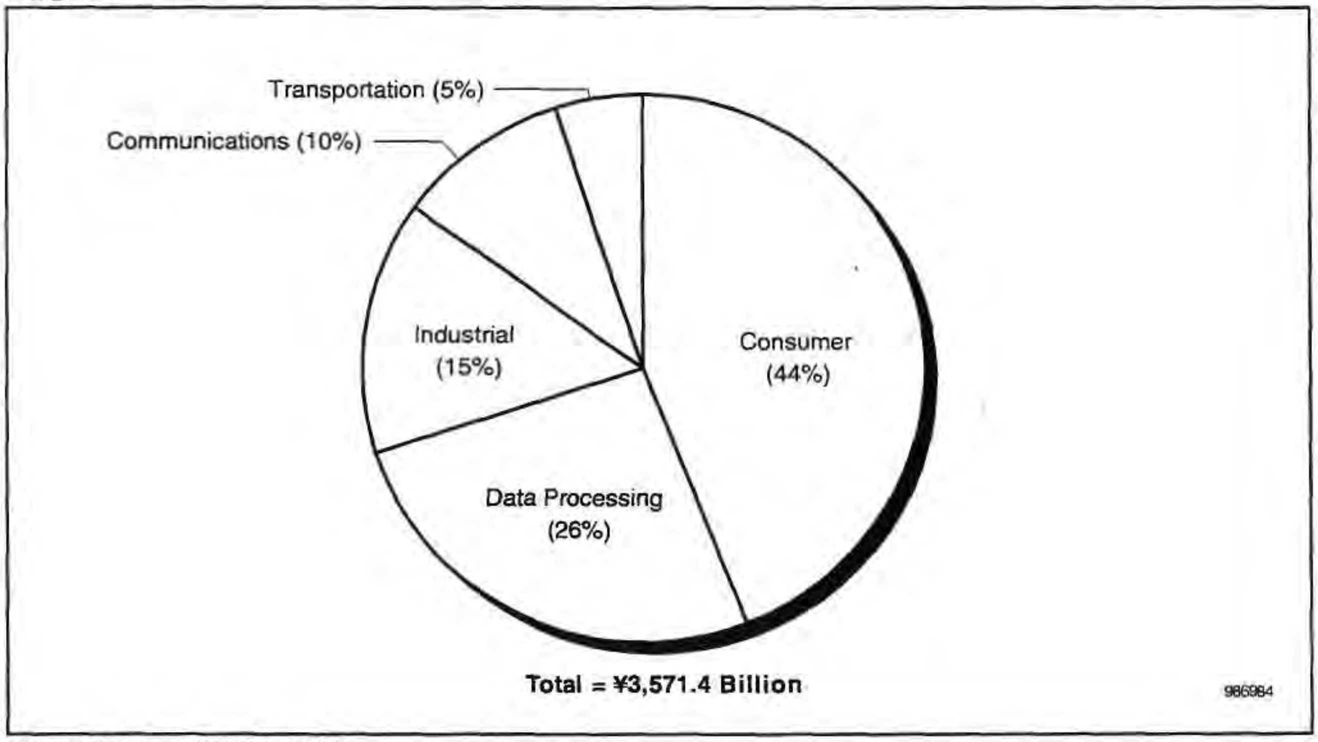
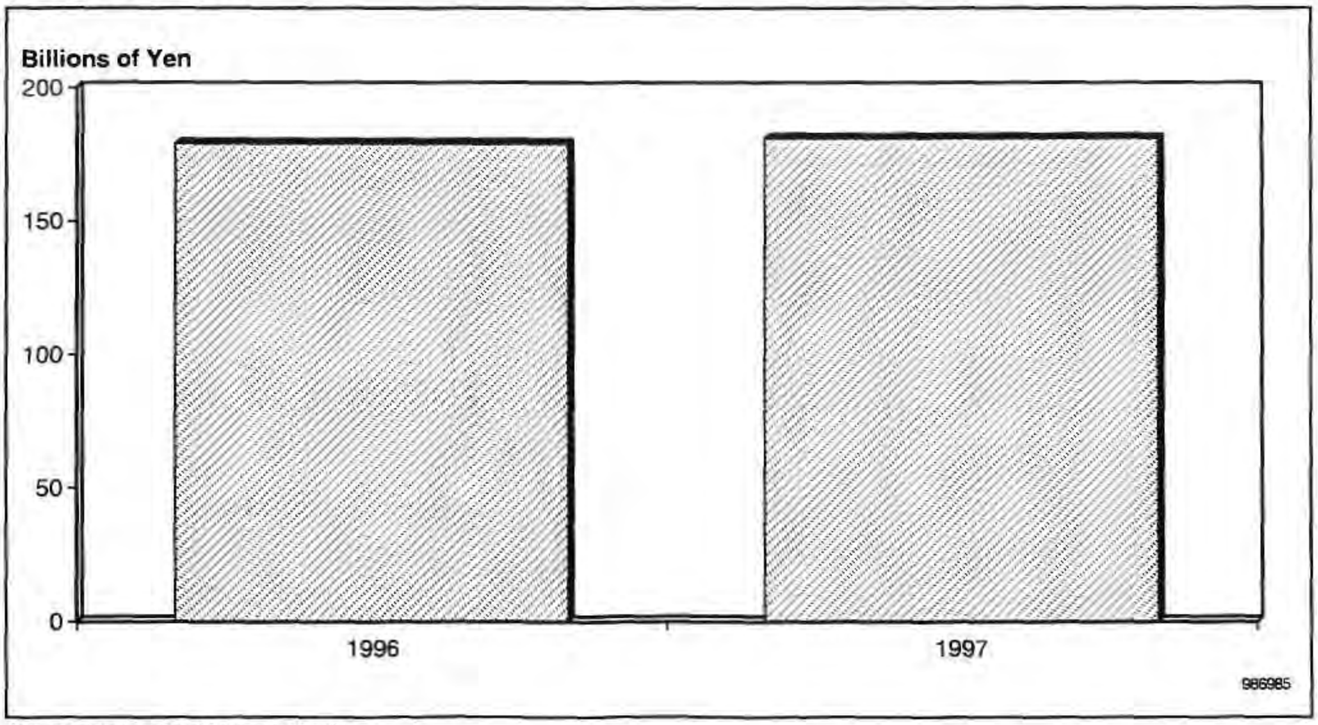
Figure 4-19
Matsushita Electric's 1997 Worldwide Electronic Equipment Production Revenue by Application



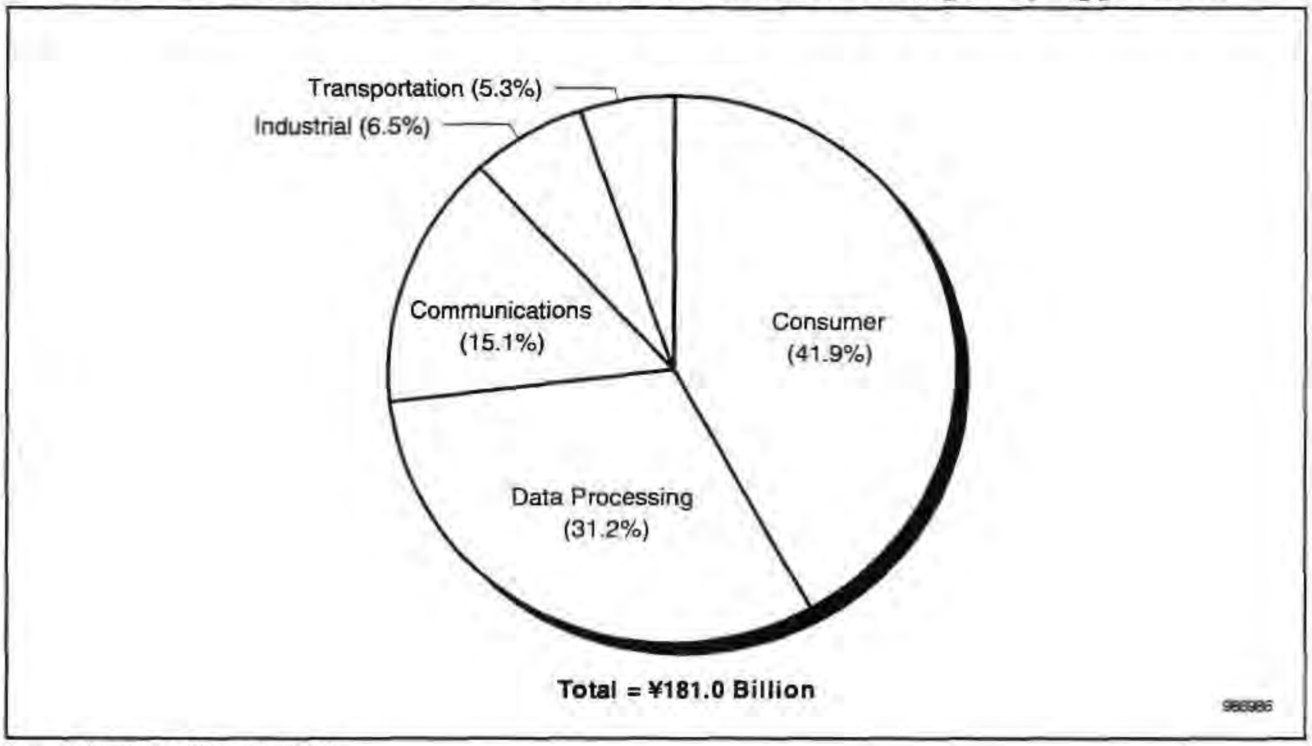
Source: Dataquest (October 1998)

Figure 4-20
Matsushita Electric's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-21
Matsushita Electric's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Matsushita Communication Industrial Co. Ltd.

Nearly one-half of Matsushita Communication's sales comes from communications equipment, including digital cellular phones for NTT DoCoMo. While the overall Japanese economy is in recession, Matsushita Communication's business has a clear focus on the growing sector of communications, showing a large increase in semiconductor purchasing, too.

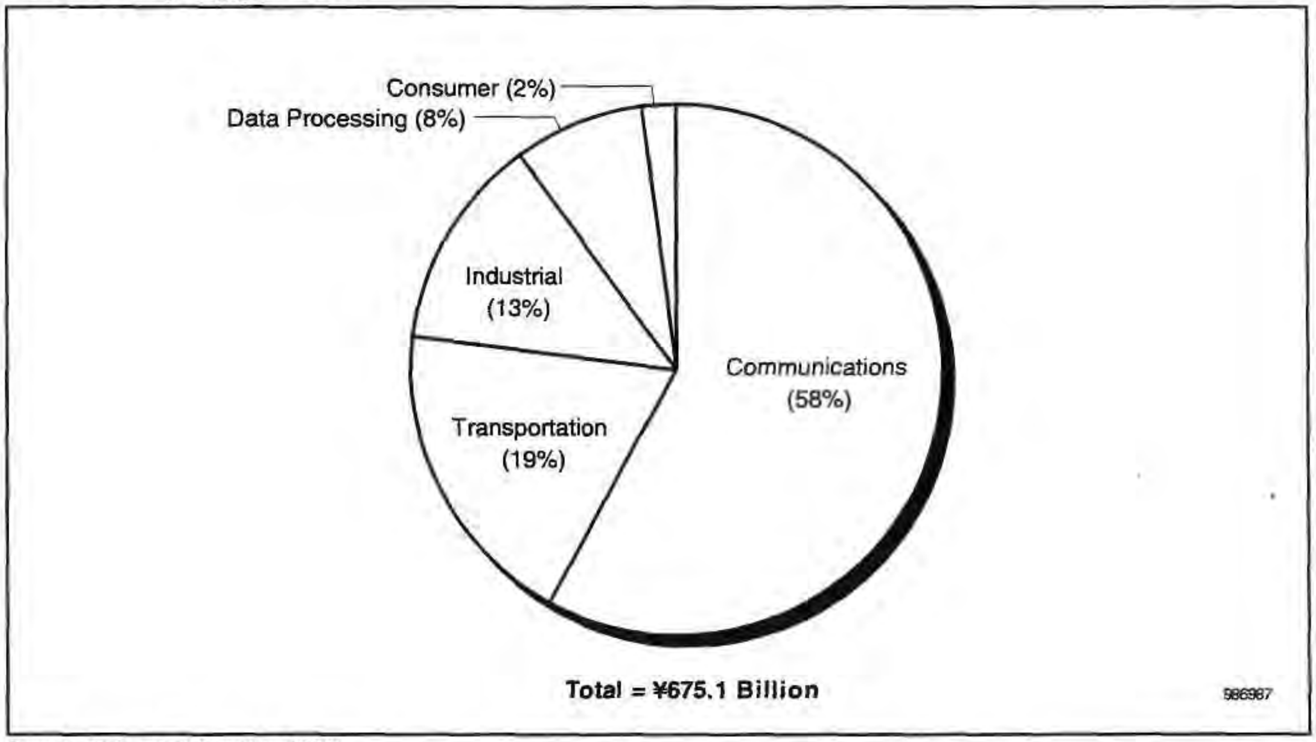
Table 4-8 shows Matsushita Communication's major electronic products. Figures 4-22 through 4-24 show Matsushita Communication's equipment production and semiconductor purchase trends.

Table 4-8
Matsushita Communication's Major Electronic Products

Application	Products
Data Processing	Flexible disk drives
Communications	Cordless phones, multifunction phones, PHSs, cellular phones, pagers, modems, PBX equipment, transmission equipment, broadcast equipment
Industrial	Test and measurement equipment
Transportation	Navigation systems, car stereos

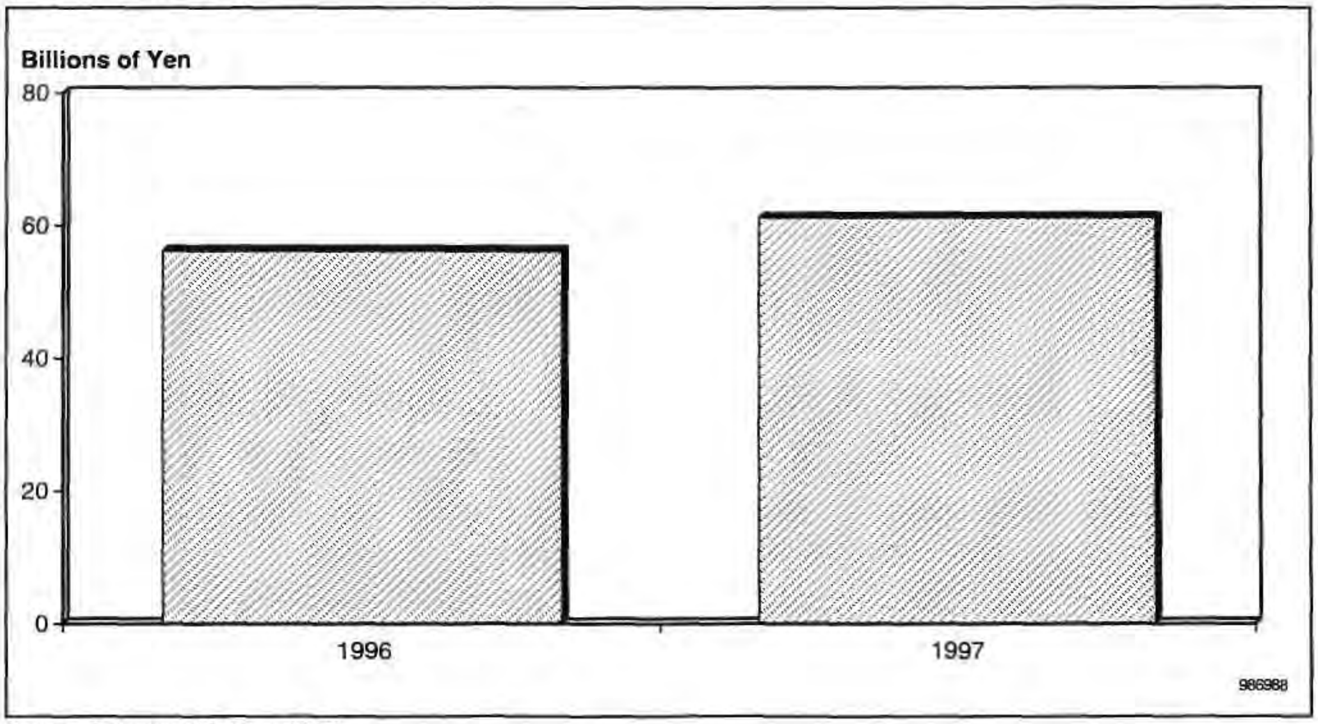
Source: Dataquest (October 1998)

Figure 4-22
Matsushita Communication's 1997 Worldwide Electronic Equipment Production Revenue by Application



Source: Dataquest (October 1998)

Figure 4-23
Matsushita Communication's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

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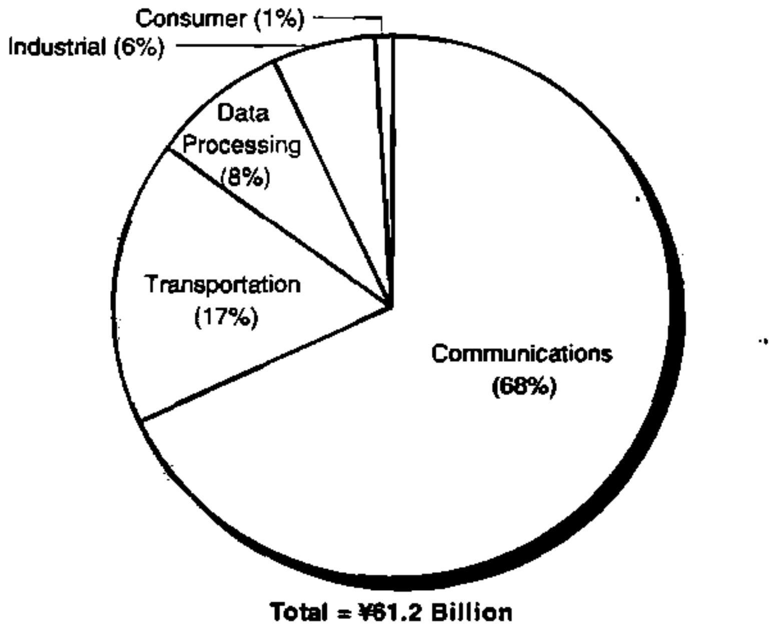
Figure 4-24
Matsushita Communication's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Matsushita Kotobuki Electronics Industries Ltd.

Matsushita Kotobuki has strength in storage devices such as CD-ROM, CD-R, and the emerging DVD-RAM, as well as in consumer appliances and industrial equipment. The majority of its semiconductor purchasing is in consumer equipment.

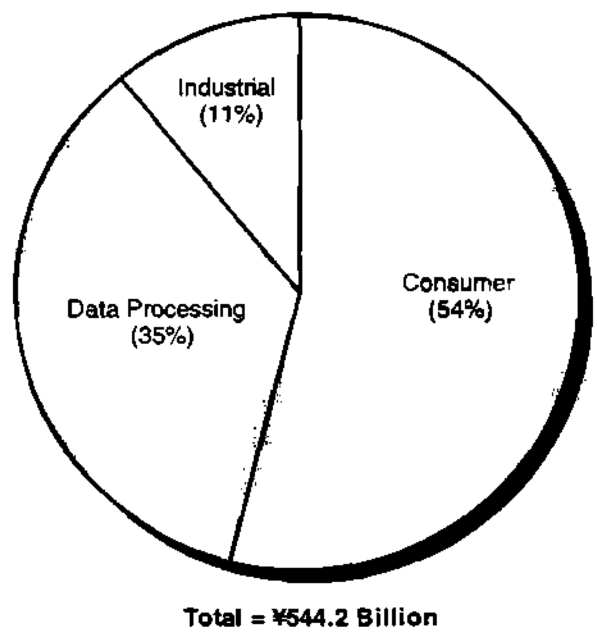
Table 4-9 shows Matsushita Kotobuki's major electronic products. Figures 4-25 through 4-27 show Matsushita Kotobuki's equipment production and semiconductor purchase trends.

Table 4-9
Matsushita Kotobuki's Major Electronic Products

Application	Products
Data Processing	Rigid disk drives, CD-ROMs
Consumer	TVs, VCRs, camcorders, CD players
Industrial	Manufacturing systems

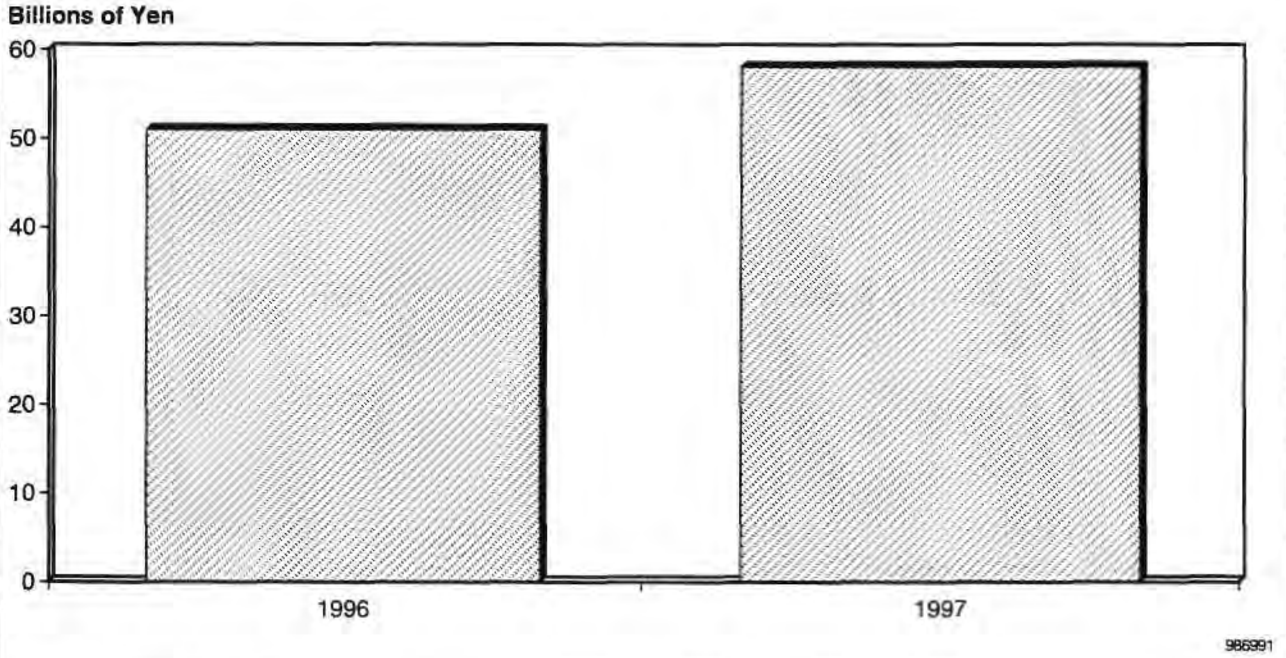
Source: Dataquest (October 1998)

Figure 4-25
Matsushita Kotobuki's 1997 Worldwide Electronic Equipment Production Revenue by Application



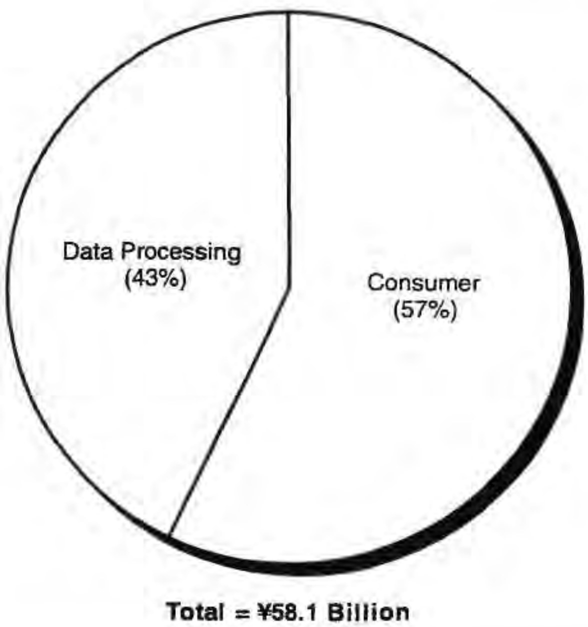
Source: Dataquest (October 1998)

Figure 4-26
Matsushita Kotobuki's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-27
Matsushita Kotobuki's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Mitsubishi Electric Corporation

Mitsubishi Electric is the third-largest "general electric" company in Japan; its products range from data processing, communications, and consumer, to heavy electric and industrial products. It experienced growth in wired communications and data processing, helped by the systems integration business. However, the decline in sales in appliances, heavy electric products, and industrial products brought the overall sales down. Data processing has the largest share of semiconductor purchasing, while the largest gain was seen in communications and the largest loss was felt in the consumer segment.

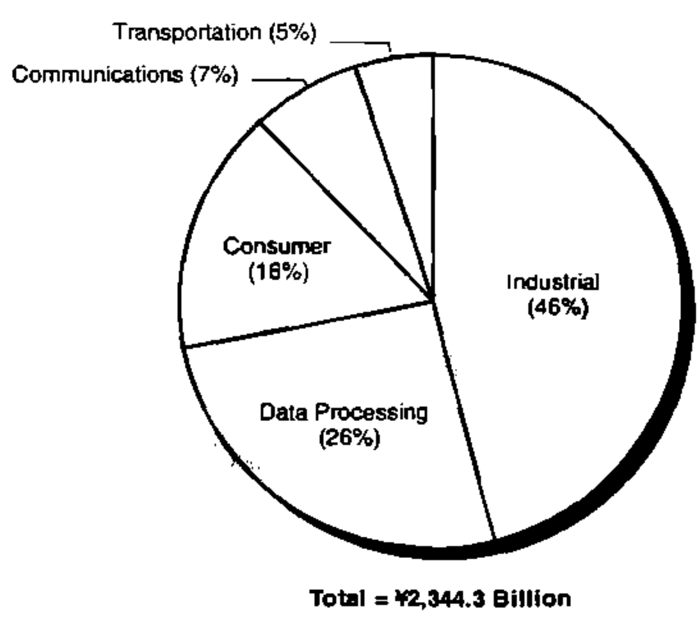
Table 4-10 shows Mitsubishi Electric's major electronic products. Figures 4-28 through 4-30 show Mitsubishi Electric's equipment production and semiconductor purchase trends.

Table 4-10
Mitsubishi Electric's Major Electronic Products

Application	Products
Data Processing	PCs, midrange computers, flexible disk drives, displays, terminals, laser beam printers, other printers, word processors, calculators
Communications	Corded phones, cordless phones, PHSs, cellular phones, pagers, fax machines, modems, transmission equipment, broadcast equipment
Consumer	TVs, VCRs, camcorders, CD players, appliances
Industrial	Manufacturing systems, test and measuring equipment, medical equipment
Transportation	Navigation systems, car stereos

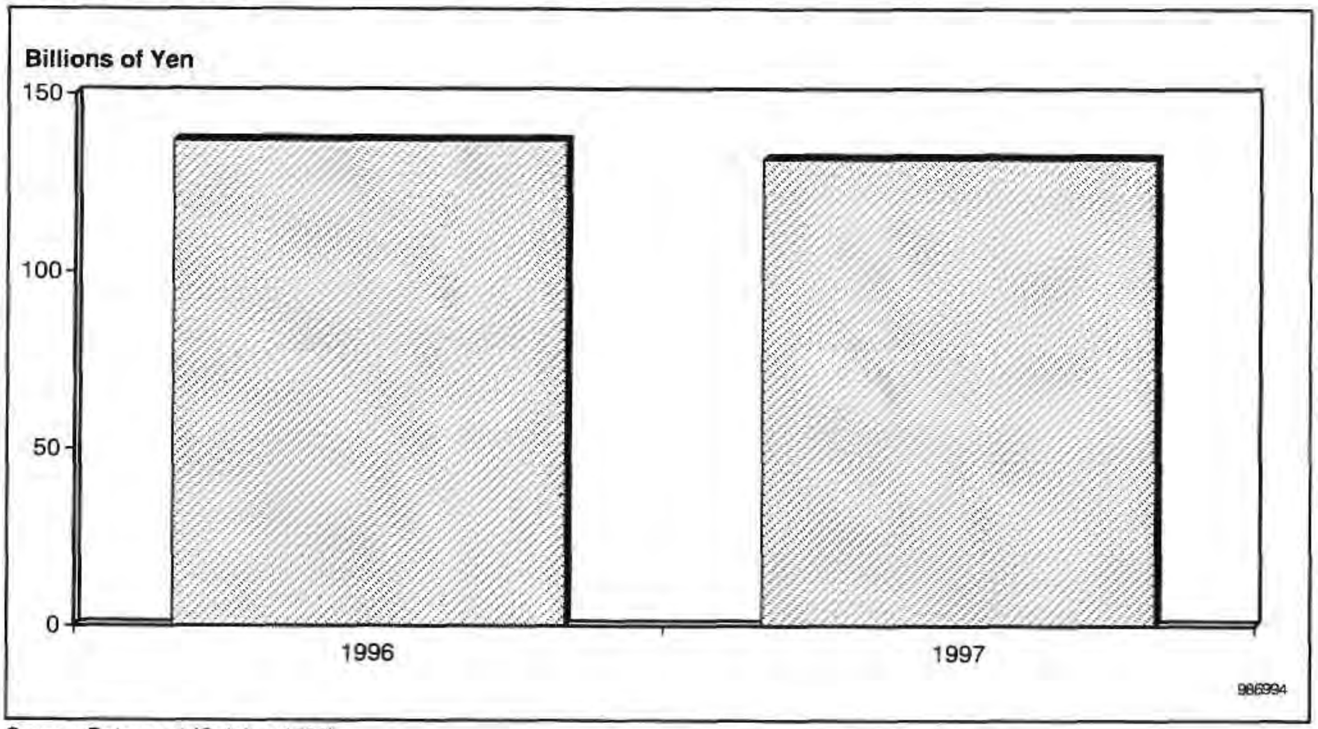
Source: Dataquest (October 1998)

Figure 4-28
Mitsubishi Electric's 1997 Worldwide Electronic Equipment Production Revenue by Application



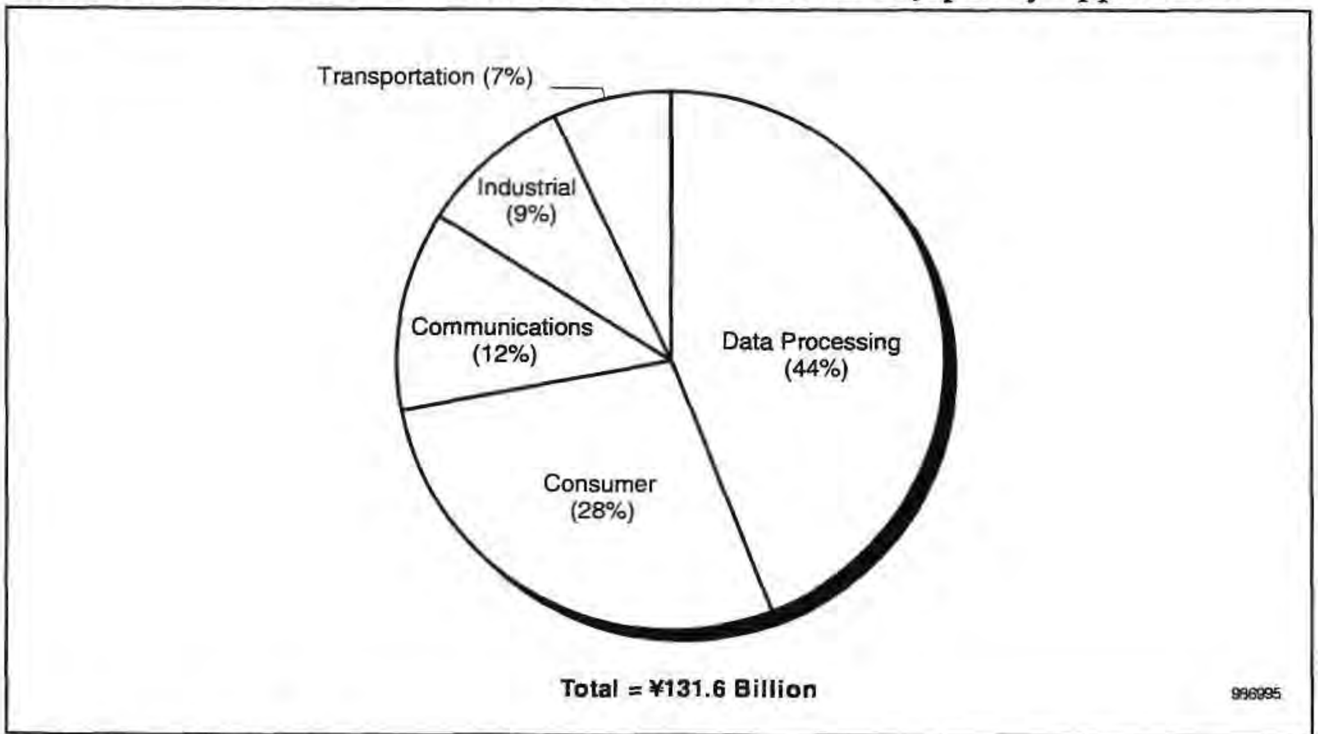
Source: Dataquest (October 1998)

Figure 4-29
Mitsubishi Electric's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-30
Mitsubishi Electric's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

NEC Corporation

NEC's core business has been in the communications area, while it leads the Japanese computer industry as well. The infrastructure equipment market in various Asian countries brought increases in communications equipment production and sales as well as in domestic NTT infrastructure equipment production. NEC was positioned as the second-largest company in terms of Japanese digital cellular phone market share in 1997.

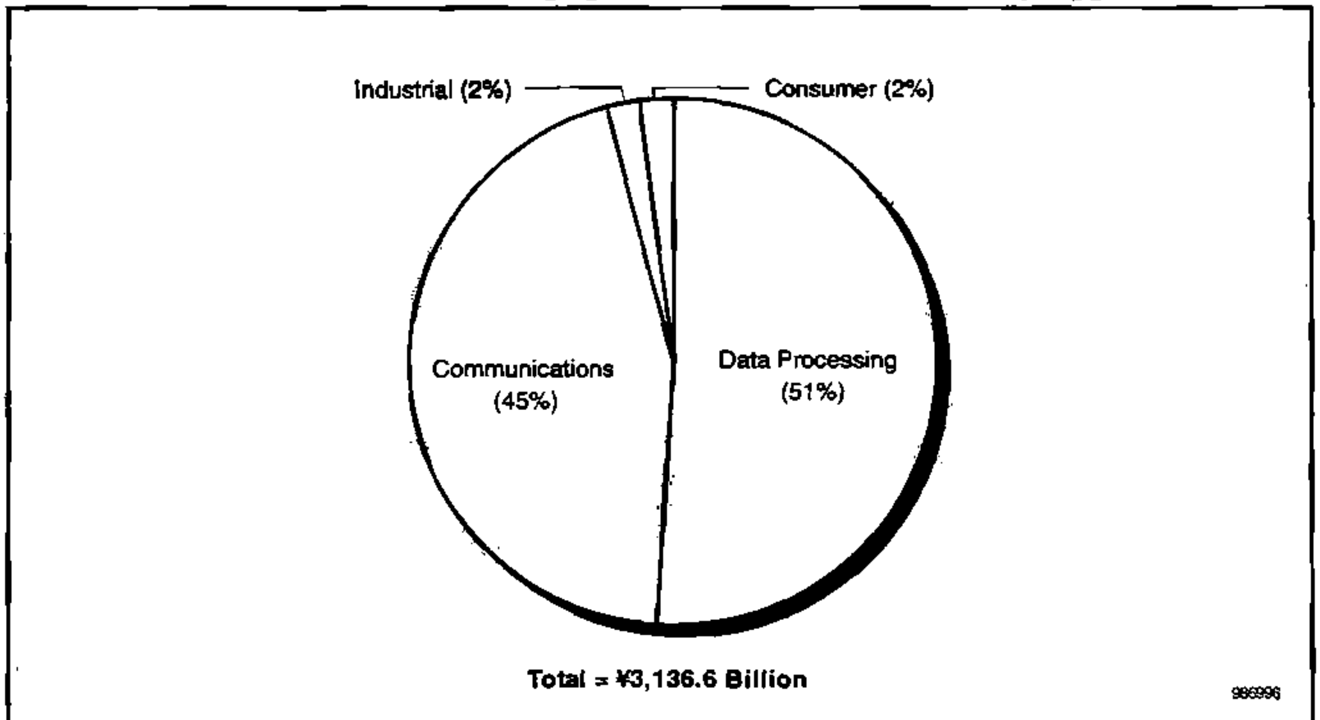
Table 4-11 shows NEC's major electronic products. Figures 4-31 through 4-33 show NEC's equipment production and semiconductor purchase trends.

Table 4-11
NEC's Major Electronic Products

Application	Products
Data Processing	PCs, workstations, mainframe computers, midrange computers, flexible disk drives, rigid disk drives, displays, terminals, laser beam printers, other printers, word processors
Communications	Corded phones, cordless phones, multifunction phones, PHSs, cellular phones, pagers, fax machines, modems, PBX equipment, transmission equipment, broadcast equipment
Industrial	Manufacturing systems, test and measuring equipment

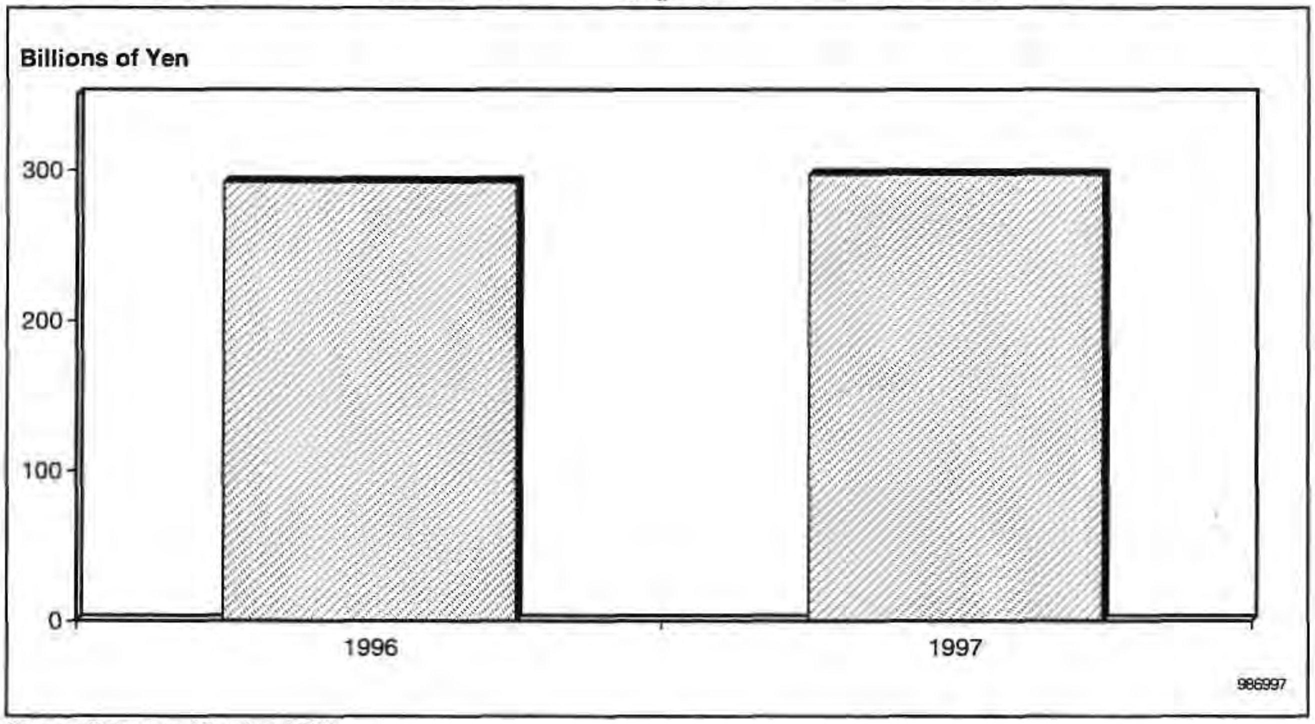
Source: Dataquest (October 1998)

Figure 4-31
NEC's 1997 Worldwide Electronic Equipment Production Revenue by Application



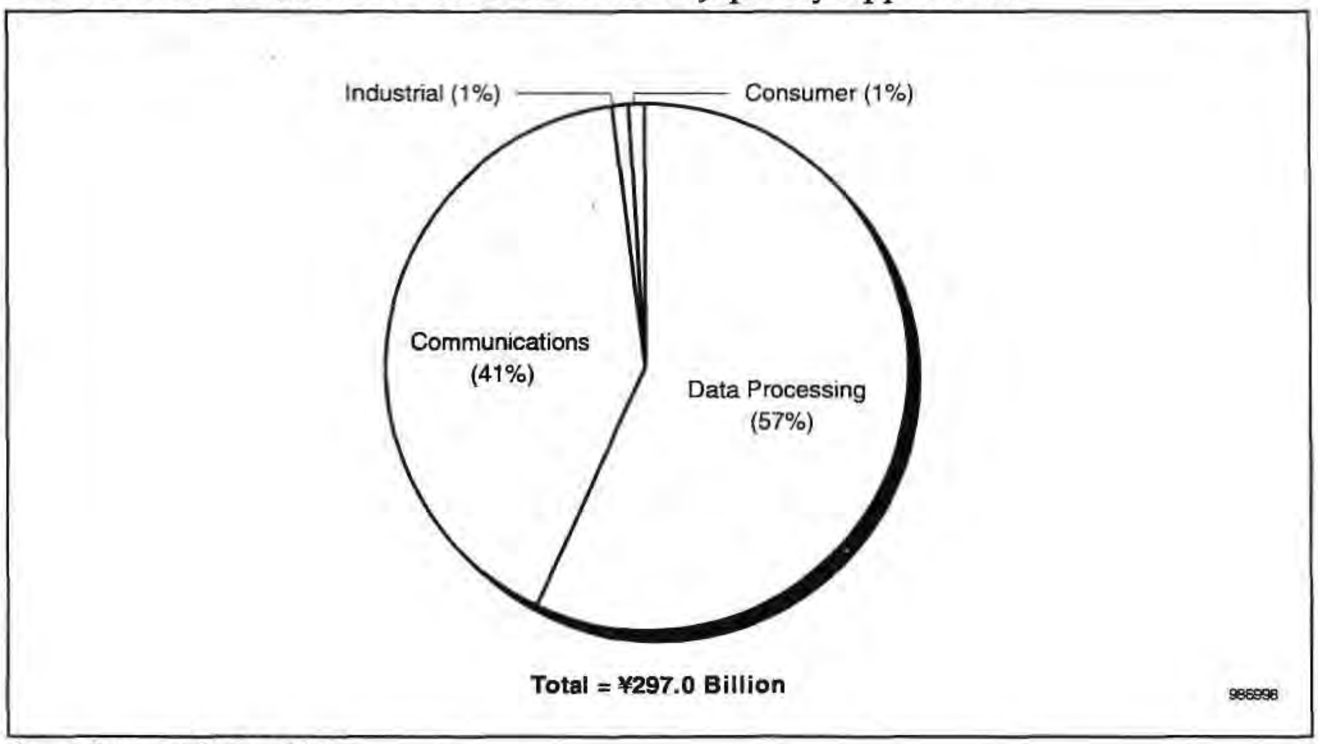
Source: Dataquest (October 1998)

Figure 4-32
NEC's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-33
NEC's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Nintendo Corporation

Nintendo boasts a wide range of product offerings in game machines, including the 8-bit Game Boy, 16-bit Super Famicon, and 64-bit Nintendo64. In particular, 8-bit machines have experienced constant expansion in market, with their portability and inexpensive pricing. Nintendo's TV games have fared better in export markets such as the United States than in the domestic market, but Nintendo's overall exports are still small in volume. Semiconductor purchasing rose because of production increases of Nintendo64s and 8-bit Game Boys with popular games such as "Pocket Monster."

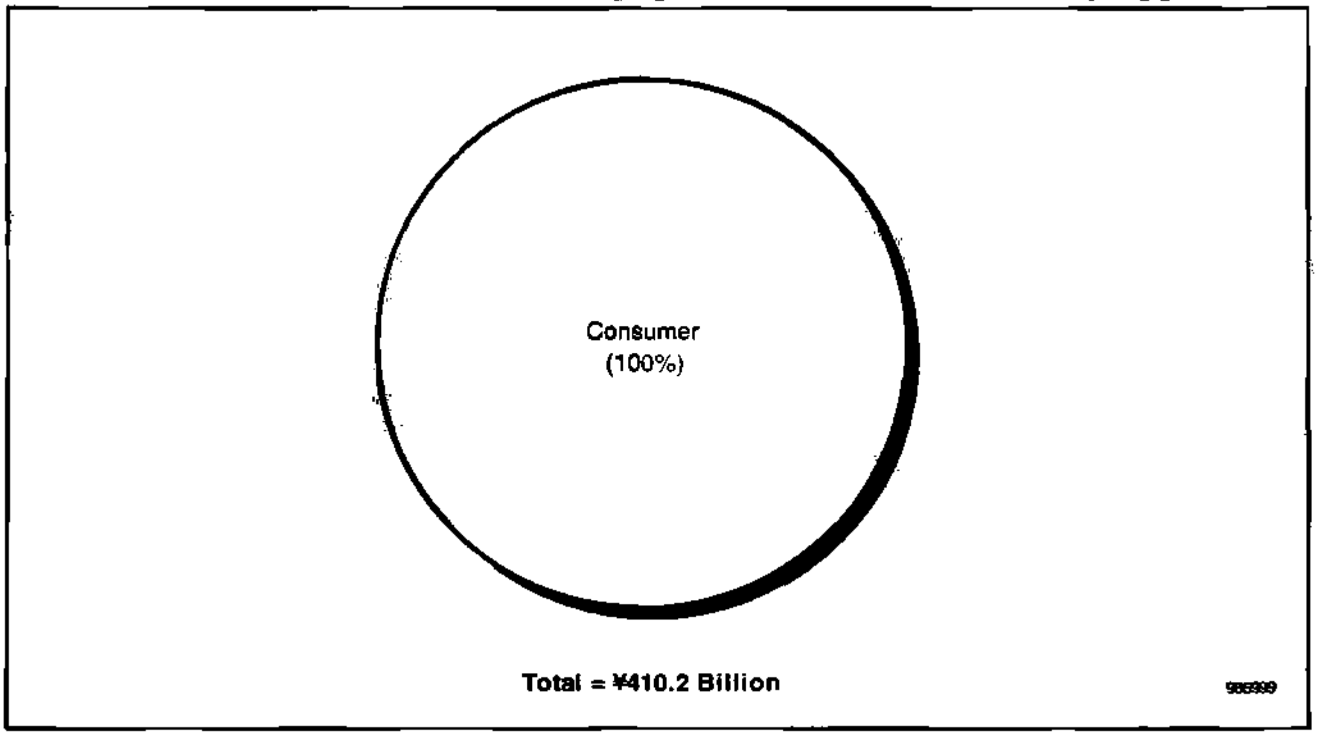
Table 4-12 shows Nintendo's major electronic products. Figures 4-34 through 4-36 show Nintendo's equipment production and semiconductor purchase trends.

Table 4-12
Nintendo's Major Electronic Products

Application	Products
Consumer	Game controllers, game cartridges

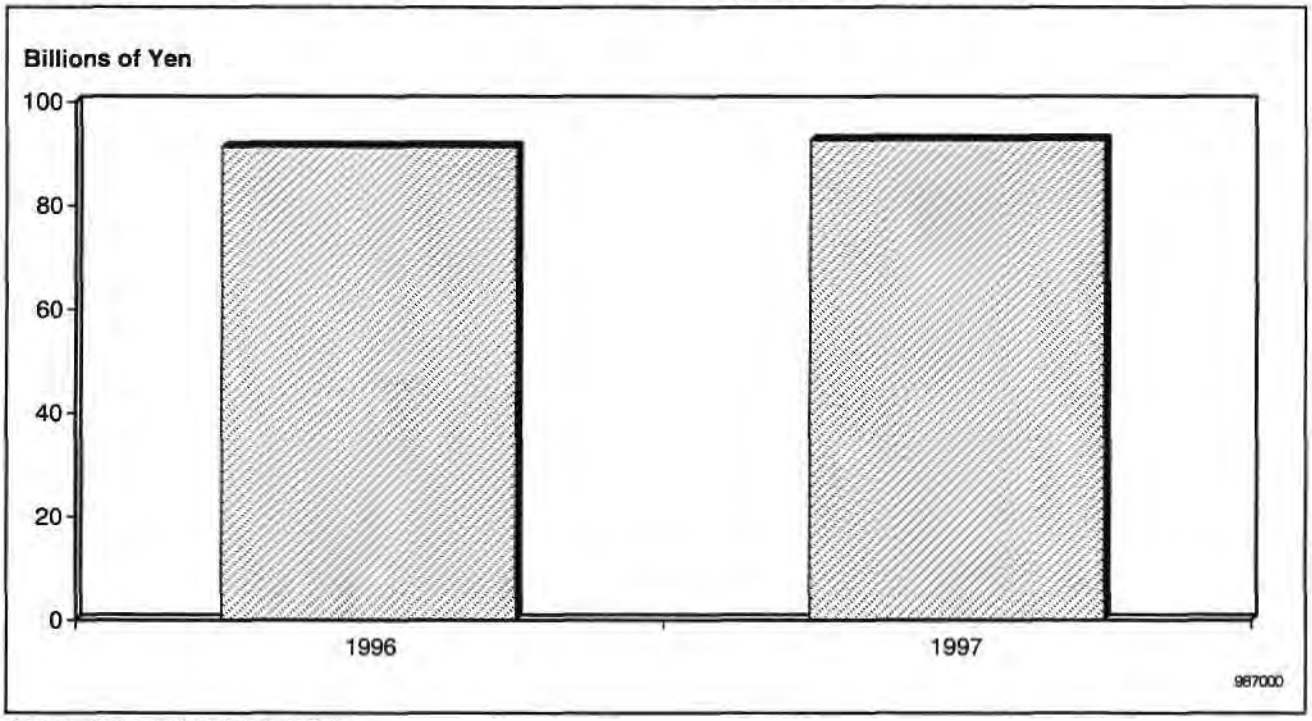
Source: Dataquest (October 1998)

Figure 4-34
Nintendo's 1997 Worldwide Electronic Equipment Production Revenue by Application



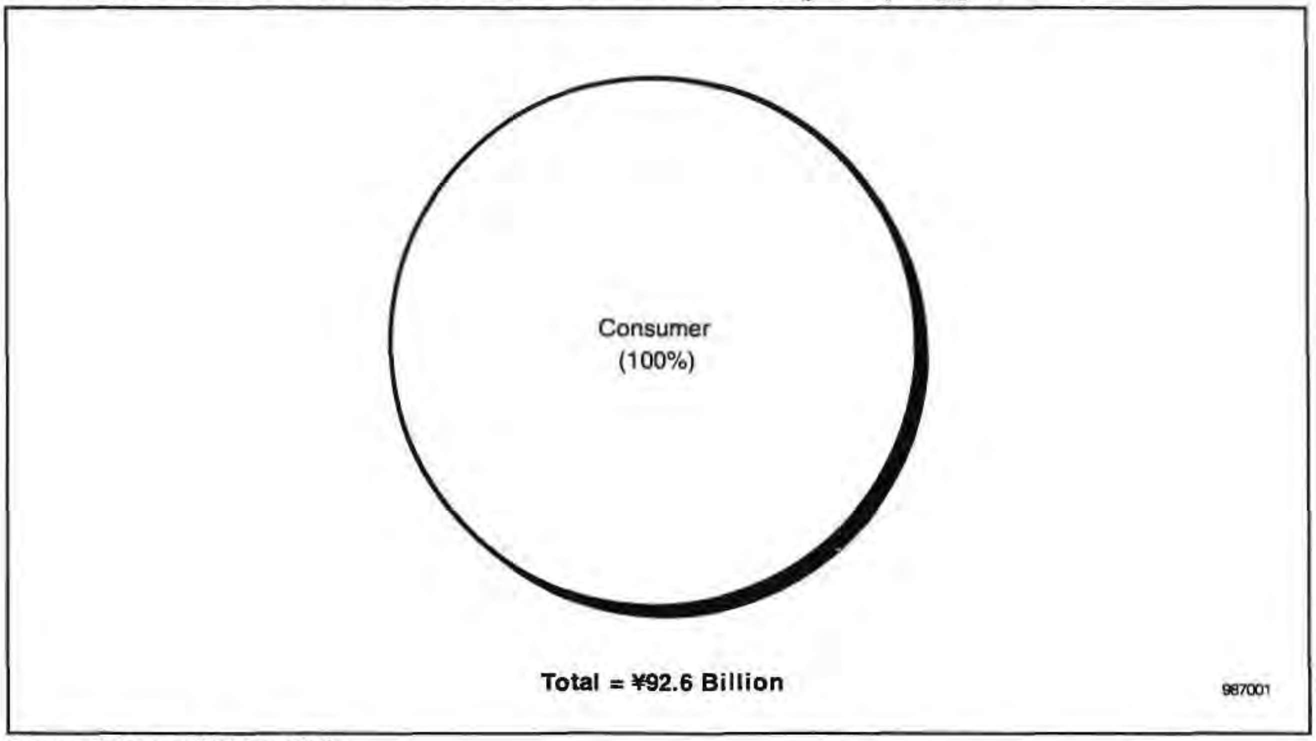
Source: Dataquest (October 1998)

Figure 4-35
Nintendo's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-36
Nintendo's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Oki Electric Industries Company Ltd.

Oki has its focus on the domestic communications market, leveraging on its strong tie with NTT. Oki also sought to expand its business in midrange computers and peripherals such as printers, but the lack of integration in product offerings brought growth only to limited segments, and Oki's overall data processing business has yet to become comparable to other leading companies in Japan.

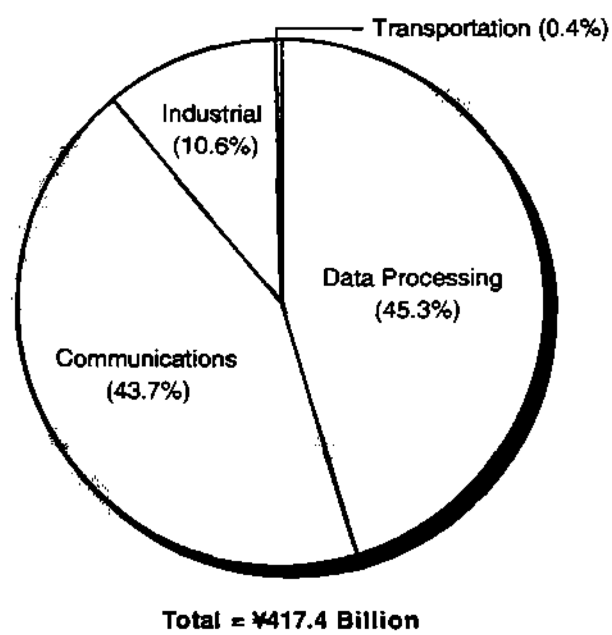
Table 4-13 shows Oki's major electronic products. Figures 4-37 through 4-39 show Oki's equipment production and semiconductor purchase trends.

Table 4-13
Oki's Major Electronic Products

Application	Products
Data Processing	PCs, workstations, midrange computers, rigid disk drives, displays, terminals, laser beam printers, other printers, word processors
Communications	Corded phones, cordless phones, multifunction phones, cellular phones, pagers, fax machines, modems, PBX equipment, transmission equipment, broadcast equipment
Industrial	Manufacturing systems, test and measuring equipment

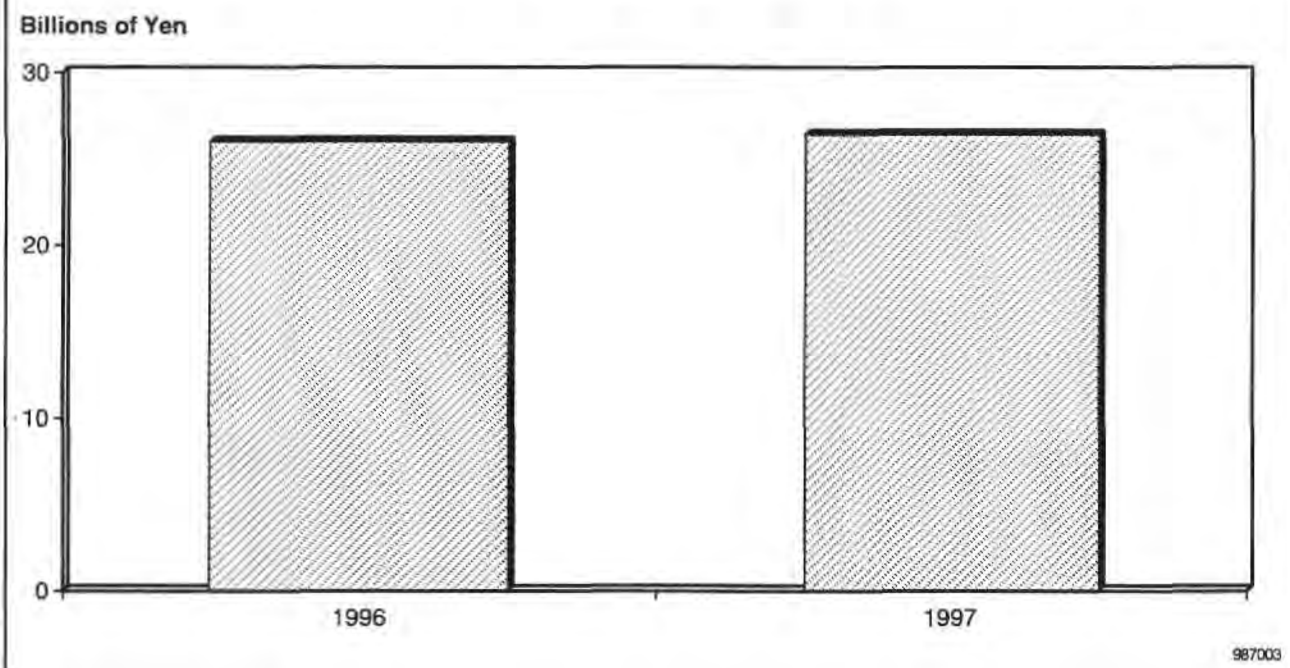
Source: Dataquest (October 1998)

Figure 4-37
Oki's 1997 Worldwide Electronic Equipment Production Revenue by Application



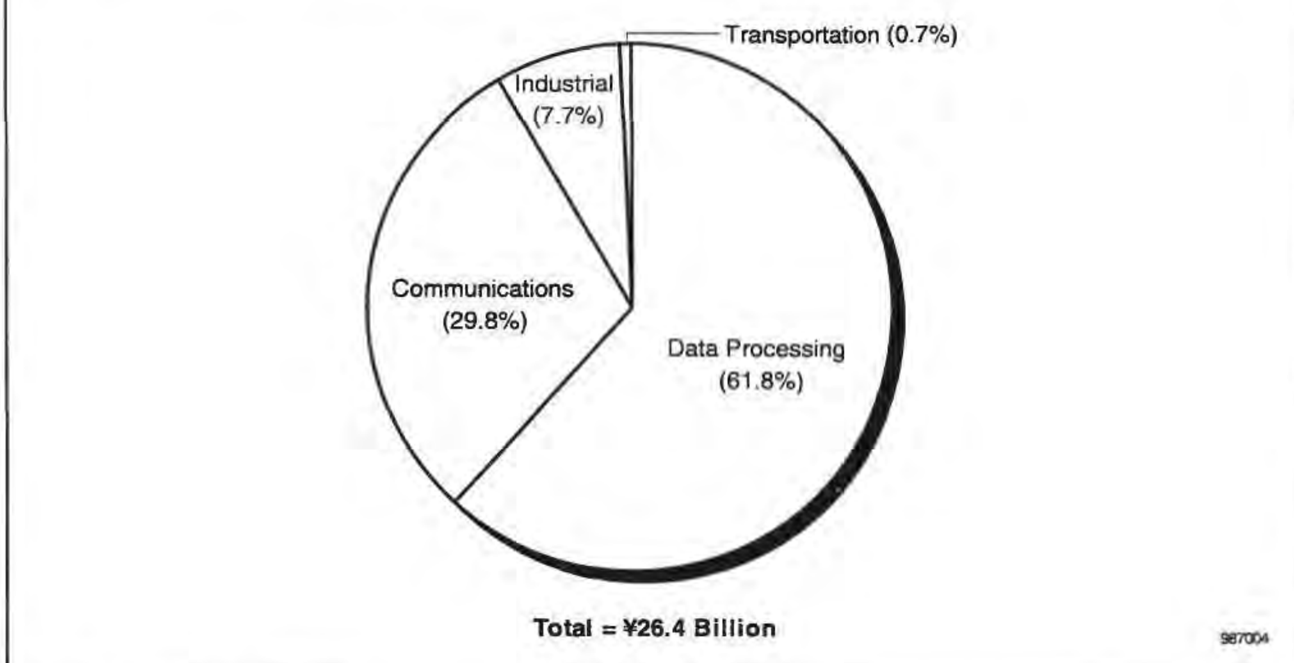
Source: Dataquest (October 1998)

Figure 4-38
Oki's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-39
Oki's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

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Pioneer Electronic Corporation

Sales declines in laser discs and karaoke systems hurt Pioneer Electronic's overall revenue, but growth was seen in DV-Cs, MDs, DVDs, and in-car navigation systems. The company's expertise in the optical disc business has encouraged it to penetrate into business-use systems and FA equipment. It is also placing new emphasis on the video business. Pioneer Electronic also has unique product lines in cellular phones and cordless phones, but the business sizes of those areas have yet to grow.

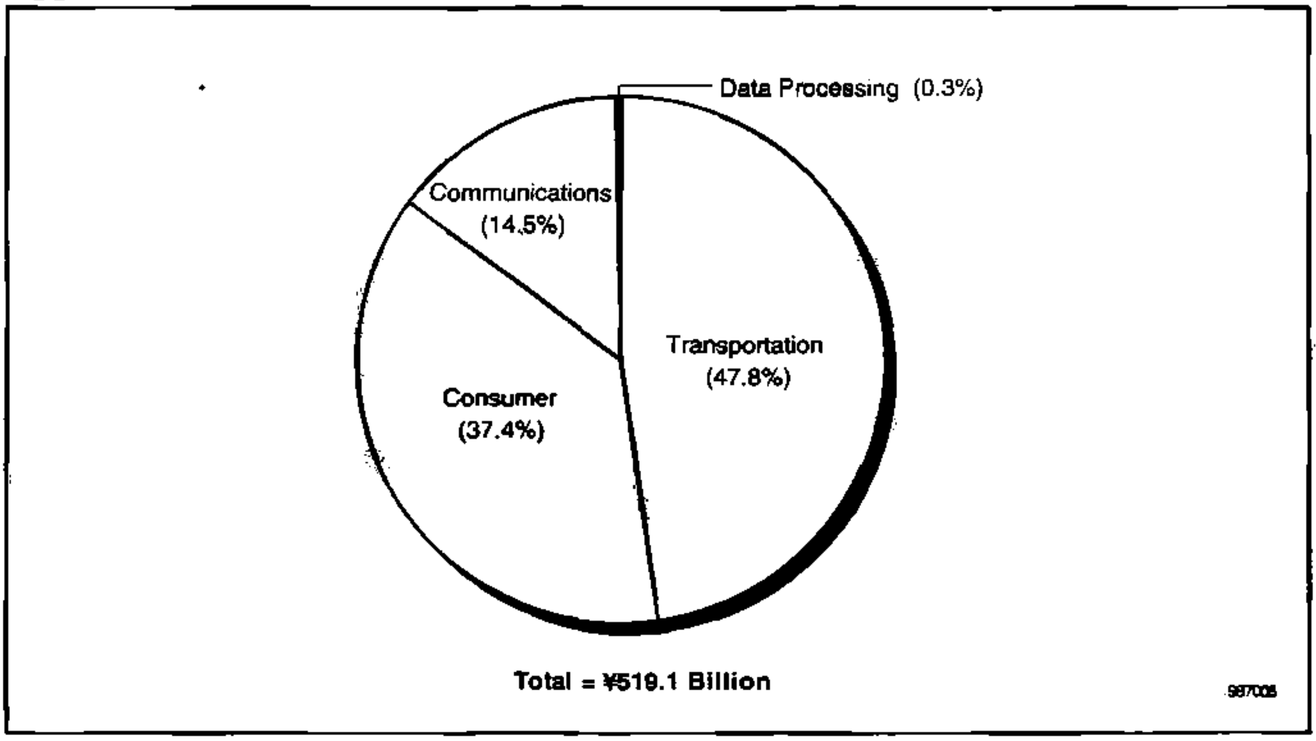
Table 4-14 shows Pioneer Electronic's major electronic products. Figures 4-40 through 4-42 show Pioneer Electronic's equipment production and semiconductor purchase trends.

Table 4-14
Pioneer Electronic's Major Electronic Products

Application	Products
Data Processing	CD-ROMs
Communications	Corded phones, cordless phones, multifunction phones
Consumer	TVs, set-top boxes, VCRs, CD players, DVD players
Transportation	Navigation systems, car stereos

Source: Dataquest (October 1998)

Figure 4-40
Pioneer Electronic's 1997 Worldwide Electronic Equipment Production Revenue by Application



Source: Dataquest (October 1998)

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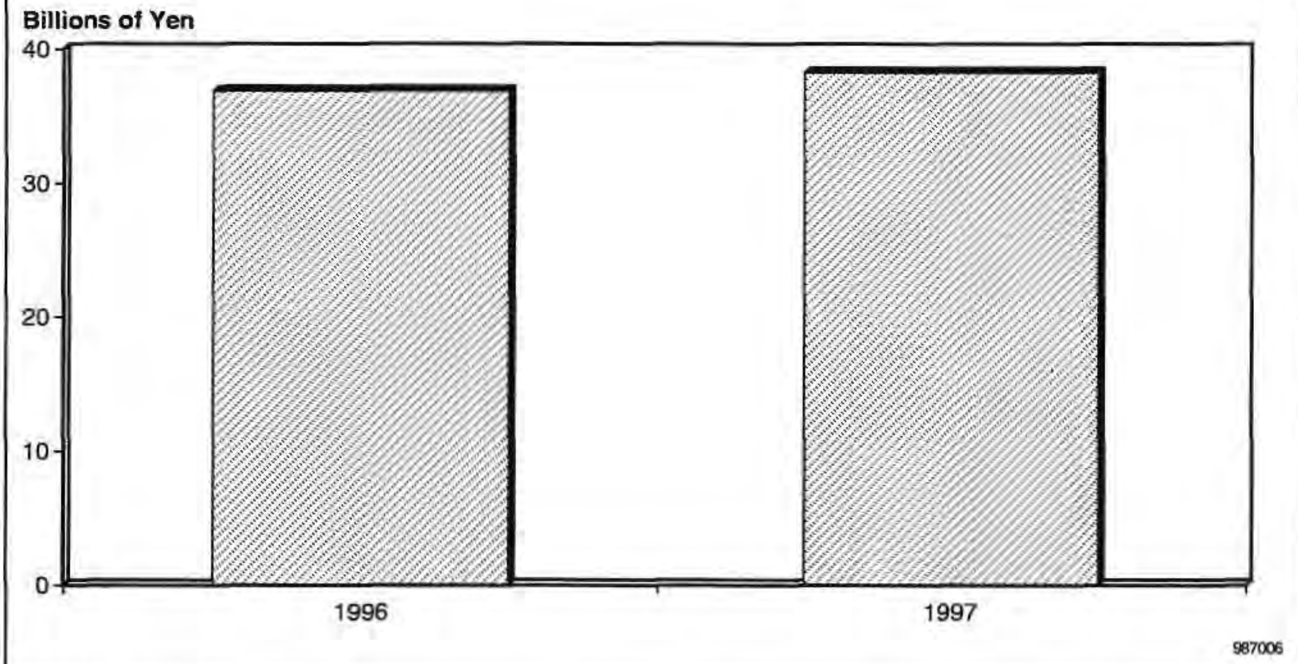
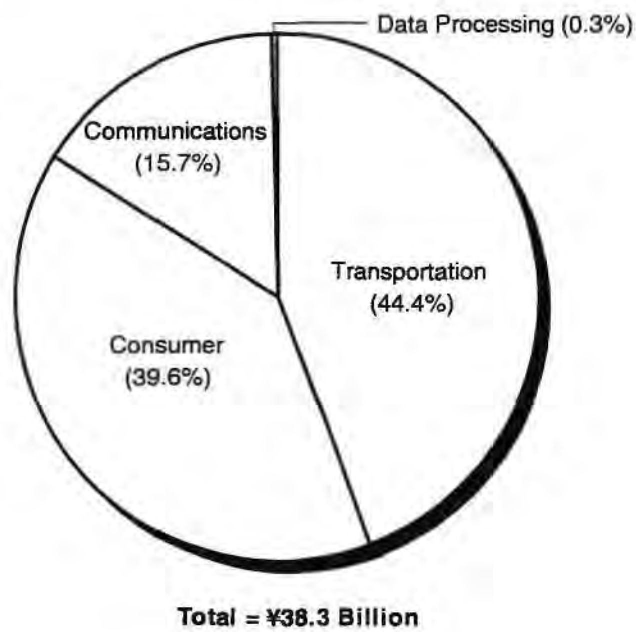
Figure 4-41
Pioneer Electronic's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-42
Pioneer Electronic's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Ricoh Company Ltd.

Ricoh is a manufacturer of dedicated data processing systems. In 1997, copy machines represented nearly 70 percent of its sales. Ricoh has leveraged on image processing technologies and has become the top vendor of facsimile machines in Japan. Optical products, including cameras and DSCs, recorded two-digit growth in sales in 1997. In the area of data processing peripherals, Ricoh has developed CD-RW media drives, offering new media that enable "Write" and "Delete" in CDs. As the penetration of office-use dedicated systems becomes high, Ricoh's continuous growth in production is not so easy. Ricoh has established global production sites in countries such as the United States, Europe, and Asia, including China, resulting in a comparatively low export ratio of about one-fourth of total sales.

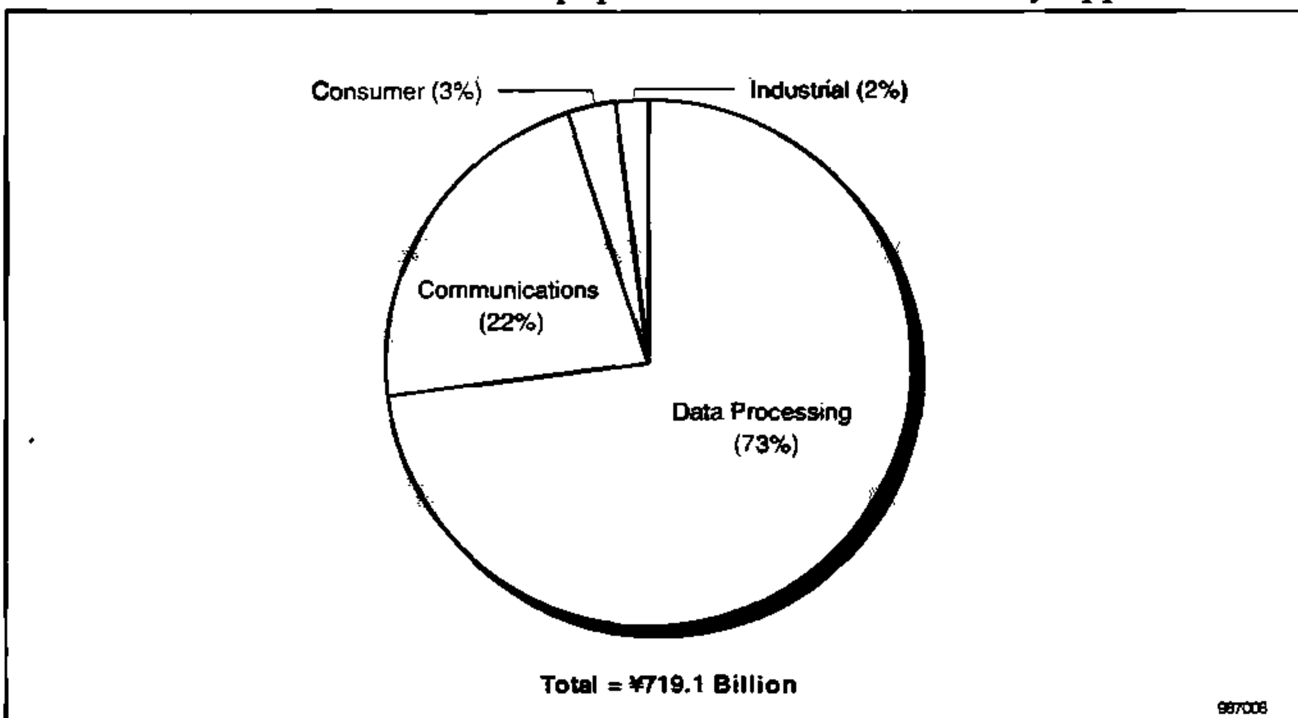
Table 4-15 shows Ricoh's major electronic products. Figures 4-43 through 4-45 show Ricoh's equipment production and semiconductor purchase trends.

Table 4-15
Ricoh's Major Electronic Products

Application	Products
Data Processing	Printers, copiers, word processors, CD-ROM/RAMs, scanners
Communications	Fax machines, transmission equipment
Consumer	Digital still cameras, cameras
Industrial	Test and measurement equipment

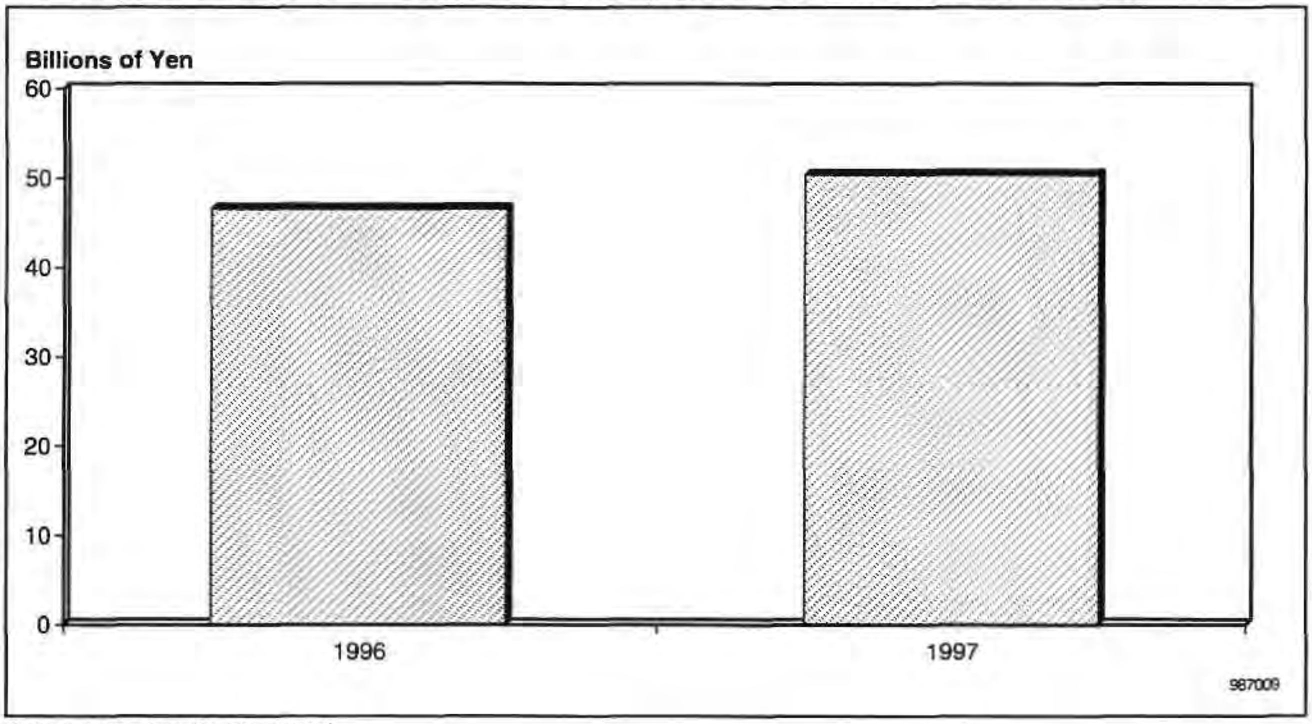
Source: Dataquest (October 1998)

Figure 4-43
Ricoh's 1997 Worldwide Electronic Equipment Production Revenue by Application



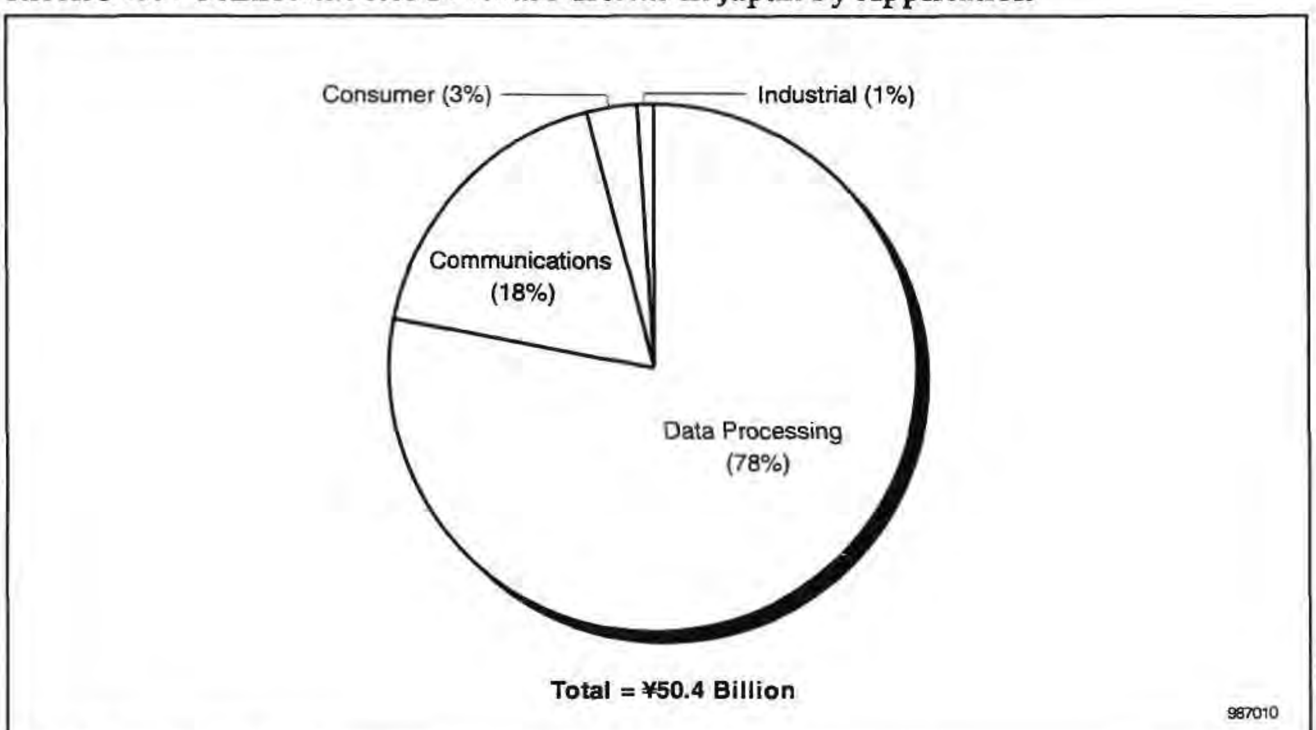
Source: Dataquest (October 1998)

Figure 4-44
Ricoh's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-45
Ricoh's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

SANYO Electric Company Ltd.

SANYO has successfully leveraged on its expertise in digital audio systems by penetrating into storage devices such as CD-ROM. Its audio technology has also helped it to develop communications products such as cordless phones and fax machines, which are growing steadily. SANYO is known to be very aggressive in seeking export markets as well as overseas equipment production. Because of this, its semiconductor purchasing in Japan has demonstrated only a constant trend, betraying its worldwide equipment revenue growth.

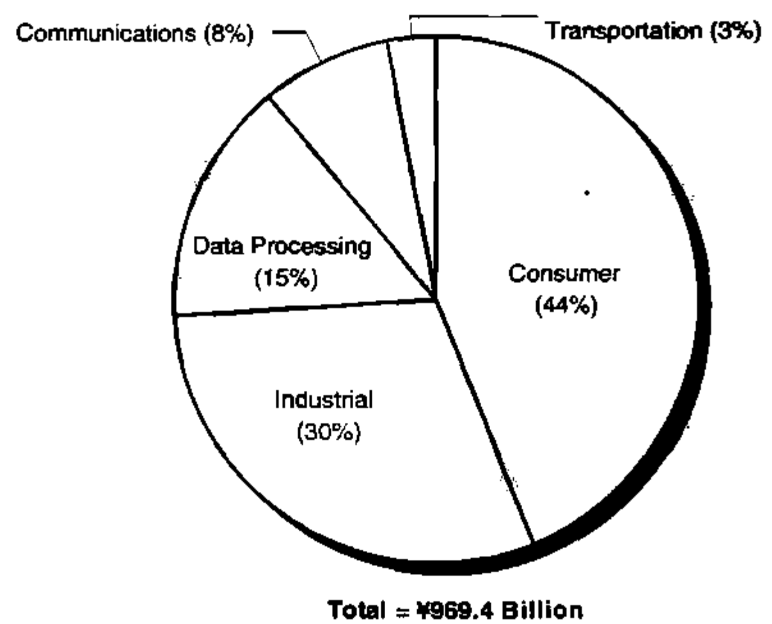
Table 4-16 shows SANYO's major electronic products. Figures 4-46 through 4-48 show SANYO's equipment production and semiconductor purchase trends.

Table 4-16
SANYO's Major Electronic Products

Application	Products
Data Processing	PCs, workstations, rigid disk drives, displays, terminals, laser beam printers, word processors, calculators, copiers
Communications	Corded phones, cordless phones, multifunction phones, PHSs, cellular phones
Consumer	TVs, camcorders, CD players, appliances
Industrial	Manufacturing systems
Transportation	Navigation systems, car stereos

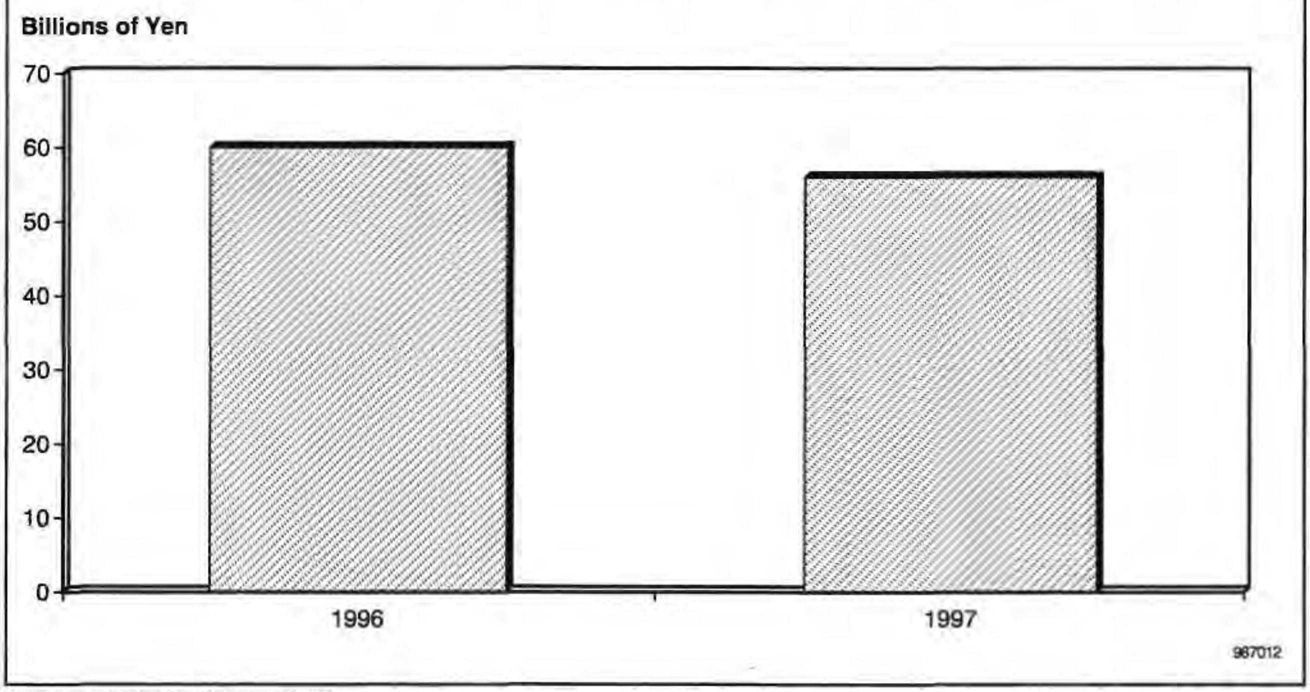
Source: Dataquest (October 1998)

Figure 4-46
SANYO's 1997 Worldwide Electronic Equipment Production Revenue by Application



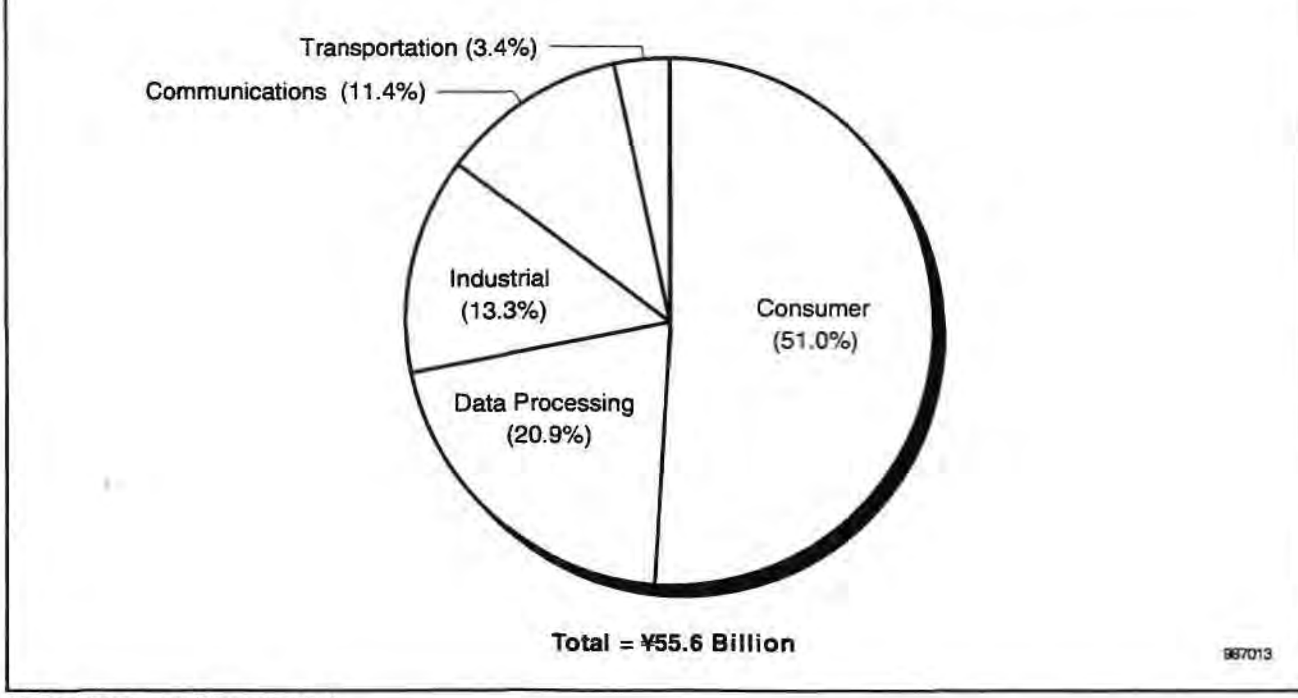
Source: Dataquest (October 1998)

Figure 4-47
SANYO's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-48
SANYO's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

SEGA Corporation

SEGA has a diversified business, including game machines and software for home use, amusement machines for business use, karaoke systems, and entertainment centers (similar to a video arcade but also including restaurants, movie theaters, and so forth) with its own machines. Home-use and business-use machines each represent 35 percent of SEGA's total revenue, and 18 percent of those machines are exported. While SEGA fares well in business-use machines, including pachinko, it is losing ground in the hardware of TV games to two other large competitors. As a result, SEGA's semiconductor purchasing declined in 1997.

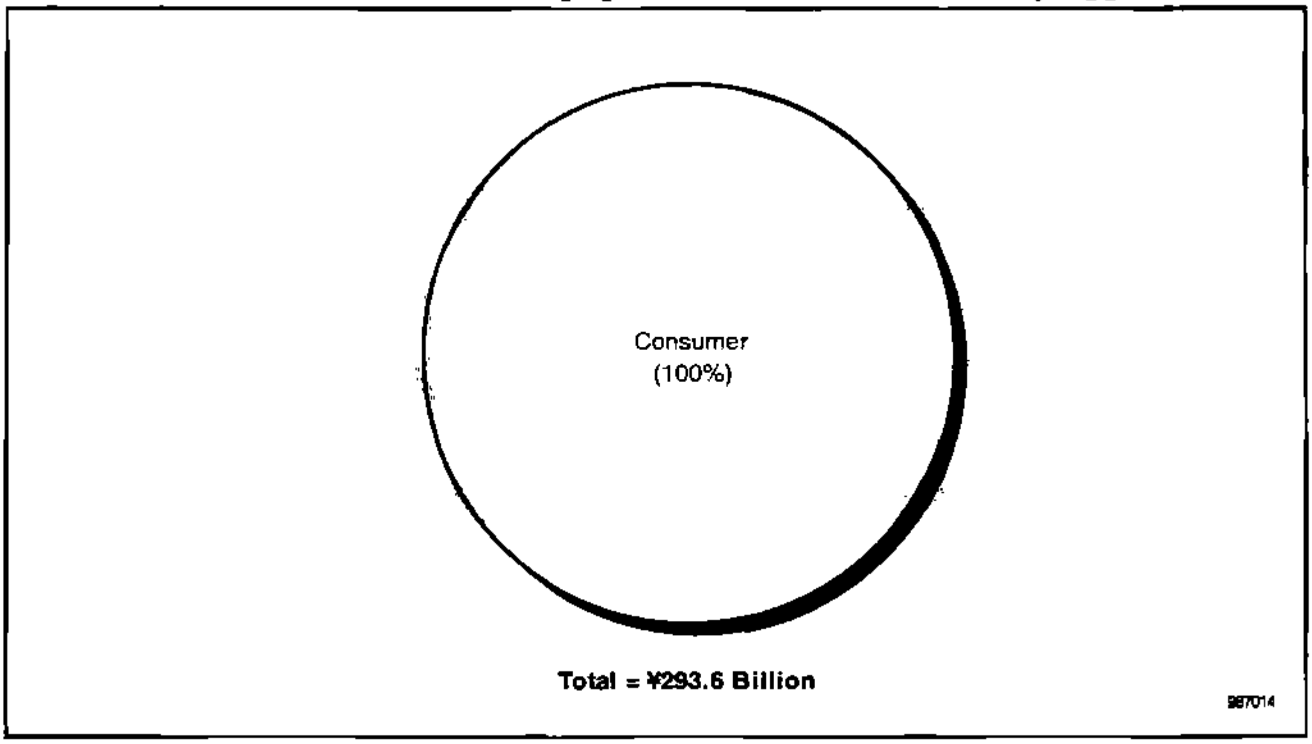
Table 4-17 shows SEGA's major electronic products. Figures 4-49 through 4-51 show SEGA's equipment production and semiconductor purchase trends.

Table 4-17
SEGA's Major Electronic Products

Application	Products
Consumer	Game controllers, arcade games

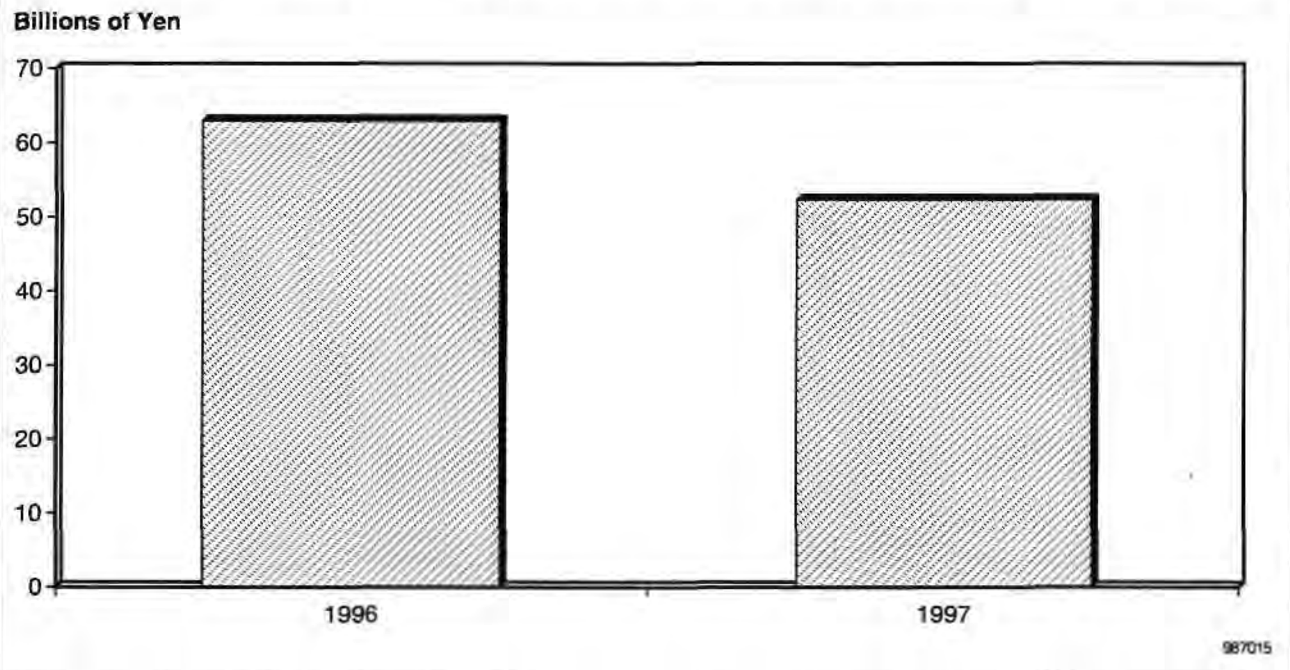
Source: Dataquest (October 1998)

Figure 4-49
SEGA's 1997 Worldwide Electronic Equipment Production Revenue by Application



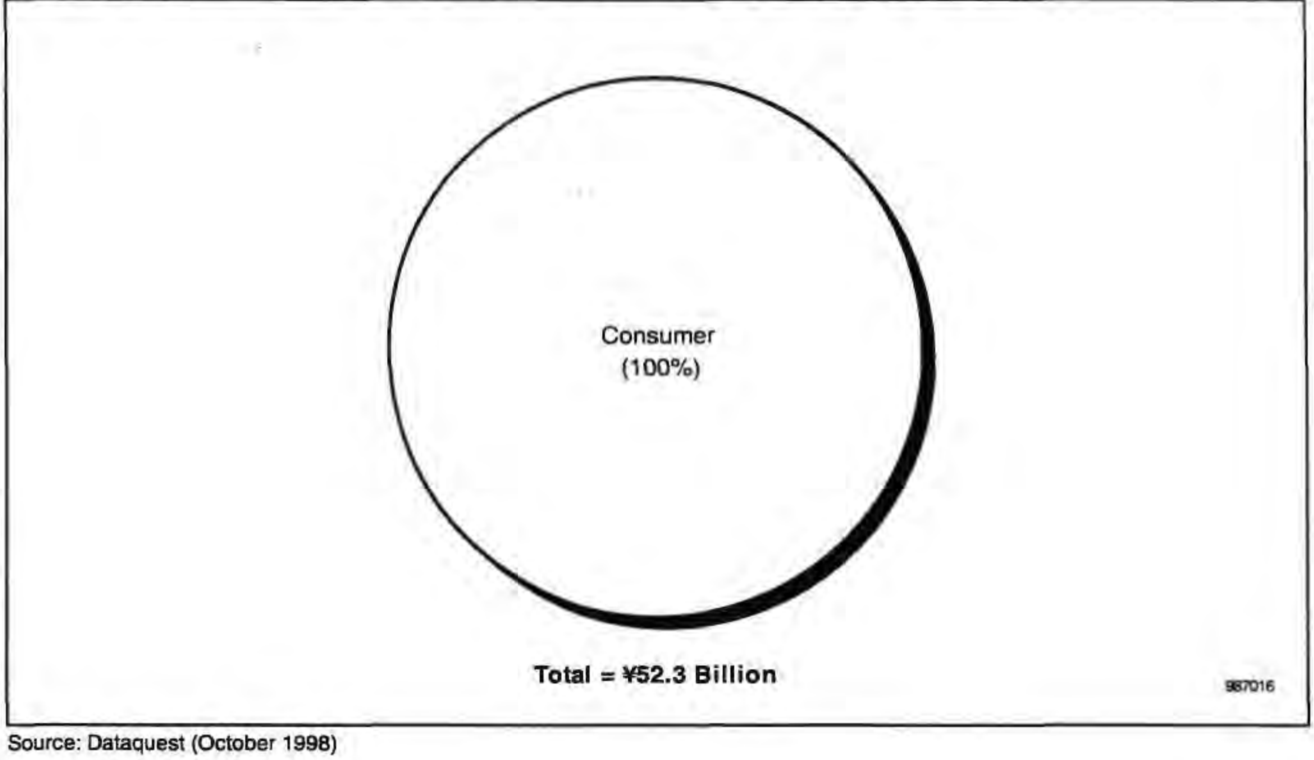
Source: Dataquest (October 1998)

Figure 4-50
SEGA's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-51
SEGA's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Seiko Epson Corporation

Data processing equipment, including PCs and peripherals, represents about one-half of Seiko Epson's revenue, with printers as the leading product. Seiko Epson also has entered the DSC market, along with its traditional product line of scanners. Other product offerings include LCD panels and application equipment, such as TV and video equipment, electric watches/clocks, and FA equipment, but the combined sales of these represent only 10 percent of total sales. Seiko Epson has been aggressive in setting up overseas production in various parts of the world, including the United States, Europe, and Asian countries, resulting in a low export ratio from Japan. Eighty percent of its semiconductor purchasing is in data processing.

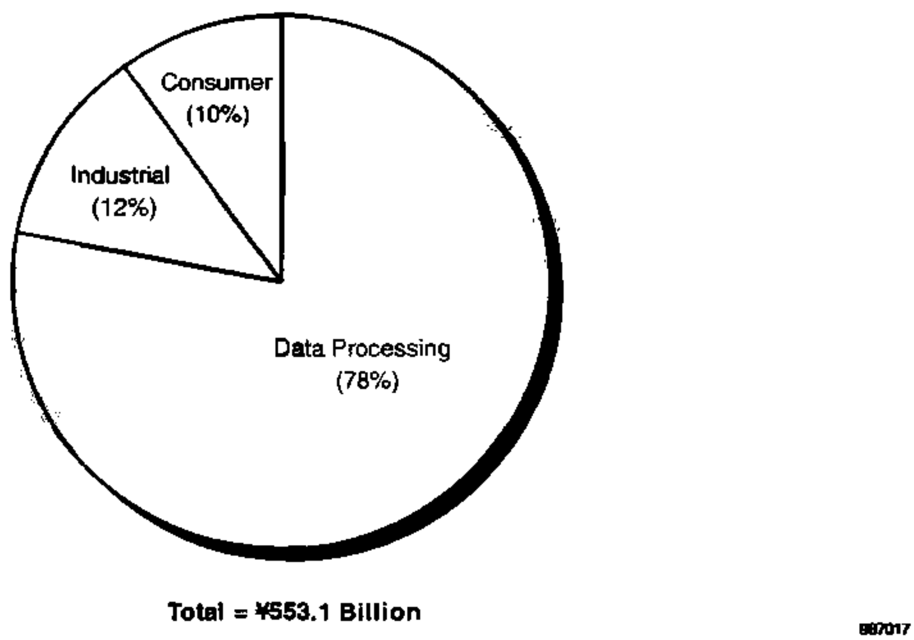
Table 4-18 shows Seiko Epson's major electronic products. Figures 4-52 through 4-54 show Seiko Epson's equipment production and semiconductor purchase trends.

Table 4-18
Seiko Epson's Major Electronic Products

Application	Products
Data Processing	PCs, flexible disk drives, rigid disk drives, displays, laser beam printers, other printers, word processors
Consumer	TVs, watches, minidiscs, digital video cameras, digital still cameras
Industrial	Manufacturing systems, test and measuring equipment

Source: Dataquest (October 1998)

Figure 4-52
Seiko Epson's 1997 Worldwide Electronic Equipment Production Revenue by Application



Source: Dataquest (October 1998)

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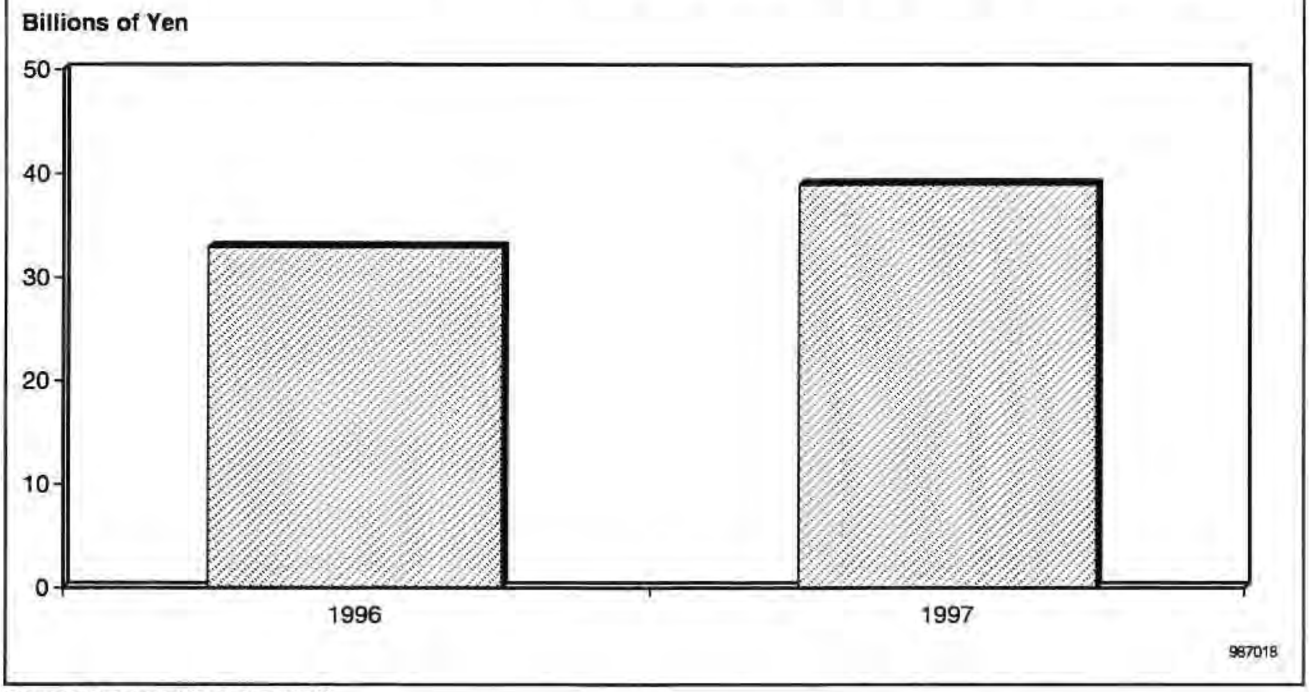
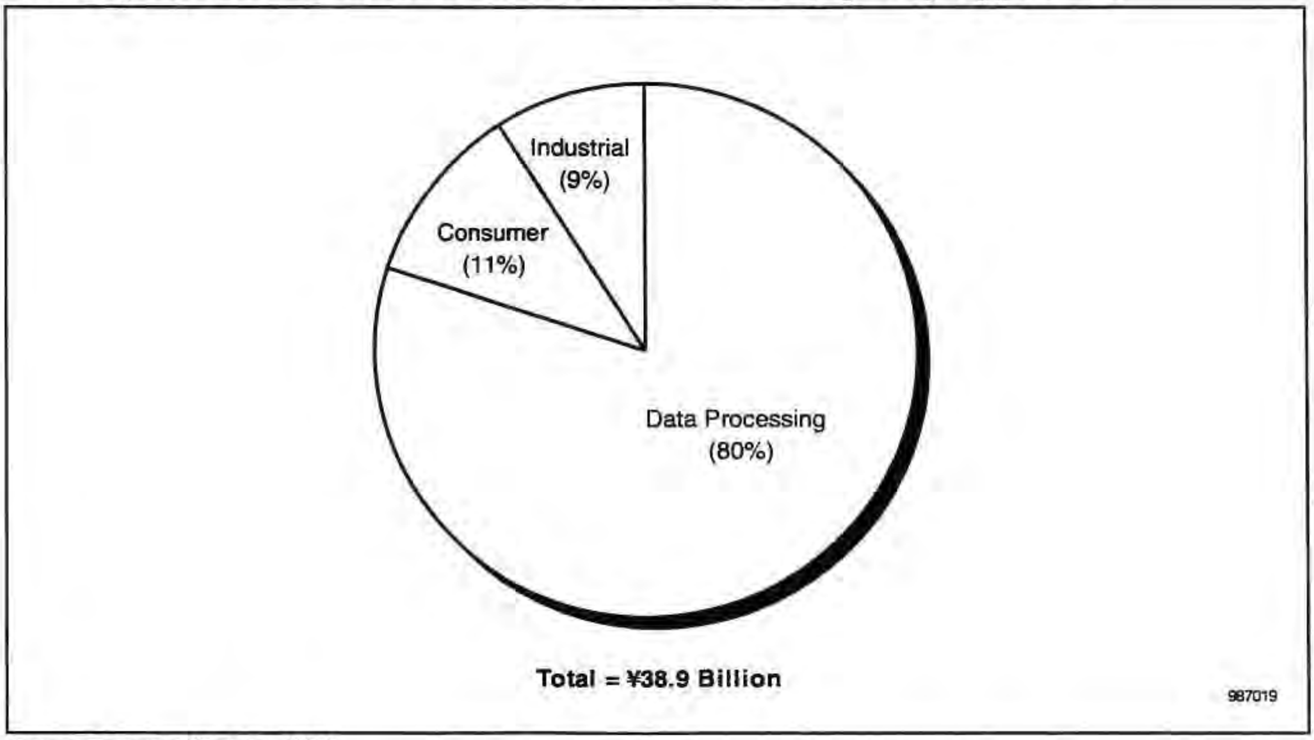
Figure 4-53
Seiko Epson's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-54
Seiko Epson's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

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Sharp Electronics Corporation

Sharp's technology and products have a clear focus: LCD products. This core competence has led the company to effectively market application products such as note PCs, digital video products, and personal digital assistants (PDAs), represented by the well-known "Zaurus" product line. While Sharp's traditional consumer product lines declined, its communications equipment lines expanded. As a result, Sharp's semiconductor purchasing has increased.

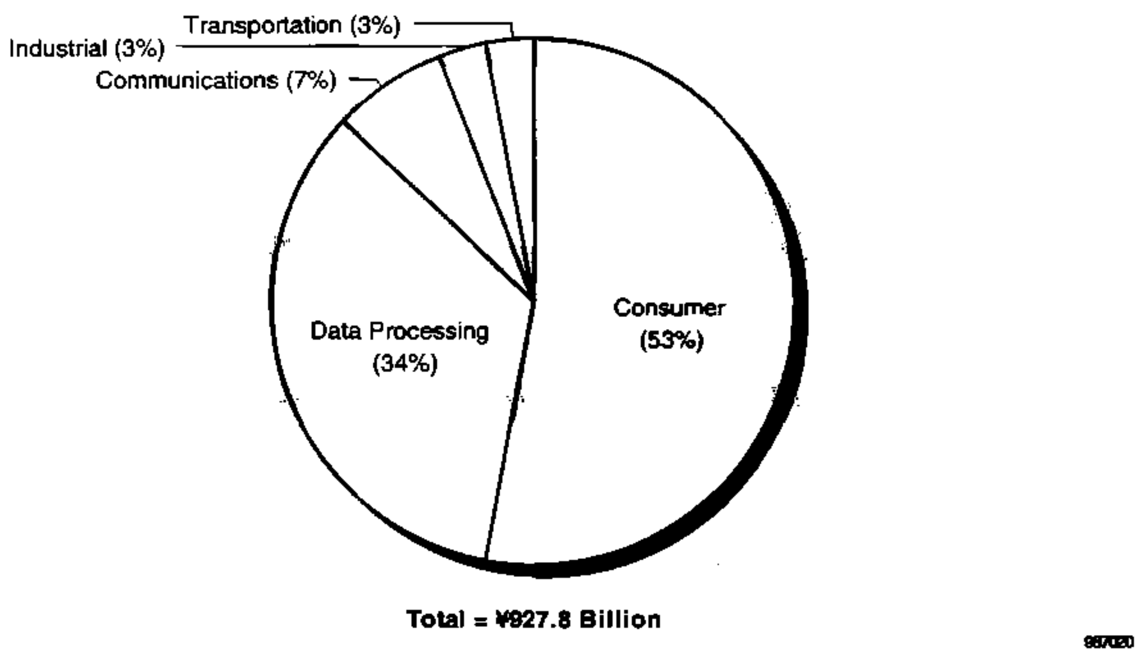
Table 4-19 shows Sharp's major electronic products. Figures 4-55 through 4-57 show Sharp's equipment production and semiconductor purchase trends.

Table 4-19
Sharp's Major Electronic Products

Application	Products
Data Processing	PCs, workstations, mainframe computers, midrange computers, CD-ROMs, displays, terminals, laser beam printers, other printers, word processors, organizers, calculators, copiers
Communications	Corded phones, cordless phones, PHSs, pagers, fax machines, modems, PBX equipment, broadcast equipment
Consumer	TVs, VCRs, camcorders, CD players, appliances, watches, minidiscs
Industrial	Manufacturing systems
Transportation	Navigation systems, car stereos

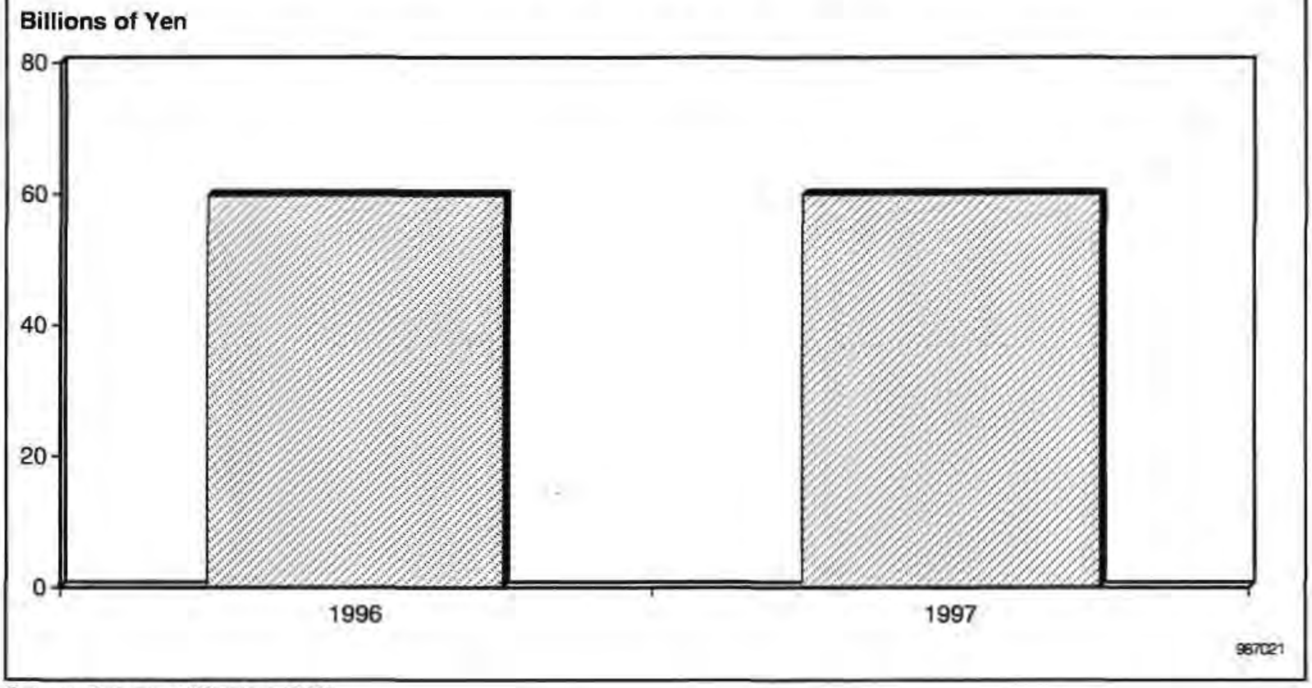
Source: Dataquest (October 1998)

Figure 4-55
Sharp's 1997 Worldwide Electronic Equipment Production Revenue by Application



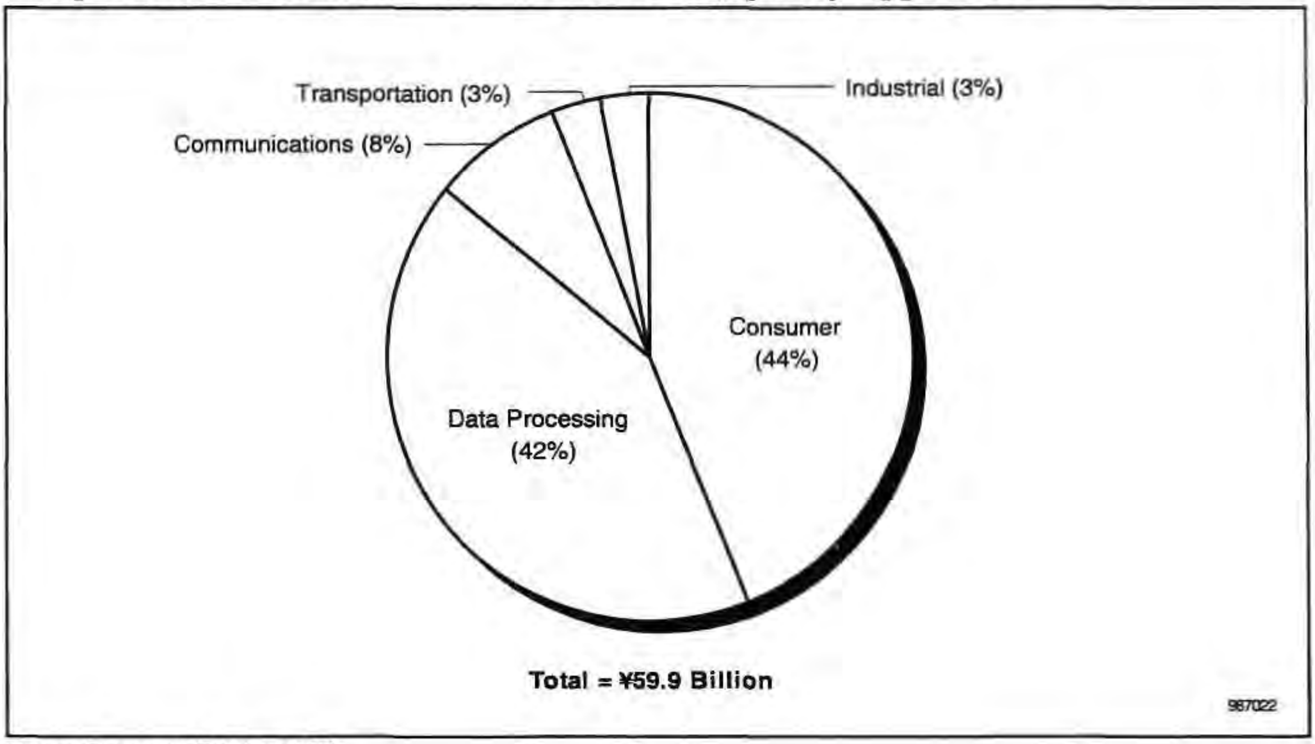
Source: Dataquest (October 1998)

Figure 4-56
Sharp's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-57
Sharp's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

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Sony Corporation

The trends toward digital consumer equipment are bringing audio/video equipment another stage of business opportunity. Growth in mobile communications has exceeded expectations. Broadcast equipment has brought sound profits, but Sony is increasingly exposed to harsh competition. Sony has leveraged on its optical disc technology to grow in computer peripherals, such as CD-ROM, but it is not free from intense competition. Sony has experienced outstanding success in the game machine area. Thus, growth in various product areas increased Sony's semiconductor purchasing in 1997, while most other consumer-oriented manufacturers decreased their semiconductor spending.

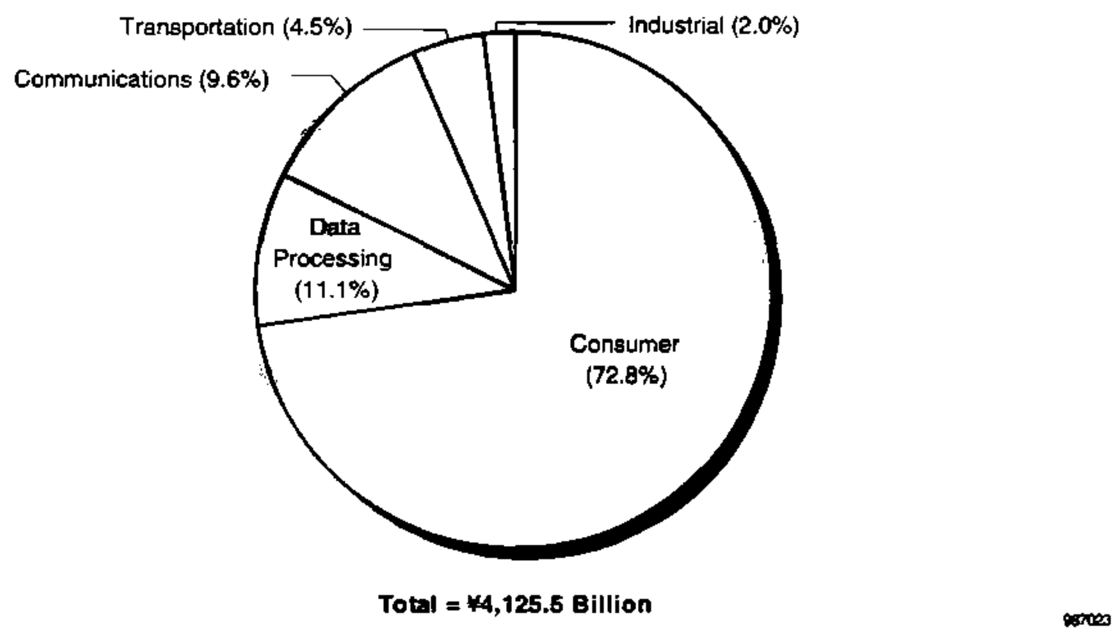
Table 4-20 shows Sony's major electronic products. Figures 4-58 through 4-60 show Sony's equipment production and semiconductor purchase trends.

Table 4-20
Sony's Major Electronic Products

Application	Products
Data Processing	PCs, workstations, monitor displays, CD-ROMs, DVD-ROMs
Communications	Corded phones, cordless phones, PDCs, PHSs, broadcast equipment products
Consumer	TVs, VCRs, STBs, camcorders, CD players, TV games, DVD players, minidiscs, DV-Cs, digital still cameras
Industrial	Security/energy management, manufacturing systems
Transportation	GPS navigation systems, car AV systems

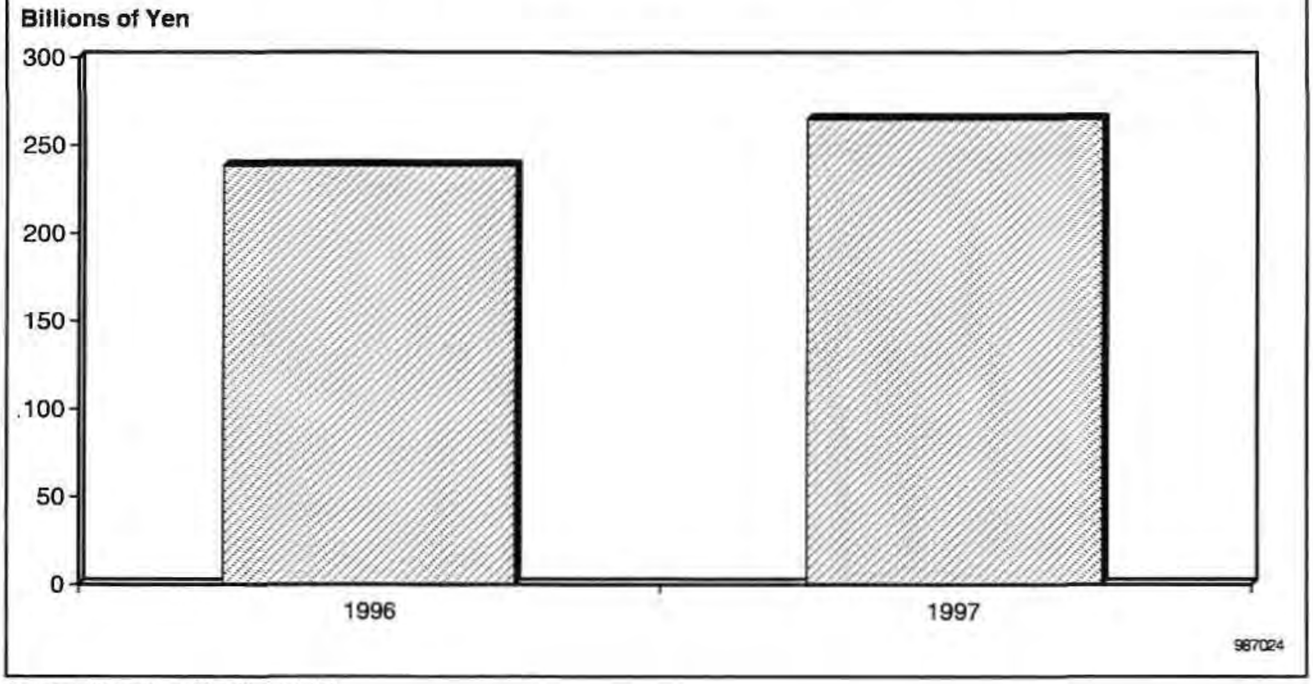
Source: Dataquest (October 1998)

Figure 4-58
Sony's 1997 Worldwide Electronic Equipment Production Revenue by Application



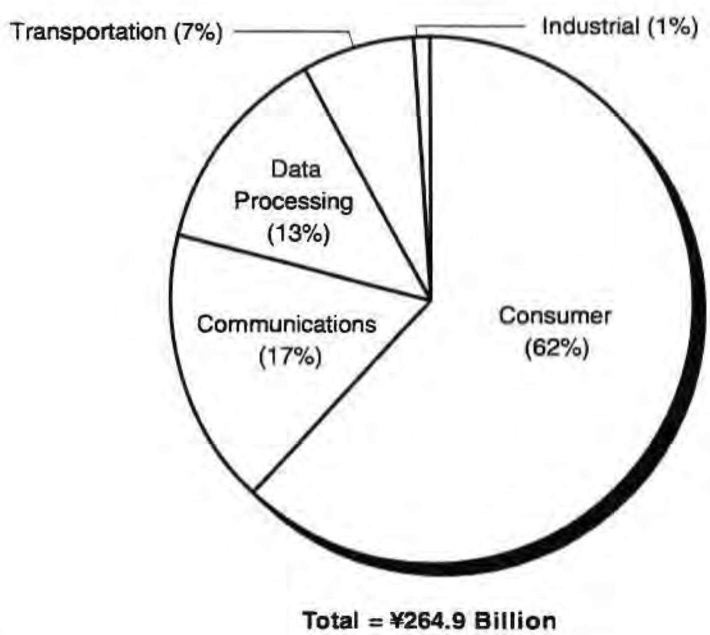
Source: Dataquest (October 1998)

Figure 4-59
Sony's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-60
Sony's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

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Toshiba Corporation

Toshiba has been known as the second-largest "general electric" company in Japan, covering all of the heavy electric, IT, and consumer equipment segments. Its recent focus, however, clearly has been in communications and data processing, where cellular phones and note PCs lead overall revenue growth.

Toshiba's semiconductor purchasing has decreased slightly because of sluggish production in the home appliance area, even though communications experienced an increase in semiconductor usage. In the consumer segment, Toshiba has been spreading production sites, resulting in large semiconductor spending outside Japan.

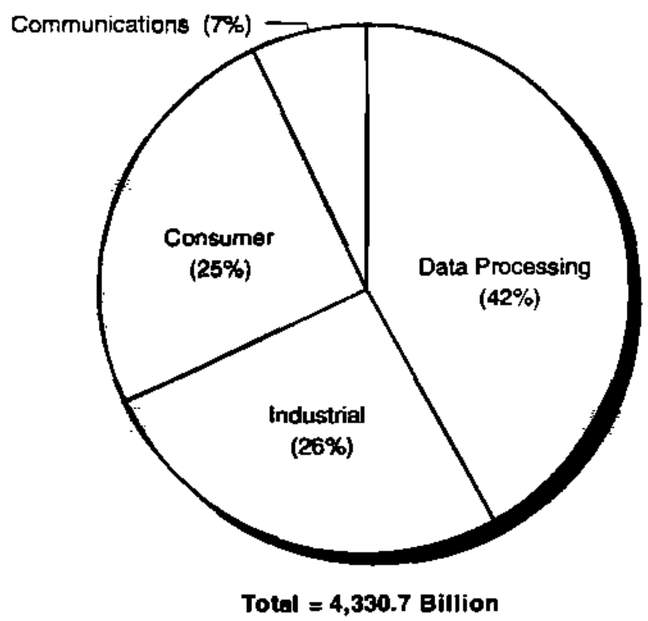
Table 4-21 shows Toshiba's major electronic products. Figures 4-61 through 4-63 show Toshiba's equipment production and semiconductor purchase trends.

Table 4-21
Toshiba's Major Electronic Products

Application	Products
Data Processing	PCs, workstations, midrange computers, flexible disk drives, rigid disk drives, displays, terminals, word processors
Communications	Corded phones, cordless phones, multifunction phones, PHSs, cellular phones, pagers, modems, PBX equipment, transmission equipment, broadcast equipment
Consumer	TVs, set-top boxes, VCRs, camcorders, CD players, appliances, DVD players
Industrial	Manufacturing systems, test and measuring equipment, medical equipment

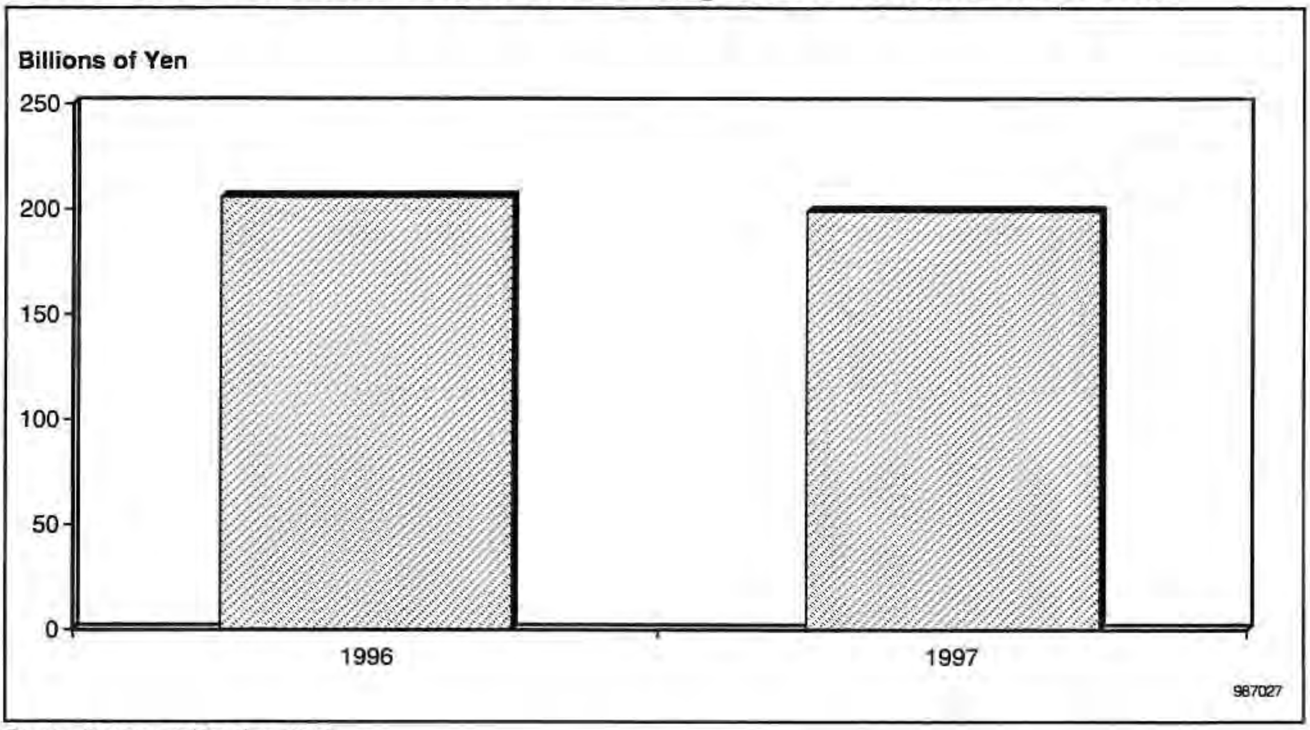
Source: Dataquest (October 1998)

Figure 4-61
Toshiba's 1997 Worldwide Electronic Equipment Production Revenue by Application



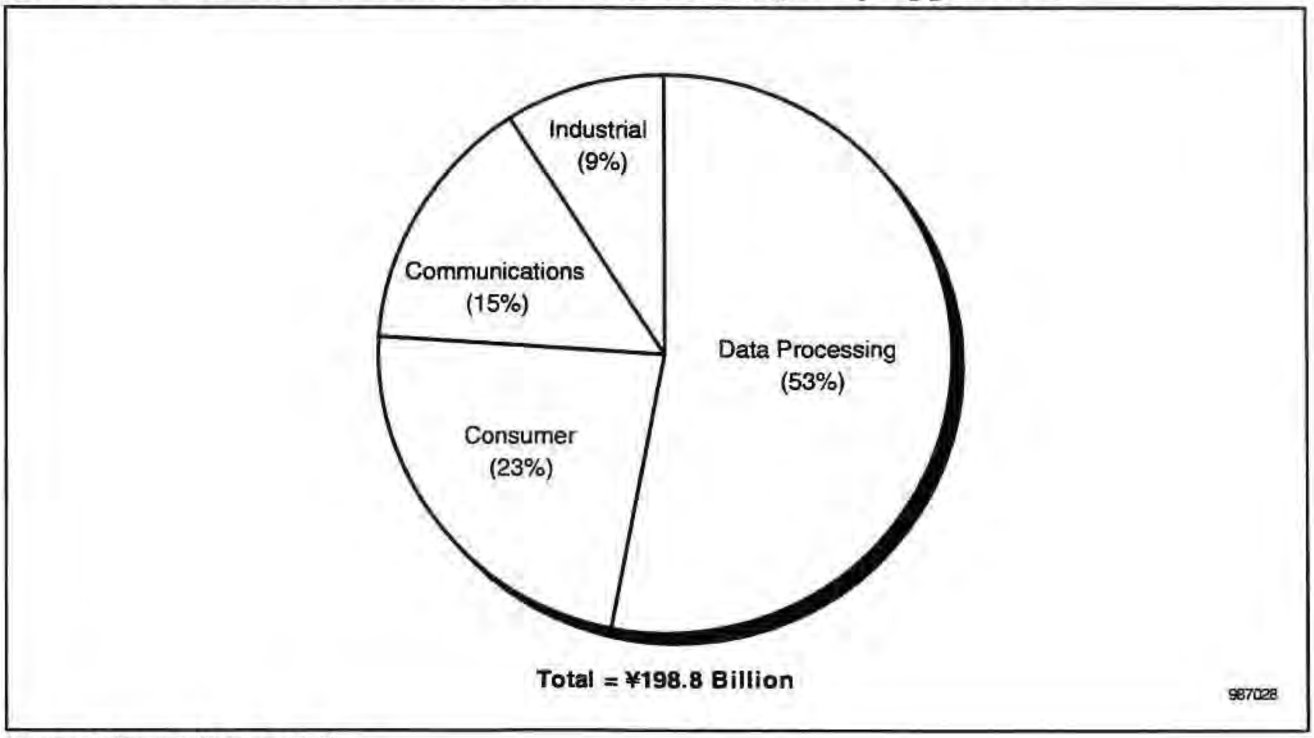
Source: Dataquest (October 1998)

Figure 4-62
Toshiba's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-63
Toshiba's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Victor Company of Japan Limited

Victor Company of Japan (JVC) belongs to the Matsushita Group, but it has sought its own proprietary technology and markets; for example, it developed its own original digital camcorders. Victor's core competence lies in audio/video equipment, for both broadcasting and business use; however, it is expanding its product line to include cordless phones and PHSs. The production of computer peripherals—mainly optical discs—is expanding, but fierce competition is hurting its profits. Digital consumer equipment holds the key to Victor's future success. It may also need to explore the possibility of overseas operation.

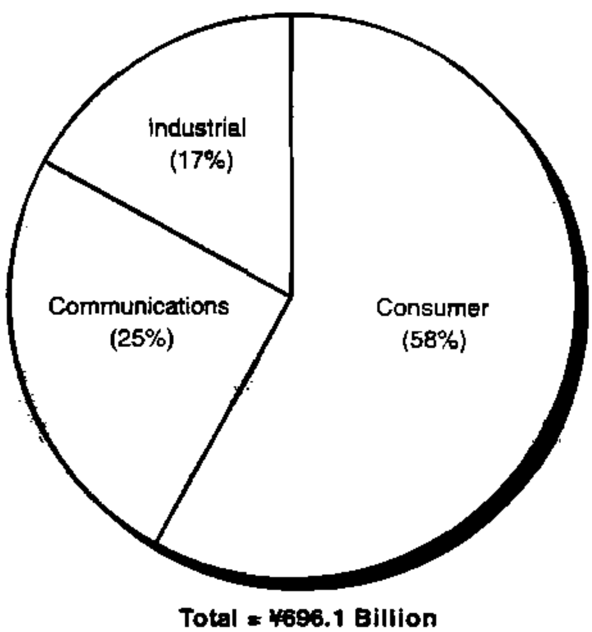
Table 4-22 shows Victor's major electronic products. Figures 4-64 through 4-66 show Victor's equipment production and semiconductor purchase trends.

Table 4-22
Victor's Major Electronic Products

Application	Products
Data Processing	Rigid disk drives, CD-ROM displays, terminals
Communications	Corded phones, cordless phones, PHSs
Consumer	TVs, VCRs, camcorders, CD players, musical instruments, minidiscs, digital still cameras
Industrial	Manufacturing systems

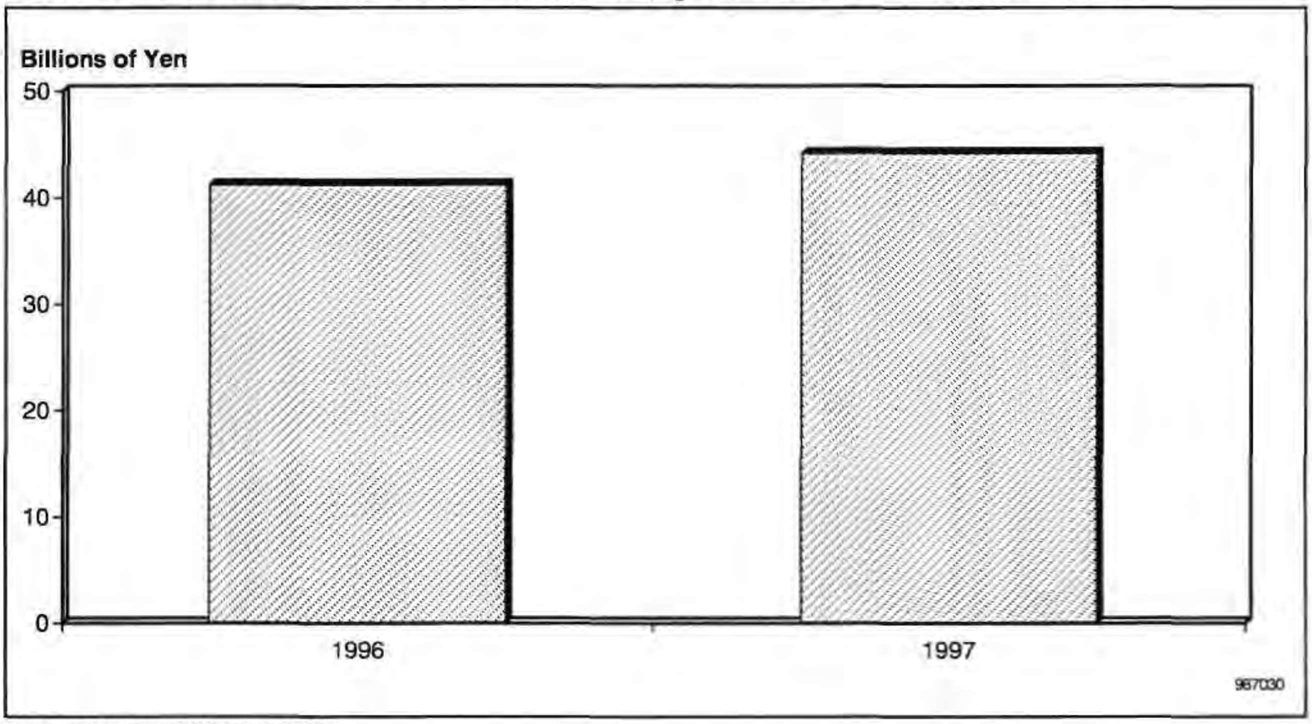
Source: Dataquest (October 1998)

Figure 4-64
Victor's 1997 Worldwide Electronic Equipment Production Revenue by Application



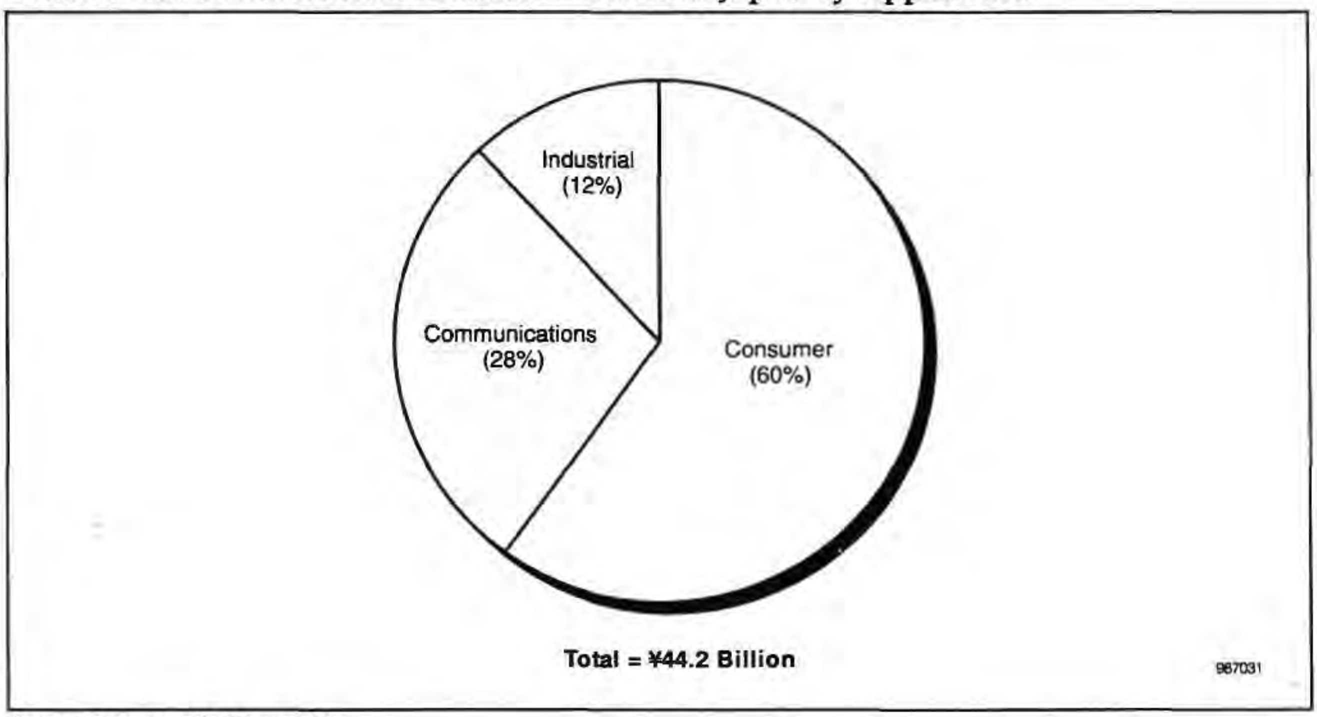
Source: Dataquest (October 1998)

Figure 4-65
Victor's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-66
Victor's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Dataquest Perspective

This survey and analysis is based on the results in 1996 and 1997, which were not years when the Japanese market showed a clear direction of future growth. Instead, those were the years when the Japanese market lost ground to foreign markets. Nevertheless, the results of this analysis seem to point out the following key concepts:

- Large companies are not necessarily going to be growth engines in Japanese electronics production, nor will they be stable and strong, if they do not have competitive products in key, growing categories.
- In the consumer category, companies of various sizes are increasing production, leveraging on new, niche product offerings.
- The growth rate of semiconductor purchasing was stronger among smaller users not included in the top 22 companies analyzed in this report.
- The category that is driving growth has shifted from data processing to communications, and in the future, users in this category will be the target customers for semiconductor vendors selling into Japan.
- Companies using semiconductors are changing their business focus, affecting semiconductor purchasing by application. Semiconductor vendors will need to focus more on tracking each user's trends rather than on measuring application markets en masse.

It should be noted that digital consumer equipment is rising steadily even though the market size is still small. Also, the production sites of Japanese electronics companies are becoming more and more regionally diversified. Moreover, sluggishness in Japanese production does not correlate with some companies' worldwide activity.

The previous statements, however, suggest the need for vendors to review customer-support strategies, especially at a time when system-oriented marketing and system-level integration (SLI) are becoming the keys to success, but these are also beginning to represent a larger load for vendors.

A more detailed analysis by application will identify the exact drivers of semiconductor consumption growth for each company using semiconductors. Also, it is essential to look into the technology potential of these companies to decide strategies for each company, both in terms of system technology to be incorporated into system-oriented chips and in terms of supporting the development of such chips, including SLI ASICs. This report does not describe whether internal user divisions are contributing to semiconductor divisions' sales, system marketing capability, and product development.

Dataquest believes that, in the era of SLI, semiconductor vendors face the challenge of strengthening their customer support and system-oriented marketing capability.

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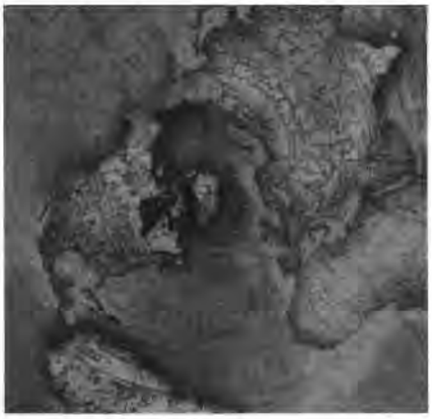

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A Competitive Study of Japanese Semiconductor Manufacturers

Competitive Trends

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Program: Semiconductors Japan
Product Code: SEMI-JA-CT-9801
Publication Date: June 8, 1998
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Chapter 1
Executive Summary

Japanese companies once enjoyed the largest share of the worldwide semiconductor market, but they are now exposed to aggressive competition, not only from new players in Asia/Pacific, but also from the American companies that the Japanese companies once thought they had beaten. However, the worldwide market continues to see oversupply in various MOS digital products, and prices do not show any sign of tightening up. This market condition is forcing Japanese companies to review their strategies in search of clues to the next growth stage.

This Competitive Trends focuses on the top 20 Japanese semiconductor companies and analyzes their competitiveness from the viewpoint of sales power, manufacturing power, and overall strategy. Sales, regional orientation, and penetration are examined for each company. In analyzing manufacturing trends, manufacturing power, defined as brand shipments plus foundry/OEM shipments, is analyzed for the first time. All metrics except for fabs, capital spending, and R&D spending, are taken from Dataquest's 1996 database because Dataquest is still in the process of finalizing 1997 revenue survey and analysis.

The appendix provides metrics such as product revenue, regional revenue, and market share by region and product for each of the top 20 Japanese companies.

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Chapter 2
Brand Sales Power

In 1996, Japanese companies recorded a combined share of 36 percent of the worldwide semiconductor market. The year was marked by rapid price declines for DRAMs and various MOS digital products, such as flash memories, microcontrollers (MCUs), and application-specific ICs (ASICs). Japanese semiconductor vendors that were largely dependent on those product categories were no exception to the sluggish revenue growth that accompanied continued robust unit shipments. This was also the year in which the yen depreciated against the U.S. dollar, and Japanese companies' revenue in dollar terms was scaled down compared with that of global competitors. As a result, Japanese companies' market share fell four points from 1995, widening the gap with Americas companies to nine points.

In the 1980s, Japanese companies rapidly increased their revenue, pumped by DRAM sales and the consumer applications on which they focused. Their combined revenue showed a record high market share of 51 percent in 1988 to 1989, which has not been achieved by any companies since.

Or take a look at rankings. In 1986 through 1992, six Japanese companies were listed in the top 10 worldwide ranking. For 1985 through 1991, the largest semiconductor company in the world was Japanese—NEC Corporation. For 1986 through 1989, the top three companies in the world-wide market were Japanese. In 1996, however, only one company was among the top three, there were only four companies in the top 10, and the leading company was Intel Corporation. Americas companies enjoyed a combined share of 45 percent in 1996, a seven-point increase over 1988.

Korean companies are quickly catching up. In 1993, when Samsung Electronics entered the global top 10 ranking, Korean companies recorded combined revenue of $5.1 billion, which was about one-seventh that of Japanese companies. In 1996, Korean companies' combined revenue had grown to equal 22 percent of Japanese companies' revenue.

What has caused this decline in Japanese companies' share of the worldwide market? Is the trend going to persist in the near future?

Japanese Companies' 1996 Market Share

In the worldwide market, the Japanese companies' decline in market share was seen in all regions, caused mainly by the DRAM revenue contraction. Non-DRAM revenue showed growth of 10 percent on a yen basis for Japanese companies but a contraction of 5 percent on a dollar basis (see Table 2-1). In DRAM, Americas companies showed the largest contraction of the four regional bases, but they also recorded the largest growth in non-DRAM revenue. This is a result of Americas companies' penetration of the MOS logic area, as well as Intel's increase in MPUs. European companies fared well, too, and surpassed Asia/Pacific companies.

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Table 2-1
Japanese Companies' Revenue Growth: A Comparison between DRAM and Non-DRAM (Percent)

	Total Semiconductor	DRAM	Non-DRAM
Total Companies	-6.3	-38.6	6.2
Japanese Companies (Dollar-Based)	-16.0	-40.3	-5.1
Japanese Companies (Yen-Based)	-2.7	-30.8	10.0
Americas Companies	6.0	-47.6	15.0
Europe, Africa, and Middle East Companies	6.6	-35.0	11.3
Asia/Pacific Companies	-24.1	-30.9	-2.9

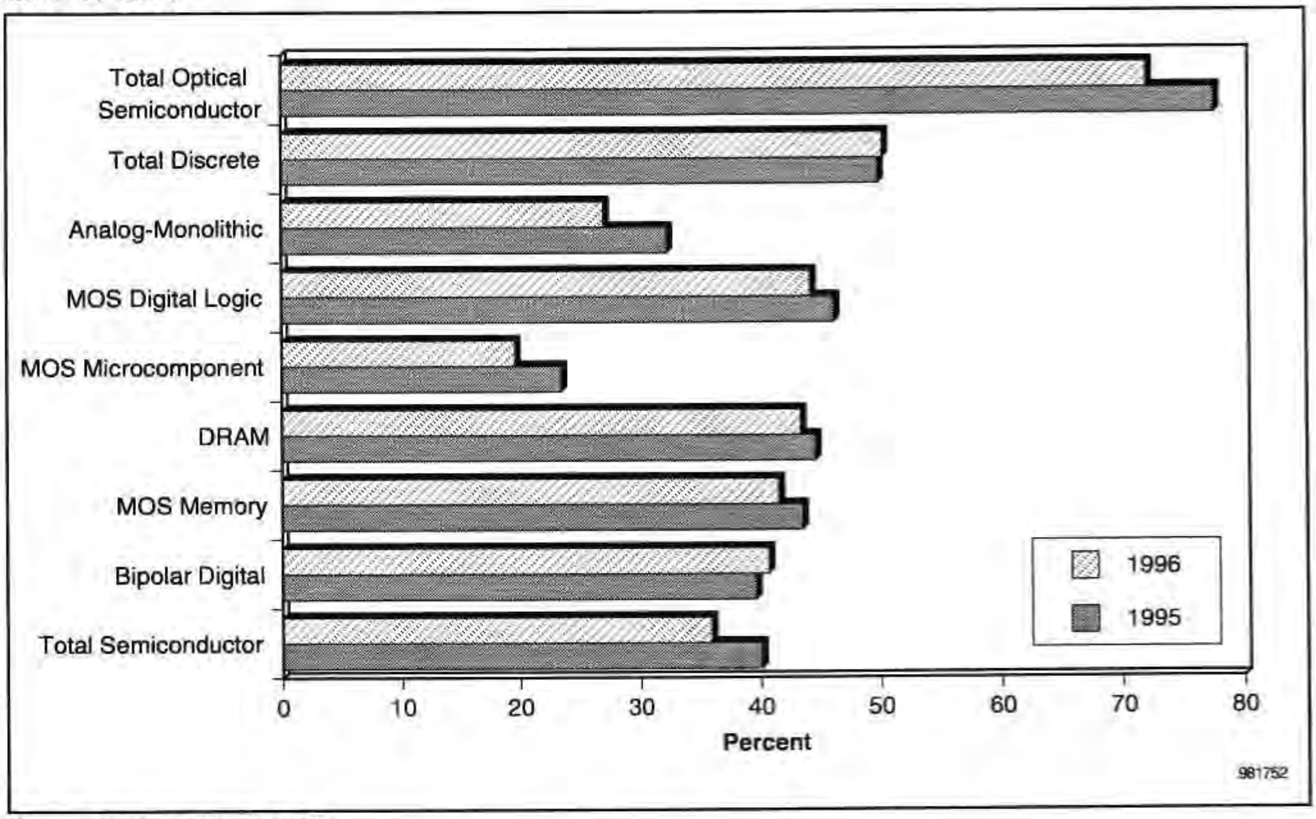
Source: Dataquest (March 1998)

In the worldwide market, eight Japanese companies ranked in the top 20: NEC Corporation, Hitachi Ltd., Toshiba Corporation, Fujitsu Ltd., Mitsubishi Corporation, Matsushita Electric Industrial Co. Ltd., SANYO Electric Company Ltd., and Sharp Electronics Corporation. Only the first four of these made it into the top 10, with Mitsubishi slipping to the 11th position, replaced by SGS-Thomson Microelectronics B.V. This is the first time since 1985 that only four Japanese companies were included in the top 10 worldwide.

Figure 2-1 shows Japanese companies' market share the in major product categories. Bipolar digital is the category in which Japanese companies still rank second to Americas. The devotion of Japanese companies to this product area stems from their internal user in their computer and communications equipment divisions. In this shrinking portion of the market, Japanese companies' combined share amounted to 41 percent in 1996.

MOS memory, especially DRAM, has been the technology driver for Japanese semiconductor industry. In this market, however, Japanese companies are being exposed to a very competitive situation. The 1996 DRAM market declined 39 percent, and it was Americas companies whose combined revenue recorded the biggest decline—negative 48 percent against 1995. Asia/Pacific companies showed the smallest decrease of all—31 percent. Japanese companies recorded a 40 percent decline and had still the largest market share, 43 percent. But a trend among Japanese companies is evident: Larger Japanese companies maintained their respective positions, but smaller Japanese DRAM suppliers showed faster declines in revenue and lower rankings. Because the DRAM market is expanding more rapidly in foreign markets, it is the larger players that can access large-volume users, including PC vendors and module manufacturers, with favorable terms of trade. Dataquest's market share survey in memory revenue and unit shipments indicated a general trend in which smaller companies' average selling prices (ASPs) are significantly lower than those of larger companies.

Figure 2-1
Japanese Companies' Worldwide Market Share in Major Product Categories, 1995 to 1996

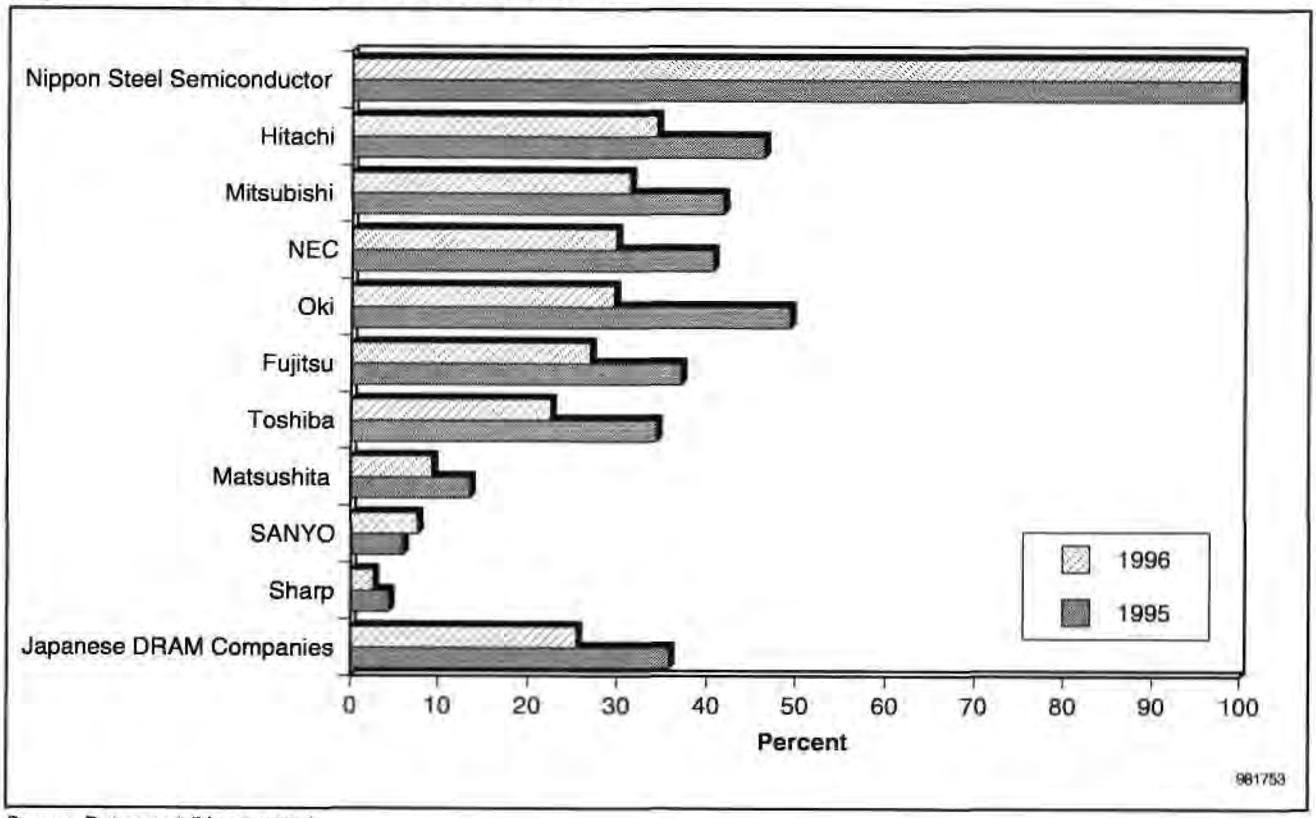


Source: Dataquest (March 1998)

DRAMs account for 22 percent of the total revenue of combined Japanese companies in 1996, a decline from 31 percent in 1995. Figure 2-2 shows DRAM ratio, focusing on Japanese DRAM vendors. After Nippon Steel Semiconductor came Hitachi, with 34 percent, followed by Mitsubishi. Japanese companies are not necessarily going out of DRAM business just because of the severe competition with Korean and Americas companies, but the diversification of products that Japanese companies planned to pursue has not yet brought significant revenue increases, forcing some Japanese companies to be even more selective in their DRAM business.

In the 1996 MOS microcomponents market, Japanese companies have nurtured expertise and consequently have enjoyed a large share of the market in MCUs. This resulted from their users' focus on consumer equipment, which brings a large number of MCU orders. As Japanese electronic equipment production shifted focus from consumer equipment to data processing and communications and as MCUs were upgraded to higher bits, Japanese semiconductor users started to explore a wider selection, including MPUs and digital signal processors (DSPs). As system-level integration (SLI) becomes the key technology for emerging applications such as digital consumer equipment, Japanese companies face decisions about reorganizing their microcomponent and logic operations to offer the best SLI solutions to users.

Figure 2-2
Japanese DRAM Vendors' DRAM Ratios



Source: Dataquest (March 1998)

In the MOS logic market, Japanese companies also leveraged consumer product large-volume orders. Among ASIC products, gate arrays have been the major product offering from Japanese vendors. This dependence caused Japanese companies to lag behind worldwide trends, which show large-scale systems preferring cell-based ICs (CBICs) and smaller systems preferring programmable logic devices (PLDs). Gate arrays fall between those two fast-growing categories, and here again, Japanese ASIC vendors must go through structural changes to refocus their operations. Also a part of the "other MOS logic" category are application-specific standard products (ASSPs); this category includes various consumer-use logic ICs, especially those used for audio and video applications equipment and LCD drivers.

Analog devices also benefited from the traditional consumer orientation of the Japanese electronics and semiconductor industry. As electronic equipment production shifts focus to data processing, communications, and automotive applications, Japanese companies have started to emphasize what they called industry-use linear ICs and then mixed-signal ICs. (The traditional consumer orientation has caused Japanese companies to call all other applications "industrial" in their own categorization.) In the standard product area, general-purpose products have found their way into a wide selection of applications, helping Japanese analog vendors run their fabs, albeit with low profits.

Some dedicated vendors have sought to expand markets and applications for discrete devices, first in consumer equipment and then in peripherals such as flexible disk drives (FDDs), rigid disk drives (RDDs), and, recently, CD-ROMs. Small-signal products, both transistors and diodes, have always found new markets in emerging applications. Because new system designs required new circuit blocks and glue logic, small-signal transistors were the best choice to start with, to be replaced by ICs afterwards. In the fastest-growing area of power devices, there are mainly two lines of products being offered by Japanese companies, power supply devices and radio frequency (RF) power devices. RF products have also become an area in which Japanese manufacturers nurtured expertise, first with radio equipment, then TV equipment, and now mobile communications.

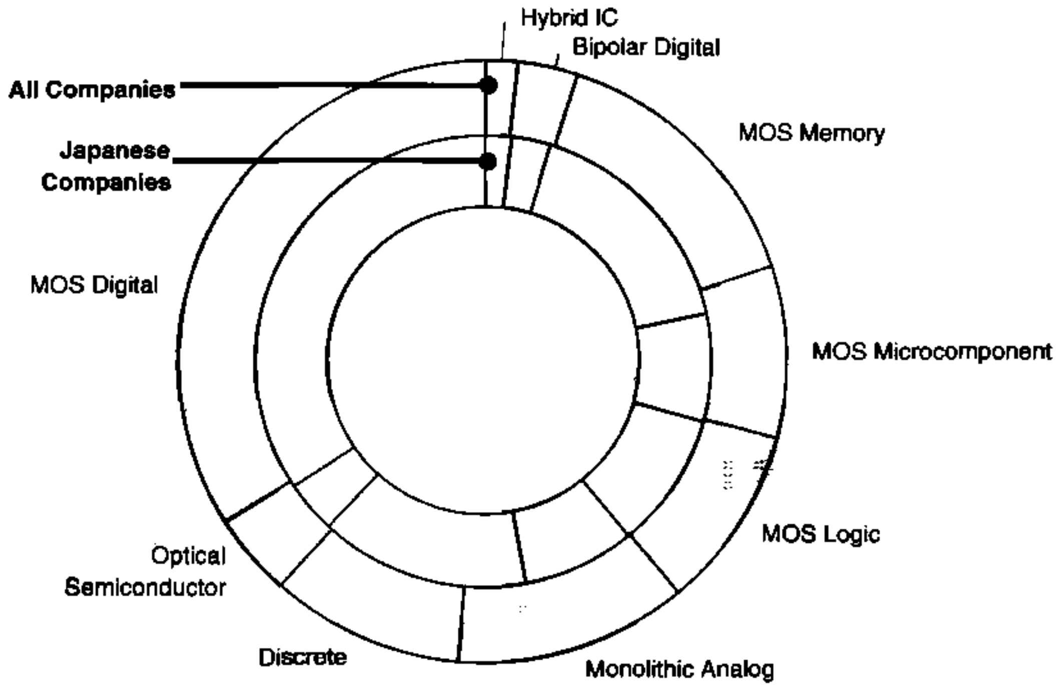
In optical semiconductors, there are dedicated suppliers such as Stanley Electric Co. Ltd. and Hamamatsu Photonics K.K. Although larger semiconductor suppliers also cover optical semiconductors, smaller, dedicated vendors have expanded the market by responding to precise requirements from customers, a practice that big companies found inefficient. As a result, LED suppliers may know of a wider range of users than IC suppliers do. Coupler and sensor markets have expanded because they are used along with microcontrollers and logic ICs and for systems with different voltage blocks. In the traditional model, volume orders for charge-coupled devices (CCDs) came from only a few consumer applications, such as camcorders, and small-volume, high-ASP orders came from broadcasting and various industrial applications. As imaging became a feature of PCs and PC peripherals, CCDs for scanners have come to hold a larger share of the increment of the CCD market. Laser diodes were high value-added products but were a small-volume market until CD players came into production. With the expansion of CD technology applications, demand for laser diodes rose rapidly, which brought costs lower and further expanded the market. Here again, Japanese vendors have leveraged domestic users' orientation in this area.

The Product Mix

Figures 2-3 and 2-4 show Japanese companies' and all companies' share of worldwide product revenue for 1992 and 1996, respectively. Figure 2-5 shows MOS digital product revenue share for Japanese companies and the worldwide market. In 1992, for both, MOS digital ICs represented a little more than half of total revenue, and the difference was negligible—one point—between the two. But in 1996, MOS digital products accounted for more than 70 percent of the worldwide market, while for Japanese companies, revenue from these products accounted for only a little more than 60 percent. Subtracting Intel's microprocessors, a unique situation, reveals basically the same picture—Japanese companies are lagging behind the worldwide market in digitization.

Although it is true that Japanese companies are losing market share to Korean and American companies even in DRAM, which has driven market share for Japanese companies, the lag is more evident in the microcomponent and logic areas, posing a threat to Japanese companies in light of trends toward system-level integration.

Figure 2-3
Worldwide Revenue Market Share by Product, 1992



Source: Dataquest (March 1998)

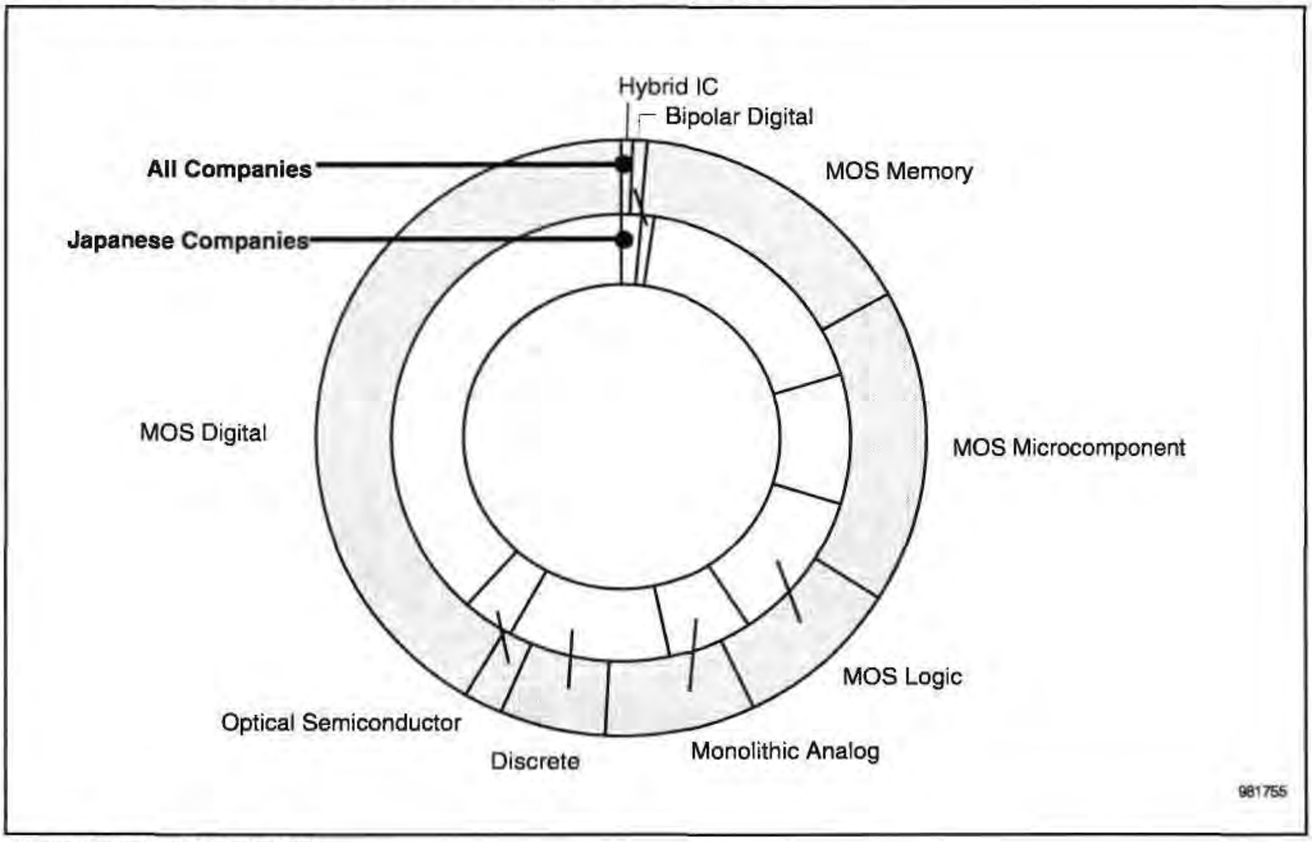
Regional Trends of Japanese Companies' Semiconductor Revenue

Historically, Japanese companies benefited from the fast-growing domestic market, where the Japanese consumer equipment manufacturers that dominated the worldwide market increased production of consumer electronics. Thus, the Japanese market was dominated by Japanese vendors (see Figure 2-6), and a large portion of Japanese companies' revenue came from the domestic market (see Figure 2-7).

The first drastic change occurred in the mid-1980s, when the Japanese yen started to appreciate and electronic equipment manufacturers started to move their production sites overseas, mostly into various Asia/Pacific countries. This meant that Japanese semiconductor companies had to have sales offices, technology support centers, and eventually, production facilities in Asia/Pacific.

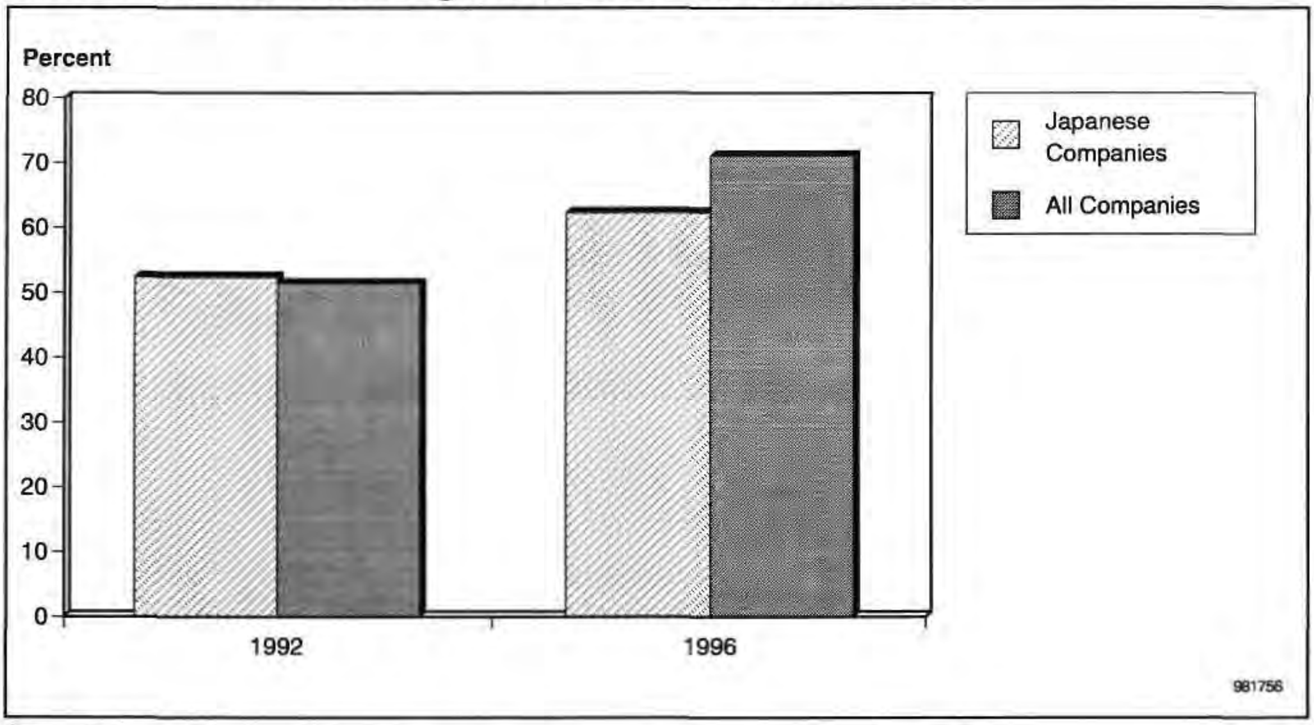
The second wave came in 1993, when the yen soared again, but this was also a year when the Japanese semiconductor market continued to be sluggish while all the other regional markets began to expand rapidly, driven by the PC boom. This trend prompted Japanese companies to expand foreign operations.

Figure 2-4
Worldwide Revenue Market Share by Product, 1996



Source: Dataquest (March 1998)

Figure 2-5
Share of Worldwide MOS Digital Product Revenue, 1992 and 1996



Source: Dataquest (March 1998)

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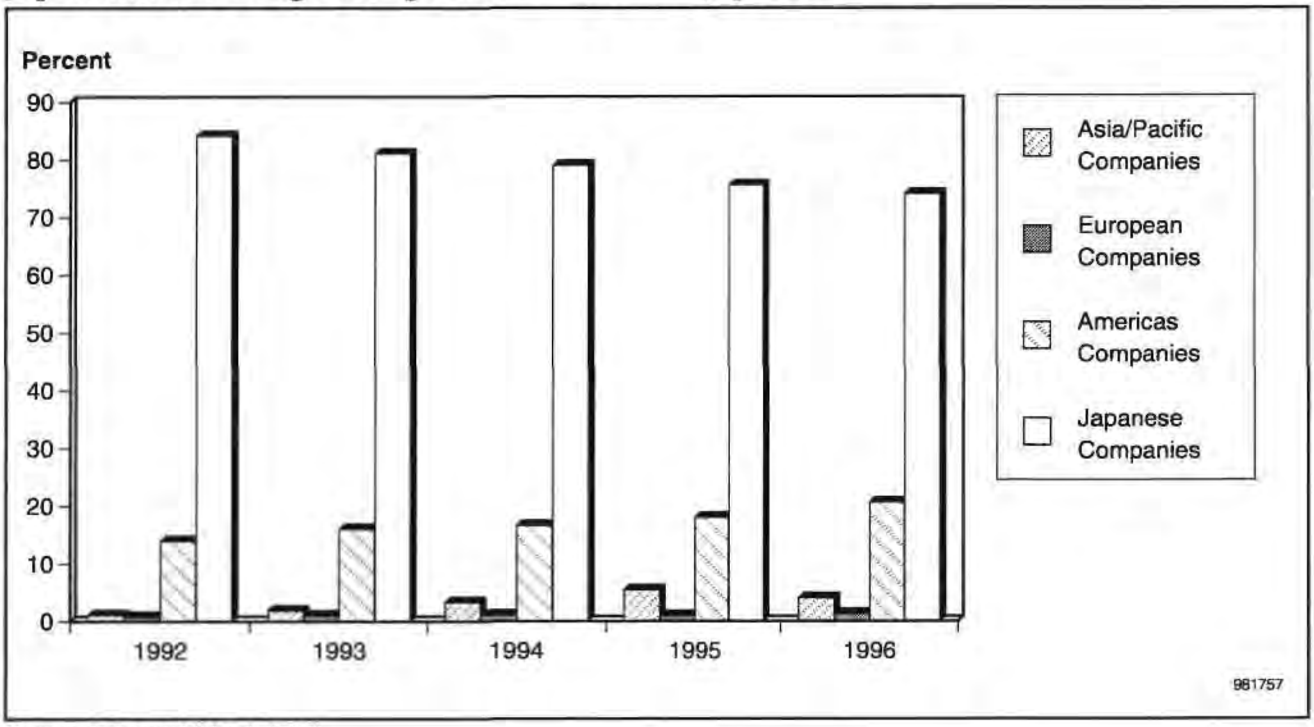
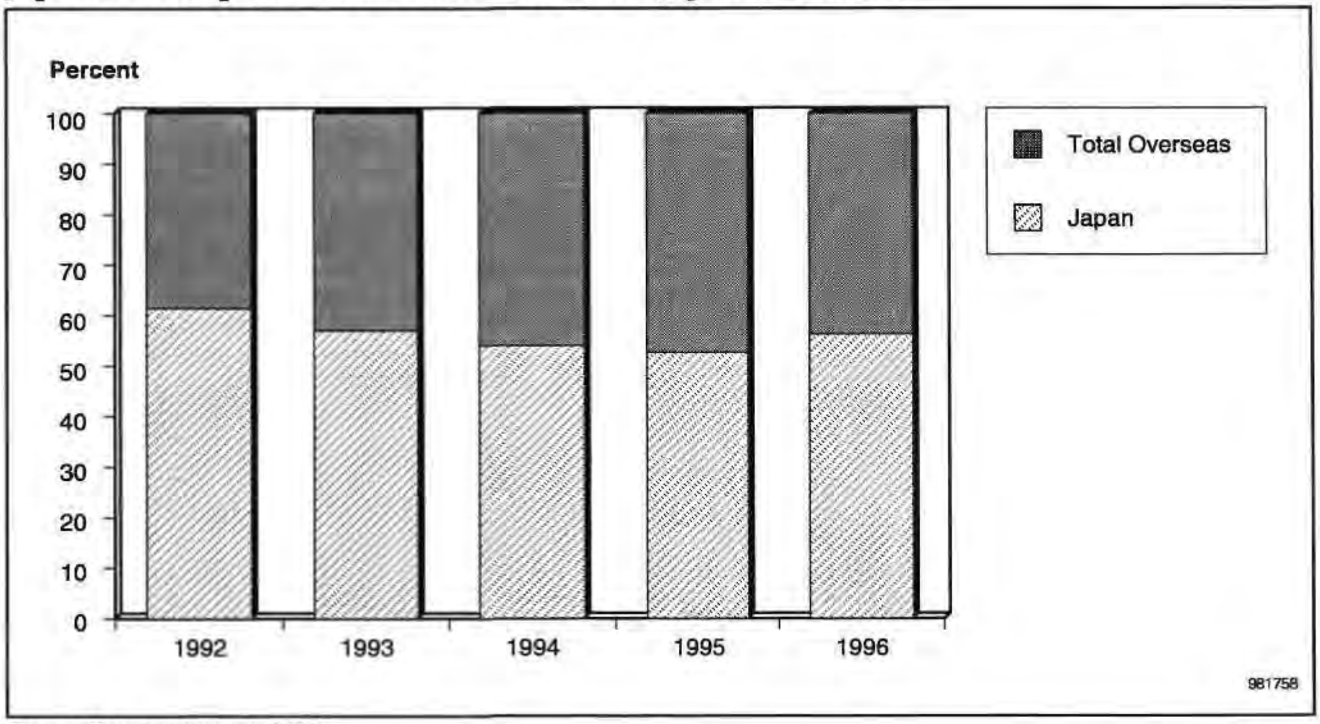
Figure 2-6
Japanese and Foreign Companies' Share of the Japanese Market



Source: Dataquest (March 1998)

Figure 2-7
Japanese Companies' Revenue Share of the Japanese Market

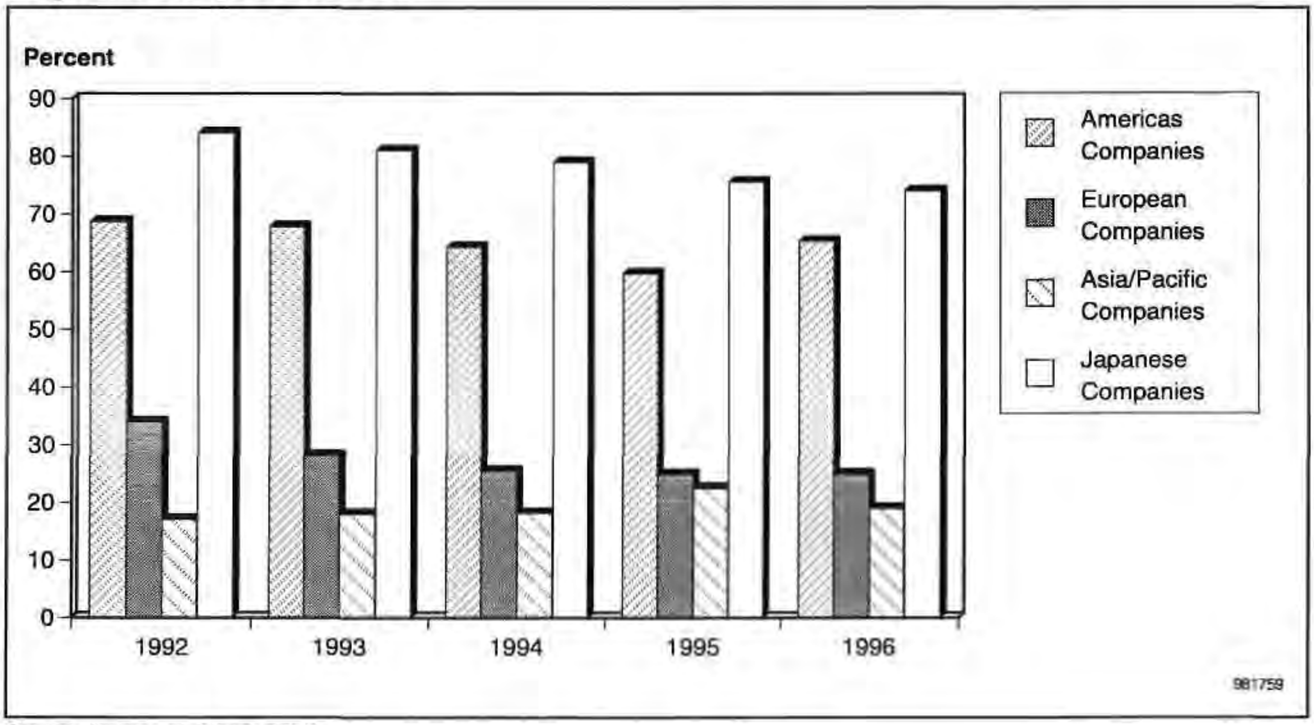


Source: Dataquest (March 1998)

Figure 2-8 compares regional companies' trends in regional sales. Among all regional companies, a sales focus on the company's own region is commonly seen. The extent of focus varies, however, according to market size and growth potentials. A notable difference between Japanese and non-Japanese companies is that non-Japanese companies tend to focus on at least one more regional market, while the domestic market seemed to be the only focus for Japanese companies. With the shift of application equipment production overseas, a focus on the Japanese semiconductor market alone could not bear much fruit. In fact, the sum of the market in Japan and in Asia/Pacific still represents about half the worldwide market, and this has encouraged Japanese companies to do close follow-up of their domestic users at foreign sites.

Tables 2-2 and 2-3 compare Japanese companies' trends in regional sales. Companies that focus on non-Japanese markets are Nippon Steel Semiconductor, Toshiba, Oki Electric Industries Company Ltd., and SANYO. They either followed their domestic users at foreign sites very closely or sought foreign markets for general-purpose products, including DRAM.

Figure 2-8
Revenue from Shipments of Semiconductors by Companies Shipping into Their Regional Base, 1992 to 1996



Source: Dataquest (March 1998)

Table 2-2
Japanese Companies' Regional Sales Orientation
(X = Regional Sales Greater than Japanese Companies' Average)

	Japan	Non-Japanese Market	Americas	Europe	Asia/Pacific
Fuji Electric	X	-	-	-	X
Fujitsu	X	-	-	X	-
Hitachi	-	X	X	X	-
Matsushita	X	-	-	-	-
Mitsubishi	-	X	X	X	-
NEC	-	X	X	X	-
New JRC	X	-	-	-	X
Nippon Steel Semiconductor	-	X	X	-	X
Oki	-	X	X	X	-
Ricoh	X	-	-	-	-
Rohm	X	-	-	-	X
Sanken	X	-	-	-	X
SANYO	-	X	-	-	X
Seiko Epson	X	-	X	-	-
Sharp	X	-	-	-	X
Shindengen Electric	X	-	-	-	X
Sony	X	-	-	-	-
Toko	X	-	-	-	X
Toshiba	-	X	X	X	X
Yamaha	X	-	-	-	X

Source: Dataquest (March 1998)

Companies such as Nippon Steel Semiconductor, Oki, NEC, Hitachi, Seiko Epson Corporation, Toshiba, and Mitsubishi generate more than 20 percent of their worldwide revenue in the Americas market. Those are the companies that are focusing heavily on either memories or logic in the region. It should be noted that, of these, NEC, Hitachi, and Mitsubishi have wafer fabs in the United States, and Toshiba has set up a joint venture with IBM.

The European market shows a somewhat different trend. Fujitsu leads Japanese companies, with 14 percent of its worldwide revenue coming from the Europe, Africa, and Middle East region. This is a benefit of having an internal user there. Hitachi, Mitsubishi, NEC, and Toshiba have a comparatively high dependence on the European market, and here again, the first three companies have wafer fab operations within the region, while Toshiba has back-end operation.

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Table 2-3
Japanese Companies' Regional Sales Penetration
(X = Company Market Share of Greater than 3 Percent)

	Worldwide	Japan	Non-Japanese Market	Americas	Europe	Asia/Pacific
Fuji Electric	-	-	-	-	-	-
Fujitsu	X	X	-	-	-	-
Hitachi	X	X	X	X	X	X
Matsushita	-	X	-	-	-	-
Mitsubishi	-	X	-	-	-	-
NEC	X	X	X	X	X	X
New JRC	-	-	-	-	-	-
Nippon Steel Semiconductor	-	-	-	-	-	-
Oki	-	-	-	-	-	-
Ricoh	-	-	-	-	-	-
Rohm	-	-	-	-	-	-
Sanken	-	-	-	-	-	-
SANYO	-	X	-	-	-	X
Seiko Epson	-	-	-	-	-	-
Sharp	-	X	-	-	-	-
Shindengen Electric	-	-	-	-	-	-
Sony	-	X	-	-	-	-
Toko	-	-	-	-	-	-
Toshiba	X	X	X	X	-	X
Yamaha	-	-	-	-	-	-
Total Japanese Companies	X	X	X	X	X	X

Source: Dataquest (March 1998)

Many Japanese companies sell hard into the Asia/Pacific market, but are not enjoying a high market share. In fact, when compared with the average orientation of Japanese companies, only Toshiba shows a determined regional orientation across the regions, while most other companies focus either on Americas and Europe or Asia/Pacific. Notably, it is the smaller companies that show high dependence on Asia/Pacific, which seems to represent their efforts to maintain business relationship with the Japanese users.

Matsushita and Sony do not seem to focus on overseas sales, but their internal sales need to be noted: These are the companies with large internal demand from user divisions and companies, and their sales of components tend to take place within Japan rather than at user divisions' actual production sites in Asia/Pacific.

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A Quick Look at the 1997 Rankings

Dataquest has completed its annual 1997 market share survey. Details of the survey have been discussed in Perspectives, and trends in the Japanese market will be discussed extensively in an upcoming Market Trends report. Tables 2-4 and 2-5 show worldwide and Japanese market share rankings, respectively.

Table 2-4
Revenue of Japanese Companies in the Top 20 Worldwide Ranking from Shipments of Semiconductors to the Worldwide Market, 1997 (Millions of Dollars)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Growth (%) 1996-1997
2	2	NEC	10,428	10,222	-2.0
5	5	Toshiba	8,065	7,253	-10.1
4	6	Hitachi	8,071	6,298	-22.0
8	8	Fujitsu	4,427	4,622	4.4
11	11	Mitsubishi	4,100	3,925	-4.3
14	14	Matsushita	3,003	2,847	-5.2
15	17	SANYO	2,491	2,471	-0.8
19	19	Sharp	2,124	2,145	1.0
23	20	Rohm	1,731	2,053	18.6

Source: Dataquest (March 1998)

Table 2-5
Revenue of the Top 10 Companies from Shipments of Semiconductors to the Japanese Region, 1997 (Millions of Dollars)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Growth (%) 1996-1997
1	1	NEC	5,756	5,666	-1.6
3	2	Toshiba	3,838	3,484	-9.2
2	3	Hitachi	4,252	3,355	-21.1
4	4	Fujitsu	2,645	2,768	4.7
5	5	Matsushita	2,268	2,244	-1.1
7	6	Intel	2,028	2,237	10.3
6	7	Mitsubishi	2,147	2,030	-5.4
8	8	Texas Instruments	1,634	1,549	-5.2
9	9	Sharp	1,561	1,491	-4.5
10	10	Sony	1,386	1,369	-1.2

Source: Dataquest (March 1998)

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NEC maintained the top position among Japanese companies, but the gap between it and the worldwide top company, Intel, has widened, with Intel recording nearly double NEC's revenue. The second- and third-ranked Japanese companies, Toshiba and Hitachi, changed places, mainly because of the hardship Hitachi faced in 1997 from DRAM price declines and slow expansion of its proprietary microcomponent product line. Other companies maintained their positions, including Toshiba and Fujitsu, but Mitsubishi could not find its way back into the top 10 ranking.

In the Japanese market, there were only a couple of changes in the ranking. Toshiba and Hitachi switched positions, as did Mitsubishi and Intel; all the others maintained their 1996 rankings. NEC not only remained at the top but widened the gap with the followers, showing only a modest decline in revenue.

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Chapter 3
Manufacturing Power

This chapter measures and analyzes Japanese companies' manufacturing power, as opposed to their brand sales power in the previous chapter.

Dataquest defines manufacturing power as:

- Manufacturing power = brand sales + foundry sales - foundry purchase

Some Japanese companies choose to announce production numbers on a fiscal year basis. Production numbers usually include both foundry shipments and foundry purchases, but some details remain unexplained. In this analysis, Dataquest applies its own measurement of all three factors in the equation above, based on its proprietary definitions.

1996 Foundry Trends

Japanese companies' foundry activity can be classified as either OEM business or foundry. OEM designates the kind of partnership business in which the provider company designs and manufactures a product sold under the partner's brand. Thus, the basic difference between OEM manufacturing and foundry lies in designing—in foundry, the user of foundry capacity designs the products, the provider manufactures them, and the products are marketed by the foundry user under its brand.

Starting in mid-1980s, Japanese semiconductor companies' foundry activity included a unique business type in which Japanese companies formed a cooperative framework to market their foreign counterparts' products, primarily to enhance foreign vendors' presence in the Japanese market. This took various forms of collaboration, including codevelopment of new products, fine-tuning of foreign-origin products to meet Japanese users' needs, sharing of production capacity and sales channels, and so on. This practice has decreased as foreign vendors built their own business systems in the Japanese market, and the recent rise in foreign companies' combined market share clearly shows that non-Japanese companies can be competitive in this market without the help of domestic competitors. In 1996, the Japanese market share of all non-Japanese semiconductor companies rose to 26 percent, and it is expected to increase further in 1997.

Historically, there was another type of foundry/OEM practice, especially among Japanese companies: fab transition, when old-generation DRAM fabs are refurbished with additional equipment to be used for other products, characteristically for microcomponents, logic, and then analog, or in the final stage, even for discrete. Those non-DRAM products could be produced at fabs that were largely, if not completely, depreciated, and thus the profitability of the overall semiconductor business was secured. Dataquest has identified this trend as the "Japan model," because this transition was possible with wide range of product offerings, which major Japanese companies have managed to grow.

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One form taken by this Japan model was OEM, with the provider offering manufacturing capacity for other companies' non-DRAM products. There were various strategic reasons for this kind of arrangement. Company A might be lagging behind in microcomponents. Rather than develop and manufacture microcomponents starting from ground zero, it might opt to turn to leading company B's product area, and then company A might provide B with A's own products in which B might not have invested as strongly. This kind of collaboration was actually based on very strategic decisions and was usually done among Japanese companies. Dataquest believes the scope and the amount of this kind of practice has largely been reduced in the 1990s.

Pure foundry has been regarded by Japanese semiconductor companies as a zero-profit operation, mostly because Japanese companies, with a few exceptions, used foundry as a way to fill their fabs. This kind of opportunistic foundry sales was encouraged when the market was in oversupply and the utilization of fabs dropped below the sound level. Rather than running the fab at low utilization, Japanese companies opted to find low-margin foundry business. Of course, there were several cases of Japanese companies' seriously seeking foundry opportunities to strengthen ties with foreign companies, especially some American and European companies. This took the form of production capacity sharing as part of an alliance on new product development or on new technology.

The emergence of dedicated foundry providers, however, has changed the framework. New foundry providers applied leading-edge technology and focused on manufacturing efficiency. (Detailed analysis of dedicated foundry providers is provided in various publications in the Dataquest's Semiconductor Contract Manufacturing Services Worldwide program.) The decline in foundry shipments stems from various factors, such as severance of a company's collaborative framework with its foreign counterparts or discontinuation of old-type Japanese OEM, but the most characteristic reason is weakening competitiveness against dedicated foundries. In view of the continued oversupply in the DRAM market, Japanese companies have sought foundry opportunities. The success of dedicated foundries in both revenue and profit has also encouraged some Japanese companies to include foundry among their business planning options.

1996 Manufacturing Revenue Estimates

Using the formula given earlier, Figure 3-1 shows Japanese companies' total foundry and manufacturing power trends, while Figures 3-2 and 3-3 show estimated manufacturing revenue for each Japanese company for 1995 and 1996, respectively.

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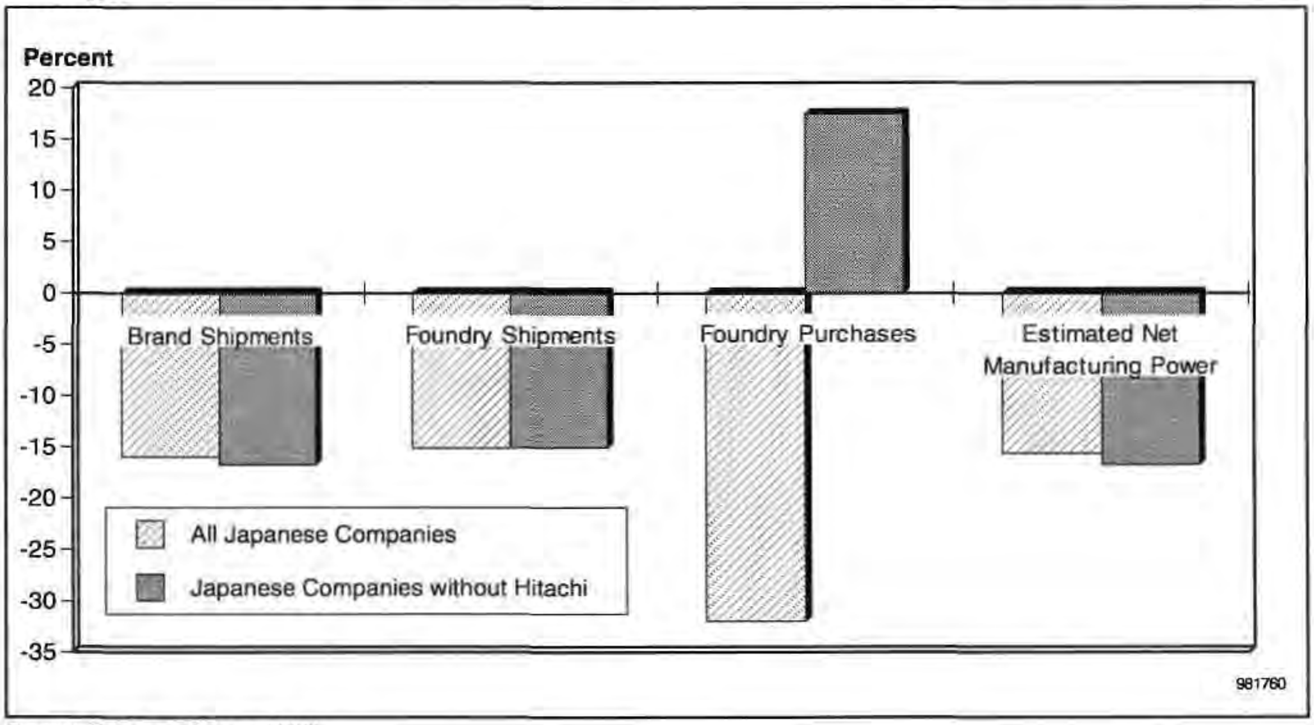
Figure 3-1
Japanese Companies' Foundry and Manufacturing Power, 1995 and 1996 (Percentage Change)



Source: Dataquest (March 1998)

The analysis of manufacturing power reveals some trends. In 1996, Japanese companies' brand shipment revenue was heavily impacted by weak pricing and declined. This was caused by the oversupply in MOS digital products caused by fast expansion of production capacity in the preceding few years. In these situations, Japanese companies have typically made efforts to increase foundry shipments to "fill the fab." Dataquest believes that this opportunism is one of the characteristics of Japanese companies' foundry business, which can still be observed in their business decisions.

But in 1996, foundry shipments declined faster than brand shipments. Revenue information for 1997 is yet to be finalized, but a preliminary look at the survey results indicates another year of declining foundry shipments. This clearly represents the hardship Japanese companies are facing in competition with dedicated foundry providers, such as some Taiwanese companies, as discussed earlier. This also seems to represent another trend—there is very little foundry business left among Japanese companies, except for some examples, such as the Mitsubishi-Seiko Epson agreement on foundry of proprietary embedded DRAM products.

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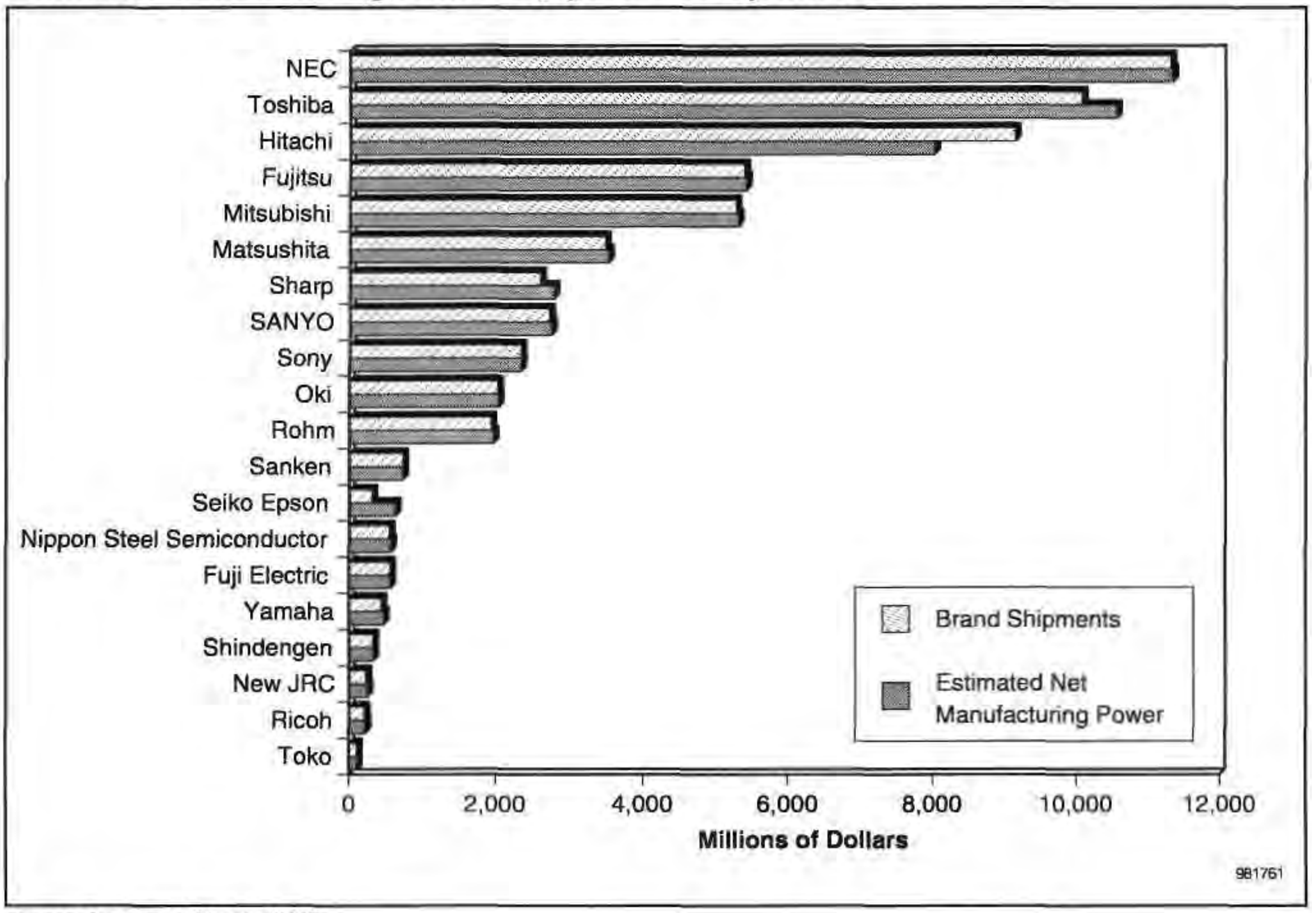
Figure 3-2
Estimated Manufacturing Power of Japanese Companies, 1995



Source: Dataquest (March 1998)

Another trend is becoming clearer: Japanese companies are increasing foundry purchases. It should be noted that DRAM OEM purchasing, such as Hitachi-LG Semicon, has been impacted by the fast price decreases, while, on a unit basis, it is growing. Again, because inter-Japanese foundry is decreasing, this increase in foundry purchases can only be attributed to alliances with non-Japanese companies. Contributing to this trend are examples such as Toshiba-Winbond and Fujitsu-Taiwan Semiconductor Mfg. Co. (Dataquest does not regard Powerchip Semiconductor Corporation as a foundry to Mitsubishi at this time). Although still small, the trend toward increasing foundry purchases is evident, and there will be more of this, both in size and in product categories, as Japanese companies try to focus on a limited number of products for efficient management of their semiconductor business.

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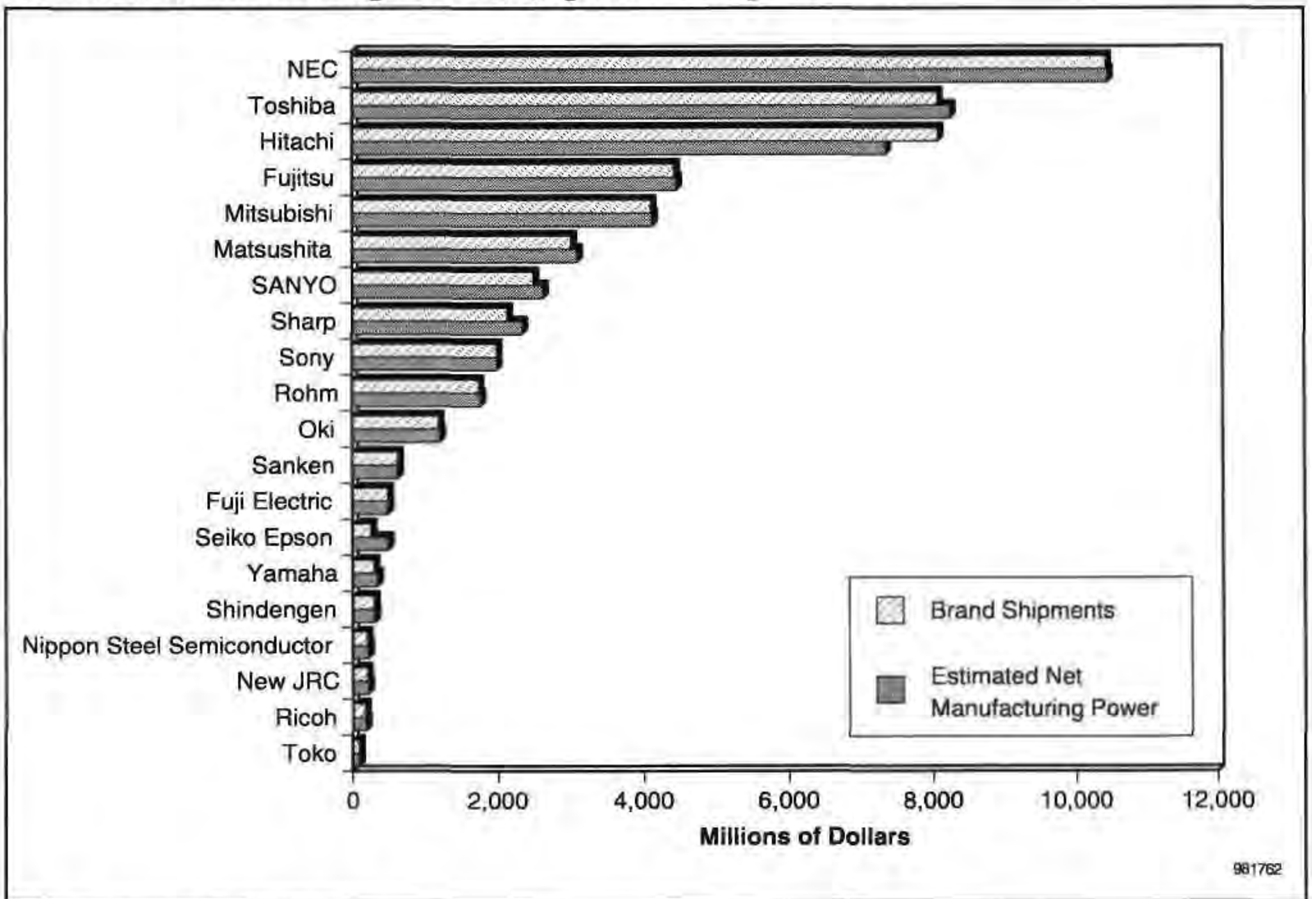
Figure 3-3
Estimated Manufacturing Power of Japanese Companies, 1996



Source: Dataquest (March 1998)

1997 Fab Trends

Manufacturing power has been the biggest factor in the rise of Japanese semiconductor companies in the worldwide market. In a fast-growing market, supply capacity played a key role in increasing revenue, and Japanese companies' strategies centered around the decision to increase capital spending on manufacturing capacity.

Trends over Time

Japanese companies' fab construction has been driven basically by two factors—DRAMs for major companies and cyclical business trends.

DRAM companies accelerate fab construction during DRAM boom years, including new shells and even new sites. To simplify the pattern, some of this effort results in oversupply after the boom years, and new shells remain empty for some time, to be filled only in the next cycle. This pattern has caused radical ups and downs in DRAM companies' capital spending.

Non-DRAM companies have built fabs at a comparatively constant pace, but again on a cyclic pattern. To these companies, business cycles were triggered by demand cycles observed up to the 1980s. When such cycles became less visible in the 1990s, the companies started to increase fab capacities at a constant but gradual pace. Some companies have chosen to make certain product areas the driver of technology and fab expansion, such as microcontrollers, analog, or power discretes, depending on product coverage.

Regional Fab Trends

In the rise of the Japanese semiconductor companies, the fast-expanding domestic market was more than enough to consume output from Japanese companies' fabs. As regional market trends changed, however, and Japan became the slowest-growing market and as the Japanese yen appreciated, Japanese semiconductor companies had to expand overseas production operations while they had a way of concentrating production facilities in the domestic region. Only a handful of companies have continuously invested in foreign countries for manufacturing. The few foreign production sites secured by Japanese companies were mostly acquired or built during or right after the semiconductor market boom. Table 3-1 lists major foreign fabs of Japanese companies.

Type of Operation

Japanese companies' foreign wafer fab operations started through acquisition of existing fabs of local companies. Then those fabs were expanded and upgraded to produce DRAMs or logic products to be marketed locally. There were exceptions, such as NEC's Roseville fab, part of the output of which has been sent to other regions to be packaged and marketed globally.

During the PC-driven boom years of 1993 to 1995, Japanese companies announced plans to enhance their overseas wafer fab operations, including new fabs such as NEC Scotland's Phase 2 and Hitachi's HISUS U3, to develop new wafer fabs at back-end sites, such as Mitsubishi's Aachen fab, or to enter joint ventures with non-Japanese companies, such as Powerchip Semiconductor (Mitsubishi-UMAX), TwinStar (Hitachi-Texas Instruments Inc.), Dominion Semiconductor (Toshiba-IBM), or joint ventures between Japanese companies, such as Hitachi-Nippon Steel Semiconductor in Singapore. The strategy varied according to each company's global strategy and the technology alliances the company had formed.

For back-end operation, an increasing portion of foreign operations seems to have been shifted from Japanese companies to local assembly and test houses, but details are yet to be surveyed. Also noteworthy is the increase in module production overseas, where local sales offices and production sites have chosen local subcontractors to assemble memory modules to meet fast-changing local demand as well as stringent price requirements.

Table 3-1
Major Japanese Companies' Overseas Fabs

Company	Fab Name	Campus Name	City	Country	Products	Date of Initial Production	Minimum Line Width (Micron)	Maximum Diameter (mm)
Fujitsu	No. 1	Durham	Newton Aycliffe	U.K.	4Mb 16Mb DRAM	1991	0.42	150
Fujitsu	No. 1	Gresham Mfg. Division	Gresham	U.S.	4Mb DRAM	1988	0.80	150
Fujitsu	No. 2	Gresham Mfg. Division	Gresham	U.S.	64Mb DRAM	1997	0.25	200
Fujitsu	Phase 2	Durham	Newton Aycliffe	U.K.	16Mb 64Mb DRAM	1999	0.25	200
Hitachi	E2	Landshut	Landshut	Germany	16Mb DRAM 8-bit MCU	1993	0.50	200
Hitachi	U2	Irving	Irving	U.S.	1Mb 4Mb DRAM 256Kb SRAM MPU	1990	0.80	150
Hitachi	U3	Irving	Irving	U.S.	MPU MCU	1998	0.25	200
Hitachi-Nippon Steel Semiconductor	Hitachi-Nippon Steel Semiconductor	Tampins	Singapore	Singapore	64Mb DRAM	1998	0.30	200
Matsushita	Fab C	MASCA	Puyallup	U.S.	1Mb 4Mb DRAM 4-bit 8-bit MCU	1992	0.60	150
Matsushita	Fab D	MASCA	Puyallup	U.S.	16-bit MPU 32-bit DSP 64Mb DRAM	1998	0.25	200
Mitsubishi	MSAI	Durham	North Durham	U.S.	16Mb DRAM MCU	1990	0.50	150
Mitsubishi	MSE	Aachen	Alsdorf	Germany	4Mb 16Mb DRAM	1997	0.35	200
Mitsubishi-UMAX (Powerchip)	Powerchip	PCS	Science Park	Taiwan	16Mb DRAM 64Mb DRAM	1996	0.35	200
NEC	K-Line	Roseville	Roseville	U.S.	ASIC MCU	1984	1.00	125
NEC	M-Line	Roseville	Roseville	U.S.	16Mb DRAM	1991	0.25	150
NEC	1 Phase	Scotland	Livingston	U.K.	ASIC Micro Logic 4Mb DRAM	1987	0.50	150
NEC	2 Phase	Scotland	Livingston	U.K.	16Mb 64Mb DRAM	1996	0.25	200
NEC	Shougang Phase 1	Shougang NEC	Beijing	China	MCU Logic	1992	1.20	150
NEC	Shougang Phase 2	Shougang NEC	Beijing	China	4Mb DRAM 4-bit MCU	1994	0.65	150
NEC		Shanghai	Shanghai	China	Memory Logic	1999	0.25	200
Sony	Fab 11	San Antonio	San Antonio	U.S.	SRAM	1991	0.45	150
Sony	Fab 12	San Antonio	San Antonio	U.S.	ASIC PLD	1982	1.25	150
Texas Instruments-Hitachi (TwinStar)	TwinStar		Richardson	U.S.	16Mb 64Mb DRAM	1996	0.30	200
Toshiba-IBM	Module 1	Dominion Semiconductor	Manassas	U.S.	64Mb DRAM	1997	0.25	200

Source: Dataquest (March 1998)

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Detailing trends in design is beyond the scope of this analysis, but significant numbers of design centers have been set up around the world in the past few years to meet local system requirement. In a limited number of cases, however, locally designed products can be marketed autonomously—a central control from the headquarters is still the norm for most Japanese companies, which foreign local users may find inefficient and time-consuming.

The Advantages in Constructing an Overseas Fab

There are various reasons for Japanese companies to set up foreign production facilities, which can be classified as demand-side (or environmental) and supply-side (or corporate-oriented) reasons. Demand or environment are also characterized as "pull" factors, because companies are pulled to overseas sites for those reasons, while supply or corporate reasons are "push" factors, for these push the companies to foreign production. The following are the factors pulling and pushing Japanese fab construction overseas:

- Demand/environment
  - Timely response to local demands
  - Enhanced dependability for local customers
  - Fast growth in local demand
  - Avoidance of trade barriers such as tariffs
  - Avoidance of trade friction by substituting export into the region with local production
  - Integration of the production process from design to assembly and test
  - Strengthening of partnerships with allied local companies
  - Alliances with local user companies
- Supply/corporate
  - Sharing fruits of codevelopment with local companies
  - Technology transfer
  - Risk diversification by having multiple suppliers
  - Slow growth in domestic demand
  - Reduction in manufacturing cost
  - Reduction in logistics cost
  - Incorporation of or deployment of local human resources
  - Deployment of various local resources from local allied companies
  - Recycling profits from local sales
  - Ample funding

Characteristics of Japanese Fab Expansion Overseas

Historically, Japanese companies' fab construction has been aggressive during semiconductor boom years. This can be attributed to two reasons. One was the increase in profits generated by the stable prices companies enjoy in up cycles. The other was semiconductor trade friction: Foreign investments were accelerated when a sudden increase of semiconductor exports from Japan caused a trade imbalance. Foreign fabs that have been built or acquired with this kind of background were not exactly based on Japanese companies' own long-term strategies, and, with a couple of exceptions, those fabs remained comparatively small in terms of wafer processing capacity. In back-end operations, reimport of output at Asia/Pacific sites to Japan was seriously considered, and in some cases, actually done to leverage on yen appreciation.

The rush in Japanese companies' overseas fab construction in 1993 through 1995 was characterized by one factor significantly different from the past—foreign markets were expanding much faster than the domestic market and "manufacturing near the market" had become the norm. NEC upgraded its Roseville, California, fab and started constructing a 200mm wafer fab in Scotland for 64Mb DRAM production. Toshiba, for the first time in its history, decided to build a DRAM wafer fab outside Japan, in alliance with IBM. Hitachi made two plans—TwinStar to produce DRAMs and HISUS U3 for production of proprietary microcomponent products. Fujitsu announced expansion at its Oregon site for production of 64Mb. Mitsubishi finally started a DRAM wafer fab at Aachen, Germany, after several years' hesitation. Matsushita decided to strengthen its fab operation in the United States by adding a 0.25-micron fab for 64Mb DRAM production. And Hitachi and Nippon Steel Semiconductor began construction of a joint wafer fab to produce 64Mb DRAM in Singapore. All those plans were aimed at seriously expanding sales of targeted products both locally and internationally.

This sudden flourish of overseas fab construction is, actually, nothing new for boom years. As discussed earlier, there are various reasons for Japanese companies to build foreign fabs, but one reason for all companies and all occasions is the ample financial resources available in boom years. This, in turn, implies that in bust years, Japanese companies' fab expansions dwindle, and in actuality, the record confirms that trend. So will negative attitudes among Japanese companies toward overseas fabs prevail in this adverse environment? There are signs to support that view, but details are yet to be announced.

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Regional Spending Trends

Capital spending in Japan has been mostly done by Japanese companies. Table 3-2 shows 1997 capital spending in Japan. In that year, almost the whole amount was estimated to have been spent by Japanese companies. During the 1980s through the early 1990s, when access to the Japanese market was a hot topic on the international scene, Japan was the largest single semiconductor market in the world. In an effort to increase sales here, non-Japanese companies started chip production in Japan. Texas Instruments could be described as one of the most aggressive, in the sense that it moved the headquarters of its DRAM operation into Japan. Some companies chose to set up joint ventures, such as Tohoku Semiconductor (Motorola Incorporated and Toshiba), Nippon Precision Circuits (LSI Logic Corporation and Kawasaki Steel Corporation), and KTI Semiconductor (Texas Instruments and Kobe Steel Ltd.). Fujitsu-AMD Semiconductor became the last to take this approach. Currently the interest of non-Japanese companies seems to have shifted to other regions, especially Asia/Pacific, for both a market and a supply base.

However, Japanese companies' spending still goes mostly into their domestic sites. In the 1980s, Japanese companies are estimated to have spent about 85 to 90 percent of their total capital spending within Japan, while in the early 1990s the ratio has dropped to 80 to 85 percent, leading to an increase in foreign production. This trend was caused by two factors: yen appreciation, which made it more lucrative for companies to produce and sell in the dollar economies, and market expansion. Foreign markets were expanding faster than Japanese markets, and if the name of the game is to "manufacture near the market," it was not advantageous to continue producing within Japan and then export the output. There were other reasons, including political decisions, but overall, the Japanese companies' spending overseas continued to increase up to the year 1996. Because total spending continued to increase in 1996, the ratio of overseas spending against the total peaked in 1995 (see Figure 3-4).

Then the tide changed. The yen started to depreciate, and the semiconductor market showed contraction. Reduced profits constrained capital spending, but Japanese companies also had to maintain capital spending for next-generation technologies and products. This has led them to spend more in advanced fabs within Japan and to review foreign operations. This was a difficult choice, because non-Japanese markets were still growing faster than the domestic market.

Table 3-2
Manufacturing Capital Spending in Japan, 1992 to 1997

	1992	1993	1994	1995	1996	1997
Japanese Spending ($M)	3,958	4,413	6,667	9,912	9,654	8,342
Growth (%)	-30.6	11.5	51.1	48.7	-2.6	-13.6

Source: Dataquest (March 1998)

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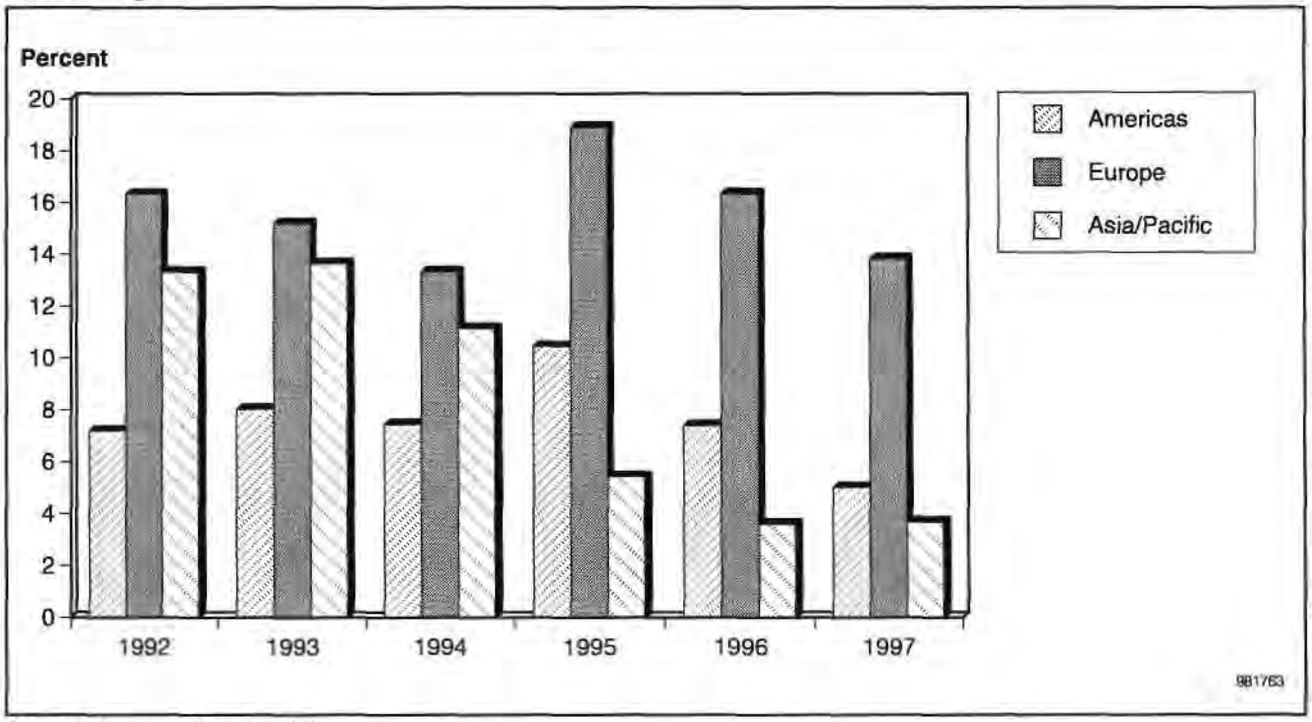
Figure 3-4
Japanese Companies' Overseas Capital Spending, 1992 to 1997 (Percentage of Total Spending)



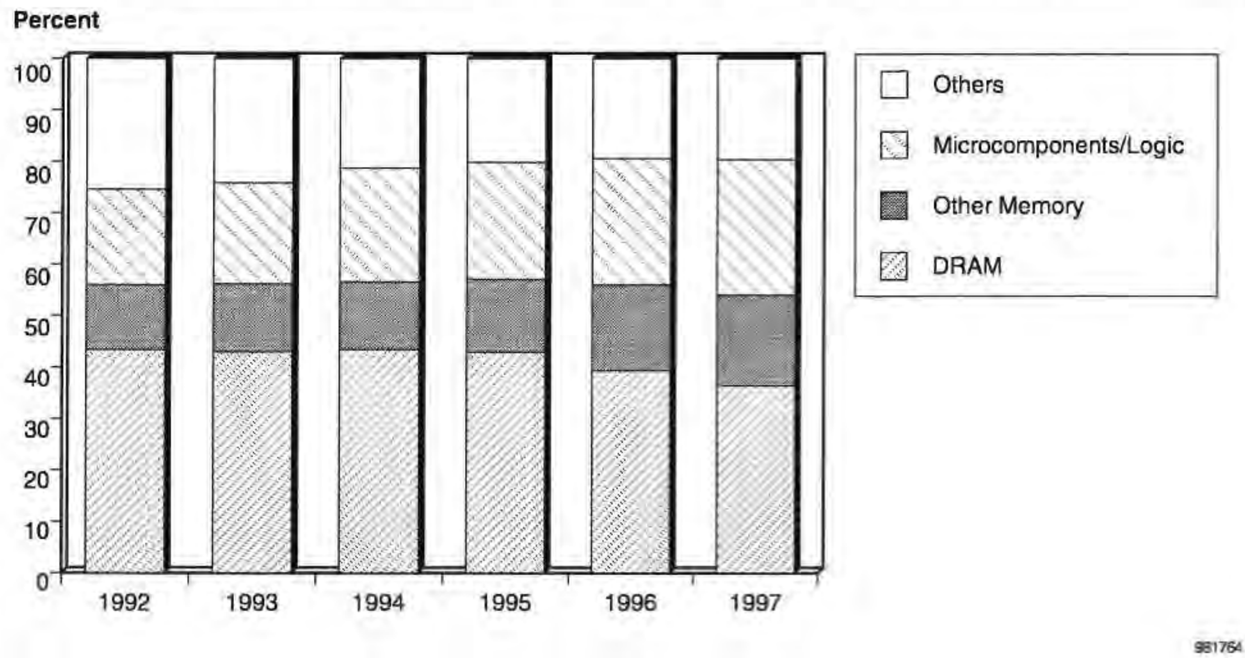
Source: Dataquest (March 1998)

Product Trends

Japanese companies' capital spending trends by product area are shown in Figure 3-5. DRAM alone represented about half the capital spending in Japan in the 1980s and more than 40 percent in the first half of 1990s. As excess capacity prevailed in the MOS digital product area, additional capacity plans for DRAMs were the first to be reviewed and eventually abandoned. Those fabs were then either redesigned for other memory products, such as flash memory, and microcomponents and logic products or postponed. In 1997, the whole memories category still represented more than half the total spending of Japanese companies. This decline in DRAM ratio does not necessarily mean that Japanese companies are abandoning the DRAM business—in fact, an increasing amount of DRAM foundry purchasing indicates that Japanese companies are determined to stay in the market while reducing the burden of capital spending into this volatile product category.

Spending for microcomponents and logic products is on the rise. Japanese companies have repeatedly attempted to focus on non-DRAM MOS digital products when the DRAM market has crashed. This time, however, the situation is quite different, because the market is moving fast toward system-level integration. The emphasis on non-DRAM products meant adding equipment to fabs originally constructed for the most advanced DRAM products, but the current focus on microcomponents and logic, especially cell-based ICs, requires the most advanced manufacturing equipment. Thus, the Japan model does not work anymore, and Japanese companies face the decision of whether to build a fab initially for logic products or memories. This implies that they will either need to prepare products that can fill those fabs afterwards to lighten the depreciation cost or they will have to turn to outsourcing—in other words, foundries.

Figure 3-5
Japanese Companies' Capital Spending Trends by Major Product Category



Source: Dataquest (March 1998)

As discussed in the section on foundry and manufacturing power, Japanese companies are adopting a new business model to make more use of contract manufacturing.

Research and Development Expenditure

Technology and product development, another aspect of manufacturing operations, will be covered in more detail in future documents. In this section, Dataquest looks only briefly at R&D expenditure; detailed information on alliances will be covered in a future Dataquest document.

The R&D spending of Japanese semiconductor companies was revisited in Dataquest's recent survey to clarify the distinction between manufacturing capital spending and R&D spending. Figure 3-6 shows estimated R&D spending for major Japanese companies. The companies can be divided into three groups according to level of spending.

Top companies spend about 10 to 15 percent of their semiconductor revenue on R&D activities, and they tend to maintain this level of spending over time (see Figure 3-7). These are the companies that lead technology development, competing hard with each other to develop and market new products ahead of everyone else. Not all of their spending brings additional revenue directly, because some part is spent on fundamental technologies and because some R&D is not fruitful. In view of the need to clarify their business focus, companies are changing this attitude and have started to explore the possibility of reducing their spending in areas on which they may not focus.

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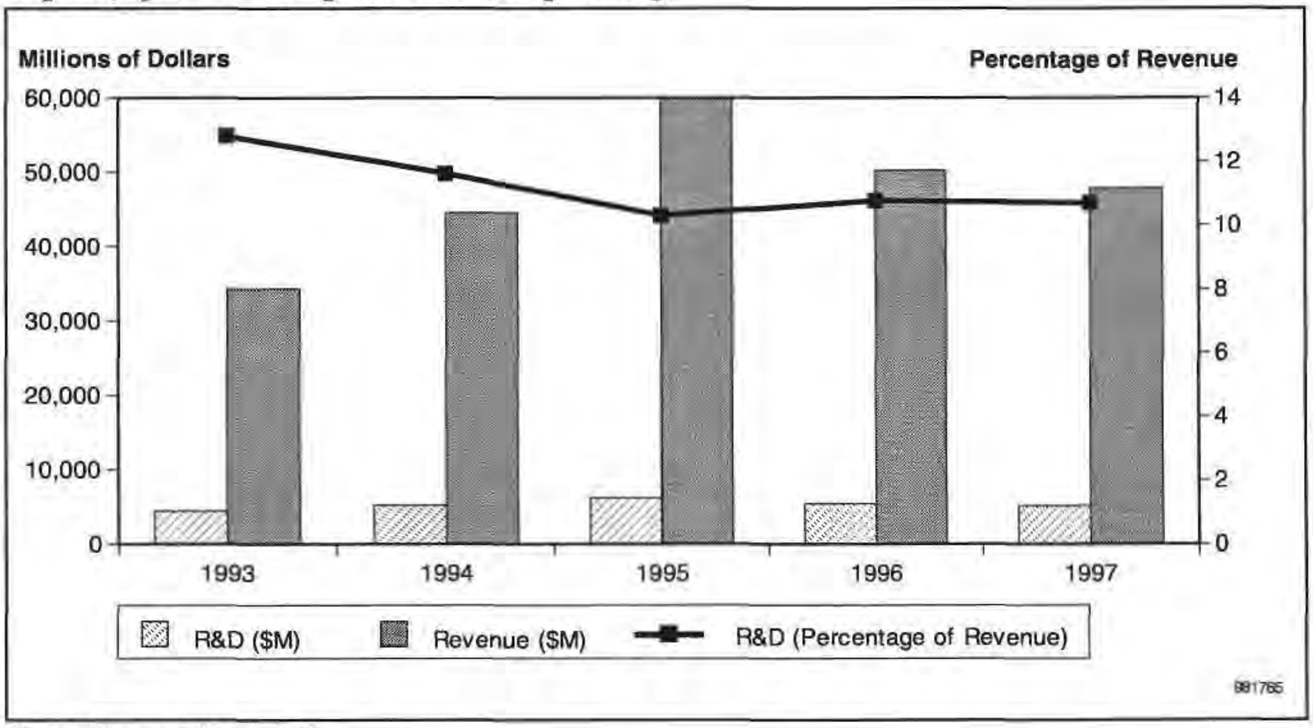
Figure 3-6
Top 20 Japanese Companies' R&D Spending



Source: Dataquest (March 1998)

This does not necessarily mean they will reduce their total spending or the ratio against revenue. But the increasing need for a strict business focus will drive those top companies to turn more to outside resources. Hitachi is an example. It is characterized by the large amount of DRAM needed from LG Semicon, as well as from joint ventures with other companies such as TI (TwinStar) and Nippon Steel Semiconductor (Hitachi/Nippon Steel Semiconductor Singapore). DRAMs produced at LG Semicon fabs to be supplied to Hitachi are generally made with Hitachi masks, and TwinStar uses a different mask set, based on codeveloped technologies. Hitachi uses yet another set of masks at its own proprietary fabs. This arrangement has enabled Hitachi to diversify risks, as well as making it easier for partners to participate in Hitachi's production scheme. This arrangement, of course, is not a complete solution and has its drawbacks in technology management, but the eventual result of this attempt will be of interest in the industry.

NEC, however, is going solo in manufacturing while participating in various technology and product alliances. Toshiba has sought alliance and foundry opportunities rather boldly among top Japanese companies. Its collaboration with Motorola on overall semiconductor operation and its codevelopment of DRAMs with Siemens and IBM have both brought about joint ventures—Tohoku Semiconductor and Dominion Semiconductor. Fujitsu followed, with Fujitsu-AMD Semiconductor Ltd. (FASL), as did Mitsubishi with Powerchip Semiconductor. Powerchip is actually a new form of joint venture in that it involves a semiconductor user company as well as financial circles, while other joint ventures have characteristically been between or among semiconductor companies.

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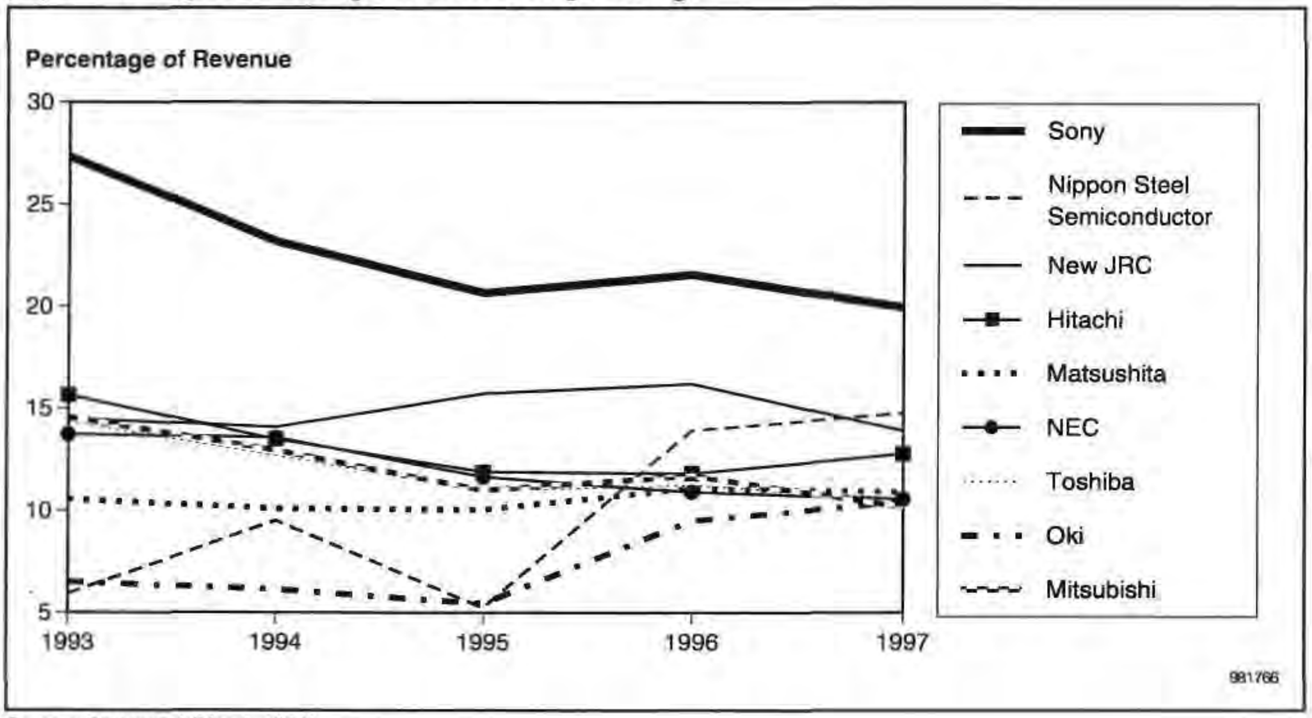
Figure 3-7
Japanese Top-Tier Companies' R&D Spending



Source: Dataquest (March 1998)

Middle-tier companies spend around 10 percent of revenue (see Figure 3-8), and the amount varies over time, depending mainly on revenue fluctuations. Those are the companies still dependent on internal demands, and similar trends can be seen in technology. These companies tend to have smaller application engineering groups, indicating that their system technology advisers lie in their user divisions, in-house.

Companies at the lower end of the list spend between 5 and 10 percent of their revenue (see Figure 3-9). They do not burden themselves with R&D expenditure and instead turn to outside resources, such as alliances. Their alliances tend to focus on specific technology and product areas that they have identified as their "battlefield," and they do not attempt to widen their coverage overnight. The spirit of kaizen, the Japanese term for gradual improvement, persists here. The companies in this group also leverage foundry opportunities, by either starting technology partnerships that include "production cooperation," a euphemism for foundry, or starting foundry businesses with additional (but usually not disclosed) contracts on technology transfer.

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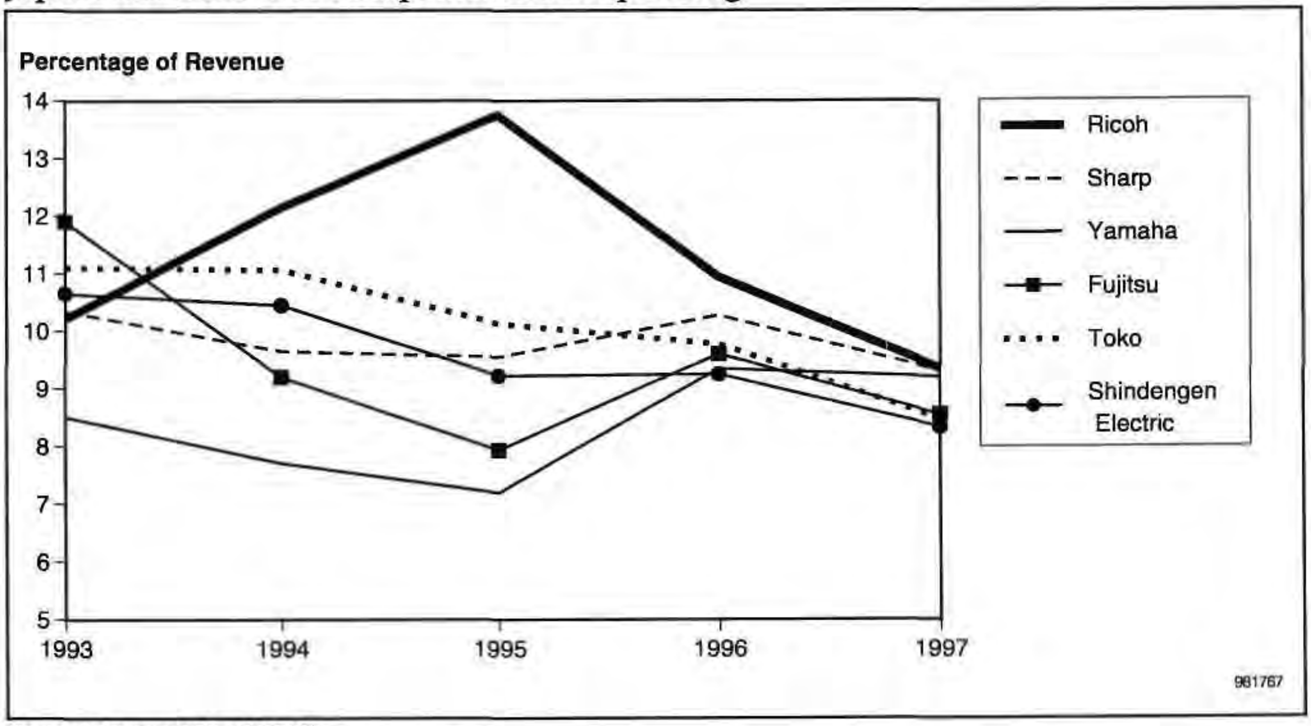
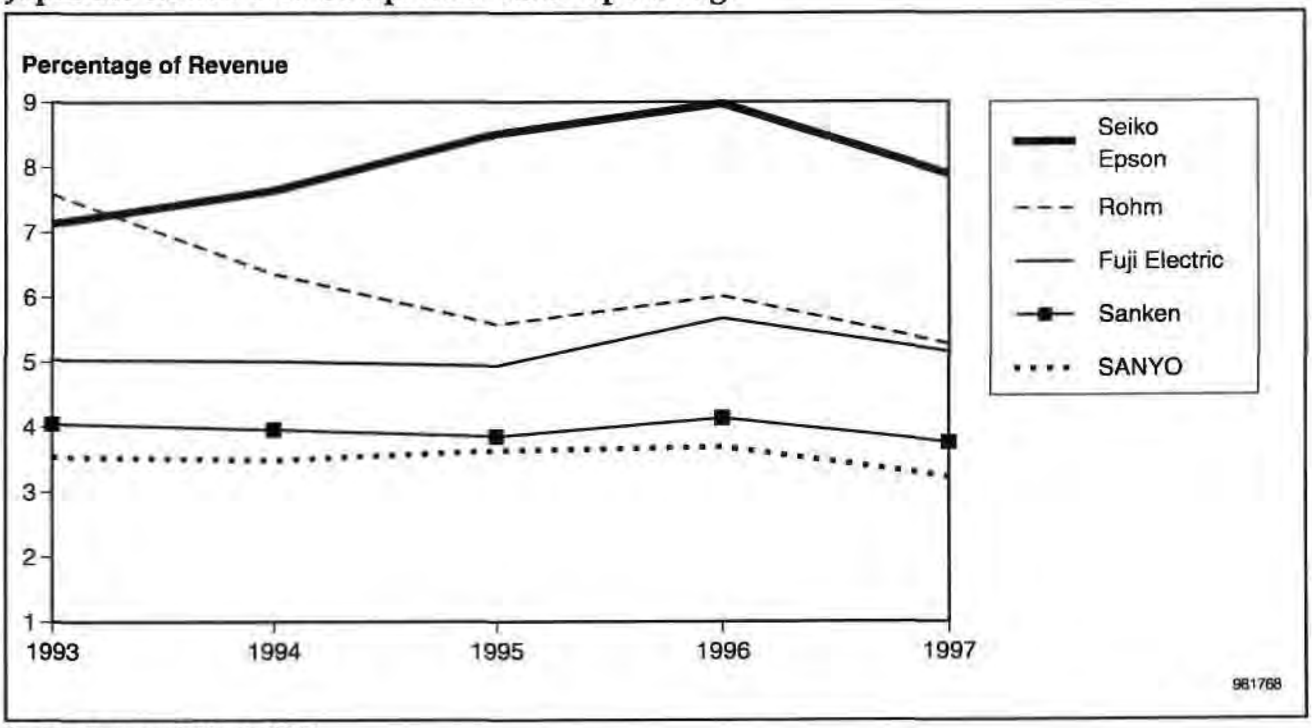
Figure 3-8
Japanese Middle-Tier Companies' R&D Spending



Source: Dataquest (March 1998)

Figure 3-9
Japanese Lower-Tier Companies' R&D Spending



Source: Dataquest (March 1998)

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Chapter 4
The Future of Japanese Semiconductor Companies

The analysis in Chapters 2 and 3 has illustrated the difficult environment as well as the difficulty in positioning faced by Japanese semiconductor companies. In the coming five years, there will be opportunities and threats for Japanese semiconductor companies. The threats can be summarized as follows:

- Demand side
  - Lack of proprietary system technology
  - Faster advances of system technology at non-Japanese systems companies
  - Diversification of regional demand
  - Sluggish outlook for domestic application equipment production
- Supply side
  - Growth of foreign competitors in the DRAM market
  - Growth of dedicated foundry providers
  - Growth of non-Japanese equipment manufacturers
  - Rising prices for manufacturing equipment
  - 300mm wafer production lead by non-Japanese companies
  - Non-Japanese ASIC companies
  - Expansion in cell-based ICs, an area in which Japanese companies have lagged behind

The opportunities that Japanese companies could enjoy can be summarized as follows:

- Demand side
  - Japanese systems companies flourishing in digital consumer equipment production
  - Expansion in communications applications, including networking
- Supply side
  - 300mm wafer production
  - Having strong manufacturing equipment and wafer companies within Japan
  - Facing, and in some cases actually making, fundamental changes as the profitability of the semiconductor business remains low for major product areas

On the demand side, the realization that the domestic market cannot drive Japanese semiconductor companies' growth is leading to a careful but determined approach toward foreign markets. Globalization has long been a cliché in the Japanese semiconductor industry. There have been efforts made in various aspects of the semiconductor business ranging from sales offices, technical support and design centers, back-end production, and wafer fab operation targeted at capturing local demand efficiently, but these were made mostly after demand prevailed. The globalization that is now required calls for a more aggressive approach toward non-Japanese systems companies, for those are the users that bring faster growth to vendors.

On the supply side, the time has come to give up the conventional Japan model of capital spending and fab utilization. In view of the rapid rise of both manufacturing capital spending and R&D spending requirements, Japanese companies have to seek ways to incorporate outsourcing in their long-term strategies, as opposed to seeking short-term helping hands in partnership. A potential shortage of engineers is also looming globally, especially in Japan, with the size of its younger population decreasing. This also increases the need for strategic alliances and global business operations to make better use of resources outside Japan. And the advent of system-level integration will require a wide range of intellectual property resources that no Japanese company is ready to provide alone. Only through alliances among semiconductor companies and through close ties with semiconductor users in various applications systems can this resource be realized.

These key factors, both on the demand and supply sides, call for organizational changes. Up to this point, Japanese companies have basically run the semiconductor business with product-oriented organizations. A few companies, such as NEC and Toshiba, are developing either virtual or actual organizations that are system- or application-oriented but most companies still follow a manufacturing-oriented organizational model with some application flavor, such as application engineering groups.

A company may have a strong, product-oriented "vertical" organization while struggling to nurture application marketing functions for "horizontal" operation. Those that have been dependent on internal user divisions may not have been burdened with big application engineering groups, but they have faced the challenge of outside system technology. As foreign markets grow faster and emerging system technologies are developed by non-Japanese users, Japanese companies have no choice but to expand overseas operations in all aspects, supported by application-oriented organizations at their headquarters.

Sales integration is also in progress. Japanese companies have had huge sales organizations, either in the form of direct sales or distributors. On one hand, the size of the salesforce not only helped in finding business opportunities, but also allowed the "mother ship" company to gather market information through the sales channel. But the slow growth of the domestic market has made a huge salesforce too burdensome in some cases, and some level of rationalization has been inevitable. One such attempt was to move direct accounts to a big sales agency and relocate the salesforce along with the accounts. Another form was to integrate distributors in the corporate groups to form a bigger entity, in expectation of improved efficiency.

Whether these "rationalization" processes will improve efficiency has yet to be seen, but they have been viewed as inevitable. And whether Japan can revive both as a regional market and as a supplier depends primarily on the overall development of electronics technology in Japan.

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Appendix A
Japanese Semiconductor Company Profiles

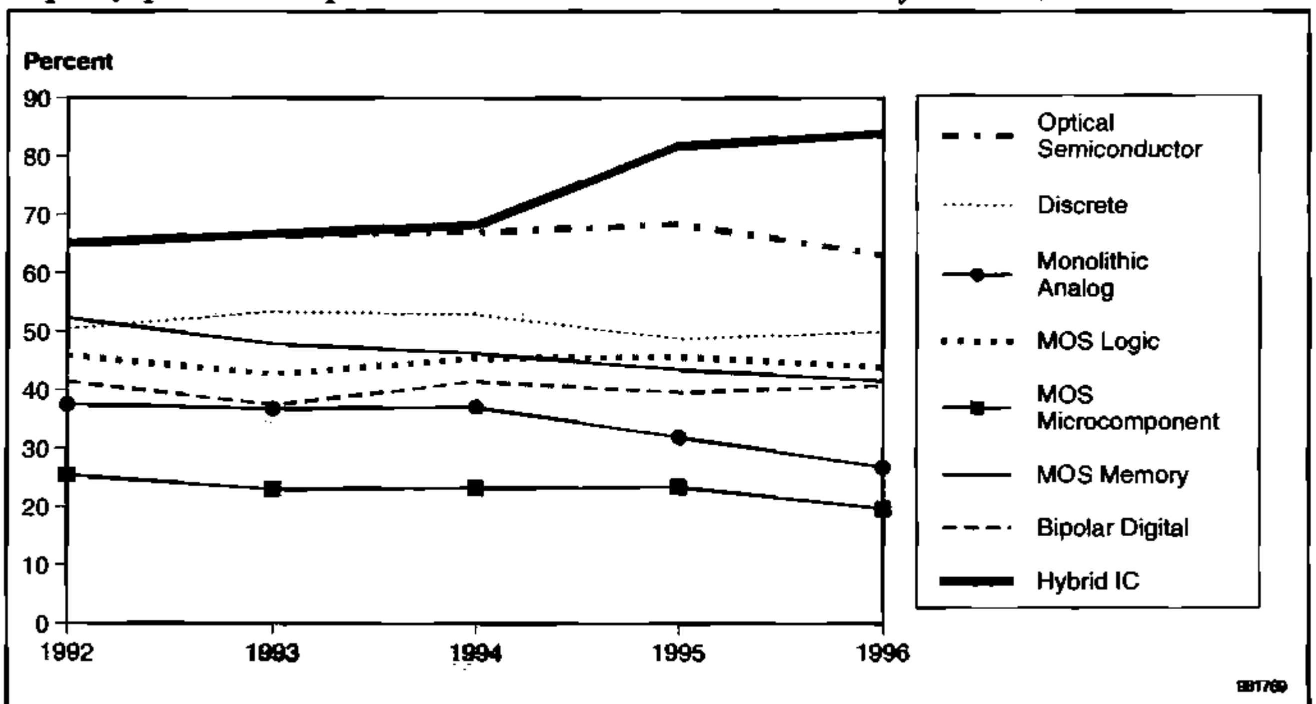
Basic information such as revenue and capital spending has been covered by a Competitive Trends document in the Semiconductors Worldwide program for the top 20 companies in the 1996 worldwide ranking (Competitive Markets in Semiconductors, 1996, SEMI-WW-CT-9701. December 1997). In this appendix, the basic information for all 20 Japanese companies is illustrated (see Tables A-1 through A-21 and Figures A-1 through A-105).

Table A-1
Revenue of Top 20 Japanese Companies by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	869	988	1,136	1,354	1,232
Bipolar Digital	1,324	1,158	1,207	972	752
MOS Memory	8,008	11,161	15,498	24,039	15,682
MOS Microcomponent	3,649	4,585	6,137	8,083	8,108
MOS Logic	4,610	5,679	7,312	9,413	9,450
Monolithic Analog	3,819	4,543	5,657	5,623	5,160
Discrete	4,118	4,861	5,692	6,987	6,732
Optical Semiconductor	1,747	1,998	2,608	3,289	3,101

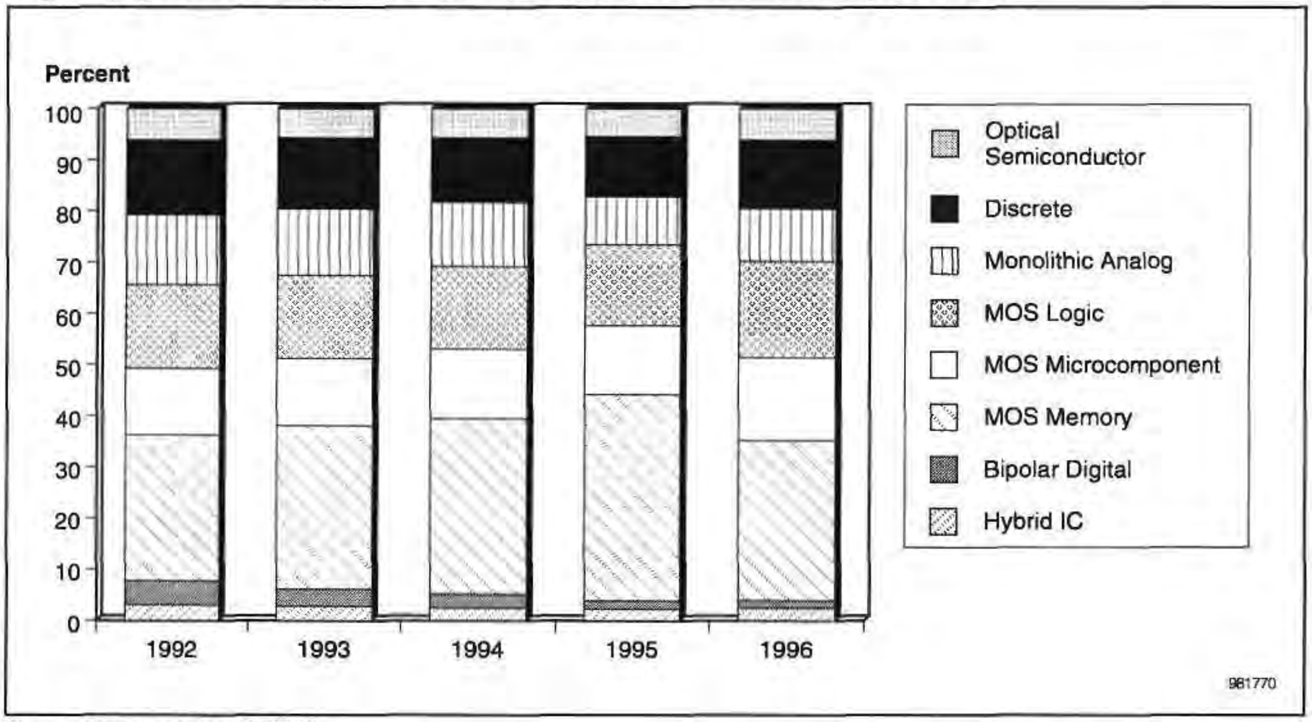
Source: Dataquest (March 1998)

Figure A-1
Top 20 Japanese Companies' Share of Worldwide Revenue by Product, 1992 to 1996



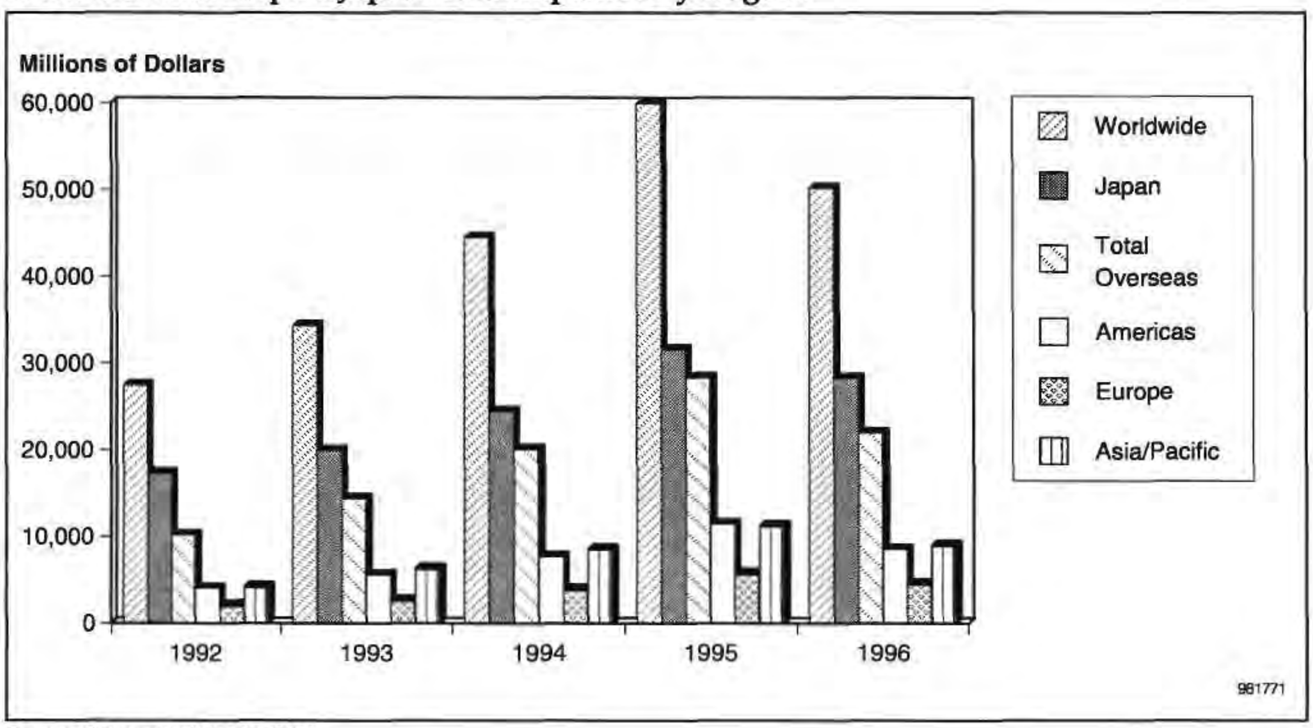
Source: Dataquest (March 1998)

Figure A-2
Top 20 Japanese Companies' Share of Japanese Revenue by Product



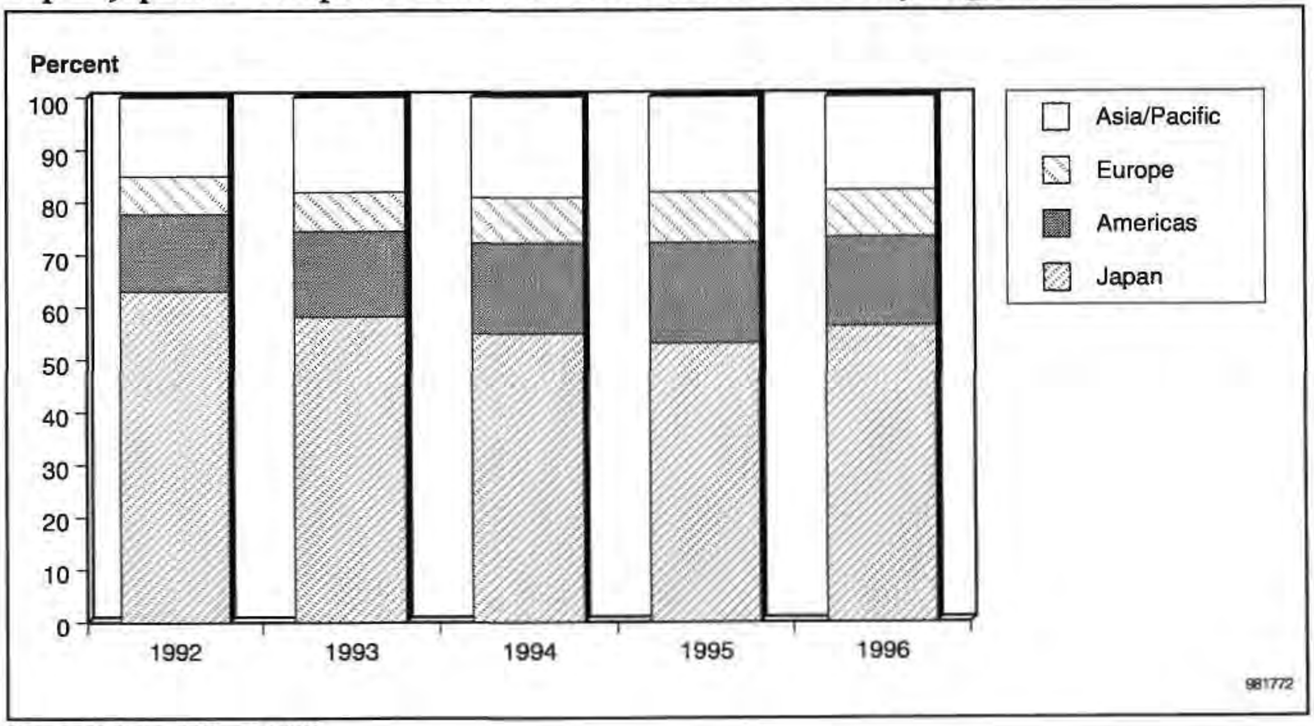
Source: Dataquest (March 1998)

Figure A-3
Revenue of the Top 20 Japanese Companies by Region



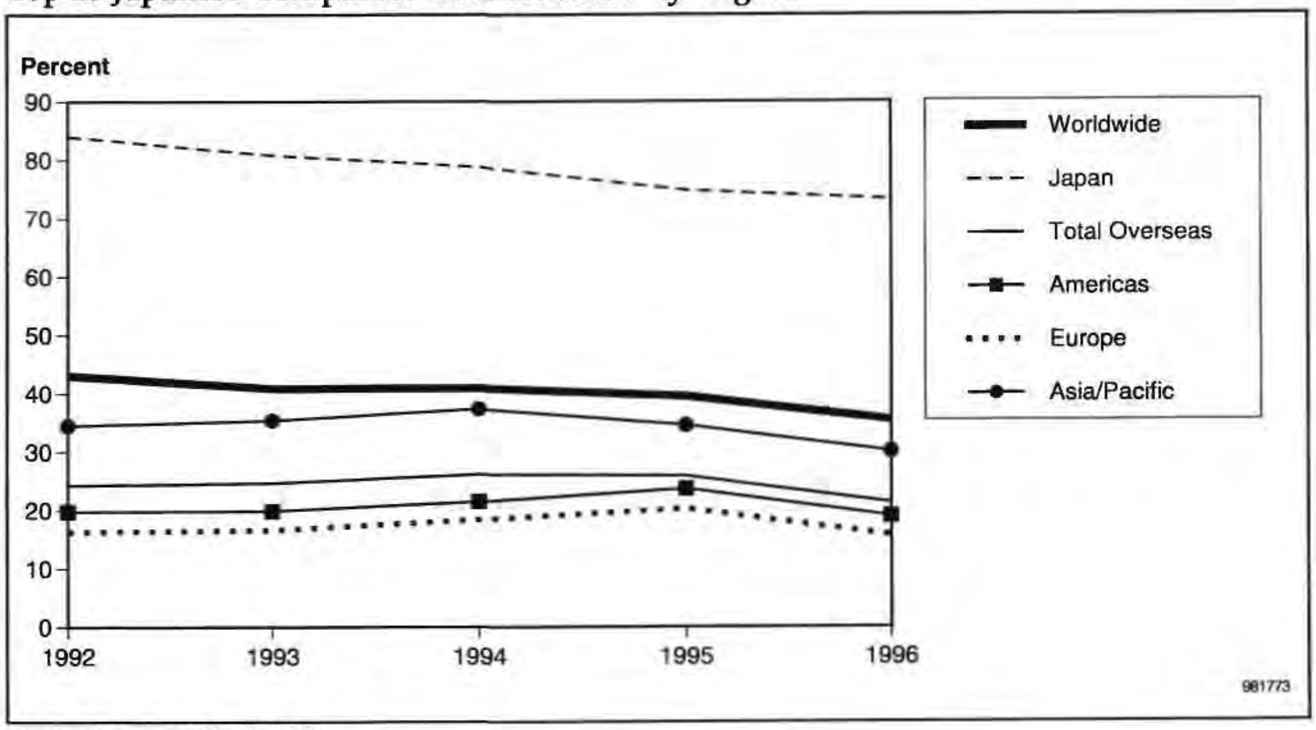
Source: Dataquest (March 1998)

Figure A-4
Top 20 Japanese Companies' Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-5
Top 20 Japanese Companies' Market Share by Region



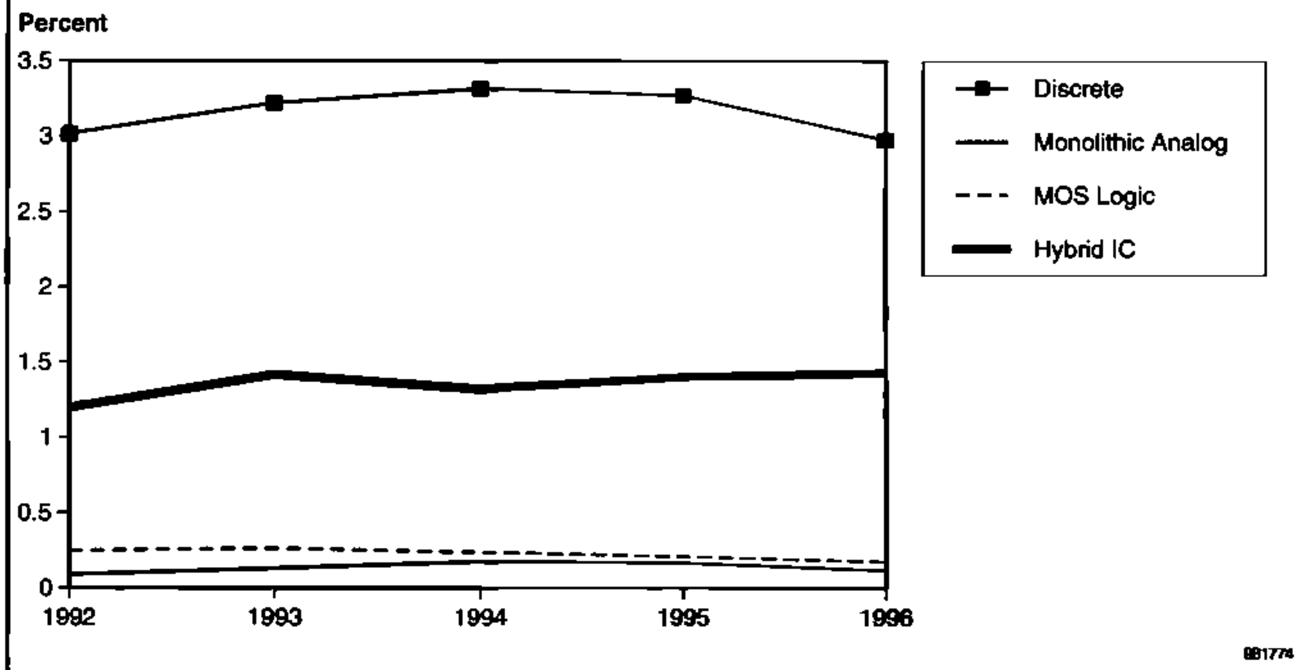
Source: Dataquest (March 1998)

Table A-2
Revenue of Fuji Electric by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	16	21	22	23	21
Bipolar Digital	0	0	0	0	0
MOS Memory	0	0	0	0	0
MOS Microcomponent	1	1	2	3	3
MOS Logic	25	35	38	43	38
Monolithic Analog	9	16	27	29	23
Discrete	246	293	357	468	401
Optical Semiconductor	0	0	0	0	0

Source: Dataquest (March 1998)

Figure A-6
Fuji Electric's Share of the Worldwide Market by Product, 1992 to 1996



Source: Dataquest (March 1998)

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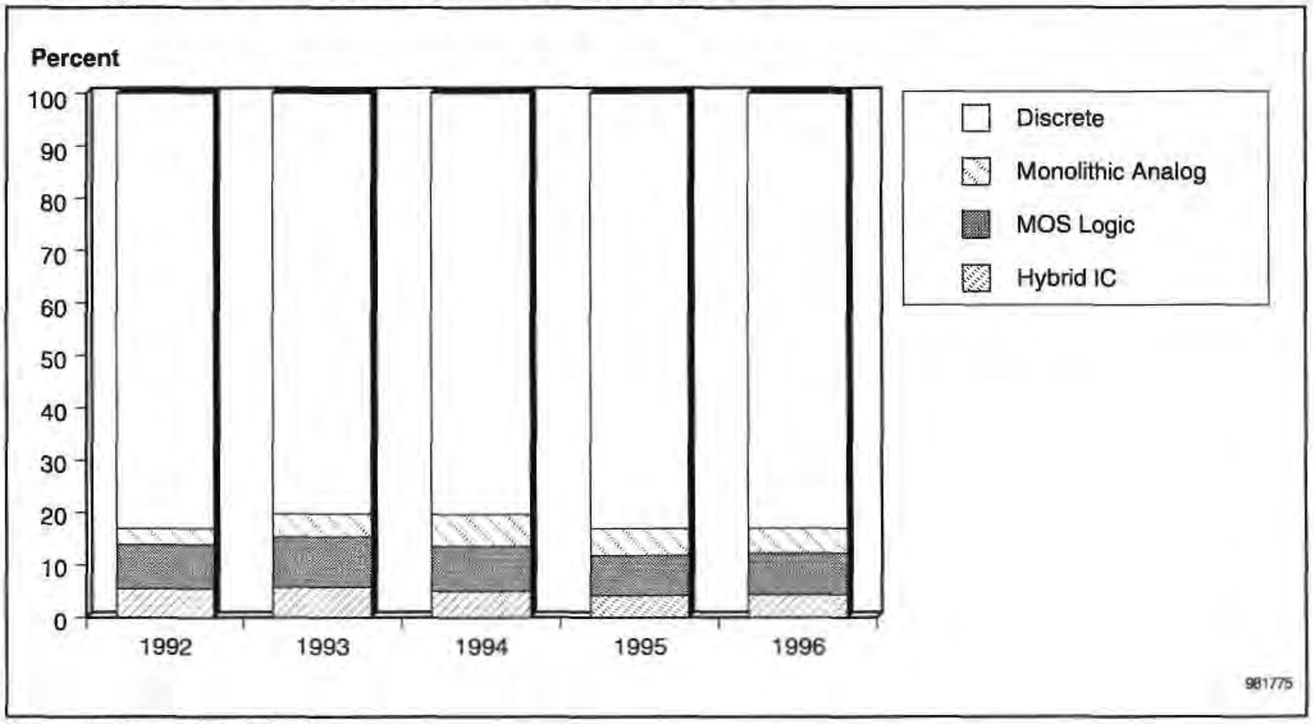
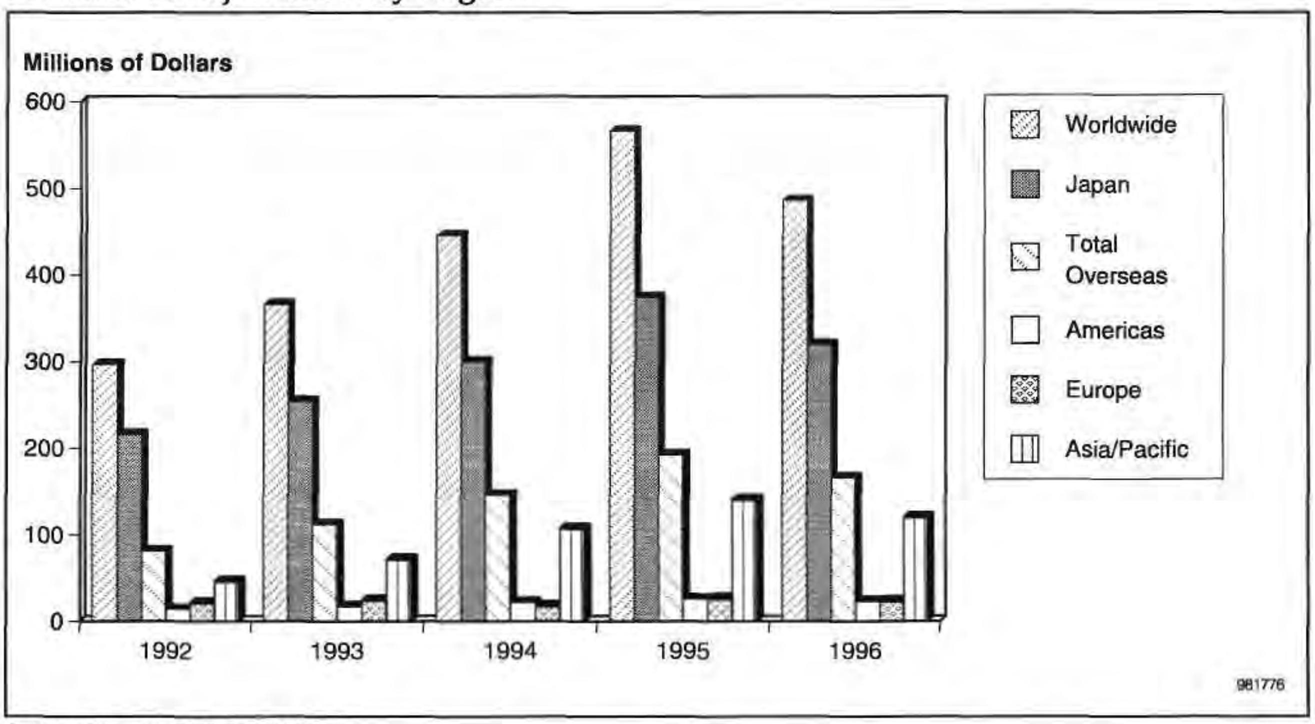
Figure A-7
Fuji Electric's Share of the Japanese Market by Product



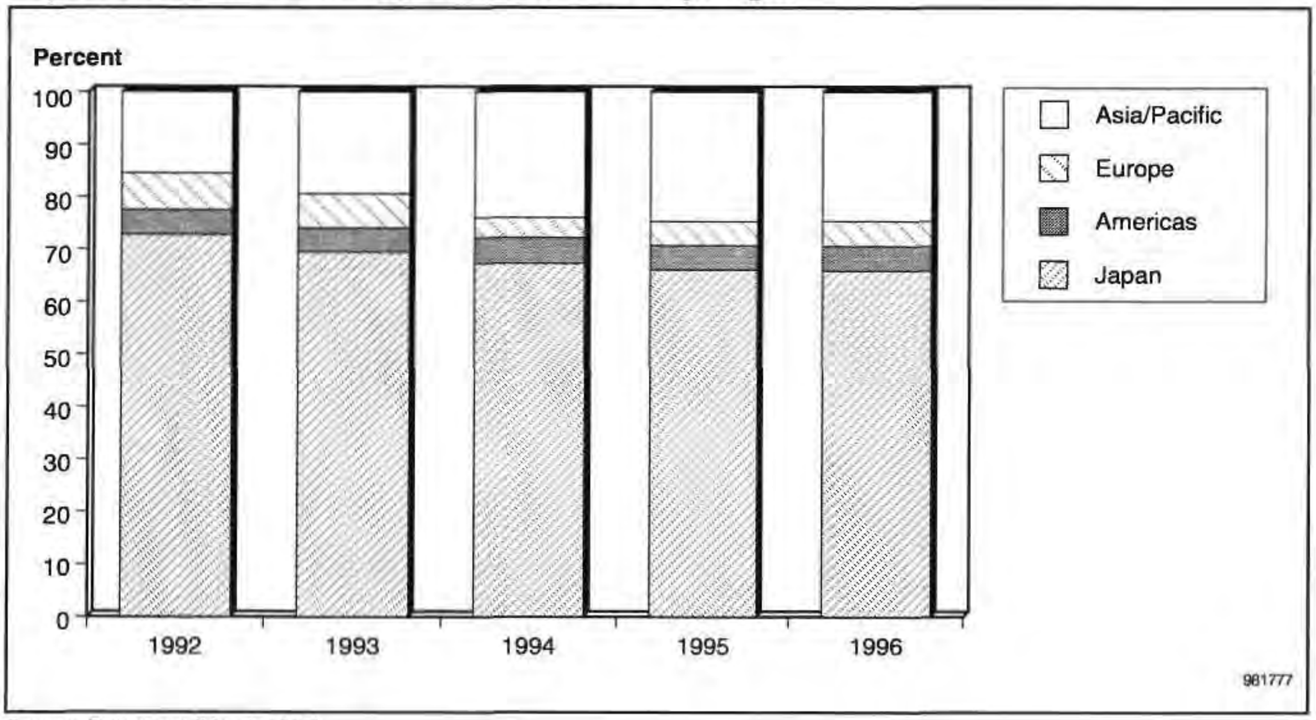
Source: Dataquest (March 1998)

Figure A-8
Revenue of Fuji Electric by Region



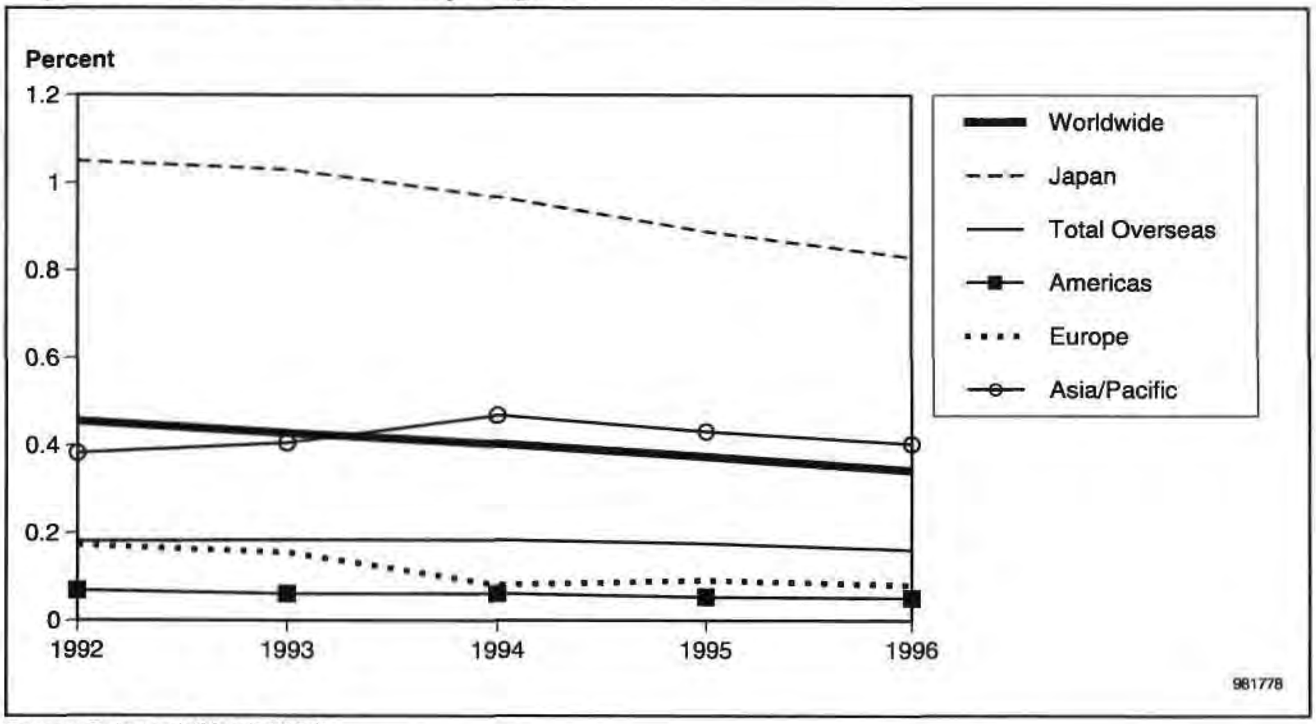
Source: Dataquest (March 1998)

Figure A-9
Fuji Electric's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-10
Fuji Electric's Market Share by Region



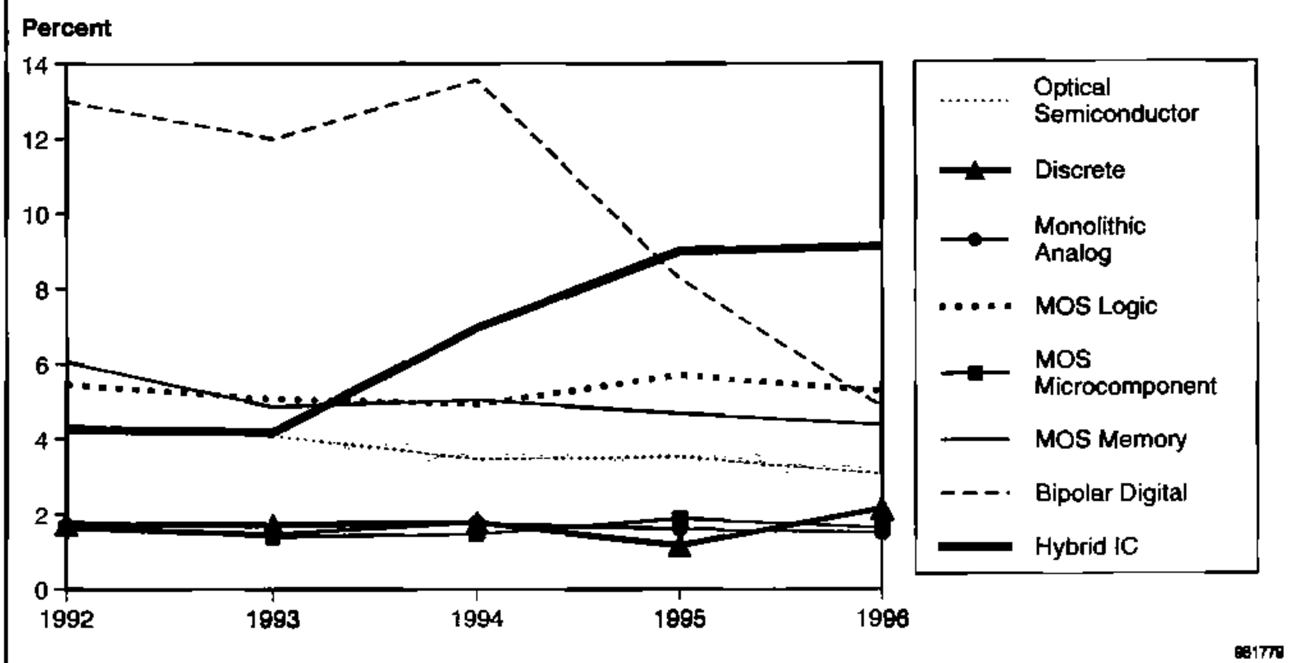
Source: Dataquest (March 1998)

Table A-3
Revenue of Fujitsu by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	57	62	116	149	134
Bipolar Digital	415	371	395	203	90
MOS Memory	927	1,135	1,692	2,589	1,656
MOS Microcomponent	233	282	390	650	677
MOS Logic	549	676	794	1,178	1,138
Monolithic Analog	118	122	155	428	291
Discrete	142	157	192	168	290
Optical Semiconductor	112	123	135	170	151

Source: Dataquest (March 1998)

Figure A-11
Fujitsu's Share of the Worldwide Market by Product, 1992 to 1996



Source: Dataquest (March 1998)

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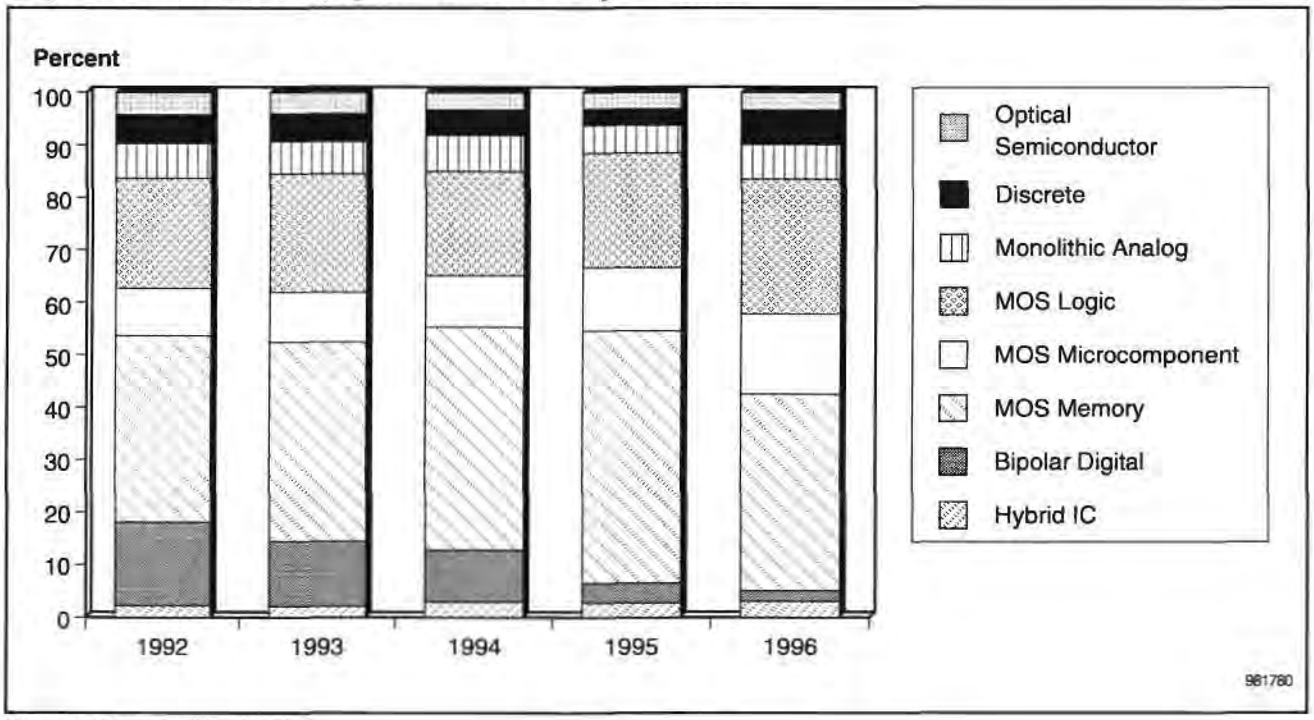
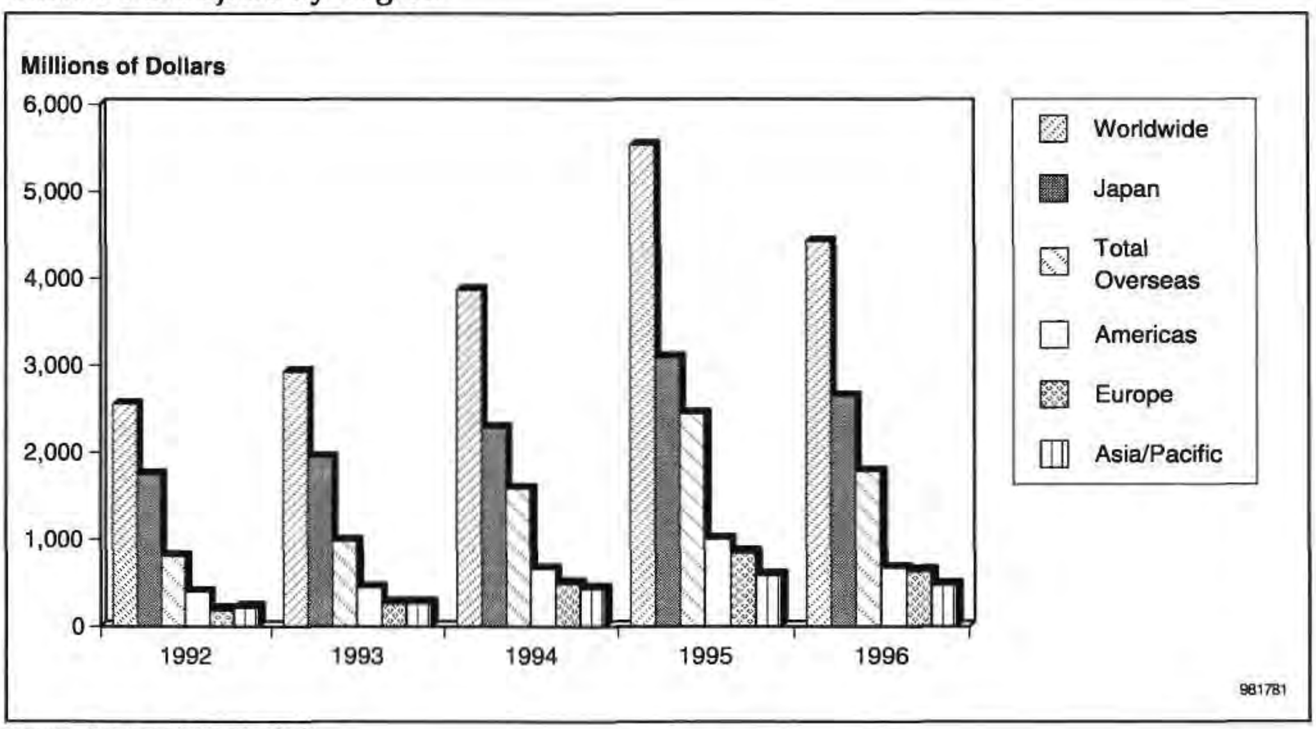
Figure A-12
Fujitsu's Share of the Japanese Market by Product



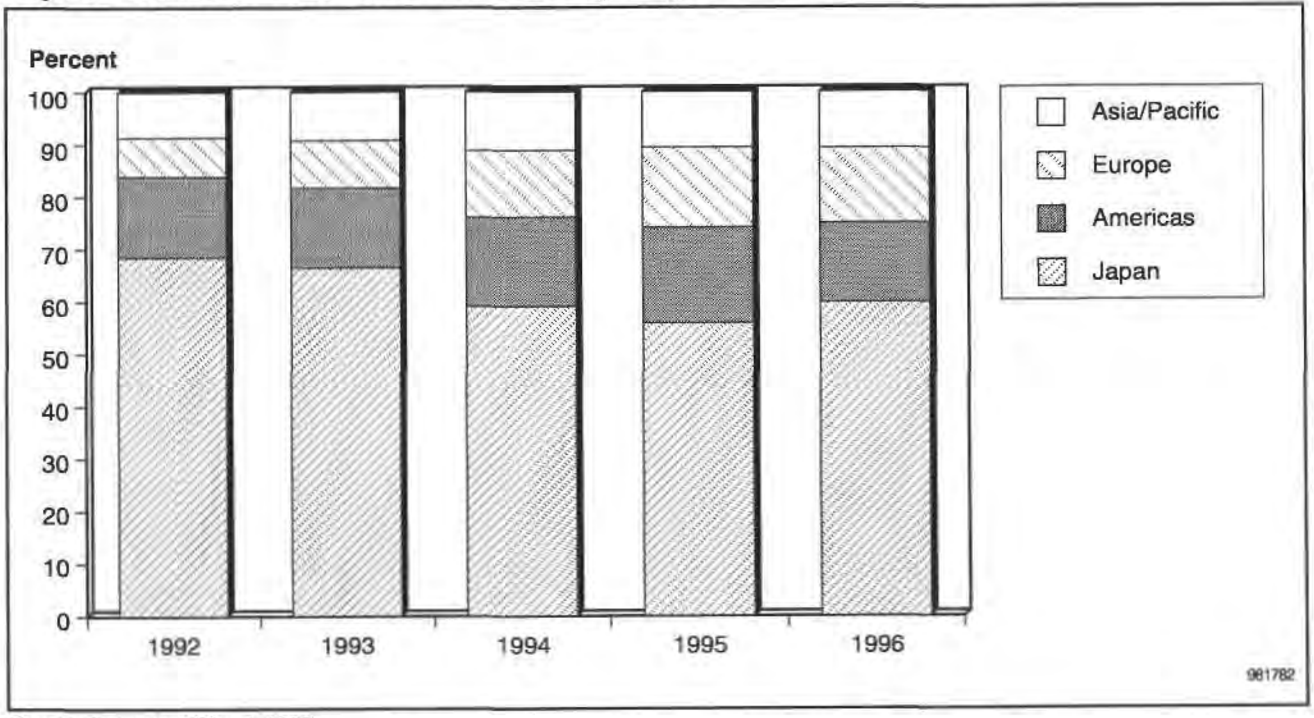
Source: Dataquest (March 1998)

Figure A-13
Revenue of Fujitsu by Region



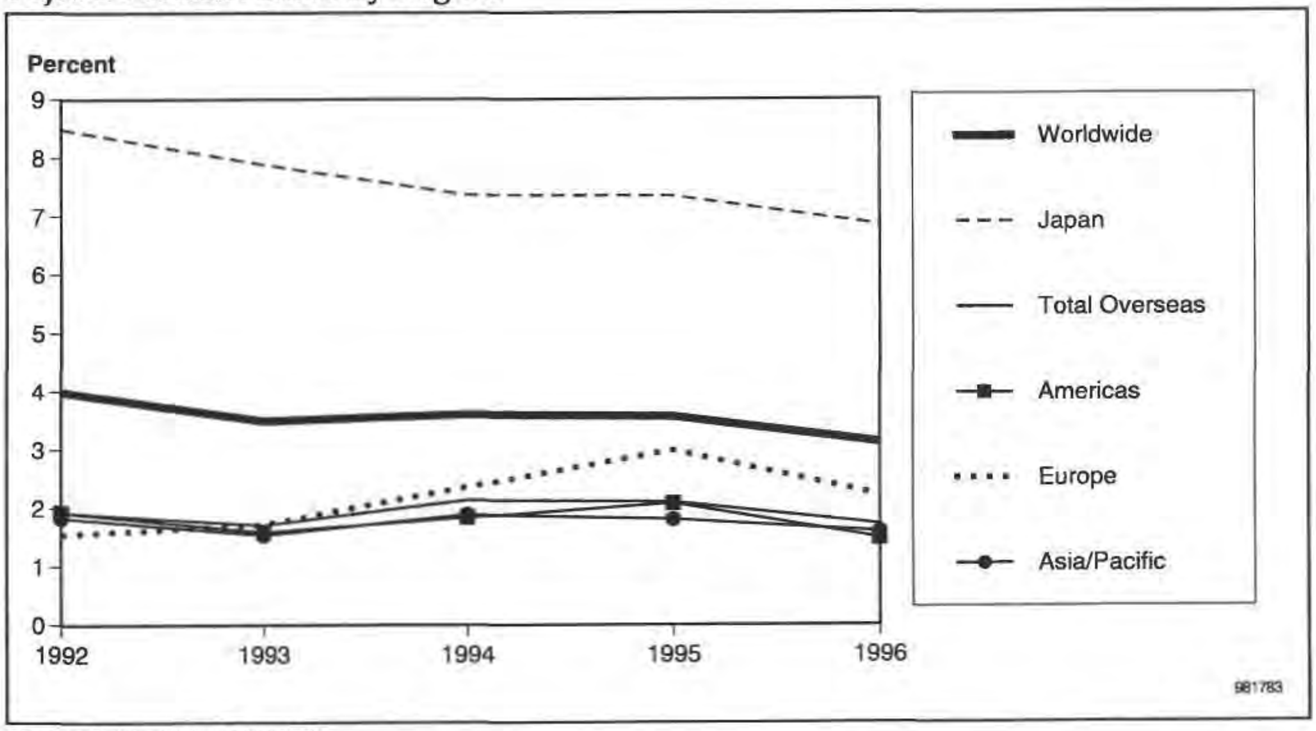
Source: Dataquest (March 1998)

Figure A-14
Fujitsu's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-15
Fujitsu's Market Share by Region



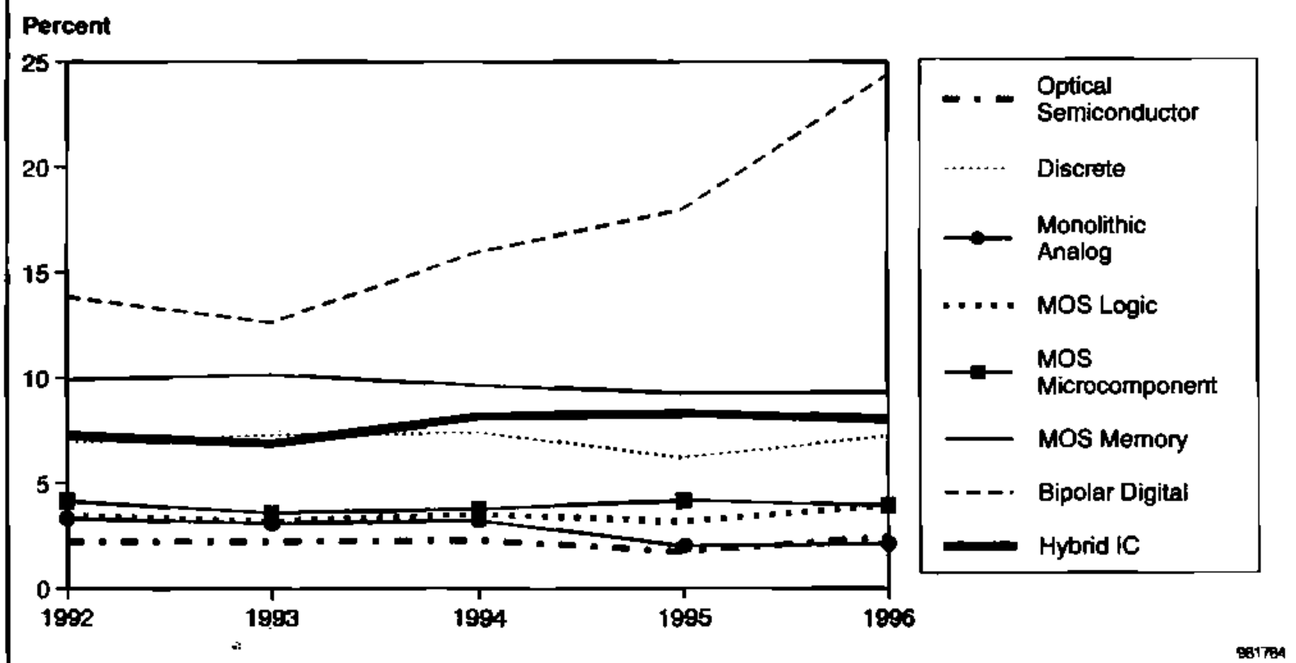
Source: Dataquest (March 1998)

Table A-4
Revenue of Hitachi by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	97	102	136	137	118
Bipolar Digital	442	391	465	442	451
MOS Memory	1,519	2,369	3,232	5,132	3,514
MOS Microcomponent	596	718	998	1,441	1,629
MOS Logic	346	426	569	655	852
Monolithic Analog	225	280	357	355	409
Discrete	566	662	798	889	977
Optical Semiconductor	60	67	89	84	121

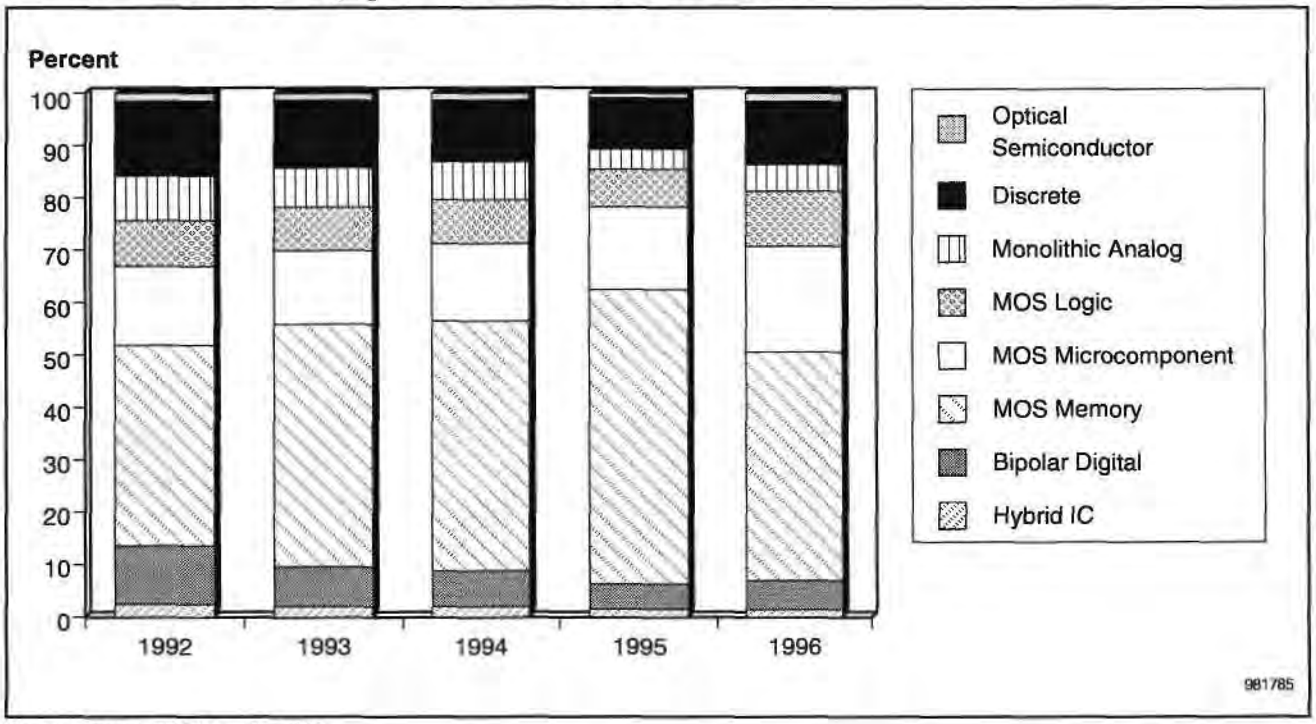
Source: Dataquest (March 1998)

Figure A-16
Hitachi's Share of the Worldwide Market by Product, 1992 to 1996



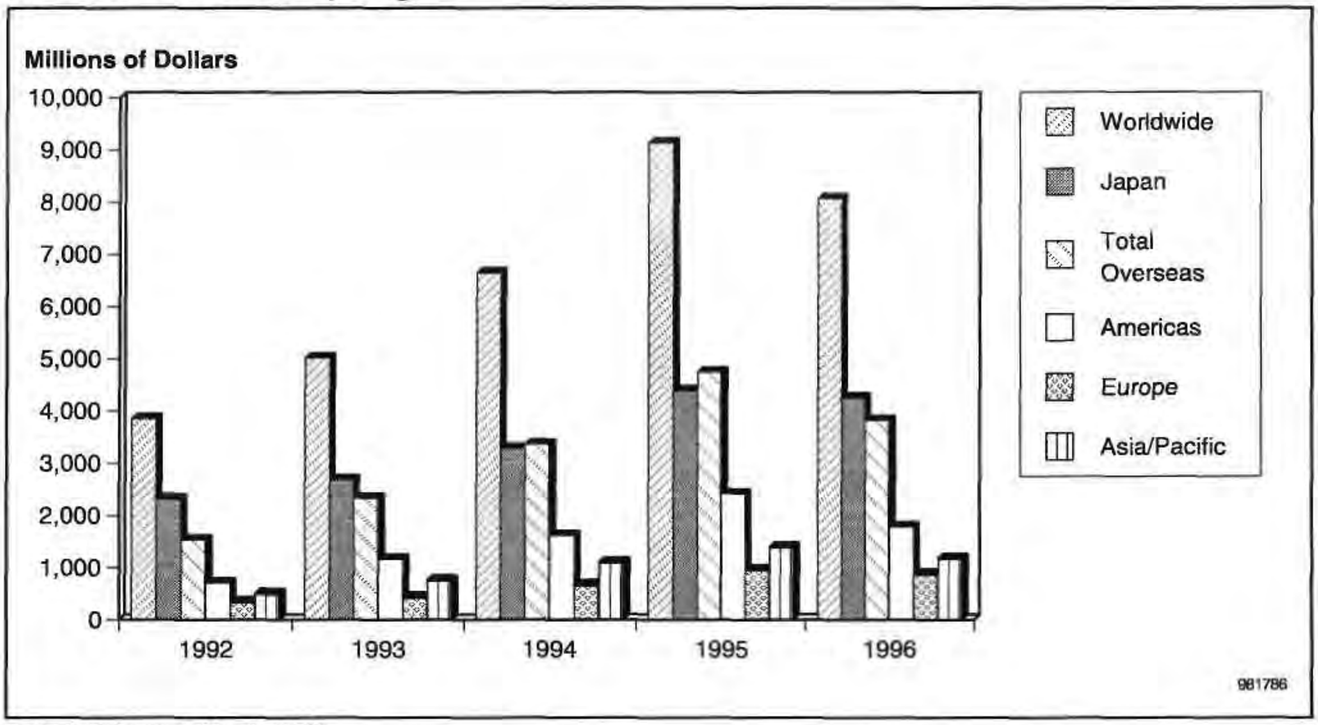
Source: Dataquest (March 1998)

Figure A-17
Hitachi's Share of the Japanese Market by Product



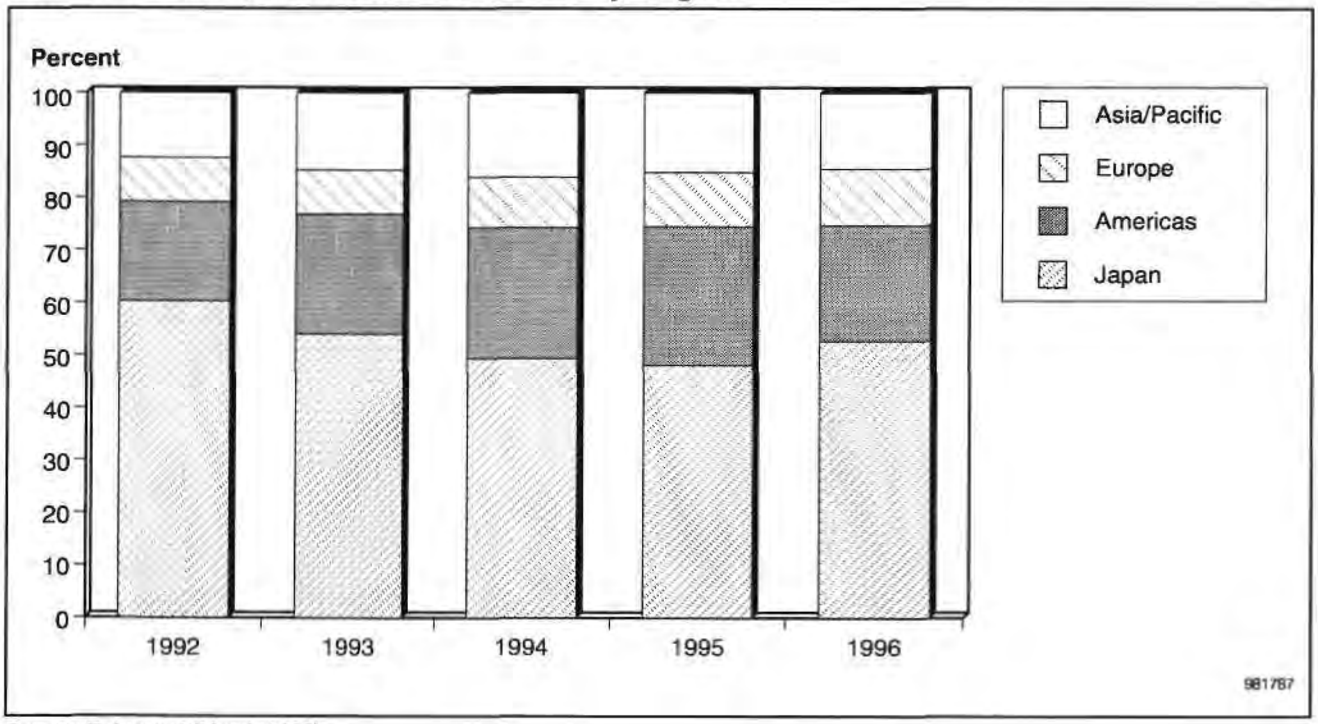
Source: Dataquest (March 1998)

Figure A-18
Revenue of Hitachi by Region



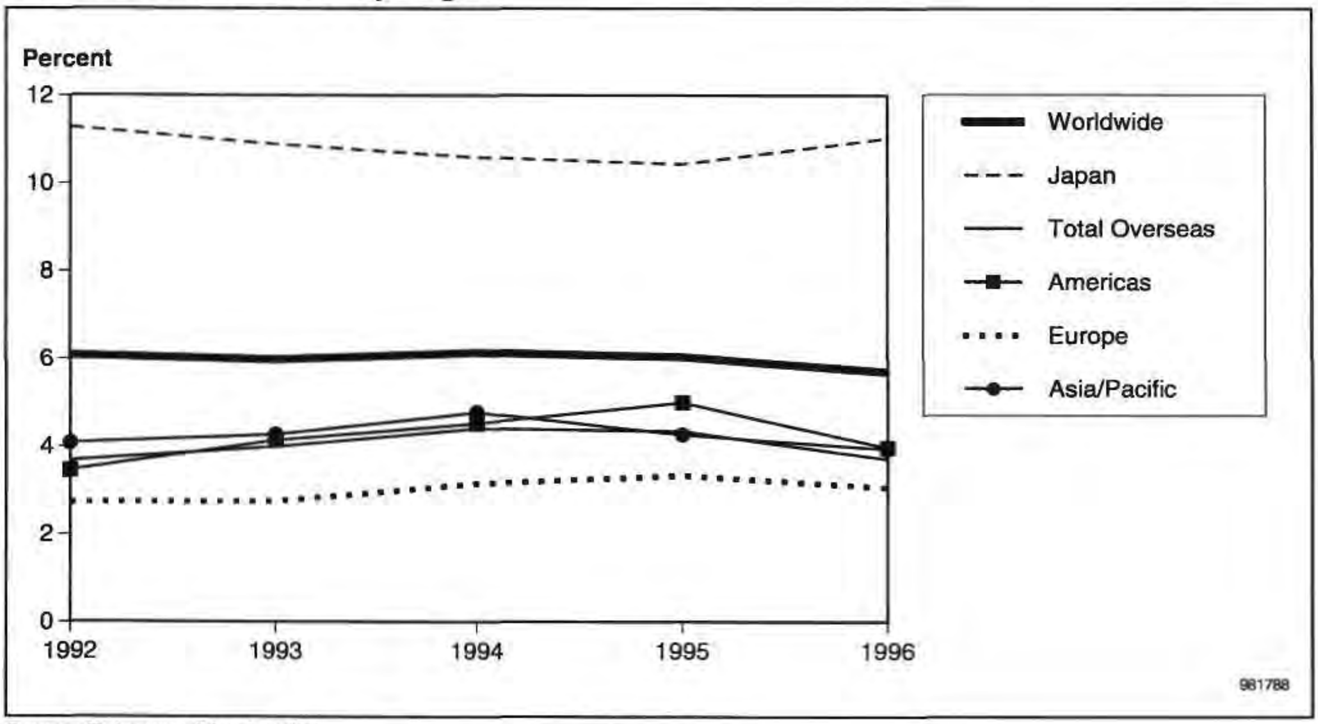
Source: Dataquest (March 1998)

Figure A-19
Hitachi's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-20
Hitachi's Market Share by Region



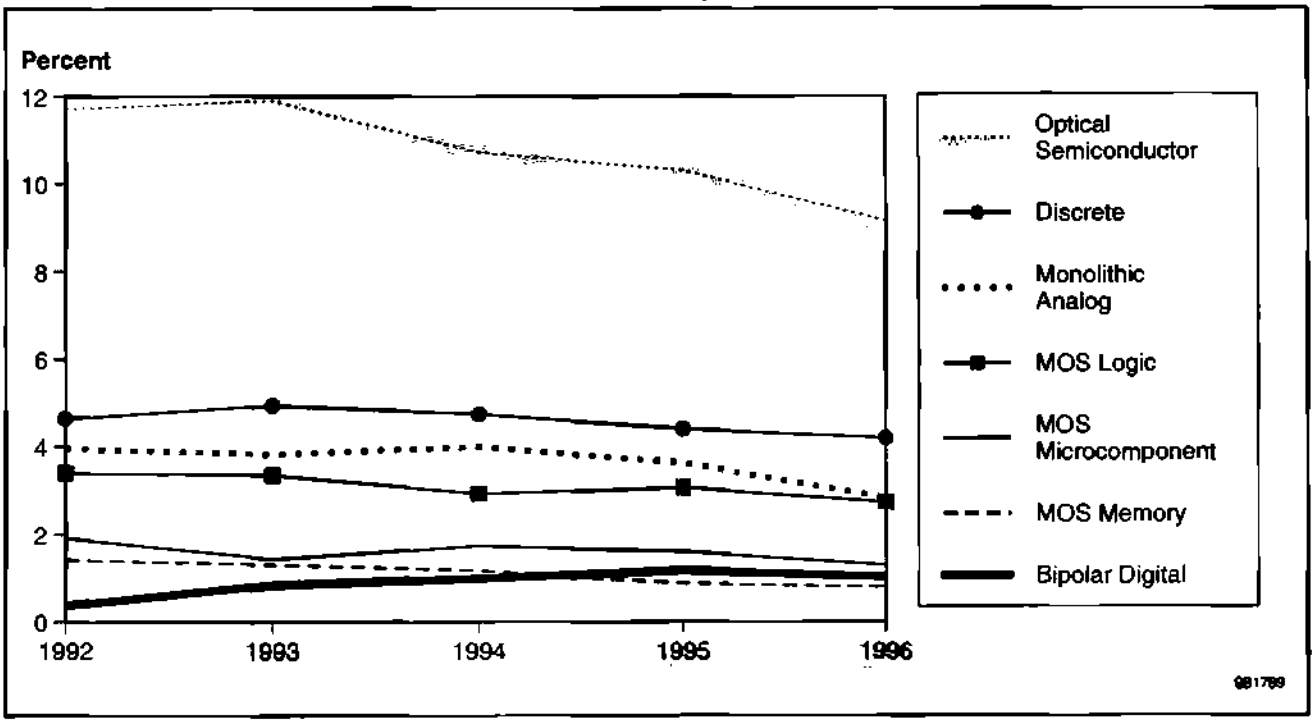
Source: Dataquest (March 1998)

Table A-5
Revenue of Matsushita by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	0	0	0	0	0
Bipolar Digital	12	26	29	29	19
MOS Memory	217	305	396	492	300
MOS Microcomponent	275	286	460	555	534
MOS Logic	342	446	472	632	588
Monolithic Analog	402	473	611	639	547
Discrete	379	450	511	631	565
Optical Semiconductor	315	358	417	496	450

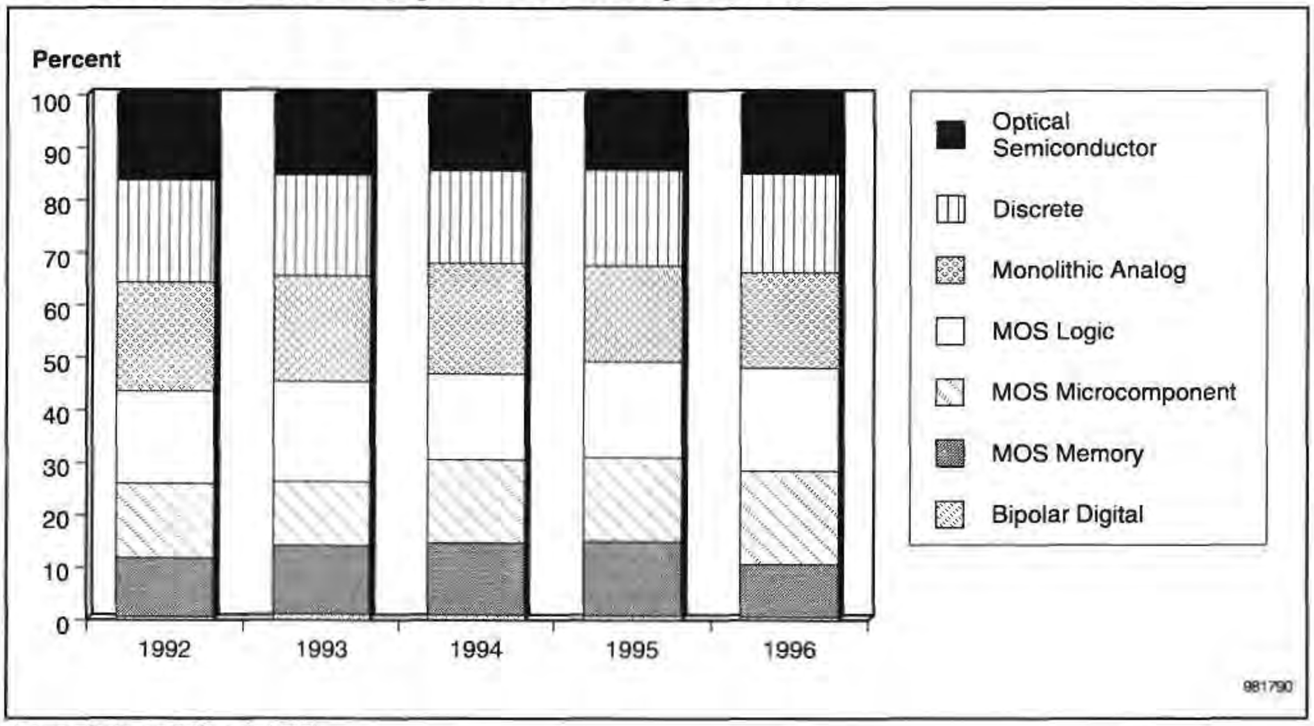
Source: Dataquest (March 1998)

Figure A-21
Matsushita's Share of the Worldwide Market by Product, 1992 to 1996



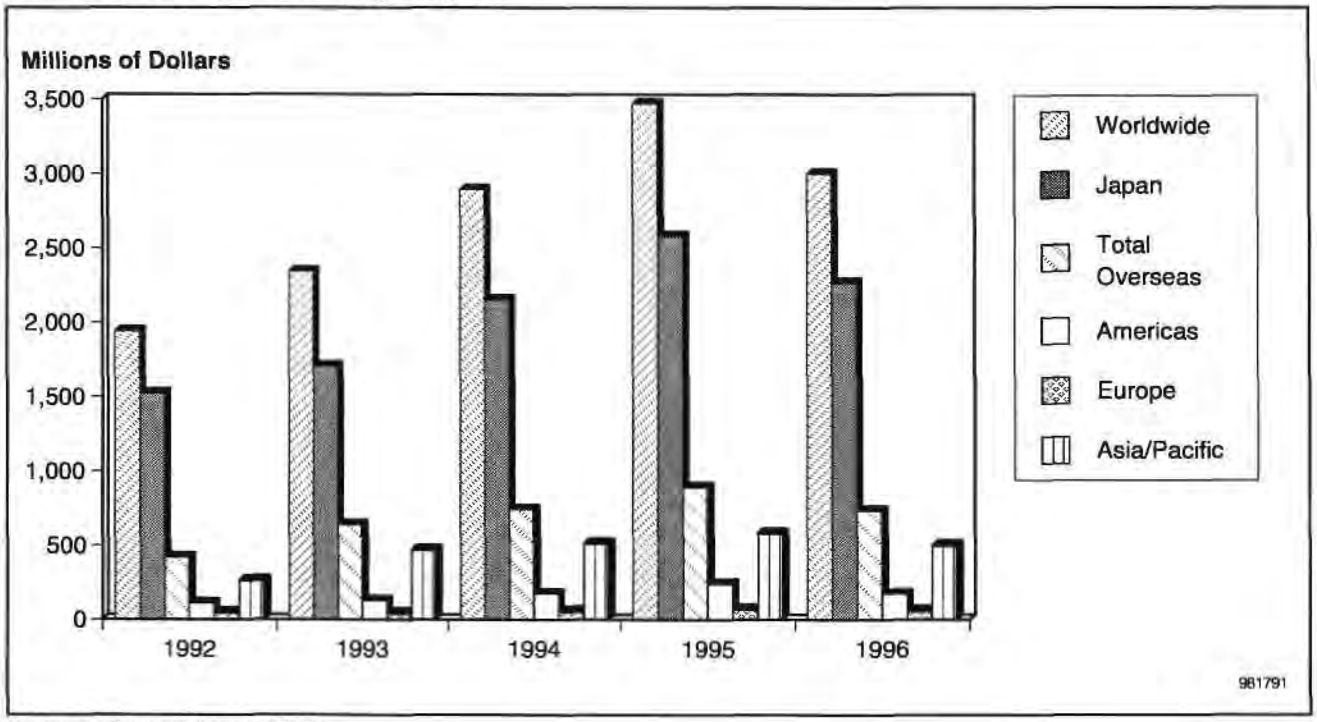
Source: Dataquest (March 1998)

Figure A-22
Matsushita's Share of the Japanese Market by Product



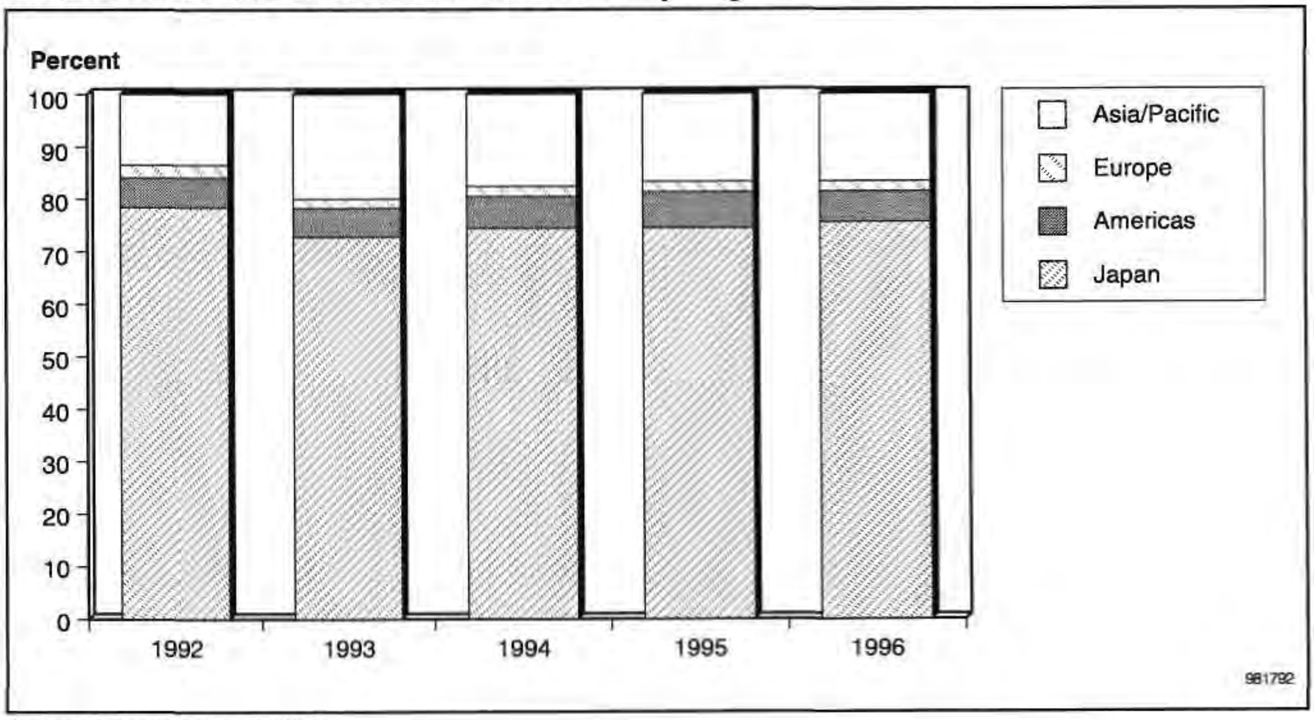
Source: Dataquest (March 1998)

Figure A-23
Revenue of Matsushita by Region



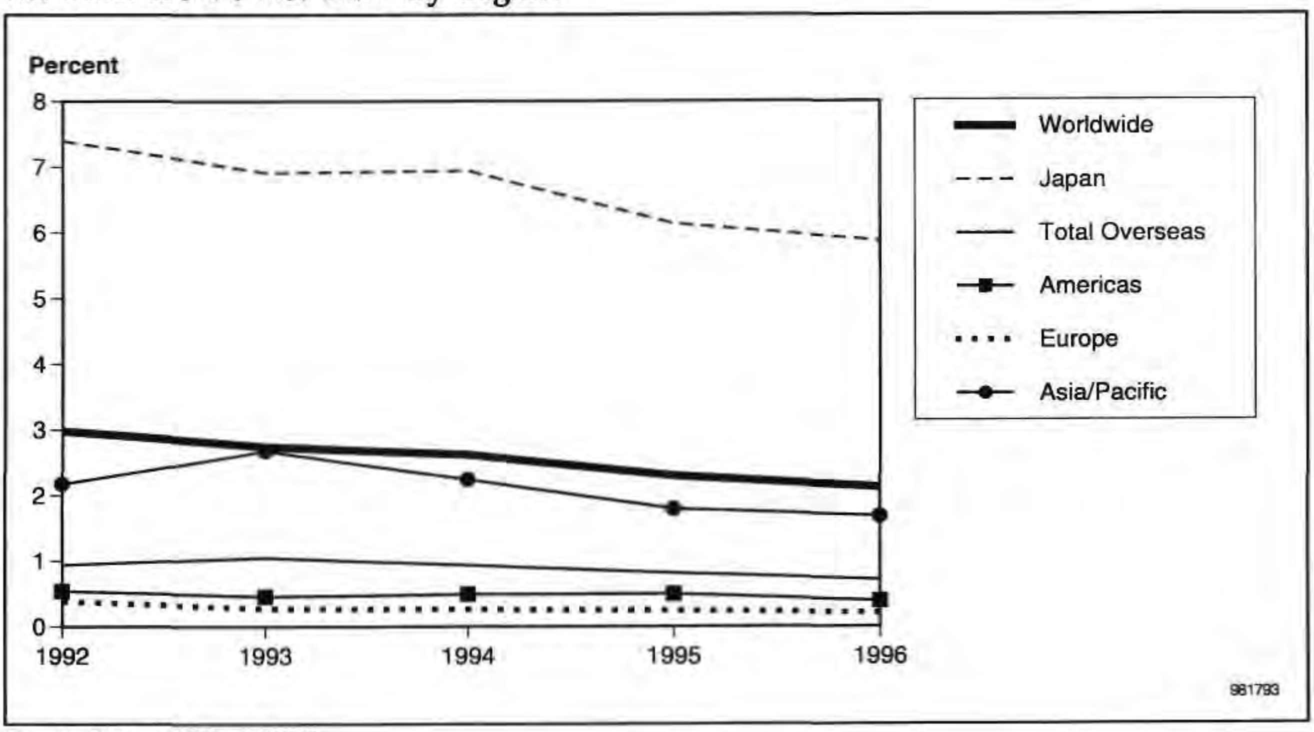
Source: Dataquest (March 1998)

Figure A-24
Matsushita's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-25
Matsushita's Market Share by Region



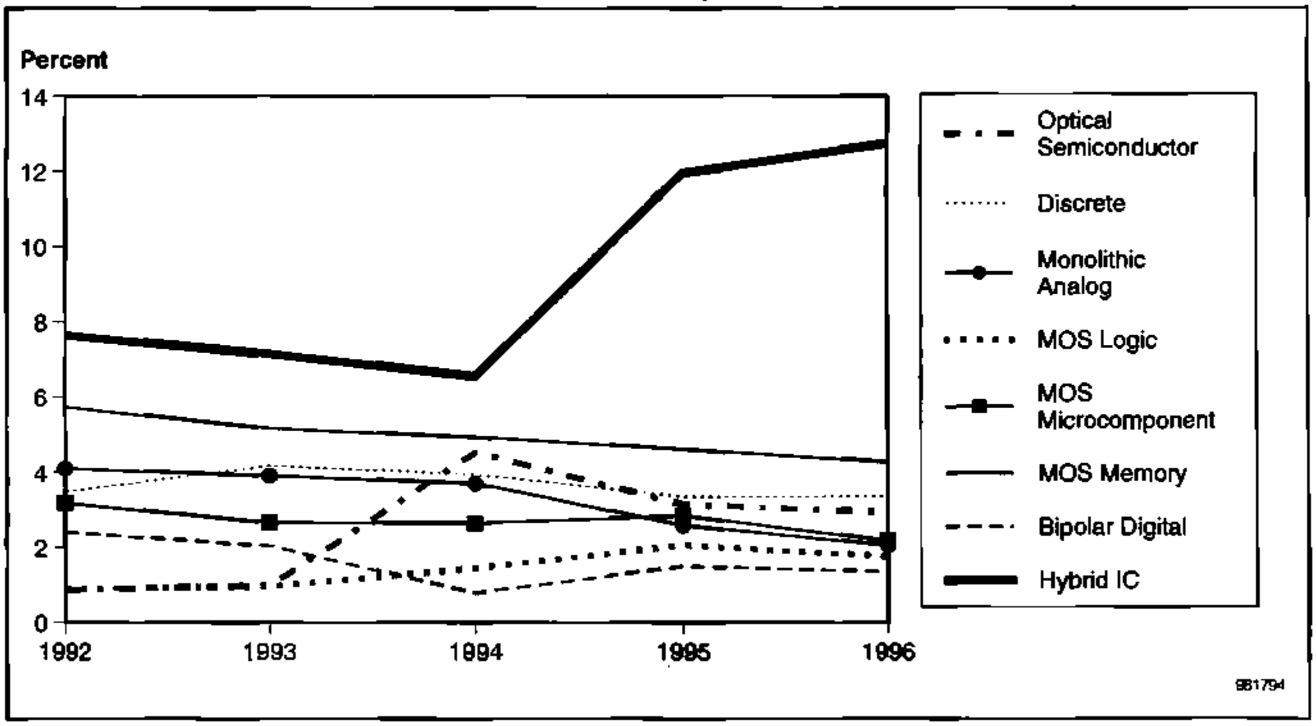
Source: Dataquest (March 1998)

Table A-6
Revenue of Mitsubishi by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	102	106	109	198	187
Bipolar Digital	77	63	23	37	25
MOS Memory	878	1,206	1,652	2,547	1,614
MOS Microcomponent	456	532	698	982	901
MOS Logic	89	129	234	425	380
Monolithic Analog	304	377	456	455	397
Discrete	284	380	424	479	452
Optical Semiconductor	23	30	176	151	144

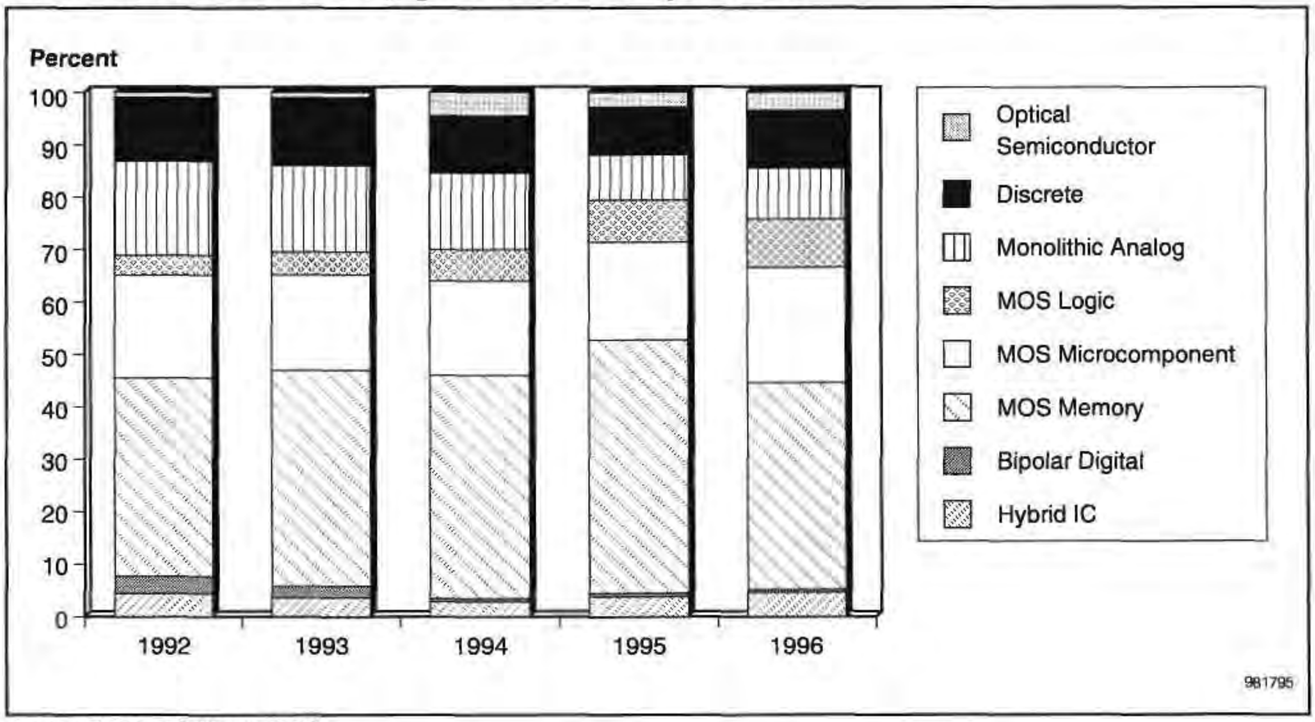
Source: Dataquest (March 1998)

Figure A-26
Mitsubishi's Share of the Worldwide Market by Product, 1992 to 1996



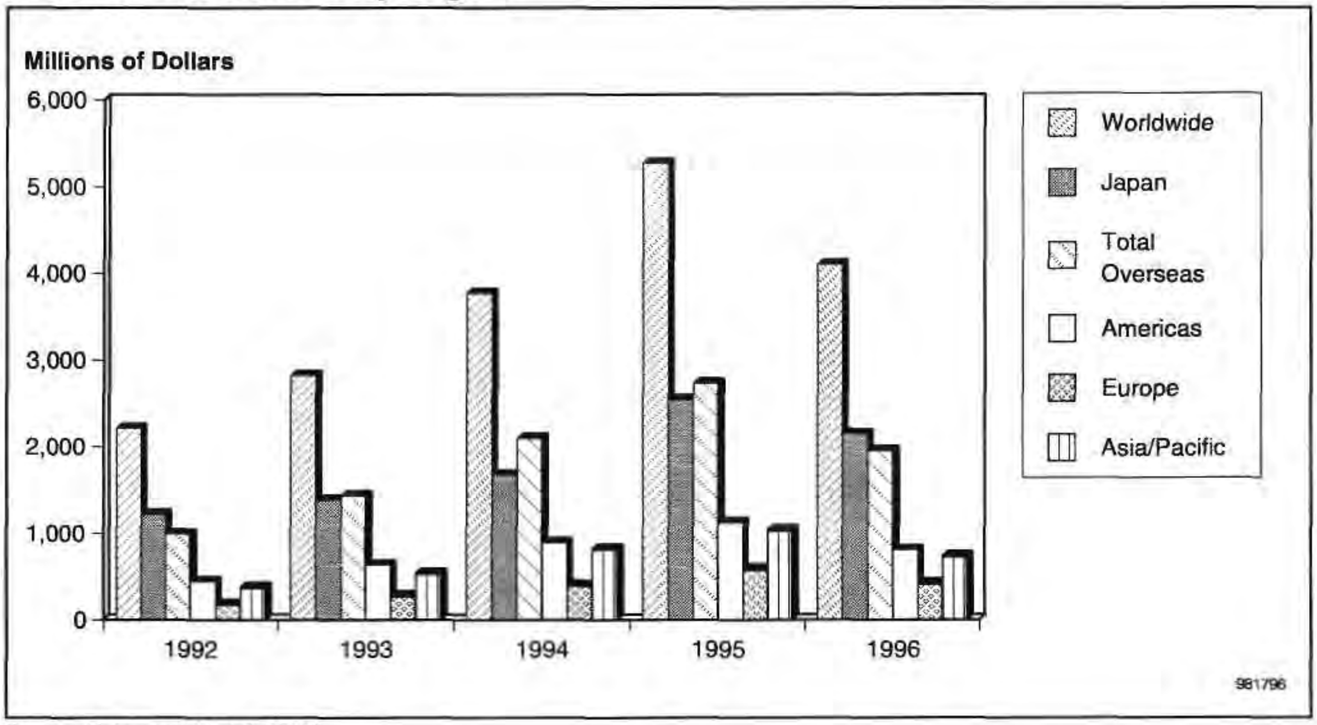
Source: Dataquest (March 1998)

Figure A-27
Mitsubishi's Share of the Japanese Market by Product



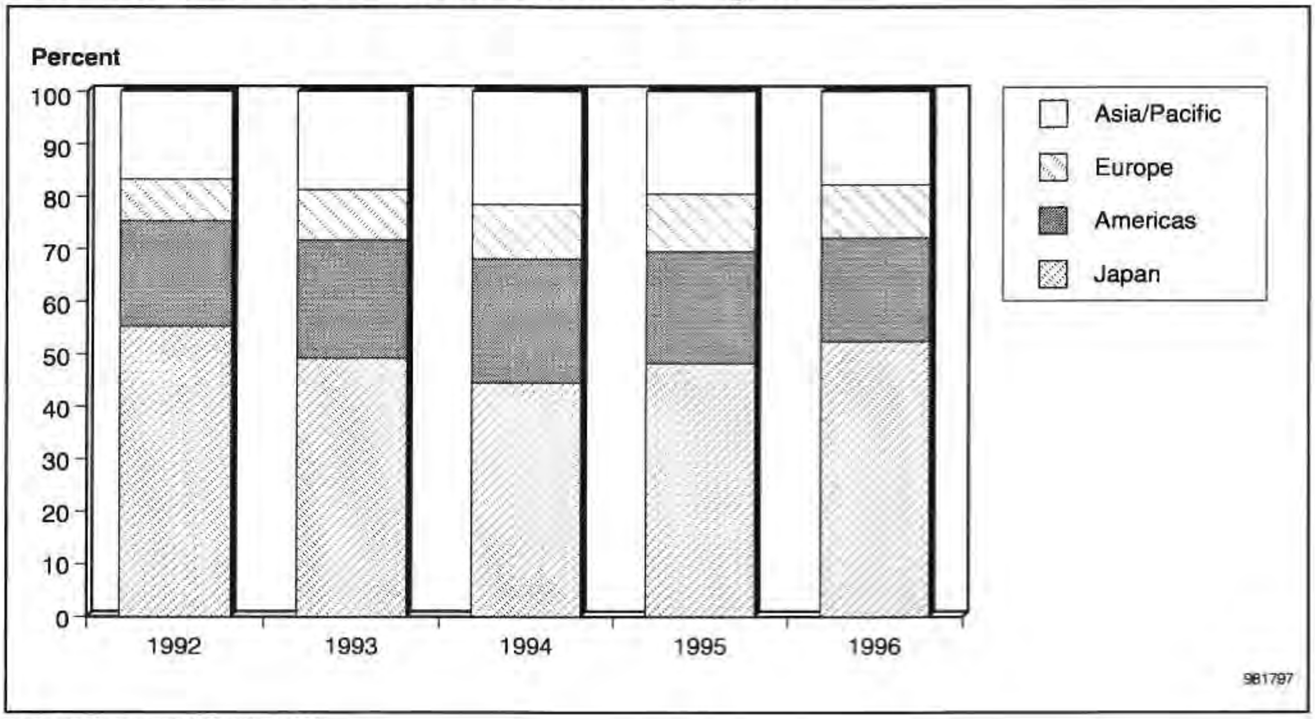
Source: Dataquest (March 1998)

Figure A-28
Revenue of Mitsubishi by Region



Source: Dataquest (March 1998)

Figure A-29
Mitsubishi's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

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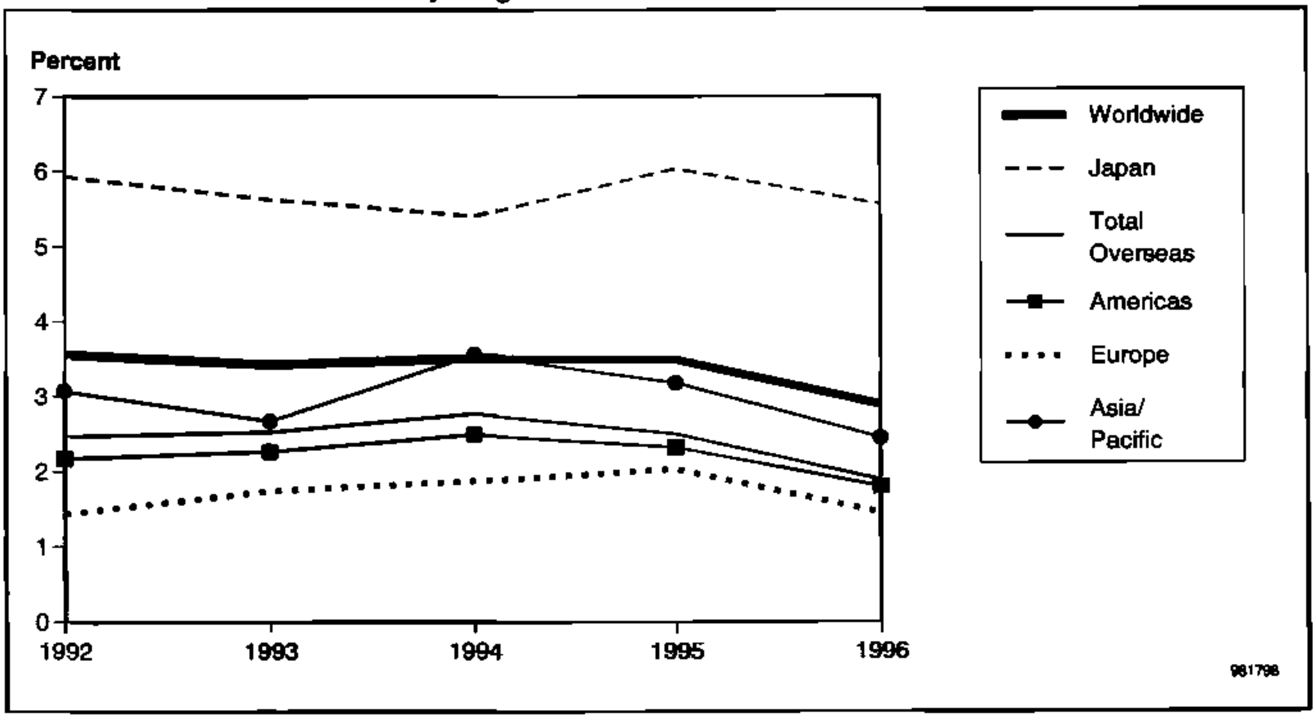
Figure A-30
Mitsubishi's Market Share by Region



Source: Dataquest (March 1998)

Table A-7
Revenue of NEC by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	83	98	98	130	125
Bipolar Digital	226	201	194	109	90
MOS Memory	1,422	2,173	3,096	5,353	3,913
MOS Microcomponent	1,130	1,341	1,678	2,061	2,179
MOS Logic	1,047	1,254	1,587	1,987	2,423
Monolithic Analog	319	377	506	641	624
Discrete	532	579	652	831	818
Optical Semiconductor	110	118	150	202	256

Source: Dataquest (March 1998)

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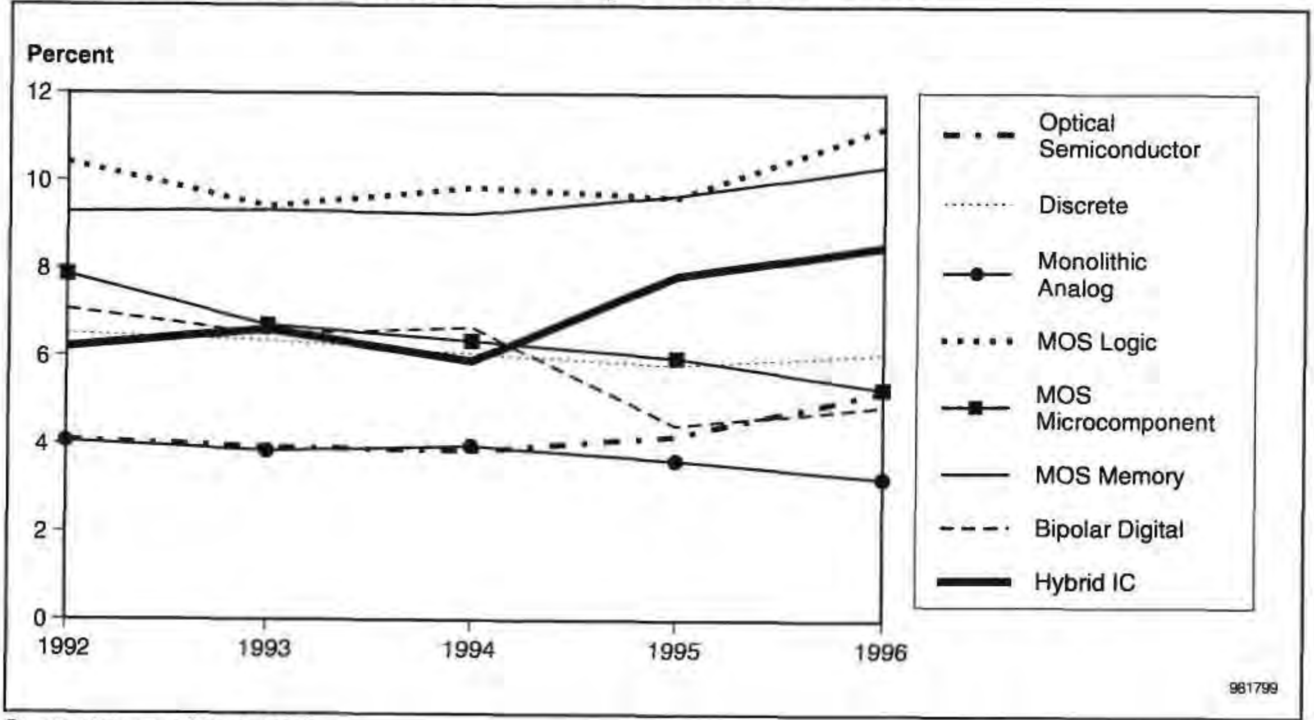
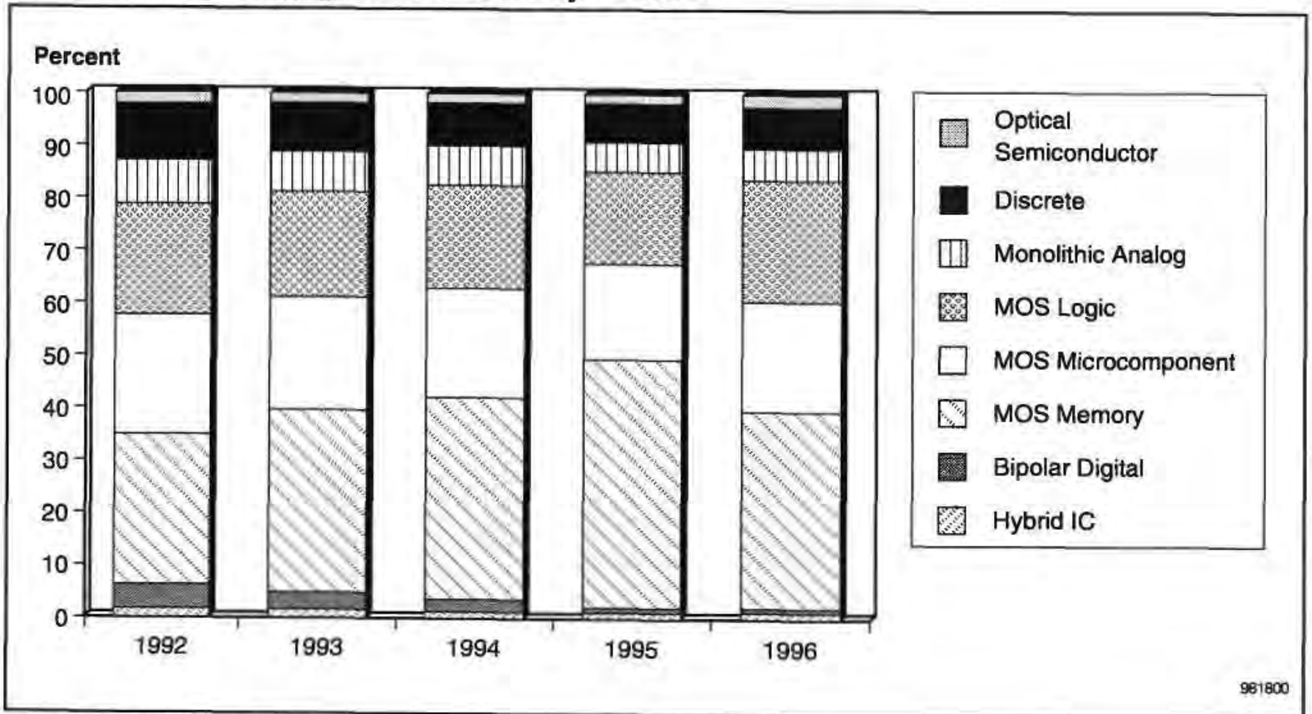
Figure A-31
NEC's Share of the Worldwide Market by Product, 1992 to 1996



Source: Dataquest (March 1998)

Figure A-32
NEC's Share of the Japanese Market by Product



Source: Dataquest (March 1998)

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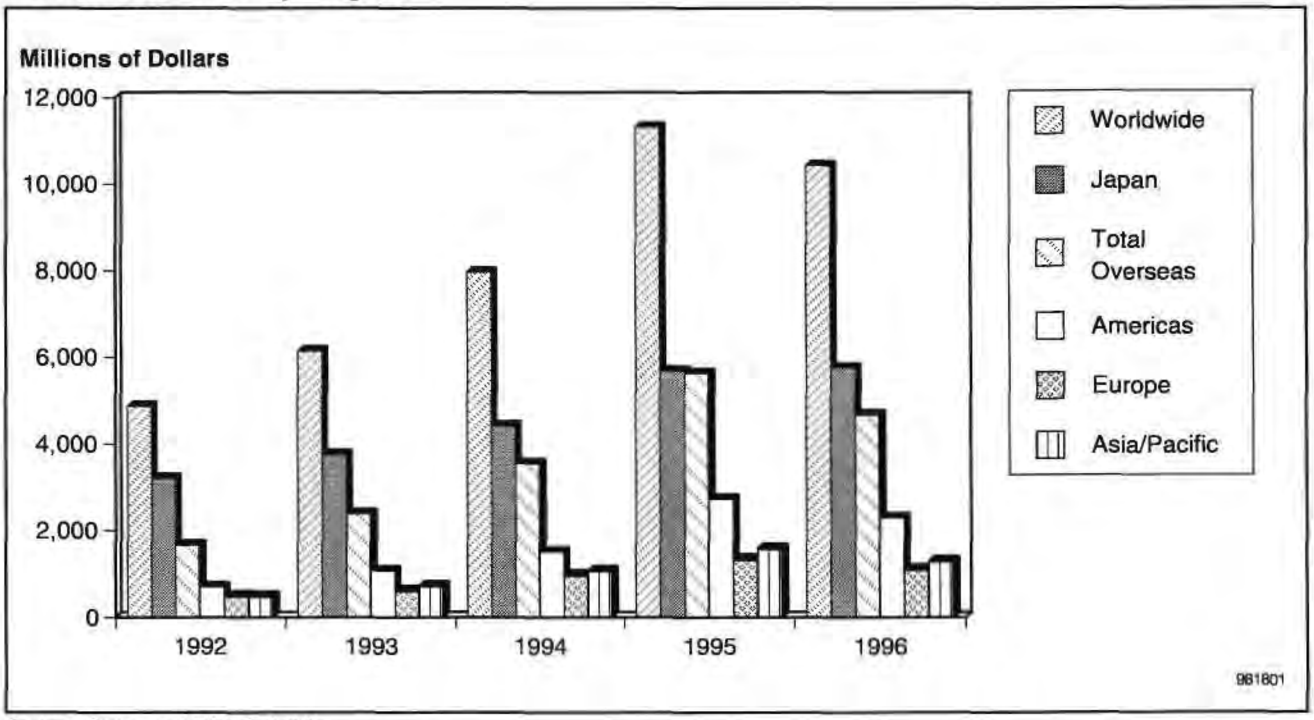
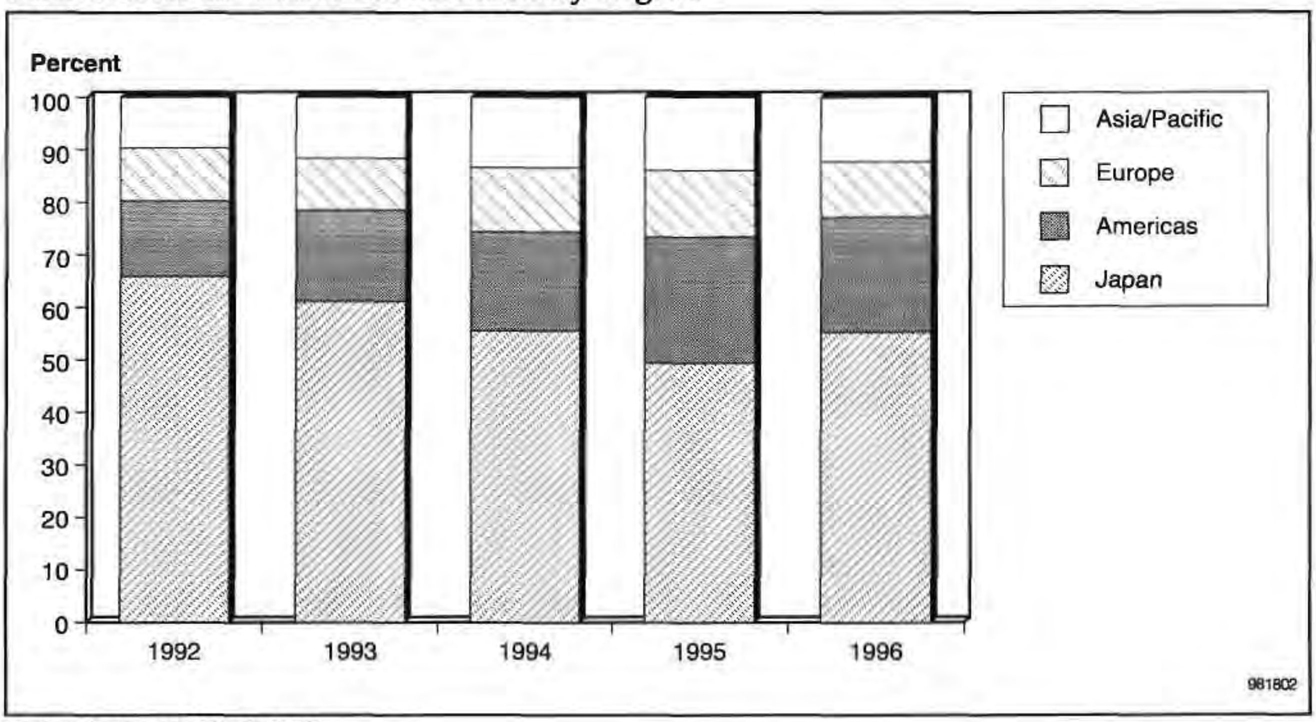
Figure A-33
Revenue of NEC by Region



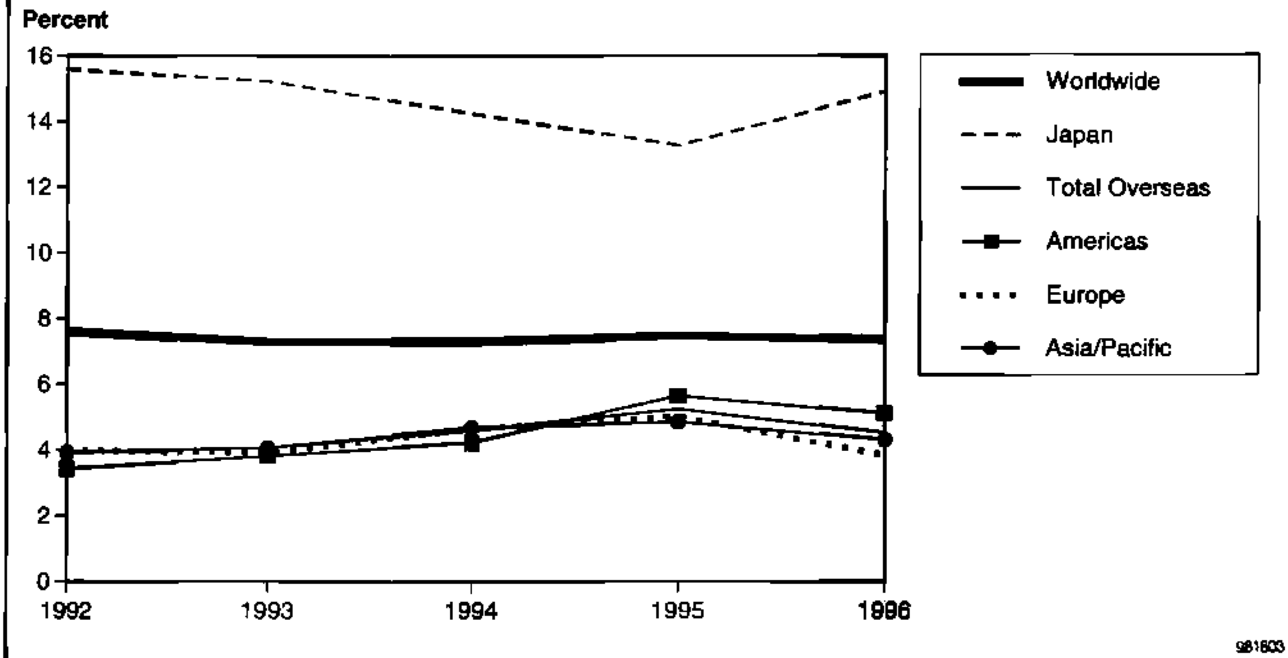
Source: Dataquest (March 1998)

Figure A-34
NEC's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-35
NEC's Market Share by Region



Source: Dataquest (March 1998)

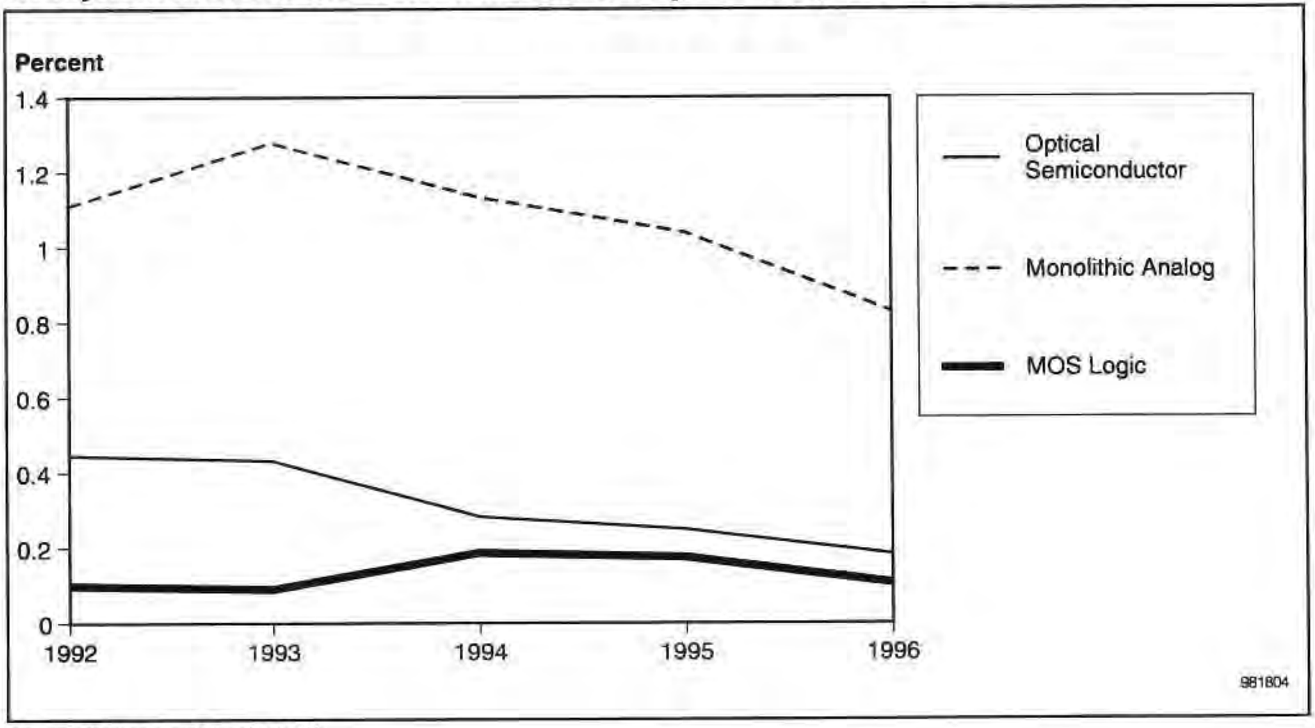
Table A-8
Revenue of New JRC by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	0	0	0	0	0
Bipolar Digital	0	0	0	0	0
MOS Memory	0	0	0	0	0
MOS Microcomponent	0	0	2	4	5
MOS Logic	10	12	30	36	23
Monolithic Analog	113	158	173	183	160
Discrete	3	3	2	2	3
Optical Semiconductor	12	13	11	12	9

Source: Dataquest (March 1998)

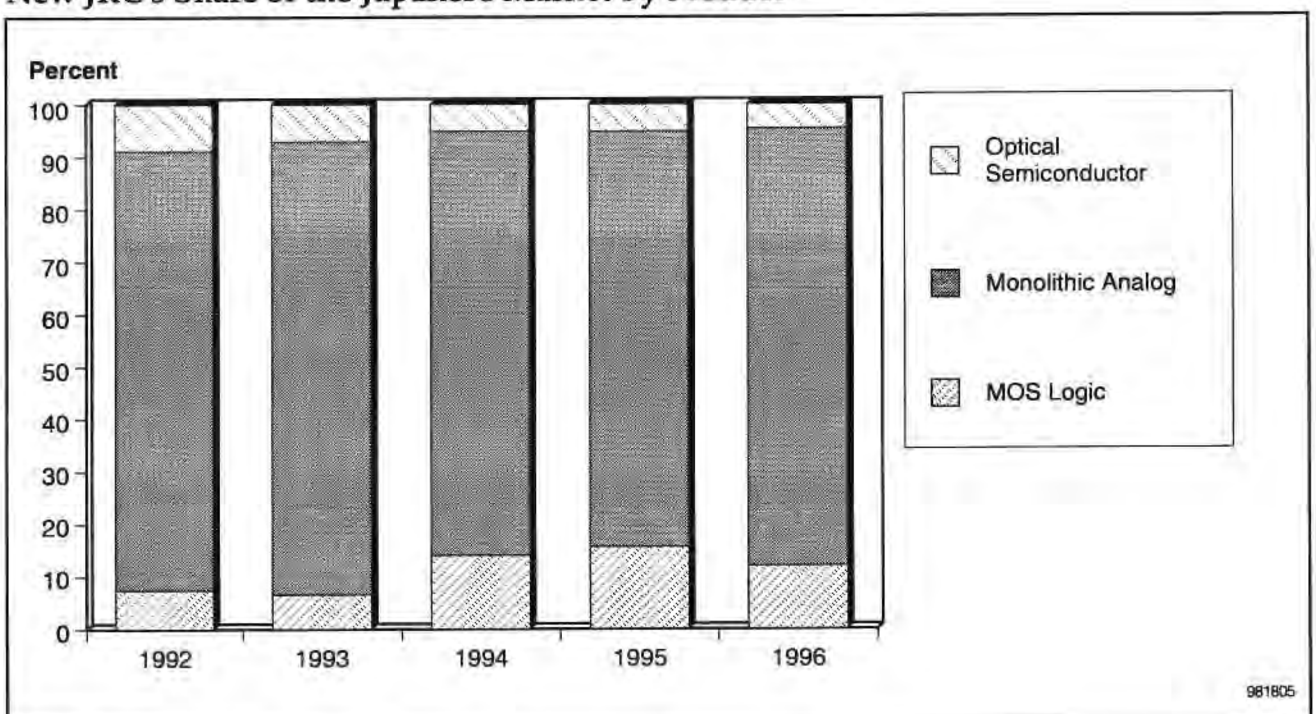
 ©1998 Dataquest

Figure A-36
New JRC's Share of the Worldwide Market by Product, 1992 to 1996



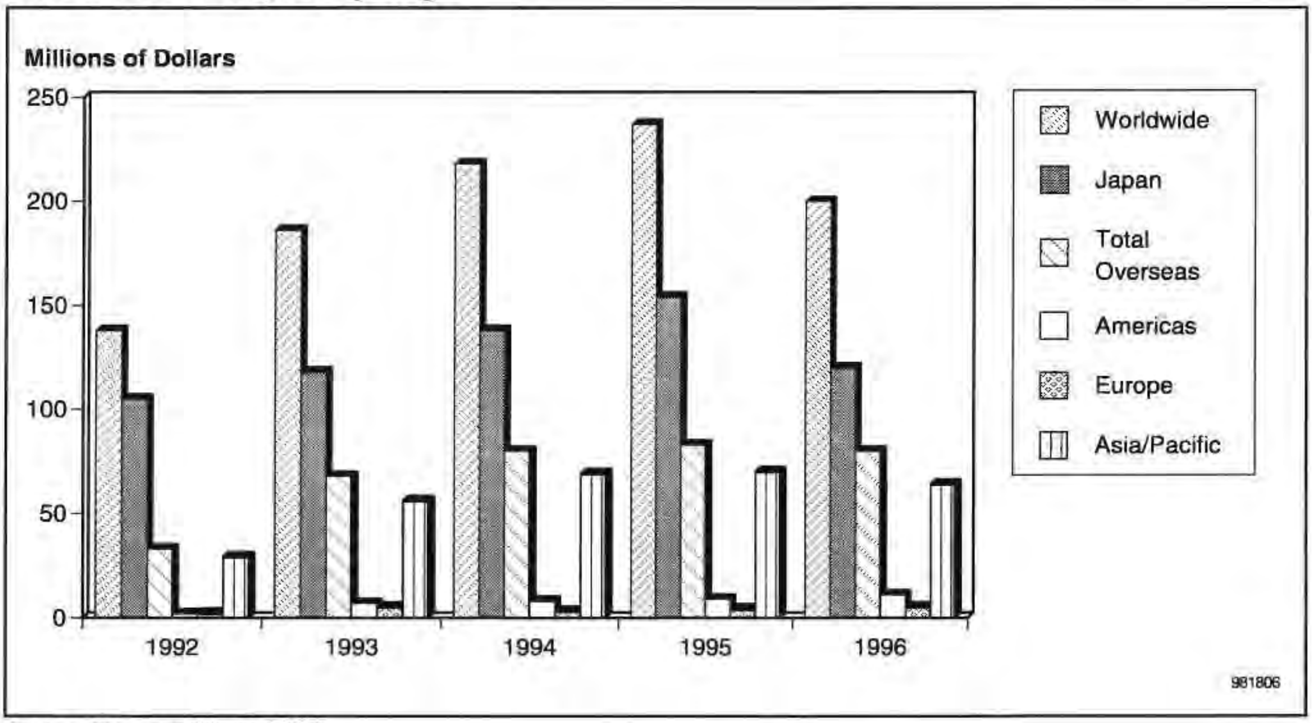
Source: Dataquest (March 1998)

Figure A-37
New JRC's Share of the Japanese Market by Product



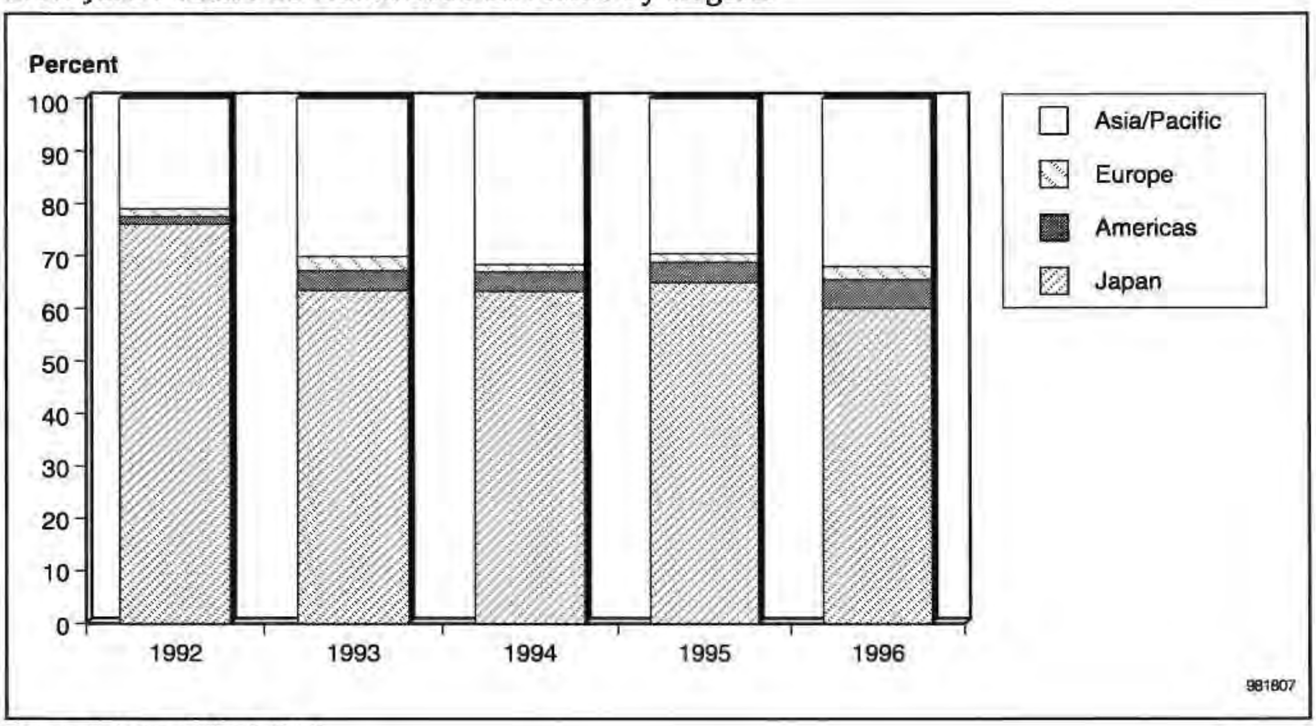
Source: Dataquest (March 1998)

Figure A-38
Revenue of New JRC by Region



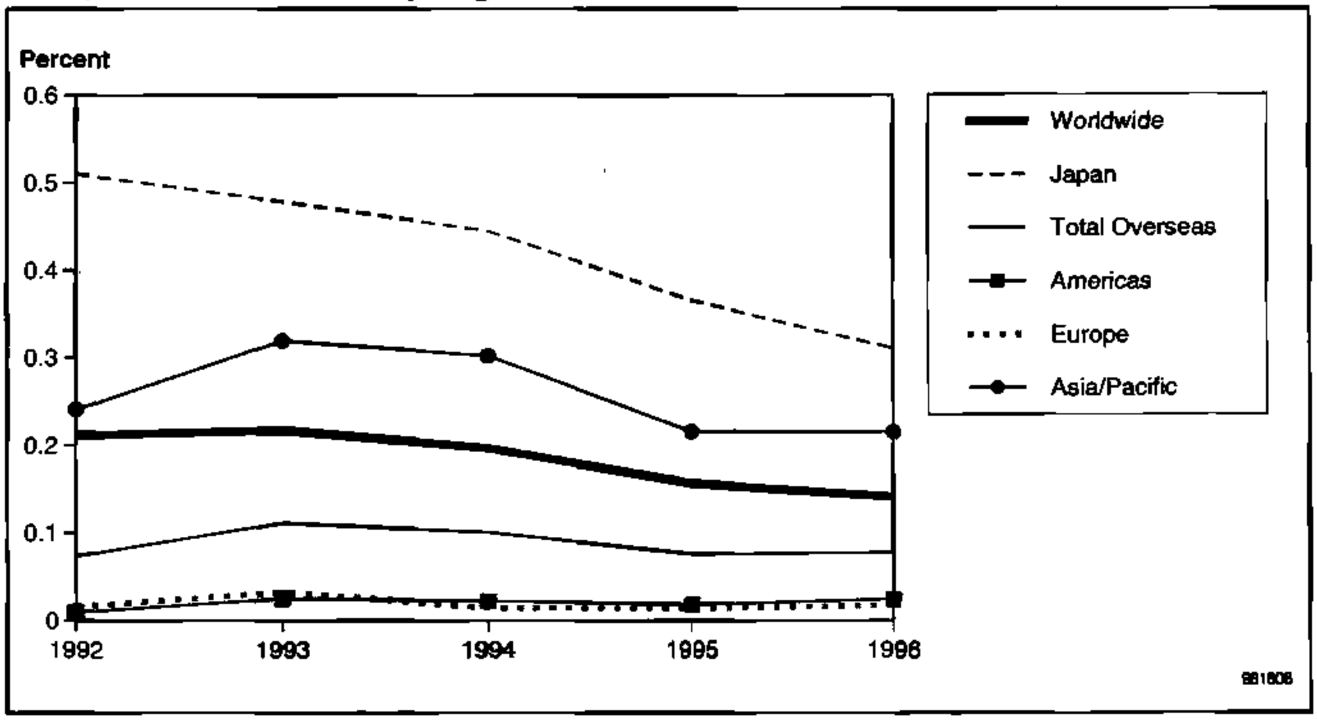
Source: Dataquest (March 1998)

Figure A-39
New JRC's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-40
New JRC's Market Share by Region



Source: Dataquest (March 1998)

Table A-9
Revenue of Nippon Steel Semiconductor by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	0	0	0	0	0
Bipolar Digital	0	0	0	0	0
MOS Memory	120	148	160	549	198
MOS Microcomponent	0	0	0	0	0
MOS Logic	0	0	0	0	0
Monolithic Analog	0	0	0	0	0
Discrete	0	0	0	0	0
Optical Semiconductor	0	0	0	0	0

Source: Dataquest (March 1998)

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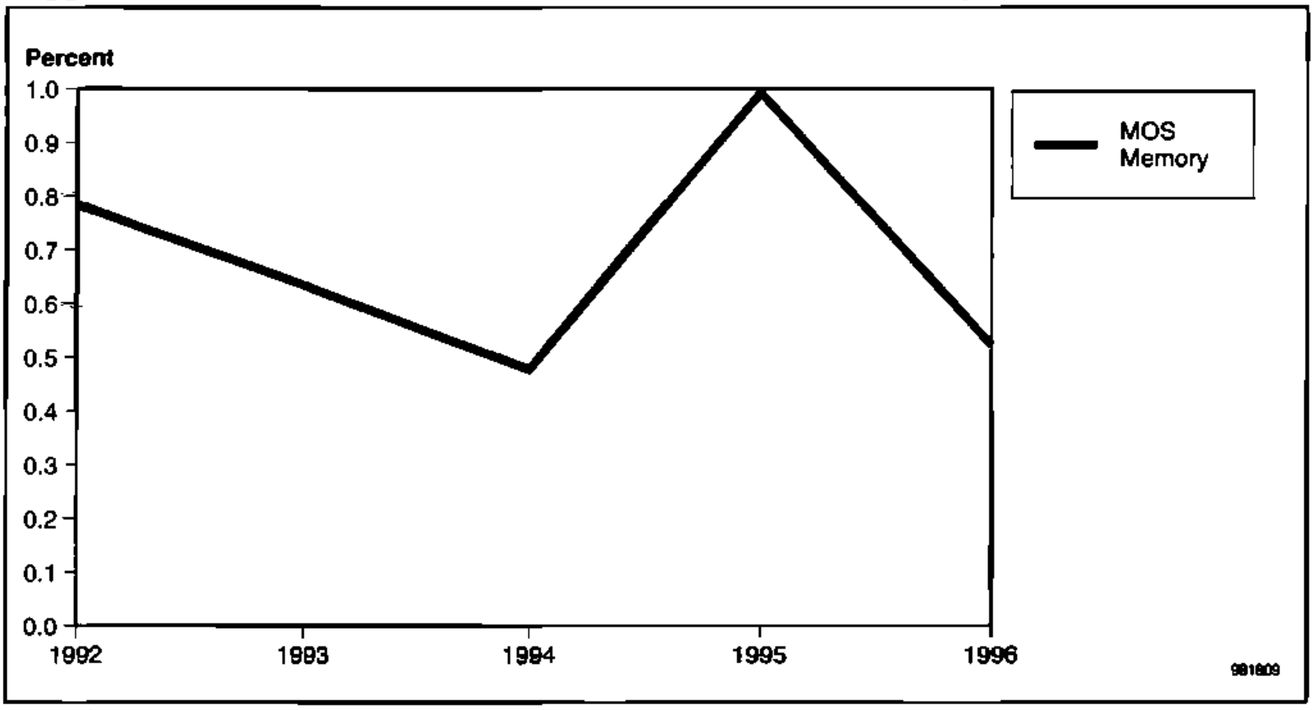
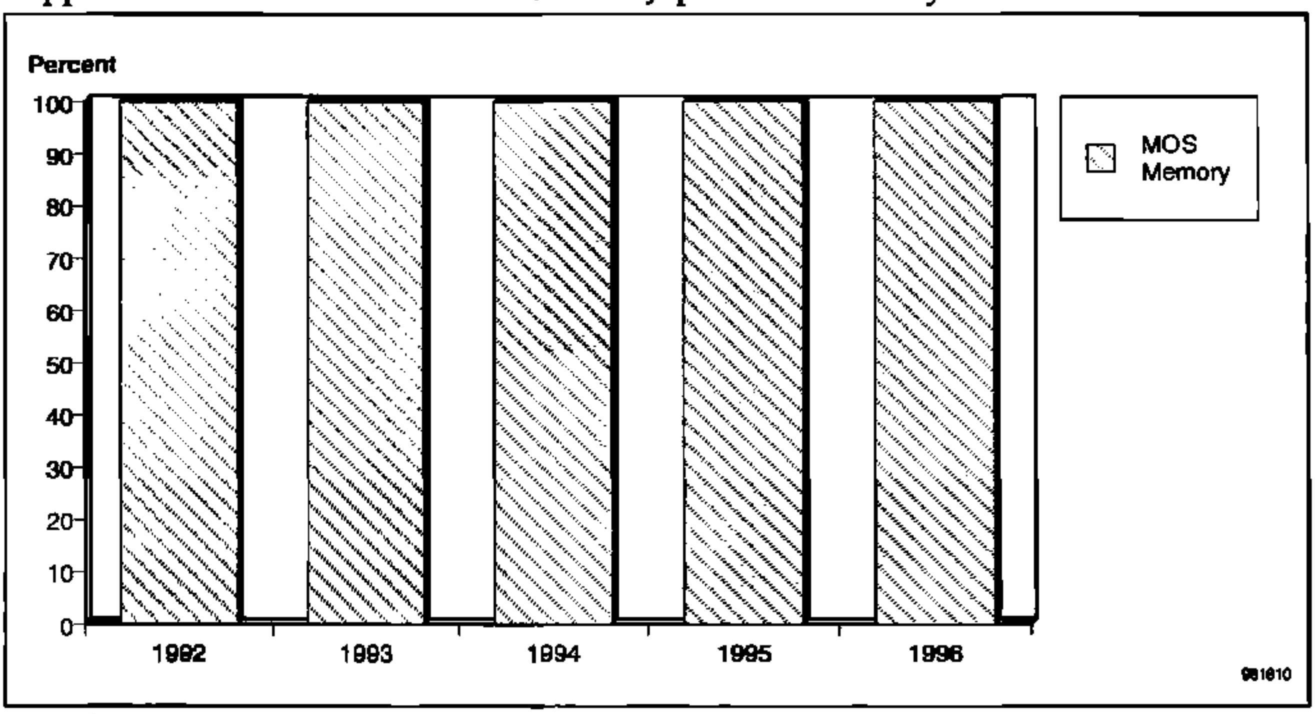
Figure A-41
Nippon Steel Semiconductor's Share of the Worldwide Market by Product, 1992 to 1996



Source: Dataquest (March 1998)

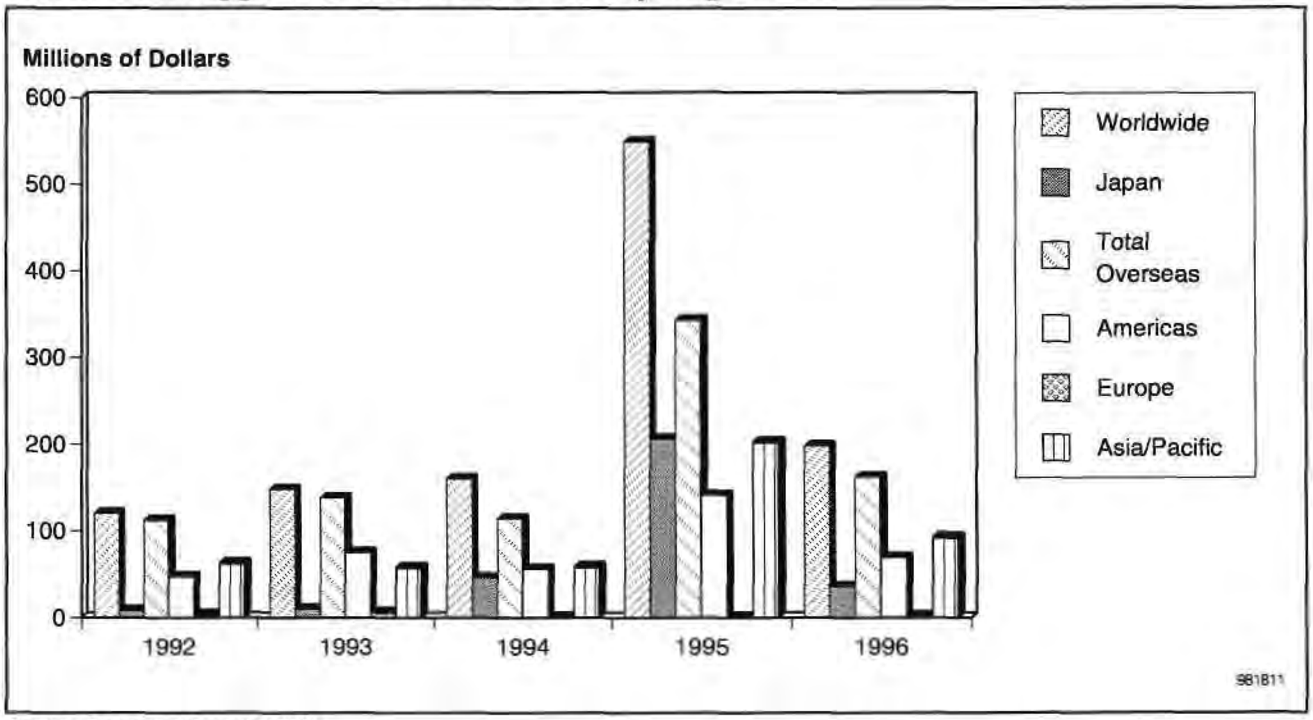
Figure A-42
Nippon Steel Semiconductor's Share of the Japanese Market by Product



Source: Dataquest (March 1998)

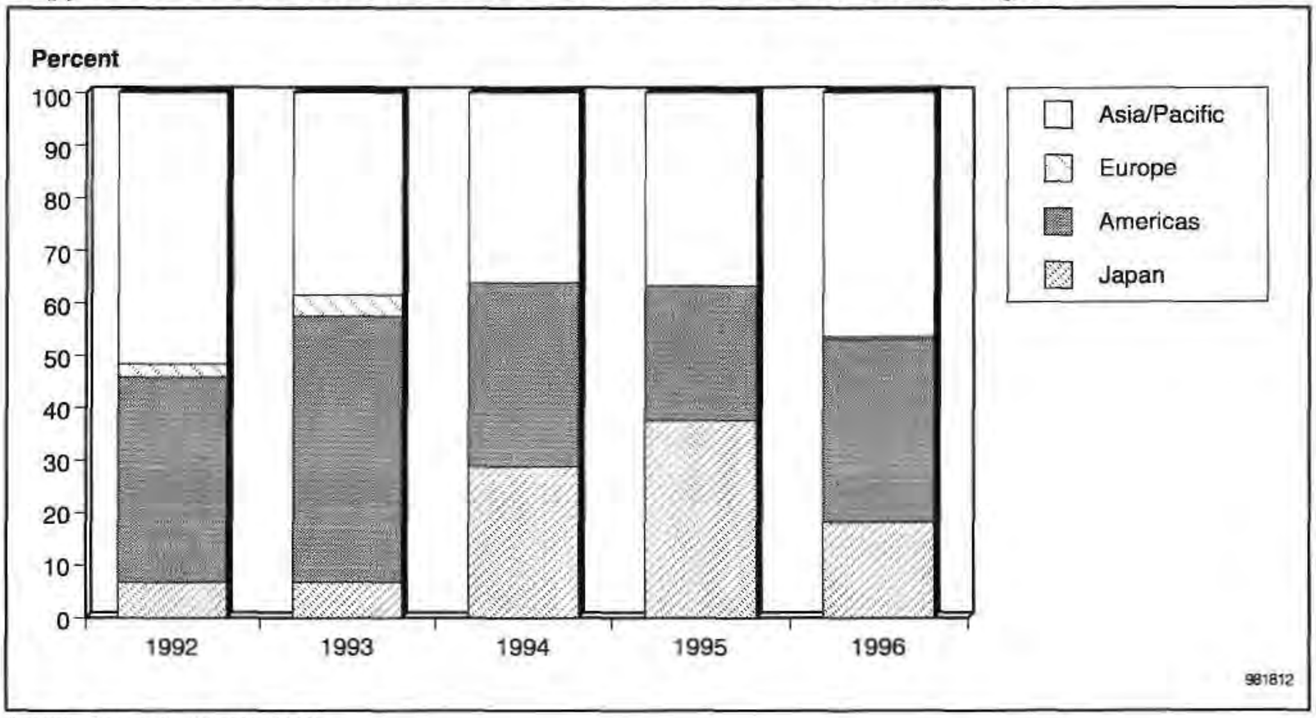
 ©1998 Dataquest

Figure A-43
Revenue of Nippon Steel Semiconductor by Region



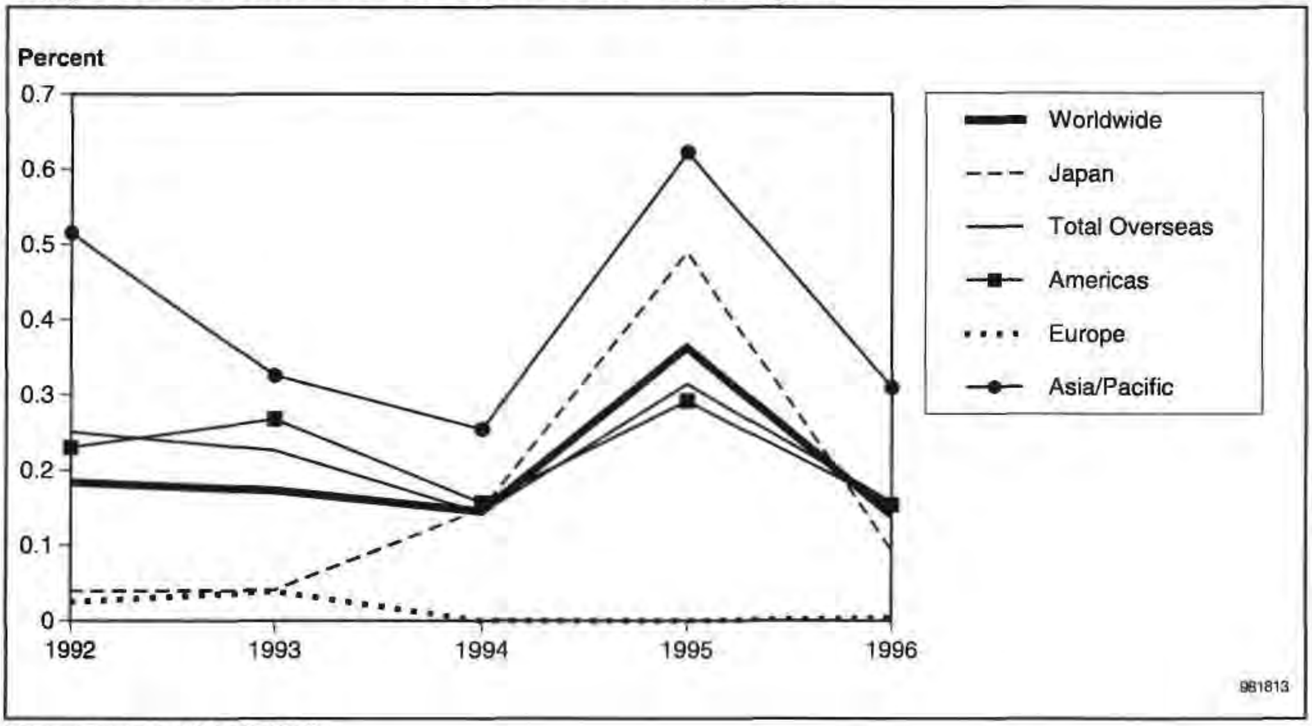
Source: Dataquest (March 1998)

Figure A-44
Nippon Steel Semiconductor's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-45
Nippon Steel Semiconductor's Market Share by Region



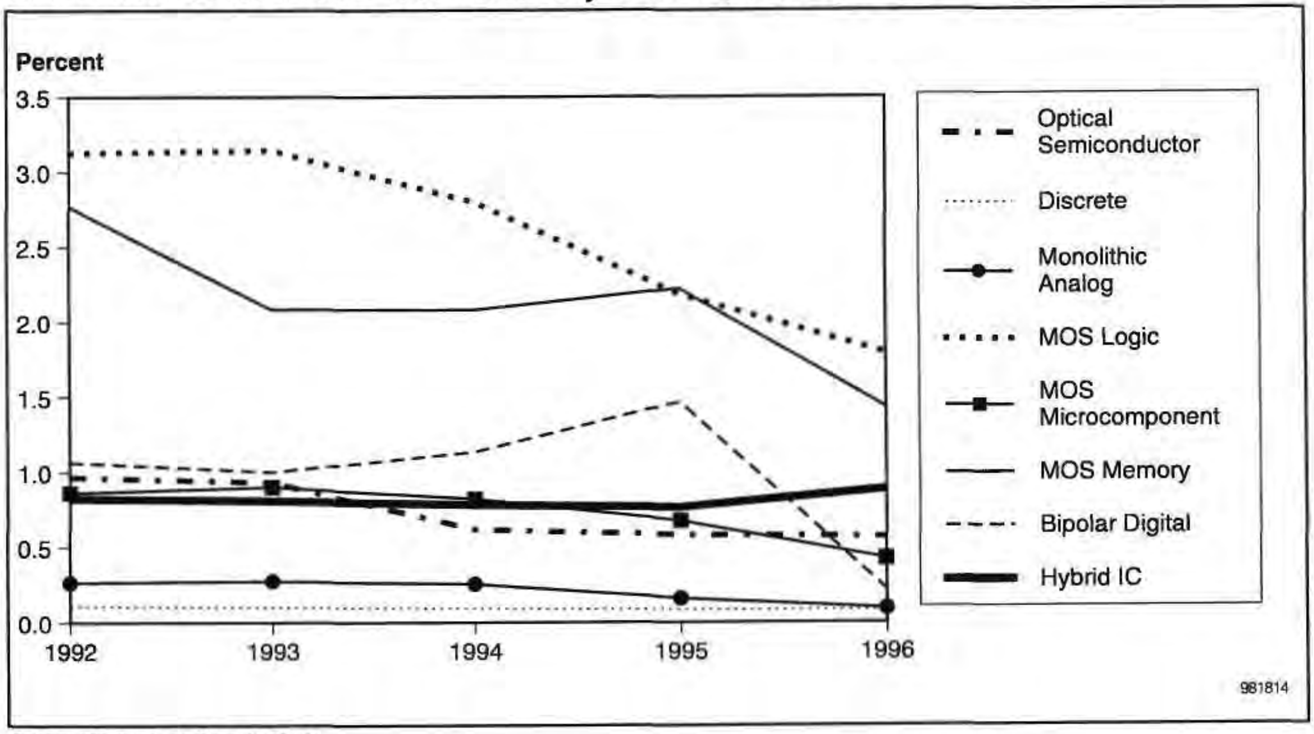
Source: Dataquest (March 1998)

Table A-10
Revenue of Oki by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	11	12	13	13	13
Bipolar Digital	34	31	33	36	4
MOS Memory	424	486	697	1,228	541
MOS Microcomponent	124	180	217	233	175
MOS Logic	314	419	451	450	387
Monolithic Analog	14	22	26	28	18
Discrete	9	9	10	12	11
Optical Semiconductor	26	28	24	28	28

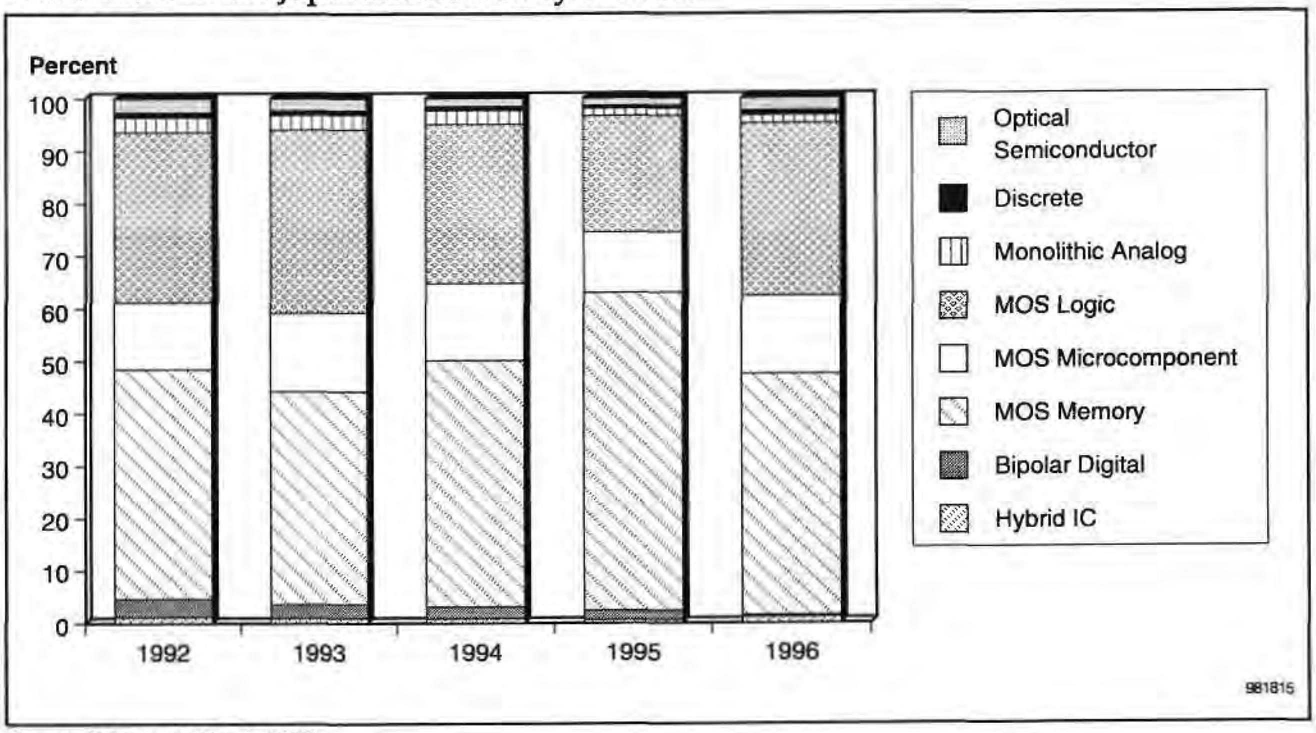
Source: Dataquest (March 1998)

Figure A-46
Oki's Share of the Worldwide Market by Product, 1992 to 1996



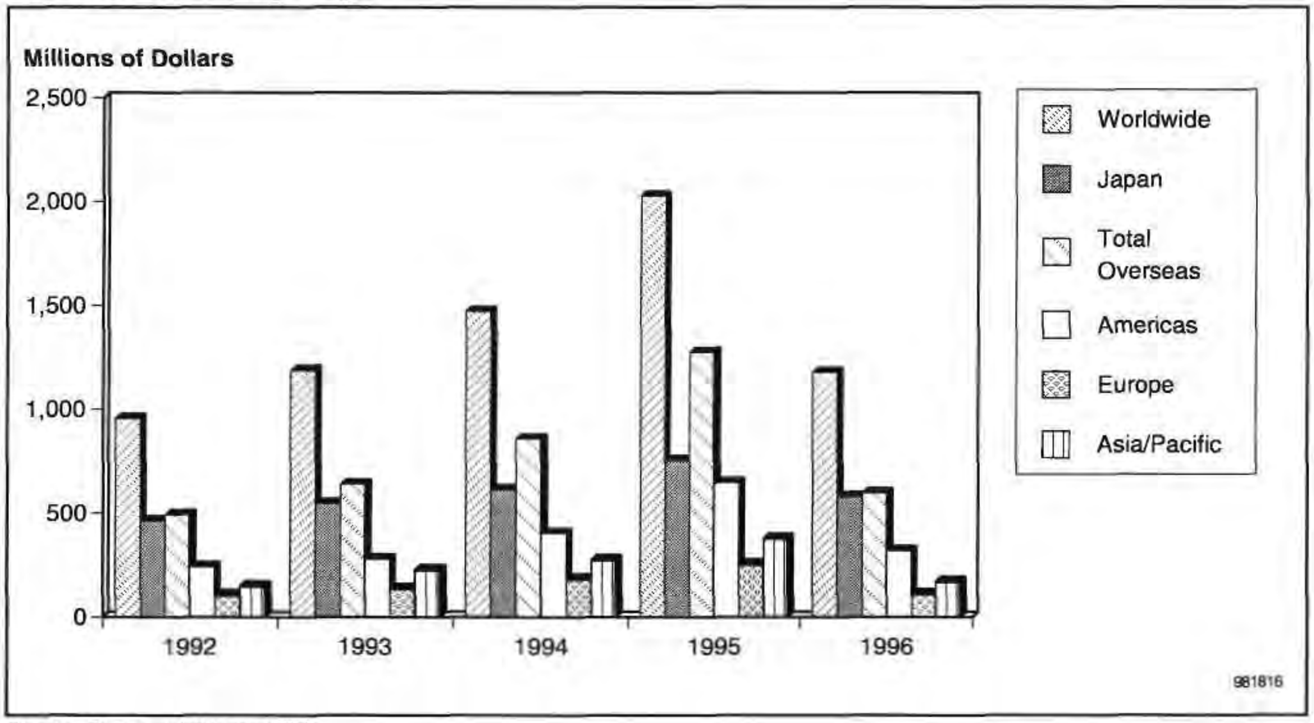
Source: Dataquest (March 1998)

Figure A-47
Oki's Share of the Japanese Market by Product



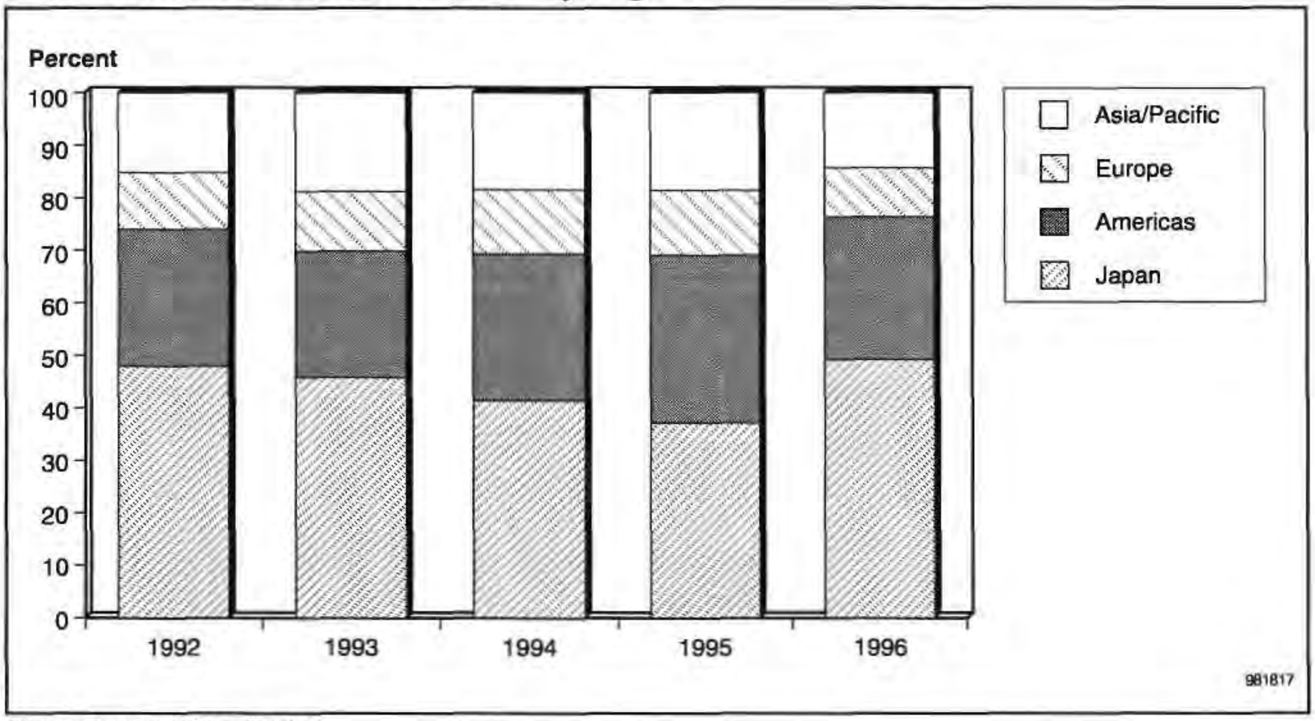
Source: Dataquest (March 1998)

Figure A-48
Revenue of Oki by Region



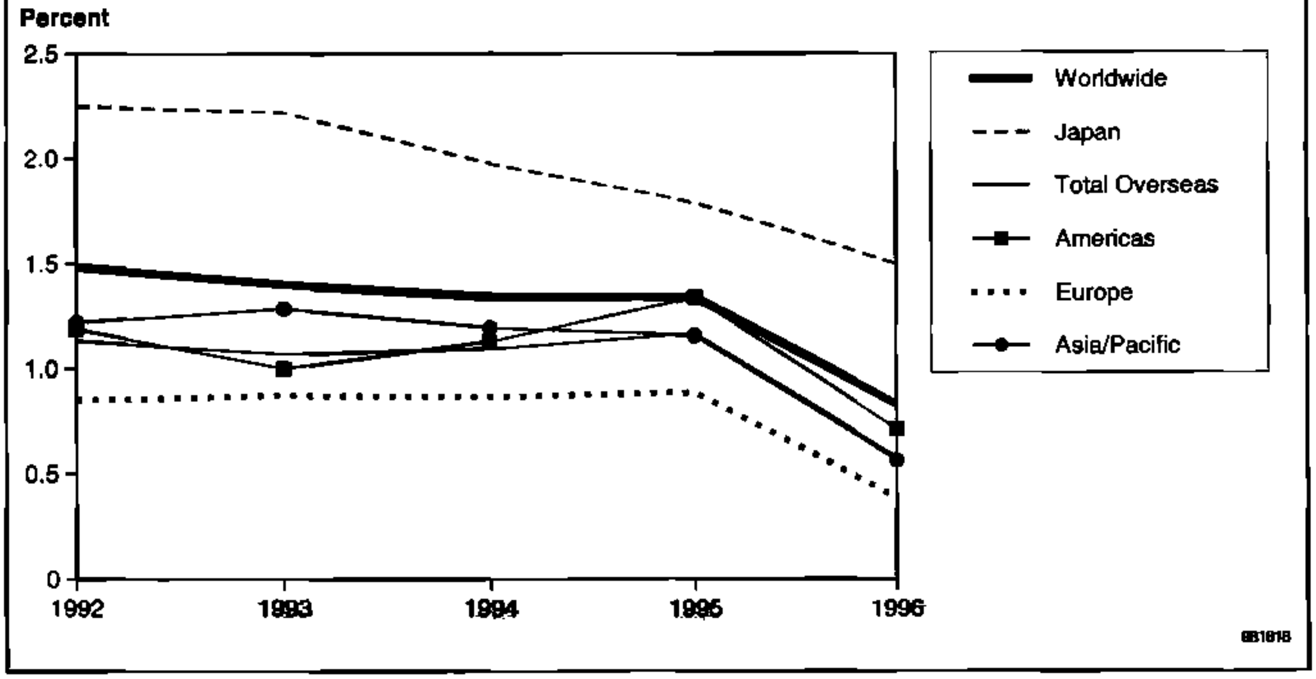
Source: Dataquest (March 1998)

Figure A-49
Oki's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-50
Oki's Market Share by Region



Source: Dataquest (March 1998)

Table A-11
Revenue of Ricoh by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	0	0	0	0	0
Bipolar Digital	0	0	0	0	0
MOS Memory	8	21	19	6	3
MOS Microcomponent	56	89	83	75	76
MOS Logic	22	25	66	94	39
Monolithic Analog	7	8	14	38	50
Discrete	0	0	0	0	0
Optical Semiconductor	0	0	0	0	0

Source: Dataquest (March 1998)

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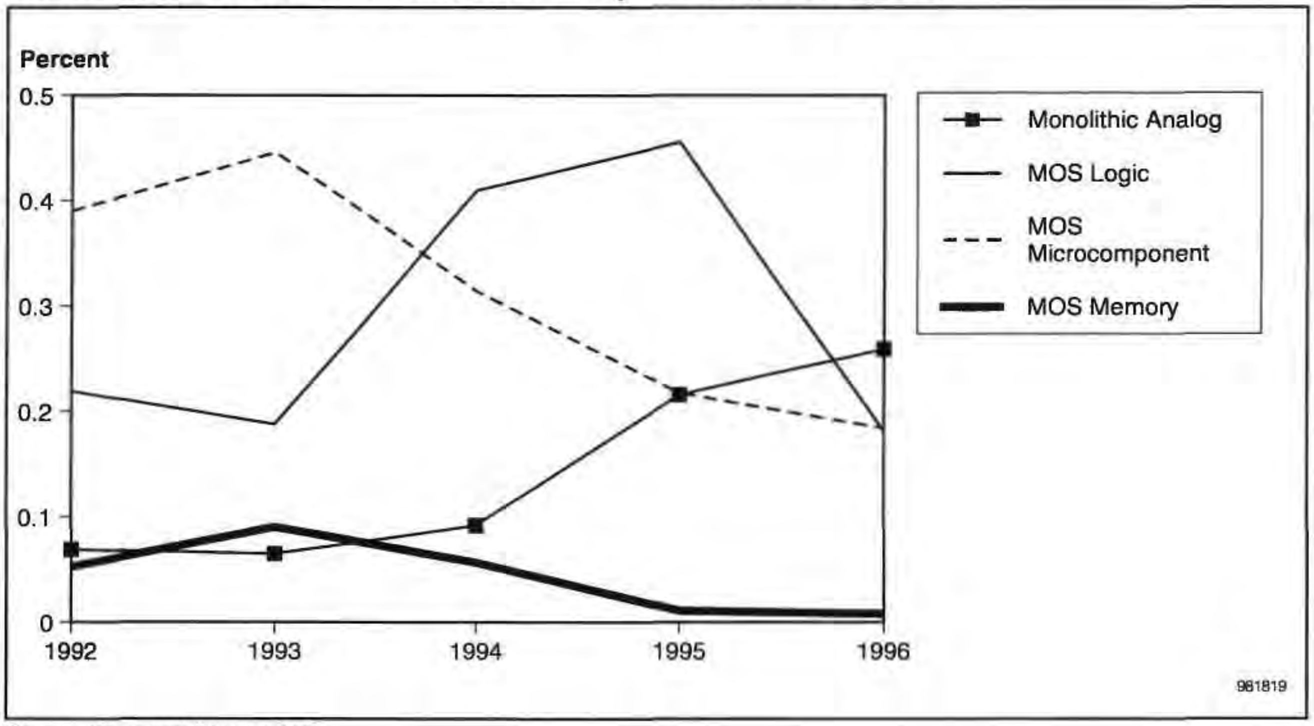
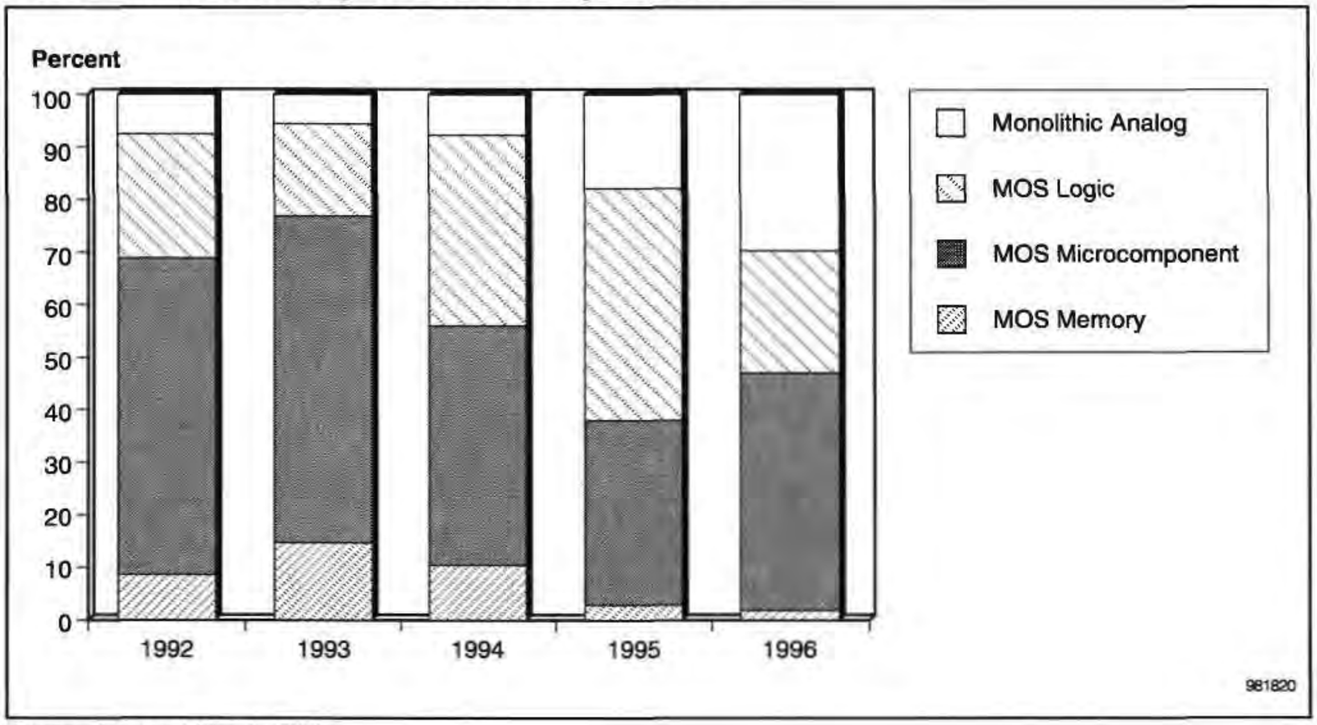
Figure A-51
Ricoh's Share of the Worldwide Market by Product, 1992 to 1996



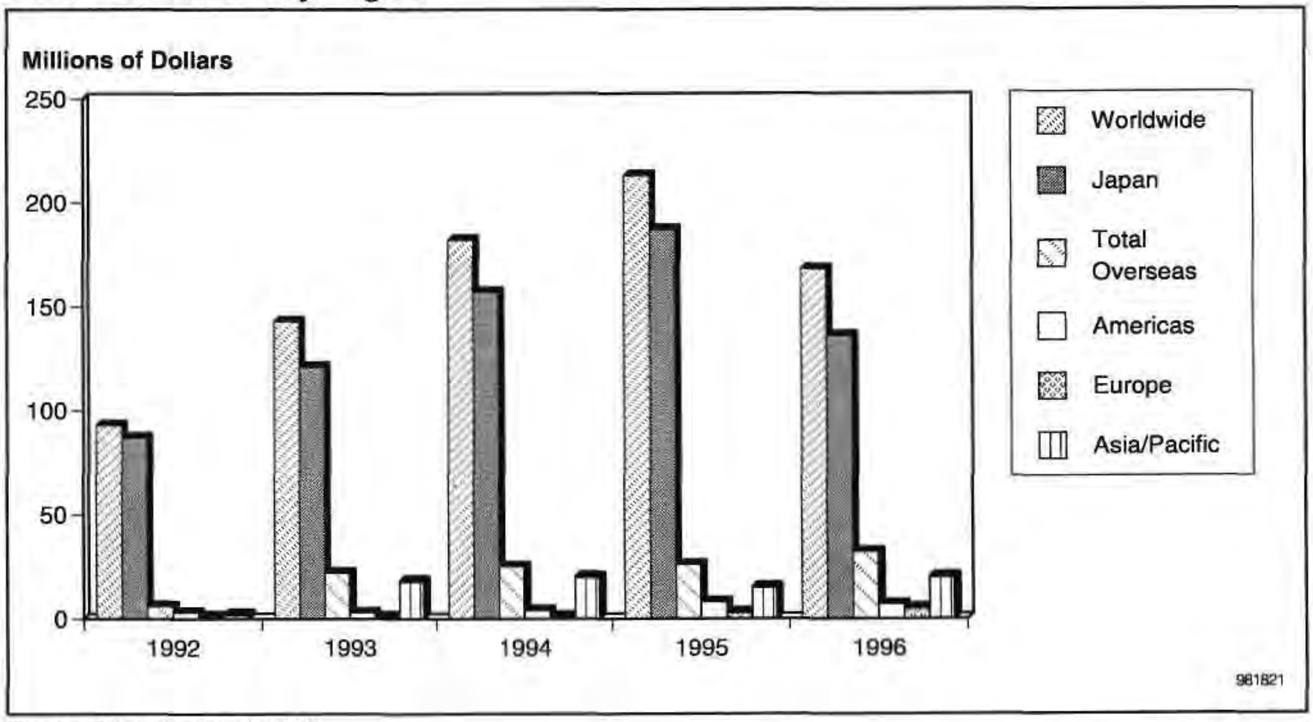
Source: Dataquest (March 1998)

Figure A-52
Ricoh's Share of the Japanese Market by Product



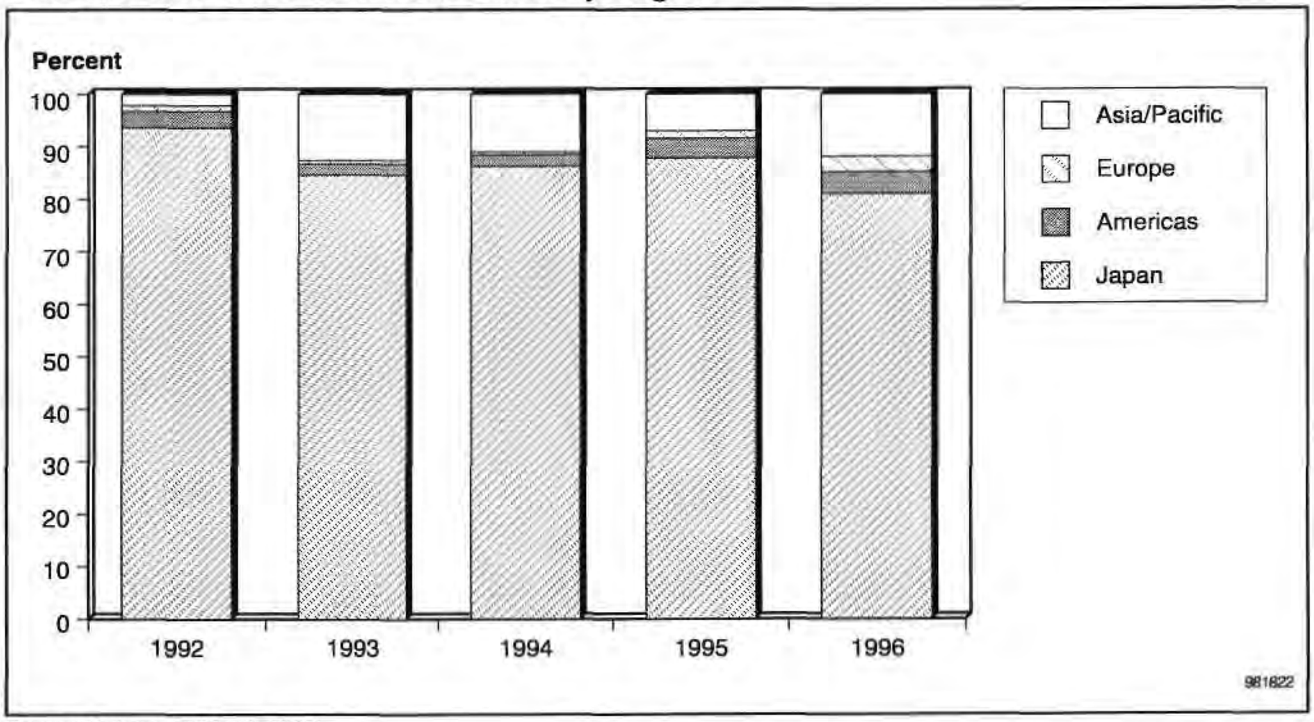
Source: Dataquest (March 1998)

Figure A-53
Revenue of Ricoh by Region



Source: Dataquest (March 1998)

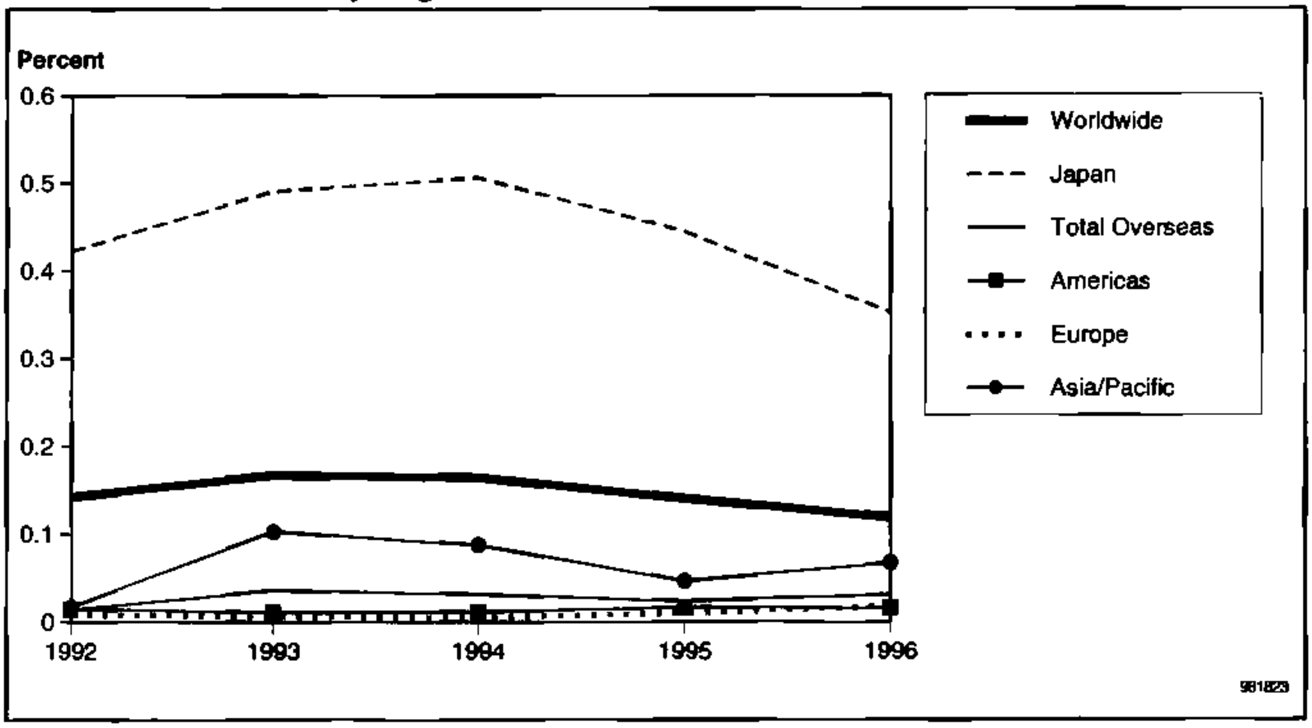
Figure A-54
Ricoh's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

 ©1998 Dataquest

Figure A-55
Ricoh's Market Share by Region



Source: Dataquest (March 1998)

Table A-12
Revenue of Rohm by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	63	68	72	78	73
Bipolar Digital	0	0	0	0	0
MOS Memory	27	39	56	61	51
MOS Microcomponent	20	23	50	71	66
MOS Logic	43	50	104	244	210
Monolithic Analog	238	258	361	423	357
Discrete	343	380	524	771	681
Optical Semiconductor	110	112	178	286	293

Source: Dataquest (March 1998)

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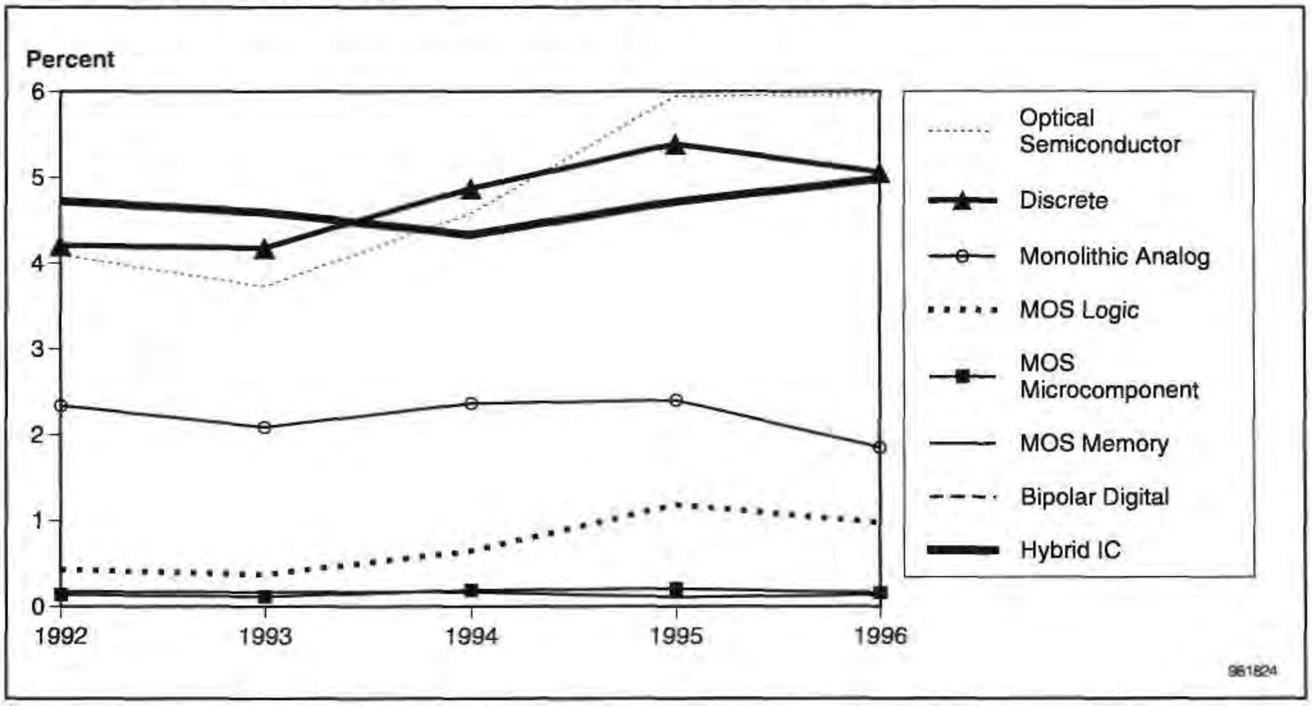
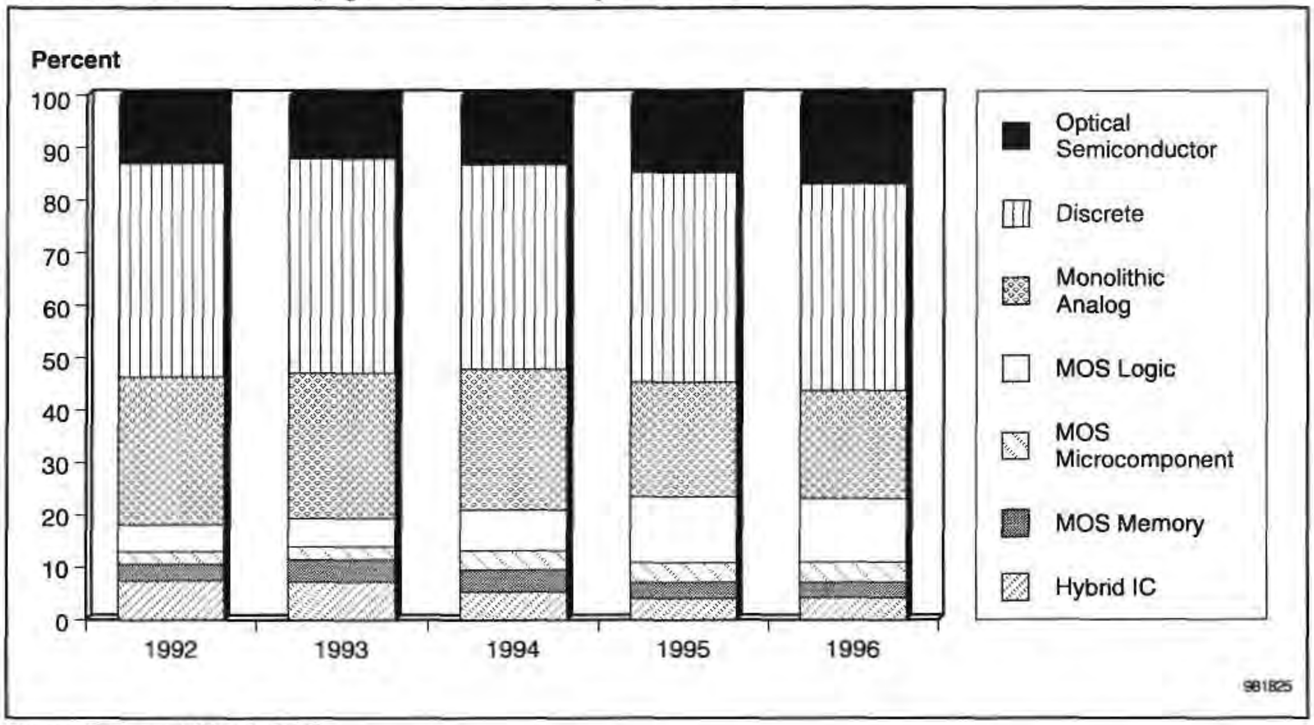
Figure A-56
Rohm's Share of the Worldwide Market by Product, 1992 to 1996



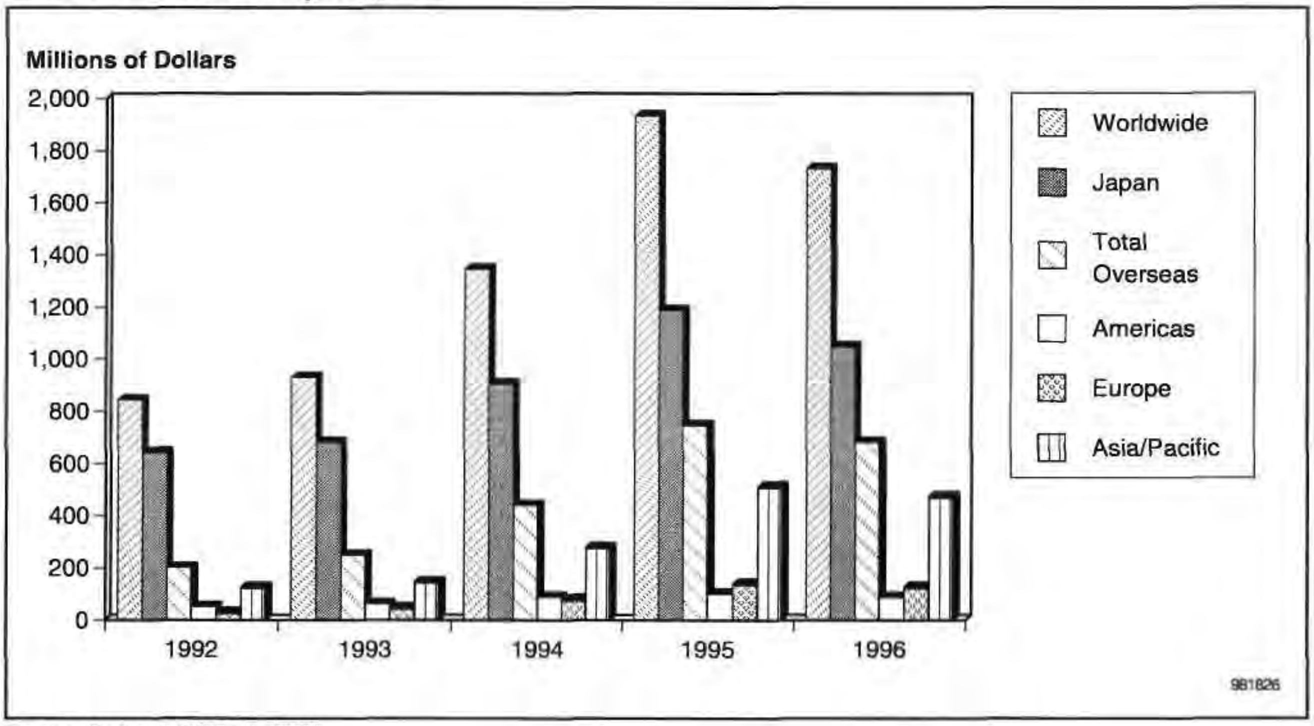
Source: Dataquest (March 1998)

Figure A-57
Rohm's Share of the Japanese Market by Product



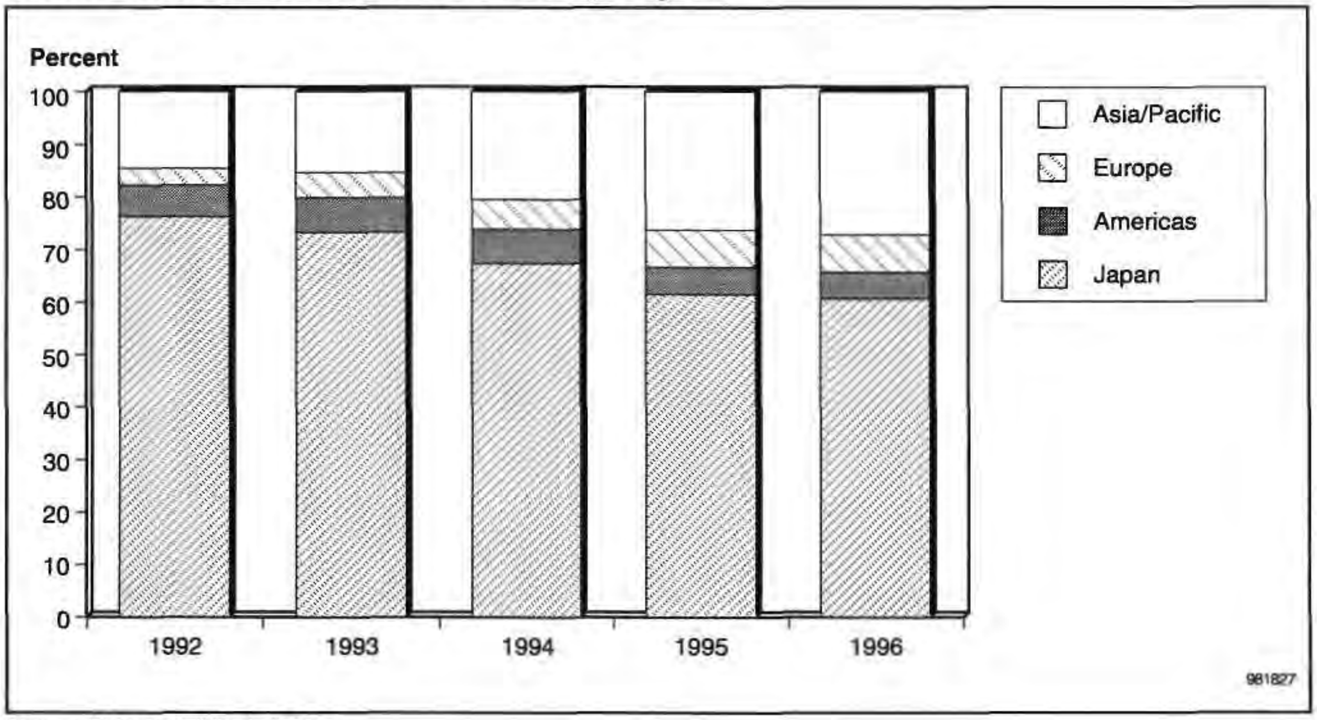
Source: Dataquest (March 1998)

Figure A-58
Revenue of Rohm by Region



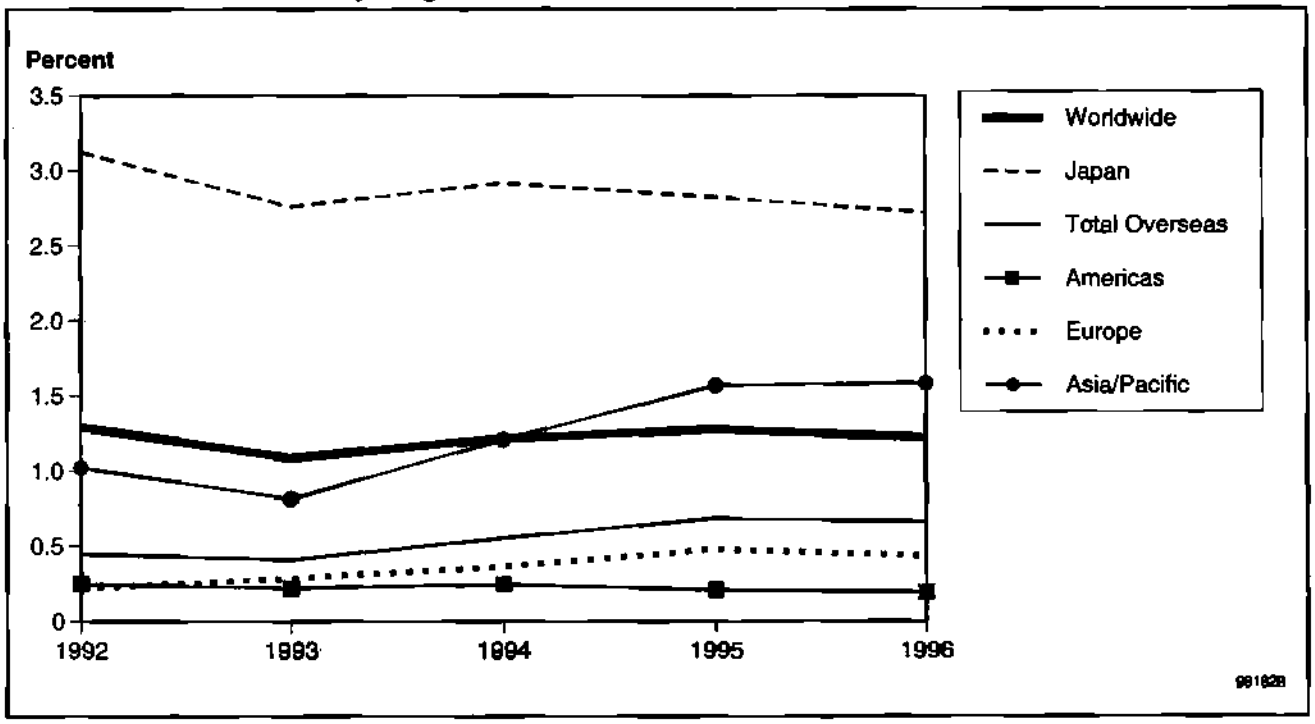
Source: Dataquest (March 1998)

Figure A-59
Rohm's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-60
Rohm's Market Share by Region



Source: Dataquest (March 1998)

Table A-13
Revenue of Sanken by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	153	202	240	283	254
Bipolar Digital	0	0	0	0	0
MOS Memory	0	0	0	0	0
MOS Microcomponent	0	0	0	0	0
MOS Logic	0	0	0	0	0
Monolithic Analog	0	0	0	0	0
Discrete	253	299	334	398	328
Optical Semiconductor	20	32	34	52	40

Source: Dataquest (March 1998)

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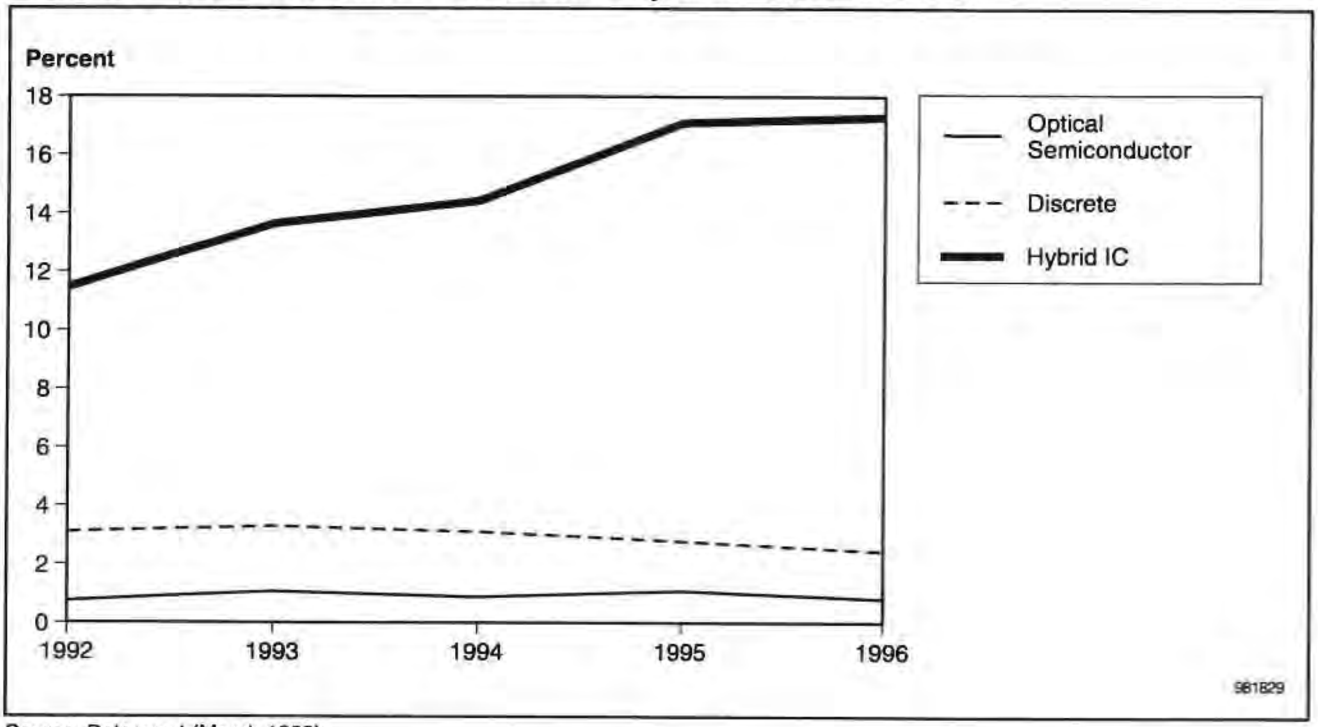
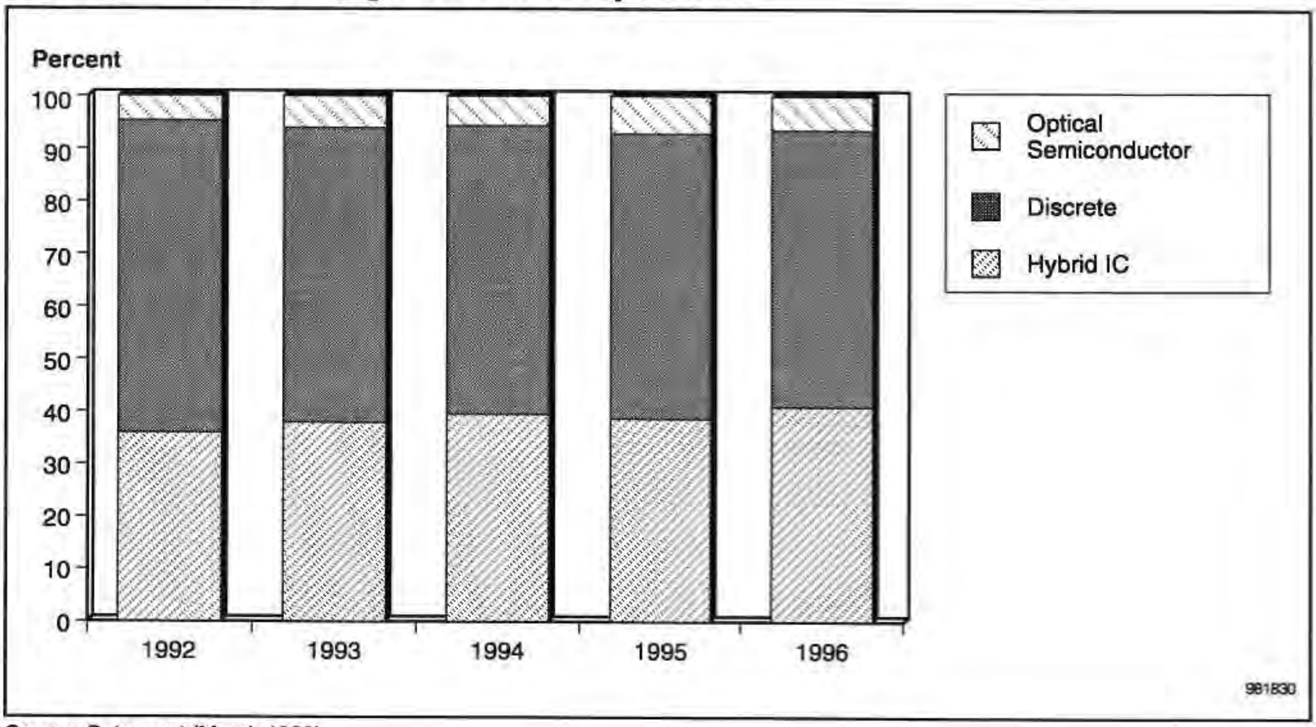
Figure A-61
Sanken's Share of the Worldwide Market by Product, 1992 to 1996



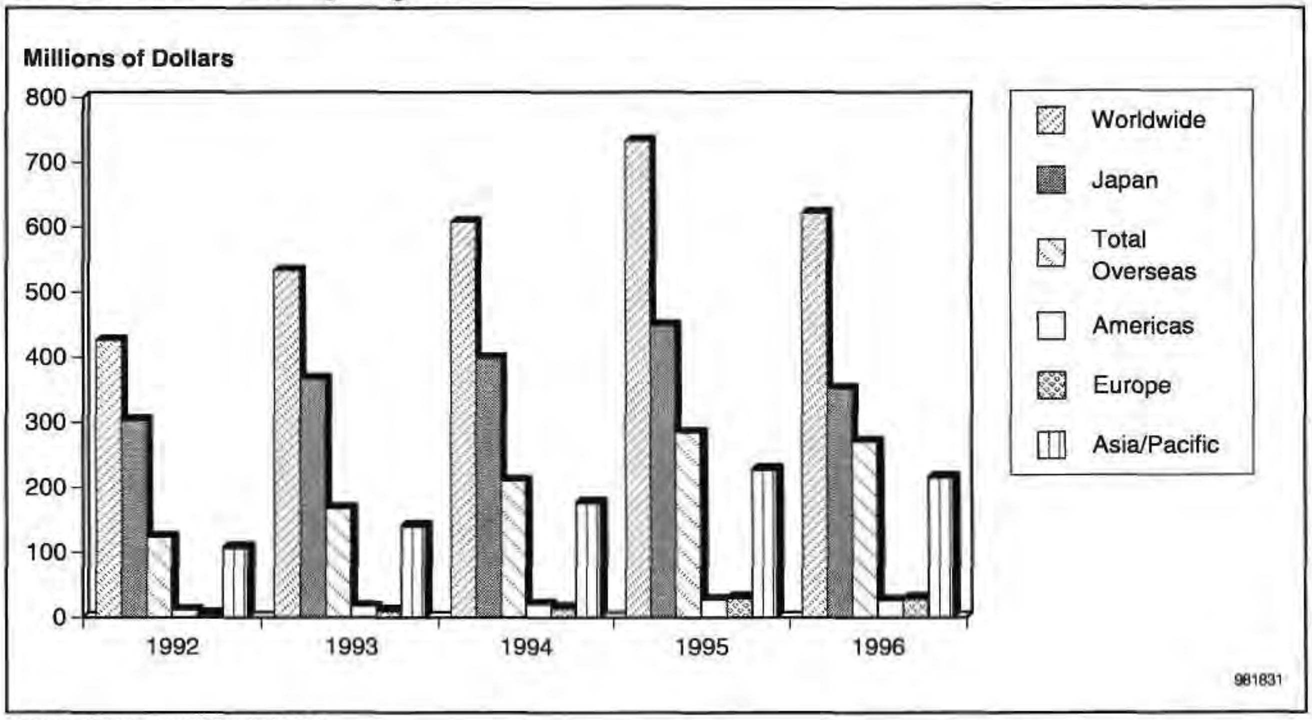
Source: Dataquest (March 1998)

Figure A-62
Sanken's Share of the Japanese Market by Product



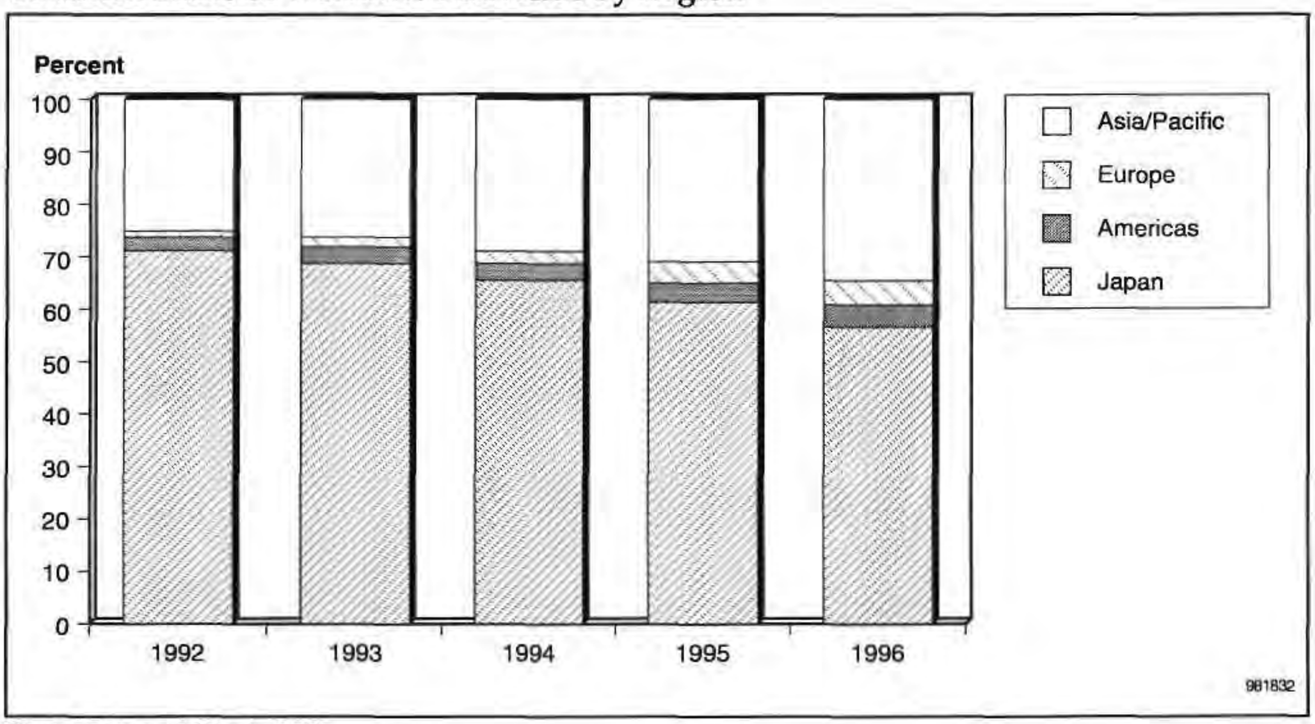
Source: Dataquest (March 1998)

Figure A-63
Revenue of Sanken by Region



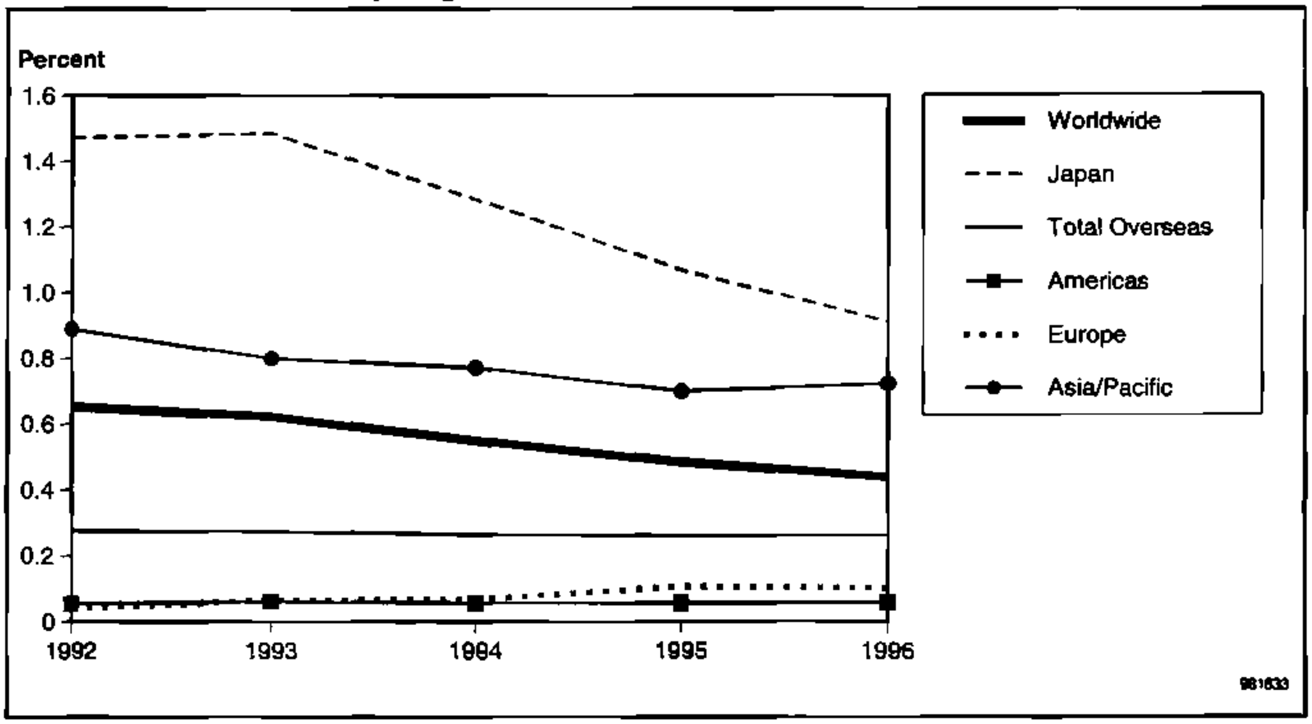
Source: Dataquest (March 1998)

Figure A-64
Sanken's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-65
Sanken's Market Share by Region



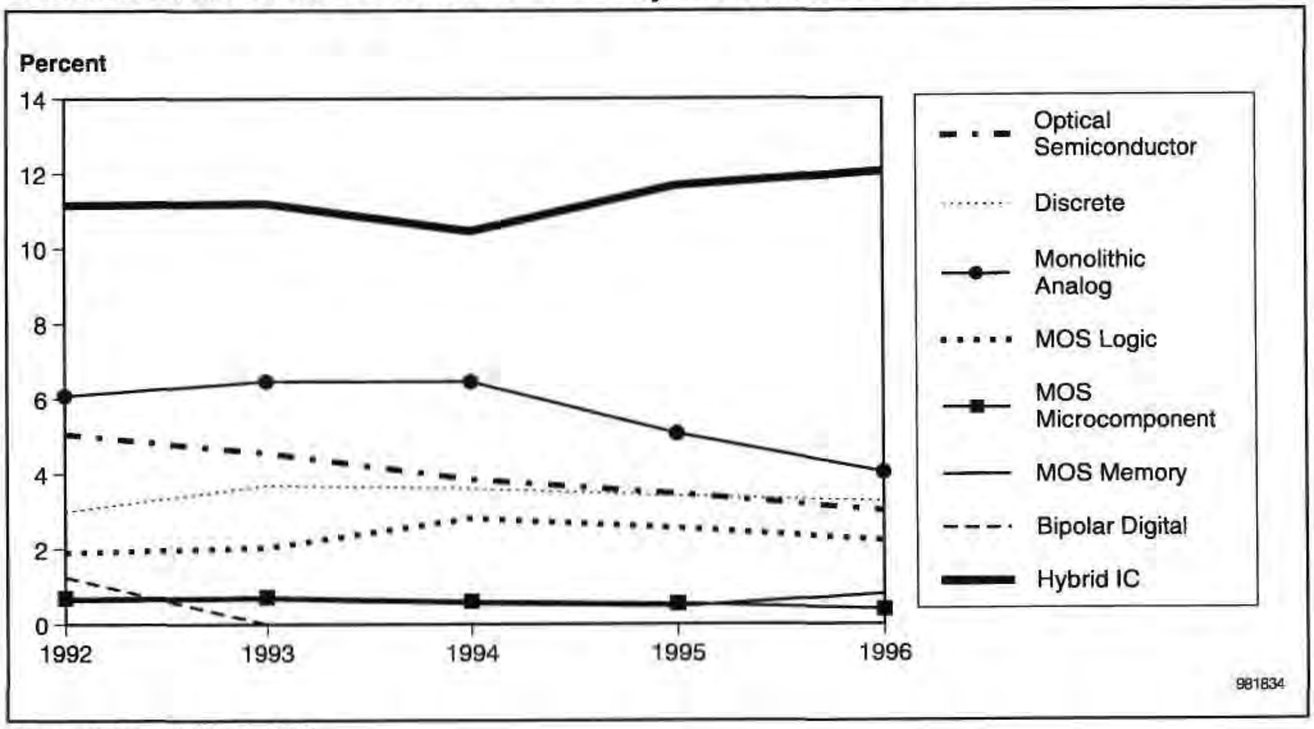
Source: Dataquest (March 1998)

Table A-14
Revenue of SANYO by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	149	166	174	193	177
Bipolar Digital	40	0	0	0	0
MOS Memory	95	155	183	257	302
MOS Microcomponent	100	145	161	187	164
MOS Logic	191	271	453	528	479
Monolithic Analog	430	633	811	894	780
Discrete	244	336	389	488	441
Optical Semiconductor	136	137	150	167	148

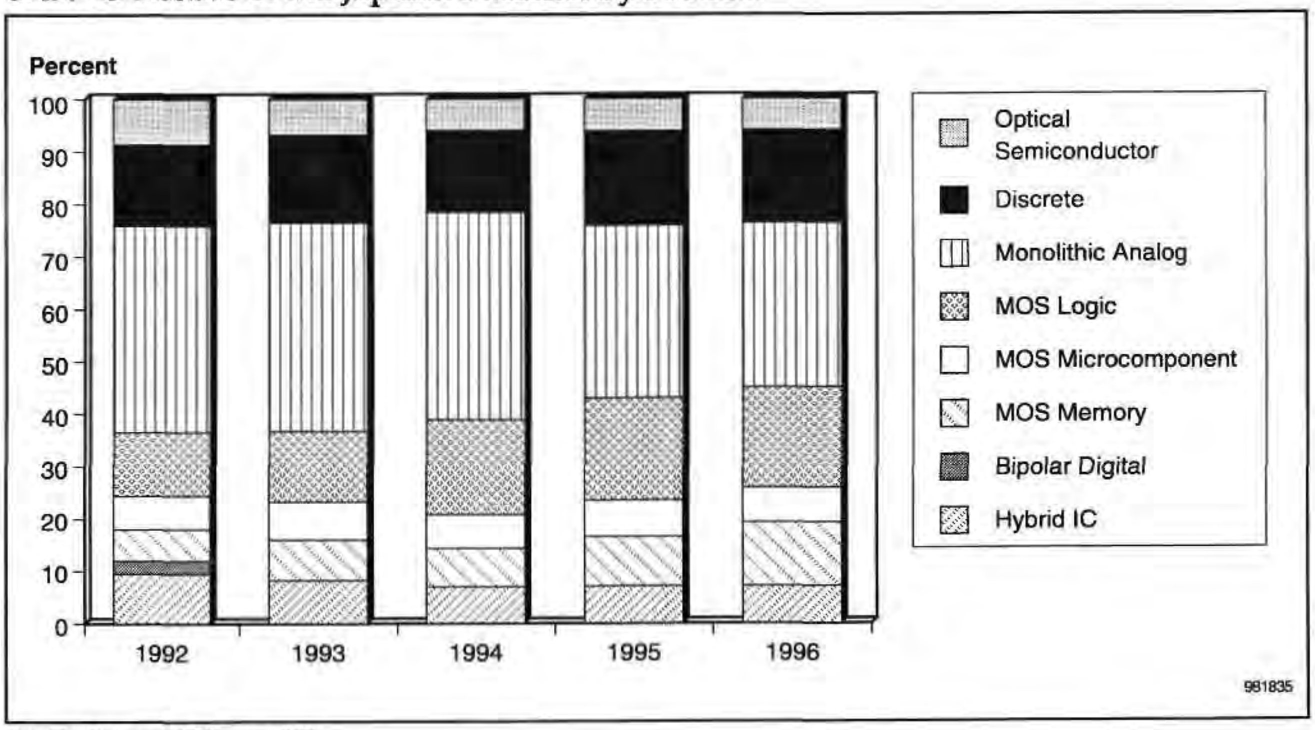
Source: Dataquest (March 1998)

Figure A-66
SANYO's Share of the Worldwide Market by Product, 1992 to 1996



Source: Dataquest (March 1998)

Figure A-67
SANYO's Share of the Japanese Market by Product



Source: Dataquest (March 1998)

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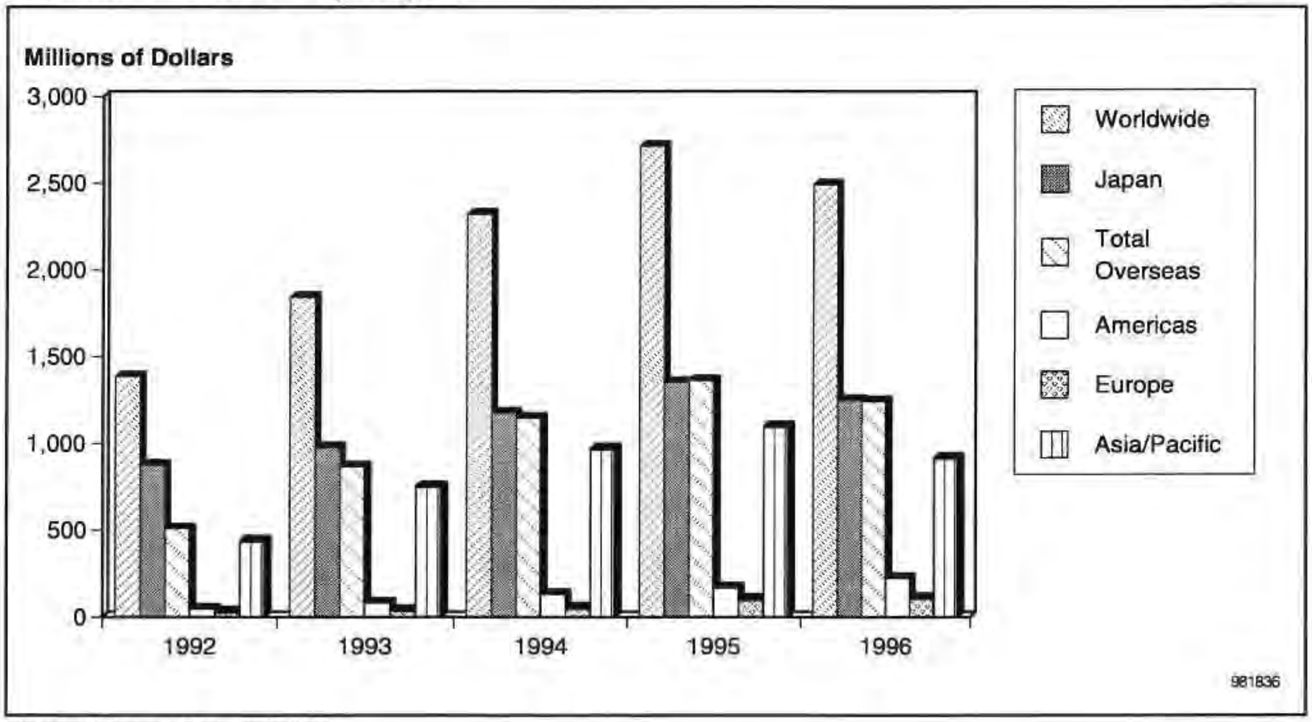
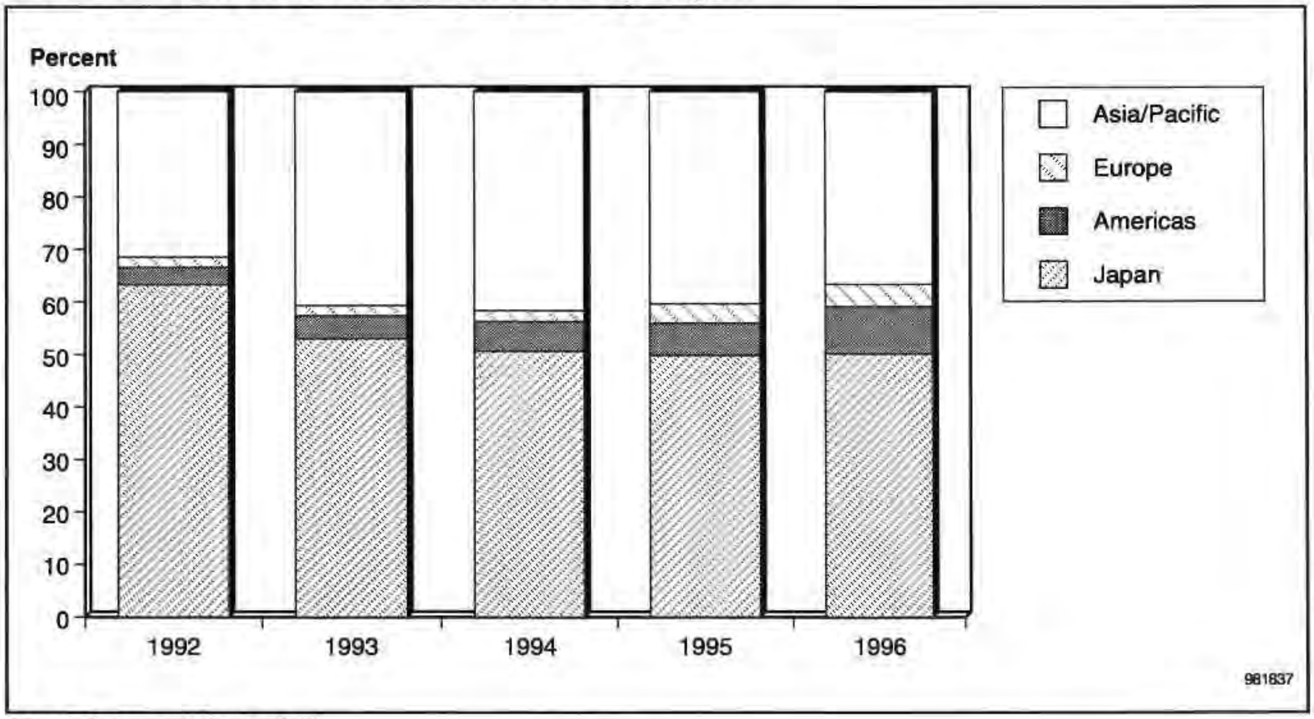
Figure A-68
Revenue of SANYO by Region



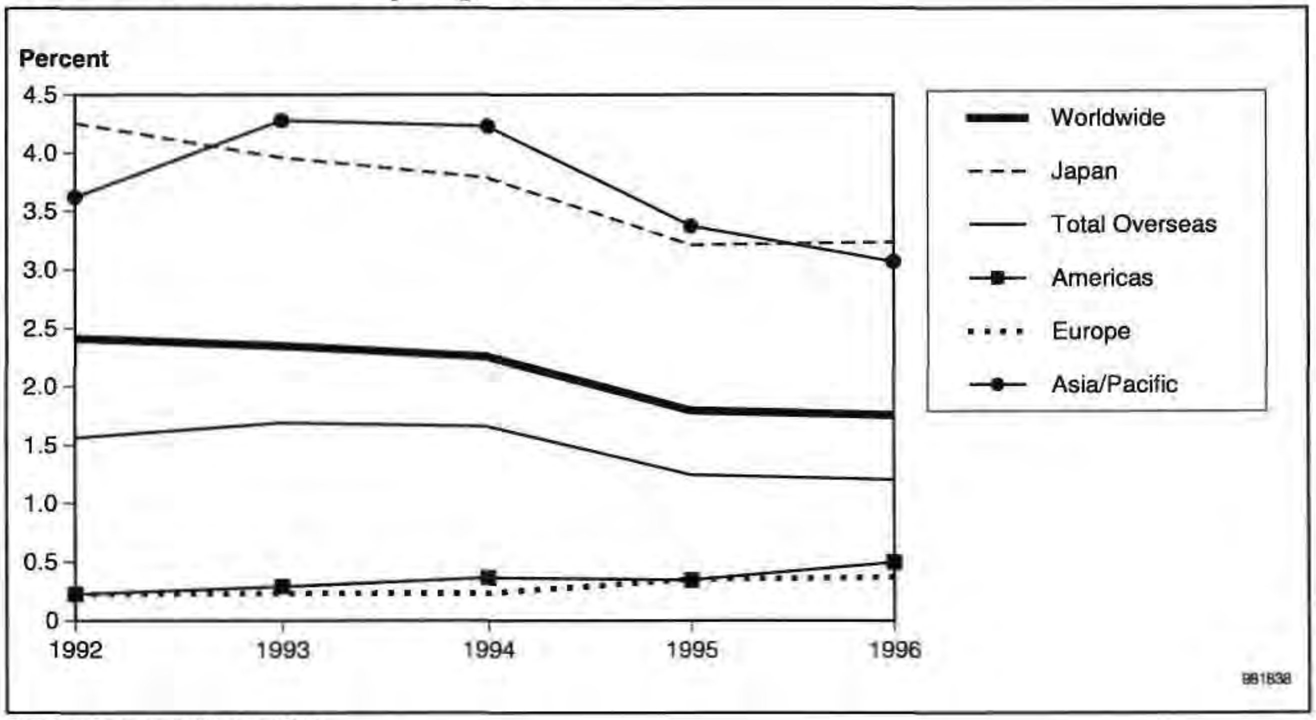
Source: Dataquest (March 1998)

Figure A-69
SANYO's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-70
SANYO's Market Share by Region



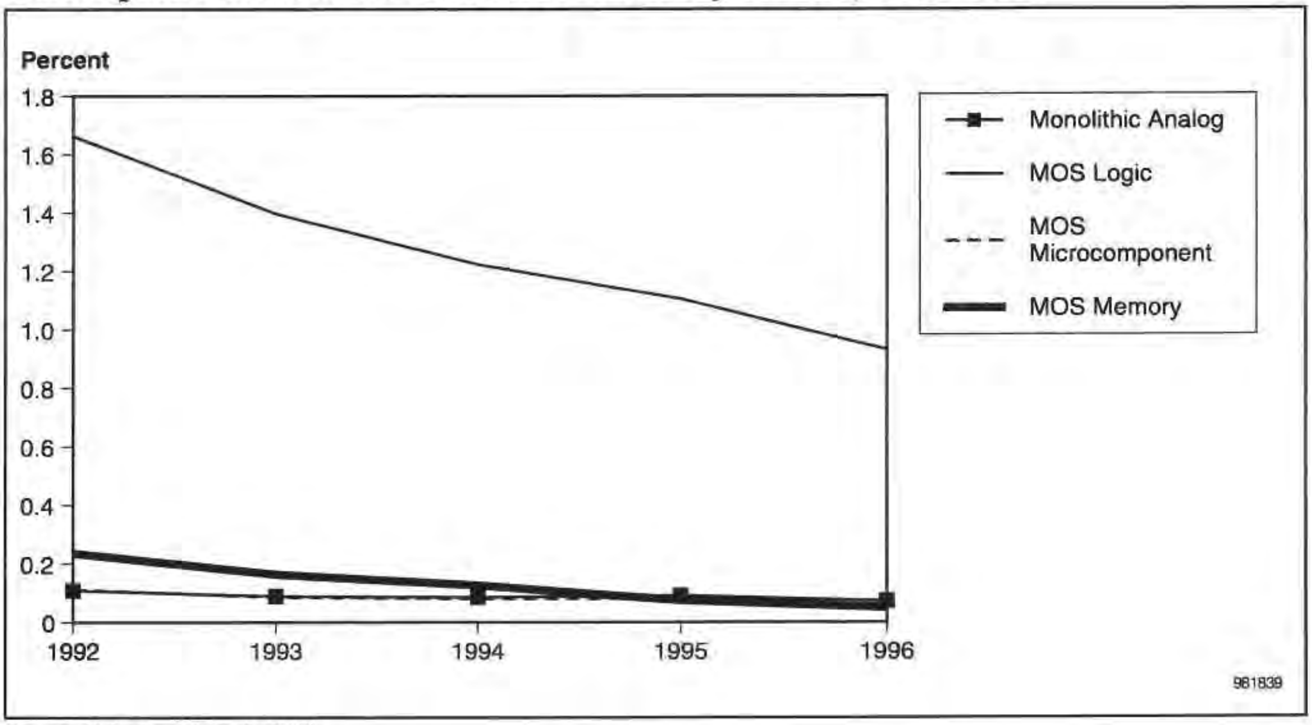
Source: Dataquest (March 1998)

Table A-15
Revenue of Seiko Epson by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	0	0	0	0	0
Bipolar Digital	0	0	0	0	0
MOS Memory	36	38	42	41	19
MOS Microcomponent	16	17	21	28	22
MOS Logic	167	186	197	228	201
Monolithic Analog	11	11	13	16	14
Discrete	0	0	0	0	0
Optical Semiconductor	0	0	0	0	0

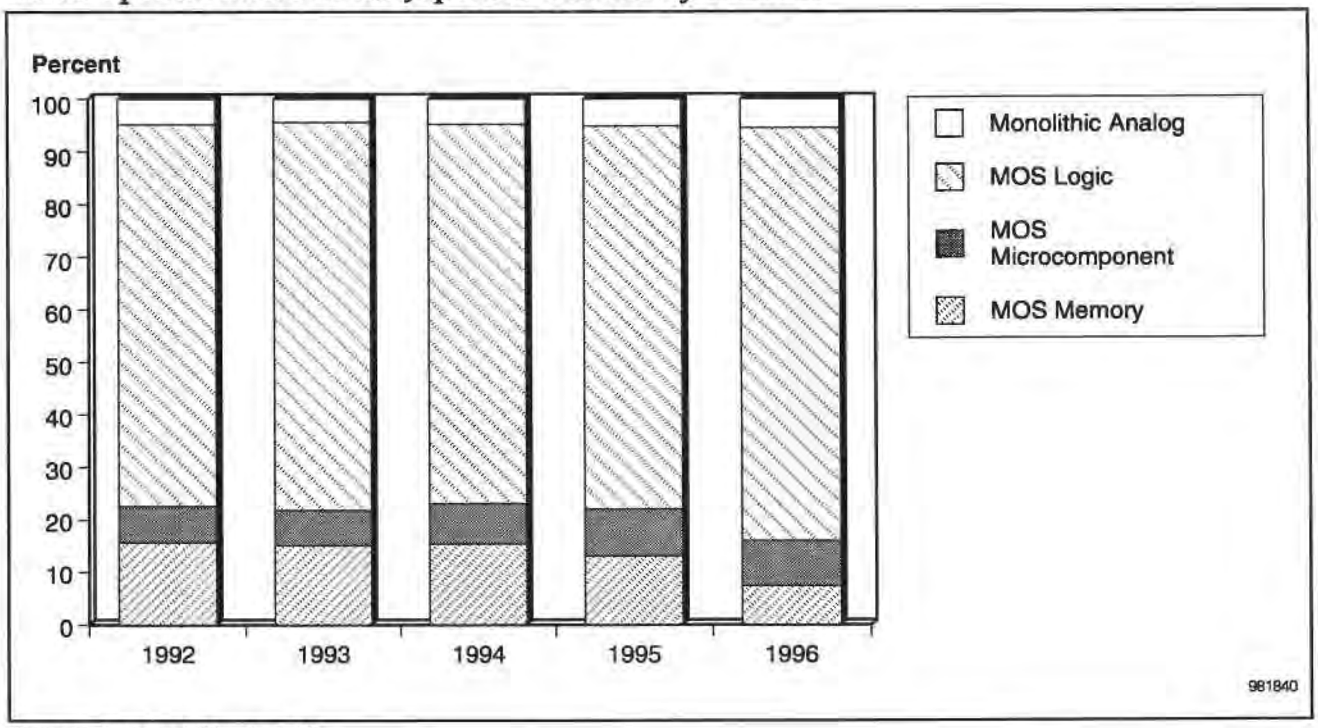
Source: Dataquest (March 1998)

Figure A-71
Seiko Epson's Share of the Worldwide Market by Product, 1992 to 1996



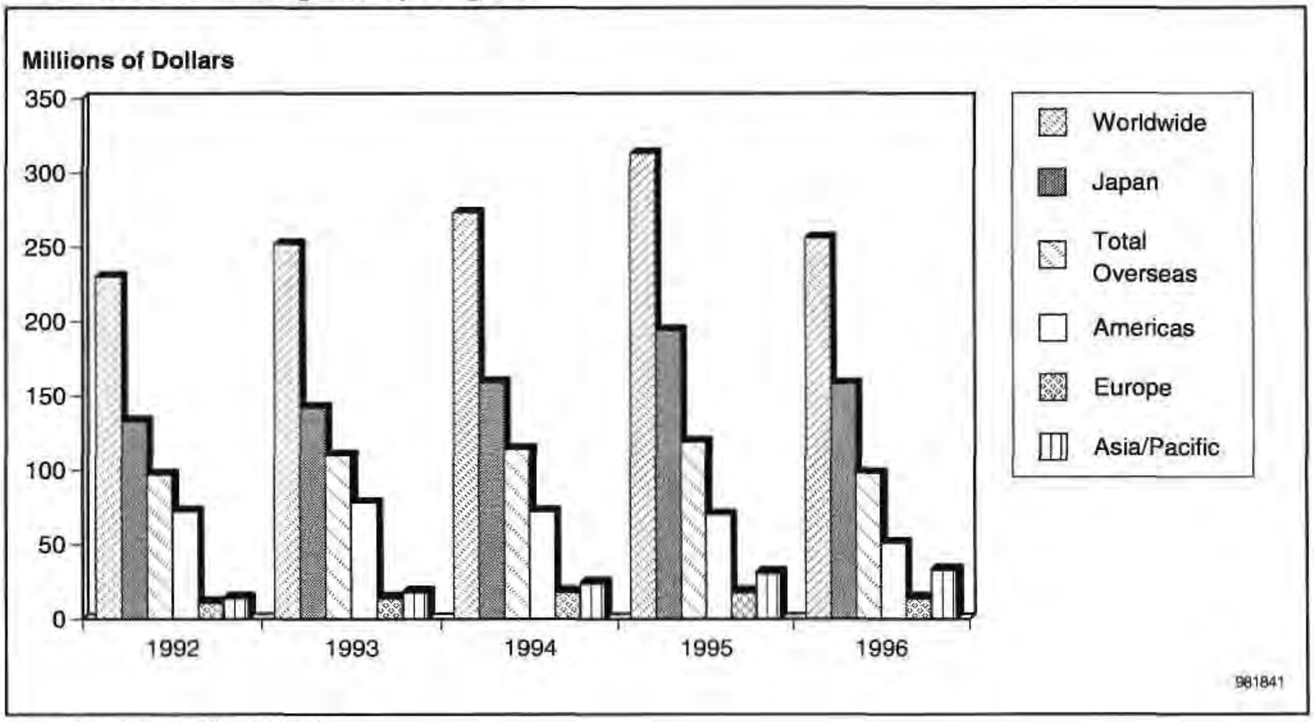
Source: Dataquest (March 1998)

Figure A-72
Seiko Epson's Share of the Japanese Market by Product



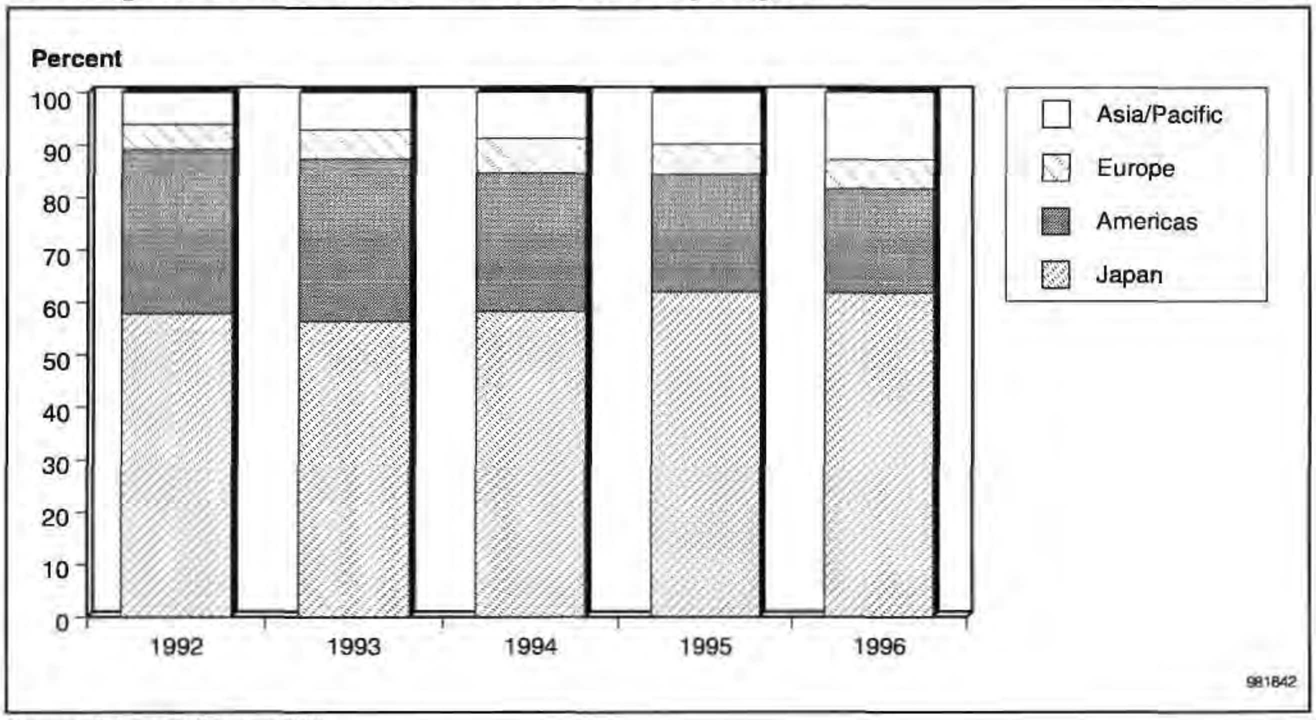
Source: Dataquest (March 1998)

Figure A-73
Revenue of Seiko Epson by Region



Source: Dataquest (March 1998)

Figure A-74
Seiko Epson's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

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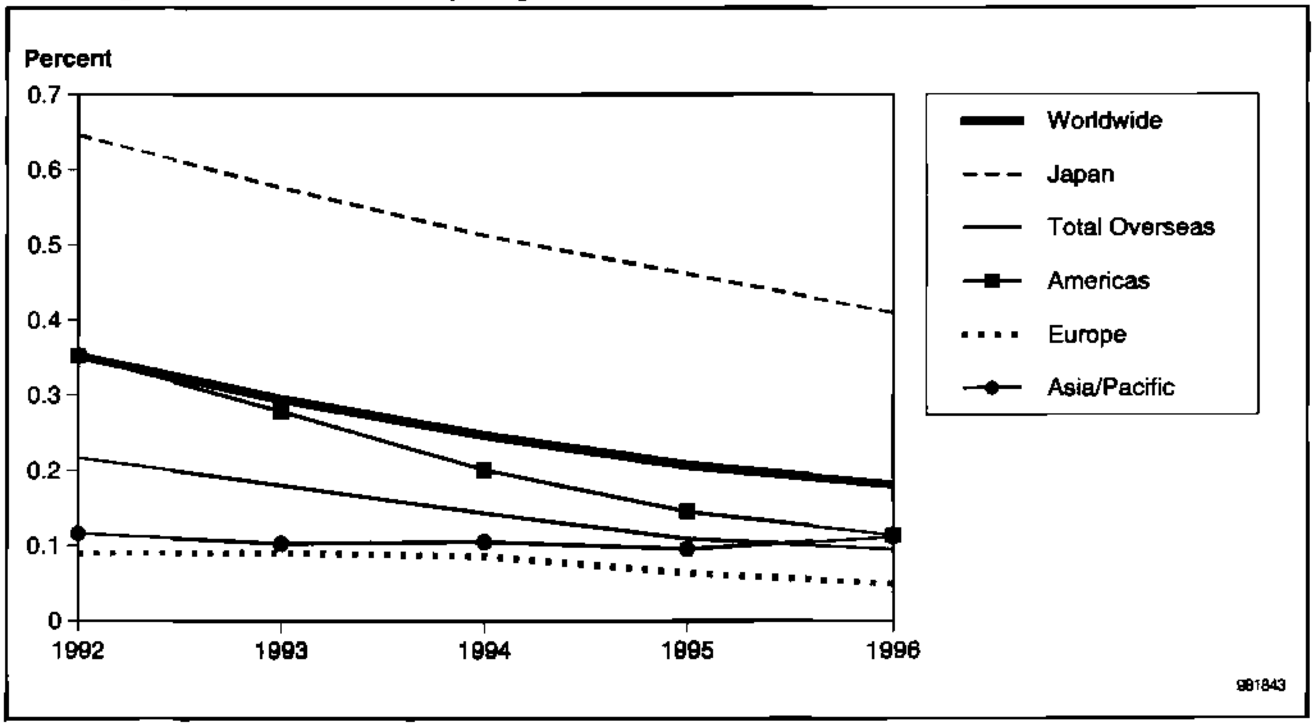
Figure A-75
Seiko Epson's Market Share by Region



Source: Dataquest (March 1998)

Table A-16
Revenue of Sharp by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	0	0	0	0	0
Bipolar Digital	0	0	0	0	0
MOS Memory	519	697	867	1,030	727
MOS Microcomponent	129	170	192	221	184
MOS Logic	290	388	523	600	504
Monolithic Analog	64	87	96	105	92
Discrete	0	0	0	0	0
Optical Semiconductor	352	418	510	636	617

Source: Dataquest (March 1998)

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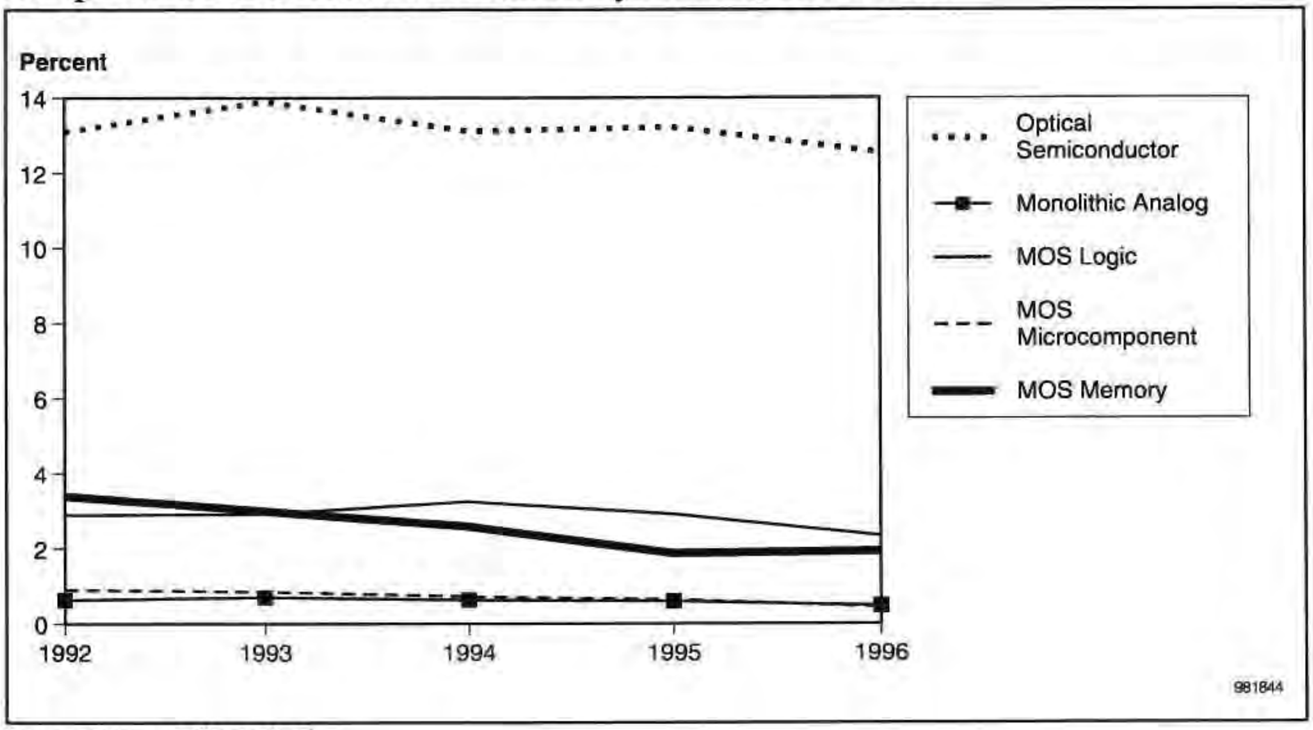
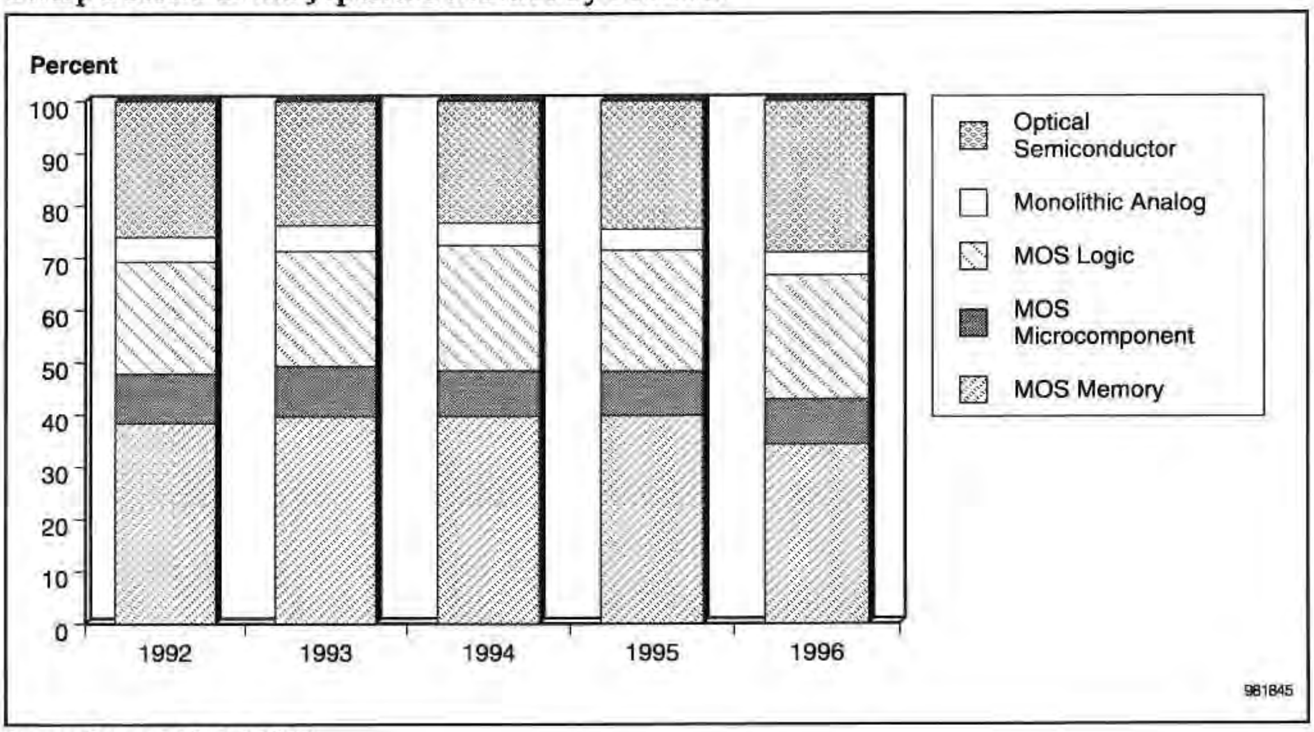
Figure A-76
Sharp's Share of the Worldwide Market by Product, 1992 to 1996



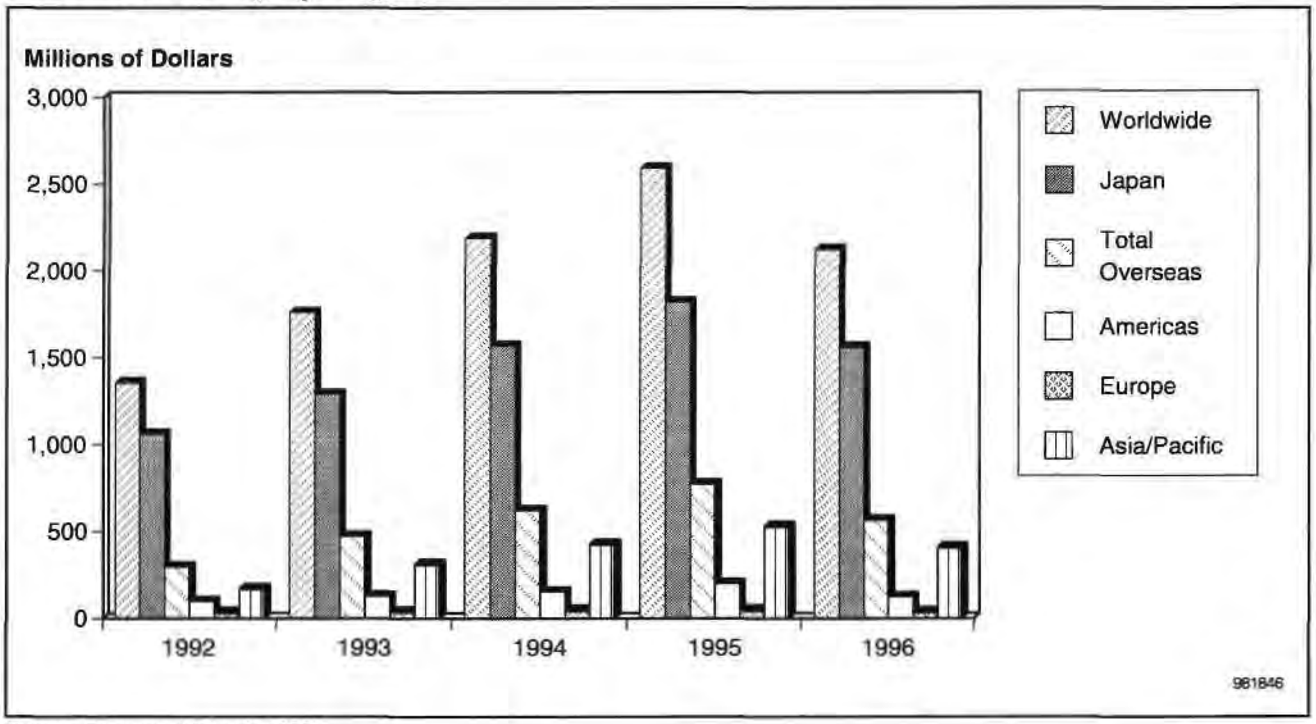
Source: Dataquest (March 1998)

Figure A-77
Sharp's Share of the Japanese Market by Product



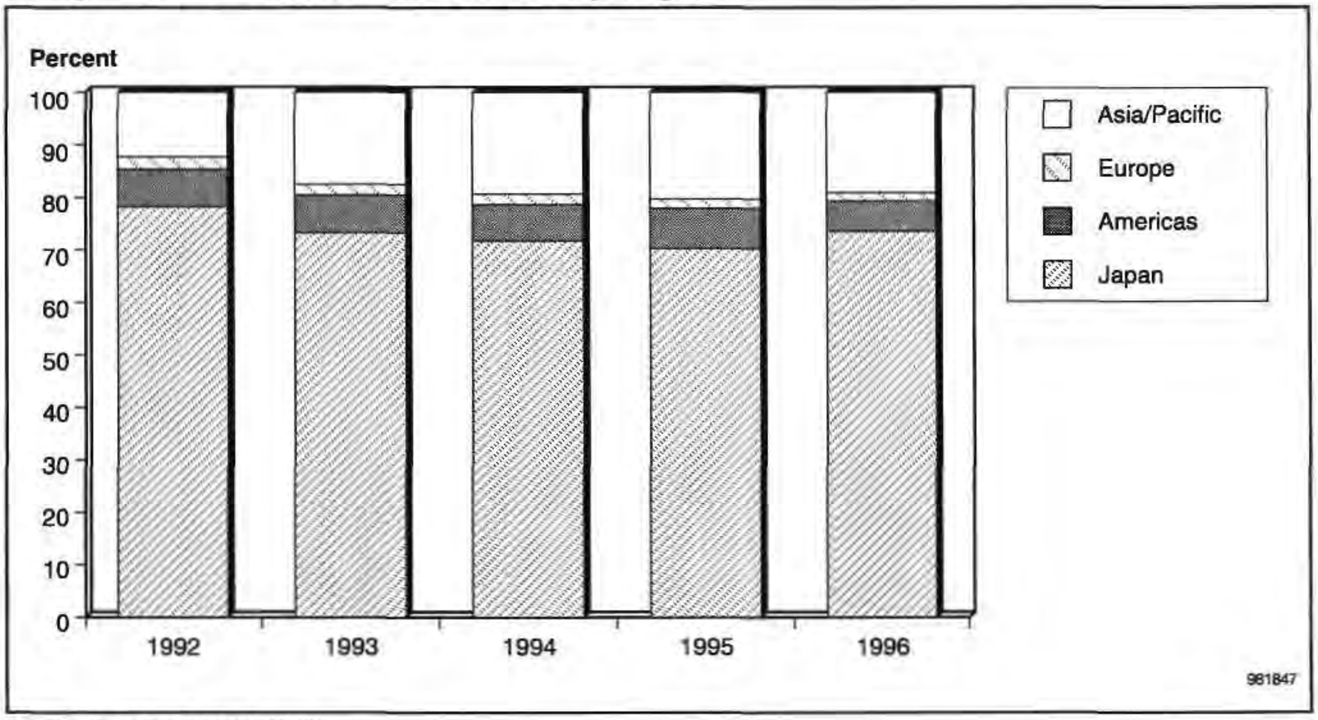
Source: Dataquest (March 1998)

Figure A-78
Revenue of Sharp by Region



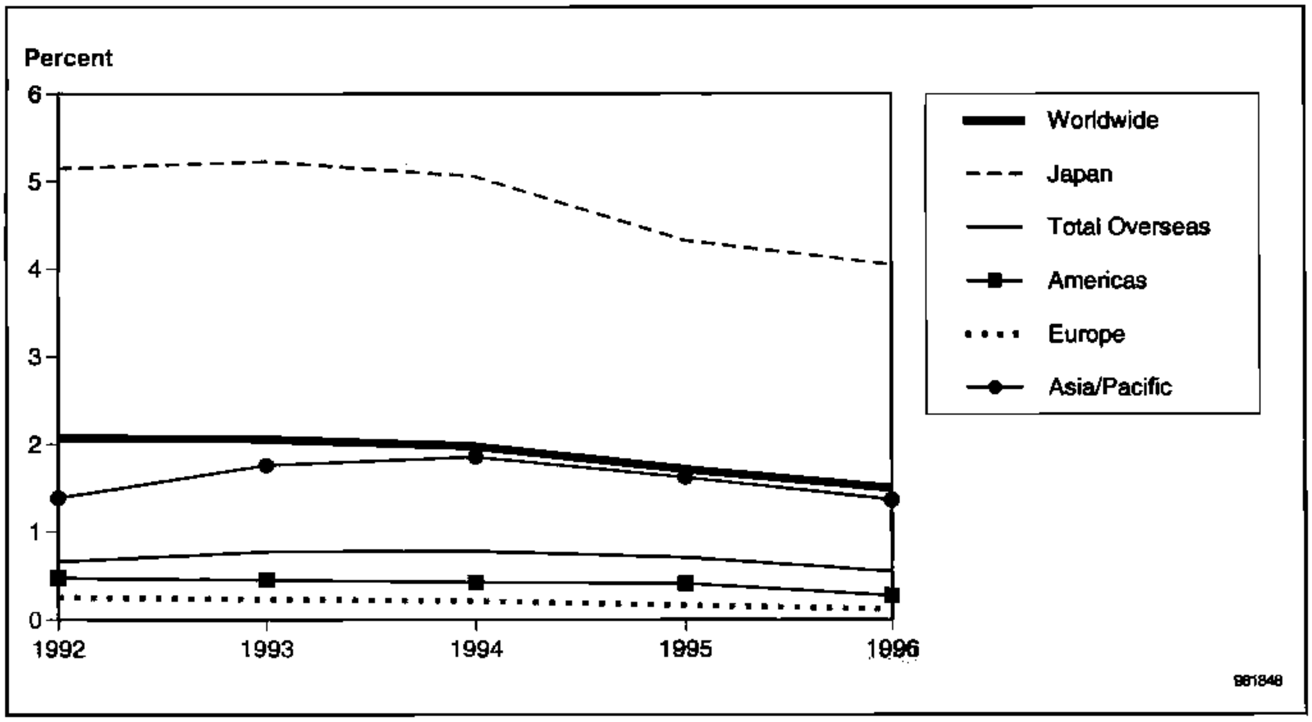
Source: Dataquest (March 1998)

Figure A-79
Sharp's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-80
Sharp's Market Share by Region



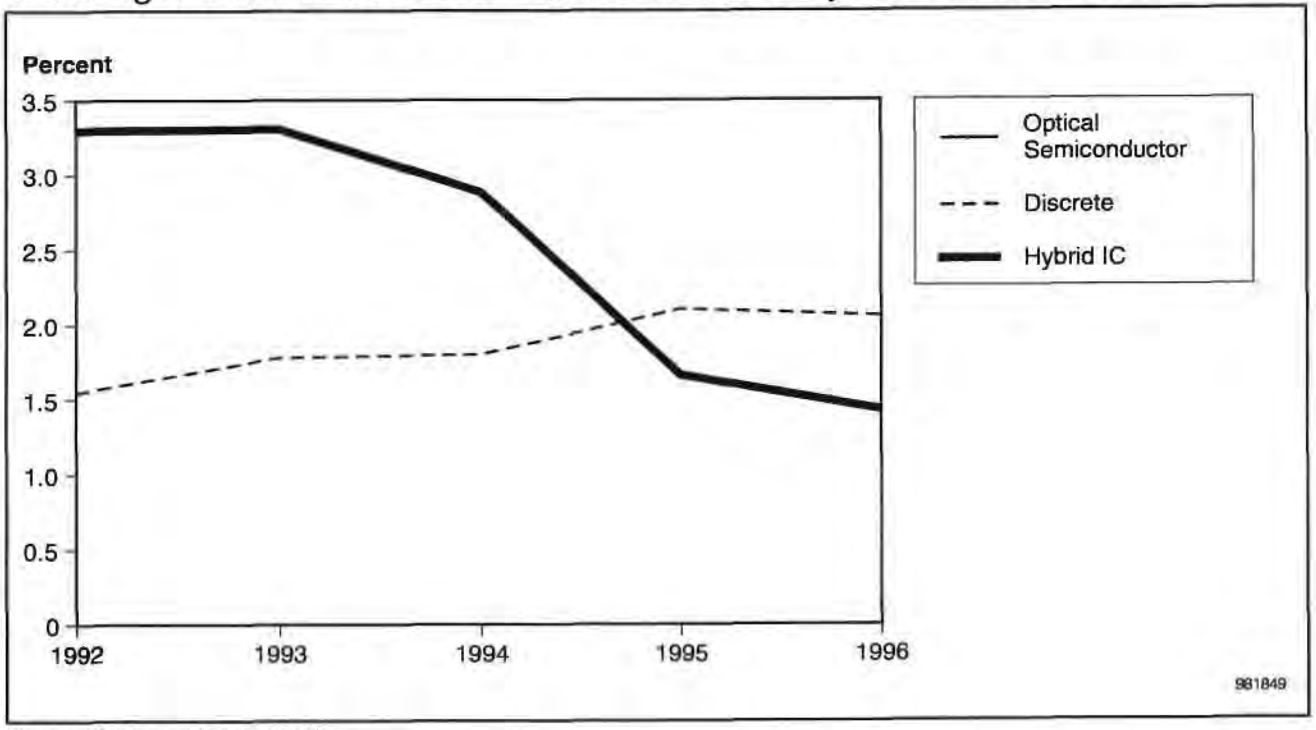
Source: Dataquest (March 1998)

Table A-17
Revenue of Shindengen Electric by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	44	49	48	28	21
Bipolar Digital	0	0	0	0	0
MOS Memory	0	0	0	0	0
MOS Microcomponent	0	0	0	0	0
MOS Logic	0	0	0	0	0
Monolithic Analog	0	0	0	0	0
Discrete	126	162	194	301	277
Optical Semiconductor	0	0	0	0	0

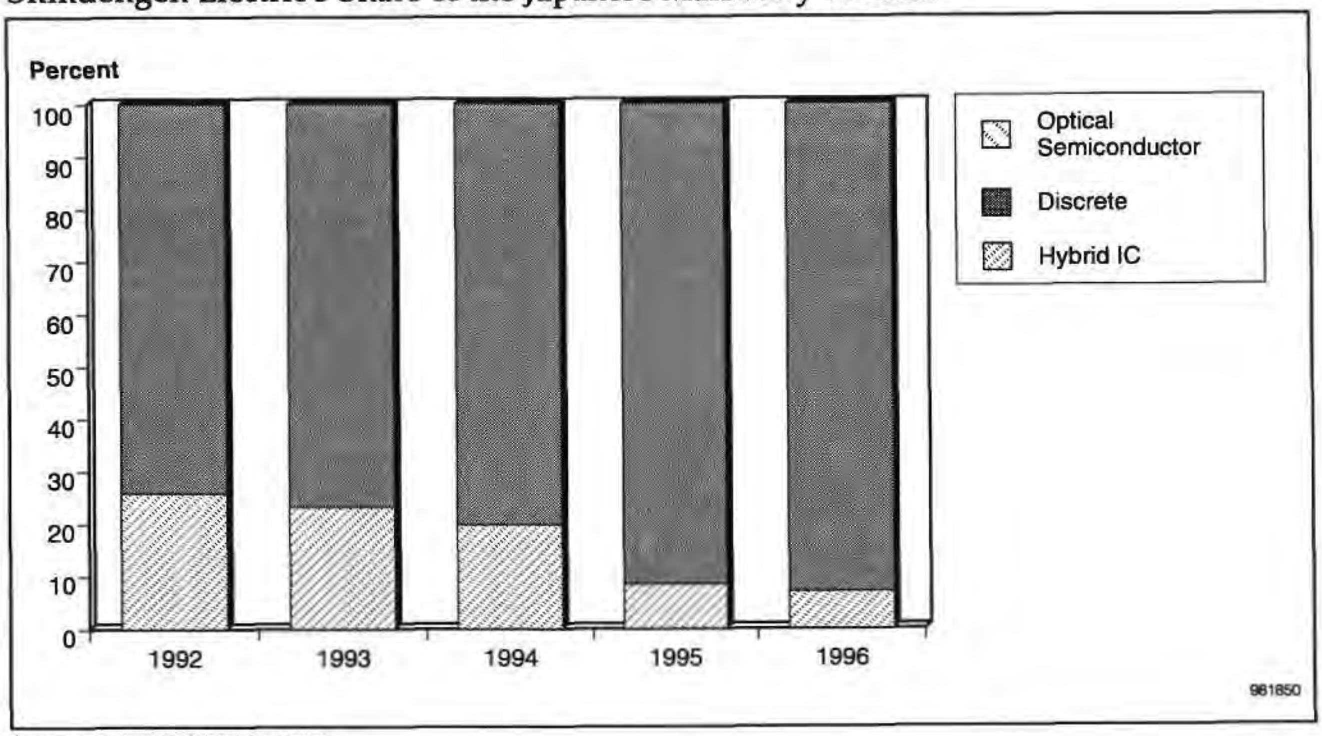
Source: Dataquest (March 1998)

Figure A-81
Shindengen Electric's Share of the Worldwide Market by Product, 1992 to 1996



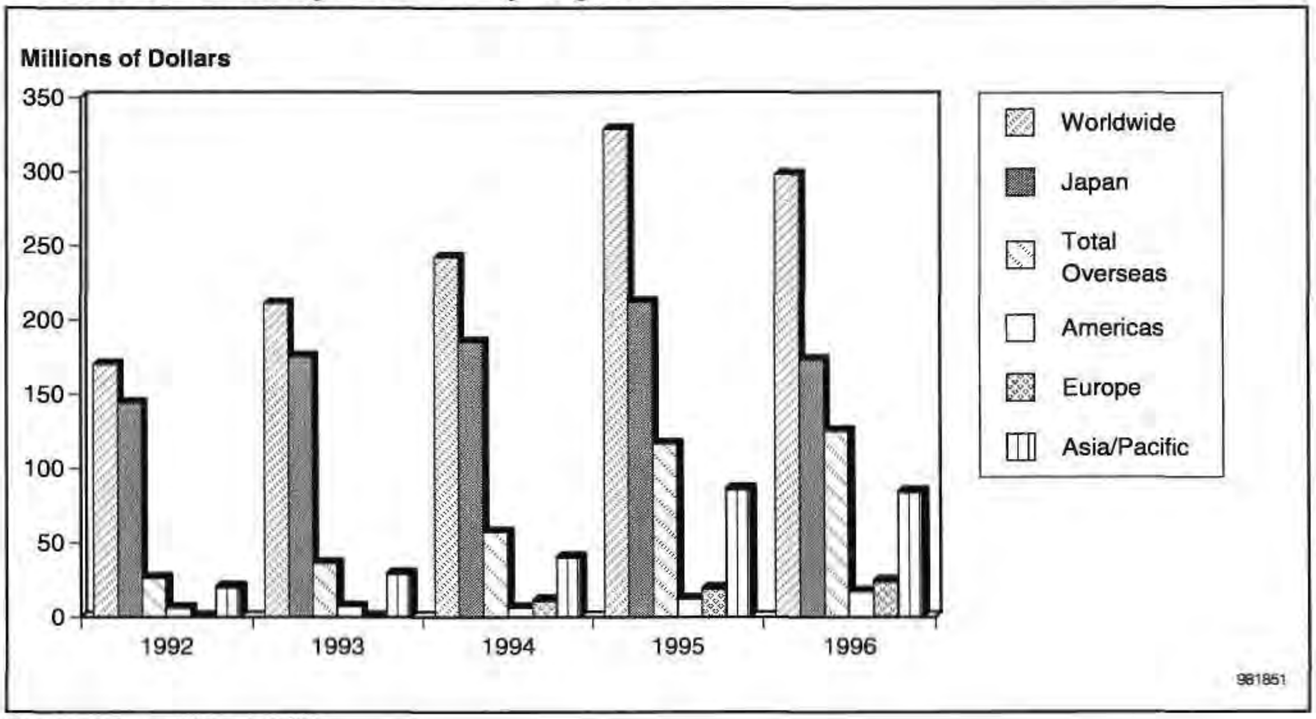
Source: Dataquest (March 1998)

Figure A-82
Shindengen Electric's Share of the Japanese Market by Product



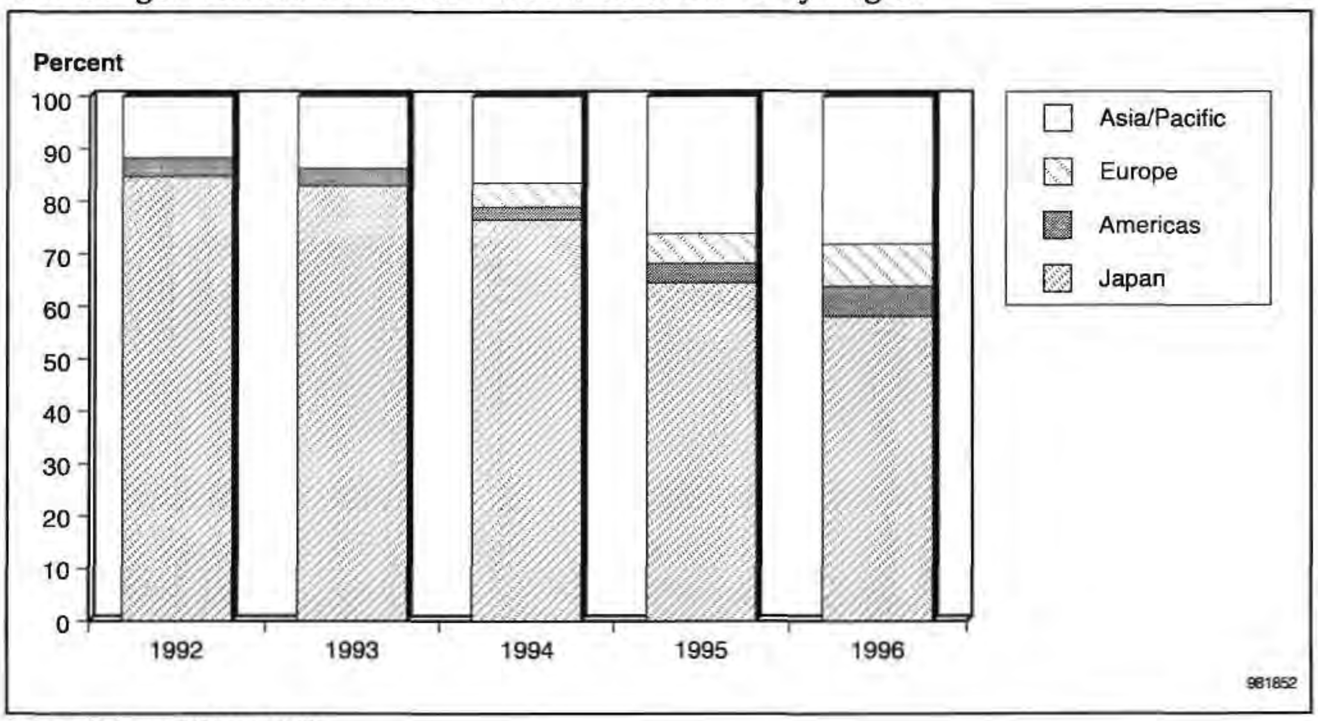
Source: Dataquest (March 1998)

Figure A-83
Revenue of Shindengen Electric by Region



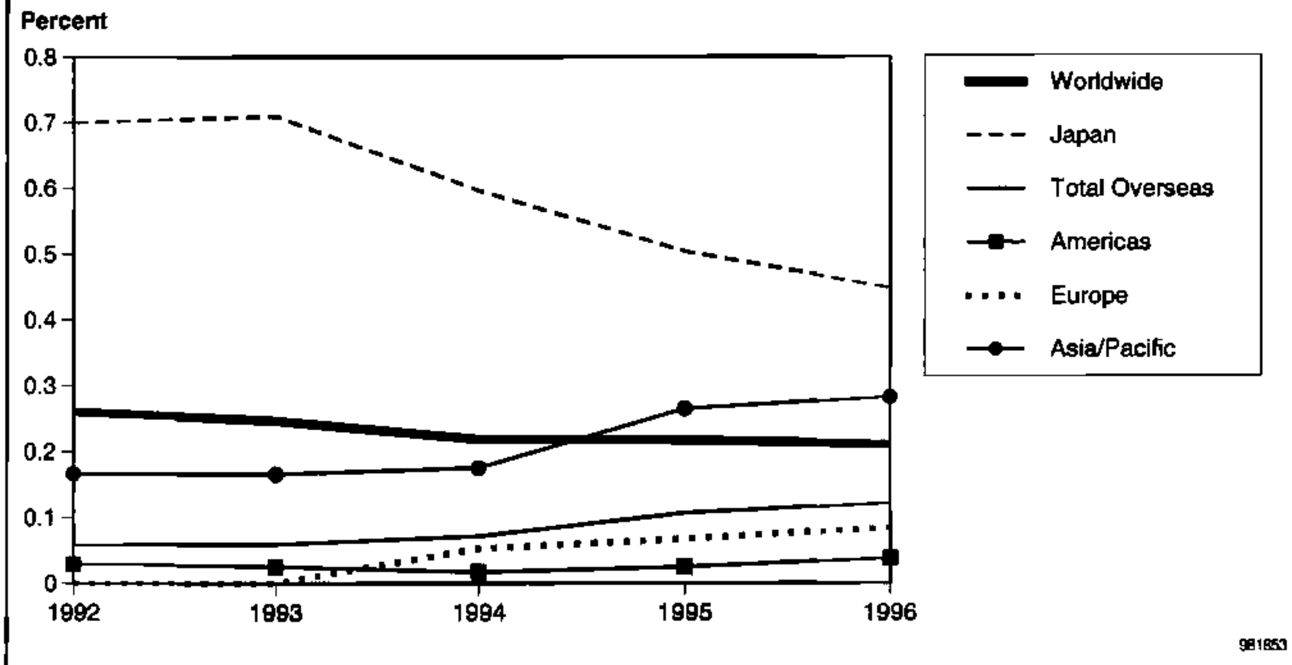
Source: Dataquest (March 1998)

Figure A-84
Shindengen Electric's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-85
Shindengen Electric's Market Share by Region



Source: Dataquest (March 1998)

Table A-18
Revenue of Sony by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	33	36	41	41	65
Bipolar Digital	1	0	0	0	0
MOS Memory	197	287	387	489	330
MOS Microcomponent	73	112	194	233	189
MOS Logic	165	213	426	581	531
Monolithic Analog	339	425	465	554	452
Discrete	79	89	50	53	43
Optical Semiconductor	216	236	313	382	373

Source: Dataquest (March 1998)

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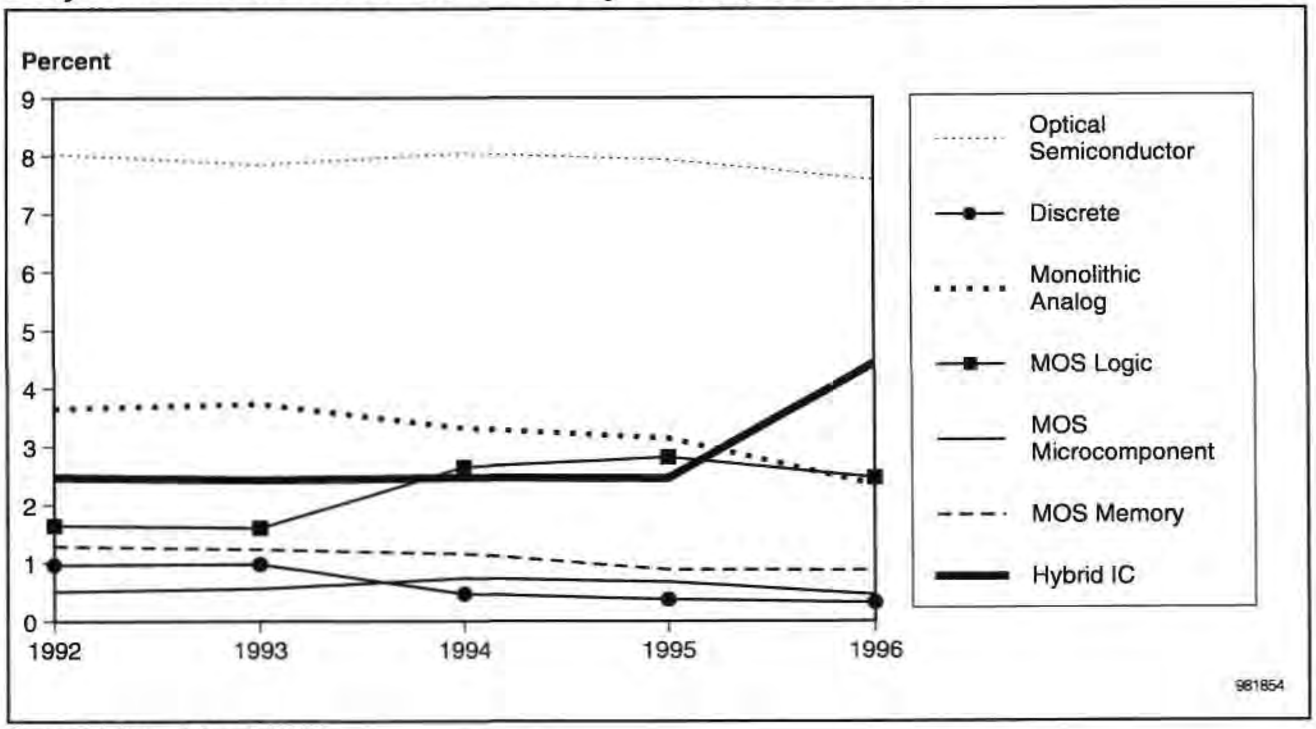
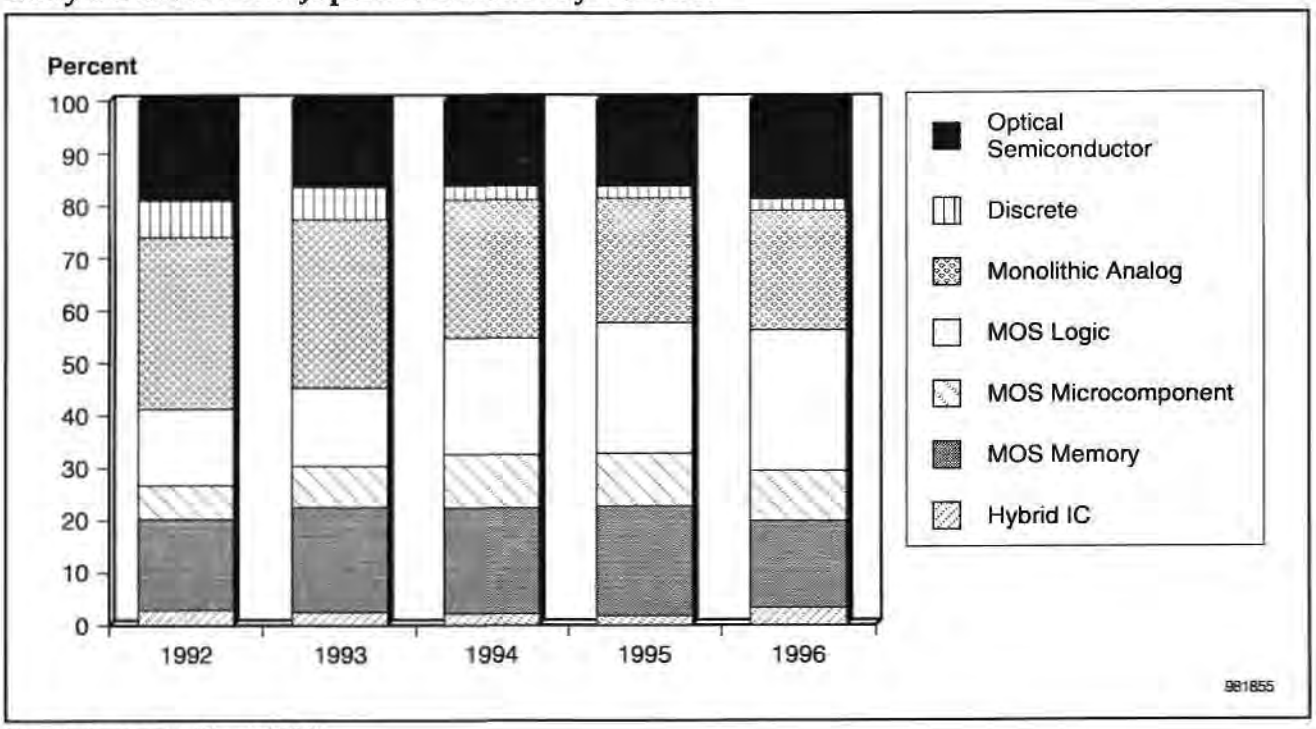
Figure A-86
Sony's Share of the Worldwide Market by Product, 1992 to 1996



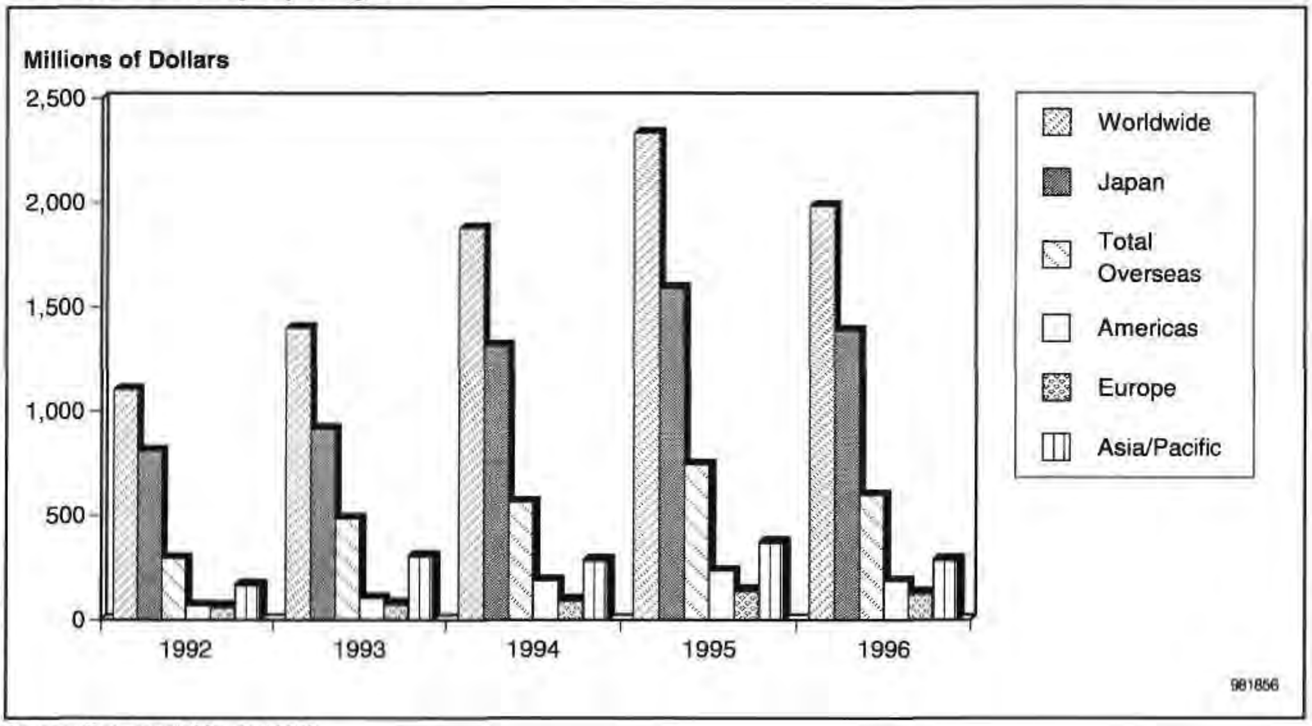
Source: Dataquest (March 1998)

Figure A-87
Sony's Share of the Japanese Market by Product



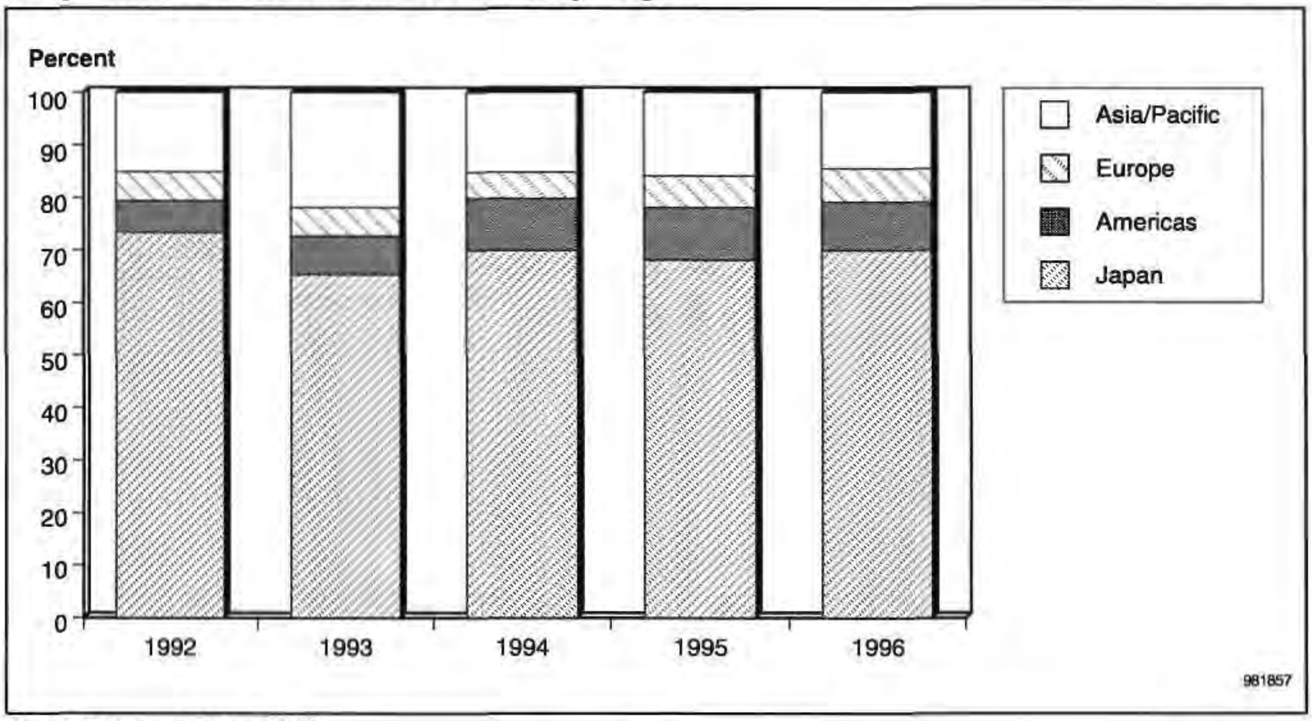
Source: Dataquest (March 1998)

Figure A-88
Revenue of Sony by Region



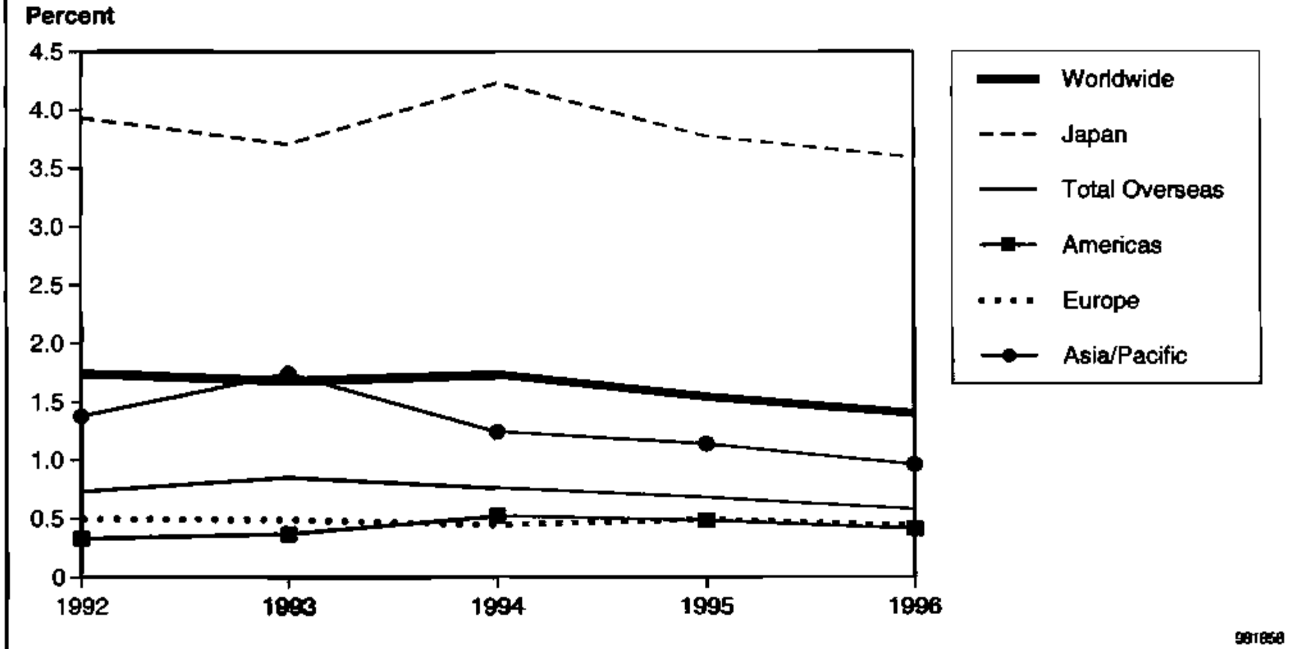
Source: Dataquest (March 1998)

Figure A-89
Sony's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-90
Sony's Market Share by Region



Source: Dataquest (March 1998)

Table A-19
Revenue of Toko by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	8	8	8	8	8
Bipolar Digital	0	0	0	0	0
MOS Memory	0	0	0	0	0
MOS Microcomponent	0	0	0	0	0
MOS Logic	0	0	0	0	0
Monolithic Analog	22	28	32	37	31
Discrete	29	45	51	68	55
Optical Semiconductor	0	0	0	0	0

Source: Dataquest (March 1998)

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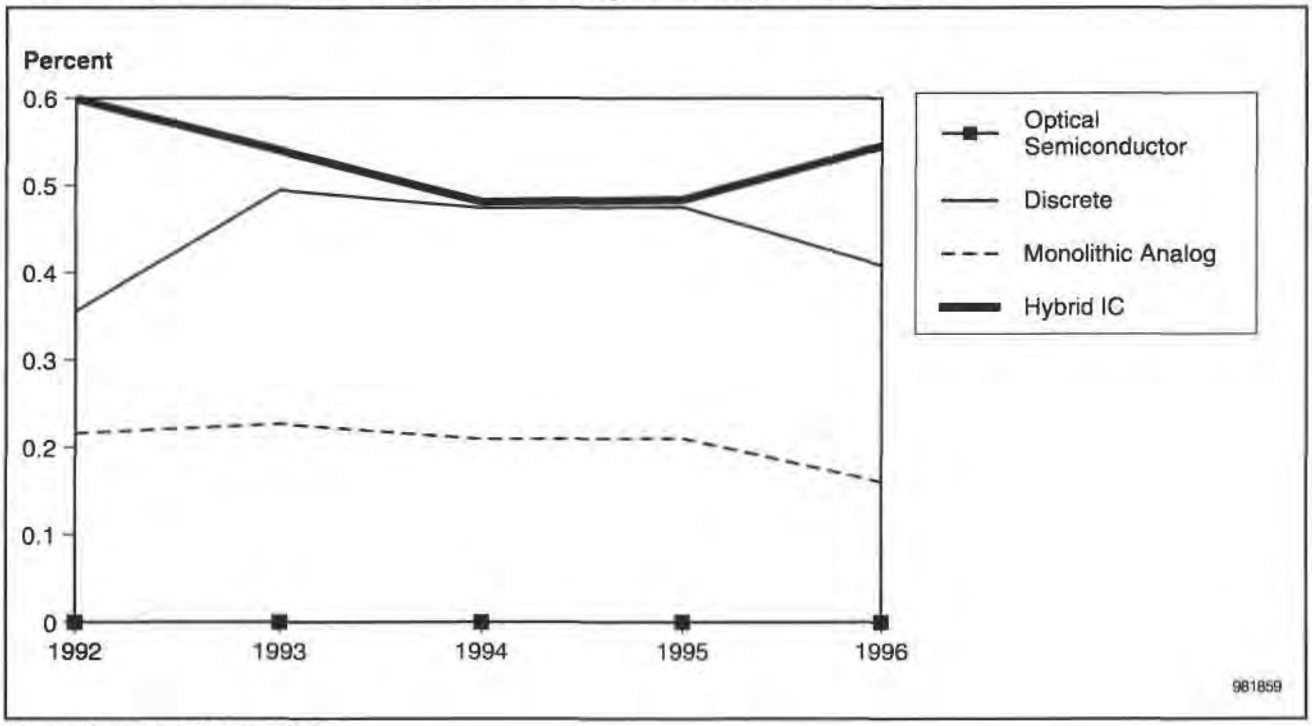
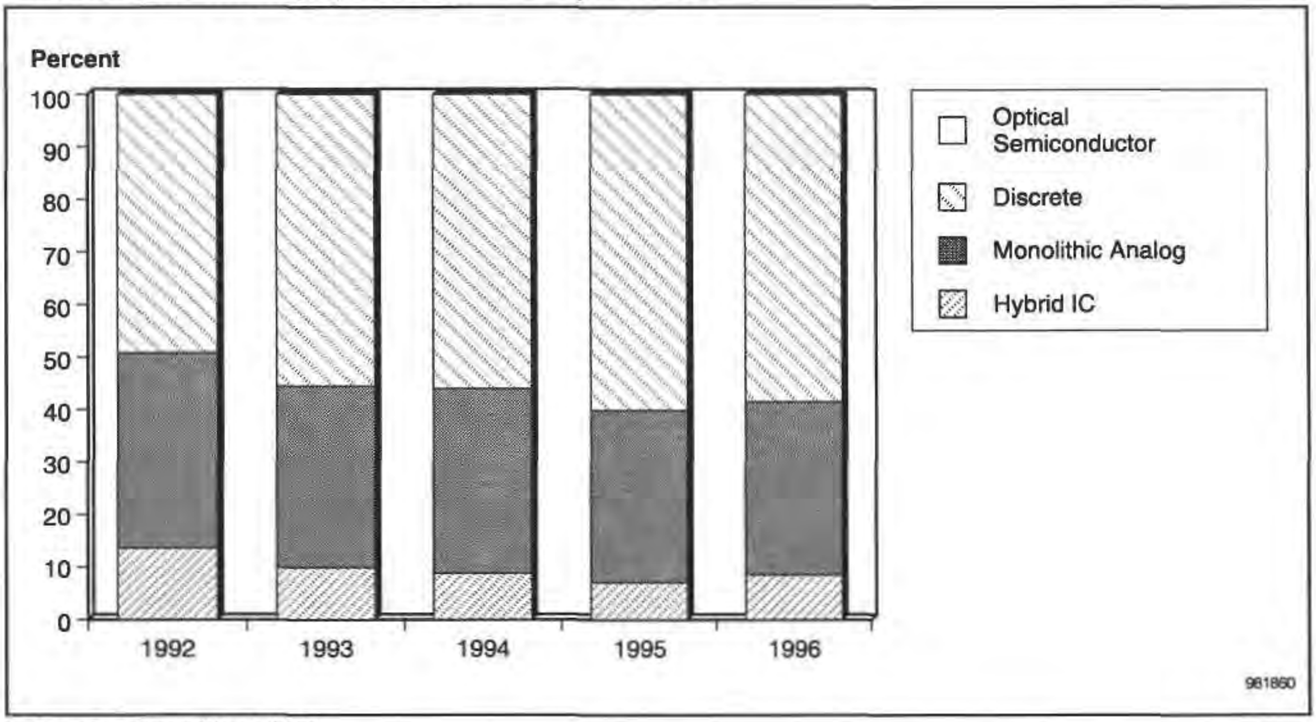
Figure A-91
Toko's Share of the Worldwide Market by Product, 1992 to 1996



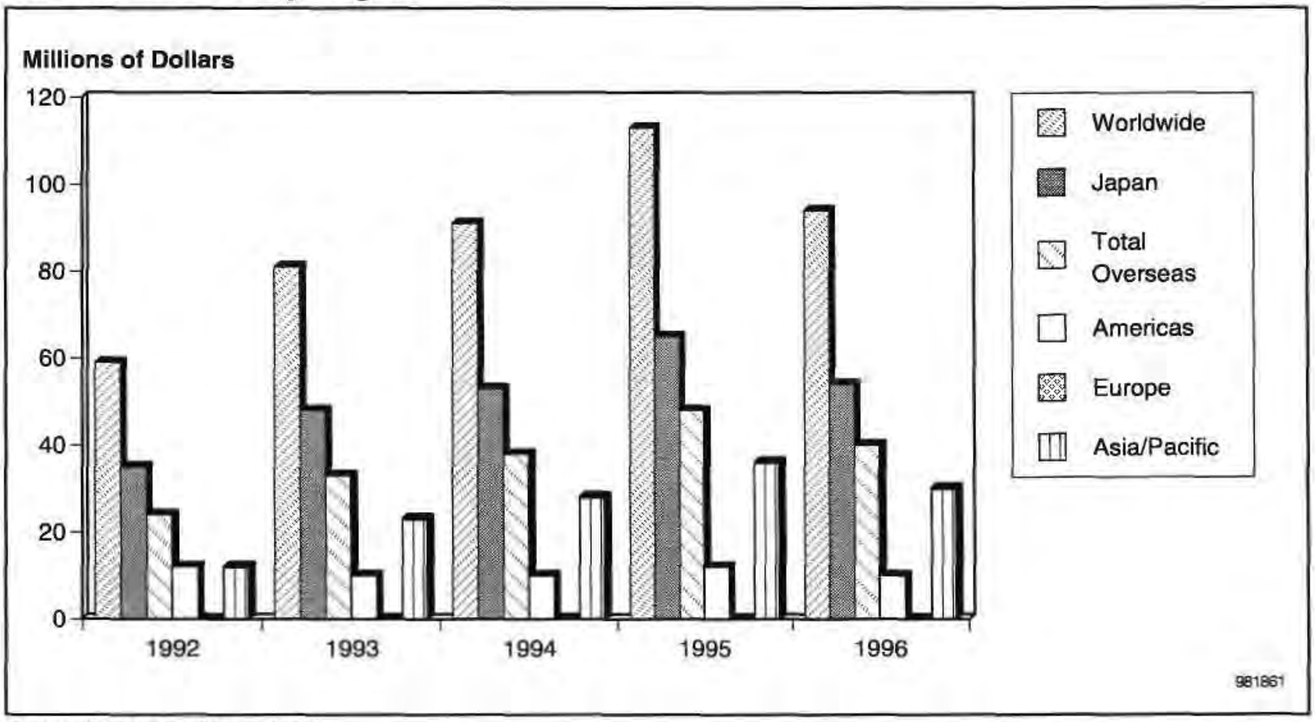
Source: Dataquest (March 1998)

Figure A-92
Toko's Share of the Japanese Market by Product



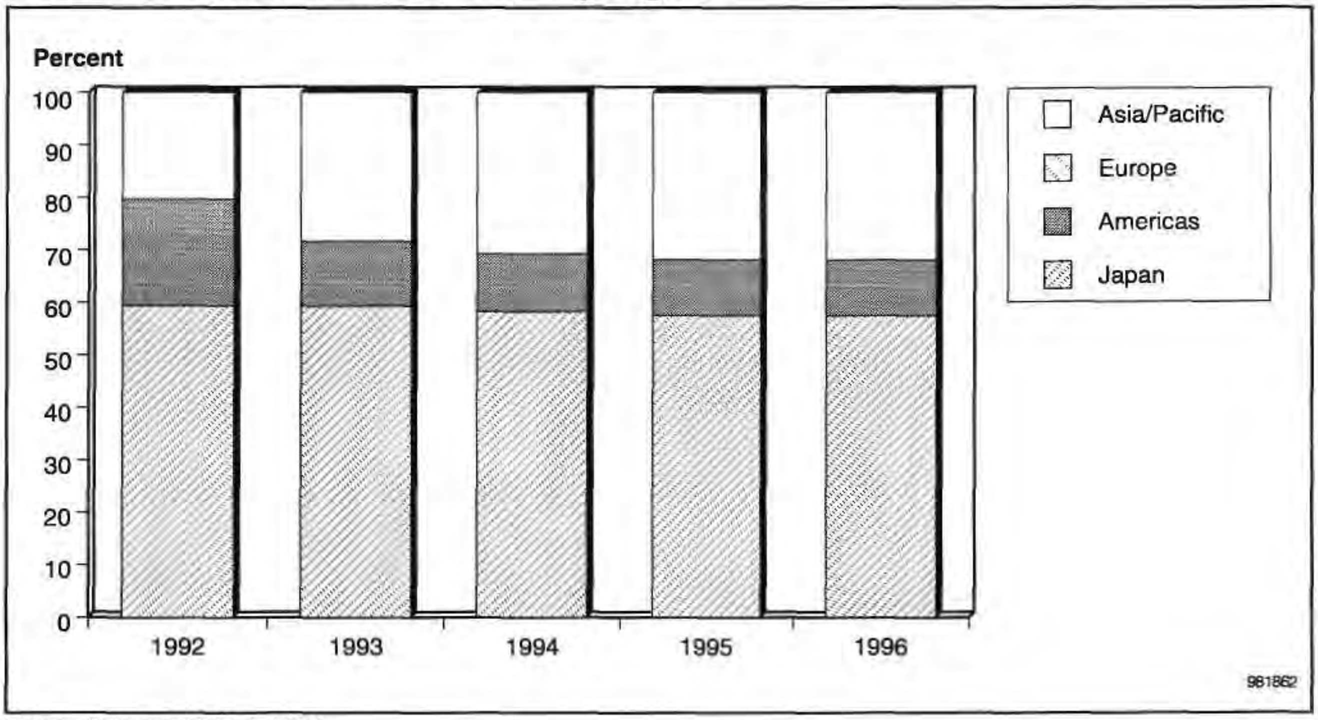
Source: Dataquest (March 1998)

Figure A-93
Revenue of Toko by Region



Source: Dataquest (March 1998)

Figure A-94
Toko's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

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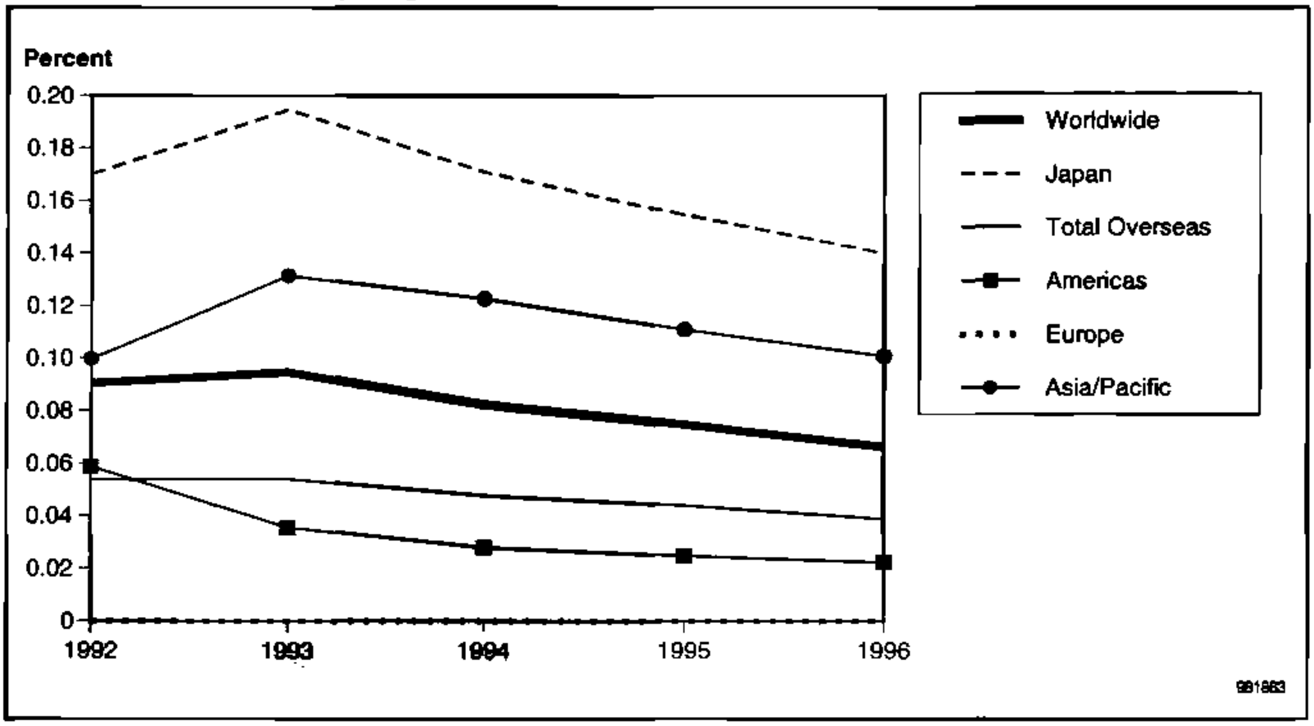
Figure A-95
Toko's Market Share by Region



Source: Dataquest (March 1998)

Table A-20
Revenue of Toshiba by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	53	58	59	74	36
Bipolar Digital	77	75	68	116	73
MOS Memory	1,618	2,101	3,018	4,264	2,513
MOS Microcomponent	440	540	718	1,094	1,197
MOS Logic	821	995	1,279	1,562	1,476
Monolithic Analog	528	615	789	915	909
Discrete	883	1,017	1,204	1,428	1,390
Optical Semiconductor	255	326	421	623	471

Source: Dataquest (March 1998)

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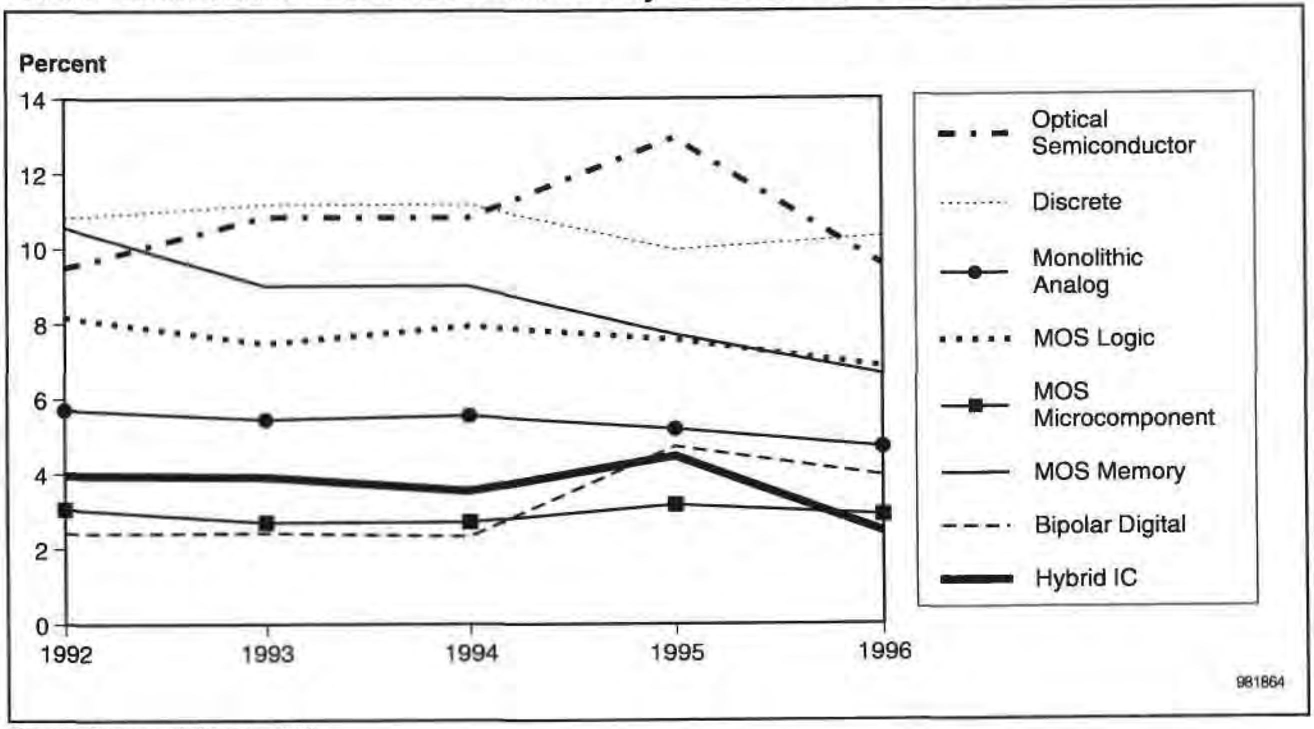
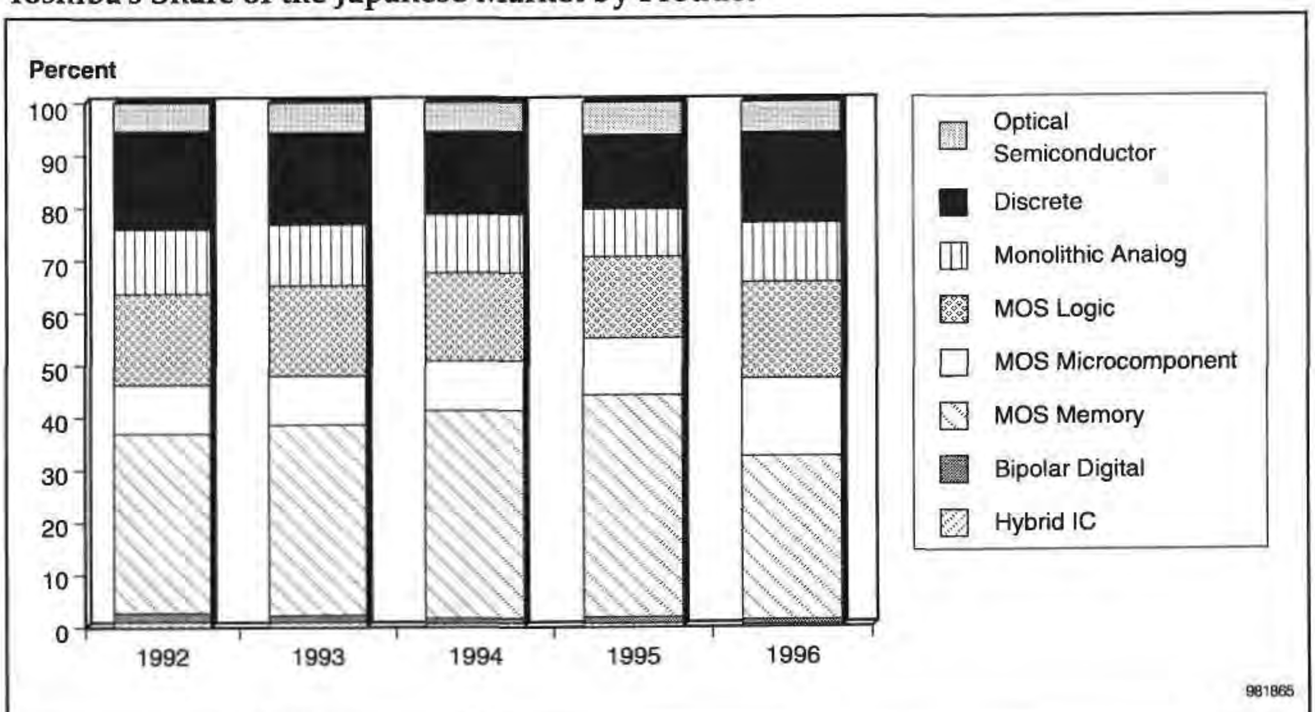
Figure A-96
Toshiba's Share of the Worldwide Market by Product, 1992 to 1996



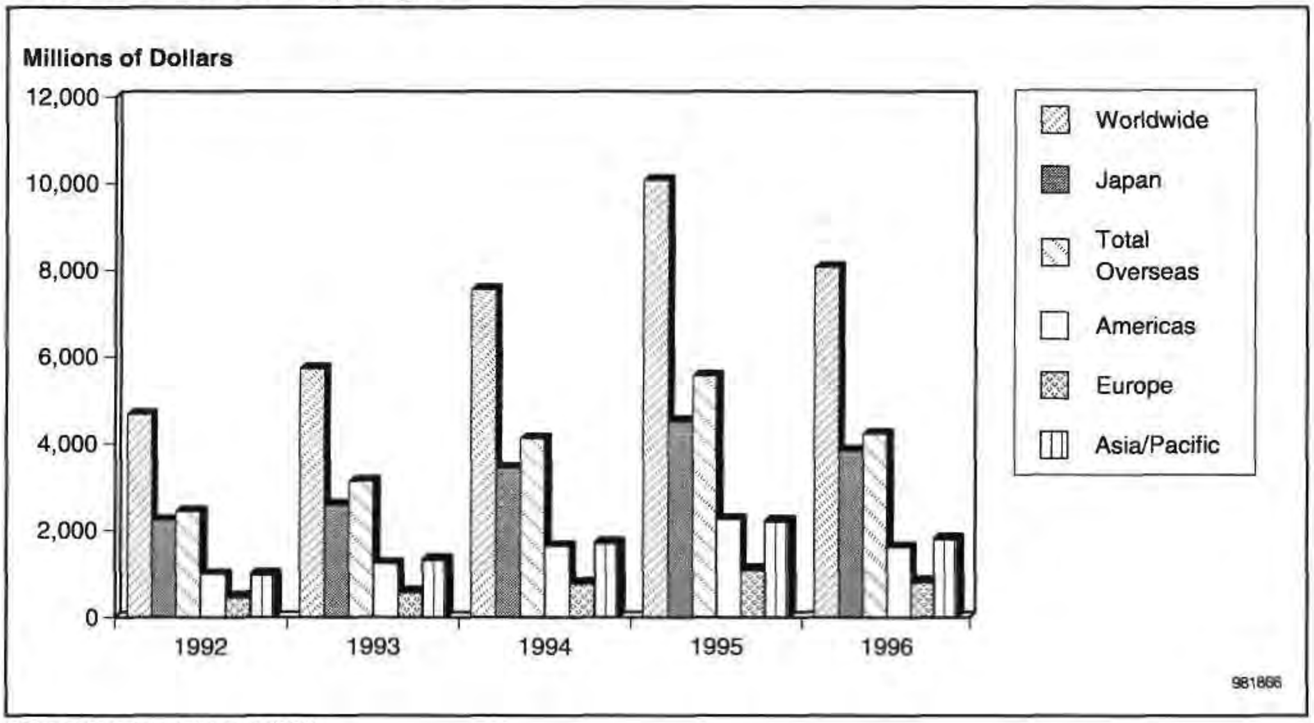
Source: Dataquest (March 1998)

Figure A-97
Toshiba's Share of the Japanese Market by Product



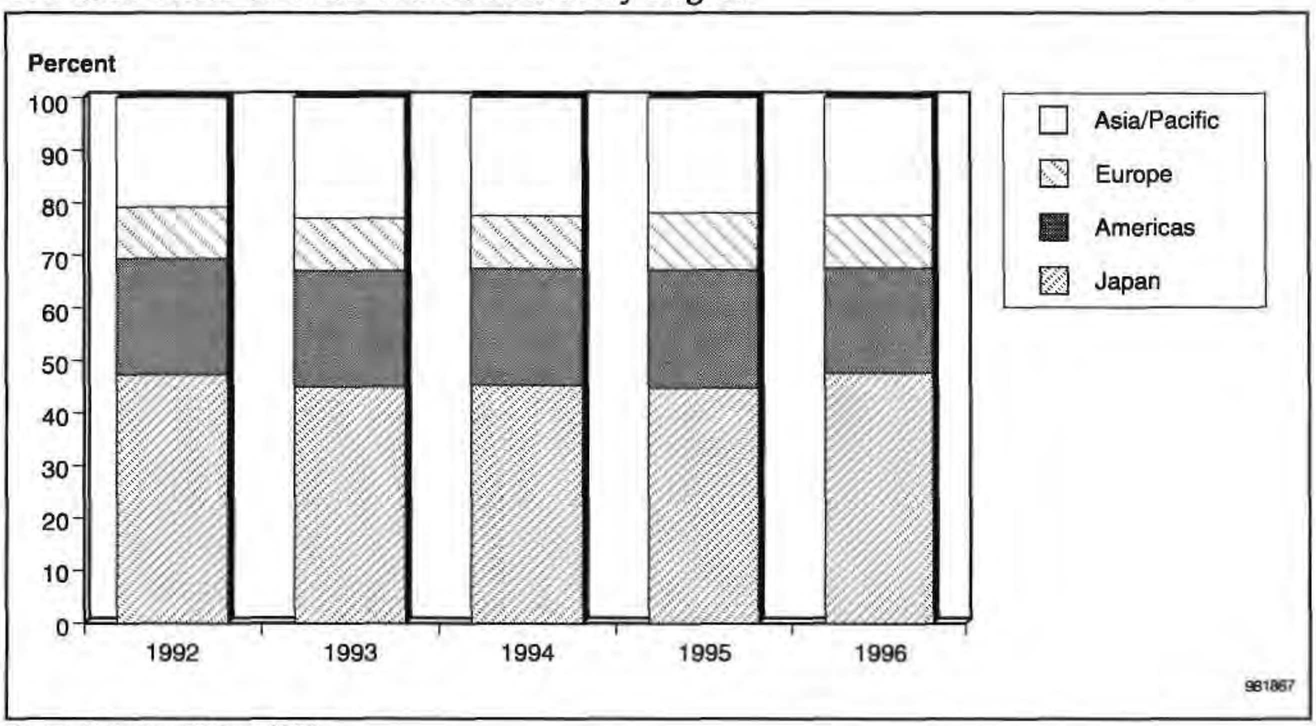
Source: Dataquest (March 1998)

Figure A-98
Revenue of Toshiba by Region



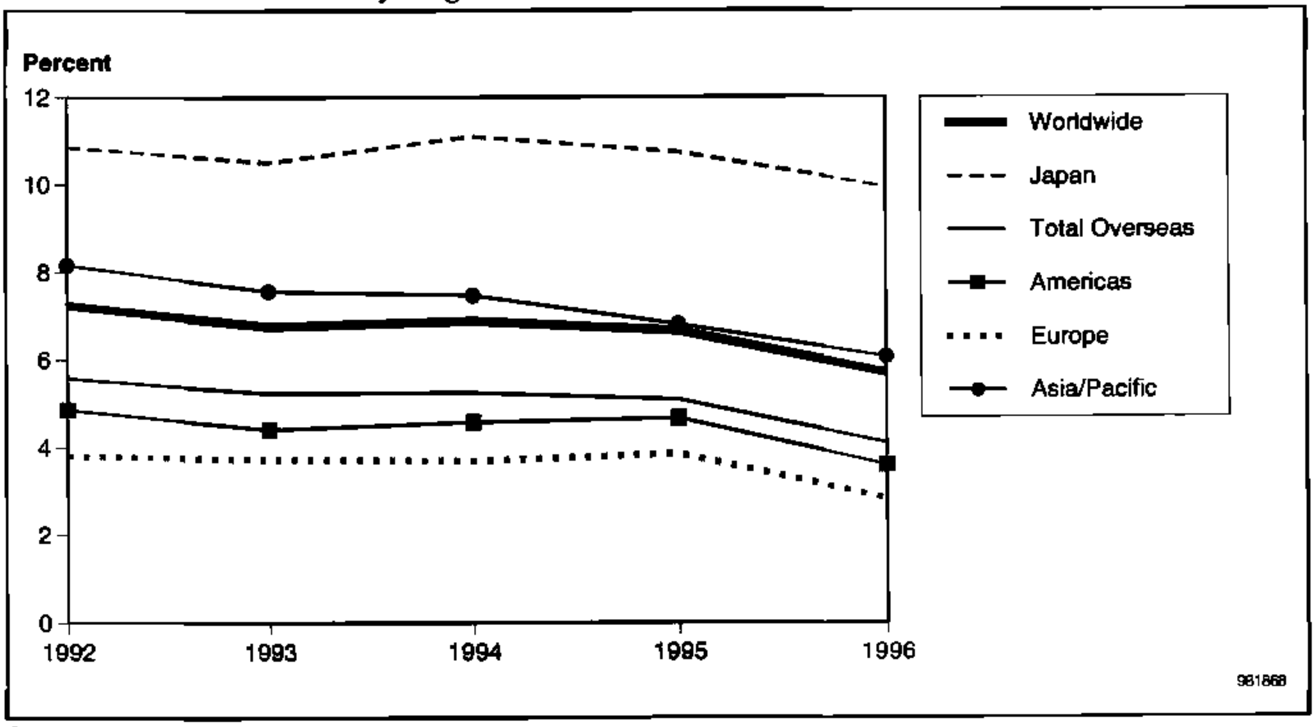
Source: Dataquest (March 1998)

Figure A-99
Toshiba's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-100
Toshiba's Market Share by Region



Source: Dataquest (March 1998)

Table A-21
Revenue of Yamaha by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	0	0	0	0	0
Bipolar Digital	0	0	0	0	0
MOS Memory	1	1	1	1	1
MOS Microcomponent	0	149	273	245	107
MOS Logic	189	154	89	170	181
Monolithic Analog	11	13	19	28	6
Discrete	0	0	0	0	0
Optical Semiconductor	0	0	0	0	0

Source: Dataquest (March 1998)

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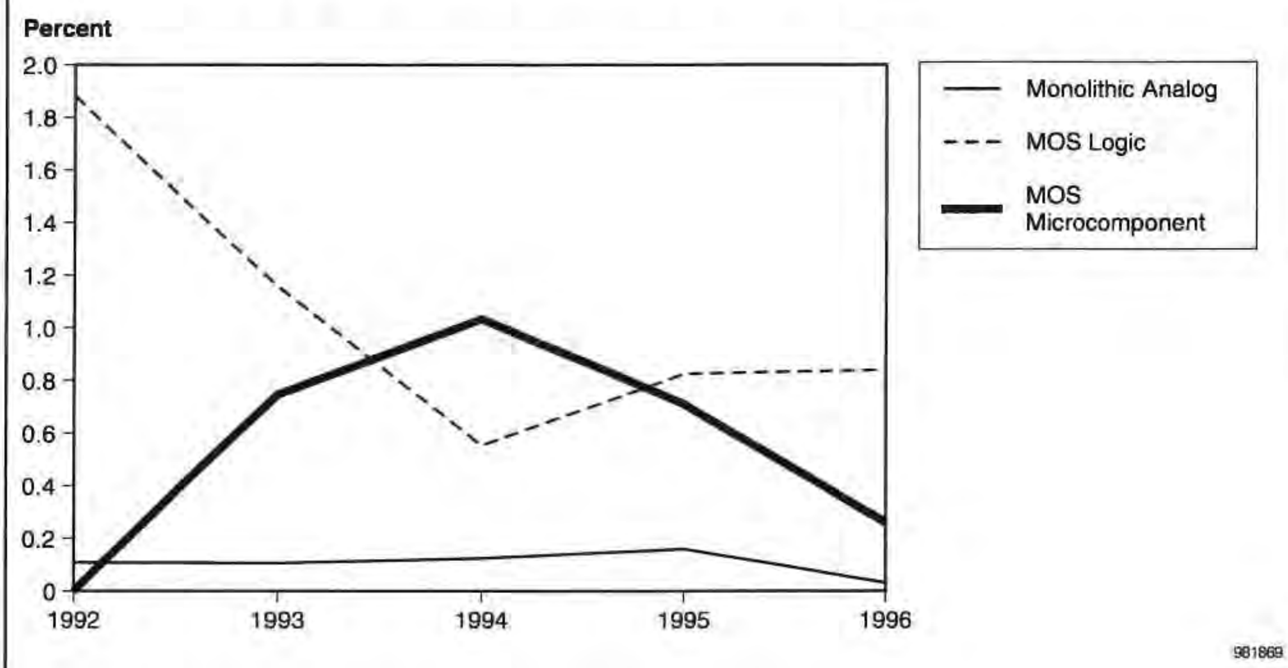
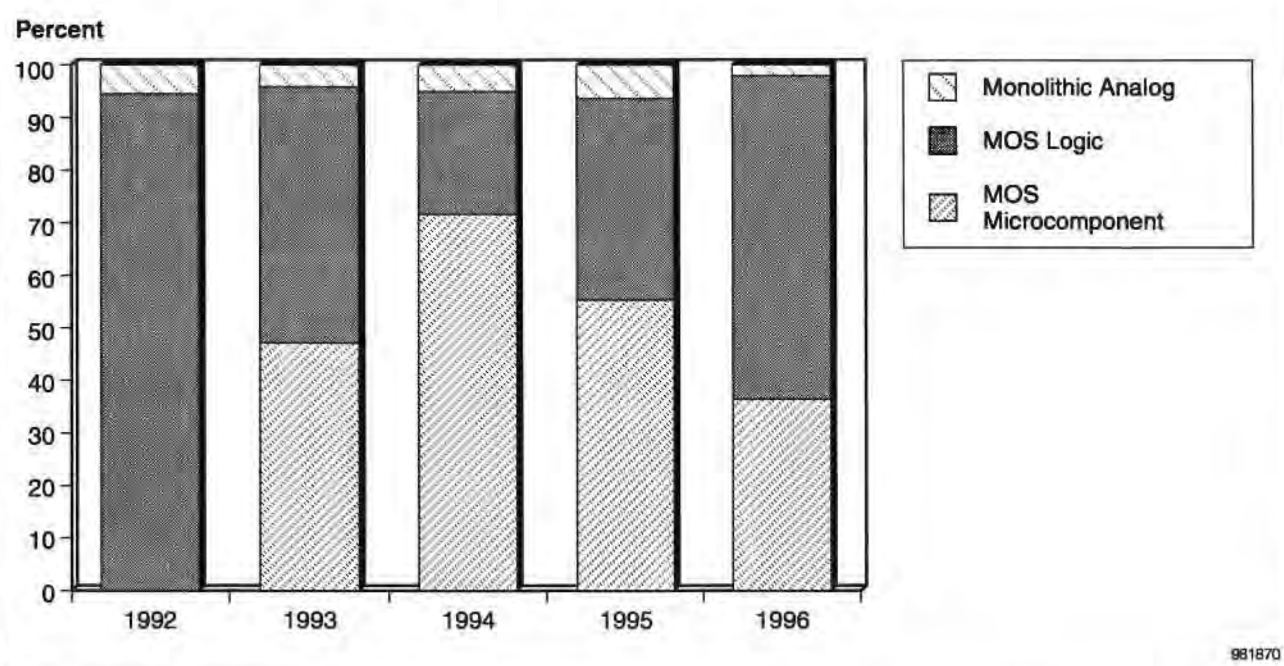
Figure A-101
Yamaha's Share of the Worldwide Market by Product, 1992 to 1996



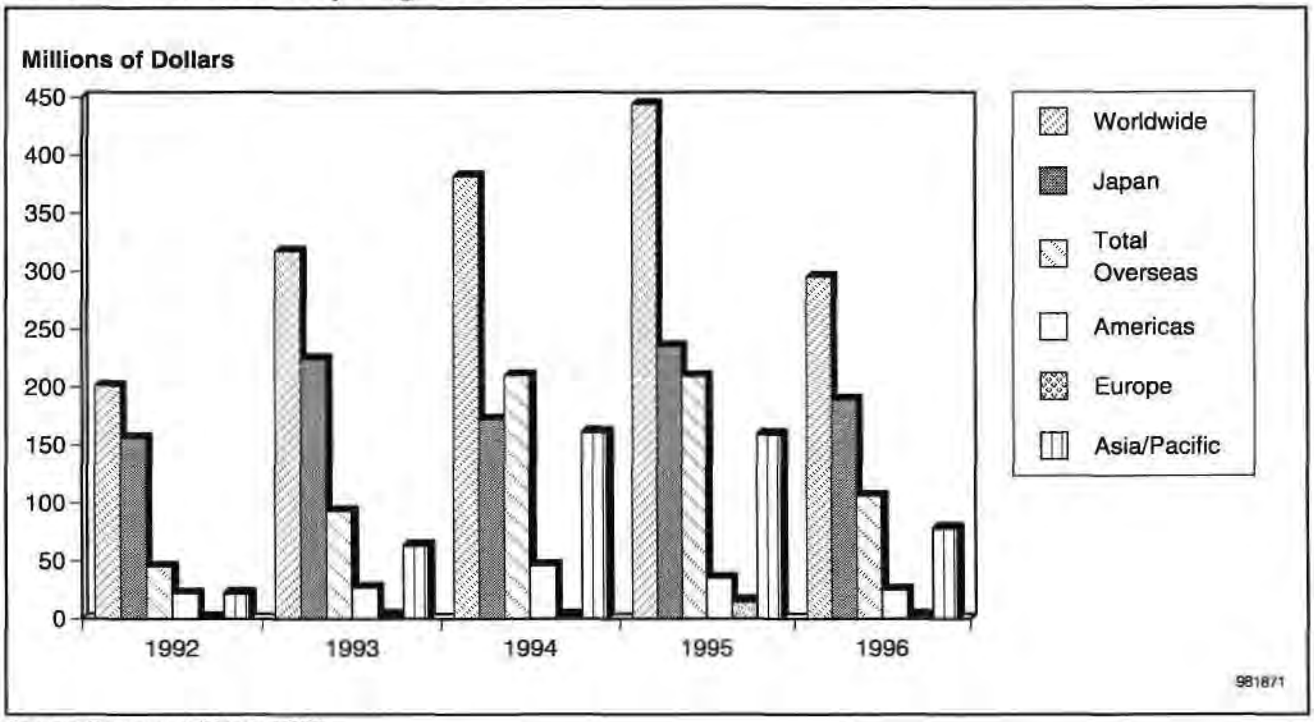
Source: Dataquest (March 1998)

Figure A-102
Yamaha's Share of the Japanese Market by Product



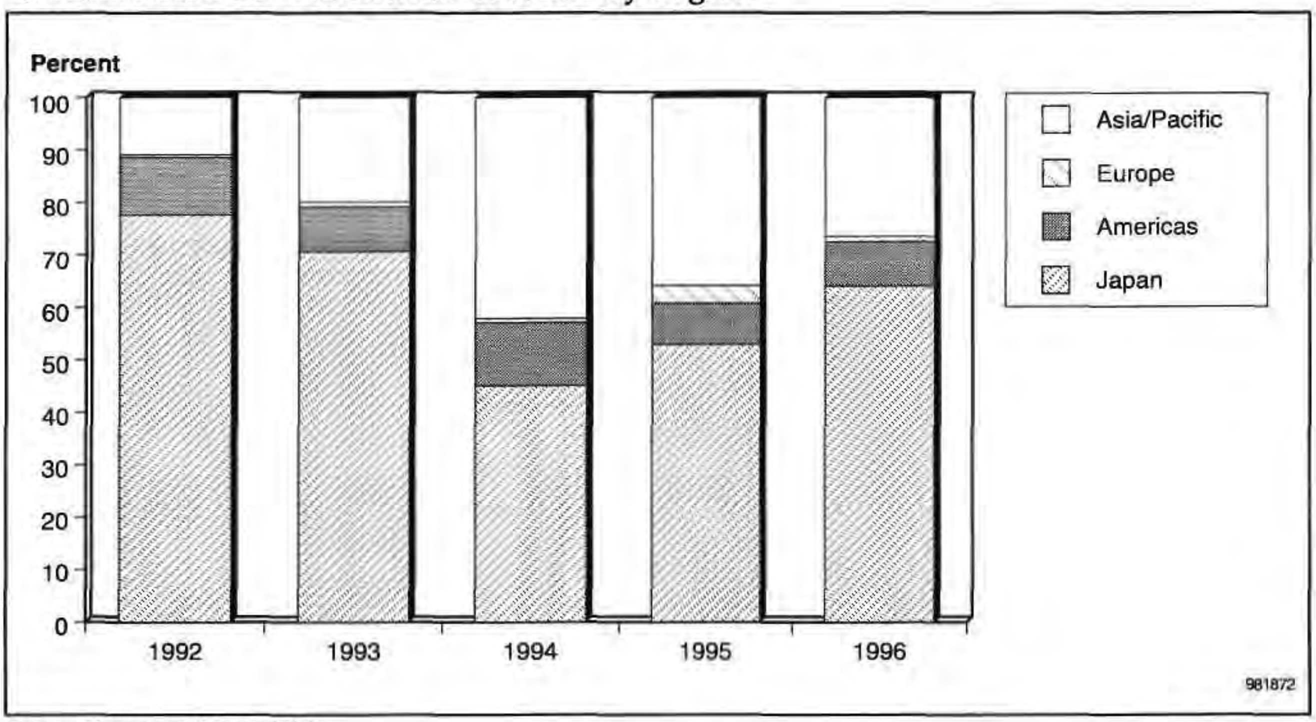
Source: Dataquest (March 1998)

Figure A-103
Revenue of Yamaha by Region



Source: Dataquest (March 1998)

Figure A-104
Yamaha's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

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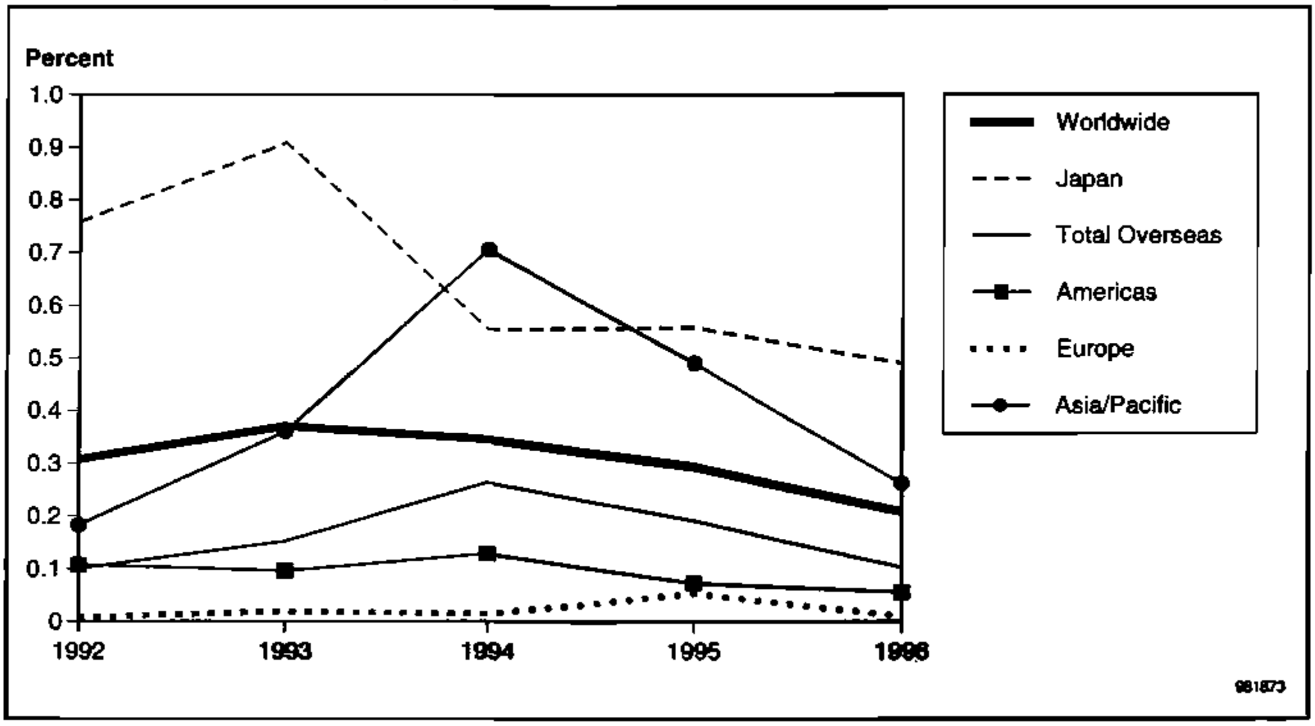
Figure A-105
Yamaha's Market Share by Region



Source: Dataquest (March 1998)

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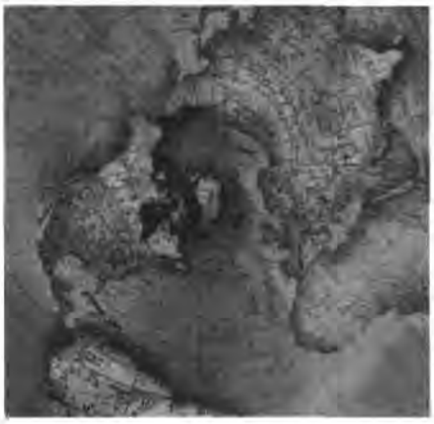

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1997 Semiconductor Strategic Alliances: Japanese Companies

Focus Report

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Product Code: SEMI-JA-FR-9801
Publication Date: April 6, 1998
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1997 Semiconductor Strategic Alliances: Japanese Companies

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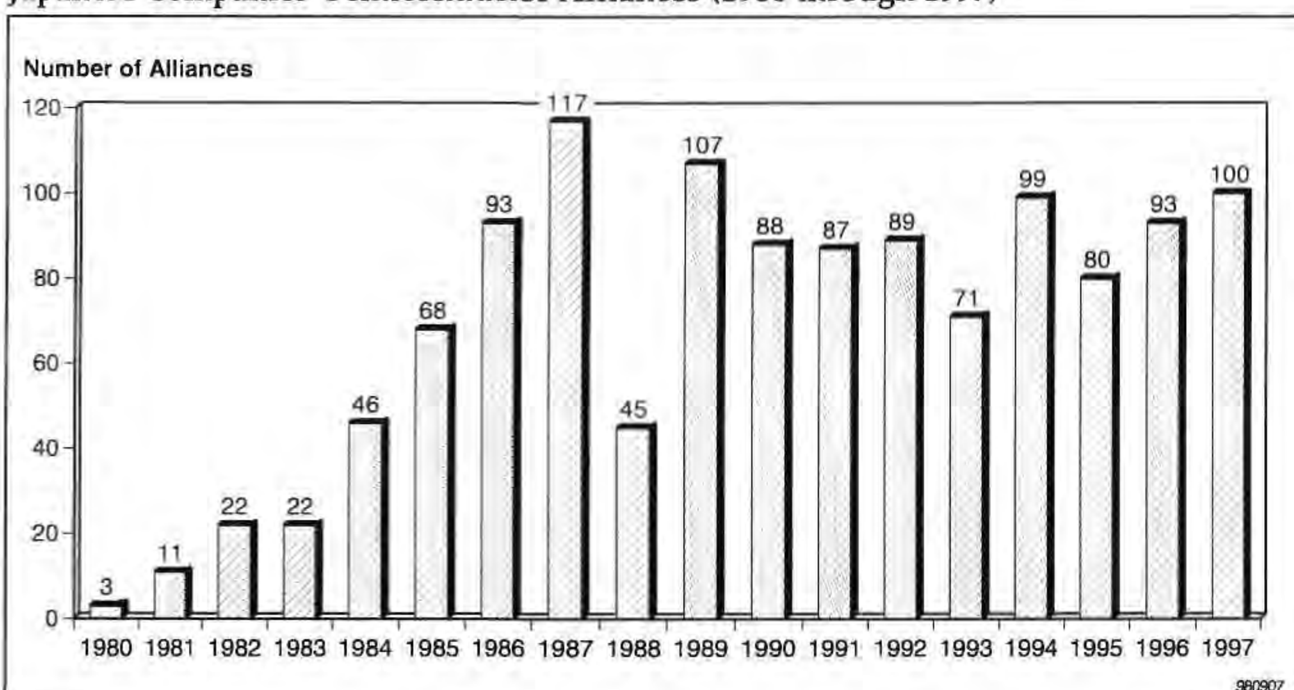
Chapter 1
Executive Summary

Despite continued economic troubles in Japan and elsewhere in Asia, Japanese vendors still engaged in a relatively high number of semiconductor-related alliances in 1997. For the second year in a row, the number of Japanese semiconductor-related alliances rose. Figure 1-1 illustrates the Japanese semiconductor alliance rate from 1980 through 1997.

There are growing indications from alliance activity in 1997 that Japanese vendors are banking on the market success of merged logic-DRAM technology as the future mainstay of their semiconductor businesses. The timing of a transition from a DRAM-centric to an embedded DRAM-centric strategy is significant, because a miscalculation by Japanese vendors could cause them to lose ground in the development of next-generation commodity DRAMs while they divert resources toward the development of embedded DRAM products. The possible gains, however, are significant because the technology has the potential to increase market share in the application-specific IC (ASIC) and logic businesses, a goal that most Japanese vendors have targeted for several years. Alliances not only will allow Japanese vendors to redistribute their resources from a DRAM to an embedded DRAM production orientation, which would effectively merge their now separate memory and logic businesses into a single unit, but they might also provide a fast-response safety net in case the companies' projected time line is off and they need to retreat to a more conservative strategy. If the embedded DRAM technology, for whatever reason, fails to mature before commodity DRAMs return to a supply-limited market, alliances will almost certainly be used as a mechanism for Japanese companies to get back into the commodity DRAM business.

Project Analyst: Junko Matsubara

Figure 1-1
Japanese Companies' Semiconductor Alliances (1980 through 1997)



Source: Dataquest (March 1998)

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Chapter 2
Diversification and Resource Allocation with Alliances

Many parts of the electronics industry were showing signs of weakness as 1997 came to a close. DRAM production lines were either being shut down or had their expansion plans delayed. Semiconductor fabrication equipment manufacturers experienced order cancellations that eventually led to layoffs of substantial portions of their workforces. Even application vendors, such as disk drive producers, were experiencing market pressures that have resulted in corporate restructuring. While the economic crisis in many parts of Asia, particularly Korea, has forced a change in the semiconductor business practices at companies in these countries and will undoubtedly have a ripple effect on electronics companies worldwide, Japan's economy has, for several years, remained in a state bordering on recession. Despite the weak economic condition of Japan, its domestic PC markets were expected to continue the growth trend that had been established during the previous year. During 1996, PC prices had fallen to world market levels, which caused a growth spurt in PC sales. However, by mid-1997, sales had flattened even though DRAM prices continued to fall, lower-priced machines had been introduced into the Japanese market, and PCs had far less penetration in the Japanese home market than in the United States.

The economic crisis that was beginning to affect many Asian countries in the last quarter of 1997 does not seem to have had much impact on the overall number of alliances that Japanese companies signed in specific countries or regions in the past two years. Nearly 60 percent of the Japan's semiconductor alliances formed in 1997 were with U.S.-based partners. This level is more or less unchanged from 1996 and reflects the continued importance that Japanese vendors place on partnerships with American companies. Figure 2-1 shows the percentage of the alliances that pair a Japanese company with a U.S.-based company over the last 13 years.

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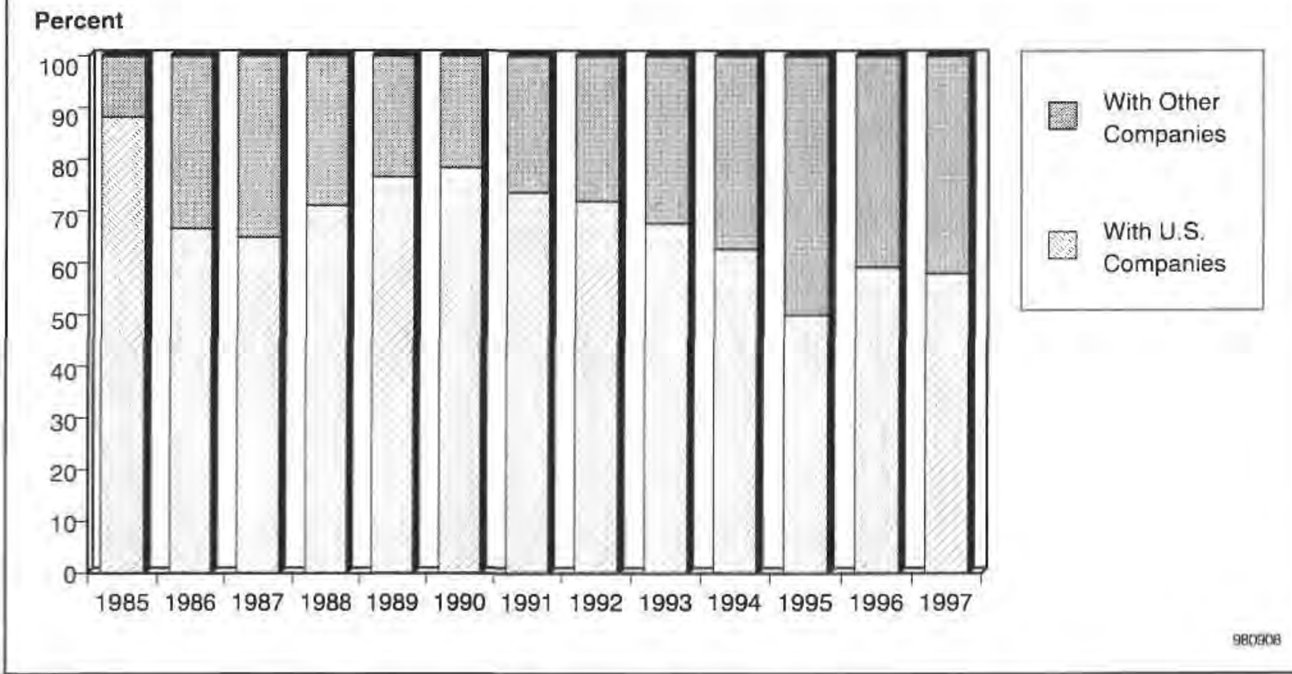
Figure 2-1
Japanese Semiconductor Alliances (U.S. Partners versus Non-U.S. Partners)



Source: Dataquest (March 1998)

DRAMs and 300mm Equipment

In 1997, Japanese vendors continued their quest to diversify away from their traditional overdependence on DRAM revenue. However, in implementing diversification plans, there are often conflicting goals that require a delicate balance of priorities in business strategy, particularly with regard to alliances. A transition to 300mm wafer production is clearly a long-term technology change that all major Japanese vendors will seek to make to remain cost competitive, but it will be difficult to justify the necessary investment in the face of a money-losing DRAM business. Furthermore, most vendors will need to secure permanent sources of commodity DRAMs for both internal consumption and to maintain their semiconductor sales organizations. The difficulty of achieving these goals increased during the year as DRAM prices continued to fall in an oversupplied market. The mass transition to 300mm production technology will occur eventually, but the weak DRAM market will likely delay or slow the adoption rate, because the large-scale equipment consumption of the commodity DRAM manufacturers will be a prerequisite to reducing the cost of 300mm equipment and make it affordable to the majority of logic and ASIC producers. For this reason, commodity DRAM alliances will likely continue with specific emphasis on 300mm equipment development. On the other hand, if DRAMs do not return to profitability before deployment of embedded DRAM products that can generate self-sustaining revenue, then a company could justify minimizing its DRAM-specific investments, farm out commodity DRAM production, and focus resources on building and accelerating its embedded DRAM capabilities. Alliances seem to provide a lot of flexibility for companies to distribute their resources to match their particular array of priorities.

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Alliances Send DRAM Production to Partners

Four alliances explicitly involving commodity DRAM occurred in 1997, but almost all can be interpreted within the context of a strategy that diversifies away from an emphasis on the commodity DRAM business (see Table 2-1). This has generally meant developing 300mm technology in joint ventures or licensing DRAM production technology to foreign-based companies, of which the Japanese company may hold a minority stake, in order to secure production output. As an example of transferring DRAM production to foreign companies, Toshiba Corporation agreed in February 1997 to purchase 20 percent of the Austin, Texas-based 64Mb DRAM facility of Samsung Electronics Company Ltd., allowing OEM procurement for Toshiba of 20 percent of the production output. In September 1997, Toshiba also provided Taiwan-based Winbond Electronics Corporation with DRAM production technology, which will secure a supply of both 64Mb and 256Mb from the Taiwan-based facility. Finally, in October 1997, Mitsubishi Electric Corporation agreed to provide Seiko Epson Corporation with 64Mb production technology. Mitsubishi will initially purchase all the production output of Seiko Epson's Sakata plant. Earlier, in May 1997, Mitsubishi had licensed Seiko Epson to produce video memory, also to be built at the Sakata plant, that would integrate 10Mb of DRAM with 2Kb of SRAM and graphics interface logic. All these alliances are consistent with a strategy of diversifying resources away from commodity DRAMs.

The only major joint venture of 1997 involving DRAMs was signed in February by Hitachi Ltd., Mitsubishi, and Texas Instruments Inc. and specified that the partners would jointly develop 1Gb DRAMs. However, this project was put on hold in February 1998. Although the partners have specified that they will resume joint development of 1Gb DRAM in one year, the future of this project will probably depend on the market outlook in 1999.

Table 2-1
DRAM and Next-Generation Wafer/Production Alliances

File Number	Company 1	Company 2	Product	Date
9	Fujitsu	Advantest	Advanced electron beam exposure system	February
23	Hitachi /Mitsubishi	Texas Instruments	1Gb DRAM	February
85	Toshiba	Samsung	64Mb DRAMs	February
82	Tokyo Seimitsu	Super Silicon Institutes	400mm-wafer wire saw	March
66	Sankyo Engineering	Sugai	Wet-type cleaning system for 300mm wafers	April
54	NEC	Samsung	300mm wafer production	July
94	Toshiba	IBM	300mm wafer production	July
34	Lapmaster SFT	Super Silicon Crystal Research	CMP machine for 400mm wafers	August
95	Toshiba	Winbond	64Mb, 256Mb DRAMs	September
70	Seiko Epson	Mitsubishi	64Mb DRAM design, technology	October

Source: Dataquest (March 1998)

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When Will 300mm Standardization Arrive?

Several other alliances made in 1997 address 300mm technology development.

Toshiba and IBM will cooperate in commercializing 300mm production, and will possibly set up a 300mm line at their joint production plant. Similarly, NEC Corporation and Samsung have agreed to share development of 300mm wafer fabrication equipment and technology across their memory plants. Both alliances are expected to have operational 300mm wafer production lines up and running by 1999. The oversupply of DRAMs, along with weak Asian currencies and economies, are contributing to very tentative ramp-ups of Japanese, Korean, and Taiwanese next-generation DRAM and 300mm wafer facilities. However, although no company has voiced concern, it seems that, if Japanese companies intend to focus their semiconductor businesses on embedded DRAM products, then they would not want any delay in the arrival of next-generation DRAM capabilities that would impede the transition to the next level of embedded DRAM products. This, of course, assumes there exists a next-level single-chip device or application that can use the higher amounts of DRAM, and presumably faster logic, provided by the next-generation merged processes. The applications that will drive the adoption of next-generation embedded DRAM products are not clear, but there are a few candidates, as described in the following sections. This uncertainty is a looming factor in the decision process that will dictate how Japanese vendors structure their alliance activities.

From DRAMs to Embedded DRAMs: How Fast Can We Get There?

There are skeptics, including individuals representing companies such as Intel Corporation, who have voiced their conviction that embedded DRAM technology will never become a mainstream technology. The basis of their argument is that the logic and memory processes of the future are incompatible. Nevertheless, if the critics are proven wrong, this would be somewhat ironic because Intel itself has essentially used its own processing expertise, including the use of BiCMOS, to counter the assault of RISC, with its inherent performance advantages, over the last few years. There have been many processing transitions over the years, such as NMOS to CMOS and bipolar to BiCMOS, and with each transition, there were always a few who either did not believe the new technology would ever become competitive or who miscalculated the timing of the transition. Today, there are enough companies that seem convinced that combining DRAM with fast logic is both feasible and an inevitable mainstream technology that one must consider the implications if these companies are correct. History has frequently proven that processing and circuit innovation has consistently surmounted the barriers they have encountered. The accuracy of Moore's law is a testament to the steady progress being made in integration capabilities. Table 2-2 lists the alliances occurring in 1997 that explicitly covered embedded DRAM technology. However, many of the other alliances of 1997, particularly those relating to RISC MPUs—described in a subsequent section—have also been extended to cover embedded DRAM technology. This is a logical extension of these alliances, since many RISC alliances involve the use of cores in ASIC libraries, which have recently been expanded to include embedded DRAM in addition to the usual RISC cores.

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Table 2-2
Embedded-Related Alliances

File Number	Company 1	Company 2	Product	Date
87	Toshiba	Sun Microsystems	Embedded Java processors	April
41	Mitsubishi	Seiko Epson	3-D video chips	May
90	Toshiba	NeoMagic	Embedded memory	May
91	Toshiba	Chartered Semiconductor	Embedded DRAM process technology	June
77	Sony	Oki Electric	System-on-a-chip	August
45	Mitsubishi	Powerchip Semiconductor	Embedded DRAM technology	November
57	NEC	Lucent Technologies	V-series RISC core	December

Source: Dataquest (March 1998)

Notebook Graphics Accelerators Still the Only Application for Embedded DRAM in 1997

In contrast to the splash that embedded DRAM alliances made in 1996, the alliance activity involving embedded DRAM technology in 1997 was very subdued. Part of the reason for this is that the graphic accelerator market, the initial market to capitalize on the benefits of embedded DRAM technology, had become overcrowded in 1997. Too many players meant steep drops in accelerator prices and shrinking market windows that resulted in some once high-flying start-ups dropping off the radar screen. With these conditions, it wasn't surprising that the shifts in the market diverted attention away from the progress being made on the merged logic-DRAM processing front. Moreover, falling graphics controller and accompanying memory prices may have also confined the embedded DRAM graphics controllers to the notebook segment only, where power efficiency is the primary selling point, and prevented migration to the desktop world, where the ratio of processing power to cost is usually the only criterion that determines market success.

Although only three or four alliances explicitly involving embedded DRAM technology were signed by Japanese companies in 1997, two of the 1997 alliances were inked by Toshiba. In June, Toshiba licensed its 0.35-micron DRAM-mixed logic technology, later to be migrated to 0.25-micron, to Chartered Semiconductor Mfg. Pte. Ltd. of Singapore. Chartered is expected to launch production with this technology in 1998. As an update to a Toshiba-Chromatic Research Inc. alliance formed in 1995, Toshiba has disclosed plans to use the second generation of Chromatic's Mpact 2 core in an embedded DRAM chip targeting notebook computers. The Mpact DSP uses a very long instruction word architecture, and the Toshiba part will be built sometime in 1998 with 4MB of DRAM and a 128-bit internal bus using Toshiba's 0.25-micron merged logic-DRAM process. The Mpact 1 and 2 were originally designed to use the Rambus DRAM and interface, and the move to an embedded DRAM part is expected to reduce power consumption by several watts, an important savings for notebook applications.

Interestingly, Toshiba also signed an alliance agreement in May 1997 to act as foundry for NeoMagic Corporation notebook graphics controllers. Strong demand for NeoMagic controllers has evidently required the company to supplement its supply of controllers being produced by Mitsubishi. Mitsubishi, an original investor in NeoMagic, will continue to make embedded DRAM controllers for NeoMagic; however, both Mitsubishi and Toshiba are, or shortly will become, competitors to NeoMagic because both have plans to build graphic controllers for notebook applications using their own designs and embedded DRAM technology. As seen below, the Mpact digital signal processor (DSP) is not the only device intended to make a transition from an external Rambus memory interface to an embedded DRAM solution.

Teams Research Multiple-MPU Parallel Processing with Embedded DRAM

Although no Japanese vendor has yet announced a formal alliance with the start-up PixelFusion Limited, based in Bristol, England, its work is particularly interesting in that it is specifically addressing the needs of the very high end of 3-D graphics accelerators by using massively parallel designs, developed at the University of North Carolina at Chapel Hill, in conjunction with an implementation in a merged logic-DRAM process. Silicon prototypes have been built by Chartered Semiconductor Manufacturing of Singapore, but the demands of building numerous processing units with large amounts of memory on a single chip may call for cutting-edge processes. It would therefore not be surprising if PixelFusion sought Japanese vendors as alliance partners to build its production designs. Indeed, the work at PixelFusion parallels the three-year research project being conducted at a Japanese consortium formed at the end of 1996. Based on the work of Professor Murakami from Kyushu University, the consortium initially anticipated that media processors using parallel processing architecture would reach the market by 1998. Similarly, a European research consortium, based at a university in Belgium, announced in December 1997 its intention to develop MPEG-4 chips that will be implemented with mixed logic-DRAM technology. Japanese partners have been included in the consortium, and project is also scheduled to run for three years, beginning in January 1998.

Because Japanese vendors arguably have been working on the development of embedded DRAM technology the longest, they have entered into several noteworthy alliances covering embedded DRAMs. This alliance activity is expected to continue; however, it should also be noted that there are conflicts within the industry that seem to be having a distinctly antialliance effect. Japanese vendors are currently suing several of their major Korean DRAM competitors for royalty payments, and, in some cases, seeking injunctions designed to prevent Korean vendors from selling their parts in the United States. With the Koreans expected to follow the Japanese vendors into the merged DRAM-logic markets, it may be that recent legal actions against the Korean companies are designed to force these competitors to pay for some of the cost of developing an embedded DRAM technology that is likely to benefit all manufacturers eventually, including Korean vendors.

As strange as it might sound, the legal action may actually have the effect of promoting alliances involving embedded DRAM development between Japanese and Korean vendors. Considering the lack of profit from the sales of commodity DRAMs, the cost of developing embedded DRAM technology will be difficult to sustain—predicting when a profitable return-on-investment will occur is not trivial, because it is dependent on finding the right uses for the technology at the right time. Furthermore, once an effective embedded DRAM process is achieved, the learning curve for nondevelopers will be simplified by information passing by way of both direct and indirect alliances. The Korean memory vendors will benefit from the pioneering work and probably cannot afford to pioneer the technology independently. The recent legal action by Japanese vendors is expected to force some Korean vendors to at least discuss either royalty payments, which would help defray the cost of developing technology, or more alliances in which vendors share the development cost of next-generation technologies.

ASICs Combine RISC Cores with Embedded DRAM to Open New Application Areas

Embedded DRAM may need to become the primary driver of the transition to 300mm technology if DRAMs continue to provide inadequate return on investment. Intel is sufficiently afraid of a mass vendor exit from the commodity DRAM business and the potential for a subsequent DRAM shortage that might affect its own microprocessor sales that the company is considering boosting its investments in major DRAM vendors by $1 billion. Meanwhile, most Japanese vendors are pushing ahead with research and development of merged logic and DRAM processes that seeks to minimize performance compromises. Besides graphics controllers for portable computing platforms, embedded DRAM products were expected to make their next appearance in hard disk drives. Because the disk drive industry seems to be in turmoil, there is less discussion of this happening soon. However, many other applications are being discussed as possible system-on-a-chip implementations that would include on-chip DRAM. A number of alliances that originally covered collaboration or licensing of RISC technology have been expanded to include RISC microcontroller (MCU) cores combined with embedded DRAM.

Alliances in Video Games, Windows CE Machines, ...

NEC is working with Nintendo Company Ltd. to eventually migrate its MIPS RISC-based video game controllers away from use of a Rambus memory interface architecture to a more efficient embedded DRAM solution. As with most custom ASICs, this can result in a lower cost-to-performance ratio in very high-volume applications only, such as video game consoles. This application is interesting because it represents a mass market product that, unlike the notebook graphics controller, is probably not using the superior power consumption efficiency of the embedded DRAM technology as its primary selling point. NEC expects to have available to ASIC customers by spring 1998 the capability of merging 200-MHz logic with 32Mb of 100-MHz DRAM connected over a 128-bit bus.

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The electrical and market performance of both the Nintendo embedded DRAM video controller and Toshiba's embedded DRAM Mpact 2 chip, both having potentially abandoned the Rambus interface and memory combination, may provide an interesting comparison benchmark for ASIC customers thus far unconvinced of the advantages of using embedded DRAM technology.

In early February 1998, Sega Inc. confirmed a long-rumored alliance with Microsoft Corporation to cooperate on the construction of a game machine. The confirmation by Sega included the revelation that the new platform will use the Windows CE operating system. Just as with the Nintendo-NEC alliance, the Sega-Microsoft game console is an application that can benefit from the use of an integrated game controller that merges embedded DRAM with logic. Dataquest would therefore expect to see in the not too distant future an alliance with a semiconductor producer, such as a manufacturer already building RISC cores for Windows CE platforms and probably at least planning on an embedded DRAM version of the Windows CE device. A large and growing number of vendors would qualify for such a project.

In the first quarter of 1997, Mitsubishi began working with ACCESS Corporation to customize a Mitsubishi chipset for use in portable Internet terminals, which include the M32R/D, a 32-bit RISC processor currently embedded with 2MB of DRAM. This processor family is scheduled to reach a clock speed of 400 MHz with 16MB of embedded DRAM, built with a 0.2-micron geometry, by the year 2000. Mitsubishi will also codevelop, as well as cross license, microcomponent cores embedded with DRAM with Motorola Incorporated, as a continuation of an alliance formed in October 1996. This alliance involves an embedded DRAM version of Mitsubishi's M32R and Motorola's 68EC000 and Coldfire processors.

In the second quarter of 1997, Toshiba partnered with Sun Microsystems Inc. to develop a Java processor for use in network computers. The micro-Java chip will incorporate a picoJava core, a memory controller, and embedded DRAM. Toshiba also announced in July 1997 the development of its MIPS based, Virtual Socket Interface (VSI)-compliant, TX19. This is a low-power, low-cost, embedded RISC processor that Toshiba intends to combine with embedded DRAM in the company's 0.25-micron DRAM-ASIC process.

In the third quarter of 1997, Hitachi announced that its SH-3 and SH-4 RISC MPU cores would be available in an embedded DRAM-enabled 0.35-micron process that ASIC clients can use to add DRAM in 256Kb increments, called "micromodules" by Hitachi. By 1999, Hitachi expects to field an SH-4 core with flash and micromodules based on 256Mb 0.25-micron DRAM technology. The number of RISC core license agreements, combined with embedded DRAM agreements, would suggest that mobile computing devices, particularly Windows CE machines, are expected to become a significant product segment making heavy use of system-on-a-chip designs that include embedded DRAM.

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In the fourth quarter of 1997, NEC and Lucent Technologies formalized an alliance that has Lucent licensing NEC's V800 series of RISC MCUs. As part of this alliance and possibly two previous alliances formed between the partners in June and October 1996, the two companies are said to be working together on an embedded DRAM process that Lucent expects to incorporate into its own 0.25-micron ASIC process by mid-1999.

Table 2-3 shows the alliances that covered RISC technology in 1997.

Table 2-3
RISC-Related Alliances

File Number	Company 1	Company 2	Product	Date
38	Mitsubishi	Access	M32R-base embedded DRAM chipset	February
49	NEC	Wind River Systems	Embedded RISC operating system	January
19	Hitachi	Mentor Graphics	CAD tools for SH RISC processor	April
88	Toshiba	MIPS Technologies	MIPS RISC technology	April
44	Mitsubishi	Mentor Graphics	M32R-base system-on-a-chip development	June
75	Sony	Advanced RISC Machines	ARM7 RISC core	July
55	NEC	Tseng Labs	PowerVR RISC core	September
59	NKK	Toshiba	32-bit RISC microcontroller	September
20	Hitachi	Seiko Epson	SH-3 microcontroller	November
21	Hitachi	NTT Electronics	SH-3 RISC processor core	November
57	NEC	Lucent Technologies	V-series RISC core	December
22	Hitachi	SGS-Thomson	64-bit RISC processor	December

Source: Dataquest (March 1998)

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Chapter 3

Displays, Micromachines, and Sensors Also Head toward Merged Processes

The synergy between traditional semiconductor circuits and integrated displays, sensors, and micromachines continues to grow and, in some cases, is already showing signs of merging with mainstream IC manufacturing. Moreover, VSI will facilitate the connection of not only standard IC cores, but also a growing array of new, CMOS-compatible devices that include sensors, micromachines, and even displays. Although start-up companies have always been expected to gamble on some of these esoteric technologies, many traditional IC companies, never having strayed too far from standard analog or digital IC fabrication technologies (at least in production), are also aggressively building exotic production-worthy process portfolios. For example, National Semiconductor Corporation is attempting to build active-matrix LCDs on standard wafers, Toshiba and Atmel Corporation are building CMOS image sensors, and Texas Instruments has made a heavy, highly publicized investment in its micromachined mirrors, also on standard wafers. The integration of such technologies with a memory-logic process should allow for the creation of such things as a true system-on-a-chip digital camera.

Although traditional IC manufacturing processes are incorporating more nonstandard components, from the opposite end of the processing spectrum, flat panel display manufacturers are starting to build circuits on their thin semiconductor films on glass or quartz substrates. There has been a recent surge in active-matrix LCDs research as this segment of the flat panel display industry continues to give upstart flat panel technologies a moving target. Nine new alliances involving LCDs occurred in 1997, which outpaced the LCD alliance activity of 1996. These alliances are listed in Table 3-1. The breadth of the technologies that are being combined with liquid polarizing crystals is beginning to overwhelm the work in other nascent technologies, such as field emission devices (FEDs), to the degree that some may already have missed their window of opportunity for commercialization because of the rapidly falling cost and improving performance of active-matrix LCDs. Active-matrix LCD reflective displays are being touted for their extreme power efficiency in mobile computing and communications applications, as well as for use in head-mounted displays or viewfinders in digital cameras and camcorders. Windows CE machines and personal digital assistants (PDAs) are expected to be among the first application markets to benefit from efficient reflective devices, some equipped with part-time backlighting capabilities. Sharp Electronics Corporation announced in September 1997 a reflective display for Windows CE machines that features a 30 percent reflection and 10:1 contrast ratio.

Table 3-1
Display-Related Alliances

File Number	Company 1	Company 2	Product	Date
37	Mitsubishi	Compaq	TFT LCDs	January
5	Dainippon Screen	Kyoto Technica	Semiconductor/LCD equipment maintenance	March
28	Itochu	Grand Pacific Petrochemical	LCD production	April
65	Ryosho Electronics	NeoParadigm Labs	LCD signal-processing ICs	April
42	Mitsubishi	Chungwa Picture Tube	TFT display technology	May
74	Sony	Toyota Group	Low-temperature polysilicon LCDs	June
99	Ulvac	Idemitsu Kosan	TFT panel transparent conductive film	June
76	Sony	Sharp/Philips	Next-generation large LCDs	July
8	Fuji Film	Kopin	Display technology	November

Source: Dataquest (March 1998)

On the materials research front, the films used to make active-matrix LCD panels are continuing to reach higher quality levels—meaning fewer defects. Although low-temperature polysilicon films are just beginning to reach commercialization, the films still in development are even closer in characteristics to bulk crystalline silicon. The fundamental materials and thin-film transistor research is yielding advances that suggest that active-matrix LCD and system ICs may well merge into another hybrid class of devices based on yet another merged process. Along these lines, Sharp's continuous grain silicon has continued the trend of improving thin films from amorphous films toward the ultimate goal of crystalline silicon-like electrical characteristics. Achieving this goal would improve the performance of active-matrix LCDs, as well allow the construction of all peripheral circuits right on the same substrate, with improved yield. If this trend continues, the 300mm technology of the silicon wafer industry may begin to have even more in common with the flat panel TFT processing technology than it already has.

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Chapter 4

Dataquest Perspective

There is a prevailing notion that for some Japanese vendors, DRAMs and embedded DRAMs have become one and the same industry. During the current DRAM oversupply, it appears that many Japanese chip vendors will continue to use alliances either to shift their commodity DRAM production to offshore joint ventures or to completely transfer their commodity production to licensed Asian partners. At the same time, the major Japanese vendors will attempt to accelerate the transition to embedded DRAM technology for a widening array of multichip products that currently use separate memory parts, particularly those that either require better power-consumption performance, such as notebook computer components, or that rely on high-speed logic-to-memory buses, such as the Rambus interface. There is certainly risk in this strategy, because the Japanese vendors may be forcing themselves to exit the commodity DRAM prematurely, at a time when embedded DRAM revenue may be insufficient to support the upgrades to 300mm equipment. However, the DRAM business for many Japanese vendors is a losing proposition with a cloudy outlook, and the successful deployment of a competitive embedded DRAM technology has the potential to boost the competitiveness of Japanese ASIC and logic businesses substantially. Moreover, alliances may also provide a fast recovery mechanism if the transition to systems-on-a-chip, using embedded DRAM technology, is delayed or the commodity DRAM business again becomes too lucrative to ignore. Regardless of how individual Japanese companies will implement their particular memory and ASIC strategies, the common denominator is certain to be their use of alliances to adapt quickly to market conditions and technology shifts. There are just too many advantages to alliances that outweigh the potential drawbacks.

The last U.S.-Japan Semiconductor Trade Agreement was allowed to expire over a year ago. The robust rate at which Japanese and U.S. companies have entered into new alliances since the expiration, as well as the continuing high market share of foreign companies in Japan, often exceeding 30 percent in the past year, provides some support for those that argue that the decision not to renew the trade agreement at the end of July 1996 was correct.

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Appendix A
1997 Japanese Semiconductor Strategic Alliances

Table A-1 lists the companies involved in publicly announced strategic alliances occurring in 1997. The individual alliance agreements are summarized in Appendix.

Dataquest classifies strategic alliances into the following 12 major categories.

- LA—Licensing agreement: A Japanese company receives or issues a license to a partner for an up-front fee or royalties.
- SS—Second-source agreement: Both companies agree to develop consistent specifications to ensure a second source.
- SA—Sales agency agreement: A Japanese company sells its partner's products, either as a sales representative or value-added reseller (VAR).
- FA—Fab agreement: A Japanese company offers fab capacity for a partner's product technology.
- AT—Assembly and testing agreement: A Japanese company sends or receives devices for assembly or testing.
- TE—Technology exchange: Both companies exchange technology, which may or may not include a transfer of money.
- JV—Joint venture: The two companies form a new joint-venture company to develop, manufacture, and market new products.
- JD—Joint development: Both companies agree to develop new products jointly, which may or may not be marketed separately.
- IV—Investment: A Japanese company invests in a partner company to secure new technology or access to new markets.
- CO—Coordination of standards: A Japanese company and a partner agree to device standards to ensure compatibility.
- PC—Procurement agreement: A Japanese company agrees to buy more foreign semiconductors as part of market access program.
- OT—Other: Joint symposia and programs

Table A-1
1997 Semiconductor Strategic Alliances: Japanese Companies

File Number	Company 1	Company 2	Product	Type	Date
1	Access	National Semiconductor	Internet TV chip	JD	September
2	Asahi Glass	Aspec Technology	ASIC libraries	SA	January
3	Asahi Glass	Advanced Micro Devices	AMD-K6 microprocessor	SA	March
4	Canon	Scientech	Stepper sales and support	JV	January
5	Dainippon Screen	Kyoto Technica	Semiconductor/LCD equipment maintenance	JV	March
6	DSI	Korean company	Vertical electric furnaces	JV	October
7	Enplas	Hicad	IC test socket	LV	June
8	Fuji Film	Kopin	Display technology	LA	November
9	Fujitsu	Advantest	Electron beam exposure system	JD	February
10	Fujitsu	LG Semicon	Chip-scale package	CO	March
11	Fujitsu	Sand Microelectronics	USB chip	LA	March
12	Fujitsu	Nantong Huada Microelectronics	Assembly of MCUs and linear ICs	JV	May
13	Fujitsu	Rambus	High-speed memory interface technology	LA	July
14	Fujitsu	Orckit	ADSL modem chip	JD, SA	August
15	Fujitsu	AMD	64Mb NAND flash	JD	October
16	Fujitsu	Sun Microsystems	picoJava core	LA	November
17	Furukawa Electric	Lucent Technologies	Assembly of optical semiconductors	JV	February
18	Gunze Sangyo	Plasmaquest	Plasma etching, plasma CVD systems	IV	February
19	Hitachi	Mentor Graphics	CAD tools for SH RISC processor	JD	April
20	Hitachi	Seiko Epson	SH-3 microcontroller	LA	November
21	Hitachi	NTT Electronics	SH-3 RISC processor core	JD	November
22	Hitachi	SGS-Thomson	64-bit RISC processor	JD	December
23	Hitachi/Mitsubishi	Texas Instruments	1Gb DRAM	JD	February
24	Hitachi Chemical	DuPont	Polyimide material	JV	September
25	Hitachi Construction Machinery	Hitachi Medico	X-ray-based inspection system	PC	December
26	Hitachi Maxell	Singlechip Systems	IC tag	TE	December
27	Innotech	Credence Systems	Memory tester	JV	November

Table A-1 (Continued)
1997 Semiconductor Strategic Alliances: Japanese Companies

File Number	Company 1	Company 2	Product	Type	Date
28	Itochu	Grand Pacific Petrochemical	LCD production	JV	April
29	Itochu	Comdisco	Semiconductor equipment leasing	JV	September
30	Kaijo	Robotic Vision Systems	BGA inspection system	SA	November
31	Kaijo	Quad Systems	Flip-chip bonder system	SA	December
32	Kanematsu Semiconductor	Integraphics Systems	Internet TV chip	SA	September
33	Kyocera	Johnson Matthey	Cross-license for packaging	LA	October
34	Lapmaster SFT	Super Silicon Crystal Research Institutes	CMP machine for 400mm wafers	JD	August
35	Matsushita	Texas Instruments	Digital video camera ICs	JD	January
36	Matsushita	CBL	Blue laser	JD	July
37	Mitsubishi	Compaq	TFT LCDs	JD	January
38	Mitsubishi	Access	Communications chipset, embedded MCU	LA	February
39	Mitsubishi	Wind River Systems	Embedded operating system	LA	March
40	Mitsubishi	Rambus	High-speed memory interface	LA	April
41	Mitsubishi	Seiko Epson	3-D video chip	LA	May
42	Mitsubishi	Chungwa Picture Tube	TFT display technology	LA	May
43	Mitsubishi	Stone Group	Semiconductor sales	JV, SA	June
44	Mitsubishi	Mentor Graphics	System-on-a-chip development	JD	June
45	Mitsubishi	Powerchip Semiconductor	Embedded DRAM technology	LA	November
46	Mitsubishi Materials	Symmetrix	Ferroelectric material	LA	December
47	Mitsui & Co.	Micron Communication	Noncontact tag	JD	April
48	Mitsui High-Tec	Ball Semiconductor	Ball-shaped silicon wafer	IV	August
49	NEC	Wind River Systems	Embedded RISC operating system	LA	January
50	NEC	Datapath	EPRML LSIs	LA, JD	February
51	NEC	Synopsys	ASIC design verification technology	JD	April
52	NEC	Shanghai Huahong Micro	Semiconductor front-end fab	JV, FA	May
53	NEC	Cadence Design Systems	Cadence CAD design tool	SA	July
54	NEC	Samsung	300mm wafer production	JD, TE	July

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Table A-1 (Continued)
1997 Semiconductor Strategic Alliances: Japanese Companies

File Number	Company 1	Company 2	Product	Type	Date
55	NEC	Tseng Labs	PowerVR RISC core	JD	September
56	NEC	Philips Semiconductor	Consumer LSIs	JD	November
57	NEC	Lucent Technologies	V-series RISC core	LA	December
58	Nichimen Electronics	Luxsonor	MPEG-2 decoder chip	SA, JD	May
59	NKK	Toshiba	32-bit RISC microcontroller	LA	September
60	Nomura Microscience	Ionics	Electrical deionization equipment	SA	July
61	Nozaki Industry	High Yield Technology	Particle monitor system	SA	May
62	Oki	Synopsys	CBA technology	LA	January
63	Oki	Artisan Components	Memory generator	LA	April
64	Rohm	DSP Group	DSP technology	LA	March
65	Ryosho Electronics	NeoParadigm Lab	LCD signal processing ICs	SA	April
66	Sankyo Engineering	Sugai	Wet-type semiconductor cleaning system	JD	April
67	Santoku /Mitsui & Co.	Merck	Ultrapure hydrogen peroxide water	JV	October
68	Seiko Epson	Lattice	Fabrication service	FA, IV	March
69	Seiko Epson	Exemplar Logic	ASIC library environment	LA	June
70	Seiko Epson	Mitsubishi	64Mb DRAM design, technology	LA, SS	October
71	Seiko Seiki	Jenoptik Infab	SMIF system	SA	December
72	Sharp	SanDisk	Cross-license for flash memory	LA	January
73	Shin-Etsu Handotai	Soitec	SOI wafer production	LA, JD	May
74	Sony	Toyota Group	Low-temperature polysilicon LCDs	JD	June
75	Sony	Advanced RISC Machines	ARM RISC	LA	July
76	Sony	Sharp/Philips	Next-generation large LCD	JD	July
77	Sony	Oki Electric	System-on-a-chip	JD	August
78	Sumitomo Chemical	Olin	I-line photoresist	LA, JV	September
79	Sumitomo Corporation	Tokyo Kaseihin and others	Lead frame	JV	January
80	Sumitomo Corporation	R. Howard Strasbaugh	CMP system	JV	June
81	Sumitomo Corporation	Pixtec	FED	SA, IV	November
82	Tokyo Seimitsu	Super Silicon Institutes	400mm-wafer wire saw	JD	March

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Table A-1 (Continued)
1997 Semiconductor Strategic Alliances: Japanese Companies

File Number	Company 1	Company 2	Product	Type	Date
83	Tokyo Seimitsu	Seiko Seiki	Wafer dicing system	JD, TE	December
84	Toshiba	Unigen	Memory module	SS	February
85	Toshiba	Samsung	64Mb DRAMs	FA, IV	February
86	Toshiba	Motorola /Fairchild	CMOS standard logic	JD	March
87	Toshiba	Sun Microsystems	Java processors	LA, JD	April
88	Toshiba	MIPS Technologies	MIPS RISC technology	LA	April
89	Toshiba	Technology Modeling Associates	3-D process simulation	JD	April
90	Toshiba	NeoMagic	Embedded memory	LA, FA	May
91	Toshiba	Chartered Semiconductor	Embedded DRAM process technology	LA	June
92	Toshiba	iReady	Internet access LSI	LA	June
93	Toshiba	ViewLogic	Logic design tool	JD	July
94	Toshiba	IBM	300mm wafer production	JD, TE	July
95	Toshiba	Winbond	64, 256Mb DRAMs	PC	September
96	Toshiba	WSMC	Logic foundry service	FA	October
97	Tosoku	Samsung Aerospace	Wire bonding	SA, JD	October
98	Ulvac	Ramtron International	Ferroelectric materials	JD	March
99	Ulvac	Idemitsu Kosan	TFT panel transparent conductive film	JD	June
100	Yamaha	Xicor	EEPROM	SA, FA	February

Source: Dataquest (March 1998)

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Appendix B
1997 Alliance Agreements

Access

1. National Semiconductor (United States), September 1997

National Semiconductor Japan has teamed up with Tokyo-based software developer Access in the systems development for Internet-capable home electronics. The Japanese subsidiary of National Semiconductor intends to supply home electronics makers in Japan with a system-on-a-chip LSI that supports Access' Internet connection and search program, Netfront. The system-on-a-chip LSI centers around National's NS486 processor core, complying with Intel's x86 architecture, and integrates PCMCIA controller, IrDA, and other peripherals, providing all the functionality necessary to give a TV or satellite receiver Internet connectivity.

Asahi Glass

2. ASPEC Technology (United States), January 1997

Asahi Glass will market ASIC libraries developed by ASPEC Technology of the United States in Japan. ASPEC already handles ASIC libraries supporting the production processes of 15 chipmakers. The price is ¥300 million per kit. Asahi Glass has also started taking orders from customers in Japan for the ASIC Division of Hyundai Electronics, which uses ASPEC's libraries.

3. Advanced Micro Devices (United States), March 1997

Asahi Glass will step up sales of Advanced Micro Devices microprocessors this fiscal year. The company deals with AMD's Windows PC MPUs and in-built processors. For Windows PC MPUs, Asahi Glass hopes to tap demand for the K6 chip from domestic PC makers. In a move to market built-in processors for numerical control and point-of-sale systems, Asahi Glass has signed a distribution agreement with Microsoft to obtain an MS-DOS license. Plans also call for commercializing AMD MPU boards that incorporate Asahi Glass hybrid ICs.

Canon

4. Scientech (Taiwan), January 1997

Canon set up a stepper sales and support joint venture in Taiwan in early February. The company's third service center in Asia, Canon Semiconductor Equipment Taiwan will be headquartered in Taipei and will be capitalized at about ¥300 million, 80 percent by Canon and 20 percent by a local distributor, Scientech. The new company will initially be staffed by 22 employees. Canon, which has already won an order for more than 20 steppers from ProMos Technologies, a joint venture between Siemens and Mosel Vitelic of Taiwan, is aiming to nearly double its share to about 50 percent of the Taiwanese stepper market by 1999.

Dainippon Screen

5. Kyoto Technica (Japan), March 1997

Dainippon Screen Manufacturing and Kyoto Technica will jointly set up a semiconductor/LCD equipment maintenance service company. Based in Kyoto, DS Tec Kansai is capitalized at ¥50 million, with Dainippon Screen investing 82 percent and Kyoto Technica 15 percent; it will start operations with more than 100 employees. Dainippon Screen, which has entrusted maintenance service to a subsidiary and Kyoto Technica, will commission delivery and maintenance of equipment for its customers in the Kinki, Chugoku, and Shikoku regions to the new company. DS Tec Kansai is expected to achieve annual revenue of ¥1.1 billion in its first year.

DSI

6. Korean company (Korea), October 1997

DSI, a Japan-based semiconductor equipment production venture, will establish a joint venture in Korea in October to manufacture vertical electric furnaces for use in next-generation semiconductor production. To be capitalized at ¥40 million, DSI Korea will be owned 70 percent by a local company and 30 percent by DSI. With an initial staff of three salespeople and two engineers, the joint venture will have a clean room at its main office. DSI, which has been assembling vertical high-vacuum annealing systems at its Shizuoka plant, intends to scale down its domestic operations and shift manufacturing technologies and equipment to the Korean company.

Emplas

7. Hicad (China), June 1997

Emplas will set up an IC test socket sales joint venture in Shanghai with its Singapore distributor, Hicad. To be capitalized at $600,000, Emplas Hicad National Trading will import IC test sockets from Japan and launch sales in late July. The joint venture will target chipmakers, including NEC and Motorola, with IC manufacturing operations in China and will aim for annual sales of ¥2 billion in three years.

Fuji Film Microdevices

8. Kopin (United States), November 1997

Kopin and Fuji Film Microdevices, Japan, announced a strategic business agreement under which the companies will incorporate Kopin's CyberDisplay active-matrix LCD into Fuji's digital camera chipsets. Fuji and Kopin will work together to integrate Fuji charge-coupled device analog and logic circuits with Kopin's CyberDisplay. The goal of the strategic alliance is to make the chipsets available to Fuji internal and external customers by the second quarter of 1998. Based on Kopin's patented Smart Slide technology, the CyberDisplay is a 0.24-inch diagonal transmissive active-matrix LCD imaging device that displays information at 320 x 240 full-color-pixel resolution. It enables portable communications devices and personal information products to display photographic images and other data or video sources.

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Fujitsu

9. Advantest (Japan), February 1997

Fujitsu and Advantest will concentrate their joint electron beam (EB) exposure system business at Advantest. The two companies jointly developed the F5120 EB exposure system for use in 256Mb or larger DRAM production, and Advantest has started marketing it. From April 1997, about 50 Fujitsu employees engaged in EB systems development will be on loan at Advantest's R&D center now under construction. Advantest expects to sell five of the ¥1 billion systems the first year.

10. LG Semicon (Korea), March 1997

Fujitsu and LG Semicon in Korea will unify the design guides of their proprietary chip-scale packages under the name "USON," for ultrathin small-outline nonleaded package. The companies plan to ask the Joint Electronic Device Engineering Council (JEDEC) to designate USON as a new standard package for memory devices. Fujitsu developed a chip-scale SON package, which has been used for its flash memory since September 1996. Compared with the conventional thin small-outline package (TSOP), the company claims, the SON package takes up about half the space in mounting, is two-thirds of the thickness, and is half the weight for 16Mb flash memory. LG Semicon developed the bottom-leaded plastic (BLP) package and has been using it for DRAM packaging. BLP is almost the same size as SON.

11. Sand Microelectronics (United States), March 1997

Fujitsu will license Virtual Socket Interface (VSI)-compliant Universal Serial Bus (USB) microcomponents from Sand Microelectronics and will commercialize a microcontroller with integrated USB microcomponents for use in monitors. The USB interface allows peripheral equipment to be connected with the PC with ease. By supporting the USB macro, Fujitsu will be able to offer LSIs that support various standard interfaces, including IEEE 1394, SCSI, and IrDA.

12. Nantong Huada Microelectronics (China), May 1997

Fujitsu has reached agreement with leading Chinese chipmaker Nantong Huada Microelectronics to establish a semiconductor assembly joint venture in China in late June. To be capitalized at $10 million, Nantong Fujitsu Microelectronics will be owned 40 percent and 60 percent by the Japanese and the Chinese companies, respectively. The joint venture will initially employ 400 people to assemble 10 million microcontrollers and linear ICs per month and will construct a new facility starting in fiscal 1998 to raise output to 40 million units.

13. Rambus (United States), July 1997

Fujitsu will team up with Rambus of California in 64Mb high-speed DRAM technology. Fujitsu will receive high-bandwidth Direct Rambus DRAM technology to develop memory systems with gigabyte-per-second-class data transfer speeds. A major reason for the alliance seems to be Intel's plan to use DRAMs with the Rambus interface as the main memory for PCs that will ship starting from 1999. Rambus' high-speed DRAM technology has been transferred to most of DRAM makers including NEC, Toshiba, Hitachi, Samsung, LG Semicon, and Hyundai.

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14. Orckit (Israel), August 1997

Fujitsu Microelectronics and Orckit Communications are teaming up to produce a single-chip, discrete multitone-standard-based Asymmetric Digital Subscriber Line (ADSL) modem. The companies will recast Orckit's two-chip digital solution and its analog front-end, currently based on discrete components, into a 0.35-micron mixed-signal CMOS chip. They will also add Asynchronous Transfer Mode (ATM) and rate-adaptation features in line with a new definition of ADSL known as Issue II. Fujitsu will market the device commercially and to Orckit. The chip is expected to be available in mid-1998.

15. Advanced Micro Devices (United States), October 1997

Advanced Micro Devices and Fujitsu will codevelop a serial NAND-type flash memory architecture, and they expect to begin production with a 64Mb device by October 1999. The two companies currently manufacture NOR-type flash at a joint-venture fab in Aizuwakamatsu, Japan, and have not sold serial flash, which offers a smaller cell size at the expense of random access speeds. A team with staff from both companies is being formed to develop the NAND-type architecture.

16. Sun Microsystems (United States), November 1997

Fujitsu has reached agreement with Sun Microsystems to license Sun's picoJava I, a Java microprocessor core. The company will develop 32-bit RISC microcontroller core specialized in Java software using 0.35-micron technology in 1998 and begin marketing the core for use in PDAs and cellular phones in 1999. The Java processor based on picoJava I is reported to outperform conventional RISC processors such as the SPARClite by a factor of five, and Fujitsu plans to use 0.25-micron technology to expand the core's applications to Network Computers. The company is aiming for Java MPU core sales of ¥10 billion in 2001, and ¥50 billion, or 30 percent of the dedicated Java MPU market, in 2003.

Furukawa Electric

17. Lucent Technologies (United States), February 1997

Furukawa Electric and Lucent Technologies have established an optical semiconductor assembly joint venture in the United States. Finet Technologies will assemble laser diodes, photo detectors, and other optical semiconductors starting in April and will market the products through the partners' sales channels in Japan and the United States. Furukawa and Lucent, already joined in an optical fiber cable manufacturing venture, Fitel Lucent Technologies, plan to invest a total of about $10 million in the new joint venture by fiscal year 2000.

Gunze Sangyo

18. Plasmaquest (United States), February 1997

Gunze Sangyo has acquired a capital stake in Texas-based semiconductor equipment maker Plasmaquest. Gunze, which has been distributing plasma etching and plasma chemical vapor deposition systems made by Plasmaquest in Japan since 1993, has bought with its U.S. subsidiary, Gunsan America, 14.81 percent of the U.S. company for $1 million. Plasmaquest needed financial support to expand production capacity to keep up with brisk demand for etching equipment in the North American market. Gunze wants to expand Japanese sales of Plasmaquest products to ¥1 billion in two years.

Hitachi

19. Mentor Graphics (United States), April 1997

Hitachi will work with Mentor Graphics to strengthen its 32-bit RISC processor development environment. Plans call for jointly developing SeamlessCVE, a hardware/software coverification tool for the Hitachi SH series microcontrollers. The tool, which will support MCUs in the SH-1, SH-2, and SH-3 series, will allow system designers to verify hardware and software and debug the software in the early stage of SH MCU-based equipment development, slashing development time by over one month. The tool is priced at ¥12 million.

20. Seiko Epson (Japan), November 1997

Hitachi and Seiko Epson announced an agreement concerning the licensing of Hitachi's 32-bit RISC microprocessor core technology to Seiko Epson. Seiko Epson intends to combine its low-power semiconductor technology with Hitachi's SH-3 core to build new ASICs and application-specific standard products (ASSPs) that better meet system requirements. Hitachi has been actively forming partnerships as part of establishing its 32-bit SH RISC engine family as an industry standard. The present agreement makes Seiko Epson the first Japanese partner and, for customers, will mean that more PC peripheral devices and portable information products built around SH MPUs will be available. Seiko Epson has developed 4-, 8-, and 32-bit CPUs. With the SH-3, Seiko Epson will address the need for products with a standard embedded CPU capable of running a standard operating system with its associated development environment.

21. NTT Electronics (Japan), November 1997

Hitachi and NTT Electronics will work together to develop a low-power SH-3 RISC microprocessor using a 0.25-micron process technology. Hitachi will provide its SH-3, designed for a 0.35-micron process, while NTT Electronics, which develops and manufactures ICs for its parent company, Nippon Telegraph & Telephone, will provide its 0.25-micron technology. Hitachi expects the collaboration will help it lower the power consumption of the SH-3 nearly 3 percent and shorten the 0.25-micron SH-3's time to market. The CPU is expected by spring of 1999.

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22. SGS-Thomson (France), December 1997

Hitachi and SGS-Thomson Microelectronics formally unveiled plans to undertake joint development of 64-bit microprocessor cores for the Super-H family. The processor architecture will be backward compatible with Hitachi's SH-4 and is being targeted as a general-purpose engine for a wide range of products. The architecture of the first core that the companies will work on together, called SH-5 by Hitachi and ST50 by SGS-Thomson, is due to be disclosed in 1998, with first implementations sampled in the second half of 2000 and volume production in 2001.

Hitachi/Mitsubishi

23. Texas Instruments (United States), February 1997

Hitachi, Mitsubishi Electric, and Texas Instruments have signed an agreement to jointly develop 1Gb DRAM. The agreement, part of a trend toward huge investments to develop complex and expensive technologies, will allow the three chipmakers to share resources and leading-edge technologies. The three companies are aiming for sample shipments of the next-generation chips by early 2000, sharing the estimated development cost of more than ¥100 billion. Since 1988, TI and Hitachi have been teaming up to research and develop 16Mb, 64Mb, and 256Mb DRAMs, while Hitachi and Mitsubishi have jointly developed 8Mb, 16Mb, and 64Mb flash memory chips. In 1995, Hitachi and TI formed a joint venture, Twinstar, a $0.5 billion wafer fab located in Richardson, Texas.

Hitachi Chemical

24. DuPont (United States), September 1997

Hitachi Chemical and DuPont of the United States will jointly set up ventures in both countries to produce and market liquid polyimide materials for semiconductors and other electronic devices. The two companies have established Hitachi Chemical DuPont Microsystems LLC in the United States, slated to open in April 1999. An initial capital contribution of $14 million for the venture will be shouldered equally by DuPont and Hitachi Chemical's sales subsidiary, Hitachi Chemical America. The new joint venture will then establish Hitachi Kasei DuPont Microsystems K.K., as a wholly owned subsidiary in Japan, with capital of ¥400 million and a targeted operation date in 2002.

Hitachi Construction Machinery

25. Hitachi Medico (Japan), December 1997

Hitachi Construction Machinery has formed a partnership with Hitachi Medico in the semiconductor inspection equipment business. The company will procure as an OEM two types of x-ray-based semiconductor inspection systems from Hitachi Medico. Its goal is to nearly double its factory automation system sales to ¥3.6 billion by 2001 by broadening its x-ray inspection system product line. The MF130M and the MF80M feature focuses of 10 micron, and 8 micron, respectively.

Hitachi Maxell

26. Singlechip Systems (United States), December 1997

Hitachi Maxell has teamed up with Singlechip Systems of California to enter the IC tag business. The partners will combine Hitachi Maxell's non-contact IC card production technology with SCS' single-chip technology to manufacture and market an IC tag that will measure 10 x 60 x 0.25mm and have a memory capacity of 1,024 bits. A reader/writer will use 2.45-GHz signals to simultaneously read data on more than 30 write-once tags that can be 35cm apart. A set of the reader/writer and 100 tags will be priced at ¥600,000 to ¥1,000,000.

Innotech

27. Credence Systems (United States), November 1997

Innotech has established in Yokohama a semiconductor tester production joint venture with Credence Systems of California. Capitalized at ¥100 million, Innotech Credence is 49.9 percent owned by the Japanese semiconductor equipment distributor and 50.1 percent by the U.S. tester maker. The joint venture will manufacture logic and memory testers and put them on the market by spring 1998, aiming to ship a total of 50 units the first year. The first-year sales target is set at ¥4 billion.

Itochu

28. Grand Pacific Petrochemical (Taiwan), April 1997

Itochu, in cooperation with Fukushima-based technical consulting company Sumcon and Taiwanese chemical company Grand Pacific Petrochemical, will set up a joint LCD production company in Taiwan. The new company, Grand Pacific Optoelectronics, will be capitalized at about (4 billion, in which Itochu, Sumcon, and Grand Pacific Petrochemical invest 25 percent, 5 percent, and 70 percent, respectively. The joint venture expected to start constructing a plant in the Hsinchu industrial park in April 1997 and to produce sub-10-inch STN color LCDs for portable information devices and notebook computers from June 1998, aiming for first-year sales of about ¥10 billion.

29. Comdisco Inc. (United States), September 1997

Itochu and U.S. semiconductor equipment leasing company Comdisco have established a joint semiconductor equipment leasing company, Commit Equipment Management Service. Capitalized at ¥490 million, the joint venture is owned 60 percent by the U.S. company and 40 percent by the Japanese trading house. The joint venture is aiming for 20 billion in leasing contracts by 2000. Predicting that demand for used equipment may expand in Asia, the partners plan to sell used equipment to Taiwanese and Korean chipmakers. The used semiconductor equipment market in Japan is estimated at ¥5 billion, about 1/10th of the size of the U.S. used equipment market.

Kaijo

30. Robotic Vision Systems Inc. (United States), November 1997

Kaijo has teamed up with Robotic Vision Systems Inc. of New York to expand its inspection system business. Kaijo will start marketing and providing support for RVSI's ball grid array (BGA) inspection and bump attachment systems in December. Through an alliance with Kaijo, RVSI wants to boost its Japanese market share, currently about 20 percent of the market.

31. Quad Systems (United States), December 1997

Kaijo has begun marketing a flip-chip bonder made by Quad Systems of Pennsylvania, signing an exclusive domestic sales contract with the U.S. company. The Advanced Packaging System APS-1 supports various types of packaging, including chip-scale package (CSP) and chip on board (COB) and uses an optical noncontact alignment system to achieve a high level of alignment. The price is ¥40 million.

Kanematsu Semiconductor

32. Intergraphics Systems (United States), September 1997

Intergraphics Systems of California will team up with semiconductor distributor Kanematsu Semiconductor and software house Access to market in Japan the CyberPro2010, a system-on-a-chip LSI enabling users to browse Internet home pages on TV. The chip integrates monitor output circuit and image control functions and a flicker-prevention function and features a built-in interface called Flexibus that makes the chip usable with all existing CPUs, including x86 and PowerPC microprocessors and Hitachi SH series microcontrollers. Intergraphics Systems claims that the chip helps Internet TV makers slash development time and design costs by nearly 60 percent, enabling them to lower retail prices from the current ¥300,000 to ¥100,000.

Kyocera Electronics Inc.

33. Johnson Matthey (United Kingdom), October 1997

Kyocera has signed a cross-license agreement with Johnson Matthey of London in the semiconductor plastic package business. The company will introduce plastic package technology from Johnson Matthey and start mass production of plastic land grid arrays (PLGAs) for microprocessors at its Sendai plant in Kagoshima Prefecture in January 1998. In return, Kyocera will provide the U.K. company with build-up substrate technology. Plans call for launching production at 500,000 units per month (45 x 45mm, 540 pins) and boosting output to 1.5 million units by July 1998, when the company will complete a new 10 billion production facility at the plant. Kyocera is aiming for PLGA sales of ¥5 billion to ¥6 billion in fiscal 1998.

Lapmaster SFT

34. Super Silicon Crystal Research Institute (Japan), August 1997

Lapmaster SFT of Tokyo will collaborate with Super Silicon Crystal Research Institute of Gunma Prefecture to develop a fully automated chemical mechanical polishing machine for processing 400mm wafers. Super Silicon will provide wafer samples, while Lapmaster will be in charge of hardware design and software development. Development costs are estimated at (100 million. Scheduled to be developed by May 1998, the machine will achieve a wafer-processing flatness of less than 0.13 micron, a surface particle diameter size of 0.04 micron, and a surface metal impurity level of 10 x 8 stoms/cm^2. The 400mm wafer-processing machine is likely to be priced at about ¥200 million.

Matsushita

35. Texas Instruments (United States), January 1997

Texas Instruments Japan and Matsushita Electric have jointly developed a digital video camera DV terminal IC that conforms to IEEE 1394, a high-speed serial bus standard for next-generation PCs and consumer electronics. The TSB13LV01 integrates on a single chip the functions of conventional LINK and PHY chips and is available in a 144-pin CSP. TI Japan will initially mass-produce the new IC exclusively for use in the latest NV-DE digital video camera from Matsushita Electric.

36. CBL (United States), July 1997

Matsushita Electronics signed an agreement with a California-based venture CBL under which the companies will jointly develop a blue-light laser. Matsushita is aiming by 1999 to commercialize a blue-light laser, necessary for next-generation DVD drives with a storage capacity of 15GB, three times the current level. Set up by Stanford University researchers, CBL has developed large-diameter gallium nitride substrates. Use of this type of substrates increases the life of a blue-light laser from the conventional 30 hours to 5,000.

Mitsubishi

37. Compaq (United States), January 1997

Compaq Computer Corporation has teamed up with Mitsubishi Electric and with Advanced Display, Mitsubishi's LCD production subsidiary, in PC LCD monitor development. The alliance brings together Compaq's understanding of customer needs, Mitsubishi's flat panel technology, and Advanced Display's motherboard and glass processing technologies. The companies developed an LCD monitor and put it on the market in the second half of 1997. Compaq will be in charge of sales and will initially target the financial and health care sectors.

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38. Access (Japan), February 1997

Mitsubishi Electric has teamed up with Access, an Internet appliance operating system developer, in the development of a portable Internet terminal chipset. The two companies will jointly develop a three-chip set including Mitsubishi's M32R/D DRAM-embedded microcontroller and a mask ROM and market the chipset at $30 to $40. Mitsubishi plans to develop a two-chip set in 1998 by integrating an ASIC and the M32R/D on a single chip. Mitsubishi, which started shipping samples of the DRAM-embedded MCU in October 1996, will launch production in April and produce 1 million units a month in late 1997. Access' Internet OS has been adopted by Sharp in its Internet TVs and word processor.

39. Wind River Systems (United States), March 1997

Wind River Systems, Japan, will develop the Tornado embedded system development environment for Mitsubishi Electric's 32-bit M32R/D RISC processor, based on an agreement the two companies have signed. The agreement will allow domestic M32R/D users to collectively purchase from Mitsubishi the license to use the VxWorks real-time operating system that is integrated into the Tornado development environment, helping them reduce system development time. Mitsubishi, which teamed up with Integrated Systems Inc. of the United States regarding its pSOS real-time OS in 1996, will support the real-time operating systems that account for some 70 percent of the world market.

40. Rambus (United States), April 1997

Mitsubishi Electric has licensed the Rambus interface technology needed to make 1.6GB/sec Direct Rambus DRAMs. The company has previously been a vocal proponent of other next-generation DRAM technologies. Nine DRAM makers have taken Rambus licenses, and some of the holdouts are believed to be negotiating with Rambus. IBM has a license for the Rambus logic interface but has yet to take a license for the memory-interface technology.

41. Seiko Epson (Japan), May 1997

Mitsubishi Electric will license 3-D video memory technology to Seiko Epson. Mitsubishi's 3D-RAM integrates 10Mb DRAM, 2Kb SRAM, and logic functions on a chip. Seiko Epson is expected to ship samples of the SDM 10092, a 3D-RAM-compatible chip, this fall and launch volume production at 20,000 units per month at its Sakata plant next spring. The sample price is likely to be set at about ¥5,000.

42. Chunghwa Picture Tube (China), May 1997

Mitsubishi Electric and Advanced Display have agreed to license their advanced thin-film transistor (TFT) LCD technologies to Chunghwa Picture Tube, a cathode-ray tube (CRT) manufacturer in Taiwan. Under the agreement, Chunghwa Picture will receive key technologies for the manufacture of TFT LCDs from Advanced Display. The displays to be manufactured by Chunghwa include 12.1-inch SVGA and XGA and 15.1-inch XGA and SXGA models. Volume production is expected to begin in January 1999. Chunghwa, an affiliate of Tatung, develops CRTs for the television and display market as well as super-twisted nematic (STN) LCD flat-panel displays.

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43. Stone Group (China), June 1997

Mitsubishi Electric has teamed up with Chinese electric equipment maker Stone Group in semiconductor sales. Mitsubishi, Stone, and Mitsui & Co. established a joint venture in Beijing in 1996, and the joint venture is building a semiconductor plant expected to be ready for operations in April 1998. Mitsubishi plans to market semiconductors to be made by the plant for use in electric appliances. First-year China semiconductor sales are expected to be ¥10 billion, including sales to be generated through distribution via Hong Kong.

44. Mentor Graphics (United States), June 1997

Mitsubishi Electric will develop system-on-a-chip LSI development software with Mentor Graphics. Hardware-Software Cosimulation Environment, the software the two companies will develop, will combine Mentor's Seamless CVE and Mitsubishi's 32-bit M32R RISC microcontroller core instruction set simulator. The new software will allow system-chip LSI design engineers to test software as hardware is being designed, helping reduce design and development time from the current eight months to five months. Sample shipment is slated for late this year.

45. Powerchip Semiconductor (Taiwan), November 1997

Mitsubishi Electric expects to provide Powerchip Semiconductor of Taiwan with DRAM-embedded microcontroller production technology in early 1998. A joint venture established by Mitsubishi, a trading company, Kanematsu, and a Taiwanese electronics maker, the UMAX Group, Powerchip will begin to produce eRAM, a system-on-a-chip LSI that integrates Mitsubishi's proprietary 32-bit RISC MCU and DRAM on a single chip. Slated to begin in mid-1998, production will reach 4,000 eight-inch wafers per month by September 1998.

Mitsubishi Materials

46. Symmetrix (United States), December 1997

Mitsubishi Materials has licensed technology to produce and market ferroelectric materials from Symmetrix of Colorado. Plans call for producing Y-1, a ferroelectric material developed by the U.S. company for forming thin-film capacitors through enhanced metallorganic deposition (EMOD) at a mass production facility under construction in the company's Mita plant. Construction will be completed by year's end, and operations have been slated to start in March 1998. The company is aiming for sales of ¥200 million in 2000.

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Mitsui & Co.

47. Micron Communications/ID Micro Systems (United States), April 1997

Mitsui & Co. will work with Micron Communications and ID Micro Systems, both of the United States, to develop a low-cost noncontact tag. The new tag will have a storage capacity of 256 bits and use the spread spectrum format to read and write data. The companies aim to price the product at about (100, enabling it to be used as a disposable tag in production and distribution management and IC card applications. Mitsui and Micron Communications will share the development cost, while ID Micro will provide noncontact tag technology. Mitsui will sell the tag in Japan and overseas, except for the United States. The tag was expected to reach the market in late 1997, with a first-year sales goal set at 10 million units.

Mitsui High-Tec

48. Ball Semiconductor (United States), August 1997

Mitsui High-Tec has invested in Ball Semiconductor of Texas, acquiring nearly 50 percent of the U.S. company for $26 million. Ball Semiconductor was established by former Texas Instruments vice president Akira Ishikawa in October 1996. Ball has developed technology to create semiconductor circuits on the surface of a silicon ball in order to increase the level of integration. The U.S. company claims that the silicon balls are easier to manufacture than silicon wafers and that a silicon ball semiconductor plant can be constructed at lower cost than conventional chip plants. Semiconductor equipment maker Disco is also reported to have chipped in more than ¥100 million to the U.S. venture.

NEC

49. Wind River Systems (United States), January 1997

NEC will procure an embedded RISC microprocessor operating system from Wind River Systems. NEC and the Japanese arm of Wind River have signed an agreement, under which the U.S. software company will develop a version of the Tornado operating systems supporting NEC's V830 series of 32-bit RISC MPUs. The B830 family is popular among office business machines and car navigation system applications, and the combination of the RISC MPU and Tornado will allow designers to develop such application systems easily. Japanese customers have been able to purchase the Tornado runtime version license together with the MPU from April 1997.

50. Datapath Systems (United States), February 1997

NEC has teamed up with U.S. venture Datapath Systems to develop an extended partial response maximum likelihood (EPRML) LSI for use in large-capacity hard disk drives (HDDs). NEC will continue its process technology with the U.S. company's circuit design technology to develop as early as this year the LSI that will enable 30 percent HDD capacity expansion over the conventional PREL system. NEC, which has to date manufactured HDD write and read LSIs, intends to expand its semiconductor business by moving into the HDD LSI market, a promising segment with huge growth potential.

51. Synopsys (United States), April 1997

NEC and Synopsys of California have reached an agreement to jointly develop microcontroller-embedded ASIC design verification technology. The move is aimed at providing a tool to enable single-chip embedded system designers to simultaneously verify both hardware and software functions and at reducing development lead time. For the development of embedded systems, hardware functions are typically verified using EDA capability and software functions using an in-circuit emulator. NEC expects the new tool will help expand sales of its V850 family of ASICs.

52. Shanghai Hua Hong Microelectronics (China), May 1997

NEC announced that it will set up a joint venture with Chinese chipmaker Shanghai Hua Hong Microelectronics to supply technology to a Chinese national project to boost domestic semiconductor output. Shanghai Hua Hong is affiliated with the Chinese government. The Chinese government will own about a 70 percent stake in the venture, to be capitalized at $700 million, and NEC will own the rest. The project, which is part of China's five-year economic plan, is called Project 909. Running through 2000, the venture will produce 20,000 chips a month. NEC will provide technology for processing memory chips.

53. Cadence Design Systems (United States), July 1997

Cadence Design Systems has signed an IC design tool contract with NEC. The three-year, $18 million contract will allow NEC to use Silicon Ensemble-DSM, an IC design tool, for deep-submicron design at its design centers worldwide. The tool boosts circuit design speed more than 20 times that of conventional tools.

54. Samsung (Korea), July 1997

NEC and Samsung have decided to cooperatively design a plant for 300mm wafers and help each other in equipment development. The alliance is aiming to get its 300mm wafer line up and running around 1999.

55. Tseng Labs (United States), September 1997

NEC Electronics announced the availability of an OEM reference design that combines the PowerVR PCX2 3-D graphics accelerator with Tseng Labs' 128-bit ET6100 2-D graphics and multimedia engine. NEC has formed a strategic alliance with Tseng Labs to develop PCI-compliant single-card reference designs based on the PowerVR architecture. This design offers PC OEM and graphics board manufacturers an all-in-one graphics solution that delivers arcade-quality 3-D rendering and high-performance 2-D acceleration for Windows applications. The single-slot PCI card supports game and entertainment titles written for Direct3D, PowerSGL, and DirectDraw, including more than 100 game titles that have been developed for or ported to the PowerVR architecture. VideoLogic's Apocalypse 5-D graphics board is the first product using the technology from NEC and Tseng Labs.

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56. Philips Semiconductor (Netherlands), November 1997

NEC and Philips Semiconductor have reached agreement to jointly develop system-on-a-chip LSIs for use in digital consumer electronic products. They will use the 64-bit VR4300 RISC microprocessor based on MIPS Technologies architecture as a core for the system-chip LSIs and share peripheral circuit libraries. Consumer sales account for 15 percent of NEC's semiconductor sales and 45 percent of Philips', respectively. The two companies plan to begin to commercialize system-chip LSIs in the second half of 1998, cooperating in production as well as marketing.

57. Lucent Technologies (United States), December 1997

Lucent Technologies' Microelectronics Group and NEC announced that Lucent has licensed NEC's 32-bit V850 MCU family core. Lucent will integrate the core into its 0.25- and 0.35-micron Silicon Suite system-level IC offering, enabling customers to design system-level integrated circuits based on NEC's 32-bit RISC MCU architecture. The agreement means the V850 core will now be available from the two companies. The core will be available to Lucent customers for integration in April 1998.

Nichimen Electronic Components

58. Luxsonor (United States), May 1997

Nichimen Electronic Components has teamed up with Luxsonor of California in DVD chip sales. The U.S. fabless company focuses on MPEG-2 decoder part development, and Nichimen planned to release as early as June the LS220, a DVD decoder chip built into a PC motherboard. To be made in Taiwan, the chip will be sold for less than 4,000. The Japanese distributor is aiming for first-year sales of ¥500 million. Luxsonor is working on the LS240, a power-saving chip, and Nichimen intends to market it, targeting notebook computer makers, within the year.

NKK Corporation

59. Toshiba (Japan), September 1997

NKK will reorganize its semiconductor business by introducing state-of-the-art semiconductor technology from Toshiba. Plans call for starting 32-bit RISC microcontroller production within the year. The steel company will pay Toshiba a one-time fee of an estimated ¥1 billion as well as license fees and will manufacture RISC chips at its Ayase Research Laboratory. NKK, which entered the semiconductor business in 1992, hopes to put its semiconductor operations into the black by fiscal year 2000, reducing its dependence on the memory business significantly.

Nomura Microsciences

60. Ionics (United States), July 1997

Nomura Microsciences has teamed up with Ionics Inc. of Massachusetts to market pure water-processing electrical deionization (EDI) equipment targeting semiconductor, pharmaceutical, and food processing companies in Japan, Korea, and Taiwan. The EDI system uses no chemicals and requires no waste water processing and therefore can remove 99 percent of silica, a task considered difficult. The U.S. company has supplied its EDI equipment to more than 50 plants worldwide, and Nomura is aiming to sell ¥20 billion to ¥30 billion worth of ultrapure water-processing systems over the next five years.

Nozaki Industry

61. High Yield Technology (United States), May 1997

Nozaki Industry will import a particle monitor system from High Yield Technology of California. The In Situ Particle Monitor (ISPM) is attached to vacuum process semiconductor equipment and eliminates use of a dummy safer. The standard system is priced at about ¥4 million. Nozaki is aiming first-year shipment of 100 ISPM systems.

Oki

62. Synopsys (United States), January 1997

Silicon Architects of Synopsys has announced that Oki Electric of Japan has licensed Synopsys' cell-based array (CBA) architecture for its 0.35-micron ASIC products. Oki will use the CBA architecture to develop 0.35-micron ASICs for both internal and commercial use. Other products will include microcontrollers, MPU and peripheral ICs, speech ICs, and telecom ICs. Oki will develop designs using CBA design tools, which integrate CBA libraries, CBA compilers, the CBA Design Systems, and commercial EDA tools. Over the past year, Synopsys has also announced CBA licensing agreements with Fujitsu, Matsushita, Mitsubishi, NEC, Toshiba, and TriTech.

63. Artisan (United States), April 1997

Artisan Components, formerly VLSI Libraries, a supplier of embedded memories and other physical component intellectual property (IP), has received a multimillion dollar worldwide purchase agreement from Oki Electric. Oki has selected Artisan as its sole external supplier of memory generators and has agreed to incorporate Artisan's family of physical IP components into all of its new 0.35- and 0.45-micron internal standard products and ASSPs. Under the agreement, Oki will purchase a complete family of Artisan's memory generator, including standard single-port and dual-port SRAMs. Also, Oki's R&D centers in both Japan and the U.S. are adopting Artisan's technology.

Rohm

64. DSP Group (United States), March 1997

Rohm will license DSP core technology from DSP Group of California. Rohm will use DSP Group-developed 16-bit fixed-point PineDSPCore and OakDSPCore to develop system-on-a-chip LSIs for mobile communications and multimedia equipment. Specifically, Rohm expected to commercialize controllers for cellular phones, high-speed modems, and CD-ROM/DVD drives by the end of 1997. DSP Group licenses its audio-compression technology to a dozen companies, including AT&T, Intel, and Microsoft, and its DSP core technology to more than 20 companies, including Asahi Chemical, Kenwood, and NEC.

Ryosho Electronics

65. NeoParadigm Labs (United States), April 1997

Ryosho Electronics signed an exclusive agreement to sell in Japan LCD signal processing ICs developed by NeoParadigm Lab (NPL) of California, a start-up developer of multimedia LSIs. Designed for large STN LCD panels, the new LCD signal-processing IC directly processes analog RGB signals from the PC, reducing the signal-processing circuit cost to less than ¥10,000. Sample shipment was expected to begin in September, and Ryosho aims to sell 50,000 units the first year. Ryosho was established to sell DRAMs produced by Powerchip Semiconductor, a Taiwan-based joint venture, and by Mitsubishi Electric, Kanematsu and the UMAX Group of Taiwan, and aimed for fiscal 1997 sales of ¥6 billion.

Sankyo Engineering

66. Sugai (Japan), April 1997

Japan-based Sankyo Engineering and Sugai revealed that the companies will form a partnership for developing new auto wet stations, which can be used for 256Mb DRAM cleaning processes and new processes for 12-inch wafers. The companies will also begin developing common part specifications for their equipment in order to reduce parts inventory, and hence cost, while maintaining availability. According to the announcement, Sankyo Engineering and Sugai will consider exchanging stock or further investment in future partnerships if they find enough benefits.

Santoku Chemical

67. Mitsui & Co./Merck (Germany), October 1997

Santoku Chemical, Mitsui & Co., and Merck of Germany have established a joint venture in Singapore to produce ultrapure hydrogen peroxide water for cleaning semiconductor chips. Capitalized at about ¥700 million, Santoku Merck is owned 49 percent by Merck, 31 percent by Santoku, and 20 percent by Mitsui. The partners will invest ¥2 billion to construct a plant with an annual processing capacity of 10,000 tons, which will start operations in November 1998. Plans call for producing hydrogen peroxide water with particle per trillion-level purity. Santoku Merck is aiming for sales of ¥2.5 billion in 2005.

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Seiko Epson

68. Lattice Semiconductor (United States), March 1997

Lattice Semiconductor has signed an agreement to advance Seiko Epson up to $150 million to assist in the funding of a new 8-inch wafer fab, currently under construction in Sakata, Japan. The agreement calls for Lattice to make a $90 million advance payment to Seiko Epson to set up the new fab over the next two years, with an option for an additional $60 million advance. In return, Lattice will receive guaranteed 8-inch, sub-micron wafer capacity. The advance payments will be repaid by Seiko Epson with wafers over a multiyear period. Lattice planned to manufacture next-generation, high-density, in-system programmable logic devices (PLDs) at the new facility beginning in 1998, initially using 0.35-micron CMOS process technology and later migrating to 0.25-micron process technology.

69. Exemplar (United States), June 1997

California-based logic synthesis tool supplier Exemplar Logic announced an agreement to jointly develop libraries for Seiko Epson/SMOS ASIC libraries for Exemplar's Leonardo design environment. As a result of this agreement, Seiko Epson/SMOS ASIC libraries are being distributed by both Seiko Epson and Exemplar Logic, and Exemplar's Leonardo becomes part of Seiko Epson/SMOS ASIC design flow worldwide. The high-precision delay models jointly developed by both companies interface to the Seiko Epson ASIC development system, Auklet. They are available to Seiko Epson/SMOS customers.

70. Mitsubishi (Japan), October 1997

Seiko Epson has tied up with Mitsubishi Electric in the DRAM business. The companies have agreed that Mitsubishi will provide Seiko Epson with 64Mb DRAM design and production technology and that the latter will launch production at 1 million units per month at its Sakata plant from the second quarter of 1998. Mitsubishi will initially purchase all units to be produced at the plant, but Seiko Epson is considering marketing the memory chips under its own brand name. Seiko Epson, which recently completed a ¥100 billion semiconductor production facility at the plant, had been looking for memory products, which will help with stability of operation.

Seiko Seiki

71. Jenoptik Infab (Germany), December 1997

Seiko Seiki, a Seiko Instruments Group company, will team up with German automated semiconductor production system maker Jenoptik Infab. The companies are signing an agreement concerning the standard mechanical interface SMIF() system, a localized clean environment system for wafer transport. Under the agreement, Seiko will provide installation, maintenance, and servicing in Japan for Jenoptik's SMIF systems, which are widely used in Europe, the United States, and Taiwan.

Sharp

72. SanDisk (United States), January 1997

SanDisk and Sharp signed a cross-licensing agreement that gives the companies worldwide rights to each other's patents for flash memory products. Terms of the agreement were not disclosed.

Shin-Etsu Handotai

73. Soitec (France), May 1997

Shin-Etsu Handotai will form a partnership with France-based Silicon on Insulator Technologies to mass-produce next-generation SOI wafers. Soitec has a cutting-edge SOI wafer technology known as Smart Cut, which combines a hydrogen ion implantation process with a conventional wafer-bonding method. This process seems to have an advantage in fabricating so-called ultrathin-film SOI wafers. Soitec has shipped the wafers under the Unibond name since the middle of 1996, and the company plans to expand its production facility in Grenoble, France. SEH and Soitec will develop mass-production technology for this process, and SEH also will construct a factory for SOI wafer production in Japan. Both companies plan to provide 1 million 8-inch wafers per year by 2000.

Sony

74. Toyoda Automatic Loom (Japan), June 1997

Sony and Toyoda Automatic Loom, the funding company of the Toyota Motor Group, are negotiating joint manufacturing of low-temperature, polysilicon active-matrix LCDs. The arrangement would give Sony the production capability to take advantage of emerging high-volume display opportunities, including the enormous automotive market, and it would provide Toyota with captive access to leading-edge display components.

75. Advanced RISC Machines (United Kingdom), July 1997

Sony has forged an alliance with Advanced RISC Machines of the United Kingdom in the 32-bit RISC processor business. Sony will develop and supply system-on-a-chip LSIs based on the ARM7TDMI RISC processor core targeting digital AV equipment, cellular phone, and PDA applications. Sony positions the ARM7 core as an MPU core for its 0.4-micron ASCS ASIC products. ARM's MPU core has been licensed to about 20 chipmakers and used for a range of applications.

76. Sharp/Philips (Netherlands), July 1997

Sony, Sharp, and Philips are jointly developing a next-generation large LCD for such applications as a wall TV. Not to be outdone by its competitors, including Fujitsu, that are leading in the large-screen display competition by concentrating on plasma display panels, the three partners will develop a plasma address LCD that they believe can be as large as 40 inches. Plans call for installing a pilot line at Sony Mizunami, where the partners will send their engineers to develop mass production technology. The companies are aiming for commercialization in 1998.

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77. Oki (Japan), August 1997

Sony and Oki Electric will team up in the system-on-a-chip LSI business. They are discussing mutually commissioning production of a chip that integrates a microprocessor and DRAM on a single chip using a 0.25-micron process technology. The two companies, which reached agreement to jointly develop 0.25-micron system-chip LSIs in May 1995, are independently marketing system-chip LSI made using a 0.35-micron process. Sony and Oki, which are about to see the result of their joint development effort, seek to effectively use their management resources by commissioning production to each other.

Sumitomo Chemical

78. Olin (United States), September 1997

Sumitomo Chemical announced that it will cooperate with Olin, a U.S. chemical company, in the area of i-line photoresists used in production of 16Mb to 64Mb memories. Olin will have exclusive manufacturing rights to Sumitomo Chemical's advanced i-line photoresists in the United States and Europe. Olin, a supplier of i-line photoresists in the U.S. and European markets, will also have nonexclusive rights to sell such materials in those regions. Use of Olin's production facilities will enable Sumitomo Chemical to secure a foothold in these markets. Sumitomo Chemical is planning to increase annual sales of i-line photoresists from the current ¥12 billion to ¥30 billion in five years.

Sumitomo Corporation

79. Tokyo Kaseihin and others (Japan), January 1997

Tokyo Kaseihin will establish a lead frame production venture in Singapore with two Japanese manufacturers through its local subsidiary. To be capitalized at $50,000, the new venture will be owned by Tokyo Kaseihin subsidiary TOK Singapore, Osaka-based parts maker Iijima Metal Seisakujo, and Osaka-based packaging materials maker Shinko at a ratio of 1:2:2.

80. R. Howard Strasbaugh (United States), June 1997

Sumitomo Corporation set up in July a joint venture with R. Howard Strasbaugh of California to sell next-generation wafer-polishing machines developed by Strasbaugh. SC Semicon Technology is capitalized at 300 million, in which Sumitomo and Strasbaugh invested 85 percent and 10 percent, respectively. The CMP machine developed by Strasbaugh features a wafer surface roughness of 250 angstroms, 10 times the precision of conventional machines, and can process about 60 wafers per hour, three times the usual throughput. It is priced at ¥200 million. SC Semicon is aiming for first-year sales of ¥3.5 billion, targeting manufacturers of 64Mb DRAM chips.

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81. Pixtec (United States), November 1997

Sumitomo Corporation has bought exclusive domestic sales rights to field-emission display (FED) panels from California-based Pixtec. The company, which is also authorized to market the products in Asia, will invest $10 million in the U.S. company in return. Pixtec plans to commission 5.2-to 8.0-inch FED panel production to leading Taiwanese LCD maker Unipac and ship 10,000 units per month starting in April 1998. Sumitomo, which handles ¥50 billion worth of CRT and LCD materials and products annually, is aiming to expand FED sales to ¥3 billion and ¥10 billion in the first and third years, respectively.

Tokyo Seimitsu

82. Super Silicon Institutes (Japan), March 1997

Tokyo Seimitsu will develop a 400mm-wafer wire saw jointly with the Super Silicon Institutes (SSI). The company will deliver a wire saw to the SSI by November, and the parties will jointly make enhancements with the goal of completing a practical unit by 2001. The SSI is a Gunma-based institute specialized in 400mm wafer technologies, established in March 1996.

83. Seiko Seiki (Japan), December 1997

Tokyo Seimitsu will form an alliance with Seiko Seiki in the semiconductor equipment business. The partners will combine Tokyo's alignment-measuring technology with Seiko's high-precision processing technology to develop wafer dicing and other technologies. In the meantime, Seiko Seiki, which has been marketing dicing saws since 1995, will stop production and procure products from Tokyo Seimitsu.

Toshiba

84. Unigen (United States), February 1997

Unigen announced that it will work with Toshiba America Electronic Components as a manufacturer of Toshiba-certified memory modules for sale under the Toshiba brand name. Toshiba expected to audit and qualify Unigen's production facility in the first quarter of 1997, and the Unigen/Toshiba team could begin shipping Toshiba product in the second quarter. Unigen is a Fremont, California-based third-party memory module manufacturer that focuses on the OEM channel.

85. Samsung (Korea), February 1997

Toshiba will acquire 20 percent of Samsung Austin Semiconductor of Texas, a Samsung Electronics subsidiary, and procure the 20 percent of 64Mb DRAMs the Texas company will manufacture for sales under its own brand name. Slated for completion in June 1997, the first facility of the Korean subsidiary, in which Intel also has a capital stake, expected to launch 64Mb DRAM production by year's end and have a monthly output capacity of 2.3 million units by the end of 1998, when it expects to be fully operational. Samsung Austin Semiconductor plans to invest $1.3 billion to construct three facilities by 2003.

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86. Motorola/Fairchild (United States), March 1997

Toshiba, Motorola, and Fairchild Semiconductor will jointly develop next-generation high-speed CMOS standard logic ICs. The three companies will work together to develop 2.5- and 3.3V CMOS standard logic ICs with a propagation delay time of 2ns. The new devices will be suited for ATM and ISDN network and engineering workstation memory address control use. They will introduce compatible products simultaneously to develop an untapped market. Plans called for commercializing the fast standard logic ICs by the end of 1997. The high-speed standard logic IC market is forecast to grow to ¥35 billion in 2000.

87. Sun Microsystems (United States), April 1997

Toshiba and Sun Microsystems have agreed to develop a Java processor chip for use in network computer terminals. The chip will consist of picoJava, microJava, and ultraJava. PicoJava will be the microprocessor's core, and microJava will integrate DRAM and a controller into picoJava. UltraJava will be an advanced model. Toshiba will be involved in developing a low-power microJava chip, with commercialization by Sun in 1998.

88. MIPS Technologies (United States), April 1997

Toshiba has licensed RISC microcontroller technology from the MIPS Group. The MIPS 16ASE is a 32-bit MCU core that helps to reduce the size and power consumption of printers and portable information devices. It allows for significant reduction of overall code size by compressing some instruction sets to 16-bit. The company plans to commercialize TX19 series MCUs based on the licensed core. The RISC type accounts for less than 10 percent of the company's total MCU sales in volume terms.

89. Technology Modeling Associates (United States), April 1997

Toshiba and Technology Modeling Associates have entered into a multi-year agreement in which the two companies will work jointly on development of software for 3-D simulation of semiconductor processes. The software tool will perform advanced modeling for diffusion, oxidation, ion implantation, rapid thermal annealing, silicidation, and point defects modeling. Toshiba is expected to use the simulator for the development of future generations of memory, microprocessor, and ASIC devices. Under the term of the agreement, Toshiba will provide funding, deep-submicron process technology development requirements, and test data. The TMA product, part of TMA's suite of semiconductor simulation tools, is expected to be released in late 1998.

90. NeoMagic (United States), May 1997

Toshiba announced in May that the company was about two months away from first silicon on a notebook graphics controller, with embedded DRAM, that will be manufactured for NeoMagic. To date, NeoMagic has worked with Mitsubishi Electric as the foundry for its graphics controllers. Toshiba will employ a 0.25-micron process optimized for embedded memory and a 128-bit on-chip memory bus.

91. Chartered Semiconductor (Singapore), June 1997

Toshiba will license DRAM-mixed logic IC technology to Chartered Semiconductor of Singapore, to which it licensed CMOS logic technology in November 1994. The Singapore company will use Toshiba's 0.25- to 0.35-micron process technology to launch production in 1998. The DRAM-mixed system-chip LSI market is expected to reach about ¥400 billion in 2000.

92. iReady (United States), June 1997

Toshiba will license Internet access LSI technology from iReady of California. The company has signed a five-year contract to use the U.S. company's Internet tuner technology for providing Internet access using an LSI, which eliminates control by a CPU and cuts power to 1/700th the level of software-driven Internet access. Toshiba planned to develop by the fall a functional block that will be embedded on a system-on-a-chip LSI to be built into cellular phones and TVs.

93. ViewLogic (United States), July 1997

Toshiba has teamed up with ViewLogic of the United States in the ASIC business. The companies will support Motive, a static timing tool that helps significantly reduce the time needed to design system ASICs with 1 million gates, and Testgen, a tool to automatically generate test patterns to test path delay trouble. Toshiba explained that, with the tools, logic testing time can be slashed to 1/40th the time it takes now. They were expected to become available starting in October.

94. IBM (United States), July 1997

Toshiba and IBM will form an alliance in new memory plant construction. The two companies will cooperate in commercializing a 300mm wafer by exchanging equipment technology information and are considering installing a joint production line at their joint production plant.

95. Winbond (Taiwan), September 1997

Toshiba has expanded its relationship with Winbond Electronics of Taiwan to include 256Mb DRAM production. Toshiba will provide Winbond with 256Mb DRAM production technologies and procure chips as an OEM starting around 2000, when demand is expected to pick up. As part of its move to establish a global DRAM production system, Toshiba expected to begin procuring 64Mb DRAMs from the Taiwanese chipmaker in January 1998.

96. Worldwide Semiconductor Manufacturing Co. (Taiwan), October 1997

Toshiba has teamed up with WSMC of Taiwan in semiconductor production. Toshiba will provide 0.25-micron logic PC process technology to the Taiwanese chipmaker and commission some of its logic IC production. A dedicated foundry set up in May 1996, WSMC is expected to start foundry production in July 1998 and launch a new line in 1999.

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Tosoku

97. Samsung (Korea), October 1997

Automotive part and precision machinery maker Tosoku has teamed up with Samsung Aerospace of Korea in the semiconductor wire bonder business. The partners planned to begin in December marketing a IC wire bonder they developed cooperatively by combining the Japanese company's semiconductor equipment and the Korean maker's linear motor technologies. The wire bonder achieves a leadframe transfer speed of 0.5 seconds/26.42mm and can process 400 42SOJ packages per hour. The companies are inclined to set the price below ¥9 million and intend to sell 100 units the first year.

Ulvac

98. Ramtron International (United States), March 1997

Semiconductor equipment maker Ulvac teamed up with Ramtron International of Colorado in ferroelectric RAM (FRAM) technology development. The companies will jointly develop ferroelectric materials such as lead zirconium titanate, ferroelectric thin-film process technology, and sputtering, etching, and ashing equipment over the next four years. Ulvac will start in 1999 to supply the new equipment it is developing in the joint project to chipmakers such as Hitachi, Rohm, Samsung, and SGS-Thomson, which uses Ramtron's FRAM technology.

99. Idemitsu Kosan (Japan), June 1997

Ulvac and Idemitsu Kosan will jointly develop a TFT panel transparent conductive film for larger substrates. They will combine Idemitsu-developed indium lead-based IDIXO film and Ulvac's sputtering equipment and process techniques to develop a transparent conductive film for use with LCD substrates of 13 and 14 inches to 17 and 20 inches. At present, polycrystal indium thin oxide film is typically used for TFT transparent conductive film. Ulvac and Idemitsu expect that LCD panel makers will start using the new film on production lines as early as 1998.

Yamaha

100. Xicor (United States), February 1997

Yamaha has teamed up with Xicor of California in the EEPROM business. Initially, the U.S. company will commission the Japanese company to manufacture EEPROMs, and both companies will cooperate in process technology development. Yamaha Kagoshima Semiconductor will start production in May 1998 at 2,000 six-inch wafers per month and will supply EEPROMs to cellular phone makers under Xicor's brand name. The world's No. 3 EEPROM maker, Xicor is reported to control the largest share, 30 percent, of the Japanese market for EEPROM used in cellular phones. Yamaha projects that Xicor-brand sales will reach ¥2 billion in the first year.

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Perspective

Semiconductors Asia/Pacific

Market Analysis

Asia/Pacific Semiconductor Industry Summary Report

Abstract: *Foundry profit is much higher than that earned by producing DRAM or other products. Considering profitability and great production capacity, no wonder global semiconductor manufacturers rush to enter the foundry market. Foundry products may actually be the battlefield we can count on. However, not every company entering this market will be able to keep its business running smoothly and make reasonable profits.*

By Jerry C. J. Yeh

An Overview

In the Asia/Pacific region, foundry is more heavily weighted in semiconductor manufacturing than before; manifest sales growth can be found in this area. Now, it is the major product of Asia/Pacific semiconductor manufacturers—especially during 1997 and 1998 when DRAM price was getting soft, foundry became the major product of semiconductor manufacturers. Although it is rather difficult to find a product able to sustain its profit at a certain level during years of economic recession, this business fills production capacity.

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Integrated Device Manufacturers—A Great Source of Foundry Customers

From the foundry client point of view, besides fabless companies that are surely in need of foundry capacity, integrated device manufacturers (IDMs) are also a great source of customers. In the past, when foundry capacity was limited and competition was less harsh, fabless companies were the major source of customers, although their order amounts were not large. However, at present, foundry capacity is increasing at a fast pace. How to get big orders from large IDMs has become a very important issue. The order amounts released by IDMs far exceed the amounts released by fabless companies.

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Therefore, it is a good idea for foundry companies to seek more orders from IDMs.

As to whether IDMs will require great amounts of overseas foundry service, it depends on changes in the manufacturing environment, such as the trend of professional division of labor, the change of production processes, equipment, production costs, and so on. Besides, one also has to observe whether IDMs will experience great change in their OEM policies. Another consideration is that European countries and Japan are less willing to seek foundry partners. Thus, although foundry business grows, it may not suddenly increase in the market. After all, it takes time and needs the change of the overall environment to encourage the large international plants to hand out their production to other semiconductor manufacturers.

Foundry Competition—Magnificent Force from U.S. Companies

There is fierce competition among many companies, including Taiwanese companies such as Taiwan Semiconductor Manufacturing Company Ltd. (TSMC), United Microelectronics Co. (UMC), and World Semiconductor Manufacturing Co. (WSMC). Korean companies such as LG Semicon Co. Ltd. and Samsung Electronics Company Ltd.; Singaporean companies such as Chartered Semiconductor Manufacturing Ltd. (CSM); Japanese companies such as Toshiba Corporation and Seiko Epson Corporation; and American companies such as IBM undertake many foundry orders. All of these companies have extraordinary business operation ability. With the exception of TSMC, UMC, CSM, and WSMC, these companies do not treat foundry as their core business. Even so, they still occupy a large market share of the foundry business. Also, some joint ventures have undertaken many foundry orders from stock companies and nonstock companies. Because these companies are supported by their mother companies, they represent a magnificent force that is not to be ignored. This is also one of the key points that will affect foundry business in the future.

An analysis of competitive ability shows that manufacturers from Japan, Korea, Southeast Asia, and Europe may not be strong enough to threaten Taiwan, the country that is the dedicated foundry giant. Mainland China may grow stronger in the future, perhaps in the next five years. The semiconductor foundry industry should pay close attention to the U.S. market because the largest clients are located in the United States. Besides, American clients are keen to the market trends, although their present disadvantage is their inability to lower their production costs, and they do not yet treat the foundry business as their core business. Even so, U.S. competing parties such as IBM are worth observing.

Korea—Conservative in Production Capacity Expansion

Korean manufacturers have largely increased their market share of DRAM. According to 1995 and 1996 statistics, the three major Korean manufacturers represent more than 30 percent of the market share. Although the overall market share is less than that of Japan, Korea is starting to play an important role and is becoming more influential in the market. From 1993 to 1995, the DRAM market experienced about three highly profitable years at market climax. Under such high profitability, Korean manufacturers invested more capital to expand their production capacity in order to create more profit in the DRAM market. However, as DRAM production capacity has been overexpanded and the production process has continuously improved since the end of 1995, the supply of DRAM started to exceed market demand. New production capacity has been released continuously, but the problem of overproduction was never improved through 1996 or 1997. During this time, the price of DRAM plunged. Although Korean manufacturers continue to expand plants and rush to occupy more market share of DRAM, since 1996, earnings and profits have been on the decline. Eventually, under severe price competition, manufacturers lost money in 1997.

Through the 1997 economic turmoil, Korea accepted the International Monetary Fund's (IMF) financial relief conditions. Although in the short term Korea's economy will be largely damaged, in the long run, it will be able to rebuild itself more steadily. Under the financial relief conditions, Korea must adopt retrenching measures. Certain relevant investment plans must be retrenched. Credits of Korean banks were downgraded one after another. The Korean monetary system will certainly face a great rearrangement. Financing for Korean manufacturers will not be as easy as before; it will only be more difficult. Besides, Korean currency keeps depreciating, and Korean manufacturers keep building more debt. Korean manufacturers' investment costs and business costs will largely increase. Therefore, plans for semiconductor plant expansion in Korea will also be affected. According to the initial forecast, the investment amount in 1998 will be reduced by more than 50 percent of that in 1997. However, the semiconductor industry has become one of Korea's most important industries being developed. Because of the economic crisis of 1997, Korea will be more conservative in production capacity expansion in the future. The country will focus more on the development of production processes and product technology, especially in the development of logic products, which seem to have become the business to which each manufacturer is devoted.

Taiwan—Rushing into the Foundry Business

While the DRAM industry is slowing, foundry is becoming more prosperous. As market demand is growing strong and prices are decreasing, even the maximum productivity of the two professional domestic foundry companies cannot meet the great market demand. Therefore, their profitability in 1997 was quite good. This is also the reason why more and more companies are swarming into this field. Except for very few companies, most domestic semiconductor manufacturers plan to enter this field to divert risks that may occur by making overconcentrated products. In the meantime, production capacity can be fully utilized. At the same time, these manufacturers can also learn part of the technology of logic products.

Now that companies are rushing into the foundry business, the market is similar to that of three or four years ago when many companies were swarming into DRAM production. In the foundry business, some companies may lose in the battlefield, but at present, we cannot yet judge the extent of the negative effect that such a situation will bring to the market. Because semiconductor manufacturers always pursue economic value, it seems that the only alternative, particularly when productivity is growing at a rapid pace, is to fully utilize production capacity, which has become an important issue to all business operators. In the competitive world of the global semiconductor industry, Taiwan is only a technology pursuer; its advantages are largely built in the mode of mass-production or flexible-production capability. Under such circumstances, choosing a single product such as DRAM or combining many factories to undertake foundry seems to be the way to go.

With a limited scale of individual domestic companies, capital and specialists in this field are not easy to be found. It will certainly be difficult to expand the production lines of each company to divert risks. This situation is the optimistic factual limit. In Taiwan, when an 8-inch wafer fab has been established, it is very difficult to find a way to fully utilize the production capacity of large production equipment for 8-inch wafer fabs. Because of this, it is not hard to imagine that it will be even more difficult when 12-inch wafer fabs are established in the future. Under such great pressure of production capacity—except for DRAM and foundry—hardly anything else can be found to fill the production capacity. Therefore, seeking orders from other companies has become a market trend, and foundry certainly has become the business that most people are interested in. This is also an inevitable market trend. However, under such circumstances, industrial competition is becoming more fierce, which will force profits to decline to a more reasonable level. This may be an inevitable market trend as well.

Singapore—Government Participates in the Investment and Planning of New Wafer Fabs

Singapore is a city state that lacks various kinds of natural resources. Even Singapore's water source depends on the supply from Malaysia. In order for people to enjoy prosperous lives, developing high-tech industries has been the only way to go. Through the efforts of a few far-sighted leaders who provided favorable measures through the government to encourage industries, and with other conditions such as Singapore's excellent geographic location, a few semiconductor manufacturers—such as Philips Semiconductors Inc., Texas Instruments Inc., and Hitachi Ltd., among others—from Europe, the Americas, and Japan started to set up plants in Singapore. Local low-cost, high-quality labor is utilized to undertake the work of "high-tech processes." Also, Singapore's excellent geographic location is utilized as a transit station in the Asia/Pacific region. Most Singapore manufacturers have sealed packaging plants that have the most extensive history in the country. Singapore has become one of the most important countries with the most sealed packaging companies in Southeast Asia.

Most foreign companies consider Singapore to be a "high-tech assembly center." To further increase its added value, the Singaporean government has used the same methodology in recent years as was used before to develop other industries, trying to introduce foreign companies to further develop the production of IC wafers. Also, the Singaporean government participates in the investment and planning of wafer plants. In 1994, the Economic Development Board (EDB) set up the Cluster Development Fund (CDF) to proceed with various strategic investments. The main purpose of the CDF is to encourage establishment of technology-intensive companies (as opposed to labor-intensive, manual assembly companies), to promote the development of industry clusters, and to solidify the industrial basic structure. Recently, EDB Investments of Singapore formed a joint venture to build a new wafer fabrication facility in Singapore's Pasir Ris Wafer Fab Park. The partners include the Royal Philips Electronics of the Netherlands and TSMC.

Dataquest Perspective

Recently, under the pressure of the declining global DRAM market, manufacturers that focused production on DRAM now have to expand their product lines to divert risks. On the other hand, under the global embedded-device trend, business operations between DRAM and logic products are no longer separate. To meet embedded and system-level integration requirements, manufacturers must obtain the new technology that they did not specialize in previously. Therefore, foundry has become one of the methods to obtain logic technology. Recently, foundry profit has been much higher than that earned by producing DRAM or other products. Considering profitability and greater production capacity, it is no wonder that global semiconductor manufacturers are rushing to enter the foundry market. Foundry products may actually be the battlefield that we can count on. However, not every company entering this market will be able to keep its business running smoothly and make reasonable profits.

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Perspective

Semiconductors Asia/Pacific
Market Analysis

Asia/Pacific Semiconductor Market Forecast, Fall 1998

Abstract: *Dataquest forecasts that Asia/Pacific semiconductor revenue will grow 14.6 percent in 1999, totaling $36 billion, following an unexpected 3.5 percent decline for 1998. By 2002, Asia/Pacific semiconductor revenue will total $61 billion, which marks a 13.3 percent-plus CAGR for the five-year period from 1997 to 2002.*
By C.S. Kim

Asia/Pacific Semiconductor Forecast Assumptions

Macroeconomic Assumptions

By all indications, Asia's economic conditions have worsened. Economic activities have slowed across Asia, and most of the region's economies now find themselves cornered and battered by a flurry of economic ills that defy easy, unilateral solutions. Meanwhile, Asia's troubles are imposing punishing economic strains on emerging economies elsewhere. From Russia and Africa to the Middle East and Latin America, emerging economies outside of Asia find themselves struggling with the depressed commodity prices and general wariness of international investors toward emerging markets that have followed in the wake of Asia's turmoil.

The 1998 outlook for the world's developing economies has dimmed. Naturally, much of this change reflects the significant downward revision of forecasts for Asia/Pacific Basin economies. Dataquest estimates that growth among Asia/Pacific's emerging economies, including China, will average just 1.8 percent in 1998. Just when and how Asia will recover remains an open question. Macroeconomic conditions among the individual economies of the region range from shaky to disastrous. In many countries, domestic spending has been crushed by high interest rates and export growth curtailed for want

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of scarce credit. More importantly, foreign-capital inflows have all but ceased, and intraregional trade in Asia has virtually collapsed.

A number of forecasters now believe that resolving the economic crisis requires new policies that concentrate on the region as whole, including Japan, rather than individual countries. Such policies would give top priority to reviving intraregional trade and reducing the threat of competitive currency devaluation. Dataquest expects that there will be gradual improvement in Asia beginning next year. Dataquest expects emerging Asian economies' growth to jump to 4.3 percent next year and average upward of 6.0 percent through 2002. Still, these results can hardly be considered a sure bet. Between Japan's distressed state and the apparent antipathy of foreign capital toward the region, Asia's economic future faces significant downside risks. Table 1 shows Asia/Pacific's projected GDP change from 1997 to 2002.

Table 1
Asia/Pacific Gross Domestic Product Growth, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002
Australia	3.3	3.3	3.3	4.0	3.8	3.7
China	8.8	7.5	8.0	8.2	8.5	8.7
Hong Kong	5.3	-1.2	-2.0	1.0	3.0	3.9
India	5.2	4.9	5.4	6.3	6.9	6.8
Indonesia	4.6	-13.5	-3.9	3.2	4.3	6.0
Japan	0.8	-1.8	1.4	2.4	2.9	3.0
Malaysia	7.8	-1.3	1.8	3.5	5.8	6.8
New Zealand	2.3	2.6	2.6	3.0	3.1	3.1
Pakistan	3.4	4.7	5.5	5.8	6.0	5.7
The Philippines	5.2	1.5	4.0	5.5	5.9	6.0
Singapore	7.8	1.3	3.0	4.8	6.8	6.8
South Korea	5.5	-4.8	0.6	4.8	5.6	5.6
Taiwan	6.8	5.2	5.3	5.4	5.7	6.1
Thailand	-0.5	-5.8	0.8	2.6	4.2	5.9
Vietnam	8.8	6.1	7.7	9.2	9.0	9.0

Source: Dataquest (July 1998)

Assumptions for Electronic Equipment Production

Assumptions for Data Processing Equipment Applications

Data processing equipment will continue to be the mainstay of Asia/Pacific electronics production. PCs and PC-related components (such as motherboards, rigid disk drives, CD-ROM drives, and application boards) will continue to constitute the backbone of regional data processing electronics.

The graphics chip market will face pricing pressure even as manufacturers continue to add features. The corporate computing market will continue to be slow to demand 3-D graphics features. While it is difficult to buy non-3-D products today, the issue is one of corporate users buying down on the value scale rather than buying up.

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The audio market will face increasing competition from integrated designs with sound chips on the motherboard. Price pressure is extreme and will continue for at least one more year.

A cyclical upturn in DRAM revenue in 2000 and 2001 will be the primary drivers of overall PC semiconductor market growth. PCs' main memory sizes will track historic trends and grow in the range of 40 percent to 45 percent annually.

Assumptions for Communications Equipment Applications

Communications equipment manufacturing is expected to grow at average annual rates in excess of 10 percent. Strong growth in mobile communications and public telecommunications equipment will provide the spark for this growth. Asia/Pacific will continue to remain the world's fastest-growing and most economically active region through the end of the decade.

The region's developing economies are expected to generate a huge demand for communications equipment of all types, but most especially, for premise and mobile equipment. Dataquest expects this surging local demand to stimulate the region's communications industry, generating high growth rates for premise telecom as well as mobile communications equipment.

Digital cordless telephones will retain continued popularity beyond 1999. The third-generation cellular technology is not expected to have a significant impact on semiconductor consumption during the 1997-to-2002 forecast horizon.

Driven by Internet bandwidth upgrades, semiconductor consumption by the public infrastructure equipment market will remain strong. Cable modems and xDSL modems are on track for deployment in the 2001/2002 time frame.

Assumptions for Consumer Electronics Applications

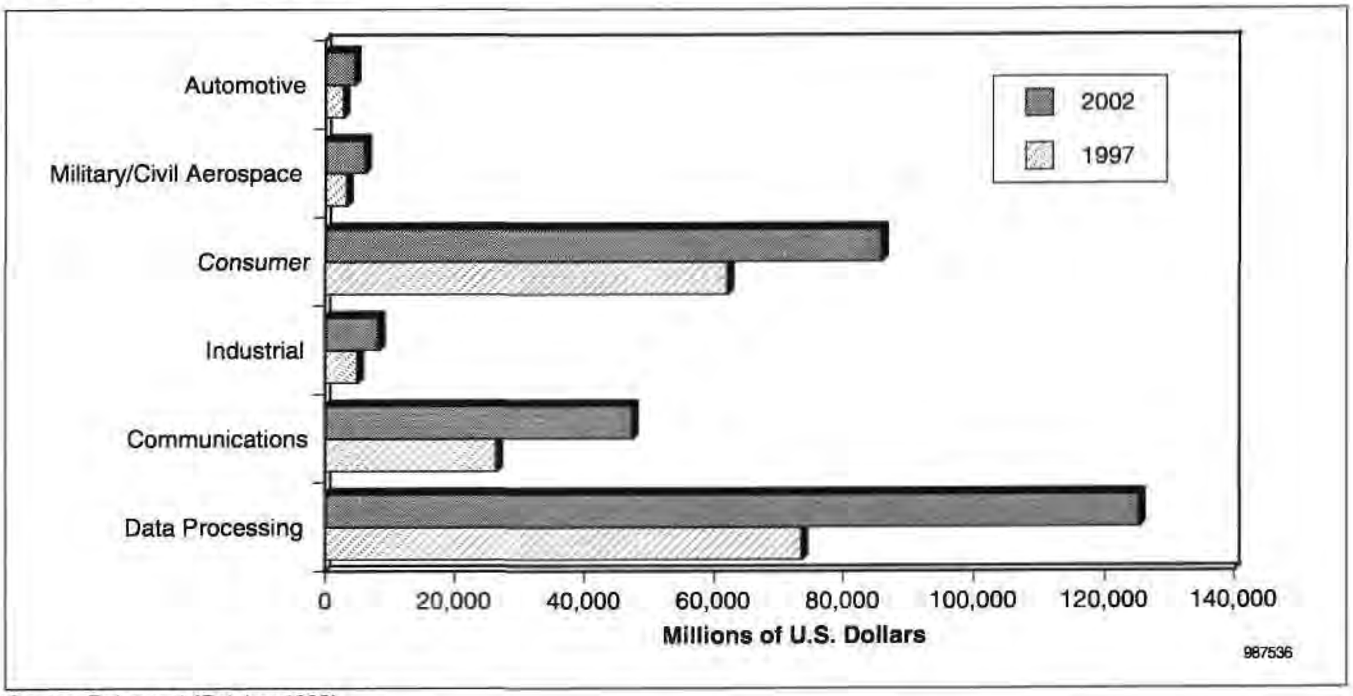
Consumer electronics will remain the second-largest segment of the region's electronics industry. Despite the recent retreat of the yen against the dollar, Dataquest expects Asia/Pacific to continue benefiting from Japan's production shift. In fact, Dataquest now expects Asia/Pacific to be the world's dominant producer of consumer electronics by 2002. Overall, consumer electronics is anticipated to average about 7 percent growth in the forecast period. Video and audio equipment will remain the mainstays of Asia/Pacific's consumer electronics production.

The Chinese demand for Asia/Pacific-produced consumer electronics could well rival export demand by 2002 if economic development in China continues at it dizzying pace.

The need to maintain low manufacturing costs for low-value-added products is likely to diffuse production of low-end consumer electronics into other parts of Asia/Pacific, especially Southeast Asia, in the forecast period. At the same time, rising labor costs in established manufacturing centers (that is, the Four Tigers) are likely to induce a shift in these centers toward higher value-added, higher-end consumer electronics.

Figure 1 illustrates the comparison by application type in Asia/Pacific electronic equipment production for 1997 and 2002.

Figure 1
Asia/Pacific Electronic Equipment Production Comparison by Application, 1997 and 2002 (Millions of U.S. Dollars)



Source: Dataquest (October 1998)

Asia/Pacific Semiconductor Forecast

Forecast Outlook

Table 2 shows that Asia/Pacific's semiconductor revenue will increase by 14.6 percent in 1999 and total $36 billion, following a 3.5 percent decline for 1998. In the long term, regional revenue will grow at a 13.3 percent CAGR and reach $61 billion by 2002.

The industry now moves toward the end of its third straight year of lackluster performance. The prior expectation had been for 1998 product market rebounds. The Asian financial crisis, along with low prices for DRAMs, cell-based ICs (CBICs), analog ICs, and other semiconductor devices, hindered semiconductor revenue growth this year. Few product segments will achieve more than marginal 1998 revenue growth, and year-end results remain a concern for semiconductor vendors.

The 1999 forecast assumes a sluggish demand in Asia/Pacific—at best—but also stable DRAM pricing. Most product markets will not strengthen until mid-1999, so next year's growth will concentrate in the second half of 1999. In addition, the long-term growth rate is slower than the prior forecast.

China/Hong Kong's semiconductor market will grow by 13.6 percent in 1999 and total nearly $7.9 billion. By 2002, the China/Hong Kong market will total $15 billion, which marks a 17.5 percent CAGR for 1997 to 2002.

Singapore's semiconductor market will grow by 13.7 percent in 1999 and total $5.4 billion. In the long term, Singapore's semiconductor market will total $9 billion in 2002, which means a 13 percent CAGR for 1997 to 2002.

South Korea's semiconductor market should increase by 13.7 percent in 1999 and reach the $5.7 billion level. By 2002, South Korea's semiconductor market will total $9.7 billion, which is a 12.1 percent CAGR for 1997 to 2002.

Taiwan's semiconductor market will increase by 15 percent in 1999 and reach about the $7.9 billion mark. By 2002, the Taiwanese semiconductor market will approach about $12 billion, for a nearly 12.3 percent CAGR for 1997 to 2002.

Table 2
Asia/Pacific Semiconductor Market Forecast by Country, 1997 to 2002
(Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Asia/Pacific	**32,534**	**31,400**	**35,978**	**44,526**	**55,815**	**60,795**	**13.3**
China/Hong Kong	6,769	6,957	7,906	10,262	13,226	15,143	17.5
Singapore	4,962	4,761	5,416	6,727	8,473	9,139	13.0
South Korea	5,490	5,055	5,747	7,090	8,589	9,733	12.1
Taiwan	6,754	6,893	7,929	9,372	11,656	12,044	12.3

Source: Dataquest (October 1998)

Forecast by Product

Asia/Pacific's semiconductor revenue will grow by 14.6 percent in 1999, totaling $36 billion, following an unexpected revenue decline of at least 3.5 percent for 1998. By 2002, Asia/Pacific's semiconductor revenue will total $61 billion, which marks a 13.3 percent-plus CAGR for the five-year period from 1997 to 2002. Table 3 provides the five-year forecast through 2002 by product type for the Asia/Pacific semiconductor market.

MOS Memory Forecast and Assumption

Table 3 shows that the Asia/Pacific memory market will increase by 23.7 percent in 1999 and total $6.2 billion, following a steep 23.6 percent decline for 1998. In the long term, the Asia/Pacific memory market will grow at a 14.5 percent CAGR and reach $12.8 billion by 2002.

The DRAM revenue for Asia/Pacific will increase by 28 percent in 1999 and total $4 billion, following a 33.6 percent decline for 1998. In the long term, it will grow at a 14.2 percent CAGR and reach $9 billion by 2002.

The Asia/Pacific SRAM revenue will increase by 20.1 percent in 1999 and total $792 million, following a 10.1 percent increase for 1998. In the long term, it will grow at a 19.8 percent CAGR and reach $1.5 billion by 2002.

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Table 3
Asia/Pacific Semiconductor Market Forecast by Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Semiconductor	**32,534**	**31,400**	**35,978**	**44,526**	**55,815**	**60,795**	**13.3**
Bipolar Digital	184	170	152	128	104	84	-14.5
MOS Memory	6,516	4,976	6,156	8,927	14,317	12,838	14.5
Dynamic RAM	4,642	3,081	3,944	6,146	11,025	9,015	14.2
Static RAM	599	660	792	1,096	1,276	1,476	19.8
Nonvolatile Memory	1,224	1,182	1,355	1,604	1,930	2,265	13.1
Other MOS Memory	51	53	65	81	86	82	10.0
MOS Microcomponent	10,885	11,050	12,210	14,250	16,700	19,610	12.5
Microprocessor	4,456	4,590	5,250	6,020	6,920	8,030	12.5
Microcontroller	2,313	2,210	2,450	2,990	3,540	4,180	12.6
Microperipheral	3,315	3,290	3,340	3,780	4,390	5,080	8.9
Digital Signal Processor	801	960	1,170	1,460	1,850	2,320	23.7
MOS Digital Logic	3,909	3,891	4,249	5,084	5,958	6,958	12.2
ASICs	1,662	1,640	1,830	2,308	2,842	3,463	15.8
Custom IC	425	311	221	155	100	60	-32.3
MOS Standard Logic	616	554	577	611	623	636	0.6
Total Other MOS Logic	1,206	1,386	1,621	2,010	2,392	2,799	18.3
Analog Monolithic	6,310	6,468	7,891	9,863	11,935	14,023	17.3
Total Discrete	3,817	3,900	4,300	5,100	5,500	5,800	8.7
Total Optical Semiconductor	913	945	1,021	1,174	1,301	1,481	10.2

Source: Dataquest (October 1998)

Nonvolatile revenue will increase by 14.6 percent in 1999 and total $1.4 billion, following a 3.4 percent decline for 1998. In the long term, Asia/Pacific's nonvolatile memory revenue will grow at a 13.1 percent CAGR and reach $2.3 billion by 2002. Flash memory and EEPROM will drive the nonvolatile market growth.

The following summarizes Asia/Pacific memory forecast assumptions:

- Nearly all memory prices will continue to suffer because of industry overcapacity.
- No near-term changes are anticipated in already existing bit or unit consumption trends.
- The effects of embedded memory on existing markets will be negligible.
- DRAM consumption will catch up with capacity in 2000, and an undercapacity will occur in 2001, which will be corrected in 2002.
- Flash memory will displace EPROM, but other memory markets will continue along their current paths: strong growth for EEPROM and modest growth for mask ROM and SRAM.

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MOS Microcomponent Forecast and Assumptions

The Asia/Pacific MOS microcomponent market will increase by 10.5 percent in 1999 and total $12.2 billion, following a 1.5 percent growth for 1998. In the long term, it will grow at a 12.5 percent CAGR and reach $19.6 billion by 2002.

The Asia/Pacific microprocessor (MPU) revenue will increase by 14.4 percent in 1999 and total $5.3 billion, following a 3 percent increase for 1998. In the long term, it will grow at a 12.5 percent CAGR and reach $8 billion by 2002.

The microcontroller (MCU) revenue in Asia/Pacific will increase by 10.9 percent in 1999 and total $2.5 billion, following a 4.5 percent decline for 1998. In the long term, the Asia/Pacific MCU revenue will grow at a 12.6 percent CAGR and reach $4.2 billion by 2002.

The Asia/Pacific microperipheral (MPR) revenue will increase by 1.5 percent in 1999 and total $3.3 billion, following a 0.8 percent decline for 1998. In the long term, it will grow at an 8.9 percent CAGR and reach $5.1 billion by 2002.

The digital signal processor (DSP) revenue will increase by 21.9 percent in 1999 and total $1.2 billion, following a 19.9 percent increase for 1998. In the long term, it will grow at a 23.7 percent CAGR and reach $2.3 billion by 2002.

The following are Asia/Pacific MOS microcomponent forecast assumptions:

- Intel Corporation's high-end Xeon processors will begin to offset desktop MPU average-selling-price erosion in the second half of 1998, but they will not be able to offset such price declines completely until 1999, when Intel offers support for four- and eight-way server configurations.
- Throughout the forecast period, general-purpose, "PC-like" devices will continue as the dominant mechanism for users to access the Internet and to perform other data processing functions in the home and office.
- PCs' average selling prices will continue to decline, as users see little reason to buy high-performance (and expensive) systems to use with current applications software that places few demands on CPU performance.
- In the later years of the forecast period, new software applications and usage paradigms will evolve, which will tax the processing power of the much faster processors than available and motivate users to replace older systems. Some of these new applications will expand the market by making computers relevant to users who previously had no need for such devices. Vast increases in communications bandwidth to homes and small office environments will enable many of these applications.
- Demand remains suitably strong for proven embedded applications, such as office equipment, routers and hubs, video games, satellite receivers, and set-top boxes.
- The attraction for building an ASIC with a deeply embedded MPU core will take away some embedded MPU business.

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- Prices for MCUs eroded rapidly during 1998, suggesting low 1999 price levels.
- Growth for 16- and 32-bit MCUs will increase more quickly than previously expected.
- More exotic features (such as flash memory) will be offered at low prices.
- Demand for cellular phones, modems, and risk drives is no longer increasing as fast as for DSPs.
- New architectures of high-performance DSPs reduce the cost per function in high-density DSP arrays.
- DSPs can open a host of new applications for mobile and Internet communications and consumer interactivity.

MOS Logic Forecast

The Asia/Pacific logic revenue will increase by 9.2 percent in 1999 and total $4.3 billion, following a 0.5 percent decline for 1998. In 1998, the ASIC market experienced the worst percentage revenue change in history. Gate array revenue declined by 13 percent, while revenue from CBICs increased marginally. In the long term, the Asia/Pacific ASIC revenue will grow at a 15.8 percent CAGR and reach $3.5 billion by 2002. This growth will be fueled, in part, by the trend to system-level integration (SLI).

ASIC and logic market growth stalled during 1998 for the following three main reasons:

- General industry slowdown
- Asian financial crisis
- An associated accelerated rate of average selling price declines

The following summarizes Asia/Pacific MOS logic forecast assumptions:

- Logic markets will remain flat into 1999. There will be no significant increase in ASIC/logic quarterly revenue until the second or third quarter of 1999.
- Other logic devices, which include application-specific products (ASSPs), should show strong unit growth but with above-average price declines.
- Custom ICs are rapidly being replaced by ASICs because they offer shorter time to market.
- Standard logic devices have a small number of suppliers, and the market remains relatively flat.
- ASIC growth will be driven by CBICs and PLDs at the expense of gate arrays.
- SLI will fuel the growth of the CBIC market as MPUs, DRAMs, and other intellectual property (IP) blocks get integrated on-chip.
- Key ASIC/ASSP application market drivers include disk drives, workstations, servers, digital cellular, LAN/WAN, premise and central

office switching systems, set-top boxes, video games, digital camcorders, still cameras, and digital TV.

- ASICs will be converted to ASSPs as each application market matures.

Analog Forecast

The Asia/Pacific analog IC revenue will increase by 22 percent in 1999 and total $7.9 billion, following disappointing marginal growth for 1998. In the long term, the Asia/Pacific analog revenue will grow at a 17.3 percent CAGR and reach $14 billion by 2002.

The following summarizes Asia/Pacific analog IC forecast assumptions:

- Demand has slowed PC, communications, consumer, and industrial equipment markets, among others.
- The Asian economic downturn and its rippling effects on the rest of the world are the main reasons for the demand slowdown.
- A recovering Asian economy and continued growth in the Americas and Europe in 1999, combined with the inventory reduction at analog IC suppliers in 1998, should bring strong growth back to analog ICs in 1999.
- A semiconductor boom cycle starting in 1999 will continue to result in strong growth for analog ICs in 2000 and 2001.
- The year 2002 could see a slowdown in analog IC growth, as the semiconductor market enters its next cyclical downturn.

Discrete Product Forecast

Asia/Pacific's discrete semiconductor revenue will increase by 10.3 percent in 1999 and total $4.3 billion, following a marginal 2.2 percent increase for 1998. In the long term, Asia/Pacific's discrete revenue will grow at an 8.7 percent CAGR and reach $5.8 billion by 2002.

The following summarizes Asia/Pacific discrete forecast assumptions:

- Product price instability across all discrete devices, which was prevalent through the first half 1998, has subsided. All discrete product groups are still in a state of ready availability. However, prices are returning to a state of stability.
- Continued instability in consumer electronics, data processing equipment, industrial equipment, and automotive equipment sectors indicate a slower-than-normal growth path for discrete devices through the second quarter of 1999.
- The delayed recovery in the semiconductor market may delay some competitor and user decisions to shift to the slowly evolving power discrete (MOSFET and IGBT) products. While large suppliers in the Americas (such as Motorola Incorporated) have lost product share to some of the European competitors, the consolidation of vendor activities and new market entrants may change the balance of supplier share and product activity in the next two years.

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- The long-term growth prospect appears moderate, as competitors and users transcend to power management devices. Consolidation or acquisition of competitors' products appear along with even more price instability for developing product areas.

Optoelectronics Product Forecast

The Asia/Pacific optoelectronic semiconductor revenue will increase by 8 percent in 1999 and total $1 billion, following a 3.5 percent growth for 1998. In the long term, Asia/Pacific's optoelectronic semiconductor revenue will grow at a 10.2 percent CAGR and reach $1.5 billion by 2002.

The following summarizes Asia/Pacific optoelectronics forecast assumptions:

- LEDs and laser diodes are the key market drivers.
- The LED growth has been moderated from the last forecast by the general industry slowdown caused by the Asian financial crisis.
- The laser diode market has been negatively affected by the slow consumer markets and positively influenced by the demand for bandwidth in the Internet-driven telecommunications market.
- Demand PCs and wireless handsets will return to higher levels in 1999.

Dataquest Perspective

In the long term, the total Asia/Pacific semiconductor market will grow steadily, at a 13.3 percent CAGR. Most semiconductor products—including analog ICs, digital ASICs, and DSPs—will grow steadily because of expanding production in digital consumer electronics and communications equipment. Their yearly growth rates will range from 16 percent to 24 percent, which mirror the total market growth rate. Following the post-1996 market decline, the DRAM market in 1999 will grow by 28 percent and reach $4 billion. The DRAM market should jump dramatically in 2000 and 2001.

Microcomponents will become the largest product market in 1999, with a $12 billion revenue. The microprocessor market growth will be slower starting in 1998 than in the high growth years of 1997 and before. In the long term, the microprocessor market will grow by 12.5 percent CAGR over the forecast period and reach $8 billion in 2002.

Non-PC applications (such as digital cellular, digital consumer electronics, and communications equipment) will drive demand for MCUs and DSPs, including embedded versions.

ASICs are a steadily growing semiconductor market. The trend toward SLI means high growth for CBICs but a long-term decline for gate arrays. The ASIC market should grow by 11.6 percent in 1999 to total about $1.8 billion. The SLI trend should drive Asia/Pacific's digital ASIC market to nearly $3.5 billion in 2002.

Analog ICs, which are used in a very wide range of products, are the second-largest product market in 1998 at $6.5 billion. Analog devices will remain the second-largest market over the forecast period. The analog device market will grow by 17.3 percent CAGR over the forecast period to total about $14 billion in 2002.

Looking at the long-term trends to 2002, mixed-signal ICs will experience solid growth, driven by applications such as digital cellular handsets. In addition, new emerging applications in consumer electronics and communications equipment markets will contribute to the growth of mixed-signal ICs. In the more traditional standard linear-product area, voltage-regulator products will continue to enjoy strong growth, as the demand for smart power continues to grow, especially in the portable electronic equipment markets.

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Perspective

Semiconductors Asia/Pacific

Vendor Analysis

AIC Semiconductor Sdn. Bhd.

Abstract: *AIC Semiconductor Sdn. Bhd. is the latest Malaysian company to enter the local semiconductor industry as a packaging subcontractor. This Perspective reviews the company's business operations and its expansion plans going forward. As semiconductor vendors continue to restructure manufacturing, AICS is positioned to gain from the trend to outsource assembly and test activities.*

By Ken Ng

Company Statistics

AIC Semiconductor Sdn. Bhd.'s company statistics include the following:

- Chairman—Haji Sarip Hamid
- Chief Executive Officer—Dr. Kuong Hoo
- General Manager—Beng Chooi Lim
- Number of Employees—518
- Estimated Fiscal 1998 Revenue—$19.2 million
- Fiscal Year-End—December 31

Company Milestones

AIC Semiconductor's two-year milestones are as follows:

- 1996
  - AIC Corporation Bhd. entered into a joint venture with Atmel Corporation to establish AIC Semiconductor Sdn. Bhd. (formerly known as Nucleus Semtek Sdn. Bhd.)

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- November—Began construction of production building
- 1997
  - June—Production building completed
  - July—Equipment installation
  - October—First production rollout and release of assembled ceramic BGA package type. Qualification release of assembled MCM-BGA package type.
  - November—Qualification release of assembled SO and PLCC package types
- 1998
  - January—Changed company name to AIC Semiconductor
  - February—Started SO package test operations
  - August—Qualification release of assembled VSOP package type
  - September—Qualification release of assembled PDIP package type

Vision Statement

The company strives to "to do an excellent job for customers, employees, and shareholders by becoming Malaysia's leading industrial group through continuously harnessing innovations and advanced technologies," according to its mission statement.

Company Structure and Operations Overview

AIC Semiconductor Sdn. Bhd. was established in May 1996 (then known as Nucleus Semtek) as the semiconductor unit of diversified Malaysian-listed AIC Corporation. AIC Corporation owns 97 percent of AIC Technology, which in turn holds the majority 55 percent stake in AIC Semiconductor. On top of this, AIC Corporation has a direct 10 percent stake in the company. The other equity owners are Atmel Corporation, with 20 percent, and Sierra Way Sdn. Bhd., a technical consultancy, taking up the remaining 15 percent stake.

AIC Semiconductor (AICS) is an assembly and test subcontractor located in the Kulim Hi-Tech Park, about 25 kilometers from the island state of Penang. The facility is sited on 11.8 acres of industrial land. The first production rollout delivered assembled BGA packages to Atmel in October 1997. A month later, the company moved into ramping output for PLCC and SO products. Packaging capacity is estimated to reach an equivalent of 312 million assembled PLCC 32-pin units. At this time, the types of packages have also increased to include PDIP and VSOP devices. AICS now operates three full production lines running on two 12-hour shifts. Table 1 presents an overview of the company's operations.

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Table 1
Overview of AIC Semiconductor's Operations

Item	Description
Location	Kulim, Malaysia
Start of Production	1997
Build-Up Floor Area	95,000 square feet
Workforce	518
Packaging Capacity (Units per Year)	312 million
Assembled Package Types	PLCC, PDIP, SOIC, TSOP, VSOP, BGA, MCM-BGA

Source: AICS and Dataquest (October 1998)

AICS' single customer, up to now, is Atmel. The five-year commitment from Atmel to take up to 100 percent of production capacity has provided the company with a stable road map to plan for increases in manufacturing volume and product range. According to Dataquest, Atmel was ranked as the third-largest worldwide vendor of nonvolatile memory devices in 1997. AICS receives probed wafers from Atmel on a consignment basis. The company returns the finished products to its customer after the assembly and test process. AICS ships the products to Atmel's three plants in San Jose and Colorado in the United States and Rousset in France.

Testing operations have started during the past six months. AICS has relied on Atmel's demand to ramp up its test operations. Total capital spending in 1997 was $24.1 million, including $7.3 million invested in land and plant construction (see Table 2 for exchange rates applied). The company expects to raise capital investment a further $6.7 million by the end of this year.

Table 2
Exchange Rates Applied, 1996 to 1998

Year	Malaysian Ringgit per U.S. Dollar
1996	2.52
1997	2.82
1998 (Projected Annual Average)	4.04

Source: Dataquest (October 1998)

Since October 1, 1998, capital controls were imposed by the Malaysian government to stabilize the ringgit and U.S. dollar exchange rate. AICS does not expect the fixed RM 3.8/U.S.$1 rate to impact its capital spending plans or direct material purchases. Instead, the controls should minimize risks from volatile, short-term currency movements. Although certain materials procured are denominated in the local currency, the majority of material purchases—such as gold wire, epoxy resin, and lead frame/substrate—are paid for in U.S. dollars. As the company's revenue is booked in U.S. dollars, the cost of material supply should be naturally hedged against proceeds from sales.

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Financial Results

AICS started initial product delivery late last year. In the first full year of operation, revenue is expected to reach $19.2 million, as production volumes and utilization rates have risen in tandem with Atmel's requirements. Assembly is estimated to account for nearly 70 percent of the 1998 revenue. The company's sales performance has also been advanced by the inclusion of the higher value-added test business. Since mid-1998, AICS has started to turn in positive cash flows on a monthly basis. However, initial expectations to record a profit for the entire year were adversely impacted by the semiconductor market downturn and the regional economic crisis. The AICS management predicts the company will just break even for the entire year. Steeper-than-expected average selling price (ASP) erosion and a delay in securing financing facilities have offset reductions in operational costs.

The company's management maintains an upbeat outlook for 1999. AICS is projected to register a twofold revenue expansion when extra production capacity and new products come onstream. AICS plans to increase the total number of production lines to five in the next fiscal year. The expansion will enable it to assemble new BGA and CSP devices. Other sources of additional revenue should come from the increased scope of test activities, finished product packaging (tape and reel type), and providing drop shipment services by the end of next year.

Organizational Structure

AICS has a total head count of 518 people, with 73 percent employed in the direct labor category. The management organization is staffed by a team of experienced industry personnel. Figure 1 illustrates AICS' senior management staff. This team is led by Dr. Kuong Hoo, the chief executive officer. He was previously with Intel Penang for 17 years, with the last two years as its managing director.

Supporting Dr. Hoo is a team of managers, each with more than 10 years of relevant experience in various multinational semiconductor companies in Malaysia. AICS has an experienced team to fill the production roles in the organization. To grow the company in the longer term, AICS intends to increase its customer base in the Asia/Pacific and North America regions. Although Dr. Hoo is leading the marketing function, AICS is also working with another partner in the United States to promote its services there.

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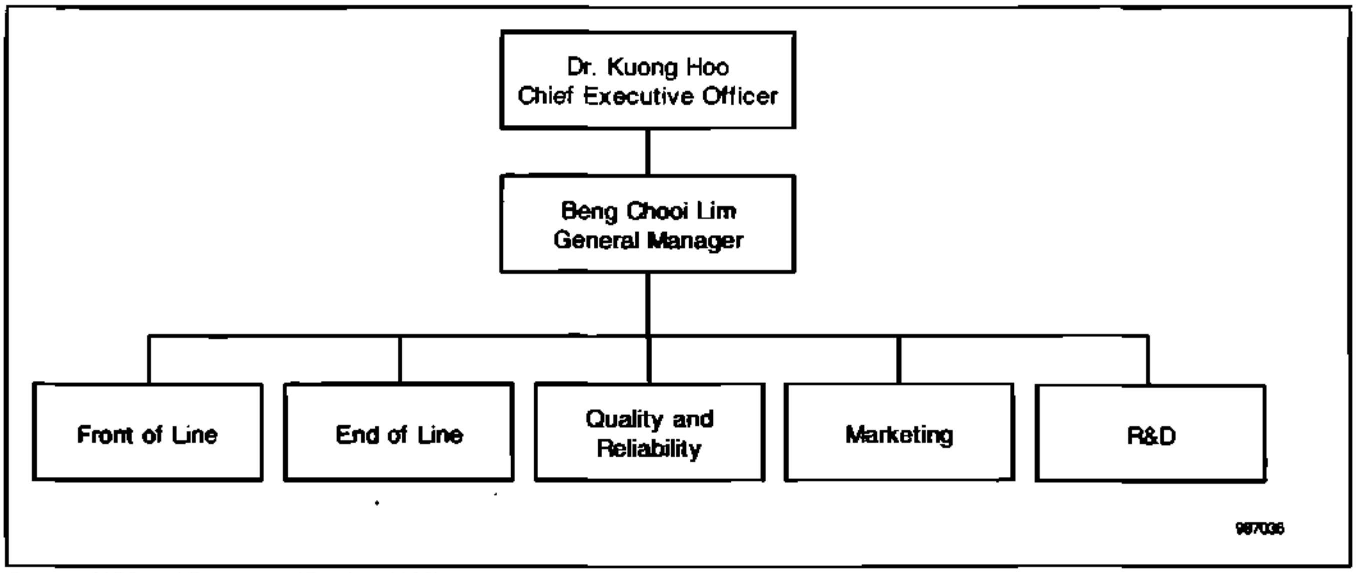
Figure 1
AIC Semiconductor's Organization



Source: AICS and Dataquest (October 1998)

Production Capacity and Growth

AICS has realized significant ramp-up of production output in its first year of operations. The facility's packaging capacity stands at an equivalent of 6 million assembled PLCC units per week, or 4 million assembly units and 2 million test units per week. Current utilization rates are estimated at 75 percent for assembly units and 25 percent of total production capacity. Recently, the company achieved full matching of assembly and testing for its SOIC package. It has managed to tool up capacity based on Atmel's demand for commodity products.

Table 3 presents AICS' packaging capability. Four more products slated for introduction in the last quarter of 1998 are PDIP 28-pin and TSOP 28-pin/32-pin/48-pin types. In addition, the packaging of smart card modules is expected to start later this year. Turnaround cycles for assembled products are comparable with industry lead times.

New products presently under development include higher value CSP (LAP) and BGA devices. AICS intends to introduce several versions of these two package types in the course of the coming year. The company's advantage lies in its fast adoption and transition into volume manufacturing of BGA packages. In 1999, unit production of smart card modules is expected to reach double the 1998 output level.

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Table 3
AIC Semiconductor's Packaging Capability

Package Type	Size
SOIC 8L	4.9mm x 6mm
PLCC 32L	12.4mm x 15mm
PDIP 28L	37mm x 16.5mm
PDIP 32L	42mm x 16.5mm
TSOP 28L	8mm x 13.4mm
TSOP 32L	8mm x 20mm
TSOP 48L	12mm x 20mm
VSOP 40L	10mm x 14mm
BGA 200 I/O	19mm x 19mm, 1.0mm ball pitch
MCM-BGA 120 I/O	14mm x 14mm, 0.8mm ball pitch

Source: AICS and Dataquest (October 1998)

The company plans to grow revenue next year by raising unit production and expanding its product range. In the volume-driven assembly business, economies of scale contribute to bringing down unit costs. Next year's capital spending budget calls for the addition of another two full production lines, requiring a commitment of $14.5 million. As installed production lines now occupy more than half of the built-up area, another 40 percent of production space is still available for expansion. In the longer term, the company also plans to reduce costs by developing materials in-house. Because there is currently only one customer, pricing agreements with Atmel have a direct impact on the company's performance. AICS strives to maintain a competitive cost structure since the benchmark prices for mature packages are based on market rates.

Strategic Alliances

AICS' capital requirements are provided by the holding company, AIC Corporation. This structure allows the start-up company to focus on its core activities, as the listed parent already has access to the capital markets. The company's strategic business partners are Atmel, its sister companies in AIC Corporation, and key suppliers.

Atmel, as the primary customer and a 20 percent stakeholder, collaborates with AICS to develop advanced packages and manufacturing processes. These include BGA, MCM-BGA, and CSP packages. Besides the in-house team of R&D professionals, this alliance represents an important source of technology transfer for the company. AIC Microelectronics Sdn. Bhd., the IC design sister company, cooperates with AICS to lay out BGA substrates. Another subsidiary in the AIC Corporation stable, Prodelcon Sdn. Bhd., supplies the assembly subcontractor with some of its packaging equipment and tooling requirements.

The supply of substrates is critical as the company targets to increase output of higher-value-added packages. Working relations have been established with key suppliers in the industry. Besides cooperating with Japanese multinational companies, the company has also engaged other suppliers in neighboring countries to develop a wide range of substrates for its products.

Future Direction

The Malaysian economic downturn has influenced AICS' growth plans. AIC Corporation had earlier intended to list its subsidiary on the proposed Malaysian technology board, called MESDAQ. However, the introduction of MESDAQ was delayed as a result of the deterioration in the local economy. AICS will now rely on financing from the parent company and Khazanah Nasional Berhad, the government's investment-holding company. Khazanah has decided to enter into a subscription agreement to participate with 25 percent equity interest in AIC Technology. This alternative source of equity injection should meet AICS' capital needs to drive growth going forward.

A continued weakness in the global semiconductor market caused Atmel to slash its capital spending plans. In May, Atmel announced the deferment of a $850 million joint-venture wafer fabrication project. The proposed 8-inch wafer fab is also located in the Kulim Hi-Tech Park. Dataquest estimates that this decision should delay the initial production start date at least until the year 2000.

Although AICS' business plans are not directly tied into this investment, output from the fab would have contributed significant positive gains to its revenue. Front-end wafer production will introduce demand for higher margin services (such as wafer probe test) and further raise assembly and testing volumes. The company's position as a major subcontractor for Atmel will be enhanced further. However, with production not expected until late 2000, AICS' revenue growth now depends on orders from Atmel's existing fabs.

To meet the quality requirements of current and prospective customers, AICS is working to obtain ISO 9002 certification by the beginning of next year. This undertaking is aligned with the company's quality policy of "total customer satisfaction." Besides the new products outlined in the previous section, the AICS road map includes new packages such as flip chip and TQFP series. The planned introduction schedule of these products ranges from mid-1999 to 2000. Figure 2 illustrates the AICS packaging road map. In the longer term, the company intends to shift production of lower-value-added products to other cost-competitive locations. Two possible countries identified for the proposed investment are China and the Philippines.

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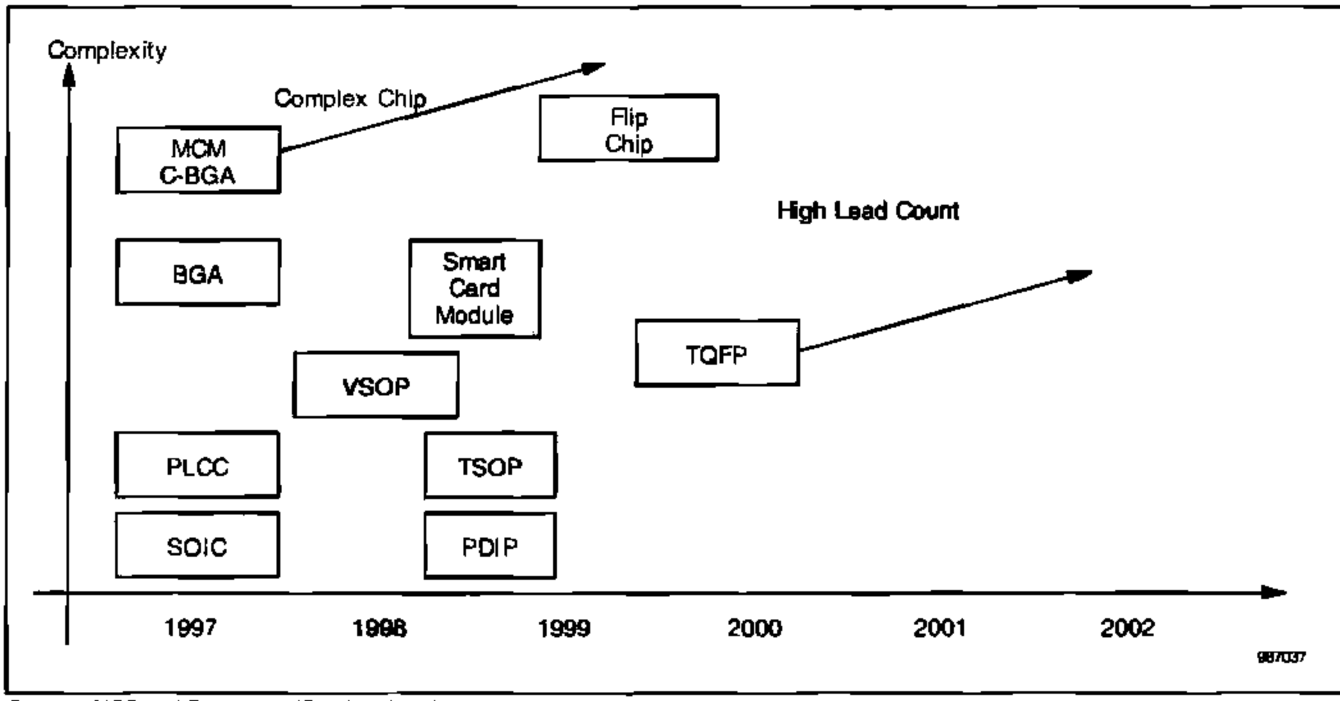
Figure 2
AIC Semiconductor's Packaging Road Map



Source: AICS and Dataquest (October 1998)

Dataquest Perspective

The evolution of worldwide semiconductor manufacturing activities has created growth for packaging subcontractors. According to Dataquest, worldwide IC packaging unit production is forecast to grow by 10.9 percent between 1997 and 2002. Among the package types, CSP and BGA devices should record the highest growth, with a compound annual growth rate (CAGR) exceeding 26 percent. AICS is poised to benefit from the growth.

AICS' smooth progression into volume production is attributed to the parent company's joint venture with Atmel, and the organization's team of experienced managers. In the highly competitive packaging business, emerging start-up companies outside the established first-tier subcontractors are challenged to become viable and to succeed. The struggle to keep afloat is even more pressing in light of the global semiconductor industry decline this year. AICS' 1998 performance reflects the tough market conditions, but on the positive side, a continuing trend by semiconductor vendors to increase outsourcing of production functions.

Other than incremental capital spending in plant and equipment, the company has already invested in methodologies to raise manufacturing efficiency. Information system investments will enable it to support other transactions and cost controls as the scope of services increases. As the company's production output rises rapidly, spare capacity would eventually become available. AICS is actively seeking out prospective customers, especially for its commodity products, to reduce reliance on a single customer. Diversification of the customer base would enable AICS to benefit from the outsourcing trend and realize balanced growth in the longer term.

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Perspective

Semiconductors Asia/Pacific

Vendor Analysis

Anam S&T Company Ltd.

Abstract: *This Perspective describes Anam S&T Company Ltd.'s financial overview, company history, and product summary and analysis. This report highlights Anam's activity in the semiconductor industry. Anam's revenue increased at an impressive 27 percent in 1997, to W 1,428.4 billion. Dataquest predicts that Anam's revenue will continue a steady growth owing to strengthened foundry business in nonmemory products, as well as packaging business.*
By C.S. Kim

Company Statistics

Anam S&T Company Ltd.'s company statistics include the following:

- CEO: In Kil Hwang
- Number of employees: 9,630 (as of June 1998)
- Fiscal 1997 company revenue: W 1,428.4 billion
- Fiscal year-end: December 31

FILE COPY:
MARIA VALENZUELA

Company Milestones

Anam's company milestones since 1968 include the following:

- 1968—Anam Industrial Co. Ltd. was founded in Seoul, Korea
- 1970—Started production and export of semiconductor products (TR, IC)
- 1977—Listed shares on the Korea Stock Exchange
- 1983—Established R&D Institute in Seoul

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- 1984—Started to produce semiconductor ICs in K2 plant
- 1988—Started to produce semiconductor ICs in K3 plant
- 1989—Established Amkor/Anam Pilipinas Inc. in the Philippines
- 1992—Achieved a cumulated export of U.S.$10 billion in the semiconductor business
- 1995—Announced entry into wafer fabrication foundry business
- 1996
  - Achieved total exports of U.S.$20 billion in the semiconductor business
  - Completed K4 plant and Buchon Fab 1
- 1998
  - The 30th anniversary
  - New CI announcement
  - Changed company name to Anam S&T Company Ltd.

Company Overview

Semiconductor Company Offers the Total Solution

Starting out as the first domestic company in South Korea's semiconductor industry in 1968, Anam has been able to maintain its leading edge in semiconductor packaging.

By adding wafer processing to its technologies in semiconductor design, photomask, packaging and testing, materials and equipment, Anam now possesses the capabilities necessary to offer total solutions for semiconductor businesses.

Anam Is a World Leader in the Packaging Market

Anam is always a step ahead of competitors in dealing with the fast-changing business management environment, especially in areas of technology innovation and the development of new materials, high-technology equipment, and new technology.

The world's major semiconductor companies pay royalties for Anam's independently developed Power Quad 2 (PQ 2) and super ball grid array (SBGA). Anam also enjoys the distinction of being the only company to export the semiconductor technology back to its country of origin, the United States.

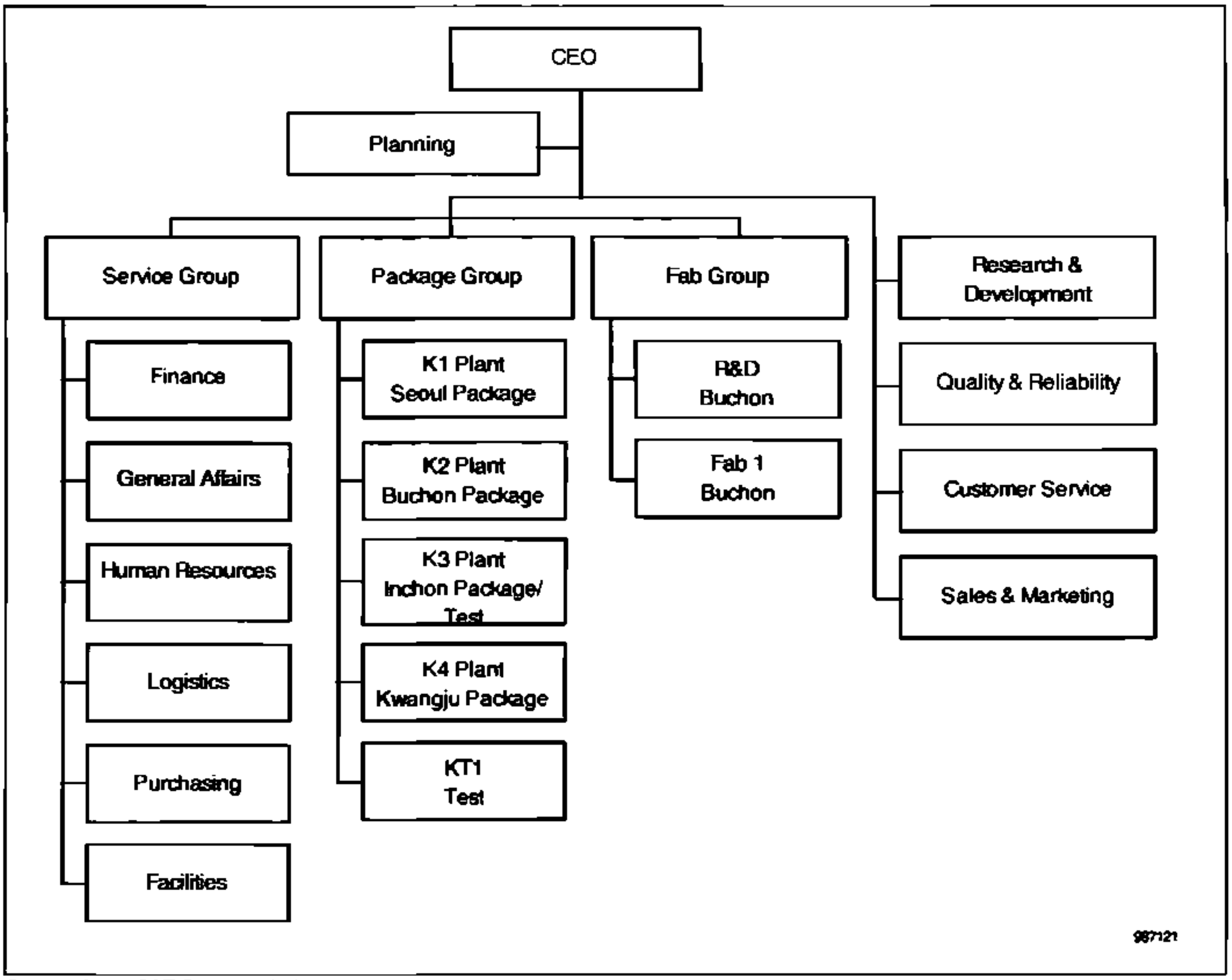
Before selecting the most optimal packaging design, Anam tries to reflect on the customer's needs and determine the affordable prices right from the product design stage.

Developing key component technologies—such as large die, fine pitch staggered bonding, multichip, and flip chip—enabled Anam to create light, simple, diversified, and highly efficient products to exert dominance in the packaging technology. It intends to continue its dominance in the world's packaging market into the next century by promptly developing and supplying the type of packaging customers want.

Organization

Anam's organization is divided into three core operating divisions. Figure 1 illustrates the structure of Anam's organization.

Figure 1
Anam S&T Company Ltd.'s Organization



Source: Anam S&T Company Ltd.

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Organization Scope

Package and Test Business Unit

Anam Will Implement Management System to Satisfy Customers

Pursuing global network and forceful marketing activities, Anam seeks effective ways to meet the total needs and demands of its customers. Its quality control is monitored by differentiating key technologies and eliminates defective products to near zero rate. Therefore, Anam's customer services are maximized.

Anam Is the World's Largest Semiconductor Packaging Company

Anam is utilizing 30 years of its accumulated technology and know-how to produce a variety of high-tech packaging. It has more than 200 customer-affiliated companies worldwide in the areas of semiconductors, electronics, information, and telecommunications. Its semiconductor IC packaging and testing company is the largest in the world. Anam has four plants in Seoul, Inchon, Kyonggi, and Kwangju, and their combined annual exports total more than U.S.$5 billion.

By 2000, the new semiconductor factory totaling 429,754 square meters will be completed at the science industrial development complex located in Kwangju, South Cholla Province. Upon completion of this large-scale plant, exports there and at plants in Manila and Laguna, the Philippines, will exceed U.S.$1 billion. This plant will have the world's largest production capacity and will corner more than 50 percent of the international semiconductor market.

Fabrication Business Unit

Anam Entered the Fabrication Industry, the Ultimate Business in Semiconductor, in September 1996

With 30 years of experience in the semiconductor business, Anam's fab division represents the ultimate semiconductor business. Equipped with 0.35-micron circuit-size high-technology and production facility, Anam's fab division will lead South Korea as the nonmemory, specialized semiconductor production company. With aggressive investment in technology development, it will become a world-renowned semiconductor foundry company.

Sales and Marketing

Anam Established a New Global Management System

Amkor Electronics Inc. was established in Philadelphia as a United States-based company to deal with Anam's overseas semiconductor marketing business. Working closely with Amkor, Anam had a head start over others in establishing a truly global management system.

Currently, Anam's customers in the United States are served through its offices in Santa Clara, Chandler (Arizona), and Dallas. There are also business offices in France, Japan, the Philippines, Singapore, and Taiwan.

Anam's business strategy is "customer first," so Anam will meet with its clients any time, any place around the world to better serve their needs.

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Financial Performance

Each year since 1968, Anam has proved progressively positive, and it has become one of the most stable companies in the industry, with profit margins of 3 percent in 1995 and 18 percent in 1997 (see Table 1). Anam's steady growth resulted from stable prices in packaging semiconductors.

Table 1
Anam's Consolidated Balance Sheet (Billions of Korean Won)

	1995	1996	1997
Net Sales	970.2	1,125.9	1,428.4
Cost of Sales	880.3	962.9	1,216.3
Gross Profit	33.1	29.2	252.2
Net Income	21.6	17.1	251.7
Cash and Deposits	70.5	291.6	190.5
Inventory	70.6	90.9	116.2
Current Assets	244.3	502.6	583.4
Assets	878.0	1,550.5	3,022.6
Current Liabilities	443.2	699.6	1,307.3
Liabilities	648.9	1,264.1	2,889.3

Source: Anam S&T Company Ltd.'s Financial Report

Semiconductor Business

Anam's overall revenue growth in worldwide sales is steadily increasing. Anam experienced outstanding growth of semiconductor revenue because of its orientation mainly toward package and test business in the semiconductor industry. Anam is a world leader in the packaging market. Dataquest expects Anam's 1998 revenue to increase by 54 percent over last year year's revenue because of the rapid demand expansion for BGA and quad flat packaging from mobile communications industry. Anam has begun operating fabrication lines since the fourth quarter of 1997. This product fabrication business will contribute to Anam's revenue expansion in 1998 (see Figure 2).

Anam's Activities in 1998

Anam to Introduce 0.18-Micron Semiconductor Lines

Anam plans to introduce the most advanced semiconductor processing technology with a circuit width of 0.18 micron in its nonmemory production lines.

Anam, a foundry service company, said it plans to introduce 0.18-micron wafer fabrication technologies from Texas Instruments Inc., its technological partner in the United States, for its 8-inch wafers.

Fine 0.18-micron precision technologies, which are mainly used for manufacturing digital signal processors (DSPs) and application-specific integrated circuits (ASICs), can integrate 125 million circuits on a chip. With

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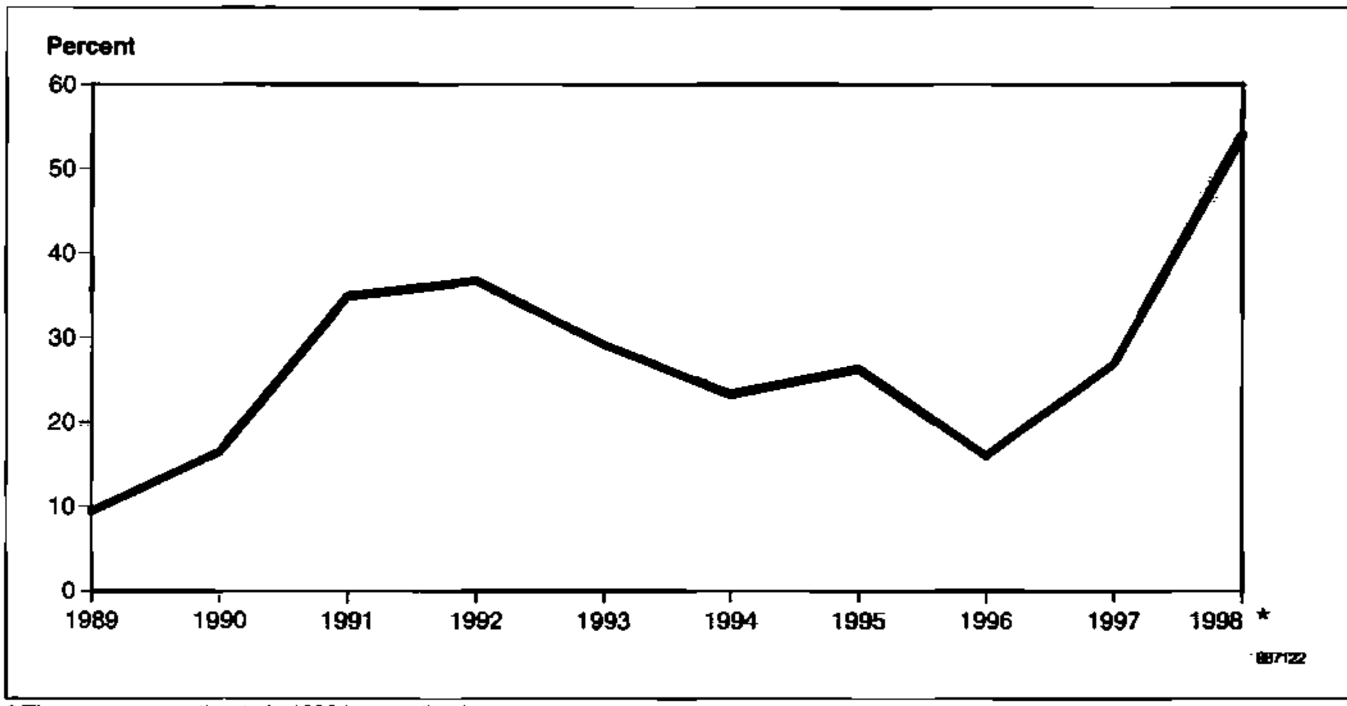
TI's technological support, Anam will install the state-of-the-art facilities at its own expense by early 1999 and supply from a minimum of 40 percent to maximum of 70 percent of its products to TI.

Since the fourth quarter of 1997, Anam, using TI's 0.25-micron and 0.35-micron technologies, has been producing DSPs from 15,000 wafers a month and supplying them to TI.

Figure 2
Anam's Revenue Growth Rates, 1989 to 1998*



* The revenue growth rate in 1998 is an estimate.
Source: Dataquest (October 1998)

When the 0.18-micron processing lines are installed, Anam expects that its wafer fabrication capacity will increase from 15,000 units to 100,000 units a month.

Anam to Sell Chip Plant for U.S.$600 Million

The Anam Group has agreed with a consortium of Salomon Smith Barney Securities Inc. and Boston Bank of the United States to sell facilities operated by its semiconductor subsidiary, Anam Semiconductor Inc., for U.S.$600 million.

The two parties, however, decided not to disclose the target of the deal before a final agreement is reached, in consideration of the remaining sensitive issues (such as managerial rights and employee transfers).

A source at Anam hinted that the sell-off target might be one of its semiconductor packaging plants located in the Seoul metropolitan area or in Kwangju, South Cholla Province, or the nonmemory semiconductor plant in Puchon, Kyonggi Province.

In fact, Anam has been trying to attract foreign investment in the range of U.S.$2.2 billion to U.S.$2.5 billion since early this year with no results.

Anam Group said the proceeds from the sell-off will be used for canceling the guarantee on mutual payment for its subsidiaries and improving its financial standing by repaying debts.

Anam to Automate Semiconductor Packaging and Testing

In an attempt to reduce production costs, Anam, the largest semiconductor packaging company, is planning to automate the processing lines for packaging and testing at its semiconductor plants.

Anam said that it will install pilot automation of semiconductor packaging and testing at its assembly plants for plastic BGAs in the Philippines, in conjunction with Amkor, its subsidiary in the United States.

The company said the new processes will comprise an automatic monorail system, data management systems, and computer integrated manufacturing (CIM) systems.

Anam expects to reduce plant space by half and shorten production time drastically if the automation project is implemented as planned. In the semiconductor industry, most wafer processing is automated, but automation of packaging and testing has lagged because of its technological complexity.

Anam Produces Micro BGA Packages

Anam has begun commercial production of micro BGA packages, the next-generation semiconductor packages.

Anam has installed production lines for micro BGA packages with a weekly capacity of 750,000 units, anticipating a rapid demand expansion. Ball pitches of its micro BGA packages are 0.50mm, 0.75mm, 0.80mm, and 1.0mm in size.

So far, micro BGA packaging technology has been applied to flash memory chips and SRAMs, but recently, it has been used for DRAMs such as direct rambus DRAMs.

Micro BGA-based packaging is a new technology, which can drastically reduce the sizes of chips. For example, when assembling a 15mm x 15mm chip, it allows reduction of the package size to 1.2 times of the chip itself. The package size is typically three times larger than the chip when conventional rod-type lead packaging technology is employed.

Product Lineup

Anam will lead the semiconductor packaging industry through customer-oriented management, competitive technology, and diversification of packaging. Anam is strengthening its business in packaging, as well as foundry, to lead the world semiconductor industry. Table 2 shows Anam's product lineup by package.

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Table 2
Anam's Product Lineup by Package

Package		Lead Counts
Quad	MQFP	44, 48, 64, 80, 100, 120, 128, 144, 160, 176, 208, 240, 256, 304
	TQFP	32, 44, 48, 52, 64, 80, 100, 120, 128, 144, 160, 176, 208, 256
	BQFP	132
	PLCC	20, 28, 32, 44, 52, 68, 84
	PQ	44, 48, 64, 80, 100, 120, 128, 144, 160, 176, 208, 240, 256, 304
Dual	SOIC/SOJ	8, 14, 16, 18, 20, 24, 26, 28, 32, 36, 40, 44, 64
	TSOP	28, 32, 40, 48
	SSOP	16, 20, 24, 28, 34, 36, 44, 48, 56, 64
	TSSOP	14, 16, 20, 24, 28, 32, 38, 48, 56, 64, 80
	PSOP	16, 20, 24, 28
BGA	PBGA	44, 119, 121, 144, 153, 156, 160, 169, 176, 192, 196, 208, 217, 225, 240, 241, 249, 256, 272, 288, 292, 300, 304, 313, 316, 324, 328, 329, 352, 357, 360, 372, 385, 404, 416, 420, 421, 452, 456, 468, 492, 496, 580
	SBGA	168, 256, 272, 276, 304, 352, 432, 596, 600
Chip Scale	Chip Array	80, 97, 180, 197
	FleXBGA	132, 144, 160, 180
	UBGA	40, 46, 48

Source: Dataquest (October 1998)

Dataquest Perspective

Anam will continue its efforts to lead various high-technology industries in semiconductors. Furthermore, to keep its competitive edge in the 21st century, Anam is reinforcing its nonmemory technology, especially the DSP business, to keep its competitive power in the semiconductor industry.

To become a pioneer of new technology in the nonmemory semiconductor specialized industry, Anam's fab division will engage in intensive research to come up with 0.25-micron and 0.18-micron technology development and transfer. At the same time, the entire Anam Group will utilize the expertise it gained from the domestic production to maintain the leading edge in the industry. Anam is actively pursuing its long-range goal of expanding production facilities abroad and maximizing its existing business areas.

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Perspective

Semiconductors Asia/Pacific

Vendor Analysis

United Microelectronics Corporation

Abstract: *Despite the sluggish market conditions that characterized the semiconductor industry in 1997, United Microelectronics Corporation not only completed the transformation of its business model but also managed to achieve U.S.$896 million in revenue, an 8.7 percent increase over the previous year, 1996. To meet strong demand growth, UMC will invest NT$500 billion to build new fabs at the Tainan Science-Based Industrial Park in the next 10 years. This Perspective profiles the Taiwan-based semiconductor company UMC and its affiliate companies.*
By Jerry C. J. Yeh

Company Statistics

Company statistics include the following:

- Chairman—Robert H.C. Tsao
- CEO—John Hsuan
- CEO—Donald W. Brooks
- President—H. J. Wu
- Number of Employees—2,751 (as of March 1998)
- Fiscal 1997 Company Revenue—U.S.$896 million
- Fiscal 1997 Net Income—U.S.$338 million
- Total 1997 Assets—U.S.$3,035 million
- Fiscal Year-End—December 31

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(For Cross-Technology, file in the Semiconductor Regional Markets and Manufacturing binder)

UMC Beliefs

United Microelectronics Corporation (UMC) states the following:

- UMC believes that by fully utilizing its employees' talents, it can outperform all competition and maintain an outstanding corporation.
- UMC believes that its employees, despite the outside factors, can determine the company's continued success based on their individual efforts.
- UMC believes that by working to benefit others, it will, in turn, benefit itself and the employees.

UMC's Long-Term Managerial Guidelines

UMC expresses the following long-term managerial guidelines:

- UMC respects the company as a public instrument, whose image, reputation, and credibility, all employees are committed to preserve.
- By increasing productivity constantly, UMC will maximize profits and thus maintain its ability to contribute to the economic growth and well-being of its community.
- Through endless innovation and a relentless pursuit of quality, UMC will become a world leader in its field.
- UMC will take every opportunity to form beneficial alliances and always treat its partners with honesty and friendship.
- UMC will actively encourage its employees to take initiative and make every effort to cultivate their talents. Furthermore, UMC will turn leadership into service rather than authority.
- UMC strives for vitality (endurance and productivity), harmony (mutual respect and cooperation), contentment (the right positions for the right people), and cheerfulness (positive attitudes), thus creating a lively, stimulating, and creative work environment.

Company Overview

The year 1997 was a key year in laying the foundations for UMC Group's turn-of-the-century expansion investment plan. During the year, UMC successfully completed the full transition of the UMC business model, continuing the process started in 1996 with the spin-off of the UMC design departments and the establishment of two independent IC design houses, Integrated Technology Express Inc. and Davicom Semiconductor Inc., in the United States. In 1997, UMC put the final touches on its restructuring program with the spin-off of its commercial product, memory, and multimedia divisions to create three new and independent design houses, Novatek Inc., AMIC Technology (Taiwan) Inc., and Mediatek Inc. With these actions, UMC committed itself fully to the dedicated foundry concept. In other accomplishments, UMC technology and process development departments further advanced UMC's process technology, entering the

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0.25-micron arena, and succeeded in developing independent advanced mask-making technology. In addition, the turnkey services of the test and packaging engineering division and design support division have made it possible for foundry customers to enjoy even faster and more complete service.

Financial Accomplishments

Table 1 shows the exchange rates for U.S. dollars and the new Taiwan dollar between 1993 and 1997. Despite the slow conditions that characterized the semiconductor industry in 1997, UMC not only completed the transformation of its business model, but also managed to achieve a U.S.$896 million revenue, an 8.7 percent increase over the previous year, 1996 (see Table 2). Net income for 1997 was U.S.$338 million, surpassing the previous year by 21.6 percent.

Table 1
Exchange Rates, 1993 to 1997

Year	New Taiwan Dollar per U.S. Dollar
1993	26.16
1994	26.45
1995	26.48
1996	27.46
1997	28.79
U.S. Dollar Appreciation (%) 1996 to 1997	4.81

Source: Dataquest (October 1998)

Table 2
UMC's Consolidated Balance Sheet (Millions of U.S. Dollars)

	1995	1996	1997
Net Sales Revenue	881	824	896
Cost of Revenue	286	475	632
Gross Profit	595	350	264
Net Income	508	278	338
Current Assets	743	949	1,036
Total Assets	1,808	2,426	3,035
Total Liabilities	605	733	716
Total Shareholders' Equity	1,203	1,693	2,319

Sources: UMC and Dataquest (October 1998)

UMC's Status on the Bond Issue

Table 3 shows UMC's status on the bond issue. To fund fab expansion, a resolution was passed to issue several bonds from 1994 to 1998. The 1996 domestic convertible bonds were used to help finance the expansion of Fab III and for reinvestment in other companies. The investment project will ultimately require a total of NT$17 billion. There are three following funding sources for this project:

- Domestic convertible bonds (NT$6 billion)
- The company's own resources
- Other financial instruments (the two latter sources must provide NT$11 billion)

According to the original schedule, UMC is expected to complete 100 percent of the expenditure by the end of 1997. However, only 91.78 percent of the expenditure was actually executed. The company is running behind schedule because of its efforts to maximize efficiency in the plant construction and capacity expansion processes. UMC plans to return to the original financing schedule in the first quarter of 1998.

The 1997 Euro-convertible bonds were used to help finance the expansion of Fab III, for operating capital, and for investment in other companies. The investment project will ultimately require a total of NT$10.8 billion. The following represent three funding resources for this project:

- Euro-convertible bonds (U.S.$300 million or about NT$8.3 billion)
- The company's own resources
- Other financial instruments (the latter two sources must provide NT$2.5 billion)

According to the original schedule, UMC expected to complete all of the expenditure by the end of 1998.

Table 3
UMC's Status on the Bond Issue

	Euro-Convertible Bonds	Unsecured Convertible Bonds	Euro-Convertible Bonds	Domestic Convertible Bonds
Total Amount	U.S.$160,000,000	NT$6,000,000,000	U.S.$300,000,000	NT$15,000,000,000
Issue Price/Each	U.S.$1,000	NT$100,000	U.S.$5,000	NT$100,000
Annual Interest Payment (%)	1.25	2.5	0.25	0
Issue Period	6/1994 to 6/2004	5/1996 to 5/2006	5/1997 to 5/2004	1/1998 to 1/2008

Sources: UMC and Dataquest (October 1998)

Intercompany Holdings

UMC is like a tree that has its root extended to the various areas, including a wafer fab joint venture, IC design house, packaging, LCD, telecommunications, venture capital, and even banking. Table 4 shows UMC's major affiliated companies and its investment shares. Basically, this information is based on UMC's financial reports, but there are many semiconductor companies' owners that invested in the related companies from their own pocket or other channel.

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Table 4
UMC's Major Affiliated Companies and Investment Shares

UMC-Affiliated Companies	Investment Shares (Common Stock) Number of Shares—Share Percentage	Investment in UMC (Common Stock) Number of Shares—Share Percentage
United Semiconductor Corp.	360,012,076—36.00	53,642,000—1.30
United Integrated Circuits Corp.	558,235,500—37.22	15,750,600—0.38
United Silicon Inc.	453,371,222—40.30	7,444,000—0.18
Unipac Optoelectronics Corp.	71,965,184—18.94	22,497,475—0.55
Hon Hai Precision Industry Co. Ltd.	3,116,588—0.61	16,142,206—0.39
Teco Electric & Machinery Co. Ltd.	45,475,520—4.70	136,518,808—3.32
Teco Information Systems Co. Ltd.	57,500,000—7.99	350,000—0.008
Sampo Corporation	27,178,346—3.31	38,427,028—0.933
Chiao Tung Bank	13,775,000—0.90	181,074,815—4.397
National Securities Corp.	10,168,902—1.85	750,000—0.018
UNI Securities Co. Ltd.	300,000—0.11	92,745—0.0022

Sources: UMC and Dataquest (October 1998)

UMC's Management Structure—Worldwide Operations

Figure 1 illustrates UMC's management personnel. Although UMC Group Chairman Robert Tsao's position and title remain unchanged, five new executive director positions were created. John Hsuan took the position of CEO of domestic operations; Don Brooks was named the CEO of international operations; I.D. Liu became the COO of expansion projects; Gary Tseng was appointed CFO of UMC Group; and J.S. Aur was installed as the CAO of the UMC Group. In other major changes, H. J. Wu became president of UMC; and Chris Chi, formerly a senior manager at Singapore's Chartered Semiconductor Manufacturing Pte. Ltd., joined the UMC family as senior vice president. Vice president Chi is currently in charge of operations at Fab III; and Fu Tai Liou, formerly a senior manager at STMicroelectronics, joined the UMC family as the senior vice president of the technology and process development division. With the addition of United Semiconductor Corporation (USC) President Peter Chang, United Integrated Circuits Corporation (UICC) President C. Y. Shu, and USIC President Frank Wen, UMC Group has put together the ideal team to launch its NT$500 billion investment plan and take it to the top of the semiconductor foundry industry.

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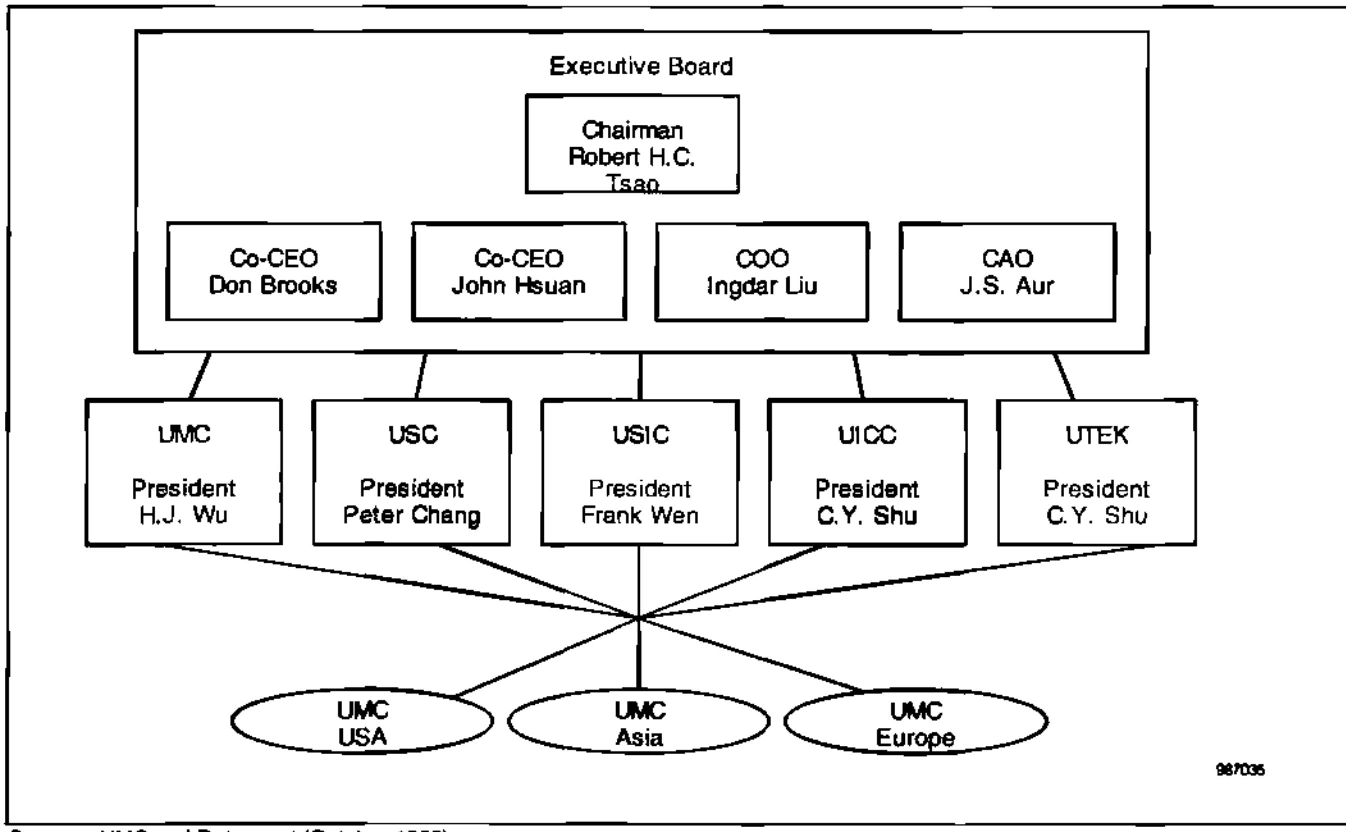
Figure 1
UMC's Management Organizational Structure



Sources: UMC and Dataquest (October 1998)

Research and Development Plans

In the area of process technology R&D in 1997, UMC's most outstanding accomplishment was the successful development of 0.25-micron logic technology and its successful qualification on a customer's product. In other area of cutting-edge manufacturing processes, UMC smoothly ramped 0.35-micron logic, 0.3-micron SRAM, and 0.35-micron DRAM products into mass production. The development of 0.25-micron logic and 0.3-micron DRAM processes was completed, and small-scale production will be launched in the first quarter of 1998. The 0.35-micron embedded DRAM process development was also completed in 1997, and UMC is working on customer products that utilize this technology. Plans for 0.18-micron process technology and device qualification were completed. At the same time, the 6-inch fab pushed EPROM and Flash EPROM processes into mass production, and it also developed a 16V process and color filter process technology. The R&D department's mask-making technology was successfully qualified, and small-scale, 0.35-micron and 0.25-micron mask making are under way. On January 13, 1998, UMC held a technology symposium in California's Silicon Valley with 400 representatives from more than 50 companies attending. The outstanding results of UMC's R&D program caused quite a sensation in the U.S. semiconductor industry.

In the next 10 years, UMC has investment plans for NT$500 billion at its Tainan Science-Based Industrial Park site. UMC intends to focus on the development of 0.18-micron and 0.13-micron logic, DRAM, and SRAM manufacturing process technologies. UMC also plans to develop E-DRAM, E-FLASH, and multivoltage process technologies to satisfy the varied demands of foundry customers. Meanwhile, UMC will develop standard cells and intellectual property, either in cooperation with other companies or on its own, thus strengthening its customers' competitive edge by offering even more comprehensive services.

Wafer Fabrication Status and Plan

In October 1997, UMC Group was dealt a shocking blow with the fire that struck the UICC fab. Following in the footsteps of the successful first UMC Group joint-venture company, USC, UICC, in the short year and a half after its birth, managed to complete fab construction and enter test production, breaking various industry speed records along the way. Tragically, just as test production had ramped up to 10,000 wafers per month and the fab was ready to enter mass production ahead of schedule, fire broke out at the fab. Fortunately, because of the unique structure and position of the UMC Group, UICC was able to guarantee capacity to its joint-venture partners and customers through cooperation with other UMC Group fabs and IC manufacturing allies in Taiwan.

Although UICC lost a year and a half of time and efforts, the fire enabled partners and customers alike to see UMC's crisis management skills in action, convincing them of UMC Group's ability to overcome whatever obstacles may lie in the future. The settlement of UICC insurance claims has also proceeded smoothly. The first payment for a sum of NT$500 million was made at the end of 1997. Total settlement should be completed by the end of 1998. To profit from this costly and tragic incident, the UMC Group has decided to invest NT$1 billion to set up a high-tech-industry-oriented fire-fighting department and has redoubled its efforts to improve every aspect of its industrial safety measures. The UMC Group also invited a leading risk management specialist from the Singapore insurance industry, K. W. Kong, to join its forces at the end of 1997. Table 5 shows UMC's wafer fabrication status and plan.

Dataquest Perspective

UMC was the first Taiwanese domestic IC manufacturing to offer wafer foundry services. With nearly two decades of design and manufacturing experience, UMC has carved out an important niche on the world stage, providing comprehensive services, such as design, mask tooling, fabrication, testing, analysis, and IC packaging. In the past few years, revenue generated by foundry services has grown exponentially. In July 1997, UMC Group announced its goal of becoming a leading name in the semiconductor foundry industry. Despite the serious setback caused by the UICC fire, UMC will accomplish this goal.

Table 5
UMC's Wafer Fabrication Status and Plan

Fab Name	Production Start	Wafer (Inches)	CMOS Process (Microns)	Capacity, Wafer/Month (as of 9/1998)	Forecast Capacity Wafer/Month (by end of 1998)
UMC Fab 2	6/1989	6	0.8 to 0.45	48K	48K
UMC Fab 3	9/1995	8	0.5 to 0.25	28K	28K
USC	4/1996	8	0.5 to 0.25	32K	33K
USIC	5/1998	8	0.35 to 0.25	12K	15K
UTEK Fab 1	4/1991	5	1.2 to 0.7	35K	35K
UTEK Fab 2	5/1998	8	0.5 to 0.25	4K	8K
UICC	Q2/1999	8	0.25 to 0.18	-	-
UMC Fab 5	Q4/1999	8	0.18 to 0.15	-	-

Source: UMC and Dataquest (October 1998)

To meet strong demand growth, UMC will invest NT$500 billion to build new fabs at the Tainan Science-Based Industrial Park in the next 10 years. Fab 5, which held its groundbreaking ceremony at the end of 1997, will start mass production in 1999. Future goals will focus on the establishment of the new fabs in the Tainan Science-Based Industrial Park, specifically on its construction, ramping up, the development of unparalleled services, and the aggressive development of leading-edge process technologies with the aim of becoming the world leader in the dedicated foundry business.

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Perspective

Semiconductors Asia/Pacific
Market Analysis

South Korean Semiconductor Industry Trends

Abstract: *This Perspective analyzes South Korea's economic status, the major electronic equipment industries, and semiconductor manufacturers' activities this year. This Perspective also examines South Korea's 1997 semiconductor market share. It reviews the top 20 semiconductor companies' market share in South Korea.*
By C.S. Kim

South Korea's Economic Review and Outlook

South Korea's Economic Downturn and Its Impact on First Quarter Industry Performance

The Korean won had strengthened slightly by the end of the first quarter of 1998, but exports remain the key to survival for most domestic companies. Companies without any export revenue have been shown to be vulnerable to the negative effects of the economic crisis.

According to a report released by Korea's National Statistical Office in April 1998, industrial production in March plunged 10.1 percent from a year ago—despite relatively robust exports—which was severely affected by depressed consumer demand. The growth declines for two months in a row translated into negative 10.8 percent in January and another negative 1.7 percent in February. In the first three months of the year, industrial output showed a 7.8 percent year-on-year decline. Dataquest expects that fiscal retrenchment, high interest rates, and high exchange rates are pushing the real economy into stagflation, or economic downturn amid soaring inflation. The Korean economy is not expected to return to normal growth for some time.

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MARIA VALENZUELA

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South Korea's Economic Sluggishness and Its Impact on Second Quarter Industry Performance

The currency exchange rate strengthened from an average of W 1,655 to the U.S.$1 dollar in the first quarter of 1998, to W 1,397 to the U.S.$1 in the second quarter of 1998. The stronger won, which actually dipped below the W 1,300 level at the end of July 1998 for the first time in seven months, put the national economy on alert. The rise of the local currency was highly undesirable in view of two consecutive months of export declines, which may further deepen the economic recession and aggravate the unemployment problem.

According to a recent Bank of Korea report, the declining household spending trend is likely to bring about serious results and may cause a vicious cycle of dwindling production, falling household income, and a further slowdown in domestic consumption. The three characteristics of the spending decline trend cited by the central bank are as follows:

- An excessive consumption reduction (with spending decreases outpacing income reduction)
- The collapse of the middle class
- The consumption decrease mainly attributed to perceived uncertainty about the future

The spending decline outpaced by a wide margin the negative 3.85 percent gross domestic product (GDP) growth reported in the first quarter of 1998. In the 1990s, household consumption has accounted for as much as 52.6 percent of Korea's GDP growth. The falling expenditures among households may fuel a continued slowdown in Korea's economic growth potential.

Sales Slump Continues through the Second Half of 1998 for Major Industries

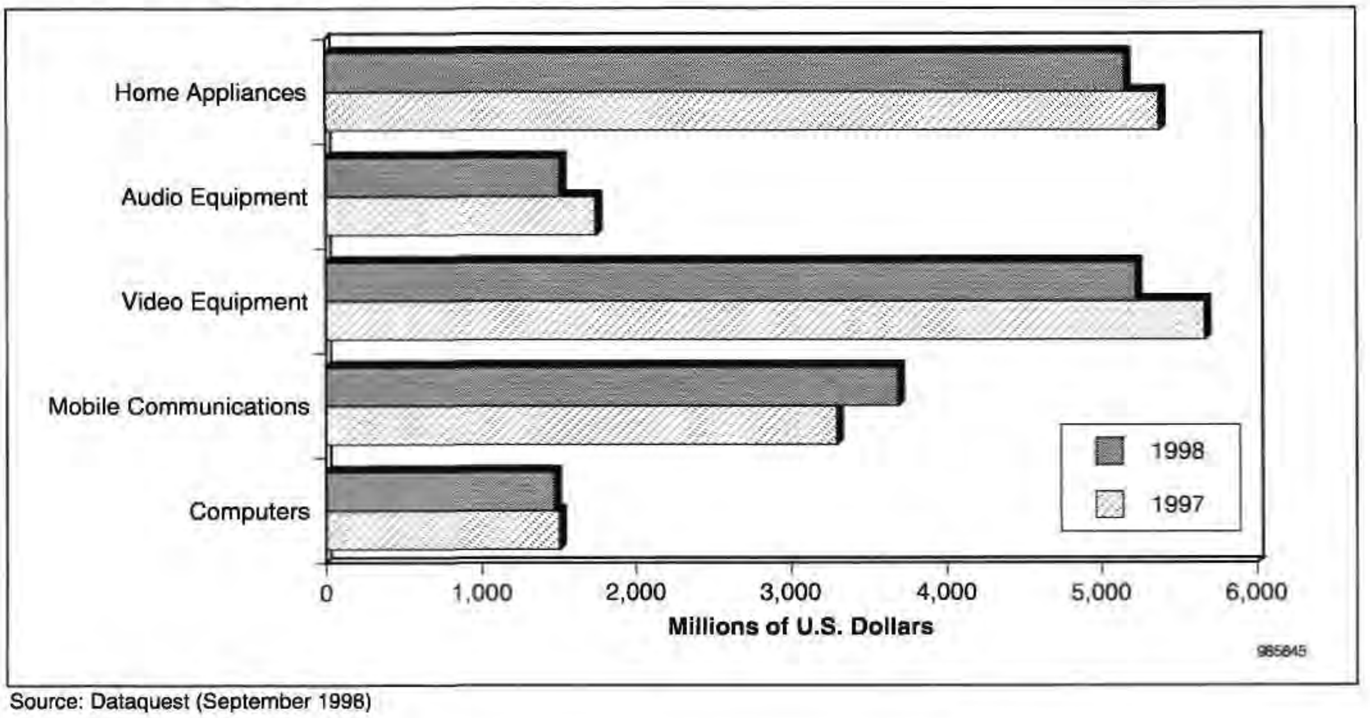
The current domestic business slump is expected to stretch through the second half of 1998 because of poor domestic sales, high inventories, and sluggish facility investments, according to the Bank of Korea. Major domestic industries are likely to undergo another six months of dismal sales—especially because markets show few signs of picking up at home or abroad. In its latest industrial forecast for the second half of 1998, the Korea Development Institute (KDI) expects that domestic consumer spending will shrink further, hit by reduced household income and mounting concerns over unemployment. The Institute forecasts the unemployment rate at 8.5 percent, with the number of unemployed reaching 1.76 million. As a result, sluggish consumer demand is unlikely to recover in the near future, despite a spate of economy-boosting measures, including the reduction of the special excise tax on durable goods and expanded construction investment. According to industry experts, domestic exporters will also suffer from a setback largely attributed to weakened price competitiveness that has arisen from the soaring Korean won and the weak Japanese yen. Instead of expanding exports, industries will try to defend their corporate profitability, which is also worsening rapidly.

South Korea's Major Electronic Equipment Production

Computer Production Expected to Decline by 1.9 Percent in 1998

Dataquest expects Korea's total computer production in 1998 to reach $1.47 billion, a 1.9 percent decline from last year (see Figure 1).

Figure 1
Major Electronic Equipment Production Comparison in South Korea, 1997 and 1998 (Millions of U.S. Dollars)



Source: Dataquest (September 1998)

As for PCs, including desktop and notebook PCs, domestic shipments in the first half of 1998 declined by 52.4 percent to $387 million, and exports increased by 78.7 percent to $120 million. The PC export increase is attributed to a 139 percent rise in exports of notebook PCs, which accounted for nearly 98 percent of the total overseas shipments.

Dataquest predicts that the total PC production this year will reach $1.28 billion, a 2.1 percent decline from last year because of the local demand slump.

Mobile Communications Equipment Production This Year Expected to Not Follow Last Year's Expansion Because of the Sluggish Local Demand of Mobile Phones in the Second Half of 1998

The domestic market for digital cellular phones is expected to fall to about 3.3 million units in the second half of 1998, spurring competition among vendors. In the first half of 1998, the three largest vendors, Samsung Electronics Company Ltd., LG Information and Communications Co. Ltd., and Hyundai Electronics Company Ltd., took more than 95 percent of the market in which 4.3 million digital cellular phones were sold. Dataquest

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expects that Korea's total mobile communications equipment production in 1998 will reach $3.7 billion, an 11.7 percent increase from last year. Such growth results in production growth of digital cellular phones.

Consumer Electronics

The following trends in Korea's consumer electronics production have been observed by Dataquest:

- Video Electronics Production Expected to Decline by 7.8 Percent in 1998
  - Korea's video production will decrease this year, falling 7.8 percent to $5.2 billion, compared with the same period last year. Such a decline results in slumping exports and freezes local demand. Domestic consumer electronics companies are strengthening their marketing strategies in the United States, with high-priced, advanced products to solve the depressed export and domestic sales. These manufacturers are shipping high-value, advanced products—such as digital video disc (DVD) players, set-top boxes, 40-inch-or-larger projection TVs, and high-definition (HD) TVs this year—to the North American market, thereby reducing OEM supplies of low-end products.
- Domestic Home Appliance Production to Decline by 4.1 Percent in 1998
  - Because of the projected sales decline both at home and overseas in the second half of 1998, domestic home appliance manufacturers are struggling to stay afloat. They are suspending or postponing the development of new products and are cutting production. Dataquest expects that the total production of home appliances in 1998 will reach $5.1 billion, a 4.1 percent decline from last year.
  - Dataquest predicts that exports of Korean companies' products to China, the Middle East, and Latin America are also dropping sharply because of economic recession in these regions. Particularly, exports to Russia, which had reached more than $500 million annually, have been nearly suspended because of that country's economic troubles. Under these circumstances, Samsung Electronics, LG Electronics, and Daewoo Electronics Corporation recently cut back appliance production at their domestic and overseas plants and canceled or postponed new-product development. These manufacturers are facing troubles, and a collapse of the domestic consumer electronics industry is not unimaginable.
- Production of Audio Equipment Sharply Decreased by 13.4 Percent
  - Domestic audio manufacturers are confronting a crisis in exports and domestic sales. Exports of their products to Southeast Asia, Russia, China, the Middle East, and Latin America have drastically declined in recent months. Furthermore, Japanese audio system vendors are lowering prices of their products in these regions.
  - To reduce production costs and increase exports, LG Electronics relocated its production lines for low-end audio systems to China early this year, while expanding shipments of its products to China,

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the Commonwealth of Independent States (CIS), Latin America, and Europe. However, the operation rate of its production lines recently dropped by 15 percent.

- Exports of audio products by Lotte Electronics Corp. and Anam Electronics Co. Ltd. have nearly ceased since May of 1998, whereas Haitai Electronics Co. Ltd. is filling only 70 percent of orders because of difficulties in procuring materials. As a result, Korea's audio equipment production this year will reach $1.5 billion, a 13.4 percent decline from last year.

South Korea's Semiconductor Industry

South Korea's Semiconductor Market Share in 1997

Dataquest estimates that in 1997, Korea's total semiconductor market revenue increased to about $5.5 billion. The top 20 suppliers dominated 69.2 percent of Korea's total semiconductor market in 1997 (see Table 1).

Samsung Electronics retained its No. 1 ranking in terms of Korea's 1997 semiconductor revenue. However, Samsung's regional revenue increased by only 2.8 percent to $620 million. Intel Corporation's revenue increased in Korea by 23.1 percent and reached $559 million in 1997. Dataquest expects Intel to surpass Samsung this year according to the semiconductor market flow. Note that most of the top 20 semiconductor suppliers in Korea also appear among the top 20 semiconductor suppliers in Asia/Pacific, with the exception of Sharp Electronics Corporation, Korean Electronics Co., Sanken Electronic Company Ltd., and Sony Corporation.

Philips Electronics NV's regional revenue grew 17.1 percent and totaled $404 million. Motorola Incorporated's revenue increased by 5.9 percent to $199 million. Toshiba Corporation's regional revenue was reduced by 16.6 percent to $196 million. Motorola and Toshiba also switched ranking positions in South Korean market in 1997, with Motorola in fifth place and Toshiba in sixth place. LG Semicon Co. Ltd. and Texas Instruments Inc. retained their positions in the top 10 semiconductor supplies in the South Korean market for 1997; however, their revenue declined by 9.1 percent and 4.2 percent, respectively. Sharp and Sanken were ranked as No. 12 and No. 15, respectively, in Korea because of Sharp's excellent supply of MOS logic devices and Sanken's discrete devices. Korean companies accounted for about 20 percent of their local market. Lucent Technologies jumped to No. 17 in South Korea in 1997 from No. 21 in 1996. Lucent and Sanken entered the top 20 group in 1997. Table 1 shows South Korea's top 20 semiconductor suppliers in 1997.

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Table 1
1997 Rankings and Market Share for the Top 20 Semiconductor Suppliers in South Korea (Millions of U.S. Dollars)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%) 1996 to 1997	1997 Market Share (%)
1	1	Samsung	603	620	2.8	11.3
2	2	Intel	454	559	23.1	10.2
3	3	Philips	345	404	17.1	7.4
4	4	LG Semicon	297	270	-9.1	4.9
6	5	Motorola	188	199	5.9	3.6
5	6	Toshiba	235	196	-16.6	3.6
7	7	SANYO	173	176	1.7	3.2
11	8	National Semiconductor	116	171	47.4	3.1
9	9	Texas Instruments	167	160	-4.2	2.9
8	10	Hitachi	172	144	-16.3	2.6
10	11	STMicroelectronics	130	141	8.5	2.6
17	12	Sharp	52	105	101.9	1.9
12	13	Korean Electronics	116	103	-11.2	1.9
16	14	Rohm	58	100	72.4	1.8
28	15	Sanken	7	89	1,171.4	1.6
13	16	NEC	92	85	-7.6	1.5
21	17	Lucent	35	80	128.6	1.5
14	18	Hyundai	88	78	-11.4	1.4
18	19	Mitsubishi	52	61	17.3	1.1
15	20	Sony	81	58	-28.4	1.1
		All Others	1,524	1,691	11.0	30.8
		Total Market	**4,985**	**5,490**	**10.1**	**100.0**

Source: Dataquest (September 1998)

Won Revenue of South Korean Semiconductor Companies Soared in First Half of 1998

Despite a continuous drop in chip prices, sales revenue (based on the Korean won) for South Korea's three major semiconductor manufacturers increased sharply in the first half of this year, climbing 22.5 percent to 46.4 percent over the same period last year. Profits in this sector, however, were lower, according to their estimates.

In the first half of 1998, sales revenue at Samsung Electronics reached W 10.9 trillion, a 22.5 percent increase over the same period last year. Hyundai Electronics posted W 2.1 trillion in sales, up by 42 percent, and LG Semicon's sales revenue increased by 46.4 percent to W 1.24 trillion. Samsung posted U.S.$105 million in profits during this period, whereas Hyundai Electronics and LG Semicon have reportedly posted deficits of several hundred million dollars each.

Samsung's favorable profits are attributed to its improvements in manufacturing technologies and the shipping of 64Mb DRAMs ahead of competitors. In addition, Hyundai Electronics and LG Semicon were affected by higher payments for leased equipment because of the weaker Korean currency, which contributed to their losses.

What Is Happening to South Korean Semiconductor Companies in 1998?

LG Semicon and Hyundai Electronics to Merge

Recent announcements state that progress is being made on Korea's "Big Deal," a scheme to move divisions between conglomerates. Among the many trades between *chaebols* (Korean conglomerates) is a merger between LG Semicon and Hyundai Electronics.

However, there appears to be some bickering about the fate of the proposed merger between Hyundai Electronics and LG Semicon. Despite their agreements on some portions of the "Big Deal," LG Semicon and Hyundai Electronics still have some strong disagreements about how the two companies should merge. Hyundai Electronics, arguing that it has the larger market share, has taken the position that it should manage the new company. LG Semicon, which actually produces more semiconductors than Hyundai Electronics but sells a large portion of them through Hitachi Ltd., has taken the position that it is a stronger manufacturer and should be in control of the merged semiconductor business.

U.S. Department of Commerce Finds LG Semicon and Hyundai Guilty of DRAM Dumping

Recently, the U.S. Department of Commerce (DOC) found LG Semicon and Hyundai Electronics—in addition to three resellers—guilty of dumping DRAMs into the U.S. market from May 1, 1996 to April 30, 1997. As a result of the finding, LG Semicon will be required to pay a tariff of 9.28 percent and Hyundai Electronics will have to pay a tariff of 3.95 percent on DRAMs imported to the United States. These tariffs compare more favorably with the preliminary tariffs of LG Semicon's 7.61 percent and Hyundai Electronics' 12.64 percent in March. Products manufactured inside the United States are not eligible for tariffs. The final ruling on this issue is to be made within the 60 days of the initial ruling. Tariffs will be imposed retroactively, starting with the period under review.

Both companies have announced their intention of appealing the ruling in the U.S. Court of International Trade in New York and are quoted as having accused the DOC of making "serious errors" in its analysis. In a statement issued after the finding, LG Semicon was quoted as saying that the DOC based its finding on DRAMs "unlawfully diverted to the U.S. market by third parties." The company also said, "We will not stand idly by while our reputation as a fair and competitive supplier of DRAMs is impugned." Hyundai Electronics simply called the ruling "unacceptable."

Although the preliminary tariffs were set based on incomplete information, a computational error made by the DOC was the reason given for the difference between Hyundai Electronics' preliminary tariff and the final ruling, while the difference for LG Semicon was attributed to the discovery of additional evidence to support the higher tariff. The companies will be

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forced to post a cash bond for shipments during the period under examination (from May 1, 1996 to April 30, 1997). Although Dataquest does not survey shipments into the United States and does not have the companies' revenue figures that correspond exactly with the dates used by the DOC, Dataquest believes that its 1996 market share figures for shipments into the United States from January 1, 1996 to December 30, 1996 are sufficiently close to giving an estimate of the penalties facing the two companies.

LG Semicon shipped $417 million worth of DRAMs into the United States, which would result in tariffs of about $39 million. Hyundai sold the United States about $819 million worth of DRAMs in 1996, a number that would saddle the company with a tariff of $32 million. In addition to those bonds, the companies will need to accrue tariffs on all 1997 and 1998 (past and future) DRAM shipments, even while their appeals are pending. The companies estimate that their current sales into the United States are about 10 percent of LG Semicon's total DRAM revenue and 40 percent of Hyundai Electronics.

The period from May 1, 1996 to April 30, 1997 is the fourth review period under the current antidumping suit, originally filed by Micron Technology Inc. in 1993, which accused these two Korean companies of dumping in 1991. Each of the prior three review periods occurred during profitable markets, and the companies were not found to be dumping—thus, no tariffs were levied. The fourth cycle was added after a request made by Micron in 1997, extending the normal three-year review used by the U.S. DOC. For a while, the Korean government was protesting that it would take this matter to the World Court because the DOC appeared to be changing its own rules midgame. However, after the Asian financial crisis bloomed, this talk subsided, perhaps because of Korea's dependence on International Monetary Fund (IMF) bailout money, a large portion of which was to come from exports to the United States.

Hyundai Electronics believes that its DRAM shipments to the United States will not be seriously affected by the new tariffs, because the company claims that 90 percent of the chips it sells in the United States are manufactured in its new $1.3 billion wafer fab in Eugene, Oregon. Of the three Korean DRAM manufacturers, Hyundai Electronics has been a pioneer in fab construction outside of South Korea in an effort to thwart this kind of threat.

Another difficulty was thrust upon the two companies in September, when Micron successfully lobbied the U.S. Congress to attach a provision onto a bill that would allow U.S. participation in the IMF bailout. The bill, currently in the U.S. Senate for approval, would provide $18 billion to the IMF to be used to bail out ailing Asian economies. The added provision would disallow the use of any IMF funds from the United States to support foreign semiconductor companies.

It will be interesting to see whether the DRAM dumping finding will cause the same sort of price stabilization that happened in 1992, when the first Micron antidumping suit was filed against Korean manufacturers. At that time, prices suddenly stopped their fall and stabilized at a level that was to

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last for an unprecedented three and a half years. Although we do not expect such an extended profitability period to occur again in our lifetimes, there is reason to believe that the current variable-cost model will give way to a more rational burdened-cost model, at least until demand catches up with capacity in 2000. This shift will most likely come about through price stabilization at current levels until burdened costs drop to current pricing.

Korean Manufacturers to Limit 64Mb DRAM Production

In an effort to bolster sagging prices, all three Korean DRAM manufacturers, Samsung, Hyundai Electronics, and LG Semicon, have announced plans to cut 64Mb DRAM production by closing their plants for one week. Korean suppliers shipped about 45 percent of the world's 64Mb DRAMs last quarter, according to Dataquest's latest DRAM Supply and Demand Quarterly Market Statistics report.

Following a one-week production suspension of 64Mb DRAMs by one of Hyundai Electronics' fabs in South Korea, Samsung planned to shut down operations of all its memory processing and assembly lines for one week starting June 14, 1998. LG Semicon said, "LG will decide its course of action after observing the policies of other companies." However, LG Semicon also reportedly planned to suspend its production operations for seven days either during the last week of June or the first week in July 1998.

This action is to be repeated periodically until the oversupply problems are resolved and prices stabilize. This idea reportedly came from a request for the Korean government's help to ease the companies' financial burdens, including high interest rates in the IMF system. The companies' representatives met with government officials and agreed to limit production and look for ways to achieve price stability.

Samsung Ships 256Mb SDRAM

Samsung claims to be the first company in the world to enter production of the 256Mb synchronous DRAM (SDRAM), having shipped samples of its second-generation device to seven of the world's largest PC makers. Samsung estimates that it is one to two years ahead of the device's anticipated production date. The company claims to have proven that the device can be mass-produced using 8-inch wafers, so that investment in 12-inch wafer fabrication lines is not necessary. The device is produced using 0.18-micron processing technology. Samsung claims to have been the first to move from 64Mb to 256Mb DRAM production without having to invest in new facilities.

Samsung's 256Mb SDRAM is designed to be compatible in both size and functionality with its current 64Mb SDRAM, allowing any computer system using 64Mb or 128Mb SDRAM to use the new 256Mb DRAM without modification. A standard dual in-line memory module (DIMM) can hold a total of eight 256Mb SDRAMs on both sides, so a single slot can expand the memory up to 1GB. Power consumption of the new 256Mb SDRAM is 70mA, 30 percent less than that available with 128Mb DRAMs, and the chip can operate at clock speeds as high as 167 MHz. The device is targeted at desktop PCs, workstations, and high-end PCs.

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Samsung plans to use its new 0.18-micron technology to manufacture a fifth-generation 64Mb DRAM, which will greatly boost the competitiveness of these chips as well.

Samsung Electronics Samples 64Mb DDR SDRAM

Samsung has developed a beta version of a 64Mb double data rate (DDR) SDRAM that fully supports Joint Electron Device Engineering Council (JEDEC) standards.

Samsung expects that it will initially supply the beta product to manufacturers of servers, workstations, and data communications equipment. It plans to produce engineering samples in late September 1998 and commercial DIMMs in October.

Samsung's new 64Mb DDR SDRAM, which has a clock frequency of 133 MHz, supports PC-100 standards. Its DIMM can be extended to a maximum of 288MB, the company said. According to Samsung, the DDR SDRAMs can be manufactured using production lines for SDRAMs, and computer platforms require only minor changes for its use.

Samsung claims that Hewlett-Packard Company has expressed its willingness to support DDR SDRAM as a next-generation, high-speed memory.

Hyundai Electronics Starts Initial Production in Eugene, Oregon

Hyundai Electronics has started its test production at its Eugene, Oregon, 64Mb DRAM fab and began making 25 sample silicon wafers on December 31, 1997, barely meeting its deadline to launch production at the $1.4 billion plant in 1997. The company is borrowing about $1.2 billion to build and equip the factory. At full production, the plant's capacity is 30,000 200mm wafers per month. Hyundai Electronics said market conditions will determine how quickly the Eugene plant will ramp up production.

Hyundai Electronics expected to run test trials through March 1998 and to be able to reach full production by fall. The plant's wafers will be shipped to Korea for final processing and assembly.

The company plans to upgrade equipment at the end of 1998 to produce 128Mb devices in 1999 and to perform upgrades in 1999 to enable 256Mb DRAM production in 2000. The cost of that additional equipment is included in Phase One's $1.4 billion price tag.

Hyundai Electronics initially hoped to break ground in July 1995 and finish construction by December 1996, but the project took a year longer because of construction delays and environmental concerns.

LG Semicon Begins Mass Production of 64Mb SDRAM

LG Semicon has started the mass production of advanced 64Mb SDRAM chips. The chip, called the fourth-generation DRAM chip, has a data processing rate of 100 MHz, which is two times faster than conventional 64Mb DRAMs. This chip is faster than any other 64Mb DRAM chip in the world and will enable the company to be competitive in the global 64Mb DRAM market.

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The company developed the new chip early this year by applying a 0.23-micron circuit-width technology, with which LG Semicon can produce 435 chips from a single 8-inch wafer, compared to 340 chips by Hitachi and 400 by Micron. LG Semicon launched its independent development of the new chip after a joint-development program with Hitachi early last year.

LG Semicon Strengthens Its High-Speed SDRAM in Global Market

LG Semicon is one of major suppliers of high-speed, SDRAMs. The company shipped a total of 13 million units of 64Mb SDRAMs for PC-100 in July and August 1998, accounting for 35 percent of the global high-speed DRAM market. LG Semicon's phenomenal record in the semiconductor market is seen as unprecedented.

The demand for SDRAMs with data processing speeds faster than 100 MHz has recently soared because of the introduction of Microsoft's Windows 98 and Intel's Pentium II processors, replacing extended data out (EDO)-based chips and 66-MHz 64Mb SDRAMs. Anticipating a rapid demand increase, LG Semicon has raised the production share of 64Mb SDRAMs for PC-100 to 92 percent of its total output. The company intends to ship 63 million 64Mb SDRAM chips for PC100 this year to strengthen its position in the high-speed SDRAM market.

South Korean Manufacturers Ramp Up SRAM Exports

Korea's static RAM (SRAM) exports are increasing rapidly. Korean SRAM vendors announced that exports of high-valued SRAMs, particularly synchronous SRAMs, increased sharply during the first quarter of 1998. The increase is attributed to the expansion of their use for computer cache memories and other information technology (IT) appliances—such as mobile phones, personal digital assistants (PDAs), and handheld PCs.

The South Korean semiconductor companies predicted that this year's export revenue will increase to between $800 million and $900 million. Samsung exported $200 million worth of SRAMs in the first quarter of 1998, a 50 percent increase over the same period in 1997. In particular, Samsung's synchronous SRAM exports during the first three months of 1998 tripled the amount of the same period last year. SRAM exports at both LG Semicon and Hyundai Electronics during the first quarter of 1998 reached nearly $40 million, twice the amount each company exported during the same period last year.

Samsung Electronics' 128Mb Flash Memory

Samsung Electronics announced that it is shipping samples of a 128Mb flash memory chip and that mass production would begin in the third quarter of 1998. Sampling of the new device comes just one year after Samsung began shipping its 64Mb flash memory chip. The Samsung chip can store and erase data at least 1 million times. The device is aimed at battery-operated consumer products, as well as mobile communications devices that require low-voltage operation. The chip is produced using the 0.27-micron process technology, enabling it to operate at 2.7 volts.

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South Korean Semiconductor Companies' Nonmemory Semiconductor Businesses Take Off

The South Korean semiconductor manufacturers' exports of nonmemory products, including media processors, merged memories with logic (MMLs), Alpha chips, and quadrature phase-shift keying (QPSK), are increasing.

LG Semicon, which developed a media processor, MPACT chip, with Chromatic Research Inc. of the United States, produces 200,000 chips. LG Semicon plans to ship its Java chip next month, which can be used for a variety of network-based IT appliances, including network computers, Internet TVs, and Internet set-top boxes.

Samsung Electronics' exports of merged DRAMs with logic (MDLs) have increased from $200,000 in January 1998 to $5 million in September. Samsung plans to expand logic-merged chips to SRAMs and flash memories. The company also said that its revenue from Alpha chips will increase substantially in the future.

Despite recently selling Symbios, its nonmemory subsidiary in the United States, Hyundai Electronics intends to enter the market for CMOS image sensors this year and ship QPSK modules for satellite-broadcast receivers. Hyundai Electronics' revenue targets in these nonmemory products are $5 million in 1998 and $20 million in 1999.

Domestic liquid crystal display (LCD) manufacturers are concentrating on the development of driver integrated circuits (ICs) and the expansion of their utility. The following LCD manufacturers were noted by Dataquest:

- LG Semicon has recently developed a gate driver IC with 150 channels that can be used for super video graphics array (SVGA) and extended graphics array (XGA) thin film transistor (TFT) LCDs. Currently, LG Semicon is producing source driver ICs that can support 384 channels in conjunction with Vivid, a U.S. venture company. LG Semicon is planning to adopt these driver ICs in its TFT LCD products next year.
- Samsung Electronics is also strengthening its LCD driver IC business by expanding production. Following the development of source driver ICs with 300 channels and 309 channels for 12.1-inch SVGA and XGA TFT LCDs, and gate driver ICs with 120 and 128 channels, Samsung plans to develop a source driver IC with 384 channels and gate driver ICs with 256 channels for larger LCDs. Samsung said the ratio of use of its own driver ICs for LCDs increased to 60 percent in 1998 from 30 percent in 1997.

Dataquest Perspective

South Korea's electronics industry may be heading for its worst economic difficulties and sluggish domestic demand this year, according to the current situation. Such a status has forced industrial companies to cut equipment investment by 40 percent. As a result, data processing equipment production is expected to decline by 2.1 percent this year, and consumer electronics production is expected to shrink by 7.0 percent. However, communications

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equipment production will grow at a 7.8 percent, owing to expanding digital cellular phone and mobile communications infrastructure equipment.

South Korea's financial crisis has resulted in Korean electronics vendors not being able to sustain the sales volume necessary to maintain their competitiveness and justify continued investment in the electronics industry. As a result, the Korean electronics vendors are experiencing massive core business restructuring, corporate mergers, acquisitions, and downsizing this year.

Semiconductor market growth depends on electronic equipment production. Regarding South Korea's electronic equipment production and falling prices—especially of memories and microcomponents—South Korea's semiconductor consumption will be entering a foggy tunnel this year. Although the South Korean electronics industry faces difficulty in increasing production because of this year's sluggish economy, its electronics industry is increasing in importance as the advanced electronic equipment manufacturing base. South Korean companies manufacturing electronic equipment are strengthening their resources in LCD, digital cellular phone, DVD player, and digital set-top box segments. As a result, semiconductor consumption for these applications will continue to grow. Therefore, semiconductor manufacturers that produce semiconductors for these applications have many opportunities in South Korea.

South Korean semiconductor manufacturers are also striving to diversify their product line-up of nonmemory to prevent them from fluctuating wildly in the memories market. Dataquest estimates that this is a part of their strategy to make up for declining revenue from memory chips sales overseas and to enhance the market competitiveness of their nonmemory products.

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Perspective

Semiconductors Asia/Pacific

Market Analysis

Singapore's Semiconductor Industry Trends

Abstract: *Singapore leads the race in the number of wafer fabrication plants in Southeast Asia. However, all three semiconductor manufacturing companies registered revenue declines in 1997. This Perspective reviews the operations and the outlook of these companies. The dynamics of Singapore's active semiconductor market are also examined. By Ken Ng*

Industry Facing Downturn

Singapore's electronics industry, which accounted for almost a 51 percent share of total manufacturing output last year, is a key component of the city-state's export-driven economy. The semiconductor sector plays an important part in Singapore's economy.

Singapore's government had earlier this year forecast a gross domestic product (GDP) growth rate of between 2.5 percent and 4.5 percent for 1998. However, with the regional economic outlook deteriorating, the government has revised the official growth rate, forecasting downward to the 0.5 percent to 1.5 percent range. In the first half of this year, GDP growth slowed to 3.8 percent, a result of the Asian financial crisis and a weaker-than-expected demand for electronics products. Electronics exports (representing 70 percent of nonoil domestic exports) decreased by 3 percent in the first half of this year. Electronics exports have fallen more significantly in U.S. dollar terms, after taking into account the Singapore depreciation.

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Oversupply and increased competition have hit Singapore's major export earners. Rigid disk drives (RDDs), the single-largest export item, have shown weak growth this year. Major RDD manufacturers, such as Seagate Technology Inc. and Western Digital Corporation, have reacted to the slowdown by cutting their workforce. PCs have also registered consistent declines in export value because of declining prices and inventory corrections.

Even the high-growth semiconductor industry has succumbed to the trend despite new investments in capacity and equipment. According to Dataquest, the Asia/Pacific market is expected to be adversely impacted by the regional economic turmoil and a persisting oversupply in the commodity chip markets. The regional semiconductor market is expected to record a revenue decline in 1998.

Singapore's Semiconductor Manufacturers

In the past few years, Singapore's semiconductor industry has witnessed large investments being made, particularly in wafer fabrication plants. Four companies already operating in Singapore are as follows:

- Chartered Semiconductor Manufacturing Ltd.
- Hitachi Nippon Steel Semiconductor Singapore Pte. Ltd.
- STMicroelectronics NV
- TECH Semiconductor Pte. Ltd.

These companies are involved in diverse manufacturing activities, such as dedicated foundry, DRAM fabrication, and integrated brand-name manufacturing. The companies also produce a wide range of products. Another characteristic of the local semiconductor manufacturing industry is the nature of government participation.

There are now 10 wafer fabrication plants—Chartered's five (including Silicon Manufacturing Partners), Hitachi Nippon Steel Semiconductor's one, STMicroelectronics' two (one building housing Fabs 1 to 4 and one housing Fab 5), and TECH's two—either in operation or under construction in Singapore at the moment. The principal products manufactured at these fabs range from MOS memory and MOS logic to analog devices. This section reviews the operations and plans of the four companies that have already committed to manufacturing in Singapore. Table 1 presents a summary of the current and planned wafer fabs in Singapore.

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Table 1
Current and Planned Wafer Fabrication Plants in Singapore

Company	Fab Name	Location	Operations Start	Wafer Size (Inches)	Current Process (Microns)	Maximum Available Capacity/Month	Products
Chartered	Fab 1	Science Park	1989	6	0.60	26,000	Foundry
Chartered	Fab 2	Woodlands	1995	8	0.35	45,000	Foundry
Chartered	Fab 3	Woodlands	1997	8	0.35	20,000	Foundry
Chartered	CSP	Woodlands	2000	8	NA	30,000	Foundry ASIC
Chartered/Lucent Microelectronics	SMP	Woodlands	1999	8	NA	26,000	Foundry ASIC
Hitachi Nippon Steel Semiconductor	Hitachi Nippon Steel Semiconductor	Tampines	1998	8	0.30	20,000	64Mb DRAM
STMicroelectronics	Fab 1	Ang Mo Kio	1988	5	2.00	28,000	MFR, MOS, ASIC
STMicroelectronics	Fab 2	Ang Mo Kio	1984	5	2.50	42,000	Analog, discrete
STMicroelectronics	Fab 3	Ang Mo Kio	1984	5	2.50	39,000	Linear power, discrete
STMicroelectronics	Fab 4	Ang Mo Kio	1996	5	1.50	23,000	Analog, discrete
STMicroelectronics	Fab 5	Ang Mo Kio	2000	8	NA	32,000	MCU, semicustom
TECH	Fab 1	Woodlands	1993	8	0.35	12,000	16Mb DRAM
TECH	Fab 2	Woodlands	1996	8	0.30	25,000	64Mb DRAM

NA = Not applicable
Source: Dataquest (August 1998)

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The 1997 Review

The year 1997 was a reality check for Singapore's semiconductor manufacturing companies. Table 2 presents the ranking and revenue of the three manufacturers last year. All of the companies experienced revenue declines—with TECH suffering the largest plunge of 29.7 percent. Last year's downturn was attributed to a global DRAM product oversupply, coupled by pricing pressures across commodity chip markets, and lower-than-predicted growth for foundry services. Overall, the revenue of the top three manufacturers declined 9.8 percent last year.

Table 2
Estimated 1997 Revenue of Top Three Semiconductor Manufacturing Companies in Singapore, Including Contract Manufacturing (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change
1	1	STMicroelectronics	1,173	1,133	-3.4
2	3	Chartered	407	374	-8.1
3	2	TECH	408	287	-29.7

Source: Dataquest (August 1998)

STMicroelectronics remained Singapore's largest manufacturer in 1997. Its position is attributed to having the highest number of wafer starts and producing its own brand-name products. The company experienced the lowest revenue decline of 3.4 percent. Chartered climbed into the second spot despite registering reduced revenue last year. The foundry nosed ahead of TECH as additional capacity came onstream.

Chartered Semiconductor Manufacturing

Chartered, a subsidiary of the government-linked Singapore Technologies Group, is a dedicated foundry currently operating three wafer fabrication plants. Fab 1 in Science Park is Chartered's oldest plant; operations started there more than eight years ago. Fabs 2 and 3 are located in Woodlands, both offering mainstream 0.35-micron process technologies. These two fabs have a combined maximum capacity of 65,000 8-inch wafers per month. Chartered Silicon Partners (CSP) was the fourth fab set up to manufacture ASICs—mainly for Hewlett-Packard Company—with additional capacity available to other fabless customers. Chartered holds the majority stake in CSP, with HP and the Singapore Economic Development Board each taking up minority stakes. Initial plans to begin production by early next year have been pushed out. The decision to delay the start of production by one year was resulted from the Asian economic downturn and a worldwide foundry capacity oversupply. By the year 2000, CSP should be able to produce more than 30,000 8-inch wafers using 0.25-or-deeper submicron process technologies.

Earlier this year, Chartered and Lucent Technologies Microelectronics Group entered into a joint venture to invest $1 billion in another wafer fabrication facility. The new joint venture company, SMP, is scheduled to begin commercial operations by 1999. At full capacity, the fab will produce 26,000 8-inch wafers per month using 0.25-micron process technology. The facility is expected to migrate to 0.18-micron process technology by 2000. Lucent holds the majority 51 percent share, with Chartered taking up a 49 percent stake. Production in this facility is planned ahead of CSP. SMP should start operations earlier as it is located in an existing plant area next to Fab 3. The equity structure allows Lucent the choice of technologies that will go into SMP to ensure that the technologies in the new fab are fully compatible with the company's Orlando, Florida, fab. This would provide Lucent with a virtual fab in Singapore to supply its customers in the Asia/ Pacific region. The agreement also enables Chartered and Lucent to share some technologies and to improve on them for the benefit of both companies.

Hitachi Nippon Steel Semiconductor

The newest entrant in Singapore's front-end semiconductor manufacturing industry is Hitachi Nippon Steel Semiconductor, a joint venture set up to produce DRAM devices. Hitachi Ltd. and Nippon Steel Semiconductor jointly hold a 35 percent equity, with the EDB taking the remaining 30 percent. The venture plans to ramp up 64Mb DRAM production to full capacity by April 1999. This $900 million plant has an estimated output of 20,000 8-inch wafers per month.

In light of the current market conditions, Hitachi Nippon Steel Semiconductor is taking a cautious approach in its ramp-up plan. The company has already started production, manufacturing both 64Mb extended data out (EDO) and synchronous DRAMs. It is expected that the plant will be manufacturing more SDRAMs, consistent with other large DRAM vendors. The wafers produced in Singapore will be sent to Hitachi's back-end plant in Penang, Malaysia, for packaging and testing. Hitachi has also outlined plans to relocate its 256Mb DRAM production from Japan to this facility by 2000.

STMicroelectronics

STMicroelectronics opened its first wholly owned wafer fab in Singapore in 1984. The company now operates four fabs in Ang Mo Kio, producing standard linear, standard logic, MOS microcomponents and logic, and semicustom products. Fabs 1 to 4 are housed in one building, with a combined capacity of more than 130,000 wafers per month. Producing 5-inch wafers, these fabs employ process technologies ranging from 1.5 microns to 2.5 microns. The Ang Mo Kio campus also serves as STMicroelectronics' Asia/Pacific regional headquarters.

STMicroelectronics has announced plans to construct another building for a new submicron fab. This wafer fab is expected to produce 8-inch wafers with geometries starting at 0.5 microns and a monthly capacity of 32,000 wafers. STMicroelectronics has subsequently postponed the new wafer fab construction. Plans for the plant to begin operation in early 1999 have now been delayed until 2000. The $700 million facility is planned to be located next to its existing facility in Ang Mo Kio.

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STMicroelectronics' decision to delay the construction of this Singapore fab reflects caution in its outlook for the semiconductor industry. The company is estimated to have sufficient capacity to meet current demand levels. The company's latest 8-inch fab in Catania, Italy, has already started full production.

TECH Semiconductor

TECH has two wafer fabs that manufacture DRAM devices exclusively. TECH was originally joint-owned by four parties—Texas Instruments Inc. and EDB each with 27.25 percent equity, HP holding a 25 percent share, and Canon Inc. controlling a 20.5 percent stake. However, a reshuffle of equity holders is expected as a result of Micron Technology Inc.'s acquisition of TI's worldwide memory business. TI's holding in TECH should be assumed by Micron when the legalities of the deal are completed.

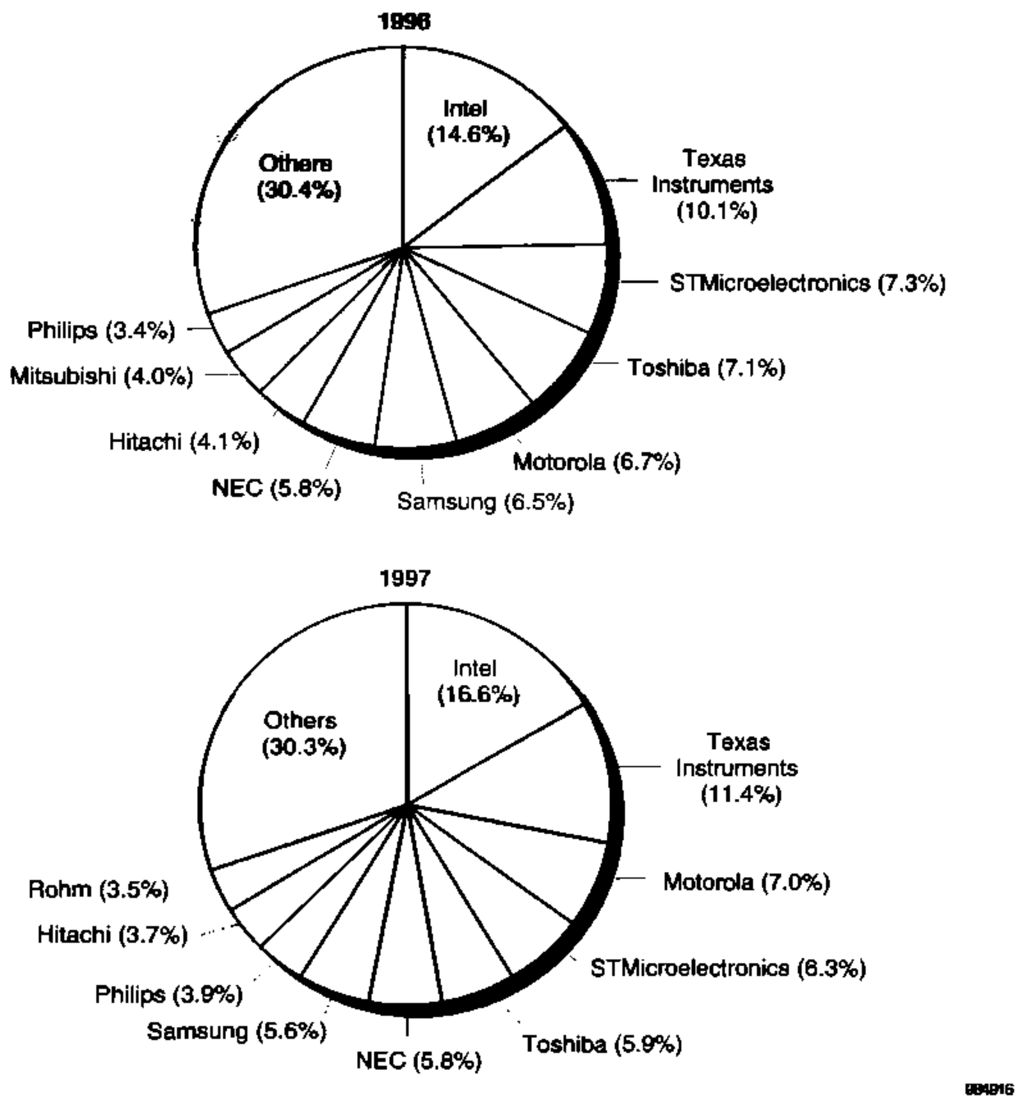
TECH's first fab was manufacturing 16Mb DRAM in 1993. In the wake of the acquisition, 16Mb wafer starts in Fab 1 will be gradually reduced in the preparation of equipment retooling. Fab 2 started operating earlier last year, producing 16Mb DRAM devices. TECH has since converted the second fab to manufacture 64Mb DRAM devices this year. As a foundry, TECH should stand to gain from Micron's technology in lowering production costs and its position as the second largest DRAM vendor worldwide.

Semiconductor Vendors in Singapore

Revenue from shipments to Singapore in 1997 by the top 32 worldwide semiconductor vendors (ranked as such by Dataquest) reached $8,656 million, an 11.7 percent increase over 1996 (for more details, please refer to SEMI-AP-MS-9803). Figure 1 illustrates the market share of the top 10 ranked companies in the Singapore semiconductor market. Intel Corporation, TI, and Motorola Incorporated occupied the top three positions in 1997, and at the same time, increased their market share among the surveyed companies last year. However, the company recording the most impressive gain in 1997 was Rohm Company Ltd. Its revenue surged by 97.4 percent on the back of rising discrete and analog sales.

Revenue from semiconductor shipments into Singapore has exceeded the actual value of semiconductors consumed in the city-state. According to Dataquest, Singapore's chip market is the largest in the Asia/Pacific region from a shipment perspective. Semiconductor sales in the local market would be typically made up of sales to end-equipment manufacturers (including contract equipment manufacturing companies), international procurement offices, and distributors. In each of these sales channels, a significant proportion of the products are then re-exported to the region for intermediate or final equipment production.

Figure 1
Top 10 Worldwide Vendors' Market Share from Shipments of Total Semiconductors to Singapore



Note: The total includes only the top 32 companies by shipment into Asia/Pacific; it does not equal the total Asia/Pacific market. This figure includes semiconductors used in Singapore and re-exported via Singapore.
Source: Dataquest (August 1998)

Singapore is established as the financial, communications, and logistic center in the Southeast Asian region. Dataquest believes that total shipment revenue attributed to the Singapore market by the top 10 ranked companies includes shipments of semiconductors to Malaysia, the Philippines, and Thailand, as well as other ASEAN countries. In certain cases, the products are also shipped and consumed in other Asia/Pacific countries. This means that the amount of semiconductors consumed locally is actually lower than total shipment revenue. The percentage of local semiconductor consumption is expected to decline, a result of the trend to relocate lower-value-added production activities to other cost-competitive countries. However, most equipment manufacturing companies should continue to procure semiconductors from Singapore, given the city-state's position as a regional business hub.

Dataquest Perspective

Trade data for the first half of 1998 has shown a slowing down of electronic exports. This trend reflects the negative impact on demand and increased pricing pressure for electronic products, brought on by excess capacity and the Asian financial crisis. Even the high-growth semiconductor manufacturing industry has succumbed to this trend, despite new investments made in plants and equipment. Singapore's electronics export growth is expected to remain weak as a result of lower output from the electronics manufacturing sector.

Singapore remains the leader in the number of wafer fabrication plants in Southeast Asia. The expansion of wafer fabs in other ASEAN countries has been impacted by the Asian economic downturn and the ensuing liquidity crunch. The year 1997 saw declining revenue for the three semiconductor manufacturing companies in Singapore. Although the number of manufacturers has risen to four in 1998, two of the companies have delayed the initial start-up schedules of their fabs as a result of the weak semiconductor market. Chartered has postponed its fourth fab, CSP, by one year. However, Chartered and Lucent are proceeding with the plan to begin production in SMP by next year. STMicroelectronics has also decided to hold back the construction of its second building to house Fab 5. The company is expected to evaluate its plan to determine an appropriate production schedule for its latest fab.

HNS, the latest entrant, is also exercising caution by adopting a gradual ramp-up approach in its 64Mb DRAM fab—a result of the global excess supply. It is expected to achieve full production by the second quarter of 1999. Another DRAM producer, TECH, is in a transition phase as it retools its fabs to Micron's manufacturing processes, following Micron's acquisition of TI's memory operations. With the upgrades undertaken at existing wafer plants, signs point to sustained semiconductor manufacturing growth in the coming years.

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In the semiconductor market, total revenue from shipments to Singapore registered an increase last year. However, the percentage of actual chip consumption in Singapore should trend lower because end-equipment companies are shifting their factories to other countries in the region. The city-state's role as the eminent business hub in Southeast Asia should lead to a higher number of manufacturing companies maintaining and expanding their purchasing functions there. Moreover, Singapore authorities continue to make improvements in the public infrastructure, enabling procurement offices of OEM/CEM companies in Singapore to source for products to supply their regional manufacturing operations.

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Perspective

Semiconductors Asia/Pacific

Market Analysis

Semiconductor Capital Spending in Asia/Pacific

Abstract: *This Perspective presents a review and outlook of Asia/Pacific's semiconductor capital spending. Dataquest examines the region's capital spending using two methodologies: Asia/Pacific companies' capital spending around the world and worldwide companies' capital spending in Asia/Pacific. The outlook for worldwide companies' capital spending in Asia/Pacific will be dynamic because of the Asian financial crisis that has affected the region's major spenders. In addition to the semiconductor market, the economic crisis will become a decisive factor in Asia/Pacific's capital spending.*
By Jerry Yeh

An Overview

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From 1992 to 1997, the compound annual growth rate (CAGR) of Asia/Pacific's capital spending by multinational companies in Asia/Pacific reached 43.8 percent, while the worldwide capital spending CAGR during the same period was 28.4 percent. According to Dataquest's midyear semiconductor capital spending forecast, worldwide capital spending for 1998 calls for a 22 percent decline. Capital spending by worldwide companies in Asia/Pacific is expected to decline by 11.7 percent in 1997, with another 26.7 percent decline in 1998.

The Asian financial crisis, which started in July of 1997, landed in Thailand first. After that, it traveled to Indonesia, and then to Korea. It destroyed these countries' economies and will become a decisive factor in semiconductor companies' capital spending by 2002. In the near future, Asia/Pacific's semiconductor capital spending is expected to decline. Although a dedicated foundry growth is anticipated, Dataquest expects a shrinkage in capital spending. It seems that crisis has not yet finished with the Asia/Pacific region.

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Notes on Asia/Pacific's Capital Spending Data

In the process of conducting data collection and preparing capital spending statistics information, Dataquest will sometimes consolidate or revise a particular company's data and differentiated data according to the region in which the investment was made. Two different methodologies have been used in this report to observe the region's reality. This section will explain any such changes contained in this Perspective for reference.

- **Statistical information of Asia/Pacific companies' capital spending in the worldwide market**—In 1997, Asia/Pacific companies spent U.S.$12.6 billion in the world. This total includes all spending to all regions, including those spending in Asia/Pacific. This methodology measures the capability of capital spending of Asia/Pacific countries or companies.
- **Statistical information of worldwide companies' capital spending in Asia/Pacific**—In 1997, worldwide companies spent $14.3 billion in Asia/Pacific. This total includes back-end manufacturing and wholly owned companies by non-Asia/Pacific companies in the region. This methodology presents the companies' activity from non-Asia/Pacific regions in Asia/Pacific.
- **Statistical information of capital spending by joint ventures**—Before joint-venture (JV) companies start operation and are included in Dataquest's survey list, their capital spending will be counted according to each investor and stake.

Asia/Pacific Companies' Capital Spending Worldwide

Companies' Semiconductor Capital Spending Ranking

The worldwide capital spending growth by Asia/Pacific semiconductor companies shrank to 51.1 percent in 1996, down from a sky-high 138.8 percent increase in 1995. In 1997, the capital spending dropped sharply to negative 10.6 percent, which was caused by the Asian financial crisis and the semiconductor market's downturn. The top 10 Asia/Pacific companies in terms of capital spending represented 76.1 percent of the 1997 semiconductor spending (see Table 1).

Korea's currency devaluation, the International Monetary Fund (IMF) bailout that shook investors' confidence, and a critical foreign currency shortage have all combined to cause Korean industrial giants to suffer from the first-ever, capital-spending cutback in 1997. LG Semicon Co. Ltd. and Samsung Electronics Company Ltd. spend almost the same amount of capital, U.S.$1.57 billion, in 1997. Despite this cutback in spending, the giant chaebols still managed to invest the largest amount of capital among Asia/Pacific companies. Totaling about U.S.$4.5 billion in 1997, the three Korean industrial giants won the top-three-spender positions, the same as in 1996.

With a tight budget and a postponed global investment, however, there is a shift in the pattern of capital spending: The capital will be invested in the state-of-the-art technology to continue Korea's lead in DRAM manufacturing. Korea's capacity may not expand as expected, but with the technology still in

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hand, Korea has the potential to continue its market dominance. Anam S&T Company Ltd. started investing in capital spending in 1997. This new fab drew more capital to the foundry in the region. Anam ranked No. 16 in 1996, and jumped to No. 6 in 1997. The total spending for 1997 was U.S.$1.1 billion.

Although the Asian financial crisis hasn't hurt Taiwan critically in 1997, many Taiwanese companies' capital spending plans had been revised. The resulting 1997 capital spending does not surprise Dataquest because all planned investment set up in the previous year cannot be changed dramatically. This result is the same as predicted by Dataquest last year.

Taiwan Semiconductor Manufacturing Co. and its joint venture Wafer Tech (TSMC Group) was the fourth-largest spender. The company's strategy and dedicated foundry goal are clear to its investors. The TSMC Group won the No. 4 place in 1997 with a U.S.$1.2 billion capital spending.

The UMC Group, consisting of United Microelectronics Corporation (UMC) and its three joint ventures—United Silicon Inc. (USI), United Semiconductor Corporation (USC), and United Integrated Circuits Corporation (UICC)—trailed closely behind TSMC. The company's three joint ventures began to consume capital in 1997. Except for UICC's fire accident, the UMC Group successfully set up two other joint ventures. This quick action allowed the company to maintain its No. 2 position in dedicated foundry worldwide. The UMC Group won the No. 5 position with a U.S.$1.2 billion capital spending in 1997.

In 1997, under Winbond Electronics Corporation's support on capital investment, World Semiconductor Mfg. Co. Ltd. (WSMC) started its new fab construction. Dataquest counted WSMC as a part of Winbond's spending in 1997. In 1997, Winbond Group won the No. 8 spot on capital spending, with U.S.$875 million.

Dataquest counts ProMOS Technologies' spending as part of Mosel Vitelic Inc. in 1997. Mosel Vitelic Group won the No. 9 position, with U.S.$564 million in 1997. Chartered Semiconductor Manufacturing Pte. Ltd. dropped from No. 4 to No. 7 in 1997 with a capital spending of U.S.$940 million. In 1997, the company's major spending focused on its new fab (Fab 3). Macronix International Company Ltd. won the No. 10 place in capital spending with U.S.$359 million in 1997 for its new fab (Fab 2).

Country-Level Spenders' Comparison: Korea, Taiwan, and Singapore

In this section, Dataquest excludes other countries in the analysis because their combined capital spending is relatively small.

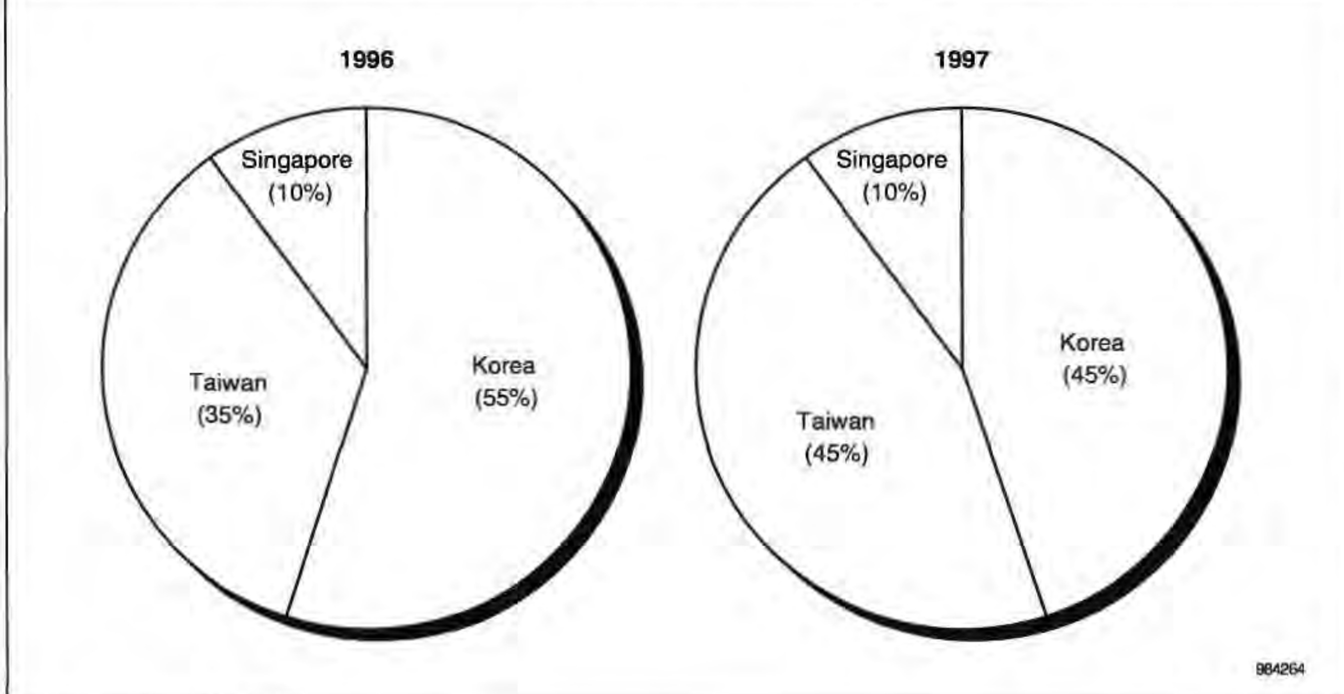
Korean companies have always been the largest investors in facilities in this region since the 1980s. The second-largest spender, Taiwan, has followed a certain distance from the Korean semiconductor giants for years. However, the gap is closing. As noted in Figure 1, Dataquest compares the three countries to illustrate the picture of country-level competition, which is always an interesting topic in the industry.

Table 1
Worldwide Capital Spending by Asia/Pacific Company: A Comparison of Top 10 Spenders, 1996 and 1997 (Millions of U.S. Dollars)

1996 Rank	1997 Rank	Company	1996	1997	Change (%) 1996 to 1997	1997 Share (%)
1	1	LG Semicon	2,732	1,572	-42	12.5
2	2	Samsung	2,236	1,572	-30	12.5
3	3	Hyundai	2,111	1,345	-36	10.7
6	4	TSMC Group	796	1,226	54	9.7
8	5	UMC Group	600	1,200	100	9.6
16	6	Anam Semiconductor	250	1,048	319	8.3
4	7	Chartered Semiconductor	872	940	8	7.5
5	8	Winbond Group	747	875	17	7.0
15	9	Mosel Vitelic Group	307	564	84	4.5
11	10	Macronix	395	359	-9	2.9
		Total Top 10 Companies	**11,046**	**10,701**	**-3**	**85.1**
		Total Asia/Pacific Capital Spending	**14,069**	**12,579**	**-11**	**100.0**
		Top 10 Companies' Percentage of Total	**78.5**	**76.1**	**-3**	**0.6**

Source: Dataquest (July 1998)

Figure 1
A Comparison of Capital Spending in Korea, Taiwan, and Singapore, 1996 and 1997



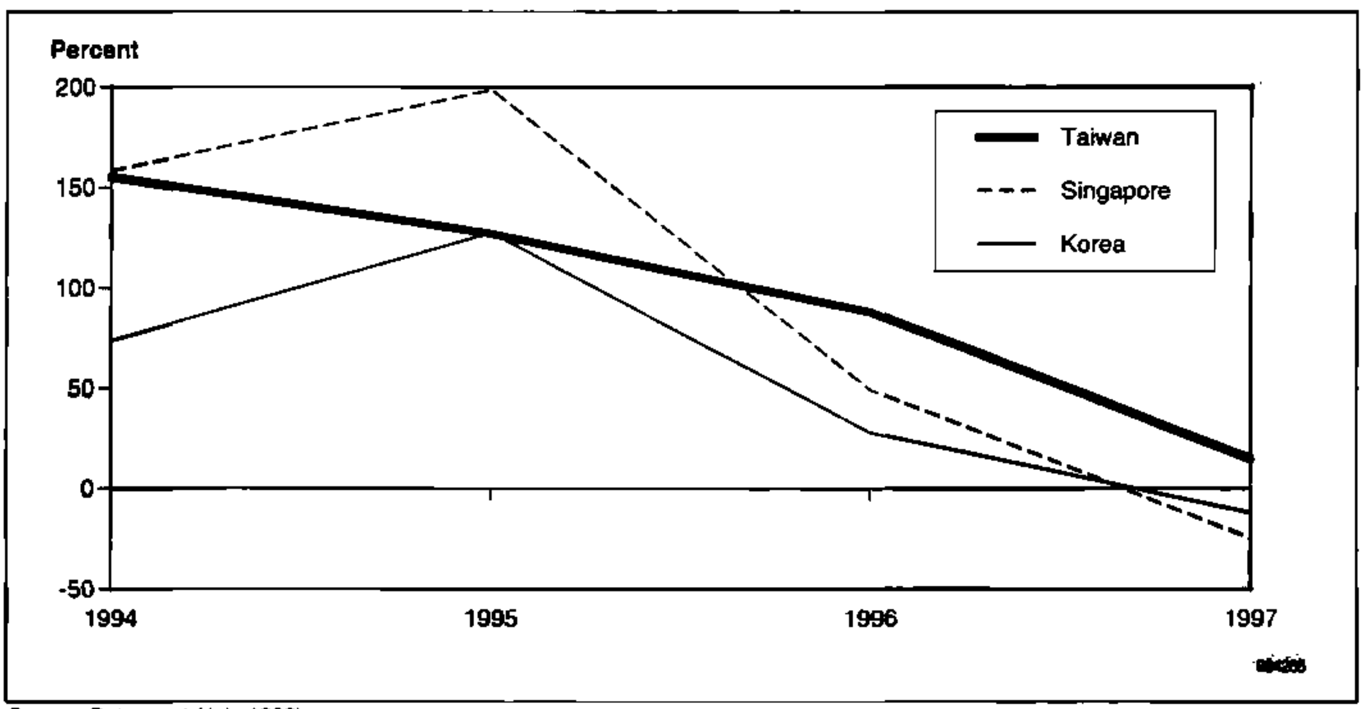
Source: Dataquest (July 1998)

In 1996, Korean companies captured the lion's share, 55 percent, of the three countries' capital spending. Taiwan's share was 35 percent, and Singapore's was 10 percent. In 1997, Korea dropped 10 percent to hold a 45 percent share, with a U.S.$5.58 billion capital spending, while Taiwan gained a 45 percent share with a U.S.$5.47 billion investment. Singapore retained the same percentage to hold a 10 percent share with a U.S.$1.16 billion. Figure 2 illustrates another comparison, the capital spending growth rate by the same countries. Taiwan continued its steady path of capital spending in the past few years. However, it shrank from an 87.9 percent growth rate in 1996 to a 14.9 percent growth rate in 1997. This growth surpassed the growth rate of total Asia/Pacific and other countries in 1997. Korea also faced declines, dropping from a 28 percent growth to a 24.5 percent decline. Singapore's spending also declined from a high of 49.2 percent to negative 11.9 percent. Benefiting from the booming DRAM market, Korea has succeeded in capital accumulation and strongly increased spending in 1996 to expand its global manufacturing. However, all those projects have been postponed in 1997.

In 1997, although a few of the originally planned Taiwanese new fabs were delayed or canceled because of the semiconductor market downturn, capital spending did not shrink at a large scale. What kept capital spending from plummeting was the new start-up companies that geared up new fab capacity and continued investment in dedicated foundry and DRAM.

After the past few years' effort, Singapore has built a semiconductor manufacturing base in the center of Southeast Asia—at the time of the Asian financial crisis and Thailand's failure to develop its semiconductor industry. Singapore now plays an important role as a regional and worldwide foundry provider.

Figure 2
Worldwide Capital Spending by Major Asia/Pacific Country, 1994 to 1997 (Rate of Change)

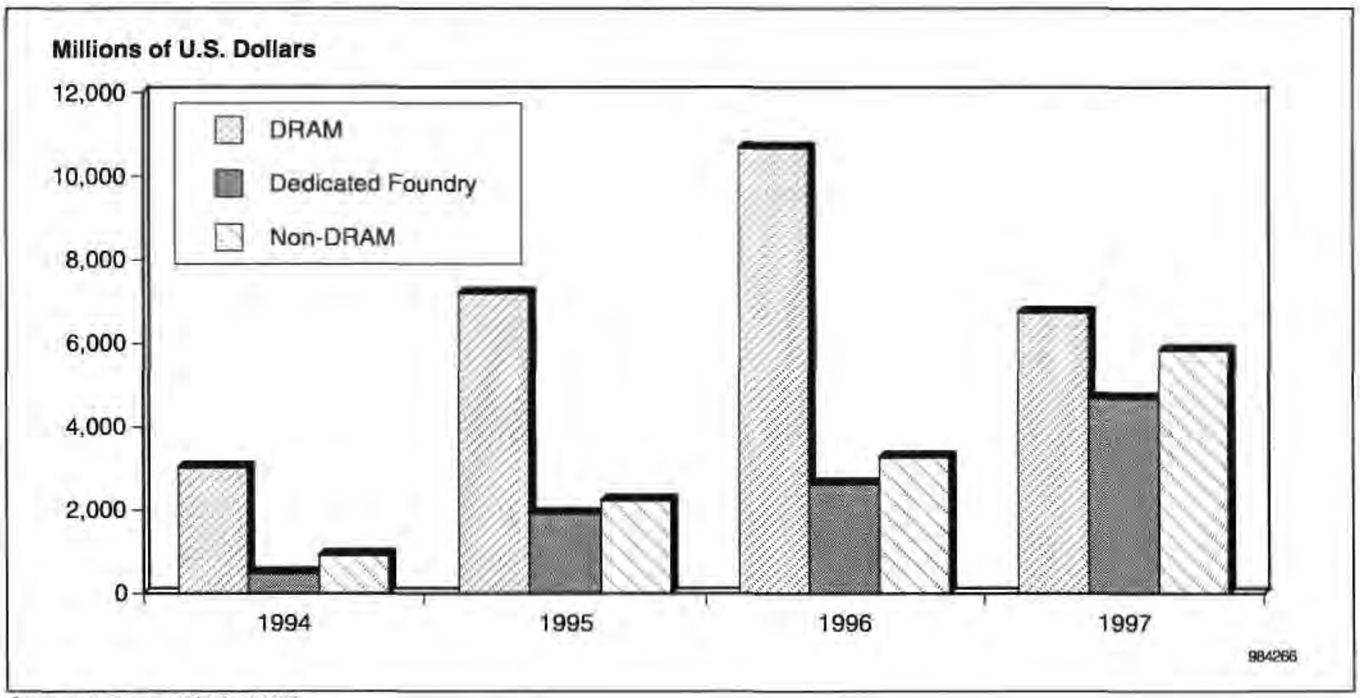


Source: Dataquest (July 1998)

Capital Moves toward Dedicated Foundry

Figure 3 illustrates worldwide capital spending by Asia/Pacific companies. DRAM has driven the Asia/Pacific capital spending growth during the past 10 years, since Korean companies first purchased the manufacturing facility for DRAM production. In 1997, Korean companies' large-scale cutback on capital spending resulted in a 36.8 percent decline on the region's DRAM segment's capital spending. In the dedicated foundry segment, a 78 percent growth in 1997 showed a capital shifting from DRAM to dedicated foundry. As non-DRAM wafer fab capacity increased—particularly the dedicated foundries—the percentage of capital spending for DRAM declined sharply. In 1996, DRAM took a 74.8 percent share of total spending, dropping to 53.6 percent in 1997. Dedicated foundry has become the second-largest segment after DRAM. In 1996, dedicated foundry reached 37.3 percent and took an 18.4 percent share of total capital spending. This segment showed a 78 percent growth in 1997, with a 37.2 percent share of the total.

Figure 3
Worldwide Capital Spending by Asia/Pacific Company, DRAM, Foundry, and Non-DRAM Comparison, 1994 to 1997



Source: Dataquest (July 1998)

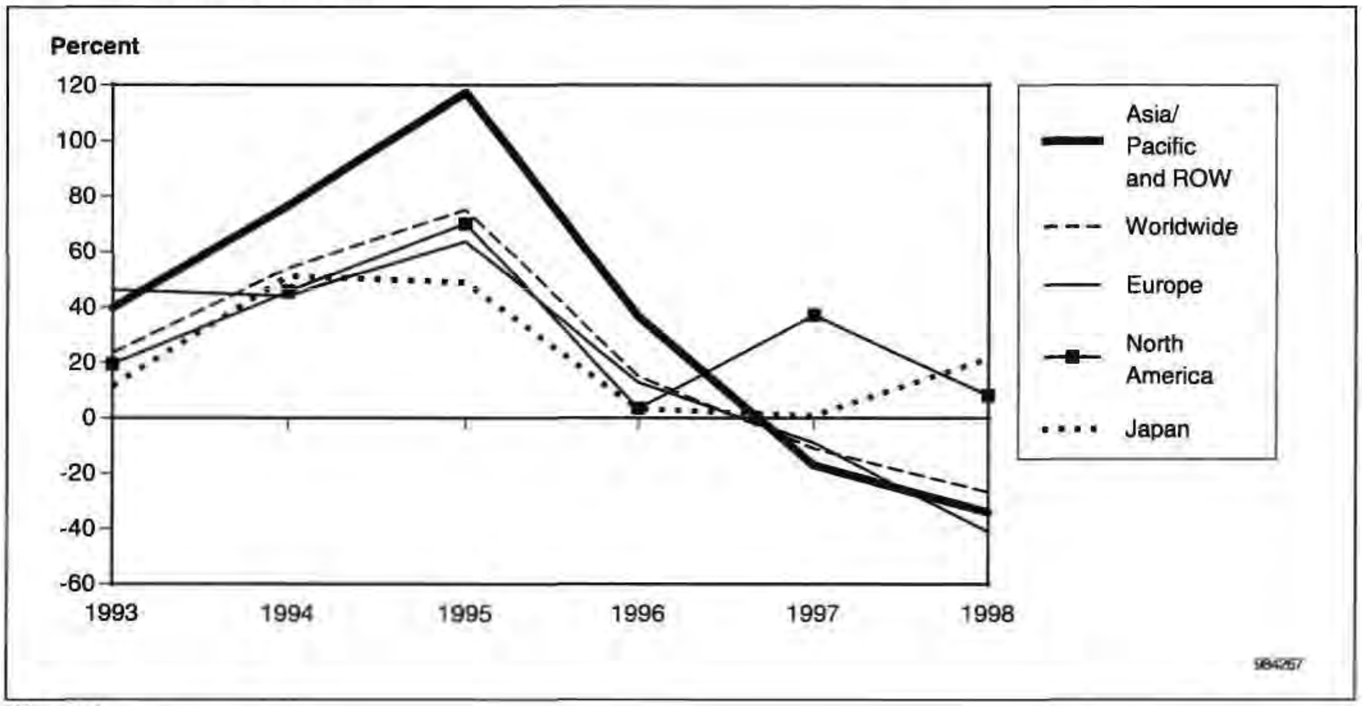
Worldwide Companies' Capital Spending in Asia/Pacific

Dataquest expects worldwide companies' capital spending in Asia/Pacific to reach a negative 0.2 percent CAGR from 1993 to 1998. Excluding the spending from Asia/Pacific companies, the actual spending from non-Asia/Pacific companies suffered a 24.7 percent decline. Figure 4 illustrates the regional growth rate of worldwide capital spending from 1993 to 1998. Figure 5 depicts worldwide companies' capital spending in Asia/Pacific in

1997 and 1998. While Asia/Pacific spenders decreased their own regional spending in 1997, the share of non-Asia/Pacific's spenders that invested in Asia/Pacific increased from 18.7 percent to 21 percent in 1997. Moreover, as Asia/Pacific continues to decrease its own regional spending in 1998, non-Asia/Pacific spenders expect to take 29 percent of the total share. Table 2 shows preliminary Asia/Pacific companies' capital spending around the world in 1997 and 1998.

For many years, Asia/Pacific companies have had the ability to invest in new wafer fabs mostly using their own capital. However, since the onset of the Asian financial crisis, non-Asia/Pacific companies have not shrank their investment in a larger scale in the region because foreign companies generally play the role of technology support and marketing in the region. For foreign companies, a small amount of investment can generate substantial benefits from their technology share with a joint venture, which encourages them to continue evaluating the region's future potential. Although the semiconductor market downturn and the Asian financial crisis caused a worldwide capital spending shrinkage, non-Asia/Pacific will not withdraw from this bargain land.

Figure 4
Regional Historical Growth Rate of Worldwide Companies' Capital Spending in Asia/Pacific, 1993 to 1998*



*Forecast
Source: Dataquest (July 1998)

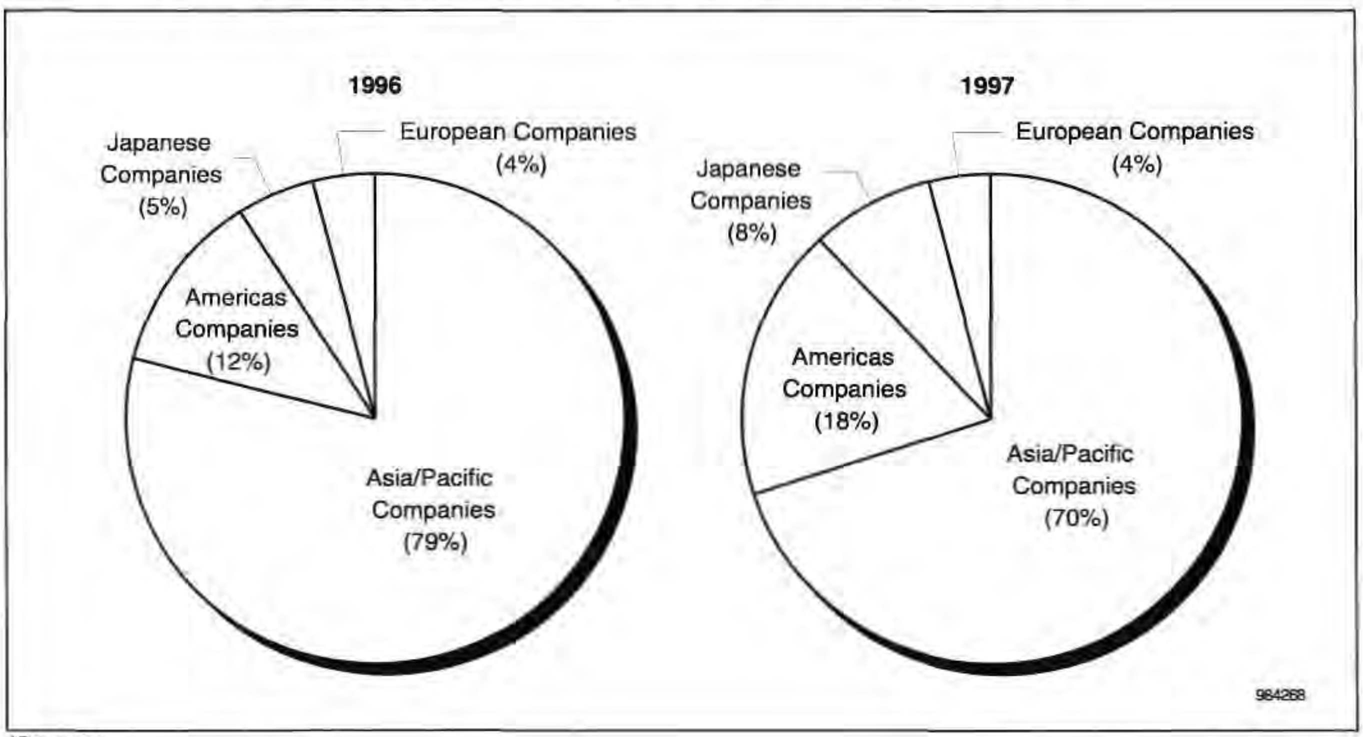
Dataquest Perspective

The picture of Asia/Pacific companies' capital spending in 1998 appears gray. Korea has cut capital spending in large scale. In the past few years, Korean companies have started investing around the world, but they face a new challenge since the economic crisis in 1997. Fortunately, it isn't too late to withdraw from the worldwide investment; otherwise, Korean companies' loss will become unpredictable. Some Taiwan companies are retaining a certain spending in 1998, but the overall spending is expected to decline. Since Thailand's currency fall and financial institutions' bankruptcies in July of 1997, there is no sign that the country will build a semiconductor industry in the near future. Singapore became a dedicated foundry center in Southeast Asia, but it still trails behind its Taiwanese foundry competitors.

While Dataquest examines the semiconductor industry in this gloomy economy, there is always a factor that is difficult to measure: What is a company's view of its future? Sometimes, a company's bottom line is mostly dependent upon the national culture (such as the national pride) and the company leaders' character.

Non-Asian companies tend to focus on a fast return on capital such as in three to five years. For example, when a U.S. or Europe-based multinational company invests in a new fab, it expects this fab to earn back its investment within three to five years. If these companies find out that their return isn't forthcoming in a few years, most of them will decide to withdraw from the business and find another way out.

Figure 5
Worldwide Companies' Capital Spending in Asia/Pacific, 1997 and 1998*



*Forecast
Source: Dataquest (July 1998)

Table 2
Preliminary Worldwide Capital Spending by Asia/Pacific Company: A Comparison of Top 10 Spenders, 1997 and 1998 (Millions of U.S. Dollars)

1997 Rank	1998 Rank	Company	1997	1998	Change (%) 1997 to 1998	1998 Share (%)
4	1	TSMC	866	920	6	11.8
2	2	Samsung	1,572	646	-59	8.3
8	3	Winbond Electronics	486	633	30	8.1
10	4	Anam Semiconductor	1,048	532	-49	6.8
5	5	UMC	401	491	22	6.3
NM	6	WSMC	389	450	16	5.8
NM	7	USC	104	440	323	5.6
1	8	LG Semicon	1,572	405	-74	5.2
3	9	Hyundai	1,345	403	-70	5.2
17	10	Holtek (Renamed Utek in 1998)	150	329	119	4.2
		Total Top 10 Companies	**7,933**	**5,249**	**-34**	**67.2**
		Total Asia/Pacific Capital Spending	**12,579**	**7,809**	**-38**	**100**
		Top 10 Companies' Percentage of Total	**63.1**	**41.7**	-	-

NM = Not meaningful
Note: Columns do not add to totals shown because of rounding.
Source: Dataquest (July 1998)

However, the Asia/Pacific company will decide to retain its business operation, even if it doesn't generate profits for several years during semiconductor downturn market. There are many reasons. In the past decades, most Asian countries were poor. Now, with their rapid industrialization and modernization, some of them have a chance to become a leading high-tech country and compete with the world's strong industrial leaders such as the United States and some European countries. So these Asia/Pacific countries and companies will invest as much resources as possible into their companies and never give up, while neglecting or relegating the financial danger that non-Asian companies often manage to avoid.

Following the national high-technology industrial policies, different Asia/Pacific countries are fully supported by their respective local governments. Most of these countries' resources—such as capital and human resources—have been invested in these high-tech industries. It is why most of Asia/Pacific electronics industries' pioneering companies have spent more than a decade investing in their companies while continuing to lose profits every year within that decade! With the darkness in the semiconductor market to last indefinitely, only the company with the technology, capital, and a resourceful management and design team can survive until the time of recovery.

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Perspective

Semiconductors Asia/Pacific

Market Analysis

1998 Asia/Pacific Microcomponent Market Trends

Abstract: *The Asia/Pacific MOS microcomponent market grew by an impressive 23.7 percent in 1997. Microprocessor products constituted the most influential segment in determining the overall trend of the microcomponent revenue. Dataquest estimates that digital signal processing (DSP) devices should record the highest growth rate among all the product segments. With the onset of the Asian financial crisis in the second half of 1997, the market is expected to experience lower growth rates this year.*

By Ken Ng

Introduction

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The microcomponent market in Asia/Pacific recorded robust growth in 1997 driven by microprocessor (MPU) revenue expansion. All of the microcomponent product segments achieved healthy increases. Digital signal processor (DSP) products emerged as the fast-rising device category. Dataquest's five-year compound annual growth rate (CAGR) forecast of 18.4 percent for the regional microcomponent market indicates that revenue should continue to rise from 1998 to 2002.

The Asian financial crisis will have an adverse impact on the semiconductor market this year. With demand for electronic equipment remaining weak and prices of end products declining, regional semiconductor revenue growth is predicted to moderate. Although the MOS memory category is expected to bear the brunt of the market slowdown, microcomponent devices should also be affected by excess capacity and pricing pressure.

This Perspective examines the 1997 Asia/Pacific regional market trends, as well as forecasting the microcomponent market up to 2002. A downside forecast scenario is presented to assess the impact of the regional economic

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turmoil. The first section reviews the competitive position of major microcomponent vendors in Asia/Pacific by analyzing market share rankings for total microcomponent revenue and in the four product segments. In addition to the Asia/Pacific view, estimates of each product category and a country-level breakdown will be provided in the later sections.

Asia/Pacific Microcomponents Revenue Ranking

Table 1 shows that the Asia/Pacific microcomponent market reached $10,796 million in 1997, representing a 23.7 percent revenue increase over 1996 (For more information, please refer to "1997 Regional Microcomponent Market Share," MCRO-WW-MS-9803). Intel Corporation, once again, topped the Asia/Pacific rankings with a 26.3 percent revenue surge, to record $3,901 million. The company accounted for a whopping 36.1 percent of total microcomponent revenue in the Asia/Pacific market. The second- and third-placed companies, Motorola Incorporated and Toshiba Corporation, also recorded revenue gains. However, Intel's revenue was almost six times the size of second-ranked Motorola—indicating that the leader is likely to remain in the first position for some years to come.

Table 1
Top 10 Worldwide Companies' Revenue from Shipments of MOS Microcomponents to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%) 1996 to 1997	1997 Market Share
1	1	Intel	3,088	3,901	26.3	36.1
2	2	Motorola	563	685	21.7	6.3
4	3	Toshiba	301	395	31.1	3.7
5	4	Texas Instruments	291	382	31.3	3.5
6	5	United Microelectronics	289	326	12.8	3.0
16	6	Advanced Micro Devices	122	311	154.8	2.9
8	7	NEC	254	309	21.6	2.9
9	8	Hitachi	227	303	33.4	2.8
3	9	Philips	386	286	-25.9	2.6
18	10	S3	104	271	160.6	2.5
		All Others	3,100	3,627	17.0	33.6
		Total Market	**8,725**	**10,796**	**23.7**	**100.0**

Source: Dataquest (July 1998)

Advanced Micro Devices Inc. (AMD) experienced a revenue doubling as a result of its increased competitiveness in the microprocessor market. The company enjoyed gains as its products were adopted by PC manufacturers. AMD experienced the fastest ascent in the rankings, advancing by 10 places.

Asia/Pacific Companies Are Emerging

United Microelectronics (UMC) was the only Asia/Pacific company represented in the top 10 ranking, based mainly on the company's microperipheral business. However, the Korean chaebols are beginning to make their presence felt in the Asia/Pacific microcomponent market. Korea's semiconductor manufacturers are placing increased emphasis on marketing their products in the Korean domestic market. Dataquest estimates that this is part of their strategy to make up for declining revenue from export sales of memory chips and enhance the competitiveness of their nonmemory products in the domestic market, which up to now, has been dominated by imports. These products are gaining acceptance among domestic electronic appliance manufacturers because of their improved price competitiveness. Equipment manufacturers will increasingly target export markets as a result of the Korean economic downturn that lowers consumer demand in the country.

Samsung Electronics Company Ltd. expects revenue from Alpha chips to increase substantially in the future. This is predicted to further add to the company's fast-increasing microcomponent business. The main applications for Alpha processors should come from servers manufactured in North America. LG Semicon Co. Ltd., which developed a media processor (MPACT chip) with Chromatic Research Inc. of the United States, is targeting to produce 200,000 units in 1998. LG also plans to deliver its Java chip in the second half of this year. This product can be used for a variety of network-based information technology appliances, including network computers, Internet TVs, and Internet set-top boxes. Although most of these new microcomponent devices will be consumed in the Korean domestic market, exports are likely to contribute a significant percentage of revenue as local equipment manufacturing is in the midst of a slowdown.

The Asia/Pacific MPU Market

In 1997, total Asia/Pacific MPU revenue expanded by 28.2 percent to reach $4,380 million. Figure 1 presents the MPU market share of the top-10-ranked companies. Intel took 80.5 percent of the MPU market in 1997. Its dominance in the MPU device category has propelled the company toward the top of the overall Asia/Pacific microcomponent rankings. Motorola and AMD also made revenue increases last year. Motorola's Power PC revenue was tied to a recovery in Apple's PC production. AMD's MPU products gained wide acceptance from PC manufacturers, including first-tier companies such as Hewlett-Packard Company and Compaq Computer Corporation. Its range of MPUs also proved to be popular with other PC makers, particularly in the sub-$1,000 PC segment. After acquiring Cyrix, National Semiconductor Corporation (NS) has established a foothold in the Asia/Pacific MPU market. Looking forward, NS with its range of MPU products targeted at lower-end PCs, should emerge as another important vendor in Asia/Pacific.

The MPU category was the largest single product segment of the microcomponent market in 1997. MPUs accounted for nearly 41 percent of total microcomponent revenue. Dataquest estimates that Asia/Pacific's PC

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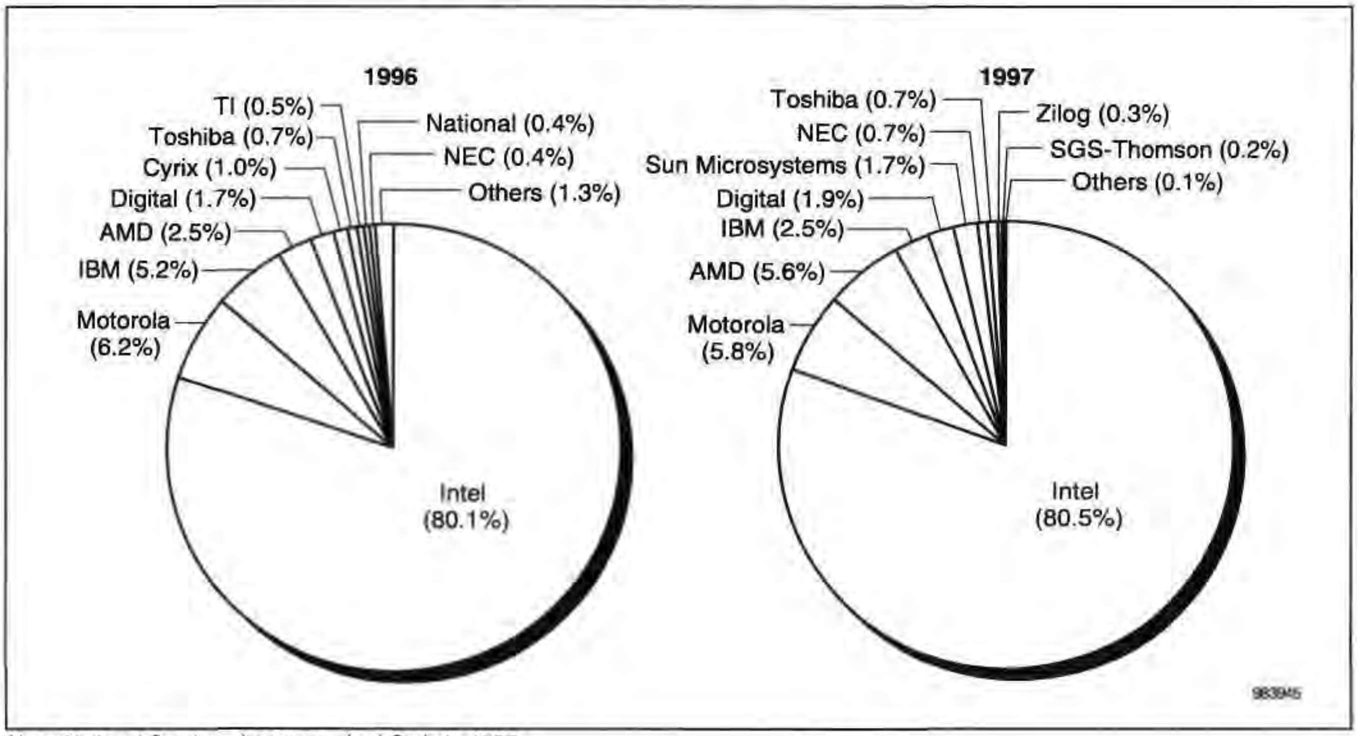
production will grow at a 22.3 percent CAGR between 1997 and 2002. With the PC output expected to rise, the MPU market and Intel's position in this space should remain on top and unchanged.

Figure 1
Asia/Pacific Microprocessor Market Share, 1996 and 1997 (Percent)



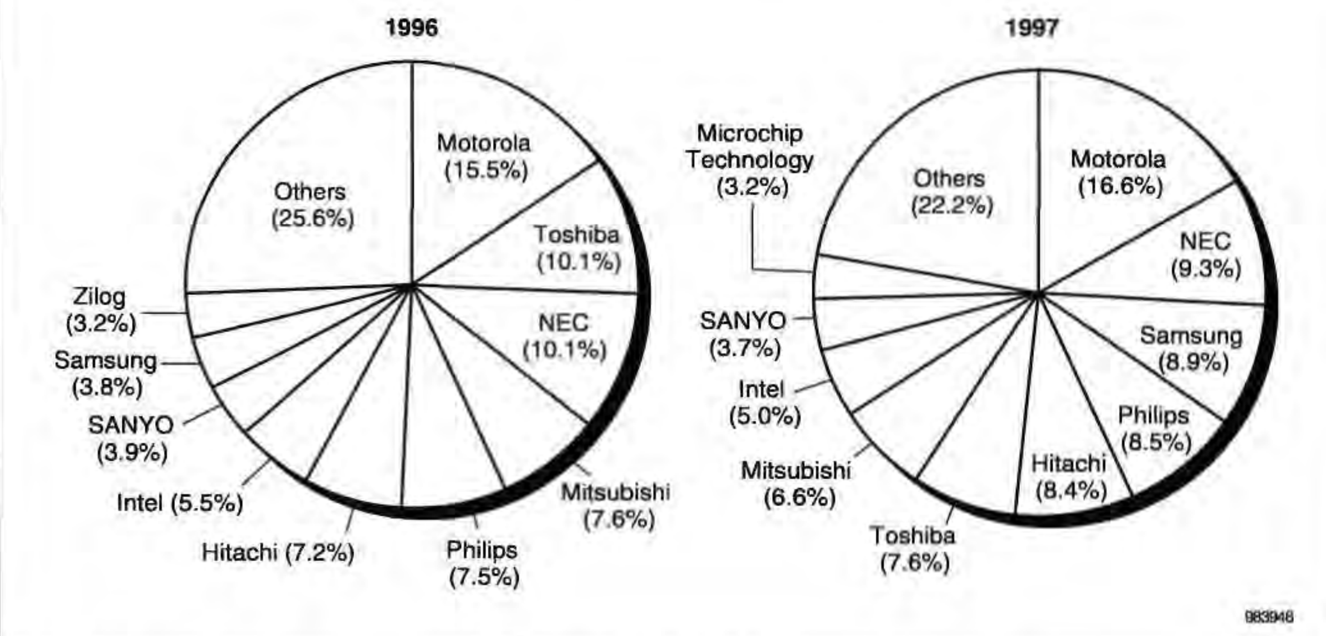
Note: National Semiconductor acquired Cyrix in 1997.
Source: Dataquest (July 1998)

The Asia/Pacific MCU Market

Total microcontroller (MCU) revenue in Asia/Pacific rose 15.2 percent to reach $2,309 million in 1997. Figure 2 provides the MCU market share of the top-10-ranked companies. Motorola occupied the top spot with 16.6 percent of the market, followed by NEC Corporation and Samsung with 9.3 percent and 8.9 percent share, respectively. Motorola's increasing share of 8-bit MCU devices has kept the company on top of the Asia/Pacific MCU rankings. A diverse mix of products, ranging from 4-bit to 16-bit MCUs, pushed NEC up a slot into second. Riding on the success of 4-bit MCUs, Samsung was the largest mover last year, gaining six positions to finish 1997 ranked third. The company's MCU sales grew as a result of revenue from consumer applications, including electronic toys.

The MCU category was the third-largest product segment of the microcomponent market. Last year, MCUs accounted for more than 21 percent of total Asia/Pacific microcomponent revenue. Dataquest projects that 16-bit and higher MCUs will find increasing usage in many types of high-volume end-electronic equipment. Vendors with an established market in these products, including Hitachi Ltd. and Motorola, should benefit from this trend.

Figure 2
Asia/Pacific Microcontroller Market Share, 1996 and 1997 (Percent)



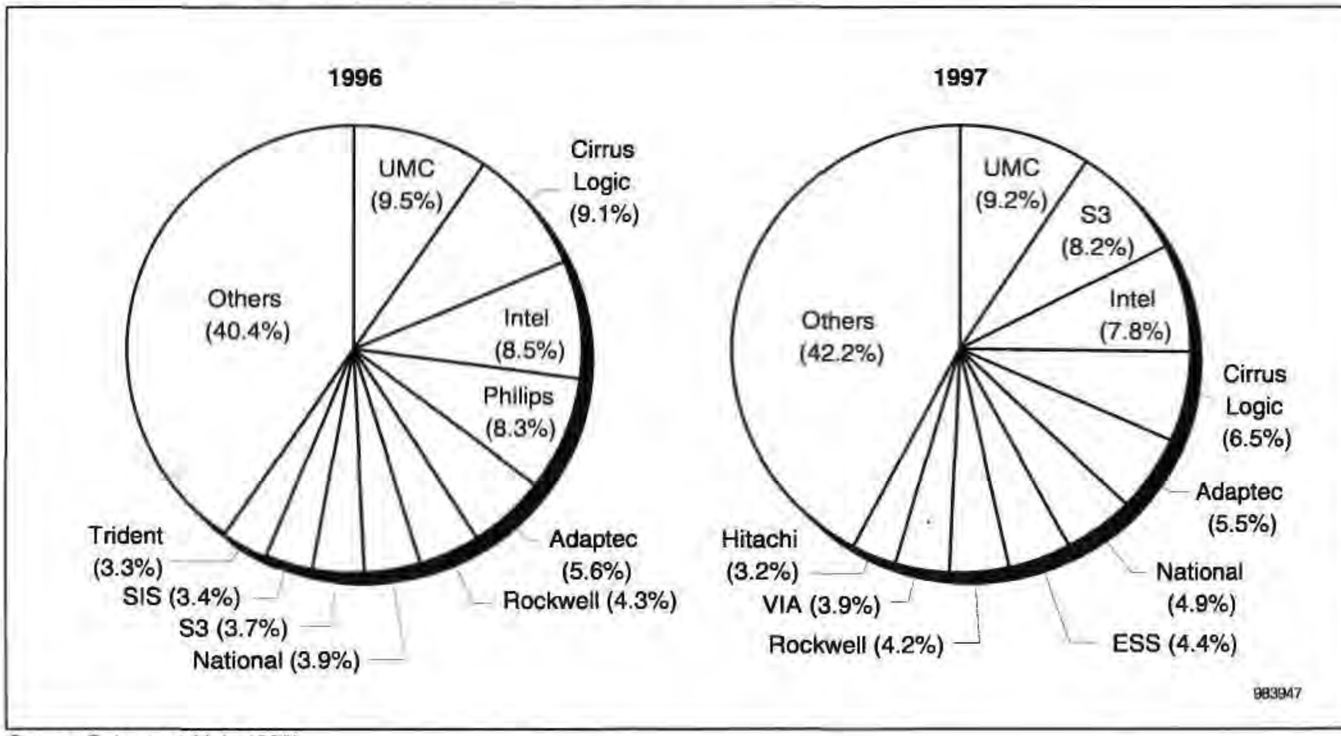
Source: Dataquest (July 1998)

The Asia/Pacific MPR Market

Total microperipheral (MPR) revenue in Asia/Pacific recorded a 17.0 percent growth to reach $3,315 million in 1997. Figure 3 charts the MPR market share of the top-10-ranked companies. UMC maintained its No. 1 position with 9.2 percent of the total market. Graphics chip manufacturer S3 Incorporated registered an impressive 161 percent revenue increase to move into the second place, followed closely behind by the Intel juggernaut. S3 and Intel had 8.2 percent and 7.8 percent of Asia/Pacific MPR market share respectively. The leading positions of UMC and Intel are attributed to their core logic chipset revenue. Another top-ranked Asia/Pacific vendor with a significant market in this segment is a fabless Taiwan company, VIA Technologies Inc. Dataquest estimates that Asia/Pacific motherboard production will register a five-year CAGR of 17.7 percent. This represents an increase from 60 million units in 1997 to nearly 136 million units by 2002. The graphics chip segment is expected to become increasingly competitive for the leader, S3. Intel's entry into this segment with the i740 chip should establish the company as a key vendor.

The MPR category was the second-largest product group of the microcomponent market. This PC-centric range of products constituted more than 30 percent of total microcomponent revenue in 1997. Besides the two largest segments of core logic and graphics chips, other major segments include communications, mass storage, and audio controllers. The major vendors in the communications segment were Rockwell International Corporation, NS, and UMC. Adaptec Inc. and Cirrus Logic Inc. dominated in the mass storage space, while ESS Technology Inc. remained as an important supplier of audio controller chips in Asia/Pacific.

Figure 3
Asia/Pacific Microperipheral Market Share (Percent)



Source: Dataquest (July 1998)

The Asia/Pacific DSP Market

DSP devices were the most promising segment of the Asia/Pacific microcomponent market. In 1997, the total DSP revenue in Asia/Pacific recorded a stunning 68.2 percent growth to reach $792 million. Figure 4 illustrates the DSP market share of the top-8-ranked companies. Texas Instruments Inc. held on to the No. 1 position with 37.9 percent of the market. Second-ranked Lucent Technologies consolidated its place, expanding revenue by a massive 79.2 percent. Toshiba catapulted into the third spot with a $93 million rise in revenue last year. These top three vendors combined commanded 79 percent of the Asia/Pacific DSP market share. Their massive gains reflect the rapid emergence of DSP products as a high-growth device category.

The DSP category was the smallest, but the fastest-growing product group of the Asia/Pacific microcomponent market. Programmable DSP products represented more than 7 percent of total microcomponent revenue in 1997. DSP products have shown rapid growth as a result of higher demand from

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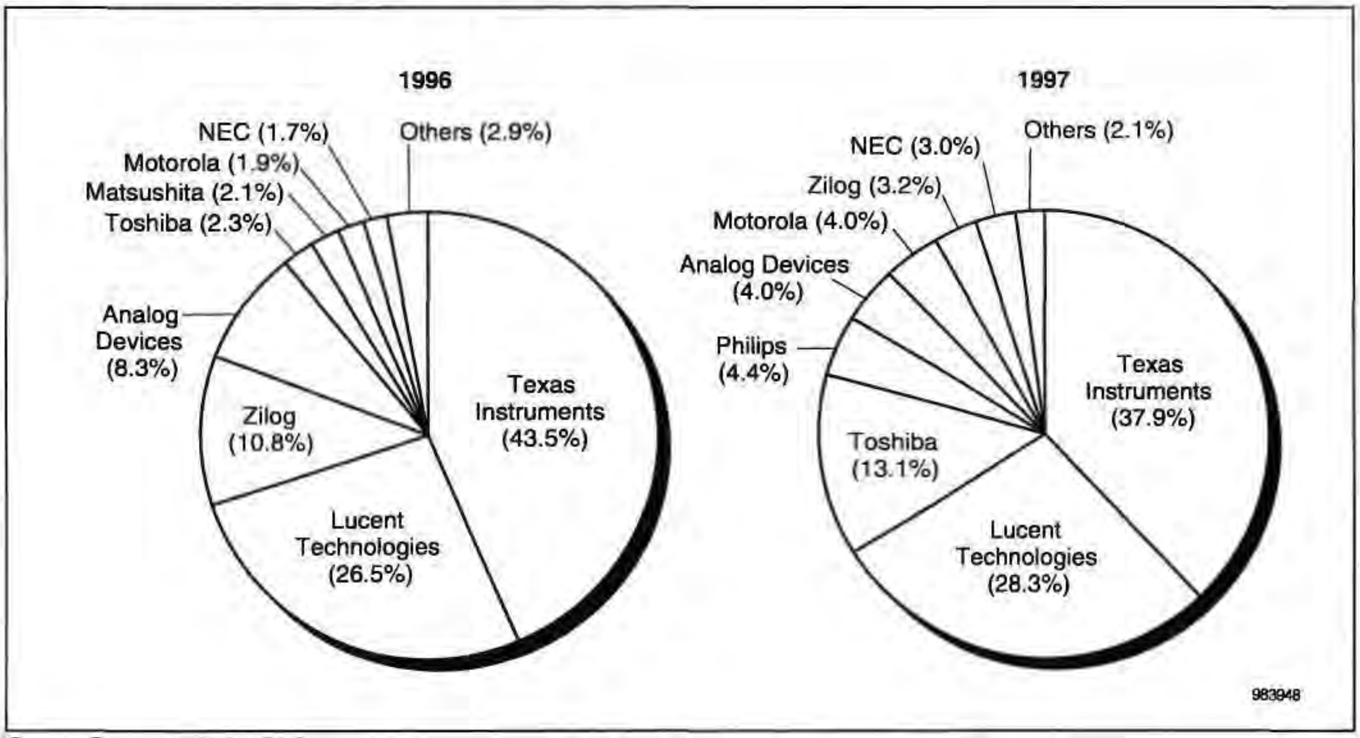
data processing, consumer and communications applications. Examples of high-volume equipment adopting DSPs include digital cellular phones and rigid disk drives (RDDs). Between 1997 to 2002, Dataquest forecasts that Asia/Pacific's digital cellular phone and RDD unit production will grow at a 50.3 percent and 22.1 percent CAGR, respectively. Modems are another application projected to show a robust growth of 22.2 percent. These applications present attractive opportunities for vendors to participate in the burgeoning DSP market.

Figure 4
Asia/Pacific DSP Market Share (Percent)



Source: Dataquest (July 1998)

Asia/Pacific MOS Microcomponent Forecast

Dataquest estimates that the Asia/Pacific MOS microcomponent market will range from $12,651 million to $11,371 million this year, and $25,170 million to $22,600 million in 2002. Table 2 presents the most likely forecast of the Asia/Pacific microcomponent market. As a result of excess capacity and the Asian financial crisis, Dataquest's most likely forecast scenario is also the optimistic forecast. The market is likely to encounter downside potential from increased pricing pressure and weaker-than-expected growth of electronic equipment production this year.

The Asia/Pacific MOS microcomponent market is predicted to register an 18.4 percent CAGR in Dataquest's most likely forecast. MPU products should remain as the largest segment, accounting for 43.3 percent of the total microcomponent revenue in 2002 (see Figure 5). However, DSP products are estimated to record the highest CAGR of 24.7 percent, with 9.5 percent share of the total microcomponent market by 2002. MCU and MPR devices are projected to post healthy CAGRs of 17.1 percent and 15.5 percent, respectively.

Table 2
Asia/Pacific MOS Microcomponent Forecast, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
MOS Microcomponent	**10,796**	**12,651**	**15,360**	**18,260**	**21,710**	**25,170**	**18.4**
Microprocessor	4,380	5,349	6,570	7,890	9,370	10,900	20.0
Microcontroller	2,303	2,630	3,060	3,710	4,430	5,080	17.1
Microperipheral	3,315	3,662	4,520	5,200	6,010	6,800	15.5
Digital Signal Processor	792	1,010	1,210	1,460	1,900	2,390	24.7

Source: Dataquest (June 1998)

In Dataquest's downside forecast scenario, the total Asia/Pacific microcomponent revenue in 1998 is estimated to be $1,280 million lower than in the original forecast. By 2002, the downside forecast estimates that revenue will decline $2,570 million, compared to the most likely scenario. This represents the potential loss in microcomponent revenue brought on by the adverse impact of the Asian economic crisis. The highlights of the downside forecast scenario are as follows:

- The 1998 downside forecast revenue is $11,371 million. The Asia/Pacific microcomponent market should grow at 5.4 percent in this scenario, as a result of lower growth from MPU and MPR products. DSP devices are also projected to record lower growth rates compared to the most likely forecast scenario. However, MCUs are estimated to record a revenue decline this year.
- The regional microcomponent market is expected to stage a strong rebound in 1999, with growth predicted to exceed 20 percent. This should be followed by two years of solid growth averaging slightly under 19 percent in 2000 and 2001.
- The 2002 downside forecast revenue is $22,600 million. The Asia/Pacific microcomponent market should grow at a 15.9 percent CAGR, driven by a recovery in the MPU, MCU, and MPR device segments. DSP devices are projected to retain similar growth rates as in the most likely forecast scenario.

The Asia/Pacific MOS Microcomponent Forecast by Country

From the most likely forecast scenario of the regional microcomponent market, China/Hong Kong should emerge as the fastest-growing single country market in Asia/Pacific. Rising electronic equipment production, especially data processing applications, will drive the country to record a 24.4 percent CAGR in the forecast cycle. Figure 7 presents the Asia/Pacific country-level breakdown forecast.

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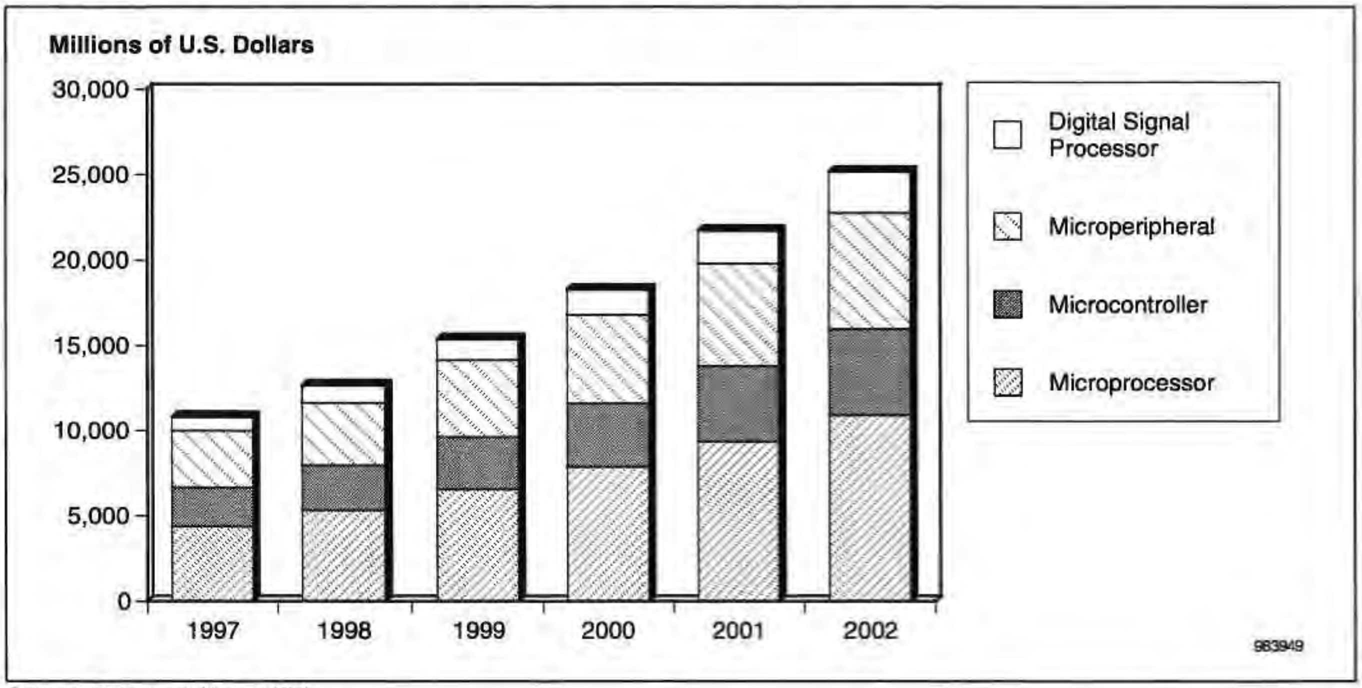
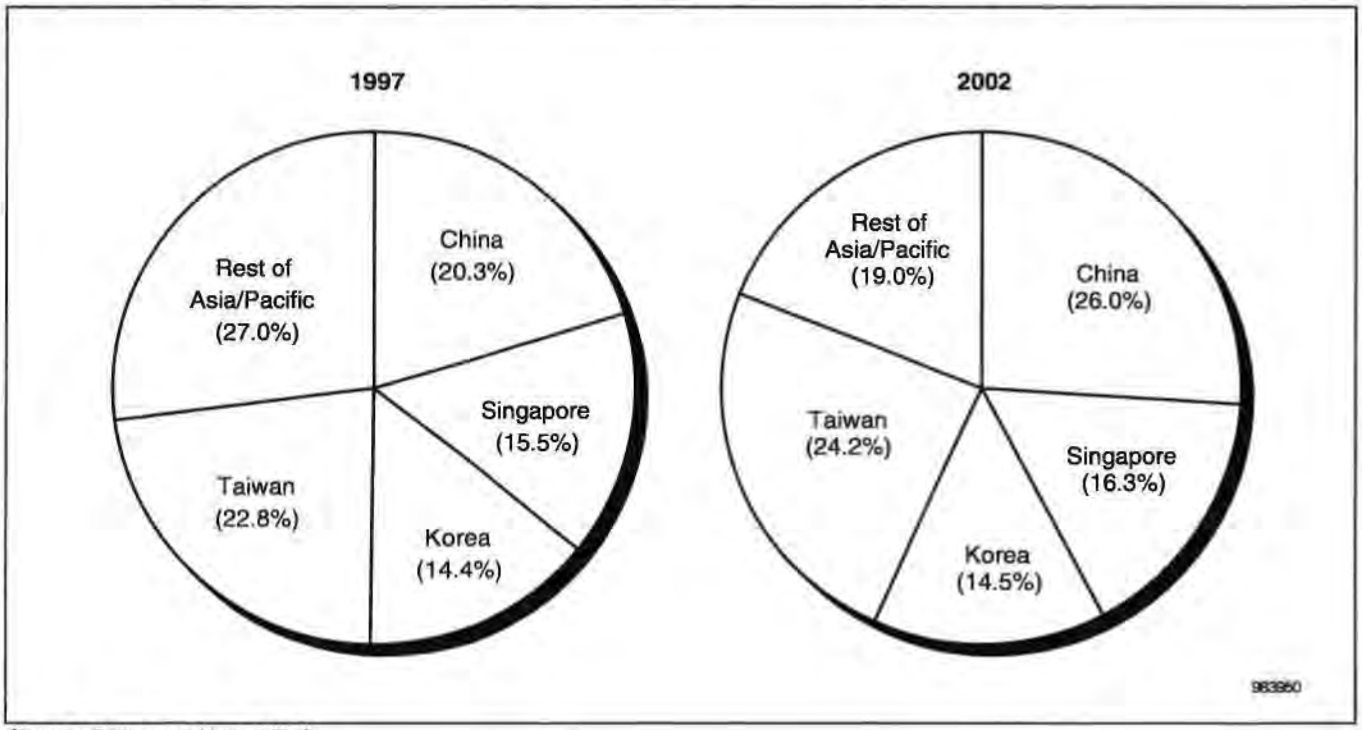
Figure 5
Asia/Pacific MOS Microcomponent Forecast, 1997 to 2002



Source: Dataquest (June 1998)

Figure 6
Asia/Pacific MOS Microcomponent Forecast by Country, 1997 and 2002 (Percent)



Source: Dataquest (June 1998)

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China/Hong Kong's position as the second-largest microcomponent market in 1997 is attributed to it leading the regional consumption for MCUs. The demand for microcomponents is estimated to be driven by rising production of electronic equipment and expanding domestic consumption. With increasing production of PCs, digital cellular phones, and a wide range of consumer electronic equipment, China/Hong Kong is expected to become the largest microcomponent device market in Asia/Pacific by 2002.

Last year, Taiwan was the largest market for microcomponent devices with a 22.8 percent share. The island's data-processing and export intensive industries made Taiwan the main country in Asia/Pacific for MPU and MPR consumption. Although Taiwan is estimated to remain as the largest market for these products up to 2002, the nation will slip into the second place overall. By 2002, Taiwan, with a 24.2 percent share of the regional microcomponent revenue, should become No. 2 to its giant neighbor's 26.0 percent share. Singapore and Korea are likely to remain as the third and fourth largest consumption markets for microcomponent products in the forecast period.

Dataquest Perspective

The Asia/Pacific MOS microcomponent market grew by an impressive 23.7 percent in 1997. With the onset of the Asian financial crisis in the second half of 1997, the market this year is expected to experience lower growth rates. Dataquest forecasts that the regional microcomponent market should reach $25,170 million in 2002. The downside forecast scenario would reduce the market potential by $1.28 billion in 1998 and nearly $2.57 billion in 2002, as a result of the adverse impacts from excess capacity and the regional economic downturn. Among the product segments, MPU devices are predicted to remain as the most influential category in determining the overall microcomponent market trend. Over the forecast horizon, DSP products are likely to become the fastest-expanding segment, driven by rising demand from a wide range of electronic equipment. With 8-bit MCUs already established as the mainstream product in the region, 16-bit-and-higher MCUs should emerge to launch MCU product growth in coming years.

Intel has secured the No. 1 microcomponent supplier position in the region with its supremacy in the MPU device revenue. Competition is emerging from AMD and NS, particularly in the lower-priced MPU market segment. In the MPR space, Intel is a key player in core logic, as well as recently setting up a presence in the graphics chip market. Among the Asia/Pacific companies, Taiwan-based UMC and VIA are regional leaders in the core logic chipset market. Korean chaebols have initiated strategies to diversify into nonmemory products. Dataquest expects Korean companies to establish a foothold in the regional microcomponent market, especially in consumer and data processing applications.

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Perspective

Semiconductors Asia/Pacific

Market Analysis

1997 Semiconductor Market Share by Country in Asia/Pacific

Abstract: *This Perspective analyzes the 1997 semiconductor market share by country in Asia/Pacific. It reviews the top 20 companies' market share in China/Hong Kong, Singapore, South Korea, and Taiwan. Detailed product information will be published as a Market Statistics report in July.*

By C.S. Kim

The Asia/Pacific Semiconductor Market Share

The Asia/Pacific region is expected to command more market attention because of its recent economic and financial crises. Table 1 shows that Intel Corporation and Samsung Electronics Company Ltd. retained their respective first- and second-place rankings in terms of 1997 semiconductor revenue in the Asia/Pacific market. A host of other companies switched positions in this market. Texas Instruments Inc. now holds the No. 3 place in Asia/Pacific, while Toshiba Corporation ranks fourth. Motorola Incorporated and Philips Electronics NV also switched positions, with Motorola now fifth in Asia/Pacific and Philips in the sixth place. NEC Corporation, Hitachi Ltd., and SANYO Electric Company Ltd. retained the same rankings for both 1996 and 1997. STMicroelectronics NV (formerly SGS-Thomson Microelectronics NV) advanced to the eighth place during 1997 from 10th in 1996. Rohm Company Ltd. also advanced, to the No. 12 place in Asia/Pacific from No. 17 in 1996. Lucent Technologies and Advanced Micro Devices Inc. (AMD) entered the top 20 group in 1997.

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Intel increased its revenue in Asia/Pacific by 25 percent, reaching the U.S.$4 billion mark in 1997. Samsung's revenue in this region increased 5 percent to $1.9 billion. TI increased its regional revenue 6.7 percent to $1.85 billion. Toshiba's revenue grew 0.2 percent to $1.8 billion. Motorola's revenue

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jumped by 18 percent to $1.68 billion. Philips' revenue in this region grew by 7.4 percent and totaled $1.58 billion. NEC increased its revenue in Asia/Pacific by 3.4 percent, which totaled $1.3 billion. STMicroelectronics' revenue saw a 5.4 percent decline to total $1.08 billion in Asia/Pacific. Hitachi's revenue declined 14.2 percent to $1 billion. LG Semicon Co. Ltd. also experienced a 15.7 percent decline, with revenue falling just under $1 billion in Asia/Pacific. Rohm's revenue grew 75.4 percent in Asia/Pacific to $826 million. Lucent Technologies increased its revenue by 78 percent to a total of $632 million in the region. AMD increased its revenue by 75 percent, reaching a total of $470 million.

Table 1
1997 Rankings and Market Share for Top 20 Semiconductor Suppliers in Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%) 1996 to 1997	1997 Market Share (%)
1	1	Intel	3,251	4,077	25.4	12.5
2	2	Samsung	1,828	1,922	5.1	5.9
4	3	Texas Instruments	1,736	1,853	6.7	5.7
3	4	Toshiba	1,804	1,807	0.2	5.6
6	5	Motorola	1,424	1,682	18.1	5.2
5	6	Philips	1,471	1,580	7.4	4.9
7	7	NEC	1,283	1,326	3.4	4.1
10	8	STMicroelectronics	1,136	1,075	-5.4	3.3
9	9	Hitachi	1,169	1,003	-14.2	3.1
8	10	LG Semicon	1,177	992	-15.7	3.0
11	11	SANYO	913	901	-1.3	2.8
17	12	Rohm	471	826	75.4	2.5
14	13	National Semiconductor	559	709	26.8	2.2
12	14	Hyundai	763	704	-7.7	2.2
13	15	Mitsubishi	729	689	-5.5	2.1
21	16	Lucent Technologies	355	632	78.0	1.9
18	17	Siemens	454	551	21.4	1.7
16	18	Fujitsu	476	477	0.2	1.5
25	19	Advanced Micro Devices	268	470	75.4	1.4
15	20	Matsushita	500	440	-12.0	1.4
		All Others				
		Americas Companies	11,506	14,076	22.3	43.3
		Japanese Companies	9,159	9,321	1.8	28.7
		European Companies	3,379	3,622	7.2	11.1
		Asia/Pacific Companies	5,642	5,515	-2.3	17.0
		Total Market	**29,686**	**32,534**	**9.6**	**100.0**

Source: Dataquest (June 1998)

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China/Hong Kong's Semiconductor Market Share

According to Dataquest's final market share statistics, China/Hong Kong's semiconductor market totaled about $6.8 billion in 1997, representing a 19.5 percent growth from 1996. In the same period, the Asia/Pacific market increased only 9.6 percent to a total of $32.5 billion.

The top 20 semiconductor suppliers' revenue in China/Hong Kong's semiconductor market in 1997 are listed by rank in Table 2. The top 20 suppliers accounted for about 77.6 percent of the total China/Hong Kong semiconductor market. Note that all top 20 companies in China/Hong Kong also appear among the top 20 semiconductor suppliers to Asia/Pacific, with the exception of Sony Corporation, which was ranked No. 19 in China/Hong Kong in 1997.

Intel's semiconductor sales to China/Hong Kong grew 22.6 percent in 1997. NEC and LG Semicon are the only ones of top 10 companies to show declines. In the top 10 group, Toshiba, Motorola, and Philips retained their No. 2, No. 3, and No. 5 position in 1997, respectively. Samsung, TI, and Rohm grew robustly in 1997 and moved up their positions, compared to 1996. Although Samsung experienced a 14.7 percent decline in DRAM revenue, its non-DRAM revenue grew 48.3 percent—owing to its expansion in microcontroller devices, analog IC devices, and discrete products in 1997. As a result, Samsung jumped from the No. 7 place to No. 4. LG Semicon and Hyundai Electronics Company Ltd. lost their positions and dropped to No. 8 and No. 11, respectively, because of the DRAM revenue decline. A notable change was Lucent Technologies, which moved into the top 20 group in 1997. The company's revenue reached $135 million with 128.8 percent growth for 1997. Rohm's revenue grew by 42.9 percent in the China/Hong Kong region to $230 million. AMD's revenue increased by 98.4 percent and totaled $121 million.

Singapore's Semiconductor Market Share

Dataquest estimates that in 1997, Singapore's total semiconductor market increased to about $9 billion. The top 20 suppliers took 86.6 percent of the total Singapore semiconductor market in 1997 (see Table 3).

Note that most of the top 20 suppliers in Singapore are also among the top 20 semiconductor suppliers in Asia/Pacific, with the exception of IBM and Sharp Electronics Corporation. Korean DRAM vendors experienced revenue declines in 1997. Their position in Singapore dropped to No. 7 in the case of Samsung, No. 12 for Hyundai, and No. 17 for LG Semicon in 1997.

Intel ranked No. 1 in the Singapore market in 1997, accounting for 15.7 percent of Singapore's market. Intel achieved significantly higher revenue in 1997 than in 1996. Dataquest estimates that Intel sold about $1.2 billion worth of microprocessors in Singapore. In addition to microprocessors, Intel also had a leading presence in Singapore's microperipheral market. According to Dataquest, Intel recorded a $104 million revenue from microperipheral devices in Singapore in 1997.

Table 2
1997 Rankings and Market Share for the Top 20 Semiconductor Suppliers in China/Hong Kong (Millions of U.S. Dollars)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%) 1996 to 1997	1997 Market Share (%)
1	1	Intel	558	684	22.6	10.1
2	2	Toshiba	488	637	30.5	9.4
3	3	Motorola	374	414	10.7	6.1
7	4	Samsung	302	405	34.1	6.0
5	5	Philips	320	359	12.2	5.3
4	6	NEC	363	353	-2.8	5.2
9	7	Texas Instruments	202	281	39.1	4.2
6	8	LG Semicon	306	280	-8.5	4.1
8	9	SANYO	224	268	19.6	4.0
13	10	Rohm	161	230	42.9	3.4
10	11	Hyundai	193	179	-7.3	2.6
11	12	STMicroelectronics	178	176	-1.1	2.6
12	13	Hitachi	164	166	1.2	2.5
15	14	National Semiconductor	131	146	11.5	2.2
23	15	Lucent Technologies	59	135	128.8	2.0
22	16	Advanced Micro Devices	61	121	98.4	1.8
20	17	Siemens	88	116	31.8	1.7
17	18	Mitsubishi	96	107	11.5	1.6
18	19	Sony	93	102	9.7	1.5
21	20	Matsushita	84	92	9.5	1.4
		All Others	1,205	1,518	26.0	22.4
		Total Market	**5,664**	**6,769**	**19.5**	**100.0**

Source: Dataquest (June 1998)

Trailing behind Intel, the second-largest supplier in Singapore was TI with 10.8 percent of the total market share. TI ranked No. 2 owing to a 27 percent growth, at $989 million in 1997. TI's strength was built on its strategy of semiconductor device diversification. TI consistently ranked in the top 10 in all the semiconductor device categories, except for discrete/optoelectronic devices.

Motorola was the third-largest supplier, capturing a 6.6 percent market share in 1997. Motorola's position was attributed to its semiconductor device diversification, since it ended up in the top 10 suppliers list for all devices except MOS memory.

Riding on its dominant position as the leading analog supplier, STMicroelectronics came in fourth in the semiconductor market share rankings with a 5.9 percent share of the Singapore market in 1997.

Toshiba was the only Japanese company among the top five suppliers in Singapore in 1997. Although Toshiba took a beating in the memory market, it was among the top five suppliers in the MOS memory, MOS logic, analog, and discrete/optoelectronic markets.

Rohm's revenue grew by 97.4 percent in Singapore to $302 million. As a result, Rohm advanced from No. 17 to the No. 10 place in Singapore in 1997.

Table 3
1997 Rankings and Market Share for the Top 20 Semiconductor Suppliers in Singapore (Millions of U.S. Dollars)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%) 1996 to 1997	1997 Market Share (%)
1	1	Intel	1,134	1,437	26.7	15.7
2	2	Texas Instruments	779	989	27.0	10.8
5	3	Motorola	519	608	17.1	6.6
3	4	STMicroelectronics	564	542	-3.9	5.9
4	5	Toshiba	546	510	-6.6	5.6
7	6	NEC	451	498	10.4	5.4
6	7	Samsung	505	482	-4.6	5.3
10	8	Philips	267	338	26.6	3.7
8	9	Hitachi	314	322	2.5	3.5
17	10	Rohm	153	302	97.4	3.3
9	11	Mitsubishi	310	277	-10.6	3.0
11	12	Hyundai	267	244	-8.6	2.7
12	13	SANYO	235	211	-10.2	2.3
15	14	National Semiconductor	156	199	27.6	2.2
19	15	Siemens	141	193	36.9	2.1
20	16	Lucent Technologies	135	175	29.6	1.9
13	17	LG Semicon	222	170	-23.4	1.9
18	18	Fujitsu	156	149	-4.5	1.6
14	19	IBM	161	142	-11.8	1.6
18	20	Sharp	153	136	-11.1	1.5
		All Others	1,127	1,226	8.8	13.4
		Total Market	**8,295**	**9,150**	**10.3**	**100.0**

Note: Includes semiconductors used in Singapore and re-exported via Singapore.
Source: Dataquest (June 1998)

South Korea's Semiconductor Market Share

Dataquest estimates that in 1997, Korea's total semiconductor market increased to about $5.5 billion. The top 20 suppliers took 69.2 percent of the total Korea semiconductor market in 1997 (see Table 4).

Samsung retained its first-place ranking in 1997 semiconductor revenue in the Korean market. However, Samsung's revenue in this region increased by only 2.8 percent to $620 million. Intel's revenue increased in Korea by 23.1 percent and reached $559 million in 1997. Dataquest expects Intel to surpass Samsung this year according to the semiconductor market flow. Note that most of the top 20 semiconductor suppliers in Korea also appear among the top 20 semiconductor suppliers in Asia/Pacific, with the exception of Sharp, Korean Electronics Co., Sanken Electronic Company Ltd., and Sony.

Philips' revenue in this region grew 17.1 percent and totaled $404 million. Motorola's revenue increased by 5.9 percent to $199 million. Toshiba's revenue was reduced by 16.6 percent in this region to $196 million. Motorola and Toshiba also switched ranking positions in 1997, with Motorola fifth in Korea and Toshiba in the sixth place. LG Semicon and TI in top 10 companies retained their positions in the Korean market for 1997; however, their revenue declined 9.1 percent and 4.2 percent, respectively. Sharp and Sanken were ranked as No. 12 and No. 15, respectively, in Korea because of their excellent supply of MOS logic devices in the case of Sharp, and discrete devices for Sanken. Korean companies accounted for about 20 percent of their local market. Lucent Technologies jumped to No. 17 in Korea from No. 21 position in 1996. Lucent Technologies and Sanken entered the top 20 group in 1997. Table 4 shows the top 20 suppliers of semiconductors in South Korea in 1997.

Table 4
1997 Rankings and Market Share for the Top 20 Semiconductor Suppliers in South Korea (Millions of U.S. Dollars)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%) 1996 to 1997	1997 Market Share (%)
1	1	Samsung	603	620	2.8	11.3
2	2	Intel	454	559	23.1	10.2
3	3	Philips	345	404	17.1	7.4
4	4	LG Semicon	297	270	-9.1	4.9
6	5	Motorola	188	199	5.9	3.6
5	6	Toshiba	235	196	-16.6	3.6
7	7	SANYO	173	176	1.7	3.2
11	8	National Semiconductor	116	171	47.4	3.1
9	9	Texas Instruments	167	160	-4.2	2.9
8	10	Hitachi	172	144	-16.3	2.6
10	11	STMicroelectronics	130	141	8.5	2.6
17	12	Sharp	52	105	101.9	1.9
12	13	Korean Electronics Co.	116	103	-11.2	1.9
16	14	Rohm	58	100	72.4	1.8
28	15	Sanken	7	89	1,171.4	1.6
13	16	NEC	92	85	-7.6	1.5
21	17	Lucent Technologies	35	80	128.6	1.5
14	18	Hyundai	88	78	-11.4	1.4
18	19	Mitsubishi	52	61	17.3	1.1
15	20	Sony	81	58	-28.4	1.1
		All Others	1,524	1,691	11.0	30.8
		Total Market	**4,985**	**5,490**	**10.1**	**100.0**

Source: Dataquest (June 1998)

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Taiwan's Semiconductor Market Share

Taiwan's semiconductor market increased 12.8 percent in 1997. The total semiconductor market reached nearly $6.8 billion. The top 20 semiconductor suppliers in Taiwan's semiconductor market in 1997 are listed by rank in Table 5. The top 20 suppliers accounted for nearly 76.4 percent of the total Taiwan semiconductor market.

Intel and Toshiba retained their respective first- and second-place rankings in Taiwan's semiconductor market in 1997. A host of other companies switched positions in this market. NEC now holds the No. 3 place in Taiwan, while TI lost its ranking in 1997 because of a 22.5 percent revenue decline. AMD increased its revenue 74 percent and generated $221 million. As a result of such high growth, AMD jumped to the No. 9 place in Taiwan's market in 1997 from No. 17 position in 1996. Lucent Technologies increased its revenue 86.4 percent to $192 million in 1997. As a result, the company jumped to No. 12 in 1997 from No. 22 in 1996.

Table 5
1997 Rankings and Market Share for the Top 20 Semiconductor Suppliers in Taiwan (Millions of U.S. Dollars)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%) 1996 to 1997	1997 Market Share (%)
1	1	Intel	741	941	27.0	13.9
2	2	Toshiba	422	426	0.9	6.3
4	3	NEC	359	374	4.2	5.5
5	4	Samsung	311	299	-3.9	4.4
3	5	Texas Instruments	374	290	-22.5	4.3
7	6	Philips	252	288	14.3	4.3
8	7	Motorola	247	266	7.7	3.9
6	8	LG Semicon	267	223	-16.5	3.3
17	9	Advanced Micro Devices	127	221	74.0	3.3
12	10	Mitsubishi	180	215	19.4	3.2
10	11	Hitachi	205	209	2.0	3.1
22	12	Lucent Technologies	103	192	86.4	2.8
11	13	Hyundai	184	173	-6.0	2.6
14	14	STMicroelectronics	154	160	3.9	2.4
NA	15	S3	NA	159	NA	2.4
15	16	Siemens	145	158	9.0	2.3
21	17	Mosel Vitelic	106	157	48.1	2.3
9	18	United Microelectronics	221	153	-30.8	2.3
16	19	Winbond Electronics	134	130	-3.0	1.9
13	20	Cirrus Logic	156	123	-21.2	1.8
		All Others	1,301	1,597	22.8	23.6
		Total Market	**5,989**	**6,754**	**12.8**	**100.0**

NA = Not available
Source: Dataquest (June 1998)

Dataquest Perspective

Although Dataquest does not indulge in market share forecasts, it does maintain extensive visibility of the products, applications, and regional markets in which all the vendors compete. The mood of the current market is cautious optimism. From 1992 to the end of 1995, the DRAM industry experienced its longest-ever period of profitability. The PC, cellular handset, automotive, and consumer electronic markets provided good price/performance competition as well as profit centers for all semiconductor vendors, but especially for the top 20. As a result, many DRAM suppliers reinvested their profits into new plants and equipment. Multiple companies poured more capital into the market than was needed. An overcapacity developed, and vendors saw their profits turn to ashes as the value of their DRAM products continued to decline.

Despite 1996's downturn in the semiconductor market, the Asia/Pacific region was still able to sustain a relatively healthy growth in 1997. This growth was attributed to a strong demand for semiconductors, which has been driven by the local electronic equipment production increase.

The Asia/Pacific semiconductor market is moving toward more difficult times as the negative impact of the Asian financial crisis takes hold. The Asia/Pacific region's GDP growth this year is expected to be depressed according to Dataquest. However, economic forecasts indicate that the Asia/Pacific region will start on the path toward economic recovery next year. When the countries regain their economic potential, we can expect the region to gain from increased competitiveness. As a result of economic recovery, Asia/Pacific's electronic equipment industry should enter into a growth stage again. Asia/Pacific's semiconductor market will continue to show healthy growth in the long term. Dataquest expects such growth in this region to be driven by data processing in Taiwan and Singapore and by communications and consumer electronics in China and Korea.

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Perspective

Semiconductors Asia/Pacific

Market Analysis

Asia/Pacific Final 1997 Semiconductor Market Share

Abstract: *This Perspective provides the final 1997 Asia/Pacific top 20 semiconductor supplier rankings. Intel Corporation remains the first-ranked Asia/Pacific supplier. This Perspective also provides further analyses. Detailed product information will be published in May.*
By C.S. Kim

Regional Vendors' Worldwide Semiconductor Market Share

Dataquest's recently completed market share analysis for worldwide semiconductors in 1997 shows that the market grew only 3.5 percent to reach U.S.$147.2 billion. Intel Corporation, at $21.7 billion in semiconductor revenue, still holds the No. 1 position and continues to outdistance the other top vendors by a fairly large margin.

Regionally, the Americas region's vendor total semiconductor revenue grew 12.9 percent, reaching $72.3 billion, while European vendors' revenue grew 8.2 percent to $14.8 billion. Japanese vendors' revenue declined 6 percent to $47.8 billion, and Asia/Pacific vendors' revenue declined 9.7 percent to $12.2 billion. Japanese and Asia/Pacific vendors suffered significant declines in DRAM revenue.

As a result, the Americas companies and European companies secured 49.1 percent and 10.1 percent, respectively, of the worldwide semiconductor market, up from 45.1 percent and 9.6 percent, respectively, recorded in 1996. Japanese companies and Asia/Pacific companies accounted for 32.5 percent and 8.3 percent, respectively, of the 1997 global market, down from 35.8 percent and 9.5 percent, respectively, in 1996 (see Figure 1).

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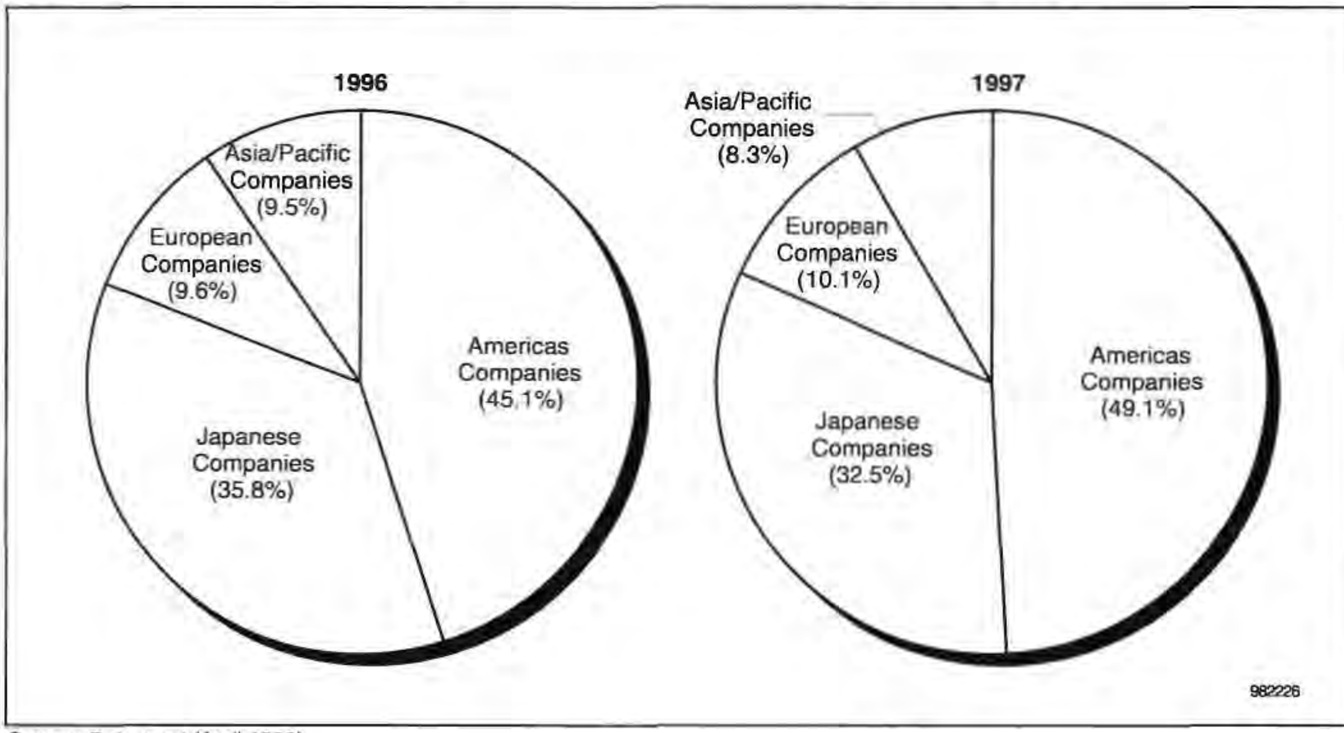
Figure 1
Regional Vendors' Worldwide Semiconductor Market Share, 1996 and 1997



Source: Dataquest (April 1998)

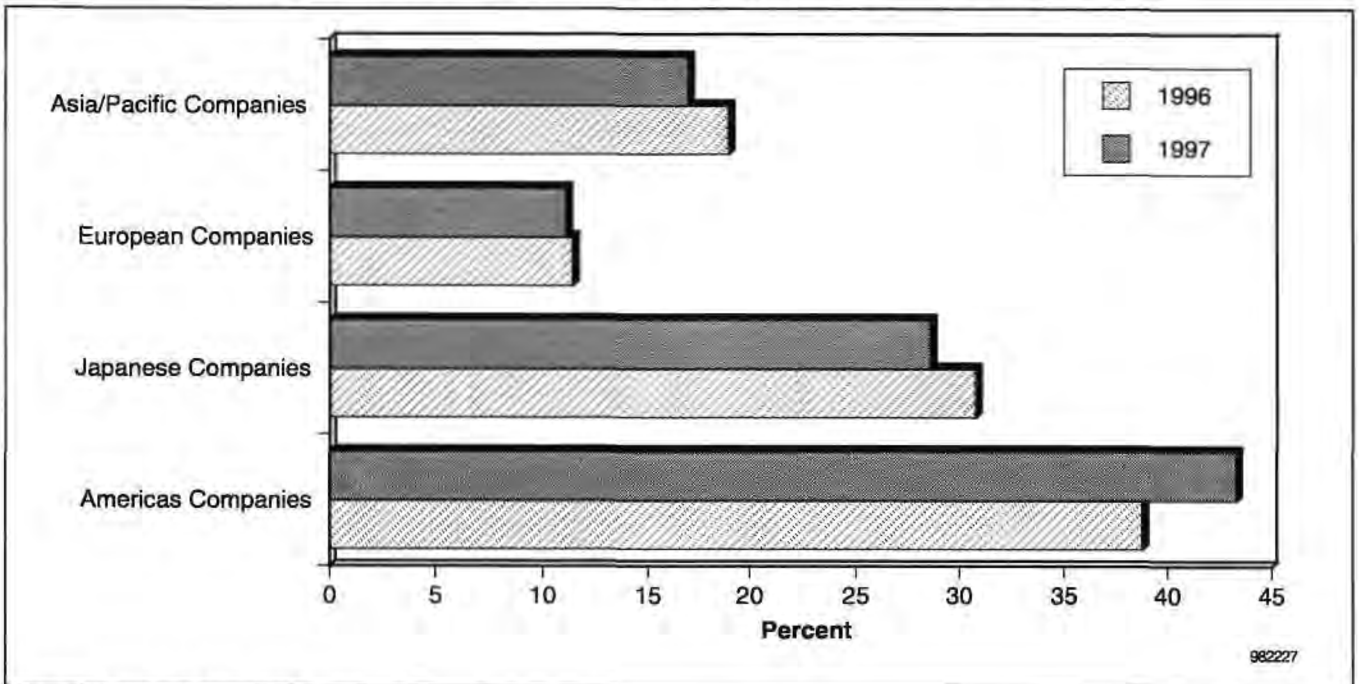
Regional Vendors' Market Share in the Asia/Pacific Region

The Asia/Pacific semiconductor market grew only 9.6 percent to reach $32.5 billion in 1997. Asia/Pacific and Japan, having many DRAM manufacturers, lost market share as regions, while the Americas region expanded its market share. Asia/Pacific companies' revenue decreased by 2.3 percent, primarily because of South Korean DRAM vendors' revenue losses. Japanese companies' revenue grew only 1.8 percent to $9.3 billion in 1997. American and European companies' revenue increased 22.3 percent and 7.2 percent, respectively. As a result, American companies accounted for 43.3 percent of Asia/Pacific market in 1997, up from 38.8 percent in 1996, while Japanese companies and Asia/Pacific companies accounted for 28.7 percent and 17 percent, respectively, of the 1997 Asia/Pacific market, down from 30.9 percent and 19 percent, respectively, in 1996 (see Figure 2).

Product Growth Trends in the Asia/Pacific Region

Dataquest's compilation of the 1997 MOS memory market shows almost 19 percent revenue decline compared to 1996 revenue; the result is a $1.5 billion revenue drop to a total market of $6.5 billion. DRAM continues to be the largest component of the memory market and the biggest influence on the market's contraction. DRAM revenue declined in 1997 by 21 percent, with average selling prices (ASPs) dropping by 36 percent. The SRAM market also remains in a severe oversupply, with revenue declining by 35.3 percent to below $600 million.

Figure 2
Regional Vendors' Semiconductor Market Share in Asia/Pacific, 1996 and 1997



Source: Dataquest (April 1998)

The product with the highest growth rate in 1997 was microcomponents, helped by increasing PC demand and the rapid acceptance of digital signal processing (DSP) devices in the mobile communications sector. Also making a significant contribution to the category's growth was the accelerating demand for graphics and imaging controllers, communications controllers, and mass storage controllers in computers, computer peripherals, and communications applications.

The Asia/Pacific MOS logic market grew 17.2 percent to $3.9 billion in 1997. The strong growth in 1997 came from cell-based ICs (CBICs), standard logic devices, and application-specific standard products (ASSPs). CBICs (37.4 percent), standard logic devices (30.5 percent), and other MOS logic products (45.1 percent) represented growth in the MOS logic market.

Asia/Pacific analog IC revenue grew a healthy 24.1 percent and reached $6.3 billion in 1997. The analog IC market picked up momentum in 1997 after modest growth in 1996. The remarkable wireless communications market growth and the continuing demand for well-conditioned power were among the key factors contributing to this momentum.

Table 1 shows growth by product category for Asia/Pacific semiconductor production.

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Table 1
Asia/Pacific Semiconductor Growth Rates by Product Category
(Millions of U.S. Dollars)

	1996 Revenue	1997 Revenue	Growth (%) 1996 to 1997	Market Share (%) 1996	Market Share (%) 1997
Total Semiconductor	**29,686**	**32,534**	**9.6**	**100.0**	**100.0**
Total Integrated Circuit	**25,418**	**27,804**	**9.4**	**85.6**	**85.5**
Bipolar Digital	236	184	-22.0	0.8	0.6
MOS Digital IC	19,927	21,310	6.9	67.1	65.5
MOS Memory	8,017	6516	-18.7	27	20
DRAM	5,878	4,642	-21.0	19.8	14.3
SRAM	926	599	-35.3	3.1	1.8
Nonvolatile Memory	1,177	1,224	4.0	4.0	3.8
Other MOS Memory	36	51	41.7	0.1	0.2
MOS Microcomponent	8,744	10,885	24.5	29.5	33.5
Microprocessor	3,392	4,456	31.4	11.4	13.7
Microcontroller	2,050	2,313	12.8	6.9	7.1
Microperipheral	2,834	3,315	17.0	9.5	10.2
Digital Signal Processor	468	801	71.2	1.6	2.5
MOS Digital Logic	3,336	3,909	17.2	11.2	12.0
Total ASIC*	1,588	1,662	4.7	5.3	5.1
Custom IC	445	425	-4.5	1.5	1.3
MOS Standard Logic	472	616	30.5	1.6	1.9
Total Other MOS Logic	831	1,206	45.1	2.8	3.7
Analog-Monolithic	5,085	6,310	24.1	17.1	19.4
Total Discrete	**3,294**	**3,817**	**15.9**	**11.1**	**11.7**
Total Optical Semiconductor	**739**	**913**	**23.5**	**2.5**	**2.8**

*Mixed-signal ASIC was moved from the analog category to total ASIC.
Source: Dataquest (April 1998)

Top 20 Ranking in the Asia/Pacific Region

The Asia/Pacific region will command tremendous market attention because of its recent economic and financial crisis. Table 2 shows that Intel and Samsung Electronics Company Ltd. retained their respective first and second place rankings in 1997 semiconductor revenue in the Asia/Pacific market. A host of other companies switched positions in this market. Texas Instruments Inc. now holds the third place in Asia/Pacific, while Toshiba Corporation ranks fourth. Motorola Incorporated and Philips Electronics NV also switched positions, with Motorola now fifth in Asia/Pacific and Philips in sixth place. NEC Corporation, Hitachi Ltd., and Sanyo Electric Company Ltd. retained their rankings in 1997 as in 1996. SGS-Thomson Microelectronics B.V. advanced to eighth place during 1997 from 10th in 1996. Rohm Company Ltd. also advanced, to No. 12 place in Asia/Pacific from No. 17 in

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1996. Lucent Technologies and Advanced Micro Devices Inc. entered the top 20 group in 1997.

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4	3	Texas Instruments	1,736	1,853	6.7	5.7
3	4	Toshiba	1,804	1,807	0.2	5.6
6	5	Motorola	1,424	1,682	18.1	5.2
5	6	Philips	1,471	1,580	7.4	4.9
7	7	NEC	1,283	1,326	3.4	4.1
10	8	SGS-Thomson	1,136	1,075	-5.4	3.3
9	9	Hitachi	1,169	1,003	-14.2	3.1
8	10	LG Semicon	1,177	992	-15.7	3.0
11	11	Sanyo	913	901	-1.3	2.8
17	12	Rohm	471	826	75.4	2.5
14	13	National Semiconductor	559	709	26.8	2.2
12	14	Hyundai	763	704	-7.7	2.2
13	15	Mitsubishi	729	689	-5.5	2.1
21	16	Lucent Technologies	355	632	78.0	1.9
18	17	Siemens	454	551	21.4	1.7
16	18	Fujitsu	476	477	0.2	1.5
25	19	Advanced Micro Devices	268	470	75.4	1.4
15	20	Matsushita	500	440	-12.0	1.4
		All Others				
		American Companies	11,506	14,076	22.3	43.3
		Japanese Companies	9,159	9,321	1.8	28.7
		European Companies	3,379	3,622	7.2	11.1
		Asia/Pacific Companies	5,642	5,515	-2.3	17.0
		Total Market	**29,686**	**32,534**	**9.6**	**100.0**

Source: Dataquest (April 1998)

In Asia/Pacific, while some companies experienced phenomenal growth, others saw their revenue decline. Intel's revenue grew by 25 percent and reached $4 billion in 1997. Samsung's revenue increased by 5 percent to $1.9 billion. Texas Instruments increased its regional revenue by 6.7 percent to total $1.85 billion. Toshiba's revenue grew by 0.2 percent to $1.8 billion.

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Motorola's revenue jumped by 18 percent to $1.68 billion. Philips' revenue in this region grew by 7.4 percent and totaled $1.58 billion. NEC boosted its revenue by 3.4 percent and captured a total of $1.3 billion. In contrast to these companies' soaring growth, SGS-Thomson experienced a 5.4 percent decline to settle with a total of $1.08 billion. Hitachi's revenue dropped by 14.2 percent to $1 billion. LG Semicon Co. Ltd. suffered a 15.7 percent decline, with its revenue dropping below $1 billion. Rohm's revenue grew by 75.4 percent to $826 million. Lucent Technologies' revenue grew 78 percent to total $632 million. AMD increased its revenue by 75 percent to $470 million.

Worldwide Market Shrinkage of Asia/Pacific Suppliers

As shown in Table 3, the Asia/Pacific companies' market share dropped from 9.5 percent in 1996 to 8.3 percent in 1997, as the dominant Korean DRAM vendors saw big revenue losses. Macronix International Company Ltd., Vanguard Cellular Systems, Korean Electronic Co., and VIA Technologies Inc. were the only companies within the top 10 to show growth, with 3.1 percent, 48.4 percent, 11.9 percent, and 37.3 percent, respectively. Korean companies' share dropped from 7.9 percent in 1996 to 6.8 percent in 1997, while Taiwan companies' share declined only 0.1 percent from 1.6 percent in 1996 to 1.5 percent in 1997.

Dataquest Perspective

Although Dataquest does not indulge in market share forecasts, it does monitor extensively the products, applications, and regional markets in which all vendors compete. The mood of the current market is cautious optimism. From 1992 to the end of 1995, the DRAM industry experienced its longest-ever profitability period. The PC, cellular handset, automotive, and consumer markets provided good price/performance competition as well as profit centers for all semiconductor vendors—but especially for the top 20. As a result, many DRAM suppliers reinvested their profits into new plants and equipment. Numerous companies poured more capital into the market than was needed. An overcapacity developed, and vendors saw their profits turn to ashes as DRAM product value continued to decline.

The decline of the Asia/Pacific companies' share in 1997 came from Korean companies that were mainly oriented toward memory, especially DRAM products. In 1997, the Korean companies' shrinking semiconductor market share resulted from DRAM ASPs dropping by 36 percent.

Table 3
Worldwide Market Share Rankings of Asia/Pacific Semiconductor Suppliers, 1996 and 1997 (Millions of U.S. Dollars)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Samsung	6,464	5,856	-9.4	4.0
2	2	Hyundai	2,247	1,939	-13.7	1.3
4	3	LG Semicon	2,243	1,792	-20.1	1.2
3	4	United Microelectronics	492	378	-23.2	0.3
6	5	Macronix	354	365	3.1	0.2
5	6	Vanguard	225	334	48.4	0.2
7	7	Winbond Electronics	339	323	-4.7	0.2
10	8	Mosel Vitelic	398	316	-20.6	0.2
9	9	Korean Electronic Co.	268	300	11.9	0.2
8	10	VIA	110	151	37.3	0.1
11	11	Holtek	99	117	18.2	0.1
17	12	Acer	50	115	130.0	0.1
14	13	Silicon Integrated Systems	127	110	-13.4	0.1
12	14	Daewoo	45	50	11.1	0.03
13	15	Hualon Microelectronics Corp.	47	46	-2.1	0.03
		Korean Companies	11,267	9,937	-11.8	6.8
		Taiwan Companies	2,241	2,255	0.6	1.5
		Asia/Pacific Companies	13,508	12,192	-9.7	8.3
		Worldwide Market	**142,150**	**147,165**	**3.5**	**100.0**

Source: Dataquest (April 1998)

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Perspective

Semiconductors Asia/Pacific

Market Analysis

Taiwan's Semiconductor Industry Trends

Abstract: *This Perspective presents the 1997 Taiwanese semiconductor companies' overall performance, including a financial analysis, local alliances, vertical integration, revenue ranking, sector performance, and a snapshot of capital spending and a wafer fab database. In the past, Dataquest has provided a microview of Taiwan's semiconductor industry because there were fewer companies then. Starting in 1998, Dataquest will provide a macroview of the industry.*

By Jerry C. J. Yeh

Introduction

Dataquest's review of the 1997 Taiwanese semiconductor manufacturing revenue—including the semiconductor contract manufacturing (SCM) and original equipment manufacturers (OEM)—shows a healthy 18.6 percent revenue growth when compared to the 1996 revenue. This growth resulted in a U.S.$841 million revenue increase to reach a total of $5.4 billion. In sector performance, SCM/OEM revenue expanded from $2.6 billion in 1996 to $3.2 billion in 1997, which indicates more than 26.6 percent growth. Brand-name revenue rose from $2 billion to $2.1 billion in 1997, a 7.7 percent increase. Fabless revenue grew from $705 million to $910 million in 1997, a 29.1 percent increase.

Four Taiwanese semiconductor companies—Taiwan Semiconductor Mfg. Co. (TSMC), United Microelectronics Corporation (UMC), Winbond Electronics Corporation, and Macronix International Company Ltd.—have been selected as a financial-analysis resource. After-tax-profit-to-net-sales ratio reached almost 50 percent in 1995, later dropping to below 30 percent in 1997. Only dedicated foundries have generated more outstanding profits

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than the nonfoundry companies. However, the foundries' price cut and capacity expansion did affect the profit since 1997. Return on total assets affected the continued investment in new wafer fabs. In 1995, the ratio reached the highest point, at 37. Dataquest expects the ratio to approximate 20 percent in 1998. In contrast to the other Asia/Pacific semiconductor companies, Taiwanese companies' financial structure and performance are healthy.

After the semiconductor market downturn, some Taiwanese semiconductor and electronics companies—such as TSMC, UMC, Nan Ya Plastics (NYP)/ Formosa Plastics Co. (FPC), Acer Inc., Winbond Electronics Co., Mosel Vitelic Inc., Powerchip Semiconductor Co.—have started an alliance (this alliance will be discussed in the next section). Although the semiconductor/electronic magnates are emerging, it doesn't mean that some companies will disappear.

An Overview of Taiwan's Semiconductor Industry Trends

Taiwan's semiconductor industry has changed dramatically in 1997. In the past, Dataquest has provided a microview of Taiwan's semiconductor industry because there were fewer companies then. Now, there are more than 15 independent semiconductor companies and more than 60 sizable design houses that produce a wide variety of products. On the other hand, Taiwan is the world's largest dedicated-foundry manufacturing base. In fact, Taiwan has become such an important SCM manufacturing base that Dataquest plans to create an internal cross service between Semiconductor Asia/Pacific (SEMI-AP) and Semiconductor Contract Manufacturing Worldwide Service (SCMS) programs especially for Taiwan.

Moreover, Taiwanese semiconductor companies have started a local alliance and vertical integration that was supported by the government's long-term target dubbed "Silicon Island." The Taiwanese companies' movement to form a local alliance and vertical integration is what motivates Dataquest to cover the analysis beyond revenue, fab capacity, and capital spending. Starting in 1998, Dataquest will provide an industry macroview. In this Perspective, financial and semiconductor group analyses are the first input. Revenue ranking, sector performance, capital spending, and wafer fabs information still remain in last year's report, but a more detailed capital spending and wafer fabs information will be presented in both SEMI-AP and SCMS-WW, which is scheduled for publication in the second half of 1998.

Actual exchange rates for Taiwan are shown in Table 1. The exchange rates are applied to all historical figures. In looking at Dataquest's historical numbers, it is important to note fluctuations in currencies in the New Taiwan dollar (NT). Dataquest uses constant exchange rates across technologies and regions. The 1998 projected exchange rates were used for forecasting all data in this report.

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Table 1
Taiwan's Exchange Rates against the U.S. Dollar, 1994 to 1998*

Year	New Taiwan Dollar per U.S. Dollar
1994	26.45
1995	26.48
1996	27.46
1997	28.89
1998*	32.50

*Projected rate
Source: Dataquest (April 1998)

A Financial Analysis of the Taiwanese Semiconductor Companies

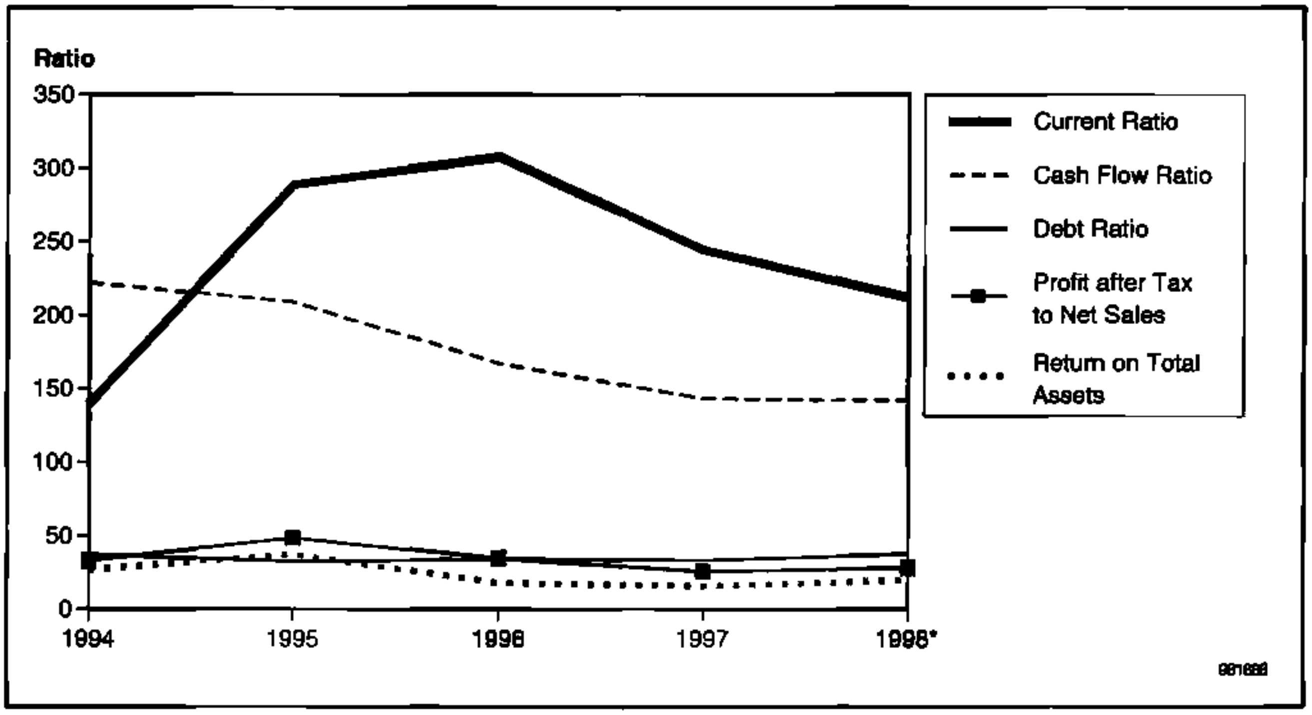
Since the second quarter of 1997, Dataquest is aware that its clients have become interested in their competitors' financial status. Financial report became one of top inquiries to Dataquest's inquiry system. Asia/Pacific companies, especially, had submitted more requests for competitors' internal financial information than other companies from other regions. This trend indicates a warning signal and a persistent question: As the market downturn market is prolonged, how long can a semiconductor company stay in business? Although almost all Asia/Pacific companies have some government support, the Asian financial crisis has shaken the legend of the Asian Tigers.

In this section, Dataquest provides a financial analysis for Taiwan. Four Taiwanese semiconductor companies, TSMC, UMC, Winbond, and Macronix, have been selected. Dataquest knows that these companies each performed differently in the past few years. This selection illustrates a more comprehensive picture of Taiwan's semiconductor financial status. Dataquest neglects the detailed information for all companies because it must protect these companies' confidential information— especially their internal forecasts.

Figure 1 presents these selected four companies' financial analysis from 1994 to 1998. Current ratio is a liquidity analysis, which shows a company's ability to repay its debts. In 1996, this ratio reached its highest ever, more than 300. Last year, the ratio suffered a 20 percent decline because of the companies' need for short-term debt to leverage their financial operation. The liquidity ratio also affects the debt ratio. The debt ratio is one of the capital-structure analysis that shows a company's fundamental financial structure. Although both current ratio and debt ratio will be affected by the increasing loans in 1998, those will still hover above 200 and below 40, respectively.

Cash-flow ratio dropped from 170 to 140 from 1996 to 1997 because of the semiconductor market downturn and revenue growth slowdown. Profit-after-tax-to-net-sales ratio reached almost 50 in 1995, dropping below 30 in 1997. Only dedicated foundries have generated more outstanding profits than the nonfoundry companies. However, the foundry price cut and capacity expansion did affect the profit since 1997. Return on total assets was affected by continued investment in new wafer fabs. In 1995, the ratio reached its highest at 37. Dataquest expects the ratio to hover at about 20 in 1998.

Figure 1
A Financial Analysis of Four Taiwanese Semiconductor Companies, 1994 to 1998*



* Forecast
Note: This ratio is the average of TSMC, UMC, Winbond, and Macronix.
Source: Dataquest (April 1998)

Compared with other Asia/Pacific semiconductor companies, Taiwanese companies' financial structure and performance are healthy. Taiwan has a lot of capital that could be used on the island's semiconductor or electronic development need. While the semiconductor market hasn't recovered, most of semiconductor capital has gone to the backend facility since 1997. Although Dataquest's financial analysis shows that a critical time is happening now, all ratios are still under control. Recently, Dataquest has heard of some local Taiwanese financial magnates who plan to join foundry manufacturing. Although this news isn't welcomed by the industry when there is still foundry overcapacity, it shows that existing semiconductor companies can still collect as much capital as they need.

Alliances and Vertical Integration: The Emerging Semiconductor/Electronics Magnates

Table 2 illustrates Taiwanese semiconductor companies' long-term investment in 1998. Basically, this information is based on companies' financial reports, but there are many semiconductor companies' owners who invested in the related companies from their own pocket. Moreover, Dataquest doesn't want to make advanced analysis, because it would make this analysis much too complicated.

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Table 2
Taiwanese Semiconductor Industry's Long-Term Investment and Company Alliances, 1998

	Silicon Wafer	Mask	Air Products/ Chemicals	IC Design House	Other Wafer Fabrication	Packaging/ Testing	LCD	System/ PC/Telecom Related	Venture Capital	Bank
TSMC	X	X	X	-	X	X	-	-	X	-
UMC	-	-	-	X	X	X	X	X	X	X
Nan Ya	X	-	-	X	-	-	X	X	X	X
Acer	-	-	-	X	-	X	X	X	X	-
Winbond	-	-	X	X	X	-	X	-	-	-
Mosel Vitelic	-	-	-	-	X	X	-	-	X	-
Macronix	-	-	-	-	-	X	-	-	-	-
Powerchip	-	-	-	X	-	-	-	X	-	-
HMC	-	-	-	X	-	-	-	-	-	-

Source: Dataquest (April 1998)

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Taiwan Semiconductor Mfg. Co.

TSMC has been ranked No. 1 in market capitalization in Taiwan in 1997, with a total value of U.S.$19.1 billion. In 1998, TSMC will have two joint ventures with the Acer Group—packaging and venture capital. Most of TSMC's investment is still within the semiconductor-related area. To concentrate on dedicated foundry, the company cannot be involved heavily in the IC design house. Hence, TSMC invests in Vanguard International Semiconductor Co.; the two companies have a very close relationship. As Taiwanese companies start forming alliances, Dataquest regards the TSMC and Vanguard team as a partnership in the same group.

United Microelectronics Corporation

UMC is ranked No. 3 in market capitalization in Taiwan in 1997, with a total value of U.S.$10.7 billion. UMC is an interesting company. The company is like a tree that has its root extended to the various areas, including a wafer fab joint venture, IC design house, packaging, LCD, telecommunications, venture capital, and, even banking. In 1998, Holtek Microelectronics Inc. promised to provide capacity to UICC. Currently, UMC holds 15 percent of Holtek, but this share can be increased in the near term. Dataquest regards all UMC's joint venture—United Semiconductor Corporation (USC), United Silicon Inc. (USI), United Integrated Circuits Corporation (UICC), and its new partner, Holtek Semiconductor Inc. (Holtek)—as the UMC group.

Nan Ya Plastics (NYP)/Formosa Plastics Co. (FPC)

Nan Ya Technology Corporation is a subsidiary of Nan Ya Plastics (NYP)/ Formosa Plastics Co. (FPC). NYP/FPC is a rising giant in Taiwan's electronics industry. It isn't an ordinary plastics company. One may not be familiar with NYP/FPC, but one must have heard of the following companies—Nan Ya Technology Co., First International Computer Inc. (FIC), VIA Technologies Inc., and Formosa Komatsu Silicon Co. These companies are related to NYP/FPC. NYP/FPC's total assets is U.S.$7.5 billion, plus a U.S.$4.7 billion revenue that was gained along with the petrochemical products in 1997.

Formosa Komatsu Silicon Co. (FKS), the 20,000-units-per-month, 8-inch silicon wafer plant, is a joint venture with NYP/FPC, Komatsu Electronics, and the Asia-Pacific Investment Co. It plans to start production in April 1998. FIC is one of the top 30 PC manufacturers. VIA Technologies Inc. is a semiconductor design house that ranked among the top three as the chipset vendor in the world in 1997. Nan Ya Plastics Co. is a manufacturer of PCB that ranked as the top 10 PCB makers in the world. NYP/FPC will be one of the largest and completely vertically integrated electronic group in Taiwan.

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The Acer Group

One of the most important semiconductor news in Taiwan during the first quarter of 1998 is that the Acer Group bought TI-Acer Inc. Acer is the world's seventh-largest PC manufacturers. This news was followed by another merger between Acer and Texas Instruments. In 1997, the company announced that it bought TI's notebook division. Now, Acer is not only a computer giant, but also a semiconductor player. In the Acer Group, Acer Peripheral Inc. (API) is one of the most well-known and profitable companies. API is one of the world's largest CD-ROM, monitor, and scanner manufacturers. The company has designed its own digital cellar phone in 1998. Acer Laboratory Inc. (ALI) also belongs to Acer. ALI is one of the world's top five chipset vendors.

Other Companies

Winbond and World Semiconductor Mfg. Co. Ltd. (WSMC) belong to the same group. Winbond's capital investment and technology helped WSMC start its new fab setup smoothly in 1997.

Mosel Vitelic has its own alliance strategy: The company has a joint venture with Siemens AG—ProMOS Technologies that started 64M DRAM production in 1997. Mosel Vitelic also gained from Siemens' 16M DRAM foundry. Mosel Vitelic invests in ChipMOS Technologies Inc., a joint venture between Mosel Vitelic and Siliconware Precision Industries Ltd. This new assembly and testing company is design for 64Mb and 1Gb DRAM. ChipMOS plans to start production in 1999.

Powerchip Semiconductor Co. is owned by UMAX Data Systems Inc. UMAX is one of the world's top three scanner manufacturers. Powerchip, a joint venture between UMAX/Elite Group and Japan's Mitsubishi Electronics America Inc., started commercial DRAM production in October 1996.

Hualon Microelectronics Corporation (HMC) may be alone for a long time. The company belongs to Hualon Co., one of the largest fiber manufacturers in Taiwan. Currently, Hualon shows no signs of forming advanced alliance with other companies.

The semiconductor/electronic magnates have been formed, but it doesn't mean that some companies will disappear. Smaller companies will persist even in a tough market because it is an old Chinese tradition that men must have their own business that will give all family glory—men are supposed to be the boss. This is why there are so many start-up companies in Taiwan, and many young people want to start their own businesses. If large wafer investments can't be achieved, IC design house will be the best choice. Actually, a compact-size company is the best fit for the fast-changing IC industry. Although having many compact-size companies can bring intense competition among them, it also provides opportunities for those companies worldwide, which want to invest or purchase in Taiwan. Taiwanese companies have suffered this long market downturn, but, finally, they have begun to learn how to unite together.

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Taiwanese Semiconductor Manufacturers' Revenue Ranking

Table 3 lists Taiwanese semiconductor manufacturers' 1997 revenue by company ranking. Taiwan Semiconductor Mfg. Co. continued its steady pace as the industry leader in Taiwan, maintaining its No. 1 position. TSMC reached $1.5 billion, representing a 7.54 percent growth. UMC remained in the same position as 1996; however, the company showed an 8.7 percent growth to reach $896 million because of its successful transfer to the foundry business. Winbond took over the third position from TI/Acer with a slight 5.25 percent decline. Winbond's two 8-inch wafer fabs were not ready in 1997. TI-Acer dropped to the No. 4 position, showing a 26.64 percent decline, impacted by the sluggish DRAM price and loss of other niche products support. Macronix is in the No. 5 position and had the slight revenue increase in Taiwan with a 5.4 percent to reach $390 million.

Trailing closely behind is Vanguard, in the No. 6 position. Vanguard has the largest growth because it is a start-up company and gained a foundry business from the TSMC. Its $348 million revenue, with a 39.2 percent growth, represented the better year enjoyed by the Taiwanese semiconductor companies.

Mosel Vitelic dropped to the No. 7 position. The company doesn't have its own 8-inch fab, but it will have investnent income from ProMOS. This is the first time that both USC and Powerchip showed up on Dataquest's top 10 ranking in 1997, winning the No. 8 and 9 positions. USC succeeded in foundry, reaching $277 million. Powerchip started DRAM mass production, which offset the sluggish DRAM price in 1997, reaching $265 million. Holtek's 27.18 percent growth helped the company to maintain its No. 10 position.

Table 3
Top 10 Taiwanese Semiconductor Manufacturing Companies' Revenue, including Contract Manufacturing and OEM (Millions of U.S. Dollars), 1994 to 1998*

Rank	Company	1994	1995	1996	1997	1998[1]	1996 Growth Rate	1997 Growth Rate
1	TSMC	730	1,085	1,432	1,540	2,167	31.98	7.54
2	UMC	575	881	824	896	923	-6.47	8.70
3	Winbond	325	664	438	415	612	-34.04	-5.25
4	TI-Acer[2]	314	531	545	402	538	2.57	-26.24
5	Macronix	211	322	370	390	498	14.91	5.40
6	Vanguard	NA	190	250	348	519	31.58	39.20
7	Mosel Vitelic	NA	496	398	308	387	-19.76	-22.61
8	USC	NA	NA	NA	277	381	NM	NM
9	Powerchip	NA	NA	NA	265	498	NM	NM
10	Holtek	69	88	103	131	220	17.05	27.18
	Others[3]	129	199	151	380	776	-24.12	151.66
	Total	2,353	4,456	4,511	5,352	7,519	1.23	18.64

NA= Not available
NM= Not meaningful
[1]Forecast
[2]TI-Acer sold to Acer in 1998
[3]Others in 1998 include HMC, Nan Ya, USI, ProMOS and Episil.
Source: Dataquest (March1998)

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Sector Performance: SCM and System OEM, Brand Name, and Fabless

This section characterizes semiconductor industry revenue by the following three general categories

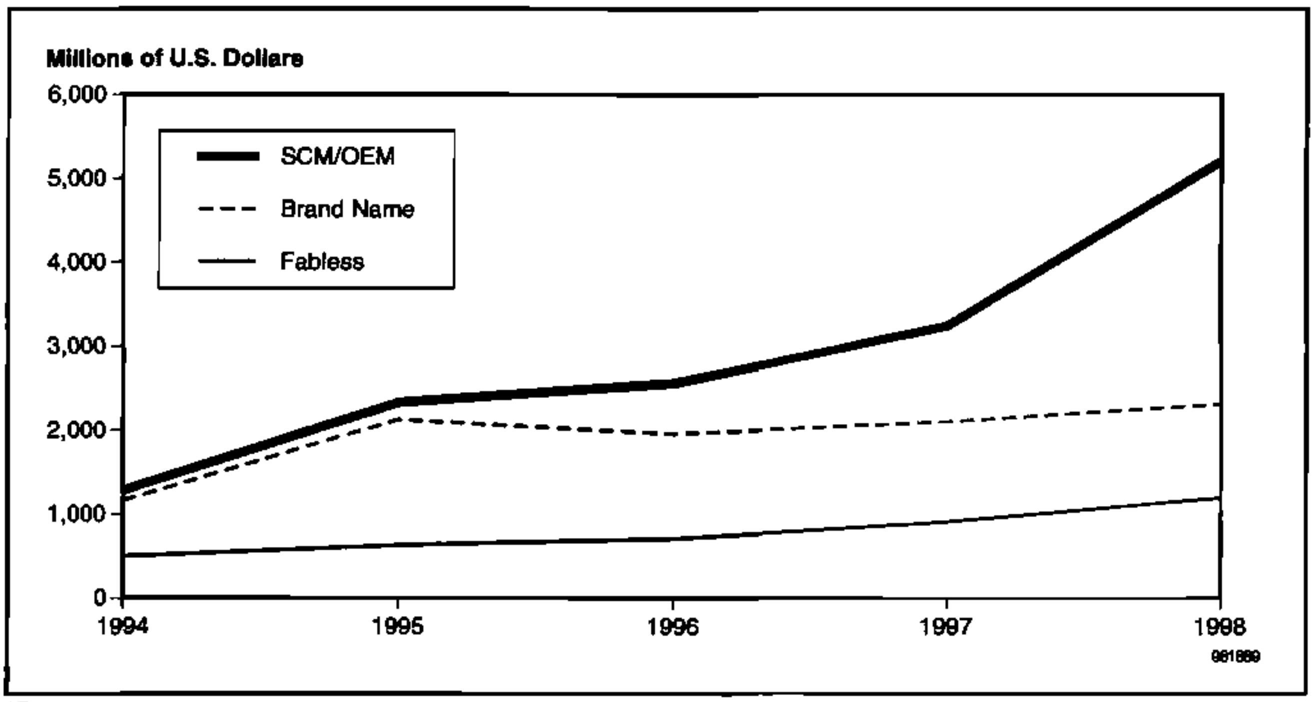
- Semiconductor contract manufacturing and system OEM, which included dedicated foundry and integrated device manufacturers (IDMs)
- Manufacturers' alliances with other brand-name products and brand-name production (by branding a company's product under its own name)
- Fabless vendors (pure design houses)

Figure 2 summarizes the results of Dataquest's recent Taiwanese industry survey and provides a split among SCM/OEM, brand name, and fabless revenue. Dataquest readers should note the overlap in the SCM and fabless. This comparison shows the fabless companies' growth in Taiwan.

SCM/OEM revenue expanded from $2.6 billion in 1996 to $3.2 billion in 1997, indicating a 26.6 percent growth. Brand-name revenue rose from $2 billion to $2.1 billion in 1997, a 7.7 percent increase. Fabless revenue grew from $705 million to $910 million in 1997, showing a 29.1 percent increase.

The total semiconductor manufacturing growth was driven by foundry, or IC design house, which is one of its main engines. Compared to worldwide IC design house, Taiwanese IC design house did not provide as much contribution to the local foundry. However, starting with UMC's dedicated foundry strategy that spun off all its design teams since 1996, Holtek also decided to spinoff its design team and transfer the company to become another dedicated foundry. In 1998, Dataquest expects the IC design house revenue to grow strongly to reach $1.3 billion, with a 31 percent growth.

Figure 2
Taiwanese Semiconductor Manufacturers' Revenue, 1994 to 1998*



*Forecast
Source: Dataquest (April 1997)

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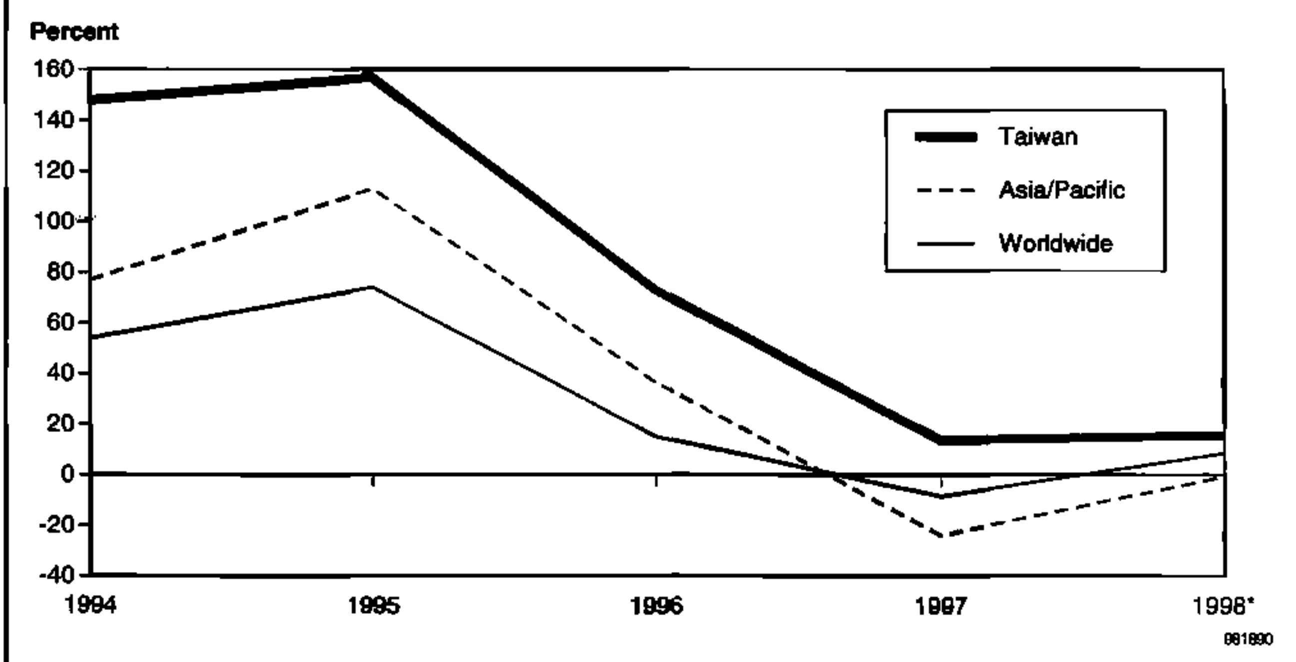
Capital Spending by Taiwanese Companies Worldwide

After a 72.6 percent growth of Taiwanese semiconductor capital spending in 1996, Taiwanese companies experienced a "slight" growth of 13.6 percent, reaching $5.3 billion in 1997 (see Figure 3)—compared to Asia/Pacific's 23.9 percent decline and the worldwide 8.5 percent decline. Taiwanese foundry companies have maintained the spending plans set early in 1996 and 1997. However, the DRAM capacity expansion slowed down. The major spending for DRAM companies was in process technology migration. Dataquest expects Taiwanese companies to generate a 15 percent growth in 1998. Figure 3 illustrates a comparison of the Taiwanese, Asia/Pacific, and worldwide companies' capital spending from 1994 to 1997, with a 1998 forecast. Figure 4 shows top 10 Taiwanese semiconductor companies' capital spending for 1997, with a forecast for 1998.

Table 4 presents details about the current and planned wafer fabs in Taiwan, including starting date, capacities, and products. More detail on capital spending and wafer fabs will be available in SEMI-AP-DP-9808, "Asia/Pacific Companies' Capital Spending," and SCMS-WW-DP-9812, "Asia/Pacific Fab Capacity Review."

Figure 3
Comparison of Taiwan, Asia/Pacific, and Worldwide Semiconductor Capital Spending, 1994 to 1998*



*Forecast
Source: Dataquest (April 1997)

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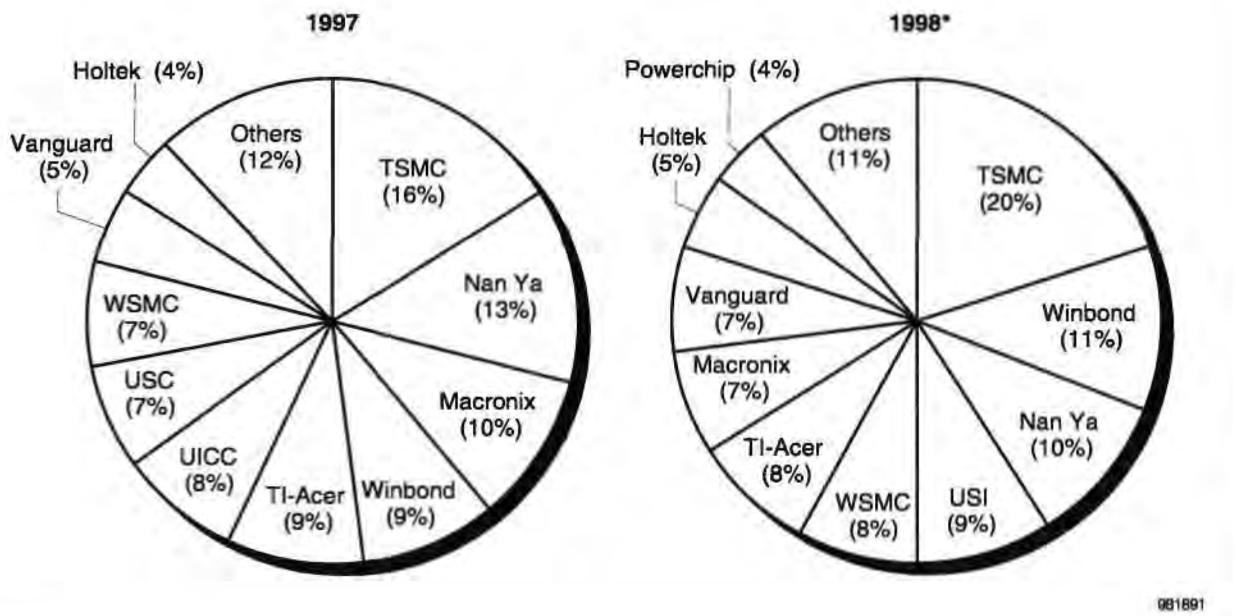
Figure 4
Top 10 Taiwanese Semiconductor Capital Spending: Share of Total Spending, 1997 and 1998*



*Forecast
Source: Dataquest (April 1997)

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Table 4
Current and Planned Wafer Fabs in Taiwan, Starting Dates, Capacities, and Products (Millions of U.S. Dollars)

Company	Fab Name	Start Date	Process	Line width (Micron)	Wafer Size (Inches)	Wafers per Month	Type [1]	Clean Room Class	Main Products
TSMC	Fab 1	1987	CMOS, BiCMOS	0.8	6	22,000	F	10	Foundry
TSMC	Fab 2-A	1990	CMOS	0.6	6	38,000	F	1	Foundry
TSMC	Fab 2-B	1992	CMOS	0.5	6	38,000	F	1	Foundry
TSMC	Fab 3	1995	CMOS	0.35-0.25	8	35,000	F	1	Foundry
TSMC	Fab 4	1996	CMOS	0.35-0.25	8	30,000	F	1	Foundry
TSMC	Fab 5	1997	CMOS	0.25-0.18	8	25,000	F	1	Foundry
TSMC	Fab 6[2]	1999	CMOS	0.18	8	60,000	F	1	Foundry
TSMC	Fab 7	2000	CMOS	0.18	12	35,000	F	1	Foundry
UMC	Fab 2	1989	CMOS	0.45	6	40,000	F,M	1	Foundry, SRAM, ROM, Logic, MPR
UMC	Fab 3	1995	CMOS	0.35	8	28,000	F,M	1	Foundry, 16Mb DRAM, SRAM
UMC	Fab 4	1999	CMOS	0.25-0.18	8	40,000	F	1	Foundry
Acer	Fab 1-A	1991	CMOS	0.45	6	24,000	C	1	Consumer IC
Acer	Fab 1-B	1995	CMOS	0.35	8	24,000	C	1	16Mb DRAM, 16Mb, 64Mb SDRAM
TI/Acer	Fab 2	1997	CMOS	0.28	8	40,000	C	1	64Mb SDRAM
Winbond	Fab 1	1988	CMOS	0.8	5	20,000	M	10	Telecom IC, foundry
Winbond	Fab 2	1992	CMOS	0.4	6	35,000	M	1	DRAM
Winbond	Fab 3	1999	CMOS	0.25	8	25,000	M	1	DRAM, SRAM, Flash
Winbond	Fab 4	1998	CMOS	0.25	8	15,000	M	1	64 Mb, 256Mb DRAM
Vanguard	Fab 1-A	1995	CMOS	0.35	8	16,000	M	1	4 Mb, 16Mb DRAM
Vanguard	Fab 1-B	1997	CMOS	0.25	8	15,000	M	1	16 Mb, 64Mb DRAM, 16Mb SDRAM

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Table 4 (Continued)
Current and Planned Wafer Fabs in Taiwan, Starting Dates, Capacities, and Products (Millions of U.S. Dollars)

Company	Fab Name	Start Date	Process	Line width (Micron)	Wafer Size (Inches)	Wafers per Month	Type [1]	Clean Room Class	Main Products
Vanguard	Fab 2A	1999	CMOS	0.18	8	30,000	M	1	64 Mb, 256Mb DRAM
Macronix	Fab 1	1992	CMOS	0.4	6	35,000	M	1	Mask ROM, EPROM, flash
Macronix	Fab 2	1997	CMOS	0.35	8	30,000	M	1	Flash, DRAM
Holtek	Fab 1	1990	CMOS	0.8	5	32,000	M	10	MCU, logic, foundry, memory
Holtek	Fab 2	1997	CMOS	0.35	8	35,000	F, M	1	Foundry, Embedded logic, consumer IC, foundry
Nan Ya	Fab 1	1996	CMOS	0.35	8	35,000	M	1	Foundry, 16Mb, 64Mb DRAM
Nan Ya	Fab 2	1999	CMOS	0.25-0.18	8	35,000	M	1	64M, 256M DRAM
Nan Ya	Fab 3	2000	CMOS	0.18	8	25,000	M	1	256M DRAM
Powerchip	Fab 1	1996	CMOS	0.35	8	25,000	C	1	16Mb, 64Mb DRAM
UICC	Fab 1	1997	CMOS	0.35	8	0	F	1	Foundry
USI	Fab 1	1997	CMOS	0.25	8	25,000	F	1	Foundry
USC	Fab 1	1996	CMOS	0.35	8	25,000	F	1	Foundry
USC	Fab 2A	2000	CMOS	0.25-0.18	8	30,000	F	1	Foundry
	Fab 2B	2001	CMOS	0.18	8 or 12	30,000	F	1	Foundry
ProMOS	Fab 1	1997	CMOS	0.35	8	35,000	M	1	64Mb DRAM
WSMC	Fab 1	1998	CMOS	0.35	8	25,000	M	1	Foundry
Mosel Vitelic	Fab 1	1995	CMOS	0.34	6	38,000	M	1	4 Mb, 16Mb DRAM, VRAM
Mosel Vitelic	Fab 2	2001	CMOS	0.18	12	25,000	M	1	64Mb, 256Mb DRAM
HMC	Fab 1	1995	CMOS	0.6	6	28,000	M	10	Logic, ASIC, MPU
Episil	Fab 1	1991	Bipolar	0.5	5	8,000	M	10	Bipolar IC, Power MOSFET

NA = Not available
[1]F = Foundry, C = Captive, M = Merchant
[2]This fab will be built in the Tainan Science-Based Industrial Park, Taiwan. It is not the new fab because it is owned by WaferTech in Camas, Washington.
Source: Dataquest (April 1998)

Dataquest Perspective

By Dataquest's market share definition, SCM and OEM are excluded from the companies' revenue. This definition prevents the overlap of revenue and reveals the actual market size. In 1997, Dataquest's *Taiwanese Semiconductor Industry Trends Report* included those sections for each company. After the Asian financial crisis and the worse-than-expected market, this methodology provides one answer to Taiwanese companies' overall performance in 1997. Since 1995, new companies that have emerged and the huge capital that was spent in Taiwanese semiconductor industry were dubbed "fab fever." In the past two years, there were endless arguments between brand and nonbrand (foundry or OEM) when the companies had to decide their strategy for future development. Dataquest believes that both will exist. Foundries will be expanded, but the brand name may not be the same as we have heard for years.

The most important event in 1997 wasn't the continuing, sluggish DRAM price, but Asia/Pacific's financial crisis, which is expected to cause poor market performance. Suddenly, the financial structure has been in the spotlight in the region. At the time of the booming semiconductor market, semiconductor companies look like they are on their way to prosperity. Although history tells us that semiconductor market cycles happen in a certain period, more announcements of Taiwan's newly constructed fabs seemed to ignore the risk. However, the downturn did come, with the winter lasting longer than expected. In the first quarter of 1998, Taiwan and its semiconductor companies are still standing after the storm.

However, the recent, drastic DRAM price decline is causing extreme uncertainties for Taiwan's semiconductor companies. During the writing of this Perspective, DRAM prices dropped from $14 to $9. It is uncertain whether they will be able to weather this latest storm. The Asian financial crisis hasn't ended, and Korean semiconductor companies are selling DRAM in the world market at spectacularly low prices because of their need for hard currency. Hence, if DRAM prices do not stop decreasing, multinational and Taiwanese DRAM vendors are likely to face another turbulent storm. DRAM oversupply is here. As history tells us, if market recovery cannot rely on increasing demand, vendors will withdraw from the market as the last solution. The question of how long a semiconductor company can stay in business is still relevant.

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Perspective

Semiconductors Asia/Pacific

Market Analysis

1998 Asia/Pacific Regional Outlook

Abstract: *Asia/Pacific has seen strong economic growth and rapid development of its electronics industries during the last decade. Growth was led by the Four Tigers—Hong Kong, Singapore, South Korea, and Taiwan—followed by Indonesia, Malaysia, and Thailand. However, Asia/Pacific's economy will be depressed in 1998 because of the financial crisis. This Perspective provides an outlook and implications of the current financial crisis in Asia/Pacific.*

By C.S. Kim

Introduction

Much has been heard about the current financial crisis in South Korea and Southeast Asia. However, the implications of the crisis for all industrial sectors are much less clear. Dataquest has been following the events during the past few months and analyzing their implications for Asia/Pacific's semiconductor industry.

Where Did the Financial Crisis Come From?

Simply stated, the financial crisis stemmed from South Korean companies' inability to repay their short-term debts. The expansion that has given South Korea an average annual gross domestic product (GDP) growth rate of 8.6 percent during the past 30 years has been achieved largely on the back of massive, politically backed, short-term borrowings, which were rolled over regularly and renewed by the country's top companies—family-run conglomerates commonly known as *chaebols*. Problems have occurred with this short-term-borrowing strategy because many investments made were long term and not suited to short-term returns. More importantly, the primarily South Korean banks, which in turn borrowed mainly U.S. dollars

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from Japanese banks, are now unable to continue rolling over the debts and granting extensions. Inevitably, the huge debts are now due for repayment. There are several factors that have caused this debt situation.

Until mid-1997, several Southeast Asian currencies, including the South Korean won, were pegged to the U.S. dollar. With the growing strength of the dollar since mid-1995, caused by the improving performance of the American economy, the won and the other Southeast Asian currencies also grew in strength. This growth made Southeast Asian exports more expensive and less competitive in a worldwide market that was already showing signs of slowing down and overcapacity because of overinvestment. In an attempt to revive South Korea's failing export-led economy, the dollar pegging was abandoned and the won devalued to make South Korean goods cheaper in the world market. This devaluation, however, increased the won value of debts borrowed in foreign currencies, massively increasing the amount of won required by banks and *chaebols* to repay their debts. In May 1997, the won/dollar rate was approximately U.S.$1:W 900. As of January 8, 1998, the rate was $1:W 1,800, meaning that South Korean companies now have to pay twice as much won for their dollar-based debts as they did in May 1997.

The second factor concerns primarily the Japanese banks that, by lending to South Korean banks, financed South Korea's growth. Japanese banks were unable to renegotiate their South Korean debts because of their own liquidity problems. Much of the security upon which Japanese banks based their value was property-based investments. However, in the early 1990s, the Japanese property market collapsed, taking with it much of the equity that Japanese banks relied upon. The equity loss impaired these banks' ability to borrow money in the international money markets, thus, less new money was available to renegotiate South Korean debts. South Korean loans, therefore, became due for repayment.

The debt problem is now so severe that the South Korea's Ministry of Finance and Economy estimates that approximately $21.5 billion of external debt will be due for repayment in the first three months of 1998. In the first six months of 1998, approximately $70 billion of external liabilities will be payable—this amount represents about 70 percent of the nation's total external debt.

Behind these statistics lies a myriad of companies with liabilities unheard of in the Western economies. Halla Group, South Korea's twelfth-largest conglomerate, declared bankruptcy on December 6, 1997, with a debt-to-equity ratio of almost 20:1 (its debts were 20 times greater than its net worth). Halla Group is not alone. The 1996 financial statements of South Korean *chaebols* reported that of the top 25 *chaebols*, 22 have debt-to-equity ratios greater than 3:1, and 10 have ratios greater than 5:1. In 1996, the top 25 companies had a combined total assets of $192 billion and debts totaling $149.5 billion.

South Korea as a Competitor

With the stringent management and restructuring requirements of the IMF bailout, the Korean semiconductor industry is planning to cut 1998's capital investment by 30 percent to 50 percent, compared to 1997. Korean DRAM manufacturers fear that their cutbacks could result in a drastically dwindling share of the world market, with market share lost particularly to Japanese and Taiwanese companies. The threat of shrinking market share is something that Korean DRAM manufacturers haven't been accustomed to; they have enjoyed a steady market share growth since 1990.

Samsung Electronics Company Ltd., currently the world's leading DRAM producer, is expected to implement a 30 percent cut in overall investment and is considering further cuts. Samsung's plans are to earmark W 800 billion to W 900 billion for semiconductor and LCD investment next year and W 400 billion to W 500 billion on research and development. LG Semicon Co. Ltd. and Hyundai Electronics Company Ltd. are also cutting back investment. LG Semicon plans to lower investment by 30 percent, or W 1.05 trillion to W 1.10 trillion for next year, while Hyundai is considering a 40 percent cut. As with Samsung, both LG Semicon and Hyundai have yet to make their investment plans final.

What impacts will these cutbacks have on projects already under consideration? LG Semicon is expected to delay the construction of its second LCD plant in southern Korea. LG Semicon and Hyundai are re-examining their plans to construct DRAM fabs in the United Kingdom, although both expect to go ahead with plans as scheduled. Most expansion plans for DRAM fabs in the United States by Samsung, LG Semicon, and Hyundai are expected to be suspended.

As explained in Dataquest's Tactical Memories Newsletter (Volume II, Number 26), much of South Korea's DRAM manufacturing costs are based on won. As the value of the won slides against international currencies, so too do the costs of South Korea's DRAM manufacturers. Given that the won has devalued by 50 percent against the dollar in the past eight months, this cost gives South Korean DRAM manufacturers a significant opportunity to cut dollar-based prices while maintaining won-based margins. In the short term, this move means that in an already-deflated DRAM market, further price pressure can be brought to bear by South Korean and other Southeast Asian DRAM manufacturers. This move will enable them to achieve greater market share and generate much-needed revenue and profit-making dollars, while putting pressure on the non-Southeast Asian competitors to such an extent that antidumping inquiries, so recently resolved, may be put back on the political agenda.

Similarly, however, many non-Southeast Asian semiconductor companies have packaging and test plants throughout the Southeast Asia region. Where these companies have fixed and variable costs based in local currencies, marginal savings will be realized because of the depreciation of those local currencies. These savings will provide those non-Southeast Asian semiconductor companies with some extra leeway to respond to competitive pricing from Southeast Asian semiconductor companies.

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South Korea as a Consumer

Perhaps the financial crisis' greater significance may be the exposure of those outside of Southeast Asia to the loss of Southeast Asia's purchasing power. In the United States, Atmel Corporation, the nonvolatile memory and ASIC supplier, has announced a fourth fiscal quarter charge of $160 million, citing credit problems with specific Asian customers. While this statement may be open to further scrutiny, it does raise the point that companies may be exposed to risks regarding the occurrence of potential bad debts and future loss of custom as a result of the inability of Southeast Asian OEMs and contract equipment manufacturers (CEMs) to obtain letters of guarantee from their banks, which are essential when they wish to trade on credit.

In 1996, non-Asia/Pacific semiconductor companies achieved sales of $24 billion (81 percent of their total revenue) through sales into the Asia/Pacific region; the percentage is likely to be similar for 1997. South Korea represents 17 percent of Asia/Pacific's semiconductor consumption. Using this percentage of non-Asia/Pacific revenue total means that South Korea represents approximately $3.1 billion of non-Asia/Pacific semiconductor companies' revenue. Most manufacturing locations within South Korea are owned locally, and this represents a problem for non-Asia/Pacific semiconductor manufacturers. With IMF restrictions in place, South Korean companies will find it difficult to obtain letters of guarantee. Without these letters, their only option is to pay cash for purchases of semiconductors. Cash has become twice as expensive to buy as it was eight months ago, and cash is even difficult to obtain. The credit and cash problems potentially put at risk a substantial proportion of the $3.1 billion revenue realized by non-Asia/Pacific semiconductor companies, both in the current and future financial years, because of a loss of the South Korean purchasing power.

Other Southeast Asian Countries

Within the rest of the Southeast Asian region, the severity of the financial crisis is varied. The Philippines, Thailand, Indonesia, and Malaysia all have problems similar to South Korea, and all have experienced IMF intervention in their economies to some degree. In total, the four countries have received more than $30 billion in IMF-led relief. The constrictions associated with IMF intervention and the currency crises being experienced in these countries will affect indigenous producers in these countries as they have affected South Korean manufacturers. A significant proportion of OEMs and CEMs in these countries are, however, not based in Southeast Asia. These companies will, therefore, experience a cost, which may encourage them to ramp up production while costs are low. Therefore, the position of semiconductor demand in these countries is unclear. Any potential demand loss from indigenous manufacturers because of the purchasing power loss may well be countered by increasing demand from nonindigenous manufacturers benefiting from cost.

Taiwan, Singapore, and China/Hong Kong are in a different position from the four countries discussed above, because their economies are financially

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more advanced. External debts within these countries are minimal in comparison to those of the above countries, and government reserves are more than adequate to cover these debts and protect the currency when necessary, although Hong Kong is coming under increasing pressure. With the exception of a general loss of confidence because of their geographical proximity, these countries have been much less severely affected, although all have experienced a weakening of their currencies and stock markets.

The Potential Effects of Lost GDP

In December 1997, the Organisation for Economic Cooperation and Development (OECD) projected that the Asian financial crisis would reduce the GDPs of Asia/Pacific countries, including Japan, by 1.4 percent in 1998, and that the knock-on effect would reduce the GDPs of Europe and the United States by 0.4 percent. Dataquest estimates that approximately 4.5 percent of GDP is spent each year on electronic equipment consumption in Southeast Asia. Dataquest estimates that in Japan, this percentage is approximately 3.0 percent. Given a 1.4 percent reduction in GDP across the Asia/Pacific region, this situation would lead to a fall in electronics equipment consumption of $2.5 billion, which would equate to semiconductor revenue of approximately $500 million. In terms of Asia/Pacific revenue, given Asia/Pacific's current market share of the worldwide total available market, this situation would mean a revenue loss of approximately $47.5 million. However, since the OECD made its December forecast, much has come to light that would indicate a worsening situation. For each additional 1 percent fall in Asia/Pacific's GDP, worldwide semiconductor revenue would fall by approximately $360 million, equating to Asia/Pacific's revenue of roughly $34.2 million.

A major assumption in this calculation is that with decreasing GDP, the marginal propensity to consume would also decrease at a uniform rate. In reality, however, the loss of confidence in the market and consumers' worry over job security and desire to save would almost certainly make the marginal propensity to consume decrease at a faster rate than the reducing GDP. Thus, electronics equipment consumption would fall more sharply, leading to a larger fall in semiconductor revenue. In addition, for each 0.5 percent fall in the rest of the world's GDP, $600 million would be lost from worldwide semiconductor revenue, equating to approximately $57 million of Asia/Pacific semiconductor revenue.

Dataquest Perspective

Dataquest believes that the currency devaluation in some countries within Asia/Pacific will have varying positive and negative effects on the region's semiconductor consumption. The countries primarily affected and discussed here are South Korea, Taiwan, Singapore, Thailand, Malaysia, Indonesia, and the Philippines. Note that the Hong Kong dollar remains the least vulnerable currency, and it was seriously attacked by speculators only after the Southeast Asian devaluation—but then to no avail. Dataquest also believes that Taiwan's electronics industry will fare well in this crisis, primarily

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because a larger percentage of components is supplied locally and because its financial sector is stronger than in the other countries.

In the short term, numerous companies selling equipment or semiconductor components to these countries report difficulty in getting payment from their channels. Consumption of end equipment such as PCs, cellular phones, and color televisions will be affected, but these are small, developing markets relative to worldwide consumption. Since 1997, Dataquest has observed a growth deceleration in Southeast Asia and an acceleration in China. China's electronics equipment production will grow at nearly 20 percent this year and is now the largest semiconductor market in Asia/Pacific. China now represents a huge consumer of communications and computer equipment, with 25 percent of all PCs purchased in Asia/Pacific and growth exceeding 40 percent. Although electronics consumption may be lower than previously expected in the selected countries, the region as a whole will continue to enjoy the fastest growth rates in the world.

The long-term impact on overall semiconductor consumption in Asia/Pacific is better understood from a company-level view. Companies in the affected Asian countries, which rely primarily on imported components, are experiencing increased costs because of their weaker local currency. However, if their finished products are exported, then this cost increase can be reversed because more local currency is received for the same U.S. dollar price.

Although recent trends show increased shipments to Southeast Asia from manufacturers based there, this output represents less than 15 percent of total production. Exports have and will continue to drive electronics production in Asia/Pacific and, therefore, strong semiconductor demand. Weaker currency means more expensive parts for some, but all will have more competitive exports. Although certain companies may be hurt, the aggregate demand will not be reduced and could well be helped in the long run.

It will take one to two years for cutbacks in Korean investment to make a significant impact on company market share and DRAM industry capacity. There is more than enough capacity already to support current demand, and as all manufacturers continue to shrink their 16Mb and 64Mb devices, industry overcapacity will continue through most of 1998 and possibly into 1999. To put device die size into perspective, the average die size of 16Mb DRAM at the end of 1998 will be 60 percent of the average die size of 4Mb DRAM at the end of 1995.

Taiwanese DRAM manufacturers will have a significant impact on when the market comes into balance. If Taiwanese companies continue with their aggressive expansion, the equilibrium point may be pushed out from three to six months well into 1999. Before the IMF actions, the Taiwanese companies planned to increase capital spending in local currency (NT$) by 10 percent. In U.S. dollar terms, this may actually represent declining capital spending because of currency devaluation. The Korean cutback in spending may encourage Taiwanese DRAM vendors to accelerate investment in an effort to take market share away from the Koreans. If Korean companies cut their

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capital spending as indicated and if Taiwanese companies continue with their capital spending plans for foundry, memory, and joint ventures, Taiwan may surpass Korea in capital spending in 1998. However, not all Taiwanese DRAM vendors are expected to increase capital spending—at this time, Mosel Vitelic Inc. and Powerchip Corporation are expected to decrease their capital spending in 1998, and others may follow.

Dataquest believes that there is a good possibility that Taiwanese manufacturers will not implement their aggressive capital spending plans. The Taiwanese companies are newcomers to the DRAM industry with no experience prior to the industry downturn. As they gain experience in the current downturn, they may decide to stop DRAM spending abruptly. This move will come with the realization that, while aggressive expansion will buy market share, it will also lengthen the DRAM industry downturn.

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Perspective

Semiconductors Asia/Pacific

Market Analysis

1997 Regional Review: Semiconductor Industry in Asia/Pacific

Abstract: *This Perspective provides a summary of the Asia/Pacific semiconductor industry news in 1997 and provides insight to the financial turmoil happening in the Asia/Pacific region.*

By C.S. Kim

Asian Currency Crisis

Dataquest believes the currency devaluation in some of the countries within the Asia/Pacific region will have varying positive and negative effects on semiconductor consumption in the region. The countries primarily affected and discussed here are Korea, Taiwan, Singapore, Thailand, Malaysia, Indonesia, and the Philippines. Note that the Hong Kong dollar remains the least vulnerable currency and it was seriously attacked by speculators only after the Southeast Asian devaluation, but then to no avail. Dataquest also believes Taiwan's electronics industry will fare well in this crisis, primarily because a larger percentage of components is supplied locally and because its financial sector is stronger than in these other countries.

In the short run, numerous companies selling equipment or semiconductor components to these countries report difficulty in getting payment from their channels. Consumption of end equipment such as PCs, cellular phones, and color televisions will be affected, but these are small, developing markets relative to worldwide consumption. Since last year, Dataquest has observed a deceleration of growth in Southeast Asia and an acceleration in China. China's electronics equipment production will grow at nearly 20 percent this year and is now the largest semiconductor market in Asia/Pacific. China now represents a huge consumer of communications and computer equipment, with 25 percent of all personal computers

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purchased in Asia/Pacific and growth exceeding 40 percent. Although electronics consumption may be lower than previously expected in selected countries, the region as a whole will continue to enjoy the fastest growth rates in the world.

The long-term impact on overall semiconductor consumption in Asia/Pacific is better understood from a company-level view. Companies in the affected Asian countries, which rely primarily on imported components, are experiencing increased costs because of their weaker local currency. However, if their finished products are exported, then this cost increase can be reversed because more local currency is received for the same U.S. dollar price.

If an electronics manufacturer receives components through internal transfer or global sourcing agreements (billed out of headquarters) and exports its finished product, then it benefits significantly—it has no cost increase, yet does have increased revenue (in local currency). So which situation is more common in Southeast Asia? The majority of production in these countries is exported rather than shipped locally. However, most components are imported from Europe, Japan, or North America, and the lion's share of these semiconductors is imported by multinationals that either have global procurement agreements or receive large amounts of transshipments from other subsidiaries.

Although recent trends show increased shipments to Southeast Asia from manufacturers based there, this output represents less than 15 percent of total production. Exports have and will continue to drive electronics production in Asia/Pacific and, therefore, strong semiconductor demand. Weaker currency means more expensive parts for some, but all will have more competitive exports. Although certain companies may be hurt, aggregate demand will not be damaged and could well be helped in the long run.

First Quarter: Semiconductor Companies' Activities

TSMC and SST Sign Licensing Agreement for Embedded Flash

Silicon Storage Technology (SST) and Taiwan Semiconductor Mfg. Co. (TSMC) have signed a technology licensing agreement covering the design, manufacture, and distribution of embedded flash memory products based on SST's SuperFlash technology. Under the licensing agreement, SST has granted TSMC a license to use SST's SuperFlash technology to provide customers access to embedded flash applications.

More and more electronic applications are memory hungry. The need to drive down chip count to reduce costs, save space, and limit weight couples with benefits such as reduced power consumption and improved system quality and reliability. The fundamental markets driving embedded applications actually remain strong. From an applications point of view, embedded flash can naturally be integrated with the microcontroller, digital signal processor (DSP), or ASIC for use in such applications as analog

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storage devices, smart card ICs, and programmable logic devices. Chips with embedded flash memory can be incorporated into a wide range of computer, communications, and consumer products.

SST's SuperFlash technology uses a thick-oxide process with fewer manufacturing steps that results in higher yields and offers significant cost benefits for embedded applications. The two companies are developing a proprietary process to allow significant amounts of embedded flash to be used without the die size penalty of traditional two-transistor thin-oxide cell embedded EEPROM flash technology. The licensing agreement covers process technologies with 0.5-micron, 0.35-micron, and smaller geometries. TSMC is planning the launch of 0.25-micron logic, embedded DRAM, SRAM, and flash processes in the fourth quarter of 1997. TSMC has affirmed its commitment to providing its customers with early access to advanced technology.

The licensing agreement has granted TSMC a license to use SST's SuperFlash technology to make embedded flash applications available to its customers. This embedded flash process will enable the customers to design application-specific standard products that integrate the appropriate amount of memory at the speed required. Dataquest expects that TSMC will provide a final solution to volume production in the vast array of applications with embedded SuperFlash technology.

Korean 16Mb DRAM Production: Slowdown or Excess Inventory?

Two months ago, three Korean DRAM vendors, Samsung Electronics Company Ltd., LG Semicon Co. Ltd., and Hyundai Electronics Industries Co. Ltd., announced a 30 percent reduction of their 16Mb DRAM output. At the time, the 16Mb DRAM production of the three Korean vendors constituted about 30 percent of the total worldwide 16Mb DRAM market. If production cuts actually reached 30 percent as announced, the three companies' 16Mb DRAM market share should have declined to about 25 percent. In January 1997, the contract price of 16Mb DRAM was $6.50 to $7.00 in Japan, and currently the price has risen to above $9.00 because of production slowdowns. The DRAM makers hope to raise the price to between $11.00 and $12.00.

Dataquest believes that the reduction has occurred in the shipment numbers of the three companies and not in their unit production. Dataquest has observed that their materials purchasing patterns have not changed. Although the volume of their silicon wafer purchases has occasionally dipped, this is probably because the shrink versions of their chips consume fewer wafers. An 8-inch wafer with 0.35-micron technology usually produces 200 to 220 16Mb DRAM dice, but the number increases to 430 to 450 when the shrink chip design is applied. The production rate for the three companies might have decreased by 10 to 20 percent, but not by 30 percent.

The Korean companies are carefully monitoring the spot market prices and have controlled their shipments. Last year, they had retained a huge inventory of 16Mb DRAM parts and had begun releasing the inventory at very low prices in May 1996. By the end of January 1997, the three

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companies had reduced their inventory to a reasonable level; however, because of the recent cutbacks, inventory has again accumulated to between one and a half and two months' worth of production. All DRAM vendors and users are very much interested in when the three Korean vendors will choose to release this inventory. If they release their inventory all at once, the flood will likely cause prices to go down rapidly. Thus, Dataquest believes the companies will release their inventory in measured amounts in order to keep prices relatively high.

The bottom line on price might also depend on the dumping issues raised by the Europeans. The Korean vendors will try to maintain a minimum price that is as high as possible when they finally release the inventory. Dataquest estimates that the minimum price might be $8.50 to $9.00. The timing for the release of their inventory could be around the end of April and the beginning of May, when Japanese DRAM manufacturers enter into a holiday season, known as Golden Week. This happened last year at about the same time, and 16Mb DRAM prices dropped dramatically. It may happen again this year.

Second Quarter: Semiconductor Companies' Activities

Singapore's Ninth Wafer Fab

Chartered Semiconductor Manufacturing (CSM) entered into a joint venture with Hewlett-Packard Company and the Economic Development Board (EDB) to build Singapore's ninth wafer fabrication plant. The new company, Chartered Silicon Partners, will cost over $1 billion. CSM, a subsidiary of government-owned Singapore Technologies, will be a majority shareholder, while HP and EDB will each take minority stakes. CSM plans to make ASICs for HP, besides serving as a chip foundry for other customers. The plant is expected to be completed by early to mid-1999. It will manufacture 30,000 eight-inch wafers per month using process technology of 0.35 micron and below.

This announcement is in line with Singapore's strategic intent to have 25 wafer fabs by the next decade. CSM is building its fourth plant, in addition to two existing fabs in operation and a third expected to begin production by the end of 1997. These fabs offer a range of processes in logic, analog, volatile and nonvolatile memories, and embedded logic/memory.

In 1995, CSM held the fifth-largest SCM worldwide market share with revenue of $285 million. CSM's Fab No. 2 is capable of making up to 40,000 eight-inch wafers, utilizing a 0.35-micron process. Dataquest predicts a 25 to 30 percent oversupply in overall semiconductor contract manufacturing capacity by 1999, with the exception of 0.25-micron process technology.

Worldwide ASIC consumption is estimated to grow 60 percent from 1996 to 1999, with ASIC designs of less than 0.3-micron expected to hit the mainstream by then. Because CSM has planned a process technology road map down to 0.18 micron, CSP will be capable of moving to more advanced process technologies later. By the time CSP begins operations in 1999, it may

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be well positioned to capitalize on a demand rise for ASICs and shortages in the 0.25-micron process.

TSMC's Big Project Starts: Promise for a New Park's Success

President Donald Brooks of TSMC led several vice presidents and top managers to Tainan County (120 miles south of Hsin Chu Science-Based Industrial Park) to visit with Mayor Chen and his staff last week. The parties discussed Tainan county government support for the Tainan Science-Based Industrial Park (TSIP). Details of the infrastructure plans and other TSMC requirements for its new wafer fabs to be built in the industrial park have been addressed.

TSIP Manufacturing Center, TSMC's U.S.$15 billion, 10-year project is now officially underway. The company has completed the procedures to acquire a 100-acre parcel of land in Tainan Science-Based Industrial Park. The next TSMC 8-inch fab (Fab 6) will be built in TSIP. Fab 6 will require investment of U.S.$145 million and is scheduled to break ground by the end of this year. In the next 10 years, TSMC will build six more advanced wafer fabs (12 inches) in TSIP.

There are two Taiwanese semiconductor companies acquiring land in TSIP after TSMC. United Microelectronics Corporation has more than 85 acres of land for a new fab and for the company's subsidiaries, including LCD panel and printed circuit board (PCB) manufacturing. Mosel Vitelic Inc. has a 64-acre parcel for the company's new 12-inch fab and testing and assembly facilities. More investments will be clarified by the end of this year.

TSIP is being offered with tax incentives and research and development grants for companies by the Taiwanese government. The branch office of the Industrial Technology Research Institute and National Cheng-Kung University and Chung-Shan Universities in the Tainan area will provide technological support and human resources for companies locating in the park, following the same model as ITRI and Tsing-Hwa and Chio-Tung Universities in the Hsin Chu area. Tainan County will also provide several alternative projects to satisfy investors' needs. Dataquest expects that other Taiwanese semiconductor companies, and foreign companies, will invest in TSIP.

After two strong expansion years in Taiwanese semiconductor capital spending (1994 to 1995), followed by an essentially flat 1996, Taiwanese semiconductor companies will see another surge of "fab fever" in next 10 years. Taiwan is clearly the new major production growth area. As Dr. Michael E. Porter of Harvard University pointed out in his address in Taiwan two weeks ago, Taiwan has the development potential to become the Asia/Pacific technology center.

The Taiwanese semiconductor companies' investments show their long-term development commitment and will make a significant contribution to their homeland rather than to others. The investments also promise that TSIP will become another semiconductor manufacturing center in Taiwan and win the same reputation that Hsin Chu Science-Based Park has in the industry.

These new science-based parks illustrate the future of the Taiwanese semiconductor industry—"Silicon Island."

Hyundai Announced 1Gb Synchronous DRAM

Hyundai officially announced the successful development of a fully working die 1Gb synchronous DRAM chip using the new silicon-on-insulator (SOI) technology. The actual chip can store an amount of information equivalent to over 8,000 newspaper pages, 160 books (320,000 two-hundred-word pages), 400 still pictures, or 16 hours of audio data.

Hyundai is the world's second chip producer to develop a fully working die, following Samsung, which demonstrated its sample last year. The Hyundai chip, however, is the world's first 1Gb DRAM developed on the SOI technology. Simply put, in this new technology, circuits are designed on a silicon layer superimposed on an insulator, which in turn is put on the ordinary bulk wafer.

The main merit of the SOI wafer is low power consumption, a key requirement for high-performance chips. The new chip consumes less power than Samsung's because the insulator placed between the two silicon layers minimizes electrical leakage. The Hyundai chip can operate on power of 1.8V, while Samsung's bulk wafer-based chip operates on 2.5V. Lower power consumption will be increasingly important because the trend in the electronics industry is toward portable equipment, such as notebook PCs. The new technology also enhances a chip's data processing speed. The maximum data processing speed of the Hyundai chip is 15ns, about 20 percent faster than Samsung's. Hyundai invested W 55 billion in the 1Gb DRAM project, employing 170 key researchers for two years.

Dataquest estimates that Hyundai's new chip has shown to the world chip industry that SOI technology, which has thus far been used for nonmemory chips, can also be used for memory-chip production. The SOI-based chip may emerge as the dominant chip structure in the future because it lends itself to development of what is called merged memory logic (MML) chips, logic chips embedded with memory chips. MML chips are increasingly used in building electronics devices because they can reduce equipment size.

Dataquest forecasts that Hyundai's 1Gb DRAM will first be used on future-generation PCs and workstations. It will also find its way to other products that require the ability to process vast amounts of data rapidly, such as videoconferencing systems with interpretation ability, medical systems, satellite telecommunications, personal digital assistants, high-definition TV, 3-D graphics, and other future digital multimedia products. The new chips will be commercially available around the turn of the century, with full-scale production forecast for around 2005.

CSM and Toshiba Enter Embedded DRAM Agreement

Chartered Semiconductor Manufacturing Pte. Ltd. and Toshiba Corporation entered into a five-year agreement that calls for technology and manufacturing cooperation on embedded DRAM. Toshiba will license its embedded DRAM technology, beginning with a 0.35-micron process and later migrating to a 0.25-micron process. After process qualification, CSM will manufacture embedded DRAM products for Toshiba by early 1998 in CSM's new Fab 3. Embedded DRAM is targeted at graphics and portable applications that require low power consumption.

CSM is among the first wafer foundries to obtain access to embedded DRAM technology from a major application-specific IC (ASIC) vendor. Embedded DRAM is a key component of system-level integration (SLI), the fastest growth area for ASIC products. Dataquest expects embedded DRAM to make up more than a quarter of the total market for SLI ASIC products by the year 2000. The SLI ASIC market is expected to exceed $15 billion in that year.

Products manufactured by CSM will use Toshiba's 1T DRAM ASIC technology. This technology is based on a one-transistor DRAM cell structure. The 0.35-micron 1T family can incorporate up to 32Mb, and the 0.25-micron 1T family offers memory capacity up to 128Mb. This partnership allows CSM to enter the fast-growing embedded DRAM market and at the same time enables Toshiba to secure a reliable second source. In the longer term, it is expected to provide CSM with additional capabilities to manufacture SLI ASIC products.

Third Quarter: Semiconductor Companies' Activities

UMC Signs Former TSMC President Don Brooks

United Microelectronics (UMC), Hsinchu, has hired the former president of Taiwan Semiconductor Manufacturing Company (TSMC), Donald Brooks. Mr. Brooks will become a member of the UMC board and president of the newly formed international operations unit, based in Sunnyvale, California, and will report to UMC president John Hsuan. Also, he will be responsible for United Foundry Services, another new operation supporting UMC's U.S. business. His extensive role in the company will include serving as vice chairman of the three foundry joint ventures (United Semiconductor, United IC Corporation, and United Silicon), and management of UMC's venture capital operation.

Mr. Brooks resigned from TSMC two months ago, saying he wanted to return to the United States to spend more time with his family. He explained his decision to join UMC in an open letter to the employees of TSMC, stating that the move provides an opportunity "to live in the United States, to be involved in the semiconductor industry with a dynamic company, and to continue to develop my relationships with the Taiwan people."

Don Brooks is a fine catch for UMC. During his six-year tenure at TSMC, he led a small, unprofitable company struggling for success with a newly conceived business model to worldwide preeminence as a dedicated foundry. He brings this experience and a long career in the semiconductor industry to UMC at a time when the company has shifted its strategy to a greater focus on the wafer foundry business. The addition of Mr. Brooks to the executive management team complements UMC's strategy quite nicely and makes it a force to be reckoned with in the foundry market.

Mr. Brooks has a well-established network of contacts in the U.S. semiconductor community, among fabless IC design companies and IDMs alike, and this will prove to be a valuable asset for UMC in its efforts to penetrate the U.S. semiconductor contract manufacturing market. His thorough understanding of business practices in Taiwan, coupled with these personal relationships, will give UMC an excellent facilitator between the factory and its U.S.-based customers. The foundry supplier/customer relationship is a strategic one, and it is fundamentally built on trust at a personal level. This is where the addition of Don Brooks is sure to make a difference, especially in the U.S. market.

TSMC has dominated the wafer foundry game in recent history, with UMC and Chartered never really mounting a serious challenge. With the signing of this star player, UMC might have a real shot at the championship, or at least an undisputed second place.

Samsung Semiconductor Opens European ASIC Design Center

Samsung Semiconductor has opened a ASIC design center in Schwalbach near Frankfurt, Germany. The center will serve both the German and wider European markets. A major focus will be the integration of Alpha and ARM processors, DSP, and memory into system-level ASICs.

This opening follows nine days after Cypress Semiconductor opened a major design center in the United Kingdom. These are only two examples of a stream of multinational semiconductor and electronic systems companies establishing design centers in Europe—mostly in Germany and the United Kingdom. Looking to the future, the problem beneath the surface is the continued availability of design engineers and the rate at which engineers are produced by the university system. At least these high-profile design centers have served to trigger much productive debate here among companies, governments, and the academic community.

The opening of the Samsung design center marks the real start of that company's ASIC operations in Europe. At first sight, ASIC may appear to be a strange market for a memory company to enter, with little synergy with existing operations. However, as the concept of system-on-a-chip (system-level integration) moves closer to reality, the ability to integrate processor cores, logic, and memory (especially DRAM) becomes critical. Furthermore, few vendors have embedded DRAM capabilities.

Samsung is clearly pushing forward with its nonmemory products with an emphasis on Alpha processor and ASIC solutions. Recognizing the need for a substantial library of system-level macros, SLMs, also known as intellectual property (IP) cores, the company has already forged links with Digital Equipment Corporation, Advanced Risk Machines, and the DSP Group, and has developed compatible macros for its cell-based process.

Armed with this library of SLMs and a proven high-density one-transistor DRAM technology, Samsung is well placed to enter such major European applications markets as GSM cellular handsets, LAN hubs/switches, and automotive.

Dataquest believes Samsung has and can acquire the technology needed for these markets but this is far from guaranteeing market success. The organization and culture of an ASIC supplier is radically different to a commodity memory vendor. Interfaces and communication channels need to be developed with customers' design groups rather than primarily with purchasing functions. Support and logistics requirements are very different. A dedicated salesforce may be needed. Samsung has the capability to make major gains in the emerging system-level ASIC market, but it must be prepared to give its ASIC specialists and marketers the flexibility they will certainly need to guarantee that success.

Three Korean Semiconductor Companies Increased 16Mb Synchronous DRAM

Three Korean semiconductor manufacturers—Samsung, Hyundai, and LG Semicon—produced synchronous DRAM totaling about 10 percent to 15 percent of their 16Mb DRAM at the end of 1996; they have currently increased their synchronous DRAM by 30 percent to 40 percent and hoped to increase synchronous DRAM production by 50 percent to 60 percent in the fourth quarter of 1997.

These three Korean semiconductor manufacturers depended heavily on memory semiconductor manufacturing. They considered a few plans to escape the difficult situation with DRAM, whose price is not stable because of the entrance of Taiwanese companies into the market and the increase in Micron's 16Mb DRAM. First, they wanted to try to balance their semiconductor production between memory and nonmemory products. Second, they wanted to strengthen their synchronous DRAM coming up to the surface of the 16Mb DRAM market.

Dataquest estimates that the three companies needed far more time to balance their production between memory and nonmemory because of their nonmemory technology. But they may be successful in keeping their DRAM market share as an expansion of synchronous DRAMs because DRAM lines for the fast page mode and extended data out devices can switch to synchronous DRAMs by process additions and changes.

Fourth Quarter: Semiconductor Companies' Activities

What Will the UICC Fire Mean for Equipment Companies?

The fire a week ago at UMC's second joint venture, United Integrated Circuits Corporation, essentially rendered unusable some wafer fab equipment. The total damage was estimated by UMC to be about $421 million. Given the severe structural damage to the building, Dataquest's guess is that some $200 million to $250 million worth of equipment was included. Dataquest has been asked recently if the equipment suppliers will benefit.

On the surface, the immediate impulse would be to point out that the equipment has to be replaced, and this means some added revenue eventually to the equipment companies. Putting this into perspective, however, reveals that it is not that big an issue: $250 million is only a little over 1 percent of the annual shipments of wafer fab equipment today, so it is not going to make anybody rich.

Furthermore, in the near term, it may actually be more disruptive than otherwise. UICC was clearly a fab in a ramping mode, with equipment deliveries scheduled continually over the next months. There is now no fab to ship to, however, so there is a level of uncertainty in the market. It is likely that much of the equipment planned for UICC will be redirected to UMC's other joint ventures, and there are indications that plans are already changing for acceleration of the expansions at both United Semiconductor (JV1) and United Silicon (JV3).

Dataquest's bottom-line assessment is that some names will change on the equipment, and the near-term impact will be minimal. The positive benefit will not likely be seen for nine to 12 months, and then be quite diffused and not noticeable. This is not a conclusion that favors those looking for sensationalism in this event, but it will probably be close to reality.

ProMOS Technologies Opens Chip Plant in Taiwan; Starts High-Volume 64Mb DRAM Production

ProMOS Technologies Inc., a joint venture of Mosel Vitelic and Siemens AG, celebrated the formal opening of its new wafer fab in Hsinchu, Taiwan. The 8-inch wafer facility enables both partners to begin high-volume 64Mb DRAM production.

The joint venture, formed only 11 months ago, represents a total capital investment of around $1.7 billion over three years. ProMOS employs 1,100 people and should have been running at full capacity by the end of 1996, beginning with 20,000 8-inch wafer starts per month of its initial product, the 64Mb DRAM chip on 0.35-micron technology. The 64Mb DRAMs are based on a technology that Siemens developed with IBM and Toshiba. Within the next three months, Mosel Vitelic and Siemens will expand their 64Mb portfolio with the release of configurations of 64Mb synchronous DRAMs (SDRAMs).

In September, Mosel Vitelic signed a contract under which Siemens will deliver to Mosel Vitelic 50 percent of the output of 16Mb DRAM and SDRAM from Siemens's new plant in North Tyneside, England. However, with the current unsteady price of 16Mb DRAM, this addition may not actually increase Mosel Vitelic's earnings. With the ProMOS joint venture, Mosel is preparing for 64Mb DRAM. Initially, the agreement calls for both Mosel Vitelic and Siemens to purchase ProMOS products for resale. Sixty-two percent of ProMOS's 64Mb DRAM will be labeled with Mosel Vitelic's brand name.

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Mosel Vitelic has also licensed 256Mb manufacturing technology from Siemens and may participate in IBM, Toshiba, and Siemens' DRAM joint development project, but an agreement has not yet been reached. If its participation is granted, Mosel Vitelic is expected to become the first Taiwanese company to acquire 1Gb DRAM technology. The cooperation in both original technology and joint-venture manufacturing between Mosel Vitelic and Siemens is significant. Other partnerships involving Taiwanese companies include Texas Instruments Inc./TI-Acer, Toshiba/Winbond Electronics Corporation, and Mitsubishi Corporation/Powerchip Semiconductor Corporation.

Mosel Vitelic was the first Taiwanese company to license Japanese technology when it opened its 6-inch-capable wafer fab with transferred and licensed DRAM technology from Oki Electric Industries Company Ltd., in 1994. Today, Mosel Vitelic is the first Taiwanese semiconductor company to set up a joint-venture company with a European semiconductor company. The result is the first Taiwanese facility to produce 64Mb DRAM.

Korean Companies Intensify Efforts for Next-Generation DRAM

Searching for the right path for next-generation DRAM, Korean DRAM manufacturers are intensifying their efforts to develop high-speed DRAM that can improve PC performance. Samsung announced that it has developed the world's first 64Mb double data rate (DDR) SDRAM, while LG Semicon announced it has begun mass production of the world's fastest 18Mb Rambus DRAM (RDRAM).

Samsung's DDR SDRAM, as its name indicates, has a data rate double that of synchronous DRAM (SDRAM), the current high-end DRAM for PCs. DDR was proposed by a group of DRAM companies, including Samsung, as an alternative to Direct RDRAM and was standardized by the Joint Electronic Device Engineering Council (JEDEC) last summer. Samsung played a leading role in the standardization process and is the first company to develop DDR SDRAM based on the standard.

While Samsung is focusing on DDR SDRAM, LG Semicon is putting more weight on Direct RDRAM. Direct RDRAM, although capable of offering higher data rates than DDR SDRAM, is expected to be more expensive to produce because of its larger die size and an associated licensing fee. According to some DRAM manufacturers, Direct RDRAM will be about 20 percent more expensive than SDRAM, a large cost penalty. This characteristic has made Samsung and other DRAM makers stop short of fully committing themselves to Direct Rambus, even though the technology has been endorsed by Intel Corporation.

The Direct RDRAM specification has only just been announced, and there has not been enough time since the development effort was started for manufacturers to produce working Direct Rambus parts. How then can LG Semicon demonstrate its commitment to the Rambus technology? LG Semicon has begun mass production of the predecessor to the Direct Rambus, the 18Mb RDRAM, which is already being used for graphics memory in PCs. LG Semicon expects RDRAM to rapidly take market share from synchronous graphics DRAM (SGDRAM) in the graphics memory market. Although LG Semicon is making a push for its RDRAM in the graphics market, the company's main concern lies in introducing Direct RDRAM to the main memory market as early as possible. RDRAM is the technology base that is being used by Rambus Inc. to develop Direct RDRAM.

Samsung and Hyundai also support Direct RDRAM and are working to develop it, but LG Semicon appears to be much more strongly committed to this technology. Direct RDRAM is generally expected to debut in 1999, but LG Semicon is determined to develop it in the first half of 1998 and establish leadership in the development and production of the new chip. One of the first companies to license RDRAM technology from Rambus, LG Semicon hopes its long development experience with RDRAM will help it attain this goal.

Another Taiwanese Company Licenses DRAM Technology

Macronix International Company Ltd. entered the DRAM market through a technology alliance with Matsushita Electric Industrial Co. Ltd. Matsushita licensed its 16Mb and 64Mb DRAM technology to Macronix, which will manufacture 16Mb DRAM on a foundry basis and then sell the output to Matsushita. Macronix expects to begin manufacturing of 64Mb DRAM in 1998. Macronix's long-term goal is not to be a commodity DRAM manufacturer, but to use its own logic process with Matsushita's DRAM technology to develop and sell a line of embedded memory devices under Macronix's brand name.

Macronix's agreement with Matsushita will help in two ways. The immediate benefit is that adding standard 16Mb DRAM to Macronix's product mix will help increase the utilization rate for its new 8-inch fab. The long-term benefit is that it adds strategically to Macronix's intellectual property portfolio. Companies with the most reusable intellectual property should have an advantage in the embedded memory market. Macronix already has experience with mask ROM, EPROM, and flash memory technologies, and it is adding DRAM capability with this agreement. It should be possible for Macronix to use its logic capability to add SRAM technology. When combined, this gives Macronix the building blocks needed for embedded memory.

Having the building blocks, however, doesn't ensure success. Many DRAM, SRAM, and nonvolatile memory companies are looking at ways to improve their own revenue stream and fab utilization with embedded memory products. From the logic side, ASIC and ASSP vendors are adding memory technology to their product portfolios. The embedded memory market promises to be very crowded. Success will depend not only on having all memory technologies and a process that optimizes for both logic and memory, but an ability to get design-wins. The design-win mentality may ultimately be the hardest addition for most memory companies because of their experience selling standard, commodity products.

Dataquest Perspective

South Korea and the International Monetary Fund (IMF) have agreed to a rescue package totaling $57 billion. South Korea agreed to implement IMF-recommended measures to revitalize its faltering economy in return for accepting the bailout fund. Even with the agreement, there are fears that the bailout may not succeed and that Korea's links to other Asia/Pacific countries may endanger those countries as well.

With the stringent management and restructuring requirements of the IMF bailout, the Korean semiconductor industry is planning to cut 1998's capital investment by 30 percent to 50 percent, compared to 1997. Korean DRAM manufacturers fear that their cutbacks could result in a drastically dwindling share of the world market, with market share lost particularly to Japanese and Taiwanese companies. The threat of shrinking market share is something Korean DRAM manufacturers haven't been accustomed to; they have enjoyed steady market share growth since 1990.

Samsung, currently the world's leading DRAM producer, is expected to implement a 30 percent cut in overall investment and is considering further cuts. Samsung's plans are to earmark W 800 billion to W 900 billion for semiconductor and LCD investment next year and W 400 billion to W 500 billion on research and development. LG Semicon and Hyundai are also cutting back investment. LG Semicon plans to lower investment by 30 percent, or W 1.05 trillion to W 1.10 trillion for next year, while Hyundai is considering a 40 percent cut. As with Samsung, both LG Semicon and Hyundai have yet to make their investment plans final.

What impact will these cutbacks have on projects already under consideration? LG Semicon is expected to delay the construction of its second LCD plant in southern Korea. LG Semicon and Hyundai are re-examining their plans to construct DRAM fabs in the United Kingdom, although both expect to go ahead with plans as scheduled. Most expansion plans for DRAM fabs in the United States by Samsung, LG Semicon, and Hyundai are expected to be suspended. Dongbu, which earlier this year announced plans to enter the semiconductor industry, decided to postpone this indefinitely, citing difficulties in borrowing money.

It will take one to two years for cutbacks in Korean investment to make a significant impact on company market share and DRAM industry capacity. There is more than enough capacity already to support current demand, and as all manufacturers continue to shrink their 16Mb and 64Mb devices, industry overcapacity will continue through most of 1998 and possibly into 1999. To put device die size into perspective, the average die size of 16Mb DRAM at the end of 1998 will be 60 percent of the average die size of 4Mb DRAM at the end of 1995.

Taiwanese DRAM manufacturers will have a significant impact on when the market comes into balance. If Taiwanese companies continue with their aggressive expansion, the equilibrium point may be pushed out three to six months, well into 1999. Before the IMF actions, the Taiwanese companies

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planned to increase capital spending in local currency (NT$) by 10 percent. In U.S. dollar terms, this may actually represent declining capital spending because of currency devaluation. The Korean cutback in spending may encourage Taiwanese DRAM vendors to accelerate investment in an effort to take market share away from the Koreans. If Korean companies cut their capital spending as indicated and if Taiwanese companies continue with their capital spending plans for foundry, memory, and joint ventures, Taiwan may surpass Korea in capital spending in 1998. However, not all Taiwanese DRAM vendors are expected to increase capital spending—at this time, Mosel Vitelic, and Powerchip are expected to decrease their capital spending in 1998, and others may follow.

Dataquest believes there is a good possibility that Taiwanese manufacturers will not implement their aggressive capital spending plans. The Taiwanese companies are newcomers to the DRAM industry and haven't experienced prior industry downturns. As they gain experience in the current downturn, they may decide to stop DRAM spending abruptly. This will come with the realization that, while aggressive expansion will buy market share, it will also lengthen the DRAM industry downturn.

Dataquest believes that the currency and financial market problems in Asia/Pacific have a lot to do with speculative investment "bubbles" in property, construction, semiconductors, and other industries, rather than to fundamental manufacturing efficiencies. Asia/Pacific will continue to be a high-growth, efficient exporter of electronic equipment. But it is clear what happens when rapid economic growth goes unchecked by a transparent financial system and clean government regulation: overcapacity and irrational loans.

These bubbles can become so serious as to bring down entire financial systems and impair international confidence, and hence, future economic growth. This situation is what is being witnessed in Korea and Thailand. The impact of electronics production will be weakened by local consumption of information technology products. But electronics exports, the mainstay of semiconductor consumption in Asia/Pacific, will be less affected—a good news for semiconductor suppliers.

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Perspective

Semiconductors Asia/Pacific

Market Analysis

Asia/Pacific Semiconductor Market Forecast, Spring 1998

Abstract: *Dataquest forecasts that the Asia/Pacific semiconductor market will grow 10.3 percent in 1998, totaling U.S.$35.9 billion. By 2002, the Asia/Pacific semiconductor market will total nearly $67.6 billion, which marks a 15.7 percent-plus CAGR for the five-year period from 1997 to 2002. This Perspective details Dataquest's forecast of the Asia/Pacific and worldwide semiconductor market by product.*
By C.S. Kim

Worldwide Semiconductor Forecast Highlights and Assumptions

The following are the key assumptions and highlights of Dataquest's forecast:

- The worldwide semiconductor market will increase by just 8 percent in 1998, totaling U.S.$159 billion. This modest recovery, which is slower than the 1998 growth rate originally expected, follows the slight 3.5 percent growth in 1997. The industry faces its third year of lackluster performance. The Asian financial crisis and the low DRAM pricing will hamper semiconductor revenue growth this year, although some product segments will achieve robust, double-digit growth rates. For 1999, the market should grow by 18 percent to total $188 billion. The long-term growth will be somewhat slower than the prior forecast. By 2002, the worldwide semiconductor market will total nearly $290 billion, which marks a 14.4 percent compound annual growth rate (CAGR) for the five-year period from 1997 to 2002 (see Table 1).
- Worldwide PC unit shipments will increase by just 15 percent in 1998 and exceed 90 million units. PC revenue will grow by just 6.4 percent this year—however, in part, attributed to the emergence of the sub-U.S.$1,000 PCs. For the long term, the semiconductor forecast assumes that

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worldwide PC unit shipments will grow at a 16 percent CAGR for the five-year period and total nearly 170 million units for 2002. PC revenue, however, will grow at a slower 9 percent CAGR because of the declining PC prices.

- The semiconductor industry should retain a long-term vitality. PCs, communications, and consumer electronics will continue to rank as the most important semiconductor application markets. The trend toward system-level integration (SLI) bodes well for the industry. The impact of information technology (IT) market challenges, such as the year 2000 problem and European Monetary Union, remain uncertain. Their effects on the semiconductor market will, however, likely "filter" through their impacts on the PC, communications, and related equipment sectors.
- The Asian financial crisis means somewhat-lower near-term and long-term expectations for Japan and Asia/Pacific. Japan will remain behind the Americas as the world's second-largest semiconductor consumption market until 2000, when Asia/Pacific should surpass Japan.
- As the central processor in the PC, the x86 architecture serves as the major driving force of the PC and microprocessor (MPU) markets. As expected, the MPU market growth will start to moderate following the extremely high-growth 1992-to-1997 period. For 1998, the worldwide MPU market will increase by just 15 percent, with a 16 percent CAGR from 1997 to 2002.
- Microprocessors in embedded applications will continue to fuel MPU growth for a wider array of vendors. For example, growth in video games, communications, and Internet appliances continues to drive the embedded RISC market.
- Digital signal processors (DSPs) rank among the highest-growing semiconductor products. These devices are the centerpiece of communications electronics (such as cell phones), modems, and the emerging consumer digital electronics. The worldwide DSP market should grow at a 25 percent CAGR from 1997 to 2002.
- Memory IC trends, especially DRAM pricing, serve as a key swing factor in both the near-term and long-term forecasts. In 1998, the worldwide memory market should grow by a scant 1.4 percent; the DRAM market will decrease by just 1 percent in 1998.
- There will be a continuing DRAM capacity oversupply through most of 1999. The long-term forecast, however, explicitly assumes a DRAM capacity shortage by 2000 and a DRAM market surge for 2001. Associated assumptions are excess DRAM capacity by 2002 and a cyclical DRAM market downturn that year.
- Cell-based ICs (CBICs) will continue to be a fast-growing logic product market and the product of choice for SLI. By contrast, gate arrays are entering the declining phase of the product life cycle.

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Table 1
Worldwide Semiconductor Market Forecast by Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Semiconductor	**147,165**	**159,249**	**188,256**	**227,054**	**275,028**	**287,895**	**14.4**
Total Integrated Circuit	127,571	138,617	165,531	201,014	247,052	257,154	15.1
Bipolar Digital	1,239	1,112	946	835	707	604	-13.4
MOS Digital IC	NA	NA	NA	NA	NA	NA	NA
MOS Memory	30,978	31,401	39,743	53,572	76,573	61,202	14.6
DRAM	20,744	20,960	26,897	38,043	57,994	40,920	14.6
SRAM	4,008	4,182	5,694	7,378	9,402	9,761	19.5
Nonvolatile Memory	5,571	5,533	6,343	7,262	8,193	9,432	11.1
Other MOS Memory	655	726	809	889	984	1,089	10.7
MOS Microcomponent	48,945	55,530	65,980	76,970	89,750	103,130	16.1
Microprocessor	23,659	27,300	32,250	37,440	43,380	49,650	16.0
Microcontroller	10,896	12,320	14,270	16,720	19,460	22,230	15.3
Microperipheral	10,736	11,300	13,660	15,580	17,810	19,990	13.2
Digital Signal Processor	3,654	4,610	5,800	7,230	9,100	11,260	25.2
MOS Digital Logic	24,757	26,573	31,084	37,061	42,793	50,818	15.5
Total ASIC	16,527	18,409	22,330	27,446	32,675	39,789	19.2
Custom IC	1,514	1,164	823	557	349	205	-33.0
MOS Standard Logic	2,266	2,373	2,565	2,739	2,775	2,805	4.4
Total Other MOS Logic	4,450	4,626	5,366	6,318	6,993	8,019	12.5
Analog Monolithic	21,652	24,001	27,777	32,577	37,229	41,400	13.8
Total Discrete	14,255	15,221	16,934	19,711	21,100	23,300	10.3
Total Optical Semiconductor	5,339	5,411	5,791	6,329	6,876	7,441	6.9

Source: Dataquest (May 1998)

Asia/Pacific Semiconductor Forecast Highlights and Assumptions

The forecast calls for the Asia/Pacific semiconductor market to grow at a 15.7 percent CAGR for 1997 through 2002, which is slower than prior expectations. The market should grow by 10.3 percent this year to total $35.9 billion and $67.6 billion by 2002. The following assumptions guide this forecast.

The Asian financial crisis will have varying effects on semiconductor consumption in the region—many are negative, but some are positive. In addition, the effects differ markedly on a country-by-country basis. For example, growth in countries such as Indonesia, Thailand, and the Philippines has decelerated, while it has accelerated in China and Taiwan. Taiwan's electronics industry will fare well in this crisis, primarily because of its large percentage of locally supplied components and its strong financial

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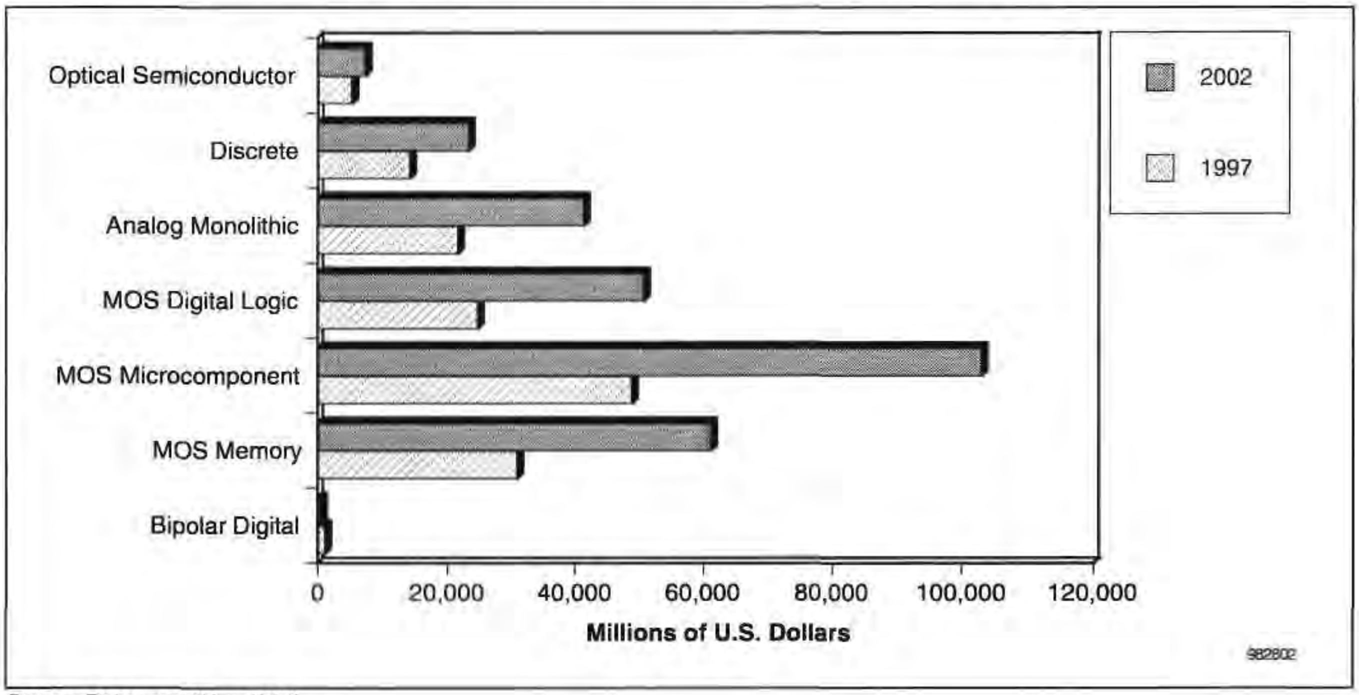
sector. Figure 1 illustrates the worldwide semiconductor market by product from 1997 to 2002.

Figure 1
Product Comparison, Worldwide Semiconductor Market, 1997 and 2002



Source: Dataquest (May 1998)

All semiconductor vendors are watching China. China's electronics equipment production will grow nearly 20 percent this year. China now stands as the Asia/Pacific's largest semiconductor market. China represents a huge communications and computer equipment consumer, accounting for 25 percent of all PCs purchased in Asia/Pacific. China's PC unit growth exceeds a 40 percent annual rate.

Although electronics consumption may be lower than previously expected in selected countries, the region as a whole will continue to enjoy the fastest growth rates in the world.

The semiconductor market for PC applications represents more than one-third of all semiconductor consumption and will continue as the key for semiconductor growth. The Asia/Pacific PC production will continue to maintain a steady growth over the forecast period. The Asia/Pacific PC production should total 23 million units in 1998. The region's PC production growth will be attributed to Pentium II, DVD, 3-D graphics, Windows NT, and Windows 98. Although much of the production gets shipped elsewhere worldwide, PC unit consumption in the region should increase by more than 20 percent this year to reach 12 million units.

In the long term, Dataquest expects the region's most important semiconductor demand driver, the PC, to sustain a solid growth in Asia/Pacific's production unit, with a CAGR of 23 percent in the five-year

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forecast period. As a result, the Asia/Pacific PC production will exceed 45 million units in 2002. The motherboard production will also continue its pace in the region.

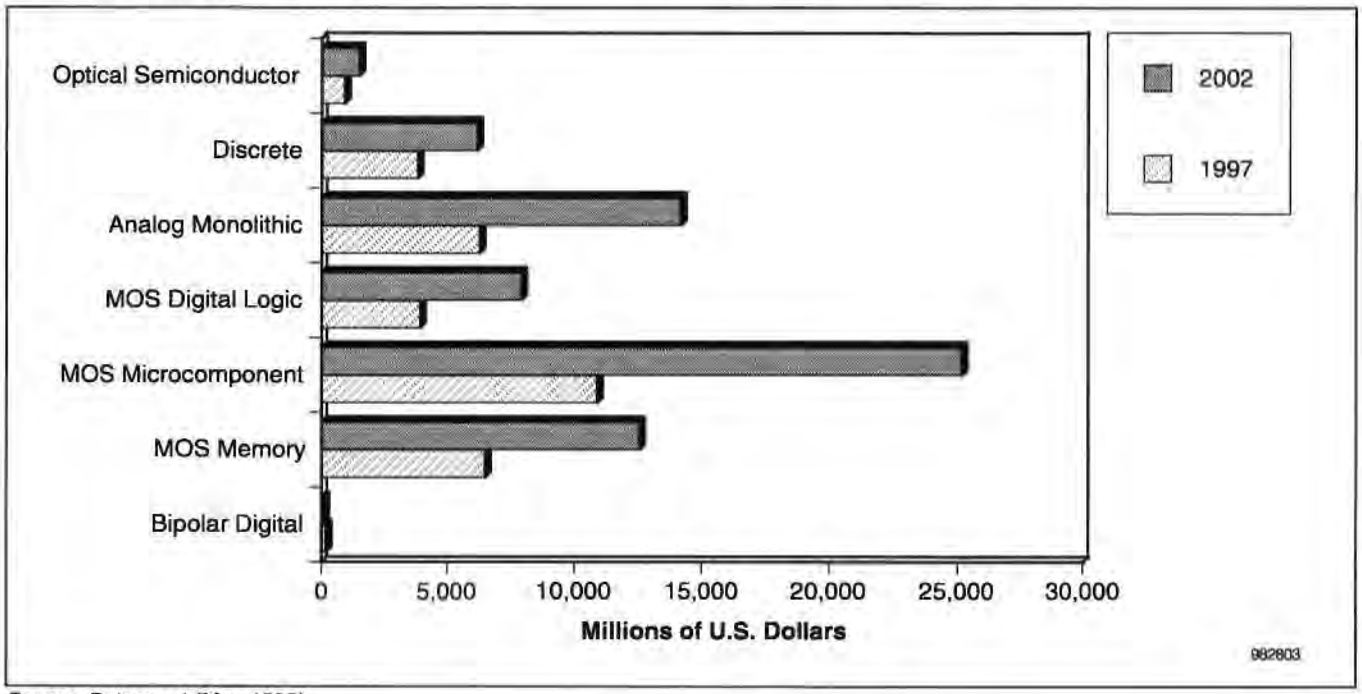
In regional consumption, the Asia/Pacific PC unit consumption will grow at a 25 percent CAGR in the period and total 30 million units in 2002. PC revenue will grow at a slower, but still impressive, 20 percent CAGR.

The communications equipment manufacturing will also generate outstanding semiconductor growth in Asia/Pacific in the forecast period, which will support the demand growth for ASICs, DSPs, ASSPs, and analog ICs. In the near term, most of the Asia/Pacific semiconductor market for communications equipment in 1998 will be driven by mobile and wireless communications. Digital consumer electronics products, such as digital set-top boxes, will also begin to contribute significantly to overall semiconductor demand.

The demand for discrete and optical semiconductors should be lower in 1998 than originally expected because of sluggish consumer equipment production, especially digital consumer application. However, these markets will continue to achieve steady growth because of post-1998 recovery in Asia/Pacific production of digital consumer equipment (see Figure 2).

Table 2 shows the Asia/Pacific semiconductor market forecast by product from 1997 to 2002.

Figure 2
Product Comparison, Asia/Pacific Semiconductor Market, 1997 and 2002



Source: Dataquest (May 1998)

Table 2
Asia/Pacific Semiconductor Market Forecast by Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Semiconductor	**32,534**	**35,899**	**42,754**	**51,751**	**64,483**	**67,561**	**15.7**
Total Integrated Circuit	27,804	30,803	37,160	45,388	57,622	59,880	16.6
Bipolar Digital	154	170	152	128	104	84	-14.5
MOS Digital IC		19,927	21,310	6.9	67.1	65.5	
MOS Memory	6,516	6,576	8,100	10,436	16,566	12,527	14.0
DRAM	4,642	4,611	5,690	7,393	13,030	8,500	12.9
SRAM	599	626	893	1,294	1,520	1,680	22.9
Nonvolatile Memory	1,224	1,286	1,452	1,668	1,930	2,265	13.1
Other MOS Memory	51	53	65	81	86	82	10.0
MOS Microcomponent	10,885	12,651	15,360	18,260	21,710	25,170	18.3
Microprocessor	4,456	5,349	6,570	7,890	9,370	10,900	19.6
Microcontroller	2,313	2,630	3,060	3,710	4,430	5,080	17.0
Microperipheral	3,315	3,662	4,520	5,200	6,010	6,800	15.5
Digital Signal Processor	801	1,010	1,210	1,460	1,900	2,390	24.4
MOS Digital Logic	3,909	4,172	4,940	5,955	6,776	7,939	15.2
Total ASIC	1,662	1,893	2,380	3,015	3,625	4,443	21.7
Custom IC	425	341	256	179	116	70	-30.3
MOS Standard Logic	616	670	743	810	826	843	6.5
Total Other MOS Logic	1,206	1,269	1,561	1,951	2,208	2,584	16.5
Analog Monolithic	6,310	7,234	8,608	10,610	12,467	14,160	17.5
Total Discrete	3,817	4,151	4,573	5,189	5,560	6,200	10.2
Total Optical Semiconductor	913	945	1,021	1,174	1,301	1,481	10.2

Source: Dataquest (May 1998)

Dataquest Perspective

The DRAM market is expected to remain volatile. The DRAM revenue forecast could swing widely for the near term and the long term because of DRAM price fluctuations. DRAM bit consumption continues in line with Dataquest's prior projections, which means that unit demand should be strong, although pricing might remain weak. As indicated, the semiconductor forecast assumes a cyclical upturn in 2001. The DRAM market peak in 2001, however, has been moderated to match similar historical peaks.

The SRAM market is still oversubscribed; however, the analog-to-digital conversion of cellular phones has increased SRAM usage in these phones dramatically. There is a big difference between this market and the PC market, the last big SRAM stronghold. Cell phone manufacturers are much more selective about their supplier base, as they use parts from top-tier suppliers and shy away from small, fabless companies. Dataquest still expects to see attrition in this market because many companies that thrived on an open market for PC cache chips will be excluded shortly from this previously highly penetrable market and will not be able to participate in the cellular telephone market.

The microprocessor market forecast remains largely consistent with prior expectations. As expected, the MPU market will increase this year and over the long term, but at a slower rate versus the 1992-to-1997 period. The x86 architecture will continue its PC market domination. Business PC demand continues to drive MPU demand. The x86 MPU technology advances still stimulate PC demand from the key, early-adopter, repeat buyers.

Non-PC applications, such as digital cellular, digital consumer electronics, and communications, will drive demand for MCUs and DSPs, including embedded versions.

The MOS digital logic market is forecast to reach a 6.7 percent growth in 1998. This is a slower growth than originally expected. Other MOS logic product forecasts have also been lowered. Supply exceeds demand for these products, which means a downward pricing pressure. ASIC product forecasts have been lowered only slightly. CBICs, the SLI product of choice, will continue as the fastest-growing logic product. Gate arrays, however, are under serious pricing pressure and are entering the decline phase of the life cycle. CBICs are displacing gate arrays from high-end applications as PLDs displace gate arrays on low-end applications. This translates into higher long-term growth in the CBIC and PLD segments and lower growth in gate arrays.

The Asia/Pacific analog IC market should grow at a CAGR of 17.5 percent for the 1997-to-2002 period and reach $14 billion by 2002. Looking at the long-term trends to 2002, mixed-signal ICs will experience solid growth, driven by applications such as digital cellular. In addition, new emerging applications in the consumer and communications market will contribute to the growth of mixed-signal ICs. In the more traditional standard linear product area, voltage-regulator products will continue to enjoy strong growth as the demand for smart power continues to grow, especially in the portable electronics markets.

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Market Trends

Dataquest

The Asia/Pacific Semiconductor Market: Fall 1998

Market Trends

Program: Semiconductors Asia/Pacific
Product Code: SEMI-AP-MT-9803
Publication Date: December 14, 1998
Filing: Market Trends

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MARIA VALENZUELA

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Chapter 1
Executive Summary

The Asia/Pacific semiconductor market will grow by 14.6 percent and total U.S.$36 billion in 1999. The economic crisis in Asia (including Japan) remains a major concern. The Asia/Pacific semiconductor market is expected to grow at a 13.3 percent compound average growth rate (CAGR) for 1997 to 2002, reaching $61 billion in 2002.

Forecast Outlook

Asia/Pacific's semiconductor revenue will grow by 14.6 percent in 1999, totaling $36 billion. This forecast follows an unexpected revenue decline of at least 3.5 percent for 1998. By 2002, Asia/Pacific's semiconductor revenue will total $61 billion, marking a 13.3 percent-plus CAGR for the five-year period from 1997 to 2002.

The semiconductor industry now moves toward the end of its third straight year of lackluster performance. Market watchers previously expected the semiconductor product market to rebound in 1998. The Asian financial crisis and low device prices (such as those for DRAMs, CBICs, and analog ICs) are hindering Asia/Pacific's semiconductor revenue growth this year. Few product segments will achieve more than marginal revenue growth for 1998, and year-end revenue results remain a concern for vendors.

Dataquest's 1999 forecast assumes sluggish demand in Asia/Pacific at best and also stable DRAM pricing. Most product markets will not strengthen until mid-1999, so next year's growth will concentrate in the second half of 1999. In addition, the long-term growth rate is slower than that of the prior forecast.

China/Hong Kong's semiconductor market will grow another 13.6 percent in 1999 and total nearly $7.9 billion. By 2002, China/Hong Kong's semiconductor market will total $15 billion, which marks a 17.5 percent CAGR from 1997 to 2002.

Singapore's semiconductor market will grow by 13.7 percent in 1999 and total $5.4 billion. In the long term, Singapore's semiconductor market will total $9 billion in 2002, which means a 13 percent CAGR for the 1997-to-2002 period.

South Korea's semiconductor market should increase by 13.7 percent in 1999 and reach the $5.7 billion level. By 2002, South Korea's semiconductor market will total $9.7 billion, which is a 12.1 percent CAGR from 1997 to 2002.

Taiwan's semiconductor market will increase by 15 percent in 1999 and reach about the $7.9 billion mark. By 2002, Taiwan's semiconductor market will be about $12 billion, for about 12.3 percent CAGR for the 1997-to-2002 period.

Project Analyst: Chang Soo Kim (Korea)

Contributors: Jerry Yeh (Taiwan), Ken Ng (Singapore), and Kelvin Fu (China/Hong Kong)

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Chapter 2
Introduction and Forecast Assumptions

This Market Trends report contains detailed information on Dataquest's view of the Asia/Pacific semiconductor market, including China/Hong Kong, Singapore, South Korea, and Taiwan.

Exchange Rates

Dataquest's research of electronic equipment markets and semiconductor consumption within those markets combines data from many countries. Most countries use currencies other than the U.S. dollar, and these have fluctuating exchange rates relative to the dollar. Because Dataquest researches electronic equipment production and semiconductor consumption in several regions of the world with the goal of reporting comparable regional values and worldwide market trends, Dataquest uses the U.S. dollar as a common currency for comparisons and aggregation. As a general rule, Dataquest collects data and formulates forecasts in local currencies, and then convert them to U.S. dollars using applicable exchange rates in Table 2-1. Dataquest maintains a database of historical exchange rates, which is updated monthly. Dataquest does not forecast future exchange rates. Instead, Dataquest assumes that future exchange rates will reflect current exchange rates.

Table 2-1
Asia/Pacific Exchange Rates against the U.S. Dollar, 1997 to 1999

	Annual Average 1997	Estimated Annual Average 1998	Forecast Annual Rate 1999 and Beyond
Australia (Dollar)	1.35	1.58	1.62
China (Renminbi)	8.32	8.31	8.31
Hong Kong (Dollar)	7.74	7.75	7.75
India (Rupee)	36.36	41.35	42.61
Indonesia (Rupiah)	2,872.61	11,997.24	13,995.87
Japan (Yen)	121.10	136.35	140.79
Malaysia (Ringgit)	2.82	4.04	4.16
New Zealand (Dollar)	1.51	1.86	1.93
Philippines (Peso)	29.47	40.77	41.67
Singapore (Dollar)	1.49	1.68	1.71
South Africa (Rand)	4.61	5.65	6.23
South Korea (Won)	954.14	1,398.99	1,295.76
Sri Lanka (Rupee)	59.02	64.54	65.91
Taiwan (Dollar)	28.79	33.91	34.39
Thailand (Baht)	31.07	42.44	41.30

Source: Dataquest (July 1998)

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Asia/Pacific Macroeconomic Outlook

By all indications, Asia's circumstances have worsened. Economic activities have slowed across Asia, and most of the region's economies now find themselves cornered and battered by a flurry of economic ills that defy easy, unilateral solutions. Meanwhile, Asia's troubles are imposing punishing economic strains on emerging economies elsewhere. From Russia and Africa to the Middle East and Latin America, emerging economies outside Asia find themselves struggling with the depressed commodity prices and general wariness of international investors toward emerging markets that have followed in the wake of Asia's turmoil. The 1998 outlook for the world's developing economies has dimmed. Naturally, much of this change reflects the significant downward revision of forecasts for Asia/Pacific's economies. Dataquest estimates that growth among Asia/Pacific's emerging economies, including China, will average just 1.8 percent in 1998. Just when and how Asia will recover remains an open question.

Macroeconomic conditions among the individual economies of Asia/Pacific region range from shaky to disastrous. In many countries, domestic spending has been crushed by high interest rates, and export growth curtailed for want of scarce credit. More importantly, foreign capital inflows have all but ceased, and trade among Asian economies has virtually collapsed. A number of forecasters now believe that resolving matters requires altogether new policies that concentrate on the region as whole, including Japan, rather than individual countries. Such policies would give top priority to reviving intraregional trade and reducing the threat of competitive currency devaluations. Dataquest expects that there will be gradual improvement in emerging Asia beginning next year. Dataquest expects growth among Asian economies to jump to 4.3 percent next year and average upward of 6.0 percent through 2002. Still, these results can hardly be considered a sure bet. Between Japan's distressed state and the apparent antipathy of foreign capital toward the region, Asia's economic future faces significant downside risks. Table 2-2 shows Asia/Pacific countries' gross domestic product (GDP) and consumer price index (CPI).

Asia/Pacific Country Analysis

The Asian financial crisis has cut the GDP growth rates in many countries, especially in Indonesia, Malaysia, South Korea, and Thailand. The monetary depreciation makes the debt counting in U.S. dollars more severe. Foreign-investment withdrawals exacerbated the debt situation. The debt crisis drags on in Southeast Asian and South Korea, and the contagion effect keeps Asia/Pacific's financial markets unsettled. For some of these countries, the governments' foreign-exchange reserves have been depleted, and they cannot afford to pay their short-term foreign debts. Meanwhile, the sluggish Japanese economy is causing a decline in exports for South Asian countries.

China

As a result of sluggish domestic consumption and export demand, China's GDP growth was slowing down to 7 percent in the first half of 1998. The central government raised the value-added tax (VAT) rebates for the exports of seven categories of machinery and electronic products and five categories of manufactured light goods effective from July 1, 1998 to meet its growth target of external trade. The 1998 GDP, as a whole, is forecast at about 7.5 percent, down from 1997's 8.8 percent.

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Table 2-2
Asia/Pacific Gross Domestic Product and Consumer Price Index Growth, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002
GDP						
Australia	3.3	3.3	3.3	4.0	3.8	3.7
China	8.8	7.5	8.0	8.2	8.5	8.7
Hong Kong	5.3	-1.2	-2.0	1.0	3.0	3.9
India	5.2	4.9	5.4	6.3	6.9	6.8
Indonesia	4.6	-13.5	-3.9	3.2	4.3	6.0
Japan	0.8	-1.8	1.4	2.4	2.9	3.0
Malaysia	7.8	-1.3	1.8	3.5	5.8	6.8
New Zealand	2.3	2.6	2.6	3.0	3.1	3.1
Pakistan	3.4	4.7	5.5	5.8	6.0	5.7
The Philippines	5.2	1.5	4.0	5.5	5.9	6.0
Singapore	7.8	1.3	3.0	4.8	6.8	6.8
South Korea	5.5	-4.8	0.6	4.8	5.6	5.6
Taiwan	6.8	5.2	5.3	5.4	5.7	6.1
Thailand	-0.5	-5.8	0.8	2.6	4.2	5.9
Vietnam	8.8	6.1	7.7	9.2	9.0	9.0
Consumer Price Index						
Australia	0.3	2.0	2.1	2.2	2.2	2.3
China	2.8	2.4	3.3	4.4	4.8	5.1
Hong Kong	5.7	4.0	2.0	2.7	3.3	4.0
India	6.8	8.9	7.8	7.7	7.5	7.1
Indonesia	6.6	74.6	36.2	17.5	9.8	6.7
Japan	1.7	0.6	0.5	1.1	1.4	1.8
Malaysia	2.7	6.0	7.3	5.7	3.8	3.7
New Zealand	1.2	2.5	2.5	2.0	1.8	1.8
Pakistan	11.8	9.4	9.7	9.3	9.7	9.3
The Philippines	5.1	9.2	10.7	9.6	6.0	5.8
Singapore	1.9	1.4	2.2	2.0	2.3	2.1
South Korea	4.4	11.1	10.5	8.4	4.9	4.8
Taiwan	0.9	2.7	4.0	3.5	3.4	3.4
Thailand	5.6	10.8	9.3	7.8	5.6	4.5
Vietnam	3.5	4.3	7.4	7.8	8.1	8.4

Source: Dataquest (July 1998)

Due to deflation of the Chinese currency, China's renminbi and Hong Kong's dollar remain stable for the short term. Nonetheless, the Chinese renminbi and the Hong Kong dollar are projected to depreciate in the long term to maintain competitiveness with the Southeast Asian countries, which is the same reason as that behind China's 1994 renminbi depreciation.

Singapore

The U.S. dollar appreciation to the Singapore dollar from 1996 to 1997 has affected the balance of payment that is relevant to intraregional trade. The Singapore economy is being adversely impacted by the sharp downturns experienced by its neighboring countries. Economic growth in 1998 has become more dependent on "pump-priming," as the manufacturing sector output remains weak.

Electronics manufacturing growth has been affected by lower demand, overcapacity, and intense price competition. Trade volume is forecast to be negative, as regional demand remains weak and key markets (such as United States and the European Union) maintain only a moderate growth. Although Singapore recorded a 3.8 percent GDP growth in the first half 1998, the regional economic outlook has deteriorated. In July, the government revised the official growth rate downward to 0.5 percent from 1.5 percent for 1998, from its earlier forecast range of 2.5 percent to 4.5 percent.

South Korea

The South Korean economy is running into serious trouble amid rapidly cooling domestic demand and dwindling exports. The South Korean economy is suffering a vicious cycle of production drops and deepening domestic demand. Economic uncertainties and credit squeezes taking place in the course of restructuring have placed immense pressure on domestic demand, and the economy is liable to plunge deeper into recession.

South Korea's 1998 GDP is expected to contract 4.8 percent before turning around at an annual rate of 0.6 percent in 1999, although the government will have to take strong macroeconomic measures. The 4.8 percent contraction, if realized, will be a steep downturn from the negative 4 percent forecast jointly made by the government and the International Monetary Fund (IMF) in July.

Some economists are warning that South Korea could face a second financial crisis, depending on the seriousness of the international economic turmoil. There has been no restoration of international confidence in emerging markets. Troubles could return at any time according to these institutes.

The South Korean domestic economy is in the doldrums. The businesses are too centralized in conglomerates with high indebtedness. The Korean won has depreciated, and investment spending is dropping. Besides the consumer price inflation jump, the growing unemployment results in a steep decline in consumer spending.

Taiwan

Although Taiwan has been sheltered from the Asian economic turmoil, owing to its healthy economic fundamentals, the local Taiwanese currency has dropped more than 15 percent since October 1997. But Taiwan should be able to cope with the turmoil and continue its robust economic performance in the long term.

While Taiwan's economic growth may slow slightly in the next two years, its private-investment outlook during the period is expected to brighten. With the opening of new international air transport routes, increased investment is expected in cargo-carrying aircraft. Ongoing, large-scale construction projects will bring in further investment as well.

Taiwan's government is expected to continue removing investment obstacles and promoting the build-operate-transfer model being followed in the construction of its high-speed rail project. The establishment of the Tainan Science-Based Industrial Park is also expected to induce more domestic and foreign direct investment in electronics.

Based on these factors, private investment is expect to grow about 14 percent in the 1998/1999 fiscal year, Taiwan's highest growth rate in the past seven years. The continuing privatization of state-owned enterprises, however, means investment in publicly owned enterprises will register a decline. Taiwan's government expects a 5.2 percent GDP growth in 1998.

Semiconductor Forecast Assumptions

Table 2-3 shows that semiconductor revenue in Asia/Pacific will increase by 14.6 percent in 1999 and total $36 billion. This follows a 3.5 percent decline for 1998. Long-term, regional revenue will grow at a 13.3 percent CAGR and reach $61 billion by 2002.

The following summarizes Asia/Pacific regional semiconductor market outlooks:

- China/Hong Kong's semiconductor market will grow by 13.6 percent in 1999 and total $7.9 billion. By 2002, China/Hong Kong's market will total $15 billion, which marks a 17.5 percent CAGR for 1997 to 2002.
- Singapore's semiconductor market will grow by 13.7 percent in 1999 and total $5.4 billion. In the long term, Singapore's semiconductor market will total $9 billion, a 13 percent CAGR for 1997-to-2002 period.
- South Korea's semiconductor market will increase by 13.7 percent in 1999 and reach about the $5.7 billion level. By 2002, South Korea's semiconductor market will total $9.7 billion, which is a 12.1 percent CAGR from 1997 to 2002.
- Taiwan's semiconductor market will increase by 15 percent in 1999 and reach the $7.9 billion mark. By 2002, Taiwan's semiconductor market will approach $12 billion, with a 12.3 percent CAGR for the 1997-to-2002 period.

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Table 2-3
Total Semiconductor Market Forecast by Country in Asia/Pacific, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Asia/Pacific	**32,534**	**31,400**	**35,978**	**44,526**	**55,815**	**60,795**	**13.3**
China/Hong Kong	6,769	6,957	7,906	10,262	13,226	15,143	17.5
Singapore	4,962	4,761	5,416	6,727	8,473	9,139	13.0
South Korea	5,490	5,055	5,747	7,090	8,589	9,733	12.1
Taiwan	6,754	6,893	7,929	9,372	11,656	12,044	12.3

Source: Dataquest (October 1998)

Assumptions for the Asia/Pacific Semiconductor Forecast

The following assumptions guide the Asia/Pacific forecast shown in Table 2-3:

- The Asian economic crisis has seriously affected Asia's semiconductor demand and pricing in 1998. Asia/Pacific economies should start to recover in 1999, with a 1 percent GDP growth.
- China's economy will grow at about 7.5 percent in 1999.
- The Asia/Pacific semiconductor market is expected to post positive growth in 1999 because of increased electronic equipment production.
- Asia/Pacific's semiconductor consumption will gradually recover during the second half of 1999.
- The highest growth rates are expected to come from microcomponents and memory products, as a result of fast-expanding data processing and communications applications.
- Asia/Pacific's semiconductor consumption growth will increase rapidly in 2000 and 2001, driven by higher revenue from the memory market. However, the balanced supply-demand situation is expected to tend toward oversupply by 2002.

Accelerators to the Asia/Pacific Forecast

The following assumptions, if they occurred, would accelerate the Asia/Pacific forecast shown in Table 2-3, which would mean higher growth rates and revenue levels than shown in the table.

- Communications equipment could generate stronger demand in the region, especially for ASICs, DSPs, ASSPs, and analog ICs.
- In the near future, mobile and wireless communications, plus digital consumer products (such as digital set-top boxes), could become quite strong.
- The region's strong production growth is likely to be driven by Pentium II, digital video disc (DVD), 3-D graphics, Windows NT, and Windows 98.
- In the long term, the most important semiconductor demand driver in the region will be PCs.

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- Electronic equipment manufacturers in Asia/Pacific gain competitiveness, winning more contract business from PC manufacturers.
- There will be rising electronic equipment production from new manufacturing investments, especially in data processing and communications applications.
- The memory market recovers earlier than expected. Average selling prices (ASPs) are likely to strengthen because of industry consolidation.

Inhibitors to the Asia/Pacific Forecast

The following factors, if they occurred, would inhibit the Asia/Pacific forecast shown in Table 2-3. This would mean lower growth rates and revenue levels than shown in the table:

- Failure of Asian economic crisis to turn economies upward in 1999. For example, Japan's economy remains in a deep slump, and Americas/European export markets exhibit reduced demand.
- Continuing overcapacity in consumer electronics.
- Related to an export slump would be concomitant slowing of local Asia consumption as a result of high unemployment.
- The lack of internal semiconductor consumption would then probably bring down Asia's economy and, ultimately, the consumption of semiconductor chips.
- Semiconductor vendors are affected even more by steeply lower prices in response to intense competition in the high-growth devices.
- Oversupply in commodity chip markets occurs earlier than 2002.

The Scope of This Market Trends Report

This Market Trends report investigates the dynamics behind consumption growth in the four countries' semiconductor markets. This report includes the following chapters:

- Chapter 1, executive summary—The executive summary includes the major conclusions of the Asia/Pacific semiconductor market trends.
- Chapter 2, introduction and forecast assumptions—Dataquest's market forecasting assumptions in macroeconomics and the semiconductor forecast are explained.
- Chapter 3, Asia/Pacific semiconductor forecast by product—Dataquest discusses semiconductor market by product and provides an analysis of each product's trends.
- Chapter 4, semiconductor market forecast by country—Dataquest analyzes semiconductor market trends in these four countries (China/Hong Kong, Singapore, South Korea, and Taiwan) and presents detailed device forecasts for them.

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Chapter 3
Asia/Pacific Semiconductor Forecast by Product

This chapter's tables and figures provide the complete five-year forecast by product type in the Asia/Pacific semiconductor market.

Asia/Pacific Electronic Equipment Production Forecast

The Asia/Pacific electronic equipment production forecast serves as a basis for the semiconductor product forecast.

PCs, mobile communications, and consumer electronics account for about 40 percent of semiconductor consumption. Trends in these application markets will determine near-term results and generate long-term growth in semiconductor revenue. For the long term, the PC remains the paramount application for computer microprocessors (MPUs) and DRAMs. Servers will eventually emerge as a key application for computer MPUs. Mobile communications, data communications, and digital consumer electronics, among other applications, should drive the growth of digital signal processors (DSPs), microcontrollers (MCUs), embedded MPUs, and digital application-specific ICs (ASICs). Flash memory and EEPROM should also benefit from these trends.

The following sections summarize the assumptions for the key semiconductor applications.

Assumptions for Electronic Equipment Production Forecast

This report's forecasts cover a product or region. Each forecast includes a set of assumptions that serve as the basis for the forecast. Table 3-1 and Figure 3-1 provide the five-year forecast to 2002 by application type and comparison for the Asia/Pacific electronic equipment production.

Table 3-1
Asia/Pacific Electronic Equipment Production Forecast by Application, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Electronic Equipment	**173,277**	**181,255**	**198,552**	**221,965**	**248,786**	**277,633**	**9.9**
Data Processing	73,626	77,624	85,316	98,174	111,303	125,332	11.2
Communications	26,420	29,131	32,302	36,431	41,717	47,492	12.4
Industrial	5,019	5,045	5,551	6,345	7,370	8,303	10.6
Consumer	62,122	62,769	68,055	72,886	79,282	85,892	6.7
Military/Civil Aerospace	3,291	3,697	4,142	4,688	5,288	6,110	13.2
Automotive	2,799	2,988	3,187	3,440	3,825	4,503	10.0

Source: Dataquest (October 1998)

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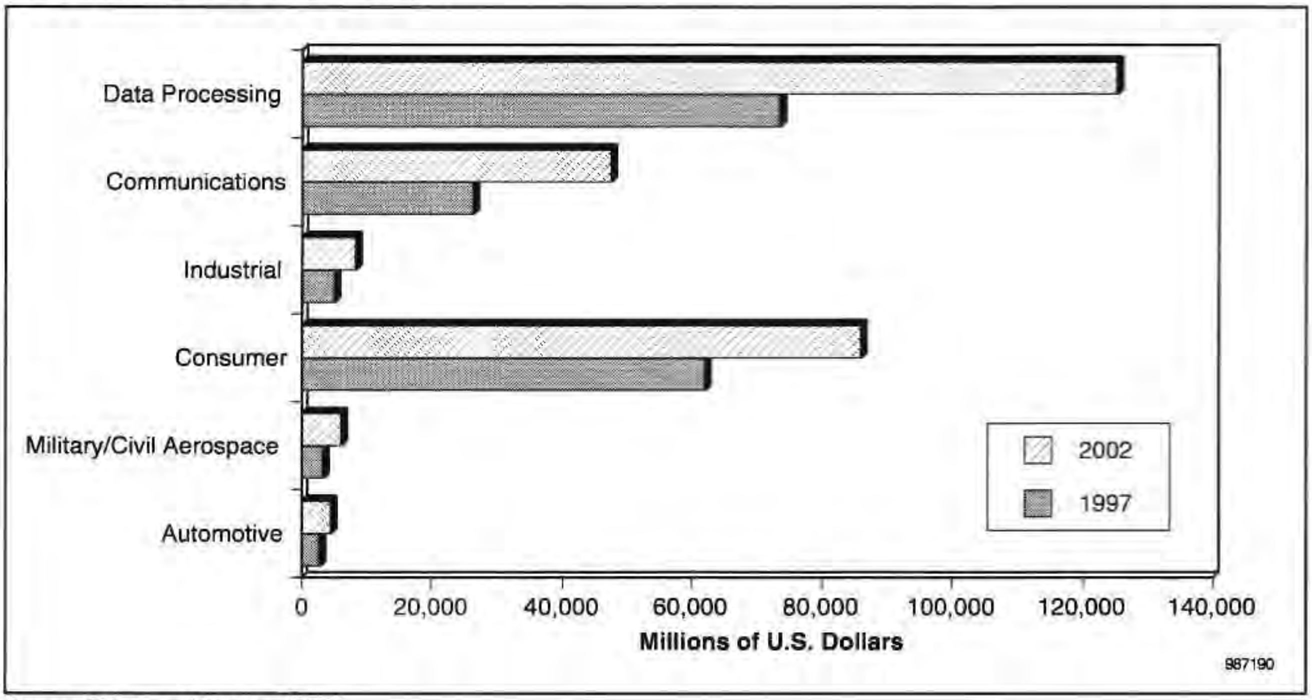
Figure 3-1
Asia/Pacific Electronic Equipment Production Comparison by Application, 1997 and 2002 (Millions of U.S. Dollars)



Source: Dataquest (October 1998)

Assumptions for Data Processing Equipment Applications

- Data processing equipment will continue to be the mainstay of Asia/Pacific's electronics production. PCs and PC-related components (such as motherboards, rigid disk drives, CD-ROM drives, and application boards) will continue to represent the backbone of the Asia/Pacific regional data processing electronics.
- The graphics chip market will face pricing pressure even as manufacturers continue to add features. The corporate computing market will continue to be slow to demand 3-D graphics features. While it is difficult to buy non-3-D products today, the issue is one of corporate users' buying down on the value scale rather than buying up.
- The audio equipment market will face increasing competition from integrated designs with sound chips on the motherboard. Price pressure is extreme and will continue for at least one more year.
- A cyclical upturn in DRAM revenue in 2000 and 2001 will be the primary driver of overall PC semiconductor market growth. PCs' main memory sizes will track historic trends and grow in the range of 40 percent to 45 percent per year.

Assumptions for Communications Equipment Applications

- Communications equipment production is expected to grow at average annual rates in excess of 10 percent. Strong growth in mobile communications and public telecommunications equipment will provide the spark for this growth. Asia/Pacific will continue to remain the world's fastest-growing and most economically active region through the end of the decade.

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- The region's developing economies are expected to generate a huge demand for communications equipment of all types, but most especially for premise and mobile equipment. Dataquest expects this surging local demand to stimulate the region's communications industry, generating high growth rates for premise telecom and mobile communications equipment.
- Digital cordless telephones will retain continued popularity beyond 1999. The third-generation cellular technology is not expected to have a significant impact on semiconductor consumption during the 1997-to-2002 forecast horizon.
- Driven by Internet bandwidth upgrades, semiconductor consumption by the public infrastructure equipment market will remain strong. Cable modems and xDSL modems are on track for deployment in the 2001/2002 time frame.

Assumptions for Consumer Electronics Applications

- Consumer electronics will remain the second-largest segment of the region's electronics industry. Despite the recent retreat of the yen against the dollar, Dataquest expects that Asia/Pacific will continue to benefit from Japan's production shift. In fact, Dataquest now expects the Asia/Pacific region to become the world's dominant producer of consumer electronics by 2002. Overall, consumer electronics equipment is anticipated to average about 7 percent growth in the forecast period. Video and audio equipment will remain the mainstays of Asia/Pacific's consumer production.
- Chinese demand for Asia/Pacific-produced consumer electronics could well rival export demand by 2002 if economic development in China continues at its current dizzying pace.
- The need to maintain low manufacturing costs for low value-added products is likely to diffuse production of low-end consumer electronics into other parts of Asia/Pacific, especially Southeast Asia, in the forecast period. At the same time, rising labor costs in established manufacturing centers (that is, the "Four Tigers") are likely to induce a shift in these centers toward higher value-added, higher-end consumer electronics.

Asia/Pacific Semiconductor Forecast by Product

The following sections identify the assumptions that serve as the basis for each semiconductor product forecast in Table 3-2. Table 3-2 and Figure 3-2 provide the five-year forecast through 2002 by product type for the Asia/Pacific semiconductor market. Table 3-2 shows that the Asia/Pacific semiconductor market should grow at a 13.3 percent CAGR during the five-year forecast period from 1997 to 2002.

Table 3-2
Asia/Pacific Semiconductor Market Forecast by Device, 1997 to 2002
(Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Semiconductor	**32,534**	**31,400**	**35,978**	**44,526**	**55,815**	**60,795**	**13.3**
Bipolar Digital	184	170	152	128	104	84	-14.5
MOS Memory	6,516	4,976	6,156	8,927	14,317	12,838	14.5
Dynamic RAM	4,642	3,081	3,944	6,146	11,025	9,015	14.2
Static RAM	599	660	792	1,096	1,276	1,476	19.8
Nonvolatile Memory	1,224	1,182	1,355	1,604	1,930	2,265	13.1
Other MOS Memory	51	53	65	81	86	82	10.0
MOS Microcomponent	10,885	11,050	12,210	14,250	16,700	19,610	12.5
Microprocessor	4,456	4,590	5,250	6,020	6,920	8,030	12.5
Microcontroller	2,313	2,210	2,450	2,990	3,540	4,180	12.6
Microperipheral	3,315	3,290	3,340	3,780	4,390	5,080	8.9
Digital Signal Processor	801	960	1,170	1,460	1,850	2,320	23.7
MOS Digital Logic	3,909	3,891	4,249	5,084	5,958	6,958	12.2
ASICs	1,662	1,640	1,830	2,308	2,842	3,463	15.8
Custom IC	425	311	221	155	100	60	-32.3
MOS Standard Logic	616	554	577	611	623	636	0.6
Total Other MOS Logic	1,206	1,386	1,621	2,010	2,392	2,799	18.3
Analog Monolithic	6,310	6,468	7,891	9,863	11,935	14,023	17.3
Total Discrete	3,817	3,900	4,300	5,100	5,500	5,800	8.7
Total Optical Semiconductor	913	945	1,021	1,174	1,301	1,481	10.2

Source: Dataquest (October 1998)

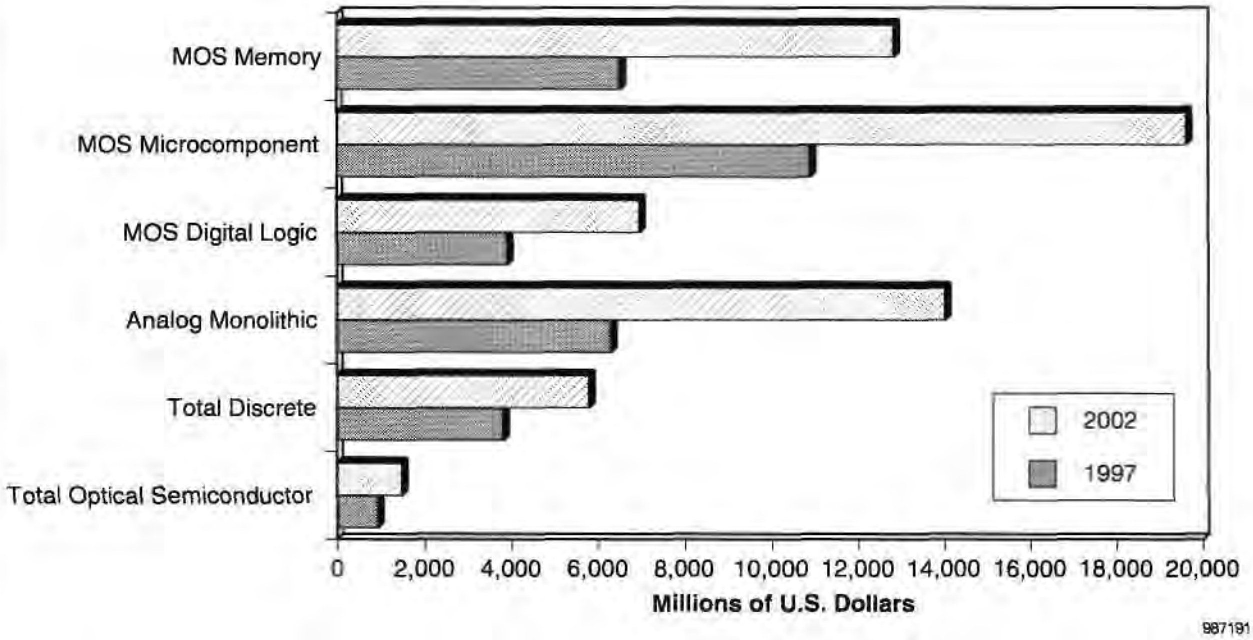
MOS Memory Forecast

Table 3-2 shows that the Asia/Pacific memory market will increase by 23.7 percent in 1999 and total $6.2 billion. This follows a steep 23.6 percent decline for 1998. In the long term, the Asia/Pacific memory market will grow at a 14.5 percent CAGR and reach $12.8 billion by 2002.

The following summarizes Asia/Pacific memory IC product outlooks:

- DRAM revenue will increase by 28 percent in 1999 and total $4 billion. This follows a 33.6 percent decline for 1998. In the long term, Asia/Pacific DRAM revenue will grow at a 14.2 percent CAGR and reach $9 billion by 2002.
- SRAM revenue will increase by 20.1 percent in 1999 and total $792 million. This follows a 10.1 percent increase for 1998. In the long term, Asia/Pacific SRAM revenue will grow at a 19.8 percent CAGR and reach $1.5 billion by 2002.
- Nonvolatile revenue will increase by 14.6 percent in 1999 and total $1.4 billion. This follows a 3.4 percent decline for 1998. In the long term, Asia/Pacific's nonvolatile memory revenue will grow at a 13.1 percent CAGR and reach $2.3 billion by 2002. Flash memory and EEPROM will drive nonvolatile market growth.

Figure 3-2
Asia/Pacific Semiconductor Market Comparison by Product, 1997 and 2002
(Millions of U.S. Dollars)



Source: Dataquest (October 1998)

Assumptions for MOS Memory Forecast

- Nearly all memory prices will continue to suffer because of industry overcapacity.
- No near-term changes are anticipated in already-existing bit or unit consumption trends.
- The effects of embedded memory on existing markets will be negligible.
- DRAM consumption will catch up with capacity in 2000, and an undercapacity will occur in 2001, which will be corrected in 2002.
- Flash memory will displace EPROM, but other memory markets will continue along their current paths: Strong growth for EEPROM, and modest growth for mask ROM and SRAM.

Assumptions for DRAM Forecast

- Bit growth in the near term will average at about 66 percent.
- Prices during late 1998 and 1999 will commence leveling off, driven partly by the conversion to PC100 and partly by antidumping findings against Hyundai Electronics Company Ltd. and LG Semicon Co. Ltd.
- The current overcapacity will not resolve itself in the near term. DRAM overcapacity will continue until demand meets capacity in 2000.
- The year 2001 will be an undercapacity year, and the resultant profit cycle will be similar to those of 1980, 1984, and 1989. A repeat of the 1995 cycle will not occur within our lifetime.

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Assumptions for SRAM Forecast

- Depressed pricing continues, despite consolidation of the PC cache market.
- Other end markets move in a relatively predictable direction. However, the current oversupply will keep prices low.
- A foundry overcapacity situation will keep prices from recovering.
- Bit growth, density migration, and speed improvement will continue along trends that have been in place for the past three years.

Assumptions for Nonvolatile Memory Forecast

- The flash memory market will continue to be oversupplied in the near term, and competitive pricing of both flash and EPROM will reflect this situation. EEPROM and mask ROM will enjoy stable pricing.
- Flash and EEPROM bit consumption will continue to grow dramatically. Mask ROM will continue to grow modestly, and EPROM will continue to be displaced by cheap flash memory.
- Flash will displace EPROM now that more attractive prices are available.
- The flash market will grow more from increased usage in new applications. However, it will also displace EPROM to a great extent over the forecast term.
- Mask ROM will continue to grow at a rate established before the great video game boom.
- EEPROM will continue to grow substantially, driven by its use in smart cards, DRAM modules, and microcontroller-based equipment.

MOS Microcomponent Forecast

Table 3-2 shows that Asia/Pacific's MOS microcomponent market will increase by 10.5 percent in 1999 and total $12.2 billion, following a 1.5 percent growth for 1998. In the long term, Asia/Pacific's microcomponent market will grow at a 12.5 percent CAGR and reach $19.6 billion by 2002.

The following summarizes the Asia/Pacific MOS microcomponent IC product outlook:

- The MPU revenue will increase by 14.4 percent in 1999 and total $5.3 billion, following a 3 percent increase for 1998. In the long term, the Asia/Pacific MPU revenue will grow at a 12.5 percent CAGR and reach $8 billion by 2002.
- The MCU revenue will increase by 10.9 percent in 1999 and total $2.5 billion, following a 4.5 percent decline for 1998. In the long term, Asia/Pacific's MCU revenue will grow at a 12.6 percent CAGR and reach $4.2 billion by 2002.
- The microperipheral (MPR) revenue will increase by 1.5 percent in 1999 and total $3.3 billion, following a 0.8 percent decline for 1998. In the long term, the Asia/Pacific MPR revenue will grow at a 8.9 percent CAGR and reach $5.1 billion by 2002.

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- The DSP revenue will increase by 21.9 percent in 1999 and total $1.2 billion, following a 19.9 percent increase for 1998. In the long term, the Asia/Pacific DSP revenue will grow at a 23.7 percent CAGR and reach $2.3 billion by 2002.

Assumptions for Microprocessor Forecast

- Intel Corporation's high-end Xeon processors will begin to offset desktop MPUs' average selling price erosion in the second half of 1998, but they will not be able to offset such a decline completely until 1999, when Intel offers support for four- and eight-way server configurations.
- Throughout the forecast period, general-purpose, "PC-like" devices will continue as the dominant mechanism for users to access the Internet and to perform other data-processing functions in the home and office.
- PCs' average selling price will continue a downward trend, as users see little reason to buy high-performance (and expensive) systems to use with current applications software that places few demands on CPU performance.
- In the later years of the forecast period, new software applications and usage paradigms will evolve, which will tax the processing power of the much faster processors then available and motivate users to replace older systems. Some of these new applications will expand the market by making computers relevant to users who previously had no need for such devices. Vast increases in communications bandwidth to homes and small-office environments will enable many of these applications.
- Demand remains suitably strong for proven embedded applications, such as office equipment, routers and hubs, video games, satellite receivers, and set-top boxes.
- The attraction of building an ASIC with a deeply embedded MPU core will take away some embedded MPU business.

Assumptions for MCU Forecast

- MCU prices eroded rapidly during 1998, indicating low 1999 price levels.
- Growth for 16- and 32-bit MCUs will increase more quickly than previously expected.
- More exotic features (such as flash memory) will be offered at low prices.

Assumptions for DSP Forecast

- Demand for cellular phones, modems, and risk drives is no longer increasing as fast as that for DSPs.
- New architectures of high-performance DSPs reduce the cost per function in high-density DSP arrays.
- DSPs can open a host of new applications for mobile and Internet communications and consumer interactivity.

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MOS Logic Forecast

Table 3-2 shows that Asia/Pacific's logic revenue will increase by 9.2 percent in 1999 and total $4.3 billion, following a 0.5 percent decline for 1998. In 1998, the ASIC market experienced the worst percentage revenue change in history. Gate array revenue declined by 13 percent, while revenue from cell-based ICs (CBICs) increased marginally. In the long term, Asia/Pacific's ASIC revenue will grow at a 15.8 percent CAGR and reach $3.5 billion by 2002. This growth will be fueled, in part, by the trend toward system-level integration (SLI).

Assumptions for ASIC Forecast

- ASIC and logic market growth stalled during 1998 for the following three main reasons:
  - General industry slowdown
  - Asian financial crisis
  - An associated accelerated rate of average selling price declines
- Logic markets will remain flat into 1999. There will be no significant increase in ASIC/logic quarterly revenue until the second or third quarter of 1999.
- Other logic devices, which include application-specific products (ASSPs), should show strong unit growth, but with average price declines.
- Custom ICs are rapidly being replaced by ASICs because they offer shorter time to market.
- Standard logic has a small number of suppliers, and the market remains relatively flat.
- ASIC growth will be driven by CBICs and PLDs at the expense of gate arrays.
- SLI will fuel the growth of the CBIC market, as microprocessors, DRAM, and other intellectual property (IP) blocks get integrated on-chip.
- Key ASIC/ASSP application market drivers include the following: disk drives, workstations, servers, digital cellular, LAN/WAN, premise and central office switching systems, set-top boxes, video games, digital camcorders, still cameras, and digital TV.
- ASICs will be converted to ASSPs as each application market matures.

Analog Forecast

The Asia/Pacific analog IC revenue will increase by 22 percent in 1999 and total $7.9 billion, following disappointing marginal growth for 1998. In the long term, Asia/Pacific's analog revenue will grow at a 17.3 percent CAGR and reach $14 billion by 2002.

Assumptions for Analog IC Forecast

- Demand has slowed PC, communications, consumer, and industrial markets, among others.
- The Asian economic downturn and its rippling effects on the rest of the world are the main reasons for the demand slowdown.

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- A recovering Asian economy and continued growth in Americas and Europe in 1999, combined with the inventory reduction at analog IC suppliers in 1998, should bring strong growth back to analog ICs in 1999.
- A semiconductor boom cycle starting in 1999 will continue to result in strong growth for analog ICs in 2000 and 2001.
- The year 2002 could see a slowdown in analog IC growth, as the semiconductor market enters its next cyclical downturn.

Discrete Product Forecast

Table 3-2 shows that the Asia/Pacific discrete semiconductor revenue will increase by 10.3 percent in 1999 and total $4.3 billion, following a marginal 2.2 percent increase for 1998. In the long term, Asia/Pacific's discrete revenue will grow at an 8.7 percent CAGR and reach $5.8 billion by 2002.

Assumptions for Discrete Forecast

- Product price instability across all discrete devices, which was prevalent through the first half 1998, has subsided. All discrete product groups are still in a state of ready availability. However, prices are returning to a state of stability.
- Continued instability in consumer, data processing, industrial, and automotive equipment sectors indicates a slower-than-normal growth path for discrete devices through the second quarter of 1999.
- The delayed recovery in the semiconductor market may delay some competitor and user decisions to shift to the slowly evolving power discrete (MOSFET and IGBT) products. While large suppliers in the Americas, such as Motorola Incorporated, have lost product share to some of the European competitors, consolidation of vendor activities and new market entrants may change the balance of supplier share and product activity in the next two years.
- The long-term growth prospect appears moderate, as competitors and users switch to power-management devices. Consolidation or acquisition of competitors' products appear as developments, along with even more price instability for developing product areas.

Optoelectronics Product Forecast

Table 3-2 shows that the Asia/Pacific optoelectronic semiconductor revenue will increase by 8 percent in 1999 and total $1 billion, following a 3.5 percent growth for 1998. In the long term, Asia/Pacific's optoelectronic semiconductor revenue will grow at a 10.2 percent CAGR and reach $1.5 billion by 2002.

Assumptions for Optoelectronics Forecast

- LEDs and laser diodes are key market drivers.
- LED growth has been moderated from the previous forecast because of a general industry slowdown caused by the Asian financial crisis.
- The laser diode market has been affected negatively by the slow consumer markets and positively by the demand for bandwidth in the Internet-driven telecommunications market.
- PC and wireless handset demand growth will return to higher levels in 1999.

Chapter 4
Asia/Pacific Semiconductor Forecast by Region

This chapter presents the semiconductor market and major electronic equipment production forecast during the five-year period from 1997 to 2002 in China/Hong Kong, Singapore, South Korea, and Taiwan. This chapter's tables and the figures provide the complete five-year forecast by region in the Asia/Pacific semiconductor market and major electronic equipment production.

China/Hong Kong's Semiconductor Forecast

While most Asia/Pacific countries will experience a decline in 1998, Dataquest predicts that China/Hong Kong's semiconductor market will grow by 2.8 percent to reach U.S.$7 billion. Dataquest expects that the growth will be sustained in China/Hong Kong's semiconductor market, despite the current Asian financial crisis because China has relatively better economic health than other Asian nations, particularly steady growth with low inflation. By 2002, China/Hong Kong's semiconductor market will total $15 billion, which marks a 17.5 percent CAGR from 1997 to 2002.

Forecast Highlights and Assumptions

The following are key assumptions and highlights of this forecast:

- China's economy is expected to grow by an estimated 7.5 percent, while Hong Kong will face a 1.2 percent decline in 1998. The Asia/Pacific region should begin to recover from the economic turmoil next year.
- China's electronics equipment production will grow 12.6 percent this year. China is now the largest semiconductor consumer in Asia/Pacific. It represents the largest consumer of computer equipment, accounting for a quarter of the region's PC shipments. China's PC unit shipments are expected to reach 3 million units, a 53 percent rise over the 1997 level.
- China/Hong Kong's semiconductor market will expand from $6.9 billion in 1997 to $15 billion in 2002, at a 17.5 percent CAGR, far higher than the region's 13.3 percent CAGR. In 1998, China/Hong Kong's semiconductor market is forecast to grow at 2.8 percent, reaching $7 billion.
- MOS memory devices are estimated to decline in 1998 because of the sluggish DRAM price in 1998. The DRAM market alone is expected to shrink by 27.5 percent in 1998, which is a result of vendors' cutthroat price competition.
- The MOS microcomponent market remains consistent with prior expectations. This product market is forecast to grow at an 18 percent CAGR from 1997 to 2002, reaching $5.1 billion in 2002. Among the fastest-growing MOS microcomponent product categories, digital signal processors and microprocessors are expected to achieve a 26.6 percent CAGR and a 20.8 percent CAGR, respectively, during the forecast period.

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- The MOS digital logic market is estimated to increase from $0.9 billion in 1997 to $1.6 billion by 2002, with a healthy 12.6 percent CAGR, but its share of total semiconductor market will decrease from 13.2 percent in 1997 to just over 10 percent in 2002.
- The analog market will surge from $1.4 billion in 1997 to $3.5 billion by 2002, with a 19.8 percent CAGR.
- Dataquest expects the market for discrete and optoelectronic devices to expand from $1 billion in 1997 to $2.2 billion in five years, with a 15.1 percent CAGR. This growth is consistent with the electronic equipment production growth in China/Hong Kong.

Electronic Equipment Production in China/Hong Kong

China/Hong Kong's electronic equipment production is expected to continue growing at a 15.1 percent CAGR to 2002, reaching $92.2 billion. This growth is driven by emerging applications in the data processing, communications, and consumer electronics segments.

Electronic equipment production is forecast to grow 12.6 percent in 1998, contrasting with 18.6 percent in 1997. The dollar value is expected to reach $51.3 billion in 1998, compared to $45.6 billion in 1997. The slower growth in 1998 is attributed to the influences of the Asian financial crisis and the nationwide restructuring of state-owned enterprises, which suppress export growth and internal consumption.

However, given the encouraging macroeconomic developments and continued favorable government policy, China's equipment production will remain on an upward curve through the end of the decade at a 15.1 percent CAGR, to reach $92.2 billion by 2002.

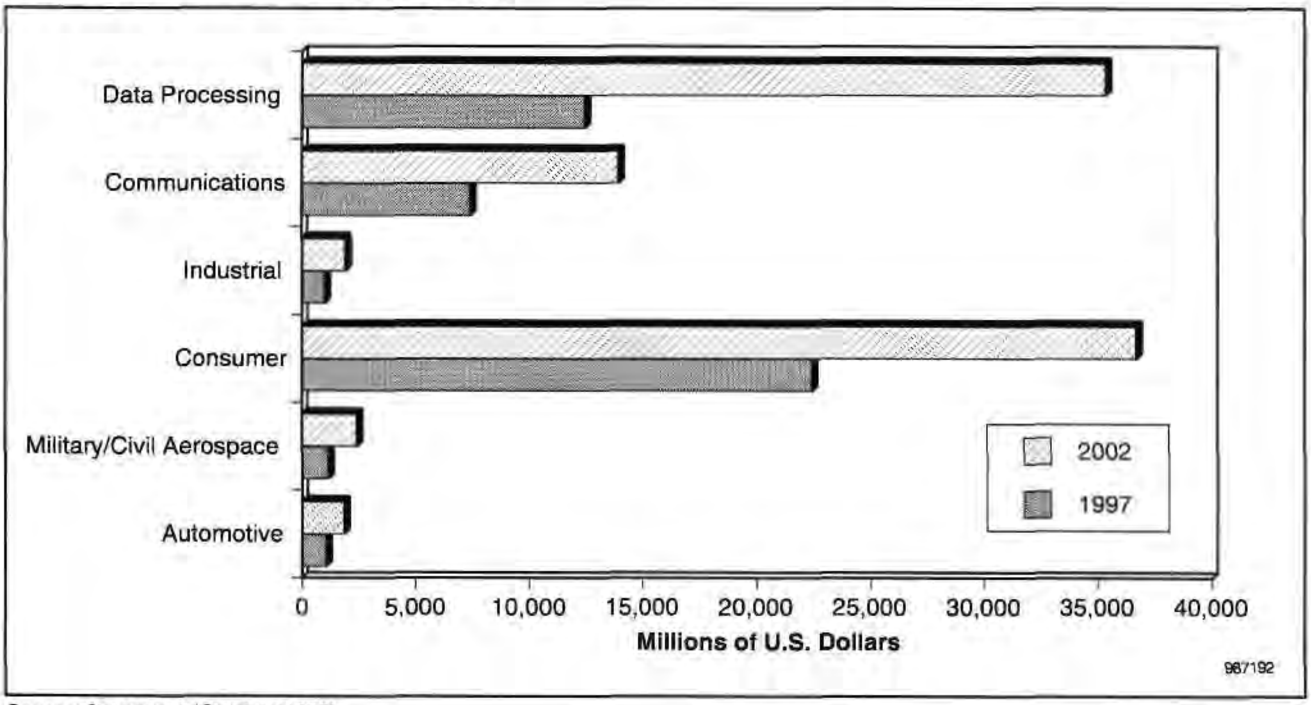
Table 4-1 and Figure 4-1 show China/Hong Kong's electronic equipment production forecast and comparison in the five-year period. In 1997, PC and monitor equipment are projected to be the most significant contributors to production growth from 1997 to 2002. The communications equipment market is estimated to be outstanding, driven by increased production of mobile communications equipment.

Table 4-1
China/Hong Kong Electronic Equipment Production Forecast, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Electronic Equipment	**45,564**	**51,324**	**59,068**	**69,080**	**80,271**	**92,208**	**15.1**
Data Processing	12,454	15,781	19,495	24,310	29,591	35,343	23.2
Communications	7,433	8,116	9,055	10,587	12,278	13,946	13.4
Industrial	1,006	1,093	1,242	1,434	1,668	1,925	13.9
Consumer	22,429	23,865	26,461	29,547	33,067	36,690	10.3
Military/Civil Aerospace	1,162	1,319	1,529	1,774	2,076	2,440	16.0
Automotive	1,079	1,151	1,286	1,428	1,591	1,863	11.5

Source: Dataquest (October 1998)

Figure 4-1
China/Hong Kong Electronic Equipment Production Comparison by Application, 1997 and 2002 (Millions of U.S. Dollars)



Source: Dataquest (October 1998)

China/Hong Kong's Semiconductor Market Trends by Product

Table 4-2 and Figure 4-2 present detailed China/Hong Kong's semiconductor market forecast and comparison for China/Hong Kong in the five-year forecast period.

MOS Memory

China/Hong Kong's consumption of MOS memory products reached $1.1 billion in 1997. Because of the astonishing price decline as a combined result of competition and overcapacity, MOS memory product revenue is expected to experience an 18.3 percent decline this year. MOS memory products will exhibit the highest fluctuating annual percentage changes, as DRAM pricing movements become largely unpredictable by vendors. From 1999 to 2001, the MOS memory market is forecast to rise again, before diving in 2002 when a DRAM device glut resurfaces again.

The MOS memory market is estimated to increase to $2.8 billion by 2002. The CAGR is forecast at 19.7 percent from 1997 to 2002. The growth will be largely driven by the growing demand in PCs and emerging digital products.

DRAM devices constituted the largest segment of the MOS memory product category in 1997, reaching $800 million. Flash memory devices took the second place, while SRAM was the third largest.

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Table 4-2
China/Hong Kong Semiconductor Market Forecast by Device, 1997 to 2002
(Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Semiconductor	**6,769**	**6,957**	**7,906**	**10,262**	**13,226**	**15,143**	**17.5**
Bipolar Digital	42	35	29	23	18	14	-19.3
MOS Memory	1,142	933	1,144	1,667	2,812	2,807	19.7
Dynamic RAM	800	580	725	1132	2157	2022	20.4
Static RAM	87	96	122	171	202	235	21.9
Nonvolatile Memory	239	240	279	344	432	531	17.2
Other MOS Memory	15	16	18	20	21	20	5.3
MOS Microcomponent	2,206	2,370	2,705	3,361	4,123	5,052	18.0
Microprocessor	881	1015	1245	1539	1853	2270	20.8
Microcontroller	680	652	675	836	1049	1297	13.8
Microperipheral	480	502	533	663	798	948	14.6
Digital Signal Processor	165	201	252	323	423	537	26.6
MOS Digital Logic	895	901	950	1171	1376	1620	12.6
ASICs	253	250	281	385	497	663	21.2
Custom IC	78	68	54	43	30	20	-23.7
MOS Standard Logic	197	178	186	197	205	216	1.9
Total Other MOS Logic	368	405	429	546	644	721	14.4
Analog Monolithic	1419	1499	1756	2369	2957	3496	19.8
Total Discrete	859	988	1065	1375	1592	1746	15.2
Total Optical Semiconductor	205	231	256	295	348	407	14.7

Source: Dataquest (October 1998)

MOS Microcomponent

China/Hong Kong's consumption of MOS microcomponent products reached $2.2 billion in 1997. Revenue from MOS microcomponent products is expected to grow at 7.4 percent this year. Although there is a strong demand in PCs and cellular phones, this is offset by the price decline pressure in microcontroller devices.

The MOS microcomponent market is estimated to rise to $5.1 billion by 2002, with an 18 percent CAGR from 1997 to 2002. MOS microcomponent products will continue to represent the largest device category over the five-year forecast period because of their importance in electronic equipment.

Microprocessor devices represent the largest segment in the MOS microcomponent product categories, followed by microcontroller and microperipheral devices. Although these devices are expected to remain dominant until 2002, the increasing use of DSP devices in many high-volume applications is likely to contribute a significant revenue growth in the MOS microcomponent market. It is expected that DSP devices will increase from 7.5 percent of the total MOS microcomponent in 1997 to 10.6 percent in 2002.

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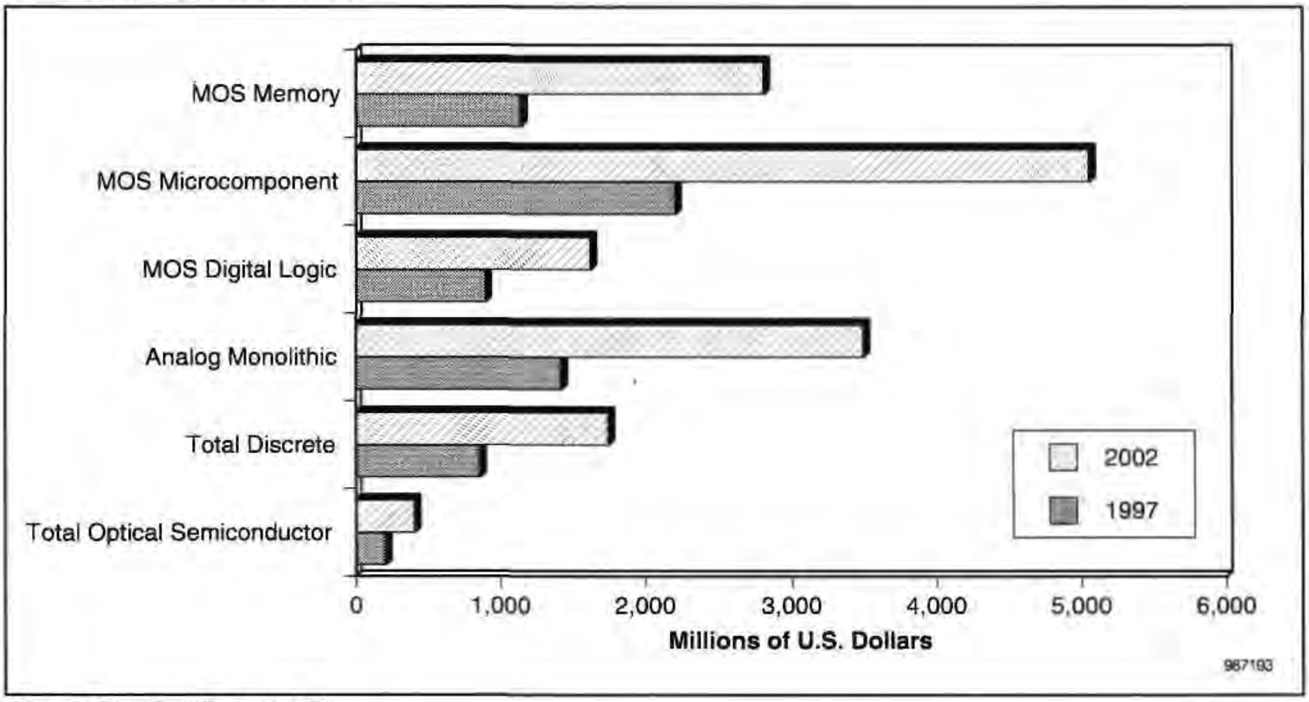
Figure 4-2
China/Hong Kong Semiconductor Market Comparison by Product, 1997 and 2002 (Millions of U.S. Dollars)



Source: Dataquest (October 1998)

MOS Digital Logic

China/Hong Kong's use of MOS digital logic devices in electronic equipment manufacturing reached $0.9 billion in 1997. MOS digital logic devices are expected to show a flat growth this year. Such low growth results from the decline of custom IC devices and the decrease in MOS standard logic prices.

The MOS digital logic market is projected to reach about $1.6 billion by 2002, with a 12.6 percent CAGR from 1997 to 2002.

ASIC devices will show the fastest-growing revenue in the MOS digital logic product category. The ASIC segment will increasingly dominate the growth trend as CBICs present the most viable path toward integrating systems on a chip.

Analog Monolithic

China/Hong Kong's consumption of analog products reached $1.4 billion in 1997. Revenue from analog products is expected to show a moderate growth of 5.6 percent this year.

Analog product consumption is estimated to increase to $3.5 billion by 2002, with a 19.8 percent CAGR from 1997 to 2002. As a result, the analog market will represent the second-largest device category, following MOS microcomponent devices.

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Discrete and Optical Semiconductor

The discrete market in China/Hong Kong is estimated to increase to $1.7 billion by 2002, with a projected 15.2 percent CAGR from 1997 to 2002. Discrete products, being a basic building block for most electronic equipment, will continue to contribute steady revenue over the five-year forecast period.

The optical semiconductor market is expected to increase from $0.2 billion to $0.4 billion by 2002 with a 14.7 percent CAGR.

Singapore's Semiconductor Forecast

The Asia/Pacific region is experiencing the pain from the Asian financial crisis that began in 1997. Asian economies continue to deteriorate as a result of consumption and investment downturns. Among the economies worst affected are the Southeast Asian nations, including Singapore. The city state's growth rate this year is projected to be 1.3 percent, according to Dataquest. This forecast is within the Singaporean government's revised GDP growth range of 0.5 percent to 1.5 percent.

Although the U.S. and European economies have shown signs of strength, the regional situation closer to Singapore continues a downward impact on the economy. Recent regional developments, including the deterioration in Southeast Asian and Japanese economies, have dampened demand for Singapore exports. Industrial production numbers shows that electronics output, which accounts for nearly half of manufacturing, contracted by 9 percent in local currency terms in August. The monthly decline reflected the lower sales of telecommunications equipment, semiconductors, and PCs.

Electronics output for the first eight months of 1998 has fallen 3.4 percent, compared to a year ago. Lower equipment production and a steep erosion in chip prices are forecast to lead to lower semiconductor consumption revenue in Singapore this year. The semiconductor market should fall by 4.0 percent in 1998 and reach about $4.8 billion. In the long term, Singapore's semiconductor market will total nearly $9.1 billion, which is a 13.0 percent CAGR from 1997 to 2002.

Forecast Highlights and Assumptions

The following are key assumptions and highlights of this forecast:

- Asia/Pacific's GDP growth rates are forecast to be depressed by the Asian financial crisis in 1998. According to Dataquest, Singapore's economy is estimated to grow by 1.3 percent, within the official forecast GDP growth range of 0.5 percent to 1.5 percent. Singapore is predicted to begin recovering from the regional economic turmoil next year.
- Singapore's semiconductor consumption is estimated to decline in 1998. This forecast represents a downgrade compared with prior expectations, as a result of lower electronic equipment output and declining chip prices. Revenue from the production of electronic equipment is predicted to fall by 4.8 percent in 1998, led by falls in data processing equipment and consumer electronic applications.

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- Pricing pressure and lower demand for memory, ASIC, MPR, and MCU products are expected to present significant adverse impacts. Memory products should suffer the largest revenue decline this year.
- Electronic equipment production is estimated to register a 7.2 percent CAGR between 1997 and 2002, driven by increased manufacturing investments from companies taking advantage of the devalued currency and Singapore's position as the Southeast Asian regional business hub. The semiconductor market should experience a higher five-year CAGR than equipment production revenue because of rising semiconductor content in electronic equipment. Data processing and communications equipment are projected to drive growth of total electronic equipment production over the forecast cycle.
- The Singapore semiconductor market is expected to post positive growth rates on the back of recovering electronic equipment production from 1999. The MOS memory category is forecast to record the highest five-year CAGR, with the DRAM market projected to move closer to demand-supply balance by the end of this decade. DRAM prices should peak in 2001, before softening again by 2002.
- MOS microcomponent products will continue to represent the largest device category over the five-year forecast cycle, as data processing and communications equipment production is estimated to increase in the forecast period.
- MOS digital logic products should retain their position as the third-largest product category in Singapore. High-volume applications for ASIC devices and the industry trend toward system-level integration should spur growth in this category.

Electronic Equipment Production in Singapore

Singapore's electronic equipment production is forecast to grow at a 7.2 percent CAGR from 1997 to 2002. Although production growth in previous years was driven by investments from multinational companies, a lower growth rate is expected as the city state starts to transition toward higher-value-added manufacturing activities. In recent years, manufacturing of lower value-added equipment in Singapore has been relocated to cost-competitive locations in the Asia/Pacific region. This has resulted in equipment production of consumer electronics, in particular, and other products dwindling, as the shift in direction to other Southeast Asian countries and China/Hong Kong gains momentum. Besides higher-value-added products, Singapore's electronic equipment production should also be driven by multinational OEMs outsourcing their production functions. The continuation of this trend will lead to contract equipment manufacturers accounting for a higher percentage of local equipment output.

Table 4-3 and Figure 4-3 present Singapore's electronic equipment production forecast from 1997 to 2002. In 1998, manufacturing revenue is expected to decline by 4.8 percent as a result of intense pricing pressures and lower demand amid the regional economic turmoil. Data processing equipment is projected to be the most significant contributor of equipment production revenue up to 2002. Singapore is still host to the world's leading producers of data storage products. In 1997, Dataquest estimates that Singapore's production output of rigid disk drives accounted for nearly 39 percent of total worldwide units. Among the three largest equipment groups, communications equipment is projected to register an 8.2 percent

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compound growth over the forecast cycle, which we expect to be driven by increased manufacturing of premise telecom and mobile communications equipment.

Figure 4-3 illustrates Singapore's electronic equipment production comparison for 1997 and 2002. As the aftereffect of the Asian financial crisis takes hold, Singapore's electronic equipment production growth is expected to remain in low gear this year. This will be compounded by the continuing trend of relocating production of lower-value-added equipment to cost-competitive countries. The shift has resulted in reduced consumer electronics production, evidenced by the declining output of VCRs and color television sets. On a positive note, the city is well on its way toward becoming a production base for higher-value-added equipment, particularly data processing and communications products. With this trend already evident, Singapore's consumption of semiconductors in manufacturing should rise as equipment with higher silicon content will make up a large majority of total production.

Singapore's major electronic equipment manufacturing is estimated to experience the highest annual growth rates in 2000 and 2001. The trend is determined by the output of data processing equipment. In 1997, revenue generated from data storage products constituted 45 percent of the total equipment revenue and is forecast to rise to exceed 48 percent by 2002.

Singapore's Semiconductor Market Trends by Product

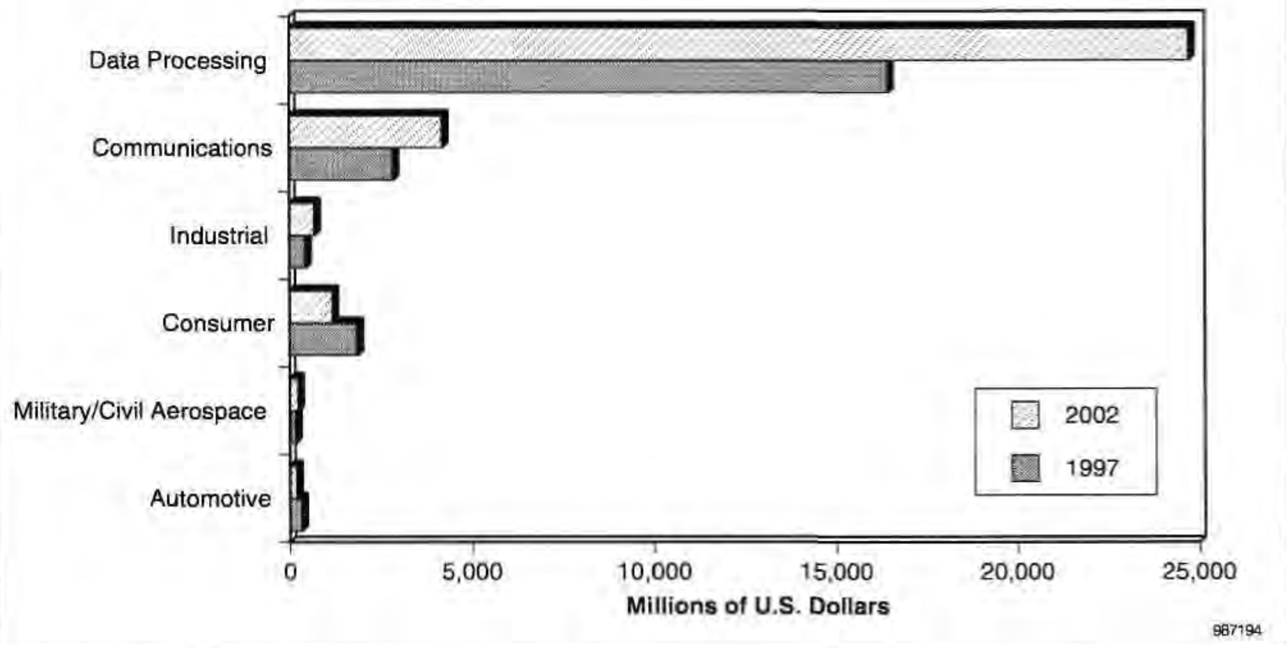
Table 4-4 presents the Singapore semiconductor market forecast by product from 1997 to 2002.

Table 4-3
Singapore Electronic Equipment Production Forecast, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Electronic Equipment	**22,076**	**21,016**	**23,066**	**25,448**	**28,277**	**31,229**	**7.2**
Data Processing	16,445	15,666	17,708	19,692	21,869	24,721	8.5
Communications	2,830	2,928	3,091	3,411	4,042	4,195	8.2
Industrial	445	467	490	563	648	698	9.4
Consumer	1,854	1,487	1,369	1,371	1,292	1,182	-8.6
Military/Civil Aerospace	172	178	185	202	224	237	6.7
Automotive	330	290	224	208	200	196	-9.9

Source: Dataquest (October 1998)

Figure 4-3
Singapore Electronic Equipment Production Comparison by Application, 1997 and 2002 (Millions of U.S. Dollars)



Source: Dataquest (October 1998)

MOS Memory

Singapore's use of MOS memory products in electronics manufacturing reached $1.2 billion in 1997. Vendors' revenue generated from MOS memory products is expected to decline by 23.1 percent this year, as a result of oversupply and lower prices. MOS memory products should exhibit the highest fluctuating annual percentage changes because of volatility in the DRAM market. From 1999 to 2001, the MOS memory market is forecast to move toward a balanced supply-demand situation. However, a memory downturn is projected in 2002 when excess capacity returns in DRAM production.

The MOS memory market is estimated to increase to $2.4 billion by 2002. The 1997-to-2002 CAGR of 15.5 percent will result in MOS memory products representing the second-largest device category over the five-year period.

DRAM devices constituted the largest segment of the MOS memory product category in 1997. Nonvolatile memory devices take a second place, with SRAMs occupying the third spot. The positions of these three device segments are forecast to be unchanged until 2002.

MOS Microcomponent

Singapore's consumption of MOS microcomponent products in manufacturing reached $1.7 billion in 1997. Vendors' revenue generated from MOS microcomponent products is expected to register a modest 8.3 percent growth this year, as a result of declining revenue predicted for microcontroller and microperipheral devices. This year's growth should be driven by robust expansion in the microprocessor and DSP markets.

Table 4-4
Singapore Semiconductor Market Forecast by Device, 1997 to 2002
(Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Semiconductor	**4,962**	**4,761**	**5,416**	**6,727**	**8,473**	**9,139**	**13.0**
Bipolar Digital	18	18	15	11	8	6	-18.1
MOS Memory	1,166	897	1,125	1,656	2,616	2,394	15.5
Dynamic RAM	845	543	686	1,082	1,936	1,590	13.5
Static RAM	90	117	155	224	260	300	27.2
Nonvolatile Memory	228	232	276	340	409	492	16.6
Other MOS Memory	3	5	8	10	11	12	32.0
MOS Microcomponent	1,689	1,829	2,081	2,439	2,807	3,288	14.3
Microprocessor	865	960	1,121	1,290	1,473	1,712	14.6
Microcontroller	335	308	330	405	457	543	10.1
Microperipheral	328	361	385	437	486	546	10.7
Digital Signal Processor	161	200	245	307	391	487	24.8
MOS Digital Logic	807	795	862	1,041	1,220	1,429	12.1
ASICs	468	451	506	648	799	963	15.5
Custom IC	54	39	28	19	13	8	-32.6
MOS Standard Logic	122	110	116	125	127	133	1.7
Total Other MOS Logic	163	195	212	249	281	325	14.8
Analog Monolithic	745	697	787	940	1,139	1,301	11.8
Total Discrete	435	419	431	506	534	551	4.8
Total Optical Semiconductor	102	106	115	134	149	170	10.8

Source: Dataquest (October 1998)

The MOS microcomponent market is estimated to rise to $3.3 billion by 2002. This segment should record the second-highest 1997-to-2002 CAGR of 14.3 percent. MOS microcomponent products is expected to remain the largest device category over the five-year forecast cycle.

Microprocessor devices accounted for the largest segment in the 1997 MOS microcomponent product category, followed by microcontroller and microperipheral devices. Although these devices are expected to remain dominant until 2002, the increasing use of DSP devices in many high-volume applications is likely to contribute significant revenue growth in the MOS microcomponent market.

MOS Digital Logic

MOS digital logic products emerged as the third-largest product category in Singapore's electronics manufacturing in 1997. The use of these products reached $0.8 billion, overtaking analog products for the first time. The MOS digital logic segment is expected to experience a 1.5 percent revenue decline in 1998.

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The MOS digital logic market is projected to increase to $1.4 billion by 2002, with a 12.1 percent CAGR from 1997 to 2002. This market is predicted to be the third-fastest-growing segment as a result of the products' increased usage in high-volume applications and the industry trend toward SLI.

ASIC devices make up the largest portion of revenue in Singapore's MOS digital logic product category, following the other MOS logic category. The ASIC segment will continue to dominate the growth trend, as designers integrate single-chip systems.

Analog Monolithic

Singapore's use of analog products in electronics manufacturing reached $0.7 billion in 1997. In 1998, the revenue from analog products is expected to decline 6.4 percent as market conditions remain weak.

The analog market is estimated to rise to $1.3 billion by 2002. Singapore's analog product market will experience steady revenue expansion over the five-year period, with a projected 1997-to-2002 CAGR of 11.8 percent.

Discrete and Optical Semiconductor

Singapore's combined use of discrete and optical semiconductor products in manufacturing reached $0.5 billion in 1997. The revenue from this combined product category is forecast to fall 2.2 percent this year, as a result of lower demand and oversupply in the discrete market.

Singapore's discrete market is estimated to rise to $0.6 billion by 2002. With a projected 1997-to-2002 CAGR of 4.8 percent, discrete products will continue to represent mature revenue expansion over the five-year period.

Singapore's optical semiconductor market is expected to increase to $0.2 billion by 2002, with a 10.8 percent CAGR.

Figure 4-4 illustrates the Singapore semiconductor market comparison by product in 1997 and 2002.

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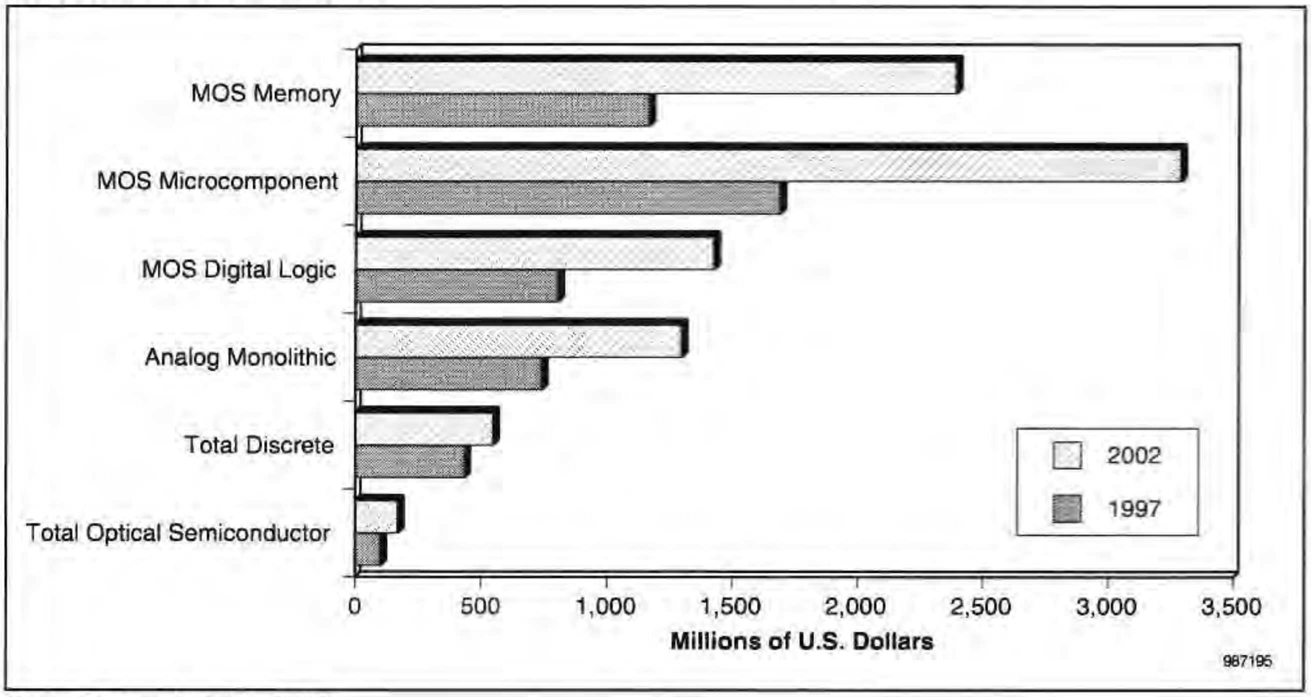
Figure 4-4
Singapore Semiconductor Market Comparison by Product, 1997 and 2002
(Millions of U.S. Dollars)



Source: Dataquest (October 1998)

South Korea's Semiconductor Forecast

The South Korean economy is running into serious trouble amid rapidly cooling domestic demand and dwindling exports. The Korean economy is suffering a vicious cycle of production drops and deepening domestic demand. Economic uncertainties and credit squeezes taking place in the course of restructuring have placed immense pressure on domestic demand, and the economy is liable to plunge deeper into recession.

The 1998 GDP is expected to contract 4.8 percent this year before turning around at an annual rate of 0.6 percent in 1999, although the government will have to take strong macroeconomic measures. The 4.8 percent contraction, if realized, will be a steep downturn from the negative 3.8 percent forecast jointly made by the government and the International Monetary Fund (IMF) in July 1998.

Some economists are warning that South Korea could face a second financial crisis, depending on the seriousness of the international economic turmoil. There has been no restoration of international confidence in emerging markets. Troubles could return at any time according to these institutes.

The South Korean domestic economy is in the doldrums. The businesses are too centralized in conglomerates with high indebtedness. The Korean won has depreciated, and investment spending is dropping. Besides the consumer price inflation jump, the growing unemployment results in a steep decline in consumer spending.

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The South Korean semiconductor market will grow by 13.7 percent in 1999 and total $5.8 billion, following a steep 7.9 percent decline for 1998. In the long term, Dataquest predicts that the South Korean semiconductor market will show its steady growth from 1999, recovering from a financial crisis next year. As a result, South Korea's semiconductor market will grow at a 12.1 percent CAGR and reach $9.7 billion by 2002.

Forecast Highlights and Assumptions

The following are key assumptions and highlights of this forecast:

- South Korea's semiconductor market will increase by 13.7 percent in 1999 to a total of $5.8 billion. The South Korean financial crisis and a low DRAM pricing hindered this year's semiconductor revenue growth, although some product segments will achieve robust double-digit growth rates. In the long term, South Korea's semiconductor market will reach nearly $9.7 billion, which marks a 12.1 percent CAGR for the five-year period from 1997 to 2002.
- South Korea's PC unit production will grow by 1.4 percent in 1999 and total 1.7 million units, following a steep 17 percent decline for 1998. For the long term, Korea's PC unit production will grow at a 6.7 percent CAGR for the five-year period and total 2.8 million units by 2002.
- The semiconductor industry should retain a long-term vitality. PCs, communications equipment, and consumer electronics will continue to rank as the most important application markets in South Korea in the five-year forecast period from 1997 to 2002.
- MOS microcomponent products, especially DSPs, will continue to fuel South Korea's semiconductor market growth. DSPs rank among the highest-growth semiconductor products. This device is the centerpiece of communications electronics (such as cellular phones and modems) and the emerging consumer digital electronics. The South Korean DSP market should grow at a 25.5 percent CAGR for the 1997-to-2002 period and reach $289 million by 2002.
- The memory market will increase by 17.4 percent in 1999 and total $646 million, following a steep 29.5 percent decline for 1998. In the long term, the Korean memory market will grow at a 9.1 percent CAGR and reach $1.2 billion by 2002.
- The MOS logic revenue will increase by 10.8 percent in 1999 and total $802 million, following a 1 percent growth for 1998. In the long term, the South Korean logic market will grow at a 14.2 percent CAGR and reach $1.4 billion by 2002. This growth will be fueled by ASICs and other MOS logic devices.
- The South Korean analog IC market will increase by 20.7 percent in 1999 and total $1.8 billion, following a disappointing marginal growth for 1998. In the long term, South Korea's analog market will grow at a 17.5 percent CAGR for the 1997-to-2002 forecast period and reach $3.2 billion by 2002.

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- South Korea's discrete semiconductor revenue will increase by 10.3 percent in 1999 and total $912 million, following a marginal 3.1 percent increase for 1998. In the long term, the South Korean discrete market will grow at a 9.4 percent CAGR and reach $1.3 billion by 2002. Optoelectronic semiconductor revenue will increase by 8.3 percent in 1999 and total $195 million, following a 2.9 percent growth for 1998. In the long term, South Korean optoelectronic semiconductor revenue will grow at an 11.4 percent CAGR and reach $300 million by 2002.

Electronic Equipment Production in South Korea

Dataquest predicts that the South Korean PC industry should experience a 17 percent decline for 1998 to about 1.7 million units. This growth will affect the memory market, especially DRAM, this year. However, Dataquest expects the PC production revenue to grow at a 6.7 percent CAGR during the five-year period from 1997 to 2002. Monitors, which represent the largest sector in South Korea's data processing industry, will increase by 14 percent in 1999 and reach 25.6 million units. Monitor production unit will grow at a 7.9 percent CAGR during the five-year period from 1997 to 2002. Monitors have been considered a major product of data processing in South Korea during the forecast period.

Unit production of digital cellular phones in South Korea is expected to enjoy a healthy growth, at 41.9 percent CAGR from 1997 to 2002. This product is expected to expand its share in electronic equipment continuously because of its healthy local demand and outstanding export growth.

Dataquest expects that the driver of consumer electronics in South Korea will come mainly from analog camcorders, DVD players, analog set-top boxes, and digital set-top boxes, which are expected to enjoy outstanding growth during the five-year forecast period from 1997 to 2002. In contrast, VCRs and personal/portable stereos will show a sluggish growth. Therefore, DVD players and digital set-top boxes, which are expected to enjoy healthy growth, will increase their share of total consumer electronics production in South Korea.

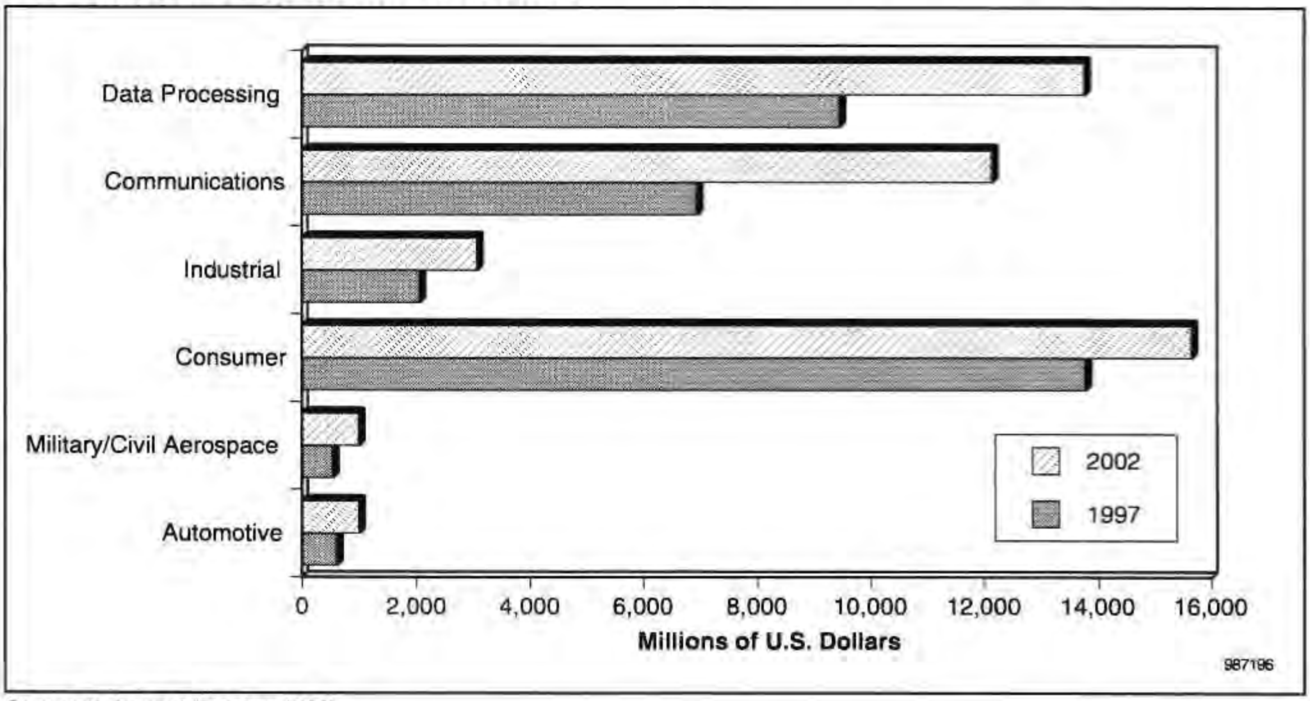
Table 4-5 shows the electronic equipment production forecast for South Korea from 1997 to 2002. Figure 4-5 illustrates the electronic equipment production comparison for 1997 and 2002.

Table 4-5
South Korea Electronic Equipment Production Forecast, 1997 to 2002
(Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Electronic Equipment	**33,356**	**32,643**	**35,630**	**38,450**	**42,418**	**46,594**	**6.9**
Data Processing	9,449	9,253	10,136	11,543	12,696	13,754	7.8
Communications	6,940	7,478	8,508	9,303	10,620	12,142	11.8
Industrial	2,060	1,900	2,048	2,345	2,737	3,075	8.3
Consumer	13,774	12,805	13,598	13,816	14,716	15,646	2.6
Military/Civil Aerospace	530	580	670	755	860	985	13.2
Automotive	603	627	671	688	789	992	10.5

Source: Dataquest (October 1998)

Figure 4-5
South Korea Electronic Equipment Production Comparison by Application, 1997 and 2002 (Millions of U.S. Dollars)



Source: Dataquest (October 1998)

South Korea's Semiconductor Market Trends by Product

Table 4-6 presents the South Korean semiconductor market forecast by device from 1997 to 2002.

MOS Memory

South Korea's consumption of MOS memory products in electronics manufacturing will increase by 17.4 percent in 1999 and total $646 million, following a sharp 29.5 percent decline for 1998. In the long term, South Korea's memory market will grow at a 9.1 percent CAGR and reach $1.2 billion by 2002. MOS memory products should exhibit the highest fluctuating annual percentage changes, as DRAM pricing movements take hold. From 1999 to 2001, the MOS memory market is forecast to rise rapidly, before nose diving in 2002 when a glut in DRAM devices resurfaces again. South Korea's MOS memory will be ranked the fourth-largest semiconductor market in the country in the five-year forecast period.

DRAM devices will be positioned in the largest segment of the MOS memory product category over the forecast period in South Korea. SRAM devices take the second place, with flash memory occupying the third spot. The positions of these three device segments are forecast to be unchanged by 2002.

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Table 4-6
South Korea Semiconductor Market Forecast by Device, 1997 to 2002
(Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Semiconductor	**5,490**	**5,055**	**5,747**	**7,090**	**8,589**	**9,733**	**12.1**
Bipolar Digital	23	21	19	18	13	11	-14.5
MOS Memory	781	550	646	884	1,256	1,207	9.1
Dynamic RAM	525	280	340	490	790	680	5.3
Static RAM	75	95	106	148	172	198	21.4
Nonvolatile Memory	174	168	190	235	282	318	12.8
Other MOS Memory	7	7	9	11	12	11	9.5
MOS Microcomponent	1,567	1,303	1,424	1,691	2,006	2,370	8.6
Microprocessor	564	330	370	420	490	560	-0.1
Microcontroller	532	504	559	684	815	971	12.8
Microperipheral	378	360	365	410	480	550	7.8
Digital Signal Processor	93	109	130	177	221	289	25.5
MOS Digital Logic	716	723	802	977	1,167	1,391	14.2
ASICs	282	286	323	413	513	639	17.8
Custom IC	86	59	43	30	19	11	-33.5
MOS Standard Logic	84	74	78	83	85	86	0.5
Total Other MOS Logic	264	304	358	450	550	655	19.9
Analog Monolithic	1,426	1,450	1,750	2,200	2,700	3,200	17.5
Total Discrete	802	827	912	1,091	1,187	1,254	9.4
Total Optical Semiconductor	175	180	195	230	260	300	11.4

Source: Dataquest (October 1998)

The following summarizes memory IC product outlooks:

- South Korea's DRAM market will increase by 21.4 percent in 1999 and total $340 million, following a 46.7 percent decline for 1998. By 2002, South Korea's DRAM revenue will total about $680 million, which marks a 5.3 percent CAGR from 1997 to 2002.
- The SRAM market in South Korea will grow by 12 percent in 1999 and total $106 million. In the long term, the country's SRAM revenue will total $198 million, or a 21.4 percent CAGR for the 1997-to-2002 forecast period.
- Nonvolatile revenue will increase by 13.1 percent in 1999 and total $190 million, following a 3.3 percent decline for 1998. In the long term, South Korea's nonvolatile memory market will grow at a 12.8 percent CAGR from 1997 to 2002 and reach $318 million by 2002.

MOS Microcomponent

South Korea's MOS microcomponent revenue will increase by 9.3 percent in 1999 and total $1.4 billion, following a 16.9 percent decline for 1998. The MOS microcomponent market is estimated to increase to $2.4 billion by 2002 with an 8.6 percent CAGR during the five-year period from 1997 to 2002.

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For 1999, South Korea's MPU revenue will increase by 12.1 percent and reach $370 million. In the long term, the country's MPU revenue should reach $560 million, which represents a flat CAGR for the 1997-to-2002 period. This growth results in the slump in PC production and demand for 1998.

South Korea's DSP revenue will increase by 19.3 percent in 1999 and total $130 million, following a 17 percent increase for 1998. By 2002, South Korea's DSP revenue will reach $289 million, which translates into a stellar 25.5 percent CAGR from 1997 to 2002.

The MCU revenue will increase by 10.9 percent in 1999 and total $559 million, following a 5.3 percent decline for 1998. Sharp price erosion for MCU products hinders the growth of MCU market for 1998. In the long term, South Korea's MCU revenue will grow at a 12.8 percent CAGR for the 1997-to-2002 period and reach $971 million by 2002.

MOS Digital Logic

The MOS digital logic segment is expected to record a 10.8 percent revenue growth in 1999 and reach $802 million. The MOS digital logic market is projected to increase to $1.4 billion by 2002. A 14.2 percent CAGR for the 1997-to-2002 period is predicted as a result of the industry trend toward SLI.

South Korea's ASIC market will increase by 12.9 percent in 1999 and total $323 million, following a 1.4 percent growth for 1998. In the long term, South Korea's ASIC revenue will grow at a 17.8 percent CAGR for the 1997-to-2002 period and reach $639 million by 2002.

South Korean custom IC revenue will decline by 27.3 percent in 1999 and total $43 million. In the long term, it will total $11 million, or a 33.5 percent CAGR decline from 1997 to 2002.

The standard logic segment will increase by 4.2 percent in 1999 and reach the $78 million level, following an 11.3 percent decline for 1998. By 2002, South Korea's standard logic revenue will total $86 million, which is a 0.5 percent CAGR from 1997 to 2002.

The other MOS logic sector will increase by 17.8 percent in 1999 and reach the $358 million mark. By 2002, South Korea's other MOS logic revenue will reach $655 million, for a 19.9 percent CAGR from 1997 to 2002.

Analog Monolithic

In 1999, South Korea's analog IC revenue is expected to grow by 20.7 percent and total $1.8 billion, following a 1.7 percent increase for 1998. In the long term, it will grow at a 17.5 percent CAGR for the 1997-to-2002 period and reach $3.2 billion by 2002.

Looking at the long-term trends to 2002, mixed-signal ICs will experience a solid growth, driven by the application markets such as digital cellular. In addition, new emerging applications in the consumer and communications markets will contribute to the growth of mixed-signal ICs. In the more traditional standard linear product area, voltage-regulator products will continue to enjoy a strong growth, as the demand for smart power continues to grow, especially in the portable equipment markets.

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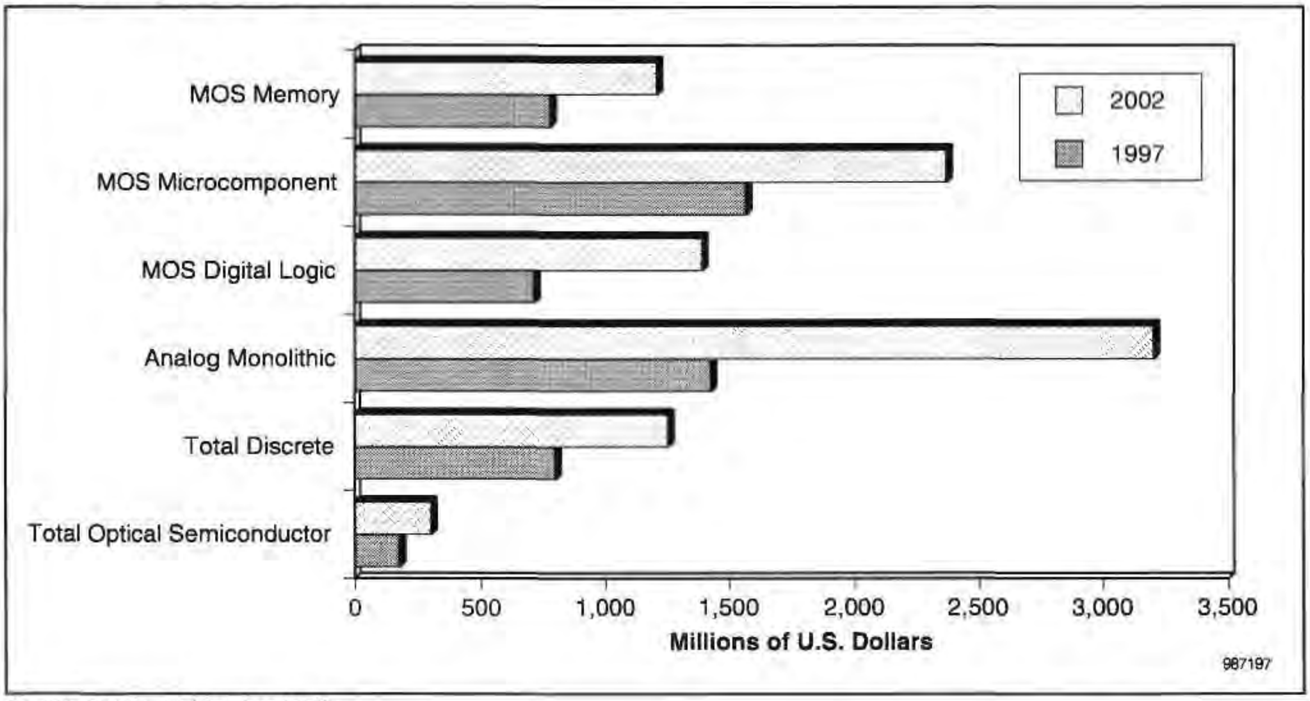
Discrete and Optical Semiconductor

South Korea's discrete product revenue will increase by 10.3 percent in 1999 and total $912 million, following a marginal growth for 1998. In the long term, it will grow at a 9.4 percent CAGR for the 1997-to-2002 period and reach $1.3 billion by 2002.

South Korea's optical semiconductor revenue will grow by 8.3 percent in 1999 and total $195 million. By 2002, it will total $300 million, which represents a 11.4 percent CAGR from 1997 to 2002.

Figure 4-6 illustrates South Korea's semiconductor market comparison by product in 1997 and 2002.

Figure 4-6
South Korea Semiconductor Market Comparison by Product, 1997 and 2002 (Millions of U.S. Dollars)



Source: Dataquest (October 1998)

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Taiwan's Semiconductor Forecast

Although Taiwan has not suffered the Asian financial crisis turmoil like its neighbors because of its healthy economic fundamentals, the local currency has dropped more than 15 percent since October 1997. But Taiwan should be able to cope with the turmoil and continue its robust economic performance over the long term. Taiwan's semiconductor market will be expanding from $6.8 billion in 1997 to $12 billion in 2002, at a 12.3 percent CAGR. In 1998, Taiwan's semiconductor market is forecast to grow at 2 percent, reaching $6.9 billion.

Forecast Highlights and Assumptions

The following are key assumptions and highlights of this forecast:

- The Taiwanese government expects 5.2 percent GDP growth in 1998. The Asia/Pacific region should begin to recover from the economic turmoil next year.
- Taiwan's electronic equipment production was estimated to register a 10.6 percent CAGR between 1997 and 2002. Data processing and communications equipment segments are expected to drive the growth of total electronic equipment production by 2002. Taiwan's electronics equipment production will grow 12.8 percent in 1998.
- Taiwan's semiconductor market will expand from $6.8 billion in 1997 to $12 billion in 2002, at a 12.3 percent CAGR. In 1998, Taiwan's semiconductor market is forecast to grow 2 percent, reaching $6.9 billion.
- MOS memories were the fastest-growing segment before 1995. However, the market has dropped since 1996. MOS memory devices are estimated to decline 15.9 percent because of the sluggish DRAM price in 1998. The DRAM market alone is expected to shrink by 21.4 percent in 1998, which is caused by vendors' price competition and oversupply.
- The Taiwanese MOS microcomponent market is the largest semiconductor device segment. It is expected to reach $2.7 billion, for an 8 percent growth in 1998. The MOS microcomponent market represents 38.9 percent of all semiconductors shipped to Taiwan in 1998, and it is expected to expand by an 11.4 percent CAGR from 1997 to 2002.
- Taiwan's MOS digital logic market is estimated to increase from $0.7 billion in 1997 to $1.2 billion by 2002, with a healthy 14.2 percent CAGR. The analog market will surge from $0.8 billion in 1997 to $1.8 billion by 2002, with a 17.4 percent CAGR.
- Taiwan's discrete and optoelectronics segments shouldo expand from $0.8 billion in 1997 to $1.3 billion in five years, with a 9.6 percent CAGR. Dataquest expects this market to show a stable growth following the growth of the demand for the equipment.

Electronic Equipment Production in Taiwan

Taiwan's electronic equipment revenue is expected to continue its healthy growth at 10.5 percent CAGR from 1997 to 2002, reaching $38 billion. Data processing production will still be the mainstay for Taiwan by 2002, growing at a moderate pace.

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Dataquest's long-term electronic equipment production forecast by sector projects data processing to sustain the lion's share of production in Taiwan from 1997 to 2002. Its CAGR is expected to be only 11.4 percent during this period. Data processing equipment accounts for more than 50 percent of total Taiwan electronic equipment production. Three niche markets—PCs, monitors, and motherboards—dominate this sector, accounting for 72 percent of total data processing equipment manufacturing.

Communications equipment production is the second-largest sector, with an 8.5 percent CAGR from 1997 to 2002, which will continue from 1997 to 2002. Revenue generated in this sector in recent years was created mainly by the modem and network card industries. Wireless communications equipment production is expected to be the most promising industry for the sector. Dataquest expects this segment to increase its revenue from $5.4 billion in 1997 to $8.2 billion in 2002.

Consumer electronics manufacturing will rank third in electronic equipment production, with a 9.7 percent CAGR from 1997 to 2002. Consumer electronics will continue to its slow growth sector, although most of Taiwan's consumer production has shifted to China and Southeast Asia. However, DVD players, digital still cameras, and set-top boxes are expected to be the major driving force of consumer growth.

Table 4-7 and Figure 4-7 show Taiwan's electronic equipment production and comparison from 1997 to 2002. In 1997, PCs and monitor equipment are projected to be the most significant contributors to production growth from 1997 to 2002. Communications equipment is estimated to be outstanding, driven by increased production of mobile communications equipment.

Taiwan's Semiconductor Market Trends by Product

Table 4-8 presents Taiwan's semiconductor market forecast by device from 1997 to 2002.

MOS Memory

The MOS memory market represented 29.2 percent of all semiconductors shipped to Taiwan in 1997, a 39.2 percent decrease from its 1996 levels. Since 1996, MOS memory had not been the largest device in the MOS digital segment. In 1997, memory products were affected by the DRAM price drop, a result of the DRAM oversupply.

Taiwan's MOS memory market reached $1.9 billion in 1997. The market is expected to face a 15.9 percent decline in 1998. The MOS memory market is estimated to increase to $3.4 billion by 2002, with an 11.8 percent CAGR from 1997 to 2002. Taiwan's developing data processing industries will lead a surge in MOS memory consumption in the next five years.

DRAM devices constituted the largest segment of the MOS memory product category in 1997, reaching $1.5 billion. DRAM devices are expected to peak in 2001 and reach $3.2 billion.

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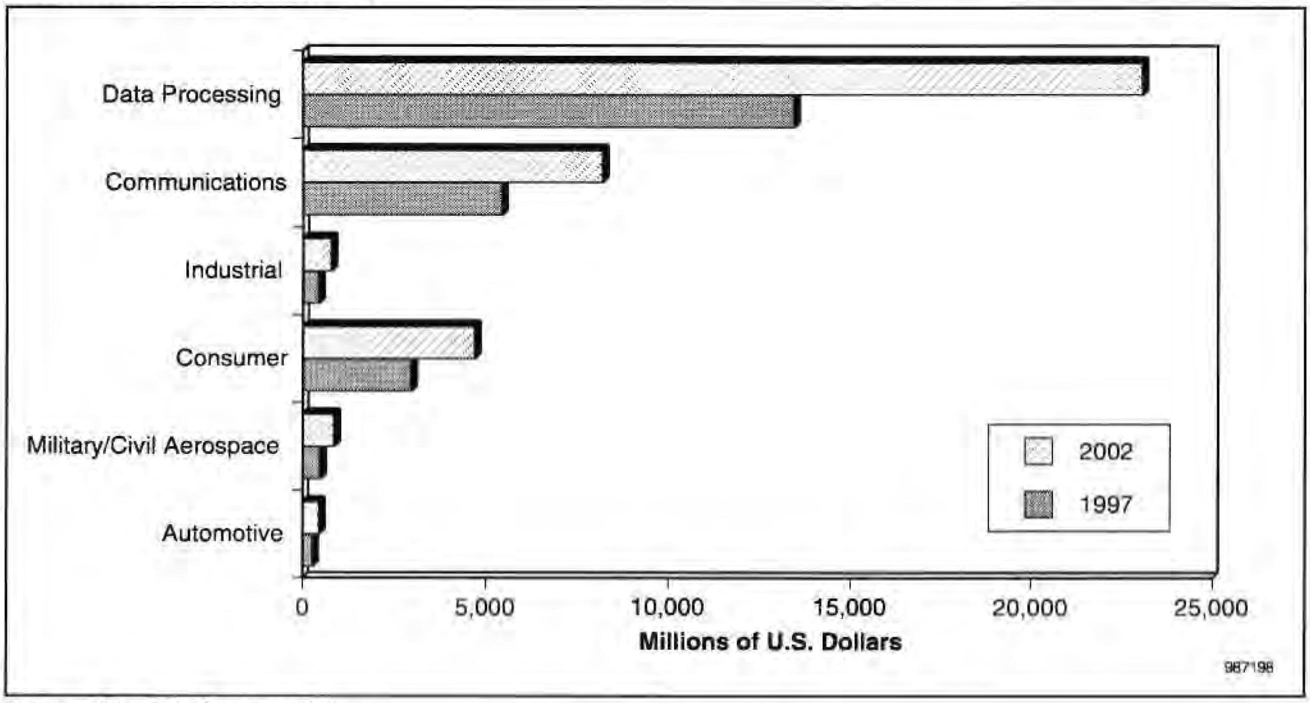
Table 4-7
Taiwan Electronic Equipment Production Forecast, 1997 to 2002
(Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Electronic Equipment	**23,039**	**25,994**	**29,148**	**32,018**	**35,159**	**38,049**	**10.6**
Data Processing	13,446	15,318	17,379	19,251	21,214	23,062	11.4
Communications	5,445	6,120	6,690	7,196	7,686	8,205	8.5
Industrial	437	497	561	621	698	773	12.1
Consumer	2,957	3,212	3,560	3,873	4,365	4,693	9.7
Military/Civil Aerospace	480	545	621	698	780	859	12.3
Automotive	274	303	337	379	417	458	10.8

Source: Dataquest (October 1998)

Figure 4-7
Taiwan Electronic Equipment Production Comparison by Application, 1997 and 2002
(Millions of U.S. Dollars)



Source: Dataquest (October 1998)

Table 4-8
Taiwan Semiconductor Market Forecast by Device, 1997 to 2002
(Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Semiconductor	**6,754**	**6,893**	**7,929**	**9,372**	**11,656**	**12,044**	**12.3**
Bipolar Digital	40	37	33	29	24	21	-12.1
MOS Memory	1,971	1,657	2,003	2,633	3,992	3,443	11.8
Dynamic RAM	1,517	1,192	1,458	1,950	3,177	2,497	10.5
Static RAM	166	175	209	290	340	390	18.6
Nonvolatile Memory	282	283	326	381	460	539	13.8
Other MOS Memory	6	7	10	12	15	17	23.2
MOS Microcomponent	2,482	2,682	3,019	3,396	3,828	4,261	11.4
Microprocessor	1,210	1,320	1,500	1,705	1,915	2,080	11.4
Microcontroller	363	349	393	470	560	652	12.4
Microperipheral	711	783	848	890	951	1,059	8.3
Digital Signal Processor	198	230	278	331	402	470	18.9
MOS Digital Logic	629	686	777	893	1,055	1,223	14.2
ASICs	301	347	398	490	600	720	19.1
Custom IC	75	55	41	28	17	9	-34.6
MOS Standard Logic	75	68	71	75	78	79	1.0
Total Other MOS Logic	178	216	267	300	360	415	18.4
Analog Monolithic	786	901	1,066	1,257	1,496	1,756	17.4
Total Discrete	651	700	780	884	951	1,005	9.1
Total Optical Semiconductor	195	230	251	280	310	335	11.4

Source: Dataquest (October 1998)

MOS Microcomponent

The Taiwanese MOS microcomponent market is the largest semiconductor device segment. PC production continues its relentless growth, driving the overall semiconductor market and, in particular, contributing to the growth of MOS microcomponent products.

Taiwan's MOS microcomponent device market is expected to reach $2.7 billion, for an 8 percent growth in 1998. The MOS microcomponent market represents 38.9 percent of all semiconductors shipped to Taiwan in 1998. The market is expected to expand by an 11.4 percent CAGR from 1997 to 2002.

Microprocessors remain the dominant revenue source in MOS microcomponents, although the other three constituent product types (microcontrollers, microperipherals, and DSPs) showed stronger growth in recent years. Although the microprocessor is expected to remain dominant until 2002, the increasing use of DSP devices in many high-volume applications is likely to contribute a significant revenue growth in the MOS microcomponent market. It is expected that DSP devices will expand by an 18.9 percent CAGR from 1997 to 2002.

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The CPU and core logic devices are the main microprocessor markets. Intel will retain its dominance of the microprocessor market. Other companies with x86-type processors will be able to increase their business and grab shares from Intel.

MOS Digital Logic

The MOS digital logic market is estimated to increase from $0.7 billion in 1997 to $1.2 billion by 2002, with a healthy 14.2 percent CAGR. The analog market will surge from $0.8 billion in 1997 to $1.8 billion by 2002, with a 17.4 percent CAGR.

Taiwan's MOS logic market demand in 1997 mainly comprised ASICs, standard logic products, and other logic devices. ASIC devices will show the fastest revenue growth in the MOS digital logic product category.

Analog Monolithic

Taiwan's analog device market reached $786 million in 1997. Revenue from analog products is expected to show a healthy growth of 14.6 percent in 1998.

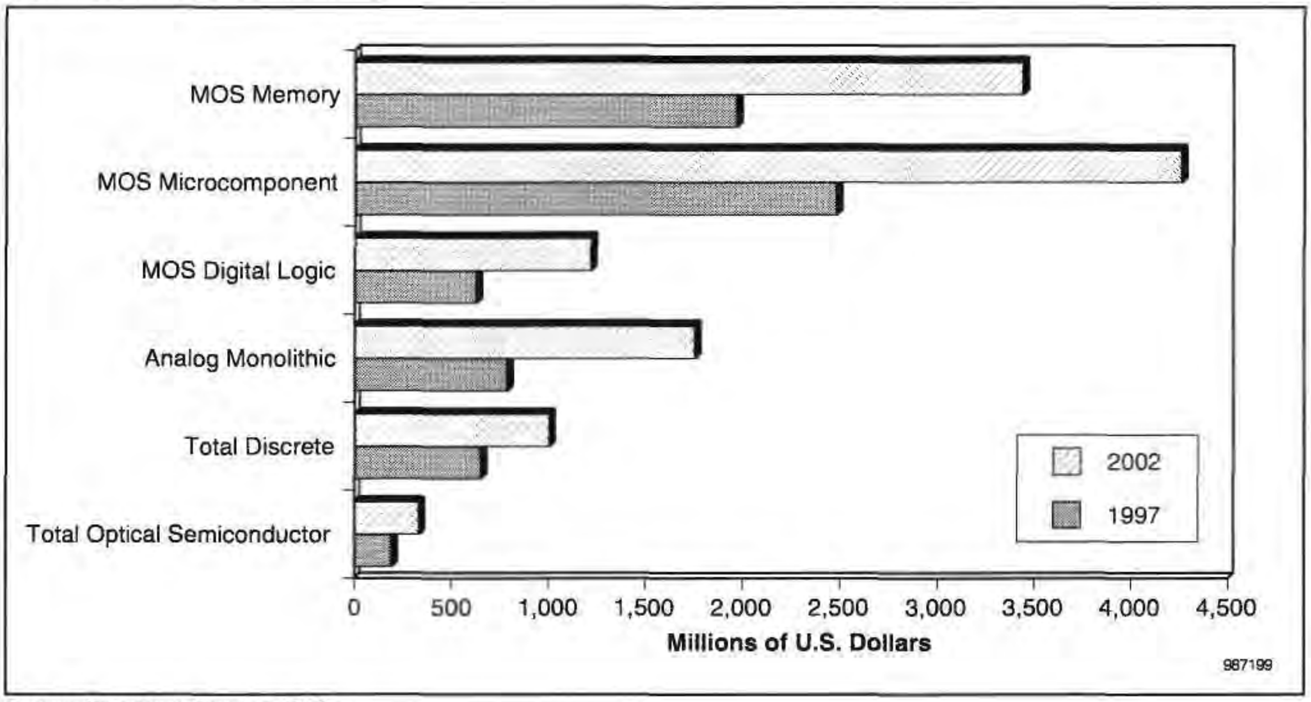
The Taiwanese analog device market is estimated to increase to $1.8 billion by 2002, with a 17.4 percent CAGR from 1997 to 2002. Consumer electronics manufacturing will still be the main application for this device.

Discrete and Optical Semiconductor

Taiwan's discrete and optoelectronic devices are expected to expand from $0.8 billion in 1997 to $1.3 billion in five years, with a 9.6 percent CAGR. Dataquest expects this market to show a stable growth.

Figure 4-8 illustrates the Taiwan semiconductor market comparison by product in 1997 and 2002.

Figure 4-8
Taiwan Semiconductor Market Comparison by Product, 1997 and 2002 (Millions of U.S. Dollars)



Source: Dataquest (October 1998)

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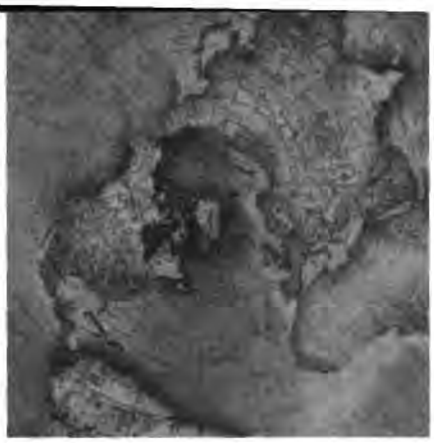

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Asia/Pacific Spring 1998 Semiconductor Market Forecast, 1997 to 2002

Market Trends

FILE COPY:
MARIA VALENZUELA

Program: Semiconductors Asia/Pacific
Product Code: SEMI-AP-MT-9802
Publication Date: July 6, 1998
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Asia/Pacific Spring 1998 Semiconductor Market Forecast, 1997 to 2002

Market Trends

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Chapter 1
Executive Summary

This Executive Summary presents the following major conclusions of the Asia/Pacific semiconductor Market Trends report:

- Dataquest forecasts that the Asia/Pacific semiconductor market will grow 10.3 percent in 1998, reaching U.S.$35.9 billion. The Asia/Pacific semiconductor market should grow at a 15.7 percent compound annual growth rate (CAGR) from 1997 to 2002, reaching $67.6 billion in 2002.
- China/Hong Kong's semiconductor market will grow by 15.5 percent in 1998 to total nearly $7.8 billion. By 2002, the China/Hong Kong market is expected to total $17.6 billion, which marks a 21.1 percent CAGR for the 1997-to-2002 period.
- Singapore's semiconductor market will grow by 11.8 percent in 1998 to total $5.6 billion. In the long term, Singapore's semiconductor market will total $11 billion, which indicates a 17.2 percent CAGR for the 1997-to-2002 period.
- South Korea's semiconductor market should increase by 9.1 percent in 1998 to reach the $6 billion level. By 2002, South Korea's semiconductor market will total $11.6 billion, which generates a 16.2 percent CAGR between 1997 and 2002.
- Taiwan's semiconductor market will increase by 13.9 percent in 1998 to reach about $7.7 billion. By 2002, Taiwan's semiconductor market will approach nearly $15 billion, for a nearly 17.2 percent CAGR for the 1997-to-2002 period.

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Contributors: Jerry Yeh (Taiwan) and Ken Ng (Singapore)

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Chapter 2
Introduction and Forecast Assumptions

This Market Trends report presents Dataquest's market data and forecast analysis of Asia/Pacific's semiconductor market including China/Hong Kong, Taiwan, South Korea, and Singapore. The Asia/Pacific region has been the fastest-growing semiconductor market in the world since 1988. However, Asia/Pacific's semiconductor market grew at only 9.6 percent in 1997. The greatest impact on the 1997 semiconductor market growth in the region will be DRAM pricing. Overall, the nonmemory markets continued a healthy expansion because of Asia/Pacific's diverse manufacturing base.

The continuation of low-end and medium-range electronic equipment production transplantation from all regions of the world to Asia/Pacific will continue to be a factor in developing markets such as China and Malaysia. This production shift has enhanced the Asia/Pacific growth that comes with the growth of its own internal consumption markets.

Semiconductor Forecast Assumptions

Dataquest forecasts that the Asia/Pacific semiconductor market will grow at a five-year CAGR of 15.7 percent, reaching $67.6 billion by 2002.

These four regions—China/Hong Kong, Taiwan, South Korea, and Singapore—constitute the major semiconductor market in Asia/Pacific (more than two-thirds of the total Asia/Pacific semiconductor market in 1997). Dataquest believes that these four regions will continue to play the major role in Asia/Pacific's semiconductor market over the forecast period.

The Asian financial crisis will have varying effects on semiconductor consumption in the region—many negative but some positive. In addition, the effects differ markedly on an Asian country-by-country basis. For example, growth in countries such as Indonesia, Thailand, and the Philippines decelerated—but growth accelerated in China and Taiwan. Taiwan's electronics industry will fare well in this crisis, primarily because a larger percentage of components is supplied locally and because its financial sector is stronger than those of other Asian countries.

All semiconductor vendors are watching China. China's electronics equipment production will grow nearly 20 percent in 1998. China now stands as the largest semiconductor market in Asia/Pacific. China represents a large consumer of communications and computer equipment, accounting for 25 percent of all PCs purchased in Asia/Pacific. China's PC unit growth exceeds a 40 percent annual rate.

Although electronics consumption may be lower than previously expected in selected countries, the region as a whole will continue to enjoy the fastest growth rates in the world.

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The semiconductor market for PC application represents more than one-third of all semiconductor consumption and will continue to play the key role for semiconductor growth. The Asia/Pacific PC production will continue to maintain a steady growth over the forecast period. Asia/Pacific's PC production should total 23 million units in 1998. The PC production growth in this region will be attributed to Pentium II, DVD, 3-D graphics, Windows NT, and Windows 98. Although much of the production gets shipped elsewhere worldwide, PC unit consumption in the region should increase by more than 20 percent this year and reach 12 million units.

In the long term, Dataquest expects the region's most important semiconductor demand driver, the PC, to sustain a solid growth in Asia/Pacific's production with a 23 percent CAGR over the five-year forecast period. As a result, PC production in Asia/Pacific will exceed 45 million units in 2002. PC motherboard production will also continue to maintain steady growth in the region.

Communications equipment will also generate outstanding semiconductor growth in Asia/Pacific over the forecast period. This application will support the demand growth for ASICs, DSPs, ASSPs, and analog ICs. In the near term, most of the Asia/Pacific semiconductor market for communications in 1998 will be driven by mobile and wireless communications. Digital consumer electronics products, such as digital set-top boxes, will also begin to make a significant contribution to overall semiconductor demand.

The markets of discrete and optical semiconductor should be lower in 1998 than originally expected because of sluggish consumer equipment production, especially digital consumer applications. However, these markets will continue to achieve steady growth to post a 1998 recovery in Asia/Pacific production of digital consumer equipment.

Economic Assumptions and Exchange Rates

Current exchange rates for the major Asia/Pacific countries are detailed in Table 2-1. Dataquest uses constant exchange rates across technologies and regions. The final and projected exchange rates from 1996 to 1999 were used for forecasting the four countries' markets in Asia/Pacific.

The Asian financial crisis cut gross domestic product (GDP) growth rates in many countries in 1997. According to Dataquest's growth rate projections (see Table 2-2), Asia/Pacific countries likely to experience depressed GDP growth include Southeast Asian countries and South Korea.

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Table 2-1
Asia/Pacific Currency Exchange Rates against the U.S. Dollar, 1996 to 1999

	1996	1997	1998*	1998* U.S. Dollar Appreciation (%)	1999* U.S. Dollar Appreciation
China (Renminbi)	8.34	8.32	8.31	-0.16	8.31
Hong Kong (Dollar)	7.73	7.74	7.75	0.07	7.75
India (Rupee)	35.52	36.36	39.61	8.92	39.70
Japan (Yen)	108.81	121.10	130.85	8.05	131.75
Malaysia (Ringgit)	2.52	2.82	3.80	34.88	3.74
Singapore (Dollar)	1.41	1.49	1.62	8.95	1.60
South Korea (Won)	805.16	954.14	1,445.74	51.52	1,391.55
Taiwan (Dollar)	27.47	28.79	33.06	14.83	33.02
Thailand (Baht)	25.36	31.07	41.43	33.35	39.65

* Estimated average
Source: Dataquest (June 1998)

Table 2-2
Asia/Pacific GDP Growth Rates (Percent)

	1996	1997	1998	1999	2000	2001	2002
Indonesia	8.0	4.6	-6.4	-1.7	4.2	6.4	6.5
Malaysia	8.6	7.8	2.0	3.0	5.5	6.8	7.0
Philippines	5.7	5.1	3.0	4.5	5.5	6.0	6.1
Singapore	6.9	7.8	2.5	4.0	6.8	6.8	6.8
Thailand	6.0	-0.5	-3.5	1.5	3.7	4.1	5.9
China	9.7	8.8	8.0	8.6	8.7	8.7	8.9
Hong Kong	4.9	5.2	2.7	4.2	5.2	5.2	5.0
Taiwan	5.7	6.8	5.2	5.6	6.0	6.0	5.8
South Korea	7.1	5.5	-1.8	2.2	5.7	5.6	5.6
India	7.5	5.0	5.4	5.8	6.3	6.9	6.7

Source: Dataquest (June 1998)

The Scope of This Market Trends Report

This Market Trends report investigates the dynamics behind consumption growth in the four countries' markets. This report includes the following chapters:

- Chapter 1, Executive Summary—The executive summary includes the major conclusions regarding the Asia/Pacific semiconductor market trends.
- Chapter 2, Introduction and Forecast Assumptions—Dataquest's market forecasting assumptions in macroeconomics and applications for semiconductor products are explained.

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- Chapter 3, Asia/Pacific Semiconductor Forecast by Product—Dataquest provides semiconductor market by product and an analysis of each product's trends.
- Chapter 4, Semiconductor Market Forecast by Region—Dataquest analyzes semiconductor market trends in these four regions (China/Hong Kong, Singapore, South Korea, and Taiwan) and presents detailed device forecasts for these four regions.

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Chapter 3
Asia/Pacific Semiconductor Forecast by Product

This chapter's tables and the figures provide the complete, five-year forecast by product type in the Asia/Pacific semiconductor market.

The Asia/Pacific Semiconductor Forecast

Dataquest forecasts that Asia/Pacific's semiconductor market will grow 10.3 percent in 1998, reaching $35.9 billion. The Asia/Pacific semiconductor market should grow at a 15.7 percent CAGR from 1997 to 2002, reaching $67.6 billion in 2002.

The following highlights summarize Asia/Pacific's regional semiconductor market outlooks:

- China/Hong Kong's semiconductor market will grow by 15.5 percent in 1998 and total nearly $7.8 billion. By 2002, China/Hong Kong's market will total $17.6 billion, which marks a 21.1 percent CAGR for the 1997-to-2002 period.
- Singapore's semiconductor market will grow by 11.8 percent in 1998 and total $5.6 billion. In the long term, Singapore's semiconductor market will total $11 billion, indicating a 17.2 percent CAGR for the 1997-to-2002 period.
- South Korea's semiconductor market will increase by 9.1 percent in 1998 and reach about the $6 billion level. By 2002, South Korea's semiconductor market will total $11.6 billion, a 16.2 percent CAGR for the five-year period from 1997 to 2002.
- Taiwan's semiconductor market will increase by 13.9 percent in 1998 and reach about the $7.7 billion mark. By 2002, Taiwan's semiconductor market will approach nearly $15 billion, with a nearly 17.2 percent CAGR from 1997 to 2002.

Table 3-1 and Figure 3-1 show total semiconductor market revenue and growth rates by region in Asia/Pacific during the next five-year period.

Table 3-1
Total Semiconductor Market Forecast by Region in Asia/Pacific, 1997 to 2002
(Millions of U.S. Dollars)

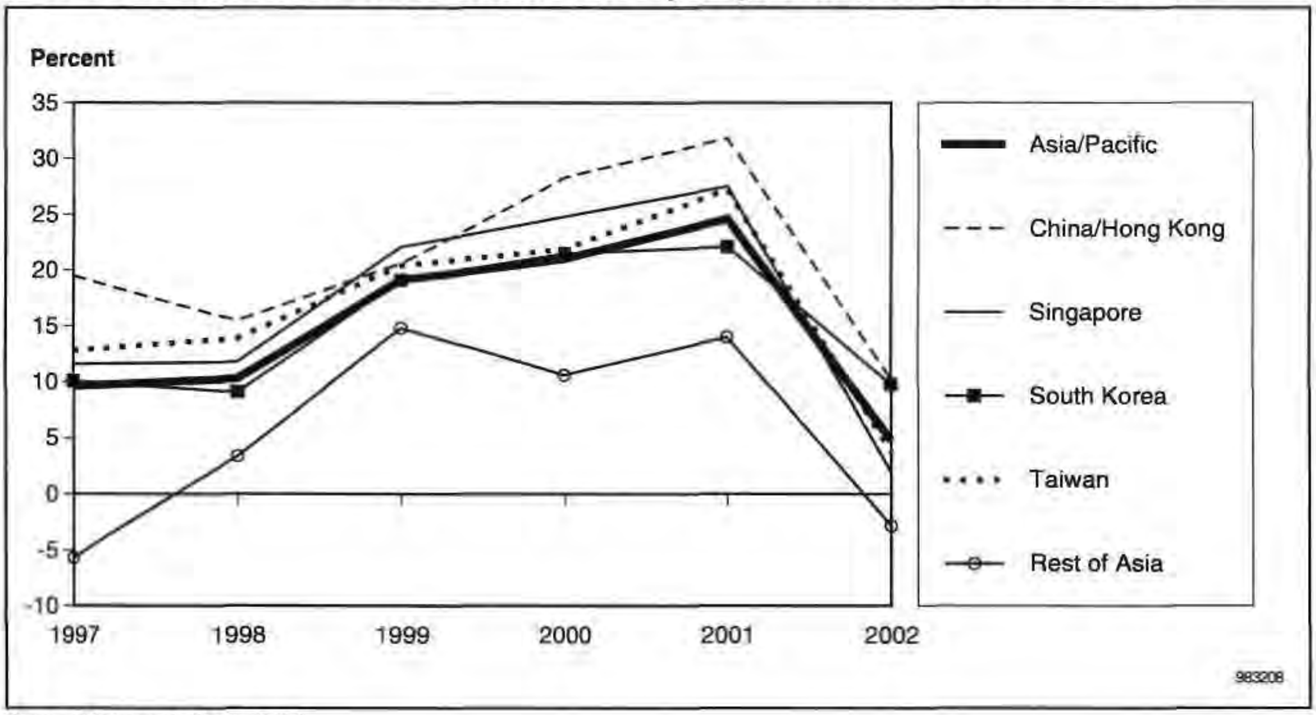
	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Asia/Pacific	32,535	35,899	42,755	51,751	64,483	67,562	15.7
China/Hong Kong	6,769	7,819	9,429	12,098	15,951	17,593	21.1
Singapore	4,972	5,560	6,790	8,472	10,798	11,012	17.2
South Korea	5,490	5,989	7,130	8,665	10,576	11,612	16.2
Taiwan	6,754	7,694	9,262	11,294	14,367	14,917	17.2
Rest of Asia	8,551	8,837	10,143	11,221	12,791	12,427	7.8

Source: Dataquest (June 1998)

The forecasts in Table 3-1 and Figure 3-1 call for modest semiconductor growth for Asia/Pacific in 1998 and stronger growth over the long term. Dataquest expects the Asia/Pacific semiconductor market as measured in revenue to grow at about 10 percent in 1998. Dataquest had expected a more robust 1998 growth rate.

DRAM and the Asian financial crisis explain much of this change. For example, the Asia/Pacific DRAM market will remain in decline in 1998, compared to the 1997 level. Dataquest previously expected a rebound in DRAM market growth for 1998. DRAM bit growth remains impressive, but excess capacity and low pricing, combined with the Asian financial crisis, mean scant DRAM revenue growth for 1998.

Figure 3-1
Total Semiconductor Market Growth Rates by Region in Asia/Pacific, 1997 to 2002



Source: Dataquest (June 1998)

Product Forecasts

The following sections highlight trends that guide key product forecasts.

MOS Memory

The DRAM market will remain volatile. The DRAM revenue forecast could swing widely for both the near term and the long term because of DRAM price fluctuations. DRAM-bit consumption continues in line with Dataquest's prior projections. This means that unit demand should be strong, although pricing might remain weak. As indicated, the semiconductor forecast assumes a cyclical upturn in 2001. The DRAM market peak in 2001, however, has been moderated to match similar historical peaks.

DRAM prices continue to hug a cost-based price curve that means low pricing. This stifles the prospect for DRAM revenue growth. Dataquest expects this situation to remain the case through 1998 and into 1999. These prices are limited on the high side by DRAM oversupply, and on the low side, by antidumping regulations.

The current Asian crisis' effects on DRAM prices will be "self-regulating" in that a temporary 1998 price downturn should shift market share to lower-cost producers, after which these low-cost suppliers' capacity will be utilized and DRAM prices will recover slightly.

The current overcapacity will continue through 1999 and into 2000. Capital expenditure did not slow in 1997 as Dataquest had originally anticipated. To reflect the impact, the DRAM market revenue peak originally expected for 2000 has been pushed out by one year to 2001. (Some manufacturing capacity may eventually exit the DRAM market; however, this is not predicted in the current forecast.)

The SRAM market is still oversubscribed. However, the analog-to-digital conversion of cellular phones has increased SRAM usage in these phones dramatically. There is a large difference between this market and the PC market, the last big SRAM stronghold. Cell phone manufacturers are much more selective about their supplier base, as they use parts from top-tier suppliers and shy away from small fabless companies. Dataquest still expects to see attrition in this market because many companies that thrived on an open market for PC cache chips will shortly be excluded from this previously highly penetrable market and thus will not be able to participate in the cellular telephone market.

In the nonvolatile memory market, Dataquest sees a continuing slow conversion from EPROM to flash memory. Most of this conversion is happening in new designs and is, therefore, occurring at the higher densities. The flash memory market has moved from high profitability toward more competitive pricing as many competitors join the fold; however, unit growth remains strong. This new, lower pricing has enabled the use of flash memory in a diverse array of new applications. Mask ROM has moved away from the "growth hump" that was characteristic of the game cartridge boom and is back on the less dramatic, pregame growth trend.

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There will continue to be substantial growth in the relatively small EEPROM market fueled by this technology's use in everything from electronic commerce to microcontroller-based systems including smart cards. New applications include universal serial bus (USB) interfaces for the PC. The conversion of DRAM modules from SIMMs to DIMMS will also help, as each new DIMM will contain one EEPROM to identify the attributes of the module.

Table 3-2 and Figure 3-2 show the MOS memory market forecast and growth rates by product in Asia/Pacific during the next five-year period.

The following summarizes Asia/Pacific's memory IC product outlooks:

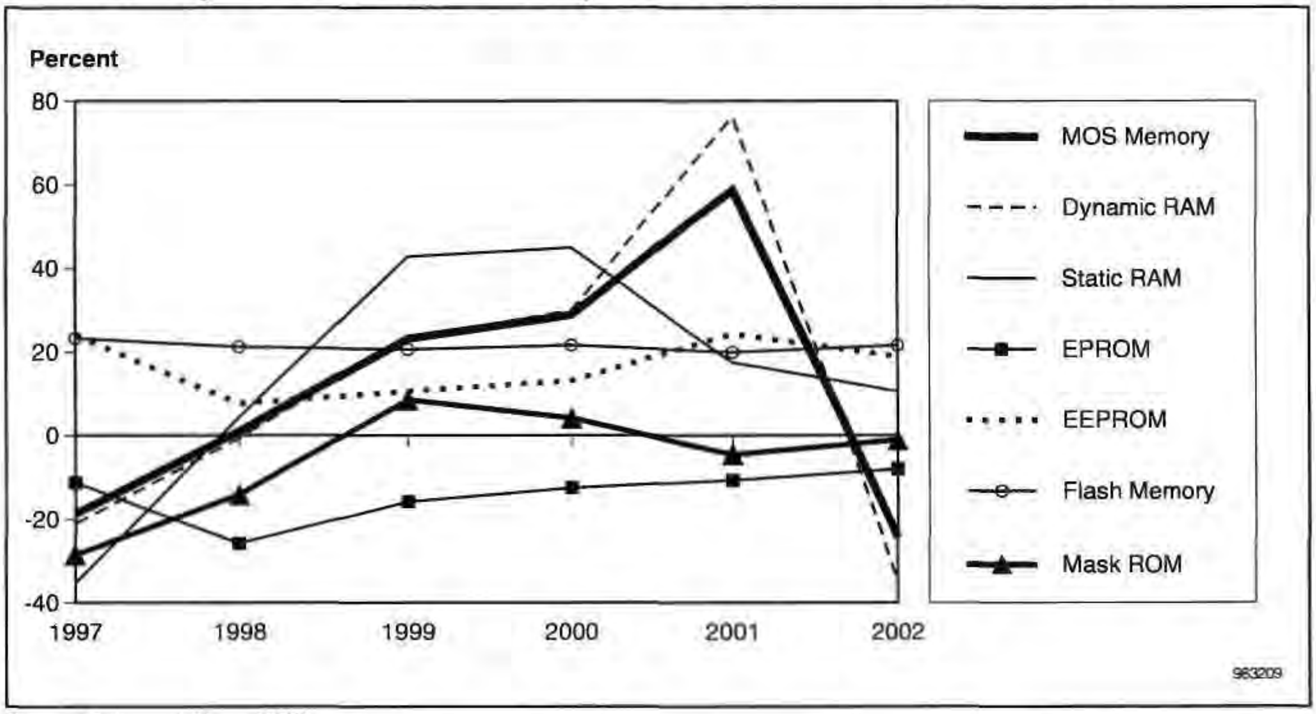
- DRAM is expected to decline by 1 percent in 1998 and total $4.6 billion. By 2002, Asia/Pacific's DRAM market will total $8.5 billion, which marks a 12.9 percent CAGR for the 1997-to-2002 period.
- SRAM will grow by 4.4 percent in 1998 and total $626 million. In the long term, Asia/Pacific's SRAM market will total nearly $1.7 billion, which means a 22.9 percent CAGR for the five-year period from 1997 to 2002.
- Flash should increase by 21.2 percent in 1998 and reach the $731 million level. By 2002, Asia/Pacific's flash market will total nearly $1.6 billion, which is a 21 percent CAGR from 1997 to 2002.
- EEPROM will increase by 7.6 percent in 1998 and reach the $227 million mark. By 2002, Asia/Pacific's EEPROM market will approach $420 million, for a nearly 15 percent CAGR from 1997 to 2002.
- EPROM is expected to decrease by more than 25 percent in 1998, declining to just about $152 million. By 2002, Asia/Pacific's EPROM market will decline to just $92 million.
- Mask ROM will decrease by 14 percent in 1998, declining to $176 million. By 2002, Asia/Pacific's mask ROM market will edge upward, however, to the $188 million level.

Table 3-2
MOS Memory Market Forecast by Product in Asia/Pacific, 1997 to 2002
(Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
MOS Memory	6,516	6,576	8,100	10,436	16,566	12,527	14.0
Dynamic RAM	4,642	4,611	5,690	7,393	13,030	8,500	12.9
Static RAM	599	626	893	1,294	1,520	1,680	22.9
Nonvolatile Memory	1,224	1,286	1,452	1,668	1,930	2,265	13.1
EPROM	205	152	128	112	100	92	-14.8
EEPROM	211	227	251	284	353	420	14.8
Flash Memory	603	731	882	1,073	1,287	1,565	21.0
Mask ROM	205	176	191	199	190	188	-1.7
Other MOS Memory	51	53	65	81	86	82	10.0

Source: Dataquest (June 1998)

Figure 3-2
MOS Memory Market Growth Rates by Product in Asia/Pacific, 1997 to 2002



Source: Dataquest (June 1998)

MOS Microcomponent

The Asia/Pacific microprocessor market forecast remains largely consistent with prior expectations. As expected, the MPU market will increase this year and over the long term, but at a slower rate versus the 1992-to-1997 period. The x86 architecture will continue its domination of the PC market. Business PC demand continues to drive MPU demand. The x86 MPU technology advances still stimulate PC demand from the key "early-adopter" repeat buyers.

Key PC market dynamics, however, are changing as of first half 1998. For example, the "sub-U.S.$1,000" PC captured consumer market demand during late 1997. Business buyers now show growing interest in low-cost PCs, which means a long-term decline in the PC average selling price (ASP). A sharp fall in the x86 MPU ASP, however, is not expected. Intel Corporation's competitors, such as Advanced Micro Devices Inc. and National Semiconductor Corporation, are not expected to cause a x86 price war.

Although the MPU price for PC desktop applications will decline, the x86 ASP will rise somewhat as MPUs absorb other system functions. In addition, Intel is creating workstation- and server-specific versions of x86 products that generate a much higher ASP (more than $500 per unit) than devices geared for PC markets. Internet appliances, communications (for example, cellular), and video games will fuel growth in the embedded RISC MPU market.

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For 1998, the Asia/Pacific MPU market should increase by 20.1 percent and reach $5.3 billion. Intel is expected to lead a strong second half 1998 rebound in the Asia/Pacific MPU market. In the long term, Asia/Pacific's MPU market should reach $10.9 billion, which represents a 19.6 percent CAGR for the 1997-to-2002 period. This is a slower, long-term MPU compound growth rate than the 24.5 percent-plus CAGR for the 1992-to-1997 period, mirroring the slower, long-term pace of PC revenue growth.

Dataquest's forecast continues to assume that non-PC applications—such as digital cellular, digital consumer electronics, and data communications, will drive demand for MCUs and DSPs, including embedded versions. The following summarizes these product forecasts:

- DSPs should increase by 26.1 percent in 1998, reaching $1 billion. By 2002, Asia/Pacific's DSP market will approach $2.4 billion, which translates into a stellar 24.4 percent CAGR for the 1997-to-2002 period.
- Sharp price erosion for microcontroller (MCU) products means lower 1998 revenue than originally expected. For 1998, Asia/Pacific's MCU market will increase by 13.7 percent and total $2.6 billion. In the long term, Asia/Pacific's MCU market will total $5.1 billion by 2002. The forecast of a 17 percent CAGR for the 1997-to-2002 period is lower than prior expectations.

Table 3-3 and Figure 3-3 show the MOS microcomponent market forecast and growth rates by product in Asia/Pacific during the next five-year period.

MOS Digital Logic

The Asia/Pacific MOS digital logic forecast calls for 6.7 percent growth in 1998. This growth is slower than originally anticipated.

The short-term forecasts on other MOS logic products have also been lowered. Supply exceeds demand for these products, which means downward pricing pressure. Standard logic remains relatively unchanged from Dataquest's prior forecasts. ASIC product forecasts have been lowered only slightly. Cell-based ICs (CBICs), the system-level integration (SLI) product of choice, will continue as the fastest-growing logic product. Gate arrays, however, are under serious pricing pressure and are entering the decline phase of the life cycle. CBICs are displacing gate arrays from high-end applications as programmable logic devices (PLDs) displace gate arrays on low-end applications. This trend translates into higher, long-term growth in the CBIC and PLD segments and lower growth in gate arrays.

For 1998, the Asia/Pacific CBIC market should grow at a 21.8 percent rate. PLDs are suffering from rapid price erosion and slow demand, so Dataquest is forecasting an 18.6 percent increase in 1998, the lowest growth rate in the market's history. Gate array revenue will continue to decline this year, by 5.5 percent. Full-custom ICs are on the most rapid decline because they are being replaced by CBICs and gate arrays to some degree. The standard logic market will increase by 8.7 percent. Other MOS logic products will grow 5.2 percent.

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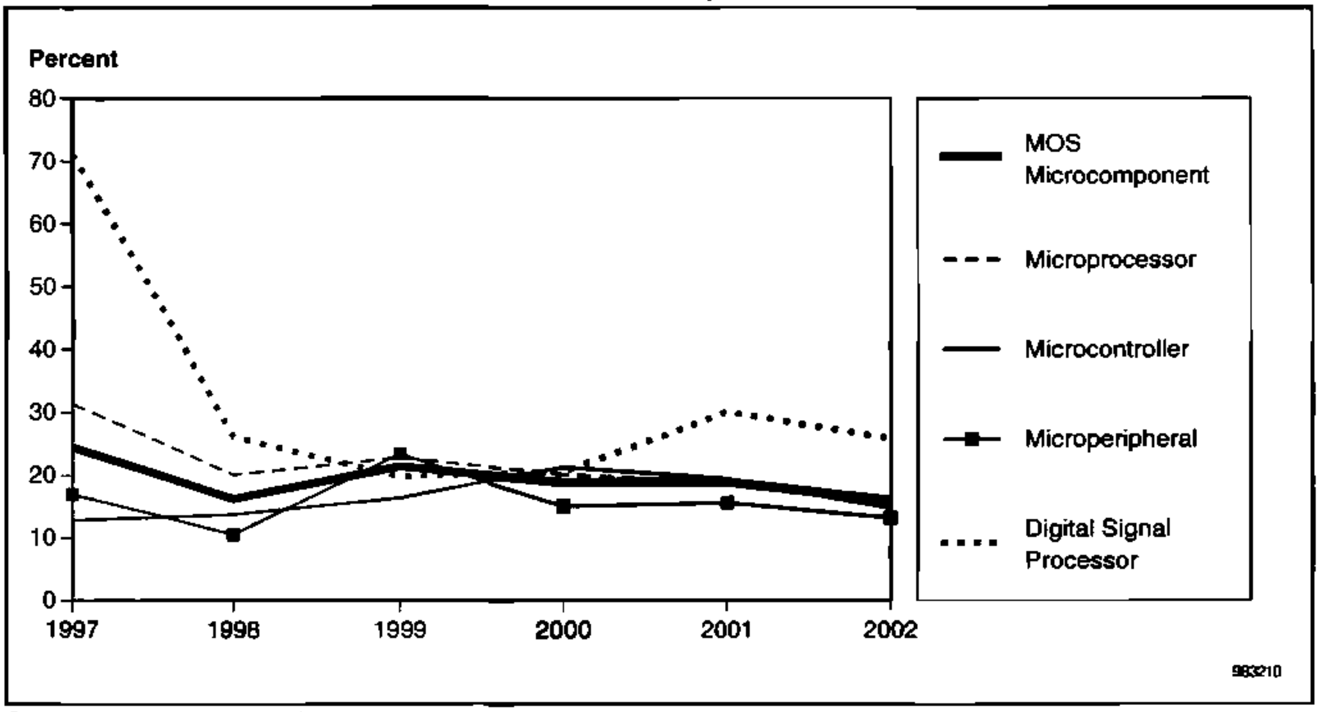
Table 3-3
MOS Microcomponent Market Forecast by Product in Asia/Pacific, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
MOS Microcomponent	10,885	12,651	15,360	18,260	21,710	25,170	18.3
Microprocessor	4,456	5,349	6,570	7,890	9,370	10,900	19.6
Microcontroller	2,313	2,630	3,060	3,710	4,430	5,080	17.0
Microperipheral	3,315	3,662	4,520	5,200	6,010	6,800	15.5
Digital Signal Processor	801	1,010	1,210	1,460	1,900	2,390	24.4

Source: Dataquest (June 1998)

Figure 3-3
MOS Microcomponent Market Growth Rates by Product in Asia/Pacific, 1997 to 2002



Source: Dataquest (June 1998)

In the long term, the CBIC market will reach $3.6 billion by 2002, an impressive 28.1 percent-plus CAGR from 1997 to 2002. PLDs will expand at nearly a 23.8 percent CAGR and reach $422 million by 2002. Other MOS logic products will grow at a respectable 16.5 percent CAGR. Standard logic will grow slowly, while gate arrays will decline.

Table 3-4 and Figure 3-4 show the MOS digital logic consumption forecast and growth rates by product in Asia/Pacific during the next five-year period.

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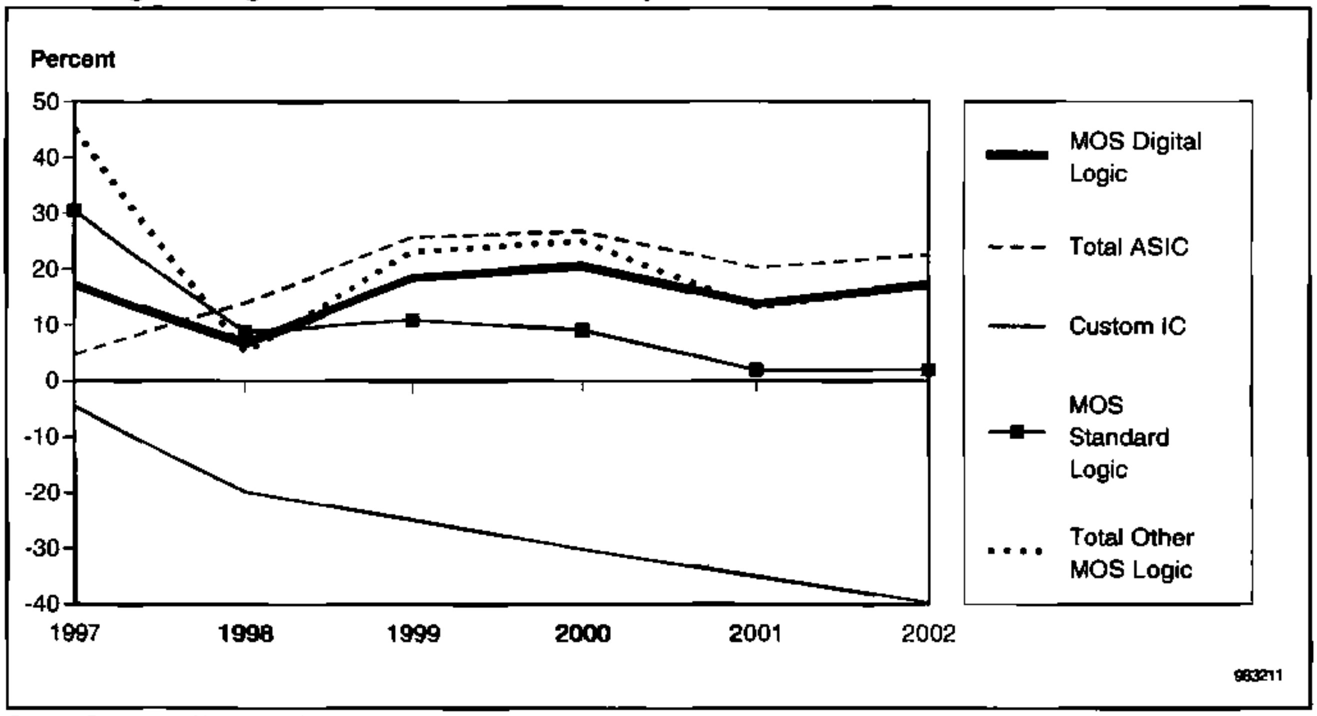
Table 3-4
MOS Digital Logic Market Forecast by Product in Asia/Pacific, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
MOS Digital Logic	3,909	4,172	4,940	5,955	6,775	7,940	15.2
Total ASIC	1,662	1,893	2,380	3,015	3,625	4,443	21.7
Custom IC	425	341	256	179	116	70	-30.3
MOS Standard Logic	616	670	743	810	826	843	6.5
Total Other MOS Logic	1,206	1,268	1,561	1,951	2,208	2,584	16.5

Source: Dataquest (June 1998)

Figure 3-4
MOS Digital Logic Market Growth Rates by Product in Asia/Pacific, 1997 to 2002



Source: Dataquest (June 1998)

Analog Monolithic

The Asia/Pacific analog IC market in 1998 is forecast to grow 14.6 percent and total $7.2 billion. The Asian financial crisis should reduce consumer demand in Asia/Pacific and Japan, which will slow analog products' growth. In 1997, the analog market expanded by 24.1 percent.

The Asia/Pacific analog IC market should grow at a 17.5 percent CAGR for the 1997-to-2002 period to reach $14.2 billion by 2002. Looking at the long-term trends to 2002, mixed-signal ICs will experience a solid growth, driven by the application markets such as digital cellular. In addition, new, emerging applications in the consumer and communications market will contribute to the growth of mixed-signal ICs. In the more traditional standard linear product area, voltage-regulator products will continue to enjoy strong growth as the demand for smart power continues to grow, especially in the portable PC and electronics markets.

Discrete and Optical Semiconductor

Asia/Pacific's discrete market should increase in 1998 by 8.8 percent to $4.2 billion. The long-term forecast assumes a stable market. Dataquest forecasts a 10.2 percent CAGR in discrete products through 2002, totaling $6.2 billion.

Asia/Pacific's optoelectronic semiconductor market will grow only 3.5 percent in 1998 and total $0.9 billion. This market grew by 23.5 percent in 1997. By 2002, Asia/Pacific's optoelectronics semiconductor market will total $1.5 billion, which represents a 10.2 percent CAGR for the five-year period from 1997 to 2002.

Table 3-5 and Figure 3-5 show the analog/discrete/optical semiconductor market forecast and growth rates in Asia/Pacific during the next five-year period.

Table 3-5
Analog/Discrete/Optical Semiconductor Market Forecast in Asia/Pacific, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Analog Monolithic	6,310	7,234	8,608	10,610	12,467	14,160	17.5
Discrete	3,817	4,151	4,573	5,189	5,560	6,200	10.2
Optical Semiconductor	913	945	1,021	1,174	1,301	1,481	10.2

Source: Dataquest (June 1998)

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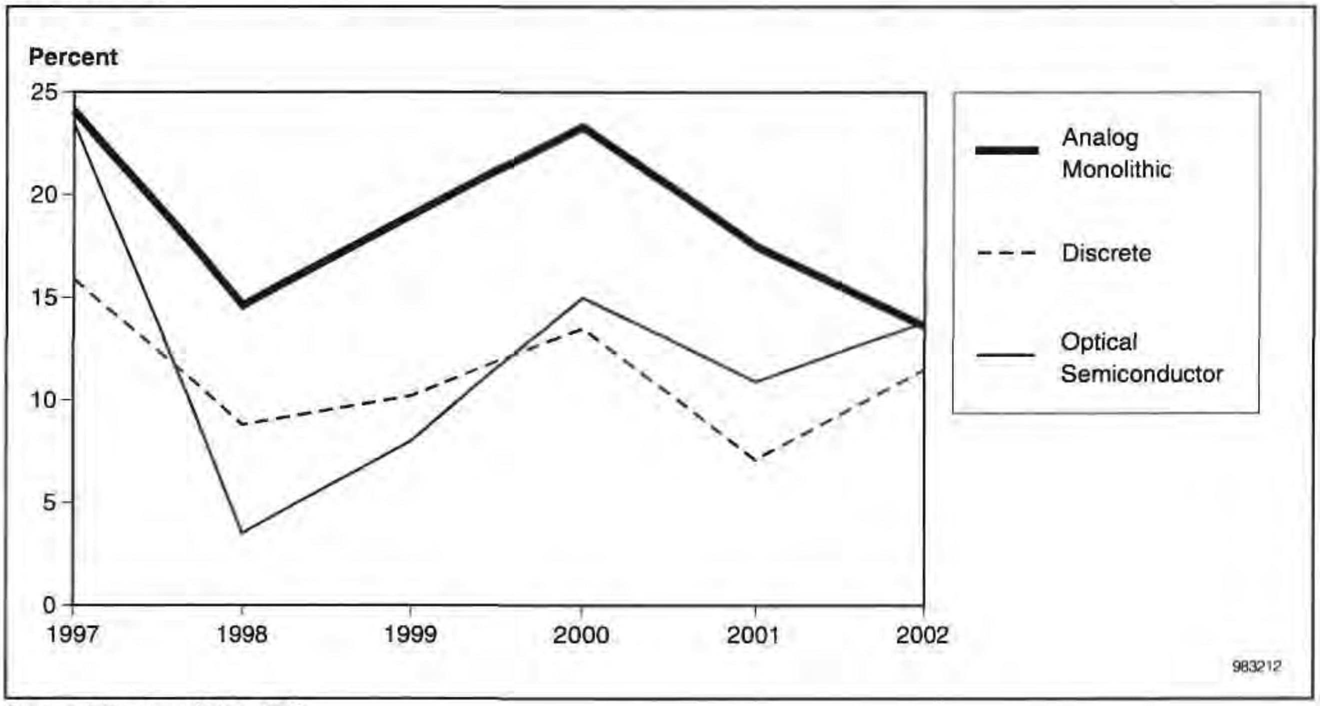
Figure 3-5
Analog/Discrete/Optical Semiconductor Market Growth Rates in Asia/Pacific, 1997 to 2002



Source: Dataquest (June 1998)

Chapter 4
Asia/Pacific Semiconductor Forecast by Region

This chapter presents the semiconductor market and major electronic equipment production forecast during the five-year period from 1997 to 2002 in China/Hong Kong, Singapore, South Korea, and Taiwan. This chapter's tables and the figures provide the complete, five-year forecast by region in the Asia/Pacific semiconductor market and major electronic equipment production.

China/Hong Kong Semiconductor Forecast

China/Hong Kong's semiconductor market is forecast to grow by 15.5 percent in 1998 and total about $7.8 billion. By 2002, China/Hong Kong's market will total $17.6 billion, which marks a 21.1 percent CAGR for the 1997-to-2002 period.

Forecast Highlights and Assumptions

The following are key assumptions and highlights of this forecast:

- The China and Hong Kong economies should grow by an estimated 8 percent and 2.7 percent, respectively. The Asia/Pacific region should begin to recover from the regional economic turmoil next year.
- China's electronics equipment production will grow nearly 20 percent this year. China now stands as the largest semiconductor market in Asia/Pacific. China represents a huge consumer of communications and computer equipment, accounting for 25 percent of all personal computers purchased in Asia/Pacific. China's PC unit growth exceeds a 40 percent annual rate.
- The five-year forecast shows that the China/Hong Kong semiconductor market will be expanded from $6.8 billion in 1997 to $17.6 billion in 2002, at a 21.1 percent CAGR, far higher than the region's 15.7 percent CAGR. In 1998, China/Hong semiconductor market will grow 15.5 percent and total nearly $7.8 billion.
- MOS memory devices will be depressed in 1998 due to the sluggishness of DRAM prices in 1998.
- MOS microcomponent market remains largely consistent with prior expections. This product market should grow at a 24.3 percent CAGR for 1997 through 2002, reaching $6.5 billion in 2002.
- However, the MOS digital logic market will increase from $0.9 billion in 1997 to $1.8 billion by 2002, with an 15.5 percent CAGR. The MOS digital logic market share of the total semiconductor market will decrease from 13.2 percent in 1997 to 10.4 percent in 2002.
- Analog market will surge from $1.4 billion in 1997 to $4.3 billion by 2002, with a 25 percent CAGR. As a result, the analog market's proportion of total semiconductors will be expected to increase from 21 percent in 1997 to 24.7 percent in 2002.
- Dataquest expects the discretes and optoelectronics market to expand from $1 billion in 1997 to $2.2 billion by 2002, with a 14.7 percent CAGR.

China/Hong Kong Semiconductor Market Trends by Product

Table 4-1 presents the China/Hong Kong semiconductor market forecast by product from 1997 to 2002.

Figure 4-1 illustrates the China/Hong Kong semiconductor market comparison by product in 1997 and 2002.

Table 4-1
Total China/Hong Kong Semiconductor Market Forecast by Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Semiconductor	**6,769**	**7,819**	**9,429**	**12,098**	**15,951**	**17,593**	**21.1**
Total Integrated Circuit	5,705	6,600	8,007	10,404	13,994	15,320	21.8
Total Bipolar Digital	42	35	29	23	18	14	-19.3
MOS Memory	1,142	1,178	1,433	2,066	3,476	2,586	17.8
Dynamic RAM	800	817	981	1,471	2,721	1,687	16.1
Static RAM	87	92	138	213	277	308	28.6
Nonvolatile Memory	239	253	297	361	456	571	19.0
EPROM	45	43	38	35	33	31	-7.0
EEPROM	55	59	64	73	91	107	14.2
Flash Memory	92	107	142	196	271	366	31.9
Mask ROM	48	45	52	57	62	67	7.0
Other MOS Memory	15	16	18	20	21	20	5.3
MOS Microcomponent	2,206	2,676	3,256	4,182	5,343	6,543	24.3
Microprocessor	881	1,092	1,376	1,789	2,290	2,863	26.6
Microcontroller	680	775	891	1,114	1,411	1,693	20.0
Microperipheral	480	560	652	842	1,095	1,304	22.1
Digital Signal Processor	165	249	336	437	547	683	32.9
MOS Digital Logic	895	978	1,128	1,310	1,548	1,838	15.5
Total ASIC	253	266	346	467	634	850	27.4
Custom IC	78	74	63	50	35	23	-21.7
MOS Standard Logic	197	223	254	262	285	300	8.8
Total Other MOS Logic	368	416	465	531	594	666	12.6
Analog Monolithic	1,419	1,731	2,161	2,824	3,609	4,339	25.0
Total Discrete	859	988	1,166	1,399	1,609	1,866	16.8
Total Optical Semiconductor	205	231	256	295	348	407	14.7

Source: Dataquest (June 1998)

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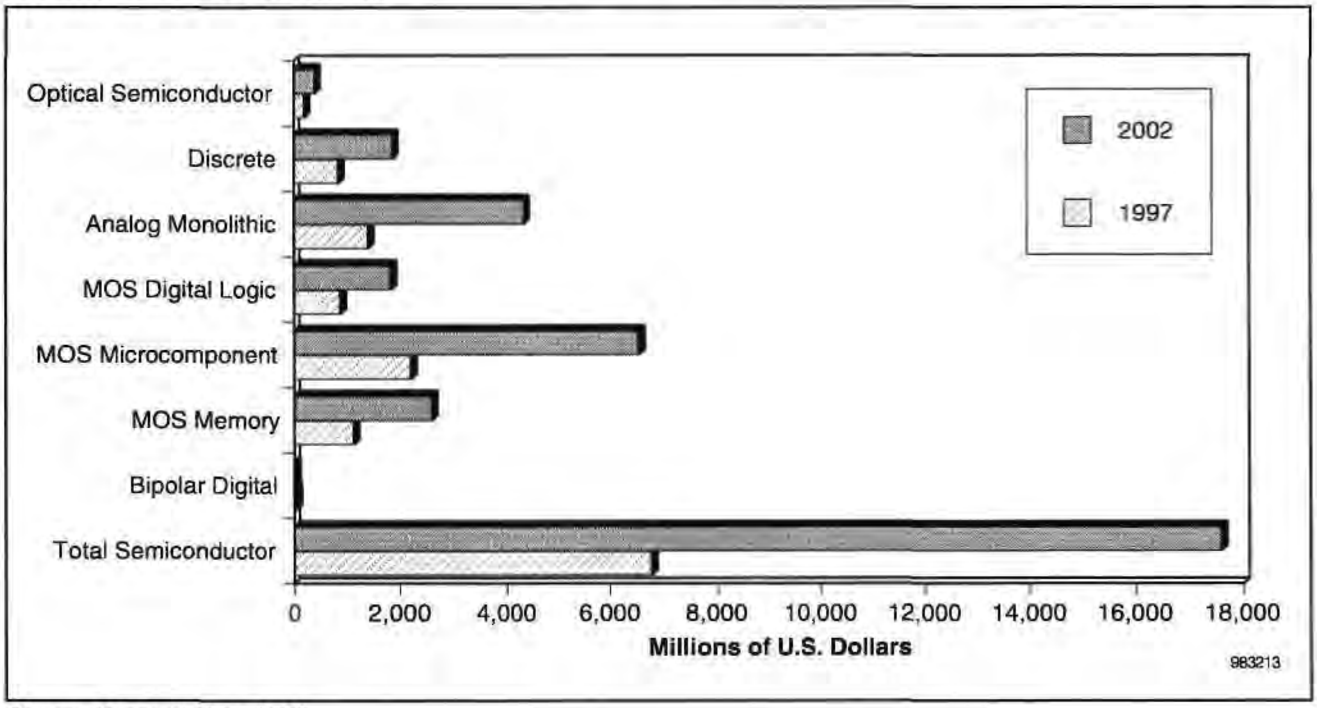
Figure 4-1
Total China/Hong Kong Semiconductor Market Comparison by Product, 1997 and 2002 (Millions of U.S. Dollars)



Source: Dataquest (June 1998)

MOS Memory

The following highlights summarize China/Hong Kong's MOS memory market:

- The consumption of MOS memory products in China/Hong Kong reached $1.1 billion in 1997. Revenue from MOS memory products is expected to show only a 3.2 percent growth in 1998 as market conditions remain weak. MOS memory products should exhibit the highest fluctuating annual percentage changes as DRAM pricing movements take hold. From 1999 to 2001, the MOS memory market is forecast to rise rapidly, before nose-diving in 2002 when a glut in DRAM devices resurfaces again.
- The MOS memory market is estimated to increase to about $2.6 billion by 2002. The 1997-to-2002 CAGR of 17.8 percent will result in MOS memory products representing the third-largest device category over the five-year forecast period.
- DRAM devices constituted the largest segment of the MOS memory product category in 1997. Flash memory devices took second place instead of SRAM. The positions of these three device segments are forecast to be unchanged in 2002.

MOS Microcomponent

MOS microcomponent market highlights are as follows:

- The consumption of MOS microcomponent products reached $2.2 billion in 1997. Revenue from MOS microcomponent products is expected to register 21.3 percent growth in 1998, as a result of increased demand from PCs and cellular phones.
- The MOS microcomponent market is estimated to rise to $6.5 billion by 2002. With a 24.3 percent CAGR from 1997 to 2002, MOS microcomponent products will continue to represent the largest device category over the five-year forecast cycle.
- Microprocessor devices represent the largest segment in the MOS microcomponent product category, followed by microperipheral and microcontroller devices. Although these devices are expected to remain dominant until 2002, the increasing use of DSP devices in many high-volume applications is likely to contribute significant revenue growth in the MOS microcomponent market.

MOS Digital Logic

MOS digital logic market highlights include the following:

- The consumption of MOS digital logic products reached $0.9 billion, overtaking discrete products for the first time in 1997. MOS digital logic is expected to record a 9.2 percent growth in 1998. Such low growth results from the decline of custom IC devices.
- The MOS digital logic market is projected to reach about $1.8 billion by 2002 with a 15.5 percent CAGR from 1997 to 2002.
- ASIC devices will show the fastest revenue growth in the MOS digital logic product category. The ASIC segment will increasingly dominate the growth trend as CBICs present the most viable path toward integrating systems on a chip.

Analog Monolithic

Analog monolithic market highlights are as follows:

- The consumption of analog products in China/Hong Kong reached $1.4 billion in 1997. Revenue from analog products is expected to show a 22 percent growth in 1998, as market conditions are expected to improve.
- Analog product revenue is estimated to increase to $4.4 billion by 2002, with a 25 percent CAGR for the 1997-to-2002 period. As a result, the analog market represents the second-largest device category over the next five-year period.

Discrete and Optical Semiconductor

Discrete and optical semiconductor highlights include the following:

- The discrete market is estimated to increase to $1.9 billion by 2002. With a projected 16.8 percent CAGR for the 1997-to-2002 period, discrete products will continue to represent steady revenue expansion in this five-year period.
- The optical semiconductor market is expected to increase to $0.4 billion by 2002 with a 14.7 percent CAGR.

Singapore's Semiconductor Forecast

The Asia/Pacific region was hit by the Asian financial crisis in 1997. The region's countries are likely to see depressed economic growth as a result of consumption and investment downturn. Among the economies worst affected are the Southeast Asian nations, including Singapore. The city state's growth rate this year is projected to be 2.5 percent, according to Dataquest. This forecast is within the Singaporean government's estimated GDP growth range of 2.5 percent to 4.5 percent.

Although the U.S. and European economies continue to show signs of strength, the regional situation closer to Singapore is expected to have a downward impact on the economy's health. Recent regional developments, including Indonesia's social unrest and the weak Japanese economy, have further dampened the demand of Singapore exports in 1998. The latest trade figures released by the government show that domestic exports contracted by 2.1 percent in April. The decline reflected the lower sales of electronic equipment, rigid disk drives, and PCs, as regional demand remains weak.

Singapore's semiconductor market will grow by 11.8 percent in 1998 and reach about $5.6 billion. In the long term, Singapore's semiconductor market will total $11 billion, with a 17.2 percent CAGR for the period from 1997 to 2002.

Forecast Highlights and Assumptions

The following are key assumptions and highlights of this forecast:

- The Asia/Pacific GDP growth rates are likely to be negatively impacted by the Asian financial crisis in 1998. Singapore's economy is expected to grow by an estimated 2.5 percent. The Asia/Pacific region should begin to recover from the regional economic turmoil next year.
- By the end of this decade, Dataquest forecasts that Asia/Pacific is likely to become the world's second-largest production region of electronic equipment. Data processing and communications equipment are forecast to drive Singapore's total electronic equipment production growth. Semiconductor consumption is expected to rise as a result of increasing semiconductor content.
- Prices of memory products, especially DRAM devices, are expected to bottom out this year. The DRAM market is projected to move closer to demand-supply balance by the end of this decade. DRAM prices are expected to peak in 2001, before softening again in 2002.
- In 1997, the top six equipment categories manufactured in Singapore included rigid disk drive, serial printer, PC, pager, color television, and digital cellular telephone. Production revenue of these six major electronic equipment segments is expected to record a five-year CAGR of 12.6 percent.
- From 1999 to 2001, the MOS memory market is expected to rise rapidly, before nose-diving in 2002 when a glut in the DRAM market re-emerges.

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- With the highest 1997-to-2002 CAGR of 19.5 percent, MOS microcomponent products will continue to represent the largest device category in this five-year forecast cycle.
- MOS digital logic products emerged as the third-largest product category in Singapore in 1997. A 16.8 percent CAGR from 1997 to 2002 is predicted as a result of these products finding increased applications and the industry trend toward system-level integration.

Singapore's Semiconductor Market Trends by Product

Table 4-2 shows Singapore's semiconductor market forecast by product from 1997 to 2002.

Figure 4-2 illustrates Singapore's semiconductor market comparison by product in 1997 and 2002. This year, Singapore's semiconductor consumption is projected to expand by 11.8 percent.

Table 4-2
Total Singapore Semiconductor Market Forecast by Product, 1997 to 2002
(Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Semiconductor	**4,972**	**5,560**	**6,790**	**8,472**	**10,798**	**11,012**	**17.2**
Total Integrated Circuit	4,435	4,920	6,065	7,640	9,868	10,007	17.7
Total Bipolar Digital	18	18	15	11	8	6	-18.1
MOS Memory	1,166	1,183	1,490	2,086	3,338	2,532	16.8
Dynamic RAM	845	840	1,060	1,500	2,650	1,750	15.7
Static RAM	90	107	155	227	270	300	27.2
Nonvolatile Memory	228	231	267	349	404	470	15.6
EPROM	47	36	31	27	24	22	-14.1
EEPROM	32	35	44	56	70	83	21.0
Flash Memory	115	125	153	225	270	325	23.1
Mask ROM	34	35	39	41	40	40	3.3
Other MOS Memory	3	5	8	10	14	12	32.0
MOS Microcomponent	1,689	1,960	2,447	2,950	3,525	4,110	19.5
Microprocessor	865	1,020	1,317	1,600	1,900	2,210	20.6
Microcontroller	335	385	450	550	660	760	17.8
Microperipheral	328	350	435	500	580	660	15.0
Digital Signal Processor	161	205	245	300	385	480	24.4
MOS Digital Logic	817	889	1,063	1,293	1,487	1,779	16.8
Total ASIC	468	531	659	818	990	1,238	21.5
Custom IC	54	40	34	26	18	14	-23.7
MOS Standard Logic	122	133	147	160	164	167	6.5
Total Other MOS Logic	173	185	223	289	315	360	15.8
Analog Monolithic	745	870	1,050	1,300	1,510	1,580	16.2
Total Discrete	435	510	585	670	750	800	13.0
Total Optical Semiconductor	102	130	140	162	180	205	15.0

Source: Dataquest (June 1998)

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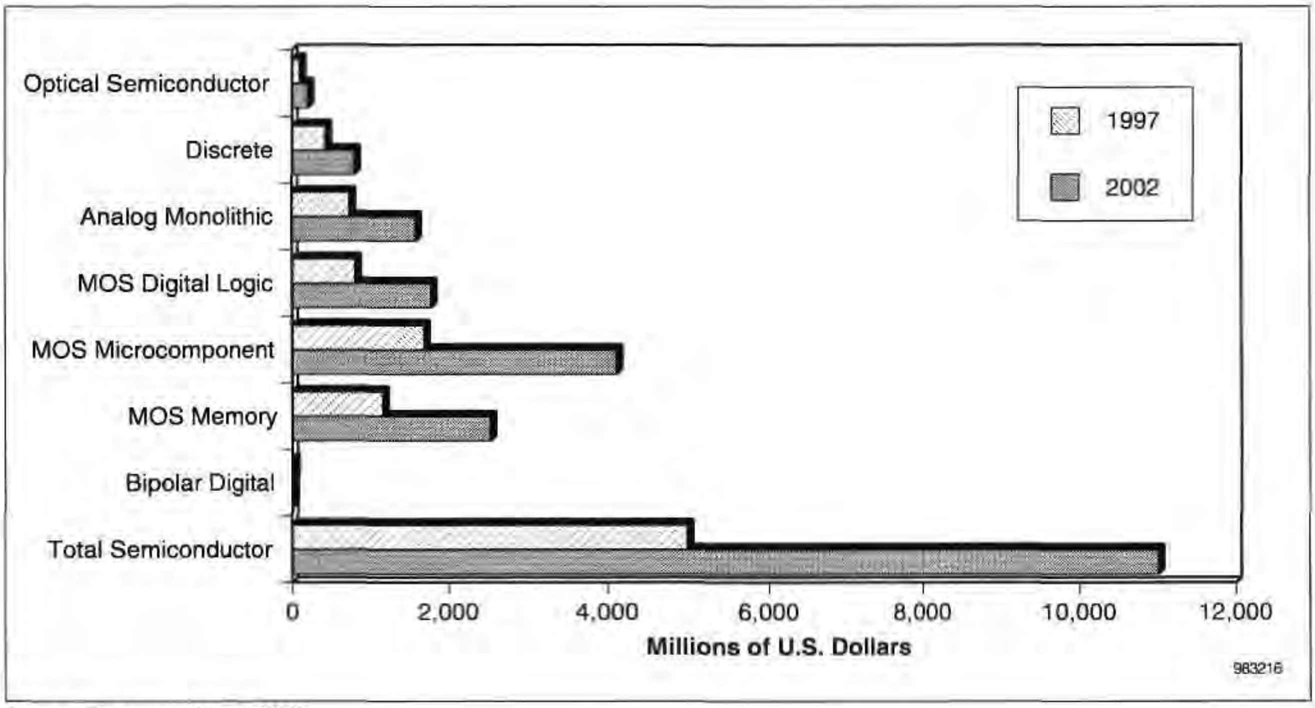
Figure 4-2
Total Singapore Semiconductor Market Comparison by Product, 1997 and 2002 (Millions of U.S. Dollars)



Source: Dataquest (June 1998)

MOS Memory

MOS memory trends include the following:

- Singapore's consumption of MOS memory products reached $1.2 billion in 1997. Revenue from MOS memory products is expected to register a flat 1.5 percent growth this year as the market remains weak. MOS memory products should exhibit the highest fluctuating annual percentage changes as DRAM pricing movements take hold. From 1999 to 2001, the MOS memory market is forecast to rise rapidly, before nose-diving in 2002 when a glut in DRAM devices resurfaces again.
- The MOS memory market is estimated to increase to $2.5 billion by 2002. The 1997-to-2002 CAGR of 16.8 percent will result in MOS memory products representing the second-largest device category over this five-year period.
- DRAM devices constituted the largest segment of the MOS memory product category in 1997. Flash memory devices took second place with SRAMs occupying the No. 3 spot. The positions of these three device segments are forecast to be unchanged by 2002.

MOS Microcomponent

MOS microcomponent trends include the following:

- The consumption of MOS microcomponent products reached $1.7 billion in 1997. MOS microcomponent revenue is expected to register a 16 percent growth in 1998, as a result of increased demand from PCs, printers, and cellular phones.
- The MOS microcomponent market is estimated to rise to $4.1 billion by 2002. With the highest 1997-to-2002 CAGR of 19.5 percent, MOS microcomponent products will continue to represent the largest device category in this five-year forecast cycle.
- Microprocessor devices represent the largest segment in the MOS microcomponent product category, followed by microcontroller and microperipheral devices. Although these devices are expected to remain dominant until 2002, the increasing use of DSP devices in many high-volume applications is likely to contribute significant revenue growth in the MOS microcomponent market.

MOS Digital Logic

MOS digital logic trends include the following:

- MOS digital logic products emerged as the third-largest product category in Singapore in 1997. The product consumption reached $0.8 billion, overtaking analog products for the first time in 1997. MOS digital logic is expected to record an 8.8 percent revenue growth in 1998.
- The MOS digital logic market is projected to increase to $1.8 billion by 2002. A 16.8 percent CAGR from 1997 to 2002 is predicted as a result of these products finding increased applications and the industry trend toward system-level integration.
- ASIC devices dominate the largest portion of revenue in the MOS digital logic product category. The ASIC segment will increasingly dominate the growth trend as CBICs present the most viable path toward integrating systems on a chip.

Analog Monolithic

Analog monolithic trends include the following:

- Singapore's consumption of analog products reached $0.7 billion in 1997. Revenue from analog products is expected to show a 16.8 percent growth this year as market conditions are expected to improve.

Discrete and Optical Semiconductor

Discrete and optical semiconductor trends include the following:

- The combined consumption of discrete and optical semiconductor products reached $0.5 billion in 1997. Revenue from this combined product category is forecast to register 19.2 percent growth this year as a result of increased demand from a wide range of data processing, consumer, and communications equipment.
- The discrete market is estimated to increase to $0.8 billion by 2002. With a projected 1997-to-2002 CAGR of 13 percent, discrete products will continue to represent steady revenue expansion in the five-year period.
- The optical semiconductor market is expected to increase to $0.2 billion by 2002 with a 15 percent CAGR.

South Korea's Semiconductor Forecast

With sluggish domestic consumption and tight money supply, the South Korean GDP is expected to be at negative 1.8 percent in 1998. If Korea fails to reform its flagging economy and its industrial restructuring go awry, the GDP may shrink by as much as 2 percent year on year. GDP measures the value of a country's total output of goods and services, subtracting income from its foreign direct investments.

Dataquest estimates that a 15 percent drop in domestic consumption will wipe out any positive effect of the trade surpluses and drag down economic growth to about negative 1.8 percent from 1997's 5.5 percent. Assisted by a sharp fall in import demands, the current-account balance was expected to swing from a deficit of $23.5 billion in 1997 to a surplus of about $35 billion. The annual jobless rate will stop short of 7 percent, or 1.5 million unemployed workers. It also expected that the consumer price index will post a yearly gain over 10 percent.

Dataquest expects that, depending on the results of the ongoing restructuring of industrial and financial companies, the Korean economy may be able to regain its vitality gradually, starting in 1999. The yearly GDP growth will climb to 2.2 percent next year, 5.7 percent in 2000, 5.6 percent in 2001, and 5.6 percent in 2002.

As the won-dollar exchange rate become more stable and domestic demand expands, however, current-account surpluses will contract, declining to $16.4 billion in 1999, $10.2 billion in 2000, $8.5 billion in 2001, and $6.7 billion in 2002. The unemployment rate will also stabilize at 3 percent to 4 percent in 2000.

Although Korea represented 17 percent of Asia/Pacific's semiconductor consumption in historical forecast, this proportion of Asia/Pacific's semiconductor consumption will decline a little in 1998 because of IMF restrictions.

Korea's semiconductor market will grow by 9.1 percent in 1998 and reach about $6 billion. Dataquest predicts that Korea's semiconductor market will show its steady growth from 1999, recovering from the financial crisis in the fourth quarter of 1998. As a result, Korea's semiconductor market will total $11.6 billion, with a 16.2 percent CAGR from 1997 to 2002.

Forecast Highlights and Assumptions

The following are key assumptions and highlights of this forecast:

- Korea's semiconductor market will increase by about 9 percent in 1998 to a total of $6 billion. The Korean financial crisis and low DRAM pricing will hamper semiconductor revenue growth in 1998, although some product segments will achieve robust double-digit growth rates. For 1999, the market should grow by 19 percent and total about $7 billion. The long-term growth will be somewhat slower than the prior forecast. By 2002, Korean semiconductor market will total $11.6 billion, which marks a 16.2 percent CAGR for the five-year period from 1997 to 2002.

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- Korea's PC unit production will decline by 14 percent in 1998 and total 1.6 million units. PC production revenue will decrease by 18 percent this year and reach about $1 billion. For the long term, the semiconductor forecast assumes that Korea's PC production will grow at a 10.4 percent CAGR for the five-year period and total just over 3 million units for 2002. PC production revenue, however, will grow at a slower 8.1 percent CAGR because of the declining PC prices.
- The semiconductor industry should retain long-term vitality. PCs, communications, and consumer electronics will continue to rank as Korea's most important application markets during the five-year forecast period from 1997 to 2002.
- MOS microcomponent products, especially digital signal processors (DSPs), will continue to fuel the growth of Korea's semiconductor market. DSPs rank among the highest-growth semiconductor products. This device is the centerpiece of communications electronics—such as cellular phones, modems, and the emerging consumer digital electronics. The Korean DSP market should grow at a 26.4 percent CAGR for the 1997-to-2002 period and approach $0.3 billion by 2002.
- Memory IC trends, especially DRAM pricing, serve as a key swing factor in both the near-term and long-term forecasts. In 1998, Korea's memory market should decline by 5.9 percent; the DRAM market is expected to decrease by 12.4 percent in 1998.
- MOS digital logic market will increase from $0.7 billion in 1997 to $1.5 billion by 2002, with a 16.5 percent CAGR.
- Analog market will grow at a 17.9 percent CAGR for the 1997-to-2002 period and approach $3.3 billion by 2002.
- Dataquest expects the combined market for discrete and optical semiconductors to expand from nearly $1 billion in 1997 to $1.6 billion by 2002, with a 10.9 percent CAGR.

South Korea's Semiconductor Market Trends by Product

Table 4-3 presents the South Korea semiconductor market forecast by product from 1997 to 2002.

Figure 4-3 depicts South Korea's semiconductor market comparison by product in 1997 and 2002.

Table 4-3
Total South Korea Semiconductor Market Forecast by Product, 1997 to 2002
(Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Semiconductor	**5,490**	**5,989**	**7,130**	**8,665**	**10,576**	**11,612**	**16.2**
Total Integrated Circuit	4,513	4,929	5,965	7,325	9,116	9,972	17.2
Total Bipolar Digital	23	21	19	18	13	11	-14.5
MOS Memory	781	735	903	1,162	1,839	1,534	14.5
Dynamic RAM	525	460	570	740	1,350	980	13.3
Static RAM	75	85	120	175	205	225	24.6
Nonvolatile Memory	174	183	204	236	272	318	12.8
EPROM	28	22	19	17	15	14	-12.9
EEPROM	42	46	51	58	72	86	15.4
Flash Memory	68	84	100	125	150	183	21.9
Mask ROM	36	31	34	36	35	35	-0.6
Other MOS Memory	7	7	9	11	12	11	9.5
MOS Microcomponent	1,567	1,780	2,178	2,620	3,125	3,640	18.4
Microprocessor	564	640	810	980	1,160	1,350	19.1
Microcontroller	532	600	700	850	1,020	1,180	17.3
Microperipheral	378	420	520	610	710	810	16.5
Digital Signal Processor	93	120	148	180	235	300	26.4
MOS Digital Logic	716	763	915	1,125	1,289	1,537	16.5
Total ASIC	282	330	420	540	655	820	23.8
Custom IC	86	65	50	35	22	13	-31.5
MOS Standard Logic	84	90	100	110	112	114	6.3
Total Other MOS Logic	264	278	345	440	500	590	17.4
Analog-Monolithic	1,426	1,630	1,950	2,400	2,850	3,250	17.9
Total Discrete	802	880	970	1,110	1,200	1,340	10.8
Total Optical Semiconductor	175	180	195	230	260	300	11.4

Source: Dataquest (June 1998)

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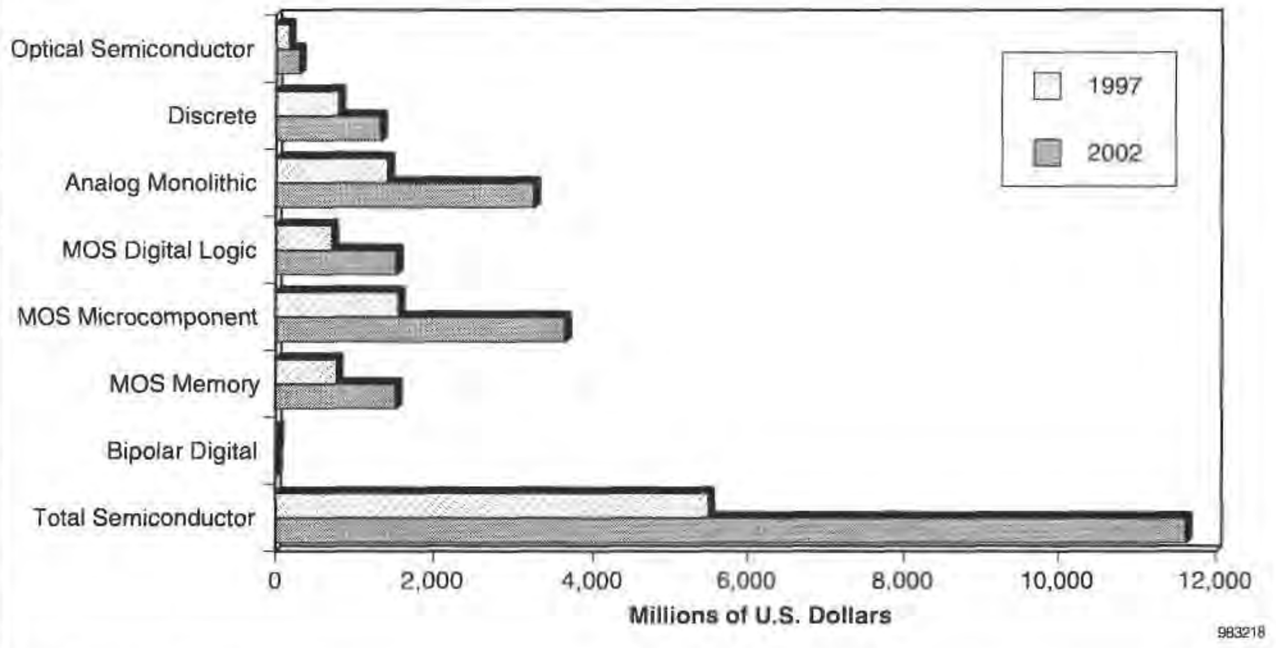
Figure 4-3
Total South Korea Semiconductor Market Comparison by Product, 1997 and 2002 (Millions of U.S. Dollars)



Source: Dataquest (June 1998)

MOS Memory

MOS memory trends include the following:

- South Korea's MOS memory consumption reached $0.8 billion in 1997. Revenue from MOS memory products is expected to decline 5.9 percent this year as the market remains weak. MOS memory products should exhibit the highest fluctuating annual percentage changes as DRAM pricing movements take hold. From 1999 to 2001, the MOS memory market is forecast to rise rapidly, before nose-diving in 2002 when a glut in DRAM devices resurfaces again.
- The MOS memory market is estimated to increase to $1.5 billion by 2002. The 1997-to-2002 CAGR of 14.5 percent will result in MOS memory products representing the fourth-largest device category in the five-year period.
- DRAM devices constituted the largest segment of the MOS memory product category in 1997. SRAM devices takes second place with flash memory occupying the third spot. The positions of these three device segments are forecast to be unchanged in 2002.

The following summarizes memory IC product outlooks:

- DRAM should decrease by 12.4 percent in 1998 and total $460 million. By 2002, South Korea's DRAM revenue will total about $980 million, which marks a 13.3 percent CAGR from 1997 to 2002.
- SRAM will grow by 13.3 percent in 1998 and total $85 million. In the long term, South Korea's SRAM revenue will total $225 million, a 24.6 percent CAGR for the period from 1997 to 2002.
- Flash should increase by 23.5 percent in 1998 and reach the $84 million level. By 2002, South Korea's flash revenue will total $183 million, which is a 21.9 percent CAGR for the 1997-to-2002 period.
- EEPROM will increase by 9.5 percent in 1998 and reach the $46 million mark. By 2002, South Korea's EEPROM revenue will approach $86 million, for a 15.4 percent CAGR from 1997 to 2002.
- EPROM should decrease by more than 20 percent in 1998, declining to $22 million. By 2002, South Korea's EPROM revenue will decline to just $14 million.
- Mask ROM will decrease by more than 13 percent in 1998, declining to $31 million. By 2002, South Korea's mask ROM revenue will edge upward, however, to the $35 million level.

MOS Microcomponent

MOS microcomponent trends include the following:

- South Korea's MOS microcomponent revenue will increase this year and over the long term, but at a slower rate versus the 1992-to-1997 period. The MOS microcomponent market is estimated to increase to $3.6 billion by 2002, with an 18.4 percent CAGR during this five-year period from 1997 to 2002.
- For 1998, South Korea's MPU revenue should increase by 13.5 percent and reach $640 million. In the long term, South Korea's MPU revenue should reach $1,350 million, representing a 19.1 percent CAGR from 1997 to 2002. This is a slower, long-term MPU compound growth rate than the 1992-to-1997 period's CAGR. This mirrors the slower, long-term pace of PC revenue growth.
- Dataquest's forecast continues to assume that non-PC applications—such as digital cellular, digital consumer electronics, and data communications—will drive demand for MCUs and DSPs, including embedded versions.
- DSPs should increase by 29 percent in 1998, exceeding $100 million. By 2002, South Korea's DSP revenue will approach $300 million, which translates into a stellar 26.4 percent CAGR for the 1997-to-2002 period.
- Sharp price erosion for microcontroller (MCU) products means lower 1998 revenue. For 1998, South Korea's MCU revenue will increase by 12.8 percent and total $600 million. In the long term, South Korea's MCU revenue will total $1,180 million by 2002, with a 17.3 percent CAGR forecast for the 1997-to-2002 period.

MOS Digital Logic

MOS digital logic trends include the following:

- MOS digital logic is expected to record a 6.6 percent revenue growth this year and reach $763 million. The MOS digital logic market is projected to increase to $1,537 million by 2002. A 16.5 percent CAGR from 1997 to 2002 is predicted as a result of the industry trend toward system-level integration.
- ASIC market should increase by 17 percent in 1998 and total $330 million. By 2002, South Korea's ASIC revenue will total about $820 million, which marks a 23.8 percent CAGR for the 1997-to-2002 period.
- Custom IC revenue will decline by 24.4 percent in 1998 and total $65 million. In the long term, South Korea's custom IC revenue will total $13 million, which means a 31.5 percent CAGR decline from 1997 to 2002.
- Standard logic should increase by 7.1 percent in 1998 and reach the $90 million level. By 2002, South Korea's standard logic revenue will total $114 million, which is a 6.3 percent CAGR from 1997 to 2002.
- Other MOS logic will increase by 5.3 percent in 1998 and reach the $278 million mark. By 2002, South Korea's other MOS logic revenue will approach $590 million, for a 17.4 percent CAGR from 1997 to 2002.

Analog Monolithic

Analog monolithic trends include the following:

- South Korea's analog IC revenue during 1998 will grow by nearly 14.3 percent and total $1,630 million. The Korean financial crisis should reduce consumer demand in South Korea, which will slow the growth of analog products.
- Analog IC revenue should grow at a 17.9 percent CAGR for the 1997-to-2002 period and reach $3,250 million by 2002. Looking at the long-term trends to 2002, mixed-signal ICs will experience solid growth, driven by application markets such as digital cellular. In addition, new emerging applications in the consumer and communications market will contribute to the growth of mixed-signal ICs. In the more traditional standard linear product area, voltage-regulator products will continue to enjoy strong growth as the demand for smart power continues to grow, especially in the portable electronics markets.

Discrete and Optical Semiconductor

Discrete and optical semiconductor market trends include the following:

- Discrete product revenue should increase in 1998 by nearly 10 percent to $880 million. The long-term forecast assumes a stable market. Dataquest forecasts a 10.8 percent CAGR in discrete products through 2002, totaling $1,340 million.
- Optical semiconductor revenue will grow only 2.9 percent in 1998 and total $180 million. By 2002, South Korea's optical semiconductor revenue will total $300 million, representing an 11.4 percent CAGR from 1997 to 2002.

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Taiwan's Semiconductor Forecast

Taiwan's semiconductor market will increase by 13.9 percent in 1998 and reach about the $7.7 billion mark. By 2002, Taiwan's semiconductor market will approach nearly $15 billion, for a nearly 17.2 percent CAGR from 1997 to 2002.

Forecast Highlights and Assumptions

The following are key assumptions and highlights of this forecast:

- The Asia/Pacific GDP growth rates are likely to be negatively impacted by the Asian financial crisis in 1998. Taiwan's economy is expected to grow by an estimated 5.2 percent. The Asia/Pacific region should begin to recover from the regional economic turmoil in 1999.
- PCs were still the largest items in Taiwan, with a $5.7 billion revenue in 1997, which represented a 49.2 percent share of total PC production in Asia/Pacific. Dataquest predicts that PCs will grow aggressively at an 11.2 percent CAGR in the next five years, to $9.6 billion by 2002.
- Monitors ranked second in 1997. Monitors, however, will show slow growth of 5.8 percent in the next five years. Motherboards were the third-largest product segment, which is expected to show a 10.8 percent CAGR growth for the next five years.
- The five-year forecast shows the Taiwanese semiconductor market expanding from $6.8 billion in 1997 to $14.9 billion in 2002, at a 17.2 percent CAGR, higher than the region's 15.7 percent growth. In 1997, Taiwan's semiconductor market showed a 12.8 percent growth, compared to 1996, resulting in a total market of $6.8 billion. Excluding DRAM, the 1997 Taiwanese semiconductor market actually grew by 30.6 percent, led by 32 percent MOS microcomponent growth.
- MOS memory devices lost their overall position to MOS microcomponents in 1997 as the largest semiconductor category. This drastic change was caused mostly by the sluggish DRAM price in 1997.
- Taiwan's MOS microcomponent emerged as the largest semiconductor market category in 1997, overtaking MOS memory for the first time. The MOS microcomponent market has grown from $958 million in 1993 to $2.5 billion in 1997.
- MOS digital logic market will surge from $629 million in 1997 to $1.5 billion by 2002, with a 19.1 percent CAGR. The MOS digital logic market share of total semiconductor market should increase from 9.3 percent in 1997 to 10 percent in 2002.
- Dataquest projects a moderate growth for discrete of 12.2 percent CAGR to $1.2 billion in 2002. Analog products' market share of the total semiconductor market should decrease from 11.6 percent in 1997 to 12.6 percent in 2002.
- Dataquest expects the market for discretes and optoelectronics to expand from $846 million in 1997 to $1.5 billion by 2002, with a 12.1 percent CAGR.

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Taiwan Semiconductor Market Trends by Product

Table 4-4 presents Taiwan's semiconductor market forecast by product from 1997 to 2002.

Figure 4-4 illustrates the Taiwan semiconductor market comparison by product in 1997 and 2002.

Table 4-4
Total Taiwan Semiconductor Market Forecast by Product, 1997 to 2002
(Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Total Semiconductor	**6,754**	**7,694**	**9,262**	**11,294**	**14,367**	**14,917**	**17.2**
Total Integrated Circuit	5,908	6,719	8,181	10,064	13,027	13,422	17.8
Total Bipolar Digital	40	37	33	29	24	21	-12.1
MOS Memory	1,971	2,026	2,420	3,148	4,892	3,938	14.8
Dynamic RAM	1,517	1,535	1,800	2,350	3,950	2,850	13.4
Static RAM	166	175	255	370	440	490	24.2
Nonvolatile Memory	282	309	355	416	487	581	15.6
EPROM	46	36	30	26	23	21	-14.5
EEPROM	42	46	52	59	74	90	16.5
Flash Memory	157	192	235	290	350	430	22.3
Mask ROM	37	35	38	41	40	40	1.6
Other MOS Memory	6	7	10	12	15	17	23.2
MOS Microcomponent	2,482	3,015	3,699	4,428	5,256	6,080	19.6
Microprocessor	1,210	1,430	1,760	2,140	2,550	2,980	19.8
Microcontroller	363	415	490	600	715	830	18.0
Microperipheral	711	940	1,170	1,350	1,570	1,800	20.4
Digital Signal Processor	198	230	279	338	421	470	18.9
MOS Digital Logic	629	740	895	1,097	1,268	1,506	19.1
Total ASIC	301	400	510	650	790	970	26.4
Custom IC	75	60	47	32	20	11	-31.9
MOS Standard Logic	75	82	91	100	103	105	7.0
Total Other MOS Logic	178	198	247	315	355	420	18.7
Analog-Monolithic	786	901	1,134	1,362	1,587	1,877	19.0
Total Discrete	651	745	830	950	1,030	1,160	12.2
Total Optical Semiconductor	195	230	251	280	310	335	11.4

Source: Dataquest (June 1998)

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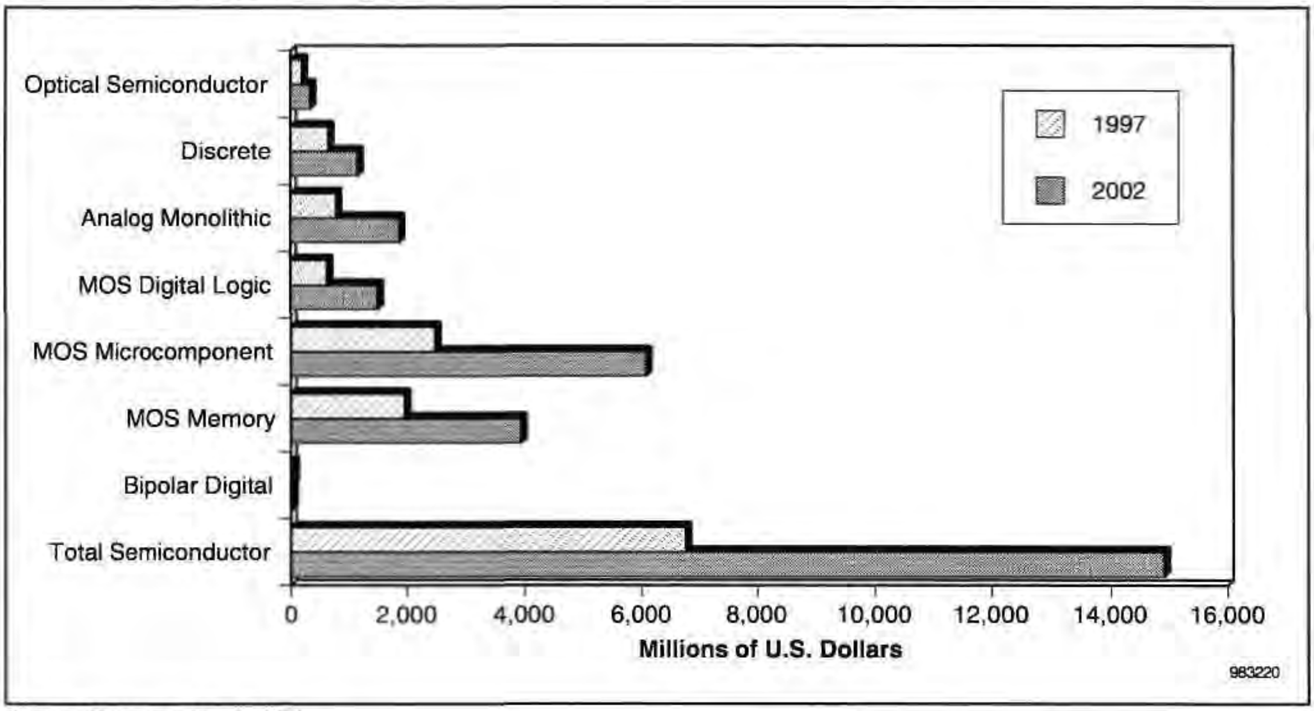
Figure 4-4
Total Taiwan Semiconductor Market Comparison by Product, 1997 and 2002 (Millions of U.S. Dollars)



Source: Dataquest (June 1998)

MOS Memory

MOS memory devices lost their overall position in 1997 as the largest semiconductor category to MOS microcomponents. This drastic change was caused mostly by the sluggish DRAM price in 1997. However, Taiwan's developing data processing industries will lead a demand for MOS memory consumption in the next five years. The MOS memory family continues to be the process driver for the semiconductor industry. Continued high demand for memory from the data processing segment and its pervasiveness in other applications will keep memory the important product family for the forecast period. Domestic demand for PCs is another driving force for the Taiwanese semiconductor market. Dataquest forecasts that the MOS memory market will surge from $2 billion in 1997 to $3.9 billion by 2002, with a 14.8 percent CAGR. MOS memory's market share of total semiconductor consumption should decrease from 29.2 percent in 1997 to 26.4 percent in 2002.

MOS Microcomponent

Taiwan's MOS microcomponent emerged as the largest semiconductor market category in 1997, overtaking MOS memory for the first time. The MOS microcomponent market has grown from $958 million in 1993 to $2.5 billion in 1997. Intel Corporation will maintain its dominance of the microprocessor market. Other companies with x86-type processors will be able to increase their business and take share from Intel. Strong demand for microcontrollers will continue. These products will continue to be designed into data processing and many other applications.

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The PC-driven microcomponents segment will increase from 36.7 percent of the semiconductor market in 1997 to almost 40.7 percent in 2002. Dataquest forecasts that the MOS microcomponent market will surge from $2.5 billion in 1997 to $6.1 billion by 2002, with a 19.6 percent CAGR.

MOS Digital Logic

MOS digital logic market demand in 1997 mainly comprised ASICs, standard logic products, other logic devices, and custom ICs. Demand for MOS digital logic devices continued to be driven by data processing, consumer, and increasingly, communications applications. MOS digital logic was the smallest subsegment of the MOS digital category. MOS digital logic market will surge from $629 million in 1997 to $1.5 billion by 2002, with a 19.1 percent CAGR. MOS digital logic's market share of the total semiconductor market will increase from 9.3 percent in 1997 to 10 percent in 2002.

Analog Monolithic

Dataquest's forecast shows analog to be the third-largest semiconductor device by 2002. Demand for analog devices now is expected to come from a more diverse mix of applications, such as communications and consumer. Dataquest projects a steady growth to $1.9 billion in 2002 with a 19 percent CAGR. Analog's market share of the total semiconductor market will decrease from 11.6 percent in 1997 to 12.6 percent in 2002.

Discrete and Optical Semiconductor

Discrete and optical semiconductor devices have an even-wider diversity of product applications that requires many types of discrete device, such as consumer, communications, and data processing. Dataquest expects the market for discretes and optoelectronics to expand from $0.8 billion in 1997 to $1.5 billion by 2002, with a 12.1 percent CAGR. The discrete and optical semiconductor market share of the total semiconductor market is expected to decrease from 12.5 percent in 1997 to 10 percent in 2002.

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1998 Semiconductor Production in Asia/Pacific

Market Trends

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Chapter 1
Executive Summary

Semiconductor production in Asia/Pacific has grown significantly in recent years. The semiconductor industry has witnessed the rise of South Korean companies as a manufacturing power, accompanied by their advancing worldwide rankings. Recently, the emergence of Taiwanese semiconductor contract manufacturing (SCM) companies has made a mark on the industry. Semiconductor production in these two countries will remain as the mainstay in the Asia/Pacific region.

Dataquest forecasts that the Asian financial crisis will reduce gross domestic product (GDP) growth of Asia/Pacific economies in 1998. South Korea (referred hereafter as Korea), one of the countries worst hit by the crisis, is predicted to stage a recovery by 1999. The impact of the Asian financial crisis on the region's semiconductor manufacturing companies is expected to cause delays in capacity expansion, according to Dataquest. As a result, growth is likely to become more moderate as companies freeze capital spending on plant and equipment.

Korea and Taiwan are the largest semiconductor production centers in the region. The next expansion wave in Asia/Pacific is predicted to come from Singapore, followed by China/Hong Kong. The benefits associated with semiconductor manufacturing—high value-added production, transfer of technology, and upskilling of the workforce—have sparked the interest of other countries in the region. Among the Southeast Asian nations, Malaysia is predicted to become a participant toward the end of this decade. By 2002, the Asia/Pacific semiconductor production revenue is predicted to grow 2.5 times its 1997 revenue.

This Market Trends report's objectives serve the following purposes:

- Review the 1997 Asia/Pacific semiconductor production—Estimate the 1997 revenue of the top manufacturers from the region's semiconductor production
- Forecast Asia/Pacific's semiconductor production trends from 1998 to 2002—Identify device segments driving the growth trends and provide breakdown of production by device segment
- Review the 1997 semiconductor production in China/Hong Kong, Korea, Singapore, and Taiwan—Estimate the 1997 revenue of the top manufacturers in each country
- Forecast semiconductor production trends in China/Hong Kong, Korea, Singapore, and Taiwan from 1998 to 2002—Identify device segments driving the growth trends in each country and provide the breakdown of production by device segment
- Provide insights into the defining characteristics for each country—Identify device segments driving the growth and break down production by device type

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Asia/Pacific's semiconductor production is defined by the place where the wafers are fabricated. The Asia/Pacific regional semiconductor production includes all regional production and production by foreign (non-Asian) manufacturers. Dataquest follows a methodology that uses the market share revenue database, the Asia/Pacific fab database, and projecting the production revenue of the device segments separately. These devices include memory, microcomponents, logic, analog, discrete, optoelectronics, and bipolar digital components. The production revenue projections are also checked against Dataquest's semiconductor device forecasts.

The following highlights the summary of the key findings:

- In 1997, almost 47 percent of Asia/Pacific's total available capacity was equipped to produce semiconductors with design rules of 0.35-micron or lower. Most of these advanced process technologies were installed in foundries and DRAM fabs. About 26 percent of total available capacity was manufacturing wafers using process technologies of 0.8-micron or higher.
- Semiconductor production revenue in Asia/Pacific reached an estimated $18,139 million in 1997. Korean companies—Samsung Electronics Company Ltd., LG Semicon Co. Ltd., and Hyundai Electronics Company Ltd.—were ranked as the top three semiconductor manufacturers. Taiwanese companies accounted for half of the top 10 spots, reflecting Taiwanese companies' rapid emergence and Taiwan's position as a major production center.
- Asia/Pacific semiconductor companies' SCM revenue reached $4,777 million in 1997. Taiwanese companies captured 71 percent of total Asia/Pacific SCM revenue. Foundry manufacturing accounted for 27 percent of total semiconductor manufacturing output in the Asia/Pacific region.
- The 1998 semiconductor production forecast ranges from $20,450 million to $23,260 million (most likely, $22,120 million). By 2002, the production forecast is expected to range from $47.7 billion to $42.8 billion (most likely, $44.8 billion).
- MOS digital logic products are expected to record the highest device compound annual growth rate (CAGR) in Asia/Pacific of 26.9 percent up to 2002. MOS microcomponent production is likely to increase by a 21.8 percent CAGR. Memory products should see a return to healthy growth on expectations of market recovery by the turn of this century. Memory device production was projected to account for 63.5 percent of total production revenue in 1997. By 2002, MOS memory is expected to remain as the single-largest device segment with 65.1 percent share of total output.
- Korea was the largest semiconductor production center in Asia/Pacific. Almost 50 percent of Korea's total production capacity was geared to make products with design rules of 0.35-micron and below. The total 1997 revenue for Korean semiconductor manufacturing companies dropped 11.4 percent to $10,283 million, given the weak market conditions for memory devices. Production output was concentrated on mass-producing DRAMs. By 2002, Dataquest forecasts Korea's semiconductor production to reach $24,096 million.

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- As a manufacturing base, Taiwan takes second place in the Asia/Pacific region. Nearly 50 percent of Taiwan's total production capacity is equipped to make products with design rules of 0.35-micron and below. Total 1997 revenue for Taiwanese semiconductor manufacturing companies grew 18.6 percent to reach $5,352 million. By 2002, Dataquest forecasts semiconductor production to achieve $13,390 million. With more companies on the island reorganizing to better target the foundry business, Taiwan is cementing its place as the world's foundry capital.
- An estimated 55 percent of Singapore's total production capacity was equipped to make products with design rules of 0.35-micron and below. The total 1997 revenue of Singapore semiconductor manufacturing companies decreased by 2.5 percent, to $1,937 million. This less-than-impressive growth can be attributed to pricing pressures on analog and DRAM devices. By 2002, Dataquest forecasts semiconductor production to reach $4,824 million. The general trend of semiconductor production in the city state will be driven by a diverse product portfolio.
- China/Hong Kong is the fastest-emerging country in the Asia/Pacific region, both as a production center and a semiconductor consumption market. Process technologies used in China/Hong Kong are less advanced, with almost 70 percent of total production capacity geared toward making products with design rules above 1-micron. In 1997, production revenue reached $490 million. By 2002, Dataquest forecasts semiconductor production to reach $1,444 million. The ownership structure is another defining characteristic of semiconductor companies operating in China/Hong Kong. A foreign majority-owned company tends to produce for export markets, while a company with local (usually Chinese government) majority ownership will tend manufacture semiconductors for the domestic consumption market.

Dataquest Perspective

The semiconductor production growth in Asia/Pacific is determined by capital investments made to build new wafer fabrication plants and to expand manufacturing capacities and the pricing level of memory products. Dataquest forecasts the worldwide memory market to record flat growth in 1998 and then register three straight years of accelerating growth, before being hit by a downturn again in 2002. Semiconductor production in the Asia/Pacific region is projected to record a five-year CAGR of 18.6 percent.

The region is likely to exhibit steady semiconductor production growth rates from 1998 to 2001. In 1998, growth is likely to be driven by new wafer plants' capacity addition in Korea, Taiwan, and Singapore. From 1999 to 2001, semiconductor production revenue is forecast to increase as a result of the recovering memory market and new companies starting commercial operations in the region.

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Korea and Taiwan are expected to remain as the manufacturing powerhouse in Asia/Pacific for the next five-year period. Korea's production revenue is likely to surge when the memory cycle picks up, while Taiwan's semiconductor production revenue takes on a different nature. Although Taiwanese companies are influenced by memory pricing fluctuations, the product mix and the estimated increase in production capacity are predicted to reduce revenue volatility.

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Chapter 2
Semiconductor Production in the Asia/Pacific Region

This chapter presents an overview of Asia/Pacific's semiconductor production. Asia/Pacific has been the fastest-growing semiconductor market since the beginning of this decade. As a production base, the region has experienced a rapid buildup of semiconductor manufacturing capacity, with Asia/Pacific and multinational semiconductor companies executing their expansion plans in the region. Semiconductor production has grown in the past few years, driven by increasing consumption within the region. It seemed that the region would continue on this growth trend as strong confidence in the economic outlook prevailed.

However, in the middle of 1997, these assumptions had to be re-examined when economic turmoil hit Asia/Pacific. The Asian financial crisis cut GDP growth rates in many countries in 1997. According to Dataquest's projections (see Table 2-1), Asia/Pacific countries likely to experience depressed GDP growth in 1998 include the Southeast Asian countries and South Korea.

Table 2-1
Asian GDP Growth Rates, 1995 to 1999 (Percent)

Country	1995	1996	1997	1998	1999
Indonesia	8.2	7.8	5.0	-2.1	0.5
Malaysia	9.5	8.2	6.8	2.0	3.0
Philippines	4.8	5.5	4.7	3.0	4.5
Singapore	8.8	7.0	7.6	2.5	4.0
Thailand	8.7	6.7	-0.5	-3.5	1.5
China	10.5	9.7	8.8	8.4	8.6
Hong Kong	4.5	4.9	5.4	3.4	4.6
Taiwan	6.0	5.7	6.4	5.1	5.5
South Korea	8.9	7.1	4.9	-2.0	2.0
Japan	1.4	4.1	0.9	0.8	1.8
India	7.1	6.8	4.6	5.3	8.6

Source: Dataquest (May 1998)

The Asian financial crisis caused many semiconductor companies to review their current operations, business portfolios, and expansion plans. According to Dataquest, Asia/Pacific's capital spending expansion comes primarily from two areas, DRAM and foundry capacity. DRAM investments made by Korean *chaebols* are likely to be cut drastically in 1998 because of the capital shortage. Foundry capacity investments, however, are projected to increase as Taiwanese companies continue to expand production cautiously. Overall, this is estimated to result in a capital-spending decline in Asia/Pacific for 1998. In the longer term, Dataquest expects Asia/Pacific to exhibit among the most aggressive capital-spending growth of any region, but it will match the worldwide growth rates much more closely than in the past.

Definitions

Semiconductor production in Asia/Pacific is defined by the place where the wafers are fabricated. The Asia/Pacific regional semiconductor production includes all production in the region and production by foreign (non-Asian) manufacturers. Dataquest follows a methodology that uses the market share revenue database, the Asia/Pacific fab database, and projecting the production revenue of the device segments separately. These devices include memory, microcomponents, logic, analog, discrete, optoelectronics, and bipolar digital components. The production revenue projections are checked against Dataquest's semiconductor device forecasts.

For example, Asia/Pacific's semiconductor production includes Samsung's and United Microelectronics Corporation's (UMC) fabs, as well as U.S., European, and Japanese companies' fabs. Semiconductor production revenue for integrated device manufacturers, such as SGS-Thomson Microelectronics B.V., counts the total value generated by all semiconductor manufacturing activities—including both front-end manufacturing and back-end operations. In the case of foundry manufacturers, all revenue gained from semiconductor contract manufacturing and related services are included. However, the value generated by packaging subcontractors and companies with only test and assembly plants in the region is not counted in the total Asia/Pacific semiconductor revenue. For instance, the revenue generated by Intel Corporation's Asia/Pacific assembly, testing, and packaging plants is not included in the total Asia/Pacific revenue. This approach provides insights into production trends for front-end manufacturing.

Semiconductor contract manufacturing is defined as a service in which a supplier performs some or all semiconductor manufacturing operations under contract to a customer. In its broadest sense, SCM can encompass wafer fabrication, packaging/assembly, and testing of semiconductor products.

An integrated device manufacturer (IDM) is a semiconductor supplier that manufactures its own products. The IDM's defining attribute is the exclusive ownership of one or more wafer fabrication facilities.

Yearly exchange rate variations can have a significant effect on data up to 1997. For more information about the exchange rates used, please refer to Table 2-2.

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Table 2-2
Asia/Pacific Exchange Rates per U.S. Dollar, 1996 and 1997

Country	1996	1997*	U.S. Dollar Appreciation (%) 1996 to 1997*
China (Renminbi)	8.34	8.32	-0.24
Hong Kong (Dollar)	7.73	7.74	0.11
India (Rupee)	35.52	36.36	2.37
Japan (Yen)	108.81	121.10	11.30
Malaysia (Ringgit)	2.52	2.82	12.00
Singapore (Dollar)	1.41	1.49	5.38
South Korea (Won)	805.16	954.14	18.50
Taiwan (Dollar)	27.47	28.79	4.81
Thailand (Baht)	25.36	31.07	22.53

*Estimated average
Source: Dataquest (June 1998)

Asia/Pacific Semiconductor Production

This section analyzes Asia/Pacific's production capacities and manufacturing technologies.

The two largest semiconductor production bases in the Asia/Pacific are Korea and Taiwan. In 1997, there were more than 25 wafer fabrication plants operating in each of these countries. Singapore is an emerging production center, with manufacturing on the island dominated by three large companies. Although China/Hong Kong has a high number of semiconductor manufacturing companies, these companies run smaller wafer production volumes. Among the other Asia/Pacific countries, Malaysia stands out as the most promising location for semiconductor production expansion. The nation, with an established semiconductor back-end infrastructure, is likely to become the next growth country.

In 1997, maximum-available wafer production capacity in the Asia/Pacific region reached 711.4 million square inches (MSI). The maximum-available capacity, as measured in MSI, is likely to increase by another 19 percent as additional capacity comes on stream this year. The bulk of the increased capacity is likely to come from Korea, Taiwan, and Singapore.

Asia/Pacific's wafer production uses a wide range of process technologies. Figure 2-1 illustrates the MSI-per-year analysis by minimum line width. In 1997, almost 47 percent of the total available capacity in the region was equipped to produce semiconductors with design rules of 0.35-micron or lower. Many of these advanced process technologies were installed in foundries and DRAM fabs. The progression to production using more advanced design rules, such as 0.25 micron and lower, is predicted to receive more emphasis in 1998 with foundries and DRAM fabs, once again, expected to lead the way. About 26 percent of total available capacity was used to manufacture wafers using process technologies of 0.8-micron or higher.

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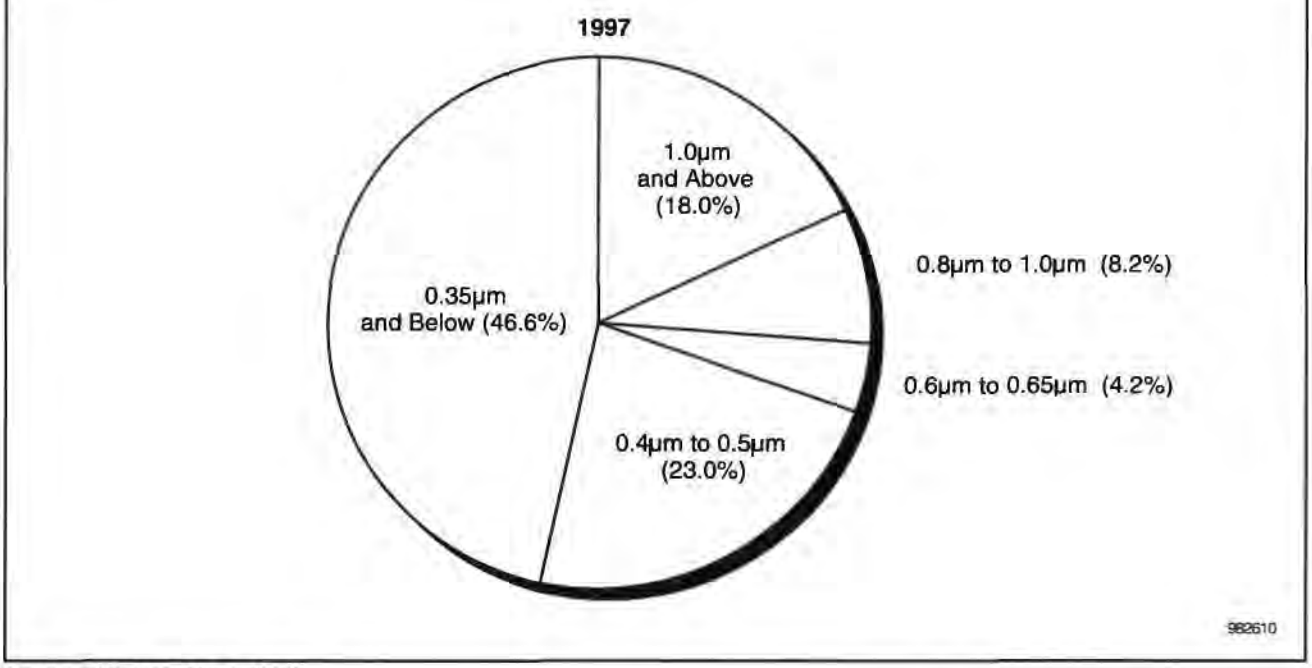
Figure 2-1
Asia/Pacific Maximum-Available Production Capacity by Process Technology, 1997 (Percent)



Source: Dataquest (June 1998)

Asia/Pacific Semiconductor Manufacturers' Revenue Ranking

Table 2-3 presents the 1997 ranking of the top 10 semiconductor manufacturers in Asia/Pacific by revenue. Korean companies occupied the top three places in the 1997 ranking. Samsung, LG Semicon, and Hyundai, which also ranked as the top three semiconductor manufacturers in 1996, held onto their ranking despite registering declining revenues last year as a result of the DRAM pricing pressures. Taiwanese companies accounted for half of the top 10 spots, reflecting Taiwanese companies' rapid emergence and Taiwan's position as a major production center.

Asia/Pacific's total semiconductor production revenue fell in 1997. All the major memory vendors suffered from the price decline and overcapacity situation in the market. Even the major analog manufacturer, SGS-Thomson, experienced a slowdown as a result of pricing pressures on its commodity products. The only group of companies to see overall revenue gains were the semiconductor contract manufacturers.

Among the foundry companies, Taiwan Semiconductor Manufacturing Company (TSMC) took the top spot in 1997. The UMC Group, another Taiwanese-owned manufacturer, locked in the largest revenue increase—a result of its successful entry into the foundry market. Another dedicated foundry that enjoyed healthy revenue growth in 1997 was Singapore's Chartered Semiconductor Manufacturing (CSM). In Asia/Pacific, the presence of the world's three largest dedicated foundries contributed a significant percentage of the total Asia/Pacific production base.

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Table 2-3
Estimated Top 10 Semiconductor Manufacturing Companies' Revenue in Asia/Pacific, Including Contract Manufacturing (Millions of U.S. Dollars)

Rank	Company	1996 Revenue	1997 Revenue	Percent Change (%) 1996 to 1997
1	Samsung	6,464	5,881	-9.0
2	LG Semicon	2,580	2,112	-18.1
3	Hyundai	2,247	1,939	-13.7
4	TSMC	1,422	1,540	8.3
5	UMC Group	824	1,173	42.4
6	SGS-Thomson	1,173	1,133	-3.4
7	Chartered Semiconductor Manufacturing	403	494	22.6
8	Winbond	438	415	-5.3
9	TI-Acer*	545	402	-26.2
10	Macronix	370	390	5.4
	Others	2,148	2,660	27.5
	Total Asia/Pacific	**18,614**	**18,139**	**-2.6**

* TI-Acer was sold to Acer in 1998
Source: Dataquest (June 1998)

Semiconductor Contract Manufacturing Revenue

The SCM revenue is important both for dedicated foundries and IDMs. With overcapacity issues and capital shortage holding up many companies' efforts to expand and upgrade their existing facilities, IDMs are increasingly looking toward semiconductor contract manufacturing for additional revenue streams. Figure 2-2 illustrates that Asia/Pacific semiconductor companies' SCM revenue reached $4,777 million in 1997. Taiwanese companies, such as TSMC and UMC Group, captured 71 percent of total Asia/Pacific SCM revenue.

In terms of output by supplier type, foundry manufacturing accounts for 27 percent of total semiconductor manufacturing output in Asia/Pacific (see Figure 2-3). This percentage is likely to increase as more companies in the region are attracted to this industry segment. The percentage of IDM revenue is dominated by Korean companies and multinational companies producing brand-name semiconductors in the region.

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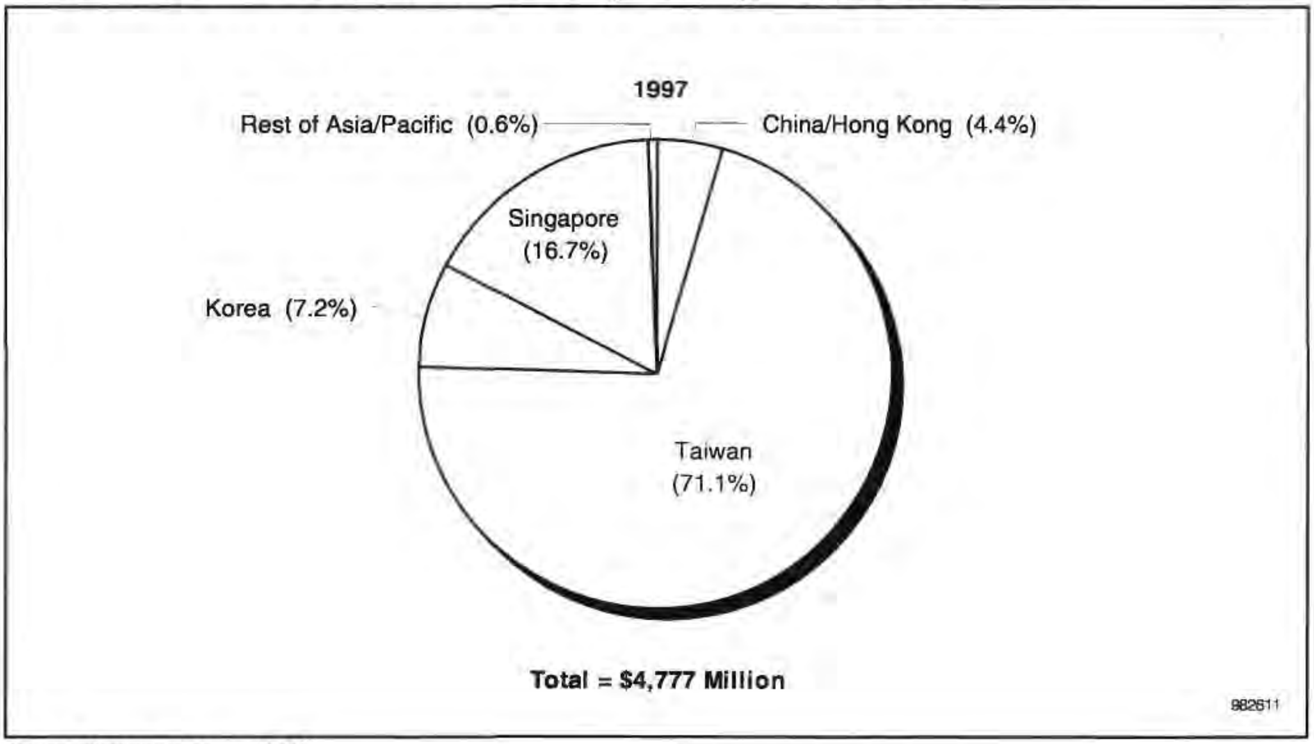
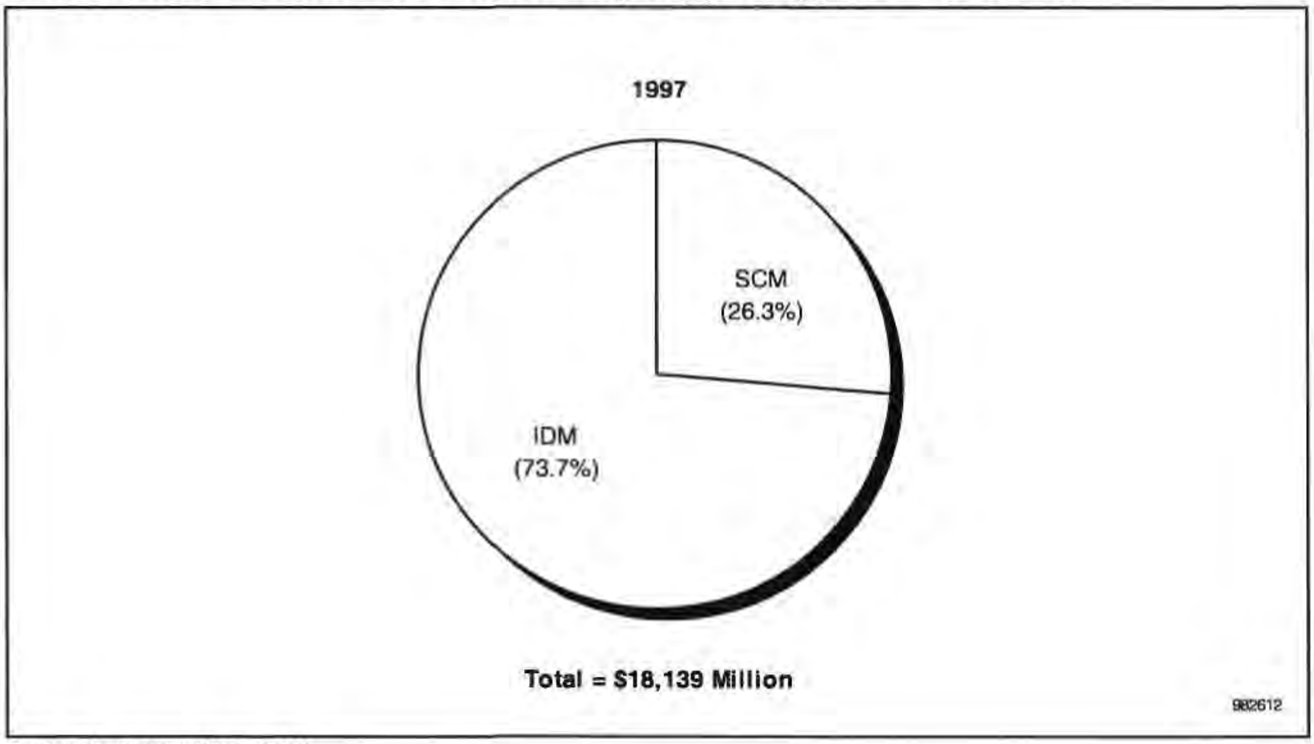
Figure 2-2
Asia/Pacific SCM Production Revenue by Country, 1997 (Percent)



Source: Dataquest (June 1998)

Figure 2-3
Asia/Pacific Semiconductor Production by Supplier Type, 1997 (Percent)



Source: Dataquest (June 1998)

Asia/Pacific Semiconductor Production Forecast

Table 2-4 shows that Asia/Pacific's semiconductor production reached $18,139 million in 1997. By 2002, Dataquest forecasts semiconductor production to register $44,764 million. This amount represents a five-year CAGR of 19.8 percent. The forecast is based on the following key assumptions:

- Semiconductor manufacturing capacity is forecast to increase in the next five-year period. Taiwanese manufacturers' capital spending will continue to grow as they seek out new business opportunities. Taiwanese semiconductor companies have strong balance sheets, which will enable them to further invest in wafer fab projects, especially in the foundry business. After recovering from the financial crisis, Korean companies are expected to increase their capital expenditure budgets quickly. The companies are likely to make investments in the upgrading equipment and building 300mm wafer fabrication plants. Foreign manufacturers will proceed with their new investments and planned expansion of existing facilities in Singapore, China/Hong Kong, and Malaysia.
- Production revenue of memory devices, especially DRAM products, is expected to rise steadily over the forecast cycle. After consolidation in 1998, DRAM revenue is expected to record rapid growth, reaching a peak in 2001. This peaking is expected to be followed by a decline in 2002, when the market is forecast to face the prospects of excess production capacity and plunging prices again. Memory devices' production sales are forecast to remain as the largest revenue earner for Asia/Pacific companies.
- Foundry manufacturing has emerged as a viable alternative to the traditional manufacturing model. SCM revenue is estimated to increase, with growing acceptance from IDMs, especially the Japanese companies, and the rapid expansion of fabless companies. Competition in dedicated foundries is forecast to become more intense. As a result, foundry wafer prices are predicted to decline in the forecast cycle. Increased competition will also mean that the foundries will have to upgrade equipment and expand production capacities continuously.

Taking the assumptions into consideration, the best-case semiconductor production forecast scenario for 1998 is $23,260 million. This amount represents an uptick of 5.2 percent over the most likely forecast. The worst-case scenario is estimated to cut production revenue back to $20,450 million. This amount represents a downside of 7.5 percent. By 2002, the production forecast is expected to range from $47.7 billion to $42.8 billion (the highest likelihood is $44.8 billion). Figure 2-4 illustrates Asia/Pacific's semiconductor production forecast from 1997 to 2002.

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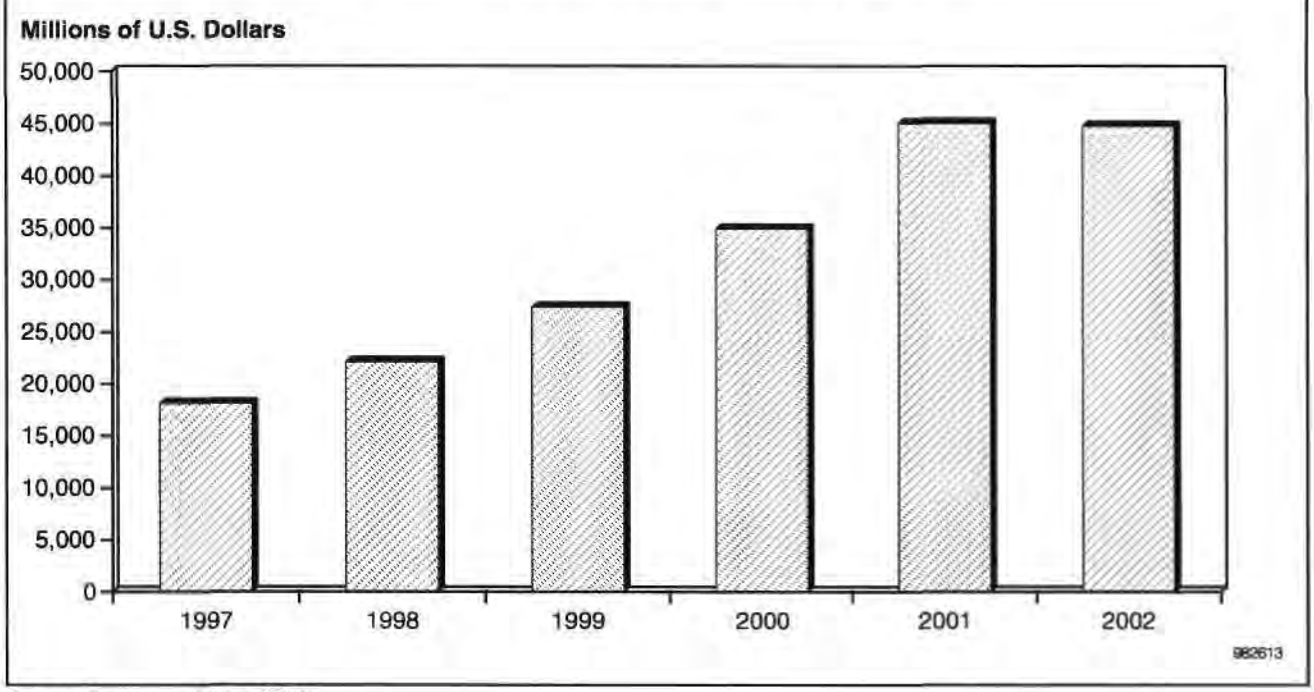
Table 2-4
Forecast of the Asia/Pacific Semiconductor Production, 1997 to 2002
(Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Total Semiconductor	**18,139**	**22,120**	**27,374**	**34,922**	**45,048**	**44,764**	**19.8**
Total Integrated Circuit	17,261	21,154	26,318	33,835	43,714	43,320	20.2
Bipolar Digital	40	38	36	35	31	29	-6.3
MOS Memory	11,516	14,046	17,391	22,257	30,591	29,150	20.4
MOS Microcomponent	2,399	3,074	3,855	5,221	5,881	6,430	21.8
MOS Digital Logic	1,591	2,134	3,022	4,135	4,818	5,238	26.9
Analog-Monolithic	1,714	1,862	2,015	2,188	2,392	2,474	7.6
Total Discrete	839	924	1,013	1,037	1,277	1,383	10.5
Total Optical Semiconductor	40	41	43	50	58	61	8.7

Note: The table contains preliminary data
Source: Dataquest (June 1998)

Figure 2-4
Asia/Pacific's Semiconductor Production Forecast, 1997 to 2002



Source: Dataquest (June 1998)

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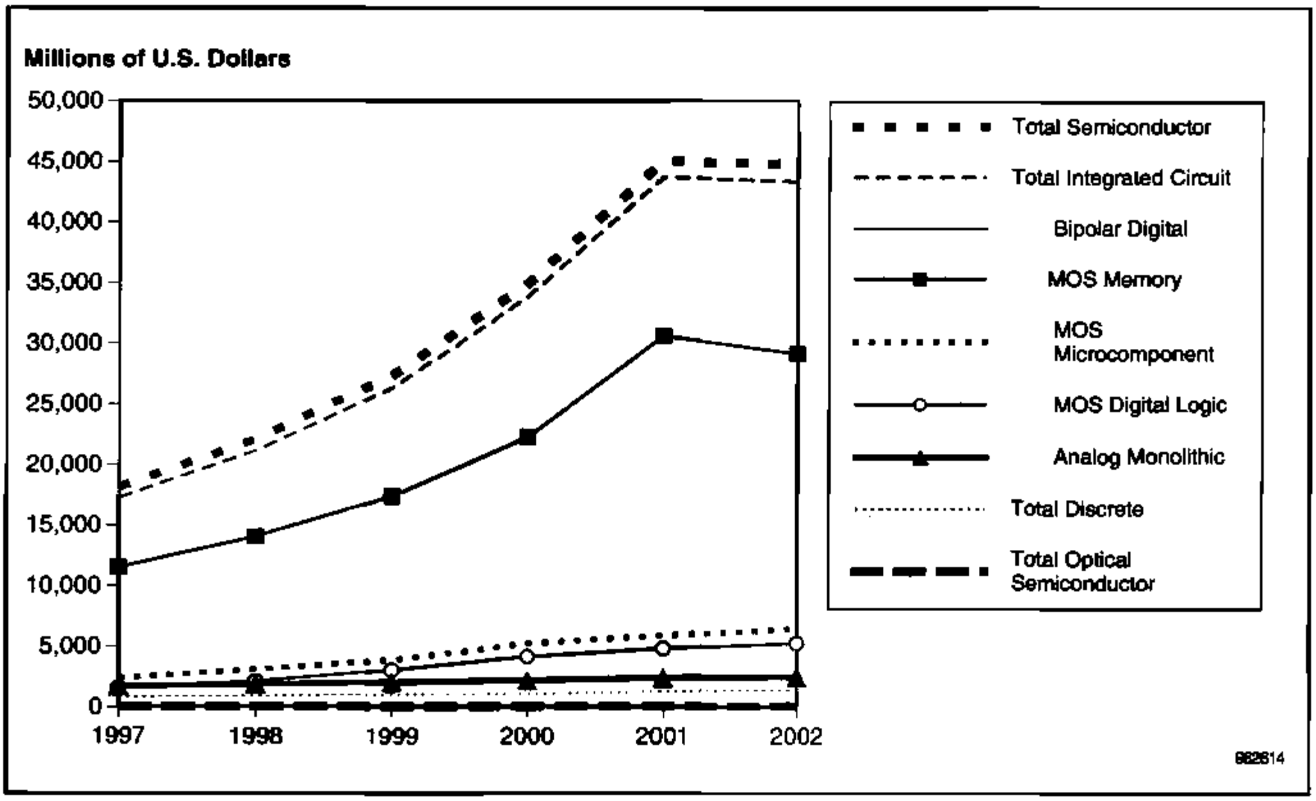
MOS digital logic products are expected to record the highest device CAGR of 26.9 percent up to 2002. Asia/Pacific companies are striving to diversify their product portfolio and reduce dependence on commodity devices, such as memory products. These companies have been intensifying efforts to diversify their product revenue base into logic and microcomponent devices. The execution of these product strategies is estimated to raise the ASIC/SLI device production, so that it will become one of the key product growth drivers as semiconductor manufacturers produce more system solutions on a single chip. MOS microcomponent production is also likely to grow at a 21.8 percent CAGR, a result of the strategy to build single-chip solutions.

Memory products should also see healthy growth on expectations that the market will recover by the turn of this century. Figure 2-5 illustrates that memory devices are likely to drive Asia/Pacific production revenue growth in the region up until 2001. With the memory market forecast to decline in 2002, logic and microcomponent products are predicted to take over as the main production revenue expansion engines. Steady growth rates, estimated for both these device segments, will tend to counteract the DRAM-cycle volatility. The highest annual growth rates are forecast to occur before 2002, when the memory market is expected to be near the supply-demand balance.

Figure 2-5
Asia/Pacific's Semiconductor Device Forecast Revenue, 1997 to 2002



Source: Dataquest (June 1998)

Memory device production was projected to account for 63.5 percent of total production revenue in 1997 (see Figure 2-6). By 2002, MOS memory is expected to remain as the single-largest device segment with a 65.1 percent share of total output. Besides memory products, the next two top device categories are forecast to be microcomponents and logic. This means that future investment dollars in Asia/Pacific will be allocated toward building advanced wafer fabrication facilities to produce these products. However, analog device production is forecast to make up a smaller percentage of the total Asia/Pacific semiconductor production in 2002.

The total semiconductor production by country (see Table 2-5) shows that Korea is the largest manufacturer in the region. Taiwan is the second-largest manufacturer, with Singapore and China/Hong Kong in third and fourth place, respectively.

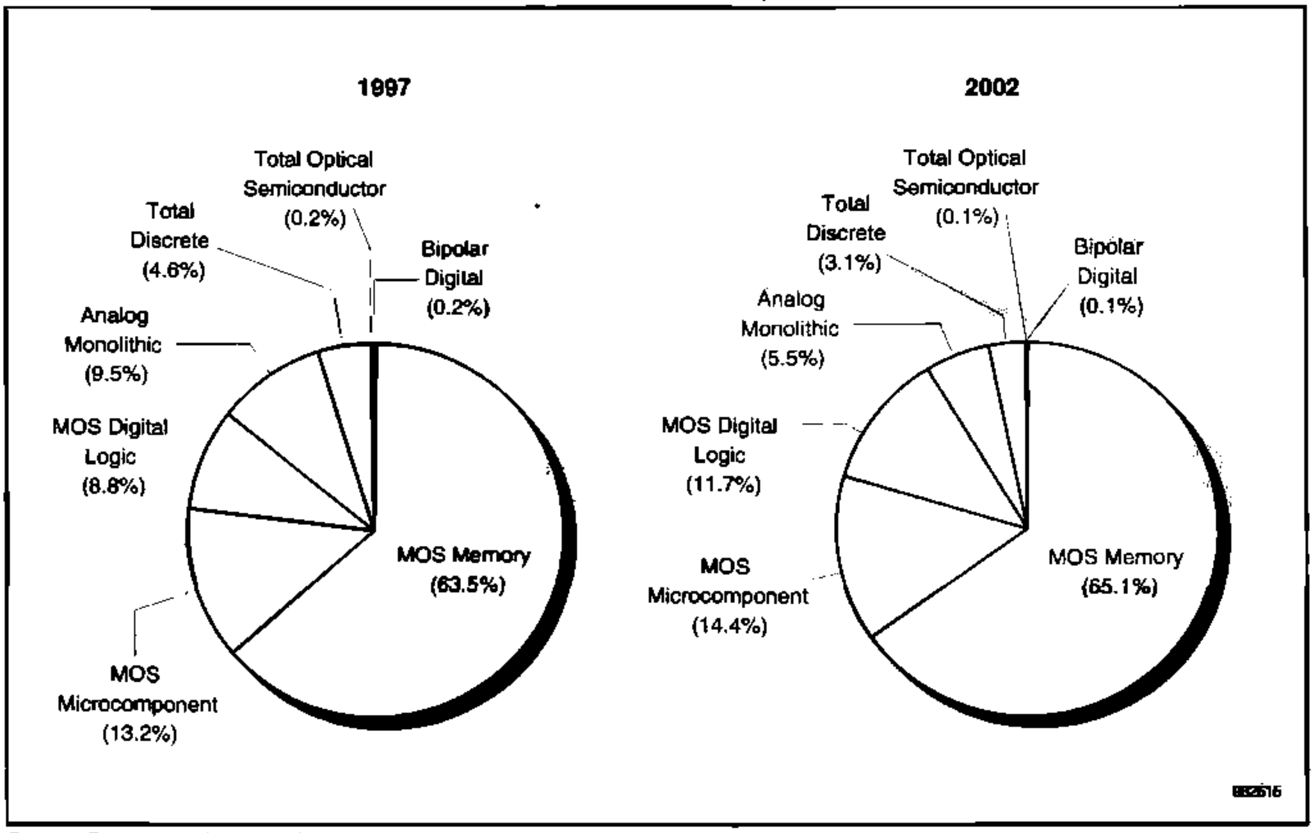
Among the four countries, China/Hong Kong is expected to register the most dynamic five-year CAGR of 24.1 percent. As semiconductor production in Asia/Pacific is almost entirely located in these four countries, the following chapters examine separately each country's production.

Table 2-5
Asia/Pacific Semiconductor Production Forecast by Country, 1997 to 2002
(Millions of U.S. Dollars)

Country	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Korea	10,283	12,012	14,524	18,103	25,266	24,096	18.6
Taiwan	5,352	6,845	8,578	10,369	12,466	13,390	20.1
Singapore	1,937	2,595	3,377	4,539	4,922	4,824	20.0
China/Hong Kong	490	588	814	1,251	1,466	1,444	24.1
Other Asia/Pacific	77	79	81	661	928	1,009	67.3
Total Asia/Pacific	**18,139**	**22,120**	**27,374**	**34,922**	**45,048**	**44,764**	**19.8**

Note: The table contains only preliminary data
Source: Dataquest (June 1998)

Figure 2-6
Asia/Pacific's Semiconductor Production Forecast by Device, 1997 and 2002



Source: Dataquest (June 1998)

Chapter 3

Semiconductor Production in Korea

This chapter presents semiconductor production in Korea. Korea is the home to the world's largest memory manufacturer. The three largest Korean companies are also positioned as the top three memory suppliers in Asia/Pacific. If Taiwan is on the fast track toward becoming the Silicon Island, then Korea is already the DRAM Peninsula.

In 1997, Korean companies accounted for 34 percent of total worldwide DRAM revenue. These companies experienced a slowdown because of the declining worldwide memory market. However, the top three Korean *chaebols* still occupied the first three places in the Asia/Pacific semiconductor production revenue rankings.

Korean companies have accumulated a wealth of know-how in process technology, a result of many years of experience in front-end wafer production. They have also built up a competitive cost structure from continuously striving to shrink chip size, improve production yields, and execute high-volume manufacturing. The country has a large skilled labor pool from its history of participation in the electronics and semiconductor industries. Furthermore, the won depreciation, brought on by the Asian financial crisis, has given Korean manufacturers an additional edge in cost. However, Korean companies are expected to face challenges in better utilizing excess production capacity. They would move toward further strengthening their foundry business. The companies are also making efforts to branch out into other nonmemory businesses, which should remove part of the volatility associated with the DRAM business cycle.

Korea's Semiconductor Manufacturing Capacity

Figure 3-1 illustrates Korea's maximum-available manufacturing capacity in 1997 by process technology. Almost 50 percent of Korea's total production capacity was geared to make products with design rules of 0.35-micron and below. As the country with most established wafer fabrication plants in Asia/Pacific, slightly more than 25 percent of fabs were manufacturing products using design rules of 0.8-micron and above. Many of the products made using these processes go into consumer electronics applications.

In 1998, the maximum-available manufacturing capacity, as measured in MSI, is forecast to increase by just 4 percent. The moderation in production capacity expansion comes as a result of the financial crisis that negatively impacted Korea in 1997. Capital spending cutbacks of up to 40 percent this year may cause some Korean manufacturers to fall behind as competitors with more stable financial structures continue to invest in new and advanced technologies. This situation could result in the *chaebols* not being able to increase their memory products' market share.

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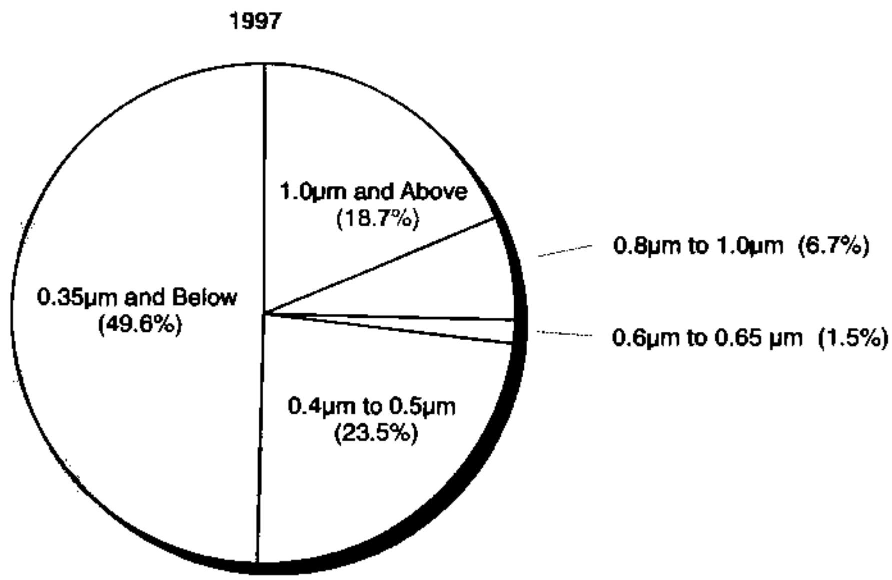
Figure 3-1
Korea's Maximum-Available Production Capacity by Process Technology, 1997 (Percent)



Source: Dataquest (June 1998)

Korean Semiconductor Manufacturers' Revenue Ranking

Table 3-1 lists the top five Korean semiconductor manufacturers' revenue in 1997. Samsung maintained its leadership as Korea's largest producer. Samsung is also ranked No. 1 in Asia/Pacific, and it was the largest MOS memory vendor worldwide for 1997—all this despite recording a declining revenue rate of 9 percent. LG Semicon's semiconductor manufacturing revenue was also negatively impacted by the overcapacity that beset the DRAM market. In third place was another large DRAM vendor, Hyundai. The company also experienced a revenue decline in 1997.

Korea Electronics Company Ltd. (KEC) recorded the highest revenue increase rate among the top-five-ranked manufacturers. The company's production output is mainly targeted at the consumer electronics market. Daewoo Electronics Corporation made the top five companies in Korea. Daewoo's revenue climbed 11 percent in 1997. This increase is not entirely surprising, given that the two companies manufacture products aimed at the less volatile analog, discrete, and microcomponent device markets.

The total 1997 revenue for Korean semiconductor manufacturing companies dropped 11.4 percent, given the weak market conditions for memory devices. Revenue gains made by KEC and Daewoo were not enough to turn this situation around. The combined revenue from both companies represented just 3 percent of the total semiconductor production revenue.

Table 3-1
Korea's Estimated Revenue of Semiconductor Manufacturing Companies, Including Contract Manufacturing, 1996 and 1997 (Millions of U.S. Dollars)

Rank	Company	1996 Revenue	1997 Revenue	Percent Change (%) 1996 to 1997
1	Samsung	6,464	5,881	-9.0
2	LG Semicon	2,580	2,112	-18.1
3	Hyundai	2,247	1,939	-13.7
4	KEC	268	300	11.9
5	Daewoo	45	50	11.1
	Others	0	1	NA
	Total	**11,604**	**10,283**	**-11.4**

NA = Not available
Source: Dataquest (June 1998)

Semiconductor Contract Manufacturing Revenue in Korea

In 1997, revenue generated by SCM business reached $346 million. SCM revenue represented a mere 3.4 percent of the total manufacturing revenue. However, the foundry business is expected to become of growing significance for Korean companies as one of the solutions to overcome the excess production capacity.

Analysis of individual companies' SCM revenue shows that LG Semicon captured the largest share of the foundry business in 1997 (see Figure 3-2). The company manufactures DRAMs for large Japanese customers such as Hitachi Ltd. Foundry revenue accounts for 15 percent of LG Semicon's total semiconductor production revenue. Emerging competition to the leader comes from Samsung and Anam S&T Company Ltd. In 1997, Samsung gained foundry revenue from manufacturing Digital Equipment Corporation's Alpha chip. Anam is expected to start high-volume production as a dedicated foundry making Texas Instrument Inc.'s digital signal processing (DSP) devices. With a capital shortage for new investments and the Asian financial crisis, Korean *chaebols* are expected to increase competition to the established foundry companies elsewhere in the world.

Korea's Semiconductor Production Forecast

Table 3-2 shows Korea's semiconductor production revenue forecast. In 1997, production revenue reached $10,283 million, the highest in Asia/Pacific. Production output was concentrated on mass producing DRAMs. By 2002, Dataquest forecasts semiconductor production to reach $24,096 million. Korea is expected to achieve a robust CAGR of 18.6 percent as a result of the DRAM market recovering by the turn of the century. The highest annual growth rates are estimated to be achieved in 2000 and 2001, with revenue projected to decline slightly by 2002 (see Figure 3-3).

MOS microcomponent devices are expected to record the highest CAGR of 24.6 percent for the five-year forecast cycle. MOS memory products should see the second-highest CAGR of 18.9 percent. This is estimated to be followed by analog and MOS logic devices. The device production growth trends are likely to be determined by the memory market recovery and the *chaebols'* efforts to diversify their product offerings.

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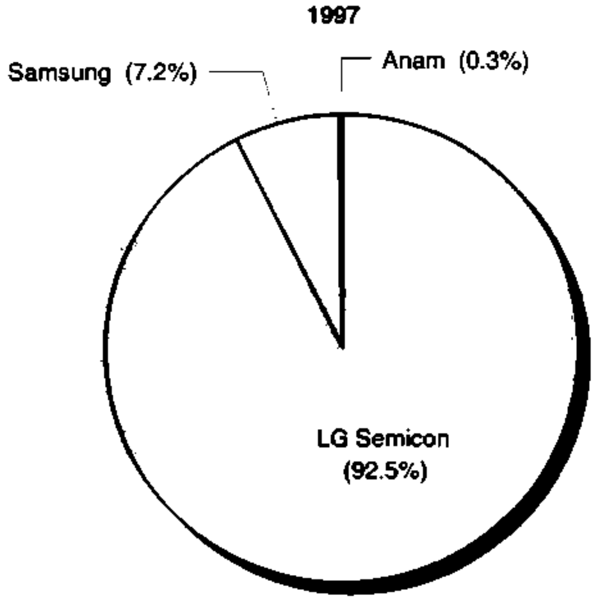
Figure 3-2
1997 Semiconductor Production in Korea by Supplier Type (Percent)



Source: Dataquest (June 1998)

Table 3-2
Korea's Semiconductor Production Forecast, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Total Semiconductor	**10,283**	**12,012**	**14,524**	**18,103**	**25,266**	**24,096**	**18.6**
Total Integrated Circuit	9,676	11,350	13,801	17,382	24,329	23,046	19.0
Bipolar Digital	8	7	7	6	5	4	-14.5
MOS Memory	8,363	9,700	11,850	15,020	21,580	19,850	18.9
MOS Microcomponent	403	611	726	871	1,022	1,212	24.6
MOS Digital Logic	440	498	589	711	803	945	16.5
Analog-Monolithic	462	533	629	775	920	1,035	17.5
Total Discrete	575	630	690	680	890	1,000	11.7
Total Optical Semiconductor	32	32	33	40	47	49	9.1

Source: Dataquest (June 1998)

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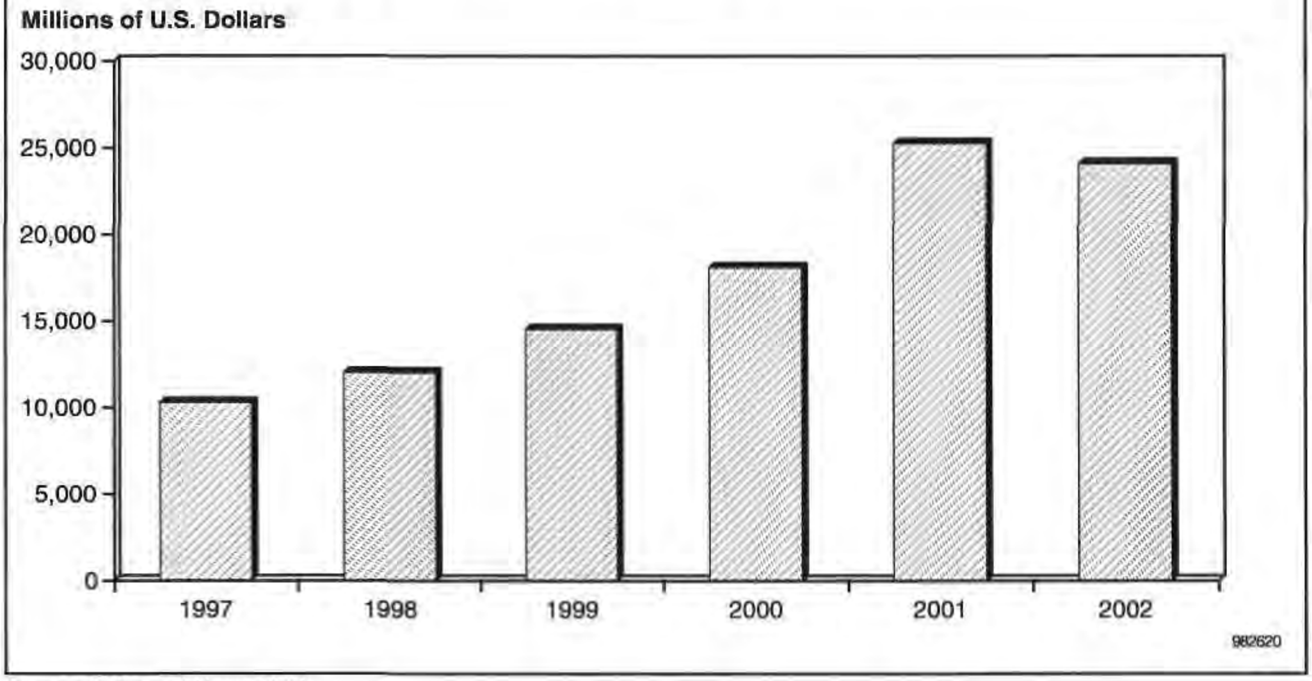
Figure 3-3
Korea's Semiconductor Production Forecast, 1997 to 2002



Source: Dataquest (June 1998)

Figure 3-4 depicts Korea's semiconductor production trend. Although microcomponent devices are predicted to be the most promising product category, total semiconductor production revenue should be driven by memory devices. Within the memory segment, DRAMs determines the general trend of semiconductor production.

Figure 3-5 illustrates the total semiconductor production by percentage share in Korea in 1997. Memory devices production represented a huge 81.3 percent share of the total revenue. Discrete products took the second-largest slice of the production value. By 2002, MOS memory devices are expected to widen the share of output to 82.4 percent. The other top device category is forecast to be microcomponents.

Korean companies' capital spending should resume after the country begins to recover from the economic slump, with Korea predicted to remain as the largest semiconductor producer in Asia/Pacific.

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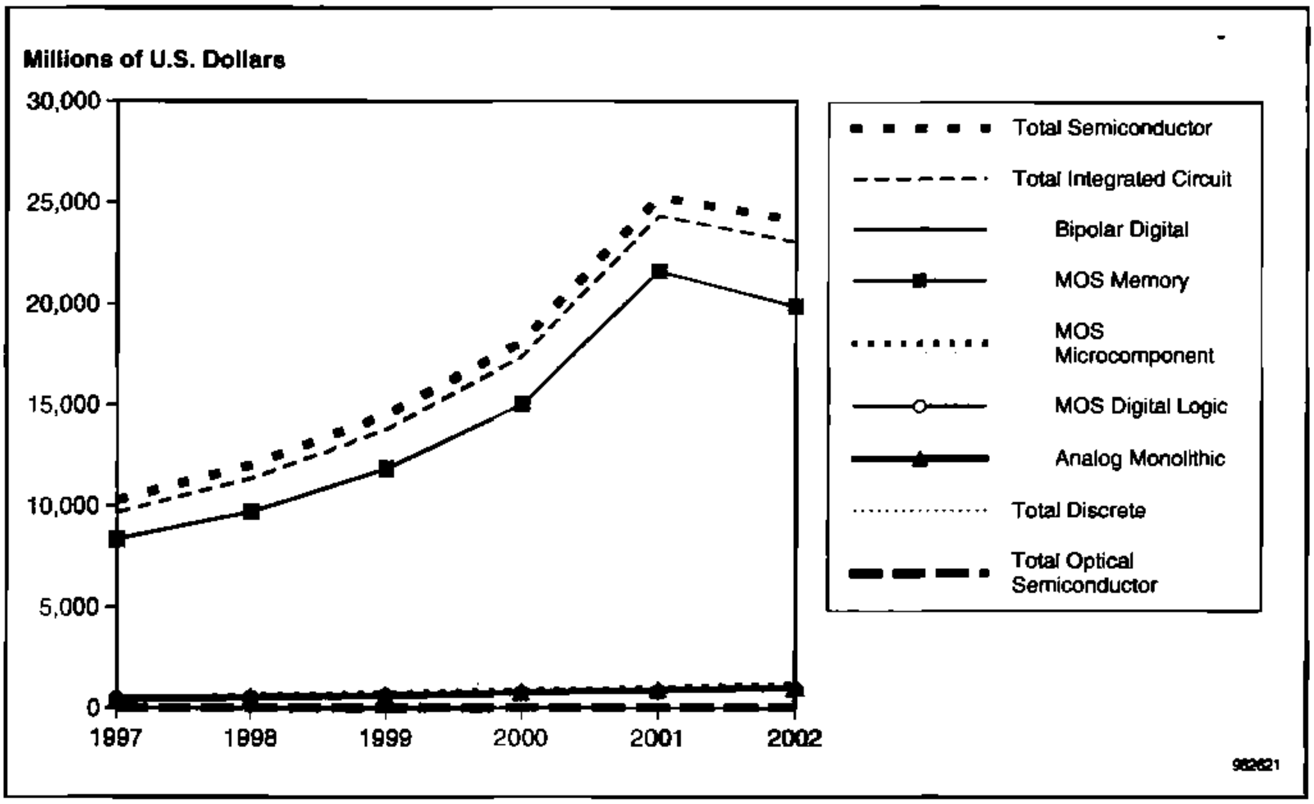
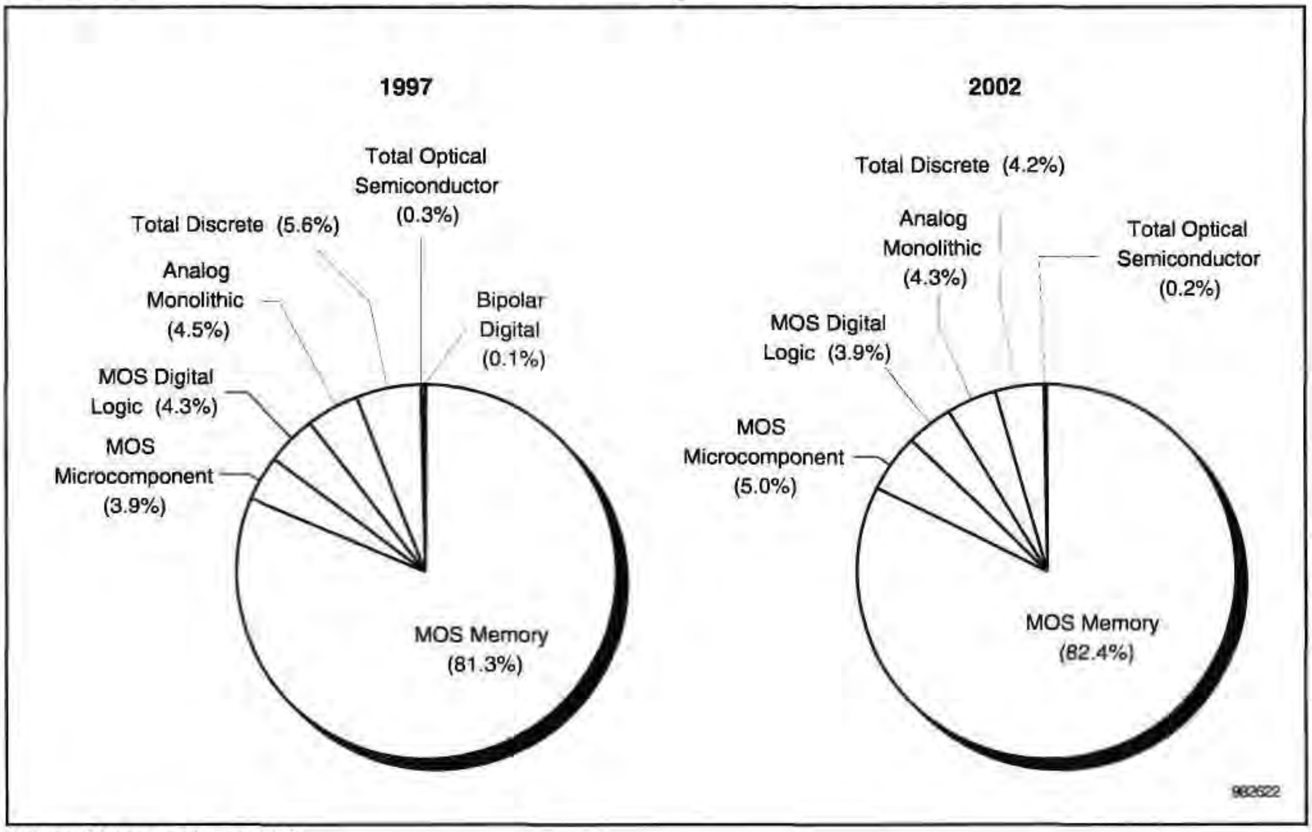
Figure 3-4
Korea's Semiconductor Device Revenue Forecast, 1997 to 2002



Source: Dataquest (June 1998)

Figure 3-5
Korea's Semiconductor Production Forecast by Device, 1997 and 2002



Source: Dataquest (June 1998)

Chapter 4
Taiwan's Semiconductor Production

In this chapter, Taiwan's semiconductor production is examined. Taiwan is the home to the world's largest dedicated foundry manufacturers. The Silicon Island continues to be the host to an increasing number wafer fabrication plants, with investments expected to come from existing manufacturers and new companies that are poised to enter the dedicated foundry industry.

The number of Taiwanese semiconductor manufacturing companies is growing, driven by alliances made by local companies, as well as joint ventures between local and multinational companies. This development has led to the setting up of new local-foreign venture entities such as Powerchip Semiconductor Co. and ProMos Technologies.

In this decade, Taiwan has emerged as a major semiconductor production center. The country has a well-educated workforce, particularly from engineering backgrounds, who have been trained since the 1970s. This is a major factor that has enabled Taiwan to play an important role in semiconductor manufacturing. In the early years, these pioneers went to the United States and joined electronics and semiconductor companies. During the past 10 years, these well-trained engineers have returned to Taiwan and established new semiconductor businesses. At the same time, the Taiwanese government has also played an important role, including setting up research centers, such as the Industrial Technology Research Institute (ITRI). Many of the current leaders in Taiwan's semiconductor industry were former ITRI R&D researchers.

In addition, the Taiwanese government has improved infrastructure by building industrial parks for semiconductor companies. Despite the regional economic turmoil, Taiwan's economy is still looking robust. With the support of local banks and healthy company financials, Taiwanese companies' capital spending is expected to rise this year. Rising electronic equipment production is likely to drive higher semiconductor demand in Taiwan. Data processing applications such as PCs, monitors, and motherboards are expected to show healthy growth.

When the Taiwanese semiconductor industry was emerging, government support played an important role in the industry's success. However, as companies become better established, the government's role has subsided. In the past few years, Taiwan's investment environment and the semiconductor manufacturing base have been set up successfully.

Taiwan's Semiconductor Manufacturing Capacity

Figure 4-1 illustrates the 1997 maximum-available manufacturing capacity for Taiwan by process technology. As a manufacturing base, Taiwan takes second place in the Asia/Pacific region. Nearly 50 percent of Taiwan's total production capacity is equipped to make products with design rules of 0.35-micron and below. Slightly higher than 11 percent of fabs are installed with equipment to manufacture line widths of 0.8-micron and above. Taiwanese fabs, particularly the foundries, are continually investing in equipment that enables wafer production using leading-edge process technologies.

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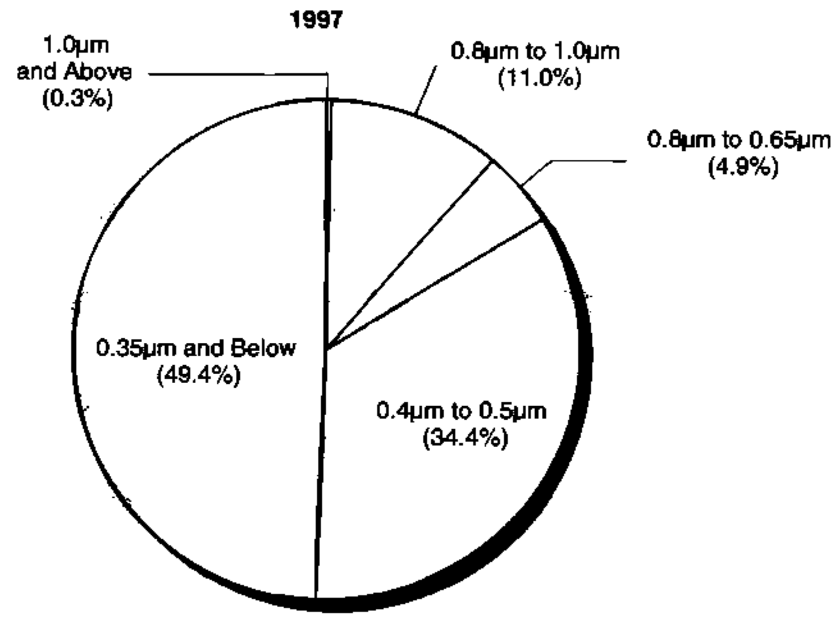
Figure 4-1
Taiwan's Maximum-Available Production Capacity by Process Technology, 1997 (Percent)



Source: Dataquest (June 1998)

In 1998, the maximum-available manufacturing capacity measured in MSI is forecast to expand by another 33 percent. The production capacity boost comes from the anticipated addition of new fabs by existing companies, such as Winbond Electronics Corporation and UMC Group, and the anticipated arrival of a new foundry company, Worldwide Semiconductor Manufacturing Corporation (WSMC).

Taiwanese Semiconductor Manufacturers' Revenue Ranking

Table 4-1 presents the top 10 Taiwanese semiconductor manufacturers' revenue in 1997. TSMC was ranked No. 1, recording an 8.3 percent growth rate. The UMC Group remained in the second position with revenue contribution coming from its new fabs, including USC and USI. Winbond climbed into the third place despite recording a drop in manufacturing revenue. TI-Acer fell one place to the fourth place, impacted by DRAM pricing pressures. This entity ceased to exist when Acer bought TI's stake in the venture this year. The new company, Acer Semiconductor Manufacturing Incorporated (ASMI), has been set up to replace TI-Acer.

Powerchip Semiconductor Co. enjoyed the highest revenue increase among the top 10 manufacturers in 1997, a result of the venture ramping up production volume. Jointly owned by UMAX Data Systems Inc. and Mitsubishi Corporation, the company started making DRAMs in October 1996. A new addition to the top 10 rankings is Nan Ya Technology Co. The company began commercial operations of its 0.35-micron fab in early 1997.

Production output is divided into making DRAMs and serving its foundry customers.

Table 4-1
Estimated 1997 Revenue of Semiconductor Manufacturing Companies in Taiwan, Including Contract Manufacturing (Millions of U.S. Dollars)

Rank	Company	1996 Revenue	1997 Revenue	Percent Change (%) 1996 to 1997
1	TSMC	1,422	1,540	8.3
2	UMC Group	824	1,173	42.4
3	Winbond	438	415	-5.3
4	TI-Acer	545	402	-26.2
5	Macronix	370	390	5.4
6	Vanguard	250	348	39.2
7	Mosel Vitelic	398	308	-22.6
8	Powerchip	10	265	2,550.0
9	Holtek	103	131	27.2
10	Nan Ya	-	110	NA
	Others	74	270	264.9
	Total	**4,511**	**5,352**	**18.6**

NA = Not available
Source: Dataquest (June 1998)

The total 1997 revenue for Taiwanese semiconductor manufacturing companies grew by 18.6 percent, despite the less-than-favorable market conditions. This growth can be attributed to revenue gained from increased output coming from new wafer fabs that started production in 1997 and design-related services. The revenue growth rate would have been even higher had not there been a fire that burnt down UMC Group's newest wafer fabrication plant, United Integrated Circuits Co. (UICC).

With the second-highest-maximum-available capacity, as measured in MSI, Taiwan achieved the second-highest total revenue from semiconductor production in Asia/Pacific in 1997. The product revenue and utilization of available capacity of top-ranked manufacturers, especially the foundries, depends on orders from their customers. Also, dedicated foundry companies have to produce a wide product range for IDMs and fabless customers, which also impacts capacity utilization.

Semiconductor Contract Manufacturing Revenue in Taiwan

In 1997, revenue generated by SCM business reached $3.4 billion. SCM revenue represented a 63 percent majority of the total manufacturing revenue (see Figure 4-2). Brand-name manufacturing represented a lower proportion of the total revenue as foundry business remained as the main growth driver of semiconductor production in Taiwan. Despite pressures on foundry wafer prices, the major players' total revenue was not negatively impacted because of their production capacity expansion.

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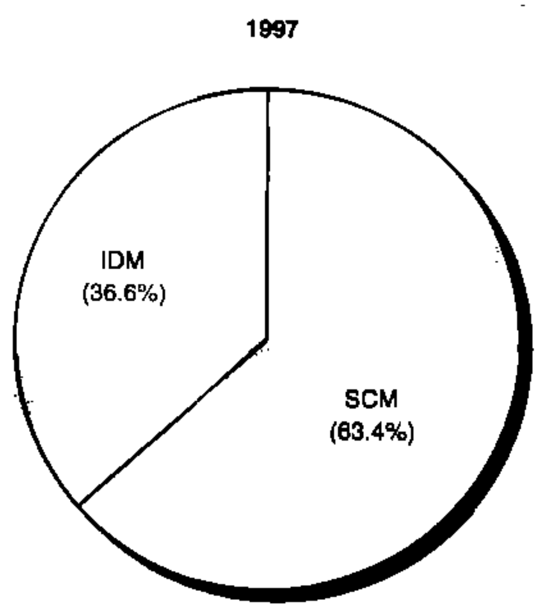
Figure 4-2
Taiwan's Semiconductor Production by Supplier Type, 1997



Source: Dataquest (June 1998)

Analysis of individual companies' SCM revenue shows that TSMC is the largest production revenue contributor in Taiwan, and the largest foundry in the world, according to Dataquest. TSMC is also the leader in installing the latest process technologies. Competition to the leader comes from the UMC Group. UMC has embarked on a dedicated-foundry strategy that led to the decision to spin-off its design teams. With more companies on the island reorganizing to better target the foundry business, Taiwan is cementing its place as the world's foundry capital.

Taiwan's Semiconductor Production Forecast

Table 4-2 shows that Taiwan's semiconductor production revenue in 1997 was $5,352 million. By 2002, Dataquest forecasts semiconductor production to reach $13,390 million. Taiwan is expected to achieve a healthy CAGR of 20.1 percent as a result of the companies' continuing expansion of their production capacities. The Taiwanese companies' financial structure is sound, which will enable them to proceed with executing the planned expansion of the new facilities.

Figure 4-3 depicts Taiwan's estimated annual growth. High annual growth rates are expected for this year and 1999.

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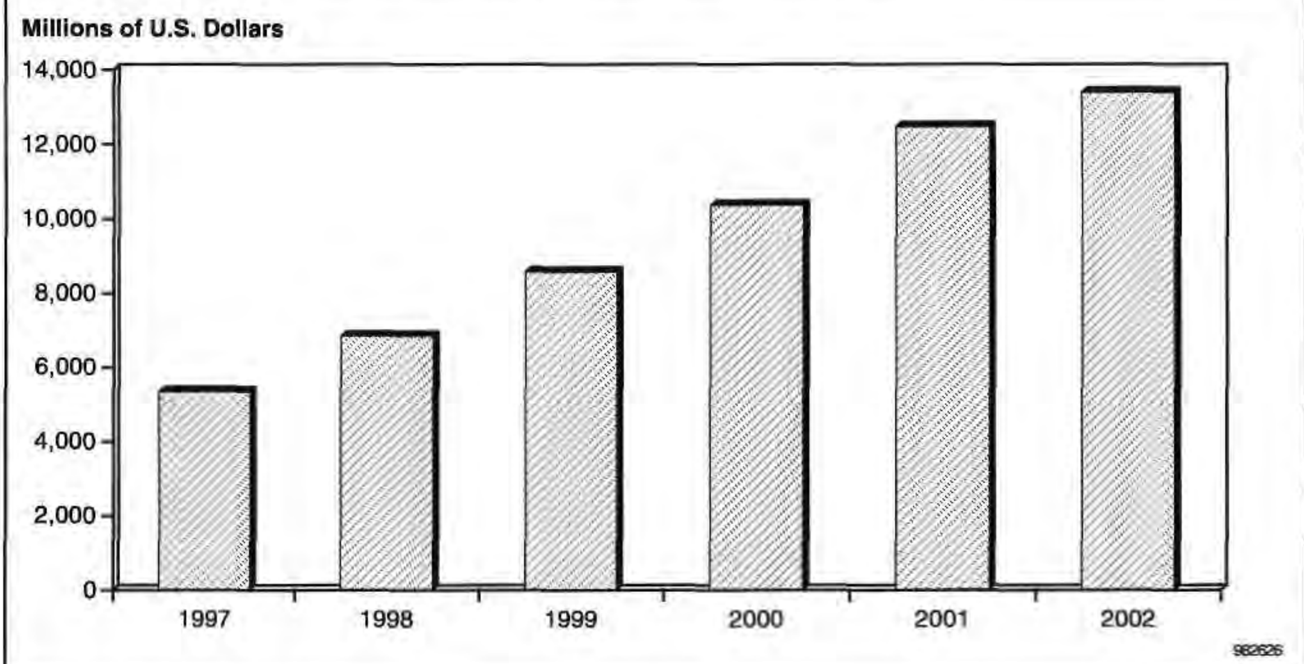
Table 4-2
Taiwan's Semiconductor Production Forecast, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Total Semiconductor	**5,352**	**6,845**	**8,578**	**10,369**	**12,466**	**13,390**	**20.1**
Total Integrated Circuit	5,352	6,845	8,578	10,369	12,466	13,390	20.1
Bipolar Digital	-	-	-	-	-	-	-
MOS Memory	2,724	3,644	4,560	5,586	6,947	7,498	22.4
MOS Microcomponent	1,697	2,000	2,442	2,864	3,217	3,460	15.3
MOS Digital Logic	871	1,137	1,510	1,850	2,227	2,354	22.0
Analog-Monolithic	60	64	66	69	75	78	5.4
Total Discrete	-	-	-	-	-	-	-
Total Optical Semiconductor	-	-	-	-	-	-	-

Source: Dataquest (June 1998)

Figure 4-3
Taiwan's Semiconductor Production Forecast, 1997 to 2002



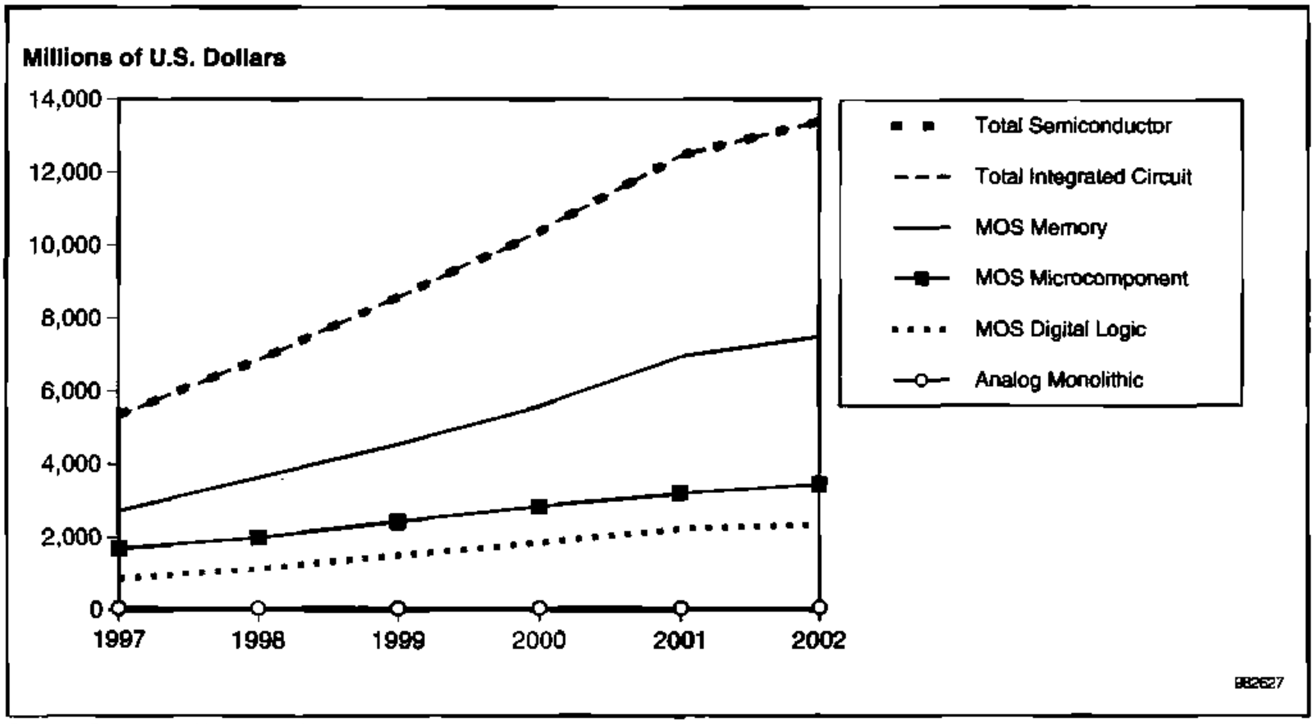
Source: Dataquest (June 1998)

MOS memory devices are expected to record the highest CAGR of 22.4 percent, followed closely by MOS digital logic devices. MOS microcomponent products should see the third-highest five-year growth rate of 15.3 percent. Again, these device growth trends are likely to be determined by the product mix of the foundries. Figure 4-4 illustrates semiconductor production's forecast growth from 1997 to 2002. Growth is expected to be driven by the production of these three large device segments: memory, logic, and microcomponent devices.

Figure 4-5 charts Taiwan's total semiconductor production by percentage share in 1997. Memory device production represented 50.9 percent of total revenue. By 2002, MOS memory devices are expected to widen the production share to 56.0 percent. The MOS logic device category is also estimated to account for a larger percentage share of production output.

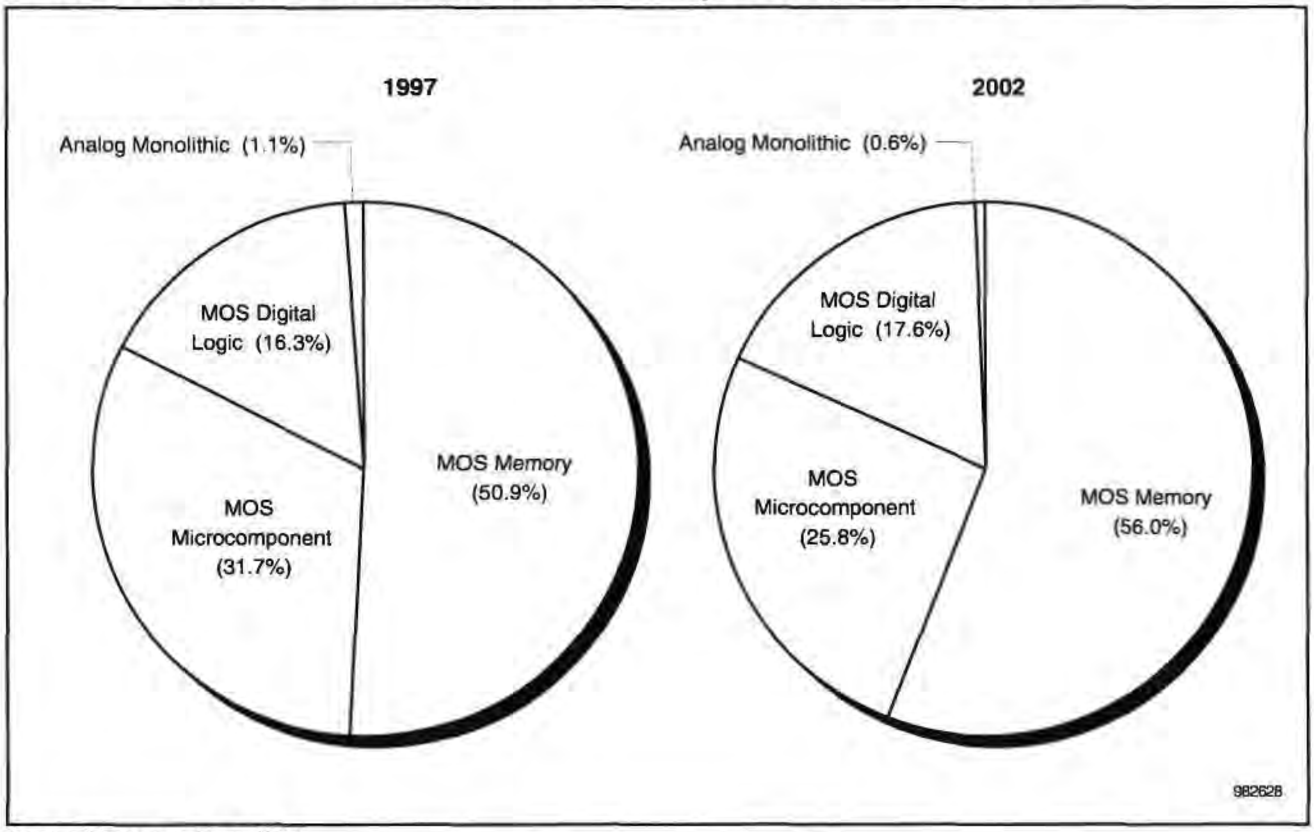
Taiwanese companies' capital spending should be maintained despite the uncertainties surrounding the regional economies. The sound financial position of the island's semiconductor manufacturing companies means that there is no capital shortage for new facility investments.

Figure 4-4
Taiwan's Semiconductor Device Forecast Revenue, 1997 to 2002
(Millions of U.S. Dollars)



Source: Dataquest (June 1998)

Figure 4-5
Taiwan's Semiconductor Production Forecast by Device, 1997 and 2002



Source: Dataquest (June 1998)

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Chapter 5
Singapore's Semiconductor Production

This chapter details Singapore's semiconductor production. Singapore's semiconductor production is diversified, both in terms of the geographic origin of companies and the device types that are produced. Multinational companies from Europe, Japan, and North America, and local companies picked the city state as their production center. A wide range of devices are manufactured, including analog, memory, microcomponents, and logic products.

The three largest semiconductor manufacturers in Singapore in 1997 were SGS-Thomson Microelectronics, Chartered Semiconductor Manufacturing Ltd. (CSM), and TECH Semiconductor Singapore Pte. Ltd. Hitachi Nippon Steel Semiconductor Singapore Pte. Ltd. came to the local manufacturing scene this year. As a production base, Singapore is positioned in the third place in Asia/Pacific.

Singapore is an attractive place for semiconductor production because it has strong government support, a well-trained, English-speaking workforce, good infrastructure, and a strategic location in the region. The government has a long-term view to realize the development of more than 20 wafer fabs in Singapore. To achieve this goal, many incentives have been offered to prospective investors. These include tax incentives and schemes such as pioneer status, development and expansion incentive, and investment allowance. The pioneer status exempts investors from corporate tax on profits for the next five to 10 years. In addition, the government also shares risks with investors by taking minority equity stakes in the projects.

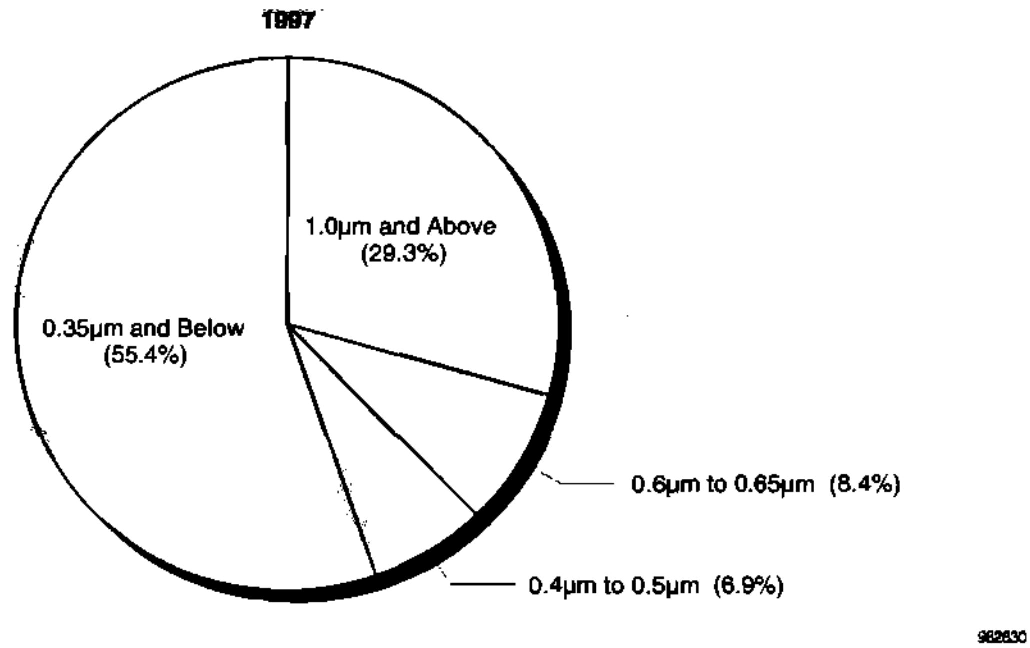
The development of a skilled workforce is also given high priority. The government's support extends to cosharing of training costs and funding research programs to assist the development of technical workforce. The island is known for its airport, sea port, and well-planned industrial parks. Advanced communications facilities and an efficient road transport network facilitate smooth access to its neighboring countries.

Semiconductor Manufacturing Capacity in Singapore

Figure 5-1 illustrates the estimated 1997 maximum-available manufacturing capacity in Singapore by process technology. More than 55 percent of total production capacity in the city state was equipped to make products with design rules of 0.35-micron and below. As a measure of its product diversity, slightly more than 29 percent of wafer fabrication plants in Singapore were making products using design rules of 1-micron and above. Many of the devices made using this process go into data processing and consumer electronics applications.

In 1998, the maximum-available manufacturing capacity, as measured in MSI, is projected to rise by 17 percent. The production capacity expansion increase comes as a result of companies following through on their investment plans, evidenced by Hitachi Nippon Steel Semiconductors starting commercial production this year. However, Asia's financial crisis is likely to influence companies operating in Singapore to exercise caution when evaluating their capital spending strategies. A slowdown in capital spending, may result in the moderation of capacity growth in the coming years.

Figure 5-1
Singapore's Maximum-Available Production Capacity by Process Technology, 1997 (Percent)



Source: Dataquest (June 1998)

Singapore Semiconductor Manufacturers' Revenue Ranking

Table 5-1 lists the top three semiconductor manufacturers' revenue in Singapore for 1997. SGS-Thomson Microelectronics maintained its leadership as the largest producer. According to Dataquest, the company was also ranked No. 2 worldwide analog chip vendor for 1997. The value of semiconductors produced by SGS-Thomson was estimated to have fallen by 3.4 percent to $1,133 million.

In 1997, CSM climbed into second place as a result of expanding production capacity. The dedicated foundry manufacturer was the only producer in Singapore to make revenue gains in 1997. DRAM foundry manufacturer TECH experienced declining revenue as prices nose-dived. The company's two wafer fabs should be producing 64Mb devices by the end of this year.

The total 1997 revenue semiconductor manufacturing companies in Singapore decreased by 2.5 percent, given the weak market conditions in 1997. This less-than-impressive growth can be attributed to pricing pressures on analog and DRAM products. CSM's estimated production revenue gains were not sufficient to improve the overall situation.

Semiconductor Contract Manufacturing Revenue in Singapore

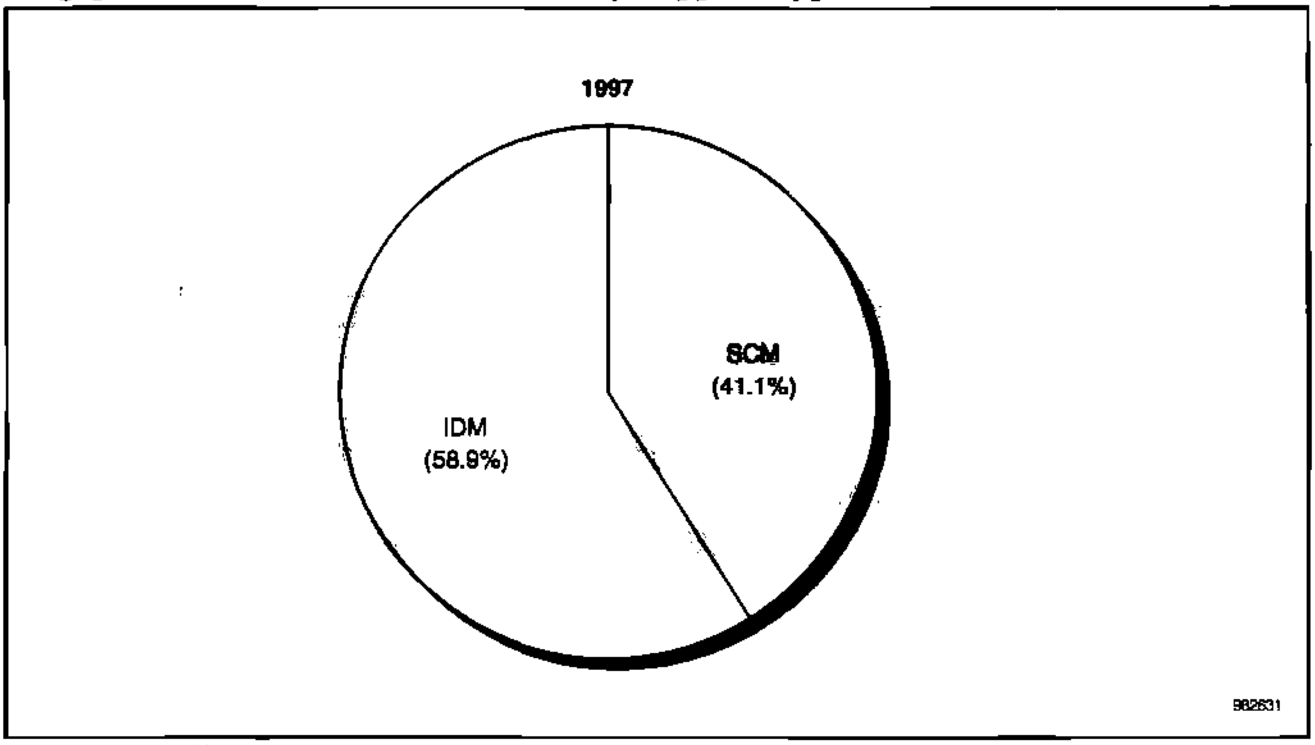
In 1997, revenue generated by the SCM business reached $796 million. SCM revenue represented a significant 41 percent of the total manufacturing revenue in Singapore (see Figure 5-2). Brand-name manufacturing dominates a majority 57 percent of the total revenue. However, the foundry business is expected to be of growing significance as CSM's production capacity expansion is expected to continue.

Table 5-1
Estimated Revenue of Semiconductor Manufacturing Companies in Singapore, Including Contract Manufacturing, 1996 and 1997 (Millions of U.S. Dollars)

Rank	Company	1996 Revenue	1997 Revenue	Percent Change (%) 1996 to 1997
1	SGS-Thomson	1,173	1,133	-3.4
2	Chartered Semiconductor Manufacturing	403	494	22.6
3	TECH Semiconductor	404	302	-25.2
	Others	7	8	14.3
	Total	**1,987**	**1,937**	**-2.5**

Source: Dataquest (June 1998)

Figure 5-2
Singapore's Semiconductor Production by Supplier Type, 1997



Source: Dataquest (June 1998)

Analysis of individual companies' SCM revenue shows that CSM had the largest share of the foundry business in 1997. CSM has entered into two agreements with Lucent Technologies Microelectronics and Hewlett-Packard Company, which will result in the setting up of two new wafer fab projects over the next two years. TECH Semiconductor is jointly owned by Texas Instruments Inc., the Singapore Economic Development Board, Hewlett-Packard, and Canon Inc. The company manufactures DRAMs for Texas Instruments. With a shortage of capital available for new investments in building and equipment, some delay of TECH's plans to expand capacity in the near term is expected.

Singapore Semiconductor Production Forecast

Table 5-2 shows the semiconductor production revenue forecast for Singapore. In 1997, production revenue reached $1,937 million. Production output was largely driven by analog device manufacturing. By 2002, Dataquest forecasts semiconductor production to reach $4,824 million. The value of Singapore's semiconductor production is forecast to grow at a CAGR of 20.0 percent as a result of the revenue boost coming from various device segments. The strongest annual growth rates are estimated to be achieved in 1998 and 2000 (see Figure 5-3).

MOS logic and microcomponent products are expected to record the highest CAGR of 43.5 percent and 40.7 percent, respectively, for the five-year forecast cycle. This is estimated to be followed by MOS memory devices. The device growth trends are likely to be determined by the expected recovery in the memory market and the foundries' efforts to upgrade equipment and to further raise capacity.

Figure 5-4 illustrates the trend of Singapore's semiconductor production. It is evident that no single device segment is expected to dominate the growth trend until 2002. Even though logic and microcomponent devices are predicted to be the fastest-growing product segments, total revenue from semiconductor production should also be determined by analog and memory products. The general trend of Singapore's semiconductor production will increasingly be driven by a diverse product portfolio.

Figure 5-5 illustrates the total semiconductor production by percentage share in 1997. Production of analog devices represented a majority 58.5 percent share of the total revenue, followed by memory devices with a 19.5 percent share. However, by 2002, analog chips' percentage share of the total production value is expected to be reduced to 26.8 percent. The two high-growth device categories, logic and microcomponents, are forecast to account for 27.8 percent and 22.4 percent share, respectively, and memory devices are projected to capture a 22.7 percent share of the total revenue.

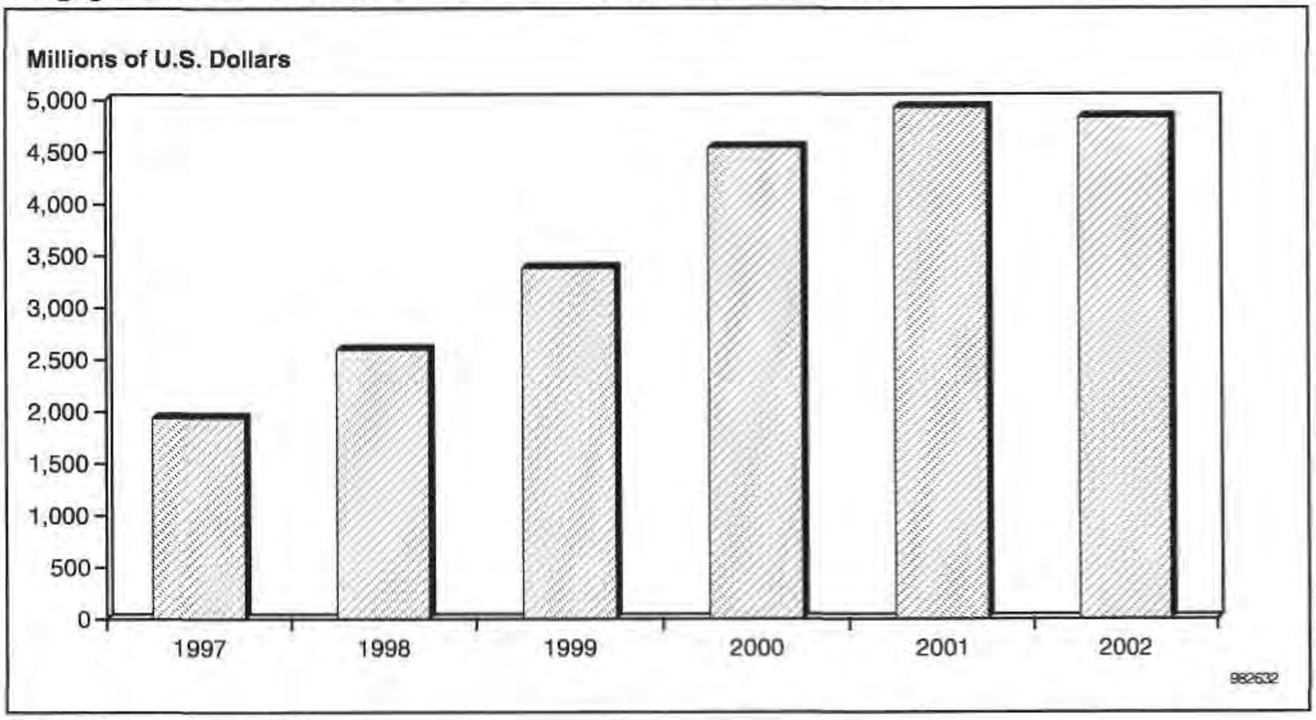
Companies' capital spending in Singapore should continue after the regional economic turmoil has stabilized. With more wafer fabs predicted to come onstream in 1998 and 2000, Singapore is predicted to remain as the largest semiconductor producer in Southeast Asia.

Table 5-2
Singapore's Semiconductor Production Forecast, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Total Semiconductor (Including Hybrid)	**1,937**	**2,595**	**3,377**	**4,539**	**4,922**	**4,824**	**20.0**
Total Integrated Circuit	1,930	2,587	3,368	4,530	4,912	4,814	20.1
Bipolar Digital	1	1	1	1	1	1	-4.4
MOS Memory	378	641	798	1,083	1,286	1,095	23.7
MOS Microcomponent	196	337	516	951	1,017	1,081	40.7
MOS Digital Logic	221	403	795	1,216	1,279	1,342	43.5
Analog-Monolithic	1,134	1,205	1,258	1,279	1,328	1,295	2.7
Total Discrete	-	-	-	-	-	-	NA
Total Optical Semiconductor	7	8	9	9	10	11	7.4

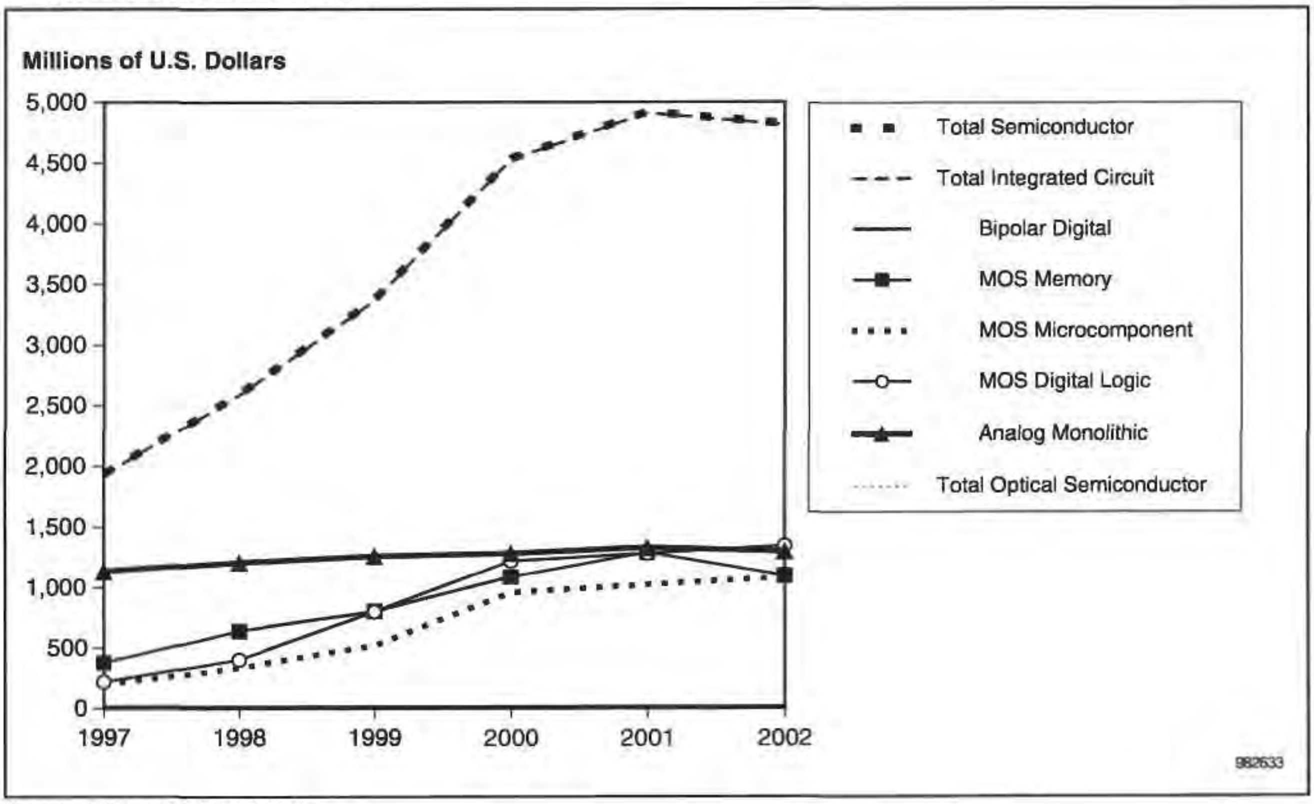
NA = Not available
Source: Dataquest (June 1998)

Figure 5-3
Singapore's Semiconductor Production Forecast, 1997 to 2002



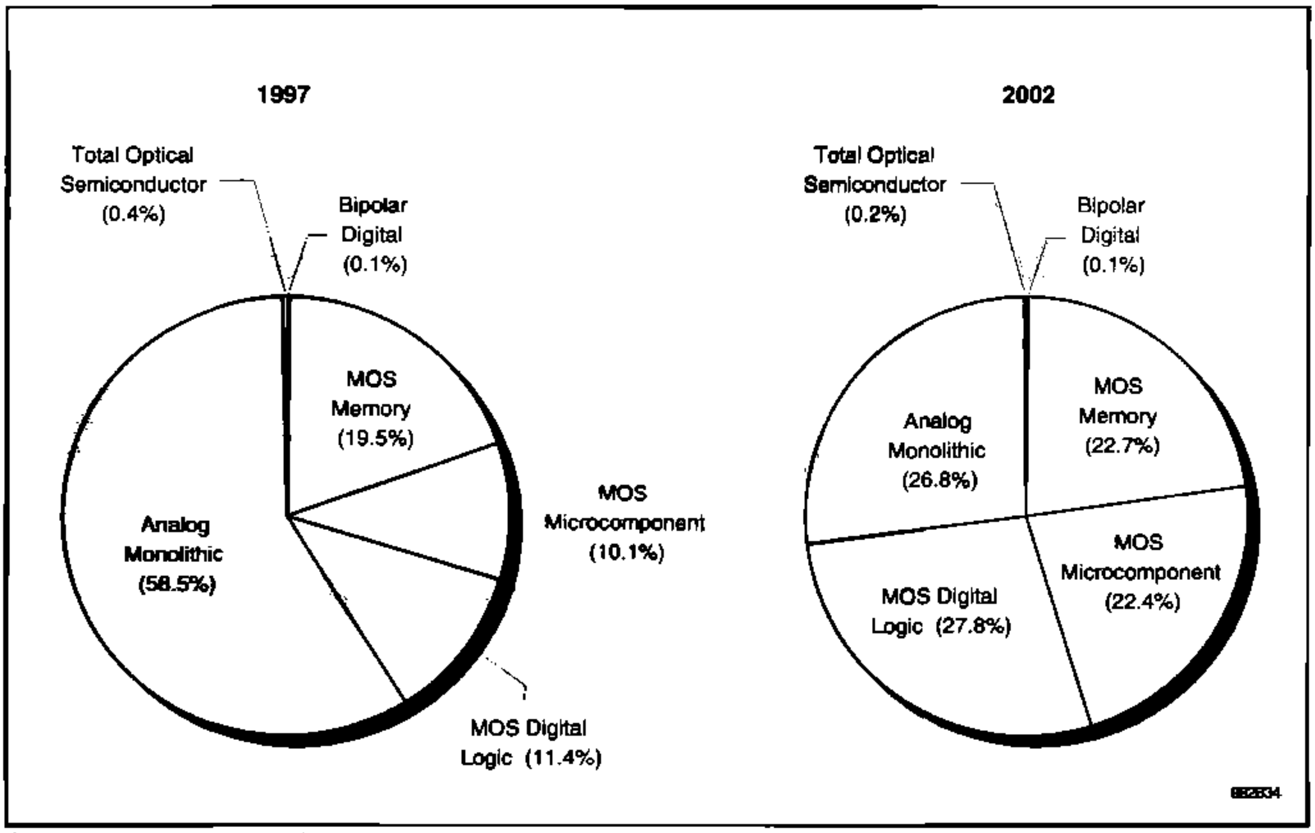
Source: Dataquest (June 1998)

Figure 5-4
Singapore's Semiconductor Device Forecast Revenue, 1997 to 2002 (Millions of U.S. Dollars)



Source: Dataquest (June 1998)

Figure 5-5
Singapore's Semiconductor Production Forecast by Device, 1997 and 2002



Source: Dataquest (June 1998)

Chapter 6
China/Hong Kong's Semiconductor Production

This chapter presents semiconductor production in China/Hong Kong. Among the four major semiconductor production countries, China/Hong Kong is the fastest emerging in Asia/Pacific. Although there are many semiconductor companies in China/Hong Kong, the largest manufacturers tend to be mainly foreign-owned companies. As a manufacturing base, China/Hong Kong occupies fourth place in Asia/Pacific.

China/Hong Kong is becoming a more important production center as a result of fast-expanding domestic semiconductor consumption and intensifying government efforts. Foreign investors are keen to start wafer fab projects in China as electronic equipment production drives increasing semiconductor consumption growth. The government is also striving to reduce the percentage of imported silicon. The authorities plan to achieve this by attracting more foreign semiconductor companies to set up front-end manufacturing in the country. The country would also gain from technology transfer.

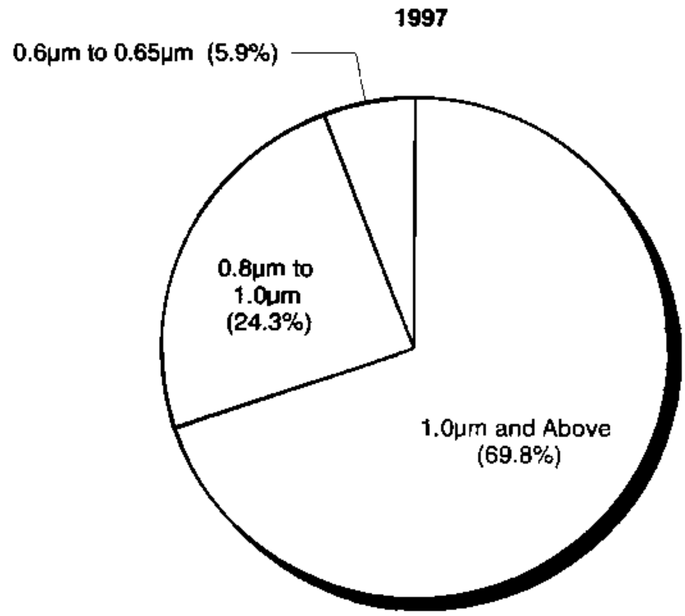
Most of the existing wafer fabrication plants in China are located in the Shanghai-Wuxi locale. The Shanghai, Jiangsu, and Zhejing provinces form an established manufacturing and industrial base. More than 50 science and engineering universities are located in these provinces, providing a steady supply of technical graduates. With central and regional government support to build higher-quality infrastructure such as industrial parks, the region's semiconductor manufacturing is set to expand.

Semiconductor Manufacturing Capacity in China/Hong Kong

Figure 6-1 depicts the 1997 maximum-available manufacturing capacity for China/Hong Kong by process technology. Process technologies used in China/Hong Kong are less advanced compared to the other three major semiconductor manufacturing countries in Asia/Pacific. Almost 70 percent of total production capacity was geared to make products with design rules of above 1-micron. Many of the products made using these processes are discrete devices and are used in consumer electronics applications.

In 1998, the maximum-available manufacturing capacity, as measured in MSI, is forecast to take off with a 55 percent growth rate. The rapid production capacity expansion comes as a result of the optimistic outlook for China/Hong Kong. Investments in the country are expected to continue despite the regional financial crisis. Foreign investors and local companies plan to further expand their existing production capacities and build new wafer fabrication facilities, particularly in mainland China.

Figure 6-1
Maximum-Available Production Capacity in China/Hong Kong by Process Technology, 1997 (Percent)



Source: Dataquest (June 1998)

China/Hong Kong Semiconductor Manufacturers' Revenue Ranking

Table 6-1 lists the top eight semiconductor manufacturers' revenue in China/Hong Kong for 1997. Shougang NEC Electronics Company maintained its leadership as the largest semiconductor producer in China/ Hong Kong. The company, 51 percent owned by NEC Corporation, manufactures 4Mb DRAM and analog devices. Up to 80 percent of the products are produced for export markets.

Second-ranked Shanghai Belling Microelectronics Manufacturing Company Limited showed a 12.7 percent growth in 1997, generating a $54 million revenue. The joint venture is 84 percent owned by China's Ministry of Posts and Telecommunications (MPT) and Alcatel Telecom, which has a 16 percent stake. The company sells up to 90 percent of its output to the domestic market, with Alcatel and the MPT being the main customers. The third-ranked company was Mosel Vitelic, located in Hong Kong. Besides Mosel Vitelic, two other companies on the list operating in Hong Kong are Hua Ko Electronics Limited and RCL Semiconductors Limited.

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Table 6-1
Estimated Revenue of Semiconductor Manufacturing Companies in China/Hong Kong, Including Contract Manufacturing, 1996 and 1997 (Millions of U.S. Dollars)

Rank	Company	1996 Revenue	1997 Revenue	Percent Change (%) 1996 to 1997
1	Shougang NEC	150	165	10.0
2	Shanghai Belling	48	54	12.7
3	Mosel Vitelic Hong Kong	39	51	31.0
4	Huajing Electronics Group	28	44	57.2
5	ASMC	36	43	20.3
6	Hua Ko Electronics	30	32	6.7
7	RCL Semiconductors	14	18	28.6
8	Hua Yue Microelectronics	11	12	12.4
	Others	68	70	2.9
	Total	**424**	**490**	**16.7**

Source: Dataquest (June 1998)

The total 1997 revenue for semiconductor manufacturing companies in China/Hong Kong rose 16.7 percent. Although there are many semiconductor companies in China/Hong Kong, the total value from semiconductor production accounted for under 3 percent of total Asia/Pacific revenue. Most of the companies in China/Hong Kong make lower-valued semiconductors, such as discrete devices. The ownership structure is a defining characteristic of semiconductor companies operating in China/Hong Kong. A foreign-majority-owned company tends to produce for export markets, while a company with local (usually Chinese government) majority ownership will manufacture semiconductors for the domestic consumption market.

Semiconductor Contract Manufacturing Revenue in China/Hong Kong

In 1997, revenue generated by SCM business reached $267 million (see Figure 6-2). SCM revenue represented almost 55 percent of revenue from total semiconductor manufacturing. Brand-name manufacturing captured almost 46 percent of the total revenue. However, the brand-name manufacturing is expected to take up a larger revenue share in China/Hong Kong with the investment commitments made by Motorola Incorporated and Shanghai Hua Hong NEC Electronics Company Ltd.

Analysis of individual companies' SCM revenue shows that Shanghai Belling had the largest share of the foundry business in 1997. The company manufactures discrete devices and chips for consumer and telecommunications applications. China Huajing Electronics Group was in second place. The company benefited from the technology transfer from Toshiba Corporation and Lucent Technologies. Third-ranked Advanced Semiconductor Manufacturing Company (ASMC) is a dedicated foundry that produces automotive, consumer, industrial, and telecommunications equipment products. This venture—jointly owned by Philips Semiconductors Inc. (38 percent), Northern Telecom Inc. or Nortel (34 percent), and the Chinese government (28 percent)—is expected to increase production capacity this year.

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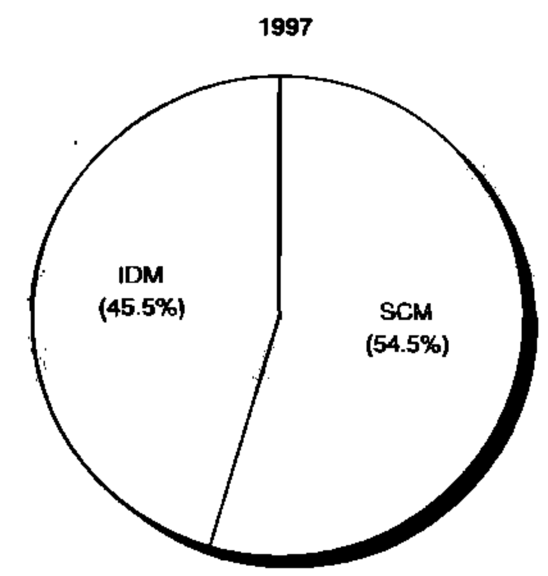
Figure 6-2
China/Hong Kong's Semiconductor Production by Supplier Type, 1997



Source: Dataquest (June 1998)

China/Hong Kong Semiconductor Production Forecast

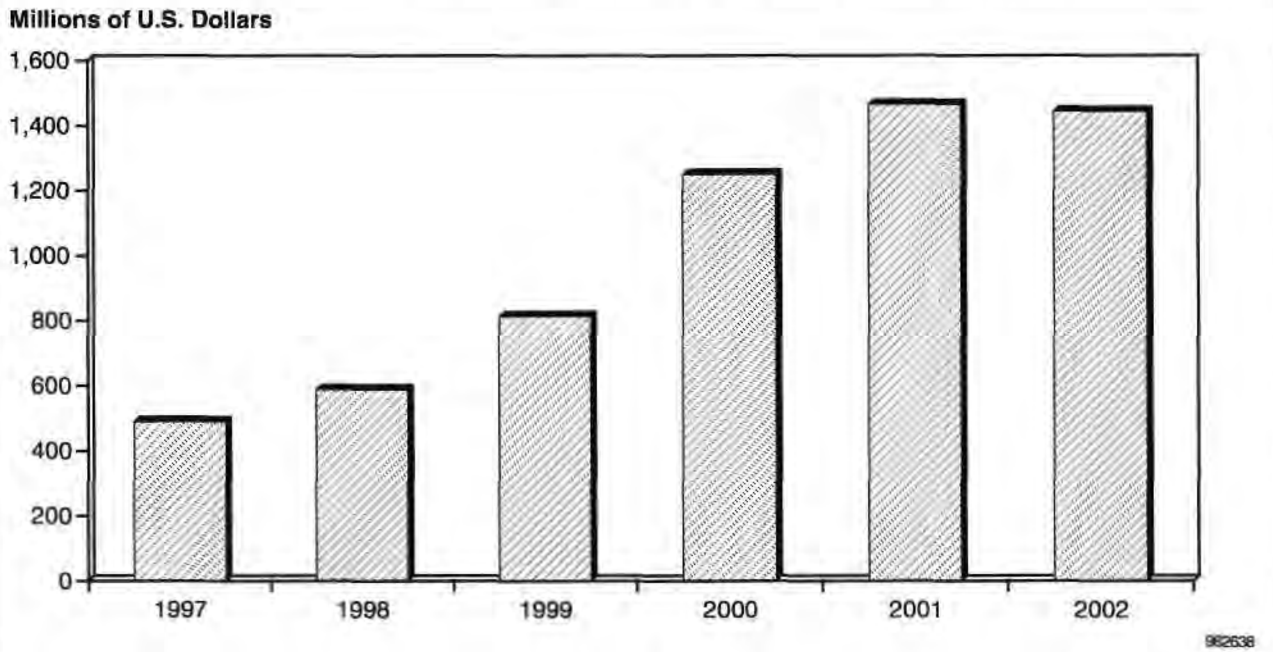
Table 6-2 shows the semiconductor production revenue forecast for China/Hong Kong. In 1997, production revenue reached $490 million. By 2002, Dataquest forecasts semiconductor production to reach $1,444 million. China/Hong Kong is expected to achieve a robust CAGR of 24.1 percent as a result of continued capital inflow pouring in from foreign investors around the turn of the century. The highest annual growth rates are estimated to be achieved in 1999 and 2000, with revenue increase projected to be more moderate in 2001 (see Figure 6-3).

Table 6-2
China/Hong Kong's Semiconductor Production Forecast, 1997 to 2002
(Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Total Semiconductor	**490**	**588**	**814**	**1,251**	**1,466**	**1,444**	**24.1**
Total Integrated Circuit	251	312	508	909	1,093	1,076	33.8
Bipolar Digital	31	30	28	28	26	25	-4.7
MOS Memory	49	59	179	391	548	502	59.0
MOS Microcomponent	101	123	169	345	363	386	30.7
MOS Digital Logic	14	44	74	85	93	103	49.1
Analog-Monolithic	55	56	57	60	63	60	2.0
Total Discrete	239	275	306	341	373	368	9.1
Total Optical Semiconductor	1	1	1	1	1	1	0.8

Source: Dataquest (June 1998)

Figure 6-3
China/Hong Kong's Semiconductor Production Forecast, 1997 to 2002



Source: Dataquest (June 1998)

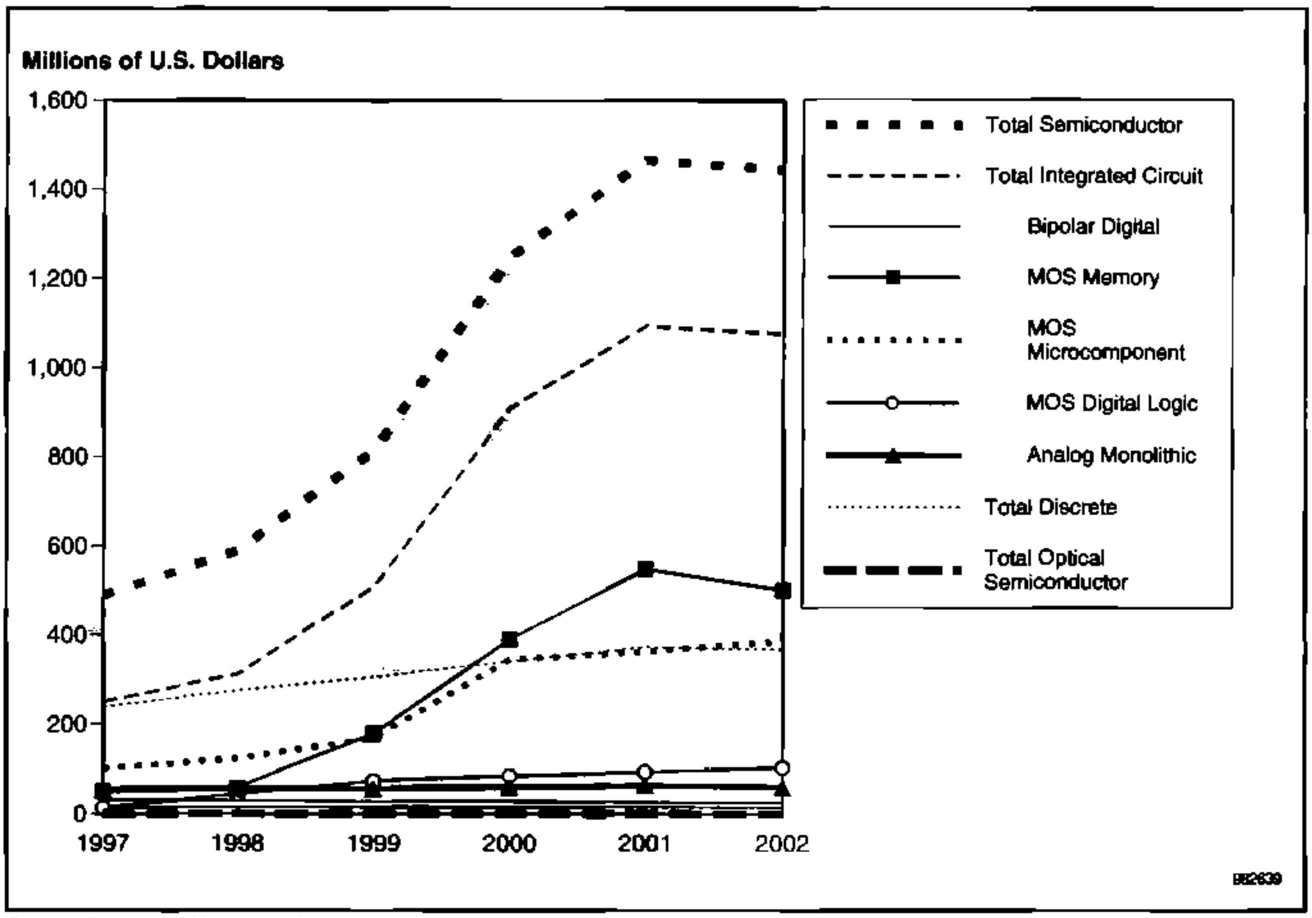
MOS memory devices are expected to record the highest CAGR of 59.0 percent for the next five-year forecast cycle. This is estimated to be followed by MOS logic devices. MOS microcomponent products should see the third-highest CAGR of 30.7 percent. These device growth trends are likely to be determined by the expected recovery in the memory market and foreign capital inflows. The anticipation of the largest and fastest-growing semiconductor consumption market in Asia/Pacific, together with incentives offered by the Chinese government, should increase the level of investments in wafer fab plants.

Figure 6-4 presents China/Hong Kong's semiconductor production trend. Although memory integrated circuits are predicted to be the most promising product category, discrete devices are expected to be the driver of semiconductor production in the country until 1999. In the subsequent years, the general semiconductor production trend is likely to be determined by the production of memory and microcomponent devices.

Figure 6-5 illustrates China/Hong Kong's percentage of semiconductors manufactured in 1997. Discrete devices production represented a significant 48.7 percent share of the total revenue. By 2002, the portfolio of semiconductor products in China/Hong Kong should become more broad-based.

By then, MOS memory devices are expected to take over with a 34.7 percent share of output. The other two top device categories, microcomponents and discrete, are forecast to account for 26.7 percent and 25.5 percent share of production output, respectively. However, the percentage share of analog chips should decline over this period.

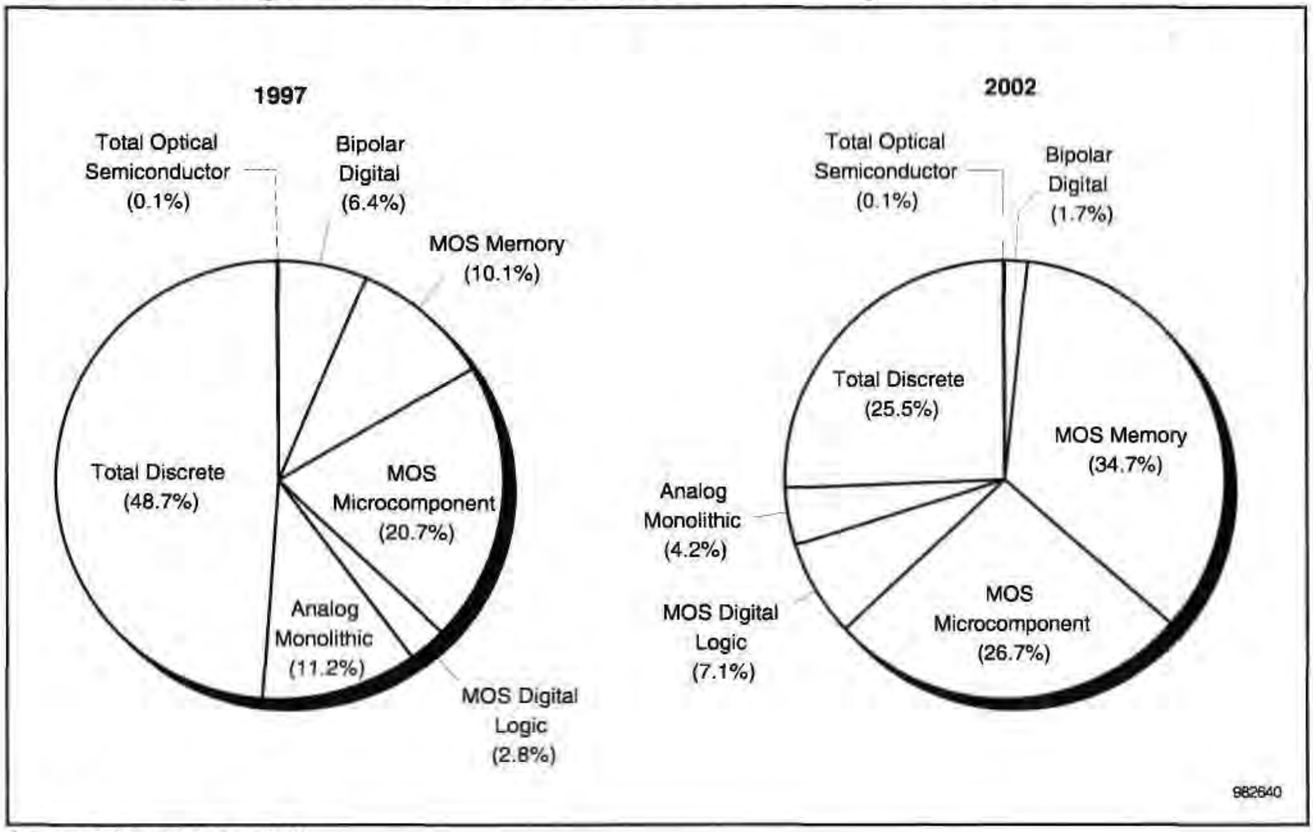
Figure 6-4
China/Hong Kong's Semiconductor Forecast Device Revenue, 1997 to 2002 (Millions of U.S. Dollars)



Source: Dataquest (June 1998)

Investors' capital spending plans to construct new facilities and to expand or upgrade existing plants should go ahead as the regional financial crisis appears not to have affected confidence in China/Hong Kong. Major commitments made by local-foreign ventures, such as the Hua Hong NEC wafer fab project, are expected to proceed as scheduled.

Figure 6-5
China/Hong Kong's Semiconductor Production Forecast by Device, 1997 and 2002



Source: Dataquest (June 1998)

Chapter 7
Dataquest Perspective

Semiconductor production growth in Asia/Pacific is determined by capital investments made to build new wafer fabrication plants and expand manufacturing capacities and the pricing level of memory products. The semiconductor production revenue declined in 1997 as a result of excess capacity and plunging memory prices. Dataquest forecasts the worldwide memory market to record flat growth in 1998, before registering three straight years of robust growth. However, memory devices are expected to be hit by a downturn again in 2002.

The region is likely to exhibit steady semiconductor production growth rates from this year to 2001. In 1998, growth is likely to be driven by capacity addition from new wafer plants in Korea, Taiwan, and Singapore. From 1999 to 2001, semiconductor production revenue is forecast to increase as a result of the recovering memory market and new companies starting commercial operations in the region.

However, annual growth rates at the country level fluctuate from year to year, and in some cases, take on a sporadic nature when increases in production capacity come onstream. Production in China/Hong Kong is likely to record a high-growth year in 1999, then peaking in 2000 when two new fabs start commercial production. Korean companies are predicted to enjoy booming growth in 2000 and 2001. Singapore's semiconductor production growth rate appears to be more "lumpy," with growth years in 1998 and 2000. Taiwan's production is expected to record highest revenue growth rates in 1998 and then peaking in 1999.

Korea and Taiwan are forecast to remain as the manufacturing powerhouses in Asia/Pacific for the coming five-year period. Korea's production revenue is likely to surge when the memory cycle picks up, while Taiwan's semiconductor production revenue takes on a different nature. Although Taiwanese companies are influenced by fluctuations in memory pricing, the product mix and the estimated production capacity increase are predicted to reduce revenue volatility.

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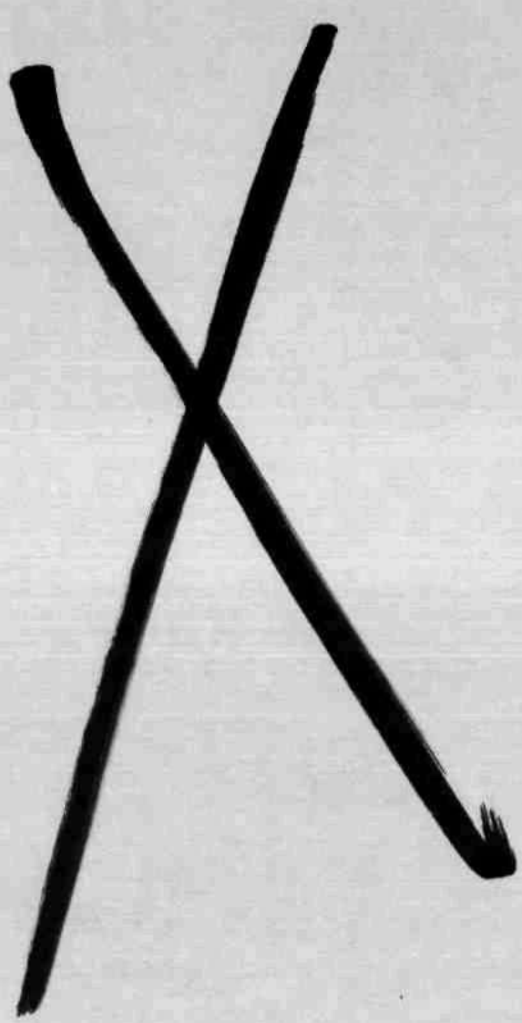

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Market Statistics

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Asia/Pacific Fab Database

Market Statistics

Program: Semiconductors Asia/Pacific
Product Code: SEMI-AP-MS-9804
Publication Date: February 8, 1999
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Asia/Pacific Fab Database

Market Statistics

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List of Tables

Chapter 1
Asia/Pacific Fab Database

Background and Methodology

This report contains the Asia/Pacific portion of Dataquest's wafer fab database. The records in these tables are fabs located in the Asia/Pacific region. The Semiconductor Equipment, Materials, and Manufacturing Worldwide (SEMM) program conducts extensive annual surveys, complemented with quarterly secondary research to maintain this database. Published once a year, this document represents Dataquest's best insights and estimates into the end market of semiconductor equipment.

The tables in this report cover planned and existing merchant, captive, and foundry fab lines. A fab line is a series of equipment to do front-end (from initial oxide through wafer probe) semiconductor manufacturing. Occasionally, two or more separate product-specific fab lines or wafer sizes operate in a single clean room or physical plant. In this situation, Dataquest divides the clean room as separate fab lines if the company dedicates equipment to each wafer size or product line. If a company installs substantially different equipment during an expansion (for example, equipment to increase its maximum wafer diameter), again Dataquest divides the clean room and creates two entries into the database. Therefore, a company may operate many fab lines at one location.

Worldwide Geographic Region Definitions and Regional Roll-Ups

Americas
Includes Central America (all nations), Canada, Mexico, United States, Puerto Rico, and South America (all nations).

Japan
Japan is the only single-country region.

Europe, Africa, and Middle East
Includes Africa (all nations), Albania, Andorra, Armenia, Azerbaijan, Belarus, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Gibraltar, Hungary, Iceland, Israel, Italy, Kazakhstan, Kyrgyzstan, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Middle East (all nations), Moldova, Monaco, Netherlands, Norway, Poland, Romania, Russia, San Marino, Scandinavia, Slovakia, Spain, Sweden, Sweden, Switzerland, Tajikistan, Turkey, Turkmenistan, Ukraine, United Kingdom, Uzbekistan, Vatican City, and all nations within the former Yugoslavia.

Asia/Pacific
Includes Australia, Bangladesh, Cambodia, China, Hong Kong, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, New Zealand, Pakistan, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, and Vietnam.

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Field Definitions

The Company field indicates the operator of the fab line. For contract manufacturers that trade capacity for capital investment in the fab, Dataquest lists the contract manufacturer. For incorporated joint ventures, Dataquest lists either the incorporated entity or the major investors, separated with slashes.

The City field displays the most detailed location information. This reference is usually a city or town, but could be an often-used district name (for example, Science Park in the city of Hsinchu, Taiwan). If this field lists a district, Dataquest will list the city in the State or Province field. In some cases, a reference to a state or province will be included in the City or District field to create a unique identifier for this location.

The Prefecture field denotes the second most detailed location. This reference is usually a state (for the United States), province (for Canada and many European and Asian countries), or a prefecture (for Japan). For countries within the United Kingdom, Dataquest lists the country name (for example, "Scotland") in this field so Dataquest can list the descriptor "U.K." in the Country field.

The Country field indicates the broadest location identifier in this report. This reference is usually a country, except in the case of the United Kingdom (see "State or Province" above). Because Japan is a single-country region, there is no regional qualifier for fabs in Japan.

The Fab Name field provides a reference to a particular fab or fab line to distinguish it from other fabs or lines owned by that company. Although Dataquest makes every attempt to match the nomenclature used by the company, occasionally some additional qualifiers (for example, "Phase 1") will appear to provide insight to the facility's history or organization.

The Products field lists the products manufactured at this site. The listings generally fall into five product groups, with the following nomenclature and definitions (when warranted):

- MOS memory
  - DRAM: Dynamic RAM
  - EEPROM: Electrically erasable PROM
  - EPROM: Ultraviolet erasable PROM
  - FERRAM: Ferroelectric RAM
  - FIFO: First-in/first-out memory
  - Flash: Flash memory
  - Mem: Memory
  - NV Mem: Nonvolatile memory (ROM, PROM, EPROM, EEPROM, and FERRAM)
  - PROM: Programmable ROM
  - RAM: Random-access memory

- ROM: Read-only memory
- SGRAM: Synchronous graphics RAM
- Sp Mem: Other specialty memory (such as dual-port, shift-register, or color lookup)
- SRAM: Static RAM
- VRAM: Video RAM

- MOS microcomponent/digital logic
  - Array: Gate array
  - ASIC: Application-specific IC
  - ASSP: Application-specific standard product
  - Bit: Bit slice (subset of MPU functions)
  - CBIC: Cell-based IC
  - Custom: Full-custom IC (single user)
  - DSP: Digital signal processor
  - FPGA: Field-programmable gate array
  - LISP: 32-bit list instruction set processor for AI
  - Logic: Standard logic
  - LSI: Large-scale integration
  - MCU: Microcontroller unit
  - MixSig ASIC: Mixed-signal ASIC
  - MPR: Microperipheral
  - MPRCom: MPR digital communication (ISDN, LAN, UART, or modem)
  - MPU: Microprocessor unit
  - PLD: Programmable logic device
  - RISC: Reduced-instruction-set computation 32-bit MPU
  - Telecom: Telecommunications chip
- Power/discrete/analog (including bipolar power)
  - A/D D/A: Analog-to-digital, digital-to-analog converter
  - Automotive: Dedicated to automobile applications
  - CODEC: Coder/decoder
  - Diode
  - Discrete
  - FET: Field-effect transistor
  - GTO: Gate turn-off thyristor
  - HEMT: High-electron-mobility transistor
  - IGBT: Insulated-gate bipolar transistor

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- Interface: Interface IC
- Linear: Linear/analog device
- MDiode: Microwave diode
- MESFET: Metal semiconductor field-effect transistor
- MFET: Microwave field-effect transistor
- Modem: Modulator/demodulator
- MMIC: Monolithic Microwave IC
- MOSFET: MOS-based field-effect transistor
- Op Amp: Operational amplifier
- Pwr IC: Power IC
- Pwr Tran: Power transistor
- Rectifier
- Reg: Voltage regulator
- RF: Radio frequency
- SCR: Schottky rectifier
- Sensor
- Smart Pwr: Smart power
- SST: Small-signal transistor
- Switches: Switching device
- Thyristor
- Tran: Transistor
- Zener Diode

- Optoelectronic
  - CCD: Charge-coupled device (imaging)
  - Coupler: Photocoupler
  - IED: Infrared-emitting diode
  - Image Sensor
  - Laser: Semiconductor laser or laser IC
  - LED: Light-emitting diode
  - Opto: Optoelectronic
  - PDiode: Photo diode
  - PTran: Photo transistor
  - SAW: Surface acoustic wave device
  - SIT Image Sensor: Static induction transistor image sensor

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- Bipolar Digital and Other Devices (includes all digital ICs using a bipolar process)
  - Darlington
  - Micromachining sensors
  - MilStd: Military Standard Logic
  - RadHard: Radiation hardened

The Process Technology field indicates each fab's use of five major types of processes. The process grouping is as follows:

- P/CMOS: P-channel metal-oxide semiconductor (PMOS) or complementary metal-oxide semiconductor (CMOS)
- NMOS: N-channel metal-oxide semiconductor (NMOS)
- BiCMOS: Bipolar and CMOS combined on a chip
- Bipolar
- III-V: Gallium arsenide and other compound semiconductor processes

The Estimated Minimum Geometry is the smallest linewidth feature size, measured in microns, attainable in production volume.

The Wafer Diameter represents the maximum wafer size that the fab or fab line can process. Wafer diameters, although expressed colloquially in inches, conform to metric specifications. For wafers greater than 3 inches in diameter, expression in inches becomes inaccurate. When calculating square inches, Dataquest uses the following approximations:

- Stated diameter of 4 inches (100mm) = Approximate diameter of 3.938 inches
- Stated diameter of 5 inches (125mm) = Approximate diameter of 4.922 inches
- Stated diameter of 6 inches (150mm) = Approximate diameter of 5.906 inches
- Stated diameter of 8 inches (200mm) = Approximate diameter of 7.87 inches
- Stated diameter of 12 inches (300 mm) = Approximate diameter of 11.84 inches.

The Year and Quarter of Initial Production displays the year (and quarter, if available) in which this line, having completed all qualifications, began manufacturing in production volumes. The format for this reference is "year.quarter" (for example, 1994.3 translates to the third calendar quarter of 1994).

The Initial Monthly Wafer Starts field indicates the initial monthly volume of production wafer throughput.

The Estimated Maximum Monthly Wafer Starts field contains the equipment-limited wafer start capacity per four-week period. Only the throughput of the installed equipment and the process complexity limits the maximum starts. Dataquest does not consider current staffing or the number of shifts operating in determining this metric.

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The Fab Type field shows the types of semiconductor manufacturing performed at this location. The fab types include the following:

- "F" indicates that this is a production-based fab.
- "R" indicates a semiconductor R&D and/or trial production facility.
- "P" means that this location produces a pilot line.
- "T" means that this location performs assembly or testing.
- "N" indicates that this location performs foundry production, or contract manufacturing.
- "VD" means that this location performs VHDL design.
- "PD" means that this location performs IC place and route design.

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Chapter 2
Market Statistics Tables

Tables 2-1 and 2-2 provide information on fabs located in the Asia/Pacific region.

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Table 2-1
Asia/Pacific's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Advanced Semiconductor Mfg (ASMC)	Shanghai	Suzhou	China	-	Foundry	-	0.50	200	1998.0	4,500	18,100	FN
Advanced Semiconductor Mfg (ASMC)	Shanghai	Suzhou	China	Fab 1	Foundry Linear Automotive	P/CMOS	0.80	150	1997.0	1,000	4,500	FN
Advanced Semiconductor Mfg (ASMC)	Shanghai	Suzhou	China	CMOS 6	Foundry Telecom Consumer ASSP	NMOS	2.00	125	1992.0	2,800	19,000	FN
Alcatel-China Gov't (Shanghai Belling)	Shanghai	Suzhou	China	Shanghai Belling Fab 1	Linear Discrete Power	P/CMOS	3.00	100	1988.0	3,500	10,000	FTRVD-PDN
Amkor/Anam	Buchon-City	Kyungki-Do	Korea	Fab II	DSP, Foundry	-	0.21	200		8,700	10,000	FT
Ankor/Anam	Buchon-City	Kyungki-Do	Korea	Fab 1	Foundry DSP ASIC	-	0.25	200	1997.4	3,700	15,000	FTN
Changzhou Semiconductor	Changzhou	Jiangsu	China	Changzhou Semiconductor Fab	Consumer ICs ASICs	Bipolar	1.00	75	1986.0	200	1,000	FT
Chartered Group	Singapore	Woodlands Industrial Park	Singapore	Fab 3A	Foundry	-	0.25	200	1997.2	4,800	32,000	FN
Chartered Group	Singapore	Woodlands Industrial Park	Singapore	Fab II	Logic MixSig ASIC SRAM ROM	P/CMOS	0.35	200	1996.0	500	50,000	FTN
Chartered Group	Singapore	Woodlands Industrial Park	Singapore	Fab I	Logic MixSig ASIC ROM EEPROM	P/CMOS	0.60	150	1989.2	500	26,000	FN
Daewoo	Guro-Dong	Seoul	Korea	MOS	Custom ASIC	-	1.00	100	1988.3	2,500	10,000	FT
Daewoo	Guro-Dong	Seoul	Korea	Bipolar	Analog	Bipolar	2.00	100	1986.3	3,000	10,000	FT
Daewoo	Kyungki-Do	Kyungki-Do	Korea	Bipolar	Diode Rectifier	Bipolar	5.00	100	1983.0	10,500	30,000	F
Dongsung	Umsung	-	Korea	Bipolar	Diode Rectifier	-	5.00	100	1996.0	10,500	30,000	FT
Government of China	Beijing	-	China	Fab 5	ASIC	-	1.20	100	1994.0	500	2,000	FTRVD
Government of China	Lintong	Shanxi	China	MAI No. 771 Institution	ASIC	Bipolar	1.20	150	1992.0	1,000	4,000	FTRVDN
Government of China	Chongqing	-	China	MEI No. 24 Institution	ASIC	Bipolar	1.20	150	1992.0	1,000	4,000	FTRVD
Government of China	Beijing	-	China	Factory No. 878	ASIC	Bipolar	5.00	75	1988.0	200	1,000	FTRVD
Government of China	Chongqing	-	China	MEI No. 25 Institution	Discrete		2.50	75	1982.0	500	1,500	FTRVD
Hua Ko Electronics	Tai Po	-	Hong Kong	-	MPU Lin ASIC Log SRAM ROM	P/CMOS	2.50	100	1982.0	2,400	8,000	FTP
Hua Yue Microelectronics	Shaoxing	Zhejiang	China	Fab 4	Consumer ICs ASIC		2.00	100	1998.0	3,500	-	FTR
Hua Yue Microelectronics	Shaoxing	Zhejiang	China	Fab 3	Consumer ICs ASIC	Bipolar	5.00	125	1995.4	6,200	12,500	FTR

Table 2-1 (Continued)
Asia/Pacific's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Hua Yue Microelectronics	Shaoxing	Zhejiang	China	Fab 1	Consumer ICs ASIC	P/CMOS	3.00	75	1993.0	7,000	20,000	F
Hua Yue Microelectronics	Shaoxing	Zhejiang	China	Fab 2	Consumer ICs ASIC	Bipolar	5.00	125	1984.4	7,000	8,000	FTR
Huajing Electronics Group	Wuxi	Jiangsu	China	Fab 1-C	Consumer ICs	P/CMOS	0.80	150	1997.0	6,000	10,000	FTRVDN
Huajing Electronics Group	Wuxi	Jiangsu	China	MOS-1	4-bit MCU	P/CMOS	2.00	125	1993.0	8,000	8,000	FTRVDN
Huajing Electronics Group	Wuxi	Jiangsu	China	Fab 1-A	Audio Visual ICs	Bipolar	2.00	125	1984.0	15,000	15,000	FTRVDN
Hualon Microelectronics	Science Park	Hsinchu	Taiwan	Fab 1	Logic ASIC MPU SRAM	P/CMOS	0.55	125	1988.4	4,500	35,000	FTVD-PDN
Hyundai	Ichon	Kyoungki-Do	Korea	Fab 7	16Mb 64Mb DRAM		0.35	200	1997.0	15,000	30,000	FR
Hyundai	Ichon	Kyoungki-Do	Korea	Fab 6	64M DRAM	P/CMOS	0.25	200	1996.0	7,500	21,000	FTPD
Hyundai	Ichon	Kyoungki-Do	Korea	Fab 5	1-2M SRAM	P/CMOS	0.35	200	1994.0	18,000	23,000	FTPD
Hyundai	Ichon	Kyoungki-Do	Korea	Fab 4	16Mb DRAM	P/CMOS	0.28	200	1993.0	8,000	9,000	FTPD
Hyundai	Ichon	Kyoungki-Do	Korea	Fab 3	4M DRAM ASIC/ASSP Foundry	P/CMOS	0.50	150	1989.0	16,000	18,000	FTPDN
Hyundai	Ichon	Kyoungki-Do	Korea	MOS R&D	DRAM	P/CMOS	0.25	150	1989.0	1,500	3,000	FRP
Hyundai	Ichon	Kyoungki-Do	Korea	MOS Fab 2-A	1Mb 4Mb DRAM	P/CMOS	0.65	150	1986.0	7,500	15,000	FR
Hyundai	Ichon	Kyoungki-Do	Korea	Fab 2	ASIC/ASSP	P/CMOS	0.50	150	1986.0	28,000	30,000	FTPDN
Hyundai	Ichon	Kyoungki-Do	Korea	MOS Fab 1-A	256K DRAM SRAM	P/CMOS	1.00	125	1985.0	7,500	15,000	F
Hyundai	Ichon	Kyoungki-Do	Korea	Fab 1	64-256 SRAM	P/CMOS	0.80	125	1985.0	18,000	20,000	FTPD
Integrated Device Technology	Canlubang	Laguna	Philippines	IDT Philippines	SRAM Logic		0.50	150	1996.2	8,000	20,000	NO
Integrated Device Technology	Penang	Penang	Malaysia	IDT Malaysia	Logic SRAM SMP FIFO MPR		0.80	150	1988.1	8,000	20,000	NO
Korea Diode Company	Buchon-City	Kyoungki-Do	Korea	Bip Line 1	Analog Trans	Bipolar	1.50	100	1975.0	7,000	20,000	FT
Korean Electronic Company	Gumi-City	Kyungbuk	Korea	Bip Line 2	Analog ICs ASIC	Bipolar	1.20	125	1986.0	4,500	15,000	FT
Kukje	Shihung	-	Korea	-	Optoelectronics	GaAs	5.00	51	1992.0	1,400	4,000	FT
LG Semicon	Chongju-City	Chungcheongbuk-do	Korea	C2-Fab 5	16Mb 64Mb DRAM	P/CMOS	0.25	200	1997.0	20,000	40,000	FTVD-PDN

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Table 2-1 (Continued)
Asia/Pacific's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
LG Semicon	Chongju-City	Chung-cheong-buk-do	Korea	C3-Fab 7	64Mb 128Mb 256Mb DRAM	P/CMOS	0.22	200	1997.0	20,000	30,000	FTVD
LG Semicon	Gumi-City	Kyeong-sansbuk-do	Korea	G2/G3	16MB 64MB DRAM	P/CMOS	0.35	200	1997.0	3,000	9,000	FTVD-PDN
LG Semicon	Gumi-City	Kyeong-sansbuk-do	Korea	G3	16M DRAM	P/CMOS	0.35	200	1995.0	16,000	23,000	FTVDPD
LG Semicon	Chongju-City	Chung-cheong-buk-do	Korea	C2-Fab 4	16Mb 64Mb DRAM SRAM Flash SGRAM ASIC	P/CMOS	0.30	200	1993.0	11,000	30,000	FTRVD PD
LG Semicon	Chongju-City	Chung-cheong-buk-do	Korea	C1-Fab 2	1M 4Mb DRAM SRAM ROM	P/CMOS	0.50	150	1991.0	24,000	28,000	FTVDPD
LG Semicon	Chongju-City	Chung-cheong-buk-do	Korea	C1-Fab 1	1Mb 4Mb DRAM SRAM ROM	P/CMOS	0.50	150	1990.0	24,000	28,000	FTVDPD
LG Semicon	Gumi-City	Kyeong-sansbuk-do	Korea	G3	SRAM ROM Logic	P/CMOS	1.20	125	1984.0	11,300	20,000	FTVDPD
LG Semicon	Gumi-City	Kyeong-sansbuk-do	Korea	Gumi Bipolar	Analog Logic	Bipolar	1.20	125	1980.0	17,500	21,000	FTVDPD
Macronix	Science Park	Hsinchu	Taiwan	Fab 2	DRAM, Flash Logic	P/CMOS	0.35	200	1997.2	5,000	15,000	FVDPD
Macronix	Science Park	Hsinchu	Taiwan	Fab 1-A	Foundry	P/CMOS	0.45	150	1994.0	3,700	25,000	FVDPDN
Macronix	Science Park	Hsinchu	Taiwan	Fab 1	ROM EPROM Flash Logic	P/CMOS	0.45	150	1992.3	12,200	35,000	FVDPD
Malaysian Institute of Microelectronic Systems (MIMOS)	Kuala Lumpur	Johor Baru	Malaysia	Mimos Phase 1	ASICS; MCU	P/CMOS	0.50	150	1997.3	300	600	FRVDP-DNP
Maxim	Philippines	-	Philip-pines	Assembly	Analog & Mixed Signal		1.20	200	1997.0	5,600	18,900	NOT
Micron-Acer	Science Park	Hsinchu	Taiwan	Fab 1B	16Mb 64Mb DRAM	P/CMOS	0.35	200	1995.3	5,000	30,000	FRN
Micron-Acer	Science Park	Hsinchu	Taiwan	Fab 1A	16Mb DRAM	P/CMOS	0.45	150	1991.4	5,000	22,000	FRN
Micron-Singapore EDB (Tech)	Singapore	-	Singa-pore	Tech Semi-conductor Fab 2	16Mb DRAM	P/CMOS	0.18	200	1996.3	10,000	14,000	FN
Micron-Singapore EDB (Tech)	Singapore	-	Singa-pore	Tech Semi-conductor Fab 1	16Mb DRAM	P/CMOS	0.28	200	1993.2	6,000	10,000	FN
Mitsubishi	Nagano	-	Japan		64Mb DRAM	P/CMOS	0.35	200	1998.2	10,000	20,000	F
Mitsubishi	Science Park	Hsinchu	Taiwan	PSC	16Mb 64Mb DRAM	P/CMOS	0.35	200	1996.0	6,000	12,000	FT
Mitsubishi-UMAX (Powerchip)	Science Park	Hsinchu	Taiwan	Powerchip	16Mb DRAM 64Mb DRAM	P/CMOS	0.30	200	1996.2	5,000	25,000	FTRVD-PDN
Mosel Vitalic (JV) Pro-Mos Technologies	Science Park	Hsinchu	Taiwan	Fab 1	64Mb 256Mb DRAM	P/CMOS	0.35	200	1998.1	5,000	20,000	FRVD-PDN

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Table 2-1 (Continued)
Asia/Pacific's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Mosel Vitelic	Science Park	Hsinchu	Taiwan	Fab 1B (Mosel Vitelic)	4M, 8M, SDRAM, SRAM, VROM, Logic	P/CMOS	0.34	150	1995.4	2,000	30,000	FRVDN
Mosel Vitelic	Hong Kong	-	Hong Kong	Vitelic Hong Kong Fab 1	Discrete Consumer ICs	-	2.20	100	1982.0	6,100	17,600	FN
Motorola	Seremban	-	Malaysia	ISMF	Small Signal Opto	Bipolar	1.25	100	1988.0	4,000	20,000	F
Motorola	Chengdu	Sichuan	China	LeShan-Phoenix	Packaging	-	-	-	1983.0	-	-	NOT
Nan Ya Technology	Tao Yuan	-	Taiwan	Fab 1 Phase 2	16M 64M DRAM Logic	P/CMOS	0.30	200	1996.4	2,000	35,000	FRVD-PDN
NEC	Shanghai	Shanghai	China	-	DRAM	P/CMOS	0.35	200	1994.4	-	-	F
Photronics	(Taiwan)	-	Taiwan	-	Opto	-	1.70	75	1984.0	3,500	10,000	FT
Quality Semiconductor	Sydney	-	Australia	-	16-bit 32-bit MCU FIFO ASIC Foundry	P/CMOS	0.60	150	1989.2	2,500	7,000	FN
RCL Semiconducors	Tai Po	-	Hong Kong	-	-	P/CMOS	2.50	125	1993.0	2,100	6,000	FT
RCL Semiconducors	Tai Po	-	Hong Kong	-	Memory MPU Log Lin Tran	P/CMOS	2.50	100	1982.0	1,200	4,000	FTP
Sammi	Yongin	Kyungki-Do	Korea	III-V	LED Ld Hemt	GaAs	5.00	51	1992.0	1,400	4,000	FT
Samsung	Kiheung-Up	Kyungki-Do	Korea	Fab 8	64Mb DRAM	P/CMOS	0.30	200	1998.0	12,500	25,000	FTVDPD
Samsung	Kiheung-Up	Kyungki-Do	Korea	Fab 7	16Mb 64Mb DRAM	P/CMOS	0.35	200	1996.0	15,000	20,000	FTVDPD
Samsung	Kiheung-Up	Kyungki-Do	Korea	Fab 6	16Mb 64Mb DRAM	P/CMOS	0.26	200	1995.1	23,000	37,000	FTVDPD
Samsung	Kiheung-Up	Kyungki-Do	Korea	Fab 5	Alpha MPU ASIC ASSP E DRAM	P/CMOS	0.35	200	1993.0	19,000	24,000	FTVDPD
Samsung	Kiheung-Up	Kyungki-Do	Korea	Fab 4	4Mb DRAM SRAM Embed DRAM	P/CMOS	0.48	150	1990.0	25,000	42,000	FTVDPD
Samsung	Kiheung-Up	Kyungki-Do	Korea	R&D	R&D	P/CMOS	0.30	300	1989.2	1,500	3,000	FTRVD-PDP
Samsung	Kiheung-Up	Kyungki-Do	Korea	Fab 3	ASIC MCRO	P/CMOS	0.46	150	1988.3	24,000	55,000	FTVDPD
Samsung	Kiheung-Up	Kyungki-Do	Korea	Fab 2	ASIC	P/CMOS	0.45	150	1985.1	25,000	46,000	FTVDPD
Samsung	Buchon-City	Kyungki-Do	Korea	Bucheon C	Analog	Bipolar	3.00	100	1985.0	23,000	68,000	FTVDPD
Samsung	Kiheung-Up	Kyungki-Do	Korea	Fab 1	ASIC	P/CMOS	1.00	100	1984.1	21,000	35,000	FTVDPD
Samsung	Buchon-City	Kyungki-Do	Korea	MOS	MICRO Logic	P/CMOSNMOS	2.00	125	1974.0	15,000	30,000	FTRVD PD
Semiconductor Complex Ltd. (SCL)	Nagar-Chandigarh	SAS Nagar Punjab	India	VLSI Fab	Telecom ICs, ASICs	P/CMOS	0.80	200	1997.0	1,000	2,000	FTRVDP-DNP

Table 2-1 (Continued)
Asia/Pacific's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Shanghai Industrial Complex	Shanghai	Suzhou	China	Fab No. 2	ASIC		1.00	100	1985.0	4,100	16,600	F
Shanghai Industrial Complex	Shanghai	Suzhou	China	Fab No. 1	Tran Lin Log Mem	NMOS	3.00	100	1983.0	300	1,200	FRP
STMicroelectronics	Singapore	-	Singa-pore	Fab 4 #7	MPU CPU	GaAs	1.5	125	1996	8000	23000	FVDPD
STMicroelectronics	Singapore	-	Singa-pore	Fab 1 # 4	MPU CPU	BiCMOSBipolar	2	125	1988	12000	28000	FVDPD
STMicroelectronics	Singapore	-	Singa-pore	Fab 3 # 6	MPU CPU	GaAs	2.5	125	1984	16000	37000	FVDPD
STMicroelectronics	Singapore	-	Singa-pore	Fab 2 # 5	MPU CPU	GaAs	2.5	125	1984	14700	42000	FVDPDP
Suzhou Complex	Suzhou	-	China	Suzhou Semi-conductor Fab	Opto Telecom Consumer ICs	Bipolar	0.80	75	1990.0	300	1,000	FTRVD
Taijin No. 1	Taijin	-	China	-	Audio ICs	-	5.00	75	1983.0	3,000	10,000	F
TSMC Group	Science Park	Hsinchu	Taiwan	Fab 5	Foundry	P/CMOS	0.18	200	1998.0	5,000	30,000	FTN
TSMC Group	Science Park	Hsinchu	Taiwan	Fab 4	Foundry	P/CMOS	0.25	200	1997.1	5,000	31,000	FTRN
TSMC Group	Science Park	Hsinchu	Taiwan	Fab 3	Foundry	P/CMOS	0.25	200	1995.3	5,000	41,000	FTN
TSMC Group	Science Park	Hsinchu	Taiwan	Fab 2-B	Foundry	P/CMOS	0.50	150	1992.4	6,000	80,000	FTX PDN
TSMC Group	Science Park	Hsinchu	Taiwan	Fab 1	Foundry	P/CMOS	0.80	150	1988.0	3,000	21,000	FN
UMC Group	Science Park	Hsinchu	Taiwan	USI	Foundry	P/CMOS	0.25	200	1998.1	5,000	8,000	FPDN
UMC Group	Science Park	Hsinchu	Taiwan	USC	Foundry	P/CMOS	0.25	200	1996.4	5,000	30,000	FN
UMC Group	Science Park	Hsinchu	Taiwan	Fab 3-A	Foundry	P/CMOS	0.25	200	1995.0	5,000	30,000	FRN
UMC Group	Science Park	Hsinchu	Taiwan	Fab 2	Foundry	P/CMOS	0.50	150	1989.0	6,000	48,000	FN
UTEK	Science Park	Hsinchu	Taiwan	Fab 2	MCU ASIC Non Vol	P/CMOS	0.25	200	1998.2	5,000	8,000	FTVD-PDN
UTEK	Science Park	Hsinchu	Taiwan	Fab 1	MCU ASIC Non Vol	P/CMOS	0.80	125	1990.4	2,000	35,000	FTVD-PDN
Vanguard International	Science Park	Hsinchu	Taiwan	Fab 1B	16Mb 64Mb SDRAM; 8M SGRAM	P/CMOS	0.25	200	1996.4	5,000	25,000	FTRVD PD
Vanguard International	Science Park	Hsinchu	Taiwan	Fab 1A	4Mb DRAM	P/CMOS	0.35	200	1995.2	5,000	15,000	FTRVD-PDN
Vanguard International	Science Park	Hsinchu	Taiwan	Fab 1	4Mb DRAM	P/CMOS	0.50	150	1991.0	2,000	4,000	FRP
Winbond Group	Science Park	Hsinchu	Taiwan	Fab 4	64Mb DRAM	P/CMOS	0.25	200	1998.3	5,000	10,000	FVDPDN
Winbond Group	Science Park	Hsinchu	Taiwan	WSMC 1	Flash, SRAM, Logic	P/CMOS	0.25	200	1998.3	5,000	5,000	FTRNP
Winbond Group	Science Park	Hsinchu	Taiwan	Fab 2	Logic, SRAM	P/CMOS	0.50	150	1992.4	5,000	35,000	FVDPDN
Winbond Group	Science Park	Hsinchu	Taiwan	Fab 1	Analog, Logic	P/CMOS	0.80	125	1988.3	6,000	22,000	FVDPDN
Xin Whey Guafon Microelectronics	Xinhui	Guangzhou	China	-	Telecom ICs	-	1.40	100	1990.0	1,500	5,000	FTRPDN

Source: Dataquest (December 1998)

Table 2-2
Asia/Pacific's Future Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Advanced Semiconductor Mfg (ASMC)	Shanghai	Suzhou	China	-	Foundry	-	0.50	200	1998.0	4,500	18,100	FN
Arcus Technology (fabless)	Bangalore	-	India	-	MixSig ASIC 16 32-bit RISC MPU	-	1.40	100	2000.0	5,200	17,400	
Chartered Group	Singapore	-	Singapore	Chartered Silicon Partners	Foundry	P/CMOS	0.25	200	2000.0	4,500		FN
Chartered Group	Singapore	Woodlands Industrial Park	Singapore	Fab IV	Foundry	-	0.25	200	2001.0	7,200	48,000	FN
DongBu Electronics	Eumsung	ChungBuk	Korea	-	64 Mb 256Mb DRAM	P/CMOS	0.25	200	1999.0	15,000	30,000	F
First Silicon	Kuching	Sarawak	Malaysia	Kuching	Foundry	-	0.25	200	1999.4	3,700	20,000	FN
Hitachi-Nippon Steel Semiconductor	Singapore	-	Singapore	Hitachi-Nippon Steel Semiconductor	64Mb DRAM	P/CMOS	0.18	200	1999.0	10,000	20,000	F
Hua Hong Microelectronics (NEC)	Poudong	Shanghai	China	Fab 1	EEPROM SRAM MCU DRAM Foundry	-	0.35	200	1999.3	3,000	20,000	FN
Hua Yue Microelectronics	Shaoxing	Zhejiang	China	Fab 4	Consumer ICs ASIC	-	2.00	100	1998.0	3,500		FTR
Macronix	Science Park	Hsinchu	Taiwan	Fab 3	ROM EPROM Flash Logic	P/CMOS	0.25	200	2000.0	10,500	30,000	FVDPD
Malaysian Institute of Microelectronic Systems (MIMOS)	Johor Baru	-	Malaysia	Phase II	ASIC	P/CMOS	0.50	200	1999.4	1,500	6,000	FRP
Micron-Acer	Science Park	Hsinchu	Taiwan	Fab 2	64Mb DRAM	P/CMOS	0.25	200	1999.2	10,000	20,000	FN
Mitsubishi	Nagano	-	Japan	-	64Mb DRAM	P/CMOS	0.35	200	1998.2	10,000	20,000	F
Mosel Vitalic (JV) ProMos Technologies	Science Park	Hsinchu	Taiwan	Fab 1	64Mb 256Mb DRAM	P/CMOS	0.35	200	1998.1	5,000	20,000	FRVD-PDN
Motorola	Tianjin	-	China	MOS-17	Telecom ASIC RF SmartMOS	-	0.50	200	1999.0	14,000	20,000	FVDPD
Nan Ya Technology	Tao Yuan	-	Taiwan	Fab 1 Phase 3	64Mb 256Mb DRAM	P/CMOS	0.25	200	1999.3	5,000	-	FRVD-PDN
NEC	Beijing	-	China	Shougang Phase 3	16Mb DRAM	P/CMOS	0.40	150	2000.0	1,500	6,000	FT
Philips-TSMC Group	Singapore	-	Singapore	8	SOC ICs for Consumer and Communications	-	0.25		2000.3			F
Samsung	Kiheung-Up	Kyungki-Do	Korea	Fab 8	64Mb DRAM	P/CMOS	0.30	200	1998.0	12,500	25,000	FTVDPD
Silicon Manufacturing Partners	Singapore	Woodlands Industrial Park	Singapore	Silicon Manufacturing Partners	ASIC MPU Foundry	P/CMOS	0.25	200	1999.0	2,000	2,000	FRP
STMicroelectronics	Singapore	-	Singapore	Fab 5	Logic	-	0.5	200	1999	4000	20000	FR
SubMicron Technology	Bangkok	Chachaersao	Thailand	Fab 1	Foundry	P/CMOS	0.35	200	1999.4	3,000	20,000	FN
TSMC Group	Science Park	Hsinchu	Taiwan	Fab 5	Foundry	P/CMOS	0.18	200	1998.0	5,000	30,000	FTN

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Table 2-2 (Continued)
Asia/Pacific's Future Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
TSMC Group	Science Park	Hsinchu	Taiwan	Fab 7	Foundry	-	0.18	200	2000.0	5,000	-	FN
TSMC Group	Tainan	Tainan	Taiwan	Fab 6	Foundry	P/CMOS	0.25	200	2001.0	9,000	60,000	FN
TSMC Group	Tainan	Tainan	Taiwan	Tainan 8 #1	Foundry	P/CMOS	0.25	200	2001.0	5,000	15,900	FN
UMC Group	Science Park	Hsinchu	Taiwan	USI	Foundry	P/CMOS	0.25	200	1998.1	5,000	8,000	FPDN
UMC Group	Science Park	Hsinchu	Taiwan	Fab 5	Foundry	P/CMOS	0.25	200	1999.0	5,000	-	FRPDN
UMC Group	Science Park	Hsinchu	Taiwan	Fab 2	Foundry	P/CMOS	0.25	200	1999.4	5,000		FN
UMC Group	Science Park	Hsinchu	Taiwan	UICC	Foundry	P/CMOS	0.25	200	1999.4	5,000	30,000	FPDN
UMC Group	Tainan Industrial Park	Tainan	Taiwan	Fab IV	Foundry 256Mb DRAM	P/CMOS	0.16	200	2000.0	7,500	50,000	FN
UTEK	Science Park	Hsinchu	Taiwan	Fab 2	MCU ASIC Non Vol	P/CMOS	0.25	200	1998.2	5,000	8,000	FTVD-PDN
Vanguard International	Science Park	Hsinchu	Taiwan	Fab 2	64M 128M SDRAM	P/CMOS	0.25	200	2000.1	8,000		FTRVD
Wafer Technology Malaysia (VLSI and Atmel)	Penang	-	Malaysia	-	Arrays CBIC MPU Telecom ICs Foundry	P/CMOS	0.25	200	2000.0	14,000	27,000	F
Winbond Group	Science Park	Hsinchu	Taiwan	Fab 4	64Mb DRAM	P/CMOS	0.25	200	1998.3	5,000	10,000	FVDPDN
Winbond Group	Science Park	Hsinchu	Taiwan	WSMC 1	Flash, SRAM, Logic	P/CMOS	0.25	200	1998.3	5,000	5,000	FTRNP
Winbond Group	Science Park	Hsinchu	Taiwan	WSMC 2	Logic	P/CMOS	0.18	200	1999.3	5,000	-	FTRN

Source: Dataquest (December 1998)

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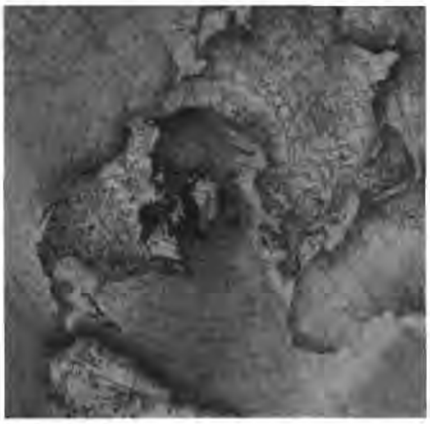

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Final 1997 Asia/Pacific Semiconductor Market Share by Country

Market Statistics

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MARIA VALENZUELA

Program: Semiconductors Asia/Pacific
Product Code: SEMI-AP-MS-9803
Publication Date: July 6, 1998
Filing: Market Statistics

Final 1997 Asia/Pacific Semiconductor Market Share by Country

Market Statistics

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Chapter 1
Final 1997 Asia/Pacific Semiconductor Market Share

Introduction

This document contains detailed information on Dataquest's view of the semiconductor market. Included in this document are 1996 and 1997 market share rankings.

Asia / Pacific market share estimates combine data from many countries, each of which has a different and fluctuating exchange rate. Estimates of non-U.S. market consumption or revenue are based on the average exchange rate for the given year. The section titled "Exchange Rates" gives more information on these average rates. As a rule, Dataquest's estimates are calculated in local currencies and then converted to U.S. dollars.

More detailed data on this market may be requested through Dataquest's client inquiry service. Qualitative analysis of this data is provided in Dataquest Perspectives.

Segmentation and Definitions

A detailed explanation of device segmentation and related definitions is contained in *Semiconductor Market Definitions, 1997* (SCND-WW-GU-9801).

Market Share Methodology

Dataquest uses both primary and secondary sources to produce market statistics data. In the fourth quarter of each year, Dataquest surveys all major participants within each industry. Selected companies are resurveyed during the first quarter of the following year to verify final annual results. This primary research is supplemented with additional primary research and secondary research to verify market size, shipment totals, and pricing information. Sources of data used by Dataquest include the following:

- Information published by major industry participants
- Estimates made by knowledgeable and reliable industry spokespersons
- Government data or trade association data (such as WSTS, MITI, and U.S. DOC)
- Published product literature and price lists
- Interviews with knowledgeable manufacturers, distributors, and users
- Relevant economic data
- Information and data from online and CD-ROM data banks
- Articles in both the general and trade press
- Reports from financial analysts
- End-user surveys

Dataquest believes that the estimates presented in this document are the most accurate and meaningful statistics available.

Despite the care taken in gathering, analyzing, and categorizing the data in a meaningful way, careful attention must be paid to the definitions and assumptions used when interpreting the estimates presented in this document. Various companies, government agencies, and trade associations may use slightly different definitions of product categories and regional groupings, or they may include different companies in their summaries. These differences should be kept in mind when making comparisons between data and numbers provided by Dataquest and those provided by other sources.

Notes on Market Share

In the process of conducting data collection and preparing market statistics information, Dataquest will sometimes consolidate or revise a particular company, model, series, or industry's numbers. In this section, we explain any such changes contained within this document for your reference.

Notes to Market Share Tables

- All rank tables in this document include only the top 30 semiconductor companies' revenue into the Asia/Pacific region. The total Asia/Pacific market in 1996 was U.S.$29,735 billion and included many more than those 30 companies.
- "Other Asia" refers to Asia/Pacific countries excluding Korea, China, Hong Kong, Singapore, and Taiwan.
- Cyrix was acquired by National Semiconductor in 1997.
- National Semiconductor divested itself of Fairchild in 1997.
- National Semiconductor's 1997 revenue includes all of Cyrix's 1997 revenue and part of Fairchild's calendar first quarter revenue.
- Power Innovations was formed through the acquisition of the Power Semiconductor interests of Texas Instruments.
- Melexis was formerly known as Elex.
- Micronas acquired ITT in 1997.
- The following companies were added to the market share database in 1997:
  - Fairchild
  - Vitesse
  - TriQuint
  - Power Innovations
  - Robert Bosch
  - Stanley

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- Toko is now tracked in other Japanese companies.
- IBM's 1996 revenue was restated in 1997.
- Singapore revenue includes "as to" billings, some of which are re-exported from Singapore.

Exchange Rates

Dataquest uses an average annual exchange rate in converting revenue to U.S. dollar amounts. Table 1-1 outlines these rates for 1996 through 1997.

Table 1-1
Exchange Rates

	1996	1997
China (Renminbi/U.S.$)	8.34	8.32
Hong Kong (Dollar/U.S.$)	7.73	7.75
Singapore (Dollar/U.S.$)	1.41	1.99
South Korea (Won/U.S.$)	805.16	954.14
Taiwan (Dollar/U.S.$)	27.47	28.79

Source: Dataquest (August 1997)

Project Analysts: Ellie Babaie, Ron Bohn, Sabrina Chiou, Marilyn David, Kelvin Fu, Dan Heyler, C.S. Kim, Kevin McClure, Yoshihiro Shimada, J.H. Son, Erwin Wong, Jerry Yeh, and Sun-Ah Yeom

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Chapter 2
Asia/Pacific Market Statistics Tables

Table 2-1
Vendor Revenue from Shipments of Total Semiconductors by Country (Millions of U.S. Dollars)

	Korea	China/ Hong Kong	Singapore	Taiwan	Other Asia	Asia/ Pacific
Intel	559	684	1,437	941	456	4,077
Samsung	620	405	482	299	116	1,922
Texas Instruments	160	281	989	290	132	1,852
Toshiba	196	637	510	426	38	1,807
Motorola	199	414	608	266	195	1,682
Philips	404	359	338	288	191	1,580
NEC	85	353	498	374	16	1,326
SGS-Thomson	141	176	542	160	58	1,077
Hitachi	144	166	322	209	165	1,006
LG Semicon	270	280	170	223	49	992
SANYO	176	268	211	109	137	901
Rohm	100	230	302	98	96	826
National Semiconductor	171	146	199	116	74	706
Hyundai	78	179	244	173	30	704
Mitsubishi	61	107	277	215	29	689
Lucent Technologies	80	135	175	192	50	632
Siemens	51	116	193	158	33	551
Fujitsu	54	68	149	69	137	477
Advanced Micro Devices	42	121	85	221	3	472
Matsushita	49	92	103	76	120	440
Sharp	105	69	136	75	48	433
Sony	58	102	121	52	41	374
United Microelectronics Corp.	-	90	10	153	91	344
Cirrus Logic	11	6	126	123	31	297
Atmel	45	92	84	69	2	292
S3	1	59	32	159	18	269
Winbond Electronics	5	32	6	130	88	261
Korean Electronic Co.	103	75	41	28	8	255
IBM	10	39	142	50	7	248
Vanguard	55	50	87	25	20	237
Sanken	89	34	34	29	4	190
Mosel Vitelic	-	12	3	157	4	176
All Other Companies	NA	NA	NA	NA	NA	5,439
Total Market	**NA**	**NA**	**NA**	**NA**	**NA**	**32,534**

NA = Not available
Source: Dataquest (June 1998)

Table 2-2
Top 30 Worldwide Vendors' Revenue from Shipments of Total Semiconductors to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	3,250	4,077	25.4	15.0
2	2	Samsung	1,828	1,922	5.1	7.1
3	4	Texas Instruments	1,735	1,852	6.7	6.8
4	3	Toshiba	1,805	1,807	0.1	6.7
5	6	Motorola	1,424	1,682	18.1	6.2
6	5	Philips	1,473	1,580	7.3	5.8
7	7	NEC	1,284	1,326	3.3	4.9
8	10	SGS-Thomson	1,128	1,077	-4.5	4.0
9	9	Hitachi	1,170	1,006	-14.0	3.7
10	8	LG Semicon	1,178	992	-15.8	3.7
11	11	SANYO	913	901	-1.3	3.3
12	17	Rohm	471	826	75.4	3.0
13	14	National Semiconductor	560	706	26.1	2.6
14	12	Hyundai	763	704	-7.7	2.6
15	13	Mitsubishi	729	689	-5.5	2.5
16	22	Lucent Technologies	355	632	78.0	2.3
17	18	Siemens	454	551	21.4	2.0
18	16	Fujitsu	476	477	0.2	1.8
19	25	Advanced Micro Devices	268	472	76.1	1.7
20	15	Matsushita	500	440	-12.0	1.6
21	20	Sharp	408	433	6.1	1.6
22	23	Sony	286	374	30.8	1.4
23	19	United Microelectronics Corp.	430	344	-20.0	1.3
24	24	Cirrus Logic	283	297	4.9	1.1
25	30	Atmel	209	292	39.7	1.1
26	116	S3	0	269	NA	1.0
27	26	Winbond Electronics	261	261	0	1.0
28	28	Korean Electronic Co.	228	255	11.8	0.9
29	21	IBM	382	248	-35.1	0.9
30	253	Vanguard	0	237	NA	0.9
		All Others	456	366	-19.7	1.4
		Americas Companies	8,466	10,527	24.3	38.9
		Japanese Companies	8,257	8,469	2.6	31.3
		European Companies	3,055	3,208	5.0	11.8
		Asia/Pacific Companies	4,929	4,891	-0.8	18.1
		Included Companies Total	**24,707**	**27,095**	**9.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-3
Top 30 Worldwide Vendors' Revenue from Shipments of Total Integrated Circuits to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	3,250	4,077	25.4	17.5
2	2	Texas Instruments	1,732	1,852	6.9	7.9
3	3	Samsung	1,568	1,615	3.0	6.9
4	7	Motorola	1,141	1,372	20.2	5.9
5	6	Philips	1,175	1,285	9.4	5.5
6	4	Toshiba	1,331	1,263	-5.1	5.4
7	8	NEC	1,093	1,083	-0.9	4.6
8	5	LG Semicon	1,178	992	-15.8	4.3
9	9	SGS-Thomson	996	934	-6.2	4.0
10	10	Hitachi	933	724	-22.4	3.1
11	12	SANYO	699	711	1.7	3.1
12	11	Hyundai	763	704	-7.7	3.0
13	14	National Semiconductor	494	673	36.2	2.9
14	19	Lucent Technologies	345	604	75.1	2.6
15	13	Mitsubishi	648	600	-7.4	2.6
16	23	Advanced Micro Devices	268	472	76.1	2.0
17	18	Siemens	375	459	22.4	2.0
18	15	Fujitsu	454	458	0.9	2.0
19	28	Rohm	199	380	91.0	1.6
20	16	United Microelectronics Corp.	430	344	-20.0	1.5
21	26	Sony	235	321	36.6	1.4
22	21	Cirrus Logic	283	297	4.9	1.3
23	27	Atmel	209	292	39.7	1.3
24	20	Matsushita	303	274	-9.6	1.2
25	30	S3	0	269	NA	1.2
26	24	Winbond Electronics	261	261	0	1.1
27	22	Sharp	277	260	-6.1	1.1
28	17	IBM	382	248	-35.1	1.1
29	31	Vanguard	0	237	NA	1.0
30	25	Mosel Vitelic	241	176	-27.0	0.8
		All Others	44	74	68.2	0.3
		Americas Companies	8,104	10,156	25.3	43.6
		Japanese Companies	6,172	6,099	-1.2	26.2
		European Companies	2,546	2,678	5.2	11.5
		Asia/Pacific Companies	4,485	4,378	-2.4	18.8
		Included Companies Total	**21,307**	**23,311**	**9.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-4
Top 13 Worldwide Vendors' Revenue from Shipments of Bipolar Digital to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Hitachi	53	54	1.9	28.9
2	1	Texas Instruments	54	49	-9.3	26.2
3	4	Motorola	31	29	-6.5	15.5
4	6	Philips	12	13	8.3	7.0
5	9	Matsushita	4	11	175.0	5.9
6	30	Mosel Vitelic	0	10	NA	5.3
7	7	LG Semicon	8	7	-12.5	3.7
8	8	Advanced Micro Devices	4	4	0	2.1
9	5	Toshiba	19	3	-84.2	1.6
10	10	Mitsubishi	3	3	0	1.6
11	11	NEC	2	2	0	1.1
12	3	National Semiconductor	45	1	-97.8	0.5
13	12	Fujitsu	1	1	0	0.5
		All Others	-	-	NA	0
		Americas Companies	134	83	-38.1	44.4
		Japanese Companies	82	74	-9.8	39.6
		European Companies	12	13	8.3	7.0
		Asia/Pacific Companies	8	17	112.5	9.1
		Included Companies Total	**236**	**187**	**-20.8**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-5
Top 30 Worldwide Vendors' Revenue from Shipments of MOS Digital ICs to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	3,250	4,077	25.4	22.8
2	2	Samsung	1,361	1,321	-2.9	7.4
3	4	Texas Instruments	1,104	1,055	-4.4	5.9
4	8	Motorola	783	947	20.9	5.3
5	3	LG Semicon	1,134	940	-17.1	5.3
6	5	NEC	951	935	-1.7	5.2
7	6	Toshiba	939	818	-12.9	4.6
8	9	Hyundai	762	701	-8.0	3.9
9	10	Philips	656	660	0.6	3.7
10	16	Lucent Technologies	313	594	89.8	3.3
11	7	Hitachi	788	543	-31.1	3.0
12	11	Mitsubishi	533	491	-7.9	2.8
13	12	Fujitsu	440	440	0	2.5
14	20	Advanced Micro Devices	243	423	74.1	2.4
15	17	Siemens	311	380	22.2	2.1
16	13	United Microelectronics Corp.	430	344	-20.0	1.9
17	15	SANYO	338	309	-8.6	1.7
18	24	Atmel	209	292	39.7	1.6
19	25	National Semiconductor	202	278	37.6	1.6
20	29	S3	0	269	NA	1.5
21	22	SGS-Thomson	237	251	5.9	1.4
22	14	IBM	382	248	-35.1	1.4
23	30	Vanguard	0	237	NA	1.3
24	19	Sharp	250	228	-8.8	1.3
25	18	Cirrus Logic	258	216	-16.3	1.2
26	23	Winbond Electronics	211	200	-5.2	1.1
27	27	Sony	146	197	34.9	1.1
28	21	Mosel Vitelic	241	166	-31.1	0.9
29	28	Rohm	101	153	51.5	0.9
30	26	Matsushita	158	134	-15.2	0.8
		All Others	-	-	NA	0
		Americas Companies	6,744	8,399	24.5	47.1
		Japanese Companies	4,644	4,248	-8.5	23.8
		European Companies	1,204	1,291	7.2	7.2
		Asia/Pacific Companies	4,139	3,909	-5.6	21.9
		Included Companies Total	**16,731**	**17,847**	**6.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-6
Top 27 Worldwide Vendors' Revenue from Shipments of MOS Memory to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	1,074	892	-16.9	15.3
2	2	LG Semicon	979	731	-25.3	12.5
3	3	Hyundai	755	697	-7.7	12.0
4	5	NEC	541	432	-20.1	7.4
5	10	Siemens	298	352	18.1	6.0
6	4	Texas Instruments	567	321	-43.4	5.5
7	8	Mitsubishi	344	305	-11.3	5.2
8	9	Fujitsu	311	279	-10.3	4.8
9	12	Atmel	179	238	33.0	4.1
10	29	Vanguard	0	237	NA	4.1
11	6	Hitachi	469	195	-58.4	3.3
12	13	Intel	163	183	12.3	3.1
13	11	Mosel Vitelic	241	166	-31.1	2.8
14	7	Toshiba	403	154	-61.8	2.6
15	15	Winbond Electronics	131	110	-16.0	1.9
16	17	SGS-Thomson	103	103	0	1.8
17	19	Advanced Micro Devices	70	93	32.9	1.6
18	16	Sharp	108	87	-19.4	1.5
19	23	Matsushita	37	59	59.5	1.0
20	18	Motorola	94	50	-46.8	0.9
21	21	IBM	52	50	-3.8	0.9
22	20	SANYO	57	32	-43.9	0.5
23	24	Sony	33	27	-18.2	0.5
24	14	United Microelectronics Corp.	140	18	-87.1	0.3
25	25	Rohm	11	10	-9.1	0.2
26	26	Philips	0	6	NA	0.1
27	22	National Semiconductor	39	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	1,164	935	-19.7	16.0
		Japanese Companies	2,314	1,580	-31.7	27.1
		European Companies	401	461	15.0	7.9
		Asia/Pacific Companies	3,320	2,851	-14.1	48.9
		Included Companies Total	**7,199**	**5,827**	**-19.1**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-7
Top 17 Worldwide Vendors' Revenue from Shipments of DRAM to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Samsung	852	724	-15.0	16.6
2	3	Hyundai	712	669	-6.0	15.3
3	1	LG Semicon	883	650	-26.4	14.9
4	5	NEC	504	402	-20.2	9.2
5	8	Siemens	298	352	18.1	8.1
6	4	Texas Instruments	536	294	-45.1	6.7
7	9	Mitsubishi	291	262	-10.0	6.0
8	18	Vanguard	0	237	NA	5.4
9	11	Fujitsu	208	181	-13.0	4.2
10	10	Mosel Vitelic	233	165	-29.2	3.8
11	6	Hitachi	391	163	-58.3	3.7
12	7	Toshiba	343	106	-69.1	2.4
13	13	Matsushita	34	57	67.6	1.3
14	15	Motorola	33	37	12.1	0.8
15	12	IBM	42	29	-31.0	0.7
16	14	SANYO	34	28	-17.6	0.6
17	16	Sharp	8	4	-50.0	0
		All Others	-	-	NA	0
		Americas Companies	611	360	-41.1	8.3
		Japanese Companies	1,813	1,203	-33.6	27.6
		European Companies	298	352	18.1	8.1
		Asia/Pacific Companies	2,680	2,445	-8.8	56.1
		Included Companies Total	**5,402**	**4,360**	**-19.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-8
Top 19 Worldwide Vendors' Revenue from Shipments of SRAM to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	162	126	-22.2	25.2
2	3	Winbond Electronics	121	102	-15.7	20.4
3	6	LG Semicon	49	41	-16.3	8.2
4	7	Toshiba	46	36	-21.7	7.2
5	8	Hyundai	43	28	-34.9	5.6
6	9	Mitsubishi	39	27	-30.8	5.4
7	10	Sony	33	27	-18.2	5.4
8	5	Hitachi	57	25	-56.1	5.0
9	14	IBM	10	21	110.0	4.2
10	2	United Microelectronics Corp.	125	17	-86.4	3.4
11	11	NEC	20	15	-25.0	3.0
12	13	Sharp	18	14	-22.2	2.8
13	4	Motorola	59	12	-79.7	2.4
14	16	Fujitsu	4	3	-25.0	0.6
15	17	Rohm	4	3	-25.0	0.6
16	12	SANYO	19	2	-89.5	0.4
17	15	Mosel Vitelic	8	1	-87.5	0.2
18	18	Matsushita	2	0	-100.0	0
19	19	SGS-Thomson	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	69	33	-52.2	6.6
		Japanese Companies	242	152	-37.2	30.4
		European Companies	1	-	-100.0	0
		Asia/Pacific Companies	508	315	-38.0	63.0
		Included Companies Total	**820**	**500**	**-39.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-9
Top 20 Worldwide Vendors' Revenue from Shipments of Nonvolatile Memory to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Atmel	179	238	33.0	24.9
2	2	Intel	163	183	12.3	19.2
3	3	SGS-Thomson	100	100	0	10.5
4	4	Fujitsu	99	95	-4.0	10.0
5	6	Advanced Micro Devices	70	93	32.9	9.7
6	5	Sharp	82	69	-15.9	7.2
7	7	Samsung	60	42	-30.0	4.4
8	8	LG Semicon	47	40	-14.9	4.2
9	10	Texas Instruments	31	27	-12.9	2.8
10	15	Mitsubishi	13	15	15.4	1.6
11	13	Toshiba	14	12	-14.3	1.3
12	14	NEC	14	12	-14.3	1.3
13	16	Winbond Electronics	10	8	-20.0	0.8
14	11	Hitachi	21	7	-66.7	0.7
15	17	Rohm	7	7	0	0.7
16	18	SANYO	4	2	-50.0	0.2
17	20	Matsushita	1	2	100.0	0.2
18	12	United Microelectronics Corp.	15	1	-93.3	0.1
19	19	Motorola	1	1	0	0.1
20	9	National Semiconductor	39	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	483	542	12.2	56.8
		Japanese Companies	255	221	-13.3	23.2
		European Companies	100	100	0	10.5
		Asia/Pacific Companies	132	91	-31.1	9.5
		Included Companies Total	**970**	**954**	**-1.6**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-10
Top Five Worldwide Vendors' Revenue from Shipments of Other MOS Memory to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	27	Philips	0	6	NA	46.2
2	1	NEC	3	3	0	23.1
3	2	SGS-Thomson	2	3	50.0	23.1
4	3	Mitsubishi	1	1	0	7.7
5	4	Motorola	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	1	-	-100.0	0
		Japanese Companies	4	4	0	30.8
		European Companies	2	9	350.0	69.2
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**7**	**13**	**85.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-11
Top 28 Worldwide Vendors' Revenue from Shipments of MOS Microcomponents to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	3,087	3,894	26.1	43.4
2	2	Motorola	558	685	22.8	7.6
3	4	Toshiba	301	395	31.2	4.4
4	5	Texas Instruments	290	382	31.7	4.3
5	6	United Microelectronics Corp.	290	326	12.4	3.6
6	8	NEC	254	307	20.9	3.4
7	10	Hitachi	237	303	27.8	3.4
8	3	Philips	385	286	-25.7	3.2
9	14	Advanced Micro Devices	122	284	132.8	3.2
10	12	National Semiconductor	136	274	101.5	3.1
11	30	S3	0	269	NA	3.0
12	13	Lucent Technologies	125	225	80.0	2.5
13	7	Cirrus Logic	258	216	-16.3	2.4
14	16	Samsung	80	207	158.8	2.3
15	11	Mitsubishi	179	173	-3.4	1.9
16	9	IBM	247	145	-41.3	1.6
17	20	LG Semicon	61	107	75.4	1.2
18	18	Winbond Electronics	76	86	13.2	1.0
19	17	SANYO	78	85	9.0	0.9
20	15	SGS-Thomson	94	80	-14.9	0.9
21	19	Fujitsu	63	75	19.0	0.8
22	21	Sharp	47	53	12.8	0.6
23	22	Matsushita	43	33	-23.3	0.4
24	24	Atmel	19	29	52.6	0.3
25	23	Sony	30	28	-6.7	0.3
26	26	Siemens	13	28	115.4	0.3
27	25	Rohm	15	6	-60.0	0
28	27	Hyundai	1	1	0	0
		All Others	-	-	NA	0
		Americas Companies	4,842	6,403	32.2	71.3
		Japanese Companies	1,247	1,458	16.9	16.2
		European Companies	492	394	-19.9	4.4
		Asia/Pacific Companies	508	727	43.1	8.1
		Included Companies Total	**7,089**	**8,982**	**26.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-12
Top 12 Worldwide Vendors' Revenue from Shipments of Microprocessors to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	2,734	3,525	28.9	82.2
2	3	Motorola	152	253	66.4	5.9
3	4	Advanced Micro Devices	87	204	134.5	4.8
4	2	IBM	241	139	-42.3	3.2
5	7	National Semiconductor	14	97	592.9	2.3
6	9	NEC	12	32	166.7	0.7
7	5	Toshiba	25	29	16.0	0.7
8	11	SGS-Thomson	3	5	66.7	0.1
9	10	Fujitsu	5	3	-40.0	0
10	6	Texas Instruments	16	1	-93.8	0
11	12	Mitsubishi	1	1	0	0
12	8	LG Semicon	13	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	3,244	4,219	30.1	98.4
		Japanese Companies	43	65	51.2	1.5
		European Companies	3	5	66.7	0.1
		Asia/Pacific Companies	13	-	-100.0	0
		Included Companies Total	**3,303**	**4,289**	**29.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-13
Top 23 Worldwide Vendors' Revenue from Shipments of Microcontrollers to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Motorola	368	384	4.3	18.0
2	3	NEC	202	212	5.0	10.0
3	8	Samsung	78	205	162.8	9.6
4	6	Philips	150	197	31.3	9.3
5	4	Hitachi	155	194	25.2	9.1
6	2	Toshiba	203	175	-13.8	8.2
7	5	Mitsubishi	153	152	-0.7	7.1
8	7	Intel	111	109	-1.8	5.1
9	9	SANYO	78	85	9.0	4.0
10	10	SGS-Thomson	68	68	0	3.2
11	15	LG Semicon	26	56	115.4	2.6
12	11	Sharp	47	53	12.8	2.5
13	12	Fujitsu	36	52	44.4	2.4
14	18	Atmel	19	29	52.6	1.4
15	13	Sony	30	28	-6.7	1.3
16	19	Siemens	13	28	115.4	1.3
17	14	Texas Instruments	29	23	-20.7	1.1
18	17	United Microelectronics Corp.	20	21	5.0	1.0
19	16	Matsushita	23	16	-30.4	0.8
20	20	National Semiconductor	12	15	25.0	0.7
21	23	Advanced Micro Devices	0	15	NA	0.7
22	21	Winbond Electronics	10	10	0	0.5
23	22	Rohm	9	2	-77.8	0
		All Others	-	-	NA	0
		Americas Companies	539	575	6.7	27.0
		Japanese Companies	936	969	3.5	45.5
		European Companies	231	293	26.8	13.8
		Asia/Pacific Companies	134	292	117.9	13.7
		Included Companies Total	**1,840**	**2,129**	**15.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-14
Top 21 Worldwide Vendors' Revenue from Shipments of Microperipherals to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	United Microelectronics Corp.	270	305	13.0	16.7
2	27	S3	0	269	NA	14.8
3	3	Intel	242	260	7.4	14.3
4	2	Cirrus Logic	258	216	-16.3	11.8
5	5	National Semiconductor	110	162	47.3	8.9
6	6	Hitachi	80	106	32.5	5.8
7	8	Toshiba	62	87	40.3	4.8
8	7	Winbond Electronics	66	76	15.2	4.2
9	10	Advanced Micro Devices	35	65	85.7	3.6
10	9	Texas Instruments	40	58	45.0	3.2
11	4	Philips	235	54	-77.0	3.0
12	15	LG Semicon	22	51	131.8	2.8
13	11	NEC	32	39	21.9	2.1
14	13	Mitsubishi	25	20	-20.0	1.1
15	12	Motorola	29	16	-44.8	0.9
16	16	Fujitsu	17	16	-5.9	0.9
17	17	Matsushita	10	9	-10.0	0.5
18	14	SGS-Thomson	23	7	-69.6	0.4
19	18	Rohm	6	4	-33.3	0.2
20	19	Samsung	2	2	0	0.1
21	20	Hyundai	1	1	0	0
		All Others	-	-	NA	0
		Americas Companies	714	1,046	46.5	57.4
		Japanese Companies	232	281	21.1	15.4
		European Companies	258	61	-76.4	3.3
		Asia/Pacific Companies	361	435	20.5	23.9
		Included Companies Total	**1,565**	**1,823**	**16.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-15
Top 10 Worldwide Vendors' Revenue from Shipments of Digital Signal Processors to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Texas Instruments	205	300	46.3	40.5
2	2	Lucent Technologies	125	225	80.0	30.4
3	3	Toshiba	11	104	845.5	14.0
4	17	Philips	0	35	NA	4.7
5	5	Motorola	9	32	255.6	4.3
6	6	NEC	8	24	200.0	3.2
7	4	Matsushita	10	8	-20.0	1.1
8	7	IBM	6	6	0	0.8
9	8	Fujitsu	5	4	-20.0	0.5
10	9	Hitachi	2	3	50.0	0.4
		All Others	-	-	NA	0
		Americas Companies	345	563	63.2	76.0
		Japanese Companies	36	143	297.2	19.3
		European Companies	-	35	NA	4.7
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**381**	**741**	**94.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-16
Top 23 Worldwide Vendors' Revenue from Shipments of MOS Digital Logic to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	6	Lucent Technologies	188	369	96.3	12.1
2	1	Philips	271	368	35.8	12.1
3	2	Texas Instruments	247	352	42.5	11.6
4	3	Toshiba	235	269	14.5	8.9
5	4	Samsung	207	222	7.2	7.3
6	8	Motorola	131	212	61.8	7.0
7	7	NEC	156	196	25.6	6.5
8	5	SANYO	203	192	-5.4	6.3
9	12	Sony	83	142	71.1	4.7
10	15	Rohm	75	137	82.7	4.5
11	10	LG Semicon	94	102	8.5	3.4
12	9	Sharp	95	88	-7.4	2.9
13	16	Fujitsu	66	86	30.3	2.8
14	18	SGS-Thomson	40	68	70.0	2.2
15	11	IBM	83	53	-36.1	1.7
16	17	Advanced Micro Devices	51	46	-9.8	1.5
17	13	Hitachi	82	45	-45.1	1.5
18	14	Matsushita	78	42	-46.2	1.4
19	20	Atmel	11	25	127.3	0.8
20	21	Mitsubishi	10	13	30.0	0.4
21	19	National Semiconductor	27	4	-85.2	0.1
22	23	Winbond Electronics	4	4	0	0.1
23	22	Hyundai	6	3	-50.0	0
		All Others	-	-	NA	0
		Americas Companies	738	1,061	43.8	34.9
		Japanese Companies	1,083	1,210	11.7	39.8
		European Companies	311	436	40.2	14.4
		Asia/Pacific Companies	311	331	6.4	10.9
		Included Companies Total	**2,443**	**3,038**	**24.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-17
Top 23 Worldwide Vendors' Revenue from Shipments of ASICs to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Lucent Technologies	188	369	96.3	29.8
2	1	Texas Instruments	196	222	13.3	17.9
3	4	NEC	117	108	-7.7	8.7
4	8	LG Semicon	74	80	8.1	6.5
5	9	Fujitsu	62	79	27.4	6.4
6	3	Samsung	134	71	-47.0	5.7
7	12	SGS-Thomson	36	57	58.3	4.6
8	6	IBM	83	53	-36.1	4.3
9	13	Motorola	35	39	11.4	3.1
10	5	Toshiba	113	37	-67.3	3.0
11	11	Hitachi	48	30	-37.5	2.4
12	10	Matsushita	52	27	-48.1	2.2
13	16	Advanced Micro Devices	22	19	-13.6	1.5
14	18	Atmel	11	15	36.4	1.2
15	7	Sharp	82	12	-85.4	1.0
16	15	Sony	26	8	-69.2	0.6
17	17	SANYO	19	4	-78.9	0.3
18	19	Hyundai	6	3	-50.0	0.2
19	21	National Semiconductor	3	3	0	0.2
20	23	Mitsubishi	2	3	50.0	0.2
21	22	Philips	2	1	-50.0	0
22	14	Rohm	32	0	-100.0	0
23	20	Winbond Electronics	4	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	538	720	33.8	58.1
		Japanese Companies	553	308	-44.3	24.8
		European Companies	38	58	52.6	4.7
		Asia/Pacific Companies	218	154	-29.4	12.4
		Included Companies Total	**1,347**	**1,240**	**-7.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-18
Top 10 Worldwide Vendors' Revenue from Shipments of Custom ICs to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	15	Sharp	0	62	NA	20.9
2	6	Samsung	0	56	NA	18.9
3	9	Motorola	0	52	NA	17.6
4	22	Rohm	0	45	NA	15.2
5	3	NEC	0	33	NA	11.1
6	16	Sony	0	17	NA	5.7
7	12	Matsushita	0	13	NA	4.4
8	14	Atmel	0	10	NA	3.4
9	10	Toshiba	0	4	NA	1.4
10	23	Winbond Electronics	0	4	NA	1.4
		All Others	-	-	NA	0
		Americas Companies	0	62	NA	20.9
		Japanese Companies	0	174	NA	58.8
		European Companies	0	-	NA	0
		Asia/Pacific Companies	0	60	NA	20.3
		Included Companies Total	**0**	**296**	**NA**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-19
Top 15 Worldwide Vendors' Revenue from Shipments of MOS Standard Logic to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	68	130	91.2	28.3
2	3	Texas Instruments	51	95	86.3	20.7
3	2	Toshiba	67	92	37.3	20.0
4	4	Motorola	49	48	-2.0	10.4
5	7	LG Semicon	20	22	10.0	4.8
6	9	Samsung	12	15	25.0	3.3
7	10	NEC	9	13	44.4	2.8
8	11	Rohm	5	13	160.0	2.8
9	13	SGS-Thomson	4	11	175.0	2.4
10	8	Hitachi	13	9	-30.8	2.0
11	12	Fujitsu	4	7	75.0	1.5
12	14	Mitsubishi	3	4	33.3	0.9
13	6	National Semiconductor	23	1	-95.7	0.2
14	5	Matsushita	23	0	-100.0	0
15	15	SANYO	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	123	144	17.1	31.3
		Japanese Companies	126	138	9.5	30.0
		European Companies	72	141	95.8	30.7
		Asia/Pacific Companies	32	37	15.6	8.0
		Included Companies Total	**353**	**460**	**30.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-20
Top 15 Worldwide Vendors' Revenue from Shipments of Total Other MOS Logic to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	201	237	17.9	22.7
2	2	SANYO	182	188	3.3	18.0
3	5	Toshiba	55	136	147.3	13.1
4	4	Sony	57	117	105.3	11.2
5	3	Samsung	61	80	31.1	7.7
6	7	Rohm	38	79	107.9	7.6
7	6	Motorola	47	73	55.3	7.0
8	8	NEC	30	42	40.0	4.0
9	15	Texas Instruments	0	35	NA	3.4
10	9	Advanced Micro Devices	29	27	-6.9	2.6
11	11	Sharp	13	14	7.7	1.3
12	10	Hitachi	21	6	-71.4	0.6
13	12	Mitsubishi	5	6	20.0	0.6
14	13	Matsushita	3	2	-33.3	0.2
15	14	National Semiconductor	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	77	135	75.3	13.0
		Japanese Companies	404	590	46.0	56.6
		European Companies	201	237	17.9	22.7
		Asia/Pacific Companies	61	80	31.1	7.7
		Included Companies Total	**743**	**1,042**	**40.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-21
Top 25 Worldwide Vendors' Revenue from Shipments of Analog-Monolithic to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Texas Instruments	574	748	30.3	14.2
2	1	SGS-Thomson	759	683	-10.0	12.9
3	3	Philips	507	612	20.7	11.6
4	4	Toshiba	373	442	18.5	8.4
5	5	SANYO	361	402	11.4	7.6
6	6	Motorola	327	396	21.1	7.5
7	7	National Semiconductor	247	394	59.5	7.5
8	8	Samsung	207	294	42.0	5.6
9	12	Rohm	98	227	131.6	4.3
10	10	NEC	140	146	4.3	2.8
11	9	Matsushita	141	129	-8.5	2.4
12	13	Hitachi	92	127	38.0	2.4
13	14	Sony	89	124	39.3	2.3
14	11	Mitsubishi	112	106	-5.4	2.0
15	21	Cirrus Logic	25	81	224.0	1.5
16	15	Siemens	64	79	23.4	1.5
17	16	Winbond Electronics	50	61	22.0	1.2
18	17	Korean Electronic Co.	44	49	11.4	0.9
19	18	LG Semicon	36	45	25.0	0.9
20	22	Advanced Micro Devices	21	45	114.3	0.9
21	20	Sharp	27	32	18.5	0.6
22	32	Sanken	0	25	NA	0.5
23	23	Fujitsu	13	17	30.8	0.3
24	19	Lucent Technologies	32	10	-68.8	0.2
25	24	Hyundai	1	3	200.0	0
		All Others	-	-	NA	0
		Americas Companies	1,226	1,674	36.5	31.7
		Japanese Companies	1,446	1,777	22.9	33.7
		European Companies	1,330	1,374	3.3	26.0
		Asia/Pacific Companies	338	452	33.7	8.6
		Included Companies Total	**4,340**	**5,277**	**21.6**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-22
Top 18 Worldwide Vendors' Revenue from Shipments of Discrete Semiconductors to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Toshiba	390	454	16.4	14.7
2	6	Rohm	193	335	73.6	10.9
3	3	Motorola	271	297	9.6	9.6
4	2	Philips	291	295	1.4	9.6
5	4	Samsung	252	295	17.1	9.6
6	5	Hitachi	203	252	24.1	8.2
7	7	Korean Electronic Co.	165	191	15.8	6.2
8	10	SANYO	136	165	21.3	5.4
9	12	Sanken	120	161	34.2	5.2
10	9	Matsushita	151	154	2.0	5.0
11	8	NEC	154	151	-1.9	4.9
12	11	SGS-Thomson	132	143	8.3	4.6
13	14	Mitsubishi	64	70	9.4	2.3
14	15	Siemens	44	56	27.3	1.8
15	13	National Semiconductor	66	33	-50.0	1.1
16	16	Fujitsu	14	17	21.4	0.6
17	17	Sony	8	9	12.5	0.3
18	18	Texas Instruments	3	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	340	330	-2.9	10.7
		Japanese Companies	1,433	1,768	23.4	57.4
		European Companies	467	494	5.8	16.0
		Asia/Pacific Companies	417	486	16.5	15.8
		Included Companies Total	**2,657**	**3,078**	**15.8**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-23
Top 16 Worldwide Vendors' Revenue from Shipments of Optical Semiconductors to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Sharp	131	173	32.1	24.5
2	3	Rohm	66	111	68.2	15.7
3	5	NEC	35	92	162.9	13.0
4	2	Toshiba	84	90	7.1	12.7
5	7	Sony	33	44	33.3	6.2
6	6	Siemens	35	36	2.9	5.1
7	8	Hitachi	25	30	20.0	4.2
8	13	Lucent Technologies	10	28	180.0	4.0
9	10	SANYO	16	25	56.3	3.5
10	11	Mitsubishi	16	19	18.8	2.7
11	9	Korean Electronic Co.	19	15	-21.1	2.1
12	12	Motorola	12	13	8.3	1.8
13	4	Matsushita	46	12	-73.9	1.7
14	14	Samsung	8	12	50.0	1.7
15	15	Sanken	2	4	100.0	0.6
16	16	Fujitsu	2	2	0	0.3
		All Others	-	-	NA	0
		Americas Companies	22	41	86.4	5.8
		Japanese Companies	456	602	32.0	85.3
		European Companies	35	36	2.9	5.1
		Asia/Pacific Companies	27	27	0	3.8
		Included Companies Total	**540**	**706**	**30.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Chapter 3
Korea Market Statistics Tables

Table 3-1
Top 30 Worldwide Vendors' Revenue from Shipments of Total Semiconductors to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	603	620	2.8	15.0
2	2	Intel	454	559	23.1	13.6
3	3	Philips	345	404	17.1	9.8
4	4	LG Semicon	297	270	-9.1	6.6
5	6	Motorola	188	199	5.9	4.8
6	5	Toshiba	235	196	-16.6	4.8
7	7	SANYO	173	176	1.7	4.3
8	11	National Semiconductor	116	171	47.4	4.1
9	9	Texas Instruments	167	160	-4.2	3.9
10	8	Hitachi	172	144	-16.3	3.5
11	10	SGS-Thomson	130	141	8.5	3.4
12	19	Sharp	52	105	101.9	2.5
13	12	Korean Electronic Co.	116	103	-11.2	2.5
14	16	Rohm	58	100	72.4	2.4
15	28	Sanken	7	89	1,171.4	2.2
16	13	NEC	93	85	-8.6	2.1
17	22	Lucent Technologies	35	80	128.6	1.9
18	14	Hyundai	88	78	-11.4	1.9
19	18	Mitsubishi	52	61	17.3	1.5
20	15	Sony	81	58	-28.4	1.4
21	253	Vanguard	0	55	NA	1.3
22	23	Fujitsu	27	54	100.0	1.3
23	20	Siemens	36	51	41.7	1.2
24	17	Matsushita	52	49	-5.8	1.2
25	21	Atmel	35	45	28.6	1.1
26	24	Advanced Micro Devices	26	42	61.5	1.0
27	27	Cirrus Logic	9	11	22.2	0.3
28	25	IBM	21	10	-52.4	0.2
29	30	Winbond Electronics	3	5	66.7	0.1
30	116	S3	0	1	NA	0
		All Others	16	-	-100.0	0
		Americas Companies	1,051	1,278	21.6	31.0
		Japanese Companies	1,002	1,117	11.5	27.1
		European Companies	511	596	16.6	14.5
		Asia/Pacific Companies	1,123	1,131	0.7	27.4
		Included Companies Total	**3,687**	**4,122**	**11.8**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-2
Top 30 Worldwide Vendors' Revenue from Shipments of Total Integrated Circuits to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Intel	454	559	23.1	16.7
2	1	Samsung	485	491	1.2	14.7
3	4	Philips	250	310	24.0	9.3
4	3	LG Semicon	297	270	-9.1	8.1
5	7	Motorola	157	165	5.1	4.9
6	11	National Semiconductor	102	164	60.8	4.9
7	5	Texas Instruments	167	160	-4.2	4.8
8	9	SANYO	146	153	4.8	4.6
9	6	Toshiba	159	129	-18.9	3.9
10	10	SGS-Thomson	110	127	15.5	3.8
11	8	Hitachi	150	124	-17.3	3.7
12	12	Hyundai	88	78	-11.4	2.3
13	18	Lucent Technologies	33	72	118.2	2.1
14	13	NEC	84	68	-19.0	2.0
15	21	Sharp	21	61	190.5	1.8
16	31	Vanguard	0	55	NA	1.6
17	19	Fujitsu	26	50	92.3	1.5
18	14	Sony	71	47	-33.8	1.4
19	17	Atmel	35	45	28.6	1.3
20	15	Mitsubishi	38	42	10.5	1.3
21	20	Advanced Micro Devices	26	42	61.5	1.3
22	24	Rohm	16	31	93.8	0.9
23	25	Siemens	16	30	87.5	0.9
24	16	Korean Electronic Co.	35	20	-42.9	0.6
25	23	Matsushita	17	15	-11.8	0.4
26	30	Sanken	0	14	NA	0.4
27	27	Cirrus Logic	9	11	22.2	0.3
28	22	IBM	21	10	-52.4	0.3
29	29	Winbond Electronics	3	5	66.7	0.1
30	32	S3	0	1	NA	0
		All Others	16	-	-100.0	0
		Americas Companies	1,004	1,229	22.4	36.7
		Japanese Companies	728	734	0.8	21.9
		European Companies	376	467	24.2	13.9
		Asia/Pacific Companies	924	919	-0.5	27.4
		Included Companies Total	**3,032**	**3,349**	**10.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 3-3
Top 11 Worldwide Vendors' Revenue from Shipments of Bipolar Digital to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	3	Hitachi	8	8	0	34.8
2	1	Texas Instruments	12	4	-66.7	17.4
3	4	LG Semicon	4	3	-25.0	13.0
4	5	Motorola	3	3	0	13.0
5	6	Philips	2	2	0	8.7
6	7	Toshiba	1	1	0	4.3
7	9	Mitsubishi	1	1	0	4.3
8	10	Advanced Micro Devices	1	1	0	4.3
9	2	National Semiconductor	8	0	-100.0	0
10	8	NEC	1	0	-100.0	0
11	11	Matsushita	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	24	8	-66.7	34.8
		Japanese Companies	12	10	-16.7	43.5
		European Companies	2	2	0	8.7
		Asia/Pacific Companies	4	3	-25.0	13.0
		Included Companies Total	**42**	**23**	**-45.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-4
Top 30 Worldwide Vendors' Revenue from Shipments of MOS Digital ICs to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	454	559	23.1	23.0
2	2	Samsung	396	375	-5.3	15.4
3	3	LG Semicon	271	241	-11.1	9.9
4	6	Philips	124	161	29.8	6.6
5	7	Motorola	105	126	20.0	5.2
6	5	Hitachi	128	103	-19.5	4.2
7	4	Texas Instruments	134	96	-28.4	3.9
8	9	Hyundai	88	78	-11.4	3.2
9	16	Lucent Technologies	28	72	157.1	3.0
10	11	SANYO	56	62	10.7	2.5
11	10	NEC	65	59	-9.2	2.4
12	8	Toshiba	92	58	-37.0	2.4
13	13	SGS-Thomson	47	56	19.1	2.3
14	29	Vanguard	0	55	NA	2.3
15	21	Sharp	20	52	160.0	2.1
16	17	Fujitsu	26	48	84.6	2.0
17	14	Atmel	35	45	28.6	1.8
18	18	National Semiconductor	25	39	56.0	1.6
19	15	Mitsubishi	33	37	12.1	1.5
20	19	Advanced Micro Devices	22	35	59.1	1.4
21	12	Sony	50	25	-50.0	1.0
22	25	Siemens	5	15	200.0	0.6
23	23	Cirrus Logic	9	11	22.2	0.5
24	20	IBM	21	10	-52.4	0.4
25	27	Rohm	3	6	100.0	0.2
26	24	Matsushita	7	5	-28.6	0.2
27	28	Winbond Electronics	2	4	100.0	0.2
28	32	S3	0	1	NA	0
29	22	Mosel Vitelic	12	0	-100.0	0
30	26	United Microelectronics Corp.	4	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	833	994	19.3	40.8
		Japanese Companies	480	455	-5.2	18.7
		European Companies	176	232	31.8	9.5
		Asia/Pacific Companies	773	753	-2.6	30.9
		Included Companies Total	**2,262**	**2,434**	**7.6**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-5
Top 25 Worldwide Vendors' Revenue from Shipments of MOS Memory to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	271	256	-5.5	37.6
2	2	LG Semicon	217	167	-23.0	24.5
3	3	Hyundai	86	77	-10.5	11.3
4	27	Vanguard	0	55	NA	8.1
5	5	Atmel	30	37	23.3	5.4
6	6	SGS-Thomson	14	20	42.9	2.9
7	4	Texas Instruments	36	15	-58.3	2.2
8	7	Intel	13	15	15.4	2.2
9	11	Advanced Micro Devices	7	8	14.3	1.2
10	14	Fujitsu	4	7	75.0	1.0
11	20	Siemens	2	6	200.0	0.9
12	9	Toshiba	9	3	-66.7	0.4
13	15	IBM	4	3	-25.0	0.4
14	10	NEC	7	2	-71.4	0.3
15	17	Sony	3	2	-33.3	0.3
16	21	Mitsubishi	1	2	100.0	0.3
17	24	Philips	0	2	NA	0.3
18	12	Hitachi	6	1	-83.3	0.1
19	13	Motorola	4	1	-75.0	0.1
20	19	Sharp	2	1	-50.0	0.1
21	23	Winbond Electronics	1	1	0	0.1
22	8	Mosel Vitelic	12	0	-100.0	0
23	16	National Semiconductor	3	0	-100.0	0
24	18	United Microelectronics Corp.	3	0	-100.0	0
25	22	Matsushita	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	97	79	-18.6	11.6
		Japanese Companies	33	18	-45.5	2.6
		European Companies	16	28	75.0	4.1
		Asia/Pacific Companies	590	556	-5.8	81.6
		Included Companies Total	**736**	**681**	**-7.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-6
Top 12 Worldwide Vendors' Revenue from Shipments of DRAM to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	220	201	-8.6	40.8
2	2	LG Semicon	188	140	-25.5	28.4
3	3	Hyundai	80	74	-7.5	15.0
4	11	Vanguard	0	55	NA	11.2
5	4	Texas Instruments	26	7	-73.1	1.4
6	9	Siemens	2	6	200.0	1.2
7	8	IBM	4	3	-25.0	0.6
8	6	Toshiba	8	2	-75.0	0.4
9	7	NEC	5	2	-60.0	0.4
10	16	Fujitsu	0	2	NA	0.4
11	10	Hitachi	2	1	-50.0	0.2
12	5	Mosel Vitelic	12	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	30	10	-66.7	2.0
		Japanese Companies	15	7	-53.3	1.4
		European Companies	2	6	200.0	1.2
		Asia/Pacific Companies	500	470	-6.0	95.3
		Included Companies Total	**547**	**493**	**-9.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-7
Top 11 Worldwide Vendors' Revenue from Shipments of SRAM to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	39	39	0	63.9
2	2	LG Semicon	14	12	-14.3	19.7
3	3	Hyundai	6	3	-50.0	4.9
4	5	Sony	3	2	-33.3	3.3
5	9	Mitsubishi	1	2	100.0	3.3
6	4	Motorola	4	1	-75.0	1.6
7	7	Toshiba	1	1	0	1.6
8	10	Winbond Electronics	1	1	0	1.6
9	6	United Microelectronics Corp.	3	0	-100.0	0
10	8	NEC	1	0	-100.0	0
11	11	Matsushita	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	4	1	-75.0	1.6
		Japanese Companies	7	5	-28.6	8.2
		European Companies	-	-	NA	0
		Asia/Pacific Companies	63	55	-12.7	90.2
		Included Companies Total	**74**	**61**	**-17.6**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 3-8
Top 12 Worldwide Vendors' Revenue from Shipments of Nonvolatile Memory to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Atmel	30	37	23.3	29.6
2	3	SGS-Thomson	14	20	42.9	16.0
3	5	Samsung	12	16	33.3	12.8
4	2	LG Semicon	15	15	0	12.0
5	4	Intel	13	15	15.4	12.0
6	6	Texas Instruments	10	8	-20.0	6.4
7	7	Advanced Micro Devices	7	8	14.3	6.4
8	8	Fujitsu	4	5	25.0	4.0
9	11	Sharp	2	1	-50.0	0.8
10	9	Hitachi	4	0	-100.0	0
11	10	National Semiconductor	3	0	-100.0	0
12	12	NEC	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	63	68	7.9	54.4
		Japanese Companies	11	6	-45.5	4.8
		European Companies	14	20	42.9	16.0
		Asia/Pacific Companies	27	31	14.8	24.8
		Included Companies Total	**115**	**125**	**8.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-9
Top 26 Worldwide Vendors' Revenue from Shipments of MOS Microcomponents to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	441	544	23.4	44.0
2	2	Hitachi	107	94	-12.1	7.6
3	4	Philips	61	83	36.1	6.7
4	3	Motorola	76	82	7.9	6.6
5	8	Samsung	33	49	48.5	4.0
6	5	NEC	48	46	-4.2	3.7
7	15	Lucent Technologies	11	45	309.1	3.6
8	11	National Semiconductor	19	39	105.3	3.2
9	6	Toshiba	44	38	-13.6	3.1
10	10	Mitsubishi	30	33	10.0	2.7
11	7	SGS-Thomson	33	28	-15.2	2.3
12	9	Texas Instruments	30	25	-16.7	2.0
13	13	Advanced Micro Devices	12	24	100.0	1.9
14	14	LG Semicon	11	24	118.2	1.9
15	12	SANYO	15	17	13.3	1.4
16	17	Fujitsu	6	17	183.3	1.4
17	19	Sharp	4	14	250.0	1.1
18	16	Cirrus Logic	9	11	22.2	0.9
19	23	Siemens	3	9	200.0	0.7
20	21	Atmel	3	5	66.7	0.4
21	18	Sony	6	3	-50.0	0.2
22	20	IBM	4	3	-25.0	0.2
23	24	Winbond Electronics	1	2	100.0	0.2
24	22	Matsushita	3	1	-66.7	0
25	30	S3	0	1	NA	0
26	25	United Microelectronics Corp.	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	605	779	28.8	63.0
		Japanese Companies	263	263	0	21.3
		European Companies	97	120	23.7	9.7
		Asia/Pacific Companies	46	75	63.0	6.1
		Included Companies Total	**1,011**	**1,237**	**22.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-10
Top Nine Worldwide Vendors' Revenue from Shipments of Microprocessors to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	393	494	25.7	90.5
2	2	Motorola	15	23	53.3	4.2
3	5	National Semiconductor	2	14	600.0	2.6
4	3	NEC	4	6	50.0	1.1
5	8	Advanced Micro Devices	2	4	100.0	0.7
6	4	IBM	4	3	-25.0	0.5
7	6	Toshiba	2	2	0	0.4
8	7	Texas Instruments	2	0	-100.0	0
9	9	LG Semicon	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	418	538	28.7	98.5
		Japanese Companies	6	8	33.3	1.5
		European Companies	-	-	NA	0
		Asia/Pacific Companies	2	-	-100.0	0
		Included Companies Total	**426**	**546**	**28.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-11
Top 20 Worldwide Vendors' Revenue from Shipments of Microcontrollers to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Hitachi	85	75	-11.8	16.3
2	3	Philips	54	71	31.5	15.5
3	2	Motorola	57	48	-15.8	10.5
4	6	Samsung	32	48	50.0	10.5
5	4	NEC	41	36	-12.2	7.8
6	8	Mitsubishi	25	28	12.0	6.1
7	7	SGS-Thomson	26	26	0	5.7
8	5	Toshiba	36	21	-41.7	4.6
9	9	Intel	21	21	0	4.6
10	10	SANYO	15	17	13.3	3.7
11	13	Fujitsu	5	15	200.0	3.3
12	12	LG Semicon	5	14	180.0	3.1
13	14	Sharp	4	14	250.0	3.1
14	17	Siemens	3	9	200.0	2.0
15	18	Atmel	3	5	66.7	1.1
16	15	National Semiconductor	3	4	33.3	0.9
17	11	Sony	6	3	-50.0	0.7
18	16	Texas Instruments	3	2	-33.3	0.4
19	19	Matsushita	2	1	-50.0	0.2
20	20	Advanced Micro Devices	0	1	NA	0.2
		All Others	-	-	NA	0
		Americas Companies	87	81	-6.9	17.6
		Japanese Companies	219	210	-4.1	45.8
		European Companies	83	106	27.7	23.1
		Asia/Pacific Companies	37	62	67.6	13.5
		Included Companies Total	**426**	**459**	**7.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-12
Top 19 Worldwide Vendors' Revenue from Shipments of Microperipherals to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	27	29	7.4	21.2
2	3	National Semiconductor	14	21	50.0	15.3
3	4	Advanced Micro Devices	10	19	90.0	13.9
4	2	Hitachi	21	18	-14.3	13.1
5	5	Cirrus Logic	9	11	22.2	8.0
6	10	LG Semicon	4	10	150.0	7.3
7	8	Toshiba	6	7	16.7	5.1
8	9	Mitsubishi	5	5	0	3.6
9	11	Texas Instruments	3	5	66.7	3.6
10	6	Philips	7	2	-71.4	1.5
11	7	SGS-Thomson	7	2	-71.4	1.5
12	12	NEC	2	2	0	1.5
13	15	Fujitsu	1	2	100.0	1.5
14	17	Winbond Electronics	1	2	100.0	1.5
15	14	Samsung	1	1	0	0.7
16	26	S3	0	1	NA	0.7
17	13	Motorola	1	0	-100.0	0
18	16	Matsushita	1	0	-100.0	0
19	18	United Microelectronics Corp.	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	64	86	34.4	62.8
		Japanese Companies	36	34	-5.6	24.8
		European Companies	14	4	-71.4	2.9
		Asia/Pacific Companies	7	13	85.7	9.5
		Included Companies Total	**121**	**137**	**13.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-13
Top Seven Worldwide Vendors' Revenue from Shipments of Digital Signal Processors to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Lucent Technologies	11	45	309.1	47.4
2	1	Texas Instruments	22	18	-18.2	18.9
3	3	Motorola	3	11	266.7	11.6
4	13	Philips	0	10	NA	10.5
5	11	Toshiba	0	8	NA	8.4
6	5	NEC	1	2	100.0	2.1
7	4	Hitachi	1	1	0	1.1
		All Others	-	-	NA	0
		Americas Companies	36	74	105.6	77.9
		Japanese Companies	2	11	450.0	11.6
		European Companies	-	10	NA	10.5
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**38**	**95**	**150.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 3-14
Top 23 Worldwide Vendors' Revenue from Shipments of MOS Digital Logic to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	3	Philips	63	76	20.6	14.7
2	1	Samsung	92	70	-23.9	13.6
3	2	Texas Instruments	68	56	-17.6	10.9
4	4	LG Semicon	43	50	16.3	9.7
5	5	SANYO	41	45	9.8	8.7
6	8	Motorola	25	43	72.0	8.3
7	12	Sharp	14	37	164.3	7.2
8	9	Lucent Technologies	17	27	58.8	5.2
9	10	Fujitsu	16	24	50.0	4.7
10	6	Sony	41	20	-51.2	3.9
11	7	Toshiba	39	17	-56.4	3.3
12	14	NEC	10	11	10.0	2.1
13	11	Hitachi	15	8	-46.7	1.6
14	24	SGS-Thomson	0	8	NA	1.6
15	18	Rohm	3	6	100.0	1.2
16	13	IBM	13	4	-69.2	0.8
17	17	Matsushita	3	4	33.3	0.8
18	16	Advanced Micro Devices	3	3	0	0.6
19	20	Atmel	2	3	50.0	0.6
20	19	Mitsubishi	2	2	0	0.4
21	21	Hyundai	2	1	-50.0	0.2
22	25	Winbond Electronics	0	1	NA	0.2
23	15	National Semiconductor	3	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	131	136	3.8	26.4
		Japanese Companies	184	174	-5.4	33.7
		European Companies	63	84	33.3	16.3
		Asia/Pacific Companies	137	122	-10.9	23.6
		Included Companies Total	**515**	**516**	**0.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 3-15
Top 18 Worldwide Vendors' Revenue from Shipments of ASICs to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Texas Instruments	53	40	-24.5	21.7
2	3	LG Semicon	33	38	15.2	20.7
3	5	Lucent Technologies	17	27	58.8	14.7
4	6	Fujitsu	16	21	31.3	11.4
5	2	Samsung	49	11	-77.6	6.0
6	20	SGS-Thomson	0	8	NA	4.3
7	10	Hitachi	10	6	-40.0	3.3
8	4	Toshiba	33	5	-84.8	2.7
9	9	Sharp	12	5	-58.3	2.7
10	11	Motorola	5	5	0	2.7
11	8	IBM	13	4	-69.2	2.2
12	17	Matsushita	1	4	300.0	2.2
13	7	Sony	15	3	-80.0	1.6
14	12	NEC	4	3	-25.0	1.6
15	14	Advanced Micro Devices	2	2	0	1.1
16	15	Atmel	2	1	-50.0	0.5
17	16	Hyundai	2	1	-50.0	0.5
18	13	Rohm	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	92	79	-14.1	42.9
		Japanese Companies	93	47	-49.5	25.5
		European Companies	-	8	NA	4.3
		Asia/Pacific Companies	84	50	-40.5	27.2
		Included Companies Total	**269**	**184**	**-31.6**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 3-16
Top Eight Worldwide Vendors' Revenue from Shipments of Custom ICs to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	9	Sharp	0	28	NA	46.7
2	5	Samsung	0	10	NA	16.7
3	10	Motorola	0	10	NA	16.7
4	13	Sony	0	5	NA	8.3
5	18	Rohm	0	3	NA	5.0
6	16	Atmel	0	2	NA	3.3
7	14	NEC	0	1	NA	1.7
8	22	Winbond Electronics	0	1	NA	1.7
		All Others	-	-	NA	0
		Americas Companies	0	12	NA	20.0
		Japanese Companies	0	37	NA	61.7
		European Companies	0	-	NA	0
		Asia/Pacific Companies	0	11	NA	18.3
		Included Companies Total	**0**	**60**	**NA**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-17
Top 13 Worldwide Vendors' Revenue from Shipments of MOS Standard Logic to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	LG Semicon	10	12	20.0	24.5
2	1	Texas Instruments	15	11	-26.7	22.4
3	3	Motorola	5	5	0	10.2
4	5	Toshiba	3	5	66.7	10.2
5	6	Philips	3	5	66.7	10.2
6	4	Samsung	3	3	0	6.1
7	18	Fujitsu	0	3	NA	6.1
8	10	Rohm	1	2	100.0	4.1
9	8	Hitachi	2	1	-50.0	2.0
10	11	NEC	1	1	0	2.0
11	12	Mitsubishi	1	1	0	2.0
12	7	National Semiconductor	3	0	-100.0	0
13	9	Matsushita	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	23	16	-30.4	32.7
		Japanese Companies	10	13	30.0	26.5
		European Companies	3	5	66.7	10.2
		Asia/Pacific Companies	13	15	15.4	30.6
		Included Companies Total	**49**	**49**	**0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 3-18
Top 13 Worldwide Vendors' Revenue from Shipments of Total Other MOS Logic to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	60	71	18.3	31.8
2	3	Samsung	40	46	15.0	20.6
3	2	SANYO	41	45	9.8	20.2
4	5	Motorola	15	23	53.3	10.3
5	4	Sony	26	12	-53.8	5.4
6	7	Toshiba	3	7	133.3	3.1
7	6	NEC	5	6	20.0	2.7
8	13	Texas Instruments	0	5	NA	2.2
9	9	Sharp	2	4	100.0	1.8
10	8	Hitachi	3	1	-66.7	0.4
11	10	Mitsubishi	1	1	0	0.4
12	11	Advanced Micro Devices	1	1	0	0.4
13	15	Rohm	0	1	NA	0.4
		All Others	-	-	NA	0
		Americas Companies	16	29	81.3	13.0
		Japanese Companies	81	77	-4.9	34.5
		European Companies	60	71	18.3	31.8
		Asia/Pacific Companies	40	46	15.0	20.6
		Included Companies Total	**197**	**223**	**13.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-19
Top 23 Worldwide Vendors' Revenue from Shipments of Analog-Monolithic to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	124	147	18.5	16.5
2	4	National Semiconductor	69	125	81.2	14.0
3	3	Samsung	89	116	30.3	13.0
4	2	SANYO	90	91	1.1	10.2
5	6	SGS-Thomson	63	71	12.7	8.0
6	5	Toshiba	66	70	6.1	7.8
7	11	Texas Instruments	21	60	185.7	6.7
8	7	Motorola	49	36	-26.5	4.0
9	9	LG Semicon	22	26	18.2	2.9
10	14	Rohm	13	25	92.3	2.8
11	10	Sony	21	22	4.8	2.5
12	8	Korean Electronic Co.	35	20	-42.9	2.2
13	15	Siemens	11	15	36.4	1.7
14	32	Sanken	0	14	NA	1.6
15	13	Hitachi	14	13	-7.1	1.5
16	16	Matsushita	9	10	11.1	1.1
17	12	NEC	18	9	-50.0	1.0
18	20	Sharp	1	9	800.0	1.0
19	19	Advanced Micro Devices	3	6	100.0	0.7
20	18	Mitsubishi	4	4	0	0.4
21	22	Fujitsu	0	2	NA	0.2
22	21	Winbond Electronics	1	1	0	0.1
23	17	Lucent Technologies	5	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	147	227	54.4	25.4
		Japanese Companies	236	269	14.0	30.2
		European Companies	198	233	17.7	26.1
		Asia/Pacific Companies	147	163	10.9	18.3
		Included Companies Total	**728**	**892**	**22.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 3-20
Top 17 Worldwide Vendors' Revenue from Shipments of Discrete Semiconductors to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	110	117	6.4	18.4
2	2	Philips	93	94	1.1	14.8
3	3	Korean Electronic Co.	71	75	5.6	11.8
4	15	Sanken	4	72	1,700.0	11.3
5	4	Toshiba	65	58	-10.8	9.1
6	7	Rohm	28	47	67.9	7.4
7	5	Motorola	30	33	10.0	5.2
8	6	Matsushita	30	32	6.7	5.0
9	8	SANYO	20	20	0	3.1
10	13	Mitsubishi	13	18	38.5	2.8
11	10	Siemens	16	17	6.3	2.7
12	11	Hitachi	15	15	0	2.4
13	9	SGS-Thomson	20	14	-30.0	2.2
14	14	NEC	6	12	100.0	1.9
15	12	National Semiconductor	14	7	-50.0	1.1
16	17	Fujitsu	1	3	200.0	0.5
17	16	Sony	2	2	0	0.3
		All Others	-	-	NA	0
		Americas Companies	44	40	-9.1	6.3
		Japanese Companies	184	279	51.6	43.9
		European Companies	129	125	-3.1	19.7
		Asia/Pacific Companies	181	192	6.1	30.2
		Included Companies Total	**538**	**636**	**18.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 3-21
Top 16 Worldwide Vendors' Revenue from Shipments of Optical Semiconductors to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Sharp	31	44	41.9	32.1
2	2	Rohm	12	22	83.3	16.1
3	5	Samsung	8	12	50.0	8.8
4	3	Toshiba	11	9	-18.2	6.6
5	6	Sony	8	9	12.5	6.6
6	4	Korean Electronic Co.	10	8	-20.0	5.8
7	12	Lucent Technologies	2	8	300.0	5.8
8	8	Hitachi	5	5	0	3.6
9	11	NEC	2	5	150.0	3.6
10	9	Siemens	4	4	0	2.9
11	10	SANYO	3	3	0	2.2
12	16	Sanken	0	3	NA	2.2
13	7	Matsushita	5	2	-60.0	1.5
14	13	Motorola	1	1	0	0.7
15	14	Mitsubishi	1	1	0	0.7
16	19	Fujitsu	0	1	NA	0.7
		All Others	-	-	NA	0
		Americas Companies	3	9	200.0	6.6
		Japanese Companies	78	104	33.3	75.9
		European Companies	4	4	0	2.9
		Asia/Pacific Companies	18	20	11.1	14.6
		Included Companies Total	**103**	**137**	**33.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Chapter 4
China/Hong Kong Market Statistics Tables

Table 4-1
Top 30 Worldwide Vendors' Revenue from Shipments of Total Semiconductors to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	558	684	22.6	11.6
2	2	Toshiba	504	637	26.4	10.8
3	3	Motorola	374	414	10.7	7.0
4	7	Samsung	302	405	34.1	6.9
5	5	Philips	320	359	12.2	6.1
6	4	NEC	363	353	-2.8	6.0
7	9	Texas Instruments	202	281	39.1	4.8
8	6	LG Semicon	306	280	-8.5	4.8
9	8	SANYO	224	268	19.6	4.6
10	13	Rohm	161	230	42.9	3.9
11	10	Hyundai	193	179	-7.3	3.0
12	11	SGS-Thomson	178	176	-1.1	3.0
13	12	Hitachi	164	166	1.2	2.8
14	15	National Semiconductor	131	146	11.5	2.5
15	23	Lucent Technologies	59	135	128.8	2.3
16	22	Advanced Micro Devices	61	121	98.4	2.1
17	20	Siemens	88	116	31.8	2.0
18	17	Mitsubishi	96	107	11.5	1.8
19	18	Sony	93	102	9.7	1.7
20	21	Matsushita	84	92	9.5	1.6
21	25	Atmel	52	92	76.9	1.6
22	19	United Microelectronics Corp.	90	90	0	1.5
23	27	Korean Electronic Co.	43	75	74.4	1.3
24	16	Sharp	120	69	-42.5	1.2
25	14	Fujitsu	134	68	-49.3	1.2
26	116	S3	0	59	NA	1.0
27	253	Vanguard	0	50	NA	0.9
28	24	IBM	57	39	-31.6	0.7
29	26	Sanken	46	34	-26.1	0.6
30	28	Winbond Electronics	26	32	23.1	0.5
		All Others	20	18	-10.0	0.3
		Americas Companies	1,500	1,977	31.8	33.6
		Japanese Companies	1,989	2,126	6.9	36.2
		European Companies	586	651	11.1	11.1
		Asia/Pacific Companies	974	1,123	15.3	19.1
		Included Companies Total	**5,049**	**5,877**	**16.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 4-2
Top 30 Worldwide Vendors' Revenue from Shipments of Total Integrated Circuits to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	558	684	22.6	14.0
2	2	Toshiba	392	487	24.2	10.0
3	6	Samsung	246	334	35.8	6.8
4	5	Motorola	288	320	11.1	6.6
5	4	NEC	304	287	-5.6	5.9
6	8	Texas Instruments	202	281	39.1	5.8
7	3	LG Semicon	306	280	-8.5	5.7
8	7	Philips	235	273	16.2	5.6
9	10	SANYO	181	208	14.9	4.3
10	9	Hyundai	193	179	-7.3	3.7
11	14	National Semiconductor	117	139	18.8	2.8
12	21	Advanced Micro Devices	61	121	98.4	2.5
13	11	SGS-Thomson	129	120	-7.0	2.5
14	23	Lucent Technologies	56	115	105.4	2.4
15	12	Hitachi	129	112	-13.2	2.3
16	18	Rohm	74	99	33.8	2.0
17	19	Sony	74	96	29.7	2.0
18	25	Atmel	52	92	76.9	1.9
19	16	United Microelectronics Corp.	90	90	0	1.8
20	20	Siemens	65	84	29.2	1.7
21	17	Mitsubishi	76	82	7.9	1.7
22	13	Fujitsu	127	66	-48.0	1.4
23	24	Matsushita	55	64	16.4	1.3
24	30	S3	0	59	NA	1.2
25	31	Vanguard	0	50	NA	1.0
26	15	Sharp	95	47	-50.5	1.0
27	22	IBM	57	39	-31.6	0.8
28	26	Winbond Electronics	26	32	23.1	0.7
29	29	Korean Electronic Co.	3	22	633.3	0.5
30	27	Mosel Vitelic	14	12	-14.3	0.2
		All Others	6	9	50.0	0.2
		Americas Companies	1,397	1,856	32.9	38.0
		Japanese Companies	1,507	1,551	2.9	31.8
		European Companies	429	477	11.2	9.8
		Asia/Pacific Companies	878	999	13.8	20.5
		Included Companies Total	**4,211**	**4,883**	**16.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-3
Top 12 Worldwide Vendors' Revenue from Shipments of Bipolar Digital to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Hitachi	11	11	0	30.6
2	1	Texas Instruments	15	10	-33.3	27.8
3	5	Motorola	7	7	0	19.4
4	6	LG Semicon	2	2	0	5.6
5	30	Mosel Vitelic	0	2	NA	5.6
6	4	Toshiba	8	1	-87.5	2.8
7	8	Philips	1	1	0	2.8
8	9	Advanced Micro Devices	1	1	0	2.8
9	10	Mitsubishi	1	1	0	2.8
10	3	National Semiconductor	9	0	-100.0	0
11	7	NEC	1	0	-100.0	0
12	11	Matsushita	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	32	18	-43.8	50.0
		Japanese Companies	22	13	-40.9	36.1
		European Companies	1	1	0	2.8
		Asia/Pacific Companies	2	4	100.0	11.1
		Included Companies Total	**57**	**36**	**-36.8**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 4-4
Top 30 Worldwide Vendors' Revenue from Shipments of MOS Digital ICs to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	558	684	22.6	18.8
2	4	Toshiba	251	311	23.9	8.5
3	3	NEC	257	267	3.9	7.3
4	2	LG Semicon	296	266	-10.1	7.3
5	7	Samsung	172	228	32.6	6.3
6	6	Motorola	187	203	8.6	5.6
7	5	Hyundai	192	176	-8.3	4.8
8	8	Philips	143	162	13.3	4.4
9	9	Texas Instruments	136	144	5.9	3.9
10	19	Advanced Micro Devices	53	105	98.1	2.9
11	21	Lucent Technologies	51	105	105.9	2.9
12	20	Atmel	52	92	76.9	2.5
13	12	SANYO	90	91	1.1	2.5
14	13	United Microelectronics Corp.	90	90	0	2.5
15	11	Hitachi	103	79	-23.3	2.2
16	15	Mitsubishi	59	63	6.8	1.7
17	10	Fujitsu	122	59	-51.6	1.6
18	17	Siemens	58	59	1.7	1.6
19	29	S3	0	59	NA	1.6
20	25	Sony	30	58	93.3	1.6
21	22	National Semiconductor	41	53	29.3	1.5
22	30	Vanguard	0	50	NA	1.4
23	14	Sharp	87	46	-47.1	1.3
24	23	Rohm	41	45	9.8	1.2
25	16	SGS-Thomson	58	42	-27.6	1.2
26	18	IBM	57	39	-31.6	1.1
27	24	Matsushita	32	38	18.8	1.0
28	27	Winbond Electronics	13	16	23.1	0.4
29	26	Mosel Vitelic	14	10	-28.6	0.3
30	28	Cirrus Logic	6	6	0	0.2
		All Others	-	-	NA	0
		Americas Companies	1,141	1,490	30.6	40.9
		Japanese Companies	1,072	1,057	-1.4	29.0
		European Companies	259	263	1.5	7.2
		Asia/Pacific Companies	777	836	7.6	22.9
		Included Companies Total	**3,249**	**3,646**	**12.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 4-5
Top 27 Worldwide Vendors' Revenue from Shipments of MOS Memory to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	LG Semicon	231	182	-21.2	18.8
2	2	Hyundai	192	176	-8.3	18.2
3	3	NEC	160	103	-35.6	10.6
4	6	Samsung	81	83	2.5	8.6
5	11	Atmel	37	65	75.7	6.7
6	8	Siemens	56	57	1.8	5.9
7	9	Texas Instruments	49	50	2.0	5.2
8	29	Vanguard	0	50	NA	5.2
9	5	Toshiba	83	32	-61.4	3.3
10	7	Hitachi	57	19	-66.7	2.0
11	13	SGS-Thomson	23	19	-17.4	2.0
12	10	Sharp	42	18	-57.1	1.9
13	15	Intel	16	18	12.5	1.9
14	16	Advanced Micro Devices	14	18	28.6	1.9
15	14	Mitsubishi	17	17	0	1.8
16	4	Fujitsu	87	11	-87.4	1.1
17	17	Mosel Vitelic	14	10	-28.6	1.0
18	19	Matsushita	8	9	12.5	0.9
19	20	IBM	7	9	28.6	0.9
20	12	Motorola	31	8	-74.2	0.8
21	21	Sony	5	7	40.0	0.7
22	23	Rohm	3	3	0	0.3
23	18	United Microelectronics Corp.	13	2	-84.6	0.2
24	22	SANYO	4	1	-75.0	0.1
25	25	Winbond Electronics	1	1	0	0.1
26	26	Philips	0	1	NA	0.1
27	24	National Semiconductor	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	156	168	7.7	17.3
		Japanese Companies	466	220	-52.8	22.7
		European Companies	79	77	-2.5	7.9
		Asia/Pacific Companies	532	504	-5.3	52.0
		Included Companies Total	**1,233**	**969**	**-21.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 4-6
Top 17 Worldwide Vendors' Revenue from Shipments of DRAM to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Hyundai	180	168	-6.7	23.7
2	1	LG Semicon	206	162	-21.4	22.9
3	3	NEC	145	95	-34.5	13.4
4	5	Samsung	68	58	-14.7	8.2
5	6	Siemens	56	57	1.8	8.1
6	18	Vanguard	0	50	NA	7.1
7	8	Texas Instruments	43	45	4.7	6.4
8	4	Toshiba	70	19	-72.9	2.7
9	9	Hitachi	36	11	-69.4	1.6
10	12	Mitsubishi	12	11	-8.3	1.6
11	10	Mosel Vitelic	14	10	-28.6	1.4
12	7	Fujitsu	55	7	-87.3	1.0
13	13	Matsushita	7	7	0	1.0
14	11	Motorola	13	4	-69.2	0.6
15	14	IBM	4	3	-25.0	0.4
16	16	SANYO	2	1	-50.0	0.1
17	15	Sharp	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	60	52	-13.3	7.3
		Japanese Companies	329	151	-54.1	21.3
		European Companies	56	57	1.8	8.1
		Asia/Pacific Companies	468	448	-4.3	63.3
		Included Companies Total	**913**	**708**	**-22.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-7
Top 15 Worldwide Vendors' Revenue from Shipments of SRAM to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	7	Samsung	7	19	171.4	23.8
2	3	Hyundai	12	8	-33.3	10.0
3	5	LG Semicon	10	8	-20.0	10.0
4	6	Toshiba	10	8	-20.0	10.0
5	9	Sharp	5	7	40.0	8.8
6	10	Sony	5	7	40.0	8.8
7	12	IBM	3	6	100.0	7.5
8	2	Hitachi	14	5	-64.3	6.3
9	1	Motorola	17	3	-82.4	3.8
10	8	NEC	6	3	-50.0	3.8
11	4	United Microelectronics Corp.	12	2	-83.3	2.5
12	11	Mitsubishi	3	2	-33.3	2.5
13	13	Fujitsu	1	1	0	1.3
14	15	Winbond Electronics	1	1	0	1.3
15	14	SANYO	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	20	9	-55.0	11.3
		Japanese Companies	45	33	-26.7	41.3
		European Companies	-	-	NA	0
		Asia/Pacific Companies	42	38	-9.5	47.5
		Included Companies Total	**107**	**80**	**-25.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 4-8
Top 19 Worldwide Vendors' Revenue from Shipments of Nonvolatile Memory to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Atmel	37	65	75.7	36.1
2	4	SGS-Thomson	23	19	-17.4	10.6
3	5	Intel	16	18	12.5	10.0
4	7	Advanced Micro Devices	14	18	28.6	10.0
5	6	LG Semicon	15	12	-20.0	6.7
6	2	Sharp	35	11	-68.6	6.1
7	10	Samsung	6	6	0	3.3
8	8	NEC	9	5	-44.4	2.8
9	11	Texas Instruments	6	5	-16.7	2.8
10	12	Toshiba	3	5	66.7	2.8
11	14	Mitsubishi	2	4	100.0	2.2
12	3	Fujitsu	31	3	-90.3	1.7
13	9	Hitachi	7	3	-57.1	1.7
14	13	Rohm	3	3	0	1.7
15	19	Matsushita	1	2	100.0	1.1
16	16	Motorola	1	1	0	0.6
17	15	National Semiconductor	2	0	-100.0	0
18	17	United Microelectronics Corp.	1	0	-100.0	0
19	18	SANYO	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	76	107	40.8	59.4
		Japanese Companies	92	36	-60.9	20.0
		European Companies	23	19	-17.4	10.6
		Asia/Pacific Companies	22	18	-18.2	10.0
		Included Companies Total	**213**	**180**	**-15.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 4-9
Top 27 Worldwide Vendors' Revenue from Shipments of MOS Microcomponents to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	542	666	22.9	34.9
2	3	Toshiba	99	136	37.4	7.1
3	2	Motorola	112	131	17.0	6.9
4	7	NEC	66	97	47.0	5.1
5	5	United Microelectronics Corp.	77	88	14.3	4.6
6	19	Samsung	16	77	381.3	4.0
7	15	Advanced Micro Devices	26	76	192.3	4.0
8	4	Philips	79	68	-13.9	3.6
9	6	Texas Instruments	67	62	-7.5	3.2
10	30	S3	0	59	NA	3.1
11	9	LG Semicon	37	56	51.4	2.9
12	12	National Semiconductor	34	53	55.9	2.8
13	13	Hitachi	31	51	64.5	2.7
14	17	Lucent Technologies	23	50	117.4	2.6
15	8	Mitsubishi	41	44	7.3	2.3
16	14	SANYO	30	40	33.3	2.1
17	16	Fujitsu	23	34	47.8	1.8
18	18	Sharp	18	23	27.8	1.2
19	10	IBM	35	20	-42.9	1.0
20	20	Atmel	13	20	53.8	1.0
21	11	SGS-Thomson	34	18	-47.1	0.9
22	22	Winbond Electronics	12	14	16.7	0.7
23	24	Matsushita	8	9	12.5	0.5
24	21	Sony	13	8	-38.5	0.4
25	25	Cirrus Logic	6	6	0	0.3
26	23	Rohm	8	3	-62.5	0.2
27	26	Siemens	2	2	0	0.1
		All Others	-	-	NA	0
		Americas Companies	858	1,143	33.2	59.8
		Japanese Companies	337	445	32.0	23.3
		European Companies	115	88	-23.5	4.6
		Asia/Pacific Companies	142	235	65.5	12.3
		Included Companies Total	**1,452**	**1,911**	**31.6**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 4-10
Top 11 Worldwide Vendors' Revenue from Shipments of Microprocessors to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	477	599	25.6	77.5
2	4	Advanced Micro Devices	20	62	210.0	8.0
3	2	Motorola	34	56	64.7	7.2
4	3	IBM	34	19	-44.1	2.5
5	9	National Semiconductor	1	15	1,400.0	1.9
6	5	Toshiba	9	11	22.2	1.4
7	8	NEC	3	8	166.7	1.0
8	11	SGS-Thomson	1	2	100.0	0.3
9	10	Fujitsu	1	1	0	0.1
10	6	LG Semicon	9	0	-100.0	0
11	7	Texas Instruments	7	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	573	751	31.1	97.2
		Japanese Companies	13	20	53.8	2.6
		European Companies	1	2	100.0	0.3
		Asia/Pacific Companies	9	-	-100.0	0
		Included Companies Total	**596**	**773**	**29.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 4-11
Top 21 Worldwide Vendors' Revenue from Shipments of Microcontrollers to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	12	Samsung	16	76	375.0	13.0
2	2	Motorola	61	60	-1.6	10.2
3	3	NEC	47	59	25.5	10.1
4	1	Toshiba	63	55	-12.7	9.4
5	4	Philips	39	51	30.8	8.7
6	5	Mitsubishi	36	40	11.1	6.8
7	7	SANYO	30	40	33.3	6.8
8	9	Hitachi	20	33	65.0	5.6
9	6	Intel	31	31	0	5.3
10	13	LG Semicon	14	27	92.9	4.6
11	11	Fujitsu	16	25	56.3	4.3
12	10	Sharp	18	23	27.8	3.9
13	14	Atmel	13	20	53.8	3.4
14	8	SGS-Thomson	27	16	-40.7	2.7
15	15	Sony	13	8	-38.5	1.4
16	16	Texas Instruments	8	6	-25.0	1.0
17	19	Matsushita	4	5	25.0	0.9
18	18	National Semiconductor	4	4	0	0.7
19	21	Advanced Micro Devices	0	3	NA	0.5
20	17	Rohm	7	2	-71.4	0.3
21	20	Siemens	2	2	0	0.3
		All Others	-	-	NA	0
		Americas Companies	117	124	6.0	21.2
		Japanese Companies	254	290	14.2	49.5
		European Companies	68	69	1.5	11.8
		Asia/Pacific Companies	30	103	243.3	17.6
		Included Companies Total	**469**	**586**	**24.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-12
Top 20 Worldwide Vendors' Revenue from Shipments of Microperipherals to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	United Microelectronics Corp.	77	88	14.3	22.6
2	26	S3	0	59	NA	15.1
3	3	Intel	34	36	5.9	9.2
4	4	National Semiconductor	29	34	17.2	8.7
5	5	Toshiba	22	32	45.5	8.2
6	7	LG Semicon	14	29	107.1	7.4
7	8	NEC	12	18	50.0	4.6
8	10	Hitachi	11	18	63.6	4.6
9	9	Winbond Electronics	12	14	16.7	3.6
10	11	Texas Instruments	9	13	44.4	3.3
11	13	Advanced Micro Devices	6	11	83.3	2.8
12	2	Philips	40	9	-77.5	2.3
13	6	Motorola	15	8	-46.7	2.1
14	16	Fujitsu	5	8	60.0	2.1
15	14	Cirrus Logic	6	6	0	1.5
16	15	Mitsubishi	5	4	-20.0	1.0
17	17	Matsushita	2	1	-50.0	0.3
18	18	Rohm	1	1	0	0.3
19	19	Samsung	0	1	NA	0.3
20	12	SGS-Thomson	6	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	99	167	68.7	42.8
		Japanese Companies	58	82	41.4	21.0
		European Companies	46	9	-80.4	2.3
		Asia/Pacific Companies	103	132	28.2	33.8
		Included Companies Total	**306**	**390**	**27.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-13
Top Nine Worldwide Vendors' Revenue from Shipments of Digital Signal Processors to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Lucent Technologies	23	50	117.4	30.9
2	1	Texas Instruments	43	43	0	26.5
3	3	Toshiba	5	38	660.0	23.5
4	4	NEC	4	12	200.0	7.4
5	17	Philips	0	8	NA	4.9
6	5	Motorola	2	7	250.0	4.3
7	6	Matsushita	2	3	50.0	1.9
8	8	IBM	1	1	0	0.6
9	7	Fujitsu	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	69	101	46.4	62.3
		Japanese Companies	12	53	341.7	32.7
		European Companies	-	8	NA	4.9
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**81**	**162**	**100.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 4-14
Top 22 Worldwide Vendors' Revenue from Shipments of MOS Digital Logic to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Toshiba	69	143	107.2	18.7
2	3	Philips	64	93	45.3	12.1
3	1	Samsung	75	68	-9.3	8.9
4	6	NEC	31	67	116.1	8.7
5	5	Motorola	44	64	45.5	8.4
6	8	Lucent Technologies	28	55	96.4	7.2
7	4	SANYO	56	50	-10.7	6.5
8	17	Sony	12	43	258.3	5.6
9	7	Rohm	30	39	30.0	5.1
10	11	Texas Instruments	20	32	60.0	4.2
11	9	LG Semicon	28	28	0	3.7
12	12	Matsushita	16	20	25.0	2.6
13	16	Fujitsu	12	14	16.7	1.8
14	15	Advanced Micro Devices	13	11	-15.4	1.4
15	13	IBM	15	10	-33.3	1.3
16	14	Hitachi	15	9	-40.0	1.2
17	19	Atmel	2	7	250.0	0.9
18	10	Sharp	27	5	-81.5	0.7
19	21	SGS-Thomson	1	5	400.0	0.7
20	20	Mitsubishi	1	2	100.0	0.3
21	25	Winbond Electronics	0	1	NA	0.1
22	18	National Semiconductor	5	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	127	179	40.9	23.4
		Japanese Companies	269	392	45.7	51.2
		European Companies	65	98	50.8	12.8
		Asia/Pacific Companies	103	97	-5.8	12.7
		Included Companies Total	**564**	**766**	**35.8**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-15
Top 17 Worldwide Vendors' Revenue from Shipments of ASICs to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Lucent Technologies	28	55	96.4	24.8
2	1	Samsung	62	33	-46.8	14.9
3	5	NEC	19	30	57.9	13.5
4	3	LG Semicon	26	26	0	11.7
5	11	Motorola	11	12	9.1	5.4
6	12	Fujitsu	10	11	10.0	5.0
7	6	Texas Instruments	15	10	-33.3	4.5
8	7	IBM	15	10	-33.3	4.5
9	9	Matsushita	12	10	-16.7	4.5
10	10	Toshiba	11	6	-45.5	2.7
11	13	Hitachi	9	5	-44.4	2.3
12	16	Atmel	2	5	150.0	2.3
13	14	Sony	4	3	-25.0	1.4
14	15	Advanced Micro Devices	4	3	-25.0	1.4
15	19	SGS-Thomson	0	2	NA	0.9
16	4	Sharp	25	1	-96.0	0.5
17	8	Rohm	13	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	75	95	26.7	42.8
		Japanese Companies	103	66	-35.9	29.7
		European Companies	-	2	NA	0.9
		Asia/Pacific Companies	88	59	-33.0	26.6
		Included Companies Total	**266**	**222**	**-16.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 4-16
Top Nine Worldwide Vendors' Revenue from Shipments of Custom ICs to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Samsung	0	18	NA	25.0
2	17	Rohm	0	15	NA	20.8
3	5	Motorola	0	10	NA	13.9
4	3	NEC	0	9	NA	12.5
5	9	Matsushita	0	8	NA	11.1
6	13	Sony	0	7	NA	9.7
7	12	Atmel	0	2	NA	2.8
8	16	Sharp	0	2	NA	2.8
9	21	Winbond Electronics	0	1	NA	1.4
		All Others	-	-	NA	0
		Americas Companies	0	12	NA	16.7
		Japanese Companies	0	41	NA	56.9
		European Companies	0	-	NA	0
		Asia/Pacific Companies	0	19	NA	26.4
		Included Companies Total	**0**	**72**	**NA**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-17
Top 14 Worldwide Vendors' Revenue from Shipments of MOS Standard Logic to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	24	46	91.7	31.3
2	3	Toshiba	11	36	227.3	24.5
3	2	Motorola	17	17	0	11.6
4	5	Texas Instruments	5	15	200.0	10.2
5	4	Samsung	6	9	50.0	6.1
6	10	NEC	2	7	250.0	4.8
7	9	Rohm	2	4	100.0	2.7
8	8	Hitachi	4	3	-25.0	2.0
9	12	Fujitsu	2	3	50.0	2.0
10	13	SGS-Thomson	1	3	200.0	2.0
11	11	LG Semicon	2	2	0	1.4
12	14	Mitsubishi	1	2	100.0	1.4
13	6	National Semiconductor	5	0	-100.0	0
14	7	Matsushita	4	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	27	32	18.5	21.8
		Japanese Companies	26	55	111.5	37.4
		European Companies	25	49	96.0	33.3
		Asia/Pacific Companies	8	11	37.5	7.5
		Included Companies Total	**86**	**147**	**70.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 4-18
Top 13 Worldwide Vendors' Revenue from Shipments of Total Other MOS Logic to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Toshiba	47	101	114.9	31.1
2	1	SANYO	56	50	-10.7	15.4
3	3	Philips	40	47	17.5	14.5
4	8	Sony	8	33	312.5	10.2
5	4	Motorola	16	25	56.3	7.7
6	6	NEC	10	21	110.0	6.5
7	5	Rohm	15	20	33.3	6.2
8	7	Advanced Micro Devices	9	8	-11.1	2.5
9	9	Samsung	7	8	14.3	2.5
10	12	Texas Instruments	0	7	NA	2.2
11	11	Sharp	2	2	0	0.6
12	18	Matsushita	0	2	NA	0.6
13	10	Hitachi	2	1	-50.0	0.3
		All Others	-	-	NA	0
		Americas Companies	25	40	60.0	12.3
		Japanese Companies	140	230	64.3	70.8
		European Companies	40	47	17.5	14.5
		Asia/Pacific Companies	7	8	14.3	2.5
		Included Companies Total	**212**	**325**	**53.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-19
Top 24 Worldwide Vendors' Revenue from Shipments of Analog-Monolithic to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Toshiba	133	175	31.6	14.6
2	8	Texas Instruments	51	127	149.0	10.6
3	3	SANYO	91	117	28.6	9.7
4	2	Motorola	94	110	17.0	9.2
5	4	Philips	91	110	20.9	9.2
6	5	Samsung	74	106	43.2	8.8
7	7	National Semiconductor	67	86	28.4	7.2
8	6	SGS-Thomson	71	78	9.9	6.5
9	11	Rohm	33	54	63.6	4.5
10	10	Sony	44	38	-13.6	3.2
11	12	Matsushita	22	26	18.2	2.2
12	19	Siemens	7	25	257.1	2.1
13	14	Hitachi	15	22	46.7	1.8
14	22	Korean Electronic Co.	3	22	633.3	1.8
15	9	NEC	46	20	-56.5	1.7
16	13	Mitsubishi	16	18	12.5	1.5
17	15	Winbond Electronics	13	16	23.1	1.3
18	18	Advanced Micro Devices	7	15	114.3	1.2
19	17	LG Semicon	8	12	50.0	1.0
20	21	Lucent Technologies	5	10	100.0	0.8
21	20	Fujitsu	5	7	40.0	0.6
22	23	Hyundai	1	3	200.0	0.2
23	32	Sanken	0	3	NA	0.2
24	16	Sharp	8	1	-87.5	0
		All Others	-	-	NA	0
		Americas Companies	224	348	55.4	29.0
		Japanese Companies	413	481	16.5	40.0
		European Companies	169	213	26.0	17.7
		Asia/Pacific Companies	99	159	60.6	13.2
		Included Companies Total	**905**	**1,201**	**32.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-20
Top 17 Worldwide Vendors' Revenue from Shipments of Discrete Semiconductors to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Toshiba	95	131	37.9	16.1
2	3	Motorola	81	89	9.9	10.9
3	2	Philips	85	86	1.2	10.6
4	4	Samsung	56	71	26.8	8.7
5	7	Rohm	43	71	65.1	8.7
6	6	SGS-Thomson	49	56	14.3	6.9
7	5	NEC	52	52	0	6.4
8	9	SANYO	35	52	48.6	6.4
9	8	Korean Electronic Co.	36	50	38.9	6.1
10	10	Hitachi	28	48	71.4	5.9
11	11	Sanken	27	31	14.8	3.8
12	12	Matsushita	19	25	31.6	3.1
13	15	Siemens	9	21	133.3	2.6
14	14	Mitsubishi	14	18	28.6	2.2
15	13	National Semiconductor	14	7	-50.0	0.9
16	17	Sony	3	4	33.3	0.5
17	16	Fujitsu	5	2	-60.0	0.2
		All Others	-	-	NA	0
		Americas Companies	95	96	1.1	11.8
		Japanese Companies	321	434	35.2	53.3
		European Companies	143	163	14.0	20.0
		Asia/Pacific Companies	92	121	31.5	14.9
		Included Companies Total	**651**	**814**	**25.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-21
Top 13 Worldwide Vendors' Revenue from Shipments of Optical Semiconductors to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Rohm	40	60	50.0	33.3
2	2	Sharp	25	22	-12.0	12.2
3	13	Lucent Technologies	3	20	566.7	11.1
4	3	Toshiba	17	19	11.8	10.6
5	7	NEC	6	14	133.3	7.8
6	4	Siemens	14	11	-21.4	6.1
7	11	SANYO	4	8	100.0	4.4
8	10	Mitsubishi	5	7	40.0	3.9
9	9	Hitachi	5	6	20.0	3.3
10	8	Motorola	5	5	0	2.8
11	6	Matsushita	10	3	-70.0	1.7
12	12	Korean Electronic Co.	4	3	-25.0	1.7
13	5	Sony	14	2	-85.7	1.1
		All Others	-	-	NA	0
		Americas Companies	8	25	212.5	13.9
		Japanese Companies	126	141	11.9	78.3
		European Companies	14	11	-21.4	6.1
		Asia/Pacific Companies	4	3	-25.0	1.7
		Included Companies Total	**152**	**180**	**18.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Chapter 5
Singapore Market Statistics Tables

Table 5-1
Top 30 Worldwide Vendors' Revenue from Shipments of Total Semiconductors to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	1,134	1,437	26.7	16.6
2	2	Texas Instruments	779	989	27.0	11.4
3	5	Motorola	519	608	17.1	7.0
4	3	SGS-Thomson	564	542	-3.9	6.3
5	4	Toshiba	554	510	-7.9	5.9
6	7	NEC	451	498	10.4	5.8
7	6	Samsung	505	482	-4.6	5.6
8	10	Philips	267	338	26.6	3.9
9	8	Hitachi	314	322	2.5	3.7
10	17	Rohm	153	302	97.4	3.5
11	9	Mitsubishi	310	277	-10.6	3.2
12	11	Hyundai	267	244	-8.6	2.8
13	12	SANYO	235	211	-10.2	2.4
14	15	National Semiconductor	156	199	27.6	2.3
15	19	Siemens	141	193	36.9	2.2
16	20	Lucent Technologies	135	175	29.6	2.0
17	13	LG Semicon	222	170	-23.4	2.0
18	16	Fujitsu	156	149	-4.5	1.7
19	14	IBM	161	142	-11.8	1.6
20	18	Sharp	153	136	-11.1	1.6
21	22	Cirrus Logic	97	126	29.9	1.5
22	25	Sony	65	121	86.2	1.4
23	21	Matsushita	122	103	-15.6	1.2
24	253	Vanguard	0	87	NA	1.0
25	26	Advanced Micro Devices	52	85	63.5	1.0
26	23	Atmel	74	84	13.5	1.0
27	27	Korean Electronic Co.	37	41	10.8	0.5
28	24	Sanken	68	34	-50.0	0.4
29	116	S3	0	32	NA	0.4
30	29	United Microelectronics Corp.	21	10	-52.4	0.1
		All Others	38	9	-76.3	0.1
		Americas Companies	3,107	3,877	24.8	44.8
		Japanese Companies	2,581	2,663	3.2	30.8
		European Companies	972	1,073	10.4	12.4
		Asia/Pacific Companies	1,090	1,043	-4.3	12.0
		Included Companies Total	**7,750**	**8,656**	**11.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 5-2
Top 30 Worldwide Vendors' Revenue from Shipments of Total Integrated Circuits to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	1,134	1,437	26.7	18.6
2	2	Texas Instruments	779	989	27.0	12.8
3	3	SGS-Thomson	546	512	-6.2	6.6
4	5	Motorola	428	508	18.7	6.6
5	7	NEC	372	455	22.3	5.9
6	4	Samsung	463	429	-7.3	5.6
7	6	Toshiba	404	354	-12.4	4.6
8	12	Philips	216	291	34.7	3.8
9	8	Mitsubishi	298	265	-11.1	3.4
10	9	Hitachi	272	249	-8.5	3.2
11	10	Hyundai	267	244	-8.6	3.2
12	16	National Semiconductor	142	192	35.2	2.5
13	18	Siemens	123	180	46.3	2.3
14	17	Lucent Technologies	132	175	32.6	2.3
15	13	SANYO	189	172	-9.0	2.2
16	11	LG Semicon	222	170	-23.4	2.2
17	15	Fujitsu	147	143	-2.7	1.9
18	14	IBM	161	142	-11.8	1.8
19	23	Rohm	54	134	148.1	1.7
20	20	Cirrus Logic	97	126	29.9	1.6
21	24	Sony	53	106	100.0	1.4
22	30	Vanguard	0	87	NA	1.1
23	25	Advanced Micro Devices	52	85	63.5	1.1
24	22	Atmel	74	84	13.5	1.1
25	21	Matsushita	84	71	-15.5	0.9
26	19	Sharp	105	57	-45.7	0.7
27	32	S3	0	32	NA	0.4
28	27	United Microelectronics Corp.	21	10	-52.4	0.1
29	28	Winbond Electronics	6	6	0	0
30	29	Korean Electronic Co.	4	4	0	0
		All Others	32	7	-78.1	0
		Americas Companies	2,999	3,770	25.7	48.9
		Japanese Companies	1,978	2,010	1.6	26.0
		European Companies	885	983	11.1	12.7
		Asia/Pacific Companies	1,015	953	-6.1	12.4
		Included Companies Total	**6,877**	**7,716**	**12.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-3
Top 10 Worldwide Vendors' Revenue from Shipments of Bipolar Digital to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Hitachi	17	20	17.6	30.3
2	2	Texas Instruments	14	12	-14.3	18.2
3	3	Motorola	13	12	-7.7	18.2
4	25	Matsushita	0	11	NA	16.7
5	6	Philips	5	5	0	7.6
6	32	Mosel Vitelic	0	3	NA	4.5
7	5	Toshiba	8	1	-87.5	1.5
8	7	LG Semicon	1	1	0	1.5
9	8	Advanced Micro Devices	1	1	0	1.5
10	4	National Semiconductor	13	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	41	25	-39.0	37.9
		Japanese Companies	25	32	28.0	48.5
		European Companies	5	5	0	7.6
		Asia/Pacific Companies	1	4	300.0	6.1
		Included Companies Total	**72**	**66**	**-8.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-4
Top 30 Worldwide Vendors' Revenue from Shipments of MOS Digital ICs to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	1,134	1,437	26.7	25.9
2	3	Texas Instruments	409	543	32.8	9.8
3	2	Samsung	447	403	-9.8	7.3
4	5	Motorola	306	362	18.3	6.5
5	4	NEC	332	360	8.4	6.5
6	6	Hyundai	267	244	-8.6	4.4
7	8	Mitsubishi	225	200	-11.1	3.6
8	7	Toshiba	250	195	-22.0	3.5
9	13	Lucent Technologies	119	175	47.1	3.2
10	14	Siemens	118	170	44.1	3.1
11	9	LG Semicon	221	169	-23.5	3.1
12	10	Hitachi	214	166	-22.4	3.0
13	11	IBM	161	142	-11.8	2.6
14	12	Fujitsu	142	139	-2.1	2.5
15	19	Philips	55	96	74.5	1.7
16	20	SGS-Thomson	52	95	82.7	1.7
17	29	Vanguard	0	87	NA	1.6
18	18	Atmel	74	84	13.5	1.5
19	15	SANYO	117	81	-30.8	1.5
20	21	Advanced Micro Devices	43	67	55.8	1.2
21	24	Sony	38	63	65.8	1.1
22	26	Rohm	28	54	92.9	1.0
23	17	Sharp	93	50	-46.2	0.9
24	23	National Semiconductor	41	50	22.0	0.9
25	16	Cirrus Logic	94	45	-52.1	0.8
26	30	S3	0	32	NA	0.6
27	22	Matsushita	42	16	-61.9	0.3
28	27	United Microelectronics Corp.	21	10	-52.4	0.2
29	28	Winbond Electronics	5	5	0	0
30	25	Mosel Vitelic	32	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	2,381	2,937	23.4	53.0
		Japanese Companies	1,481	1,324	-10.6	23.9
		European Companies	225	361	60.4	6.5
		Asia/Pacific Companies	993	918	-7.6	16.6
		Included Companies Total	**5,080**	**5,540**	**9.1**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 5-5
Top 27 Worldwide Vendors' Revenue from Shipments of MOS Memory to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	414	326	-21.3	17.0
2	2	Hyundai	267	244	-8.6	12.7
3	8	Siemens	113	158	39.8	8.2
4	3	LG Semicon	213	154	-27.7	8.0
5	7	NEC	136	142	4.4	7.4
6	4	Mitsubishi	158	135	-14.6	7.0
7	6	Texas Instruments	142	117	-17.6	6.1
8	9	Fujitsu	103	110	6.8	5.7
9	28	Vanguard	0	87	NA	4.5
10	11	Atmel	70	76	8.6	4.0
11	5	Hitachi	149	72	-51.7	3.7
12	12	Intel	53	60	13.2	3.1
13	10	Toshiba	102	44	-56.9	2.3
14	15	SGS-Thomson	35	44	25.7	2.3
15	14	Sharp	41	41	0	2.1
16	13	SANYO	48	27	-43.8	1.4
17	18	IBM	17	27	58.8	1.4
18	19	Advanced Micro Devices	16	19	18.8	1.0
19	21	Sony	10	14	40.0	0.7
20	17	Motorola	31	12	-61.3	0.6
21	23	Rohm	5	4	-20.0	0.2
22	24	Matsushita	2	4	100.0	0.2
23	25	Winbond Electronics	2	2	0	0.1
24	20	United Microelectronics Corp.	12	1	-91.7	0
25	27	Philips	0	1	NA	0
26	16	Mosel Vitelic	32	0	-100.0	0
27	22	National Semiconductor	9	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	338	311	-8.0	16.2
		Japanese Companies	754	593	-21.4	30.9
		European Companies	148	203	37.2	10.6
		Asia/Pacific Companies	940	814	-13.4	42.4
		Included Companies Total	**2,180**	**1,921**	**-11.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-6
Top 17 Worldwide Vendors' Revenue from Shipments of DRAM to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	310	265	-14.5	18.3
2	2	Hyundai	249	233	-6.4	16.1
3	8	Siemens	113	158	39.8	10.9
4	3	LG Semicon	203	146	-28.1	10.1
5	7	NEC	122	124	1.6	8.6
6	6	Mitsubishi	131	115	-12.2	8.0
7	5	Texas Instruments	137	114	-16.8	7.9
8	17	Vanguard	0	87	NA	6.0
9	10	Fujitsu	61	72	18.0	5.0
10	4	Hitachi	143	65	-54.5	4.5
11	11	SANYO	30	24	-20.0	1.7
12	9	Toshiba	70	17	-75.7	1.2
13	13	IBM	17	12	-29.4	0.8
14	14	Motorola	6	7	16.7	0.5
15	15	Matsushita	2	4	100.0	0.3
16	16	Sharp	1	3	200.0	0.2
17	12	Mosel Vitelic	29	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	160	133	-16.9	9.2
		Japanese Companies	560	424	-24.3	29.3
		European Companies	113	158	39.8	10.9
		Asia/Pacific Companies	791	731	-7.6	50.6
		Included Companies Total	**1,624**	**1,446**	**-11.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-7
Top 18 Worldwide Vendors' Revenue from Shipments of SRAM to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	83	47	-43.4	29.6
2	2	Toshiba	25	22	-12.0	13.8
3	21	IBM	0	15	NA	9.4
4	8	Sony	10	14	40.0	8.8
5	4	Hyundai	18	11	-38.9	6.9
6	5	Mitsubishi	18	11	-38.9	6.9
7	7	LG Semicon	10	8	-20.0	5.0
8	10	NEC	8	8	0	5.0
9	11	Sharp	6	6	0	3.8
10	3	Motorola	25	5	-80.0	3.1
11	12	Hitachi	3	5	66.7	3.1
12	6	SANYO	17	2	-88.2	1.3
13	15	Winbond Electronics	2	2	0	1.3
14	9	United Microelectronics Corp.	10	1	-90.0	0.6
15	14	Rohm	2	1	-50.0	0.6
16	16	Fujitsu	1	1	0	0.6
17	13	Mosel Vitelic	3	0	-100.0	0
18	17	SGS-Thomson	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	25	20	-20.0	12.6
		Japanese Companies	90	70	-22.2	44.0
		European Companies	1	-	-100.0	0
		Asia/Pacific Companies	126	69	-45.2	43.4
		Included Companies Total	**242**	**159**	**-34.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 5-8
Top 16 Worldwide Vendors' Revenue from Shipments of Nonvolatile Memory to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Atmel	70	76	8.6	24.4
2	2	Intel	53	60	13.2	19.3
3	5	SGS-Thomson	34	43	26.5	13.8
4	3	Fujitsu	41	37	-9.8	11.9
5	4	Sharp	34	32	-5.9	10.3
6	7	Advanced Micro Devices	16	19	18.8	6.1
7	6	Samsung	21	14	-33.3	4.5
8	8	Mitsubishi	9	9	0	2.9
9	12	NEC	3	7	133.3	2.3
10	10	Toshiba	7	5	-28.6	1.6
11	11	Texas Instruments	5	3	-40.0	1.0
12	14	Rohm	3	3	0	1.0
13	13	Hitachi	3	2	-33.3	0.6
14	16	SANYO	1	1	0	0.3
15	9	National Semiconductor	9	0	-100.0	0
16	15	United Microelectronics Corp.	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	153	158	3.3	50.8
		Japanese Companies	101	96	-5.0	30.9
		European Companies	34	43	26.5	13.8
		Asia/Pacific Companies	23	14	-39.1	4.5
		Included Companies Total	**311**	**311**	**0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-9
Top 27 Worldwide Vendors' Revenue from Shipments of MOS Microcomponents to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	1,081	1,377	27.4	50.4
2	2	Motorola	238	299	25.6	10.9
3	3	Texas Instruments	149	222	49.0	8.1
4	5	NEC	106	138	30.2	5.1
5	7	Toshiba	89	111	24.7	4.1
6	4	IBM	117	89	-23.9	3.3
7	9	Hitachi	46	84	82.6	3.1
8	8	Mitsubishi	62	58	-6.5	2.1
9	11	National Semiconductor	27	50	85.2	1.8
10	6	Cirrus Logic	94	45	-52.1	1.6
11	12	Samsung	21	41	95.2	1.5
12	16	Advanced Micro Devices	15	37	146.7	1.4
13	30	S3	0	32	NA	1.2
14	13	Philips	20	30	50.0	1.1
15	10	Lucent Technologies	45	20	-55.6	0.7
16	20	SGS-Thomson	6	20	233.3	0.7
17	21	Sony	6	15	150.0	0.5
18	17	SANYO	15	12	-20.0	0.4
19	22	Siemens	5	12	140.0	0.4
20	23	LG Semicon	3	10	233.3	0.4
21	19	United Microelectronics Corp.	9	9	0	0.3
22	18	Matsushita	14	8	-42.9	0.3
23	14	Fujitsu	16	5	-68.8	0.2
24	15	Sharp	16	5	-68.8	0.2
25	25	Winbond Electronics	1	2	100.0	0
26	26	Atmel	0	1	NA	0
27	24	Rohm	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	1,766	2,172	23.0	79.5
		Japanese Companies	372	436	17.2	16.0
		European Companies	31	62	100.0	2.3
		Asia/Pacific Companies	34	62	82.4	2.3
		Included Companies Total	**2,203**	**2,732**	**24.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-10
Top 10 Worldwide Vendors' Revenue from Shipments of Microprocessors to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	944	1,234	30.7	82.5
2	3	Motorola	59	101	71.2	6.8
3	2	IBM	114	86	-24.6	5.7
4	4	Advanced Micro Devices	13	31	138.5	2.1
5	7	NEC	3	17	466.7	1.1
6	8	National Semiconductor	2	14	600.0	0.9
7	5	Toshiba	10	11	10.0	0.7
8	9	Mitsubishi	1	1	0	0
9	10	SGS-Thomson	1	1	0	0
10	6	Texas Instruments	5	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	1,137	1,466	28.9	98.0
		Japanese Companies	14	29	107.1	1.9
		European Companies	1	1	0	0
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**1,152**	**1,496**	**29.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-11
Top 21 Worldwide Vendors' Revenue from Shipments of Microcontrollers to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Motorola	175	184	5.1	28.9
2	2	NEC	94	101	7.4	15.9
3	4	Mitsubishi	57	54	-5.3	8.5
4	3	Toshiba	59	51	-13.6	8.0
5	6	Hitachi	30	48	60.0	7.5
6	7	Samsung	20	41	105.0	6.4
7	5	Intel	40	39	-2.5	6.1
8	8	Philips	20	26	30.0	4.1
9	16	SGS-Thomson	4	18	350.0	2.8
10	14	Sony	6	15	150.0	2.4
11	10	SANYO	15	12	-20.0	1.9
12	15	Siemens	5	12	140.0	1.9
13	11	Texas Instruments	14	11	-21.4	1.7
14	18	LG Semicon	2	6	200.0	0.9
15	9	Sharp	16	5	-68.8	0.8
16	17	National Semiconductor	3	4	33.3	0.6
17	12	Matsushita	9	3	-66.7	0.5
18	13	Fujitsu	7	3	-57.1	0.5
19	21	Advanced Micro Devices	0	2	NA	0.3
20	27	Atmel	0	1	NA	0.2
21	19	Rohm	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	232	241	3.9	37.9
		Japanese Companies	295	292	-1.0	45.9
		European Companies	29	56	93.1	8.8
		Asia/Pacific Companies	22	47	113.6	7.4
		Included Companies Total	**578**	**636**	**10.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 5-12
Top 17 Worldwide Vendors' Revenue from Shipments of Microperipherals to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	97	104	7.2	30.4
2	2	Cirrus Logic	94	45	-52.1	13.2
3	5	Hitachi	16	35	118.8	10.2
4	3	Texas Instruments	22	32	45.5	9.4
5	4	National Semiconductor	22	32	45.5	9.4
6	26	S3	0	32	NA	9.4
7	6	Toshiba	15	22	46.7	6.4
8	8	NEC	8	12	50.0	3.5
9	7	United Microelectronics Corp.	9	9	0	2.6
10	12	Advanced Micro Devices	2	4	100.0	1.2
11	15	LG Semicon	1	4	300.0	1.2
12	10	Mitsubishi	4	3	-25.0	0.9
13	11	Matsushita	3	3	0	0.9
14	9	Fujitsu	6	2	-66.7	0.6
15	16	Winbond Electronics	1	2	100.0	0.6
16	14	SGS-Thomson	1	1	0	0.3
17	13	Samsung	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	237	249	5.1	72.8
		Japanese Companies	52	77	48.1	22.5
		European Companies	1	1	0	0.3
		Asia/Pacific Companies	12	15	25.0	4.4
		Included Companies Total	**302**	**342**	**13.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-13
Top 10 Worldwide Vendors' Revenue from Shipments of Digital Signal Processors to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Texas Instruments	108	179	65.7	69.4
2	3	Toshiba	5	27	440.0	10.5
3	2	Lucent Technologies	45	20	-55.6	7.8
4	4	Motorola	4	14	250.0	5.4
5	8	NEC	1	8	700.0	3.1
6	21	Philips	0	4	NA	1.6
7	6	IBM	3	3	0	1.2
8	7	Matsushita	2	2	0	0.8
9	11	Hitachi	0	1	NA	0.4
10	5	Fujitsu	3	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	160	216	35.0	83.7
		Japanese Companies	11	38	245.5	14.7
		European Companies	-	4	NA	1.6
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**171**	**258**	**50.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 5-14
Top 22 Worldwide Vendors' Revenue from Shipments of MOS Digital Logic to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Texas Instruments	118	204	72.9	23.0
2	3	Lucent Technologies	74	155	109.5	17.5
3	2	NEC	90	80	-11.1	9.0
4	8	Philips	35	65	85.7	7.3
5	6	Motorola	37	51	37.8	5.7
6	13	Rohm	21	50	138.1	5.6
7	5	SANYO	54	42	-22.2	4.7
8	4	Toshiba	59	40	-32.2	4.5
9	16	Samsung	12	36	200.0	4.1
10	12	Sony	22	34	54.5	3.8
11	17	SGS-Thomson	11	31	181.8	3.5
12	9	IBM	27	26	-3.7	2.9
13	11	Fujitsu	23	24	4.3	2.7
14	15	Advanced Micro Devices	12	11	-8.3	1.2
15	14	Hitachi	19	10	-47.4	1.1
16	20	Mitsubishi	5	7	40.0	0.8
17	21	Atmel	4	7	75.0	0.8
18	19	LG Semicon	5	5	0	0.6
19	7	Sharp	36	4	-88.9	0.5
20	10	Matsushita	26	4	-84.6	0.5
21	22	Winbond Electronics	2	1	-50.0	0.1
22	18	National Semiconductor	5	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	277	454	63.9	51.2
		Japanese Companies	355	295	-16.9	33.3
		European Companies	46	96	108.7	10.8
		Asia/Pacific Companies	19	42	121.1	4.7
		Included Companies Total	**697**	**887**	**27.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-15
Top 20 Worldwide Vendors' Revenue from Shipments of ASICs to Singapore
(Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Lucent Technologies	74	155	109.5	31.4
2	1	Texas Instruments	104	152	46.2	30.8
3	3	NEC	74	51	-31.1	10.3
4	10	SGS-Thomson	10	29	190.0	5.9
5	6	IBM	27	26	-3.7	5.3
6	7	Fujitsu	21	23	9.5	4.7
7	14	Samsung	6	14	133.3	2.8
8	11	Motorola	9	10	11.1	2.0
9	4	Toshiba	33	9	-72.7	1.8
10	13	Advanced Micro Devices	7	6	-14.3	1.2
11	17	Atmel	4	5	25.0	1.0
12	9	SANYO	16	3	-81.3	0.6
13	16	Hitachi	4	3	-25.0	0.6
14	19	Mitsubishi	2	3	50.0	0.6
15	8	Matsushita	18	2	-88.9	0.4
16	15	Sony	4	2	-50.0	0.4
17	18	Philips	2	1	-50.0	0.2
18	5	Sharp	28	0	-100.0	0
19	12	Rohm	7	0	-100.0	0
20	20	Winbond Electronics	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	225	354	57.3	71.7
		Japanese Companies	207	96	-53.6	19.4
		European Companies	12	30	150.0	6.1
		Asia/Pacific Companies	8	14	75.0	2.8
		Included Companies Total	**452**	**494**	**9.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-16
Top Nine Worldwide Vendors' Revenue from Shipments of Custom ICs to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	3	NEC	0	19	NA	30.2
2	19	Rohm	0	13	NA	20.6
3	7	Samsung	0	11	NA	17.5
4	8	Motorola	0	10	NA	15.9
5	16	Sony	0	4	NA	6.3
6	11	Atmel	0	2	NA	3.2
7	15	Matsushita	0	2	NA	3.2
8	9	Toshiba	0	1	NA	1.6
9	20	Winbond Electronics	0	1	NA	1.6
		All Others	-	-	NA	0
		Americas Companies	0	12	NA	19.0
		Japanese Companies	0	39	NA	61.9
		European Companies	0	-	NA	0
		Asia/Pacific Companies	0	12	NA	19.0
		Included Companies Total	**0**	**63**	**NA**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-17
Top 15 Worldwide Vendors' Revenue from Shipments of MOS Standard Logic to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	33	64	93.9	38.6
2	4	Texas Instruments	14	32	128.6	19.3
3	2	Toshiba	26	25	-3.8	15.1
4	3	Motorola	20	19	-5.0	11.4
5	10	Rohm	2	7	250.0	4.2
6	6	Hitachi	7	5	-28.6	3.0
7	8	LG Semicon	5	5	0	3.0
8	7	NEC	6	4	-33.3	2.4
9	13	SGS-Thomson	1	2	100.0	1.2
10	11	Fujitsu	2	1	-50.0	0.6
11	12	Samsung	1	1	0	0.6
12	15	Mitsubishi	1	1	0	0.6
13	5	Matsushita	7	0	-100.0	0
14	9	National Semiconductor	5	0	-100.0	0
15	14	SANYO	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	39	51	30.8	30.7
		Japanese Companies	52	43	-17.3	25.9
		European Companies	34	66	94.1	39.8
		Asia/Pacific Companies	6	6	0	3.6
		Included Companies Total	**131**	**166**	**26.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 5-18
Top 13 Worldwide Vendors' Revenue from Shipments of Total Other MOS Logic to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	SANYO	37	39	5.4	23.8
2	3	Rohm	12	30	150.0	18.3
3	2	Sony	18	28	55.6	17.1
4	13	Texas Instruments	0	20	NA	12.2
5	5	Motorola	8	12	50.0	7.3
6	8	Samsung	5	10	100.0	6.1
7	4	NEC	10	6	-40.0	3.7
8	9	Advanced Micro Devices	5	5	0	3.0
9	14	Toshiba	0	5	NA	3.0
10	7	Sharp	8	4	-50.0	2.4
11	10	Mitsubishi	2	3	50.0	1.8
12	6	Hitachi	8	2	-75.0	1.2
13	11	Matsushita	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	13	37	184.6	22.6
		Japanese Companies	96	117	21.9	71.3
		European Companies	-	-	NA	0
		Asia/Pacific Companies	5	10	100.0	6.1
		Included Companies Total	**114**	**164**	**43.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 5-19
Top 23 Worldwide Vendors' Revenue from Shipments of Analog-Monolithic to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Texas Instruments	356	434	21.9	20.6
2	1	SGS-Thomson	494	417	-15.6	19.8
3	3	Philips	156	190	21.8	9.0
4	4	Toshiba	146	158	8.2	7.5
5	6	National Semiconductor	88	142	61.4	6.7
6	5	Motorola	109	134	22.9	6.4
7	11	NEC	40	95	137.5	4.5
8	8	SANYO	72	91	26.4	4.3
9	21	Cirrus Logic	3	81	2,600.0	3.8
10	12	Rohm	26	80	207.7	3.8
11	7	Mitsubishi	73	65	-11.0	3.1
12	10	Hitachi	41	63	53.7	3.0
13	9	Matsushita	42	44	4.8	2.1
14	14	Sony	15	43	186.7	2.0
15	13	Samsung	16	26	62.5	1.2
16	17	Advanced Micro Devices	8	17	112.5	0.8
17	19	Siemens	5	10	100.0	0.5
18	16	Sharp	12	7	-41.7	0.3
19	18	Fujitsu	5	4	-20.0	0.2
20	20	Korean Electronic Co.	4	4	0	0.2
21	32	Sanken	0	4	NA	0.2
22	22	Winbond Electronics	1	1	0	0
23	15	Lucent Technologies	13	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	577	808	40.0	38.3
		Japanese Companies	472	654	38.6	31.0
		European Companies	655	617	-5.8	29.2
		Asia/Pacific Companies	21	31	47.6	1.5
		Included Companies Total	**1,725**	**2,110**	**22.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 5-20
Top 17 Worldwide Vendors' Revenue from Shipments of Discrete Semiconductors to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	3	Rohm	89	156	75.3	20.7
2	1	Toshiba	115	120	4.3	15.9
3	2	Motorola	89	98	10.1	13.0
4	8	Hitachi	33	64	93.9	8.5
5	6	Samsung	42	53	26.2	7.0
6	5	Philips	48	47	-2.1	6.2
7	10	Korean Electronic Co.	32	36	12.5	4.8
8	11	SANYO	27	34	25.9	4.5
9	7	Sanken	36	30	-16.7	4.0
10	9	Matsushita	32	30	-6.3	4.0
11	12	SGS-Thomson	18	30	66.7	4.0
12	4	NEC	60	27	-55.0	3.6
13	14	Mitsubishi	11	10	-9.1	1.3
14	13	National Semiconductor	14	7	-50.0	0.9
15	15	Siemens	9	5	-44.4	0.7
16	16	Fujitsu	5	5	0	0.7
17	17	Sony	2	1	-50.0	0.1
		All Others	-	-	NA	0
		Americas Companies	103	105	1.9	13.9
		Japanese Companies	410	477	16.3	63.3
		European Companies	75	82	9.3	10.9
		Asia/Pacific Companies	74	89	20.3	11.8
		Included Companies Total	**662**	**753**	**13.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-21
Top 15 Worldwide Vendors' Revenue from Shipments of Optical Semiconductors to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Sharp	48	79	64.6	42.2
2	2	Toshiba	35	36	2.9	19.3
3	3	NEC	19	16	-15.8	8.6
4	8	Sony	6	14	133.3	7.5
5	6	Rohm	6	12	100.0	6.4
6	5	Hitachi	8	9	12.5	4.8
7	4	Siemens	9	8	-11.1	4.3
8	9	SANYO	3	5	66.7	2.7
9	7	Matsushita	6	2	-66.7	1.1
10	11	Motorola	2	2	0	1.1
11	14	Mitsubishi	1	2	100.0	1.1
12	12	Korean Electronic Co.	1	1	0	0.5
13	15	Fujitsu	1	1	0	0.5
14	10	Lucent Technologies	3	0	-100.0	0
15	13	Sanken	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	5	2	-60.0	1.1
		Japanese Companies	134	176	31.3	94.1
		European Companies	9	8	-11.1	4.3
		Asia/Pacific Companies	1	1	0	0.5
		Included Companies Total	**149**	**187**	**25.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Chapter 6
Taiwan Market Statistics Tables

Table 6-1
Top 30 Worldwide Vendors' Revenue from Shipments of Total Semiconductors to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	741	941	27.0	15.8
2	2	Toshiba	422	426	0.9	7.2
3	4	NEC	359	374	4.2	6.3
4	5	Samsung	311	299	-3.9	5.0
5	3	Texas Instruments	374	290	-22.5	4.9
6	7	Philips	252	288	14.3	4.8
7	8	Motorola	247	266	7.7	4.5
8	6	LG Semicon	267	223	-16.5	3.7
9	17	Advanced Micro Devices	127	221	74.0	3.7
10	12	Mitsubishi	180	215	19.4	3.6
11	10	Hitachi	205	209	2.0	3.5
12	22	Lucent Technologies	103	192	86.4	3.2
13	11	Hyundai	184	173	-6.0	2.9
14	14	SGS-Thomson	154	160	3.9	2.7
15	116	S3	0	159	NA	2.7
16	15	Siemens	145	158	9.0	2.7
17	21	Mosel Vitelic	106	157	48.1	2.6
18	9	United Microelectronics Corp.	221	153	-30.8	2.6
19	16	Winbond Electronics	134	130	-3.0	2.2
20	13	Cirrus Logic	156	123	-21.2	2.1
21	23	National Semiconductor	103	116	12.6	1.9
22	20	SANYO	109	109	0	1.8
23	27	Rohm	35	98	180.0	1.6
24	24	Matsushita	70	76	8.6	1.3
25	25	Sharp	51	75	47.1	1.3
26	19	Fujitsu	121	69	-43.0	1.2
27	26	Atmel	48	69	43.8	1.2
28	29	Sony	26	52	100.0	0.9
29	18	IBM	125	50	-60.0	0.8
30	28	Sanken	34	29	-14.7	0.5
		All Others	26	53	103.8	0.9
		Americas Companies	2,024	2,427	19.9	40.8
		Japanese Companies	1,612	1,732	7.4	29.1
		European Companies	551	606	10.0	10.2
		Asia/Pacific Companies	1,249	1,188	-4.9	20.0
		Included Companies Total	**5,436**	**5,953**	**9.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-2
Top 30 Worldwide Vendors' Revenue from Shipments of Total Integrated Circuits to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	741	941	27.0	18.0
2	2	Texas Instruments	374	290	-22.5	5.6
3	4	Toshiba	304	265	-12.8	5.1
4	5	Samsung	276	263	-4.7	5.0
5	7	Philips	225	261	16.0	5.0
6	3	NEC	315	257	-18.4	4.9
7	9	Motorola	211	227	7.6	4.3
8	6	LG Semicon	267	223	-16.5	4.3
9	16	Advanced Micro Devices	127	221	74.0	4.2
10	21	Lucent Technologies	102	192	88.2	3.7
11	12	Mitsubishi	162	189	16.7	3.6
12	10	Hyundai	184	173	-6.0	3.3
13	30	S3	0	159	NA	3.0
14	20	Mosel Vitelic	106	157	48.1	3.0
15	8	United Microelectronics Corp.	221	153	-30.8	2.9
16	14	Siemens	135	144	6.7	2.8
17	11	Hitachi	164	141	-14.0	2.7
18	15	Winbond Electronics	134	130	-3.0	2.5
19	13	Cirrus Logic	156	123	-21.2	2.4
20	18	SGS-Thomson	122	123	0.8	2.4
21	22	National Semiconductor	92	110	19.6	2.1
22	24	Atmel	48	69	43.8	1.3
23	23	SANYO	67	66	-1.5	1.3
24	19	Fujitsu	118	64	-45.8	1.2
25	28	Rohm	18	59	227.8	1.1
26	25	Matsushita	39	55	41.0	1.1
27	26	Sharp	31	52	67.7	1.0
28	17	IBM	125	50	-60.0	1.0
29	27	Sony	22	32	45.5	0.6
30	32	Vanguard	0	25	NA	0.5
		All Others	2	5	150.0	0
		Americas Companies	1,976	2,382	20.5	45.6
		Japanese Companies	1,240	1,183	-4.6	22.7
		European Companies	482	528	9.5	10.1
		Asia/Pacific Companies	1,190	1,126	-5.4	21.6
		Included Companies Total	**4,888**	**5,219**	**6.8**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-3
Top 12 Worldwide Vendors' Revenue from Shipments of Bipolar Digital to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Texas Instruments	11	19	72.7	46.3
2	2	Hitachi	10	12	20.0	29.3
3	4	Philips	2	2	0	4.9
4	5	Motorola	2	2	0	4.9
5	14	NEC	0	2	NA	4.9
6	7	LG Semicon	1	1	0	2.4
7	8	Advanced Micro Devices	1	1	0	2.4
8	9	Mitsubishi	1	1	0	2.4
9	18	Mosel Vitelic	0	1	NA	2.4
10	3	National Semiconductor	6	0	-100.0	0
11	6	Matsushita	2	0	-100.0	0
12	10	Fujitsu	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	20	22	10.0	53.7
		Japanese Companies	14	15	7.1	36.6
		European Companies	2	2	0	4.9
		Asia/Pacific Companies	1	2	100.0	4.9
		Included Companies Total	**37**	**41**	**10.8**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-4
Top 30 Worldwide Vendors' Revenue from Shipments of MOS Digital ICs to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	741	941	27.0	21.0
2	4	NEC	280	234	-16.4	5.2
3	6	Samsung	252	232	-7.9	5.2
4	3	Toshiba	285	230	-19.3	5.1
5	5	LG Semicon	260	215	-17.3	4.8
6	15	Advanced Micro Devices	123	214	74.0	4.8
7	2	Texas Instruments	292	211	-27.7	4.7
8	20	Lucent Technologies	96	192	100.0	4.3
9	8	Hyundai	184	173	-6.0	3.9
10	9	Mitsubishi	148	170	14.9	3.8
11	29	S3	0	159	NA	3.5
12	12	Motorola	138	158	14.5	3.5
13	17	Mosel Vitelic	106	156	47.2	3.5
14	7	United Microelectronics Corp.	221	153	-30.8	3.4
15	13	Siemens	126	133	5.6	3.0
16	10	Cirrus Logic	148	123	-16.9	2.7
17	18	Philips	102	112	9.8	2.5
18	11	Hitachi	140	107	-23.6	2.4
19	19	Winbond Electronics	100	89	-11.0	2.0
20	21	National Semiconductor	63	75	19.0	1.7
21	23	Atmel	48	69	43.8	1.5
22	16	Fujitsu	115	61	-47.0	1.4
23	14	IBM	125	50	-60.0	1.1
24	22	SGS-Thomson	59	48	-18.6	1.1
25	24	Matsushita	34	48	41.2	1.1
26	26	Sharp	29	40	37.9	0.9
27	25	SANYO	31	35	12.9	0.8
28	30	Vanguard	0	25	NA	0.6
29	28	Rohm	6	18	200.0	0.4
30	27	Sony	16	14	-12.5	0.3
		All Others	-	-	NA	0
		Americas Companies	1,774	2,192	23.6	48.9
		Japanese Companies	1,084	957	-11.7	21.3
		European Companies	287	293	2.1	6.5
		Asia/Pacific Companies	1,123	1,043	-7.1	23.3
		Included Companies Total	**4,268**	**4,485**	**5.1**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-5
Top 27 Worldwide Vendors' Revenue from Shipments of MOS Memory to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	LG Semicon	247	196	-20.6	11.1
2	3	Samsung	231	176	-23.8	10.0
3	4	NEC	225	176	-21.8	10.0
4	5	Hyundai	181	171	-5.5	9.7
5	10	Mosel Vitelic	106	156	47.2	8.8
6	8	Mitsubishi	115	133	15.7	7.5
7	7	Siemens	124	131	5.6	7.4
8	2	Texas Instruments	246	120	-51.2	6.8
9	6	Toshiba	180	69	-61.7	3.9
10	13	Winbond Electronics	74	62	-16.2	3.5
11	9	Hitachi	115	61	-47.0	3.5
12	14	Atmel	42	60	42.9	3.4
13	15	Advanced Micro Devices	33	48	45.5	2.7
14	11	Fujitsu	103	46	-55.3	2.6
15	19	Matsushita	22	42	90.9	2.4
16	17	Intel	23	26	13.0	1.5
17	30	Vanguard	0	25	NA	1.4
18	18	SGS-Thomson	23	14	-39.1	0.8
19	12	United Microelectronics Corp.	95	13	-86.3	0.7
20	21	Sharp	16	10	-37.5	0.6
21	22	IBM	14	10	-28.6	0.6
22	20	Motorola	17	9	-47.1	0.5
23	23	Sony	12	4	-66.7	0.2
24	25	Rohm	3	3	0	0.2
25	24	SANYO	4	2	-50.0	0.1
26	29	Philips	0	1	NA	0
27	16	National Semiconductor	25	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	400	273	-31.8	15.5
		Japanese Companies	795	546	-31.3	31.0
		European Companies	147	146	-0.7	8.3
		Asia/Pacific Companies	934	799	-14.5	45.3
		Included Companies Total	**2,276**	**1,764**	**-22.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-6
Top 17 Worldwide Vendors' Revenue from Shipments of DRAM to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	NEC	219	172	-21.5	12.1
2	3	LG Semicon	218	172	-21.1	12.1
3	6	Hyundai	175	166	-5.1	11.7
4	9	Mosel Vitelic	102	155	52.0	10.9
5	4	Samsung	190	149	-21.6	10.5
6	7	Siemens	124	131	5.6	9.2
7	10	Mitsubishi	98	120	22.4	8.5
8	1	Texas Instruments	238	112	-52.9	7.9
9	5	Toshiba	178	65	-63.5	4.6
10	8	Hitachi	105	55	-47.6	3.9
11	12	Matsushita	21	42	100.0	3.0
12	11	Fujitsu	86	35	-59.3	2.5
13	21	Vanguard	0	25	NA	1.8
14	13	IBM	14	10	-28.6	0.7
15	14	Motorola	6	7	16.7	0.5
16	15	Sharp	5	1	-80.0	0
17	16	SANYO	2	1	-50.0	0
		All Others	-	-	NA	0
		Americas Companies	258	129	-50.0	9.1
		Japanese Companies	714	491	-31.2	34.6
		European Companies	124	131	5.6	9.2
		Asia/Pacific Companies	685	667	-2.6	47.0
		Included Companies Total	**1,781**	**1,418**	**-20.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-7
Top 16 Worldwide Vendors' Revenue from Shipments of SRAM to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Winbond Electronics	67	56	-16.4	40.0
2	3	Samsung	30	21	-30.0	15.0
3	4	LG Semicon	15	13	-13.3	9.3
4	1	United Microelectronics Corp.	85	12	-85.9	8.6
5	5	Mitsubishi	15	12	-20.0	8.6
6	8	Hitachi	8	5	-37.5	3.6
7	9	Hyundai	6	5	-16.7	3.6
8	6	Sony	12	4	-66.7	2.9
9	10	NEC	5	4	-20.0	2.9
10	12	Toshiba	2	3	50.0	2.1
11	7	Motorola	11	2	-81.8	1.4
12	13	Rohm	2	2	0	1.4
13	11	Mosel Vitelic	4	1	-75.0	0.7
14	14	Matsushita	1	0	-100.0	0
15	15	Fujitsu	1	0	-100.0	0
16	16	SANYO	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	11	2	-81.8	1.4
		Japanese Companies	47	30	-36.2	21.4
		European Companies	-	-	NA	0
		Asia/Pacific Companies	207	108	-47.8	77.1
		Included Companies Total	**265**	**140**	**-47.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-8
Top 18 Worldwide Vendors' Revenue from Shipments of Nonvolatile Memory to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Atmel	42	60	42.9	29.7
2	2	Advanced Micro Devices	33	48	45.5	23.8
3	4	Intel	23	26	13.0	12.9
4	5	SGS-Thomson	22	12	-45.5	5.9
5	6	Fujitsu	16	11	-31.3	5.4
6	7	LG Semicon	14	11	-21.4	5.4
7	9	Sharp	11	9	-18.2	4.5
8	11	Texas Instruments	8	8	0	4.0
9	8	Samsung	11	6	-45.5	3.0
10	12	Winbond Electronics	7	6	-14.3	3.0
11	10	United Microelectronics Corp.	10	1	-90.0	0.5
12	13	Hitachi	2	1	-50.0	0.5
13	16	Rohm	1	1	0	0.5
14	17	SANYO	1	1	0	0.5
15	20	Toshiba	0	1	NA	0.5
16	3	National Semiconductor	25	0	-100.0	0
17	14	Mitsubishi	1	0	-100.0	0
18	15	NEC	1	0	-100.0	0
		All Others	[illegible]	[illegible]	NA	0
		Americas Companies	131	142	8.4	70.3
		Japanese Companies	33	24	-27.3	11.9
		European Companies	22	12	-45.5	5.9
		Asia/Pacific Companies	42	24	-42.9	11.9
		Included Companies Total	**228**	**202**	**-11.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-9
Top 27 Worldwide Vendors' Revenue from Shipments of MOS Microcomponents to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	718	915	27.4	41.4
2	30	S3	0	159	NA	7.2
3	6	Advanced Micro Devices	68	146	114.7	6.6
4	3	United Microelectronics Corp.	126	140	11.1	6.3
5	2	Cirrus Logic	148	123	-16.9	5.6
6	4	Motorola	100	113	13.0	5.1
7	7	Toshiba	57	104	82.5	4.7
8	9	Lucent Technologies	38	90	136.8	4.1
9	12	National Semiconductor	27	74	174.1	3.3
10	8	Philips	55	52	-5.5	2.4
11	13	Texas Instruments	24	48	100.0	2.2
12	15	Hitachi	20	43	115.0	1.9
13	11	Mitsubishi	31	35	12.9	1.6
14	20	Samsung	7	31	342.9	1.4
15	5	IBM	87	30	-65.5	1.4
16	14	Winbond Electronics	24	26	8.3	1.2
17	10	NEC	32	23	-28.1	1.0
18	17	LG Semicon	10	16	60.0	0.7
19	18	SANYO	8	13	62.5	0.6
20	16	SGS-Thomson	11	10	-9.1	0.5
21	19	Fujitsu	7	7	0	0.3
22	23	Sharp	3	4	33.3	0.2
23	22	Atmel	3	3	0	0.1
24	21	Matsushita	5	2	-60.0	0
25	25	Siemens	2	2	0	0
26	26	Hyundai	1	1	0	0
27	24	Sony	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	1,213	1,701	40.2	77.0
		Japanese Companies	165	231	40.0	10.5
		European Companies	68	64	-5.9	2.9
		Asia/Pacific Companies	168	214	27.4	9.7
		Included Companies Total	**1,614**	**2,210**	**36.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-10
Top 11 Worldwide Vendors' Revenue from Shipments of Microprocessors to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	685	881	28.6	79.0
2	3	Advanced Micro Devices	52	107	105.8	9.6
3	4	Motorola	35	58	65.7	5.2
4	7	National Semiconductor	3	31	933.3	2.8
5	2	IBM	85	28	-67.1	2.5
6	5	Toshiba	4	5	25.0	0.4
7	6	Fujitsu	4	2	-50.0	0.2
8	11	SGS-Thomson	1	2	100.0	0.2
9	9	NEC	2	1	-50.0	0
10	8	Texas Instruments	2	0	-100.0	0
11	10	LG Semicon	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	862	1,105	28.2	99.1
		Japanese Companies	10	8	-20.0	0.7
		European Companies	1	2	100.0	0.2
		Asia/Pacific Companies	2	-	-100.0	0
		Included Companies Total	**875**	**1,115**	**27.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-11
Top 22 Worldwide Vendors' Revenue from Shipments of Microcontrollers to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Motorola	55	50	-9.1	14.7
2	2	Toshiba	37	45	21.6	13.3
3	3	Philips	32	41	28.1	12.1
4	8	Hitachi	16	33	106.3	9.7
5	11	Samsung	7	31	342.9	9.1
6	4	Mitsubishi	21	27	28.6	8.0
7	5	United Microelectronics Corp.	20	21	5.0	6.2
8	7	Intel	17	16	-5.9	4.7
9	6	NEC	18	13	-27.8	3.8
10	10	SANYO	8	13	62.5	3.8
11	9	Winbond Electronics	10	10	0	2.9
12	22	Advanced Micro Devices	0	9	NA	2.7
13	12	LG Semicon	5	8	60.0	2.4
14	13	SGS-Thomson	3	4	33.3	1.2
15	14	Sharp	3	4	33.3	1.2
16	20	Fujitsu	1	4	300.0	1.2
17	15	Atmel	3	3	0	0.9
18	16	National Semiconductor	2	3	50.0	0.9
19	18	Siemens	2	2	0	0.6
20	17	Matsushita	2	1	-50.0	0.3
21	21	Texas Instruments	1	1	0	0.3
22	19	Sony	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	78	82	5.1	24.2
		Japanese Companies	108	140	29.6	41.3
		European Companies	37	47	27.0	13.9
		Asia/Pacific Companies	42	70	66.7	20.6
		Included Companies Total	**265**	**339**	**27.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-12
Top 19 Worldwide Vendors' Revenue from Shipments of Microperipherals to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	26	S3	0	159	NA	27.4
2	1	Cirrus Logic	148	123	-16.9	21.2
3	2	United Microelectronics Corp.	106	119	12.3	20.5
4	4	National Semiconductor	22	40	81.8	6.9
5	7	Advanced Micro Devices	16	30	87.5	5.2
6	5	Toshiba	16	25	56.3	4.3
7	6	Intel	16	18	12.5	3.1
8	8	Winbond Electronics	14	16	14.3	2.8
9	13	Hitachi	4	10	150.0	1.7
10	10	Mitsubishi	10	8	-20.0	1.4
11	14	LG Semicon	3	8	166.7	1.4
12	11	NEC	10	7	-30.0	1.2
13	3	Philips	23	5	-78.3	0.9
14	9	Motorola	10	5	-50.0	0.9
15	12	SGS-Thomson	7	4	-42.9	0.7
16	17	Texas Instruments	1	2	100.0	0.3
17	15	Fujitsu	1	1	0	0.2
18	18	Hyundai	1	1	0	0.2
19	16	Matsushita	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	213	377	77.0	64.9
		Japanese Companies	42	51	21.4	8.8
		European Companies	30	9	-70.0	1.5
		Asia/Pacific Companies	124	144	16.1	24.8
		Included Companies Total	**409**	**581**	**42.1**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-13
Top Eight Worldwide Vendors' Revenue from Shipments of Digital Signal Processors to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Lucent Technologies	38	90	136.8	51.4
2	2	Texas Instruments	20	45	125.0	25.7
3	12	Toshiba	0	29	NA	16.6
4	18	Philips	0	6	NA	3.4
5	3	NEC	2	2	0	1.1
6	5	IBM	2	2	0	1.1
7	4	Matsushita	2	1	-50.0	0.6
8	6	Fujitsu	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	60	137	128.3	78.3
		Japanese Companies	5	32	540.0	18.3
		European Companies	-	6	NA	3.4
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**65**	**175**	**169.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-14
Top 23 Worldwide Vendors' Revenue from Shipments of MOS Digital Logic to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Lucent Technologies	58	102	75.9	20.0
2	3	Philips	47	59	25.5	11.5
3	2	Toshiba	48	57	18.8	11.2
4	7	Texas Instruments	22	43	95.5	8.4
5	9	Motorola	21	36	71.4	7.0
6	6	NEC	23	35	52.2	6.8
7	13	Sharp	10	26	160.0	5.1
8	11	Samsung	14	25	78.6	4.9
9	4	SGS-Thomson	25	24	-4.0	4.7
10	8	Advanced Micro Devices	22	20	-9.1	3.9
11	10	SANYO	19	20	5.3	3.9
12	19	Rohm	3	15	400.0	2.9
13	5	IBM	24	10	-58.3	2.0
14	23	Sony	2	10	400.0	2.0
15	15	Fujitsu	5	8	60.0	1.6
16	18	Atmel	3	6	100.0	1.2
17	14	Matsushita	7	4	-42.9	0.8
18	16	Hitachi	5	3	-40.0	0.6
19	17	LG Semicon	3	3	0	0.6
20	21	Mitsubishi	2	2	0	0.4
21	12	National Semiconductor	11	1	-90.9	0.2
22	20	Winbond Electronics	2	1	-50.0	0.2
23	22	Hyundai	2	1	-50.0	0.2
		All Others	-	-	NA	0
		Americas Companies	161	218	35.4	42.7
		Japanese Companies	124	180	45.2	35.2
		European Companies	72	83	15.3	16.2
		Asia/Pacific Companies	21	30	42.9	5.9
		Included Companies Total	**378**	**511**	**35.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-15
Top 19 Worldwide Vendors' Revenue from Shipments of ASICs to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Lucent Technologies	58	102	75.9	43.8
2	5	NEC	18	22	22.2	9.4
3	6	Texas Instruments	17	20	17.6	8.6
4	4	SGS-Thomson	23	18	-21.7	7.7
5	2	Toshiba	31	16	-48.4	6.9
6	3	IBM	24	10	-58.3	4.3
7	8	Advanced Micro Devices	9	8	-11.1	3.4
8	11	Fujitsu	5	8	60.0	3.4
9	10	Motorola	6	7	16.7	3.0
10	9	Samsung	7	5	-28.6	2.1
11	7	Sharp	10	4	-60.0	1.7
12	12	Matsushita	5	4	-20.0	1.7
13	14	Atmel	3	4	33.3	1.7
14	13	Hitachi	5	3	-40.0	1.3
15	17	Hyundai	2	1	-50.0	0.4
16	19	National Semiconductor	1	1	0	0.4
17	15	Rohm	2	0	-100.0	0
18	16	Winbond Electronics	2	0	-100.0	0
19	18	Sony	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	118	152	28.8	65.2
		Japanese Companies	77	57	-26.0	24.5
		European Companies	23	18	-21.7	7.7
		Asia/Pacific Companies	11	6	-45.5	2.6
		Included Companies Total	**229**	**233**	**1.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-16
Top Nine Worldwide Vendors' Revenue from Shipments of Custom ICs to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	11	Sharp	0	18	NA	34.6
2	9	Motorola	0	10	NA	19.2
3	10	Samsung	0	9	NA	17.3
4	17	Rohm	0	5	NA	9.6
5	2	NEC	0	3	NA	5.8
6	5	Toshiba	0	3	NA	5.8
7	13	Atmel	0	2	NA	3.8
8	18	Winbond Electronics	0	1	NA	1.9
9	19	Sony	0	1	NA	1.9
		All Others	-	-	NA	0
		Americas Companies	0	12	NA	23.1
		Japanese Companies	0	30	NA	57.7
		European Companies	0	-	NA	0
		Asia/Pacific Companies	0	10	NA	19.2
		Included Companies Total	**0**	**52**	**NA**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-17
Top 10 Worldwide Vendors' Revenue from Shipments of MOS Standard Logic to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	4	Texas Instruments	5	20	300.0	30.3
2	1	Toshiba	16	18	12.5	27.3
3	5	Philips	5	9	80.0	13.6
4	3	Motorola	7	7	0	10.6
5	8	SGS-Thomson	2	6	200.0	9.1
6	6	LG Semicon	3	3	0	4.5
7	7	Samsung	2	2	0	3.0
8	12	NEC	0	1	NA	1.5
9	2	National Semiconductor	10	0	-100.0	0
10	9	Matsushita	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	22	27	22.7	40.9
		Japanese Companies	18	19	5.6	28.8
		European Companies	7	15	114.3	22.7
		Asia/Pacific Companies	5	5	0	7.6
		Included Companies Total	**52**	**66**	**26.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-18
Top 12 Worldwide Vendors' Revenue from Shipments of Total Other MOS Logic to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	42	50	19.0	31.3
2	2	SANYO	19	20	5.3	12.5
3	8	Toshiba	1	20	1,900.0	12.5
4	3	Advanced Micro Devices	13	12	-7.7	7.5
5	4	Motorola	8	12	50.0	7.5
6	9	Rohm	1	10	900.0	6.3
7	5	Samsung	5	9	80.0	5.6
8	6	NEC	5	9	80.0	5.6
9	10	Sony	1	9	800.0	5.6
10	16	Sharp	0	4	NA	2.5
11	11	Texas Instruments	0	3	NA	1.9
12	7	Mitsubishi	2	2	0	1.3
		All Others	-	-	NA	0
		Americas Companies	21	27	28.6	16.9
		Japanese Companies	29	74	155.2	46.3
		European Companies	42	50	19.0	31.3
		Asia/Pacific Companies	5	9	80.0	5.6
		Included Companies Total	**97**	**160**	**64.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-19
Top 24 Worldwide Vendors' Revenue from Shipments of Analog-Monolithic to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	121	147	21.5	21.2
2	4	SGS-Thomson	63	75	19.0	10.8
3	2	Motorola	71	67	-5.6	9.7
4	3	Texas Instruments	71	60	-15.5	8.7
5	7	Winbond Electronics	34	41	20.6	5.9
6	13	Rohm	12	41	241.7	5.9
7	9	National Semiconductor	23	35	52.2	5.1
8	10	Toshiba	19	35	84.2	5.1
9	5	SANYO	36	31	-13.9	4.5
10	8	Samsung	24	31	29.2	4.5
11	11	Hitachi	14	22	57.1	3.2
12	6	NEC	35	21	-40.0	3.0
13	12	Mitsubishi	13	18	38.5	2.6
14	16	Sony	6	18	200.0	2.6
15	21	Sharp	2	12	500.0	1.7
16	14	Siemens	9	11	22.2	1.6
17	17	LG Semicon	6	7	16.7	1.0
18	20	Matsushita	3	7	133.3	1.0
19	19	Advanced Micro Devices	3	6	100.0	0.9
20	22	Fujitsu	2	3	50.0	0.4
21	32	Sanken	0	3	NA	0.4
22	23	Korean Electronic Co.	2	2	0	0.3
23	15	Cirrus Logic	8	0	-100.0	0
24	18	Lucent Technologies	6	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	182	168	-7.7	24.2
		Japanese Companies	142	211	48.6	30.4
		European Companies	193	233	20.7	33.6
		Asia/Pacific Companies	66	81	22.7	11.7
		Included Companies Total	**583**	**693**	**18.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-20
Top 17 Worldwide Vendors' Revenue from Shipments of Discrete Semiconductors to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Toshiba	104	140	34.6	24.3
2	2	NEC	36	60	66.7	10.4
3	6	Hitachi	33	60	81.8	10.4
4	4	SANYO	34	38	11.8	6.6
5	7	SGS-Thomson	32	37	15.6	6.4
6	3	Samsung	35	36	2.9	6.2
7	5	Motorola	33	36	9.1	6.2
8	12	Rohm	15	33	120.0	5.7
9	8	Philips	25	27	8.0	4.7
10	10	Sanken	21	26	23.8	4.5
11	9	Korean Electronic Co.	22	24	9.1	4.2
12	13	Mitsubishi	15	21	40.0	3.6
13	11	Matsushita	19	18	-5.3	3.1
14	15	Siemens	5	8	60.0	1.4
15	14	National Semiconductor	11	6	-45.5	1.0
16	16	Fujitsu	2	5	150.0	0.9
17	17	Sony	1	2	100.0	0.3
		All Others	-	-	NA	0
		Americas Companies	44	42	-4.5	7.3
		Japanese Companies	280	403	43.9	69.8
		European Companies	62	72	16.1	12.5
		Asia/Pacific Companies	57	60	5.3	10.4
		Included Companies Total	**443**	**577**	**30.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-21
Top 14 Worldwide Vendors' Revenue from Shipments of Optical Semiconductors to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	4	NEC	8	57	612.5	36.3
2	1	Sharp	20	23	15.0	14.6
3	2	Toshiba	14	21	50.0	13.4
4	11	Sony	2	18	800.0	11.5
5	5	Hitachi	6	8	33.3	5.1
6	6	Siemens	5	6	20.0	3.8
7	12	Rohm	1	6	500.0	3.8
8	7	SANYO	4	5	25.0	3.2
9	9	Mitsubishi	3	5	66.7	3.2
10	3	Matsushita	12	3	-75.0	1.9
11	8	Motorola	3	3	0	1.9
12	10	Korean Electronic Co.	2	2	0	1.3
13	13	Fujitsu	1	0	-100.0	0
14	14	Lucent Technologies	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	4	3	-25.0	1.9
		Japanese Companies	71	146	105.6	93.0
		European Companies	5	6	20.0	3.8
		Asia/Pacific Companies	2	2	0	1.3
		Included Companies Total	**82**	**157**	**91.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Chapter 7
Other Asian Countries Market Statistics Tables

Table 7-1
Top 30 Worldwide Vendors' Revenue from Shipments of Total Semiconductors to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	363	456	25.6	18.3
2	9	Motorola	96	195	103.1	7.8
3	3	Philips	289	191	-33.9	7.7
4	2	Hitachi	315	165	-47.6	6.6
5	6	SANYO	172	137	-20.3	5.5
6	20	Fujitsu	38	137	260.5	5.5
7	4	Texas Instruments	213	132	-38.0	5.3
8	5	Matsushita	172	120	-30.2	4.8
9	7	Samsung	107	116	8.4	4.7
10	16	Rohm	64	96	50.0	3.9
11	10	United Microelectronics Corp.	94	91	-3.2	3.7
12	11	Winbond Electronics	92	88	-4.3	3.5
13	18	National Semiconductor	54	74	37.0	3.0
14	8	SGS-Thomson	102	58	-43.1	2.3
15	23	Lucent Technologies	23	50	117.4	2.0
16	14	LG Semicon	86	49	-43.0	2.0
17	21	Sharp	32	48	50.0	1.9
18	24	Sony	21	41	95.2	1.6
19	13	Toshiba	90	38	-57.8	1.5
20	19	Siemens	44	33	-25.0	1.3
21	27	Cirrus Logic	15	31	106.7	1.2
22	22	Hyundai	31	30	-3.2	1.2
23	12	Mitsubishi	91	29	-68.1	1.2
24	253	Vanguard	0	20	NA	0.8
25	116	S3	0	18	NA	0.7
26	26	NEC	18	16	-11.1	0.6
27	28	Korean Electronic Co.	6	8	33.3	0.3
28	25	IBM	18	7	-61.1	0.3
29	15	Mosel Vitelic	77	4	-94.8	0.2
30	17	Sanken	60	4	-93.3	0.2
		All Others	2	5	150.0	0.2
		Americas Companies	784	968	23.5	38.9
		Japanese Companies	1,073	831	-22.6	33.4
		European Companies	435	282	-35.2	11.3
		Asia/Pacific Companies	493	406	-17.6	16.3
		Included Companies Total*	**2,785**	**2,487**	**-10.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-2
Top 30 Worldwide Vendors' Revenue from Shipments of Total Integrated Circuits to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	363	456	25.6	21.3
2	15	Motorola	57	152	166.7	7.1
3	2	Philips	249	150	-39.8	7.0
4	18	Fujitsu	36	135	275.0	6.3
5	4	Texas Instruments	210	132	-37.1	6.2
6	5	SANYO	116	112	-3.4	5.2
7	3	Hitachi	218	98	-55.0	4.6
8	7	Samsung	98	98	0	4.6
9	8	United Microelectronics Corp.	94	91	-3.2	4.2
10	9	Winbond Electronics	92	88	-4.3	4.1
11	6	Matsushita	108	69	-36.1	3.2
12	16	National Semiconductor	41	68	65.9	3.2
13	17	Rohm	37	57	54.1	2.7
14	10	SGS-Thomson	89	52	-41.6	2.4
15	22	Lucent Technologies	22	50	127.3	2.3
16	11	LG Semicon	86	49	-43.0	2.3
17	21	Sharp	25	43	72.0	2.0
18	25	Sony	15	40	166.7	1.9
19	26	Cirrus Logic	15	31	106.7	1.4
20	20	Hyundai	31	30	-3.2	1.4
21	14	Toshiba	72	28	-61.1	1.3
22	13	Mitsubishi	74	22	-70.3	1.0
23	19	Siemens	36	21	-41.7	1.0
24	28	Vanguard	0	20	NA	0.9
25	29	S3	0	18	NA	0.8
26	23	NEC	18	16	-11.1	0.7
27	24	IBM	18	7	-61.1	0.3
28	12	Mosel Vitelic	77	4	-94.8	0.2
29	27	Advanced Micro Devices	2	3	50.0	0.1
30	32	Atmel	0	2	NA	0
		All Others	-	2	NA	0
		Americas Companies	728	919	26.2	42.9
		Japanese Companies	719	621	-13.6	29.0
		European Companies	374	223	-40.4	10.4
		Asia/Pacific Companies	478	381	-20.3	17.8
		Included Companies Total	**2,299**	**2,144**	**-6.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-3
Top Eight Worldwide Vendors' Revenue from Shipments of Bipolar Digital to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	3	Motorola	6	5	-16.7	23.8
2	5	Texas Instruments	2	4	100.0	19.0
3	28	Mosel Vitelic	0	4	NA	19.0
4	2	Hitachi	7	3	-57.1	14.3
5	4	Philips	2	3	50.0	14.3
6	1	National Semiconductor	9	1	-88.9	4.8
7	8	Fujitsu	0	1	NA	4.8
8	6	Toshiba	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	17	10	-41.2	47.6
		Japanese Companies	9	4	-55.6	19.0
		European Companies	2	3	50.0	14.3
		Asia/Pacific Companies	-	4	NA	19.0
		Included Companies Total	**28**	**21**	**-25.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-4
Top 30 Worldwide Vendors' Revenue from Shipments of MOS Digital ICs to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	363	456	25.6	26.2
2	15	Fujitsu	35	133	280.0	7.6
3	2	Philips	232	129	-44.4	7.4
4	12	Motorola	47	98	108.5	5.6
5	6	United Microelectronics Corp.	94	91	-3.2	5.2
6	3	Hitachi	203	88	-56.7	5.1
7	7	Winbond Electronics	91	86	-5.5	4.9
8	5	Samsung	94	83	-11.7	4.8
9	4	Texas Instruments	133	61	-54.1	3.5
10	16	National Semiconductor	32	61	90.6	3.5
11	21	Lucent Technologies	19	50	163.2	2.9
12	8	LG Semicon	86	49	-43.0	2.8
13	13	SANYO	44	40	-9.1	2.3
14	20	Sharp	21	40	90.5	2.3
15	24	Sony	12	37	208.3	2.1
16	27	Cirrus Logic	1	31	3,000.0	1.8
17	17	Hyundai	31	30	-3.2	1.7
18	18	Rohm	23	30	30.4	1.7
19	14	Matsushita	43	27	-37.2	1.5
20	11	Toshiba	61	24	-60.7	1.4
21	10	Mitsubishi	68	21	-69.1	1.2
22	28	Vanguard	0	20	NA	1.1
23	29	S3	0	18	NA	1.0
24	23	NEC	17	15	-11.8	0.9
25	19	SGS-Thomson	21	10	-52.4	0.6
26	22	IBM	18	7	-61.1	0.4
27	25	Siemens	4	3	-25.0	0.2
28	26	Advanced Micro Devices	2	2	0	0.1
29	30	Atmel	0	2	NA	0.1
30	9	Mosel Vitelic	77	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	615	786	27.8	45.1
		Japanese Companies	527	455	-13.7	26.1
		European Companies	257	142	-44.7	8.2
		Asia/Pacific Companies	473	359	-24.1	20.6
		Included Companies Total	**1,872**	**1,742**	**-6.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-5
Top 23 Worldwide Vendors' Revenue from Shipments of MOS Memory to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	12	Fujitsu	14	105	650.0	21.3
2	6	Intel	58	64	10.3	13.0
3	3	Samsung	77	51	-33.8	10.4
4	7	Winbond Electronics	53	44	-17.0	8.9
5	1	Hitachi	142	42	-70.4	8.5
6	5	LG Semicon	71	32	-54.9	6.5
7	9	Hyundai	29	29	0	5.9
8	14	Motorola	11	20	81.8	4.1
9	27	Vanguard	0	20	NA	4.1
10	2	Texas Instruments	94	19	-79.8	3.9
11	8	Mitsubishi	53	18	-66.0	3.7
12	17	Sharp	7	17	142.9	3.5
13	13	NEC	13	9	-30.8	1.8
14	10	Toshiba	29	6	-79.3	1.2
15	16	SGS-Thomson	8	6	-25.0	1.2
16	18	Matsushita	4	4	0	0.8
17	11	United Microelectronics Corp.	17	2	-88.2	0.4
18	21	SANYO	1	2	100.0	0.4
19	15	IBM	10	1	-90.0	0.2
20	22	Philips	0	1	NA	0.2
21	4	Mosel Vitelic	77	0	-100.0	0
22	19	Sony	3	0	-100.0	0
23	20	Siemens	3	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	173	104	-39.9	21.1
		Japanese Companies	266	203	-23.7	41.3
		European Companies	11	7	-36.4	1.4
		Asia/Pacific Companies	324	178	-45.1	36.2
		Included Companies Total	**774**	**492**	**-36.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-6
Top 16 Worldwide Vendors' Revenue from Shipments of DRAM to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	11	Fujitsu	6	65	983.3	22.0
2	5	Samsung	64	51	-20.3	17.3
3	1	Hitachi	105	31	-70.5	10.5
4	4	LG Semicon	68	30	-55.9	10.2
5	7	Hyundai	28	28	0	9.5
6	17	Vanguard	0	20	NA	6.8
7	10	Motorola	8	19	137.5	6.4
8	2	Texas Instruments	92	16	-82.6	5.4
9	6	Mitsubishi	50	16	-68.0	5.4
10	9	NEC	13	9	-30.8	3.1
11	12	Matsushita	4	4	0	1.4
12	8	Toshiba	17	3	-82.4	1.0
13	21	SANYO	0	2	NA	0.7
14	13	IBM	3	1	-66.7	0.3
15	3	Mosel Vitelic	76	0	-100.0	0
16	14	Siemens	3	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	103	36	-65.0	12.2
		Japanese Companies	195	130	-33.3	44.1
		European Companies	3	-	-100.0	0
		Asia/Pacific Companies	236	129	-45.3	43.7
		Included Companies Total	**537**	**295**	**-45.1**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-7
Top 13 Worldwide Vendors' Revenue from Shipments of SRAM to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Winbond Electronics	50	42	-16.0	70.0
2	2	Hitachi	32	10	-68.8	16.7
3	3	United Microelectronics Corp.	15	2	-86.7	3.3
4	4	Toshiba	8	2	-75.0	3.3
5	6	Sharp	7	1	-85.7	1.7
6	9	Motorola	2	1	-50.0	1.7
7	11	Fujitsu	1	1	0	1.7
8	12	Hyundai	1	1	0	1.7
9	5	IBM	7	0	-100.0	0
10	7	Samsung	3	0	-100.0	0
11	8	Sony	3	0	-100.0	0
12	10	Mitsubishi	2	0	-100.0	0
13	13	Mosel Vitelic	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	9	1	-88.9	1.7
		Japanese Companies	53	14	-73.6	23.3
		European Companies	-	-	NA	0
		Asia/Pacific Companies	70	45	-35.7	75.0
		Included Companies Total	**132**	**60**	**-54.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-8
Top 13 Worldwide Vendors' Revenue from Shipments of Nonvolatile Memory to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	58	64	10.3	47.1
2	3	Fujitsu	7	39	457.1	28.7
3	13	Sharp	0	16	NA	11.8
4	4	SGS-Thomson	7	6	-14.3	4.4
5	10	Texas Instruments	2	3	50.0	2.2
6	7	Winbond Electronics	3	2	-33.3	1.5
7	8	LG Semicon	3	2	-33.3	1.5
8	11	Mitsubishi	1	2	100.0	1.5
9	5	Hitachi	5	1	-80.0	0.7
10	6	Toshiba	4	1	-75.0	0.7
11	2	Samsung	10	0	-100.0	0
12	9	United Microelectronics Corp.	2	0	-100.0	0
13	12	SANYO	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	60	67	11.7	49.3
		Japanese Companies	18	59	227.8	43.4
		European Companies	7	6	-14.3	4.4
		Asia/Pacific Companies	18	4	-77.8	2.9
		Included Companies Total	**103**	**136**	**32.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-9
Top 26 Worldwide Vendors' Revenue from Shipments of MOS Microcomponents to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	305	392	28.5	43.9
2	3	United Microelectronics Corp.	77	89	15.6	10.0
3	6	Motorola	32	60	87.5	6.7
4	7	National Semiconductor	29	58	100.0	6.5
5	2	Philips	170	53	-68.8	5.9
6	4	Winbond Electronics	38	42	10.5	4.7
7	5	Hitachi	33	31	-6.1	3.5
8	23	Cirrus Logic	1	31	3,000.0	3.5
9	8	Texas Instruments	20	25	25.0	2.8
10	15	Lucent Technologies	8	20	150.0	2.2
11	29	S3	0	18	NA	2.0
12	10	Matsushita	13	13	0	1.5
13	12	Fujitsu	11	12	9.1	1.3
14	19	Samsung	3	9	200.0	1.0
15	16	Sharp	6	7	16.7	0.8
16	11	Toshiba	12	6	-50.0	0.7
17	13	SGS-Thomson	10	4	-60.0	0.4
18	9	Mitsubishi	15	3	-80.0	0.3
19	14	SANYO	10	3	-70.0	0.3
20	17	Rohm	5	3	-40.0	0.3
21	18	IBM	4	3	-25.0	0.3
22	21	NEC	2	3	50.0	0.3
23	22	Siemens	1	3	200.0	0.3
24	20	Sony	3	2	-33.3	0.2
25	24	Advanced Micro Devices	1	1	0	0.1
26	25	LG Semicon	0	1	NA	0.1
		All Others	-	-	NA	0
		Americas Companies	400	608	52.0	68.2
		Japanese Companies	110	83	-24.5	9.3
		European Companies	181	60	-66.9	6.7
		Asia/Pacific Companies	118	141	19.5	15.8
		Included Companies Total	**809**	**892**	**10.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-10
Top Five Worldwide Vendors' Revenue from Shipments of Microprocessors to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	235	317	34.9	88.3
2	3	National Semiconductor	6	23	283.3	6.4
3	2	Motorola	9	15	66.7	4.2
4	4	IBM	4	3	-25.0	0.8
5	10	Texas Instruments	0	1	NA	0.3
		All Others	-	-	NA	0
		Americas Companies	254	359	41.3	100.0
		Japanese Companies	-	-	NA	0
		European Companies	-	-	NA	0
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**254**	**359**	**41.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-11
Top 17 Worldwide Vendors' Revenue from Shipments of Microcontrollers to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Motorola	20	42	110.0	38.5
2	12	Samsung	3	9	200.0	8.3
3	9	Philips	5	8	60.0	7.3
4	8	Sharp	6	7	16.7	6.4
5	7	Matsushita	6	6	0	5.5
6	6	Fujitsu	7	5	-28.6	4.6
7	10	Hitachi	4	5	25.0	4.6
8	5	SGS-Thomson	8	4	-50.0	3.7
9	2	Mitsubishi	14	3	-78.6	2.8
10	3	SANYO	10	3	-70.0	2.8
11	4	Toshiba	8	3	-62.5	2.8
12	11	Texas Instruments	3	3	0	2.8
13	15	NEC	2	3	50.0	2.8
14	16	Siemens	1	3	200.0	2.8
15	13	Sony	3	2	-33.3	1.8
16	14	Intel	2	2	0	1.8
17	26	LG Semicon	0	1	NA	0.9
		All Others	[illegible]	[illegible]	NA	0
		Americas Companies	25	47	88.0	43.1
		Japanese Companies	60	37	-38.3	33.9
		European Companies	14	15	7.1	13.8
		Asia/Pacific Companies	3	10	233.3	9.2
		Included Companies Total	**102**	**109**	**6.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-12
Top 17 Worldwide Vendors' Revenue from Shipments of Microperipherals to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	United Microelectronics Corp.	77	89	15.6	23.9
2	3	Intel	68	73	7.4	19.6
3	4	Winbond Electronics	38	42	10.5	11.3
4	1	Philips	165	38	-77.0	10.2
5	6	National Semiconductor	23	35	52.2	9.4
6	15	Cirrus Logic	1	31	3,000.0	8.3
7	5	Hitachi	28	25	-10.7	6.7
8	26	S3	0	18	NA	4.8
9	7	Texas Instruments	5	6	20.0	1.6
10	11	Matsushita	3	5	66.7	1.3
11	8	Rohm	5	3	-40.0	0.8
12	9	Fujitsu	4	3	-25.0	0.8
13	10	Motorola	3	3	0	0.8
14	12	Toshiba	3	1	-66.7	0.3
15	16	Advanced Micro Devices	1	1	0	0.3
16	13	SGS-Thomson	2	0	-100.0	0
17	14	Mitsubishi	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	101	167	65.3	44.8
		Japanese Companies	44	37	-15.9	9.9
		European Companies	167	38	-77.2	10.2
		Asia/Pacific Companies	115	131	13.9	35.1
		Included Companies Total	**427**	**373**	**-12.6**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-13
Top Seven Worldwide Vendors' Revenue from Shipments of Digital Signal Processors to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Lucent Technologies	8	20	150.0	39.2
2	1	Texas Instruments	12	15	25.0	29.4
3	9	Philips	0	7	NA	13.7
4	14	Fujitsu	0	4	NA	7.8
5	3	Matsushita	4	2	-50.0	3.9
6	5	Toshiba	1	2	100.0	3.9
7	4	Hitachi	1	1	0	2.0
		All Others	-	-	NA	0
		Americas Companies	20	35	75.0	68.6
		Japanese Companies	6	9	50.0	17.6
		European Companies	-	7	NA	13.7
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**26**	**51**	**96.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-14
Top 21 Worldwide Vendors' Revenue from Shipments of MOS Digital Logic to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	62	75	21.0	20.9
2	2	SANYO	33	35	6.1	9.8
3	13	Sony	6	35	483.3	9.8
4	10	Lucent Technologies	11	30	172.7	8.4
5	7	Rohm	18	27	50.0	7.5
6	9	Samsung	14	23	64.3	6.4
7	14	Motorola	4	18	350.0	5.0
8	6	Texas Instruments	19	17	-10.5	4.7
9	8	LG Semicon	15	16	6.7	4.5
10	11	Fujitsu	10	16	60.0	4.5
11	12	Sharp	8	16	100.0	4.5
12	3	Hitachi	28	15	-46.4	4.2
13	5	Toshiba	20	12	-40.0	3.4
14	4	Matsushita	26	10	-61.5	2.8
15	15	IBM	4	3	-25.0	0.8
16	16	National Semiconductor	3	3	0	0.8
17	18	NEC	2	3	50.0	0.8
18	30	Atmel	0	2	NA	0.6
19	19	Hyundai	2	1	-50.0	0.3
20	20	Advanced Micro Devices	1	1	0	0.3
21	17	SGS-Thomson	3	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	42	74	76.2	20.7
		Japanese Companies	151	169	11.9	47.2
		European Companies	65	75	15.4	20.9
		Asia/Pacific Companies	31	40	29.0	11.2
		Included Companies Total	**289**	**358**	**23.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-15
Top 18 Worldwide Vendors' Revenue from Shipments of ASICs to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	4	Lucent Technologies	11	30	172.7	28.0
2	3	LG Semicon	15	16	6.7	15.0
3	6	Fujitsu	10	16	60.0	15.0
4	1	Hitachi	20	13	-35.0	12.1
5	5	Samsung	10	8	-20.0	7.5
6	2	Matsushita	16	7	-56.3	6.5
7	11	Motorola	4	5	25.0	4.7
8	12	IBM	4	3	-25.0	2.8
9	9	Sharp	7	2	-71.4	1.9
10	16	National Semiconductor	2	2	0	1.9
11	17	NEC	2	2	0	1.9
12	10	Toshiba	5	1	-80.0	0.9
13	13	SANYO	3	1	-66.7	0.9
14	18	Hyundai	2	1	-50.0	0.9
15	7	Rohm	8	0	-100.0	0
16	8	Texas Instruments	7	0	-100.0	0
17	14	SGS-Thomson	3	0	-100.0	0
18	15	Sony	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	28	40	42.9	37.4
		Japanese Companies	73	42	-42.5	39.3
		European Companies	3	-	-100.0	0
		Asia/Pacific Companies	27	25	-7.4	23.4
		Included Companies Total	**131**	**107**	**-18.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-16
Top Seven Worldwide Vendors' Revenue from Shipments of Custom ICs to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	9	Sharp	0	14	NA	28.6
2	7	Motorola	0	12	NA	24.5
3	15	Rohm	0	9	NA	18.4
4	5	Samsung	0	8	NA	16.3
5	6	Matsushita	0	3	NA	6.1
6	20	Atmel	0	2	NA	4.1
7	11	NEC	0	1	NA	2.0
		All Others	-	-	NA	0
		Americas Companies	0	14	NA	28.6
		Japanese Companies	0	27	NA	55.1
		European Companies	0	-	NA	0
		Asia/Pacific Companies	0	8	NA	16.3
		Included Companies Total	**0**	**49**	**NA**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-17
Top Six Worldwide Vendors' Revenue from Shipments of MOS Standard Logic to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Texas Instruments	12	17	41.7	53.1
2	2	Toshiba	11	8	-27.3	25.0
3	4	Philips	3	6	100.0	18.8
4	17	National Semiconductor	0	1	NA	3.1
5	3	Matsushita	8	0	-100.0	0
6	5	SANYO	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	12	18	50.0	56.3
		Japanese Companies	20	8	-60.0	25.0
		European Companies	3	6	100.0	18.8
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**35**	**32**	**-8.6**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-18
Top 12 Worldwide Vendors' Revenue from Shipments of Total Other MOS Logic to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	59	69	16.9	40.6
2	7	Sony	4	35	775.0	20.6
3	2	SANYO	29	34	17.2	20.0
4	3	Rohm	10	18	80.0	10.6
5	6	Samsung	4	7	75.0	4.1
6	5	Toshiba	4	3	-25.0	1.8
7	4	Hitachi	8	2	-75.0	1.2
8	11	Advanced Micro Devices	1	1	0	0.6
9	13	Motorola	0	1	NA	0.6
10	8	Matsushita	2	0	-100.0	0
11	9	National Semiconductor	1	0	-100.0	0
12	10	Sharp	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	2	2	0	1.2
		Japanese Companies	58	92	58.6	54.1
		European Companies	59	69	16.9	40.6
		Asia/Pacific Companies	4	7	75.0	4.1
		Included Companies Total	**123**	**170**	**38.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-19
Top 23 Worldwide Vendors' Revenue from Shipments of Analog-Monolithic to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	SANYO	72	72	0	18.9
2	1	Texas Instruments	75	67	-10.7	17.6
3	13	Motorola	4	49	1,125.0	12.9
4	3	SGS-Thomson	68	42	-38.2	11.0
5	4	Matsushita	65	42	-35.4	11.0
6	7	Rohm	14	27	92.9	7.1
7	5	Siemens	32	18	-43.8	4.7
8	6	Philips	15	18	20.0	4.7
9	12	Samsung	4	15	275.0	3.9
10	10	Hitachi	8	7	-12.5	1.8
11	21	National Semiconductor	0	6	NA	1.6
12	9	Toshiba	9	4	-55.6	1.0
13	14	Sharp	4	3	-25.0	0.8
14	15	Sony	3	3	0	0.8
15	19	Winbond Electronics	1	2	100.0	0.5
16	11	Mitsubishi	6	1	-83.3	0.3
17	17	NEC	1	1	0	0.3
18	18	Fujitsu	1	1	0	0.3
19	20	Advanced Micro Devices	0	1	NA	0.3
20	31	Korean Electronic Co.	0	1	NA	0.3
21	32	Sanken	0	1	NA	0.3
22	8	Cirrus Logic	14	0	-100.0	0
23	16	Lucent Technologies	3	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	96	123	28.1	32.3
		Japanese Companies	183	162	-11.5	42.5
		European Companies	115	78	-32.2	20.5
		Asia/Pacific Companies	5	18	260.0	4.7
		Included Companies Total	**399**	**381**	**-4.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-20
Top 16 Worldwide Vendors' Revenue from Shipments of Discrete Semiconductors to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Hitachi	94	65	-30.9	21.8
2	2	Matsushita	51	49	-3.9	16.4
3	3	Philips	40	41	2.5	13.8
4	4	Motorola	38	41	7.9	13.8
5	7	Rohm	18	28	55.6	9.4
6	6	SANYO	20	21	5.0	7.0
7	12	Samsung	9	18	100.0	6.0
8	8	SGS-Thomson	13	6	-53.8	2.0
9	9	National Semiconductor	13	6	-53.8	2.0
10	14	Korean Electronic Co.	4	6	50.0	2.0
11	10	Toshiba	11	5	-54.5	1.7
12	13	Siemens	5	5	0	1.7
13	11	Mitsubishi	11	3	-72.7	1.0
14	5	Sanken	32	2	-93.8	0.7
15	16	Fujitsu	1	2	100.0	0.7
16	15	Texas Instruments	3	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	54	47	-13.0	15.8
		Japanese Companies	238	175	-26.5	58.7
		European Companies	58	52	-10.3	17.4
		Asia/Pacific Companies	13	24	84.6	8.1
		Included Companies Total	**363**	**298**	**-17.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-21
Top 13 Worldwide Vendors' Revenue from Shipments of Optical Semiconductors to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Rohm	7	11	57.1	24.4
2	6	Siemens	3	7	133.3	15.6
3	3	Toshiba	7	5	-28.6	11.1
4	4	Sharp	7	5	-28.6	11.1
5	5	Mitsubishi	6	4	-33.3	8.9
6	8	SANYO	2	4	100.0	8.9
7	1	Matsushita	13	2	-84.6	4.4
8	10	Hitachi	1	2	100.0	4.4
9	11	Motorola	1	2	100.0	4.4
10	7	Sony	3	1	-66.7	2.2
11	9	Korean Electronic Co.	2	1	-50.0	2.2
12	12	Sanken	1	1	0	2.2
13	13	Lucent Technologies	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	2	2	0	4.4
		Japanese Companies	47	35	-25.5	77.8
		European Companies	3	7	133.3	15.6
		Asia/Pacific Companies	2	1	-50.0	2.2
		Included Companies Total	**54**	**45**	**-16.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Asia/Pacific MOS Memory Forecast: Spring 1998

Market Statistics

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Program: Semiconductors Asia/Pacific
Product Code: SEMI-AP-MS-9802
Publication Date: June 8, 1998
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Asia/Pacific MOS Memory Forecast: Spring 1998

Market Statistics

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Chapter 1
The Asia/Pacific MOS Memory Forecast

This Market Statistics report details Dataquest's forecast of six segments of the Asia/Pacific MOS memory market: DRAM, SRAM, EPROM, EEPROM, flash memory, and ROM. For each segment, Dataquest forecasts revenue, units shipped, average selling price, megabytes shipped, and price per megabyte.

Asia/Pacific MOS memory revenue should total U.S.$6.6 billion for 1998, a 1 percent increase from 1997 revenue of $6.5 billion. By the second half of 1999, Dataquest expects to see a successful return to a normal market. Although much of the profit has evaporated in SRAM and flash memory, Dataquest still expects that 1998 will be a profitable year in these two segments. On the other hand, 1998 is likely to be the least-profitable year in DRAM since 1992.

Dataquest sees a long-term growth in most segments, including DRAM, SRAM, flash, and EEPROM, but negative performance in the EPROM and ROM markets. Asia/Pacific memory revenue should grow at a compound annual growth rate (CAGR) of 14 percent from 1997 to 2002, with Asia/Pacific revenue reaching $16.6 billion in 2001 and retreating to about $12.5 billion in 2002.

Forecast Highlights and Assumptions

The following top-level assumptions guide Dataquest's forecast. The baseline assumptions associated with the six memory product forecasts appear in the sections that discuss those forecasts. This assessment highlights changes in assumptions since the previous forecast.

Dataquest's Asia/Pacific memory forecast assumes the following:

- The DRAM market will remain volatile. The DRAM revenue forecast could swing widely for both the near term and long term because of DRAM price fluctuations. DRAM bit consumption continues in line with Dataquest's prior projections. This means that unit demand should be strong, although pricing might remain weak. As indicated, the semiconductor forecast assumes a cyclical upturn in 2001. The DRAM market peak in 2001, however, has been moderated to match similar historical peaks.
- DRAM prices continue to hug a cost-based price curve that indicates low pricing. The cost-based price stifles the prospect for DRAM revenue growth. Dataquest expects this to remain the case through 1998 and into 1999. These prices are limited on the high side by DRAM oversupply, and on the low side by antidumping regulations.
- The effects of the current Asian financial crisis on DRAM prices will be "self-regulating" in that a temporary 1998 price downturn should shift market share to lower-cost producers, after which these low-cost suppliers' capacity will be utilized and DRAM prices will recover slightly.

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- The current overcapacity will continue through 1999 and into 2000. Capital expenditure did not slow in 1997 as Dataquest had originally anticipated. To reflect the impact, the DRAM market revenue peak originally expected for 2000 has been pushed out by one year to 2001. (Some manufacturing capacity may eventually exit the DRAM market. However, this is not predicted in the current forecast.)
- The SRAM market is still oversubscribed. However, the analog-to-digital conversion of the cellular phones has increased SRAM usage dramatically in these phones. There is a big difference between this market and the PC market, the last big SRAM stronghold. Cellular phone manufacturers are much more selective about their supplier base, as they use parts from top-tier suppliers and shy away from small fabless companies. Dataquest still expects to see attrition in this market because many companies that thrived on an open market for PC cache chips will shortly be excluded from this previously highly penetrable market, and will not be able to participate in the cellular telephone market.
- In the nonvolatile memory market, there is a continuing slow conversion from EPROM toward flash memory. Most of this conversion is happening in new designs, and is, therefore, occurring at the higher densities. The flash memory market has moved from high profitability toward more competitive pricing as many competitors join the fold; however, unit growth remains strong. This new lower pricing has acted to enable the use of flash memory in a diverse array of new applications. Mask ROM has moved away from the "growth hump" that was characteristic of the game-cartridge boom and is back on the less dramatic pregame growth trend.
- There will be a continued, substantial growth in the relatively small EEPROM market fueled by this technology's use in everything from electronic commerce to microcontroller-based systems, including smart cards. New applications include universal serial bus (USB) interfaces for the PC. The conversion of DRAM modules from SIMMs to DIMMs will also help, as each new DIMMs will contain one EEPROM to identify the attributes of the module.

The following summarizes memory product outlook:

- The Asia/Pacific DRAM market should decrease by about 1 percent in 1998 and total $4.6 billion. By 2002, the Asia/Pacific DRAM market will total $8.5 billion, which marks a 12.9 percent CAGR from 1997 to 2002.
- The Asia/Pacific SRAM market will grow by 4.4 percent in 1998 and total $626 million. In the long term, the Asia/Pacific SRAM market will total $1,680 million, which means a 22.9 percent CAGR from 1997 to 2002.
- The Asia/Pacific flash memory market should increase by 21 percent in 1998 and reach the $731 million level. By 2002, Asia/Pacific flash memory market will total $1,565 million, which is a 21 percent CAGR from 1997 to 2002.
- The Asia/Pacific EEPROM market will increase by 7.6 percent in 1998 and reach the $227 million mark. By 2002, the Asia/Pacific EEPROM market will approach $420 million, nearly 15 percent CAGR from 1997 to 2002.

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- The Asia/Pacific EPROM market should decrease by nearly 26 percent in 1998, declining to $152 million. By 2002, the Asia/Pacific EPROM market will decline to $92 million.
- The Asia/Pacific mask ROM market will decrease by nearly 14 percent in 1998, declining to $176 million. By 2002, the Asia/Pacific mask ROM market will edge upward, however, to the $188 million level.

Project Analyst: Chang Soo Kim

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Chapter 2

Market Statistics Tables

In this chapter, Tables 2-1 to 2-35 present Dataquest's Asia/Pacific MOS memory forecast.

Table 2-1
Asia/Pacific MOS Memory Revenue Forecast, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Dynamic RAM	4,642	4,611	5,690	7,393	13,030	8,500	12.9
Static RAM	599	626	893	1,294	1,520	1,680	22.9
EPROM	205	152	128	112	100	92	-14.8
EEPROM	211	227	251	284	353	420	14.8
Flash Memory	603	731	882	1,073	1,287	1,565	21.0
Mask ROM	205	176	191	199	190	188	-1.7
Other MOS Memory	51	53	65	81	86	82	10.0
Total MOS Memory	**6,516**	**6,576**	**8,100**	**10,436**	**16,566**	**12,527**	**14.0**
Growth (%)	**-18.9**	**0.9**	**23.2**	**28.8**	**58.7**	**-24.4**	**-**

Source: Dataquest (June 1998)

Table 2-2
Asia/Pacific MOS Memory Average Selling Price Forecast, 1997 to 2002 (U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Dynamic RAM	6.05	6.19	8.26	11.30	16.68	11.95	14.6
Static RAM	3.42	4.08	5.33	6.59	7.55	6.99	15.3
EPROM	2.18	1.76	1.62	1.56	1.53	1.53	-6.9
EEPROM	0.72	0.64	0.61	0.60	0.61	0.62	-2.8
Flash Memory	4.67	3.95	4.00	4.14	4.24	4.41	-1.1
Mask ROM	2.82	2.33	2.60	2.65	2.42	2.29	-4.0
Total MOS Memory	**4.22**	**4.08**	**4.90**	**5.98**	**8.19**	**5.87**	**6.8**
Growth (%)	**-39.0**	**-3.5**	**20.1**	**22.0**	**37.1**	**-28.4**	**-6.1**

Source: Dataquest (June 1998)

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Table 2-3
Asia/Pacific MOS Memory Unit Shipment Forecast, 1997 to 2002 (Millions of Units Shipped)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Dynamic RAM	767.0	745.0	689.0	654.0	781.2	711.1	-1.5
Static RAM	174.9	153.3	167.4	196.4	201.4	240.2	6.6
EPROM	94.0	86.4	78.9	71.6	65.3	60.2	-8.5
EEPROM	293.0	354.4	412.0	476.6	582.0	672.9	18.1
Flash Memory	129.1	185.3	220.3	258.9	303.6	354.7	22.4
Mask ROM	72.8	75.6	73.4	75.1	78.5	82.0	2.4
Total MOS Memory	**1,531**	**1,600**	**1,641**	**1,733**	**2,012**	**2,121**	**6.7**
Growth (%)	**32.4**	**4.5**	**2.6**	**5.6**	**16.1**	**5.4**	-

Source: Dataquest (June 1998)

Table 2-4
Asia/Pacific MOS Memory Megabyte Shipment Forecast, 1997 to 2002 (Millions of Megabytes Shipped)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Dynamic RAM	1,205.6	1,943.7	3,035.3	4,694.5	8,984.7	12,729.6	60.2
Static RAM	16.9	23.0	36.9	63.9	93.1	138.5	52.4
EPROM	13.5	13.0	12.5	11.9	11.4	11.0	-4.0
EEPROM	0.4	0.6	0.8	1.1	1.7	2.3	39.9
Flash Memory	74.4	152.1	262.7	431.5	662.5	1,005.6	68.3
Mask ROM	108.9	147.5	180.7	236.8	303.6	370.6	27.8
Total MOS Memory	**1,419.7**	**2,279.9**	**3,528.8**	**5,439.8**	**10,057.0**	**14,257.5**	**58.6**
Growth (%)	**80.1**	**60.6**	**54.8**	**54.2**	**84.9**	**41.8**	-

Source: Dataquest (June 1998)

Table 2-5
Asia/Pacific MOS Memory Price-per-Megabyte Forecast, 1997 to 2002 (U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Dynamic RAM	3.85	2.37	1.87	1.57	1.45	0.67	-29.6
Static RAM	35.53	27.23	24.18	20.24	16.32	12.13	-19.3
EPROM	15.19	11.66	10.24	9.41	8.79	8.38	-11.2
EEPROM	490.61	396.65	324.46	256.46	213.27	182.27	-18.0
Flash Memory	8.11	4.81	3.36	2.49	1.94	1.56	-28.1
Mask ROM	1.88	1.19	1.06	0.84	0.63	0.51	-23.1
Total MOS Memory	**4.55**	**2.86**	**2.28**	**1.90**	**1.64**	**0.87**	**-28.1**
Growth (%)	**-55.1**	**-37.2**	**-20.4**	**-16.4**	**-13.9**	**-46.7**	-

Source: Dataquest (June 1998)

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Table 2-6
Asia/Pacific DRAM Revenue Forecast, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
64K Standard	0	0	0	0	0	0	-
256K Standard	0.4	0	0	0	0	0	-100.0
256K Display	2.9	0.5	0	0	0	0	-100.0
1Mb Standard	57.9	36.3	31.2	13.7	4.4	1.8	-50.0
1Mb Display	8.5	17.2	11.7	7.5	9.1	8.0	-1.3
2Mb Display	49.8	27.0	20.1	13.7	8.2	3.0	-43.0
4Mb Standard	462.5	234.2	93.1	34.0	21.1	8.2	-55.4
4Mb Display	90.8	63.0	20.1	6.2	7.3	4.6	-45.0
8Mb Display	87.6	155.5	91.7	2.6	0.9	0.7	-61.5
16Mb Standard	3,105.8	1,723.2	974.2	508.3	167.3	26.6	-61.4
16Mb Display	0	139.1	119.3	427.7	162.0	23.0	-
64Mb Standard	775.9	2,104.6	2,832.0	3,394.8	5,148.2	1,856.6	19.1
128Mb Standard	0	11.7	169.8	230.1	425.6	95.3	-
256Mb Standard	0	98.8	1,326.9	2,754.0	7,075.7	6,472.3	-
Total	**4,642.2**	**4,611.2**	**5,690.2**	**7,392.7**	**13,029.6**	**8,500.1**	**12.9**
Growth (%)	**-21.3**	**-0.7**	**23.4**	**29.9**	**76.3**	**-34.8**	**-**

Source: Dataquest (June 1998)

Table 2-7
Asia/Pacific DRAM Average Selling Price Forecast, 1997 to 2002 (U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
64K Standard	0	0	0	0	0	0	-
256K Standard	1.31	0	0	0	0	0	-
256K Display	2.14	2.25	2.25	2.49	4.10	2.45	2.8
1Mb Standard	1.39	1.40	1.50	1.47	1.83	1.75	4.7
1Mb Display	4.06	4.00	3.94	3.86	4.49	4.28	1.0
2Mb Display	2.91	3.00	3.00	2.94	3.65	2.88	-0.2
4Mb Standard	2.41	2.20	1.84	1.72	2.09	1.96	-4.1
4Mb Display	9.41	8.49	6.08	4.32	5.40	5.00	-11.9
8Mb Display	6.90	6.08	4.71	3.97	4.04	3.57	-12.4
16Mb Standard	6.56	3.90	3.18	3.14	3.20	3.05	-14.2
16Mb Display	0	31.17	12.93	9.00	9.00	5.67	-
64Mb Standard	45.82	17.63	11.00	9.50	9.50	4.83	-36.2
128Mb Standard	0	59.24	33.16	20.85	21.41	11.44	-
256Mb Standard	0	737.06	200.72	71.88	54.12	21.81	-
Total	**6.05**	**6.19**	**8.26**	**11.30**	**16.68**	**11.95**	**14.6**
Growth (%)	**-38.2**	**2.3**	**33.4**	**36.9**	**47.6**	**-28.3**	**-**

Source: Dataquest (June 1998)

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Table 2-8
Asia/Pacific DRAM Unit Shipment Forecast, 1997 to 2002 (Millions of Units Shipped)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
64K Standard	0	0	0	0	0	0	-
256K Standard	0.3	0	0	0	0	0	-
256K Display	1.3	0.2	0	0	0	0	-
1Mb Standard	41.8	26.0	20.8	9.3	2.4	1.0	-52.2
1Mb Display	2.1	4.3	3.0	1.9	2.0	1.9	-2.3
2Mb Display	17.1	9.0	6.7	4.7	2.2	1.0	-42.9
4Mb Standard	191.5	106.5	50.7	19.7	10.1	4.2	-53.5
4Mb Display	9.6	7.4	3.3	1.4	1.3	0.9	-37.6
8Mb Display	12.7	25.6	19.5	0.7	0.2	0.2	-56.1
16Mb Standard	473.5	441.8	306.8	162.0	52.3	8.7	-55.0
16Mb Display	0	4.5	9.2	47.5	18.0	4.1	-
64Mb Standard	16.9	119.4	257.3	357.4	541.9	384.1	86.7
128Mb Standard	0	0.2	5.1	11.0	19.9	8.3	-
256Mb Standard	0	0.1	6.6	38.3	130.7	296.7	-
Total	**767.0**	**745.0**	**689.0**	**654.0**	**781.2**	**711.1**	**-1.5**
Growth (%)	**27.5**	**-2.9**	**-7.5**	**-5.1**	**19.4**	**-9.0**	**-**

Source: Dataquest (June 1998)

Table 2-9
Asia/Pacific DRAM Megabyte Shipment Forecast, 1997 to 2002 (Millions of Megabytes Shipped)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
64K Standard	0	0	0	0	0	0	-
256K Standard	0	0	0	0	0	0	-
256K Display	0	0	0	0	0	0	-
1Mb Standard	5.2	3.2	2.6	1.2	0.3	0.1	-52.2
1Mb Display	0.3	0.5	0.4	0.2	0.3	0.2	-2.3
2Mb Display	4.3	2.3	1.7	1.2	0.6	0.3	-42.9
4Mb Standard	95.8	53.2	25.3	9.9	5.0	2.1	-53.5
4Mb Display	4.8	3.7	1.7	0.7	0.7	0.5	-37.6
8Mb Display	12.7	25.6	19.5	0.7	0.2	0.2	-56.1
16Mb Standard	947.0	883.7	613.5	324.0	104.7	17.4	-55.0
16Mb Display	0.0	8.9	18.4	95.0	36.0	8.1	-
64Mb Standard	135.5	955.1	2,058.7	2,858.9	4,335.3	3,072.5	86.7
128Mb Standard	0.0	3.2	81.9	176.6	318.1	133.3	-
256Mb Standard	0.0	4.3	211.6	1,226.1	4,183.6	9,494.9	-
Total	**1,205.6**	**1,943.7**	**3,035.3**	**4,694.5**	**8,984.7**	**12,729.6**	**60.2**
Growth (%)	**89.2**	**61.2**	**56.2**	**54.7**	**91.4**	**41.7**	**-**

Source: Dataquest (June 1998)

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Table 2-10
Asia/Pacific DRAM Price-per-Megabyte Forecast, 1997 to 2002 (U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
64K Standard	-	-	-	-	-	-	-
256K Standard	41.80	-	-	-	-	-	-
256K Display	68.39	72.00	-	-	-	-	-
1Mb Standard	11.08	11.20	11.99	11.73	14.62	13.96	4.7
1Mb Display	32.48	32.00	31.51	30.88	35.92	34.20	1.0
2Mb Display	11.65	12.00	12.01	11.75	14.62	11.52	-0.2
4Mb Standard	4.83	4.40	3.68	3.45	4.18	3.93	-4.1
4Mb Display	18.82	16.99	12.15	8.63	10.80	10.00	-11.9
8Mb Display	6.90	6.08	4.71	3.97	4.04	3.57	-12.4
16Mb Standard	3.28	1.95	1.59	1.57	1.60	1.53	-14.2
16Mb Display	-	15.58	6.46	4.50	4.50	2.84	-
64Mb Standard	5.73	2.20	1.38	1.19	1.19	0.60	-36.2
128Mb Standard	-	3.70	2.07	1.30	1.34	0.71	-
256Mb Standard	-	23.03	6.27	2.25	1.69	0.68	-
Total	**3.85**	**2.37**	**1.87**	**1.57**	**1.45**	**0.67**	**-29.6**
Growth (%)	**-58.4**	**-38.4**	**-21.0**	**-16.0**	**-7.9**	**-54.0**	**-**

Source: Dataquest (June 1998)

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Table 2-11
Asia/Pacific SRAM Revenue Forecast, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
16K							
4-8ns	0	0	0	0	0	0	-
10, 12, 15ns	0	0	0	0	0	0	-24.2
20, 25, 35ns	0.4	0.2	0.2	0.2	0.1	0.1	-27.0
45, 55, 70ns	0.2	0.1	0	0	0	0	-39.1
Slow	1.2	0.6	0.3	0.3	0.2	0.2	-33.5
Pseudo	0	0	0	0	0	0	-
16K Total	**1.8**	**0.9**	**0.5**	**0.5**	**0.3**	**0.3**	**-32.0**
64K							
4-8ns	0.1	0	0	0	0	0	-24.8
10, 12, 15ns	2.6	0.6	0.4	0.3	0.3	0.3	-36.3
20, 25, 35ns	9.9	2.6	1.2	1.0	0.7	0.6	-43.2
45, 55, 70ns	1.5	1.1	1.0	1.0	0.8	0.7	-15.9
Slow	16.0	9.1	6.6	6.3	4.8	4.1	-23.9
Pseudo	0	0	0	0	0	0	-
64K Total	**30.1**	**13.5**	**9.2**	**8.8**	**6.6**	**5.6**	**-28.6**
256K							
4-8ns	0.2	0.1	0.1	0.1	0	0	-25.2
10, 12, 15ns	38.9	10.1	3.3	2.2	1.1	0.9	-52.4
20, 25, 35ns	11.3	3.0	2.0	1.6	0.8	0.6	-44.7
45, 55, 70ns	9.8	6.4	5.3	4.4	3.1	2.6	-23.1
Slow	57.7	50.8	47.5	35.7	25.7	22.8	-16.9
Pseudo	3.6	2.9	1.8	0.9	0.5	0.3	-38.7
256K Total	**121.5**	**73.2**	**60.0**	**44.9**	**31.3**	**27.3**	**-25.8**
512K and 1Mb							
4-8ns	15.8	15.8	15.1	13.2	10.2	8.0	-12.7
10, 12, 15ns	87.0	57.4	70.3	73.8	49.9	39.7	-14.5
20, 25, 35ns	45.4	27.5	25.2	22.3	11.9	7.2	-30.8
45, 55, 70ns	6.0	2.3	1.8	1.5	1.1	1.0	-29.8
Slow	85.9	90.1	109.1	124.3	121.7	121.5	7.2
Pseudo	6.9	5.7	4.5	4.6	3.8	3.2	-14.5
512K and 1Mb Total	**247.1**	**198.8**	**226.0**	**239.7**	**198.6**	**180.6**	**-6.1**

Table 2-11 (Continued)
Asia/Pacific SRAM Revenue Forecast, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
2Mb and 4Mb							
4-8ns	45.9	53.2	60.8	76.4	77.2	91.6	14.8
10, 12, 15ns	75.8	92.0	147.8	213.7	196.2	183.6	19.3
20, 25, 35ns	17.2	50.1	83.3	122.3	158.5	144.6	53.1
45, 55, 70ns	14.8	19.3	33.7	42.0	44.2	39.9	21.9
Slow	40.6	64.7	103.7	151.5	194.6	180.7	34.8
Pseudo	4.1	2.4	1.9	1.6	0.8	0.5	-34.2
2Mb and 4Mb Total	**198.5**	**281.6**	**431.2**	**607.4**	**671.5**	**640.9**	**26.4**
16Mb							
4-8ns	0	3.9	12.5	23.5	38.9	128.0	-
10, 12, 15ns	0	10.4	23.1	79.6	125.5	185.5	-
20, 25, 35ns	0	10.0	31.2	90.6	122.3	133.2	-
45, 55, 70ns	0	10.4	39.7	82.7	118.2	145.6	-
Slow	0	23.0	59.5	116.4	206.8	232.9	-
Pseudo	0	0	0	0	0	0	-
16Mb Total	**0**	**57.7**	**165.9**	**392.8**	**611.7**	**825.2**	**-**
Grand Total	**599.0**	**625.6**	**893.0**	**1,294.0**	**1,520.0**	**1,680.0**	**22.9**
Growth (%)	**-35.4**	**4.4**	**42.7**	**44.9**	**17.5**	**10.5**	**-**

Source: Dataquest (June 1998)

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Table 2-12
Asia/Pacific SRAM Average Selling Price Forecast, 1997 to 2002 (U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
16K							
4-8ns	0	0	0	0	0	0	-
10, 12, 15ns	1.34	1.42	1.50	1.50	1.50	1.50	2.3
20, 25, 35ns	1.02	1.18	1.25	1.25	1.25	1.25	4.1
45, 55, 70ns	1.02	1.05	1.10	1.10	1.10	1.10	1.4
Slow	1.02	1.05	1.10	1.10	1.10	1.10	1.4
Pseudo	0	0	0	0	0	0	-
16K Total	**1.04**	**1.10**	**1.16**	**1.16**	**1.16**	**1.16**	**2.2**
64K							
4-8ns	2.06	2.00	2.00	2.00	2.00	2.00	-0.6
10, 12, 15ns	1.81	1.10	1.10	1.10	1.10	1.10	-9.4
20, 25, 35ns	1.81	1.10	1.10	1.10	1.10	1.10	-9.4
45, 55, 70ns	1.42	1.25	1.23	1.31	1.31	1.31	-1.5
Slow	1.25	1.25	1.23	1.31	1.31	1.31	1.0
Pseudo	0	0	0	0	0	0	-
64K Total	**1.44**	**1.19**	**1.20**	**1.27**	**1.27**	**1.27**	**-2.4**
256K							
4-8ns	5.25	4.06	2.65	2.30	2.05	2.05	-17.2
10, 12, 15ns	2.06	1.25	1.10	1.10	1.10	1.10	-11.8
20, 25, 35ns	1.47	1.10	1.10	1.10	1.10	1.10	-5.6
45, 55, 70ns	1.44	1.10	1.10	1.10	1.10	1.10	-5.3
Slow	1.38	1.44	1.52	1.52	1.52	1.52	1.9
Pseudo	1.99	2.00	2.00	2.00	2.00	2.00	0.1
256K Total	**1.59**	**1.41**	**1.43**	**1.43**	**1.44**	**1.44**	**-2.0**
512K and 1Mb							
4-8ns	3.54	3.31	2.75	2.50	2.20	1.75	-13.1
10, 12, 15ns	4.58	2.60	2.50	2.20	1.60	1.25	-22.9
20, 25, 35ns	5.17	3.30	3.26	3.23	3.41	3.41	-8.0
45, 55, 70ns	5.07	3.25	3.21	3.13	3.30	3.30	-8.2
Slow	3.33	3.25	3.21	3.13	3.30	3.30	-0.2
Pseudo	2.38	3.49	3.50	3.69	3.69	3.69	9.1
512K and 1Mb Total	**4.00**	**3.17**	**2.93**	**2.75**	**2.56**	**2.36**	**-10.0**

Table 2-12 (Continued)
Asia/Pacific SRAM Average Selling Price Forecast, 1997 to 2002 (U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
2Mb and 4Mb							
4-8ns	27.88	18.49	16.36	15.52	13.93	11.00	-17.0
10, 12, 15ns	14.72	12.00	10.00	8.00	6.00	4.50	-21.1
20, 25, 35ns	17.53	13.00	12.70	11.55	11.33	7.00	-16.8
45, 55, 70ns	16.50	12.71	12.64	11.45	11.13	7.00	-15.8
Slow	11.35	12.70	12.64	11.45	11.13	7.00	-9.2
Pseudo	5.26	5.15	5.40	5.38	5.38	5.50	0.9
2Mb and 4Mb Total	**15.33**	**14.16**	**11.74**	**9.99**	**8.66**	**6.18**	**-16.6**
16Mb							
4-8ns	0	503.82	298.49	174.80	110.00	80.00	-
10, 12, 15ns	0	119.96	71.07	62.37	45.00	35.00	-
20, 25, 35ns	0	83.35	73.91	59.36	35.00	20.00	-
45, 55, 70ns	0	35.99	36.75	27.75	20.00	15.00	-
Slow	0	34.91	29.40	22.20	20.00	15.00	-
Pseudo	0	0	0	0	0	0	-
16Mb Total	**-**	**52.47**	**42.64**	**35.20**	**26.73**	**21.27**	**-**
Grand Total	**3.42**	**4.08**	**5.33**	**6.59**	**7.55**	**6.99**	**15.3**
Growth (%)	**-11.8**	**19.2**	**30.7**	**23.5**	**14.5**	**-7.3**	**-**

Source: Dataquest (June 1998)

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Table 2-13
Asia/Pacific SRAM Unit Shipment Forecast, 1997 to 2002 (Millions of Units Shipped)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
16K							
4-8ns	-	-	-	-	-	-	-
10, 12, 15ns	0	0	0	0	0	0	-25.9
20, 25, 35ns	0.4	0.2	0.1	0.1	0.1	0.1	-29.9
45, 55, 70ns	0.2	0.1	0	0	0	0	-40.0
Slow	1.1	0.5	0.3	0.2	0.2	0.1	-34.4
Pseudo	-	-	-	-	-	-	-
16K Total	**1.8**	**0.8**	**0.5**	**0.4**	**0.3**	**0.2**	**-33.5**
64K							
4-8ns	0	0	0	0	0	0	-24.3
10, 12, 15ns	1.4	0.6	0.4	0.3	0.3	0.2	-29.6
20, 25, 35ns	5.5	2.4	1.1	0.9	0.7	0.5	-37.3
45, 55, 70ns	1.1	0.9	0.8	0.8	0.6	0.5	-14.6
Slow	12.8	7.3	5.3	4.8	3.6	3.1	-24.7
Pseudo	0.1	0.1	0				-100.0
64K Total	**21.0**	**11.2**	7.7	**6.9**	**5.1**	**4.4**	**-26.9**
256K							
4-8ns	0	0	0	0	0	0	-9.7
10, 12, 15ns	18.8	8.1	3.0	2.0	1.0	0.9	-46.1
20, 25, 35ns	7.7	2.7	1.8	1.5	0.7	0.5	-41.4
45, 55, 70ns	6.8	5.8	4.8	4.0	2.8	2.4	-18.9
Slow	41.8	35.4	31.3	23.5	16.9	15.0	-18.5
Pseudo	1.8	1.4	0.9	0.5	0.2	0.2	-38.8
256K Total	**76.9**	**53.4**	**41.9**	**31.4**	**21.7**	**19.0**	**-24.4**
512K and 1Mb							
4-8ns	4.5	4.8	5.5	5.3	4.6	4.6	0.4
10, 12, 15ns	19.0	22.1	28.1	33.6	31.2	31.8	10.8
20, 25, 35ns	8.8	8.3	7.7	6.9	3.5	2.1	-24.8
45, 55, 70ns	1.2	0.7	0.6	0.5	0.3	0.3	-23.5
Slow	25.8	27.7	34.0	39.7	36.9	36.8	7.4
Pseudo	2.9	1.6	1.3	1.3	1.0	0.9	-21.6
512K and 1Mb Total	**62.1**	**65.2**	**77.2**	**87.1**	**77.5**	**76.4**	**4.2**

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Table 2-13 (Continued)
Asia/Pacific SRAM Unit Shipment Forecast, 1997 to 2002 (Millions of Units Shipped)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
2Mb and 4Mb							
4-8ns	1.6	2.9	3.7	4.9	5.5	8.3	38.3
10, 12, 15ns	5.2	7.7	14.8	26.7	32.7	40.8	51.3
20, 25, 35ns	1.0	3.9	6.6	10.6	14.0	20.7	84.0
45, 55, 70ns	0.9	1.5	2.7	3.7	4.0	5.7	44.7
Slow	3.6	5.1	8.2	13.2	17.5	25.8	48.5
Pseudo	0.8	0.5	0.4	0.3	0.2	0.1	-34.8
2Mb and 4Mb Total	**13.0**	**21.5**	**36.3**	**59.4**	**73.8**	**101.4**	**50.7**
16Mb							
4-8ns	-	0	0	0.1	0.4	1.6	-
10, 12, 15ns	-	0.1	0.3	1.3	2.8	5.3	-
20, 25, 35ns	-	0.1	0.4	1.5	3.5	6.7	-
45, 55, 70ns	-	0.3	1.1	3.0	5.9	9.7	-
Slow	-	0.7	2.0	5.2	10.3	15.5	-
Pseudo	-	-	-	-	-	-	-
16Mb Total	**-**	**1.2**	**3.9**	**11.2**	**22.9**	**38.8**	**-**
Grand Total	**174.9**	**153.3**	**167.4**	**196.4**	**201.4**	**240.2**	**6.6**
Growth (%)	**-26.8**	**-12.4**	**9.2**	**17.3**	**2.6**	**19.3**	**-**

Source: Dataquest (June 1998)

Table 2-14
Asia/Pacific SRAM Megabyte Shipment Forecast, 1997 to 2002 (Millions of Megabytes Shipped)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
16K							
4-8ns	-	-	-	-	-	-	-
10, 12, 15ns	0	0	0	0	0	0	-25.9
20, 25, 35ns	0	0	0	0	0	0	-29.9
45, 55, 70ns	0	0	0	0	0	0	-40.0
Slow	0	0	0	0	0	0	-34.4
Pseudo	-	-	-	-	-	-	-
16K Total	**0**	**0**	**0**	**0**	**0**	**0**	**-33.5**
64K							
4-8ns	0	0	0	0	0	0	-24.3
10, 12, 15ns	0.01	0	0	0	0	0	-29.6
20, 25, 35ns	0.04	0.02	0.01	0.01	0.01	0	-37.3
45, 55, 70ns	0.01	0.01	0.01	0.01	0	0	-14.6
Slow	0.10	0.06	0.04	0.04	0.03	0.02	-24.7
Pseudo	0	0	0	-	-	-	-100.0
64K Total	**0.16**	**0.09**	**0.06**	**0.05**	**0.04**	**0.03**	**-26.9**
256K							
4-8ns	0	0	0	0	0	0	-9.7
10, 12, 15ns	0.59	0.25	0.09	0.06	0.03	0.03	-46.1
20, 25, 35ns	0.24	0.08	0.06	0.05	0.02	0.02	-41.4
45, 55, 70ns	0.21	0.18	0.15	0.12	0.09	0.07	-18.9
Slow	1.30	1.11	0.98	0.73	0.53	0.47	-18.5
Pseudo	0.06	0.04	0.03	0.01	0.01	0	-38.8
256K Total	**2.4**	**1.7**	**1.3**	**1.0**	**0.7**	**0.6**	**-24.4**
512K and 1Mb							
4-8ns	0.6	0.6	0.7	0.7	0.6	0.6	0.4
10, 12, 15ns	2.4	2.8	3.5	4.2	3.9	4.0	10.8
20, 25, 35ns	1.1	1.0	1.0	0.9	0.4	0.3	-24.8
45, 55, 70ns	0.1	0.1	0.1	0.1	0	0	-23.5
Slow	3.2	3.5	4.2	5.0	4.6	4.6	7.4
Pseudo	0.4	0.2	0.2	0.2	0.1	0.1	-21.6
512K and 1Mb Total	**7.8**	**8.2**	**9.6**	**10.9**	**9.7**	**9.6**	**4.2**

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Table 2-14 (Continued)
Asia/Pacific SRAM Megabyte Shipment Forecast, 1997 to 2002 (Millions of Megabytes Shipped)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
2Mb and 4Mb							
4-8ns	0.8	1.4	1.9	2.5	2.8	4.2	38.3
10, 12, 15ns	2.6	3.8	7.4	13.4	16.4	20.4	51.3
20, 25, 35ns	0.5	1.9	3.3	5.3	7.0	10.3	84.0
45, 55, 70ns	0.4	0.8	1.3	1.8	2.0	2.8	44.7
Slow	1.8	2.5	4.1	6.6	8.7	12.9	48.5
Pseudo	0.4	0.2	0.2	0.1	0.1	0	-34.8
2Mb and 4Mb Total	**6.5**	**10.7**	**18.1**	**29.7**	**36.9**	**50.7**	**50.7**
16Mb							
4-8ns	-	0	0.1	0.3	0.7	3.2	-
10, 12, 15ns	-	0.2	0.7	2.6	5.6	10.6	-
20, 25, 35ns	-	0.2	0.8	3.1	7.0	13.3	-
45, 55, 70ns	-	0.6	2.2	6.0	11.8	19.4	-
Slow	-	1.3	4.0	10.5	20.7	31.0	-
Pseudo	-	-	-	-	-	-	-
16Mb Total	**-**	**2.3**	**7.8**	**22.3**	**45.8**	**77.6**	**-**
Grand Total	**16.9**	**23.0**	**36.9**	**63.9**	**93.1**	**138.5**	**52.4**
Growth (%)	**3.6**	**36.3**	**60.8**	**73.1**	**45.6**	**48.7**	**-**

Source: Dataquest (June 1998)

Table 2-15
Asia/Pacific SRAM Price-per-Megabyte Forecast, 1997 to 2002 (U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
16K							
4-8ns	-	-	-	-	-	-	-
10, 12, 15ns	686.54	726.13	768.00	768.00	768.00	768.00	2.3
20, 25, 35ns	522.83	605.11	640.00	640.00	640.00	640.00	4.1
45, 55, 70ns	524.41	537.60	563.20	563.20	563.20	563.20	1.4
Slow	524.41	537.60	563.20	563.20	563.20	563.20	1.4
Pseudo	0	0	0	0	0	0	-
16K Total	**527.25**	**558.11**	**591.83**	**593.33**	**593.19**	**593.19**	**2.4**
64K							
4-8ns	264.05	256.00	256.00	256.00	256.00	256.00	-0.6
10, 12, 15ns	231.05	140.80	140.80	140.80	140.80	140.80	-9.4
20, 25, 35ns	231.05	140.80	140.80	140.80	140.80	140.80	-9.4
45, 55, 70ns	181.27	160.00	157.35	167.80	167.80	167.80	-1.5
Slow	159.49	160.00	157.35	167.80	167.80	167.80	1.0
Pseudo	0	0	0	-	-	-	-
64K Total	**183.32**	**154.25**	**153.67**	**163.01**	**163.16**	**163.13**	**-2.3**
256K							
4-8ns	168.05	129.89	84.73	73.58	65.47	65.47	-17.2
10, 12, 15ns	66.01	40.00	35.20	35.20	35.20	35.20	-11.8
20, 25, 35ns	47.07	35.20	35.20	35.20	35.20	35.20	-5.6
45, 55, 70ns	46.14	35.20	35.20	35.20	35.20	35.20	-5.3
Slow	44.23	45.95	48.60	48.60	48.60	48.60	1.9
Pseudo	63.56	64.00	64.00	64.00	64.00	64.00	0.1
256K Total	**50.53**	**43.87**	**45.87**	**45.67**	**45.99**	**46.07**	**-1.8**
512K and 1Mb							
4-8ns	28.28	26.47	22.00	20.00	17.60	14.00	-13.1
10, 12, 15ns	36.62	20.80	20.00	17.60	12.80	10.00	-22.9
20, 25, 35ns	41.40	26.40	26.08	25.84	27.28	27.28	-8.0
45, 55, 70ns	40.52	26.00	25.69	25.07	26.40	26.40	-8.2
Slow	26.66	26.00	25.69	25.07	26.40	26.40	-0.2
Pseudo	19.07	27.93	28.00	29.52	29.52	29.52	9.1
512K and 1Mb Total	**31.81**	**24.38**	**23.43**	**22.01**	**20.49**	**18.90**	**-9.9**

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Table 2-15 (Continued)
Asia/Pacific SRAM Price-per-Megabyte Forecast, 1997 to 2002 (U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
2Mb and 4Mb							
4-8ns	55.77	36.97	32.72	31.05	27.85	22.00	-17.0
10, 12, 15ns	29.43	24.00	20.00	16.00	12.00	9.00	-21.1
20, 25, 35ns	35.07	26.00	25.41	23.11	22.66	14.00	-16.8
45, 55, 70ns	33.01	25.43	25.28	22.91	22.26	14.00	-15.8
Slow	22.69	25.40	25.28	22.91	22.26	14.00	-9.2
Pseudo	10.51	10.30	10.79	10.76	10.76	11.00	0.9
2Mb and 4Mb Total	**30.44**	**26.23**	**23.77**	**20.45**	**18.19**	**12.64**	**-16.1**
16Mb							
4-8ns	-	251.91	149.25	87.40	55.00	40.00	-
10, 12, 15ns	-	59.98	35.53	31.18	22.50	17.50	-
20, 25, 35ns	-	41.67	36.96	29.68	17.50	10.00	-
45, 55, 70ns	-	17.99	18.38	13.88	10.00	7.50	-
Slow	-	17.45	14.70	11.10	10.00	7.50	-
Pseudo	-	-	-	-	-	-	-
16Mb Total	**-**	**24.80**	**21.32**	**17.60**	**13.36**	**10.64**	**-**
Grand Total	**35.53**	**27.23**	**24.18**	**20.24**	**16.32**	**12.13**	**-19.3**
Growth (%)	**-37.7**	**-23.4**	**-11.2**	**-16.3**	**-19.3**	**-25.7**	**-**

Source: Dataquest (June 1998)

Table 2-16
Asia/Pacific EPROM Revenue Forecast, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
16K	0.8	0.5	0.4	0.3	0.2	0.2	-27.3
32K	0.7	0.4	0.3	0.2	0.2	0.1	-26.4
64K	5.6	4.6	3.7	3.0	2.5	2.0	-18.4
128K	2.1	1.8	1.6	1.3	1.1	1.0	-14.6
256K	35.6	29.2	25.6	22.2	19.3	16.9	-13.8
512K	37.3	31.4	27.9	25.0	22.0	20.0	-11.7
1Mb	31.5	26.4	22.6	20.4	18.6	17.1	-11.5
2Mb	26.5	18.9	15.8	14.0	12.8	12.2	-14.3
4Mb	58.4	35.2	27.5	23.3	21.3	20.5	-18.9
8Mb	4.9	2.9	2.1	1.8	1.7	1.6	-20.0
16Mb	1.5	0.7	0.5	0.4	0.3	0.3	-26.5
Total	**204.9**	**152.0**	**128.0**	**112.0**	**100.0**	**92.0**	**-14.8**
Growth (%)	**-11.3**	**-25.8**	**-15.8**	**-12.5**	**-10.7**	**-8.0**	**-**

Source: Dataquest (June 1998)

Table 2-17
Asia/Pacific EPROM Average Selling Price Forecast, 1997 to 2002 (U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
16K	1.84	1.58	1.50	1.47	1.44	1.43	-5.0
32K	2.01	1.49	1.44	1.42	1.38	1.39	-7.2
64K	1.39	1.36	1.36	1.36	1.36	1.36	-0.4
128K	1.16	1.13	1.13	1.13	1.13	1.13	-0.4
256K	1.45	1.35	1.35	1.35	1.35	1.35	-1.4
512K	1.51	1.40	1.38	1.38	1.35	1.36	-2.1
1Mb	1.93	1.72	1.58	1.55	1.53	1.51	-4.7
2Mb	2.93	2.17	1.90	1.77	1.69	1.69	-10.4
4Mb	4.89	2.96	2.35	2.04	1.91	1.86	-17.6
8Mb	7.42	4.23	3.11	2.63	2.40	2.30	-20.9
16Mb	16.77	7.60	4.83	3.75	3.28	2.99	-29.2
Total	**2.18**	**1.76**	**1.62**	**1.56**	**1.53**	**1.53**	**-6.9**
Growth (%)	**-24.5**	**-19.3**	**-7.8**	**-3.6**	**-2.1**	**-0.1**	**-**

Source: Dataquest (June 1998)

Table 2-18
Asia/Pacific EPROM Unit Shipment Forecast, 1997 to 2002 (Millions of Units Shipped)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
16K	0.4	0.3	0.3	0.2	0.2	0.1	-23.5
32K	0.3	0.3	0.2	0.2	0.1	0.1	-20.8
64K	4.0	3.3	2.7	2.2	1.8	1.5	-18.0
128K	1.8	1.6	1.4	1.2	1.0	0.9	-14.2
256K	24.5	21.7	18.9	16.4	14.3	12.5	-12.6
512K	24.7	22.5	20.3	18.1	16.3	14.7	-9.8
1Mb	16.4	15.3	14.3	13.1	12.2	11.3	-7.1
2Mb	9.0	8.7	8.3	7.9	7.5	7.2	-4.4
4Mb	12.0	11.9	11.7	11.4	11.2	11.0	-1.6
8Mb	0.7	0.7	0.7	0.7	0.7	0.7	1.1
16Mb	0.1	0.1	0.1	0.1	0.1	0.1	3.8
Total	**94.0**	**86.4**	**78.9**	**71.6**	**65.3**	**60.2**	**-8.5**
Growth (%)	**17.5**	**-8.0**	**-8.7**	**-9.2**	**-8.8**	**-7.9**	**-**

Source: Dataquest (June 1998)

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Table 2-19
Asia/Pacific EPROM Megabyte Shipment Forecast, 1997 to 2002 (Millions of Megabytes Shipped)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
16K	0	0	0	0	0	0	-23.5
32K	0	0	0	0	0	0	-20.8
64K	0	0	0	0	0	0	-18.0
128K	0	0	0	0	0	0	-14.2
256K	0.8	0.7	0.6	0.5	0.4	0.4	-12.6
512K	1.5	1.4	1.3	1.1	1.0	0.9	-9.8
1Mb	2.0	1.9	1.8	1.6	1.5	1.4	-7.1
2Mb	2.3	2.2	2.1	2.0	1.9	1.8	-4.4
4Mb	6.0	5.9	5.8	5.7	5.6	5.5	-1.6
8Mb	0.7	0.7	0.7	0.7	0.7	0.7	1.1
16Mb	0.2	0.2	0.2	0.2	0.2	0.2	3.8
Total	**13.5**	**13.0**	**12.5**	**11.9**	**11.4**	**11.0**	**-4.0**
Growth (%)	**18.0**	**-3.4**	**-4.1**	**-4.8**	**-4.4**	**-3.5**	-

Source: Dataquest (June 1998)

Table 2-20
Asia/Pacific EPROM Price-per-Megabyte Forecast, 1997 to 2002 (U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
16K	941.85	811.47	769.61	753.82	734.97	729.91	-5.0
32K	514.82	382.16	367.49	362.44	352.57	355.01	-7.2
64K	178.07	174.24	174.24	174.24	174.24	174.24	-0.4
128K	74.06	72.46	72.46	72.46	72.46	72.46	-0.4
256K	46.44	43.20	43.20	43.20	43.20	43.20	-1.4
512K	24.16	22.34	22.04	22.04	21.58	21.73	-2.1
1Mb	15.41	13.76	12.68	12.42	12.28	12.11	-4.7
2Mb	11.73	8.67	7.59	7.10	6.78	6.78	-10.4
4Mb	9.78	5.93	4.70	4.08	3.82	3.72	-17.6
8Mb	7.42	4.23	3.11	2.63	2.40	2.30	-20.9
16Mb	8.39	3.80	2.42	1.87	1.64	1.49	-29.2
Total	**15.19**	**11.66**	**10.24**	**9.41**	**8.79**	**8.38**	**-11.2**
Growth (%)	**-24.8**	**-23.2**	**-12.2**	**-8.1**	**-6.6**	**-4.6**	-

Source: Dataquest (June 1998)

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Table 2-21
Asia/Pacific EEPROM Revenue Forecast, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
256-Bit	1.2	0.7	0.5	0.3	0.2	0.1	-34.8
512-Bit	0	0	0	0	0	0	-
1K	25.3	26.4	26.5	25.5	22.8	18.5	-6.1
2K	23.4	26.6	28.5	30.3	34.1	34.6	8.2
4K	32.4	33.1	36.0	40.2	50.0	58.1	12.4
8K	10.6	13.1	16.2	21.0	31.4	39.2	30.0
16K	42.0	46.1	53.3	57.9	69.7	81.7	14.2
64K	52.7	57.3	66.0	82.9	111.9	149.5	23.2
256K	15.3	15.2	15.8	17.4	22.9	26.6	11.6
512K	0.5	0.5	0.5	0.6	0.7	0.8	9.8
1Mb	7.2	7.6	7.5	7.5	8.9	10.5	8.0
4Mb	0.5	0.3	0.3	0.3	0.3	0.3	-6.0
Total	**211.0**	**227.0**	**251.0**	**284.0**	**353.0**	**420.0**	**14.8**
Growth (%)	**24.1**	**7.6**	**10.6**	**13.1**	**24.3**	**19.0**	-

Source: Dataquest (June 1998)

Table 2-22
Asia/Pacific EEPROM Average Selling Price Forecast, 1997 to 2002 (U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
256-Bit	0.27	0.26	0.25	0.25	0.25	0.25	-1.2
512-Bit	-	-	-	-	-	-	
1K	0.25	0.23	0.22	0.22	0.22	0.22	-2.2
2K	0.35	0.32	0.31	0.30	0.30	0.30	-3.3
4K	0.64	0.51	0.46	0.43	0.42	0.41	-8.5
8K	0.90	0.77	0.70	0.67	0.66	0.64	-6.5
16K	1.48	1.24	1.11	0.97	0.86	0.81	-11.2
64K	2.18	1.84	1.54	1.28	1.11	1.02	-14.1
256K	5.29	3.63	2.63	1.91	1.66	1.38	-23.6
512K	14.38	10.47	6.92	5.19	4.11	3.24	-25.8
1Mb	34.60	25.12	18.20	13.12	9.55	7.94	-25.5
4Mb	169.09	75.86	43.65	27.54	18.62	15.49	-38.0
Total	**0.72**	**0.64**	**0.61**	**0.60**	**0.61**	**0.62**	-2.8
Growth (%)	**-55.2**	**-11.1**	**-4.9**	**-2.2**	**1.8**	**2.9**	-

Source: Dataquest (June 1998)

Table 2-23
Asia/Pacific EEPROM Unit Shipment Forecast, 1997 to 2002 (Millions of Units Shipped)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
256-Bit	4.6	2.8	1.8	1.2	0.9	0.6	-34.0
512-Bit	0	0	0	0	0	0	
1K	103.1	114.0	118.7	115.2	103.7	84.3	-4.0
2K	67.0	82.9	92.3	101.9	115.3	117.1	11.8
4K	50.7	64.8	78.9	92.6	118.1	141.8	22.8
8K	11.8	17.0	23.1	31.3	47.8	61.2	39.1
16K	28.4	37.1	47.9	59.8	80.6	100.5	28.7
64K	24.2	31.2	42.8	64.9	100.6	146.7	43.4
256K	2.9	4.2	6.0	9.1	13.8	19.3	46.0
512K	0	0.1	0.1	0.1	0.2	0.2	47.9
1Mb	0.2	0.3	0.4	0.6	0.9	1.3	45.0
4Mb	0	0	0	0	0	0	51.7
Total	**293.0**	**354.4**	**412.0**	**476.6**	**582.0**	**672.9**	**18.1**
Growth (%)	**176.8**	**21.0**	**16.3**	**15.7**	**22.1**	**15.6**	**-**

Source: Dataquest (June 1998)

Table 2-24
Asia/Pacific EEPROM Megabyte Shipment Forecast, 1997 to 2002 (Millions of Megabytes Shipped)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
256-Bit	0	0	0	0	0	0	-34.0
512-Bit	0	0	0	0	0	0	-
1K	0.01	0.01	0.01	0.01	0.01	0.01	-4.0
2K	0.02	0.02	0.02	0.02	0.03	0.03	11.8
4K	0.02	0.03	0.04	0.05	0.06	0.07	22.8
8K	0.01	0.02	0.02	0.03	0.05	0.06	39.1
16K	0.06	0.07	0.09	0.12	0.16	0.20	28.7
64K	0.19	0.24	0.33	0.51	0.79	1.15	43.4
256K	0.09	0.13	0.19	0.29	0.43	0.60	46.0
512K	0	0	0	0.01	0.01	0.02	47.9
1Mb	0.03	0.04	0.05	0.07	0.12	0.17	45.0
4Mb	0	0	0	0	0.01	0.01	51.7
Total	**0.43**	**0.57**	**0.77**	**1.11**	**1.66**	**2.30**	**39.9**
Growth (%)	**40.7**	**33.1**	**35.2**	**43.1**	**49.5**	**39.2**	**-**

Source: Dataquest (June 1998)

Table 2-25
Asia/Pacific EEPROM Price-per-Megabyte Forecast, 1997 to 2002 (U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002	Bits
256-Bit	8,702.95	8,403.30	8,345.45	8,193.13	8,193.13	8,193.13	-1.2	256
512-Bit	-	-	-	-	-	-	-	512
1K	2,011.42	1,898.41	1,829.74	1,817.15	1,804.64	1,796.35	-2.2	1,024
2K	1,430.45	1,316.32	1,265.79	1,220.00	1,211.60	1,211.60	-3.3	2,048
4K	1,307.51	1,045.51	933.96	889.88	867.62	840.10	-8.5	4,096
8K	921.18	787.59	716.64	689.13	671.89	656.60	-6.5	8,192
16K	755.76	637.19	569.21	495.76	442.86	416.17	-11.2	16,384
64K	278.55	235.08	197.34	163.38	142.30	130.38	-14.1	65,536
256K	169.16	116.18	84.17	60.97	53.11	44.17	-23.6	262,144
512K	230.02	167.54	110.69	83.02	65.80	51.77	-25.8	524,288
1Mb	276.82	200.95	145.58	104.99	76.42	63.55	-25.5	1,048,576
4Mb	338.18	151.72	87.30	55.08	37.24	30.98	-38.0	4,194,304
Total	**490.61**	**396.65**	**324.46**	**256.46**	**213.27**	**182.27**	**-18.0**	-
Growth (%)	**-11.8**	**-19.2**	**-18.2**	**-21.0**	**-16.8**	**-14.5**		-

Source: Dataquest (June 1998)

Table 2-26
Asia/Pacific Flash Revenue Forecast, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
256K	4.1	2.5	1.4	0.8	0.5	0.4	-36.9
512K	17.0	15.1	11.9	7.1	3.4	1.4	-39.6
1Mb	79.4	94.3	88.1	78.6	65.5	58.3	-6.0
2Mb	48.4	51.2	52.2	52.8	59.7	59.0	4.0
4Mb	146.4	139.6	134.6	137.3	137.1	139.4	-1.0
8Mb	208.1	218.8	222.2	215.5	209.2	212.1	0.4
16Mb	93.0	138.4	190.3	242.6	302.2	330.8	28.9
32Mb	4.2	43.8	96.9	161.6	216.0	271.6	130.6
64Mb	2.3	27.3	74.1	135.3	184.4	299.2	164.7
128Mb	0.0	0.0	10.3	41.4	109.0	192.8	-
Total	**603.0**	**731.0**	**882.0**	**1,073.0**	**1,287.0**	**1,565.0**	**21.0**
Growth (%)	**23.3**	**21.2**	**20.7**	**21.7**	**19.9**	**21.6**	-

Source: Dataquest (June 1998)

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Table 2-27
Asia/Pacific Flash Average Selling Price Forecast, 1997 to 2002 (U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
256K	2.37	2.12	2.11	2.10	2.10	2.10	-2.4
512K	2.39	2.16	2.15	2.14	2.14	2.14	-2.2
1Mb	2.26	2.19	2.18	2.17	2.16	2.16	-0.9
2Mb	3.41	2.65	2.48	2.38	2.32	2.29	-7.7
4Mb	4.75	3.46	3.03	2.87	2.69	2.58	-11.5
8Mb	6.82	4.65	4.06	3.61	3.28	3.16	-14.3
16Mb	10.12	6.65	5.60	4.90	4.52	4.23	-16.0
32Mb	15.41	9.16	7.41	6.65	6.07	5.68	-18.1
64Mb	32.94	16.29	12.47	10.33	8.81	7.82	-25.0
128Mb	-	40.93	22.75	18.11	14.62	12.47	-
Total	**4.67**	**3.95**	**4.00**	**4.14**	**4.24**	**4.41**	**-1.1**
Growth (%)	**-42.5**	**-15.5**	**1.5**	**3.5**	**2.3**	**4.1**	**-**

Source: Dataquest (June 1998)

Table 2-28
Asia/Pacific Flash Unit Shipment Forecast, 1997 to 2002 (Millions of Units Shipped)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
256K	1.7	1.2	0.7	0.4	0.2	0.2	-35.3
512K	7.1	7.0	5.5	3.3	1.6	0.6	-38.3
1Mb	35.2	43.0	40.4	36.2	30.3	27.0	-5.2
2Mb	14.2	19.3	21.1	22.1	25.7	25.8	12.7
4Mb	30.8	40.3	44.5	47.8	51.0	54.0	11.9
8Mb	30.5	47.1	54.7	59.8	63.7	67.2	17.1
16Mb	9.2	20.8	34.0	49.5	66.9	78.3	53.5
32Mb	0.3	4.8	13.1	24.3	35.6	47.8	181.5
64Mb	0.1	1.7	5.9	13.1	20.9	38.3	252.9
128Mb	0	0	0.5	2.3	7.5	15.5	-
Total	**129.1**	**185.3**	**220.3**	**258.9**	**303.6**	**354.7**	**22.4**
Growth (%)	**114.3**	**43.5**	**18.9**	**17.5**	**17.3**	**16.8**	**-**

Source: Dataquest (June 1998)

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Table 2-29
Asia/Pacific Flash Megabyte Shipment Forecast, 1997 to 2002 (Millions of Megabytes Shipped)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
256K	0.1	0	0	0	0	0	-35.3
512K	0.4	0.4	0.3	0.2	0.1	0	-38.3
1Mb	4.4	5.4	5.1	4.5	3.8	3.4	-5.2
2Mb	3.6	4.8	5.3	5.5	6.4	6.5	12.7
4Mb	15.4	20.2	22.2	23.9	25.5	27.0	11.9
8Mb	30.5	47.1	54.7	59.8	63.7	67.2	17.1
16Mb	18.4	41.6	68.0	99.1	133.8	156.5	53.5
32Mb	1.1	19.1	52.3	97.2	142.4	191.4	181.5
64Mb	0.6	13.4	47.5	104.8	167.4	306.2	252.9
128Mb	0	0	7.2	36.6	119.3	247.3	-
Total	**74.4**	**152.1**	**262.7**	**431.5**	**662.5**	**1,005.6**	**68.3**
Growth (%)	**179.7**	**104.5**	**72.7**	**64.3**	**53.5**	**51.8**	-

Source: Dataquest (June 1998)

Table 2-30
Asia/Pacific Flash Price-per-Megabyte Forecast, 1997 to 2002 (U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
256K	75.9	67.7	67.4	67.1	67.1	67.1	-2.4
512K	38.2	34.6	34.4	34.2	34.2	34.2	-2.2
1Mb	18.1	17.5	17.4	17.4	17.3	17.3	-0.9
2Mb	13.6	10.6	9.9	9.5	9.3	9.1	-7.7
4Mb	9.5	6.9	6.1	5.7	5.4	5.2	-11.5
8Mb	6.8	4.6	4.1	3.6	3.3	3.2	-14.3
16Mb	5.1	3.3	2.8	2.4	2.3	2.1	-16.0
32Mb	3.9	2.3	1.9	1.7	1.5	1.4	-18.1
64Mb	4.1	2.0	1.6	1.3	1.1	1.0	-25.0
128Mb			1.4	1.1	0.9	0.8	-
Total	**8.11**	**4.81**	**3.36**	**2.49**	**1.94**	**1.56**	**-28.1**
Growth (%)	**-55.9**	**-40.7**	**-30.1**	**-26.0**	**-21.9**	**-19.9**	-

Source: Dataquest (June 1998)

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Table 2-31
Asia/Pacific ROM Revenue Forecast, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
64K	0	0	0	0	0	0	-100.0
128K	0	0	0	0	0	0	-100.0
256K	0.7	0.3	0.2	0.1	0.1	0	-41.3
512K	0.6	0.1	0.1	0	0	0	-49.6
1Mb	4.2	2.3	0.8	0.3	0.1	0.1	-49.8
2Mb	9.4	5.0	3.1	1.7	0.4	0.4	-46.5
4Mb	36.4	31.3	28.8	28.6	26.7	25.5	-6.9
8Mb	27.0	19.6	13.3	9.1	6.5	4.2	-31.1
16Mb	63.1	49.7	44.2	42.9	40.2	37.7	-9.8
32Mb	27.4	24.1	21.4	20.7	22.0	22.8	-3.5
64Mb	24.8	21.4	18.3	18.9	20.4	22.0	-2.4
128Mb	11.5	22.4	26.8	26.4	27.9	29.3	20.7
256Mb	0	0	34.1	50.2	45.6	45.9	-
Total	**205.0**	**176.0**	**191.0**	**199.0**	**190.0**	**188.0**	**-1.7**
Growth (%)	**-28.6**	**-14.1**	**8.5**	**4.2**	**-4.5**	**-1.1**	**-**

Source: Dataquest (June 1998)

Table 2-32
Asia/Pacific ROM Average Selling Price Forecast, 1997 to 2002 (U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
64K	0.69	-	-	-	-	-	-100.0
128K	0.76	-	-	-	-	-	-100.0
256K	0.88	0.86	0.84	0.82	0.81	0.79	-2.0
512K	1.00	0.98	0.96	0.94	0.92	0.90	-2.0
1Mb	1.03	1.01	0.99	0.97	0.95	0.93	-2.0
2Mb	1.34	1.18	1.14	1.06	1.02	0.99	-5.8
4Mb	1.72	1.35	1.25	1.20	1.12	1.08	-9.0
8Mb	2.22	1.69	1.48	1.43	1.35	1.30	-10.2
16Mb	3.40	2.30	1.99	1.84	1.65	1.52	-14.8
32Mb	4.78	3.30	2.63	2.30	2.06	1.91	-16.8
64Mb	10.53	5.35	3.72	3.13	2.74	2.49	-25.0
128Mb	41.94	21.48	13.21	8.18	5.94	4.68	-35.5
256Mb	-	-	101.52	45.50	24.15	16.83	-
Total	**2.82**	**2.33**	**2.60**	**2.65**	**2.42**	**2.29**	**-4.0**
Growth (%)	**-31.7**	**-17.4**	**11.8**	**1.9**	**-8.6**	**-5.4**	**-**

Source: Dataquest (June 1998)

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Table 2-33
Asia/Pacific ROM Unit Shipment Forecast, 1997 to 2002 (Millions of Units Shipped)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
64K	0	-	-	-	-	-	-100.0
128K	0	-	-	-	-	-	-100.0
256K	0.8	0.3	0.2	0.1	0.1	0.1	-40.1
512K	0.6	0.1	0.1	0	0	0	-48.6
1Mb	4.1	2.3	0.8	0.4	0.1	0.1	-48.8
2Mb	7.0	4.3	2.7	1.6	0.4	0.4	-43.3
4Mb	21.2	23.2	23.1	23.9	23.9	23.7	2.3
8Mb	12.2	11.5	9.0	6.4	4.8	3.2	-23.3
16Mb	18.5	21.6	22.2	23.4	24.4	24.8	5.9
32Mb	5.7	7.3	8.1	9.0	10.7	12.0	15.9
64Mb	2.4	4.0	4.9	6.0	7.4	8.8	30.2
128Mb	0.3	1.0	2.0	3.2	4.7	6.3	87.1
256Mb	0	0.1	0.3	1.1	1.9	2.7	169.3
Total	**72.8**	**75.6**	**73.4**	**75.1**	**78.5**	**82.0**	**2.4**
Growth (%)	**4.6**	**3.9**	**-2.9**	**2.2**	**4.5**	**4.6**	**-**

Source: Dataquest (June 1998)

Table 2-34
Asia/Pacific ROM Megabyte Shipment Forecast, 1997 to 2002 (Millions of Megabytes Shipped)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
64K	0	-	-	-	-	-	-100.0
128K	0	-	-	-	-	-	-100.0
256K	0	0	0	0	0	0	-40.1
512K	0	0	0	0	0	0	-48.6
1Mb	0.5	0.3	0.1	0	0	0	-48.8
2Mb	1.8	1.1	0.7	0.4	0.1	0.1	-43.3
4Mb	10.6	11.6	11.5	11.9	11.9	11.8	2.3
8Mb	12.2	11.5	9.0	6.4	4.8	3.2	-23.3
16Mb	37.1	43.2	44.4	46.7	48.8	49.5	5.9
32Mb	22.9	29.2	32.5	36.1	42.8	47.9	15.9
64Mb	18.9	32.0	39.3	48.3	59.6	70.5	30.2
128Mb	4.4	16.7	32.5	51.6	75.2	100.4	87.1
256Mb	0.6	2.1	10.8	35.3	60.4	87.2	169.3
Total	**108.9**	**147.5**	**180.7**	**236.8**	**303.6**	**370.6**	**27.8**
Growth (%)	**13.2**	**35.5**	**22.5**	**31.0**	**28.2**	**22.0**	**-**

Source: Dataquest (June 1998)

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Table 2-35
Asia/Pacific ROM Price-per-Megabyte Forecast, 1997 to 2002 (U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
64K	87.69	-	-	-	-	-	-
128K	48.95	-	-	-	-	-	-
256K	28.04	27.48	26.93	26.39	25.86	25.35	-2.0
512K	15.93	15.61	15.30	15.00	14.70	14.40	-2.0
1Mb	8.24	8.07	7.91	7.75	7.60	7.45	-2.0
2Mb	5.34	4.72	4.54	4.25	4.08	3.97	-5.8
4Mb	3.44	2.70	2.49	2.39	2.24	2.15	-9.0
8Mb	2.22	1.69	1.48	1.43	1.35	1.30	-10.2
16Mb	1.70	1.15	1.00	0.92	0.82	0.76	-14.8
32Mb	1.20	0.83	0.66	0.58	0.51	0.48	-16.8
64Mb	1.32	0.67	0.47	0.39	0.34	0.31	-25.0
128Mb	2.62	1.34	0.83	0.51	0.37	0.29	-35.5
256Mb	-	-	3.17	1.42	0.75	0.53	-
Total	**1.88**	**1.19**	**1.06**	**0.84**	**0.63**	**0.51**	**-23.1**
Growth (%)	**-36.9**	**-36.6**	**-11.4**	**-20.5**	**-25.5**	**-18.9**	-

Source: Dataquest (June 1998)

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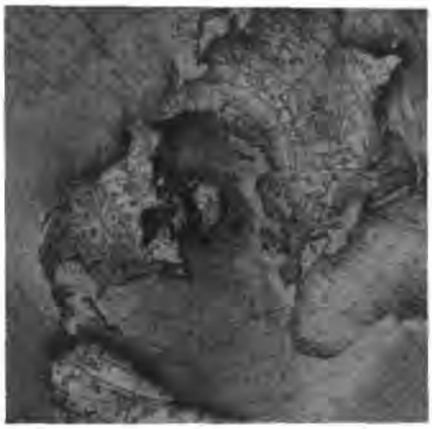

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Dataquest

Final 1997 Asia/Pacific Semiconductor Market Share

Market Statistics

Program: Semiconductors Asia/Pacific
Product Code: SEMI-AP-MS-9801
Publication Date: May 11, 1998
Filing: Market Statistics

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Chapter 1
Final 1997 Asia/Pacific Semiconductor Market Share

Introduction

This document contains detailed information on Dataquest's view of the semiconductor market. Included in this document are the following:

- 1995-1997 market share estimates
- 1996-1997 market share rankings

Asia/PacificAsia/Pacific market share estimates combine data from many countries, each of which has a different and fluctuating exchange rate. Estimates of non-U.S. market consumption or revenue are based on the average exchange rate for the given year. Refer to the section titled "Exchange Rates" for more information regarding these average rates. As a rule, Dataquest's estimates are calculated in local currencies and then converted to U.S. dollars.

More detailed data on this market may be requested through Dataquest's client inquiry service. Qualitative analysis of this data is provided in the Dataquest Perspectives.

Segmentation and Definitions

A detailed explanation of device segmentation and related definitions is contained in the Semiconductor Market Definitions Guide (SCND-WW-GU-9801).

Market Share Methodology

Dataquest uses both primary and secondary sources to produce market statistics data. In the fourth quarter of each year, Dataquest surveys all major participants within each industry. Selected companies are resurveyed during the first quarter of the following year to verify final annual results. This primary research is supplemented with additional primary research and secondary research to verify market size, shipment totals, and pricing information. Sources of data used by Dataquest include the following:

- Information published by major industry participants
- Estimates made by knowledgeable and reliable industry spokespersons
- Government data or trade association data (such as WSTS, MITI, and U.S. DOC)
- Published product literature and price lists
- Interviews with knowledgeable manufacturers, distributors, and users
- Relevant economic data
- Information and data from online and CD-ROM data banks
- Articles in both the general and trade press

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- Reports from financial analysts
- End-user surveys

Dataquest believes that the estimates presented in this document are the most accurate and meaningful statistics available.

Despite the care taken in gathering, analyzing, and categorizing the data in a meaningful way, careful attention must be paid to the definitions and assumptions used herein when interpreting the estimates presented in this document. Various companies, government agencies, and trade associations may use slightly different definitions of product categories and regional groupings, or they may include different companies in their summaries. These differences should be kept in mind when making comparisons between data and numbers provided by Dataquest and those provided by other sources.

Notes on Market Share

In the process of conducting data collection and preparing market statistics information, Dataquest will sometimes consolidate or revise a particular company, model, series, or industry's numbers. In this section, we explain any such changes contained within this document for your reference.

Notes to Market Share Tables

1. Cyrix was acquired by National Semiconductor in 1997.

2. National Semiconductor divested itself of Fairchild in 1997.

3. National Semiconductor's 1997 revenue includes all of Cyrix's 1997 revenue and part of Fairchild's calendar first quarter revenue.

4. Power Innovations was formed through the acquisition of the Power Semiconductor interests of Texas Instruments.

5. Melexis was formerly known as Elex.

6. Micronas acquired ITT in 1997.

7. The following companies were added to the market share database in 1997:

- Fairchild
- Vitesse
- TriQuint
- Power Innovations
- Robert Bosch
- Stanley

8. Toko is now tracked in other Japanese companies.

9. IBM's 1996 revenue was restated in 1997.

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Exchange Rates

Dataquest uses an average annual exchange rate in converting revenue to U.S. dollar amounts. Table 1-1 outlines these rates for 1995 through 1997.

Table 1-1
Exchange Rates

	1995	1996	1997
Japan (Yen/U.S.$)	93.90	108.81	121.10
France (Franc/U.S.$)	4.97	5.12	5.84
Germany (Deutsche Mark/U.S.$)	1.43	1.50	1.73
United Kingdom (U.S.$/Pound Sterling)	1.59	1.56	1.64

Source: Dataquest (April 1998)

Project Analyst: Kevin McClure

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Chapter 2
Market Share Tables

Tables 2-1 through 2-10 show each company's factory revenue by technology category. Tables 2-11 through 2-20 show the top companies' factory revenue by technology category.

Table 2-1
Each Company's Factory Revenue from Total Semiconductor Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**32,451**	**29,686**	**32,534**	**100.0**	**100.0**	**100.0**
Americas Companies	**10,874**	**11,506**	**14,076**	**33.5**	**38.8**	**43.3**
8x8	10	12	14	0	0	0
ACC Microelectronics	22	25	28	0	0	0
Actel	10	8	8	0	0	0
Adaptec	106	159	181	0.3	0.5	0.6
Advanced Micro Devices	447	268	470	1.4	0.9	1.4
Allegro MicroSystems	29	19	17	0	0	0
Alliance Semiconductor	62	32	30	0.2	0.1	0
Altera	24	33	38	0	0.1	0.1
Anadigics	0	0	28	0	0	0
Analog Devices	79	183	156	0.2	0.6	0.5
Appian Technology	1	1	1	0	0	0
Applied Micro Circuits Corp.	5	3	2	0	0	0
ATI Technologies	0	10	15	0	0	0
Atmel	90	209	292	0.3	0.7	0.9
Burr-Brown	17	9	8	0	0	0
C-Cube	0	42	48	0	0.1	0.1
California Micro Devices	5	5	0	0	0	0
Catalyst	9	12	20	0	0	0
Cherry Semiconductor	10	6	7	0	0	0
Chip Express	0	1	2	0	0	0
Chips & Technologies	45	53	31	0.1	0.2	0
Cirrus Logic	317	283	297	1.0	1.0	0.9
Cypress Semiconductor	37	35	53	0.1	0.1	0.2
Dallas Semiconductor	79	96	107	0.2	0.3	0.3
Digital	0	63	82	0	0.2	0.3
DSP Group	29	34	39	0	0.1	0.1
Elantec	0	5	3	0	0	0
Electronic Designs	0	3	0	0	0	0
ESS	0	0	148	0	0	0.5
ETEQ Microsystems	1	1	1	0	0	0

Table 2-1 (Continued)
Each Company's Factory Revenue from Total Semiconductor Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Exar	20	12	12	0	0	0
Fairchild	0	0	137	0	0	0.4
G-Link USA	6	7	20	0	0	0
General Semiconductor	138	118	128	0.4	0.4	0.4
GENNUM	1	1	1	0	0	0
Gould AMI	3	0	4	0	0	0
Harris Semiconductor	76	69	101	0.2	0.2	0.3
Hewlett-Packard	78	109	124	0.2	0.4	0.4
I.S.D.	0	0	11	0	0	0
IBM	512	333	248	1.6	1.1	0.8
IMI	17	19	18	0	0	0
IMP	3	0	0	0	0	0
Integrated Circuit Systems	47	34	43	0.1	0.1	0.1
Integrated Device Technology	64	41	39	0.2	0.1	0.1
Integrated Silicon Solutions	74	39	40	0.2	0.1	0.1
Intel	2,080	3,251	4,077	6.4	11.0	12.5
International CMOS Technology	1	1	0	0	0	0
International Rectifier	68	66	89	0.2	0.2	0.3
IXYS	6	5	5	0	0	0
Lattice	28	18	20	0	0	0
Level One Communications	16	25	31	0	0	0
Linear Technology	51	51	63	0.2	0.2	0.2
Linfinity	1	1	1	0	0	0
Logic Devices	1	1	1	0	0	0
LSI Logic	61	47	63	0.2	0.2	0.2
Lucent Technologies	246	355	632	0.8	1.2	1.9
Maxim	24	80	108	0	0.3	0.3
MICREL	3	3	0	0	0	0
Micro Linear	17	17	20	0	0	0
Microchip Technology	69	85	140	0.2	0.3	0.4
Micron Technology	335	123	130	1.0	0.4	0.4
Microsemi	5	8	9	0	0	0
Mitel	20	27	39	0	0	0.1
Motorola	1,582	1,424	1,682	4.9	4.8	5.2
National Semiconductor	561	559	709	1.7	1.9	2.2
Oak Technology	33	45	76	0.1	0.2	0.2
Optek	1	1	2	0	0	0
OPTI	70	52	52	0.2	0.2	0.2

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Table 2-1 (Continued)
Each Company's Factory Revenue from Total Semiconductor Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Paradigm	10	2	1	0	0	0
PMC Sierra Semiconductor	30	60	72	0	0.2	0.2
Q Logic	9	10	11	0	0	0
Quality Semiconductor	10	12	13	0	0	0
Quality Technologies	14	8	9	0	0	0
QuickLogic	0	2	2	0	0	0
Ramtron	14	0	0	0	0	0
Raytheon	5	5	5	0	0	0
Rockwell	66	133	155	0.2	0.4	0.5
S3	80	104	271	0.2	0.4	0.8
SEEQ Technology	0	5	6	0	0	0
Semtech	10	20	20	0	0	0
Silicon Storage Technology	25	48	39	0	0.2	0.1
Standard Microsystems	60	70	80	0.2	0.2	0.2
Sun Microsystems	0	10	75	0	0	0.2
Supertex	2	2	2	0	0	0
Symbios	36	47	42	0.1	0.2	0.1
Symphony Laboratories	14	16	18	0	0	0
Teccor Electronics	7	7	6	0	0	0
Telcom-	4	4	13	0	0	0
Texas Instruments	1,779	1,736	1,853	5.5	5.8	5.7
Trident Microsystems	82	95	74	0.3	0.3	0.2
Tseng Labs	23	8	7	0	0	0
Unitrode	23	29	36	0	0	0.1
Vitesse	0	0	6	0	0	0
VLSI Technology	135	87	32	0.4	0.3	0
VTC	113	115	90	0.3	0.4	0.3
WaferScale Integration	5	6	3	0	0	0
Xicor	3	4	5	0	0	0
Xilinx	21	23	37	0	0	0.1
Zilog	99	112	82	0.3	0.4	0.3
Zoran	0	8	10	0	0	0
Japanese Companies	**11,426**	**9,159**	**9,321**	**35.2**	**30.9**	**28.7**
Fuji Electric	140	120	118	0.4	0.4	0.4
Fujitsu	587	476	477	1.8	1.6	1.5
Hitachi	1,384	1,169	1,003	4.3	3.9	3.1
Matsushita	582	500	440	1.8	1.7	1.4
Mitsubishi	1,032	729	689	3.2	2.5	2.1

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Table 2-1 (Continued)
Each Company's Factory Revenue from Total Semiconductor Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
NEC	1,575	1,283	1,326	4.9	4.3	4.1
New JRC	70	64	86	0.2	0.2	0.3
Nippon Steel Semiconductor	202	92	82	0.6	0.3	0.3
OKI	376	168	150	1.2	0.6	0.5
Other Japanese	**120**	**218**	**163**	**0.4**	**0.7**	**0.5**
Ricoh	15	20	11	0	0	0
Rohm	509	471	826	1.6	1.6	2.5
Sanken	227	215	190	0.7	0.7	0.6
Sanyo	1,095	913	901	3.4	3.1	2.8
Seiko Epson	31	33	29	0	0.1	0
Sharp	527	406	433	1.6	1.4	1.3
Shindengen Electric	86	84	69	0.3	0.3	0.2
Sony	370	286	374	1.1	1.0	1.1
Stanley	94	0	93	0.3	0	0.3
Toshiba	2,209	1,804	1,807	6.8	6.1	5.6
Yamaha	159	78	54	0.5	0.3	0.2
European Companies	**2,848**	**3,379**	**3,622**	**8.8**	**11.4**	**11.1**
Alcatel Microelectronics	6	2	3	0	0	0
Austria Mikro Systeme	10	10	7	0	0	0
EM Microelectronics Marin	6	7	8	0	0	0
Ericsson	14	8	13	0	0	0
Eupec	7	20	0	0	0	0
Fagor	7	0	12	0	0	0
GEC Plessey	74	48	40	0.2	0.2	0.1
Micronas	0	0	42	0	0	0.1
Other European	10	11	6	0	0	0
Philips	1,120	1,471	1,580	3.5	5.0	4.9
Power Innovations	0	0	4	0	0	0
Robert Bosch	0	0	10	0	0	0
Semikron	18	16	17	0	0	0
SGS-Thomson	862	1,136	1,075	2.7	3.8	3.3
Siemens	528	454	551	1.6	1.5	1.7
TCS	0	0	12	0	0	0
TEMIC	176	186	214	0.5	0.6	0.7
Zetex	10	10	28	0	0	0

Table 2-1 (Continued)
Each Company's Factory Revenue from Total Semiconductor Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Asia/Pacific Companies	**7,303**	**5,642**	**5,515**	**22.5**	**19.0**	**17.0**
ACER	80	30	105	0.2	0.1	0.3
Daewoo	49	45	50	0.2	0.2	0.2
HOLTEK	82	93	112	0.3	0.3	0.3
Hualon Microelectronics Corp.	107	43	42	0.3	0.1	0.1
Hyundai	1,611	763	704	5.0	2.6	2.2
Korean Electronic Co.	243	228	255	0.7	0.8	0.8
LG Semicon	1,482	1,177	992	4.6	4.0	3.0
Macronix	93	111	126	0.3	0.4	0.4
Mosel Vitelic	197	241	174	0.6	0.8	0.5
Samsung	2,475	1,828	1,922	7.6	6.2	5.9
Silicon Integrated Systems	97	96	63	0.3	0.3	0.2
United Microelectronics	427	430	344	1.3	1.4	1.1
Vanguard	0	209	237	0	0.7	0.7
VIA	0	86	129	0	0.3	0.4
Winbond Electronics	360	262	260	1.1	0.9	0.8

Source: Dataquest (April 1998)

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Table 2-2
Each Company's Factory Revenue from Total Integrated Circuit Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**28,238**	**25,653**	**27,804**	**100.0**	**100.0**	**100.0**
Americas Companies	**10,125**	**10,848**	**13,317**	**35.9**	**42.3**	**47.9**
8x8	10	12	14	0	0	0
ACC Microelectronics	22	25	28	0	0	0.1
Actel	10	8	8	0	0	0
Adaptec	106	159	181	0.4	0.6	0.7
Advanced Micro Devices	447	268	470	1.6	1.0	1.7
Allegro MicroSystems	24	19	17	0	0	0
Alliance Semiconductor	62	32	30	0.2	0.1	0.1
Altera	24	33	38	0	0.1	0.1
Anadigics	0	0	28	0	0	0.1
Analog Devices	79	183	156	0.3	0.7	0.6
Appian Technology	1	1	1	0	0	0
Applied Micro Circuits Corp.	5	3	2	0	0	0
ATI Technologies	0	10	15	0	0	0
Atmel	90	209	292	0.3	0.8	1.1
Burr-Brown	17	9	8	0	0	0
C-Cube	0	42	48	0	0.2	0.2
California Micro Devices	5	5	0	0	0	0
Catalyst	9	12	20	0	0	0
Cherry Semiconductor	10	6	7	0	0	0
Chip Express	0	1	2	0	0	0
Chips & Technologies	45	53	31	0.2	0.2	0.1
Cirrus Logic	317	283	297	1.1	1.1	1.1
Cypress Semiconductor	37	35	53	0.1	0.1	0.2
Dallas Semiconductor	79	96	107	0.3	0.4	0.4
Digital	0	63	82	0	0.2	0.3
DSP Group	29	34	39	0.1	0.1	0.1
Elantec	0	5	3	0	0	0
Electronic Designs	0	3	0	0	0	0
ESS	0	0	148	0	0	0.5
ETEQ Microsystems	1	1	1	0	0	0
Exar	20	12	12	0	0	0
Fairchild	0	0	81	0	0	0.3
G-Link USA	6	7	20	0	0	0
GENNUM	1	1	1	0	0	0
Gould AMI	3	0	4	0	0	0
Harris Semiconductor	51	43	64	0.2	0.2	0.2

Table 2-2 (Continued)
Each Company's Factory Revenue from Total Integrated Circuit Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Hewlett-Packard	51	66	79	0.2	0.3	0.3
I.S.D.	0	0	11	0	0	0
IBM	512	333	248	1.8	1.3	0.9
IMI	17	19	18	0	0	0
IMP	3	0	0	0	0	0
Integrated Circuit Systems	47	34	43	0.2	0.1	0.2
Integrated Device Technology	64	41	39	0.2	0.2	0.1
Integrated Silicon Solutions	74	39	40	0.3	0.2	0.1
Intel	2,080	3,251	4,077	7.4	12.7	14.7
International CMOS Technology	1	1	0	0	0	0
International Rectifier	1	1	1	0	0	0
Lattice	28	18	20	0	0	0
Level One Communications	16	25	31	0	0	0.1
Linear Technology	51	51	63	0.2	0.2	0.2
Linfinity	1	1	1	0	0	0
Logic Devices	1	1	1	0	0	0
LSI Logic	61	47	63	0.2	0.2	0.2
Lucent Technologies	238	345	604	0.8	1.3	2.2
Maxim	24	80	108	0	0.3	0.4
MICREL	3	3	0	0	0	0
Micro Linear	17	17	20	0	0	0
Microchip Technology	69	85	140	0.2	0.3	0.5
Micron Technology	335	123	130	1.2	0.5	0.5
Mitel	20	27	39	0	0.1	0.1
Motorola	1,246	1,141	1,372	4.4	4.4	4.9
National Semiconductor	500	494	676	1.8	1.9	2.4
Oak Technology	33	45	76	0.1	0.2	0.3
OPTI	70	52	52	0.2	0.2	0.2
Paradigm	10	2	1	0	0	0
PMC Sierra Semiconductor	30	60	72	0.1	0.2	0.3
Q Logic	9	10	11	0	0	0
Quality Semiconductor	10	12	13	0	0	0
QuickLogic	0	2	2	0	0	0
Ramtron	14	0	0	0	0	0
Raytheon	5	5	5	0	0	0
Rockwell	66	133	155	0.2	0.5	0.6
S3	80	104	271	0.3	0.4	1.0
SEEQ Technology	0	5	6	0	0	0

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Table 2-2 (Continued)
Each Company's Factory Revenue from Total Integrated Circuit Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Semtech	10	19	17	0	0	0
Silicon Storage Technology	25	48	39	0	0.2	0.1
Standard Microsystems	60	70	80	0.2	0.3	0.3
Sun Microsystems	0	10	75	0	0	0.3
Supertex	2	2	2	0	0	0
Symbios	36	47	42	0.1	0.2	0.2
Symphony Laboratories	14	16	18	0	0	0
Telcom-	4	4	13	0	0	0
Texas Instruments	1,776	1,733	1,853	6.3	6.8	6.7
Trident Microsystems	82	95	74	0.3	0.4	0.3
Tseng Labs	23	8	7	0	0	0
Unitrode	23	29	36	0	0.1	0.1
Vitesse	0	0	6	0	0	0
VLSI Technology	135	87	32	0.5	0.3	0.1
VTC	113	115	90	0.4	0.4	0.3
WaferScale Integration	5	6	3	0	0	0
Xicor	3	4	5	0	0	0
Xilinx	21	23	37	0	0	0.1
Zilog	99	112	82	0.4	0.4	0.3
Zoran	0	8	10	0	0	0
Japanese Companies	**9,087**	**6,919**	**6,609**	**32.2**	**27.0**	**23.8**
Fuji Electric	25	22	19	0	0	0
Fujitsu	575	460	458	2.0	1.8	1.6
Hitachi	1,178	941	721	4.2	3.7	2.6
Matsushita	376	303	274	1.3	1.2	1.0
Mitsubishi	950	649	600	3.4	2.5	2.2
NEC	1,399	1,094	1,083	5.0	4.3	3.9
New JRC	67	60	86	0.2	0.2	0.3
Nippon Steel Semiconductor	202	92	82	0.7	0.4	0.3
OKI	376	168	150	1.3	0.7	0.5
Other Japanese	**64**	**69**	**82**	**0.2**	**0.3**	**0.3**
Ricoh	15	20	11	0	0	0
Rohm	233	212	380	0.8	0.8	1.4
Sanken	96	93	25	0.3	0.4	0
Sanyo	883	761	711	3.1	3.0	2.6
Seiko Epson	31	33	29	0.1	0.1	0.1
Sharp	396	276	260	1.4	1.1	0.9
Shindengen Electric	4	4	0	0	0	0

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Table 2-2 (Continued)
Each Company's Factory Revenue from Total Integrated Circuit Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Sony	328	245	321	1.2	1.0	1.2
Toshiba	1,719	1,330	1,263	6.1	5.2	4.5
Yamaha	159	78	54	0.6	0.3	0.2
European Companies	**2,199**	**2,688**	**2,876**	**7.8**	**10.5**	**10.3**
Alcatel Microelectronics	6	2	3	0	0	0
Austria Mikro Systeme	10	10	7	0	0	0
EM Microelectronics Marin	6	7	8	0	0	0
Ericsson	12	6	12	0	0	0
GEC Plessey	70	47	39	0.2	0.2	0.1
Micronas	0	0	30	0	0	0.1
Other European	5	5	0	0	0	0
Philips	849	1,180	1,285	3.0	4.6	4.6
Robert Bosch	0	0	7	0	0	0
SGS-Thomson	729	1,003	932	2.6	3.9	3.4
Siemens	462	375	459	1.6	1.5	1.7
TEMIC	50	53	93	0.2	0.2	0.3
Zetex	0	0	1	0	0	0
Asia/Pacific Companies	**6,827**	**5,198**	**5,002**	**24.2**	**20.3**	**18.0**
ACER	80	30	105	0.3	0.1	0.4
Daewoo	49	45	50	0.2	0.2	0.2
HOLTEK	82	93	112	0.3	0.4	0.4
Hualon Microelectronics Corp.	107	43	42	0.4	0.2	0.2
Hyundai	1,611	763	704	5.7	3.0	2.5
Korean Electronic Co.	40	44	49	0.1	0.2	0.2
LG Semicon	1,482	1,177	992	5.2	4.6	3.6
Macronix	93	111	126	0.3	0.4	0.5
Mosel Vitelic	197	241	174	0.7	0.9	0.6
Samsung	2,202	1,568	1,615	7.8	6.1	5.8
Silicon Integrated Systems	97	96	63	0.3	0.4	0.2
United Microelectronics	427	430	344	1.5	1.7	1.2
Vanguard	0	209	237	0	0.8	0.9
VIA	0	86	129	0	0.3	0.5
Winbond Electronics	360	262	260	1.3	1.0	0.9

Source: Dataquest (April 1998)

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Table 2-3
Each Company's Factory Revenue from Shipments of Bipolar Digital to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**321**	**236**	**184**	**100.0**	**100.0**	**100.0**
Americas Companies	**207**	**135**	**82**	**64.5**	**57.2**	**44.6**
Advanced Micro Devices	7	4	2	2.2	1.7	1.1
Applied Micro Circuits Corp.	2	1	0	0.6	0.4	0
Lucent Technologies	10	0	0	3.1	0	0
Motorola	46	31	29	14.3	13.1	15.8
National Semiconductor	63	45	1	19.6	19.1	0.5
Texas Instruments	79	54	50	24.6	22.9	27.2
Japanese Companies	**83**	**82**	**74**	**25.9**	**34.7**	**40.2**
Fujitsu	1	1	1	0.3	0.4	0.5
Hitachi	65	53	54	20.2	22.5	29.3
Matsushita	6	4	11	1.9	1.7	6.0
Mitsubishi	4	3	3	1.2	1.3	1.6
NEC	2	2	2	0.6	0.8	1.1
Toshiba	5	19	3	1.6	8.1	1.6
European Companies	**20**	**11**	**13**	**6.2**	**4.7**	**7.1**
Philips	16	11	13	5.0	4.7	7.1
SGS-Thomson	4	0	0	1.2	0	0
Asia/Pacific Companies	**11**	**8**	**15**	**3.4**	**3.4**	**8.2**
LG Semicon	11	8	7	3.4	3.4	3.8
Mosel Vitelic	0	0	8	0	0	4.3

Source: Dataquest (April 1998)

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Table 2-4
Each Company's Factory Revenue from MOS Digital IC Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**22,918**	**20,097**	**21,310**	**100.0**	**100.0**	**100.0**
Americas Companies	**8,304**	**8,841**	**10,811**	**36.2**	**44.0**	**50.7**
8x8	10	12	14	0	0	0
ACC Microelectronics	22	25	28	0	0.1	0.1
Actel	10	8	8	0	0	0
Adaptec	106	159	181	0.5	0.8	0.8
Advanced Micro Devices	402	243	423	1.8	1.2	2.0
Allegro MicroSystems	0	1	2	0	0	0
Alliance Semiconductor	62	32	30	0.3	0.2	0.1
Altera	24	33	38	0.1	0.2	0.2
Analog Devices	9	41	34	0	0.2	0.2
Appian Technology	1	1	1	0	0	0
Applied Micro Circuits Corp.	3	2	2	0	0	0
ATI Technologies	0	10	15	0	0	0
Atmel	88	209	292	0.4	1.0	1.4
C-Cube	0	42	48	0	0.2	0.2
California Micro Devices	2	2	0	0	0	0
Catalyst	9	12	20	0	0	0
Chip Express	0	1	2	0	0	0
Chips & Technologies	45	53	31	0.2	0.3	0.1
Cirrus Logic	297	258	216	1.3	1.3	1.0
Cypress Semiconductor	37	35	53	0.2	0.2	0.2
Dallas Semiconductor	79	80	87	0.3	0.4	0.4
Digital	0	63	82	0	0.3	0.4
DSP Group	29	34	39	0.1	0.2	0.2
Electronic Designs	0	3	0	0	0	0
ESS	0	0	145	0	0	0.7
ETEQ Microsystems	1	1	1	0	0	0
Exar	4	4	5	0	0	0
Fairchild	0	0	81	0	0	0.4
G-Link USA	6	7	20	0	0	0
Gould AMI	3	0	4	0	0	0
Harris Semiconductor	21	24	18	0	0.1	0
Hewlett-Packard	51	66	79	0.2	0.3	0.4
I.S.D.	0	0	11	0	0	0
IBM	512	333	248	2.2	1.7	1.2
IMI	15	19	18	0	0	0
IMP	1	0	0	0	0	0

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Table 2-4 (Continued)
Each Company's Factory Revenue from MOS Digital IC Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Integrated Circuit Systems	20	28	36	0	0.1	0.2
Integrated Device Technology	64	41	39	0.3	0.2	0.2
Integrated Silicon Solutions	74	39	40	0.3	0.2	0.2
Intel	2,071	3,251	4,077	9.0	16.2	19.1
International CMOS Technology	1	1	0	0	0	0
Lattice	28	18	20	0.1	0	0
Logic Devices	1	1	1	0	0	0
LSI Logic	61	47	63	0.3	0.2	0.3
Lucent Technologies	173	325	594	0.8	1.6	2.8
MICREL	1	1	0	0	0	0
Micro Linear	0	1	3	0	0	0
Microchip Technology	69	85	140	0.3	0.4	0.7
Micron Technology	335	123	130	1.5	0.6	0.6
Motorola	922	783	947	4.0	3.9	4.4
National Semiconductor	169	207	281	0.7	1.0	1.3
Oak Technology	33	45	76	0.1	0.2	0.4
OPTI	70	52	52	0.3	0.3	0.2
Paradigm	10	2	1	0	0	0
PMC Sierra Semiconductor	11	26	30	0	0.1	0.1
Q Logic	9	10	11	0	0	0
Quality Semiconductor	10	12	13	0	0	0
QuickLogic	0	2	2	0	0	0
Ramtron	14	0	0	0	0	0
Raytheon	0	0	1	0	0	0
Rockwell	66	122	141	0.3	0.6	0.7
S3	80	104	271	0.3	0.5	1.3
SEEQ Technology	0	1	4	0	0	0
Silicon Storage Technology	25	48	39	0.1	0.2	0.2
Standard Microsystems	60	70	80	0.3	0.3	0.4
Sun Microsystems	0	10	75	0	0	0.4
Symbios	20	47	42	0	0.2	0.2
Symphony Laboratories	14	16	18	0	0	0
Texas Instruments	1,514	1,105	1,055	6.6	5.5	5.0
Trident Microsystems	82	95	74	0.4	0.5	0.3
Tseng Labs	23	8	7	0.1	0	0
Vitesse	0	0	3	0	0	0
VLSI Technology	135	87	32	0.6	0.4	0.2
WaferScale Integration	5	6	3	0	0	0

Table 2-4 (Continued)
Each Company's Factory Revenue from MOS Digital IC Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Xicor	3	4	5	0	0	0
Xilinx	21	23	37	0	0.1	0.2
Zilog	99	112	82	0.4	0.6	0.4
Zoran	0	8	10	0	0	0
Japanese Companies	**7,098**	**5,081**	**4,626**	**31.0**	**25.3**	**21.7**
Fuji Electric	12	11	11	0	0	0
Fujitsu	551	440	440	2.4	2.2	2.1
Hitachi	1,026	787	540	4.5	3.9	2.5
Matsushita	205	158	134	0.9	0.8	0.6
Mitsubishi	812	533	491	3.5	2.7	2.3
NEC	1,259	951	935	5.5	4.7	4.4
New JRC	12	12	12	0	0	0
Nippon Steel Semiconductor	202	92	82	0.9	0.5	0.4
OKI	375	167	149	1.6	0.8	0.7
Other Japanese	**47**	**45**	**46**	**0.2**	**0.2**	**0.2**
Ricoh	12	9	3	0	0	0
Rohm	106	101	153	0.5	0.5	0.7
Sanyo	407	338	309	1.8	1.7	1.5
Seiko Epson	28	29	25	0.1	0.1	0.1
Sharp	366	249	228	1.6	1.2	1.1
Sony	207	146	197	0.9	0.7	0.9
Toshiba	1,328	938	818	5.8	4.7	3.8
Yamaha	143	75	53	0.6	0.4	0.2
European Companies	**1,054**	**1,353**	**1,372**	**4.6**	**6.7**	**6.4**
Alcatel Microelectronics	1	2	3	0	0	0
Austria Mikro Systeme	6	7	4	0	0	0
EM Microelectronics Marin	0	3	6	0	0	0
GEC Plessey	24	39	17	0.1	0.2	0
Micronas	0	0	28	0	0	0.1
Philips	380	655	660	1.7	3.3	3.1
SGS-Thomson	218	312	250	1.0	1.6	1.2
Siemens	404	311	380	1.8	1.5	1.8
TEMIC	21	24	24	0	0.1	0.1
Asia/Pacific Companies	**6,462**	**4,822**	**4,501**	**28.2**	**24.0**	**21.1**
ACER	80	30	105	0.3	0.1	0.5
Daewoo	27	21	21	0.1	0.1	0
HOLTEK	82	93	112	0.4	0.5	0.5
Hualon Microelectronics Corp.	98	39	37	0.4	0.2	0.2

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Table 2-4 (Continued)
Each Company's Factory Revenue from MOS Digital IC Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Hyundai	1,609	762	701	7.0	3.8	3.3
LG Semicon	1,431	1,132	940	6.2	5.6	4.4
Macronix	93	111	126	0.4	0.6	0.6
Mosel Vitelic	197	241	166	0.9	1.2	0.8
Samsung	2,006	1,360	1,321	8.8	6.8	6.2
Silicon Integrated Systems	97	96	63	0.4	0.5	0.3
United Microelectronics	427	430	344	1.9	2.1	1.6
Vanguard	0	209	237	0	1.0	1.1
VIA	0	86	129	0	0.4	0.6
Winbond Electronics	315	212	199	1.4	1.1	0.9

Source: Dataquest (April 1998)

Table 2-5
Each Company's Factory Revenue from MOS Memory Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**12,565**	**8,017**	**6,516**	**100.0**	**100.0**	**100.0**
Americas Companies	**2,387**	**1,505**	**1,370**	**19.0**	**18.8**	**21.0**
Advanced Micro Devices	80	70	93	0.6	0.9	1.4
Alliance Semiconductor	59	30	28	0.5	0.4	0.4
Atmel	68	179	238	0.5	2.2	3.7
Catalyst	9	12	20	0	0.1	0.3
Cypress Semiconductor	31	27	33	0.2	0.3	0.5
Dallas Semiconductor	21	0	0	0.2	0	0
Electronic Designs	0	3	0	0	0	0
Fairchild	0	0	25	0	0	0.4
G-Link USA	6	7	20	0	0	0.3
Harris Semiconductor	1	0	0	0	0	0
IBM	128	34	50	1.0	0.4	0.8
Integrated Device Technology	47	26	30	0.4	0.3	0.5
Integrated Silicon Solutions	74	39	40	0.6	0.5	0.6
Intel	101	163	183	0.8	2.0	2.8
Microchip Technology	23	37	64	0.2	0.5	1.0
Micron Technology	335	123	130	2.7	1.5	2.0
Motorola	223	95	50	1.8	1.2	0.8
National Semiconductor	32	39	0	0.3	0.5	0
Paradigm	10	2	1	0	0	0
Ramtron	14	0	0	0.1	0	0
Silicon Storage Technology	25	48	39	0.2	0.6	0.6
Texas Instruments	1,093	566	321	8.7	7.1	4.9
WaferScale Integration	2	1	0	0	0	0
Xicor	3	4	5	0	0	0
Japanese Companies	**4,264**	**2,478**	**1,717**	**33.9**	**30.9**	**26.4**
Fujitsu	426	311	279	3.4	3.9	4.3
Hitachi	745	468	194	5.9	5.8	3.0
Matsushita	62	37	59	0.5	0.5	0.9
Mitsubishi	604	344	305	4.8	4.3	4.7
NEC	877	541	432	7.0	6.7	6.6
Nippon Steel Semiconductor	202	92	82	1.6	1.1	1.3
OKI	249	60	41	2.0	0.7	0.6
Other Japanese	**9**	**11**	**12**	**0**	**0.1**	**0.2**
Rohm	12	11	10	0	0.1	0.2
Sanyo	95	57	32	0.8	0.7	0.5
Seiko Epson	6	3	3	0	0	0

Table 2-5 (Continued)
Each Company's Factory Revenue from MOS Memory Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Sharp	171	108	87	1.4	1.3	1.3
Sony	74	33	27	0.6	0.4	0.4
Toshiba	732	402	154	5.8	5.0	2.4
European Companies	**491**	**405**	**460**	**3.9**	**5.1**	**7.1**
Philips	0	0	6	0	0	0
SGS-Thomson	97	107	102	0.8	1.3	1.6
Siemens	394	298	352	3.1	3.7	5.4
Asia/Pacific Companies	**5,423**	**3,629**	**2,969**	**43.2**	**45.3**	**45.6**
HOLTEK	0	2	5	0	0	0
Hualon Microelectronics Corp.	54	21	18	0.4	0.3	0.3
Hyundai	1,600	755	697	12.7	9.4	10.7
LG Semicon	1,283	979	731	10.2	12.2	11.2
Macronix	62	76	95	0.5	0.9	1.5
Mosel Vitelic	197	241	166	1.6	3.0	2.5
Samsung	1,803	1,074	892	14.3	13.4	13.7
United Microelectronics	167	141	18	1.3	1.8	0.3
Vanguard	0	209	237	0	2.6	3.6
Winbond Electronics	257	131	110	2.0	1.6	1.7

Source: Dataquest (April 1998)

Table 2-6
Each Company's Factory Revenue from MOS Microcomponent Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	7,253	8,744	10,885	100.0	100.0	100.0
Americas Companies	4,839	6,105	7,843	66.7	69.8	72.1
8x8	10	12	14	0.1	0.1	0.1
ACC Microelectronics	22	25	28	0.3	0.3	0.3
Adaptec	106	159	181	1.5	1.8	1.7
Advanced Micro Devices	271	122	284	3.7	1.4	2.6
Alliance Semiconductor	3	2	2	0	0	0
Analog Devices	9	39	32	0.1	0.4	0.3
Appian Technology	1	1	1	0	0	0
ATI Technologies	0	10	15	0	0.1	0.1
Atmel	15	19	29	0.2	0.2	0.3
C-Cube	0	42	48	0	0.5	0.4
California Micro Devices	2	2	0	0	0	0
Chips & Technologies	45	53	31	0.6	0.6	0.3
Cirrus Logic	297	258	216	4.1	3.0	2.0
Cypress Semiconductor	3	3	0	0	0	0
Dallas Semiconductor	14	40	44	0.2	0.5	0.4
Digital	0	63	82	0	0.7	0.8
DSP Group	29	34	39	0.4	0.4	0.4
ESS	0	0	145	0	0	1.3
Harris Semiconductor	6	4	3	0	0	0
IBM	280	216	145	3.9	2.5	1.3
Integrated Device Technology	6	1	0	0	0	0
Intel	1,970	3,088	3,894	27.2	35.3	35.8
LSI Logic	9	9	9	0.1	0.1	0
Lucent Technologies	43	125	225	0.6	1.4	2.1
Microchip Technology	46	48	76	0.6	0.5	0.7
Motorola	557	558	685	7.7	6.4	6.3
National Semiconductor	111	136	277	1.5	1.6	2.5
Oak Technology	33	45	76	0.5	0.5	0.7
OPTI	70	52	52	1.0	0.6	0.5
PMC Sierra Semiconductor	11	23	26	0.2	0.3	0.2
Q Logic	9	10	11	0.1	0.1	0.1
Rockwell	66	122	141	0.9	1.4	1.3
S3	80	104	271	1.1	1.2	2.5
SEEQ Technology	0	1	4	0	0	0
Standard Microsystems	60	70	80	0.8	0.8	0.7
Sun Microsystems	0	10	75	0	0.1	0.7

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Table 2-6 (Continued)
Each Company's Factory Revenue from MOS Microcomponent Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Symbios	5	7	9	0	0	0
Symphony Laboratories	14	16	18	0.2	0.2	0.2
Texas Instruments	228	291	382	3.1	3.3	3.5
Trident Microsystems	82	95	74	1.1	1.1	0.7
Tseng Labs	23	8	7	0.3	0	0
VLSI Technology	58	20	17	0.8	0.2	0.2
WaferScale Integration	3	5	3	0	0	0
Zilog	99	112	82	1.4	1.3	0.8
Zoran	0	8	10	0	0	0
Japanese Companies	**1,450**	**1,333**	**1,534**	**20.0**	**15.2**	**14.1**
Fujitsu	61	63	75	0.8	0.7	0.7
Hitachi	209	237	303	2.9	2.7	2.8
Matsushita	43	43	33	0.6	0.5	0.3
Mitsubishi	196	179	173	2.7	2.0	1.6
NEC	242	254	307	3.3	2.9	2.8
New JRC	2	2	2	0	0	0
OKI	57	44	27	0.8	0.5	0.2
Ricoh	12	9	3	0.2	0.1	0
Rohm	14	15	6	0.2	0.2	0
Sanyo	98	78	85	1.4	0.9	0.8
Seiko Epson	6	4	4	0	0	0
Sharp	55	46	53	0.8	0.5	0.5
Sony	41	30	28	0.6	0.3	0.3
Toshiba	306	301	395	4.2	3.4	3.6
Yamaha	108	28	40	1.5	0.3	0.4
European Companies	**260**	**517**	**415**	**3.6**	**5.9**	**3.8**
GEC Plessey	1	1	0	0	0	0
Micronas	0	0	2	0	0	0
Philips	152	386	286	2.1	4.4	2.6
SGS-Thomson	78	95	80	1.1	1.1	0.7
Siemens	10	13	28	0.1	0.1	0.3
TEMIC	19	22	19	0.3	0.3	0.2
Asia/Pacific Companies	**704**	**789**	**1,093**	**9.7**	**9.0**	**10.0**
ACER	77	30	105	1.1	0.3	1.0
Daewoo	23	18	18	0.3	0.2	0.2
HOLTEK	32	42	23	0.4	0.5	0.2
Hyundai	1	1	1	0	0	0
LG Semicon	56	59	107	0.8	0.7	1.0

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Table 2-6 (Continued)
Each Company's Factory Revenue from MOS Microcomponent Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Macronix	31	12	28	0.4	0.1	0.3
Samsung	71	79	207	1.0	0.9	1.9
Silicon Integrated Systems	97	96	63	1.3	1.1	0.6
United Microelectronics	260	289	326	3.6	3.3	3.0
VIA	0	86	129	0	1.0	1.2
Winbond Electronics	56	77	86	0.8	0.9	0.8

Source: Dataquest (April 1998)

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Table 2-7
Each Company's Factory Revenue from MOS Digital Logic Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**3,100**	**3,336**	**3,909**	**100.0**	**100.0**	**100.0**
Americas Companies	**1,078**	**1,231**	**1,598**	**34.8**	**36.9**	**40.9**
Actel	10	8	8	0.3	0.2	0.2
Advanced Micro Devices	51	51	46	1.6	1.5	1.2
Allegro MicroSystems	0	1	2	0	0	0
Altera	24	33	38	0.8	1.0	1.0
Analog Devices	0	2	2	0	0	0
Applied Micro Circuits Corp.	3	2	2	0	0	0
Atmel	5	11	25	0.2	0.3	0.6
Chip Express	0	1	2	0	0	0
Cypress Semiconductor	3	5	20	0	0.1	0.5
Dallas Semiconductor	44	40	43	1.4	1.2	1.1
ETEQ Microsystems	1	1	1	0	0	0
Exar	4	4	5	0.1	0.1	0.1
Fairchild	0	0	56	0	0	1.4
Gould AMI	3	0	4	0	0	0.1
Harris Semiconductor	14	20	15	0.5	0.6	0.4
Hewlett-Packard	51	66	79	1.6	2.0	2.0
I.S.D.	0	0	11	0	0	0.3
IBM	104	83	53	3.4	2.5	1.4
IMI	15	19	18	0.5	0.6	0.5
IMP	1	0	0	0	0	0
Integrated Circuit Systems	20	28	36	0.6	0.8	0.9
Integrated Device Technology	11	14	9	0.4	0.4	0.2
International CMOS Technology	1	1	0	0	0	0
Lattice	28	18	20	0.9	0.5	0.5
Logic Devices	1	1	1	0	0	0
LSI Logic	52	38	54	1.7	1.1	1.4
Lucent Technologies	130	200	369	4.2	6.0	9.4
MICREL	1	1	0	0	0	0
Micro Linear	0	1	3	0	0	0
Motorola	142	130	212	4.6	3.9	5.4
National Semiconductor	26	32	4	0.8	1.0	0.1
PMC Sierra Semiconductor	0	3	4	0	0	0.1
Quality Semiconductor	10	12	13	0.3	0.4	0.3
QuickLogic	0	2	2	0	0	0
Raytheon	0	0	1	0	0	0
Symbios	15	40	33	0.5	1.2	0.8
Texas Instruments	193	248	352	6.2	7.4	9.0

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Table 2-7 (Continued)
Each Company's Factory Revenue from MOS Digital Logic Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Vitesse	0	0	3	0	0	0
VLSI Technology	77	67	15	2.5	2.0	0.4
Xilinx	21	23	37	0.7	0.7	0.9
Japanese Companies	**1,384**	**1,270**	**1,375**	**44.6**	**38.1**	**35.2**
Fuji Electric	12	11	11	0.4	0.3	0.3
Fujitsu	64	66	86	2.1	2.0	2.2
Hitachi	72	82	43	2.3	2.5	1.1
Matsushita	100	78	42	3.2	2.3	1.1
Mitsubishi	12	10	13	0.4	0.3	0.3
NEC	140	156	196	4.5	4.7	5.0
New JRC	10	10	10	0.3	0.3	0.3
OKI	69	63	81	2.2	1.9	2.1
Other Japanese	**38**	**34**	**34**	**1.2**	**1.0**	**0.9**
Rohm	80	75	137	2.6	2.2	3.5
Sanyo	214	203	192	6.9	6.1	4.9
Seiko Epson	16	22	18	0.5	0.7	0.5
Sharp	140	95	88	4.5	2.8	2.3
Sony	92	83	142	3.0	2.5	3.6
Toshiba	290	235	269	9.4	7.0	6.9
Yamaha	35	47	13	1.1	1.4	0.3
European Companies	**303**	**431**	**497**	**9.8**	**12.9**	**12.7**
Alcatel Microelectronics	1	2	3	0	0	0
Austria Mikro Systeme	6	7	4	0.2	0.2	0.1
EM Microelectronics Marin	0	3	6	0	0	0.2
GEC Plessey	23	38	17	0.7	1.1	0.4
Micronas	0	0	26	0	0	0.7
Philips	228	269	368	7.4	8.1	9.4
SGS-Thomson	43	110	68	1.4	3.3	1.7
TEMIC	2	2	5	0	0	0.1
Asia/Pacific Companies	**335**	**404**	**439**	**10.8**	**12.1**	**11.2**
ACER	3	0	0	0	0	0
Daewoo	4	3	3	0.1	0	0
HOLTEK	50	49	84	1.6	1.5	2.1
Hualon Microelectronics Corp.	44	18	19	1.4	0.5	0.5
Hyundai	8	6	3	0.3	0.2	0
LG Semicon	92	94	102	3.0	2.8	2.6
Macronix	0	23	3	0	0.7	0
Samsung	132	207	222	4.3	6.2	5.7
Winbond Electronics	2	4	3	0	0.1	0

Source: Dataquest (April 1998)

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Table 2-8
Each Company's Factory Revenue from Analog-Monolithic Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**4,743**	**5,085**	**6,310**	**100.0**	**100.0**	**100.0**
Americas Companies	**1,599**	**1,859**	**2,424**	**33.7**	**36.6**	**38.4**
Advanced Micro Devices	38	21	45	0.8	0.4	0.7
Allegro MicroSystems	24	18	15	0.5	0.4	0.2
Anadigics	0	0	28	0	0	0.4
Analog Devices	64	136	122	1.3	2.7	1.9
Atmel	2	0	0	0	0	0
Burr-Brown	17	7	8	0.4	0.1	0.1
California Micro Devices	3	3	0	0	0	0
Cherry Semiconductor	10	6	7	0.2	0.1	0.1
Cirrus Logic	20	25	81	0.4	0.5	1.3
Dallas Semiconductor	0	16	20	0	0.3	0.3
Elantec	0	5	3	0	0	0
ESS	0	0	3	0	0	0
Exar	16	8	7	0.3	0.2	0.1
GENNUM	1	1	1	0	0	0
Harris Semiconductor	30	19	46	0.6	0.4	0.7
IMI	2	0	0	0	0	0
IMP	2	0	0	0	0	0
Integrated Circuit Systems	27	6	7	0.6	0.1	0.1
Intel	9	0	0	0.2	0	0
International Rectifier	1	1	1	0	0	0
Level One Communications	16	25	31	0.3	0.5	0.5
Linear Technology	51	51	63	1.1	1.0	1.0
Linfinity	1	1	1	0	0	0
Lucent Technologies	55	20	10	1.2	0.4	0.2
Maxim	24	80	108	0.5	1.6	1.7
MICREL	2	2	0	0	0	0
Micro Linear	17	16	17	0.4	0.3	0.3
Mitel	12	23	39	0.3	0.5	0.6
Motorola	278	327	396	5.9	6.4	6.3
National Semiconductor	268	242	394	5.7	4.8	6.2
PMC Sierra Semiconductor	19	34	42	0.4	0.7	0.7
Raytheon	5	5	4	0.1	0	0
Rockwell	0	11	14	0	0.2	0.2
SEEQ Technology	0	4	2	0	0	0
Semtech	10	19	17	0.2	0.4	0.3
Supertex	2	2	2	0	0	0

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Table 2-8 (Continued)
Each Company's Factory Revenue from Analog-Monolithic Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Symbios	16	0	0	0.3	0	0
Telcom-	4	4	13	0	0	0.2
Texas Instruments	183	574	748	3.9	11.3	11.9
Unitrode	23	29	36	0.5	0.6	0.6
Vitesse	0	0	3	0	0	0
VTC	113	115	90	2.4	2.3	1.4
Japanese Companies	**1,688**	**1,548**	**1,909**	**35.6**	**30.4**	**30.3**
Fuji Electric	10	8	8	0.2	0.2	0.1
Fujitsu	16	13	17	0.3	0.3	0.3
Hitachi	77	92	127	1.6	1.8	2.0
Matsushita	165	141	129	3.5	2.8	2.0
Mitsubishi	133	112	106	2.8	2.2	1.7
NEC	137	140	146	2.9	2.8	2.3
New JRC	55	48	74	1.2	0.9	1.2
OKI	1	1	1	0	0	0
Other Japanese	**13**	**19**	**36**	**0.3**	**0.4**	**0.6**
Ricoh	3	11	8	0	0.2	0.1
Rohm	113	98	227	2.4	1.9	3.6
Sanken	0	0	25	0	0	0.4
Sanyo	410	361	402	8.6	7.1	6.4
Seiko Epson	3	4	4	0	0	0
Sharp	30	27	32	0.6	0.5	0.5
Sony	110	89	124	2.3	1.8	2.0
Toshiba	386	373	442	8.1	7.3	7.0
Yamaha	16	3	1	0.3	0	0
European Companies	**1,102**	**1,310**	**1,491**	**23.2**	**25.8**	**23.6**
Alcatel Microelectronics	5	0	0	0.1	0	0
Austria Mikro Systeme	4	3	3	0	0	0
EM Microelectronics Marin	6	4	2	0.1	0	0
Ericsson	2	4	12	0	0	0.2
GEC Plessey	46	8	22	1.0	0.2	0.3
Micronas	0	0	2	0	0	0
Philips	445	507	612	9.4	10.0	9.7
Robert Bosch	0	0	7	0	0	0.1
SGS-Thomson	507	691	682	10.7	13.6	10.8
Siemens	58	64	79	1.2	1.3	1.3
TEMIC	29	29	69	0.6	0.6	1.1
Zetex	0	0	1	0	0	0

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Table 2-8 (Continued)
Each Company's Factory Revenue from Analog-Monolithic Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Asia/Pacific Companies	**354**	**368**	**486**	**7.5**	**7.2**	**7.7**
Daewoo	22	24	29	0.5	0.5	0.5
Hualon Microelectronics Corp.	9	4	5	0.2	0	0
Hyundai	2	1	3	0	0	0
Korean Electronic Co.	40	44	49	0.8	0.9	0.8
LG Semicon	40	37	45	0.8	0.7	0.7
Samsung	196	208	294	4.1	4.1	4.7
Winbond Electronics	45	50	61	0.9	1.0	1.0

Source: Dataquest (April 1998)

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Table 2-9
Each Company's Factory Revenue from Total Discrete Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**3,475**	**3,294**	**3,817**	**100.0**	**100.0**	**100.0**
Americas Companies	**700**	**600**	**680**	**20.1**	**18.2**	**17.8**
Allegro MicroSystems	5	0	0	0.1	0	0
Fairchild	0	0	56	0	0	1.5
General Semiconductor	138	118	128	4.0	3.6	3.4
Harris Semiconductor	25	26	37	0.7	0.8	1.0
Hewlett-Packard	17	16	18	0.5	0.5	0.5
International Rectifier	67	65	88	1.9	2.0	2.3
IXYS	6	5	5	0.2	0.2	0.1
Microsemi	5	8	9	0.1	0.2	0.2
Motorola	321	271	297	9.2	8.2	7.8
National Semiconductor	61	65	33	1.8	2.0	0.9
Semtech	0	1	3	0	0	0
Teccor Electronics	7	7	6	0.2	0.2	0.2
Texas Instruments	2	3	0	0	0	0
Japanese Companies	**1,723**	**1,643**	**1,974**	**49.6**	**49.9**	**51.7**
Fuji Electric	115	98	99	3.3	3.0	2.6
Fujitsu	10	14	17	0.3	0.4	0.4
Hitachi	189	203	252	5.4	6.2	6.6
Matsushita	155	151	154	4.5	4.6	4.0
Mitsubishi	64	64	70	1.8	1.9	1.8
NEC	147	154	151	4.2	4.7	4.0
Other Japanese	**10**	**11**	**38**	**0.3**	**0.3**	**1.0**
Rohm	212	193	335	6.1	5.9	8.8
Sanken	129	120	161	3.7	3.6	4.2
Sanyo	179	136	165	5.2	4.1	4.3
Shindengen Electric	82	80	69	2.4	2.4	1.8
Sony	10	8	9	0.3	0.2	0.2
Toshiba	396	390	454	11.4	11.8	11.9
European Companies	**598**	**634**	**677**	**17.2**	**19.2**	**17.7**
Eupec	7	20	0	0.2	0.6	0
Fagor	7	0	12	0.2	0	0.3
GEC Plessey	4	1	1	0.1	0	0
Micronas	0	0	12	0	0	0.3
Other European	3	4	4	0	0.1	0.1
Philips	271	291	295	7.8	8.8	7.7
Power Innovations	0	0	4	0	0	0.1
Robert Bosch	0	0	3	0	0	0

Table 2-9 (Continued)
Each Company's Factory Revenue from Total Discrete Shipments to Asia/Pacific
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Semikron	18	16	17	0.5	0.5	0.4
SGS-Thomson	133	133	143	3.8	4.0	3.7
Siemens	39	44	56	1.1	1.3	1.5
TCS	0	0	12	0	0	0.3
TEMIC	106	115	91	3.1	3.5	2.4
Zetex	10	10	27	0.3	0.3	0.7
Asia/Pacific Companies	**454**	**417**	**486**	**13.1**	**12.7**	**12.7**
Korean Electronic Co.	185	165	191	5.3	5.0	5.0
Samsung	269	252	295	7.7	7.7	7.7

Source: Dataquest (April 1998)

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Table 2-10
Each Company's Factory Revenue from Total Optical Semiconductor Shipments to Asia/Pacific (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**738**	**739**	**913**	**100.0**	**100.0**	**100.0**
Americas Companies	**49**	**58**	**79**	**6.6**	**7.8**	**8.7**
Hewlett-Packard	10	27	27	1.4	3.7	3.0
Lucent Technologies	8	10	28	1.1	1.4	3.1
Motorola	15	12	13	2.0	1.6	1.4
Optek	1	1	2	0.1	0.1	0.2
Quality Technologies	14	8	9	1.9	1.1	1.0
Texas Instruments	1	0	0	0.1	0	0
Japanese Companies	**616**	**597**	**738**	**83.5**	**80.8**	**80.8**
Fujitsu	2	2	2	0.3	0.3	0.2
Hitachi	17	25	30	2.3	3.4	3.3
Matsushita	51	46	12	6.9	6.2	1.3
Mitsubishi	18	16	19	2.4	2.2	2.1
NEC	29	35	92	3.9	4.7	10.1
New JRC	3	4	0	0.4	0.5	0
Other Japanese	**46**	**138**	**43**	**6.2**	**18.7**	**4.7**
Rohm	64	66	111	8.7	8.9	12.2
Sanken	2	2	4	0.3	0.3	0.4
Sanyo	33	16	25	4.5	2.2	2.7
Sharp	131	130	173	17.8	17.6	18.9
Sony	32	33	44	4.3	4.5	4.8
Stanley	94	0	93	12.7	0	10.2
Toshiba	94	84	90	12.7	11.4	9.9
European Companies	**51**	**57**	**69**	**6.9**	**7.7**	**7.6**
Ericsson	2	2	1	0.3	0.3	0.1
Other European	2	2	2	0.3	0.3	0.2
Siemens	27	35	36	3.7	4.7	3.9
TEMIC	20	18	30	2.7	2.4	3.3
Asia/Pacific Companies	**22**	**27**	**27**	**3.0**	**3.7**	**3.0**
Korean Electronic Co.	18	19	15	2.4	2.6	1.6
Samsung	4	8	12	0.5	1.1	1.3

Source: Dataquest (April 1998)

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Table 2-11
Top 40 Worldwide Companies Factory Revenue from Total Semiconductor Shipments to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Intel	3,251	4,077	25.4	12.5
2	2	Samsung	1,828	1,922	5.1	5.9
4	3	Texas Instruments	1,736	1,853	6.7	5.7
3	4	Toshiba	1,804	1,807	0.2	5.6
6	5	Motorola	1,424	1,682	18.1	5.2
5	6	Philips	1,471	1,580	7.4	4.9
7	7	NEC	1,283	1,326	3.4	4.1
10	8	SGS-Thomson	1,136	1,075	-5.4	3.3
9	9	Hitachi	1,169	1,003	-14.2	3.1
8	10	LG Semicon	1,177	992	-15.7	3.0
11	11	Sanyo	913	901	-1.3	2.8
17	12	Rohm	471	826	75.4	2.5
14	13	National Semiconductor	559	709	26.8	2.2
12	14	Hyundai	763	704	-7.7	2.2
13	15	Mitsubishi	729	689	-5.5	2.1
21	16	Lucent Technologies	355	632	78.0	1.9
18	17	Siemens	454	551	21.4	1.7
16	18	Fujitsu	476	477	0.2	1.5
25	19	Advanced Micro Devices	268	470	75.4	1.4
15	20	Matsushita	500	440	-12.0	1.4
20	21	Sharp	406	433	6.7	1.3
23	22	Sony	286	374	30.8	1.1
19	23	United Microelectronics	430	344	-20.0	1.1
24	24	Cirrus Logic	283	297	4.9	0.9
30	25	Atmel	209	292	39.7	0.9
44	26	S3	104	271	160.6	0.8
26	27	Winbond Electronics	262	260	-0.8	0.8
28	28	Korean Electronic Co.	228	255	11.8	0.8
22	29	IBM	333	248	-25.5	0.8
31	30	Vanguard	209	237	13.4	0.7
32	31	TEMIC	186	214	15.1	0.7
29	32	Sanken	215	190	-11.6	0.6
35	33	Adaptec	159	181	13.8	0.6
27	34	Mosel Vitelic	241	174	-27.8	0.5
33	35	Analog Devices	183	156	-14.8	0.5
36	36	Rockwell	133	155	16.5	0.5
34	37	OKI	168	150	-10.7	0.5

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Table 2-11 (Continued)
Top 40 Worldwide Companies Factory Revenue from Total Semiconductor Shipments to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
NA	38	ESS	0	148	NA	0.5
52	39	Microchip Technology	85	140	64.7	0.4
NA	40	Fairchild	0	137	NA	0.4
		All Others	3,799	4,162	9.6	12.8
		Americas Companies	11,506	14,076	22.3	43.3
		Japanese Companies	9,159	9,321	1.8	28.7
		European Companies	3,379	3,622	7.2	11.1
		Asia/Pacific Companies	5,642	5,515	-2.3	17.0
		Total Market	**29,686**	**32,534**	**9.6**	**100.0**

Source: Dataquest (April 1998)

Table 2-12
Top 40 Worldwide Companies Factory Revenue from Total Integrated Circuit Shipments to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Intel	3,251	4,077	25.4	14.7
2	2	Texas Instruments	1,733	1,853	6.9	6.7
3	3	Samsung	1,568	1,615	3.0	5.8
7	4	Motorola	1,141	1,372	20.2	4.9
5	5	Philips	1,180	1,285	8.9	4.6
4	6	Toshiba	1,330	1,263	-5.0	4.5
8	7	NEC	1,094	1,083	-1.0	3.9
6	8	LG Semicon	1,177	992	-15.7	3.6
9	9	SGS-Thomson	1,003	932	-7.1	3.4
10	10	Hitachi	941	721	-23.4	2.6
12	11	Sanyo	761	711	-6.6	2.6
11	12	Hyundai	763	704	-7.7	2.5
14	13	National Semiconductor	494	676	36.8	2.4
18	14	Lucent Technologies	345	604	75.1	2.2
13	15	Mitsubishi	649	600	-7.6	2.2
23	16	Advanced Micro Devices	268	470	75.4	1.7
17	17	Siemens	375	459	22.4	1.7
15	18	Fujitsu	460	458	-0.4	1.6
27	19	Rohm	212	380	79.2	1.4
16	20	United Microelectronics	430	344	-20.0	1.2
25	21	Sony	245	321	31.0	1.2
21	22	Cirrus Logic	283	297	4.9	1.1
28	23	Atmel	209	292	39.7	1.1
20	24	Matsushita	303	274	-9.6	1.0
38	25	S3	104	271	160.6	1.0
22	26	Sharp	276	260	-5.8	0.9
24	27	Winbond Electronics	262	260	-0.8	0.9
19	28	IBM	333	248	-25.5	0.9
29	29	Vanguard	209	237	13.4	0.9
32	30	Adaptec	159	181	13.8	0.7
26	31	Mosel Vitelic	241	174	-27.8	0.6
30	32	Analog Devices	183	156	-14.8	0.6
33	33	Rockwell	133	155	16.5	0.6
31	34	OKI	168	150	-10.7	0.5
NA	35	ESS	0	148	NA	0.5
47	36	Microchip Technology	85	140	64.7	0.5
34	37	Micron Technology	123	130	5.7	0.5

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Table 2-12 (Continued)
Top 40 Worldwide Companies Factory Revenue from Total Integrated Circuit Shipments to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
46	38	VIA	86	129	50.0	0.5
37	39	Macronix	111	126	13.5	0.5
43	40	HOLTEK	93	112	20.4	0.4
		All Others	2,872	3,144	9.5	11.3
		Americas Companies	10,848	13,317	22.8	47.9
		Japanese Companies	6,919	6,609	-4.5	23.8
		European Companies	2,688	2,876	7.0	10.3
		Asia/Pacific Companies	5,198	5,002	-3.8	18.0
		Total Market	**25,653**	**27,804**	**8.4**	**100.0**

Source: Dataquest (April 1998)

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Table 2-13
Top 14 Worldwide Companies Factory Revenue from Bipolar Digital Shipments to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
2	1	Hitachi	53	54	1.9	29.3
1	2	Texas Instruments	54	50	-7.4	27.2
4	3	Motorola	31	29	-6.5	15.8
6	4	Philips	11	13	18.2	7.1
9	5	Matsushita	4	11	175.0	6.0
NA	6	Mosel Vitelic	0	8	NA	4.3
7	7	LG Semicon	8	7	-12.5	3.8
5	8	Toshiba	19	3	-84.2	1.6
10	9	Mitsubishi	3	3	0	1.6
8	10	Advanced Micro Devices	4	2	-50.0	1.1
11	11	NEC	2	2	0	1.1
3	12	National Semiconductor	45	1	-97.8	0.5
12	13	Fujitsu	1	1	0	0.5
13	14	Applied Micro Circuits Corp.	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	135	82	-39.3	44.6
		Japanese Companies	82	74	-9.8	40.2
		European Companies	11	13	18.2	7.1
		Asia/Pacific Companies	8	15	87.5	8.2
		Total Market	**236**	**184**	**-22.0**	**100.0**

Source: Dataquest (April 1998)

Table 2-14
Top 40 Worldwide Companies Factory Revenue from MOS Digital IC Shipments to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Intel	3,251	4,077	25.4	19.1
2	2	Samsung	1,360	1,321	-2.9	6.2
4	3	Texas Instruments	1,105	1,055	-4.5	5.0
8	4	Motorola	783	947	20.9	4.4
3	5	LG Semicon	1,132	940	-17.0	4.4
5	6	NEC	951	935	-1.7	4.4
6	7	Toshiba	938	818	-12.8	3.8
9	8	Hyundai	762	701	-8.0	3.3
10	9	Philips	655	660	0.8	3.1
16	10	Lucent Technologies	325	594	82.8	2.8
7	11	Hitachi	787	540	-31.4	2.5
11	12	Mitsubishi	533	491	-7.9	2.3
12	13	Fujitsu	440	440	0	2.1
21	14	Advanced Micro Devices	243	423	74.1	2.0
18	15	Siemens	311	380	22.2	1.8
13	16	United Microelectronics	430	344	-20.0	1.6
14	17	Sanyo	338	309	-8.6	1.5
24	18	Atmel	209	292	39.7	1.4
26	19	National Semiconductor	207	281	35.7	1.3
35	20	S3	104	271	160.6	1.3
17	21	SGS-Thomson	312	250	-19.9	1.2
15	22	IBM	333	248	-25.5	1.2
25	23	Vanguard	209	237	13.4	1.1
20	24	Sharp	249	228	-8.4	1.1
19	25	Cirrus Logic	258	216	-16.3	1.0
23	26	Winbond Electronics	212	199	-6.1	0.9
30	27	Sony	146	197	34.9	0.9
28	28	Adaptec	159	181	13.8	0.8
22	29	Mosel Vitelic	241	166	-31.1	0.8
36	30	Rohm	101	153	51.5	0.7
27	31	OKI	167	149	-10.8	0.7
NA	32	ESS	0	145	NA	0.7
32	33	Rockwell	122	141	15.6	0.7
43	34	Microchip Technology	85	140	64.7	0.7
29	35	Matsushita	158	134	-15.2	0.6
31	36	Micron Technology	123	130	5.7	0.6
42	37	VIA	86	129	50.0	0.6

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Table 2-14 (Continued)
Top 40 Worldwide Companies Factory Revenue from MOS Digital IC Shipments to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
34	38	Macronix	111	126	13.5	0.6
39	39	HOLTEK	93	112	20.4	0.5
66	40	ACER	30	105	250.0	0.5
		All Others	2,038	2,105	3.3	9.9
		Americas Companies	8,841	10,811	22.3	50.7
		Japanese Companies	5,081	4,626	-9.0	21.7
		European Companies	1,353	1,372	1.4	6.4
		Asia/Pacific Companies	4,822	4,501	-6.7	21.1
		Total Market	**20,097**	**21,310**	**6.0**	**100.0**

Source: Dataquest (April 1998)

Table 2-15
Top 40 Worldwide Companies Factory Revenue from MOS Memory Shipments to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Samsung	1,074	892	-16.9	13.7
2	2	LG Semicon	979	731	-25.3	11.2
3	3	Hyundai	755	697	-7.7	10.7
5	4	NEC	541	432	-20.1	6.6
10	5	Siemens	298	352	18.1	5.4
4	6	Texas Instruments	566	321	-43.3	4.9
8	7	Mitsubishi	344	305	-11.3	4.7
9	8	Fujitsu	311	279	-10.3	4.3
13	9	Atmel	179	238	33.0	3.7
12	10	Vanguard	209	237	13.4	3.6
6	11	Hitachi	468	194	-58.5	3.0
14	12	Intel	163	183	12.3	2.8
11	13	Mosel Vitelic	241	166	-31.1	2.5
7	14	Toshiba	402	154	-61.7	2.4
17	15	Micron Technology	123	130	5.7	2.0
16	16	Winbond Electronics	131	110	-16.0	1.7
19	17	SGS-Thomson	107	102	-4.7	1.6
22	18	Macronix	76	95	25.0	1.5
23	19	Advanced Micro Devices	70	93	32.9	1.4
18	20	Sharp	108	87	-19.4	1.3
21	21	Nippon Steel Semiconductor	92	82	-10.9	1.3
29	22	Microchip Technology	37	64	73.0	1.0
30	23	Matsushita	37	59	59.5	0.9
20	24	Motorola	95	50	-47.4	0.8
31	25	IBM	34	50	47.1	0.8
24	26	OKI	60	41	-31.7	0.6
28	27	Integrated Silicon Solutions	39	40	2.6	0.6
26	28	Silicon Storage Technology	48	39	-18.8	0.6
34	29	Cypress Semiconductor	27	33	22.2	0.5
25	30	Sanyo	57	32	-43.9	0.5
35	31	Integrated Device Technology	26	30	15.4	0.5
33	32	Alliance Semiconductor	30	28	-6.7	0.4
32	33	Sony	33	27	-18.2	0.4
NA	34	Fairchild	0	25	NA	0.4
37	35	Catalyst	12	20	66.7	0.3
39	36	G-Link USA	7	20	185.7	0.3
15	37	United Microelectronics	141	18	-87.2	0.3

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Table 2-15 (Continued)
Top 40 Worldwide Companies Factory Revenue from MOS Memory Shipments to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
36	38	Hualon Microelectronics Corp.	21	18	-14.3	0.3
38	39	Rohm	11	10	-9.1	0.2
NA	40	Philips	0	6	NA	0
		All Others	65	26	-60.0	0.4
		Americas Companies	1,505	1,370	-9.0	21.0
		Japanese Companies	2,478	1,717	-30.7	26.4
		European Companies	405	460	13.6	7.1
		Asia/Pacific Companies	3,629	2,969	-18.2	45.6
		Total Market	**8,017**	**6,516**	**-18.7**	**100.0**

Source: Dataquest (April 1998)

Table 2-16
Top 40 Worldwide Companies Factory Revenue from MOS Microcomponent Shipments to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Intel	3,088	3,894	26.1	35.8
2	2	Motorola	558	685	22.8	6.3
4	3	Toshiba	301	395	31.2	3.6
5	4	Texas Instruments	291	382	31.3	3.5
6	5	United Microelectronics	289	326	12.8	3.0
8	6	NEC	254	307	20.9	2.8
9	7	Hitachi	237	303	27.8	2.8
3	8	Philips	386	286	-25.9	2.6
15	9	Advanced Micro Devices	122	284	132.8	2.6
13	10	National Semiconductor	136	277	103.7	2.5
18	11	S3	104	271	160.6	2.5
14	12	Lucent Technologies	125	225	80.0	2.1
7	13	Cirrus Logic	258	216	-16.3	2.0
23	14	Samsung	79	207	162.0	1.9
12	15	Adaptec	159	181	13.8	1.7
11	16	Mitsubishi	179	173	-3.4	1.6
10	17	IBM	216	145	-32.9	1.3
NA	18	ESS	0	145	NA	1.3
16	19	Rockwell	122	141	15.6	1.3
22	20	VIA	86	129	50.0	1.2
29	21	LG Semicon	59	107	81.4	1.0
44	22	ACER	30	105	250.0	1.0
25	23	Winbond Electronics	77	86	11.7	0.8
24	24	Sanyo	78	85	9.0	0.8
17	25	Zilog	112	82	-26.8	0.8
28	26	Digital	63	82	30.2	0.8
20	27	SGS-Thomson	95	80	-15.8	0.7
26	28	Standard Microsystems	70	80	14.3	0.7
32	29	Microchip Technology	48	76	58.3	0.7
34	30	Oak Technology	45	76	68.9	0.7
27	31	Fujitsu	63	75	19.0	0.7
57	32	Sun Microsystems	10	75	650.0	0.7
21	33	Trident Microsystems	95	74	-22.1	0.7
19	34	Silicon Integrated Systems	96	63	-34.4	0.6
33	35	Sharp	46	53	15.2	0.5
31	36	OPTI	52	52	0	0.5
38	37	C-Cube	42	48	14.3	0.4

Table 2-16 (Continued)
Top 40 Worldwide Companies Factory Revenue from MOS Microcomponent Shipments to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
39	38	Dallas Semiconductor	40	44	10.0	0.4
45	39	Yamaha	28	40	42.9	0.4
42	40	DSP Group	34	39	14.7	0.4
		All Others	571	491	-14.0	4.5
		Americas Companies	6,105	7,843	28.5	72.1
		Japanese Companies	1,333	1,534	15.1	14.1
		European Companies	517	415	-19.7	3.8
		Asia/Pacific Companies	789	1,093	38.5	10.0
		Total Market	**8,744**	**10,885**	**24.5**	**100.0**

Source: Dataquest (April 1998)

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Table 2-17
Top 40 Worldwide Companies Factory Revenue from MOS Digital Logic Shipments to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
6	1	Lucent Technologies	200	369	84.5	9.4
1	2	Philips	269	368	36.8	9.4
2	3	Texas Instruments	248	352	41.9	9.0
3	4	Toshiba	235	269	14.5	6.9
4	5	Samsung	207	222	7.2	5.7
8	6	Motorola	130	212	63.1	5.4
7	7	NEC	156	196	25.6	5.0
5	8	Sanyo	203	192	-5.4	4.9
13	9	Sony	83	142	71.1	3.6
16	10	Rohm	75	137	82.7	3.5
11	11	LG Semicon	94	102	8.5	2.6
10	12	Sharp	95	88	-7.4	2.3
18	13	Fujitsu	66	86	30.3	2.2
22	14	HOLTEK	49	84	71.4	2.1
20	15	OKI	63	81	28.6	2.1
19	16	Hewlett-Packard	66	79	19.7	2.0
9	17	SGS-Thomson	110	68	-38.2	1.7
NA	18	Fairchild	0	56	NA	1.4
26	19	LSI Logic	38	54	42.1	1.4
12	20	IBM	83	53	-36.1	1.4
21	21	Advanced Micro Devices	51	46	-9.8	1.2
14	22	Hitachi	82	43	-47.6	1.1
24	23	Dallas Semiconductor	40	43	7.5	1.1
15	24	Matsushita	78	42	-46.2	1.1
28	25	Altera	33	38	15.2	1.0
33	26	Xilinx	23	37	60.9	0.9
30	27	Integrated Circuit Systems	28	36	28.6	0.9
25	28	Symbios	40	33	-17.5	0.8
NA	29	Micronas	0	26	NA	0.7
41	30	Atmel	11	25	127.3	0.6
38	31	Lattice	18	20	11.1	0.5
48	32	Cypress Semiconductor	5	20	300.0	0.5
37	33	Hualon Microelectronics Corp.	18	19	5.6	0.5
34	34	Seiko Epson	22	18	-18.2	0.5
36	35	IMI	19	18	-5.3	0.5
27	36	GEC Plessey	38	17	-55.3	0.4
17	37	VLSI Technology	67	15	-77.6	0.4

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Table 2-17 (Continued)
Top 40 Worldwide Companies Factory Revenue from MOS Digital Logic Shipments to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
35	38	Harris Semiconductor	20	15	-25.0	0.4
23	39	Yamaha	47	13	-72.3	0.3
40	40	Quality Semiconductor	12	13	8.3	0.3
		All Others	214	162	-24.3	4.1
		Americas Companies	1,231	1,598	29.8	40.9
		Japanese Companies	1,270	1,375	8.3	35.2
		European Companies	431	497	15.3	12.7
		Asia/Pacific Companies	404	439	8.7	11.2
		Total Market	**3,336**	**3,909**	**17.2**	**100.0**

Source: Dataquest (April 1998)

Table 2-18
Top 40 Worldwide Companies Factory Revenue from Analog-Monolithic Shipments to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
2	1	Texas Instruments	574	748	30.3	11.9
1	2	SGS-Thomson	691	682	-1.3	10.8
3	3	Philips	507	612	20.7	9.7
4	4	Toshiba	373	442	18.5	7.0
5	5	Sanyo	361	402	11.4	6.4
6	6	Motorola	327	396	21.1	6.3
7	7	National Semiconductor	242	394	62.8	6.2
8	8	Samsung	208	294	41.3	4.7
14	9	Rohm	98	227	131.6	3.6
10	10	NEC	140	146	4.3	2.3
9	11	Matsushita	141	129	-8.5	2.0
15	12	Hitachi	92	127	38.0	2.0
16	13	Sony	89	124	39.3	2.0
11	14	Analog Devices	136	122	-10.3	1.9
17	15	Maxim	80	108	35.0	1.7
13	16	Mitsubishi	112	106	-5.4	1.7
12	17	VTC	115	90	-21.7	1.4
28	18	Cirrus Logic	25	81	224.0	1.3
18	19	Siemens	64	79	23.4	1.3
21	20	New JRC	48	74	54.2	1.2
25	21	TEMIC	29	69	137.9	1.1
19	22	Linear Technology	51	63	23.5	1.0
20	23	Winbond Electronics	50	61	22.0	1.0
22	24	Korean Electronic Co.	44	49	11.4	0.8
34	25	Harris Semiconductor	19	46	142.1	0.7
23	26	LG Semicon	37	45	21.6	0.7
32	27	Advanced Micro Devices	21	45	114.3	0.7
24	28	PMC Sierra Semiconductor	34	42	23.5	0.7
31	29	Mitel	23	39	69.6	0.6
26	30	Unitrode	29	36	24.1	0.6
27	31	Sharp	27	32	18.5	0.5
29	32	Level One Communications	25	31	24.0	0.5
30	33	Daewoo	24	29	20.8	0.5
NA	34	Anadigics	0	28	NA	0.4
NA	35	Sanken	0	25	NA	0.4
42	36	GEC Plessey	8	22	175.0	0.3
37	37	Dallas Semiconductor	16	20	25.0	0.3

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Table 2-18 (Continued)
Top 40 Worldwide Companies Factory Revenue from Analog-Monolithic Shipments to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
35	38	Semtech	19	17	-10.5	0.3
38	39	Micro Linear	16	17	6.3	0.3
39	40	Fujitsu	13	17	30.8	0.3
		All Others	177	194	9.6	3.1
		Americas Companies	1,859	2,424	30.4	38.4
		Japanese Companies	1,548	1,909	23.3	30.3
		European Companies	1,310	1,491	13.8	23.6
		Asia/Pacific Companies	368	486	32.1	7.7
		Total Market	**5,085**	**6,310**	**24.1**	**100.0**

Source: Dataquest (April 1998)

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Table 2-19
Top 40 Worldwide Companies Factory Revenue from Total Discrete Shipments to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Toshiba	390	454	16.4	11.9
6	2	Rohm	193	335	73.6	8.8
3	3	Motorola	271	297	9.6	7.8
2	4	Philips	291	295	1.4	7.7
4	5	Samsung	252	295	17.1	7.7
5	6	Hitachi	203	252	24.1	6.6
7	7	Korean Electronic Co.	165	191	15.8	5.0
10	8	Sanyo	136	165	21.3	4.3
12	9	Sanken	120	161	34.2	4.2
9	10	Matsushita	151	154	2.0	4.0
8	11	NEC	154	151	-1.9	4.0
11	12	SGS-Thomson	133	143	7.5	3.7
13	13	General Semiconductor	118	128	8.5	3.4
15	14	Fuji Electric	98	99	1.0	2.6
14	15	TEMIC	115	91	-20.9	2.4
18	16	International Rectifier	65	88	35.4	2.3
19	17	Mitsubishi	64	70	9.4	1.8
16	18	Shindengen Electric	80	69	-13.8	1.8
20	19	Siemens	44	56	27.3	1.5
NA	20	Fairchild	0	56	NA	1.5
21	21	Harris Semiconductor	26	37	42.3	1.0
17	22	National Semiconductor	65	33	-49.2	0.9
28	23	Zetex	10	27	170.0	0.7
24	24	Hewlett-Packard	16	18	12.5	0.5
25	25	Semikron	16	17	6.3	0.4
27	26	Fujitsu	14	17	21.4	0.4
NA	27	Micronas	0	12	NA	0.3
NA	28	Fagor	0	12	NA	0.3
NA	29	TCS	0	12	NA	0.3
29	30	Sony	8	9	12.5	0.2
30	31	Microsemi	8	9	12.5	0.2
31	32	Teccor Electronics	7	6	-14.3	0.2
32	33	IXYS	5	5	0	0.1
NA	34	Power Innovations	0	4	NA	0.1
35	35	Semtech	1	3	200.0	0
NA	36	Robert Bosch	0	3	NA	0
34	37	GEC Plessey	1	1	0	0
22	38	TOKO	21	0	-100.0	0

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Table 2-19 (Continued)
Top 40 Worldwide Companies Factory Revenue from Total Discrete Shipments to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
23	39	Eupec	20	0	-100.0	0
26	40	ITT	15	0	-100.0	0
		All Others	18	42	133.3	1.1
		Americas Companies	600	680	13.3	17.8
		Japanese Companies	1,643	1,974	20.1	51.7
		European Companies	634	677	6.8	17.7
		Asia/Pacific Companies	417	486	16.5	12.7
		Total Market	**3,294**	**3,817**	**15.9**	**100.0**

Source: Dataquest (April 1998)

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Table 2-20
Top 23 Worldwide Companies Factory Revenue from Total Optical Semiconductor Shipments to Asia/Pacific (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Sharp	130	173	33.1	18.9
3	2	Rohm	66	111	68.2	12.2
NA	3	Stanley	0	93	NA	10.2
5	4	NEC	35	92	162.9	10.1
2	5	Toshiba	84	90	7.1	9.9
7	6	Sony	33	44	33.3	4.8
6	7	Siemens	35	36	2.9	3.9
9	8	Hitachi	25	30	20.0	3.3
11	9	TEMIC	18	30	66.7	3.3
15	10	Lucent Technologies	10	28	180.0	3.1
8	11	Hewlett-Packard	27	27	0	3.0
12	12	Sanyo	16	25	56.3	2.7
13	13	Mitsubishi	16	19	18.8	2.1
10	14	Korean Electronic Co.	19	15	-21.1	1.6
14	15	Motorola	12	13	8.3	1.4
4	16	Matsushita	46	12	-73.9	1.3
16	17	Samsung	8	12	50.0	1.3
17	18	Quality Technologies	8	9	12.5	1.0
19	19	Sanken	2	4	100.0	0.4
20	20	Fujitsu	2	2	0	0.2
22	21	Optek	1	2	100.0	0.2
21	22	Ericsson	2	1	-50.0	0.1
18	23	New JRC	4	0	-100.0	0
		All Others	140	45	-67.9	4.9
		Americas Companies	58	79	36.2	8.7
		Japanese Companies	597	738	23.6	80.8
		European Companies	57	69	21.1	7.6
		Asia/Pacific Companies	27	27	0	3.0
		Total Market	**739**	**913**	**23.5**	**100.0**

Source: Dataquest (April 1998)

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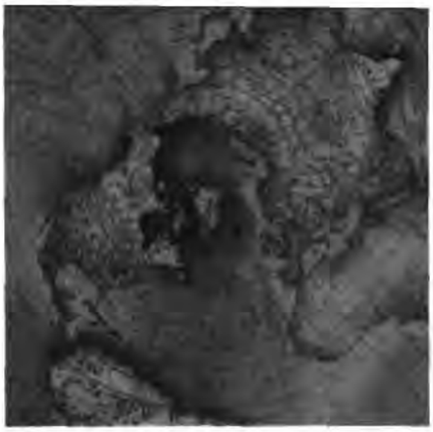

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The 1998 Directory of Asia/Pacific Semiconductor Companies

Focus Report

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MARIA VALENZUELA

Program: Semiconductors Asia/Pacific
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The 1998 Directory of Asia/Pacific Semiconductor Companies

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Chapter 1
Executive Summary

This Focus Report surveys the semiconductor companies, covering merchant and captive manufacturers and users. This report contains information gathered through company surveys and telephone interviews, as well as secondary research. Secondary research was conducted using the following sources:

- Articles in the general business and trade press
- Company and product directories
- Company press release and product literature
- Financial information
- Local publications

In the Asia/Pacific region, there are 327 semiconductor companies in 1997. Dataquest has defined six categories of semiconductor companies as follows:

- Wafer fabrication companies
- Fabless companies
- Mask manufacturing
- Silicon wafer suppliers
- Equipment manufacturing companies
- Packaging and testing companies

All local and foreign companies, merchant and captive manufacturers, and users will be included. This report shows a potential industry trend—food chain—in Asia/Pacific, and it provides business opportunities for semiconductor or semiconductor-related industries. This report does not include some small companies with year-end revenue of less than U.S.$1 million. Therefore, the actual number of companies in each category should be more than those listed in the report—especially for the fabless and packaging/testing companies.

Table 1-1 shows the currency exchange rates of the major Asia/Pacific countries in 1997 and 1998.

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Table 1-1
Currency Exchange Rates of the Major Asia/Pacific Countries, 1997 and 1998

Country	1997	1998*	Change (%) 1997 to 1998
Indonesia (Rupiah)*	2,872.61	11,525.00	-75.1
South Korea (Won)	954.14	1,450.74	-34.2
Malaysia (Ringgit)	2.82	3.86	-26.9
Philippines (Peso)*	29.47	39.16	-24.7
Thailand (Baht)	31.07	41.13	-24.5
New Zealand (Dollar)	1.51	1.82	-16.8
Taiwan (Dollar)	28.79	33.36	-13.7
Australia (Dollar)	1.35	1.56	-13.5
Singapore (Dollar)	1.49	1.64	-9.6
India (Rupee)	36.36	40.12	-9.4
Japan (Yen)	121.10	132.95	-8.9
Hong Kong (Dollar)	7.74	7.75	-0.1
China (Renminbi)	8.32	8.31	0.1

*Estimate
Source: Dataquest (July 1998)

Project Analyst: Jerry Yeh

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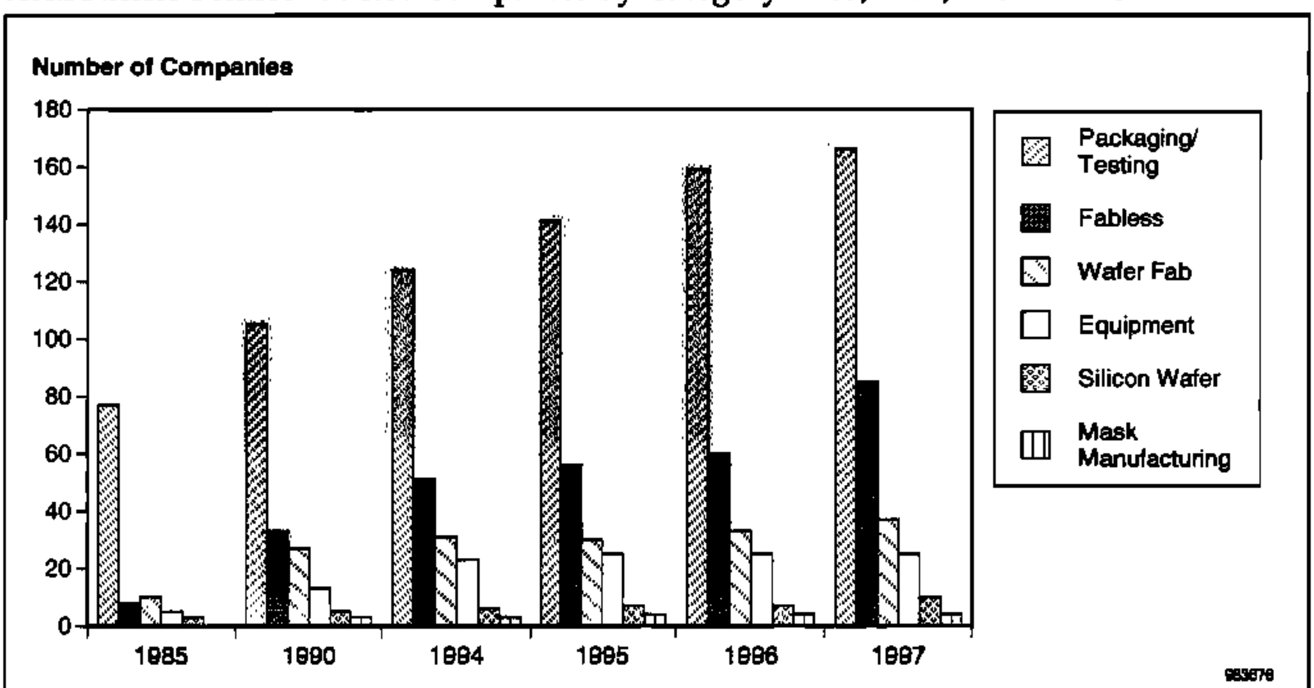
Chapter 2
An Overview of the Asia/Pacific Semiconductor Companies

Figure 2-1 illustrates Asia/Pacific's semiconductor companies by category. In 1997, the sluggish worldwide semiconductor market and the Asian financial crisis caused decelerating growth of the Asia/Pacific semiconductor revenue and reduced the total number of Asia/Pacific semiconductor companies, including merchant and captive. The total number of Asia/Pacific semiconductor companies in 1997 showed a modest increase, totaling 327 companies, at a 13.5 percent growth rate over the 1996 total. Taiwan shows a strong growth in fabless and assembly/testing companies.

Wafer Fabrication

The number of wafer fabrication companies reached 37, growing at 12.1 percent. Wafer fabrication grew fourfold between 1985 and 1997. The number of wafer fabrication companies grew strongly in 1990, but it faced slower growth between 1990 and 1995. In 1996, more new wafer fabrication companies started operation, which resulted in a surging capital spending. However, the sluggish semiconductor market and the Asian financial crisis impacted the industry, caused a stalling of a few planned companies, particularly in Thailand. Taiwan, a fast-growing country, also delayed its semiconductor equipment installation until 1998. The success of wafer fabrication expansion drove more demand on wafer manufacturing, mask, equipment and packaging, and testing in this area. However, the flat growth of 1997 slowed down the industry's growth path.

Figure 2-1
Asia/Pacific Semiconductor Companies by Category: 1985, 1990, and 1994 to 1997



Source: Dataquest (July 1998)

Fabless Companies

Fabless companies grew dramatically during the past decade. More new fabless companies started operation in 1997 because of the foundry services' success and the variety demand from application market. The number of fabless companies reached 85, growing at an impressive 41.7 percent. Although there are some start-up companies in 1997, their revenue was all relatively small. Taiwan shows a strong growth in fabless companies in the region, and it still maintained its lead in this category.

Mask Manufacturing

No additional country joined mask manufacturing in 1997. The number of companies in Taiwan and Korea in 1997 remained the same as in 1996. Except for a few semiconductor manufacturing companies, most of Taiwan's wafer fabrication companies did not have in-house mask manufacturing. The number of mask manufacturing is four in the region, the same as in 1996.

Silicon Wafer Suppliers

In 1997, the number of silicon wafer supplying companies in Taiwan and Korea remained the same as in 1996. A new supplier allowed Malaysia to become one of the major silicon wafer manufacturing-base countries in the region. The number of silicon wafer suppliers reached 10, three more than the 1996 total. Taiwan's fast-growing revenue, number of companies, and capacity will allow it to become the region's leading supplier by 2000.

Equipment Manufacturing Companies

The financial crisis and a weak demand resulted in Korean equipment manufacturing companies' withdrawing from this market. The Taiwanese equipment manufacturing industry was slower in 1997 than in 1996 because of continued sluggishness in the semiconductor market. In 1997, the number of equipment manufacturing companies remained the same as in 1996. Some Korean companies withdrew, and some Taiwanese companies joined the market.

Packaging and Testing Companies

The number of packaging and testing companies reached 166 in 1997. In this category, the number of Taiwanese companies grew significantly, offsetting Korean companies' decline. For many decades, the abundant and often cheap labor attracted worldwide investment in this region. Most of the packaging and testing companies were set up by multinational companies outside of Asia/Pacific. However, Taiwan, Korea, and Singapore's strong front-end manufacturing continued to consume the packaging and testing market locally. The packaging and testing industry has shown a restless growth in Asia/Pacific since the 1980s. The percentage of packaging and testing companies decreased substantially, while the total number of semiconductor companies grew; however, the number of packaging and testing companies doubled from 1985 to 1996.

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Chapter 3

Wafer Fabrication Companies

Table 3-1
Korean Wafer Fabrication Companies

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Investments 1997 (U.S.$M)	Capacity (MSI/m)	Major Products
Anam Semiconductor	280-8, 2-ga, Sungsu-dong, Sungdong-gu, Seoul, Korea	82-2-460-5114/ 82-2-465-2607	1968	850	1	600	0.75	DSP, ASIC
Daewoo Electronics	60-8 Kasan-dong, Kumchun-gu, Seoul, Korea	82-2-818-9600/ 82-2-865-2912	1986	391	50	2	0.251	MCU, ASIC, analog
Hyundai Electronics	41-2 Chungdam-dong, Kangnam-gu, Seoul, Korea	82-336-30-4114/ 82-336-30-4604	1983	11,800	1,939	1,349	5.6	Memory, ASIC, ASSP, micro
Korea Electronics	9F, Chamber Bldg., 45 4-ka Namdaemun-ro, Chung-gu, Seoul, Korea	82-2-757-5700/ 82-2-775-3712	1969	2,300	300	69	0.546	Discrete, anolog, optoelectronic
Kukje	Kukje Center, 191 Hangang-ro 2ga, Youngsan-gu, Seoul, Korea	82-2-797-7111/ 82-2-797-5444	1990	72	4	1	0.1	Low-noise MESFET, HEMT, HBT
LG Semicon	891, Daechi-dong, Kangnam-gu, Seoul, Korea	82-2-3459-3114/ 82-2-3459-3434	1989	9,300	1,792	1,572	6.1	Memory, micro, ASIC, logic, analog
Samsung Electronics	Samsung Main Bldg., 250 Taepyung-ro 2ga, Chung-gu Seoul, Korea	82-2-776-0114/ 82-2-753-0967	1974	17,000	5,856	1,500	7.9	Memory, micro, ASIC, logic, analog, discrete,optoelectronic

Revenue = Semiconductor revenue of the company (U.S.$M)
Investments = Capital spending, including R&D facility (U.S.$M)
Capacity = MSI/m (Million square inches per month)
Source: Dataquest (July 1998)

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Table 3-2
Taiwanese Wafer Fabrication Companies

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Investments 1997 (U.S.$M)	Capacity (MSI/m)	Major Products
Episil Technologies, Incorporated	No. 3, Innovation Rd. I, Science-Based Industrial Park, Hsinchu, Taiwan	8863-577-9245/ 8863-577-6286	1985	285	10	5	0.1	Bipolar IC, power transistor
Holtek Microelectronics Inc.	No. 5, Creation Rd. II, Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-4888/ 8863-577-0879	1988	1,500	131	198	0.9	ASIC, consumer and communications IC
Hualon Microelectronics Co.	No. 1, R&D Rd. IV, Science-Based Industrial Park,Hsinchu, Taiwan	8863-577-4945/ 8863-577-4305	1987	870	98	20	0.6	VGA, I/O controller, LAN chip, CCD
Macronix International Co. Ltd.	No. 3, Creation Rd. III, Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-3333/ 8863-577-8689	1989	2,777	390	521	1.1	Mask ROM, EPROM, fLash, DSP, chipsets
MOsel/Vitelic Inc.	No. 1, R&D Rd. I, Science-Based Industrial Park, Hsinchu, Taiwan	8863-577-0055/ 8863-577-2595	1987	1,498	308	182	1.0	DRAM, SRAM, voice and other consumer IC
Nan Ya Technology Co.	336, Sec. 1, NanKan Rd. Luchu, Tauyuan, Taiwan	8863-322-3751/ 8863-321-0974	1996	900	110	690	0.6	DRAM
Powerchip Semiconductor Co.	No. 1, Industry E. Rd. III, Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-8939/ 8863-577-0355	1996	1,570	265	139	0.7	DRAM
ProMOS	No. 19, Li Hsin Rd, Science-Based Industrial Park, Hsinchu, Taiwan	8863-579-8308/ 8863-579-4441	1997	1,010	85	250	0.2	DRAM
Taiwan Semi. Manufacturing Co.	No. 121, Park Ave. III Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-0221/ 8863-577-0354	1987	5,600	1,540	860	5.4	Foundry
TI-Acer Inc.	No. 6, Creation Rd. II Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-5112/ 8863-578-2038	1990	1,649	402	487	2.0	DRAM, ASIC, ASM
United Integrated Circuit Co.	No. 8, Li Hsin Rd. III, Science-Based Industrial Park, Hsinchu, Taiwan	8863-579-7966/ 8863-579-7988	1997	NA	NA	NA	NA	Foundry

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Table 3-2 (Continued)
Taiwanese Wafer Fabrication Companies

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Investments 1997 (U.S.$M)	Capacity (MSI/m)	Major Products
United Microelectronics Co.	No. 13, Innovation Rd. I, Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-2258/ 8863-577-4767	1980	2,751	896	133	3.1	Foundry, memory, ASIC, DSP
United Semiconductor Co.	No. 3, Li Hsin Rd. II, Science-Based Industrial Park, Hsinchu, Taiwan	8863-579-5158/ 8863-579-5156	1996	970	277	347.0	0.1	Foundry, memory
United Sillicon Integrated Co.	No. 6, Li Hsin Rd. III,Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-9388/ 8863-577-4798	1998	NA	NA	104	NA	Foundry, memory
Vanguard International Semi. Co.	No. 123, Park Ave., III, Science-Based Industrial Park, Hsinchu, Taiwan	8863-577-0355/ 8863-578-9851	1995	1,891	348	269	1.8	DRAM
Winbond Electronics Co.	No. 4, Creation Rd. III, Science-Based Industrial Park, Hsinchu, Taiwan	8863-577-0066/ 8863-578-9467	1987	3,335	415	463	1.6	MCU, MPR, consumer IC, memory, DRAM, foundry service
World Semicoductor Manufacturing Co.	No. 40, Park Ave., II Science-Based Industrial Park, Hsinchu, Taiwan	8863-567-8888/ 8863-579-7747	1998	NA	NA	388	NA	NA

NA = Not available
Revenue = Semiconductor revenue of the company (U.S.$M)
Investments = Capital spending, including R&D facility (U.S.$M)
Capacity = MSI/m (Million square inches per month)
Source: Dataquest (July 1998)

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Table 3-3
Singapore Wafer Fabrication Companies

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Investments 1997 (U.S.$M)	Capacity (MSI/m)	Major Products
Chartered Semiconductor Manufacturing Ltd.	60 Woodlands Industrial Park D, Street 2, Singapore 73840	(65) 3622838/ (65) 3622937	1987	1,219	494	1,400	2.7	Foundry
Hitachi Nippon Steel Semiconductor Singapore Pte. Ltd.	1 Tampines Industrial Avenue 5, Singapore 528830	(65) 2607666/ (65) 2607279	1998	NA	NA	NA	1.0	64Mb DRAM
SGS-Thomson Microelectronics Pte. Ltd.	28 Ang Mo Kio Ind Park 2, Singapore 569508	(65) 4821411/ (65) 4820240	1984	3,200	NA	NA	2.5	Telecom IC, disk drive IC, special consumer IC
TECH Semiconductor Singapore Pte. Ltd.	1 Woodlands Industrial Park D, Street 1, Singapore 738799	(65) 3651998/ (65) 3652016	1993	1,100	302	100	0.6	16Mb DRAM, 64Mb DRAM

NA = Not available
Revenue = Semiconductor revenue of the company (U.S.$M)
Investments = Capital spending, including R&D facility (U.S.$M)
Capacity = MSI/m (Million square inches per month)
Source: Dataquest (July 1998)

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Table 3-4
China/Hong Kong Wafer Fabrication Companies

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Investments 1997 (U.S.$M)	Capacity (MSI/m)	Major Products
Advanced Semiconductor Manufacturing Company (ASMC)	385 Hong Cao Road, Shanghai, China	86-21-6485-1900/ 86-21-6485-1056	1992	470	48	NA	5.0	Logic/microcomponents; analog ICs for telecom, consumer, automotive, and industrial electronics equipment
Central Semiconductor Manufacturing Co.	14 Liangxi Road, Wuxi, Jiangsu, China	NA	June 1998	NA	NA	NA	2.7	E2PROM and flash memory IC
China Huajing Electronics Group	14 Liangxi Road, Wuxi, Jiangsu, China	86-510-580-7123/ 86-510-580-1291	1984	5,600	35	NA	3.4	Discrete; bipolar IC; MOS ICs for TV, telephone, and audio equipment
Hua Ko Electronics Limited	9 Dai Shun St. Tai Po Industrial Estate, New Territories, Hong Kong (SAR)	852-2667-0373/ 852-2664-3720	1981	250	32	NA	1.2	Bipolar transistor; semiconductors for clocks, watches, melodies, sound generators, telephones, and decoders/encoders
Huayue Microelectronics Company Limited	P.O. Box 3, Shaoxing, Zhejiang, China	86-575-516-5105/ 86-575-516-5134	1991	1,000	13	NA	2.9	Bipolar, semiconductors for appliances and power management
Motorola (China) Electronics Limited	Xiqing Economic Development Zone, Tianjin, China	86-10-6843-7222/ 86-10-6842-1999	1999	500	0	NA	11.7	Microcontroller
Nantong Huarong Electronics Group Co. Ltd.	No. 107, Gongnong Road, Nantong, Jiangsu Province	86-513-3583306/ 86-513-3583306	NA	2500	61	NA	NA	Aluminum electrolysis capacitor
RCL Semiconductors Limited	3 Dai Fu St., Tai Po Industrial Estate, New Territories, Hong Kong (SAR)	852-2665-9229/ 852-2666-9913	1981	180	18	NA	0.6	Semiconductors for calculators, watches, and voice/music toys
Shanghai Belling Microelectronics Manufacturing Company Limited	810 Yishan Road, Shanghai, China	86-21-6485-4745/ 86-21-6485-4424	1988	530	48	NA	1.5	Discrete; switching, consumer, other telecom ICs

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Table 3-4 (Continued)
China/Hong Kong Wafer Fabrication Companies

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Investments 1997 (U.S.$M)	Capacity (MSI/m)	Major Products
Shanghai Hua Hong NEC Electronics Company Ltd.	Pudong Waigaoqiao Free Trade Zone, Shanghai, China	86-10-6512-6370/ 86-10-6524-7727	1999	500	0	NA	11.7	64Mb DRAM, logic
Shougang NEC Electronics Company (SGNEC)	45 Badachu Road, Shjingshan, Beijing, China	86-10-6512-6370/ 86-10-6524-7727	1996	700	95	NA	2.0	4Mb DRAM, linear IC
Vitelic Hong Kong Limited	19 Dai Fu Street, Tai Po Industrial Estate, New Territories, Hong Kong (SAR)	852-2666-3373/ 852-2667-7613	1983	290	52	NA	2.6	Discrete (power transistors) for switching/consumer, logic
Shanghai Electronics Components Co.	No. 816, Yanan Middle Road, Shanghai	86-21-62564628/ 86-21-62582652	NA	9,500	113	AT		RC components, relay, and capacitor, discrete

NA = Not available
Revenue = Semiconductor revenue of the company (U.S.$M)
Investments = Capital spending, including R&D facility (U.S.$M)
Capacity = MSI/m (Million square inches per month)
Source: Dataquest (July 1998)

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Table 3-5
Malaysian Wafer Fabrication Companies

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Investments 1997 (U.S.$M)	Capacity (MSI/m)	Major Products
Malaysian Institute of Microelectronic Systems (Mimos) Bhd.	Technology Park Malaysia, 57000 Kuala Lumpur, Malaysia	(603) 9665000/ (603) 9662755	1997	50	NA	NA	0.02	ASIC
Motorola Semiconductor Sdn. Bhd..	Lot 122, Senawang Industrial Estate, PO Box 465, 70750 Seremban, Malaysia	(606) 6773088/ (606) 6774062	1987	2700	NA	NA	0.05	Power and small signal transistor

NA = Not available
Revenue = Semiconductor revenue of the company (U.S.$M)
Investments = Capital spending, including R&D facility (U.S.$M)
Capacity = MSI/m (Million square inches per month)
Source: Dataquest (July 1998)

Table 3-6
Wafer Companies in Rest of Asia/Pacific

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Investments 1997 (U.S.$M)	Capacity (MSI/m)	Major Products
Quality Semiconductor Australia Pty. Ltd.	Sydney, Australia	61-2-9761-3455/ 61-2-9761-3415	1988	NA	NA	NA	1.0	16-bit 32-bit MCU, FIFO, foundry

NA = Not available
Revenue = Semiconductor revenue of the company (U.S.$M)
Investments = Capital spending, including R&D facility (U.S.$M)
Capacity = MSI/m (Million square inches per month)
Source: Dataquest (July 1998)

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Chapter 4

Fabless Companies

Table 4-1
Korean Fabless Companies

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Major Products
Anam Semiconductor & Technology	Anam Bldg., 154-17 Samsung-dong Kangnam-gu, Seoul, Korea	82-2-3450-7114/ 82-2-553-2109	1987	246	31	ASICs for CDMAs, DVDs, and set-top boxes
ASIC Plasa	734-11, Yeoksam-dong Kangnam-gu, Seoul, Korea	82-2-569-1960/ 82-2-569-2398	1995	18	1	ASICs for peripherals, set-top boxes, LEDs, and decode ICs
C&S Technology	41-2, Chungdam-dong, Kangnam-gu, Seoul, Korea	82-2-515-4468/ 82-2-515-4469	1993	45	12	ASIC for multimedia/ communications, chipset for pagers
Seodoo Logic	647-5, Yeoksam-dong Kangnam-gu, Seoul, Korea	82-2-563-6431/ 82-2-562-4657	1990	22	9	Controller for set-top box

Revenue = Semiconductor revenue of the company (U.S.$M)
Note: Number of employees in Singapore includes all company employees.
Source: Dataquest (July 1998)

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Table 4-2
Taiwanese Fabless Companies

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Major Products
Acer Laboratories Inc.	5F, No. 156, Tung Hsing St. Taipei, Taiwan	8862-762-8800/ 8862-719-8690	1987	300	120	Core logic, ASIC, I/O peripheral, graphics, multimedia
ADM	1F, No. 9, Industry Rd. 9, Science-Based Industrial Park, Taiwan	8863-578-8879/ 8863-578-8871	1997	NA	NA	Logic IC, memory
Advance Reality Technology Inc.	3F, No. 609, Kuang Fu Rd. Sec. 1, Hsinchu City, Taiwan	8863-578-5104/ 8863-578-5094	1994	10	1	ASIC, gate array
Analog & Power	5F, No. 2, Li Shin Rd. Science-Based Industrial Park, Hsinchu, Taiwan	8863-564-2000/ 8863-564-2050	1997	NA	NA	Logic IC, memory
Analog Integrations Co.	4F, No. 9, Industry Rd. 9, Science-Based Industrial Park, Hsinchu, Taiwan	8863-577-2500/ 8863-577-2510	1992	30	3	Monolithic and hybrid analog ICs
Aplus Integrated Circuits Inc.	6F-3, No. 7, 75 Lane, Ta An Rd. Taipei, Taiwan	8862-781-8277/ 8862-781-5779	1992	35	3	Audio IC
Aslic Microelectronics Co.	5F, No 317, Sung Chiang Rd. Taipei, Taiwan	8862-501-4996/ 8862-505-6421	1987	25	2	Consumer IC, encoder, decoder
Avid Electronics	4F, 11, Park Ave. II, Hsinchu Science-Based Industrial Park, Hsinchu, Taiwan	8863-579-5222/ 8863-578-7789	1996	10	2	Logic IC
ASIX	2F, No. 28, Industry E. Rd. Science-Based Industrial Park, Taiwan	8863-579-9500/ 8863-579-9558	1985	NA	NA	Logic IC, memory
Best Integrated Technology Inc.	1F, 48, Park Ave. II, Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-4437/ 8863-578-3078	1997	68	NA	Logic IC
Brilliance Technology	2F, 40, Park Ave. II, Hsinchu Science-Based Industrial Park, Hsinchu, Taiwan	8863-579-8801/ 8863-579-4728	1996	30	2	Communications IC
Chesen Electronics Co.	5F-2, No. 94, Pao Chung Rd., Hsin Tien City, Taiwan	8862-916-1299/ 8862-910-4935	1984	50	15	Communications IC
Chip Design Technology Inc.	4F-3, No. 26, Wu Chuan 2nd Rd. Wu Ku Industry Dist. Wu Ku, Shing Chuang City, Taiwan	8862-299-4908/ 8862-299-0133	1985	NA	5	ASIC
Davicom Semiconductor Inc.	4F, 17, Park Ave Rd. II, Science-Based Industrial Park, Hsinchu, Taiwan	8863-579-8797/ 8863-579-8858	1996	80	5	Communications IC

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Table 4-2 (Continued)
Taiwanese Fabless Companies

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Major Products
Direction Technology Co.	5F, 9, Lane 24, Alley 68, Kang Fu Rd. Sec. 1, Shan Chung City, Taipei County, Taiwan	8862-2995-3081/ 8862-2995-3084	1997	20	2	Logic IC
E-CMOS Co.	1F, No. 58, Park Ave. 2, Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-3622/ 8863-578-3630	1987	20	5	Mouse controller, ASIC
Elan Microelectronics Co.	7F-1, No. 9, Prosperity Rd. I, Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-7505/ 8863-577-9095	1994	160	72	Neural-fuzzy IC, digital signal processor, DSP, 8-bit MCU, ASIC
Elecvision	2F., No. 28, R&D II Rd. Science-Based Industrial Park, Hsinchu, Taiwan	8863-579-8602/ 8863-579-4589	1996	NA	NA	Logic IC, memory
Eplus Co.	2F-2, No. 2, 253 Lane, Fu Shing S. Rd. Sec. 1, Taipei, Taiwan	8862-754-8038/ 8862-706-3617	1989	20	NA	PIR
Etron Technology Inc.	1F, No. 1,Prosperity Rd. I, Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-2345/ 8863-577-9001	1991	150	48	SRAM, DRAM, ASIC
Eureka	3F., No. 7, Industry E. Rd. 9, Science-Based Industrial Park, Hsinchu, Taiwan	8863-579-9255/ 8863-579-9253	1995	NA	NA	Logic IC, memory
Evermore	2F, No. 7, R&D Rd. I, Science-Based Industrial Park, Hsinchu, Taiwan	8863-564-2060/ 8863-579-8303	1997	NA	NA	Logic IC, memory
Etrend	2F, No. 22, Industry Rd. 9, Science-Based Industrial Park, Hsinchu, Taiwan	8863-569-0716/ 8863-564-2050	1997	NA	NA	Logic IC, memory
F3	2F, No. 7, Industry E. Rd. 7, Science-Based Industrial Park, Hsinchu, Taiwan	8863-577-7882/ 8863-577-5532	1997	NA	NA	Logic IC, memory
Faraday Technology Co.	7F-3, No. 9, Prosperity 1 Rd., Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-788/ 88863-578-7889	1993	110	40	ASIC
G-Link Technology Co.	2F, 12, R&D Rd. II, Hsinchu Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-2833/ 8863-578-3259	1995	50	15	DRAM, SRAM
Genesys	10F, No. 11, Shen Ken, Taipei County, Taiwan	8862-2664-6655/ 8862-2664-5757	1997	NA	NA	Logic IC, memory

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Table 4-2 (Continued)
Taiwanese Fabless Companies

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Major Products
GinJet Technology Co.	No. 18-1, 76 Lane, Long Chiang Rd. Taipei Taiwan	8862-506-3439/ 8862-507-2064	1989	27	4	ASIC, monitor OSD, pager decoder/encoder
Golden Technology Co.	4F, 221, Chung Yang Rd. Nan Kang District, Taipei, Taiwan	8862-2652-2255/ 8862-2651-0598	1997	35	NA	Logic IC
Hitachi Asia PTE Ltd.	3F, 167, Dun Hua N. Rd., Taipei, Taiwan	8862-718-3666/ 8862-718-8180	1987	110	NA	NA
Holylite Microelectronics Co.	10F-2, No. 67, Chih Hu Rd., Hsinchu City, Taiwan	8863-542-0523/ 8863-542-1634	1992	NA	NA	Melody, analog IC, mixed MOD
Hwa Mye Electronic Co. Ltd.	8F, No. 80, Sung Te Rd. Taipei, Taiwan	8862-729-8873/ 8862-729-1282	1988	20	3	ASIC
Inno Technology Ltd.	7F, No. 181, Yung Chi Rd. Taipei, Taiwan	8862-768-9099/ 8862-768-9100	1993	15	2	Consumer IC
Integrated Silicon Solution (Taiwan) Inc.	1F, No. 10 Prosperity Rd. II, Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-0333/ 8863-578-3000	1990	240	108	EEPROM, flash, SRAM, DSP, voice EPROM
Integrated Technology Express (Taiwan) Inc.	15F, 376, Sec. 4, Jen Ai Rd. Taipei, Taiwan	8862-707-9589/ 8862-703-8389	1996	131	43	Core logic
Lucent	16F, No. 156, Ming Shen E. Rd. Sec. 3, Taipei, Taiwan	8862-2547-7027/ 8862-2547-7440	1990	NA	NA	Logic IC
Media Tek	1F, No. 13, Innovation Rd. 1, Science-Based Industrial Park, Hsinchu, Taiwan	8863-567-0766/ 8863-578-7610	1997	NA	NA	Logic IC, memory
Micro Advance Technology Co. Ltd.	8F, No. 26, 204 Lane, Sung San Rd. Taipei, Taiwan	8862-760-8850/ 8862-762-6099	1992	40	4	ASIC
Micro Electronic Co. Ltd.	5F-5, No 12, 609 Lane, Chung Shing Rd. Sec. 5, San Chung City, Taiwan	8862-999-1822/ 8862-999-4991	1991	NA	NA	ASIC
Micron Design Technology Ltd.	5F, 164-2, Lian Chan Rd. Chun Ho City, Taipei Conty, Taiwan	8862-2248-9697/ 8862-2248-9547	1997	20	NA	Logic IC
MOS Design Semiconductor Co.	6F-5, No. 10, 609 Lane, Chung Shin Rd. San Chung City, Taiwan	8862-278-3733/ 8862-278-3633	1988	84	12	Melody, sound effector
MOSART Semiconductor Co.	11F-2, No. 33, Ming Shen Rd. Sec. 1, Pan Chiao City, Taiwan	8862-959-9180/ 8862-959-9323	1993	32	2	Communications and consumer ICs

Table 4-2 (Continued)
Taiwanese Fabless Companies

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Major Products
Motorola Electronics Taiwan Ltd.	9F, 296, Sec. 4, Jen AI Rd. Taipei, Taiwan	8862-705-8000/ 8862-708-6362	1967	115	NA	Communications and consumer ICs
Myson Technology Inc.	No. 2, Industry E Rd. 3, Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-4866/ 8863-578-5002	1991	148	35	ASIC, LAN IC, bipolar IC
NEC Electronics Taiwan Ltd.	7F, 363, Fu Shing N. Rd. Taipei, Taiwan	8862-719-2377/ 8862-719-5951	1990	55	NA	ASIC
N-One	Roon 106, No. 47, Park Ave. II, Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-0146/ 8863-578-0153	1997	NA	NA	Logic IC, memory
Novatek	2F, No. 13, Innovation Rd. I, Science-Based Industrial Park, Hsinchu, Taiwan	8863-567-0889/ 8863-577-0132	1997	NA	NA	Logic IC, memory
Princeton Technology Co.	2F, No. 233-1, Pao Chiao Rd. Hsin Tien City, Taiwan	8862-917-5004/ 8862-917-4598	1986	90	13	Remote controller, encoder/ decoder, audio IC
Progate Group Co.	14F, No. 482, Chung Hsiao E. Rd. Taipei Taiwan	8862-759-0680/ 8862-759-0408	1991	21	2	ASIC
Realtek Semi. Co. Ltd.	1F, No. 11, Industry E Rd. 9, Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-0211/ 8863-577-6047	1987	220	63	Video/graphic IC, consumer IC, LAN IC, ASIC
Roco Enterprise Co.	2F, 33, Yung Chi Rd. Taipei, Taiwan	8862-766-0156/ 8862-761-5691	1985	14	1	Consumer IC
SARC Technology Co.	15F-1, No. 159, Sung Te Rd. Taipei, Taiwan	8862-726-6460/ 8862-759-3174	1989	20	2	ASIC
Silicon-Based Technology Co.	1F, 23, R&D Rd. I, Hsinchu Science-Based Industrial Park, Hsinchu, Taiwan	8863-577-7897/ 8863-577-9832	1995	25	5	SRAM
Silicon Interated Systems Co.	2F, No. 17, Innovation Rd. I, Science-Based Industrial Park, Hsinchu, Taiwan	8862-759-0680/ 8862-759-0408	1987	311	109	Core logic, ASIC
Silicon Touch	2F, No. 8, Jian Shing Rd. Hsinchu City, Taiwan	8863-572-7171/ 8863-572-7390	1997	NA	NA	Logic IC, memory

Table 4-2 (Continued)
Taiwanese Fabless Companies

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Major Products
Sun Plus Technology Co. Ltd.	1F, No. 21, R&D Rd. II, Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-6005/ 8863-578-6006	1990	103	45	DSP, ASIC, consumer IC, voice and music synthesizer, multimedia-related ICs
Syntek Semiconductor Co. Ltd.	1F, No. 40, Park Ave. II, Science-Based Industrial Park, Hsinchu, Taiwan	8863-577-3181/ 8863-577-9475	1981	102	42	Microcontroller with LCD drivers
Taiwan Memory Technology Inc.	No. 3, R&D Rd., I, Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-7720/ 8863-578-7719	1993	43	61	DRAM, SRAM
Tamarack Microelectronics Inc.	16F-4, Fu Shing N. Rd. Taipei, Taiwan	8862-772-7400/ 8862-776-0545	1987	35	8	Hybrid IC, ASIC, LAN chipset
Tontek Design	6F, 770, Chung Zan Rd. Chung Ho City	8862-222-4475/ 8862-222-4764	1986	17	2	Logic IC
Topro	6F, No. 130, Sui Wei Rd. Hsinchu City, Taiwan	8863-525-1565/ 8863-525-1596	1997	NA	NA	Logic IC, memory
Unisonic Technology Co.	4F-2, 16, Lane 609, Chung Sing Rd. Sec. 5, San Chung City, Taipei Conty. Taiwan	8862-2999-5031/ 8862-2999-1561	1990	20	2	Logic IC
Utron Technology Inc.	1F, No. 11, R&D Rd. II, Science-Based Industrial Park, Hsinchu, Taiwan	8863-577-7882/ 8863-577-7919	1993	98	80	ASIC, SRAM
VIA Technologies Inc.	8F, No. 533, ChunZan Rd. Hsin Tien City, Taiwan	8862-218-5452/ 8862-218-5453	1987	225	152	Core logic, ISA/PCI/ PCMCIA LAN chip
VLSI Technology Asia Ltd.	Room C,15F, No. 170, Tun Hua N. Rd. Taipei, Taiwan	8862-719-5466/ 8862718-3204	1990	NA	NA	Core logic
Weltrend Semiconductor Inc.	2F, No. 24, Industry E. Rd. IX, Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-0241/ 8863-577-0419	1989	70	12	Multisync monitor discriminator IC, consumer IC
Yuban Co.	5F, No. 29, Jen Ai Rd. Sec. 3, Taipei, Taiwan	8862-773-0022/ 8862-731-2698	1993	18	2	DRAM, SRAM

NA= Not available
Revenue = Semiconductor revenue of the company (U.S.$M)
Note: Number of employees in Singapore includes all company employees.
Source: Dataquest (July 1998)

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Table 4-3
Singapore Fabless Companies

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Major Products
Azfin Semiconductors Pte. Ltd.	31 Ubi Road 1, Aztech Building, Singapore 408694	65-747-9855/ 65-747-9655	1995	12	NA	ASIC
Hewlett Packard Singapore Pte. Ltd.	452 Alexandra Road, Singapore 119961	65-374-7702/ 65-274-2450	1970	1,000	NA	ASIC
Hitachi Asia Pte. Ltd.	16 Collyer Quay, #20-00, Hitachi Tower, Singapore 049318	65-535-2100/ 65-535-1533	1989	353	NA	MCU
Linear Technology Pte. Ltd.	507 Yishun Industrial Park A, Singapore 768734	65-753-2692/ 65-754-4113	1989	382	NA	High-performance linear IC
Lucent Technologies Microelectronics Asia/Pacific	77 Science Park Drive, #03-02A/04, Cintech III, Singapore 118256	65-778-8833/ 65-777-7495	1985	500	NA	Semicustom IC design
Matsushita Denshi (S) Pte. Ltd.	22 Ang Mo Kio Indl Park 2, Singapore 569506	65-481-8811/ 65-481-6486	1978	770	NA	Linear IC
Samsung Asia Pte. Ltd.	83 Clemenceau Avenue #08-01, UE Square, Singapore 239920	65-235-4921/ 65-833-3476	NA	NA	NA	Semicustom IC design
Sharp Electronics (Singapore) Pte. Ltd.	4538A Alexandra Road #05-01, Alexandra Technopark, Singapore 119967	65-271-3566/ 65-271-3855	1987	54	NA	Semicustom IC design
Siemens Components Pte. Ltd.	166 Kallang Way, Singapore 349249	65-741-7418/ 65-840-0291	1979	2,000	NA	DRAM, analog, discrete
Sony International (Singapore) Pte. Ltd.	10 Hoe Chiang Rd. 21/F Keppel Towers, Singapore 409573	65-223-3188/ 65-329-1795	1984	NA	NA	Linear IC
STMicroelectronics Pte. Ltd.	28 Ang Mo Kio Ind Park 2, Singapore 569508	65-482-1411/ 65-482-0240	1984	3,200	NA	Analog/linear IC, power transistor
Texas Instruments Singapore (Pte.) Ltd.	990 Bendemeer Rd., Singapore 339942	65-290-2000/ 65-298-9294	1990	2,000	NA	IC package design
Tritech Microelectronics Ltd.	5 Yishun Street 23 #05-01, Singapore 768442	65-752-2788/ 65-752-6557	1990	196	73 (1996)	ASIC, ASSP

NA= Not available
Revenue = Semiconductor revenue of the company (U.S.$M)
Note: Number of employees in Singapore includes all company employees.
Source: Dataquest (July 1998)

Chapter 5

Mask Manufacturers

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Table 5-1
Korean Mask Manufacturers

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Major Products
Anam Photronix Korea	Anam Bldg., 154-17 Samsung-dong, Kangnam-gu, Seoul, Korea	82-2-553-2106/ 82-2-553-2109	1,995	120	9	Photomask
Dupont Photomasks Korea	341-1, Sooha-ri Shindoon-myon Ichon-kun, Kyunggi-do, Korea	82-336-30-1811/ 82-336-34-2951	1,988	240	30	Photomask

Revenue = Semiconductor revenue of the company (U.S.$M)
Source: Dataquest (July 1998)

Table 5-2
Taiwanese Mask Manufacturers

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Major Products
Innova Inc.	No. 20, Prosperity Rd. 1, Science-Based Industry Park, Hsinchu, Taiwan	8863-578-2366/ 8863-578-2019	1989	90	29	Photomask, lead frame, reticle, optical encoder
Taiwan Mask Co.	No. 11, Innovation I Rd. Science-Based Industry Park, Hsinchu, Taiwan	8863-578-1370/ 8863-578-0752	1988	120	61	Photomask

Revenue = Semiconductor revenue of the company (U.S.$M)
Source: Dataquest (July 1998)

Chapter 6
Silicon Wafer Manufacturers

Table 6-1
Korean Silicon Wafer Manufacturers

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M	Investments 1997 (U.S.$M)	Capacity (MSI/m)	Major Products (Inches)
LG Siltron	Hanshin Securities Bldg., 15F 34-7, Yoido-dong, Yungdungpo-ku, Seoul, Korea	82-2-768-6260/ 82-2-786-4878	1983	1,239	244	NA	44	4, 5, 6, 8
POSCO Huls	27, Ohmok-ri, Sunggeo-eup, Chonan-kun, Chungnam, Korea	82-417-550-4114/ 82-417-550-4498	1990	910	221	NA	18	6, 8

NA = Not available
Revenue = Semiconductor revenue of the company (U.S.$M)
Investments = Capital spending, including R&D facility (U.S.$M)
Capacity = MSI/m (Million square inches per month)
Source: Dataquest (July 1998)

Table 6-2
Taiwanese Silicon Wafer Manufacturers

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M	Investments 1997 (U.S.$M)	Capacity (MSI/m)	Major Products (Inches)
Episil Technologies Inc.	No. 3, Innovation Rd. I, Science-Based Industrial Park, Hsinchu, Taiwan	8863-577-9245/ 8863-577-6289	1985	380	32	7	5	6
Formosa Komatsu	R. 660, 5F, No. 201, Dun Hua N. Rd., Taipei City, Taiwan	8862-2712-2211/ 8862-2711-8567	1995	NA	NA	NA	NA	8
Shin-Etsu Handotai Taiwan Co., Ltd.	2F, No. 32, Industry E. Rd. IV, Science-Based Industrial Park, Hsinchu, Taiwan	886-3-526-5948/ 886-3-526-4754	1995	NA	NA	NA	NA	8
Sino-American Silicon Products Inc.	No. 8, Industry E. Rd. II, Science-Based Industrial Park, Hsinchu, Taiwan	8863-577-2233/ 8863-578-1706	1981	264	130	NA	NA	8
TAISIL Electronic Materials Co.	8F, No. 11, Park Ave. II, Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-3131/ 8863-578-7287	1995	680	180		NA	8
Topco Scientific Co. Ltd.	6F, No 178, Ming Shen E. Rd. Sec. 2, Taipei, Taiwan	8862-501-3636/ 8862-502-1781	1990	NA	NA	NA	NA	4, 5, 6, 8

NA = Not available
Revenue = Semiconductor revenue of the company (U.S.$M)
Investments = Capital spending, including R&D facility (U.S.$M)
Capacity = MSI/m (Million square inches per month)
Source: Dataquest (July 1998)

Table 6-3
Malaysian Silicon Wafer Manufacturers

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M	Investments 1997 (U.S.$M)	Capacity (MSI/m)	Major Products (Inches)
MEMC Electronic Materials Sdn. Bhd.	1, Jl SS8/2, Sungei Way FIZ 47300 Petaling Jaya, Selangor	603-777-3277/ 603-774-5246	1972	518	36	NA	NA	4, 5
NSC Electron (Malaysia) Sdn. Bhd.	Lot 32 Jl Hi-Tech 4, Kulim Hi-Tech Park, 09000 Kulim, Kedah	604-403-2800/ 604-403-2820	1997	120	NA	142	NA	8

NA = Not available
Revenue = Semiconductor revenue of the company (U.S.$M)
Investments = Capital spending, including R&D facility (U.S.$M)
Capacity = MSI/m (Million square inches per month)
Source: Dataquest (July 1998)

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Chapter 7
Semiconductor Equipment Manufacturers

Table 7-1
Korean Semiconductor Equipment Manufacturers

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Major Products
APEX	81-18, Ohjung-dong, Daeduk-gu, Daejeon-city, Korea	82-431-60-2000/ 82-431-60-2500	1991	75	4	Furnace, LP CVD (Low-pressure chemical vapor deposition), RTP (rapid thermal process)
DNS Korea	4-1, Chaam-dong, Chonan-city, Chungnam, Korea	82-417-550-8000/ 82-417-550-8008	1993	250	47	Spinner, spin scrubber, wet station
Dong Yang Semiconductor Equipment	41-2, Chungdam-dong, Kangnam-gu, Seoul, Korea	82-32-672-7023/ 82-32-672-7024	1980	75	16	Ink marking system, laser marking handler, automatic SMD mark system, mold and die set
Hangyang Technology	1048-5, Shingil-dong, Ansan-city, Kyunggi-do, Korea	82-345-491-0296/ 82-345-491-1746	1986	150	38	Special toxic gas cylinder cabinet, automatic wet station, automatic quartz tube cleaner, wet gas scrubber, cleaning equipment
Hanjoo	691-2, Kumjung-dong, Gunpo-city, Kyunggi-do, Korea	82-343-59-4777/ 82-343-29-0648	1990	30	9	I.P.A. vapor dryer, wet station, wet gas scrubber, parts clean station
Hanyang Engineering	31-6, Mangpo-ri, Taean-eup, Hwaseung-kun, Kyunggi-do, Korea	82-331-214-0141/ 82-331-214-0140	1988	305	66	Ultrahigh purity plant and piping system, central chemical supply system, ball cleaning system
Jaelim Engineering	4F, Cheonhae Bldg., Poee-dong, Kangnam-gu, Seoul, Korea	82-2-577-5493/ 82-2-573-3106	1988	20	3	Vacuum component, custom-designed system
Kuck Dong Numeric	200-10, Anyang 7-dong, Anyang-city, Kyungki-do, Korea	82-343-45-8141/ 82-343-45-8140	1986	66	12	Transistor/linear IC tester, direct-current/VBE tester
LG Industrial Systems	20, Yoido-dong, Yongdungpo-gu, Seoul, Korea	82-2-787-6780/ 82-2-787-4968	1987	NA	26	In-circuit tester, lead inspector, die bonder, wire bonder
Mirae Corporation	9-2 Chaam-dong, Chunan-city, Chungnam, Korea	82-417-554-5070/ 82-417-554-5090	1983	269	56	Test handler
Nano Hitec Electronics	816, Jowon-dong, Jangan-gu, Suwon-city, Kyunggi-do, Korea	82-331-44-2221/ 82-331-44-3633	1991	58	16	Burn-in board, test board, test system
Ohsung Technology	532-2 Yuchon-ri, Kumwang-up, Umsung-kun, Chungbuk, Korea	82-446-877-2717/ 82-446-877-2716	1990	14	3	Wet station
P.S.K. Tech	430-3, Mogok-dong, Songtan-city, Kyunggi-do, Korea	82-333-665-4521/ 82-333-665-4520	1990	46	18	Photoresist stripper, barrel-type asher, signal-type asher, LCD etcher/asher

Table 7-1 (Continued)
Korean Semiconductor Equipment Manufacturers

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Major Products
Shinsung Technology Research	59-4, Hwaam-dong, Yusung-gu, Taejon, Korea	82-42-861-1540/ 82-42-861-1544	1991	36	7	Air shower, clean bench, clean booth
Songwon Edwards	625-7, Upsung-dong, Chunan-city, Chungchongnam-do, Korea	82-417-554-7070/ 82-417-554-7300	1992	192	50	Dry-vacuum pump and pumping system, vacuum-coating system, freeze dryer
Sungdo Engineering	8F, Daegun Bldg., 822-5, Yoksam-dong, Kangnam-gu, Seoul, Korea	82-2-555-5231/ 82-2-553-6912	1987	150	37	Semiconductor-grade central chemical supply system, automatic chemical bottle/drum-cleaning machine, wet bench, effluent gas scrubber (dry/wet), clean-room utility system installation
Taesuk Machinery	149 Kongdan-dong, Gumi-city, Kyungbuk, Korea	82-546-461-7491/ 82-546-461-7493	1989	70	19	In-line bonder, die bonder, wire bonder, taping machine, laser marking, frame loader, handler, solder
Towa Korea	4-4, Chaam-dong, Chunan-city, Chungchongnam-do, Korea	82-417-559-5010/ 82-417-559-5005	1993	140	22	Molding machine, trim and form machine
Union Industry	278-3, Weisammi-dong, Osan-city, Kyunggi-do, Korea	82-339-72-9421/ 82-339-72-9427	1988	45	11	Spin dryer, wet station, hot DI system, tube cleaner
Varian Korea	433-1, Mogok-dong, Songtan-city, Kyunggi-do, Korea	82-333-665-5171/ 82-333-665-0115	1985	230	78	Ion implanter, sputtering system, chemical-vapor deposition system, evaporator system, vacuum coater, UHV system

NA = Not available
Revenue = Semiconductor revenue of the company (U.S.$M)
Capacity = Sys/m (Systems per month)
Source: Dataquest (July 1998)

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Table 7-2
Singapore Semiconductor Equipment Manufacturers

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Major Products
Advanced Systems Automation Ltd.	65A Jalan Tenteram #04-08 St Michael's Industrial Estate, Singapore 328958	65-355-1328/ 65-251-6233	NA	330	68	Automolding, trim and form systems
Sunright Ltd.	1093 Lower Delta Rd. #02-01/08, Singapore 169204	65-272-5842/ 65-273-5107	1993	1800	10	Dual burn-in and testing systems

NA = Not available
Revenue = Semiconductor revenue of the company (U.S.$M)
Capacity = Sys/m (Systems per month)
Source: Dataquest (July 1998)

Table 7-3
Taiwanese Semiconductor Equipment Manufacturers

Company Name	Address	Phone No./ Fax No.	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Major Products
Helix Technology Inc.	1F, No. 15, Industry E. Rd. IV, Science-Based Industrial Park, Taiwan	886-3-578-7788/ 886-3-578-4489	1994	120	5	Automolding, trim and form system
International Technology Co. Ltd.	5F, 2, Lane 337, Un Ho Rd. Chung Ho City, Taiwan	886-2-2221-8187/ 886-2-2225-5973	1986	110	NA	Clean bench, booth
Venatron Enterprise Co. Ltd.	2F-3, 171, Chang An E. Rd. Sec. 2., Taipei	886-2-2721-9767/ 886-2-2721-9768	1988	150	4	Molding tooling

NA = Not available
Revenue = Semiconductor revenue of the company (U.S.$M)
Capacity = Sys/m (Systems per month)
Source: Dataquest (July 1998)

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Chapter 8

Packaging and Testing Manufacturers

Table 8-1
Korean Packaging and Testing Manufacturers

Company Name	Address	Phone No./ Fax No.	Country Origin	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Type of Business	Major Products
Anam Semiconductor	280-8, 2-ga, Sungsu-dong, Sungdong-gu, Seoul, Korea	82-2-460-5114/ 82-2-465-2607	Korea	1968	8,500	1,009	AT	PLCC, SOIC, TSOP, QFP, TQFP, BGA, PQZ
Gupyung	272, Yomchang-dong, Kangsuh-gu, Seoul, Korea	82-2-652-5081/ 82-2-653-4713	Korea	1966	811	149	AT	SOP, PDIP, PLCC, QFP
Hyundai Electronics	San 136-1, Ami-ri, Bubal-eub, Ichon-kun, Kyonggi-do, Korea	82-336-30-4114/ 82-336-30-4604	Korea	1983	2,500	112	AT	PDIP, SMD, hybrid IC, memory card, COB module, smart card
Motorola Korea	41-2, Chungdam-dong, Kangnam-gu, Seoul, Korea	82-2-3440-7000/ 82-2-3440-7203	United States	1967	2,500	262	AT	IC and discrete

Revenue = Semiconductor revenue of the company (U.S.$M)
Business: A = Assembly, T = Test
Source: Dataquest (July 1998)

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Table 8-2
Taiwanese Packaging and Testing Manufacturers

Company Name	Address	Phone No./ Fax No.	Country Origin	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Type of Business	Major Products
Advanced Semi. Engineering Inc.	No. 26, Chin 3 Rd. Nan Chi E.P. Zone. Kao Hsiung City, Taiwan	8867-361-7131/ 8867-361-3094	Taiwan	1984	3,780	420	A	PDIP, SOJ, PLCC, QFP, BGA, TSOP, PQZ
ASE Test	10, West 5 St., Nan Tze Export Procession Zone, Kao Hsiung, Taiwan	8867-363-6641/ 8867-363-6663	Taiwan	1987	930		T	Logic IC
Apack Technology	No. 2, Li Shin 3 Rd. Science-Based Industrial Park, Hsinchu, Taiwan	8863-528-4171/ 8863-528-3640	Taiwan	1997	NA	NA	A	PDIP, SOJ, PLCC, QFP, BGA, TSOP, PQZ
APTOS Technology	No. 3, Industry E. 3 Rd. Science-Based Industrial Park Hsinchu, Taiwan	8863-577-2700/ 8863-564-1269	Taiwan	1997	NA	NA	A	PDIP, SOJ, PLCC, QFP, BGA, TSOP, PQZ
Acer Testing Inc.	100, Sec. 2, Chung Yuen Rd. Lung Tan, Tao Yuen County, Taiwan	886-3-471-8398/ 886-3-471-6378	Taiwan	1996	270	2	T	Memory logic IC
Caesar Technology Inc.	1F, No. 13, Industry E. Rd. II, Science-Based Industrial Park, Hsinchu, Taiwan	8863-582-4500/ 8863-577-9204	Taiwan	1993	750	42	A	PDIP, SOJ, PLCC, QFP, BGA, TSOP, PQZ
ChanTek Electronic Co. Ltd.	No. 37, Shing Tai Rd., Chu Pei, Hsinchu, Taiwan	8863-551-9181/ 8863-551-9088	Taiwan	1989	700	40	A	PDIP, SOJ, PLCC, QFP, BGA, TSOP, PQZ
Chant World Electronic	No. 37-2, Center Rd. Nan Tze Export Procession Zone, Kao Hsiung, Taiwan	8867-363-4567/ 8867-365-7789	Taiwan	1994	NA	NA	A	PDIP, SOJ, PLCC, QFP, BGA, TSOP, PQZ
Chino-Excel Technology	No. 21, Ping Hong Rd. Chung Ho, Taipei County, Taiwan	8862-2537-6035/ 8862-2537-6305	Taiwan	1984	NA	NA	A	PDIP, SOJ, PLCC, QFP, BGA, TSOP, PQZ
ChipBond Technology	No. 21, Prosperity Rd. I, Science-Based Industrial Park, Hsinchu, Taiwan	8863-567-8788/ 8863-567-8789	Taiwan	1997	NA	NA	A	PDIP, SOJ, PLCC, QFP, BGA, TSOP, PQZ
ChipMOS Technology	No. 1, R&D Rd. I, Science-Based Industrial Park, Hsinchu, Taiwan	8863-577-0055/ 8863-566-8989	Taiwan	1997	NA	NA	AT	PDIP, SOJ, PLCC, QFP, BGA, TSOP, PQZ

Table 8-2 (Continued)
Taiwanese Packaging and Testing Manufacturers

Company Name	Address	Phone No./ Fax No.	Country Origin	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Type of Business	Major Products
First International Co.	No. 10, Prosperity Rd. I, Science-Based Industrial Park, Hsinchu, Taiwan	8863-578-0011/ 8863-577-5314	Taiwan	1993	1,000	50	AT	PDIP, SOJ, PLCC, QFP, BGA, TSOP, PQZ
Focused Semiconductor	No. 1, King Shen St. Hsinchu City, Taiwan	8863-564-2091/ 8863-524-2092	Taiwan	1997	NA	NA	A	PDIP, SOJ, PLCC, QFP, BGA, TSOP, PQZ
Formosa Advanced Technology Co.	329, Ho Nan St., Dou Liu City, Yuen Lin County 604, Taiwan	8865-557-4888/ 8865-557-4601	Taiwan	1995	350	30	A	PDIP, SOJ, QFP, TSOP
FUPO Technology	1F., No. 60, Park Ave. II, Science-Based Industrial Park, Hsinchu, Taiwan	8863--579-8841/ 8863-579-8842	Taiwan	1997	NA	NA	A	PDIP, SOJ, PLCC, QFP, BGA, TSOP, PQZ
Greatek Electronics	358, Hoshing Rd., Chu Nan 350 Industry District, Miao Li Shien, Taiwan	8863-758-3456/ 8863-758-3333	Taiwan	1995	800	40	A	PDIP, SOJ, QFP, TSOP
Hi-Yield Technology & Service Co. Ltd.	No. 59, Sec. 3, Chung Hwa Rd. Hsinchu, Taiwan	8863-539-7372/ 8863-522-0995	Taiwan	1993	50	2	T	IC
Kingpaq Technology	No. 10, Sze Wei Rd. Hsinchu Industry Park, Hu Kou, Hsinchu, Taiwan	8863-597-0888/ 8863-597-0999	Taiwan	1997	NA	NA	A	PDIP, SOJ, PLCC, QFP, BGA, TSOP, PQZ
Kes Rood Technology Taiwan Ltd.	5F-1, No. 9, Prosperity Rd. I, Science-Based Industrial Park, Hsinchu, Taiwaan	8863-578-8578/ 8863-577-2849	Singapore	1994	160	7	T	IC
LingSen Precision Industry Ltd.	No 5-1, Nan 2nd Rd. Tan Tzu, Taichung Hsien, Taiwan	8864-533-5120/ 8864-532-7904	Taiwan	1973	1,050	56	A	PDIP, SOJ, PLCC, QFP
Linktech Semiconductor	No. 7, South 4 St. Nan Tze Export Procession Zone, Kao Hsiung, Taiwan	8867-227-4919/ 8867-227-4921	Taiwan	1996	NA	NA	A	PDIP, SOJ, PLCC, QFP
Micro Silicon Electronics Inc.	No. 174, Chung Shing Rd. II, Chu Tung, Hsinchu, Taiwan	8863-596-5770/ 8863-595-3278	Taiwan	1989	160	22	AT	PDIP, SOJ, PLCC, QFP
MicroChip Technology Taiwan	No. 9-1, West 1st St. Kao Hsiung, Taiwan	8867-821-2171/ 8867-831-1593	United States	1966	600	NA	T	IC

Table 8-2 (Continued)
Taiwanese Packaging and Testing Manufacturers

Company Name	Address	Phone No./ Fax No.	Country Origin	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Type of Business	Major Products
Micropag Co.	4, Wen Hua Rd. Hsinchu Industry Park, Hu Kao, Hsinchu, Taiwan	8863-597-9402/ 8863-597-9406	Taiwan	1986	300	14	T	IC
More Power Electronics Co. Ltd.	No. 436, Sec. 1, Pai Shing Rd. Chu Tung, Hsinchu, Taiwan	8863-595-9213/ 8863-595-5611	Taiwan	1989	380	20	A	PDIP, SOJ, PLCC, QFP
Motorola Electronic Taiwan Ltd.	550, Sec. 1, Chung Hua Rd. Chun Li City, Tao Yuen County, Taiwan	8863-452-7120/ 8863-452-9154	United States	1985	2,980	NA	AT	PDIP, SOJ, PLCC, QFP, BGA, TSOP, PQZ
Orient Semi. Electronics Ltd.	No. 12-2, Hua Nan Rd. Nan Chi External Processing Zone, Kao Hsiung, Taiwan	8867-361-3131/ 8867-363-2319	Taiwan	1971	2,450	312	A	PDIP, SOJ, PLCC, QFP, BGA, TSOP, PQZ
Pan Pacific Semiconductor	No. 269, Bay Shing Rd. Sec. 1, Chu Dong, Hsinchu, Taiwan	8863-469-6871/ 8863-469-5828	Taiwan	1887	NA	NA	A	PDIP, SOJ, PLCC, QFP
Philips Electronics Building Elements Industry, Taiwan Ltd.	10, Chin 5 Rd. Nan Tze Export Procession Zone, Kao Hsiung City, Taiwan	8867-361-2511/ 8867-361-2164	Netherlands	1967	2,900	710	AT	PDIP, SOJ, PLCC, QFP, BGA, TSOP, PQZ
Powertest	6F., No. 11, 541 Lan, Chung Sing Rd. II, Chu Dong, Hsinchu, Taiwan	8863-583-0706/ 8863-583-0702	Taiwan	1997	NA	NA	T	ICs
Q Test	5F., No. 16, Lane 218, Chung Shing Rd. Sec. 2, Hsin Dia City, Taiwan	8862-913-0812/ 8862-913-0711	Taiwan	1996	NA	NA	T	ICs
Quality Test System Inc.	2F, No, 10, Li-Hsin Rd. Hsinchu Science-Based Industrial Park	8863-577-7825/ 8863-577-9204	Taiwan	1997	87	NA	T	IC
Sampo Semiconductor	1, Sec. Kao Ping, Chung Fong Rd., Long Tain, Tao Yuen, Taiwan	8863-471-9597/ 8863-471-6420	Taiwan	1996	400	2	A	PDIP, SOJ, PLCC, QFP, BGA
Sigurd Co.	No. 436, Sec. 1, Tei-Shing Rd., Chu Tung, Hsihchu, Taiwan	886-3-594-6627/ 886-3-594-6657	Taiwan	1996	70	1	T	Logic IC
Siliconix Semi. Co.	No. 3-3, East 2nd St., NanTze Export Procession Zone Kao Hsiung City, Taiwan	8867-361-5101/ 8867-361-3484	German	1974	360	NA	A	PDIP, SOJ, PLCC, QFP

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Table 8-2 (Continued)
Taiwanese Packaging and Testing Manufacturers

Company Name	Address	Phone No./ Fax No.	Country Origin	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Type of Business	Major Products
Siliconware Co.	No. 17, Park Ave. II, Science-Based Industrial Park, Hsinchu, Taiwan	886-3-577-3151/ 886-3-577-8929	Taiwan	1993	905	70	AT	PDIP, SOJ, PLCC, QFP
Siliconware Precision Industies Co.	No. 123, TaHang Rd., Sec. 3 Tan Chi, Tai Chun City, Taiwan	8864-534-1525/ 8864-534-0472	Taiwan	1984	1,900	240	A	PDIP, SOJ, PLCC, QFP, BGA, TSOP, PQZ, SOP, LOC-SOJ, STD-SOJ, SSOP
Taicera Electronics Co. Ltd.	No. 8-3, Nan-Er Rd., Tan Tzu, Taichung, Taiwan	8864-532-2111/ 8864-533-7146	Taiwan	1981	2,100	257	A	SOJ, PLCC, QFP, TQFP, PDIP
Taiwan Electronics Packaging Co.	No. 16, 676 Lane, Chung Hua Rd. Chu Pei, Hsinchu, Taiwan	8863-552-9911/ 8863-552-0420	Taiwan	1995	320	40	A	PDIP, SOJ, PLCC, QFP
Test Service	120-3, Chung Hua Rd., Hsinchu Industrial Park, Taiwan	8863-597-0670/ 8863-597-0671	Taiwan	1992	50	3	T	Memory, logic IC
Texas Instruments Taiwan Ltd.	142, Sec. 1, Hsin Nan Rd., Chung Ho City, Taipei County, Taiwan	8862-943-5141/ 8862-314-0994	United States	1969	2,000	NA	AT	PDIP, SOJ, PLCC, QFP, BGA, TSOP, PQZ
Thailin Semiconductor Co.	No. 6, Render Rd., Hsinchu Industrial Park, Hsinchu County 303, Taiwan	8863-598-5959/ 8863-598-3012	Taiwan	1996	115	9	T	Memory IC
Ucomm	6F-1, No. 2, Wu Tong Rd. Hsinchu City, Taiwan	8863-564-2052/ 8863-564-2051	Taiwan	1997	NA	NA	T	ICs
United Test Center Inc.	2F, No. 5 , R&D Rd. I, Science-Based Industrial Park, Hsinchu, Taiwan	886-3-578-8780/ 886-3-578-8760	Taiwan	1995	870	56	T	Memory IC
VATE Test	1F. 52, Park Ave. II, Science-Based Industrial Park, Hsinchu, Taiwan	886-3-577-0345/ 886-3-577-0668	Taiwan	1988	520	NA	T	Memory IC
Whole Win Technology	No. 6, Lan 102, Sing Ho Rd., Sing Hong, Hsinchu, Taiwan	8863-568-0699/ 8863-568-6060	Taiwan	1997	NA	NA	A	PDIP, SOJ, PLCC, QFP

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Table 8-2 (Continued)
Taiwanese Packaging and Testing Manufacturers

Company Name	Address	Phone No./ Fax No.	Country Origin	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Type of Business	Major Products
World Wide Test Technology Inc.	No. 112, Chung Ho St., Chu Pei City, Hsinchu, Taiwan	8863-553-5608/ 8863-553-3095	Taiwan	1996	120	4	T	IC
Walsin Advanced Electronics Ltd.	No. 1, East-E St., Kao Hsiung External Processing Zone	8867-811-5191/ 8867-821-4749	Taiwan	1995	850	32	AT	PDIP, SOJ, PLCC, QFP, TSOP, PQZ
Yuan Chyau	No. 93-3, Shen Chung Pu, Chu Dong, Hsinchu, Taiwan	8863-583-0000/ 8863-583-0575	Taiwan	1995	NA	NA	T	ICs

NA = Not available
Revenue = Semiconductor revenue of the company (U.S.$M)
Business: A = Assembly, T = Test
Source: Dataquest (July 1998)

Table 8-3
Singapore Packaging and Testing Manufacturers

Company Name	Address	Phone No./ Fax No.	Country Origin	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Type of Business	Major Products
Adaptec Manufacturing (Singapore) Pte. Ltd.	Block 1003, Bukit Merah Central #07-09/12, Singapore 159836	65-278-7300/ 65-278-3708	United States	1987	1,200	NA	T	ASIC
Advanced Micro Devices (Singapore) Pte. Ltd.	512 Chai Chee Lane #03-06, Bedok Indl Estate, Singapore 469028	65-448-1066/ 65-449-2360	United States	1984	1,100	70 (1996)	T	IC
Delco Electronics Singapore Pte. Ltd.	501 Ang Mo Kio Industrial Park 1, Singapore 569621	65-453-8544/ 65-730-9598	United States	1978	2,500	NA	AT	Automotive IC
Fujitsu Microelectronics Asia Pte. Ltd.	2 Second Chin Bee Rd., Jurong, Singapore 618769	65-265-6511/ 65-265-6275	Japan	1986	240	NA	AT	IC
Hewlett-Packard Singapore Pte. Ltd.	450 Alexandra Road, Singapore 119960	65-275-3888/ 65-275-6389	United States	1970	1,000	NA	DAT	IC
Linear Technology Pte. Ltd.	507 Yishun Industrial Park A, Singapore 768734	65-753-2692/ 65-754-4113	United States	1989	382	NA	DAT	Analog
Lucent Technologies Microelectronics Asia Pacific	3 Kallang Sector, Kolam Ayer Industriaal Park, Singapore 349278	65-741-9855/ 65-840-2568	United States	1985	1,000	NA	DAT	ASIC
Matsushita Denshi (S) Pte. Ltd.	22 Ang Mo Kio Industrial Park 2, Singapore 569506	65-481-8811/ 65-481-6486	Japan	1978	770	NA	DAT	Memory, MCU, analog, transistor
National Semiconductor Pte. Ltd.	11 Lorong 3, Toa Payoh, Singapore 319579	65-253-1066/ 65-253-8422	United States	1968	1,750	709 (1996)	AT	Logic, linear, gate array, memory, custom LSI, transistor, optoelectronic
NEC Semiconductors Singapore Pte. Ltd.	38 Ang Mo Kio Industrial Park 2, Singapore 569511	65-481-9881/ 65-481-8497	Japan	1976	830	NA	AT	DRAM, SIMM module, ASIC, MCU
Siemens Components Pte. Ltd.	166 Kallang Way, Singapore 349249	65-741-7418/ 65-840-0291	Germany	1979	2,000	430 (1996)	DAT	DRAM, analog, discrete
Silicon Systems (Singapore) Pte. Ltd.	3015A Ubi Rd.1, #03-01/13, Kampung Ubi Indl Estate, Singapore 408705	65-744-7700/ 65-747-7609	United States	1984	690	78 (1996)	DAT	Analog

Table 8-3 (Continued)
Singapore Packaging and Testing Manufacturers

Company Name	Address	Phone No./ Fax No.	Country Origin	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Type of Business	Major Products
ST Assembly Test Services Pte. Ltd.	5 Yishun Street 23, Singapore 768442	65-755-5885/ 65-755-9006	Singapore	1995	1,023	87	AT	Subcontractor
STMicroelectronics Pte. Ltd.	28 Ang Mo Kio Industrial Park 2, Singapore 569508	65-482-1411/ 65-482-0240	France	1969	3,500	1,075	DAT	MPU, memory/ linear IC, power transistor (analog, discrete)
Texas Instruments Singapore (Pte.) Ltd.	990 Bendemeer Rd., Singapore 339942	65-290-2000/ 65-298-9294	United States	1968	2,200	NA	DAT	DRAM, EPROM
Unitrode Electronics (Singapore) Pte. Ltd.	55 Ayer Rajah Crescent #05-17/26, Singapore 139949	65-779-2777/ 65-779-4395	United States	1986	140	NA	AT	Analog, discrete
Unizon Technology Pte. Ltd.	3 Gul Circle, Singapore 629632	65-863-2680/ 65-863-3019	Japan	1987	120	NA	AT	Diode

NA = Not available
Revenue = Semiconductor revenue of the company (U.S.$M)
Business: A = Assembly, T = Test
Source: Dataquest (July 1998)

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Table 8-4
China/Hong Kong Packaging and Testing Manufacturers

Company Name	Address	Phone No./ Fax No.	Country Origin	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Type of Business	Major Products
Alphatech Electronics Shanghai	Pudong Waigaoqiao Free Trade Zone, Shanghai, China	86-21-5855-4128/ 86-21-5855-4119	Thailand	1997	280	NA	AT	NA
AMD (Suzhou)	Suzhou Industrial Park, Suzhou, Jiangsu, China	86-512-724-2210/ 86-512-724-2905	United States	1997	400	NA	AT	Flash, PLD
ASAT	14/F QPL Industrial Bldg., 138 Texaco Road, Tsuen Wan, Hong Kong (SAR)	852-2415-7811/ 852-2415-0755	Hong Kong	1989	1,700	NA	A	Packages: PLCC, QFP, TQPF, SOIC, TSOP, EDQUAD, BGA, TBGA
Electronic Devices Ltd. (EDL)	Kwai Cheong Road, Kwai Chung, Hong Kong (SAR)	852-2424-4024/ 852-2481-6182	Hong Kong	1969	NA	NA	AT	Electronic components
Hana Technologies	1-8/F, Southeast Industrial Building, 611-619 Castle Peak Road, Tsuen Wan, Hong Kong (SAR)	852-2499-6292/ 852-2411-6015	Korea	1996	1,500	NA	A	Packages: CQFP, GA MQUAD (R)
Harris Semiconductor	Suzhou Industrial Part, Suzhou, Jiangsu, China	NA	United States	1997	NA	NA	AT	Telecom IC
Hitachi Semiconductor (Suzhou) Company	Suzhou Industrial Park, Suzhou, Jiangsu, China	86-21-6279-8351/ 86-21-6279-8275	Japan	1997	250	NA	AT	16Mb DRAM, SIMM module
Hyundai Electronics China Shanghai (HECS)	Xi Jiao Economic & Technological Development Zone, Shanghai, China	86-21-5976-5858/ 86-21-5976-3838	Korea	1996	1,200	NA	AT	DRAM, SRAM
Intel (China) Technology Limited (ICTL)	Pudong Waigaoqiao Free Trade Zone, Shanghau, China	NA	United States	1998	500	NA	AT	Flash
STMicroelectronics Pte. Ltd.	27-1 West People Road, Leshan, Sechuan, China	86-833-212-7909/ 86-833-212-6374	United States/ China	1995	NA	NA	AT	Discrete (small signal transistor)

Table 8-4 (Continued)
China/Hong Kong Packaging and Testing Manufacturers

Company Name	Address	Phone No./ Fax No.	Country Origin	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Type of Business	Major Products
Shenzhen STS Microelectronics Co. Ltd.	52, Tao Hua Rd., Futian Free Trade Zone, China	86-755-3590950/ 86-755-3591155	France/China	1998	600	NA	AT	Power transistor, E2PROM, standard linear, standard locgic, ASIC
Wuxi Huazhi Semiconductor Co. Ltd.	14 Liangxi Road, Wuxi, Jiangsu Province, China	86-510-6707123/ 86-510-6788746	Japan/China	1994	120	35	AT	Audio IC and discrete

NA = Not available
Revenue = Semiconductor revenue of the company (U.S.$M)
Business: A = Assembly, T = Test
Source: Dataquest (July 1998)

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Table 8-5
Malaysian Packaging and Testing Manufacturers

Company Name	Location	Country	Country Origin	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Type of Business	Major Products
Advanced Micro Devices Export Sdn. Bhd.	Bayan Lepas Industrial Zone, Phase II, 11900 Penang	Malaysia	United States	1972	2,716	217	A	Programmable logic device (PLD), flash memory, EPROM
AIC Semiconductors Sdn. Bhd.	Lot 26/27, Jalan Hitech 4, Kulim Hi-Tech Park, 09000 Kulim Kedah	Malaysia	Malaysia	1997	150	NA	AT	IC packaging subcontractor
ASE Electronics (M) Sdn. Bhd.	Bayan Lepas Free Trade Zone, Phase IV, 11900 Penang	Malaysia	Taiwan	1991	1,418	50	AT	IC packaging subcontractor
Carsem (M) Sdn. Bhd.	Jalan Lapangan Terbang, P.O. Box 204, 30270 Ipoh, Perak	Malaysia	Malaysia	1972	6,100	149	AT	IC packaging subcontractor
China Semiconductor Corp. (M) Sdn. Bhd.	8712 Phase 3, Batu Berendam FIZ, 75350 Batu Berendam, Melaka	Malaysia	Taiwan	1990	200	NA	A	LED
Fairchild Semiconductor Sdn. Bhd.	Phase 2, Bayan Lepas FIZ, 11900 Bayan Lepas, Penang	Malaysia	US	1972	2,300	57	AT	IC, transistor
Fujitsu Microelectronics (M) Sdn. bhd.	Persiaran Kuala Selangor Seksyen 26, 40000 Shah Alam, Selangor	Malaysia	Japan	1988	730	NA	AT	MOS memory, linear IC
Globetronics Sdn. Bhd.	Plot 1, Phase 4 Bayan Lepas Free Industrial Zone, 11900 Bayan Lepas, Penang	Malaysia	Malaysia	1990	1,500	20	A	IC packaging subcontractor
Golden Tech Discrete Semiconductor (M) Sdn. Bhd.	Plot 491, Lrg. Perusahaan Baru Dua, KP Prai, 13600 Prai, Penang	Malaysia	Taiwan	1994	NA	NA	NA	Rectifier
Harris Advanced Technology (M) Sdn. Bhd.	Lot 73 Lorong Enggang, Ulu Kelang Free Trade Zone, 54200 Kuala Lumpur	Malaysia	United States	1980	4,700	NA	AT	Linear, power IC, MOSFET, IC, transistor, hybrid devices
Hewlett-Packard (M) Sdn. Bhd.	Bayan Lepas Free Trade Zone, 11900 Penang	Malaysia	United States	1972	NA	NA	AT	LED, microwave diode
Hitachi Semiconductor (M) Sdn. Bhd.	Bayan Lepas Free Trade Zone, 11900 Penang	Malaysia	Japan	1972	2,000	NA	AT	SRAM, DRAM, microcontroller, memory module, diode, transistor

Table 8-5 (Continued)
Malaysian Packaging and Testing Manufacturers

Company Name	Location	Country	Country Origin	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Type of Business	Major Products
Hitachi Semiconductor (Kedah) Sdn. Bhd.	Plot 54, Kulim Industrial Estate, 09000 Kulim, Kedah	Malaysia	Japan	1981	NA	NA	A	Diode, transistor, standard logic IC
Integrated Device Technology (M) Sdn. Bhd.	Bayan Lepas Free Industrial Zone, 11900 Penang	Malaysia	United States	1987	945	NA	AT	SRAM
Intel Technology Sdn. Bhd.	Bayan Lepas Free Industrial Zone, 11900 Penang	Malaysia	United States	1977	5,200	426	DAT	Pentium, MCU, microperiphral
Linear Semiconductor Sdn. Bhd.	Plot 21 (B), Phase 4, Bayan Lepas FIZ, 11900 Bayan Lepas	Malaysia	United States	1994	NA	NA	AT	IC
Motorola (Malaysia) Sdn. Bhd.	Sungai Way FIZ, 47300 Petaling Jaya, Selangor	Malaysia	United States	1972	4,900	NA	AT	MCU, MPU, analog
Motorola Semiconductor Sdn. Bhd.	Lot 122, Senawang Industrial Estate, P.O. Box 465, 70750 Seremban	Malaysia	United States	1979	2,700	NA	AT	Discrete
National Semiconductor Sdn. Bhd.	Batu Berendam Free Trade Zone, 75350 Malacca	Malaysia	United States	1971	2,554	162	AT	Analog/linear IC
NEC Semiconductors (M) Sdn. Bhd.	Telok Panglima Garang FTZ, KM15 Jalan Banting, 42500 Kuala Langat, Selangor	Malaysia	Japan	1974	1,632	305	AT	Transistor, consumer/industrial linear IC, LED, DRAM
Quality Technologies Optoelectronics (M) Sdn. Bhd.	5 Jalan SS8/2, Sungei Way FTZ, 47300 Petaling Jaya, Selangor	Malaysia	United States	1979	1,200	29	AT	Optoelectronics, LED, displays
Rectron (M) Sdn. Bhd.	No 2473 Tingkat Perusahaan Enam, Prai Industrial Estate FTZ, 13600 Prai	Malaysia	Taiwan	1987	403	11	AT	Diode and bridge rectifiers, LED
Rohm-Wako (M) Sdn. Bhd.	Lot 58 Jalan 26/6, Hicom Industrial Estate, 40000 Shah Alam, Selangor	Malaysia	Japan	1987	230	25	AT	LED
SGS-Thomson Microelectronics Sdn. Bhd.	Tanjong Agas Industrial Area, 84007 Muar, Johor	Malaysia	France	1974	3,800	751	AT	Power IC, transistor, diode
Siemens Components (Advanced Technology) Sdn. Bhd.	Batu Berendam FTZ, 75350 Malacca	Malaysia	Germany	1980	3,800	638	AT	Power transistor, diode, 4Mb DRAM, 16Mb DRAM

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Table 8-5 (Continued)
Malaysian Packaging and Testing Manufacturers

Company Name	Location	Country	Country Origin	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Type of Business	Major Products
Siemens Semiconductor Sdn. Bhd.	Bayan Lepas Free Industrial Zone, 11900 Penang	Malaysia	Germany	1972	1,900	113	AT	Optocoupler, display
Texas Instruments Malaysia Sdn. Bhd.	1 Lorong Enggang 33, Ulu Kelang FTZ, 54200 Kuala Lumpur	Malaysia	United States	1972	3,200	288	AT	IC, optothermostat, motor protector, materials and control products, industrial automation
Toshiba Electronics (M) Sdn. Bhd.	Km. 15 Jalan Klang Banting, 42507 Telok Panglima Garang, Kuala Langat, Selangor	Malaysia	Japan	1973	1,700	NA	AT	DRAM, transistor
Toyo Dempa (M) Sdn. Bhd.	Lot 26 & 27, Phase 3, Batu Berendam FIZ, 75350, Melaka	Malaysia	Japan	1994	NA	NA	AT	Diode, transistor, standard logic IC
Unisem (M) Sdn. Bhd.	No 1 Persiaran Pulai Jaya 9, Kawasan Perindustrian Pulai Jaya, 31300 Ipoh, Perak	Malaysia	Malaysia	1989	1,400	56	A	IC packaging subcontractor

NA = Not available
Revenue = Semiconductor revenue of the company (U.S.$M)
Business: A = Assembly, T = Test
Source: Dataquest (July 1998)

Table 8-6
Packaging and Testing Manufacturers in Rest of Asia/Pacific

Company Name	Location	Country	Country Origin	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Type of Business	Major Products
TI India	Banglore, India	India	United States	1986	NA	NA	D	DSP
P.T. Astra Microtronics Technology	Jl. S. Parman Kav. 201, Batamindo Industrial Park, Muka Kuning, Batam 29433	Indonesia	Indonesia	1991	2426	73	A	IC packaging subcontractor
P.T. NEC Humpuss Semiconductors Indonesia	EJIP Industrial Park Plot 5E, Lemahabang Bekasi 17550	Indonesia	Japan	1996	245	0.4	AT	Linear IC and signal transistor
P.T. Omedata Electronics	Jl. Sukarno Hatta, Km. 2, No. 106	Indonesia	Indonesia	1986	2200	NA	A	IC packaging subcontractor
Sharp Semiconductor Indonesia	KIIC, Jalan Tol Jakarta-Cikampek,Lot F3, Km. 47, Karawang Barat, Java	Indonesia	Japan	1995	880	NA	AT	Optoelectronics, SRAM, and DRAM
AMI (Philippines) Inc.	9701 Dr. A. Santos Avenue, Paranaque, Metro Manila 1700	Philippines	United States	1980	700	NA	AT	NA
Amkor Anam (Philippines) Industrial Inc.	Km. 22, East Service Rd., South Superhighway, Muntinlupa, Metro Manila 1702	Philippines	Korea	1976	1500	NA	A	Subcontractor
Ampang Industries Phippines Co.	NA	Philippines	NA	NA	NA	NA	NA	NA
Analog Devices (Philippines) Inc.	Km. 14, Edison Avenue, South Expressway, Paranaque, Metro Manila 1700	Philippines	United States	1981	800	NA	A	IC
Asionics Philippines Inc.	122 Shaw Blvd, Pasig, Metro Manila 1600	Philippines	NA	1973	275	NA	A	Subcontractor, bipolar, MOS IC
Automated Microelectronics Inc.	Km. 22, East Service Rd., South Superhighway, Bo Cupang, Metro Manila 1702	Philippines	Philippines	NA	NA	NA	NA	NA
C.F. International Manufacturing Inc.	NA	Philippines	NA	NA	NA	NA	NA	NA
Cebu Mitsumi Inc.	NA	Philippines	Japan	NA	NA	NA	NA	NA
Champion Electronics Co.	NA	Philippines	NA	NA	NA	NA	NA	NA
Cirtek Electronics Corp.	1025 San Marcelino St., Ermita, Manila	Philippines	Philippines	1984	180	NA	A	Subcontractor, bipolar, MOS IC
Complex Electronics Co.	NA	Philippines	NA	NA	NA	NA	NA	NA

Table 8-6 (Continued)
Packaging and Testing Manufacturers in Rest of Asia/Pacific

Company Name	Location	Country	Country Origin	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Type of Business	Major Products
Complex Electronics Corp.	Km. 21 South Superhighway, Muntinlupa, Metro Manila 1702	Philippines	Philippines	1974	1160	NA	A	Subcontractor, bipolar, MOS IC
Dai-Ichi Denshi Industries Inc.	NA	Philippines	Japan	NA	NA	NA	NA	NA
Dai-Ichi Electronics Mfg. Co.	NA	Philippines	Japan	NA	NA	NA	NA	NA
Dynesem Electronics Co.	FTI Complex, Taguig, Metro Manila 1604	Philippines	Philippines	1986	2500	NA	A	Subcontractor, ASIC
Electronic Test Lab Co.	TDC Building, Electronics Ave., FTI Complex, Taguig, Metro Manila 1604	Philippines	Philippines	NA	35	NA	A	Subcontractor
Encore Filipinas Micro Electronics Inc.	National Road, Barrio Almanza, Las Pinas, Metro Manila 1701	Philippines	Philippines	1981	3120	NA	A	Transistor
Equidata (Philippines) Inc.	NA	Philippines	NA	NA	NA	NA	NA	NA
Gateway Electronics Corp.	Gateway Business Park, Crisanto los Reyes Avenue, Javalera, Gen. Trias, Cavite	Philippines	Philippines	1996	NA	NA	AT	Subcontractor, IC
Integrated Circuit Philippines Inc.	8393 South Superhighway Km. 19, Paranaque, Metro Manila	Philippines	Philippines	1979	350	NA	A	Subcontractor, IC
Integrated Microelectronics Inc.	Km22 South Superhighway, Bo Cupang Muntinlupa, Metro Manila 1702	Philippines	Phillppines	1980	3164	NA	A	Subcontractor, IC
Intel Philippines Manufacturing Inc.	1321 Apolinario St., Bangkal, Makati, Metro Manila 1200	Philippines	United States	NA	1600	NA	A	Pentium, EPROM
Ionics Circuits Inc.	Ionics Bldg. 2296, Light Industry Science Park, Barrio Diezmo, Cabayao, Makati, Metro Manila 4025	Philippines	Philippines	1986	250	NA	A	Subcontractor, MOS IC, bipolar, discrete
Labtech Manufacturing Industries	No. 6, 21st Ave, Cubao, Quezon City, Metro Manila 1110	Philippines	Philippines	1976	350	NA	AT	Diode, bridge rectifier, power transistor, transistor array
Magnatron Co.	NA	Philippines	NA	NA	NA	NA	NA	NA
Motorola Philippines Inc.	Bormaheco Bldg., 17 South Superhighway, Paranaque, Metro Manila 1700	Philippines	United States	NA	NA	NA	AT	Discrete, IC

Table 8-6 (Continued)
Packaging and Testing Manufacturers in Rest of Asia/Pacific

Company Name	Location	Country	Country Origin	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Type of Business	Major Products
National Semiconductor Inc.	Mactan Processing Zone, Lapu-lapu City, Cebu 6015	Philippines	United States	NA	NA	NA	A	Transistor, diode
NEC Technologies Philippines Inc.	NA	Philippines	Japan	NA	NA	NA	NA	NA
Pacific Semiconductors Inc.	FTI Complex, Taguig, Metro Manila 1604	Philippines	Philippines	1974	NA	NA	A	Transistor, IC
Philips Semiconductor Philippines Inc.	203 Valero St., Salcedo Village, Makati, Metro Manila 1200	Philippines	Netherlands	1981	4450	NA	A	Transistor, power device
Rohm Electronics Philippines Inc.	People's Technology Complex, Carmona, Cavite	Philippines	Japan	NA	NA	NA	A	IC
Semiconductor Devices Inc.	FTI Complex, Taguig, Metro Manila 1604	Philippines	NA	NA	NA	NA	A	IC
Silicon Technology	CAA Compound, Pasay City, Metro Manila	Philippines	NA	NA	NA	NA	A	NA
Stanford Microsystem Inc.	Pasig Boulevard Extension, Bo Maybunga, Pasig, Metro Manila 1600	Philippines	Philippines	1970	NA	NA	A	IC, discrete
Team Pacific Corp.	FTI Complex, Electronics Avenue, Taguig, Metro Manila 1604	Philippines	United States	1976	3041	NA	A	Subcontractor, IC, transistor, clock display
Temic Telefunken Microelectronics (Philippines) Inc.	Telefunken Bldg., FTI Complex, Taguig, Metro Manila 1604	Philippines	Germany	1974	1400	NA	A	IC, transistor
Texas Instruments (Philippines) Inc.	Loakan Road, Baguio City, Benguet 2600	Philippines	United States	NA	NA	NA	A	ASIC, MCU
Zilog Philippines Inc.	8460, Dr. A. Santos Ave., Sucat, Paranaque, Metro Manila 1700	Philippines	United States	1979	500	NA	A	ASSP
Alphatec Electronics Public Co. Ltd.	17/2 Moo 18, Suwinthawong Rd., Saladaeng, Bangnam prow, Chachoengsao 24000	Thailand	Thailand	1988	1800	486 (1996)	DAT	IC packaging, test subcontractor
AMD (Thailand) Co. Ltd.	229 Moo 4, Chaengwattana Road, Bangphood, Pak Kret, Nonthaburi 11120	Thailand	United States	1988	827	NA	AT	IC

Table 8-6 (Continued)
Packaging and Testing Manufacturers in Rest of Asia/Pacific

Company Name	Location	Country	Country Origin	Business Start Year	No. of Employees	Revenue 1997 (U.S.$M)	Type of Business	Major Products
Lucent Technologies Microelectronics (Thai) Co. Ltd.	101/32-33 Navanakorn Indl Est Km. 46, Phaholyothin Rd., Pathumthani	Thailand	United States	1980	1000	166 (1995)	AT	IC
Chinteik Electronics Ind. Co. Ltd.	101/67-68 Navanakorn Village, Klongluang, Pathumthani 12120	Thailand	Thailand	1985	2000	103 (1995)	AT	IC packaging, test subcontractor
Data General Thailand Co. Ltd.	189 New Phetahabom Rd., Bangkok 10400	Thailand	United States	NA	NA	NA	A	Bipolar device
Hana Semiconductor (BKK) Co. Ltd.	10/4 Moo 7, Soi Mahanakom Nivs, Vipharadee-Rangsit Rd., Donmuang, Bangkok 10210	Thailand	Thailand	1984	1500	48 (1995)	AT	IC packaging, test subcontractor
Honeywell Synertek (Thai) Co. Ltd.	101/3-33 Phahonyothin Rd., Pathumthani 12000	Thailand	United States	1981	550	NA	AT	IC, RAM, ROM, microprocessor
Microchip Technology	NA	Thailand	Taiwan	NA	NA	NA	NA	NA
NS Electronics Bangkok Co. Ltd.	40/10 Soi Lasal, Sukhumvit 105 Bangna, Prakanong, Bangkok 10260	Thailand	Thailand	1973	2000	NA	AT	MOS memory, digital linear device, bipolar LSI
Ngam Tawee Electronics	NA	Thailand	Thailand	NA	NA	NA	NA	IC
Oki	NA	Thailand	Japan	NA	NA	NA	NA	IC
Philips Semiconductors (Thailand) Co. Ltd.	303 Moo7, Chaengwattana Rd., Donmuang, Bangkok 10210	Thailand	Netherlands	1974	3700	541 (1996)	AT	IC
Sanyo Semiconductor (Thailand) Co. Ltd.	Rojana Industrial Park 1/7 Moo 5, Karaham Uthai Ayudhya 13210	Thailand	Japan	1991	1000	135 (1996)	AT	Printed circuit board assembly (PCBA), test
Sony Semiconductor (Thailand) Co. Ltd.	Bangkadi Industrial Park 140 Moo 5, Amphurmuang Pathumthani 12000	Thailand	Japan	1988	1293	258 (1996)	AT	IC
Thai Micro System Technology Co. Ltd.	132 Moo 5, Bangkadi Indl Park Tivanondh Rd., Pathum Thani 12000	Thailand	Thailand	1990	224	NA	A	Subcontractor
Toshiba Semiconductor (Thailand) Co. Ltd.	Bangkadi Industrial Park 135 Moo 5, Tiranont Rd., Pathumthani 12000	Thailand	Japan	1990	1171	49 (1995)	AT	IC

NA = Not available
Revenue = Semiconductor revenue of the company (U.S.$M)
Business: A = Assembly, T = Test
Source: Dataquest (July 1998)

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Perspective

Semiconductors China

Dataquest Predicts

Hong Kong's Electronics Future: Add Value or Die!

Abstract: *In light of new policies from the Hong Kong Special Administrative Region aimed at promoting information technology development and overall competitiveness, Dataquest presents forward-thinking scenarios for semiconductor vendors and distributors to consider if they wish to capitalize on the dramatic developments likely to come.*
By Daniel Heyler

Overview

It is well known that Hong Kong has disappeared as a major Asian base for electronic equipment or semiconductor manufacturing since the 1970s. "Activist" government spending and investment incentives in Japan, South Korea, Singapore, and Taiwan helped jump-start those electronics powerhouses, but Hong Kong adhered to its laissez-faire principles. After the exit of the British government and the establishment of the Special Administrative Region (SAR) government, the administration of the SAR's chief executive, C.H. Tung, began introducing ambitious measures to bolster both the development and commercialization of technology in Hong Kong. In the Hong Kong culture of lean, noninterfering government, such measures can be extremely controversial. However, the decline of the property market and the weakening of the financial markets has created a crisis, leading to support for Mr. Tung's development strategy focusing on information technology (IT). A confluence of government, industry, technological, economic, and mainland China forces suggests that Hong Kong's electronics development is at a turning point.

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Downstream Application of Information Technology

When a semiconductor executive thinks of Hong Kong, electronics production is the last thing to come to mind. Hong Kong is known for its efficient logistics and distribution, but most of its production has moved across the border to China (although product development remains in Hong Kong). Most consider Hong Kong's core competencies to be commerce, finance, and shipping or air cargo, especially trade with China's wealthy, industrialized South. But what semiconductor executives may be overlooking is that Hong Kong leads the region in its *application* of technology. Hong Kong industries and government are adept at testing and adopting new information technologies into business processes relative to the rest of Asia/Pacific. Hong Kong's companies are often the first to move and have gained competitive advantage in doing so. Some obvious examples are wireless communications, the Internet, a smart card-based transportation system, a new airport, electronic shopping, electronic data interchange in shipping, video-on-demand, electronic securities trading, and air cargo processing. Multinationals have often used Hong Kong as a test market because of its unique characteristics—high income, dense population, a multicultural society, bilingual economy, laissez-faire capitalism, free trade, efficient administration, transparent government (a three-branch system), and strong legal system. Leaders in the interactive television initiative, for example, believe that if a technology is not economically viable in Hong Kong, then it will not be viable anywhere.

The government initiative attempts to leverage this unique market position so that Hong Kong itself begins to develop products and services for its own economy. Those opposed say Hong Kong can keep importing what it needs rather than building it domestically, fearing government waste and preferential treatment. Those in favor of the initiative believe Hong Kong needs to find new areas of growth and believe it can leverage its understanding of applications and markets to develop and sell products to the rest of the region, particularly China.

Sources of Competitive Advantage

The 1998 Global Competitiveness Report of the World Economic Forum ranks the Hong Kong Special Administrative Region as second worldwide, after the United States, the same position as in 1997. The report judges the competitiveness of 53 countries by their ability to achieve sustained high rates of growth in gross domestic product per capita. The final rating assesses performance in eight categories: openness, government, finance, infrastructure, technology, management, labor, and institutions. For semiconductor users, this means that Hong Kong companies can purchase components less expensively and faster than those in any other country in Asia and incur lower taxes, financing costs, and transportation costs than companies in most other countries in the world. But what happens when IT enables transactions to bypass Hong Kong intermediaries and go directly to factories in China? Dataquest concurs that the Hong Kong government is

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right to be concerned about the rate and scope of the structural changes in logistics. Won't Hong Kong lose its competitive advantage?

Do Laissez-Faire and IT Policies Mix?

Hong Kong's laissez-faire approach has led to success in the finance, transportation, cargo, and communications industries, enabled by access to cost-effective solutions without any government intervention. Other Asian governments levy duty on imports on the industries they intend to develop. An activist Hong Kong government would not adopt such protectionist measures because Hong Kong has a long history as a free port to components. It is likely to continue to rely on market forces and incentives. Many of the recent initiatives, described later, focus on building an environment in which innovation and technology can develop and become commercialized. Hong Kong is likely to remain a free port and the purest market economy in the world. Incentive programs will provide electronics and technology companies with preferential treatment, but these industries enable competition, and they add value to local service and traditional industries.

Lowering Fixed Costs of Doing Business

Hong Kong is the most productive economy in Asia and ranks second in the world, but it is criticized by executives as one of most expensive countries in which to do business. However, the main source of the high cost is property, because higher salaries must be paid to employees and higher rents must be paid by businesses. Two positive signs indicating that the days of speculation are passing are that prices have fallen 20 to 30 percent since 1997 and that the Tung administration is committed to regulating speculation and releasing more land. Singapore has successfully attracted corporate regional headquarters by reducing income taxes. The Hong Kong government appears to be continuing a hands-off strategy, keeping a competitive, level playing field. Hong Kong's competitive advantage will be found among small and medium-size industries, whereas Singapore depends on multinationals. Taiwan's success, even in the current financial crisis, is due primarily to the competitive power of small- and medium-size businesses. Hong Kong is adamant about avoiding becoming totally dependent on the innovation of outside parties and in their control. Hong Kong should be concerned that wealth creation will slow with a slowdown in the finance and property industries and that diversification into technology will enable sustainable value creation.

Technology and Innovation

Universities and institutes are not the answer but will be important, and the government will be pressured to modernize its education system. Dataquest does not believe that providing a university with a mission is the most effective approach. Most of the key technologies of today's IT era have come from pure research emanating from the U.S. military and space programs.

Hong Kong's newly established Commission on Innovation and Technology proposes establishing an applied science and technology research institute. The idea is that the institute would provide R&D capability by turning concepts into technologies, which could be commercialized by local companies. But local companies can continue to purchase fully developed, debugged, and commercially proven technologies from the United States, Japan, and Europe. The success of local industry is based on its ability to find the least expensive and most effective IT solutions from global sources. The so-called "weak R&D culture" is really part of a successful business formula. However, Dataquest believes that localized technology development would bolster Hong Kong companies competing in a digital economy. Electronics and software products and services need to be developed for the functions, features, and culture of the local Hong Kong/Chinese markets. If local businesses have access to local semiconductor design, software developers, and systems designers and integrators, this technology can be more effectively integrated into their business strategies. Manufacturing of ICs or hardware can be done in Taiwan or China, but products and services must suit local business needs for functionality, service, logistics, and time to market. The hope is that a robust information technology industry in Hong Kong will become a strong source of new revenue growth as businesses expand to Chinese businesses and consumers in China and the rest of Asia/Pacific.

The government is also proposing a long-term education initiative to turn preuniversity schools into dynamic and innovative learning institutions by linking students with the vast network of knowledge and information globally.

Obtaining and Retaining Talent

However, what has made Silicon Valley and Taiwan competitive is the ability to attract outside engineers, entrepreneurs, and investors (venture capitalists). In Taiwan, the government was instrumental in turning a brain drain into a brain gain by the early 1990s, which led to a world-class manufacturing base with strong connections to North American technology and talent. Hong Kong's approach—to tap its greatest asset, overseas Chinese—will not be difficult, given the scope and capital of the Tung government's initiative. Furthermore, Hong Kong has yet another card to play, mainland Chinese immigration policy. Hong Kong can grant residency to Chinese Ph.D.s and experts in such strategic areas as materials, communications, and software.

Electronic Government

Hong Kong's recently formed Information Technology Services Department has pledged that it will provide the ability to transact business with government online and seamlessly through the use of information kiosks installed at convenient public locations, personal computers at home or in the office, telephone interactive voice response systems, or interactive television. Public services are expected to be available 24 hours a day, and the scheme is intended to transform the way public services are delivered. The Information Technology Services Department will also build central gateways and a common Chinese interface for electronic communication between government departments and the public by 2000. An electronic link with Guangdong province will be set up next year.

The government is also looking into the need for a legal framework to enhance confidence in the conduct of electronic transactions. The objective is to help electronic transactions take hold in Hong Kong. Singapore has moved ahead of Hong Kong in developing a legal framework that has enabled banks to move quickly in an attempt to take market share from Hong Kong. Hong Kong must also move quickly if it is to keep its edge.

Links with China

Where will innovation come from in the future? Skeptics have denigrated the potential electronics innovation power of China and Hong Kong. Yet rapid advances in software and product development skills continue, largely because of inexpensive Internet-based communication between once-isolated academia in China and industry. A tremendous force will be unleashed in China as the Internet unlocks virtually unlimited information and enhances collaboration among a vast network of research institutes. The governments of Hong Kong and China realize the importance of these links and have set a budget of $23 million for the launch of the first phase of electronic service delivery in 2000. The Trade and Industry Bureau has been assigned the task of working on new projects to foster cooperation on information technology between industry and academia and between Hong Kong and the mainland. The Information Technology Broadcasting Bureau will focus on IT infrastructure in Hong Kong.

As many as 6,000 technology developers and resellers operating in the Chinese capital alone, the majority of them privately run, have maintained an average yearly growth of 30 percent for the past decade. Targeting the capital shortage facing most high-technology start-ups, the city government has launched a $24 million fund to provide guarantees for a select group of small and medium-size high-tech companies.

The more a product or system with an external network is used, the more valuable that investment becomes, as is the case with a telephone system. Linking Hong Kong with Chinese cities, universities, and stock markets will have major consequences for innovation and product development within the China/Hong Kong region. The value of these initiatives cannot be gauged by traditional return-on-investment or payback metrics because the outcomes reach every sector of the economy in positive but intangible ways.

Capital Sources and Financing

A variety of capital sources is being formulated by various parts of the Hong Kong government.

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Second Securities Board

Hong Kong is planning a second securities board to encourage listings by new high-tech companies. Indeed, competition might heat up if Shanghai creates another board to encourage such listings. The Beijing Securities Regulatory Commission (SRC) reported that it raised U.S.$866 million from the securities market in 1997, 12 times its 1996 total. However, Beijing and Shanghai are welcoming Hong Kong's move, hoping that listing Beijing-based high-tech companies will contribute to both optimizing the diversity of the Hong Kong securities market and improving the management of high-tech start-ups. The SRC has not yet come up with regulations covering the listing of mainland high-tech companies on a Hong Kong board. The regulations will be based on how Hong Kong regulates the market.

Going public is the most attractive way for a venture capitalist to realize a return on an initial investment. It could take a year and a half for Shanghai's second board to open. The most likely initial start-ups in Hong Kong will be in software and networks.

Government Investment and Science Park

The chief executive of Hong Kong, Mr. Tung, has promised a total of $646 million in government investment in the SAR's electronics sector. About $84 million has been allocated to a newly formed innovation and technology fund by the SAR government; $3 million has been marked for a public intranet project; and $55 million is being spent on a technology and science park (currently under construction).

Incentives

Singapore has introduced a wide range of tax concessions to attract foreign investment. Hong Kong may follow suit by raising the allowance for corporate investment in high-tech infrastructure to 200 percent. Companies now enjoy a 100 percent tax break on the cost of bringing in computers and other high-tech equipment.

Overseas Chinese Capital

San Francisco's WI Harper Group recently announced that it is raising $50 million to invest in technology companies in China. The Beijing Technology Development Fund is the first offshore technology venture fund blessed by China's communist government, which is investing $10 million through Hong Kong's Beijing Enterprises Holdings. Peter Liu, Harper's chairman, expects to raise another $10 million to $15 million in Taiwan. The rest will come from U.S. technology companies, banks, and venture capital companies. The fund will invest in software, telecommunications, multimedia, and biotechnology start-ups, with a goal of taking the start-ups public in the United States.

Competitive Bandwidth

Hong Kong plans to allow greater competition in its broadcasting and telecommunications industries. The government will open up the pay-television and video-on-demand markets by allowing an unlimited number

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of licenses. That means that monopoly license holders Wharf (Holdings), its subsidiary Wharf Cable, and Hong Kong Telecommunications, could soon face competition for services. The government wants telephone service providers to be able to provide television programs, including pay-television and video-on-demand, and for broadcasters to be able to provide telephony services. That would require more interconnection among broadcasters and telephone service providers, which the government is also proposing. The government wants to see trials of digital and high-definition television start in Hong Kong and will encourage broadcasters to apply digital technology. To further facilitate competition, the government wants to abolish subscription and advertising royalties that cost the industry U.S.$40 million and to revamp its broadcasting laws. But the government does not plan to offer more terrestrial network licenses, saying there is limited transmission space. The government has not yet decided whether to continue restricting the number of fixed-network telephone licenses, now held by four companies.

Scenarios for Semiconductor Distribution in China/Hong Kong

As discussed previously, Dataquest anticipated increasing economic interdependence between China and Hong Kong. The service sector continues to fuel Hong Kong's economy, but manufacturing is the largest and fastest-growing part of the mainland's economy. China's economic expansion in the past decade has broadened Hong Kong's service sector, which now supports China's industrialization. Hong Kong-based companies have provided critical links between Chinese manufacturers and imported technology and components. Hong Kong is now the source of more than two-thirds of the semiconductor components on which China depends.

Figure 1 illustrates the current trend of Hong Kong companies to act as intermediaries and not producers of electronics. Domestic exports have shown flat growth, while re-exports of components and equipment continue to increase. Are these intermediaries serving China or other markets? Figure 2 shows re-exports by destination. Hong Kong's role in China is growing fastest, but the growth is symmetrical.

Disintermediation

Hong Kong's distributors serve as intermediaries for semiconductor vendors and electronics manufacturers in China. The competitive advantage of distributors consists essentially of logistics, information, and relationships. Semiconductor vendors in Asia/Pacific may still operate on a commodity product mentality, offering little service and focusing on low cost. But a key competitive advantage of semiconductor vendors in the region will be their ability to provide manufacturing services and development support to their customers. Asian OEMs are facing very competitive times and must rapidly transform their business processes or risk being supplanted by contract manufacturers with lower costs for procurement, inventory management, and built-to-order/configure-to-order business processes. Manufacturers in China/Hong Kong will rely on information technology to source components, seek technical support, manage logistics, and market or sell

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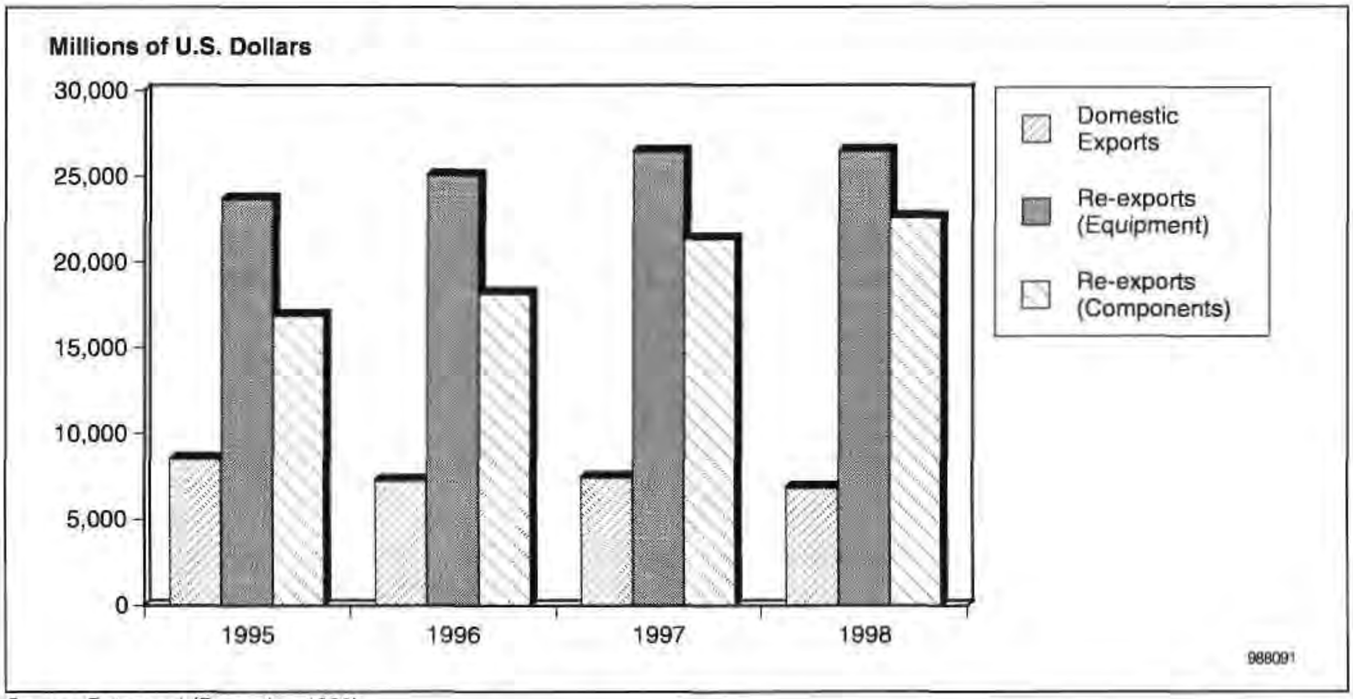
their products. Hong Kong distributors and trading companies soon will become obsolete and must find ways to add value. We also see that design and development of products is moving closer to the markets in which they are consumed. Dataquest anticipates a continued increase in fabless semiconductor companies in China/Hong Kong because of the growth in local product development (for local consumption). Venture capital provides an important source of income, and the combination of local and overseas Chinese is providing the necessary technical and business talent.

Figure 1
Hong Kong Re-exports and Domestic Exports of Electronic Equipment and Components, 1995 to 1998 (Millions of U.S. Dollars)



Source: Dataquest (December 1998)

Reintermediate or Die!

The threat of disintermediation is not yet significant in Hong Kong and China but is increasing fast. Electronic commerce for semiconductor companies is enabling lower coordination costs with suppliers and customers, as well as internally. The role of the distributors will be diminished by vendors able to deliver real-time, online service, information, technical support, and logistics management. Hong Kong distributors will have to devise strategies to regain their status as intermediaries within a few years or simply close up shop. They will be challenged to introduce value-added services to semiconductor users (electronically) in China as links between vendors and manufacturers grow close. A possible scenario is that distributors will invest in IT, use their market power to become order collectors, and then negotiate the best prices and delivery terms with vendors. An extreme example of reintermediation would be if Hong Kong were to establish a semiconductor electronics market; it has no industry that

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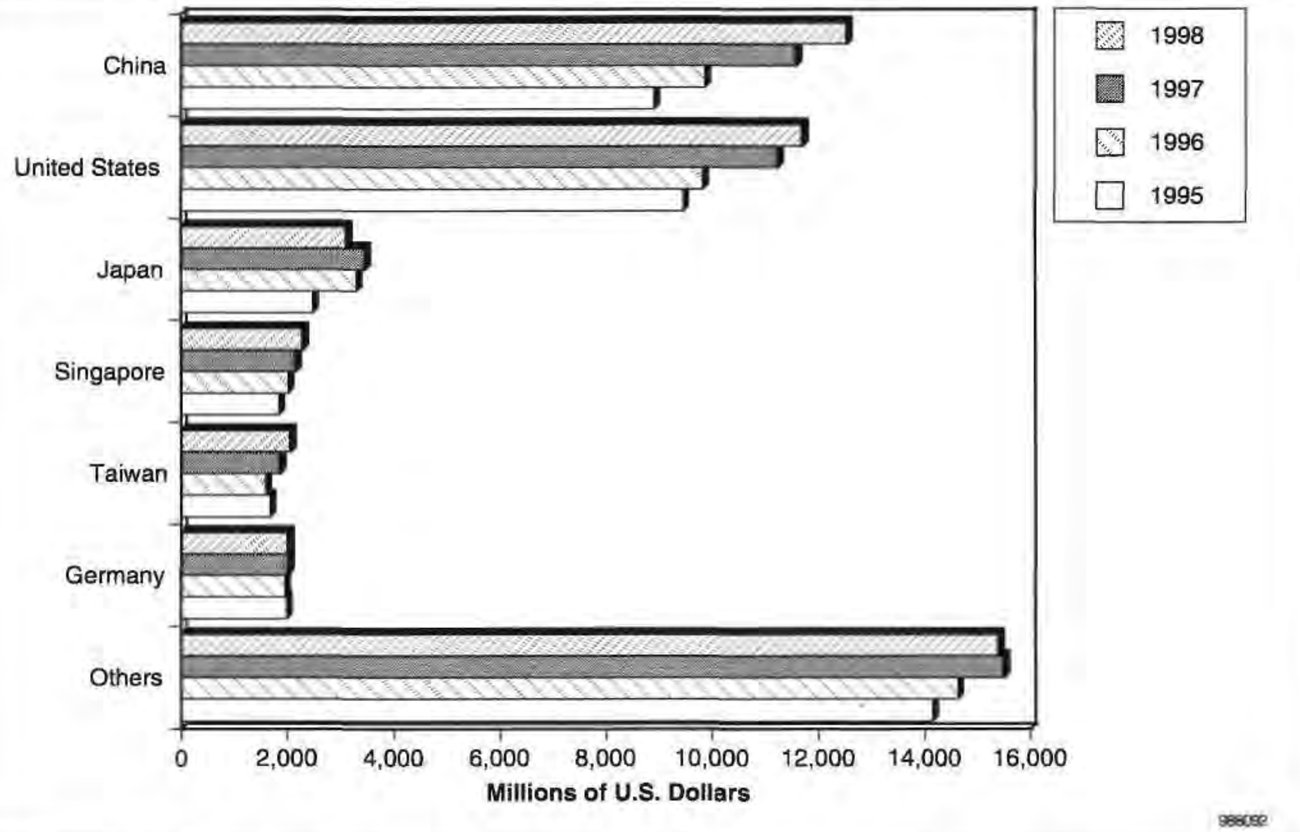
would be hurt, and it currently is the main source of semiconductors to Asia/Pacific's largest market.

Figure 2
Destination of Hong Kong Electronic Exports, 1995 to 1998 (Millions of U.S. Dollars)



Source: Dataquest (December 1998)

Future Start-Ups

Hong Kong has entrepreneurial zeal, access to information, and venture capital comparable to Taiwan's but lacks the industrial/technological infrastructure of small and medium-size component suppliers key to Taiwan's success. However, its population density, open markets, high income, and links with mainland China (for manufacturing, workforce, and markets) have made Hong Kong an ideal test market for services such as wireless communications, interactive television, electronic banking, electronic commerce, smart cards, transportation, electronic cash, and so on. It is commonly thought that if a product cannot become profitable in Hong Kong, then it certainly will not be profitable elsewhere in Asia.

Electronic products and systems development in Hong Kong and major Chinese cities is accelerating, and semiconductor vendors will find opportunities to lock in customers as local vendors and start-ups speed product development. Guangdong province provides a strong electronics manufacturing base nearby that will provide a competitive outsourcing center for Hong Kong product developers. It is likely that new and

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innovative products and technology will be developed for the technology-driven Hong Kong service economy, but it will take two to five years for the current measures to take root and for local start-ups or spin-offs to begin to design semiconductors, equipment, software, or services marketable in Hong Kong's technology-hungry economy.

Dataquest Perspective

Government-led initiatives rarely seem to achieve what they set out to accomplish. However, they raise the level of public debate, which then leads to a realistic balance between government hype and commercial viability. The Hong Kong government is, by tradition, wary of bureaucracy but believes an electronics industry development strategy is critical in the long term. Aggressive IT adoption, access to capital, free trade and information flow, efficient telecommunications, logistics expertise, strong management skills, and strong links with China (between government, academics, and businesses) are critical factors for Hong Kong to remain an attractive conduit for and recipient of technology transfer.

The worst-case scenario would be that the government would drop its initiatives after being criticized for spending millions of dollars in the wrong areas with little results. This is the least likely scenario. The economic crisis has created an environment leading to rapid and dramatic policy changes. Unlike past initiatives, the government is appointing able, outside leadership to spearhead key commissions. The best-case scenario is that government investment and policies could lead to an acceleration of start-ups in Hong Kong from local entrepreneurs, academics, overseas Chinese, and mainland Chinese.

The most likely scenario is that the Hong Kong government will accelerate its commitment to the development of technology in Hong Kong as a matter of economic survival. But the model will not be one seen before in Asia. Hong Kong is not likely to become a tax-free assembler of imported manufacturing, which made Singapore a large producer—but not an innovator—of electronics. Nor will it become an OEM exporter of semiconductors, personal computers, consumer electronics, or high-end communications equipment, as seen in other parts of Asia.

Semiconductor vendors should continue to watch and influence downstream developments in Hong Kong, because the current course of government and business is a leading indicator of the shape of applications to come in all of Asia. It is not likely that semiconductor distributors will have the resources or culture to add value to OEMs or establish electronic commerce in the rest of the region. This means dramatic changes in the channels are ahead. Semiconductor vendors should prepare to establish an IT strategy in China/Hong Kong as a means of penetrating the large, fragmented market and of developing localized applications. Most companies are simply not thinking ahead and will miss huge growth opportunities. Companies that establish an IT strategy in China/Hong Kong will effectively lock in their future customer base and will help ensure that that base can remain competitive.

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Perspective

Semiconductors China
Market Analysis

The 1998 China/Hong Kong Semiconductor Market in Review

Abstract: *The year 1998 in the China/Hong Kong semiconductor market will be a year to forget for semiconductor vendors. While most of Asia/Pacific was crumbling, China could only stand by and watch nervously. As Dataquest makes sense of the events in 1998, it highlights events that significantly influenced the region's market development. This Market Analysis Perspective highlights industry events and announcements that exemplify significant strategic initiatives either from private companies or the Chinese government.*
By Daniel Heyler

Introduction

FILE COPY: MARIA VALENZUELA

Asia's 1998 economic downturn will fundamentally shift how local and foreign companies conduct business in China/Hong Kong in the future. The downturn is going to be a test not only of China and Hong Kong's new political leaders but also of the leaders who are charting their companies through dangerous and uncharted territory. Dataquest's various key industry surveys illustrate a wide variance in competitiveness among semiconductor vendors in the China/Hong Kong region. This Market Analysis Perspective highlights industry events and announcements that exemplify significant strategic initiatives either from private companies or the Chinese government.

First Quarter

After the Asian financial crisis began to sweep Asia/Pacific, China remained unscathed, and multinational companies' investments continued to pour into the country, but not as aggressively as in the first quarter of 1997. China's PC market showed little sign of slowdown, while the rest of the region contracted. The market pull and competition from Chinese domestic

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manufacturers resulted in greater foreign investment from companies such as Dell Computer Corporation.

January

E-Commerce Was Started: GE Accelerated Investments in Downturn

General Electric Company seemed to be accelerating its bargain-hunting and strategic ventures in Asia/Pacific during the Asian financial crisis. General Electric (GE) Information Services, an arm of GE of the United States, announced that it would open an electronic commerce hub for Asia in Hong Kong, as well as an electronic commerce center in the Philippines in 1998.

GE officials said that its China center would be based in Shanghai, but the full details would be released only after an agreement with its partner, China's Ministry of Posts and Telecommunications (MPT), was finalized. Electronic commerce (e-commerce) is business transactions conducted through computers. This is intended to replace the previously required extensive paperwork and physical delivery of papers. E-commerce also includes the opening of a "virtual marketplace" where companies can shop for goods or seek business partners electronically, using computers to seek the best price.

February

IBM Invested $20 Million to Build RDD MR Heads in China

IBM announced plans to invest $20 million to build a new facility to manufacture magnetoresistive (MR) heads for rigid disk drives (RDDs) in southern China. The company said the new plant would be operated by Shenzhen IBM Technology Products Co., a newly established unit of IBM. IBM also said it will supply MR heads to Maxtor Corporation for its desktop PC drives.

This MR plant is another boost to IBM's storage investments China. In 1997, the company had established a $50 million joint venture to produce MR assemblies in Shenzhen. The venture involved two large Chinese companies, Great Wall Computer Group and Shenzhen Kaifa Technology (HK) Company. IBM's RDD investments are its largest in China. Based on past announcements, this one brings IBM's MR investment commitments to more than $100 million. There has not been a noticeable decline in technology-related ventures in China since the Asian financial crisis.

Government Reacted to the Asian Financial Crisis

China's new economic czar, Zhu Rongji, backed many of the 1998 initiatives to address China's inefficiencies and financial problems. By far the most dramatic gesture was the government's decision to raise $32.6 billion to recapitalize nearly bankrupt state banks. The money is to come from a special Ministry of Finance bond issue to be made sometime later this year. The plan was approved by the Standing Committee of the National People's Congress. A stabilization plan for China's banks, which the World Bank said have a "negative" net worth—has been mooted for weeks. But the amount is dozens of times higher than previous estimates, a sign that China is serious about dealing with the problem.

Similarly, the decision by Communist Party leaders to ask the NPC to approve the largest-scale streamlining of the country's bloated government bureaucracy in five decades calls for much more severe cuts. This is the largest reform of government departments since the People's Republic of China was formed in 1949 and the most dramatic.

March

Dell Announces Plans to Build a PC Assembly Plant in Southern China

Dell announced Chinese government approval for the establishment of a Dell China Customer Center (CCC) for order fulfillment in mainland China. The CCC will fulfill product configuration, inbound telephone sales, direct customer services, and technical support functions for the domestic market. Dell Asia Pacific has stated that the facility expects to employ about 200, and that operations are expected to commence before the end of 1998. The facility is to be leased in Xiamen—a Special Economic Zone (SEZ) on the Fujian coast directly across from Taichung, Taiwan—and will occupy a total of 13,658 square meters. Production will cover the full range of Dell desktop, notebook, workstation, and server systems.

This is first and foremost a market development initiative by Dell. The Chinese PC market is Asia/Pacific's fastest growing and largest, accounting for about one-third of the entire Asia/Pacific market (excluding Japan). However, competition is increasingly fierce among both local and foreign brands in China. Dell is a latecomer to China and is playing catch-up through this first major manufacturing investment. The president of Dell Computer Asia Pacific cited the main reasons for investing saying, "We have selected Xiamen for many reasons, primarily for its infrastructure, proximity to customers, favorable business climate, and highly educated and adaptable labor force."

Investments by PC manufacturers in China have been inherently different from their other facilities in Asia/Pacific. These investments in China have not detracted from investments in highly automated volume facilities in Singapore, Taiwan, and Malaysia, which are oriented to volume and global exports. Compaq Computer Corporation's facility in China, for example, is totally dedicated to the local market, while its Singapore facility maximizes economies of scale and automation and ships PC systems globally. Market development, government relationship-building, and distribution are critical success factors in China, which Dell has lacked. The downside risk for multinational vendors in China has been increased costs because of increased complexity in sourcing and operations, in addition to China's uniquely difficult business environment. However, high market growth and the need to compete for channels have resulted in foreign investment in local production. Compaq's facility and Xiamen's probusiness government, located in the southeastern province of Fujian, were able to offer the least risk for Dell to launch its market expansion to China's more prosperous coastal region.

Baiyi Electronic Information Center in Fuzhou, Fujian

China's Fujian Province has signed 10 high-tech contracts with investors from the United States, Japan, and Taiwan. Officials dubbed this region the

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Silicon Valley of Fujian, with investment reaching $120 million. The two major contracts include a Sino-U.S. joint venture to produce PCs and a Taiwan-funded enterprise involving total investment of some $30 million each.

The center, which plans to attract more investors, has built a number of infrastructure facilities, including water plant, transformer substation, roads, gas pipeline, plant workshops, and an apartment complex. The center, which covers 3 square kilometers, is the largest electronics production base in Fujian. The province has approved 94 electronics enterprises and joint ventures for the center, with a total investment approaching $800 million. Fujian is the most popular destination of Taiwanese investors, and Baiyi accounted for one-third of investment in Fujian in 1997.

Second Quarter

April

Motorola Announced Ferroelectric R&D Alliance with Nanjing University

Motorola Electronics (China) Limited and Nanjing University, one of the noted universities in China, launched an advanced materials joint research program to investigate fundamental properties of ferroelectric thin-film materials. The project is focused mainly on fundamental research and understanding of the impact of microstructure on ferroelectric thin-film properties. Through this project, Motorola is expected to establish a long-term partnership with this key national lab, which will result in more extensive technology collaborations.

It is apparent that the joint project is intended to promote the rapid development of nonvolatile memory technology and spur development of applications of this kind of material. Motorola's Materials Research and Strategic Technologies Group will benefit from the talent and R&D brainpower of National Laboratory of Solid State Microstructures at Nanjing University, while Nanjing University benefits from Motorola's application prowess and technology. Similar announcements have been made by Texas Instruments Inc. during the past six months, and the company is ahead of the game in setting up applications-oriented laboratories at China's leading microelectronics graduate schools.

Dataquest often hears of electronics companies investing in China to develop their market presence or lower their manufacturing cost. Less known, but increasingly critical, is investment because of shortages of engineering talent worldwide. At China's current development rate, it will take less than 20 years, possibly 10, for the country to become the world's largest source of electrical engineers.

May

Intel Established a China Research Center

Intel Corporation announced that it will invest $50 million in the next five years in an information technology (IT) and development center in China. The announcement was made in Beijing by Chairman Andy Grove, who said

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the investment is part of the $2.8 billion the company plans to spend on global research in 1998. The Intel China Research Center, to be based in Beijing, will focus on Internet research and other information technologies, such as speech recognition. It will conduct its own research and fund projects at China's universities and research institutes.

Unlike most leading semiconductor companies, Intel's investments in the semiconductor value chain within China, including design, wafer fabrication, and assembly and test, has been negligible relative to its revenue generated in the country. Intel's strategy remains focused on building brand equity in China, as achieved in other major markets. The company's only other major manufacturing investment is a flash memory assembly plant in Shanghai, which will commence production this year, exporting most of its production. Conversely, the company is accelerating spending in advertising campaigns and product education, while working with China's largest PC manufacturers.

Intel is investing only $50 million over a five-year period in this Research Design Center, which is small change for Intel. Nevertheless, it helps build good relations with the Chinese government. The project also has its technology relevance, however. It's a way for Intel to tap China's best brains and talent to try to develop voice recognition capabilities for PCs. Dataquest believes that voice recognition in China will be the most significant enabler of PC consumption growth in China since the introduction of the PC to this market. The keyboard remains a cumbersome PC interface for Chinese users because the Chinese language contains thousands of unique words, or characters, and more than 100 radicals, or components, as opposed to 26 for English. China consumed approximately 2.2 million new PCs in 1997, and the number is expect to increase by 50 period to 60 percent for the next two years. While the Asian financial crisis has seriously dampened PC growth in the rest of the region, Intel and other companies expect the Chinese market, consuming almost one-third of PCs shipped to Asia/Pacific today, to maintain its breakneck growth.

Third Quarter

July

China's Economy Far from Crisis: June Data Shows Output and Trade Increasing

When reading through the plethora of press reports on the Asian financial crisis, it becomes clear that the drivers for semiconductor demand have not been fundamentally shaken in China as in most other Asia/Pacific countries. The following three factors that have driven demand are facing downward pressure but are far from collapsing:

- Electronics exports have grown by about 8 percent during the first half of 1998.
- Domestic consumption continues to absorb more than half of domestic electronics production.
- Investment from foreign manufacturers continues to provide impetus to semiconductor demand.

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Global semiconductor pricing is hurting margins for most vendors, but once the industry recovers from overcapacity, China's expanding export and consumption base can easily return to its double-digit growth.

China has yet to show any signs of a critical economic downturn attributable to the Asian financial crisis and the Asian economic crisis. Halfway through 1998, China's gross domestic product (GDP) growth forecast has been lowered somewhat, from 8 percent to 6.5 percent to 7 percent, which is still well above even Taiwan, the second-strongest economy in the region. Hong Kong is in recession, but most people believe that it will be the first to rebound within two years. China, Hong Kong, and Taiwan are considered the only first-tier economies in the region, which are two years away from recovery.

While the rest of Asia/Pacific's industrial base is contracting (or in a state of transition), China's industrial output rose 7.8 percent in June, compared with the same month in 1997. This growth rate was comparable to May's output. What about the export downturn in China many had expected? Exports have grown by 7.6 percent year on year from January to June 1998. Yes, this is slower than the breakneck 21 percent growth in 1997, but it is nevertheless a strong growth in light of the regional chaos. Considering that 1996 exports grew about 2 percent during the same period, China's 7.6 percent is well within its five-year trade cycle.

China seemed to face a currency disadvantage over other countries, but as Dataquest had noted six months ago, the following factors would enable China to maintain reasonable growth:

- Cash-flow problems inhibit Southeast Asian companies from expanding exports and increase the costs of key semiconductor components that are predominantly imported.
- Running day-to-day operations with a weak cash flow and unavailable short-term financing, China may have a relative currency disadvantage. But it must import most of its key components, which now are less expensive relative to devalued currencies.
- Plentiful, cheap labor has helped keep operating costs low in China.
- The most obvious and critical factor is the element of political stability and transparency, which currently prevent international investors from investing in affected countries.

There are new downward pressures and threats to growth to consider. Exports in the second half of the year will probably be weaker than in the first half, but no one is expecting an export or currency crisis. Total imports expanded by only 2.2 percent because of slowing domestic demand. State-owned enterprises (SOEs) will continue to pull down overall growth and experienced only 2.7 percent growth, as opposed to nonstate companies, which expanded by 12 percent. China is implementing $5 billion in infrastructure projects to boost the economy. The economy has a large tolerance for such deflationary pressure, as SOEs gradually privatize, resulting in rising unemployment and low inflation.

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On the export threat, Dataquest sees Japan's policy stagnation and imminent weakening of the yen as China's major threat, rather than Southeast Asia's currency devaluation. But exports represent 20 percent of China's GDP, so such damage is controllable. Less expensive Japanese components, on which China depends, benefit electronics companies selling to China. Furthermore, the Chinese government is implementing tax rebates to exporters (17 percent) to help improve their bottom line and easing credit terms for export-oriented industries. These measures will have the same effect as a minor renminbi devaluation of about 7 percent to 10 percent for certain industries.

Semiconductor vendors are now turning their attention to China for growth in Asia/Pacific, but they are concerned that China may face the same fate as the rest of Asia. Dataquest highlights at least one fundamental difference in China: the way the government manages its economy. Economists whom Dataquest has spoken with believe that China's policymakers can successfully manage the renminbi by continuing a bottom-up economic policy rather than a top-down fiscal policy. Some even believe that the renminbi will not be convertible for the next 10 years because China will manage its economic growth through its various microeconomic levers to companies (such as tax cuts, extended credit, and discounted loans, among others).

China's economic planners can and will avoid the fiscal chaos experienced in Russia by keeping its currency nonconvertible. But the economic disparity between prosperous coastal provinces and poor inland provinces—likely to persist for another decade—could cause the greatest problems for policymakers, resulting in interest-rate havoc once the renminbi becomes convertible. China's long-term economic development plan is to build its economy on its own terms, rather than on international terms, through bottom-up economic management. To achieve this goal, its currency must remain unconvertible and the Hong Kong peg must remain intact.

June

China Announced Plans for Digital Broadcasts

China's broadcasting industry is looking for ways to boost its domestic TV, radio, and cable equipment sectors as planners decide whether to adopt a U.S. or European digital-broadcast standard. China's State Administration of Radio, Film, and Television announced that it was working to trace global technology progress in the TV and radio industry, such as direct broadcast by satellite (DBS), digital video and audio equipment, high-definition television (HDTV), set-top boxes, and other new-generation terminals. The government is focusing on pushing new technology transfers to industrial products from major foreign companies.

The sheer size of the Chinese TV and radio markets has caught the attention of European, Japanese, and U.S. manufacturers, as well as standards groups. China's government reports indicate an estimated 300 million analog television sets in China, along with about 500 million radios. The emerging digital market is expected to be equally large. Precisely when Chinese officials will select a digital TV standard is hard to predict, especially in light

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of a government restructuring that involves various agencies and individuals that were charged with administering radio, TV, and film industry issues.

September

Samsung Announced Color Picture Tube Plant

South Korean conglomerate Samsung Electronics Company Ltd. announced that it plans to invest $838 million in a joint venture to manufacture color picture tubes for television sets and computer monitors in China. Chinese government sources reported that Tianjin-Samsung Display Device Co. Ltd. has been completed now with a designed capacity of 1.8 million units per year. Production was scheduled to begin early next year at the factory, which was one of six Samsung ventures in Tianjin.

The Chinese government estimates that South Korean companies had invested more than $1 billion in approximately 700 projects.

Nokia Expanded Switching Venture

Finnish telecommunications company Nokia Telecommunications announced that it will expand its four-year-old manufacturing venture with Chinese company Hang Xing Machinery Manufacturing. The venture already manufactures DX 20 fixed-switching systems and will cover mobile-switching centers and base station controllers for sale in China and other markets.

Ministry of Information Industry Announced Healthy Growth

China's telecommunications industry grew by 42 percent in the first eight months of this year with a RMB 119 billion turnover (U.S.$1 is about RMB 8.28), according to China's Ministry of Information Industry (MII). It reported that the number of households with access to a fixed-line telephone grew by 11.7 million to reach 82.0 million by the end of August, while mobile phone users increased by 6.8 million to 20.1 million during this period. In 1998, a total of RMB 160 billion will be invested in telecommunications fixed assets. That investment will add 30 million telephones to the country's network, according to MII.

Fourth Quarter

October

Chinese Government Announced Super-VCD Standard

The Chinese government announced the final specification for the super video compact disc (VDC) standard. C-Cube Microsystems Inc. had pushed for a competing VCD standard. The company would have to incur minor additional costs to switch from VCD to super VCD. C-Cube's chipset already has built-in support for both 1/2-D1 and 2/3-D1 picture resolutions—the key technical difference between the two incompatible formats. The super VCD standard specifies 2/3-D1 resolution; the VCD standard gives authoring companies the option of picking either one. C-Cube announced that it was encouraging authoring companies to drop the use of a copy-protection feature C-Cube developed for VCD encoding.

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Legend to Build Printer for Hewlett-Packard Company

Legend Group, a mainland-backed computer company listed on Hong Kong's stock exchange, said it has invested RMB 6.0 million in a new factory in Huiyang in China's southern Guangdong province. The facility can produce up to 500,000 HP DeskJet 200 ink jet printers annually. Legend has been distributing Hewlett-Packard Company's PC and related products in China since 1987.

Taiwanese Government Approved Electronics Investments

After several years of chilly relations, tension on both sides of the Taiwan straits eased in October. The Ministry of Economic Affairs has approved 10 indirect investment projects by Taiwanese companies in the mainland worth $83.1 million. Among those companies given the green light, Kinpo Electronics Inc. has been approved to invest some $20 million in calculator manufacturing and marketing operations in China. Another, First International Computer Inc. has been given the go-ahead to inject $8 million into a desktop PC and motherboard plant in the southern Chinese province of Guangdong. Liton Electronic Corp. can also invest $10 million in power supply manufacturing operations in Guangdong.

China's PC Distribution Channels Consolidated, while Domestic Manufacturers Continued to Gain Market Share

While much of the Asia/Pacific market has slipped further into a recession, China's PC market has posted healthy growth because of the popularity of unbranded, white box PCs. White box PCs accounted for 27 percent of all first half 1998 shipments in Asia/Pacific and 60 percent of all units ordered directly by end users in this period. PC shipments in the China market alone (excluding Hong Kong) exceeded 1.4 million units in the first half of 1998, accounting for one-third of the region's total units. More than 600,000 PCs were ordered through direct means in China during the first half of the year. Continued growth in the volume of direct-channel PCs in Asia/Pacific reflects massive white box consumption and the impact of large markets such as China, which are still growing this year, according to Dataquest's PC and Printer Distribution Channels Asia/Pacific program.

Margin pressure from local brands and white boxes configured by PC stores and dealers from standardized, low-cost components is affecting the competitiveness of some traditional brands. The region's PC component volume remains high in the wake of tremendous price erosion from the original manufacturers. Asia/Pacific is already seeing the sub-$500 PCs creeping into the market, courtesy of the white box assemblers.

Channel consolidation is an inevitable trend in Asia/Pacific as buying power continues to diminish and the region's PC market grows less attractive to official resellers. With white box and entry-level PC prices eroding traditional margins, the low-cost, high-availability, direct-order model is being reinforced in the Asia/Pacific market this year.

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Dataquest Perspective

The downturn in China/Hong Kong's semiconductor consumption is a result of worldwide industry problems, rather than the Asian financial crisis. For this reason, Dataquest believes that China/Hong Kong will be the first to bounce back once worldwide capacity reaches higher utilization rates.

Several factors appear to be driving China's semiconductor market, despite heavy pricing pressure and regional economic problems. China's exports have remained competitive, and the country will record a significant surplus in 1998, despite having enacted no currency devaluation measures. Domestic electronics consumption has slowed but not dived. China's PC consumption is expected to grow another 40 percent in 1998. Local computer-related industries proved even more competitive and cutthroat then ever, reflecting the pricing pressures in the semiconductor industry. Communications spending received a big boost from the Chinese government, but communications equipment companies have long-term plans that were not affected by the Asian financial crisis. Consumer electronics are showing slowing demand and overcapacity. But the government's initiatives in standards (such as SVCDs and its intention to begin digital broadcasting) are aimed to give local manufacturers a competitive edge. Foreign investments have slowed, but political chaos in Southeast Asia benefit China, which is now the most stable region to invest in production. It appears that the large domestic market, export competitiveness, and diverse semiconductor applications are stablizers, which enable China to weather very volatile market factors in 1998 and prepare for a slow but steady recovery in 1999.

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Perspective

Semiconductors China

Market Analysis

China/Hong Kong's Semiconductor Market Outlook: Slow Growth Strikes in 1998, Recovery Likely in 1999

Abstract: *Dataquest released its fall worldwide semiconductor forecast, describing a prolonged semiconductor downturn caused by persistent overcapacity and below-cost memory pricing. How is China/Hong Kong, the largest Asia/Pacific market, affected by the worldwide semiconductor slowdown and so-called Asia/Pacific financial crisis? This Perspective assesses the past year's market performance and our outlook for 1999 and 2000. Dataquest has also incorporated new worldwide assumptions to assess its new long-term outlook for China/Hong Kong, which has been lowered from last year's projections.*
By Daniel Heyler

An Overview of the China/Hong Kong Semiconductor Market

FILE COPY:
MARIA VALENZUELA

Dataquest has learned one thing from the worldwide overcapacity and financial crisis on four continents: No one is insulated from these effects. Until recently, China's semiconductor industry had been relatively protected from the worldwide downturn that started in 1996. The market had rebounded in 1997 to 15 percent growth, nearly double the Asia/Pacific rate. As explained in several Dataquest publications, the level of market growth has been severely impacted by two major phenomena. Technology and efficiency gains in semiconductor manufacturing have outpaced the pace of innovation in systems hardware and software. This protracted global overcapacity has spread from memories to other devices, and the industry is not expected to recover until late 1999, at best, assuming a handful of companies exit the memory market. The second major growth inhibitor has been the global financial crisis that has destroyed wealth-creation and economic activities. Lower worldwide gross domestic product (GDP) is exacerbating a slowdown in computer and consumer electronics consumption; hence, prices are falling in almost every product area.

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China/Hong Kong remains an area of high electronic equipment production and consumption. There are signs of economic problems gradually worsening this year, but, as previously forecast, there has not been a dramatic industry decline as seen in most other Asia/Pacific countries. Dataquest's applications surveys revealed that much of this system-level volume is attributed to PCs, peripherals, and communications equipment production in China. Local demand and exports are helping China survive the global financial crisis. Consumer electronics are a slowing sector now because of overcapacity and weaker consumer spending. PC unit consumption will expand by another 40 percent to 50 percent in 1998 and average about 35 percent to 40 percent for the next four years. Furthermore, new investments in high-volume semiconductor consumption growth have been made by Japanese multinational manufacturers (albeit weakened by lower contribution margins).

What Has Changed since Dataquest's Previous Forecast?

While the Asian financial crisis continues to takes its toll on Asia/Pacific semiconductor consumption, China/Hong Kong's electronics industry has benefited from a number of key competitive advantages. These were discussed in Dataquest's previous (spring) forecast, but we will review them here and assess to what extent these assumptions have changed.

GDP Growth

When the global financial crisis began in Asia, Chinese Premier Zhu Rongji announced a bold plan to keep the economy on track. He vowed to make the collapsing state sector profitable in three years and to pump U.S.$750 billion into infrastructure by the end of the century. However, this announcement was made before the onset of the Russian financial crisis and the unraveling of the global financial system.

Growth through Public Spending

The Chinese government announced that it will issue an additional $12 billion worth of bonds to fund power, telecommunications, transport, housing, and irrigation projects before the end of the year, a steep increase over last year's public-spending injection. Economists say that the Chinese government's infrastructure spending may now reach $398 billion this year. In late August, Beijing also announced that it would raise this year's total bank lending quota from $108 billion to $120 billion. GDP growth appears on track, although most of Asia/Pacific is contracting. Dataquest has forecast 7.5 percent to 8 percent GDP growth in 1997, which was closely to projections because of these government measures.

Because China's neighbors have depreciated currencies, the pressure on the Chinese yuan has caused declines in China's exports. But, China is still expected to have a trade surplus again this year largely because of the demand from North America. The central government has reiterated that the Chinese yuan will not be devaluated.

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Balancing the Trade-Off: Reform and Unemployment

Economists once believed that there was a systematic trade-off between inflation and unemployment. In China, this has been disproved certainly, because the economy is experiencing deflation and rising unemployment. It appears that the trade-off lies between banking and industry reform with unemployment.

Reforms of state-owned enterprises will slow until the world economy improves. This is to temper the rising unemployment that is leading to increased social unrest in the form of small-scale labor demonstrations. The risk is that nonperforming loans will grow at the expense of China's fragile banking system. Dataquest believes that China's $140 in billion foreign reserves will enable it to balance this trade-off between reform and unemployment for at least 18 months longer.

China's Electronic Equipment Exports

China's electronic equipment exports expanded by approximately 20 percent in 1997, Asia/Pacific's fastest-growing hardware export. Because Europe and the North America have increased their share of total exports to approximately 60 percent, China is weathering the Asian crisis relatively well, compared to the rest of the region. China's declining exports to Japan and Southeast Asia, which represent approximately 30 percent of its electronic exports globally, are where most of the industry's slowdown is occurring.

Overall, Dataquest expects electronics exports to expand by half of 1997's growth (10 percent) because of the decelerating growth since the beginning of the year. China's total exports in September tumbled 6.7 percent from the same period last year to reach $15.48 billion. The January-to-September export growth rate also slid to 3.9 percent from 5.5 percent by the end of August, according to the General Administration of Customs statistics. China's export growth rate has declined to 2.2 percent in the third quarter of 1998, from 1997's whopping 24 percent growth.

Measures for 1998 and 1999

Several government ministries have recognized the export problem and are taking measures to reverse this downward trend. Private companies no longer need export permits, tax rebates are being facilitated to exporting companies, approval for foreign investments is being streamlined, refunds on import tariffs are being expedited, corruption is being attacked, centralization of control is being implemented to improve the environment for multinational companies, and provincial-level governments are also trying to improve their exports through increased trade shows and easier approval steps.

Imports

Although imports into China have maintained a relatively constant growth for the first nine months in 1998, compared with 1997, their month-to-month performance has fluctuated. On a positive note, the Chinese government has relaxed tariffs on imports of communications and electronics equipment in

1997, which led to a substantial import increase during the first nine months of 1998.

IT Markets and Electronic Equipment Production

In the spring forecast, Dataquest assume that domestic consumption of electronics—especially domestically produced equipment—would not be impacted by the Asian financial crisis. Dataquest assumed that the Chinese government would not devalue the renminbi. Imported component costs have remained unaffected or fallen in relative terms, because all other Asian currencies (except the Hong Kong dollar) were depreciating. China imports 95 percent of its semiconductors, most of which come from Japan, Korea, and Taiwan. This assumption had been realized. However, semiconductor prices have fallen even more dramatically because of Asian semiconductor suppliers' financial woes and competitive challenges.

PC Market Momentum

While PC unit shipments are declining in most of Asia/Pacific, China's PC consumption shows no sign of deceleration in 1998, almost completely impervious to the market crises around Asia. PC vendors' shipment data, gathered by Dataquest's Computer Systems and Peripherals group on a quarterly basis, predicts total PC consumption to grow by 54 percent in 1998 and 26 percent in 1999.

The Chinese PC market continued to grow rapidly in 1998, as demand in this large country nearly doubled, rising some 48.3 percent. Companies driving the market are local, Chinese manufacturers that are aggressively expanding their powerful distribution channels. Their "push development" of the immature home market, forecast in 1997, is a now a powerful reality in the 1998 growth.

The results of Dataquest's Semiconductor group's survey of computer and peripherals manufacturers in August provide a consistent view of the PC market from a production point of view (see Dataquest Perspective "Semiannual Equipment Vendor Survey: Manufacturers' Scale Growth Plans for 1998 and 1999"). Local manufacturers now have a less optimistic view than in January, but they still expect factory revenue to increase by 34 percent on average. This is dramatically higher revenue growth than the single-digit revenue growth that is expected worldwide for the next few years. China's five-year revenue compound annual growth rate (CAGR) for PCs is 33 percent. Dataquest continues to focus on PCs as the primary semiconductor market driver in China/Hong Kong. Today, access to the Internet has become the major motivation for consumers buying PCs. Most estimates of China's Internet users exceed 1 million for 1998.

In early October, China's news service, Xinhua, said that the State Council, or cabinet, released a timetable calling for the government to fix its year 2000 problems by the end of March 1999 and complete a series of checks and tests by September 1999. Correcting the problem in advance is not considered difficult technically, but it is painstaking and time-consuming to complete the huge task by the Ministry of Information Industry's product department. China has more than 10 million computers and large numbers of embedded chips. Gartner Group projects the global bill for fixing the problem is expected to be approximately $600 billion, but the Chinese government has not estimated the cost to fix its system.

In contrast, Dataquest has seen Thailand, Indonesia, Korea, and Malaysia post the most substantial setbacks over 1997. The relatively small Indonesian PC market was crippled by the country's volatile economy as shipments were reduced by some 80.4 percent. Thailand saw its PC market cut in half (50.3 percent) during the same period. The Korean PC market was also significantly hurt, falling by an estimated 46.1 percent, with Malaysia not far behind, dropping by about 42 percent.

Communications Electronic Equipment Market

One positive effect of the downward GDP growth pressure has been accelerated government spending in telecommunications infrastructure. All major first-tier telecommunications infrastructure equipment manufacturers have set up joint ventures in China to tap the lucrative, high-growth market. Increased government spending is resulting in production expansion by these joint ventures. In October, Finnish telecommunications company Nokia expanded its four-year-old manufacturing venture with Chinese company Hang Xing Machinery Manufacturing. The venture already manufactured DX 200 fixed switching systems, and its role will be expanded to cover mobile switching centers and base station controllers for sale in China and other markets.

The communications sector has maintained steady growth since 1997, without suffering any major interruption caused by the Asian financial crisis. Dataquest's survey of China's major manufacturers revealed that their 1998 production plans of expanding 13 percent to 14 percent have not changed on average since January 1998. However, the mobile communications equipment segment is experiencing a deceleration in 1998, to a disappointing 7 percent revenue growth, and this growth is not expected to improve much in 1999. A high growth in premises equipment, namely, cordless handsets from southern China, will likely maintain a 20 percent growth forecast for 1998 and 15 percent for 1999.

Unfortunately, like data processing, this sector is experiencing severe pressure in semiconductor prices, which are causing semiconductor shipments to increase at a slower rate than electronic system revenue.

Consumer Electronics Markets

China's consumer electronics market has been the worst hit in 1998 because of multiple market inhibitors. Consumer spending is down in China because of the increased economic uncertainty and rising unemployment. Overcapacity plagues most of the major consumer electronics sectors, namely, video compact disc (VCD) players, color televisions, and other home audio/video and appliance electronics. Consumer electronics companies have suffered not only from shrinking domestic demand, but also from an investment slowdown from credit-constrained Japanese manufacturers. In addition, China's major export markets for consumer electronics for are Asia, Eastern Europe, and Russia, all of which are suffering economically.

Dataquest surveyed 20 companies in China's consumer electronics industry in August and concluded that companies have revised their growth plans from an average of 22 percent to 4 percent in 1998. Dataquest expects a 3 percent-to-5 percent contraction in 1999. Consumer-related semiconductor purchases are forecast to increase by 8.5 percent, rather than 18 percent as previously expected in spring. As forecast, manufacturers are experiencing a worsening market for the rest of 1998 and well into 1999. The main cause lies in VCD players, which were the consumer electronics market savior in 1997 but are facing saturation in 1998. However, there is some hope that the next-generation, government-sanctioned super-VCD (S-VCD) will begin shipping by year's end and reach mass production in early 1999. This product will help China avoid a declining consumer semiconductor market year in 1999.

China/Hong Kong's Semiconductor Market Outlook and Forecast Assumptions

While most of Dataquest's assumptions remain intact from its spring forecast, the most important one, semiconductor pricing, has been dramatically reduced. As explained in other Dataquest worldwide documents, overcapacity has expanded beyond memories to all major semiconductor segments, including MOS digital logic, MOS microcomponent, analog, and discretes. Companies continued to spend in 1997 and remained resistant to revamping their product strategy. To maintain cash flows, memory suppliers defied Dataquest's assumption by shipping at below-manufacturing cost. China/Hong Kong has been affected more severely by overcapacity because the countries with the worst overcapacity problems literally surround China. And because the Chinese market is not protected from dumping by any agency similar in function to the U.S. International Trade Commission (ITC) or the European Community (EC), pricing pressure has been severe. Hence, although China's demand is much stronger than the rest of Asia from a volume standpoint, vendors' shipment revenue growth into China has been reduced from the price cuts.

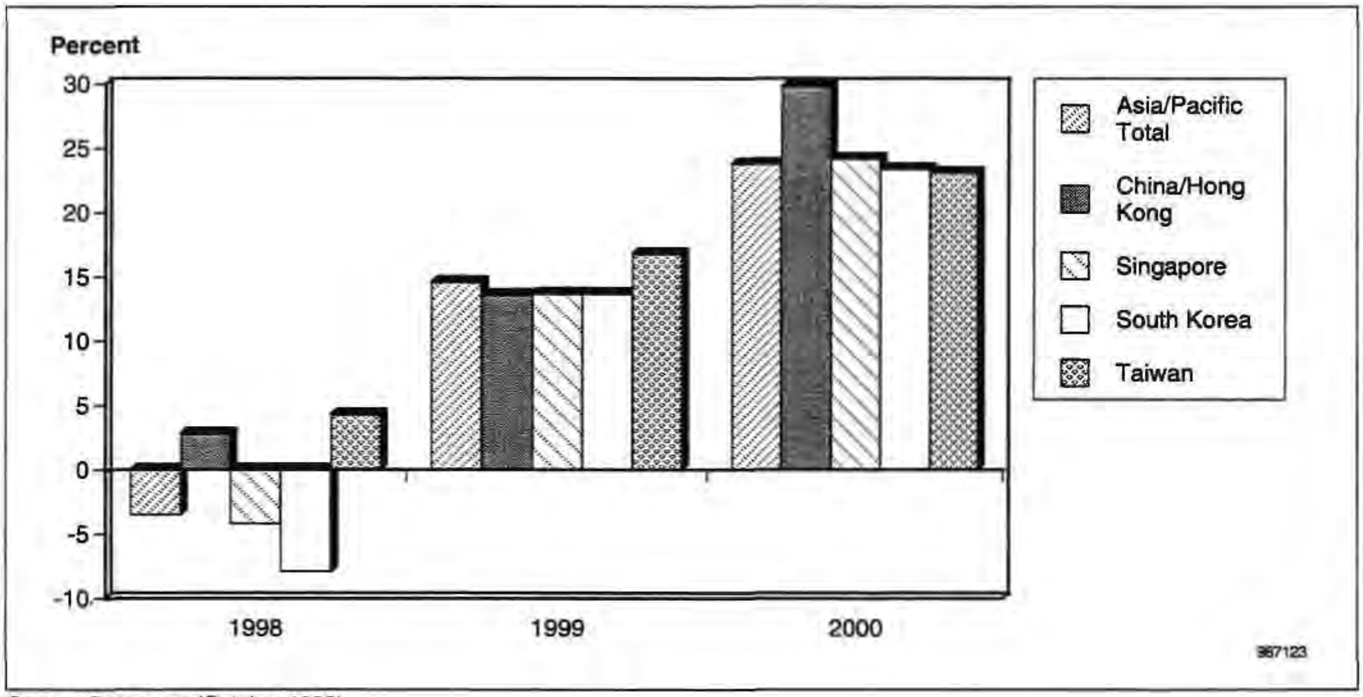
Dataquest's 1999-to-2000 Most Likely Scenario

Dataquest's worldwide view of 1999 is that the global financial crisis has increased the cost of capital because of risk-averse investors. The prolonged slump in the semiconductor industry exacerbates the capital cost problem. Reduced operating cash flows and falling rates of return on invested capital have impaired semiconductor manufacturers' investment for demand needed for the year 2000. Dataquest believes that bit prices will begin to rise in the second half of 1999 and assumes the exit of the several DRAM manufacturers. The DRAM market will enter a period of shortages starting from late 1999 and into 2000.

A Comparison of the China/Hong Kong and Asia/Pacific Semiconductor Markets

As a result of the previously discussed factors, Dataquest has revised its total semiconductor consumption forecast in line with local and worldwide market condition changes. Figure 1 illustrates Dataquest's total semiconductor consumption forecast for the major country markets in Asia/Pacific.

Figure 1
Comparison of Semiconductor Consumption Growth by Country in Asia/Pacific, 1998 to 2000



Source: Dataquest (October 1998)

In 1998, the China/Hong Kong market is likely to lose its status as the fastest-growing market in Asia/Pacific to Taiwan. The market is forecast to grow by only 3 percent in 1998. A recovery is expected to come in late 1999, but the market should still achieve a 14 percent growth. As expected, Korea is the most affected by the Asian financial crisis and the semiconductor market slump. Dataquest expects the Korean market to contract by 8 percent in 1998 and recover modestly by 14 percent in 1999. The Singapore market is also projected to contract in 1998 with a 4.2 percent decline. The disk driver industry has been the worst-affected sector. This market is expected to recover at a rate of 14 percent in 1999. Taiwan has been least affected by the downturn because of its successful OEM/ODM manufacturers, in large part, which are selling primarily to North America and Europe. The market is forecast to expand by 4 percent in 1998 and 18 percent in 1999, attributable primarily to memory and foundry pricing increases.

Long-Term Market Growth Scenario for the Next Silicon Cycle

Without a doubt, China/Hong Kong will remain the fastest-growing semiconductor market in Asia/Pacific from 1998 to 2002. As illustrated in Figure 2, Dataquest expects China/Hong Kong to achieve an 18 percent CAGR, compared to a 13 percent CAGR for Asia/Pacific. This growth trajectory incorporates another overcapacity in starting in 2002. Note that this is a lower level of growth from the previous silicon cycle, primarily attributable to an overall electronic industry slowdown that is affecting China's exports. Figure 3 illustrates Dataquest's electronic equipment production projections that will be driving the semiconductor demand.

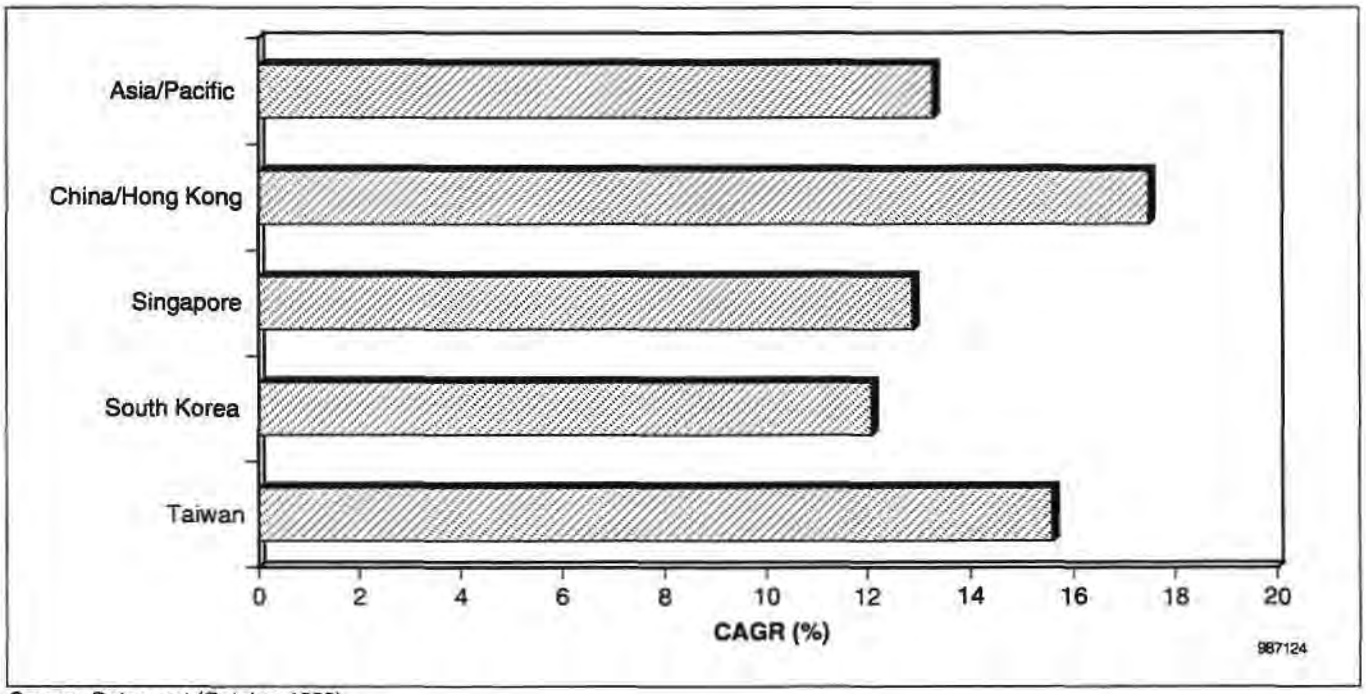
China/Hong Kong will maintain a high level of industry growth for the next four years and will continue to outpace the rest of Asia/Pacific.

Dataquest assumes that China's economy will maintain its relative stability during this forecast window. China will not change to a convertible currency during this period, despite the public promises by Chinese authorities to convert the currency within the next few years. Dataquest believes that at least the following three significant events must happen prior to convertibility:

- Restructuring of the state-owned enterprises
- Reform and development of China's domestic and international financial systems
- Reduction in economic disparities (economic development of central and western China)

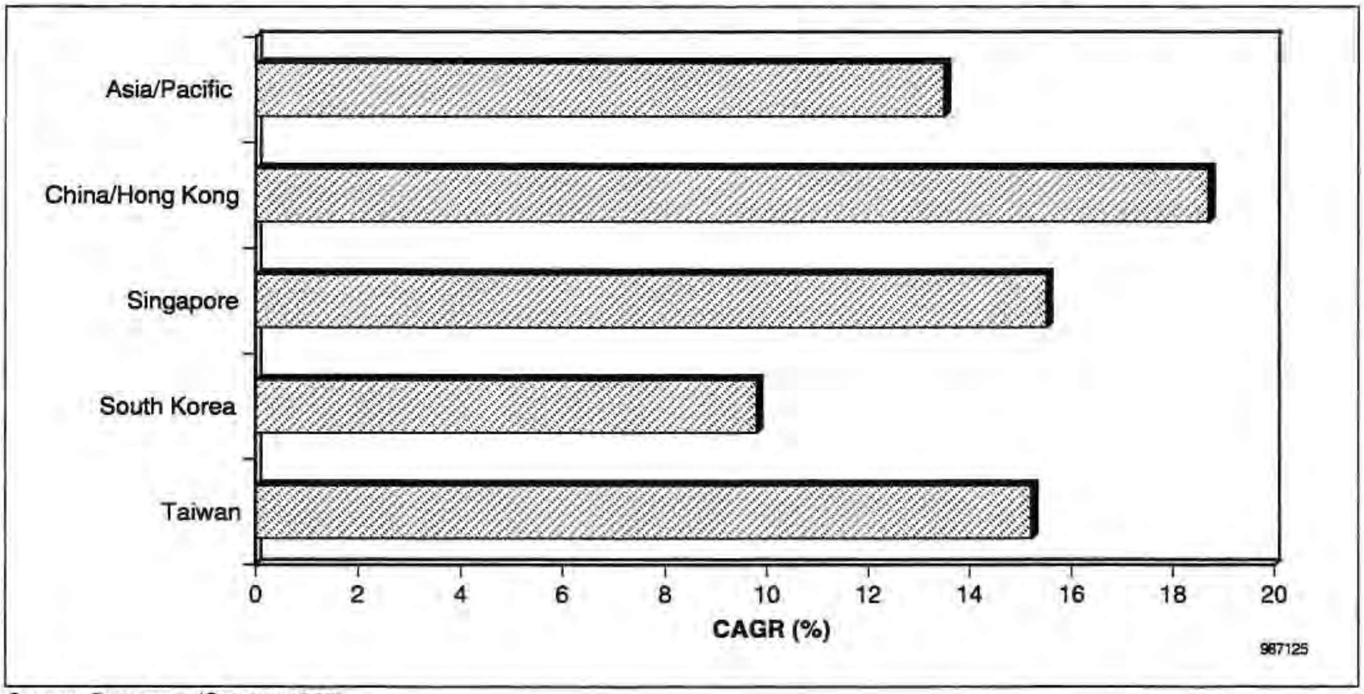
Because these events cannot happen in a recessionary world economy, Dataquest expects the completion of the agenda after 2002.

Figure 2
Long-Term Forecast of Semiconductor Consumption by Asia/Pacific Country, 1997 to 2002



Source: Dataquest (October 1998)

Figure 3
Electronic Equipment Production Forecast by Country in Asia/Pacific, 1996 to 2001



Source: Dataquest (October 1998)

As illustrated in Figure 4, China/Hong Kong is forecast to continue to outpace the rest of Asia/Pacific both in terms of electronic equipment production and semiconductor consumption. Dataquest predicts the following:

- China/Hong Kong's share of total Asia/Pacific electronic equipment production will rise from 26 percent in 1997 to 33 percent in 2002.
- China/Hong Kong's share of total Asia/Pacific semiconductor consumption will grow from 21 percent in 1997 to 25 percent in 2002.

Semiconductor Consumption in China/Hong Kong's PC Production

China's PC production is expected to maintain a 35 percent-to-40 percent unit growth rate. Dataquest sees negligible effects from the Asian financial crisis on China's PC demand. China's total PC consumption will expand by 30 percent from 1998 to 2002. Growth will be driven by the private or nonprofessional markets, with unit growth forecast to expand at a more than 60 percent CAGR. Chinese PC manufacturers will further strengthen their hold on the distribution channels. The less successful local manufacturers will likely focus on distribution of foreign brands or get bought out by larger Chinese manufacturers. The availability of multiple microprocessor suppliers and increased production localization will lower product costs and bolster market growth. In the next five years, although certain regions of China will experience slower growth, there will be no major inhibitors to the current growth rate because the overall market is still immature.

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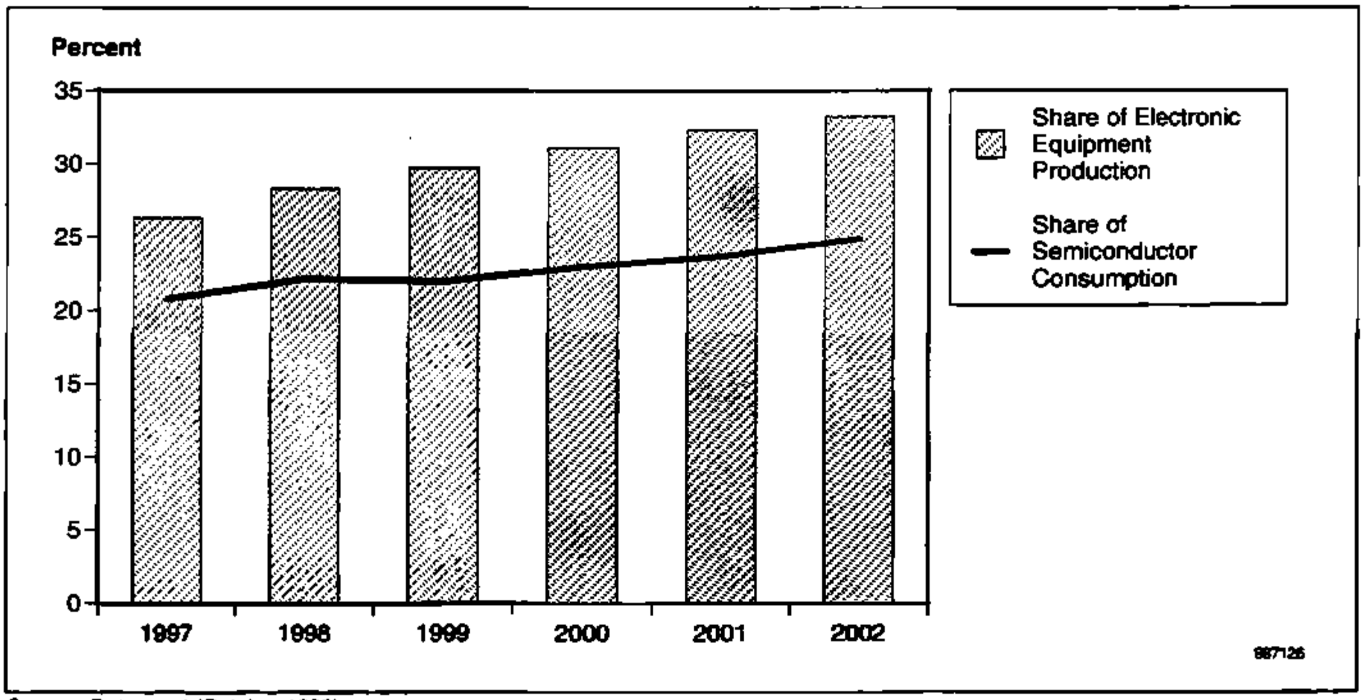
Figure 4
China/Hong Kong's Share of Total Asia/Pacific Electronic Equipment Production and Semiconductor Consumption, 1997 to 2002



Source: Dataquest (October 1998)

China's Semiconductor Consumption in Communications Electronic Equipment Production

China's communications electronic equipment semiconductor consumption is expected to accelerate in the next five years because of the following factors:

- Standardization of equipment design and semiconductor components will enable Chinese manufacturers, with the assistance of major semiconductor suppliers (with key components, intellectual property, and reference designs), to compete with first-tier imported equipment suppliers.
- Chinese government's support of localized production and the increased availability of turnkey production solutions will accelerate the localization of digital cellular phone manufacturing in China.
- First-tier equipment suppliers will move production to China to compete with local vendors for a local market share.
- Accelerated communications infrastructure spending with increased centralization by the superstrong Ministry of Information Industry (MII) and the Ministry of Foreign Trade, Exports, and Commerce (MOFTEC).

China's Semiconductor Consumption in Consumer Electronic Equipment Manufacturing

China's consumer electronic equipment market is entering a period of slow growth. Digital television standards will be implemented within the next

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two years, enabling a new wave of consumer electronics growth in China from 2001 to 2002. Copyright protection is projected to progress slowly, but the issue will persist as a problem for software and media companies for the next five to 10 years. Dataquest's forecast assumes the current VCD industry model will continue. Ironically, pirated software and movie content will continue to be the hardware consumption and market-driving enabler. Super VCD is the new industry standard that will revitalize an industry for a short period until it quickly reaches a state of overcapacity, as experienced with the VCDs.

The problem with the DVD standard is that companies are putting the carriage before the horse. The consumer market *expects* an inexpensive content, as a result of the VCD experience. If DVD manufacturers want to establish a standard, it would make much more sense to offer inexpensive content (probably at a loss for a few years) to enable the hardware infrastructure to develop. Once the market is penetrated with DVD, then companies should worry about salvaging their investment in content by raising prices and enforcing intellectual property laws. A reverse strategy of pushing hardware and technology without recognizing consumer purchasing patterns will fail while the VCD model prevails with DVD.

Device Trends

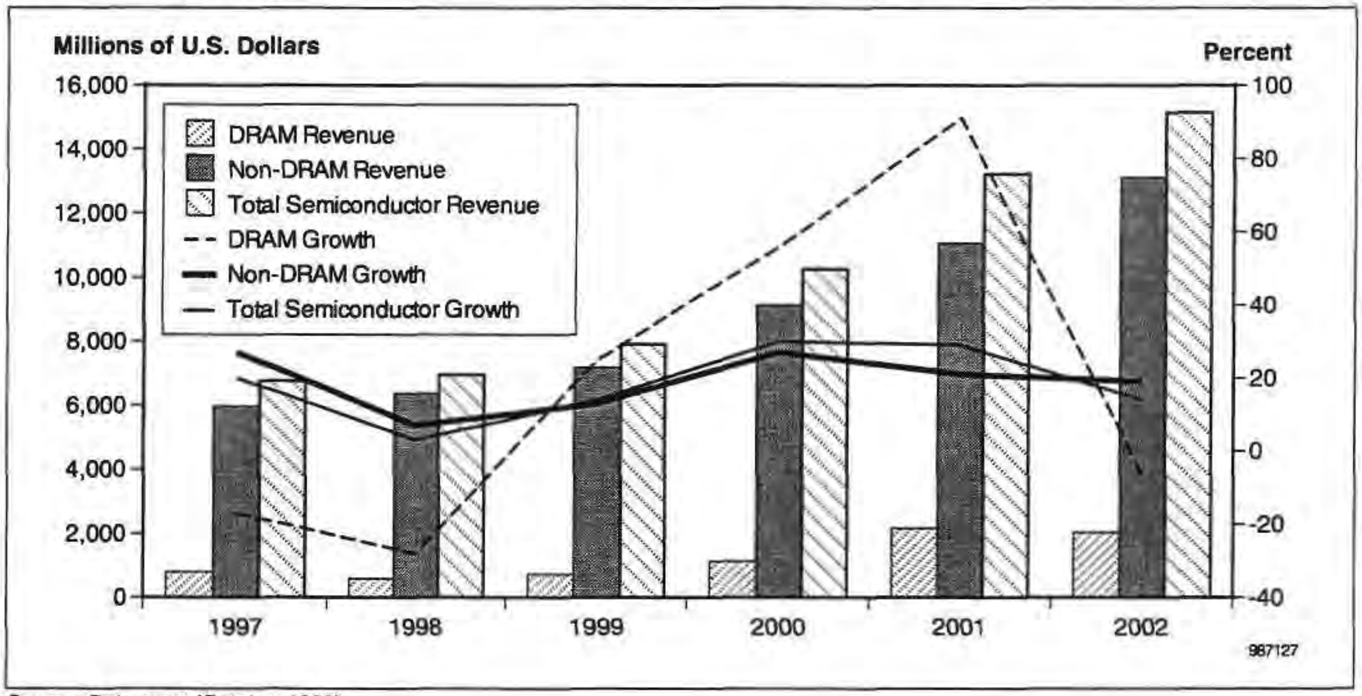
Just as DRAMs led the industry into this far-reaching glut, Dataquest expects DRAMs to lead the industry to recovery. Figure 5 illustrates Dataquest's device-level forecast for DRAM, non-DRAM, and total semiconductor markets. The absence of DRAMs presents a market of high growth and high stability in China/Hong Kong. One major consequence of China/Hong Kong's PC market/industry boom has been increased volatility in the semiconductor market, attributable to DRAM fluctuations.

Dataquest forecasts that DRAM revenue will fall from $800 million to $580 million in 1998, a 28 percent contraction. Conversely, non-DRAM products will expand by 6.9 percent from $5.9 billion to $6.4 billion. As a result of the DRAM decline, Dataquest's overall semiconductor market forecast is on 2.8 percent growth in 1998. Assuming an optimistic DRAM recovery of 25 percent, the overall market could achieve a 14 percent growth in 1999.

Memories, Microcomponents, and Standard Logic/ASIC Forecast

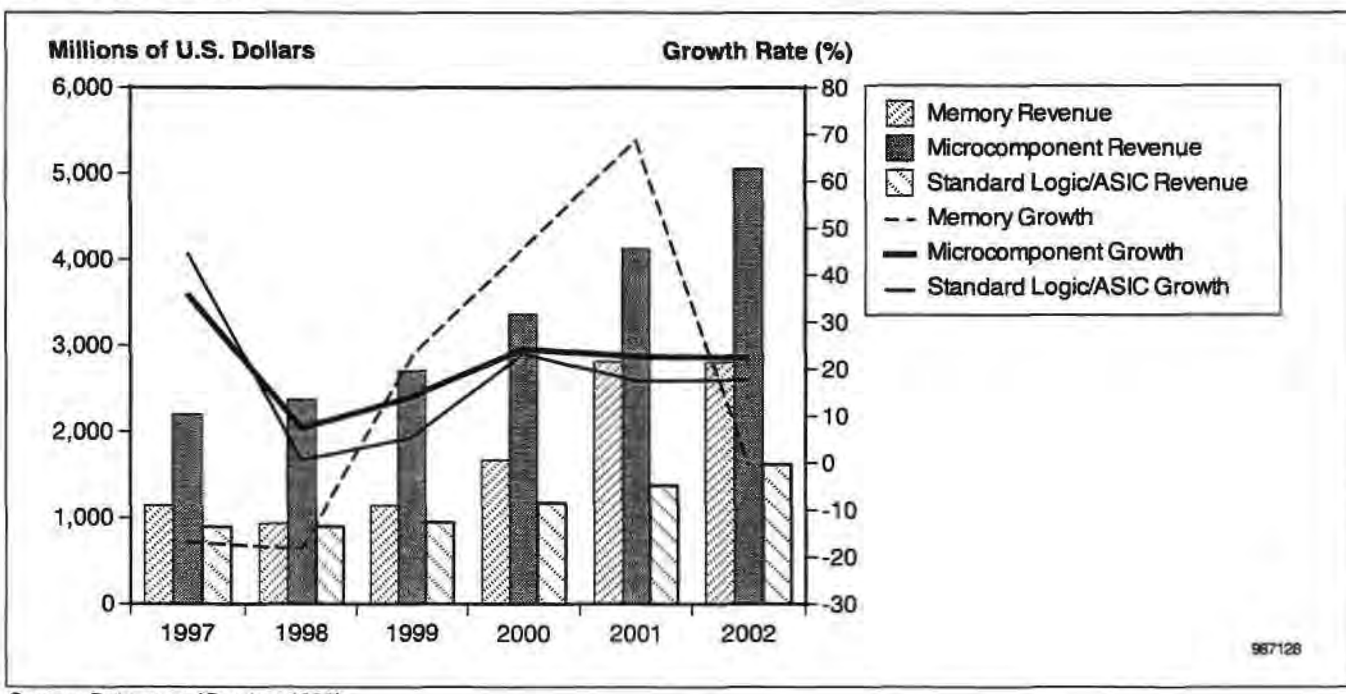
Figure 6 illustrates the 1997-to-2002 consumption forecast of three MOS digital segments—memory, microcomponents, and standard logic/ASICs. In the next five years, Dataquest does not expect microcomponents and standard logic/ASICs to return to their impressive growth levels of 36 percent and 45 percent, respectively, in 1997. Pricing pressure in these sectors has reduced revenue growth, affecting even microprocessors. Nevertheless, these products will exhibit a healthy growth. Standard logic/ASICs will achieve a 13 percent CAGR, while microcomponents will grow by 18 percent during the 1997-to-2002 period. MOS memories will grow the fastest, at 20 percent, but this is attributable to both the decline in 1997 and the projected industry shortage in 2000.

Figure 5
China/Hong Kong's Semiconductor Market Forecast, 1997 to 2002



Source: Dataquest (October 1998)

Figure 6
China/Hong Kong's Memory, Microcomponent, and Standard Logic/ASIC Consumption Forecast, 1997 to 2002

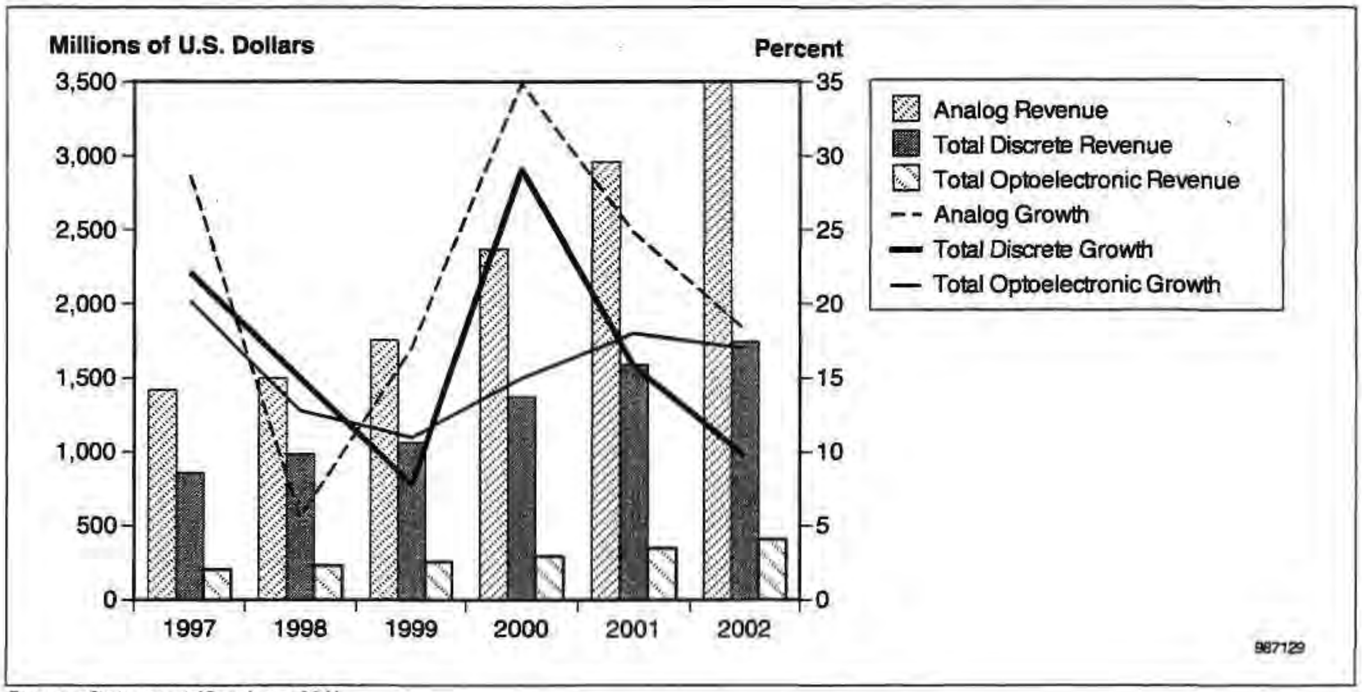


Source: Dataquest (October 1998)

Analog, Discrete, and Optoelectronic Forecast

Figure 7 illustrates Dataquest's forecast of analog, discrete, and optoelectronic markets. These products are primarily influenced by the consumer electronics and, to some extent, communications markets (mixed-signal projects) in China/Hong Kong. All three sectors are slowing in 1998, but analog products have been hit the hardest. As discussed previously, the analog segments of consumer electronics, namely, audio and video equipment, are suffering in 1998. The worldwide analog glut and price erosion have aggravated China/Hong Kong's market. Hence, Dataquest forecasts this market to expand by 5.6 percent in 1998. In the long term, however, Dataquest expects analog to recover and maintain a 20 percent CAGR from 1997 to 2002.

Figure 7
China/Hong Kong's Analog, Discrete, and Optoelectronic Consumption Forecast, 1997 to 2002



Source: Dataquest (October 1998)

Tables 1 and 2 show detailed product splits and forecasts from 1997 to 2002.

Dataquest Perspective

A plethora of factors is enabling China/Hong Kong's electronics companies to weather the global financial storm, but the economic and market situation is likely to get worse before it gets better. The most significant factor in China/Hong Kong market's sliding semiconductor revenue stems from overcapacity rather than from any of Dataquest's key industry or economic assumptions. The year 1998 will be a down year for China/Hong Kong semiconductor suppliers. However, the market maintains a fundamental strength and robustness that will enable it to bounce back strongly once prices stabilize.

Table 1
Revenue Forecast of Semiconductor Consumption in China/Hong Kong by Semiconductor Segment, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Total Semiconductor	**6,769**	**6,957**	**7,906**	**10,262**	**13,226**	**15,143**
Bipolar Digital	42	35	29	23	18	14
MOS Memory	1,142	933	1,144	1,667	2,812	2,807
Dynamic RAM	800	580	725	1,132	2,157	2,022
Static RAM	87	96	122	171	202	235
Nonvolatile Memory	239	240	279	344	432	531
Other MOS Memory	15	16	18	20	21	20
MOS Microcomponent	2,206	2,370	2,705	3,361	4,123	5,052
Microprocessor	881	1,015	1,245	1,539	1,853	2,270
Microcontroller	680	652	675	836	1,049	1,297
Microperipheral	480	502	533	663	798	948
Digital Signal Processor	165	201	252	323	423	537
MOS Digital Logic	895	901	950	1,171	1,376	1,620
ASICs	253	250	281	385	497	663
Custom IC	78	68	54	43	30	20
MOS Standard Logic	197	178	186	197	205	216
Total Other MOS Logic	368	405	429	546	644	721
Analog Monolithic	1,419	1,499	1,756	2,369	2,957	3,496
Total Discrete	859	988	1,065	1,375	1,592	1,746
Total Optical Semiconductor	205	231	256	295	348	407

Source: Dataquest (October 1998)

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Table 2
Percentage Forecast of Semiconductor Consumption in China/Hong Kong by Semiconductor Segment, 1997 to 2002 (Percentage Change)

	1998	1999	2000	2001	2002	1998 to 2002 CAGR (%)
Total Semiconductor	**2.8**	**13.6**	**29.8**	**28.9**	**14.5**	**17.5**
Bipolar Digital	-16.3	-18.0	-19.5	-21.4	-21.4	-19.3
MOS Memory	-18.3	22.7	45.7	68.7	-0.2	19.7
Dynamic RAM	-27.5	25.0	56.1	90.5	-6.3	20.4
Static RAM	10.3	26.6	40.0	18.4	16.2	21.9
Nonvolatile Memory	0.3	16.3	23.3	25.5	22.8	17.2
Other MOS Memory	6.0	10.0	11.0	4.0	-4.0	5.3
MOS Microcomponent	7.4	14.1	24.3	22.7	22.5	18.0
Microprocessor	15.2	22.7	23.6	20.4	22.5	20.8
Microcontroller	-4.1	3.5	23.9	25.5	23.6	13.8
Microperipheral	4.6	6.2	24.4	20.4	18.8	14.6
Digital Signal Processor	21.8	25.4	28.2	31.0	27.0	26.6
MOS Digital Logic	0.6	5.4	23.3	17.5	17.7	12.6
ASICs	-1.3	12.4	37.0	29.1	33.4	21.2
Custom IC	-12.3	-20.6	-20.4	-30.2	-33.3	-23.7
MOS Standard Logic	-9.6	4.5	5.9	4.1	5.4	1.9
Total Other MOS Logic	10.1	5.9	27.3	17.9	12.0	14.4
Analog Monolithic	5.6	17.1	34.9	24.8	18.2	19.8
Total Discrete	15.0	7.8	29.1	15.8	9.7	15.2
Total Optical Semiconductor	12.8	11.0	15.0	18.0	17.0	14.7

Source: Dataquest (October 1998)

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Perspective

Semiconductors China

Market Analysis

Can Digital Consumer Electronics Become China's Future Cash Cow?

Abstract: *China is a large market for consumer electronics, which occupied 48 percent of China's total electronics production in 1998. China has surprised Westerners by becoming the largest consumption and production base for video compact disc (VCD) players in less than three years. As the worldwide consumer electronics market is being boosted by a digital transformation, foreign manufacturers are rushing to tap this lucrative market. This Perspective evaluates whether China has an appetite for digital electronics yet.*
By Kelvin Fu

China's Consumer Electronics Overview

FILE COPY:
MARIA VALENZUELA

China has one of the largest consumer electronic markets in the world, which has a high potential as its middle-income group grows. China's consumer electronics industry has achieved a double-digital growth, driven by traditional home appliances—such as color televisions, air conditioners, refrigerators, and, currently, video compact disc (VCD) players—and captured the world's attention.

In the past few years, consumer electronics has been the largest sector in the electronics equipment industry. In 1998, consumer electronics is the largest sector, occupying 48 percent of China's total electronics production. However, after a few years of rapid growth, it has reached a saturation point. A slowdown trend is expected to occur from 1998 to 1999 because of the Asian financial crisis and the restructuring of Chinese state-owned enterprises. Figure 1 illustrates China's consumer electronic equipment production revenue forecast from 1996 to 2002.

Dataquest

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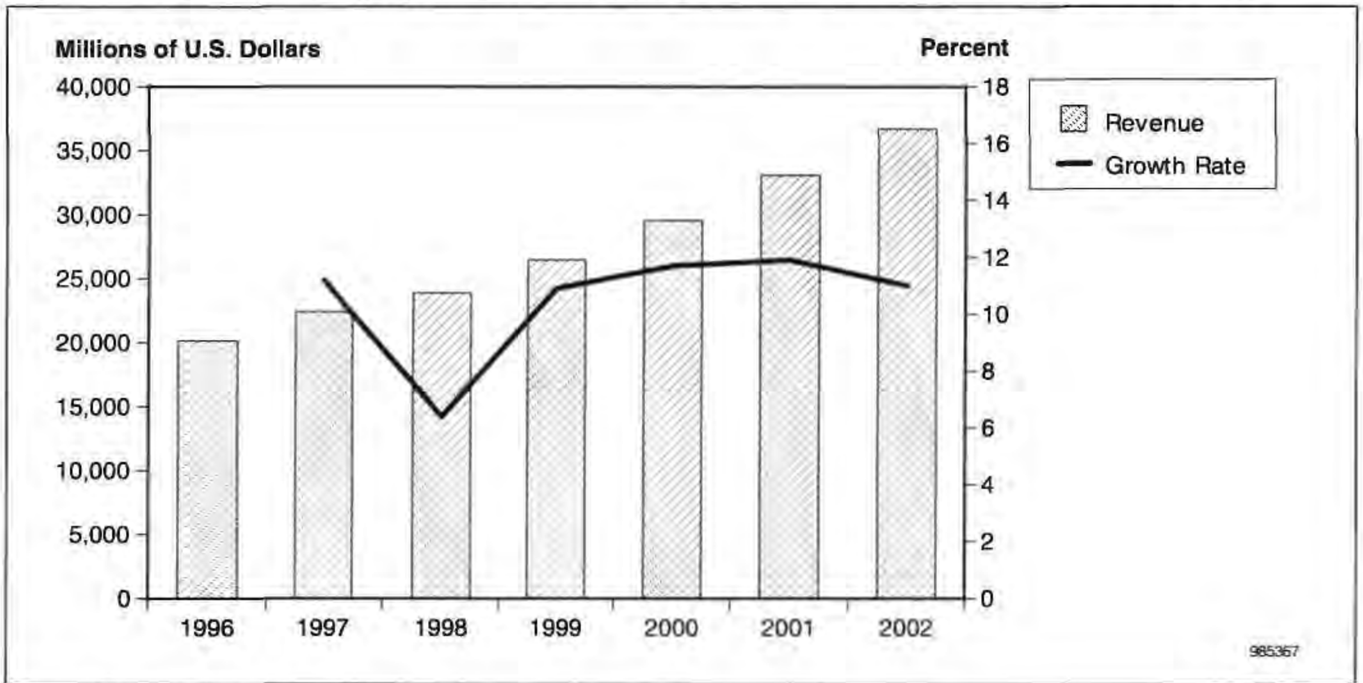
Figure 1
Consumer Electronic Equipment Production Revenue Forecast in China, 1996 to 2002



Source: Dataquest (September 1998)

China's consumer electronics production mainly consisted of video and audio products, which combined to occupy more than 59 percent of the total consumer electronics manufacturing.

The recovery of the consumer electronics market will rely heavily on the market's new cash cow, digital electronics products, which just began selling worldwide. Many Chinese manufacturers are looking closely at the digital trends that will be the future driving force for industry growth.

Digital Technology

Digital transmission and coding certainly have many advantages over analog technology, has reached a point where further quality and capacity improvements become costly and difficult in technical terms. Digital technology, on the other hand, provides combined advantages of noise-free transmission, higher video and audio quality, robust response to channel problems, easier multiplexing of multiple forms of information (for example, data, voice, and video), greater error protection, and a higher system capacity achieved through compression of digital data. Digital compression enables more information to be stored and transmitted, thus new audiovisual applications in the fields of communications, multimedia, and broadcasting become possible based on digital technologies.

In addition, there are emerging international standards for digital coding and processing as this technology develops. One such standard used intensively for digital video coding is MPEG-1 and MPEG-2, issued by the Moving Picture Experts Group in 1992 and 1994, respectively. MPEG-1 compression technology is commonly seen in China's VCD players, whereas digital video disc (DVD) players and the currently debated products of the China video disc (CVD) type and later, super VCD players are based on MPEG-2 standards. Digital broadcasting in the United States and Europe will also be based on MPEG-2 as a digital compression standard. This kind of standardization has an immediate advantage of making video and audio communications equipment from different vendors compatible. It increases the attractiveness of using and buying digital equipment as it can enable large-scale international data exchange. This increased demand, in turn, can lead to economies of scale in chips, which will ultimately bring the equipment prices to a more affordable level.

The information transfer, processing, and storage for digital TV and computer will become identical and based on the same standards. Therefore, in the future, it is not difficult to see that digital TV sets equipped with communications hardware and software compatible with computers could be connected to the information superhighways. Meanwhile, computers can also receive information from terrestrial cable or satellite digital broadcasts. Both digital TV viewers and PC users will then be able to receive digital TV broadcasting, surf the Internet, and use high-density storage media such as DVDs.

With all the advantages of digital technology over its analog counterparts, consumer electronics digitalization will certainly be the future trend. As the first digital broadcasts begin in 1999, consumer electronics equipment manufacturers in the United States are expecting digital products, such as digital high-definition television (HDTV), to arouse consumer demand and stimulate volume sales throughout the industry.

However, the question remains for China: Will China follow the tide of digitalization? Do digital television, DVD players, digital satellite set-top boxes, and digital radios, or the like have a future in China?

Digital Is a Future Trend, but China Is Lagging

China's digital consumer electronics production is in its infancy, as most Chinese manufacturers have not yet mastered the digital technology and acquired the skill level required for the production of digital products. Digital cameras, digital VCRs, and digital camcorders are new terms to most Chinese people. However, with two digital superstars in China, the VCD and DVD players, this new electronics equipment will become familiar to people soon.

Dataquest expects China's VCD player production to reach 18.5 million units in 1998, sustaining a 26 percent growth. This growth is moderate, compared with 1997's nearly 155 percent growth over 1996.

In 1996 and 1997, the VCD player market grew explosively in China, with 5.8 million units and 14.7 million units, respectively, making it the world's No. 1 production and consumption base for such products.

VCD players were first introduced into China in 1993. China started VCD player production in 1994 when the output was only 20,000 units. In 1995, the output expanded at a factor of 10, reaching 220,000 units. Since then, the VCD has gained a wide acceptance among Chinese consumers; more suppliers have joined the production craze. Driven by the strong domestic consumption, the total VCD player output reached 5.8 million units in 1996. This dramatic increase is not the end of the story. In 1997, the VCD demand was fueled by suppliers' promotional efforts, and the output finally reached 14.7 million units.

Currently, there is a heated debate in China whether to adopt worldwide DVD standards or develop China's own version of digital production. There is an intensified standards war between CVD, led by C-Cube Microsystems Inc., Philips Electronics NV, and some major VCD player manufacturers, and Super VCD, represented by Japan Victor Corporation (JVC), Panasonic Communications & Systems Company, Philips Electronics, and Sony Corporation for the second-generation standard of VCD players. CVD and Super VCD players are based on MPEG-2, as core compression technology, and the players maintain backward compatibility with MPEG-1 VCD players. The immediate advantage of these new standards is improved picture quality at only minor hardware and software cost.

In the first half of 1998, Dataquest did not see any volume sales in DVD players and noticed no substantial efforts from DVD makers to promote their products in the market. Although a few leading VCD manufacturers have already announced their DVD product line for quite a while, they had been low profile in promotion in fear that it was still not the right time, right place, and right price for DVD players to take off. The environment is still not favorable to DVD players' popularity. Manufacturers have been hesitant to invest heavily in DVD player production because of the technical expertise involved and the fact that few DVD titles are available. A DVD player is still two to three times more expensive than a VCD player, whose price falls between U.S.$80 and U.S.$200. Dataquest has predicted that the price crossover point for DVD players to dominate over VCD players is likely to occur at a factor of 1.5, given that DVD players can offer better picture quality and backward compatibility with VCD players. Dataquest expects that this price crossover point will only be possible when DVD technology has been adopted by the rest of the world as standard digital media and core chips and mechanisms become more affordable.

Many television manufacturers—such as Changhong Group, Konka Group Co. Ltd., and Skyworth Electronics Co. Ltd.—have turned their initial efforts to digital TV development, competing to be the first mover in the market, because the Ministry of Information Industry (MII) is planning to introduce the first digital broadcast station in China in 2000. Table 1 shows the current activities of some major television and VCD player manufacturers in response to the digital tide.

Table 1
Major Television and VCD Manufacturers' Activities in Digital Electronics

Company	Product	Timing
Changhong Group	Large-screen DTV	Allocated $157 million for R&D
Great Wall Electronics Group	Digital TV	Year-end
Haier Electrical Appliances Co. Ltd.	Digital TV	Aggressive R&D
Hisense Electronic Co. Ltd.	Digital TV	R&D
Huanghe Machinery & Electronics Co. Ltd.	Multimedia TV	September 1997
Jiangsu Shinco Electronics Group Co.	DVD player	Announced in August 1997
Konka Group Co. Ltd.	Digital TV	Government loan for R&D
Qingdao Haier Electrical Appliances Co. Ltd.	Digital TV	R&D
Shenzhen SAST Laserdisc System Co.	DVD player	Announced in August 1997
Skyworth Electronics Co. Ltd.	100Hz TV	Early this year
TCL Group Co.	Digital TV	Year-end
Thakral Technology	DVD player	Mass production in February 1998
West Lake Electronics Co. Ltd.	Digital TV	R&D
Xiamen Overseas Chinese Electronic Co. Ltd.	Multimedia TV	NA
Yanion Co. Ltd.	DVD player	Year-end
Shanghai Thakral Electronics Industrial Corp. Ltd.	DVD player	Sample DVD in October 1997
Zhenjiang Jiang Kui Group	DVD player	Sample DVD in October 1997

NA = Not available
Source: Dataquest (September 1998)

Color television manufacturers are moving their focus from large-screen television to digitally processing television, or the so-called multimedia televisions (MMTV), which can be connected to a PC serving as a "large-screen" monitor. One example of this is Konka Group's new, large, 38-inch television that can function as a computer monitor with a range of associated features including a screen saver.

Many Chinese have mistakenly regarded MMTV with digital-processing ICs as digital television. Current China-made TV sets receive only analog broadcast signals that should be distinguished from digital TV, which can receive digital broadcast signals. The standards for digital TV (DTV) technologies, according to the Federal Communications Commission (FCC), should include MPEG-2 video compression, Dolby AC-3 audio compression, and a digital-transmission technology. The end result is that DTV can provide high-quality pictures at resolutions and digital multichannel surround sound of CD quality.

China plans to produce 35 million color televisions and export 10 million units by the end of this century, according to the MII. China is determined to put its efforts into designing and developing large-screen television, and then manufacturing key components and parts for self-sufficiency. While maintaining the dominance in the domestic color television market, it will develop digital TV to form an annual production capacity of 600,000 HDTV units in 2004.

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Demand Forecast of Digital Consumer Market

This section provides a local consumption forecast for the China's consumer market. This is not intended to be a shipment forecast of these products by Chinese manufacturers. As China is still at an earlier stage for digital consumer electronics, the forecast is based on Dataquest's understanding of the market through continuous research with key equipment manufacturers.

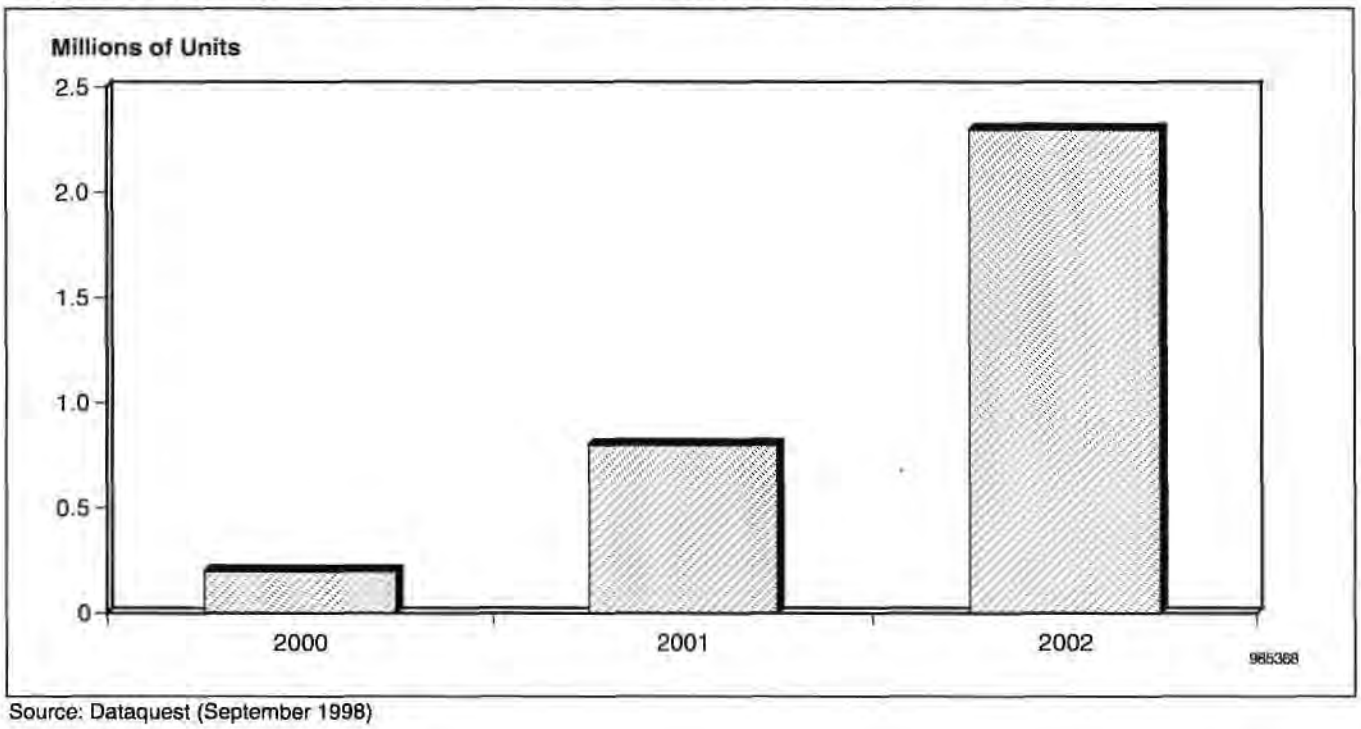
Digital TV

China is the largest analog color TV set production center in the world with an annual production capacity of more than 40 million units. Dataquest predicts that its color television production in 1998 will reach 26.7 million units.

Currently, China has a total installed base of 150 million to 160 million units of analog color television sets. The penetration rate per family has reached 93 percent in urban cities and 23 percent in rural areas. The Chinese government plans to start its first digital broadcast station in 2000. The digital broadcast standard will likely follow digital video broadcast (DVB) standards in Europe, but this is still under feasibility study.

Dataquest expects that the digital TV demand will begin after 2000, with the first-year consumption estimated at about 200,000 units. The growth will then accelerate as the Chinese people see the benefits of digital broadcasting, and as a result of digital equipment's downward price trends. Figure 2 illustrates the digital television set production forecast for China's consumer market from 2000 to 2002.

Figure 2
Digital Television Set Forecast for China's Consumer Market, 2000 to 2002



Source: Dataquest (September 1998)

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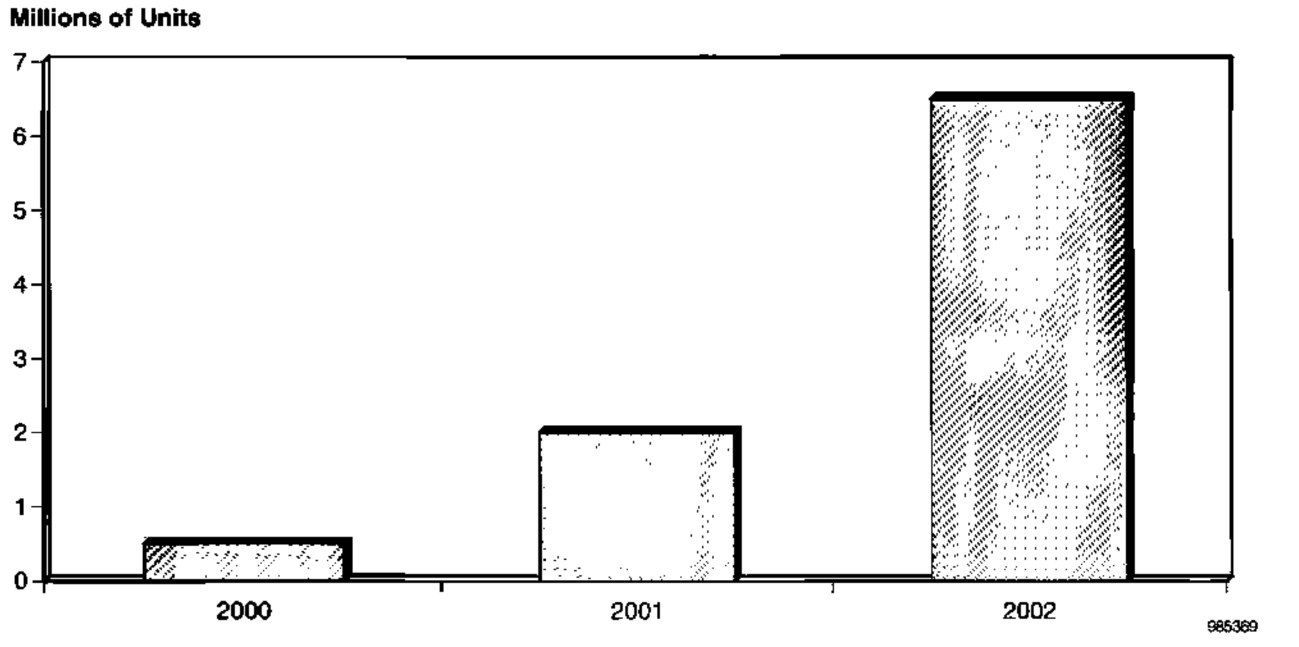
Digital TV Set-Top Box

Digital TV set-top boxes will be used for the conversion of digital broadcast signals to analog signals. China's huge installed base of analog TV will provide a great potential market for digital TV set-top boxes. Figure 3 depicts the digital TV set-top box forecast for China's consumer market from 2000 to 2002.

Figure 3
Digital TV Set-Top Box Forecast for China's Consumer Market, 2000 to 2002



Source: Dataquest (September 1998)

The DTV growth will take off in 2001 and peak in 2004; possibly more digital broadcast stations will have been built. Compared to DTV sets, digital set-top boxes will be an economical solution for existing analog TV users to enjoy the digital-quality broadcast. However, for the long term, analog TV will be replaced by digital sets. The transformation from analog to fully digital broadcast will take about 15 years, compared to an estimated 10 years in the United States.

Digital Satellite Set-Top Box

Digital satellite set-top boxes may represent the fast-growing market for video and audio compression and processing devices based on primarily MPEG II compression technology. As the Chinese government, in general, does not allow individuals to receive satellite signals, the satellite set-top box market is very limited now. However, this limitation is gradually reduced in some cities in Jiangsu Province and Sichuan Province, and in Shanghai. The central government is also planning to reduce this restriction to encourage the country's digitalization. Dataquest expects this volume market to be established in the second half of 1999 and start to proliferate in 2000. Figure 4

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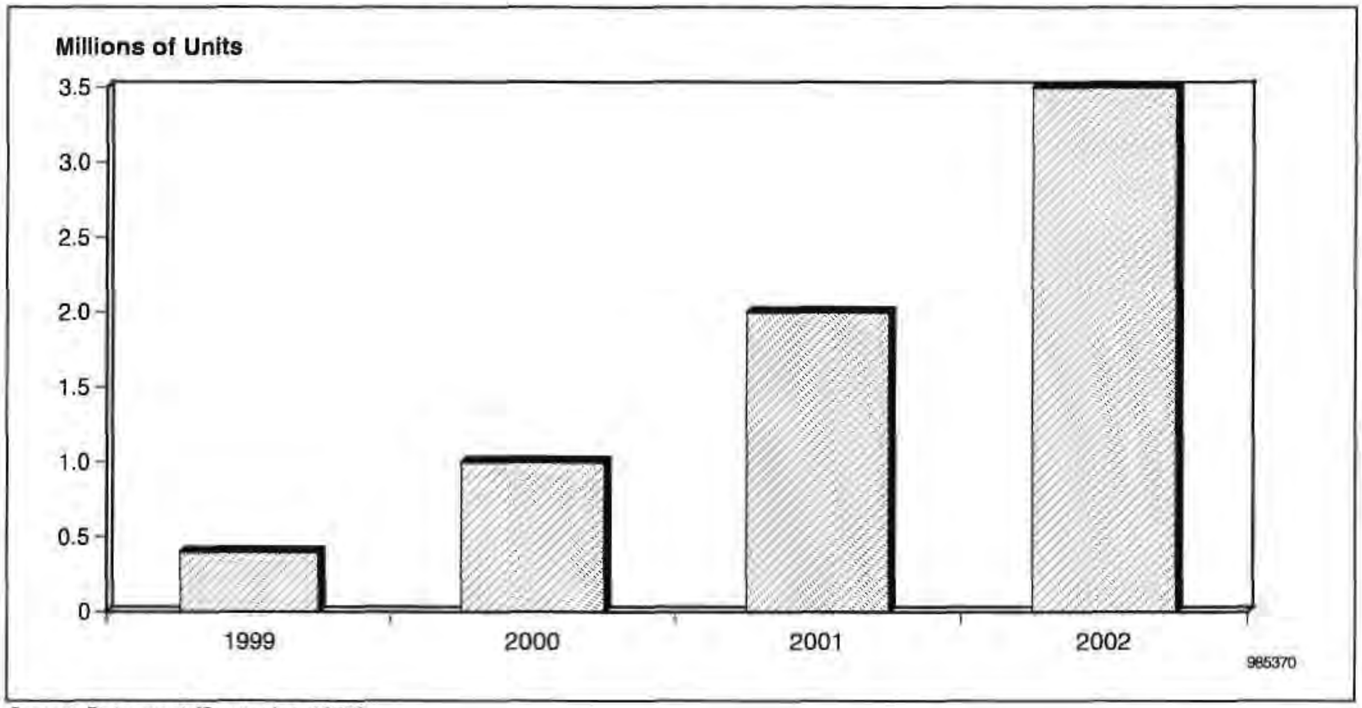
shows a forecast of the digital satellite set-top boxes in the Chinese consumer market.

Figure 4
Digital Satellite Set-Top Box Forecast for China's Consumer Market, 1999 to 2002



Source: Dataquest (September 1998)

DVD Players

Consumers are still maintaining a wait-and-see attitude to anticipate a price drop. DVD players, being priced about three times more than VCD players, are still not affordable to most Chinese consumers. DVD players' mass adoption in the U.S. market is expected in 1999 and 2000, and its reception in China will likely take off after 2000, when the equipment price is at a more affordable level resulting from worldwide economies of scale. Figure 5 predicts the DVD player demand forecast in China's consumer market from 1998 to 2002.

VCD Players

The expected sales of VCD players will reach 12.8 million units in 1998. The introduction of CVD and Super VCD players (the final standard was issued by MII in early September), based on the MPEG-2 technology, will extend the product life of VCD players, giving consumers much better video quality at an affordable price. Dataquest expects that VCD players will still play a dominant role over DVD players in 1999. Figure 6 illustrates the VCD player forecast for China's consumer market from 1998 to 2002.

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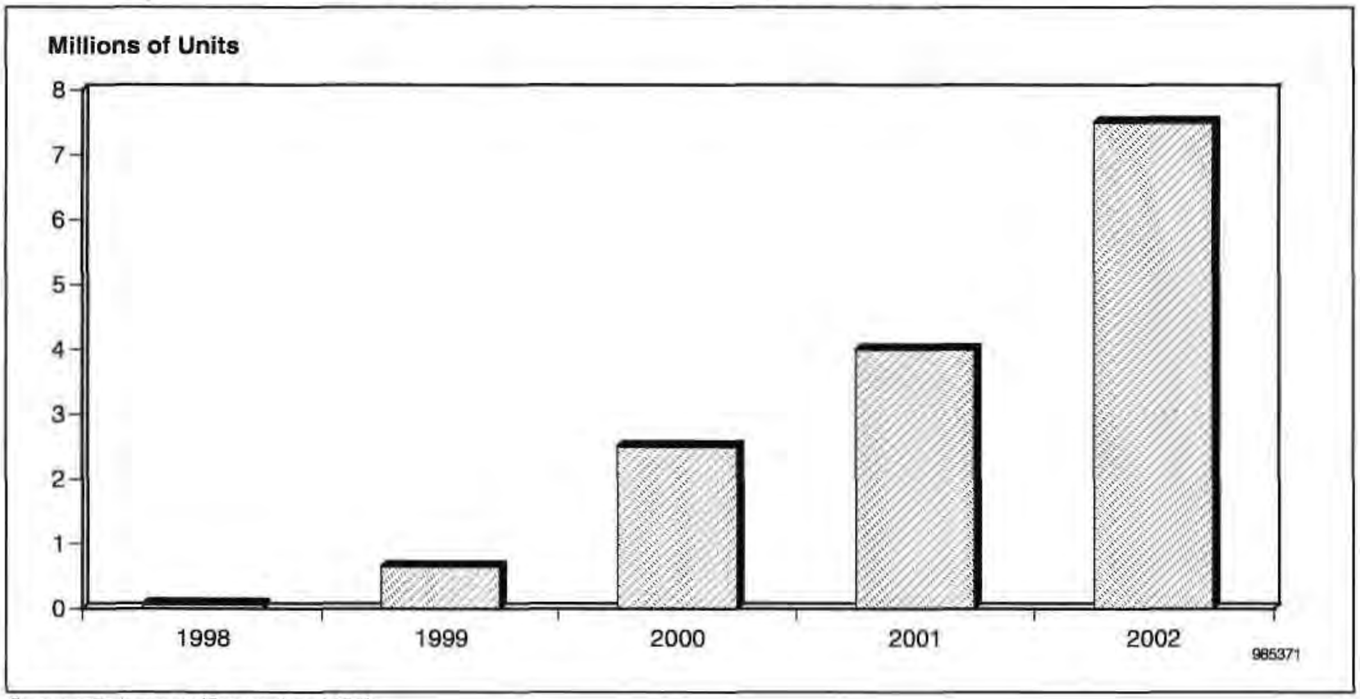
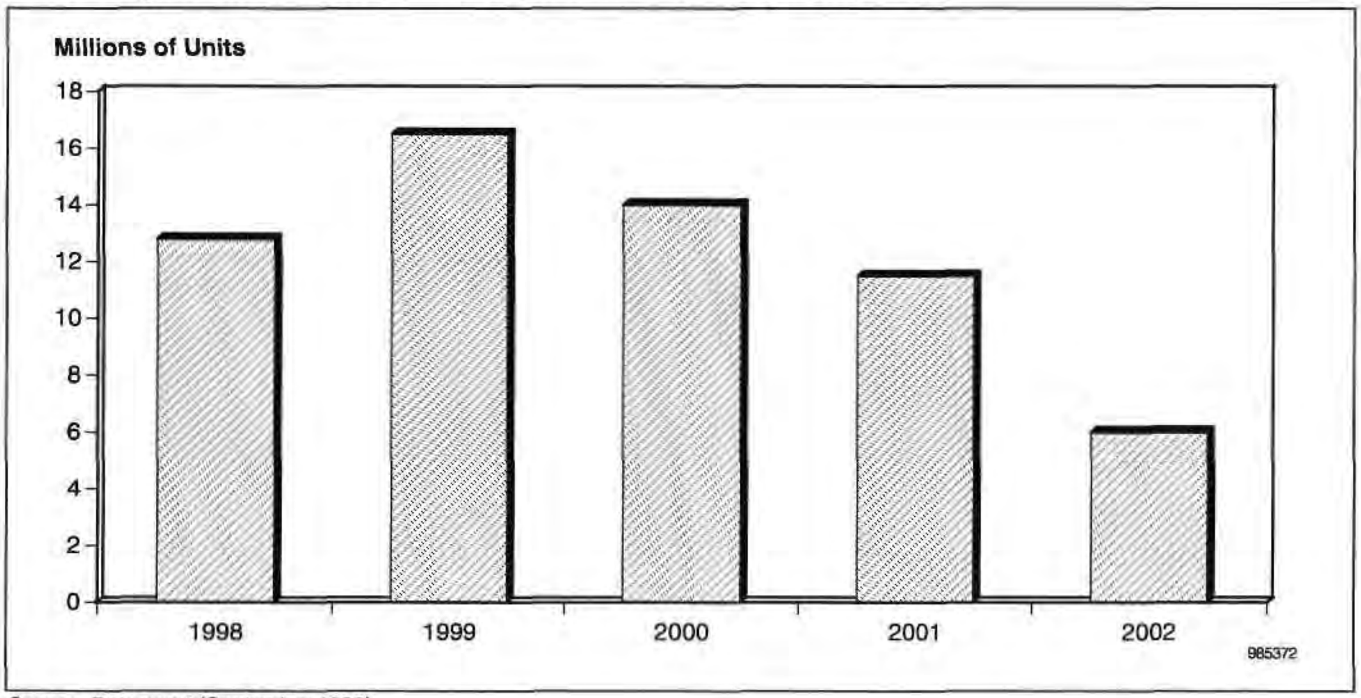
Figure 5
DVD Player Forecast for China's Consumer Market, 1998 to 2002



Source: Dataquest (September 1998)

Figure 6
VCD Player Forecast for China's Consumer Market, 1998 to 2002



Source: Dataquest (September 1998)

Digital Still Cameras

Digital still cameras are a niche market in China. The available market for digital cameras is expected to be limited to PC owners. Expected PC shipments in 1998 will reach 3.5 million units. Of these, less than 13 percent will enter the home market. With the majority of PC sales to the business sector, the demand for digital still cameras will be confined to business users. The volume sales of digital cameras will not be expected in the short term. Apart from the high price of digital cameras, more product education is also required for Chinese consumers because pictures taken by digital cameras demand processing by PC photo editors. Chinese consumers are still not ready for this product, and the penetration takes time and effort from the manufacturers.

Other Next-Generation Consumer Electronic Products

Other digital consumer electronics include digital camcorders based on digital videocassette (DVC) and DVD audio players. As these applications are just emerging, China is not expected to be the market innovator to absorb these products. Rather, Chinese consumers will wait and see the real benefits of these digital products before taking money out of their pocket.

Dataquest Perspective

Will digital consumer electronics be a future driver for the next boom in China? Probably, it is too early to draw a conclusion now. So far, Chinese consumers only taste the very inferior digital technology, as in the VCD players, which bring them just good enough personal movies with karaoke songs to sing with friends. Higher-quality DVD players at a higher price may not be the choice of the mass market now.

China is not yet a consumer with a digital appetite—at least, for the next few years. Most people are at still living at a low-income level. The median annual family income for urban dwellers is U.S.$1,200, and that for rural farmers is just about U.S.$720. According to a survey of household spending patterns from 3,700 families, the average portion of monthly income they would spend on entertainment is just better than 3.6 percent. Most of the people are still at the bottom, struggling to satisfy their basic needs. Hence, most consumers do not demand the high entertainment quality that digital electronics can deliver. Instead, they are looking for cheap entertainment that is affordable and the best value of their money. Complexity in digital electronic products will also be an obstacle to the acceptance. A digital TV equipped with Windows CE, for example, cannot become a mainstream product for the Chinese consumers who are generally less educated about PCs.

The Chinese government emphasizes the standards for China's own digital products, taking into consideration consumers' purchasing power. As in the case of new standards for VCD players, no matter what the standard is for CVD or Super VCD, both of them are serving the gap between low-quality VCD players and high-price DVD players. Few Chinese consumers can afford a complete set of home theater equipment to enjoy the superior picture quality with 5.1 multichannel surround sound provided by DVD players.

VCD player manufacturers probably understand China's situation well and, therefore, try to invent an intermediate solution to fill the demand gap. They want to provide a better value for consumers, while defending their falling revenue from the cutthroat price competition. In fact, the VCD, CVD/Super VCD, and DVD players can coexist in the market where they can serve different target segments. Like the PC market with different processor grades, VCD manufacturers can consider differentiating their products according to consumers' income level. The entry-level product can be VCD players that can tap the price-conscious, low-income group. The CVD or Super VCD players can be positioned to the "best-value" buyers, while DVD players can target the innovative buyers who look for performance and a status symbol. The three market segments can coexist until the DVD player price comes down to a level that is affordable for the mass market.

On the production side, China will be an attractive location for assembly. The proliferating of digital products in the United States, Europe, and Japan will drive China's production. China's electronics industry will be transformed by the worldwide digital tide and create a great business potential. Major digital manufacturers will begin manufacturing digital products in China, if they see a local demand there. With a 20 percent import tariff and a 17 percent value-added tax for foreign-made products, manufacturers cannot succeed in the market by staying outside.

Component makers will likely start to provide digital technology as a black box. A black-box assembly can ensure that Chinese manufacturers go to the digital playground with the lowest possible cost and quickest time. One example of this black box will be provided by a strategic alliance between Singapore's Thakral Corporation Ltd. and LSI Logic Corporation for providing DVD player manufacturing kits that offer a production-ready set of hardware, software, debugging, and testing tools. However, in the long term, Chinese companies will have to diversify from screwdriver plants. As they lag behind the hardware development technology, they will diversify into software development for digital products that adds value to their production capabilities.

Chinese consumer electronics makers have successfully moved their battlefield from cutthroat pricing competitions to diversification in functionality, features, and quality. The next battle stage will be set on digital technology, pushed forward by a handful of leading manufacturers worldwide. The successful digitalization of China's consumer electronics industry will need the votes from the Chinese consumers after all.

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Perspective

Semiconductors China

Market Analysis

China/Hong Kong Semiconductor User Ranking in 1997 and 1998

Abstract: *In this Perspective, Dataquest presents its ranking of the top 30 semiconductor consumers in China/Hong Kong in 1997 and forecasts usage in 1998 by vendor and application.*

By Daniel Heyler

Introduction

China/Hong Kong's semiconductor shipment revenue is concentrated among large manufacturers with about 25 percent of electronic equipment production, which accounted for more than 40 percent of semiconductor purchases. Recently, Dataquest has surveyed 60 major electronic equipment manufacturers (with one or multiple factories) in the computer, communications, and consumer electronic equipment segments to help anticipate future market trends vis-à-vis this sample group. This Perspective presents Dataquest's analysis, ranking, and forecasts of the top 31 electronic equipment manufacturers and the 20 largest semiconductor users by application from Dataquest's sample of 60 companies. (Dataquest's estimates include merchant market purchases, either from distributors or semiconductor vendors, as well as internally transferred products.)

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MARIA VALENZUELA

Electronic Equipment Company Ranking

Table 1 lists the top 31 major electronic equipment producers in China/Hong Kong in 1997 and 1998, according to Dataquest. Seagate Technology Inc., which operates two major disk drive facilities in China, is the largest electronic equipment producer measured in factory revenue. After its rapid growth in 1997, Dataquest expects a modest 7.8 percent growth because of

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the eroding disk drive average selling price (ASP). China's Sichuan Changhong Electric Appliance Co. Ltd. ranked second but is also suffering from a consumer electronics slowdown in color televisions and video compact disc (VCD) players. We expect the company to expand by 7.3 percent in 1999. In the third place is China's Legend Group, which will repeat another year of rapid production expansion with a 70 percent growth in 1998. The company moved from No. 8 to No. 3 from 1997 to 1998. Its main products are PCs and motherboards that are sold mostly on China's domestic market.

China's second-largest color television manufacturer, behind Changhong, is Konka Electronics Group Company. The company has expanded by 41 percent in 1998 but is likely to face a slowdown in 1999 because of a saturation in color television and video compact disc players, its two main revenue sources. Samsung Electronics Company Ltd. ranked fifth because of its production of a variety of audio and video equipment in China. The company's main factory revenue comes from color televisions, VCRs, stereo equipment, and video compact disc players. Although Dataquest expects the company to outperform Changhong and Legend in 1998 with a 16 percent growth, it will probably contract by 2 percent in 1999 because no investments are being made in 1998 for new production in 1999. Revenue will decline because of falling ASPs in a surely saturated 1999 market.

Company-Level Semiconductor Consumption Ranking

Table 2 provides Dataquest's estimates and ranking of semiconductor usage by major equipment manufacturer. Company ranking varies considerably from the electronic equipment ranking. Legend moved from the second ranking to the first in 1998 to become China/Hong Kong's largest semiconductor consumer. Dataquest expects Legend to maintain its lead in 1999 and to expand purchases by 33 percent. Taiwan's PC Chips Manufacturing Ltd. is the largest motherboard manufacturer in China, but it exports all of its production. The company expanded production in 1998 by 21 percent but doesn't plan to add capacity for 1999. Dataquest forecasts the company's semiconductor consumption to increase by 7.7 percent, based on current production plans.

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Table 1
Company-Level Electronic Equipment Production Revenue Forecast in China/Hong Kong, 1998 to 1999 (Millions of U.S. Dollars)

1997 Rank	1998 Rank	Company	1997 Final	1998 Forecast	Change (%) 1997 to 1998	Change (%) 1998 to 1999
1	1	Seagate	1,049	1,190	13.4	7.8
2	2	Changhong	973	1,061	9.0	7.3
8	3	Legend	447	751	67.9	31.7
5	4	Konka	517	731	41.2	17.7
4	5	Samsung	585	676	15.6	-1.8
3	6	Motorola	661	655	-0.8	-3.0
6	7	PC Chips	497	627	26.3	3.2
13	8	Great Wall/IBM	333	505	51.9	23.0
7	9	Shanghai Bell	449	503	12.0	7.3
9	10	FIC	405	497	22.7	11.9
12	11	Philips	339	465	37.1	1.1
11	12	TCL	349	408	16.9	28.4
14	13	Siemens	322	383	19.0	23.8
21	14	Xia Hua	235	362	54.5	34.6
15	15	Hitachi	307	336	9.5	20.0
16	16	Matsushita	300	326	8.5	4.5
17	17	Uniden	278	313	12.5	10.9
18	18	NEC	277	310	12.0	19.6
37	19	Acer	103	288	179.4	44.0
10	20	Jiangsu Shinco	403	283	-29.9	-45.5
23	21	BISC	211	259	22.5	11.2
20	22	LG	236	258	9.1	-9.0
22	23	Huawei	215	253	17.6	13.8
24	24	SANYO	205	245	19.4	26.1
26	25	Ericsson	196	245	25.2	17.3
35	26	Phone Star	104	230	121.7	20.4
25	27	Vtech	197	226	14.5	10.8
19	28	Idall	243	224	-7.8	-18.6
31	29	Founder	126	216	71.1	82.8
27	30	Shanghai Guangdian	170	210	23.2	19.1
33	31	Tontru	122	207	69.9	62.9
		Top 31 Total	**10,854**	**12,473**	**22.0**	**13.4**
		Top 60 Total	**12,537**	**15,276**	**21.9**	**14.4**

Source: Dataquest (August 1998)

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Table 2
Company-Level Semiconductor Consumption Forecast in China/Hong Kong, 1998 to 1999 (Millions of U.S. Dollars)

1997 Rank	1998 Rank	Company	1997 Revenue	1998 Revenue	Forecast Change (%) 1997 to 1998	Forecast Change (%) 1998 to 1999	1999 Revenue
2	1	Legend	242	394	63.1	33.0	524
1	2	PC Chips	246	297	20.8	7.7	320
3	3	Great Wall/IBM	190	278	46.2	21.2	336
4	4	FIC	181	217	19.5	9.7	238
5	5	Seagate	160	204	27.6	19.5	243
6	6	Motorola	155	171	10.1	4.5	179
7	7	Chang Hong	129	162	25.7	6.3	172
8	8	Samsung	111	134	21.1	-5.1	127
12	9	Tontru	72	117	63.6	59.0	187
11	10	Konka	75	116	53.9	16.7	135
10	11	Uniden	77	92	20.6	20.7	111
20	12	Founder	57	87	50.9	87.2	162
16	13	Siemens	67	86	27.7	18.6	102
14	14	NEC	71	85	19.0	36.8	116
13	15	Shanghai Bell	71	77	7.1	5.9	81
18	16	Matsushita	65	73	12.9	5.0	77
21	17	Philips	55	72	29.9	-11.2	64
17	18	Vtech	66	72	9.0	18.9	85.5
9	19	Jiangsu Shinco	95	67	-29.5	-44.4	37.3
23	20	TCL	50	66	31.9	35.3	89.4
		Top 20 Total	**2,235**	**2,865**	**28.2**	**18.2**	-
		Top 63 Total	3,009	3,842	**27.7**	**19.6**	-

Source: Dataquest (August 1998)

The joint venture between China Great Wall Computer Group and IBM increased semiconductor usage from approximately $190 million to $278 million in 1998. Dataquest believes that about 15 percent of production is motherboards and the other 85 percent is functional PCs. In the fourth position is Taiwan First International Computer Inc. (FIC), which consumed $181 million in 1997 and is forecast to consume $217 million in 1998. This revenue growth of 20 percent stemmed from three product lines, motherboards, PCs, and computer monitors. Like PC Chips, FIC exports a high percentage of its products and, therefore, is likely to experience a slower growth in 1999 relative to Legend and Great Wall/IBM. Seagate ranked first in electronic equipment production (factory revenue) but fifth in semiconductor consumption both in 1997 and 1998. Semiconductor consumption is maintaining its high growth level because volumes at Seagate are not slowing, despite the sliding ASPs. Semiconductor consumption will increase by 28 percent in 1998 and is likely to slow slightly, growing by 20 percent in 1999.

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Semiconductor Consumption Ranking by Application

Table 3 provides Dataquest's final ranking of semiconductor users in China/Hong Kong by end markets in 1998, which are aggregated in three major segments: communications, consumer, and data processing. The top five semiconductor consumers in China/Hong Kong are PC and/or motherboard manufacturers. Ranked No. 6 is Motorola Incorporated, the largest communications-related semiconductor user. Motorola manufactures cellular phones in Tianjin and Hangzhou and pagers in Tianjin and Shanghai. Following behind Motorola in semiconductor consumption are two consumer electronics companies, Changhong and Samsung. The remaining companies are a mix of consumer, computer, and communications equipment companies.

Table 3
Company-Level Semiconductor Consumption by Application in China/Hong Kong, 1998 (Millions of U.S. Dollars)

Company	Communications	Consumer	Data Processing	Total
Legend	0	0	394	394
PC Chips	0	0	297	297
Great Wall + IBM	0	0	278	278
FIC	0	0	217	217
Seagate	0	0	204	204
Motorola	171	0	0	171
Chang Hong	0	162	0	162
Samsung	28	106	0	134
Tontru	0	0	117	117
Konka	0	116	0	116
Uniden	92	0	0	92
Founder	0	0	87	87
Siemens	47	0	39	86
NEC	54	0	31	85
Shanghai Bell	77	0	0	77
Matsushita	26	35	0	73
Philips	0	46	25	72
Vtech	62	10	0	72
Jiangsu Shinco	0	67	0	67
TCL	42	24	0	66
Acer	0	0	64	64
Stone + Compaq	0	0	59	59
LG	0	58	0	58
Dataexpert	0	0	58	58
Idall	7	48	0	55
Other Surveyed Companies	253	272	144	684
Total Surveyed Companies	**857**	**945**	**2,013**	**3,842**

Note: Numbers may not add up to total because of rounding.
Source: Dataquest (August 1998)

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Communications Semiconductor Purchasers and Products

Table 4 lists major consumers, their respective communications products, and the estimated value of semiconductors used by those segments in 1998. Twenty-four companies consumed approximately $860 million in communication semiconductors in 1997, which is equal to 13 percent of the China/Hong Kong semiconductor market.

Five of the top 10 communications semiconductor consuming-companies are central office or PBX (CO/PBX) manufacturers. Four of the top 10 are cordless phone manufacturers. The top communications semiconductor consumer, Motorola (China) Electronics Company Ltd., is the largest of about six cellular phone handset manufacturers in China/Hong Kong. Motorola's $171 million in semiconductor consumption was derived from pagers ($67 million) and cellular phones ($104 million). The company will produce 1.5 million cellular phones in 1998 and is expected to increase output to 1.8 million in 1999.

Uniden Electronics Products' cordless phone business consumed about $92 million worth of semiconductors. Shanghai Bell Telephone Equipment Company is a Sino-American joint venture with Bell Atlantic Corporation manufacturing S1240 central office switches for sale in the Chinese market. The company purchased approximately $76.5 million in communications semiconductors in 1998, which was the third-largest amount in the communications sector. Dataquest expects Uniden, Vtech Communications Ltd., and TCL Communications Equipment Co. Ltd. to become the fastest-growing communications semiconductor users in 1998.

Consumer Semiconductor Purchasers and Products

The 24 companies listed in Table 5 consumed approximately $945 million in consumer semiconductors in 1998, or 14 percent of China/Hong Kong's $6.8 billion total semiconductor market. Eight of the top 10 users are VCD manufacturers, and five of those are color television (CTV) manufacturers. The three VCD manufacturers that are not color television makers are Guangzhou Idall Company Ltd., Shanghai Lejin Guangdian Electronics Co. Ltd., and Fujian Malata Company. Vtech was the first company to enter the set-top box market in late 1997 and shipped products to South Africa. The company plans to produce 300,000 units in 1998 using STMicroelectronics' standard application-specific integrated circuit (ASIC).

Data Processing Semiconductor Purchasers and Products

More than half of the semiconductor purchase revenue from Dataquest's preselected 63 companies is from data processing semiconductors. As shown in Table 6, this $2 billion will be shipped to 24 major manufacturers in 1998. But the concentration of purchases is among the top five PC and/or motherboard manufacturers (except for Seagate that only manufactures rigid disk drives), which accounted for approximately 70 percent of the revenue, or $1.3 billion. The three fastest-growing companies in 1998 are predicted to be Acer Computer International Inc., Langchao Electronic Group Co., and Xiamen Huaqiao Electronic Company (XiaHua). Most of Acer's production in China is located at the Suzhou Mingji Computer Company Ltd. in Jiangsu Province, which will double its monitor production from 600,000 units in 1997 to 1.3 million units in 1998, after several years of investment delays. By 1999, the company plans to produce 2 million monitors, 85 percent of which will be exported. Langchao Electronic Group Co., a small PC manufacturer shipping entirely to the Chinese domestic market, will expand production from 20,000 units in 1997 to 150,000 units in 1999.

Table 4
Key Market Segments and Users of Communications Semiconductors in China/Hong Kong, 1998 (Millions of U.S. Dollars)

Company	Cellular Phone	CO/PBX	Corded Phone	Cordless Phone	Fax Machine	Pager	Grand Total
Motorola	104.3	0	0	0	0	66.7	170.9
Uniden	0	0	0	92.3	0	0	92.3
Shanghai Bell	0	76.5	0	0	0	0	76.5
Vtech	0	0	0	62.4	0	0	62.4
NEC	33.4	20.3	0	0	0	0	53.6
Siemens	6.7	38.8	1.2	0.1	0	0	46.9
TCL	0	0	22.1	19.5	0	0	41.6
Phone Star	0	0	20.8	19.5	0	0	40.3
BISC	0	39.4	0	0	0	0	39.4
Huawei	0	38.5	0	0	0	0	38.5
Ericsson	31.3	5.4	0	0	0	0	36.7
Samsung	0	3.4	0	0	24.4	0	27.7
Matsushita	12.5	0	0	0	0	13.1	25.6
Nokia	13.9	4.1	0	0	0	0	18.0
TCL + NEC	0	0	0	0	0	13.8	13.8
Sony	0	0	0	13.0	0	0	13.0
XiaHua (Xoceco)	0	0	5.2	6.5	0	0	11.7
HuaGuang	0	11.3	0	0	0	0	11.3
JiangDu	0	0	10.4	0	0	0	10.4
DaTang	0	10.1	0	0	0	0	10.1
Idall	0	0	0	6.5	0	0	6.5
Toshiba	0	4.8	0	0	0	0	4.8
Rainbow	0	0	3.9	0	0	0	3.9
SANYO	0	0	0	1.3	0	0	1.3
Grand Total	**2,02.0**	**2,52.4**	**63.6**	**221.1**	**24.4**	**93.6**	**857.1**

Note: Columns do not add up to the total shown because of rounding.
Source: Dataquest (August 1998)

Table 5
Key Market Segments and Users of Consumer Electronics Semiconductors in China/Hong Kong, 1998 (Millions of U.S. Dollars)

Company	Analog Camcorder	Smart Card Reader	Color TV	Hi-Fi	Personal Stereo	Set-Top Box	VCD Player	VCR	Total
Chang Hong	0	0	142.8	0	0	0	19.2	0	162.0
Konka	0	0	91.8	0	0	0	23.8	0	115.6
Samsung	0	0	39.2	18.2	0	0	11.0	37.6	106.0
Jiangsu Shinco	0	0	0	0	0	0	67.2	0	67.2
LG	0	0	0	12.2	4.7	0	19.2	22.4	58.4
Hitachi (FuRi)	0	0	49.0	0	0	0	0	0	49.0
Idall	0	0	0	0	0	0	48.0	0	48.1
Philips	0	0	8.3	6.1	5.4	0	23.6	3.1	46.5
SANYO	0	0	24.5	2.7	4.7	0	0	3.3	40.9
Fujian Malata	0	0	0	0	0	0	36.0	0	36.0
Matsushita	0	0	0	13.0	16.6	0	0	5.3	34.8
Shanghai GuangDian	0	0	30.6	0	0	0	0	0	30.6
TCL	0	0	24.5	0	0	0	0	0	24.5
Xiamen Xiaxin	0	0	0	0	0	0	23.6	0	23.6
XiaHua (Xoceco)	0	0	20.4	0	0	0	0	0	20.4
Sony	17.9	0	1.8	0	0	0	0	0	19.7
Toshiba	0	0	15.5	0	0	0	0	0	15.5
Panda	0	0	12.2	0	0	0	0	0	12.4
Vtech	0	0	0	0	0	9.5	0	0	9.5
Sharp	0	0	3.1	2.0	0	0	3.6	0	8.7
Hitachi	7.3	0	0	0	0	0	0	0	7.3
Beijing Aerospace	0	1.6	0	0	0	0	0	0	1.6
HuaXu	0	0.8	0	0	0	0	0	0	0.8
Hunan Computer	0	0.5	0	0	0	0	0	0	0.5
Grand Total	**25.2**	**3.0**	**463.6**	**54.1**	**31.3**	**9.5**	**275.3**	**71.6**	**944.6**

Note: Columns do not add up to the total shown because of rounding.
Source: Dataquest (August 1998)

Dataquest Perspective

The semiconductor consumption outlook for 1998 and 1999 appears increasingly pessimistic as the market shows signs of softening. Dataquest's fall survey concludes that 25 percent of the electronics industry will expand by 14 percent in 1999 after growing 22 percent in 1998. Because of the worsening market conditions, Dataquest believes that semiconductor purchases among these manufacturers will decline from between 20 percent and 25 percent growth in 1998 to between 15 percent and 20 percent in 1999. Currently, there are more growth inhibitors than stimulants in China/Hong Kong. The result is that exports are hurt by the Asian financial crisis, and local consumption of end equipment is impeded by slowing economic growth and overcapacity. Hence, most manufacturers are not expanding production capacity because of their concern about the worsening market conditions in late 1998 and most of 1999.

Table 6
Key Market Segments and Users of Data Processing Semiconductors in China/Hong Kong, 1998 (Millions of U.S. Dollars)

Company	Monitor	Motherboard	PC	Plug-In Card	Power PC	Printer	Rigid Disk Drive	Terminal	Total
Legend	0	159.1	234.8	0	0	0	0	0	393.9
PC Chips	0	296.8	0	0	0	0	0	0	296.8
Great Wall + IBM	0	42.7	234.8	0	0	0	0	0	277.5
FIC	10.2	107.7	98.6	0	0	0	0	0	216.5
Seagate	0	0	0	0	0	0	203.7	0	203.7
Tontru	0	0	117.4	0	0	0	0	0	117.4
Founder	8.3	0	78.3	0	0	0	0	0	86.6
Acer	22.9	0	41.1	0	0	0	0	0	64.0
Stone + Compaq	0	0	58.7	0	0	0	0	0	58.7
Dataexpert	0	58.2	0	0	0	0	0	0	58.2
Hisense	0	0	39.1	0	0	0	0	0	39.1
Siemens	0	0	39.1	0	0	0	0	0	39.1
Langchao	0	0	31.3	0	0	0	0	0	31.3
NEC	0	0	31.3	0	0	0	0	0	31.3
Philips	25.5	0	0	0	0	0	0	0	25.5
XiaHua (Xoceco)	17.0	0	0	0	0	0	0	0	17.0
Hsin Ming	0	0	0	12.2	0	0	0	0	12.2
Great Wall	7.8	0	0	0	0	0	0	3.5	11.3
HuaFei	8.5	0	0	0	0	0	0	0	8.5
Rainbow	8.5	0	0	0	0	0	0	0	8.5
HuiLiDa	5.9	0	0	0	0	0	0	0	5.9
Fujitsu	0	0	0	0	0	4.3	0	0	4.3
Sony	2.5	0	0	0	0	0	0	0	2.5
Stone + Fujitsu	0	0	0	0	0	2.4	0	0	2.4
Grand Total	**117.2**	**664.5**	**1,004.7**	**12.2**	**0**	**7.7**	**203.7**	**3.5**	**2,013.5**

Note: Columns do not add up to the total shown because of rounding.
Source: Dataquest (August 1998)

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Dataquest
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Perspective

Semiconductors China

Market Analysis

Semiannual Equipment Vendor Survey: Manufacturers' Scale Growth Plans for 1998 and 1999

Abstract: *The recent increase in market uncertainty among semiconductor vendors warrants a closer, forward-looking survey of electronic equipment manufacturers. Dataquest has completed a survey of computer, consumer, and communications companies to measure their production plan changes. Dataquest uses this bottom-up research to gauge changes in semiconductor consumption resulting from increases or decreases in electronic equipment production plans. The fall data is compared with spring production plans for 1998 to understand downstream market threats or opportunities in the semiconductor market.*
By Daniel Heyler

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MARIA VALENZUELA

Introduction

The primary purpose of Dataquest's semiannual electronic manufacturer survey is to provide strategic planners with knowledge of major China/Hong Kong manufacturers' production plans and changes. Dataquest's aggregated sample production size is U.S.$12 billion, about 24 percent of all China/Hong Kong's electronic equipment production in 1998. This pool of companies represents 41 percent of China/Hong Kong's semiconductor consumption, thus providing a large enough sample size to gauge forthcoming consumption changes. Dataquest has chosen a stratified sampling by surveying high-volume manufacturers across two major dimensions: all major electronic equipment applications (communications, data processing, and consumer electronics) and ownership regions (Chinese, European, Japanese, Americas, Taiwanese, and Hong Kong companies). Dataquest's company-level tracking now accounts for 30 percent of China/Hong Kong's production, but for spring and fall 1998 comparison purposes, only the group for which Dataquest has two years' data is focused on.

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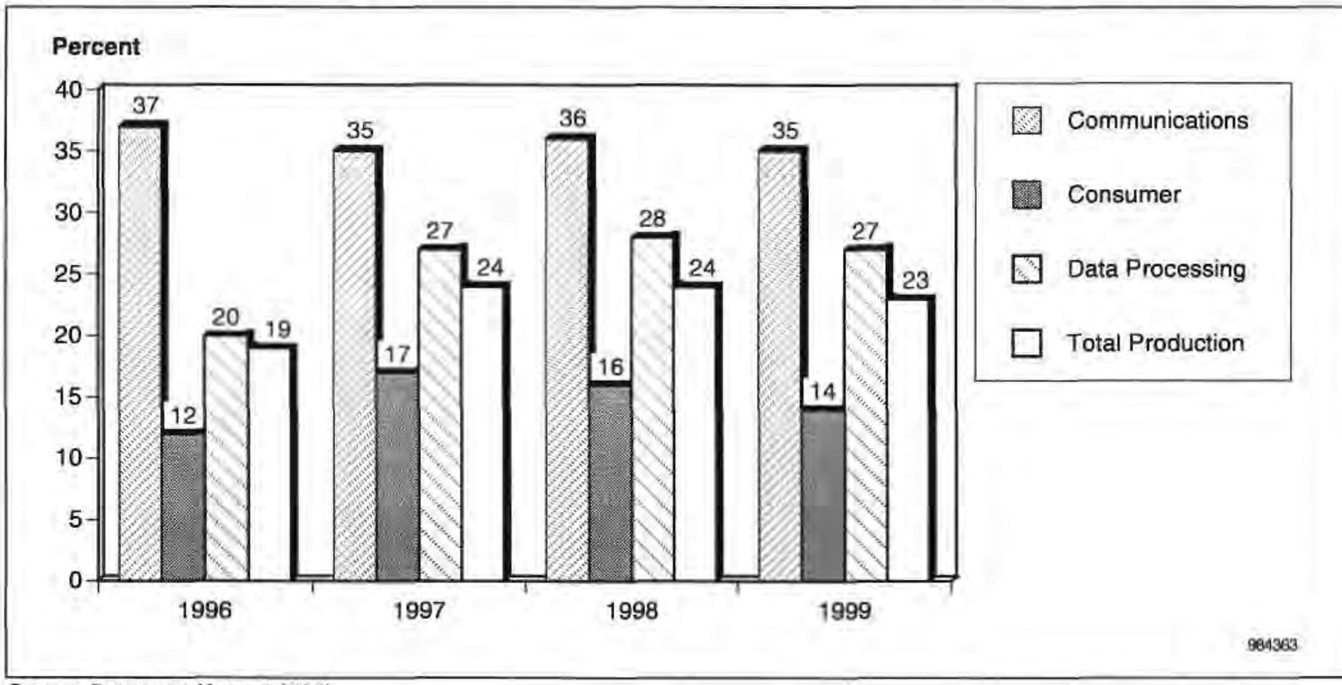
As shown in Figure 1, communications companies represent the largest proportional sample group in 1998, with 36 percent of all communications factory revenue included. Data processing companies are the second-largest proportional group, representing 28 percent of data processing factory revenue. Because the consumer electronics sector is more dispersed (more companies with less revenue per company) than either the data processing or communications sector, this survey covers only 16 percent of consumer factory revenue in China/Hong Kong in 1998. On the whole, a statistically valid share of 24 percent of all electronics factory revenue is represented by Dataquest's selected sample group. The data, analysis, and conclusions presented are based entirely on the information provided by more than 100 manufacturers selected from the overall vendor population. As one would expect, there are new companies entering the Chinese market by investing in production, as well as companies that are exiting or changing products.

Figure 1
Surveyed China/Hong Kong Manufacturers' Share of Total Production, 1996 to 1999

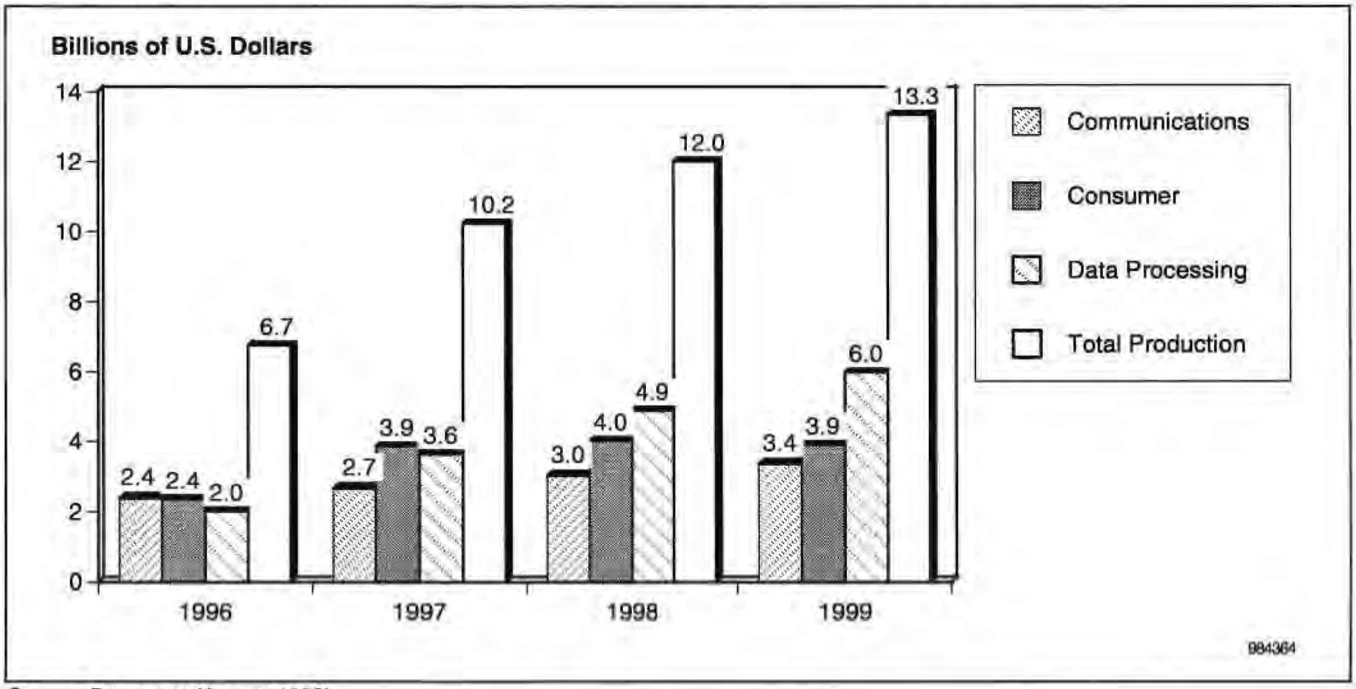


Source: Dataquest (August 1998)

Manufacturers Expect Slower Growth in 1998 than 1997

In dollar terms, the communications companies sampled (36 percent of this segment's production) expects to grow by 14 percent, from $2.7 billion in 1997 to $3.0 billion in 1998 (see Figure 2). Although 14 percent is modest growth for this market, it is actually a modest acceleration over 1997's 12 percent growth. The largest group in revenue terms, data processing expects a 36 percent growth from $3.6 billion in 1997 to $4.9 billion in 1998. This growth also represents a substantial slowdown from 1997's near doubling of revenue from $2 billion. The downside story is much more severe for consumer electronics companies, which expect a bleak 4.1 percent growth from $3.9 billion in 1997 to $4 billion in 1998. On the whole, in 1998, 24 percent of China/Hong Kong's electronics industry expects to expand by 17.4 percent on average, compared to 51.6 percent in 1997. Two key factors behind the high growth in 1997 were that new products were introduced into the Chinese market in 1997 (such as video compact discs [VCDs]) and that Chinese companies rapidly expanded production capacity in computer, communications, and consumer areas.

Figure 2
Surveyed China/Hong Kong Manufacturers' Total Production, 1996 to 1999



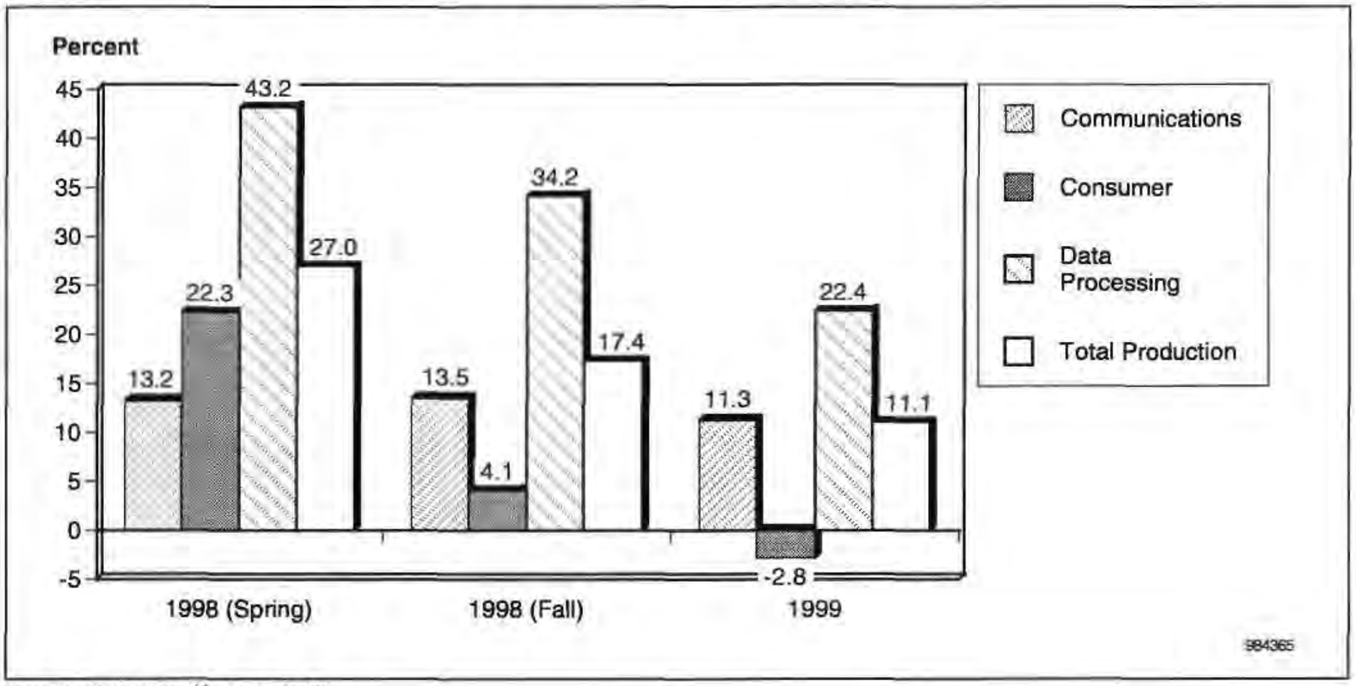
Source: Dataquest (August 1998)

Companies Prepare for a Prolonged Slowdown into 1999

As revealed in Figure 3, manufacturers' sentiments had substantially worsened since the beginning of 1998 as they slashed expansion plans from an average of 27 percent growth forecast in the spring to an average of 17 percent forecast in the fall. The most dramatic decline is seen among the consumer electronics companies that have reduced their 22 percent revenue growth forecast to 4 percent. Moreover, their expectations for 1999 worsen, with a projected revenue contraction of about 3 percent (this view is representative of 16 percent of the entire Chinese consumer electronics industry).

Dataquest believes the consumer electronics industry will probably experience a contraction in 1999 unless certain technology hurdles allow to be a second-generation VCD system is introduced in the Chinese market. Dataquest also believes that the impact of DVDs and set-top boxes won't be felt until late 1999 and 2000. Hence, the video segment of the consumer market has deteriorated, as a 22 percent projected factory revenue growth was slashed to 2 percent (see Table 1), and manufacturers expect another 5 percent decline in 1999.

Figure 3
A Comparison of Surveyed China/Hong Kong Manufacturers' 1998 Production Plans, Spring versus Fall, 1998 and 1999 (Growth Rate as Percentage)



Source: Dataquest (August 1998)

The data processing sector's sample group is the most bullish in its outlook for 1998, striving for 34 percent growth improvement over the 1997 level. This growth forecast is 9 percentage points less than the spring forecast of 43 percent, but it is a result of falling average selling prices rather than changes in unit production. A relatively strong demand in China's PC market is the main driver behind the data processing sector's higher level of growth, although this is only half of 1997's growth. However, most computer companies expect 1999 to be worse than 1998, and they look for an average production increase of 25 percent. Similarly, computer peripherals manufacturers (input/output segment), which expect a very strong 1998, are halving their 1999 growth plans from 71 percent in 1998 to 34 percent in 1999. Storage revenue has declined the most since Dataquest's last survey. In spring, Seagate Technology Inc. expected 34 percent growth in factory revenue, but lowered its forecast to 13 percent for fall.

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Table 1
Segmented View of Manufacturers' 1998 and 1999 Production Plans (Millions of Dollars)

	Spring 1998	Fall 1998	Forecast 1999
Mobile Communications			
Semiconductor Consumption (U.S.$M)	1,514.9	1,343.5	1,424.6
Change (%)	5.6	6.8	6.0
Premise Telecommunications			
Semiconductor Consumption (U.S.$M)	1,941.2	1,674.6	1,933.1
Change (%)	20.0	19.6	15.4
Total Communications			
Semiconductor Consumption (U.S.$M)	3,456.1	3,018.1	3,357.7
Change (%)	13.2	13.5	11.3
Audio			
Semiconductor Consumption (U.S.$M)	435.0	417.5	470.4
Change (%)	27.9	26.5	12.7
Personal Electronics			
Semiconductor Consumption (U.S.$M)	18.8	18.8	21.6
Change (%)	20.0	20.0	15.1
Video			
Semiconductor Consumption (U.S.$M)	5,060.2	3,585.1	3,415.9
Change (%)	21.9	1.9	-4.7
Total Consumer			
Semiconductor Consumption (U.S.$M)	5,514.0	4,021.4	3,907.9
Change (%)	22.3	4.1	-2.8
Computers			
Semiconductor Consumption (U.S.$M)	2,982.4	2,847.7	3,570.3
Change (%)	41.3	36.7	25.4
Data Storage Devices			
Semiconductor Consumption (U.S.$M)	1,752.6	1,190.0	1,282.6
Change (%)	34.0	13.4	7.8
Input/Output Devices			
Semiconductor Consumption (U.S.$M)	875.3	809.8	1,082.8
Change (%)	77.9	70.6	33.7
Other Data Processing			
Semiconductor Consumption (U.S.$M)	36.5	36.5	43.5
Change (%)	14.0	14.0	19.1
Total Data Processing			
Semiconductor Consumption (U.S.$M)	5,646.9	4,884.0	5,979.2
Change (%)	43.2	34.2	22.4
Transportation			
Semiconductor Consumption (U.S.$M)	111.4	87.0	99.8
Change (%)	18.0	18.0	14.7
Total			
Semiconductor Consumption (U.S.$M)	14,728.3	12,010.5	13,344.6
Change (%)	-	17.4	11.1

Source: Dataquest (August 1998)

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The exception to the downward production changes observed across different segments of the electronics industry is the communications equipment manufacturers, which have maintained their 1998 production forecast of about 13 percent to 14 percent in the spring and fall. The mobile communications equipment segment has slowed in 1998 to a mere 7 percent revenue growth, and this growth is not expected to accelerate in 1999. A high growth in premises equipment, namely handsets, is still expected as surveyed companies maintain a 20 percent growth forecast for 1998 and 15 percent for 1999.

Semiconductor Purchases to Be Reduced by $650 Million

In terms of semiconductor consumption, all companies surveyed consume approximately $3.2 billion in semiconductors, or 41 percent of the total China/Hong Kong semiconductor market in 1998. Dataquest has increased its sample size in this fall survey, compared with the spring one, to account for a larger percentage of local Chinese manufacturers. Dataquest's rationale for covering more Chinese companies is that because multinationals are apt to consign product on global contracts, local companies represent a large opportunity because purchasing decisions are made entirely locally.

Figure 4 illustrates the impact of reduced growth on semiconductor consumption. The reduction in electronic equipment production plans from 27 percent to 17 percent growth in 1998 renders a reduction in semiconductor consumption of approximately $650 million. In growth terms, this is a decline from 27 percent (spring forecast) to 23 percent (fall forecast). In spring, Dataquest had forecast the total worldwide 1998 semiconductor market to grow by 19.6 percent to $7.8 billion, based on its sampling of manufacturers' production plans and pricing assumptions. But midyear reductions among Dataquest's sample population and falling prices will reduce growth by about half, to 9.7 percent, or $7.1 billion. Compounding the problem is the continued price erosion across various semiconductor segments, which will lessen growth further in 1998.

One exception to this midyear reduction trend is seen in the communications equipment companies, which have not needed to reduce their production plans. Factory revenue growth is still expected to expand by about 13 percent, while Dataquest estimates semiconductor consumption to sustain approximately 19 percent growth in the communications sector. As shown in Table 2, the primary driver for semiconductor consumption growth is in premises equipment, which is expanding by 23 percent. Mobile communications equipment production growth has dropped to 6 percent, as previously mentioned, attributed in part to declining pager demand. Dataquest expects mobile semiconductor consumption to maintain a 14 percent growth (no change from spring) among these companies in 1998, with 12 percent in 1999 (see Table 2).

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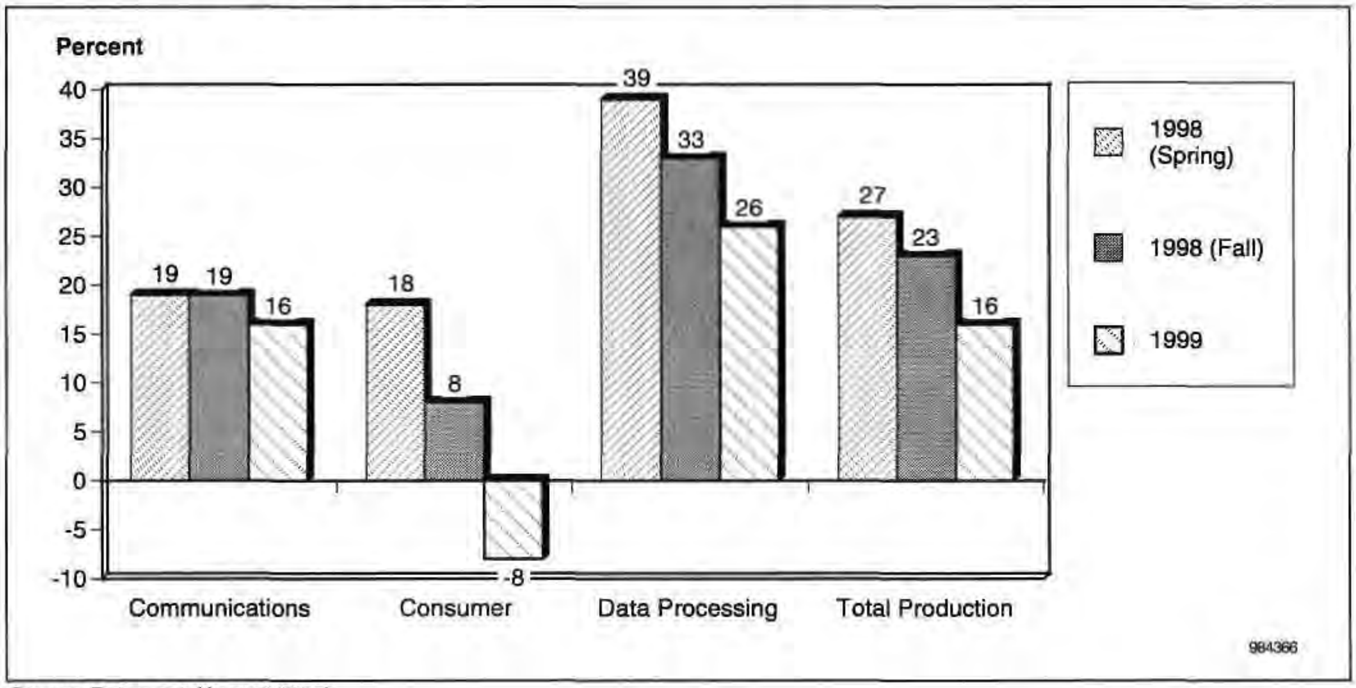
Figure 4
Estimated 1998 and 1999 Semiconductor Consumption Growth Rates of Surveyed China/Hong Kong Companies



Source: Dataquest (August 1998)

Consumer electronics companies are suffering from a falling domestic demand, a slowdown in investments from credit-constrained Japanese manufacturers, and a sluggish export demand. Dataquest's surveyed companies (representing 20 percent of the overall consumer equipment production) slashed their growth plans from an average of 22.3 percent to 4.1 percent in 1998, and they expect a 2.8 percent contraction in 1999. Consumer-related semiconductor purchases are forecast to increase by 8.5 percent, rather than 18 percent as previously expected in spring. Manufacturers expect the situation to worsen in the latter half of 1998 and in 1999, which is forecast to contract by 8 percent. The main problem is that VCDs were the consumer market savior in 1997, but they faced saturation in 1998. However, there are next-generation VCDs under development that avoid the royalty constraints/costs on media content of DVDs and could surprise the market in 1999.

Data processing-related companies in Dataquest's survey expect to reduce production growth from 43 percent, as forecast in spring, to 34 percent in fall. The value of semiconductors purchased by data processing companies could reach $1.8 billion, but it is likely to fall short of vendors' expectations because of severe price erosion that was not previously anticipated. Most of the revenue reduction stems from cutbacks in rigid disk drive production. Data storage had been forecast to expand by 34 percent in the beginning of 1998, but manufacturers—namely Seagate—forecast an expansion of only 13 percent in output. Revenue reduction is attributed almost entirely to falling average selling prices rather than volume cuts.

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Table 2
A Segmented View of China/Hong Kong Electronic Equipment Manufacturers' 1998 and 1999 Semiconductor Consumption

	1998 Spring	1998 Fall	1999 Forecast
Mobile Communications			
Semiconductor Consumption (U.S.$M)	285.8	295.5	331.2
Change (%)	10.5	14.0	12.1
Premise Telecommunications			
Semiconductor Consumption (U.S.$M)	647.7	351.5	420.8
Change (%)	23.4	22.7	19.7
Total Communications			
Semiconductor Consumption (U.S.$M)	933.5	647.0	752.0
Change (%)	19.2	18.5	16.2
Audio			
Semiconductor Consumption (U.S.$M)	87.5	86.0	92.9
Change (%)	27.1	28.6	8.0
Personal Electronics			
Semiconductor Consumption (U.S.$M)	5.6	5.3	6.0
Change (%)	20.0	12.4	13.8
Video			
Semiconductor Consumption (U.S.$M)	1,046.7	656.8	590.9
Change (%)	17.6	6.3	-10.0
Total Consumer			
Semiconductor Consumption (U.S.$M)	1,139.8	748.1	689.7
Change (%)	18.3	8.5	-7.8
Computers			
Semiconductor Consumption (U.S.$M)	1,449.2	1,481.3	1,883.1
Change (%)	38.7	31.7	27.1
Data Storage Devices			
Semiconductor Consumption (U.S.$M)	203.7	203.7	243.5
Change (%)	27.7	27.6	19.5
Input/Output Devices			
Semiconductor Consumption (U.S.$M)	87.4	88.4	114.8
Change (%)	78.8	76.9	29.8
Other Data Processing			
Semiconductor Consumption (U.S.$M)	16.4	12.2	14.7
Change (%)	14.0	7.2	20.1
Total Data Processing			
Semiconductor Consumption (U.S.$M)	1,756.7	1,785.7	2,256.1
Change (%)	38.6	32.7	26.3
Transportation			
Semiconductor Consumption (U.S.$M)	20.0	20.0	24.1
Change (%)	20.9	20.9	20.6
Total			
Semiconductor Consumption (U.S.$M)	3,850.0	3,200.8	3,721.9
Change (%)	27.0	23.2	16.3

Source: Dataquest (August 1998)

Therefore, Dataquest has not changed its storage semiconductor consumption forecasts from a 28 percent growth in the spring. Our outlook for 1999 calls for storage semiconductor purchases to slow to a 20 percent growth. The computer segment is also experiencing softer average selling prices in end equipment, especially among PC manufacturers that have reduced the growth projection from 41 percent to 37 percent. Computer-related semiconductor purchases are likely to grow by 32 percent rather than 39 percent, which was forecast in spring. As mentioned, computer peripherals' production continues to be the fastest-growing segment, as manufacturers stick to their targets of more than 70 percent growth, down only slightly from their previous target of 78 percent. Although peripherals' semiconductors consumption should maintain at about 77 percent growth, it is still a small segment.

Sentiment Varies by Origin of Vendor: Chinese and Taiwanese Companies Expand Production, While Americas Companies Scale Back Plans

Table 3 provides an electronic equipment production history and forecast of surveyed companies, grouped by their origin of ownership. Chinese and Hong Kong companies represent 37 percent of the sample group's production revenue, while multinational companies manufacturing within China/Hong Kong constituted 63 percent. The sum of Chinese, Hong Kong, and Taiwanese companies, or "Greater China companies," represent 50 percent of Dataquest's sample group. There is a high proportion of multinational companies included in this survey because high-volume products that are rich in semiconductor content are produced mainly by foreign companies.

Americas companies surveyed have scaled back production expansion plans made in the beginning of 1998. As shown in Table 3, Americas manufacturers have planned for 21 percent factory revenue increase but later reduced their forecasts dramatically to 0.7 percent. As previously mentioned, disk drive downsizing had the largest impact on the bottom-line growth.

Consistent with Dataquest's consumer electronics sector's scenario, we observed that Japanese companies that modified plans to expand output 23 percent were expecting only 15 percent at best. European companies, buoyed by China's communications market growth, altered production plans the least with only 1 percent change, from 27 percent to 26 percent growth expected for 1998. Taiwanese companies are, by far, the most aggressive of the group and show some signs of slowdown—but not significantly. They had planned for a 48 percent output increase in their spring forecast but now expect 40 percent for fall.

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Table 3
Surveyed Vendor Production Plans by Origin of Ownership, 1997 to 1999

	1997 Final	1998 Spring Plans	1998 Fall Revisions	1999 Forecast
Americas Companies				
Revenue (U.S.$M)	1,833.5	2,691.5	1,845.4	1,918.6
Change (%)	-	21.2	0.7	4.0
Chinese Companies				
Revenue (U.S.$M)	3,539.7	5,375.8	4,211.0	4,775.8
Change (%)	-	30.8	19.0	13.4
European Companies				
Revenue (U.S.$M)	1,012.8	1,405.2	1,272.0	1,434.9
Change (%)	-	26.7	25.6	12.8
Hong Kong Companies				
Revenue (U.S.$M)	194.7	185.2	211.7	231.6
Change (%)	-	-8.3	8.7	9.4
Japanese Companies				
Revenue (U.S.$M)	1,683.1	2,327.0	1,933.7	2,249.6
Change (%)	-	22.7	14.9	16.3
Korean Companies				
Revenue (U.S.$M)	847.3	1,092.1	964.7	935.3
Change (%)	-	15.6	13.9	-3.0
Taiwanese Companies				
Revenue (U.S.$M)	1,123.7	1,651.5	1,572.0	1,798.8
Change (%)	-	48.3	39.9	14.4
Total Production Revenue				
Revenue (U.S.$M)	10,234.7	14,728.3	12,010.5	13,344.6
Change (%)	-	27.0	17.4	11.1

Source: Dataquest (August 1998)

Table 4 quantifies the resulting changes in semiconductor consumption by Dataquest's surveyed companies' origin of ownership. Chinese companies remain the fastest-growing segment of the semiconductor market with growth expected to sustain a 32 percent level (no change from spring estimates). Similarly, Taiwanese companies will likely consume 31 percent more semiconductors in 1998 than in 1997. Americas companies' semiconductor consumption is likely to contract by 2.8 percent in 1998 and show modest growth of about 13 percent in 1999. Japanese companies' 15 percent equipment growth may sustain a 22 percent growth in semiconductor purchases. In general, consumer products have suffered a market slowdown but have experienced less price erosion than computer products. Dataquest expects the European group's semiconductor consumption in 1998 to increase by 26 percent, compared with spring projections of 19 percent.

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Table 4
Surveyed Vendor Semiconductor Consumption Estimates, 1997 to 1999

	1997 Final	1998 Spring Plans	1998 Fall Revisions	1999 Forecast
U.S. Companies				
Revenue (U.S.$M)	385.4	439.2	374.6	422.1
Change (%)	-	19.1	-2.8	12.7
Chinese Companies				
Revenue (U.S.$M)	973.9	1,555.9	1,285.6	1,570.4
Change (%)	-	31.8	32.0	22.2
European Companies				
Revenue (U.S.$M)	168.8	230.2	212.6	233.1
Change (%)	-	18.9	25.9	9.7
Hong Kong Companies				
Revenue (U.S.$M)	64.2	109.2	62.4	74.3
Change (%)	-	1.0	-2.7	19.0
Japanese Companies				
Revenue (U.S.$M)	343.0	634.1	418.4	506.5
Change (%)	-	25.2	22.0	21.1
Korean Companies				
Revenue (U.S.$M)	169.1	223.6	199.4	188.0
Change (%)	-	11.6	17.9	-5.7
Taiwanese Companies				
Revenue (U.S.$M)	493.2	657.8	647.8	727.6
Change (%)	-	39.1	31.3	12.3
Total Production Revenue				
Revenue (U.S.$M)	2,597.6	3,850.0	3,200.8	3,721.9
Change (%)	-	27.0	23.2	16.3

Source: Dataquest (August 1998)

Dataquest Perspective

The growth reduction in electronic equipment production plans from 27 percent to 17 percent in 1998 renders a reduction in semiconductor consumption of approximately $650 million. This is a growth decline from 27 percent (spring forecast) to 23 percent (fall forecast). In spring, Dataquest had forecast the total 1998 semiconductor market to grow 19.6 percent to reach $7.8 billion—basing on a sampling analysis of manufacturers' production plans. However, a midyear slowdown in domestic shipments and exports among Dataquest's sample companies, in addition to falling semiconductor prices, will result in reduced semiconductor consumption growth from 19.6 percent to 9.7 percent, or $7.1 billion instead of $7.8 billion. Compounding the problem is continued price erosion in the second half of 1998 across various semiconductor segments, which will further lessen growth.

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The following key findings and changes in the industry were observed from analyzing data on Americas, Chinese, European, Hong Kong, Japanese, Korean, and Taiwanese companies:

- Manufacturers' outlook has worsened substantially since spring, and Dataquest expects the declining trend to continue, thereby bringing the semiconductor market's growth rate to a single digit in 1998.
- The data processing segment remains healthy, albeit not as robust as in 1997.
- Consumer segments, especially video, have softened substantially, with more contractions expected in 1999.
- Communications markets have showed little variance between 1997 and 1998; these markets appear to be least affected by macroeconomic factors.
- Americas and Korean companies have scaled back expansion plans substantially, while Chinese and Taiwanese are sustaining high-growth projects despite the Asian economic slowdown.

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Perspective

Semiconductors China

Market Analysis

China/Hong Kong Market Share Survey Results: A Time of Dazzling Gains and Dismal Losses

Abstract: *Dataquest has released the final semiconductor shipment and market share estimates for China/Hong Kong. This Perspective summarizes Dataquest's survey results, as well as data tables with revenue, growth rates, and ranking for the top 10 suppliers in 1997 in memory, microcomponent, logic, analog, discrete, optoelectronic, and bipolar digital devices. Dataquest's Semiconductors China clients should refer to the complete Market Statistics database for further company or product information.*
By Daniel Heyler

Introduction

Dataquest provides market share statistics to clients twice a year. Worldwide companies' shipments to Asia/Pacific are released in April, and the China/Hong Kong (referred to in this Perspective as "China") statistics for the top 32 Asia/Pacific suppliers are published in July.

Company estimates are generated from a worldwide effort by Dataquest analysts located in Asia/Pacific, Europe, Japan, and North America. After finalizing each corporation's Asia/Pacific shipments, the Dataquest market share team conducts primary and secondary research to estimate country-level shipments for the largest vendors. Direct surveys of the top 32 semiconductor vendors are conducted with both the country or regional manager or the responsible representative based in the headquarters of the companies surveyed. Therefore, every company has an opportunity to review, revise, or comment on Dataquest's estimates. In rare cases, both headquarters and country/regional offices are surveyed to improve accuracy. Companies with large captive semiconductor markets are certainly surveyed at headquarters to ensure that all revenue is counted.

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Dataquest's reporting of company shipments combines the revenue from China and Hong Kong into one China number because most vendors report internally as such. Whether a multinational company transfers semiconductors to subsidiaries in China or ships semiconductors directly to distributors or end users, Dataquest counts all revenue as "shipments" to China. Dataquest's definition for the China survey is consistent with worldwide market share definitions and methodology.

Dataquest's market share data provides a useful measurement for companies to benchmark their performance against their competitors. However, market share alone is not the only important benchmark of success because cash flow and profits enable a company to reinvest in its future technologies and markets. In a market downturn, maintaining market share for many companies can become religion, which usually hurts more than helps a company's competitiveness.

Market Overview: Nonmemory Recovery Results in Revenue Growth

As expected, the China overall market recovered in 1997. As shown in Table 1, the range of product growth among major product segments was dramatic. At the negative extreme, shipments of MOS memories declined 16 percent. At the positive-growth end, the MOS logic market expanded 38 percent, as well as microcomponents, which expanded by 36 percent. A healthy growth in commodity analog and discrete parts further contributed to the market rebound. The overall result was a 19.5 percent growth in total semiconductor consumption, compared with a meager 0.8 percent in 1996. As analyzed in latter sections, the dynamic and fragmented nature of China's market has resulted in wide disparity in company performances, even within the market's growth segments.

Performance variance within a declining memory market was even more severe. Japanese companies' memory shipments to China, for instance, declined by 54 percent, while U.S. companies increased 7.7 percent. The DRAM market went from bad to worse as the worldwide oversupply flooded even China's elaborate distribution channels. Even the emerging flash memories increased by only 6 percent to $92 million (in U.S. dollars).

Nevertheless, China's diverse semiconductor market was able buffer the memory slump in its third year of contraction. In addition to microcomponents and MOS logic, analog and discrete enjoyed strong growth and price stability. MOS logic had contracted 9 percent in 1996, and analog and discrete grew less than 10 percent. However, both bounced back in 1997: Analog and discrete grew 29 percent and 22 percent, respectively. Microcomponents remain the pillar of growth in China. Even with microprocessor (MPU) revenue slowing to 31.2 percent from a 50 percent growth in 1996, the overall microcomponent segment was still able to expand by 36 percent from 17 percent in 1996, because of strong microperipheral (MPR), microcontroller (MCU), and digital signal processor (DSP) demand.

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Table 1
China/Hong Kong's Semiconductor Market, 1996 and 1997 (Millions of U.S. Dollars)

	1996	1997	Growth (%) 1996	Growth (%) 1997
Total Semiconductor	**5,664**	**6,769**	**0.8**	**19.5**
Total IC	4,790	5,705	-0.7	19.1
Bipolar Digital	58	42	-32.6	-26.5
MOS Digital	3,629	4,243	-1.6	16.9
MOS Memory	1,357	1,142	-14.6	-15.8
DRAM	968	800	-16.7	-17.3
SRAM	103	87	-27.9	-15.0
Nonvolatile	263	239	7.1	-9.0
EPROM	44	45	10.0	2.0
EEPROM	65	55	120.3	-15.0
Flash	86	92	200.7	6.6
Mask ROM	68	48	-53.9	-30.0
Other Memory	24	15	-40.0	-35.5
MOS Microcomponent	1,622	2,206	17.3	36.0
Microprocessor	671	881	49.5	31.2
Microcontroller	532	680	-15.1	27.7
Microperipheral	343	480	19.1	40.0
Digital Signal Processor	75	165	294.7	120.0
MOS Logic	650	895	-9.3	37.8
ASIC	277	253	5.1	-8.6
Custom IC	31	78	24.0	150.0
Standard Logic	97	197	-54.7	103.1
Other Standard Logic	245	368	14.5	50.1
Analog (Monolithic + Hybrid)	1,104	1,419	4.9	28.6
Total Discrete	704	859	9.6	22.1
Total Optoelectronic	170	205	12.2	20.2

Source: Dataquest (June 1998)

Top 30 Total Semiconductor Suppliers: Newcomers Take Share

Dataquest's company-level market share statistics and demand analysis conclude that the total semiconductor market reached $6.8 billion in 1997. Excluding Rohm Company Ltd. and SANYO Semiconductor Corporation, the other eight suppliers in China's top 10 list also made the top 10 list in Asia/Pacific. China's top 10 suppliers lost share from 59 percent in 1996 to 57 percent in 1997. Similarly, as shown in Table 2, the top 32 companies in Asia/Pacific controlled 87 percent of the China semiconductor market in 1997, compared to 89 percent in 1996.

In Asia/Pacific, however, the top 32 companies gained market share, from 83 percent in 1996 to 83.2 percent in 1997. In China, established vendors had greater difficulty maintaining market share than other markets in the region.

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The top 32 companies expanded by 16.4 percent, while the overall semiconductor market grew a few percentage points faster (19.5 percent). In previous years, these companies were controlling more and more of the market, but the following two factors explain this reversal in trend:

- Major DRAM suppliers (all within the top 32) lost significant overall market share because of revenue erosion.
- Other microcomponents and MOS logic vendors entered the Chinese market either to develop entirely new segments such as in video compact disks (VCDs), or to seek new demand for mature products such as microcontrollers (in the case of Samsung Semiconductor Inc.) or microprocessors (in the case of Advanced Micro Devices Inc.).

Table 2 lists the top 30 semiconductor suppliers in China/Hong Kong.

Another factor in the memory market was the increased market share of new players in China's varied emerging markets and plethora of channel opportunities. For example, several Taiwanese memory suppliers, facing excess capacity at home, increased their efforts in China's various PC sectors. Price-sensitive white-box PC markets throughout China have become well stocked in Taiwan-made memories, including DRAMs. White-box PCs represent about one-fourth of PCs manufactured in China. As explained in later sections, the DRAM market was particularly difficult for the market leaders, which saw market share and margins dissolve, even in China's booming PC market. As a result, the top 17 DRAM suppliers' revenue declined 23 percent, while the overall market declined 17 percent. Taiwan's Vanguard International Semiconductor Corp. had almost no sales in 1996 in China, but then was able to achieve a ranking of No. 27 with $50 million sales in 1997. For Japanese companies, DRAM revenue declined 54 percent, led by a 70 percent decline by Toshiba Corporation and Hitachi Ltd., both of which seemed to have exited the market.

Another important market trend was the entry of new players in China's various sectors. The market saw efforts from various vendors to seek growth opportunities in China. Some companies have ignored China, waiting for the "right time," but chose the 1997 downturn to seek necessary growth opportunities in China's robust electronics industry. Others have introduced new products into totally new segments and done extremely well. An example of new players with an old product are AMD and National Semiconductor Corporation (formerly Cyrix Corporation). AMD doubled its sales revenue and moved to No. 16 from No. 22. National Semiconductor grew from less than $1 million to $15 million in processor sales. S3 Incorporated was a new company creating an entirely new market. S3 was not a player prior to 1997, but appeared out of nowhere to penetrate the core logic chipset market for VCD players. The company ranked No. 2 in 1997 in microperipheral sales and immediately moved to rank No. 26 in overall sales.

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Table 2
Top 30 Worldwide Semiconductor Vendor Revenue from Shipments of Total Semiconductors to China/Hong Kong in 1997 (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percent Change (%) 1996 to 1997	1997 Market Share (%)
1	1	Intel	558	684	22.6	10.1
2	2	Toshiba	504	637	26.4	9.4
3	3	Motorola	374	414	10.7	6.1
4	7	Samsung	302	405	34.1	6.0
5	5	Philips	320	359	12.2	5.3
6	4	NEC	363	353	-2.8	5.2
7	9	Texas Instruments	202	281	39.1	4.2
8	6	LG Semicon	306	280	-8.5	4.1
9	8	SANYO	224	268	19.6	4.0
10	13	Rohm	161	230	42.9	3.4
11	10	Hyundai	193	179	-7.3	2.6
12	11	SGS-Thomson	178	176	-1.1	2.6
13	12	Hitachi	164	166	1.2	2.5
14	15	National Semiconductor	131	146	11.5	2.2
15	23	Lucent Technologies	59	135	128.8	2.0
16	22	Advanced Micro Devices	61	121	98.4	1.8
17	20	Siemens	88	116	31.8	1.7
18	17	Mitsubishi	96	107	11.5	1.6
19	18	Sony	93	102	9.7	1.5
20	21	Matsushita	84	92	9.5	1.4
21	25	Atmel	52	92	76.9	1.4
22	19	United Microelectronics	90	90	0	1.3
23	27	Korean Electronic Co.	43	75	74.4	1.1
24	16	Sharp	120	69	-42.5	1.0
25	14	Fujitsu	134	68	-49.3	1.0
26	116	S3	0	59	NA	0.9
27	253	Vanguard	0	50	NA	0.7
28	24	IBM	57	39	-31.6	0.6
29	26	Sanken	46	34	-26.1	0.5
30	28	Winbond Electronics	26	32	23.1	0.5
		All Others	20	18	-10.0	0.3
		Top 32 Total	5,049	5,877	16.4	86.8
		Total Market	**5,664**	**6,769**	19.5	-

NA = Not available
* Includes only the top 32 companies by shipment into Asia/Pacific.
Total does not equal total Asia/Pacific Market.
Source: Dataquest (June 1998)

Intel—Narrowed Focus, Increased Competition

Despite increased competition and loss of market share, Intel Corporation remained the largest semiconductor supplier to China in 1997. Demand for non-Intel microprocessors increased because of AMD's aggressive marketing and pricing efforts. Intel's revenue growth dropped sharply to 22.6 percent in 1997, compared to 48.8 percent in 1996. Intel's share of Asia/Pacific sales to China remained at approximately 17 percent. Intel has adopted a mass-marketing strategy with large advertising campaigns; these tactics are hard for any company other than Intel to match. However, the fragmented nature of the market enables a company such as AMD to gain market share through tactical wins in the marketplace. AMD doubled its revenue in China to $121 million, moving up six ranks to No. 16.

Toshiba—Broad Focus, Increased Penetration

Although Toshiba exited the DRAM market, it experienced strong growth by broadened penetration into communications, monitors, and, even home appliances. Exiting the DRAM market represented a critical strategic decision, which quickly paid off for Toshiba. Its overall growth of 26.4 percent exceeds Intel's 22.6 percent growth, and if the company has another good year, it could regain its No. 1 ranking after losing it in 1996. Toshiba was able to diversify end-market application markets. For example, its expansion in cordless phone (CT0 and 900-MHz) markets boosted the bottom line. Toshiba's flexibility further paid off as it was able to provide design support and kit solutions (MCUs and combo chips) to Chinese manufacturers. This had been a key to success in China's television markets in the 1980s, and the company applied this concept to the communications market.

Motorola—Medium Focus, Declining Penetration

Toshiba was able to exit losing markets and expand market penetration from its mainstream products. In contrast, Motorola Incorporated's growth slowed, while its own product market accelerated. There was no changing its product focus or broadened end markets, hence its sales penetration declined. In 1997, while all of the major markets that Motorola participated in recovered, Motorola's shipments expanded at half of these markets' 1996 growth rates.

Motorola's semiconductor shipments, including transfer shipments, grew 10.7 percent in 1997, about half of the overall market rate. In addition to missing merchant market opportunities, Motorola's semiconductor division has been unable to capitalize on its strong communications equipment sales since the pager market slumped in 1996. In short, the company lost market share in almost every major sector in which it competes. Its 1997 worldwide restructuring process evidently impeded the company's ability to compete. The lost business and opportunity costs will take years to recover, if at all. China was once the cornerstone of Motorola's Asian strategy, occupying about 26 percent of Asia/Pacific semiconductor sales. This share was on a declining slope, with only 24 percent share in 1997. When considering the fact that China increased its share of regional consumption from 19 percent to 21 percent in 1997, this decline in relative revenue was actually 5 percentage points.

Samsung—Broadened Focus, Increasing Penetration

In the worst memory downturn of China's semiconductor history, Samsung still emerged from the dust with a 34 percent revenue growth and improved market share ranking from No. 7 to No. 4. China was at the center of Samsung's Asia/Pacific sales growth. Samsung's regional sales expanded only 5 percent in 1997, while its sales to China expanded seven-times faster. Samsung's decision to diversify into MCUs seemed risky given the market decline in 1996. However, the company was able to expand its regional sales from $78 million to $205 million attributed largely to its success in China, which accounted for more than one-third of microcontroller sales in the region. Samsung moved from No. 12 to No. 1, replacing Motorola as the No. 1 MCU supplier in China, expanding sales from $16 million to $76 million, an impressive 375 percent growth rate. In addition to product diversification, Samsung was able to maintain or increase its market position in other key markets in which it participates, such as analog, discrete, and memories. MOS logic was the only area in which the company lost market share.

Table 3 ranks the top 30 worldwide vendors of integrated circuits in China/Hong Kong (total semiconductors minus discrete and optoelectronic devices).

Memories: Oversupply Led to Overcrowded Channels

Table 4 lists the top 10 MOS memory vendors in China during 1997. In no other segment do company performances vary as widely among the top 10 suppliers. The market leader Atmel Corporation moved from No. 11 to No. 5 on a 76 percent sales growth. At the other extreme, Hitachi's sales dropped 67 percent. Toshiba was not much better with a 61 percent revenue decline. NEC Corporation also faced a 35 percent revenue decline.

Taiwanese vendor Vanguard was able to increase DRAM revenue to $50 million after negligible sales in 1996. China proved to be a prime market for cheap 16Mb DRAMs, as well as a place to dump outdated 4Mb parts. Prices for most memory parts in China's major computer markets reached price points comparable with Taipei. Pressure from the U.S. International Trade Commission (ITC) on Taiwan's memory industry resulted in manufacturers and traders focusing more on China to shed excess inventories. Consequently, the DRAM market declined 17 percent and SRAMs slipped 15 percent. The capacity and marketing might of Samsung were too much for most SRAM vendors to match. Samsung was able to double its revenue in a declining market. Sony Corporation and Sharp Electronics Corporation were the only two other companies able to grow revenue, and they only did so by $2 million, while Samsung dramatically extended its SRAM market share to 23.8 percent.

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Table 3
Top 30 Worldwide Vendor Revenue from Shipments of Integrated Circuits to China/Hong Kong in 1997 (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percent Change (%) 1996 to 1997	Market Share (%) 1997
1	1	Intel	558	684	22.6	12.0
2	2	Toshiba	392	487	24.2	8.5
3	6	Samsung	246	334	35.8	5.9
4	5	Motorola	288	320	11.1	5.6
5	4	NEC	304	287	-5.6	5.0
6	8	Texas Instruments	202	281	39.1	4.9
7	3	LG Semicon	306	280	-8.5	4.9
8	7	Philips	235	273	16.2	4.8
9	10	SANYO	181	208	14.9	3.6
10	9	Hyundai	193	179	-7.3	3.1
11	14	National Semiconductor	117	139	18.8	2.4
12	21	Advanced Micro Devices	61	121	98.4	2.1
13	11	SGS-Thomson	129	120	-7.0	2.1
14	23	Lucent Technologies	56	115	105.4	2.0
15	12	Hitachi	129	112	-13.2	2.0
16	18	Rohm	74	99	33.8	1.7
17	19	Sony	74	96	29.7	1.7
18	25	Atmel	52	92	76.9	1.6
19	16	United Microelectronics	90	90	0	1.6
20	20	Siemens	65	84	29.2	1.5
		All Others	6	9	50.0	0.2
		Total Market	**4,790**	**5,705**	**19.1**	**100.0**

Note: Includes only the top 32 companies by shipment into Asia/Pacific.
Total does not equal total Asia/Pacific Market.
Source: Dataquest (June 1998)

Microcomponents: Non-Intel Players Take 14 Percent MPU Share, While MCUs, MPRs, and DSPs Accelerate

Table 5 lists the top 10 microcomponent vendors in China in 1997. Intel dominates this sector, but if one deducts Intel's $599 million in MPU sales, then only $67 million remains, which is split equally between microcontrollers and microperipherals. Intel's 22.9 percent growth is attributed to a 25.6 percent growth in microprocessors rather than to MCUs and MPRs, which were relatively flat products.

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Table 4
Top 10 Worldwide Semiconductor Vendor Revenue from Shipments of Memories to China/Hong Kong in 1997 (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percent (%) Change 1996 to 1997	Market Share (%) 1997
1	1	LG Semicon	231	182	-21.2	15.9
2	2	Hyundai	192	176	-8.3	15.4
3	3	NEC	160	103	-35.6	9.0
4	6	Samsung	81	83	2.5	7.3
5	11	Atmel	37	65	75.7	5.7
6	8	Siemens	56	57	1.8	5.0
7	9	Texas Instruments	49	50	2.0	4.4
8	29	Vanguard	0	50	NA	4.4
9	5	Toshiba	83	32	-61.4	2.8
10	7	Hitachi	57	19	-66.7	1.7
		Total Market	**1,357**	**1,142**	**-15.8**	**100.0**

NA = Not available
Source: Dataquest (June 1998)

The overall microprocessor market expanded 31.2 percent, and Intel lost market share, with non-Intel parts expanding 75 percent. Non-Intel x86 MPU vendors, including AMD, National Semiconductor, STMicroelectronics NV (formerly SGS-Thomson Microelectronics NV), and IBM, accounted for 14.1 percent of x86 MPU shipments to China in 1997. However, this 14.1 percent share has a significant impact on Intel's pricing and product strategy in China. In 1998, tightened budgets in business and home resulted in price-conscious buying behavior that has benefited the non-Intel camp. Additional challenges lie ahead for Intel, as the market move to the sub-$1,000 PC diminishes brand association, which is likely to benefit non-Intel vendors. At the same time, diminished margins make retail-level marketing all the more expensive and difficult to rationalize, but, perhaps, all the more necessary.

The microperipheral market was bolstered by VCDs, communications, and continued strength in PC production. The market accelerated from a 22.7 percent growth to a 40 percent growth in 1997. S3 moved from insignificant sales to 15 percent market share in one year, ranking No. 2 behind United Microelectronics Corporation (UMC) in 1997. UMC remained as the dominant microperipherals vendor because of its dominance in the PC motherboard segment. Only a few major PC vendors rely on Intel's core logic chipsets and their combined revenue is one-third of UMC's.

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Table 5
Top 10 Worldwide Vendor Revenue from Shipments of Microcomponents to China/Hong Kong in 1997 (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percent Change (%) 1996 to 1997	Market Share (%) 1997
1	1	Intel	542	666	22.9	30.2
2	3	Toshiba	99	136	37.4	6.2
3	2	Motorola	112	131	17.0	5.9
4	7	NEC	66	97	47.0	4.4
5	5	United Microelectronics	77	88	14.3	4.0
6	19	Samsung	16	77	381.3	3.5
7	15	Advanced Micro Devices	26	76	192.3	3.4
8	4	Philips	79	68	-13.9	3.1
9	6	Texas Instruments	67	62	-7.5	2.8
10	30	S3	0	59	NA	2.7
		Total Market	**1,622**	**2,206**	**36.0**	**100.0**

NA = Not available
Source: Dataquest (June 1998)

The MCU market also accelerated recovery with 27.7 percent growth after experiencing a decline in 1996. The primary growth areas were communications and home appliance markets. As previously discussed, Samsung made an aggressive and successful splash in this market. Because of the diversity of applications, the success stories vary. Companies in the communications sector generally outperformed those in consumer electronics. Toshiba made strong gains in the home appliance sector, but low average selling prices (ASPs) resulted in below-average market performance.

The fourth segment in microcomponents is DSPs, which doubled from $81 million to $162 million in 1997. Lucent Technologies usurped the No. 1 position from Texas Instruments Inc. by doubling its sales, while TI experience a flat growth. Philips Electronics NV's market presence was felt as its sales went from zero to $8 million in 1997, securing a top five position. Toshiba promoted its DSPs in the communications markets and expanded revenue nearly sixfold to approximately $40 million.

MOS Logic: ASICs Decline but Standard Logic Recovers

Table 6 lists the top MOS digital logic vendors in China during 1997. The overall 37.8 percent market growth from a negative 9.3 was a sharp turnaround in the MOS logic market. However, the range of vendor performance was more dramatic than most years. The main reason for these variances is the volatility in various end markets. Although ASIC consumption declined 8.6 percent in 1997, standard logic kept pace with the broad-based growth within the communications, consumer, and computer sectors in China. Lucent, NEC, Motorola, and Fujitsu Ltd. are exceptions among the top 10, which experienced positive revenue growth in ASICs. The rest, Samsung, TI, Matsushita Electric Industrial Company Ltd., IBM,

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Toshiba, and LG Semicon Co. Ltd. suffered declining sales. The MOS logic market was helped by strength in standard logic and other MOS logic, which grew 103 percent and 50 percent, respectively.

Table 6
Top 10 Worldwide Vendor Revenue from Shipments of MOS Digital Logic to China/Hong Kong in 1997 (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percent Change (%) 1996 to 1997	Market Share (%) 1997
1	2	Toshiba	69	143	107.2	16.0
2	3	Philips	64	93	45.3	10.4
3	1	Samsung	75	68	-9.3	7.6
4	6	NEC	31	67	116.1	7.5
5	5	Motorola	44	64	45.5	7.1
6	8	Lucent Technologies	28	55	96.4	6.1
7	4	SANYO	56	50	-10.7	5.6
8	17	Sony	12	43	258.3	4.8
9	7	Rohm	30	39	30.0	4.4
10	11	Texas Instruments	20	32	60.0	3.6
		Total Market	**650**	**895**	**37.8**	**100.0**

Source: Dataquest (June 1998)

Analog Market: Major Vendors Gain Share

Table 7 lists the top 10 worldwide analog vendors in China in 1997. The total analog market in China expanded 28.6 percent in 1997 because of the surprisingly strong growth in China's communications markets. The large, dispersed monolithic-analog IC market represents a formidable 21 percent of China's total semiconductor consumption. The 32 companies surveyed increased sales by 32.7 percent, and therefore, gained market share. TI jumped from No. 8 to No. 2 because of its 149 percent revenue growth. Market leader Toshiba held first place with above-average growth of 31.6 percent. The consumer analog market also performed well in 1997 and vendors—such as SANYO and Rohm—expanded their market share.

Discrete Market: A Bright Spot for Japanese Companies

The discrete market represents 12.7 percent of total semiconductor consumption in China but continues to undergo steady growth year after year. In 1997, the market expanded 22.1 percent. The surveyed companies increased shipments to China by 25.8 percent and gained market share over less-competitive domestic manufacturers. This segment's consumer applications track relatively closely with discrete, as seen with the vendor shipment performance. Toshiba, SANYO, Rohm, and Philips are able to leverage their consumer market presence to ship analog and discrete products to the same customers. Among the top 10 discrete suppliers to China, only NEC, Korean Electronic Company, and Hitachi were not among the top 10 analog suppliers. Table 8 lists the top 10 monolithic analog vendors in China/Hong Kong in 1997.

Table 7
Top 10 Worldwide Vendor Revenue from Shipments of Total Analog to China/Hong Kong in 1997 (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percent Change (%) 1996 to 1997	Market Share (%) 1997
1	1	Toshiba	133	175	31.6	12.3
2	8	Texas Instruments	51	127	149.0	8.9
3	3	SANYO	91	117	28.6	8.2
4	2	Motorola	94	110	17.0	7.8
5	4	Philips	91	110	20.9	7.8
6	5	Samsung	74	106	43.2	7.5
7	7	National Semiconductor	67	86	28.4	6.1
8	6	SGS-Thomson	71	78	9.9	5.5
9	11	Rohm	33	54	63.6	3.8
10	10	Sony	44	38	-13.6	2.7
		Total Market	**1,104**	**1,419**	**28.6**	**100.0**

Source: Dataquest (June 1998)

Dataquest Perspective

What factors led to vendors' dazzling gains or dismal losses in China? It is clear that it is not enough to market the right products for a growing market. A company with a unique product can reap a windfall, such as S3 in 1997's VCD boom. But such successes are short-lived—unless there is an exceptional operational strategy in place—because competitors can quickly replicate or leapfrog lucrative technology. The best example of competition eroding once-monopolized markets is China's PC industry. PC production in unit terms expanded 83 percent in 1997, but Intel's revenue grew only 25 percent with a market share loss. Similarly, the DRAM market shrank 16 percent, and almost all suppliers suffered revenue declines.

On the other end of the spectrum, there are companies without technology focus or product innovations, which are still able to gain market share because of their more effective and efficient operations. Toshiba and Samsung, without any revolutionary products, were able to gain market share effectively in very competitive, mature markets. Samsung was able to grow 34 percent and entered the commodity microcontroller business with a huge success. Toshiba provided better service and support to manufacturers in China, which resulted in revenue gains for the same products.

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Table 8
Top 10 Worldwide Vendor Revenue from Shipments of Monolithic Analog to China/Hong Kong in 1997 (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percent Change (%) 1996 to 1997	Market Share (%) 1997
1	1	Toshiba	95	131	37.9	15.3
2	3	Motorola	81	89	9.9	10.4
3	2	Philips	85	86	1.2	10.0
4	4	Samsung	56	71	26.8	8.3
5	7	Rohm	43	71	65.1	8.3
6	6	SGS-Thomson	49	56	14.3	6.5
7	5	NEC	52	52	0	6.1
8	9	SANYO	35	52	48.6	6.1
9	8	Korean Electronic Co.	36	50	38.9	5.8
10	10	Hitachi	28	48	71.4	5.6
		Total Market	**704**	**859**	**22.1**	**100.0**

Source: Dataquest (June 1998)

In the technology-driven semiconductor market where fixed costs dwarf variable operational costs, it is too easy for companies to lose sight of their after-manufacturing processes, which must be examined continually in light of the (ever-changing) strategic position of the company. The strategic position starts with understanding why a customer buys a product and then focuses people and processes in the company on meeting that need, whether technology or service driven. It sounds easy, but it is these gaps in customer awareness and in vendors' fit between their market strategy and operations where the most opportunities are lost.

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Perspective

Semiconductors China

Market Analysis

Video CD Player Craze in China

Abstract: *China is a huge market for electronic equipment. It has become the largest consumption and production base for video compact disc (VCD) players. China started its first VCD player production line in 1994, with an output of 20,000 units. Within three years, it has built up a 50 million production capacity, with an output reaching 14.7 million units in 1997. This astonishing growth has attracted a great number of local and foreign players that want to enter this market. Dataquest sees 1998 as a growing year for VCD players, with growth forecast at 26 percent over the 1997 level.*

By Kelvin Fu

Explosive Growth of Video Compact Disc (VCD) Players

FILE COPY:
MARIA VALENZUELA

Dataquest expects the video compact disc (VCD) player production in China to reach 18.5 million units in 1998, sustaining a 26 percent growth. This growth is moderate, compared with 1997's nearly 155 percent growth over 1996.

In 1996 and 1997, the VCD player market grew explosively in China with 5.8 and 14.7 million units, respectively, making it the world's No. 1 production and consumption base for such products.

VCD players were first introduced into China in 1993. China started VCD player production in 1994 when the output was only 20,000 units. In 1995, the output expanded at a factor of 10, reaching 220,000 units. Since then, the VCD has gained a wide acceptance among Chinese consumers; more suppliers have joined the production craze. Driven by the strong domestic consumption, the total VCD player output reached 5.8 million units in 1996. This dramatic increase did not end the story. In 1997, the demand was fueled by the suppliers' promotional efforts, and the output finally reached 14.7 million.

Dataquest

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Compared to 1994, the 1997 VCD player output is over 700 times greater. This astonishing VCD player growth in China has taken many foreign manufacturers by surprise. When VCDs first appeared in the market, many Japanese and multinational manufacturers regarded them as an inferior product with poor image quality, which is ultimately expected to be replaced by digital video disc (DVD) players.

However, Chinese consumers have proved to the world an exceptional case by showing overwhelming acceptance of the product. Today, the VCD is a supplementary product to color television.

To cope with the massive increase in domestic demand for VCD players, many China and Hong Kong manufacturers are planning to increase, or even double, their VCD player production capacity in the coming year.

China's Consumer Electronics Market

China is a large country with a huge population of more than 1.2 billion people. As a result of the government's successful and continuing reform since 1979, China has become a focal point of economic attention worldwide. The main attraction is the potential of its huge consumer market.

The country's preferential foreign-investment policies, low wages, and vast natural resources are transforming China from an agricultural community into an industrial society. China is turning into a world manufacturing center as it continues to enjoy an influx of foreign direct investment and technology. China has maintained a high gross domestic product with double-digit growth during the 1990s. The high economic growth brings more disposable income to its consumers. The immediate benefits can be seen in the speedy growth in the consumer electronics market, which is growing at an average of 15 percent.

In the early 1990s, the three superstars in consumer electronics were color television sets, refrigerators, and washing machines. Possessing these gadgets symbolizes affluence and modernity. As incomes rise, consumer-spending behavior reflects the change. A current survey shows that in recent years, consumer electronics superstars have changed to VCD players, PCs, camcorders, and fax machines.

Also changed is the consumer-buying behavior in urban areas. Most consumers will first think of needs when they make purchasing decisions. Then, they will consider the brand and the price, respectively, in order of importance. Their value system has changed to a "need-brand-price" model rather than the "price-need-brand" of a few years ago, according to a report from China's State Statistics Bureau. Brand awareness has been gaining more importance when consumers shop for electronic goods.

Brand Localization

Supported by strong domestic demand, local brands have gained opportunities to grow and obtain more share in the consumer electronics market, which was dominated by foreign brands in the 1980s. Now, Chinese brands dominate the domestic consumer electronics market, occupying, on average, 70 percent, while foreign brands, imported or manufactured locally, take another 30 percent share. About 86 percent of VCD players consumed domestically are produced by local manufacturers. The explanation for their popularity is their price competitiveness. An imported VCD player costs 50 percent or more than the local VCD player.

Table 1 summarizes market share by Chinese brands in some major consumer electronics products.

Table 1
Localization of Eight Major Consumer Electronics Brands in China

Product	Market Share of Chinese Brands (%)
Air Conditioner	75
Color Television	80
Audio System	46
Microwave Oven	70
Refrigerator	93
VCD Player	86
VCR	3.5
Washing Machine	82

Source: Dataquest (June 1998)

Brand concentration on a few popular brands is another characteristic in the Chinese consumer electronics market. For most consumer electronics products, the top 10 usually occupy 75 percent or more of the market share. This high brand concentration is explained by the consumers' emphasis on promotional efforts by the manufacturers and word-of-mouth recommendations from other users. The top 10 brands' market share in the eight major consumer electronics segments is shown in Table 2. In the VCD player market, eight out of the top 10 are Chinese brands. The top 10 brands occupy 87 percent of the total VCD player market in China.

Table 2
Top 10 Brands' Market Share of Eight Major Consumer Electronics Products in China

Products	Market Share of Top 10 Brands (%)
Air Conditioner	75
Color Television	80
Audio System	82
Microwave Oven	94
Refrigerator	91
VCD Player	87
VCR	98
Washing Machine	90

Source: Dataquest (June 1998)

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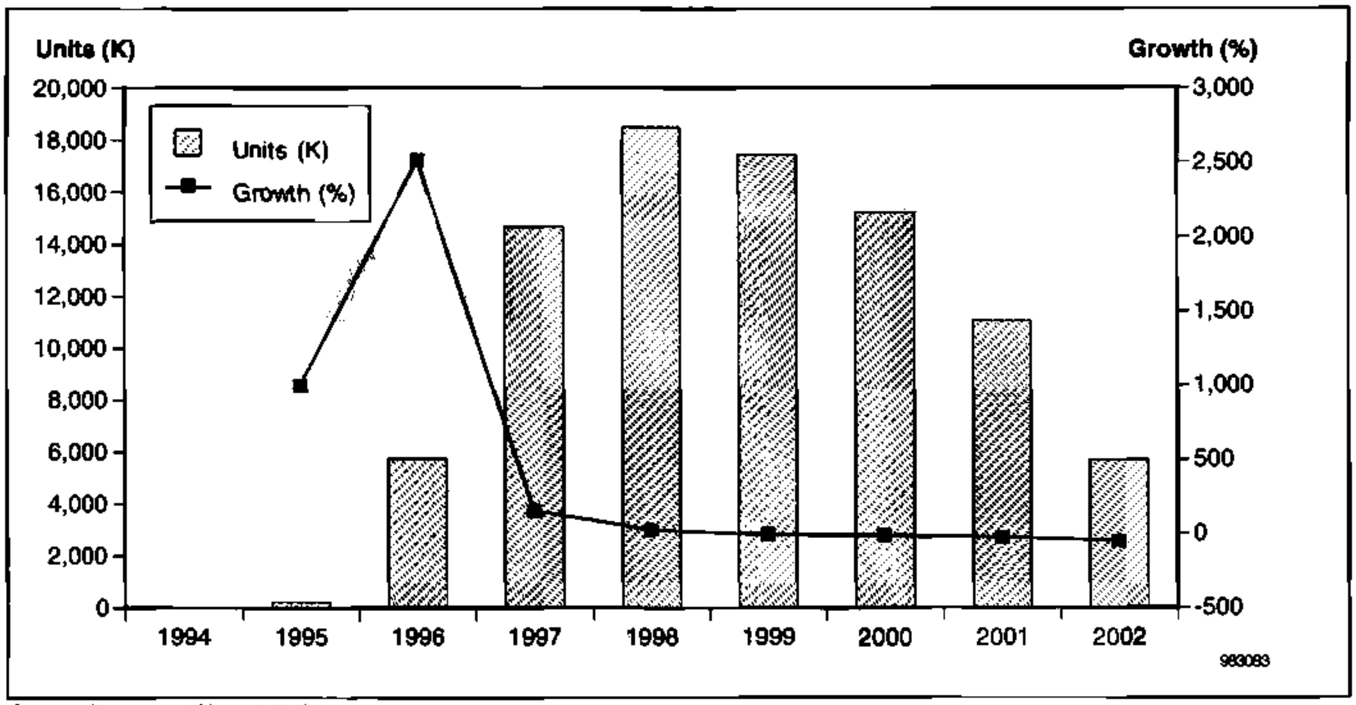
China had a substantial tax cut on 5,000 commodities effective October 1997. On average, the import tariff was reduced from 23 percent to 17 percent. The tariff cut will benefit the competitive domestic companies that are buying foreign technology, equipment, and raw materials; weak players will face tougher challenges from overseas competitions. In the VCD player market, more than 90 percent of key components—including CD mechanisms and decoding chips—are relying on imports. The import tariff reduction will benefit the local manufacturers and give them larger margins to compete with imported products.

VCD Player Production Forecast

Dataquest predicts that China's VCD player production will surge 26 percent on an annual basis to reach 18.5 million units in 1998 (see Figure 1). The growth trend will decline starting in 1999 when DVD players are expected to expand in the market and finally erode the market share of VCD players.

Figure 1
China's VCD Player Production Forecast, 1994 to 2001



Source: Dataquest (June 1998)

The top five VCD player makers are all Chinese brands; they combine to account for 53.6 percent of the total VCD player market. About one-fifth of this market is occupied by the largest market leader, Jiangsu Province's Jiangsu Shinco Electronic Group Company. The top three occupy nearly half of the overall player market. Table 3 shows the market share and the estimated production of the top five brands in the market in 1997.

Table 3
Top Five Manufacturers of VCD Players in China, 1997

Manufacturers	Brands	Market Share (%)	Estimated Production (K Units)
Jiangsu Shinco Electronic Group Co.	Shinco	21.8	3,200
Guangdong Idall Co. Ltd.	Idall	13.2	1,930
Fujian Malata Co. Ltd.	Malata	9.2	1,350
Shell Electric Manufacturing (Holdings) Co.	SMC	4.8	710
Shenzhen SAST Laserdisk System Co.	SAST	4.6	670

Source: Dataquest (June 1998)

In view of the VCD player market's explosive growth, many manufacturers want to share the piece of the pie that belongs to the leading manufacturers. The television giant, Changhong Electronic Group Co., has planned to expand its VCD player production capacity from 400,000 units to 3 million units in 1998.

Many Taiwanese makers are also eyeing China's VCD player market. The Acer Group and Sampo Corporation are both supplying VCD technology and OEM kits to their Chinese partner for assembly. Their ultimate goal, however, is to make and distribute DVD players to this market.

In the face of increased competitions in the VCD player market, the top 12 VCD manufacturers took the lead to join the nationwide warranty network to strengthen their market presence. This move was initiated by the Ministry of Electronics Industry to improve the "after-sales" services for consumers.

Demand Factors

VCD players are proliferating in the Chinese market for some simple reasons. First, the hardware is cheap and simple in technology. VCD players combine CD players with a MPEG decoder to produce acceptable video-playing capabilities. The majority of manufacturers get key components from a few suppliers: Sony Corporation of America and Philips Electronics NV for CD mechanisms, and C-Cube Microsystems Inc. and ESS Technology Inc. for decoding chips.

Second, the proliferation of private software has fueled the demand for the VCD market in China. The Intellectual-copyright concept is still weakly understood among Chinese consumers. They can easily get low-cost private software or even rent VCD movies at a cost below U.S.$1 in some cities. The third reason is the lack of an installed base of VCRs and audio CDs in China. The popularity of color TV and karaoke among the Chinese has also contributed to the strong demand of VCD players.

In terms of the substitution by DVD players, the price and software gap will lengthen the time needed for DVD players to take off in the market. Although DVD players provide consumers with high-quality pictures and sounds, better performance, and a wider range of features, Chinese consumers do not currently have the purchasing power to buy them. The higher price is not the only barrier for DVD players to enter the China

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market. Consumers are concerned about the limited availability of DVD titles that cost much more than VCD titles. Also the existing color television sets, limited by 350-line, cannot produce a high-resolution effect required by DVD players.

On the other hand, the DVD player emergence will encourage VCD player manufacturers to improve the quality of their VCD products. Because of the backward compatibility of DVD players, VCD software will still prevail unless the prices of DVD titles can match. VCD players will be able to survive in the presence of DVD players.

Future Consumption Drivers

As most consumer electronics show a slowdown in the cities, VCD players can find their way into the rural areas that are home to 72 percent of the country's 1.2 billion population. As farmers' income level and living standard rise, their consumer demand is also expected to grow. The consumer electronics market for products such as TV sets and VCD players will be brisk—especially in the central and western areas where most families still do not own these products. The key for this market segment is low price. As the VCD player prices continue at a downward trend, farmers can easily afford to buy one.

Another driving force comes from the government, which plans to adopt international standards for digital-consumer electronics that will be produced in China alone. The government is taking a leading role to build China's digital electronics.

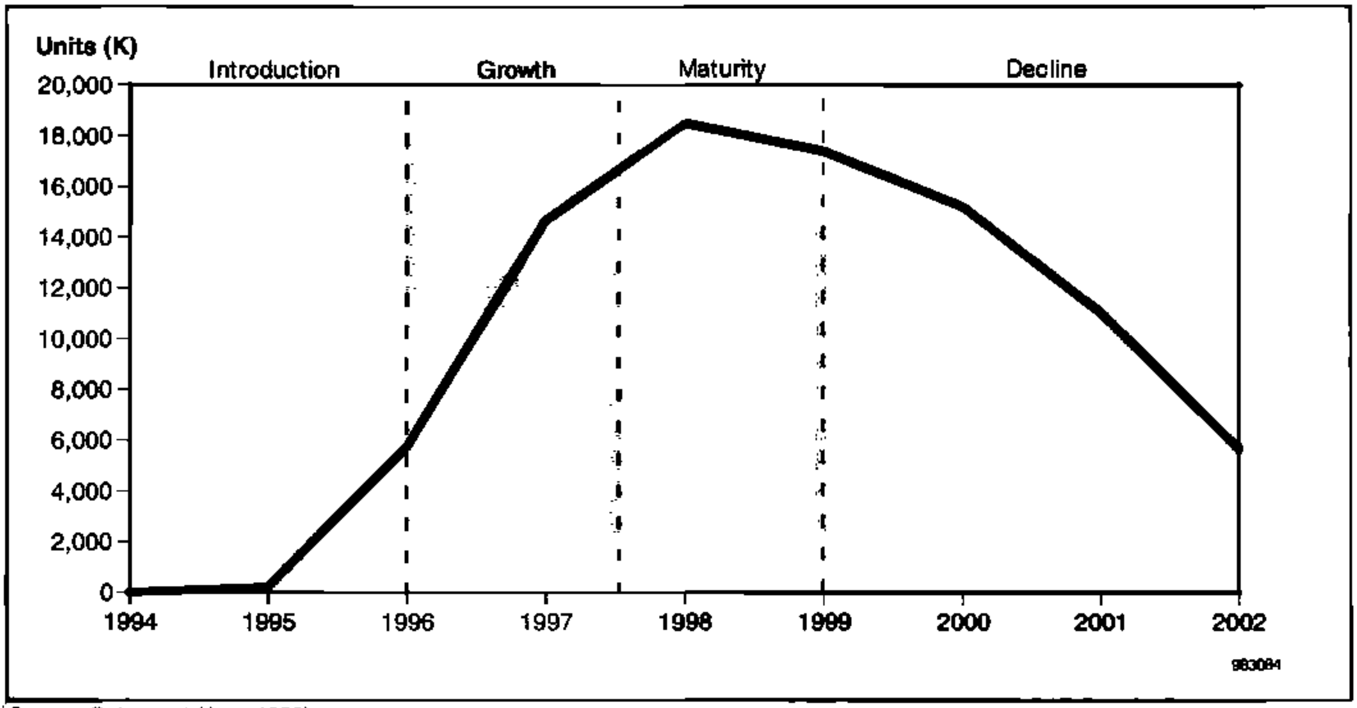
Dataquest expects VCD players in China will be able to keep their dominance in the market for another three years. Although DVD players have a higher definition and larger capacity, prices of both hardware and software are at least more than double that of VCD players, which will defer consumers' buying decisions.

Product Trend

China's VCD player market follows a typical product life cycle; it has gone through the introduction stage and high-growth stage and is now approaching the maturity stage. The declining stage will start in 1999 when DVD players begin to penetrate the market. Figure 2 depicts the four stages of the product life cycle of VCD players in China.

At the current maturity stage, manufacturers are competing on prices to achieve volume and fighting for market shares. Efforts are being put into efficiency and cost reduction. Meanwhile, market leaders like Shinco and Idall are advertising heavily to emphasize brand differentiation and special product features. Manufacturers extend the product life by means of incorporating more functions into their VCD players. Built-in karaoke functions are now a standard. Other choices are integrated VCD hi-fi systems, multidisk changers, and two-in-one TV/VCD sets. There are also many manufacturers that are concerned with improving the picture quality.

Figure 2
Product Life Cycle of VCD Players in China



Source: Dataquest (June 1998)

New Standards

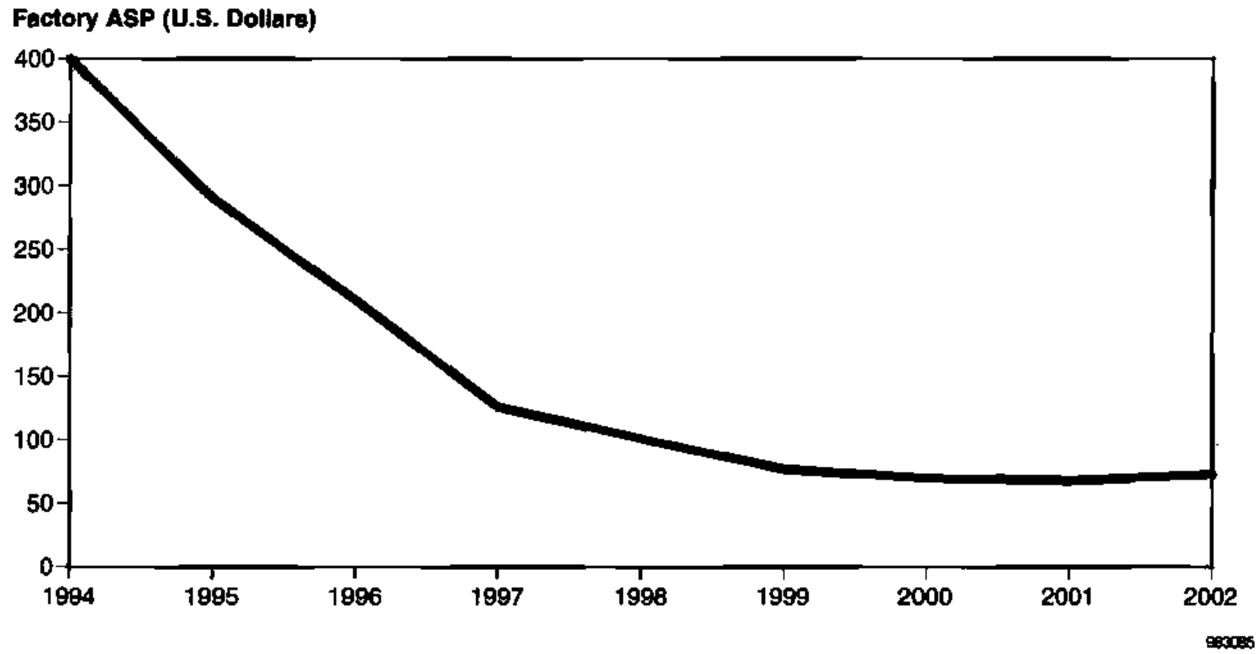
One example of extended product life in China can been seen in Yuanwei Technological Co. Ltd. under Yuanwang Group. The company recently announced a four-in-one VCD in Beijing. The four-in-one VCD player uses MPEG I 3.0. The product has built-in new functions such as enlarging pictures and digital echoing for karaoke.

Japan Victor Corporation (JVC), Panasonic Communications & Systems Company, Philips Electronics, and Sony Corporation are planning to introduce Super VCD players to the market, priced at about U.S.$200. A Super VCD player has improved picture quality by using a disk that is encoded at a higher bit rate. The images produced are near-DVD quality. The disadvantage of this is its requirement of multiple disks because images are encoded at higher bit rates that require more storage space. C-Cube will be the first to supply Super VCD technology to Chinese manufacturers to protect and expand its dominance in the VCD player market.

Price Trends

The average selling prices (ASPs) of VCD players follow an exponential decay curve. The price decline resulted from the economies of scale and increasing competition. A VCD player sold for more than U.S.$400 in 1994, U.S.$290 at the beginning of 1995, U.S.$210 at the end of 1996, and at U.S.$126 last year. Driven by the tough competition in the market, the manufacturers' cutthroat prices will continue until they finally bottom out at about the U.S.$70 level. At this price level, vendors can hardly make profits, and Dataquest expects that small-scale manufacturers will be squeezed out of the market. Figure 3 illustrates the VCD player ASP in China from 1994 to 2002.

Figure 3
Average Selling Prices of VCD Players in China, 1994 to 2002



Source: Dataquest (June 1998)

DVD Dominance in 2000

More than 50 percent of a DVD player's cost comes from the drive's optics, drive mechanism, and decoding chips. Many DVD manufacturers are looking for sources of cheaper bill of materials. As DVD players have many advantages in quality and function aspects over VCD players, Chinese consumers are willing to pay more within their range of affordability. When the DVD's downward price curve drops to about 150 percent of the VCD player prices, the DVD players may begin to take over the VCD player market, and consumers will become willing to buy DVD players that have incorporated backward compatibility for VCD. Dataquest expects the DVD takeover to occur in 2000.

Many foreign manufacturers are preparing for the arrival of the DVD boom in China because they cannot afford to again miss this potential market of millions of units a year. Matsushita Electric Industrial Company Ltd., for example, began manufacturing DVD players in China early this year at an initial production units of 500 units per month at Matsushita's Dalian plant. Local television set manufacturer Panda Electronics Group Co. has also started DVD research and development in the hope of getting a piece of the pie from the VCD player market.

Overcapacity Problems of VCD Players

The threat of China's VCD player market is not only from the substitution of DVD players, but also from its serious overcapacity problem. There are more than 400 VCD player makers in the country, with an estimated production capacity of 50 million units per year. These are far beyond the domestic demand and exports. To be scale-efficient in VCD player production, a manufacturer is estimated to have an output between 150,000 and 200,000 units per year. More than 85 percent of the share is concentrated among the top 10 suppliers, with other small players not expected to achieve scale economy. The smaller manufacturers will be forced to quit as margins continue to shrink.

From the VCD manufacturers' point of view, the expanded production line of VCD players will not be wasted because when VCD players are replaced by DVD players, their production lines can provide an immediate, cost-effective solution to assemble DVD players. Though Chinese manufacturers have great manufacturing and assembly skills, they lack technology for the research and development of DVD players. Because the core materials will still rely on imports, it will be difficult, but not impossible, for Chinese makers to become the cost leader in DVD player production.

Internal Consumption

State-owned enterprise reform by Zhu Rongji has made one-third of the state workers redundant. Official figures estimate that 16.5 million urban dwellers are unemployed or have been laid off. Another 30 million will likely join the unemployed in a few years. This number represents 13.8 percent of urban residents. Urbanites may therefore spend less on immediate needs and put aside more for the future. The government has already felt the people's worries over the future and sensed the pressure in the slowdown of internal consumption. Therefore, it is planning to spend billions on infrastructure construction and has cut the country's interest rates to vitalize the retail consumption, especially in consumer goods. The unemployment problem in China is so great that it may cause consumers to defer purchase decisions, therefore endangering the VCD manufacturers' plan for achieving their production target in 1998. The problem of overcapacity will soon surface if there is not enough internal demand.

Dataquest Perspective

This year, the competition in the China VCD player market will be in two dimensions. One is the head-to-head competition between local manufacturers for shares, and the other is the product dominance competition between VCD players and DVD players represented by local and foreign manufacturers, respectively.

Dataquest expects China's VCD player market in 1998 to be dominated by local suppliers that are mainly competing on prices. Price cutting and promotional efforts of manufacturers will drive the growth rate to 26 percent, reaching 18.5 million units; however, it will slow down and become negative in 1999 when the DVD player emerges. Foreign vendors face difficulty in

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trying to squeeze into this low-profit market, but they may turn their target to the DVD player market or enhanced-quality VCD players, which offer more growing opportunities.

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Perspective

Semiconductors China

Dataquest Predicts

China's Semiconductor Industry: Leader of the New Asian Order or the Next Victim of the Asian Financial Crisis?

Abstract: *Dataquest recently completed four country "Semiconductor Predicts" seminars held in South Korea, Taiwan, Hong Kong, and Singapore. This Perspective summarizes the content of the presentation on China/Hong Kong's economy, electronics, and semiconductor consumption outlook.*

By Daniel Heyler

Introduction: Predictions Made

The immediate impact of the Asian financial crisis (AFC) poses the following important questions for strategic planners and marketers in Asia/Pacific:

- How important is the China/Hong Kong semiconductor market?
- Will the economy hold up? What about investments and exports?
- What is the export-downside risk for electronics?
- Will the domestic market's IT spending compensate for a possible exports slowdown?
- How will domestic and foreign manufacturers respond?
- What about electronic equipment production prospects, including computers, communications, and consumer?
- What is the outlook on semiconductor consumption?
- How important is China to Asia/Pacific demand?
- Which vendors are winning in China/Hong Kong?

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How China's economic growth holds up impacts both electronic equipment export competitiveness and domestic IT spending.

Dataquest discusses which areas of electronic equipment production potentially benefit and lose from the Asian financial crisis, both in exports and local shipments. Dataquest then assesses and quantifies short- and long-term semiconductor demand and lists vendors' performance. Dataquest also assesses the prospects of China's semiconductor industry.

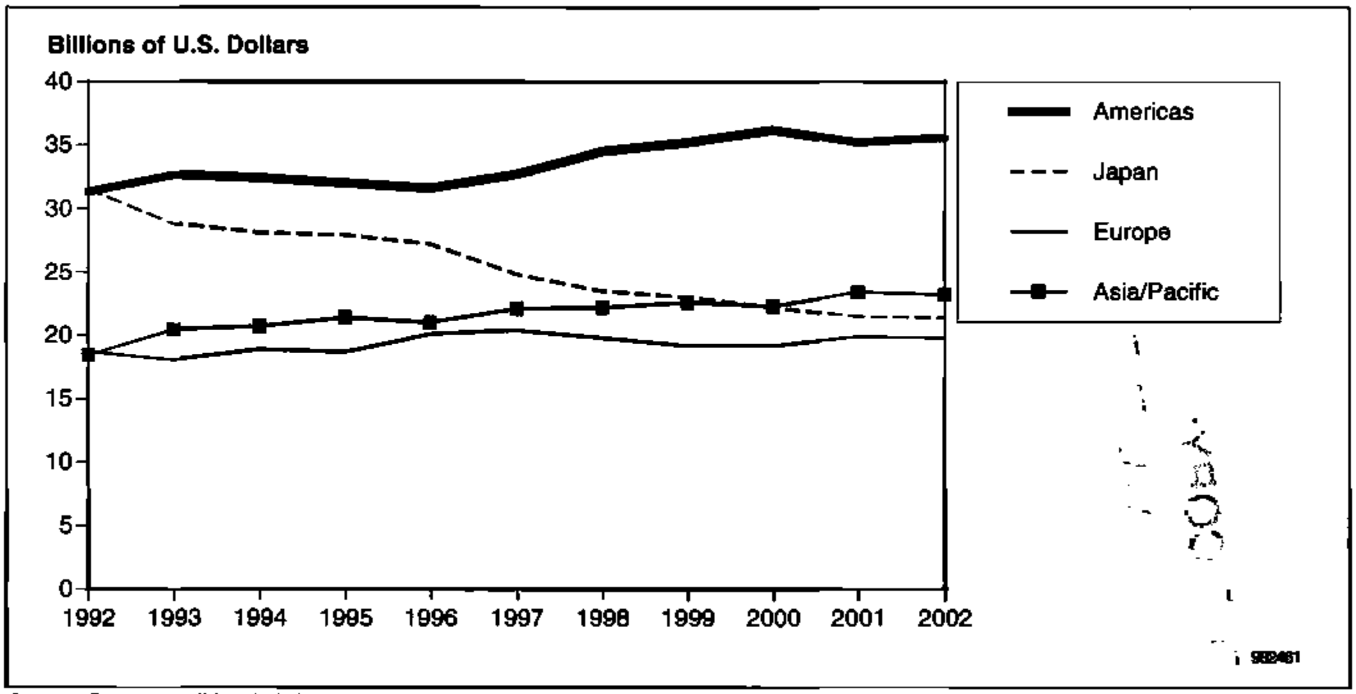
The Importance of China/Hong Kong to Asia/Pacific

First of all, why even talk about China/Hong Kong? How important is the China/Hong Kong semiconductor market in a regional and global context?

The Asia/Pacific region surpassed Europe in 1992 to become the third-largest semiconductor market. Europe has maintained an average share of about 20 percent. Japan has continued to lose share, since its consumer electronic boom during the 1980s. The Americas and Asia/Pacific have benefited from the 1990s PC industry boom and have been gaining share.

Asia/Pacific will increase share from about 21 percent to 23 percent within four years and is forecast to surpass Japan to become the second-largest consuming region in the world. China is playing a key part in this growth. Figure 1 illustrates semiconductor consumption by region from 1992 to 2002.

Figure 1
Semiconductor Consumption by Region, 1992 to 2002



Source: Dataquest (May 1998)

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In revenue terms, China/Hong Kong is now the largest and fastest-growing semiconductor market within Asia/Pacific, accounting for 20 percent of consumption in 1997. China/Hong Kong is the growth engine, approaching 5 percent of worldwide semiconductor consumption in 1998.

Where is China/Hong Kong in terms of electronic equipment production? China/Hong Kong is the largest electronics producer on the whole because of the large consumer electronics volumes and, more recently, computer, peripherals and communications equipment. So, from both a semiconductor consumer and electronic equipment manufacturing standpoint, China/Hong Kong is important now.

But will this trend continue in light of the new competitive dynamics? This question is the subject of this Perspective.

A Recent Look at the Currency, GDP, Trade, and Investment

Before discussing the economy and electronic equipment production, it is useful to look at the electronic production interrelationship with semiconductor demand.

At a worldwide level, electronic production has grown three times faster than the GDP, and semiconductor shipments have increased three times faster than electronics shipments.

In immature markets such as China, there will be a delayed effect. As electronic technologies and design improve in China, the electronic equipment manufactured in China will increasingly become richer in semiconductor content, thus further bolstering demand for semiconductors. It is this increase in semiconductor content that will enable the Chinese market to accelerate, even though the GDP may decelerate.

China's Currency and Stock Markets Remain Stable while Most of Asia/Pacific Crashes

The currency devaluation created critical problems for Asia/Pacific semiconductor suppliers and users that are almost entirely dependent on imports. Indonesia's currency devalued more than 70 percent during the past six months, and its stock market dropped more than 80 percent. As a result of the financial turmoil, stock markets in Korea, Thailand, the Philippines, and Malaysia have declined by approximately 60 percent. China and Hong Kong have remained unaffected, but Hong Kong's economy is suffering. China's stock market share value increased by an average 28 percent in 1997.

In theory, one would expect exports from Southeast Asia to become more competitive, assuming component costs (mostly imported) and financing costs do not outstrip these gains. However, this has yet to be the case because of the difficulties many companies are having in financing their operations and investing.

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GDP Forecast

Dataquest's latest economic data in March 1998 averages data from more than 10 major banks. Recently released April data from the Organization of Economic Cooperation and Development (OECD) corresponds rather closely with Dataquest's numbers. Most economists agree that China's stable currency and domestic reform will enable it to sustain between 7.5 percent to 8.0 percent GDP growth in 1998. China is expected to improve performance to more than 8 percent in 1999. Japan is the wild card, which would stimulate growth in Asia/Pacific economic recovery. On top of growth, China's population creates tremendous market pull, especially in electronics, as discussed later. Not only is China's GDP about three times the rest of Asia/Pacific, its population accounts for nearly one-half of Asia/Pacific. An important factor in China's GDP growth is that the economy is diversified with expansion taking place in industries, manufacturing, services, and agriculture. This broad-based growth will enable the economy to weather exterior financial crises or industry cycles.

Hong Kong has an absolutely pivotal role in capital, expertise, and information flow to foster China's consecutive GDP growth. This role is enhanced, not hindered, by the handover from the United Kingdom. The combination of China's and Hong Kong's GDP was approximately U.S.$1 billion in 1997. The combination of Hong Kong's services economy (83 percent of GDP) and China's industries (50 percent of GDP) represents an overall economy that is not dependent on one sector and, therefore, is less vulnerable to specific industry cycles than most other Asian countries. Another important driver of China's economy, investments, and information technology (IT) is the continuous geographic expansion from the coastal to the land-locked provinces.

Foreign Investment Trends in China

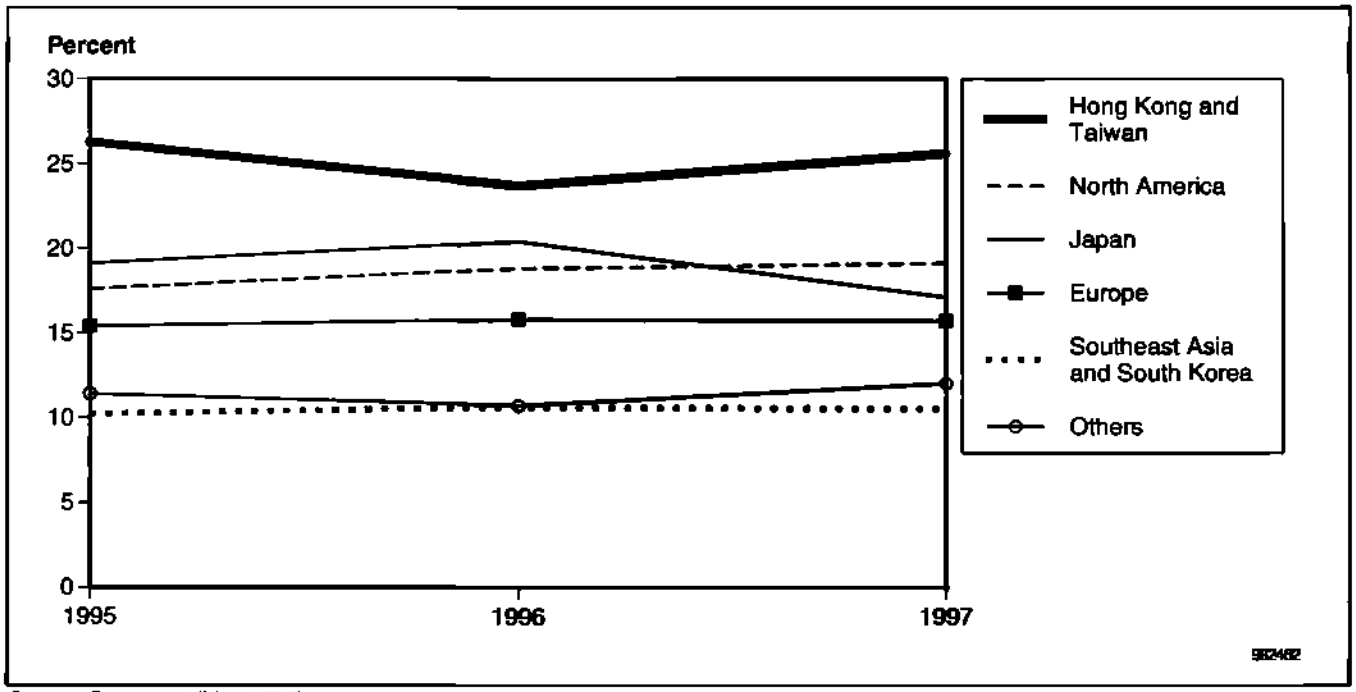
Hong Kong accounted for 59 percent of foreign-invested capital in China from 1980 to 1997. In the past few years, there has been a decline of contracted investments in China from $88 billion in 1994 to $72 billion in 1997. However, the actual utilized investment increased from $33 billion to $44 billion during this period. There is uncertainty in 1998, and most forecasts indicate a decline in utilized investments to $37 billion for the first time in at least five years. Dataquest also expects contracted investments to decrease because of the investor uncertainty that is the short-term outcome of China's aggressive reforms to be undertaken in 1998. However, once the dust settles, investment flow is expected to resume in 1999. In the first quarter of 1998 figures show growth of more than 10 percent over 1997, an indication that the Asian financial crisis has not dramatically affected China.

The Importance of Foreign Trade

China's GDP will exceed $900 billion in 1998, of which total trade is nearly $400 billion. China's export machine has proved to be formidable. The economy's trade surplus was expected to increase beyond $50 billion in 1998 prior to the financial crisis, but as the result of the financial crisis, it is expected to decrease. The first two months of 1998 show exports to the United States to be at the same levels as 1997, while imports are slightly down. In short, there is no dramatic downturn expected in China because of a slowdown in Asia/Pacific economies.

As illustrated in Figure 2, China is exposed to the Asian financial crisis by about 11 percent because 11 percent of its exports go to Southeast Asia and Korea. Exports to Japan have been declining since 1995, but exports to Europe, North America, and Taiwan have been increasing and represent the lion's share of exports. More than 60 percent of China's exports head for Europe, North America, and Taiwan, and 15 percent go to Japan.

Figure 2
China's Worldwide Exports by Region, 1995 to 1997



Source: Dataquest (May 1998)

Electronic Equipment Exports

Out of China's $190 billion in exports, 12 percent was related to electronics, and the sector is increasing in total share. The following three important factors help buffer China's electronics exports from the AFC:

- Components are about half of finished equipment, but they are rising the fastest.
- The United States has become the major importer of China-made electronics, accounting for about 40 percent of China's component and equipment exports.
- Overall export growth is helped by U.S. demand, which is not only the largest but the fastest growing.

However, we believe that consumer electronic exports will be negatively impacted by the AFC pinch, more so than computers and communications

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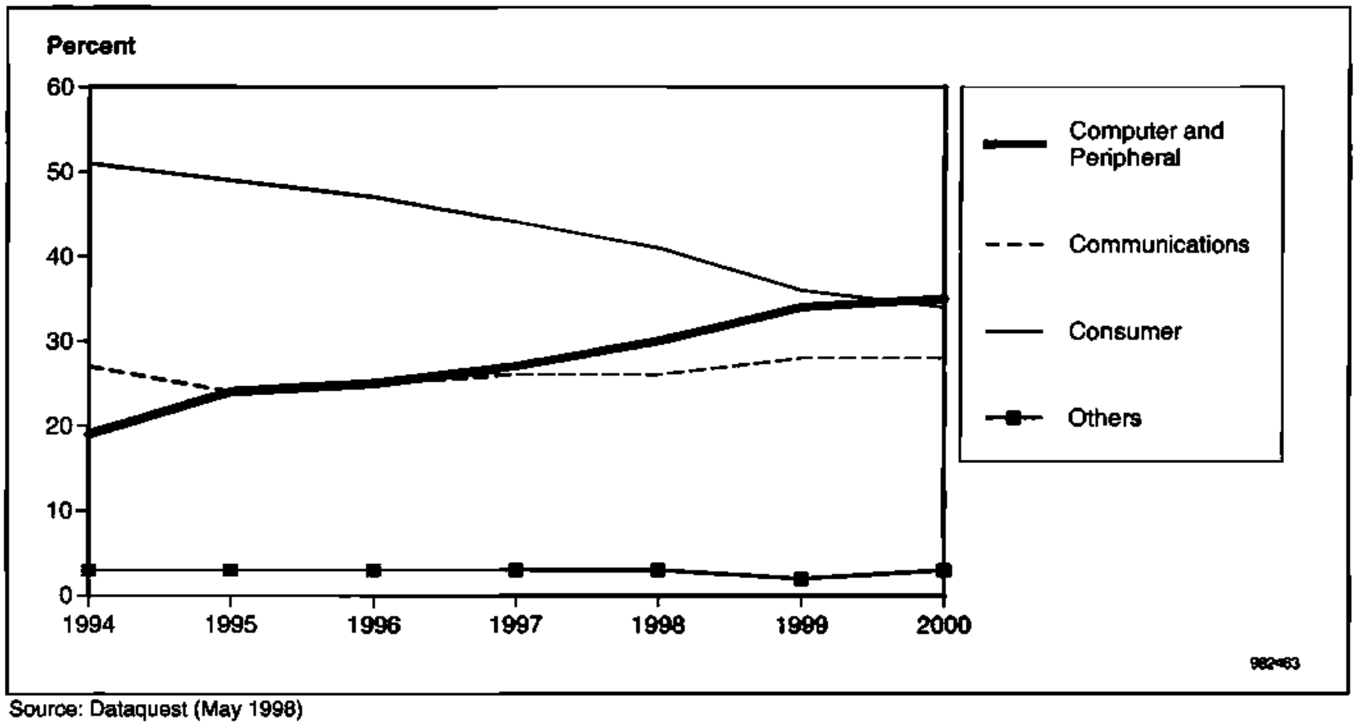
equipment. Dataquest's trend analysis is consistent with previous data, suggesting a consumer electronics export decline, impeded primarily by Japan's protracted economic troubles. The AFC will cause this trend to continue, even if the Japanese economy recovers. Conversely, there has been rapid investment in computer and communications manufacturing within China by U.S., European, and Taiwanese manufacturers. Dataquest forecasts a convergence of consumer electronics and computer and peripheral exports by 2000 (see Figure 3).

Figure 3
Chinese Electronic Export Share by Sector, History and Forecast, 1994 to 2000



Source: Dataquest (May 1998)

Of the $46.5 billion in electronic equipment production in 1997, Dataquest estimates that 56 percent, or $26 billion, will be exported. Dataquest has established that the exports' downside risk is insignificant, and that the domestic market is playing an increasing important role in electronic equipment production growth.

Key Domestic Market Trends

Dataquest places China at the high end of both spending magnitude and growth, second only to Japan. China is expected to reduce its IT spending by less than 5 percent as a result of the AFC.

Personal Computer Market

The PC market growth is a revealing window into future IT growth prospects. The currency, economic, and financial problems associated with the Asian turmoil have seriously impacted electronic equipment shipments to several countries. Dataquest reported a severe decline in fourth-quarter

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1997 and first-quarter 1998 PC shipments in half of the Asian countries after years of double-digit growth. Hong Kong's consumption declined 14 percent. China has been least affected thus far, experiencing about three-to-five times Asia/Pacific's average growth rate.

Without a doubt, businesses have been the largest PC and IT equipment and service purchasers in China. China's attempt to streamline the government's administrative bureaucracies and the financial sector will result in continued spending. As ministries reorganize, some are delaying purchases, however. The home and education markets are rapidly awakening segments of IT spending growth.

Overall shipment growth will slow from a high of 60 percent for three years and settle at a more sustainable 30 percent unit growth from 2000 to 2002. Desktops still dominate, but notebooks and servers will become significant in a few years.

The long-term forecast has not changed significantly from Dataquest's projections in 1997. Most agree that the industry will ship 10 million PCs to China in 2002. There is a plethora of peripherals and communications equipment that will mirror this shipment level.

Electronic Equipment Production Trends

Consistent with export and market trends, there is a slowdown in 1998 in all sectors based on Dataquest's survey of manufacturers in China/Hong Kong. Semiconductor revenue growth will improve slightly because of the bottoming out of average selling price (ASP) declines in 1998, laying the base for acceleration in 1999.

Dataquest's semiannual survey of electronic equipment production in China/Hong Kong represents a significant sample size of 30 percent of overall electronic equipment revenue. In data processing, Dataquest covers about 30 percent of China/Hong Kong's production, 25 percent of consumer, and 40 percent of communications equipment.

This data indicates that 1997 was a very good year in all sectors—but not as good as expected in August 1997. And the expectation for 1998 is cautious with expansion plans at nearly half of the 1997 level.

There is an anomaly in consumer electronics, which is showing a falling export growth and high cable TV penetration (as mentioned previously). The reason for the unexpected strong growth is the surge in video compact disc (VCD) manufacturing, which joined the fray in late 1997.

Several factors contribute to data processing's high growth. Figure 4 illustrates Dataquest's view of the Asia/Pacific semiconductor consumption and electronic equipment production from 1997 to 1999.

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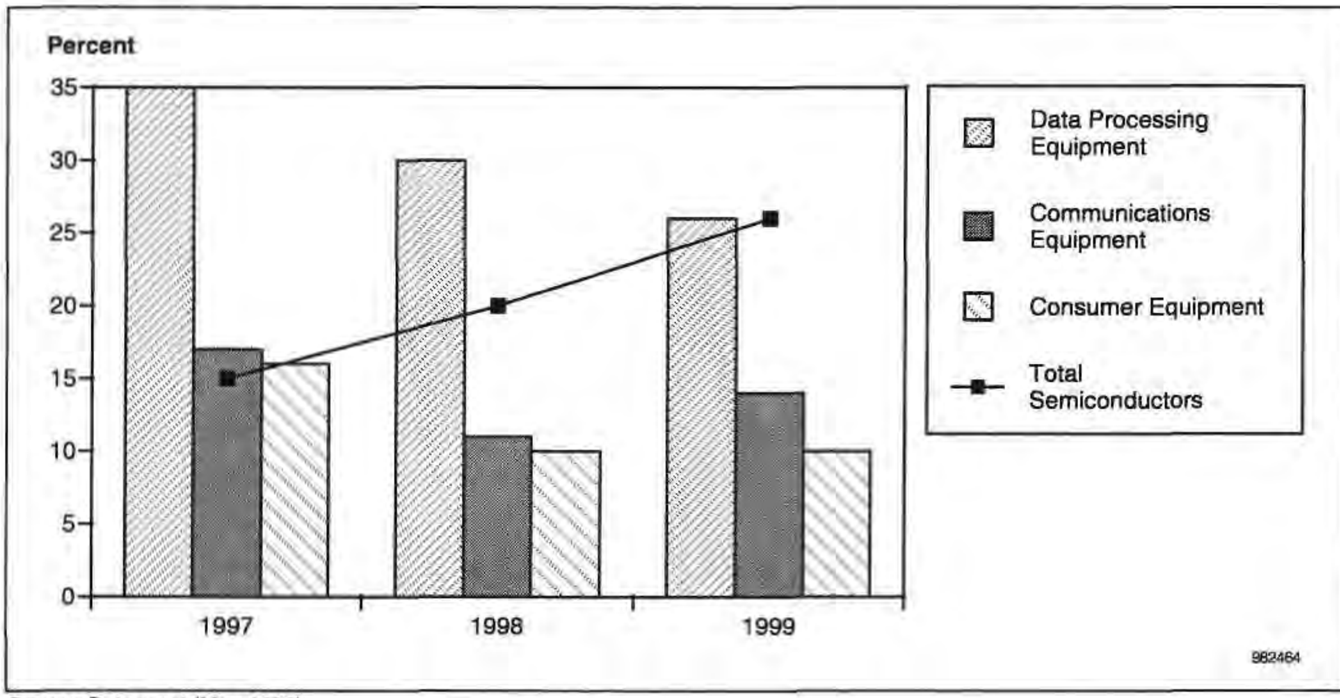
Figure 4
Semiconductor Consumption and Electronic Equipment Production, 1997 to 1999 (Growth)



Source: Dataquest (May 1998)

Personal Computer Production

Vendor shipments include imports and locally produced PCs, while manufacturer shipments includes all PCs produced in China (including what is exported). Dataquest's research indicates that imports and exports have reached parity, hence China is now producing as many PCs as it is consuming. Dataquest's long-term outlook shows the local industry will continue to keep pace with the surging market because of local manufacturers' competitive advantage over importers.

Foreign and joint-venture manufacturers are producing as many PCs as Chinese companies, but they will export about 50 percent of output compared to about 1 percent by Chinese companies. Foreign companies have trouble shipping locally, primarily because of the restrictions established by the Chinese government when the ventures were established. Although Chinese companies' products have inferior quality, because of consumers' lack of brand awareness, they have gained market share by accessing the local sales channels and lowering production costs. The lower production costs are a result of faster time to market, lower taxes (by 15 percent to 25 percent), lower inventory costs, and the ability to source components locally (a key cost advantage in an oversupplied market).

Long-Term Electronic Equipment Production Forecast

Dataquest's aggregated forecast of each sector indicates strong growth driven by a healthy balance of computer, consumer, and communications production, and a balance between exports and consumption. Dataquest

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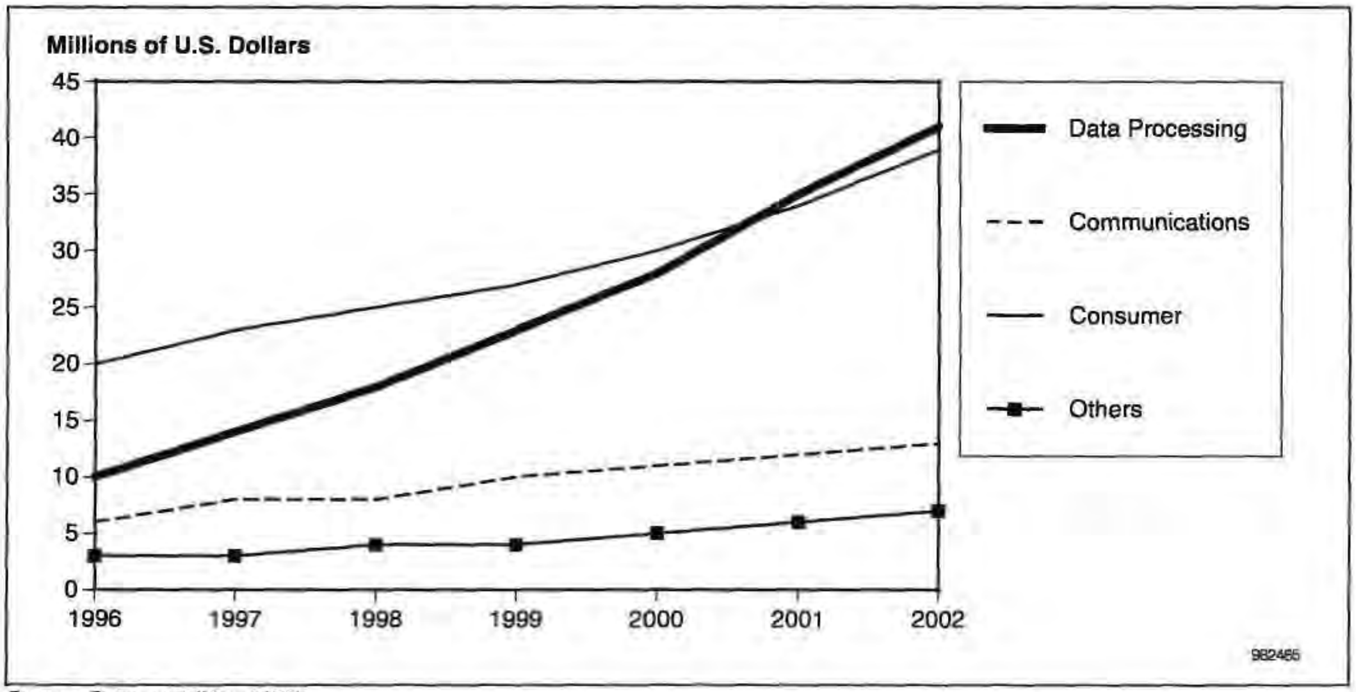
expects data processing, led by PCs and peripherals, to overtake consumer electronics by 2001 (see Dataquest's Semiconductors China Perspective titled "PC and Peripherals Semiconductor Forecast"). PCs and peripherals will become the largest semiconductor markets, with more than 48 million motherboards and 13 million PCs to be manufactured in 2002. But consumer electronics will be able to continue to grow, despite the maturity of TVs and radios. The latest, newfangled consumer electronics are the digital consumer electronics, in which China is already proving to be a major player. Communications equipment is growing quickly for switching equipment, cordless telephones, answering machines, pagers, and cellular phones. However, pricing pressure is pulling down overall revenue growth. Figure 5 depicts the electronic equipment production forecast trend in China/Hong Kong.

Figure 5
China/Hong Kong Electronic Equipment Production Forecast, 1996 to 2002



Source: Dataquest (May 1998)

Semiconductor Market Forecast

The Asia/Pacific semiconductor market has been the fastest-growing region worldwide since 1992. As shown in Figure 6, China/Hong Kong did not expand as quickly as Asia/Pacific as a whole. Much of the new demand growth was generated by Southeast Asia and Taiwan, attributed, in part, to strong memory prices and high memory consumption in these regions.

The China/Hong Kong market expansion actually accelerated in 1996 and 1997, but the ASP pressure reduced revenue growth in China. In addition, because memories are a smaller percentage of its market, China has been more insulated than the rest of the region.

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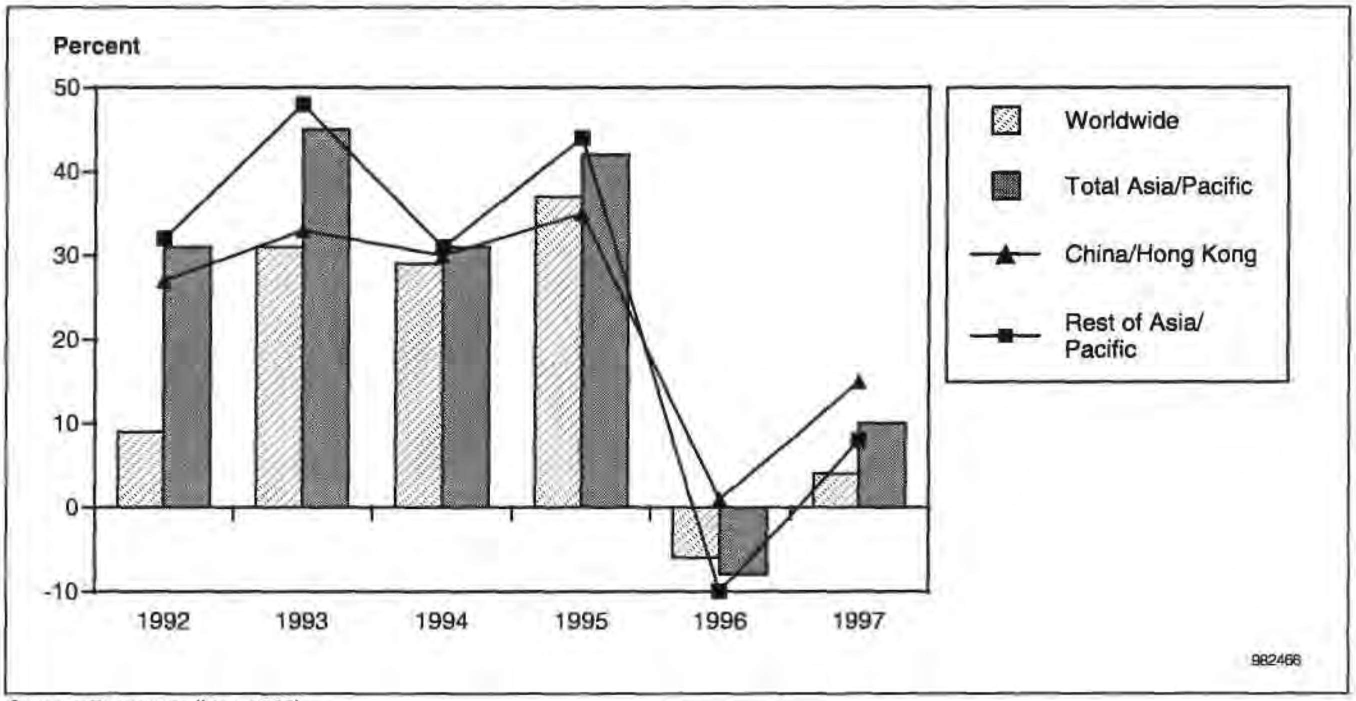
Figure 6
Semiconductor Market Growth by Region, 1992 to 1997



Source: Dataquest (May 1998)

Figure 7 depicts Dataquest forecast by product segment.

Dataquest expects China/Hong Kong to lead the region in semiconductor consumption during the next five years. Dataquest forecasts the semiconductor market to expand by a CAGR of 25 percent from 1997 to 2002, compared to Asia/Pacific's 18 percent growth.

Which Devices?

Microcomponents are forecast to grow by a CAGR of about 28 percent, analog by 19 percent, discrete by 15 percent, and logic and ASICs by 19 percent. Because of the existing overcapacity, the beginning of the next memory silicon cycle will not begin until 2000. By that time, China will be producing 10 million PCs and 40 million motherboards. Hence, memory consumption will grow by 35 percent to $5.3 billion.

Which Applications Will Set the Pace?

Where will these semiconductors be consumed? As indicated earlier, PCs and motherboards will be the largest semiconductor consumers by 2002, followed by cordless telephones, color televisions, corded phones, digital cellular phones, and central office line cards. These seven applications alone will account for about 35 percent of China's $20 million market in 2002.

Who's Buying?

Dataquest's 1997 survey of semiconductor consumption by origin of factory ownership shows China with about 35 percent of semiconductor consumption (see Figure 8). Chinese companies include joint-venture companies, wholly owned Chinese companies, and state-owned enterprises.

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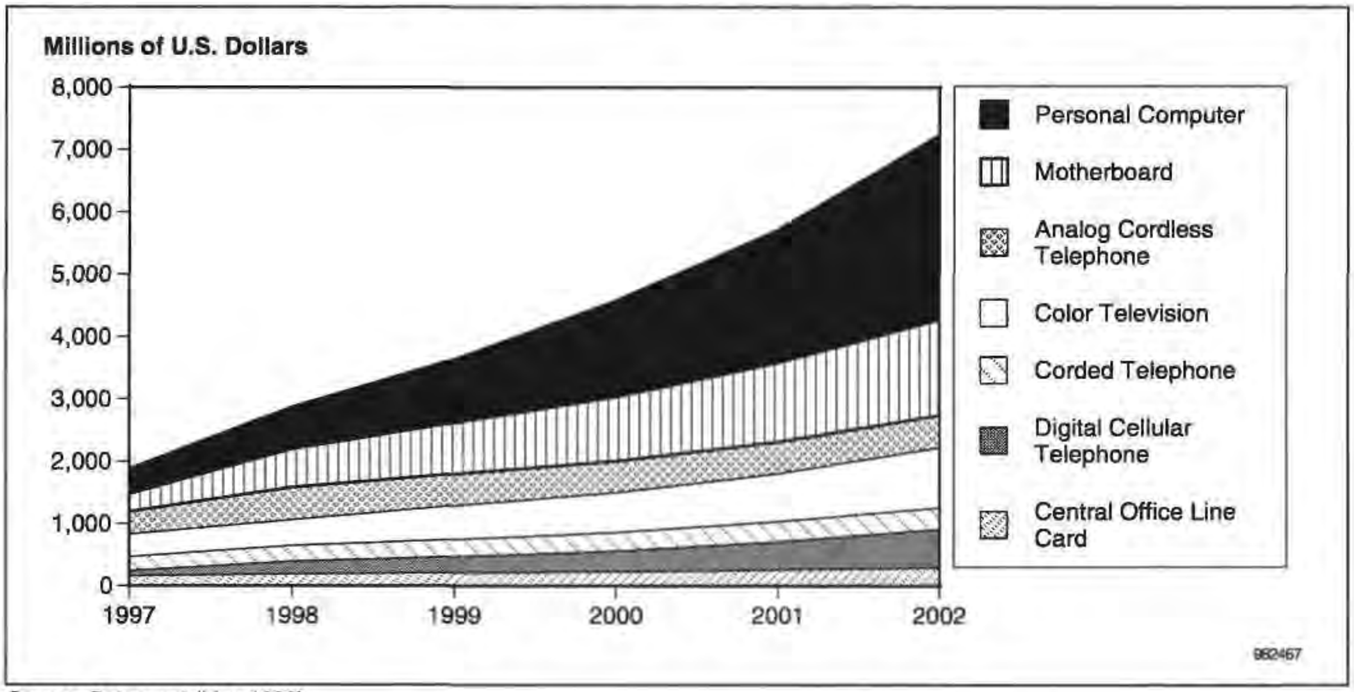
Dataquest includes semiconductors purchased locally as well as those shipped via internal transfer.

Figure 7
Top Seven Semiconductor Application Markets, 1997 to 2002



Source: Dataquest (May 1998)

Who's Selling?

It should come as no surprise to see Intel Corporation at the top of both Asia/Pacific and China/Hong Kong ranking in 1997. Table 1 presents Dataquest's preliminary estimates of top-tier semiconductor vendors' revenue concentration in China/Hong Kong.

Table 1 answers the question, "Which company has the largest share of Asia/Pacific sales in China/Hong Kong?" Rohm Company Ltd. had a 34 percent share because of its discrete, analog, and optoelectronic sales. Rohm was followed by NEC Corporation and Motorola Incorporated, which ranked third and fifth, respectively, with 26 percent and 28 percent of their Asia/Pacific revenue generated from China/Hong Kong.

How are these companies shipping products into China/Hong Kong? Approximately 42 percent of total revenue from semiconductor shipments goes to distributors, while 49 percent goes directly to manufacturers and the rest, 9 percent, comes from internal transfer from one subsidiary to another. Note that this includes shipment to China and Hong Kong. Hong Kong predominates in the distributor business. There will be a large variance in channel mix between products. Dataquest estimates that more than 90 percent of memory shipments come from distributors, for example.

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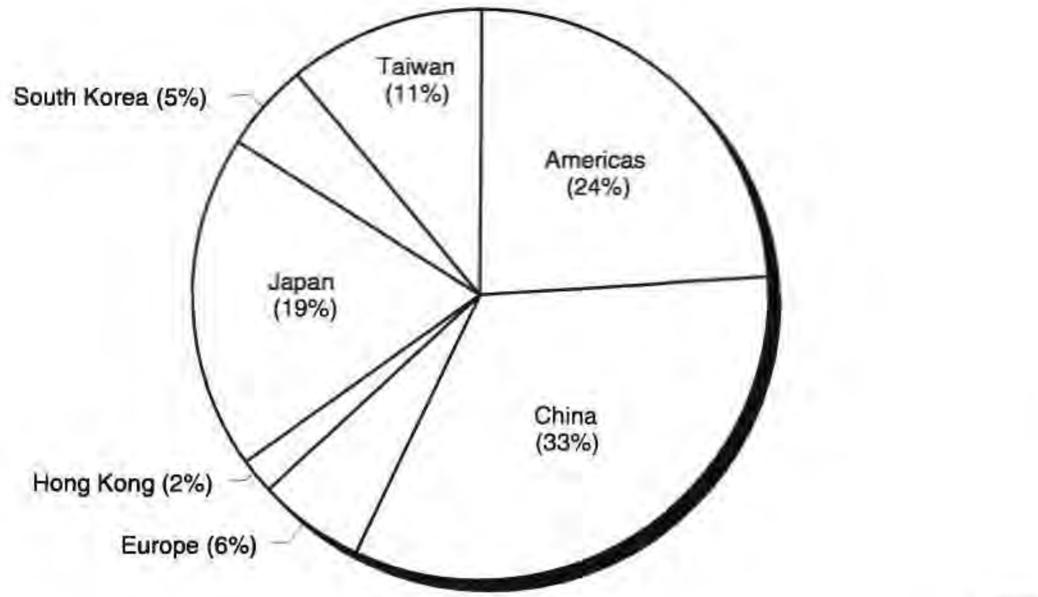
Figure 8
Estimated Semiconductor Consumption by Factory Ownership, 1997 (Percent Share)



Source: Dataquest (May 1998)

Table 1
Top 11 Semiconductor Vendors' Shipments to China/Hong Kong as a Share of Total Asia/Pacific Business, 1997

Company	China/Hong Kong's Share of Asia/Pacific Business (%)	Ranking Asia/Pacific	Ranking China/Hong Kong*
Intel	17.2	1	1
Toshiba	24.9	2	4
Motorola	26.3	3	5
Samsung	22.0	4	2
NEC	28.3	5	7
Philips	21.8	6	6
Rohm	34.2	7	12
LG Semicon	25.9	8	10
SANYO	24.5	9	11
Texas Instruments	11.6	10	3
SGS-Thomson	15.7	11	8

* Preliminary
Source: Dataquest (May 1998)

Motorola has also become the largest investor in both front- and back-end semiconductor manufacturing. NEC is in close second. Earlier, we indicated that these two companies had the largest share of Asia/Pacific sales in China/Hong Kong in 1997. It is not a coincidence. In fact, semiconductors

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are not different from PCs. Manufacturing is following markets in China as it its elsewhere in the world. So, although China's semiconductor industry has yet to boom, the building blocks are being laid for rapid expansion after 1999.

Dataquest Perspective

Because of the Asian financial turmoil, economic growth has been lower than previously forecast. However, with Zhu Rongji at the helm, it is apparent that state-owned enterprises' aggressive reforms, balanced export growth, and prudent fiscal policies will enable China to avoid its own crisis.

IT spending will continue to lead the region in size and growth rates. Local consumption reduces China's export exposure as production follows markets to improve time to market and access to distribution channels, and potentially improve design to market performance.

About 50 percent of China's total production is exported to the United States, representing the largest share. Since the majority of the exports are manufactured by foreign investors, Dataquest believes that exports will continue to grow.

Dataquest's key predictions for 1998 are as follows:

- The importance of the Chinese market—China occupies 20 percent of Asia/Pacific's semiconductor market and 27 percent of electronics production.
- The economy—China's GDP growth is expected to be 7.8 percent this year.
- Electronic exports—China's 10 percent growth represents 47 percent of total production.
- IT spending—PCs are expected to grow 60 percent in unit terms.
- Electronic equipment production—This sector will show a 16 percent growth.
- Semiconductor market—China's market will grow approximately 19 percent.
- Semiconductor industry—China has $600 million in production, and capital spending will surge to $1.5 billion in 1999.

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Perspective

Semiconductors China

Market Analysis

PC and Peripheral Semiconductor Market Forecast

Abstract: *This Perspective presents Dataquest's final 1997 figures and the forecast from 1998 to 2002 for the production of personal computers, monitors, motherboards, multimedia cards, and printers. Dataquest presents an integrated supply and demand view of the PC industry in China/Hong Kong. As a means of forecasting semiconductor consumption, this Perspective also analyzes PC technology (microprocessor consumption), product (form factors), and market trends (imports, exports, and local shipments).*
By Daniel Heyler

Introduction

To help semiconductor component suppliers stay abreast of PC semiconductor trends in China/Hong Kong, Dataquest presents an integrated analysis of manufacturers of PC systems and subsystems, combined with an end-user, or PC market, analysis. Dataquest's understanding of the market is critical in anticipating how manufacturers might respond, and ultimately, which companies will achieve their production targets.

Dataquest's approach in analyzing semiconductor demand in PCs and peripherals is stated straightforward as follows:

- Survey the manufacturers (market push)
- Analyze the market segments (industry pull)
- Assess the technologies and pricing (semiconductor content)

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PC manufacturing success and marketing success are increasingly interdependent in China, as the market moves away from imports to locally made products. Thus, the impact on semiconductor demand will continue to be huge. Dataquest's final 1997 figures estimate the size of the PC-related

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semiconductor market to be $1.6 billion in China/Hong Kong. This Perspective attempts to provide insights into this fast-growing semiconductor segment by addressing the following six questions:

- What are the production plans of major manufacturers of PC systems, motherboards, disk drives, monitors, and printers in 1998, and to what extend do these companies represent all of China/Hong Kong?
- To what extent will the combined effects of desire for foreign PC brands and Southeast Asia's currency depreciation result in a PC import boom, thereby weakening production growth?
- Will foreign-owned or foreign-invested (joint-venture) companies continue to invest in manufacturing within China given the intense competition from local manufacturers and white box assemblers?
- Can local manufacturers maintain their high production growth and slim margin even in face of China's open markets to foreign products and falling import prices?
- What PC products or peripherals will China export, and will China become a global contract manufacturer to either compete or complement Taiwan's leadership?
- Assuming that the above scenario occurs, what is the PC semiconductors revenue demand forecast for China/Hong Kong?

The phenomenal growth in PC consumption *and* production in China has resulted in significant semiconductor market growth. Multinational companies have invested in China expecting high market growth, but they have not performed as well as their Chinese competitors in the recent past year. Dataquest first examines these manufacturers' production plans and then turn to the analysis of the key driving force: the booming PC market in China.

Dataquest notes that the analysis of the PC market focuses on China (mainland), while industry or production analysis includes both China and Hong Kong (denoted as China/Hong Kong). Dataquest's rationale is that Hong Kong market has little bearing on the overall PC production (as a free port), but it is an integral part of production, distribution, and component sourcing for China's PC producers.

Personal Computer and Peripherals Production Forecast

Dataquest surveyed PC and peripheral manufacturers in China/Hong Kong in September 1997 and again in March 1998 for unit level production figures. The survey results contain Dataquest's final unit numbers for 1997 and forecast for 1998, as summarized by product type in Figure 1. Dataquest continues to update and add companies to its company-level electronic equipment unit production surveys. To provide accurate comparisons of production over two points in time, Dataquest will input the historical data of the manufacturer to reflect their rate of growth accurately. Dataquest's discussion of key unit-survey results, containing final 1997 and forecast 1998 figures, are as follows:

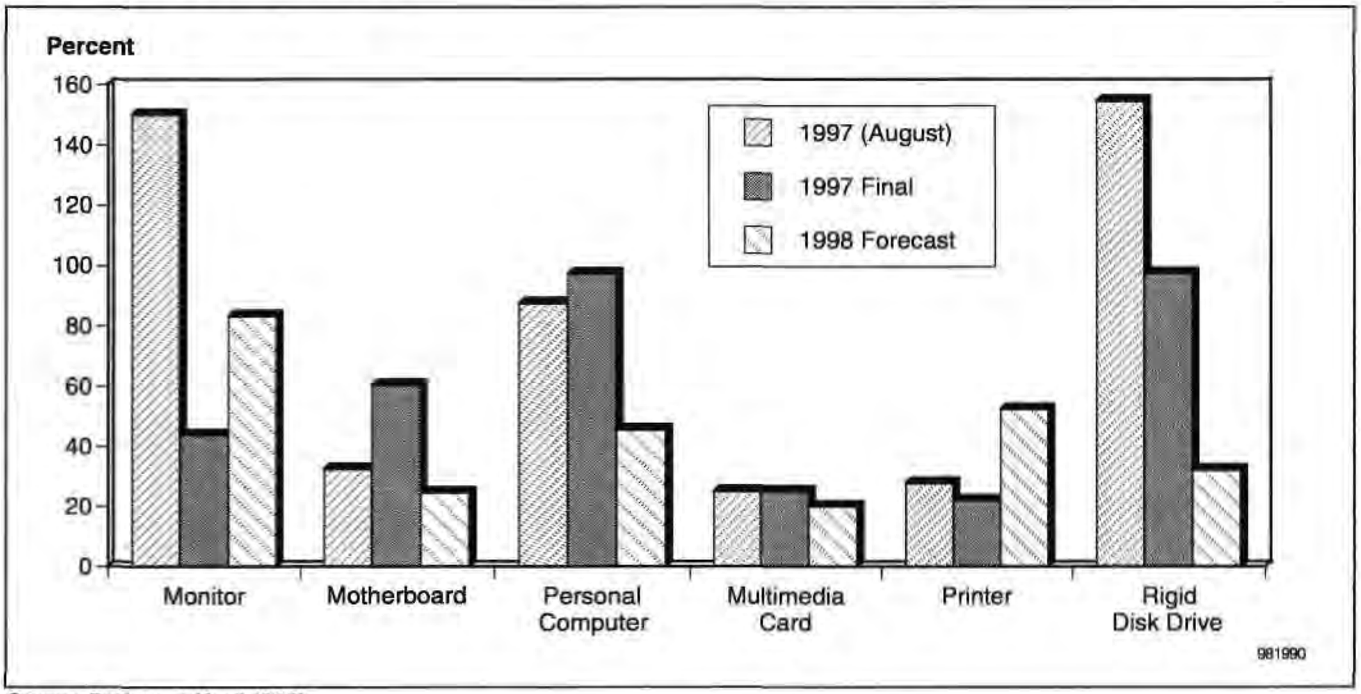
Personal Computer Manufacturers' Forecast

PC manufacturers expect a significant slowdown in production expansion in 1998 relative to 1997—from 97 percent to 46 percent, respectively (see Figure 1). Approximately 84 percent of China/Hong Kong-based PC manufacturers' unit output was surveyed in both periods (see Figure 2). These manufacturers, as a group, had exceeded their production plans of 88 percent growth in September 1997 and reported their final 1997 growth to be 97 percent. This performance is consistent with local Chinese companies' local market share gains, which expanded by 44 percent to 2.2 million units in 1997.

Motherboard Manufacturers' Forecast

Production is dominated by volume manufacturers from Taiwan. China/Hong Kong production grew 60 percent to reach 15.2 million units in 1997, but it is expected to slow to 24 percent in 1998. Exports constituted the majority of growth in 1997. Dataquest's sample represented 98 percent of volume production in China/Hong Kong.

Figure 1
Surveyed Companies' PC and Peripheral Production Quantity in China/Hong Kong, 1997 and 1998 (Unit Growth)



Source: Dataquest (April 1998)

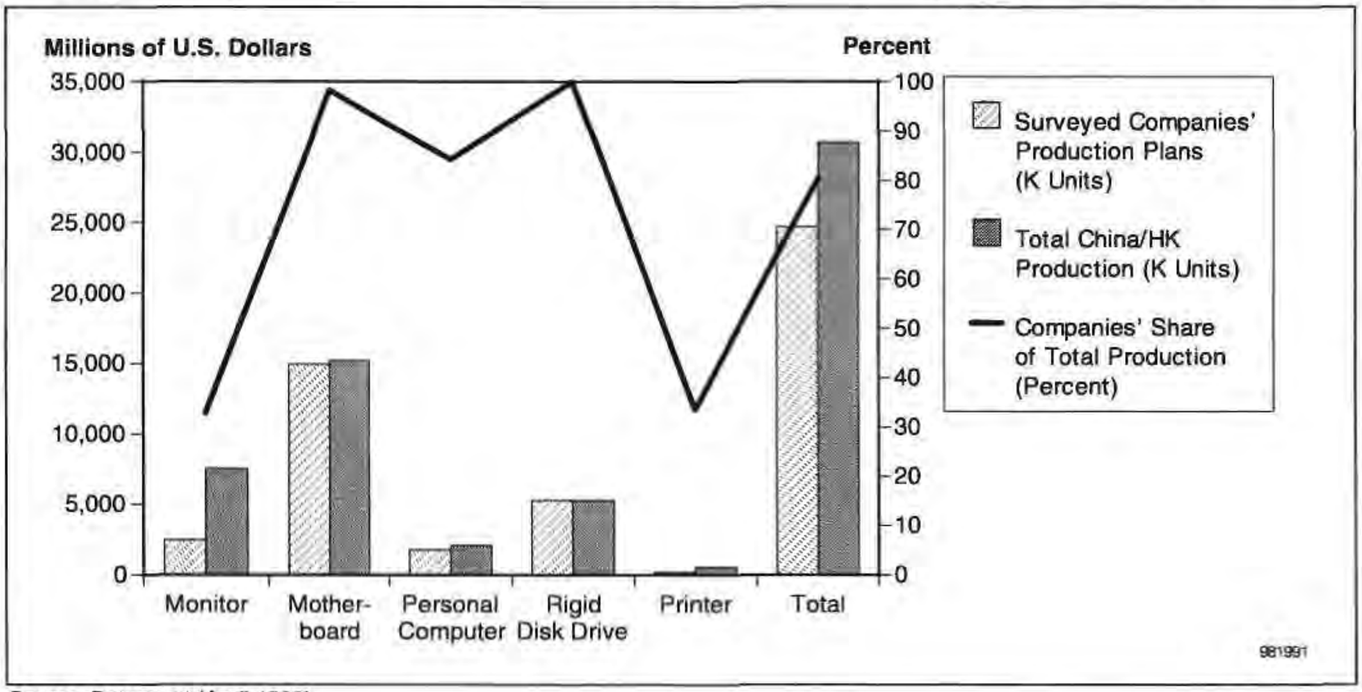
Monitor Production Forecast

Total monitor production increased by 39 percent in 1997. Monitor production was much weaker in 1997 than previously forecast, primarily attributed to LG Electronics (Shenyang) Co. Ltd. terminating monitor production in China. Approximately one-third of the industry was surveyed: Production expanded by 44 percent in 1997. Dataquest expects production to increase by 88 percent in 1998. This growth is attributed to a doubling of production at Suzhou Mingji Computer Co. Ltd., which is owned by Acer Computer International Ltd. and Suzhou Philips Consuming Electronics Co. Ltd.

Printer Production Forecast

Total production of page printer and serial printer manufacturers expanded 15 percent to reach 653,000 units in 1997. Production was dominated by serial printers, and the market relied heavily on imported foreign brands for laser or page printers. Dataquest's survey sample of 34 percent of total production did not meet 1997's expectations of 28 percent production growth. After growing 22 percent, these manufacturers forecast even stronger growth of 52 percent for 1998. Dataquest expects page printers to grow 45 percent, while serial printer growth will remain at about 13 percent in 1998.

Figure 2
Surveyed Companies' Revenue and Share of Total China/Hong Kong Production, 1997



Source: Dataquest (April 1998)

Rigid Disk Drives (RDD) Production Forecast

Dataquest includes Seagate Technology Inc. as the only rigid disk drive (RDD) manufacturer in China/Hong Kong, although Dataquest knows about the small assemblers of low-end drivers. Seagate expanded the RDD production at its established plant, Seagate (Shenzhen) International Technology Co. Ltd., and ramped production at Seagate (Wuxi) International Technology Co. Ltd. from 783,000 units in 1996 to 2.8 million units in 1997. Fully 90 percent of production is exported, but Seagate's strategy has proved successful, as it continues to dominate the RDD market in China.

Multimedia Board Production Forecast

This category consists mainly of audio and video add-in or plug-in cards that are sold to PC manufacturers or retailers in China or exported to vendors or distributors. Dataquest currently does not have a total production number for China/Hong Kong. However, Dataquest estimates that 1 million boards are produced by the Taiwanese-owned factory, Weijia Technology Co. Ltd., in 1997. The company expects to increase production to 1.2 million in 1998 and exports 100 percent of its product.

PC Market Segmentation and Demand Factors

China's PC market will represent about one-third of all shipments to the Asia/Pacific region (excluding Japan) in 1998. At the same time, its unit growth will likely double the regional average.

Only a couple of years ago, PC vendors were debating whether or not the Chinese would buy computers given their high prices, character-entry difficulty, and a lack of applications (in business and entertainment software, as well as Internet access). The market has not yet addressed these issues, but Chinese professionals are learning and adopting the PC to business uses (entertainment is a small, but growing, market). The point skeptics missed is that the nascent demand for PCs can be attributed to their high perceived value in China from years of media attention to the computer age and modernization. Although most Chinese have limited exposure to PCs, consumer awareness is high. So when prices declined, channels increased, and compelling Chinese software applications appeared, it took little product promotion and end-user training for sales to skyrocket.

Business Markets Dominate and Still Show High Growth

To understand the source of the business markets' growth, Dataquest segments the market by customer, form factor, and processor class. The business market was the first to adopt PCs in China. In 1995, the business segment absorbed nearly three-fourths of all PCs shipped in China (see Figure 3). Strong demand from foreign businesses in China later spilled over into local export-oriented companies. Foreign brands will not be the automatic product of choice because many local vendors now produce credible quality and are learning aftersales service. The private sector remains China's engine for economic growth, and PCs will be rapidly deployed in this large and booming sector. However, the emergence of government, home, and education markets lowered business segment's share to 56 percent in 1997. But the PC market more than doubled, so PCs for business use still grew from 700,000 to 1.2 million units from 1995 to 1997.

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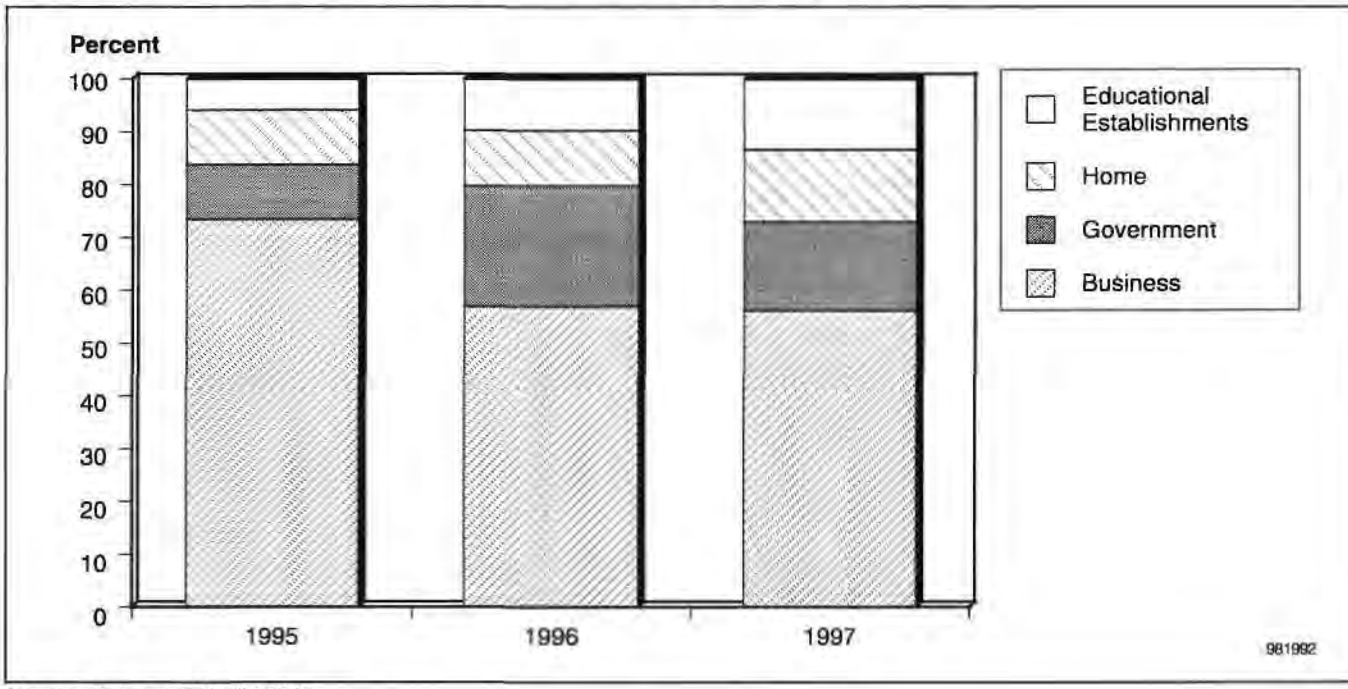
Figure 3
PC Market Segments by User in China, 1995 to 1997 (Percent)



Source: Dataquest (April 1998)

Government Sector Shows Strength

The government market accounted for about 10 percent of the PC market in 1995 and nearly doubled in share to 17 percent by 1997. The government and home markets each purchased only about 100,000 units in 1995. But the government segment grew faster, reaching 372,000 units in 1997. The government's recent initiative to streamline government, reduce ministries, and cut red tape will necessitate the computerization of administrative functions across China's central government. However, the pace at which China can achieve such a mammoth task will be slow, and the funds available will be increasingly scarce.

Home Market Awakes

There are few reasons to believe that the Chinese will have any less of a desire for home PCs than is seen in the United States, where approximately 40 percent of homes have PCs. This is another example of high nascent demand, since urban families have shown a high interest in PCs to educate their children to get ahead in China's competitive education system. In China, about 0.05 percent of the population own PCs, and only about 0.25 of 1 percent of families own PCs (assuming an average family size of five persons). The current economic growth rate, resulting in higher disposable incomes, would suggest that it will take about 10 years for 20 percent of Chinese families to own PCs. Another way to look at this trend is as follows: If an average of 5 percent of PCs are retired per year in the next decade, and the home market grows by 50 percent per year, then 85 million PCs would be sold just to families in China between now and 2008.

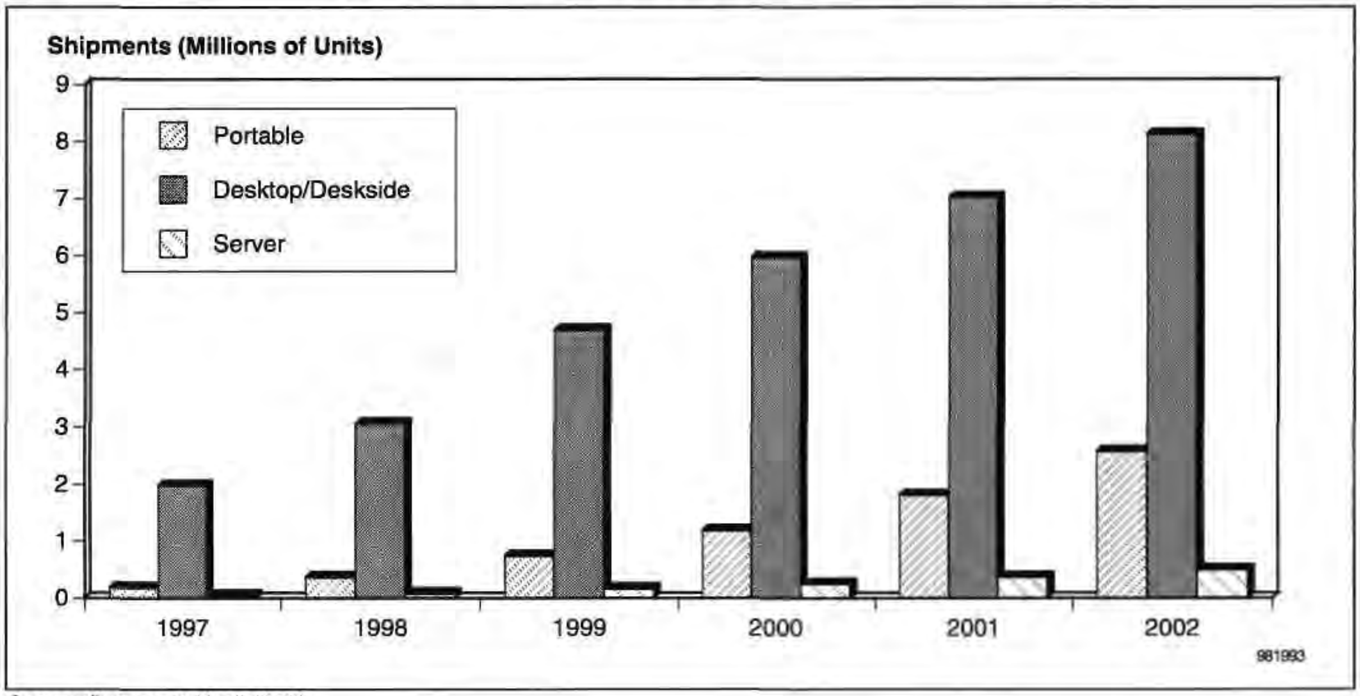
Education Users Surge

China's education market was the fastest growing during the past three years. Only 6 percent of PCs sold in 1995 went to educational establishments, but by 1997, this more than doubled to 13 percent. The university environment is the heaviest user on a per-PC basis, with hundreds of students sharing one or two PCs. But it is also the least funded. Vendors are wise to develop market share in this segment (providing discounts) as an efficient means of building brand recognition with China's next generation of business and government leaders.

Form-Factor Trends

In addition to market segmentation by end user, Dataquest segments PC shipments by form factor, as shown in Figure 4. The Chinese market has been dominated by desktop computers. But in 1997, the notebook computer market doubled to 173,000 units after several years of slow growth. Dataquest forecasts the market to continue this growth level through 1999 and then settle to a 50 percent average growth from 2000 to 2002. Dataquest has yet to see a local notebook computer manufacturer in China, but expects volume production to begin in 1999. Significant semiconductor opportunities will emerge as portables grow from a mere 9 percent in 1997 to 26 percent in 2002. Desktop PCs remain the "bread and butter" of the industry. Desktop PC shipments will grow from 1.7 million units in 1997 to 6.5 million units in 2002. Overall PC shipment share will fall from a high of 88 percent in 1997 to 68 percent in 2002. Figure 5 illustrates the compound annual growth rates (CAGR) for each form-factor segment from 1997 to 2002.

Figure 4
PC Segment Forecast by Form Factor in China, 1997 to 2002 (Millions of Units)



Source: Dataquest (April 1998)

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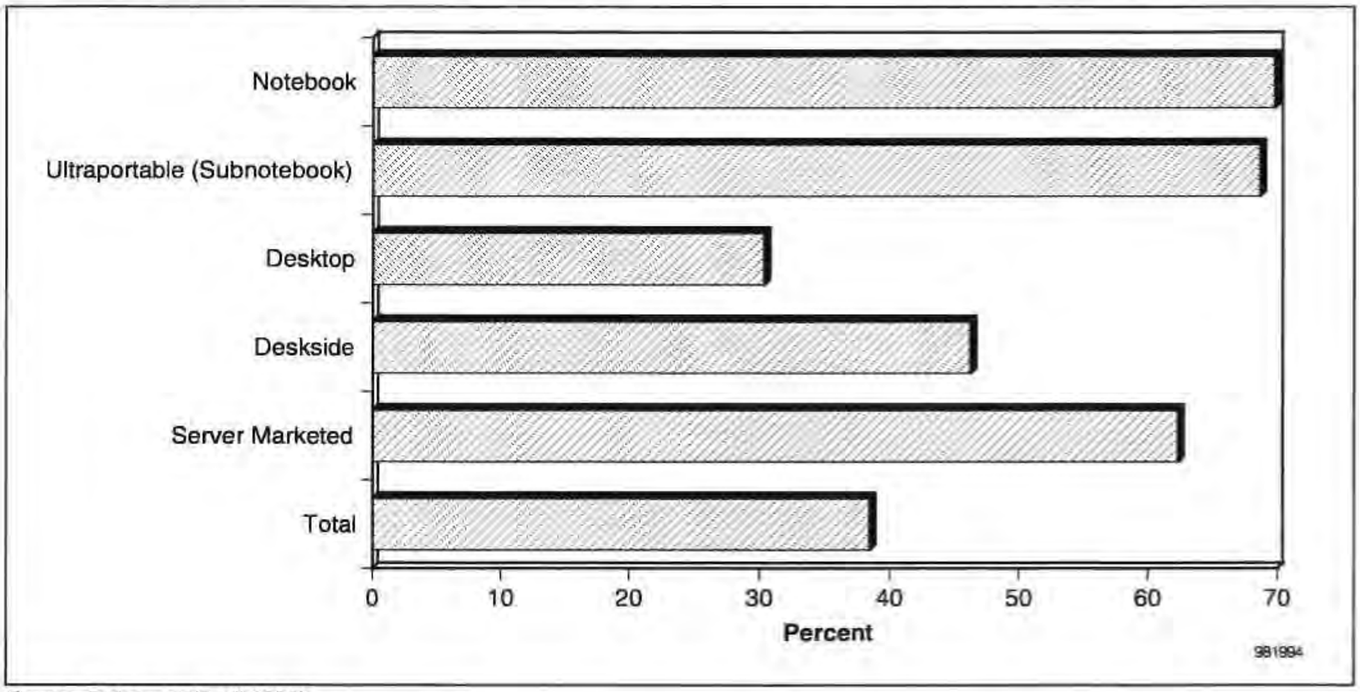
Figure 5
Detailed PC Segment Forecast by Form Factor in China, 1997 to 2002 (CAGR)



Source: Dataquest (April 1998)

Brands in China

Dataquest currently divides brands in China into the following three major categories. PC production within China cuts across all three types of brands with white box and minor brands increasing share rapidly.

- **Major brand**—Multinational PC brands tracked globally by Dataquest. Vendors in the major-brand market include Compaq Computer Corporation, IBM, Hewlett-Packard Company, Acer, Siemens Nixdorf Informationssysteme, Dell Computer Corporation, NEC Technologies Inc., and Toshiba Corporation.
- **Minor brand**—PC brands that are recognized nationally within any one country but are not generally known to buyers outside of that region.
- **White box**—PCs that are unbranded, or have brands that are only recognized within restricted geographic boundaries such as in a province or small town, but are not recognized nationally. Marketing is typically restricted to advertising in local newspapers, window advertising, distributing printed flyers, and/or adding a unique badge to the external casing.

Manufacturers' Response to Market Trends

Multinational companies have invested in China, expecting high market growth. However, their contracts require a high percentage of production to be exported, and their large investments also translated into a higher market share until China's domestic manufacturers entered the fray. These local manufacturers have the coveted local sales permit (*"nei xiao pai"*) issued by the government. Quality has been Chinese consumers' major concern, so the consumers were willing to pay more for a foreign brand. However, since much of demand growth has been in the government sector, local brands have gained an advantage. Incentives are provided to agencies that purchase Chinese brands. The joint venture between IBM and China Great Wall Computer Group has responded to these market conditions by producing both IBM and Great Wall brands for both government and private sectors.

Dataquest has yet to see one company that can do both manufacturing and marketing on a sustained basis within China's tumultuous, high-growth PC market. High growth does not come without risk and fluidity in the marketplace. AST Research Inc. was once the envy and business model for vendors seeking market entry to China. AST seemed have the ideal formula of manufacturing and marketing in China. But dynamic market changes and AST management's inability to respond to competition quickly eroded its margins. High turnover of personnel and persistent quality problems plagued the company, which now shows little sign of recovery.

A Five-Year Forecast for Key PC Industries

Dataquest believes that the previously discussed industry and market force will translate into a 45 percent CAGR for PCs. (Dataquest's five-year forecast of PC and peripherals are itemized in Table 1.) Motherboards, monitors, and RDDs will exceed a 26 percent CAGR. But the component growth has been lagging PC growth because a large portion of the current production is exported. Dataquest expects production to increasingly serve the local market. Dataquest also expects Southeast Asia's currency depreciation to result in that region attracting more foreign investments in export-oriented industries. Therefore, Dataquest forecasts a foreign-capital-commitment slowdown in China from 1998 to 2000, compared with the previous three years. Furthermore, China's entry to the World Trade Organization (WTO) will further open markets.

Despite these factors that will slow foreign investment, Dataquest cannot discount the pull of China's IT markets. With increased competition in China, products increasingly have similar features at similar costs. Vendors' main competitive advantage in China will be their distribution channels and time to market. Vendors with a local key component supply and designs are clearly going to be tomorrow's leaders.

PC Semiconductor Market Forecast

The consumption of PC-related semiconductors reached $1.6 billion in 1997, a 61 percent increase. If not for falling memory prices, the revenue growth would have exceed 100 percent. Instead, semiconductor market growth merely matched equipment production unit growth, a dismal performance on the whole. Dataquest's long-term forecast assumes a modest, rather than dramatic, recover in memory average selling prices (ASPs) after 2000.

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Table 1
PCs and Peripherals Semiconductor Market Forecast in China/Hong Kong, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Semiconductor Consumption (U.S.$M)	1,589.6	2,262.8	3,098.1	4,085.6	5,275.8	6,719.0	33.4
Annual Growth (%)	61	42	37	32	29	27	
Total Equipment Production (Units K)	**30,708**	**42,095**	**54,692**	**71,312**	**88,727**	**108,688**	**28.8**
Monitor	7,550	12,118	15,147	19,691	23,630	27,883	29.9
Motherboard	15,200	18,802	24,368	31,167	39,083	48,658	26.2
Personal Computer	2,096	3,230	5,028	7,160	10,038	13,401	44.9
Rigid Disk Drive	5,300	7,292	9,377	12,369	14,843	17,325	26.7
Page Printer	51	74	119	195	319	523	59.2
Serial Printer	511	579	653	731	815	898	12.0
Total Equipment Production (Percentage Growth)	**60**	**37**	**30**	**30**	**24**	**22**	
Monitor	39	61	25	30	20	18	
Motherboard	60	24	30	28	25	25	
Personal Computer	83	54	56	42	40	34	
Rigid Disk Drive	98	38	29	32	20	17	
Page Printer	45	45	60	64	64	64	
Serial Printer	13	13	13	12	12	10	

Source: Dataquest (April 1998)

Consequently, Dataquest now forecasts that PC semiconductor demand will expand at a 33 percent CAGR from 1997 to 2002.

Microprocessor Adoption Rates

If not for a near monopoly in microprocessors, we might even see a decline in semiconductor content per system. Table 2 presents Dataquest's estimates of PC production by microprocessor type in each quarter of 1997. Pentium II and Advanced Micro Devices Inc.'s (AMD) K6 were the only other non-Pentium, x86 products to increase in the fourth quarter of 1997. The success of domestic manufacturers within China is attributed to their ability to introduce next-generation products before technically superior foreign brands could import and distribute their products in China. Their proximity to their channels and ability to source locally buys critical time to market.

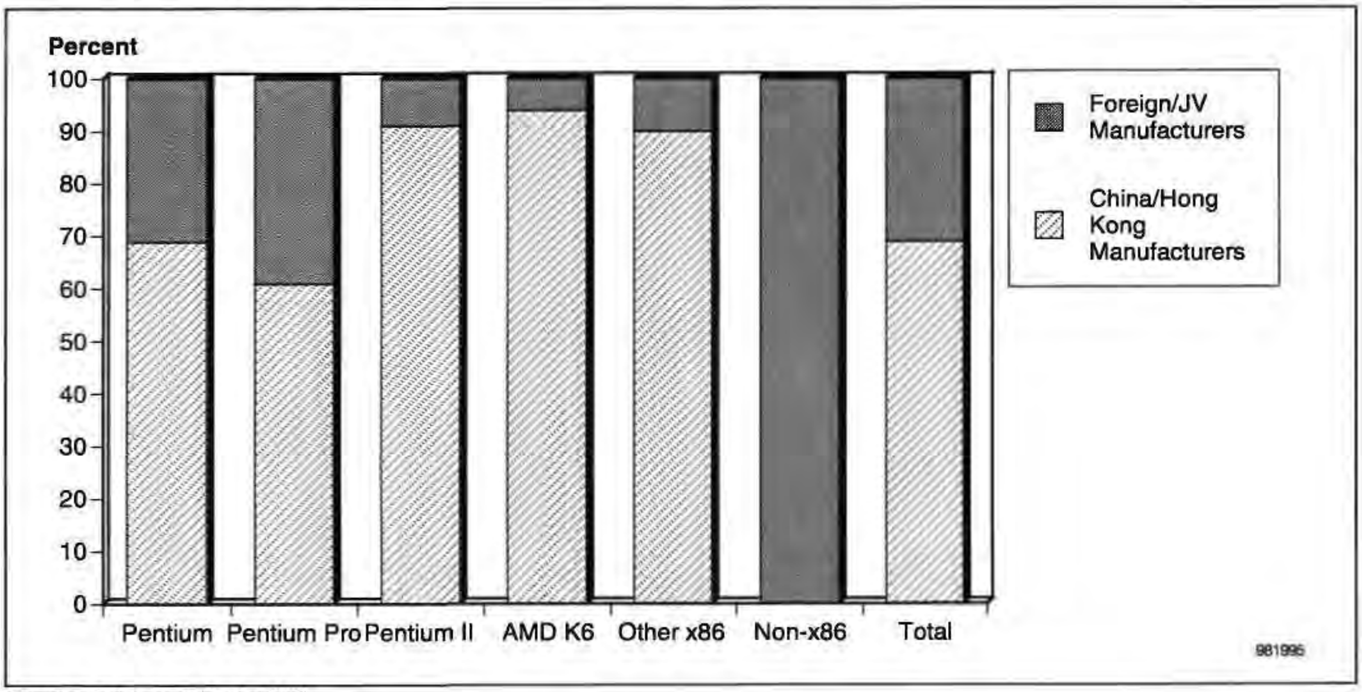
Chinese companies are accelerating their rate of technology adoption and surpassing their foreign counterparts in Pentium II consumption in the fourth quarter of 1997, as illustrated in Figure 6. For the year, foreign versus local Pentium-class processor consumption was proportional to total PC production. In short, there was no marked difference between foreign and local manufacturers' technology level relative to the Chinese market.

Table 2
China/Hong Kong Quarterly PC Production by Microprocessor Configuration (Units and Growth Rates)

	1996 Total	Q1/97	Q2/97	Q3/97	Q4/97	1997 Total
Units						
Pentium	874,936	336,687	465,809	522,175	571,594	1,896,264
Pentium Pro	5,216	14,041	24,426	32,602	23,440	94,509
Pentium II	0	-	-	8,065	14,051	22,116
AMD K6	0	-	-	-	8,492	8,492
Other x86	257,904	24,507	24,495	12,685	3,131	64,818
Non-x86	8,944	1,418	3,378	2,021	2,984	9,801
Total	**1,147,000**	**376,653**	**518,108**	**577,547**	**623,691**	**2,096,000**
Consecutive Growth Rate (Percent)						
Pentium	522.3	-13.6	38.4	12.1	9.5	116.7
Pentium Pro	-	1240.4	74.0	33.5	-28.1	1,712.0
Pentium II	-	-	-	-	74.2	-
AMD K6	-	-	-	-	-	-
Other x86	-56.5	-41.3	-0.1	-48.2	-75.3	-74.9
Non-x86	24.2	176.7	138.1	-40.2	47.7	9.6
Total	**54.9**	**-13.0**	**37.6**	**11.5**	**8.0**	**82.7**

Source: Dataquest (April 1998)

Figure 6
Microprocessor Usage in China/Hong Kong: Chinese versus Foreign/Joint-Venture Manufacturers, 1997 (Percent)



Source: Dataquest (April 1998)

Personal Computer Export and Import Trend Analysis

Exports as a percentage of total PC production continues to drop in China. In 1996, 38 percent of production was exported; by 1997, this amount had dropped to 27 percent. Dataquest forecasts exports to drop to 25 percent in 1998 attributable to a high currency valuation of the renminbi relative to Southeast Asian nations. The Asian financial crisis will hurt foreign and joint-venture manufacturers more than their Chinese competitors because about half of their production in China is exported (see Table 3).

Table 3
PC Production and Exports: Chinese versus Foreign/Joint-Venture Companies, 1996 to 1998 (Thousands of Units)

				Annual Growth (%)	
	1996	**1997**	**1998**	**1997**	**1998**
Chinese Companies' Production	490	1,136	1,668	132	47
Foreign and JV Companies' Production	657	960	1,562	46	63
Chinese Companies' Exports	18	15	21	-20	45
Foreign and JV Companies' Exports	417	552	787	32	43
Total Production	1,147	2,096	3,230	83	54
Total Exports	435	566	808	30	43
Exports Share of Production: Chinese Companies (%)	4	1	1	-	-
Exports Share of Production: Foreign Companies (%)	63	57	50	-	-
Total Export Share of Production (%)	**38**	**27**	**25**	-	-

Source: Dataquest (April 1998)

PC imports in China declined in 1997 relative to 1996 because of the local producers' ability to steal market share from branded (imported) products. The declining imports and exports confirm a clear trend that local producers are increasingly dependent upon and successful in their own high-growth markets. It also raises doubt whether Chinese companies have the need or ability to emphasize exports as announced prior to the Asian financial crisis. In fact, Dataquest expects Chinese companies to remain focused on their local markets and to face difficult challenges in exporting. Dataquest forecasts the Chinese companies' exports to drop from 4 percent to 1 percent of total production and foreign/joint-venture companies to drop from 57 percent to 50 percent, as they try to turn as much production to the local market as possible (see Figure 7).

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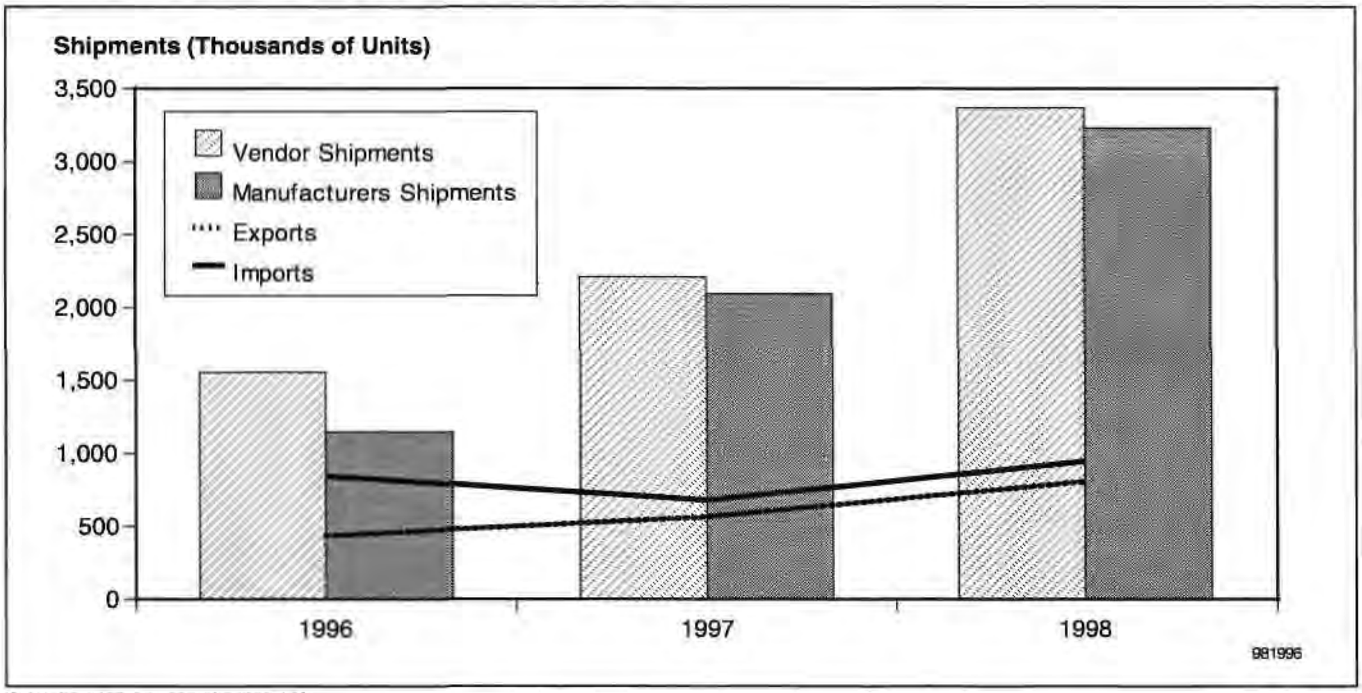
Figure 7
China's PC Production, Exports, Imports, and Vendor Shipments: A History and Forecast, 1996 to 1998 (Thousands of Units)



Source: Dataquest (April 1998)

Dataquest Perspective

Dataquest summarizes the following answers to the original six questions that have been analyzed in this report:

Q: What are the production plans of major manufacturers of PC systems, motherboards, disk drives, monitors, and printers in 1998, and to what extent do these companies represent all of China/Hong Kong?

A: Production is expanding for both multinational companies and Chinese companies, but Chinese manufacturers are winning in both production and marketing of PCs. PC peripherals are export-oriented, but they will increasingly be turned to the local market because of the demand surge from system makers and currency depreciation in other Asian countries.

Q: To what extent will the desire for foreign PC brands and the currency depreciation in Southeast Asia result in a PC import boom, thereby weakening production growth?

A: Imports of major and minor brands will increase after their decline in 1996 and 1997 because of the falling PC prices from Southeast Asia, Korea, and to a lesser extent, Taiwan. But time to market and distribution are the major competitive advantages for local vendors in China, so import growth will be only modest compared with local production growth. PC exports will also decline for both Chinese and multinational manufacturers in China—as a result of China's and Hong Kong's relatively higher currency values. But

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Chinese companies currently export less than 4 percent of total production, while multinational companies export 57 percent of their production.

Q: Will foreign-owned or foreign-invested (joint-venture) companies continue to invest in manufacturing within China given the intense competition from local manufacturers and white box assemblers?

A: Foreign investments will continue to compete within the local market. Chinese consumers have become sophisticated buyers in a short period of time and they now have a local supply to offset slow-to-market, more expensive foreign brands. Waiting until the last possible moment to purchase key components means lower prices for Chinese brands over their imported competitors that also face tariff and distribution expenses.

Q: What PC products or peripherals will China export, and will China become a global contract manufacturer to either compete with or complement Taiwan's leadership?

A: China will only become a world PC and peripheral powerhouse if local companies can compete within China and match their multinational competitors' market growth. The government is moving toward building *chaebols* (Korean-style conglomerates), but China faces a massive bureaucracy and limited capital and technology. As for low-end products such as power supplies and consumer electronics, China will continue to expand worldwide market share.

Q: Assuming that the above scenario occurs, what is the PC semiconductors revenue demand forecast for China/Hong Kong?

A: Consumption in 1997 was about $1.6 billion and will grow at 33 percent CAGR to reach $6.7 billion in 2002.

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Perspective

Semiconductors China
Market Analysis

Electronics Manufacturing Issues and Outlook in 1998

Abstract: *Dataquest recently conducted a survey of major American, Chinese, European, Japanese, Korean, and Taiwanese electronic equipment manufacturers in China to ascertain the impact of domestic and Asian economic problems on various sectors of China's electronics industries. Dataquest's January Perspective provided a view of the key industry factors influencing the electronics industry. This Perspective analyzes the performance of specific electronic industry segments in 1997 and forecasts 1998.*
By Daniel Heyler

Survey Overview

The slowdown in semiconductor consumption during the January and February time frame is a seasonal phenomenon caused, in part, by two to three weeks (or longer) of Chinese New Year's holidays for many manufacturers and, in part, to a strong fourth quarter push by exporters. By the end of February, however, vendors typically begin to see obvious indications of stronger demand and market recovery. It is this lack of a demand upsurge for many vendors that is causing concern. Dataquest has surveyed major manufacturers to understand their short-term (1998) outlook and explore below the various levels of market factors impacting current growth.

Dataquest's sampling of manufacturers represents approximately 30 percent of total electronic equipment revenue in 1998. As shown in Figure 1, Dataquest varied the survey across communications, consumer, and data processing sectors to provide a segmented view of the marketplace. Dataquest concentrated on volume manufacturers that produce mainstream or high-growth products for both export and local consumption. For these

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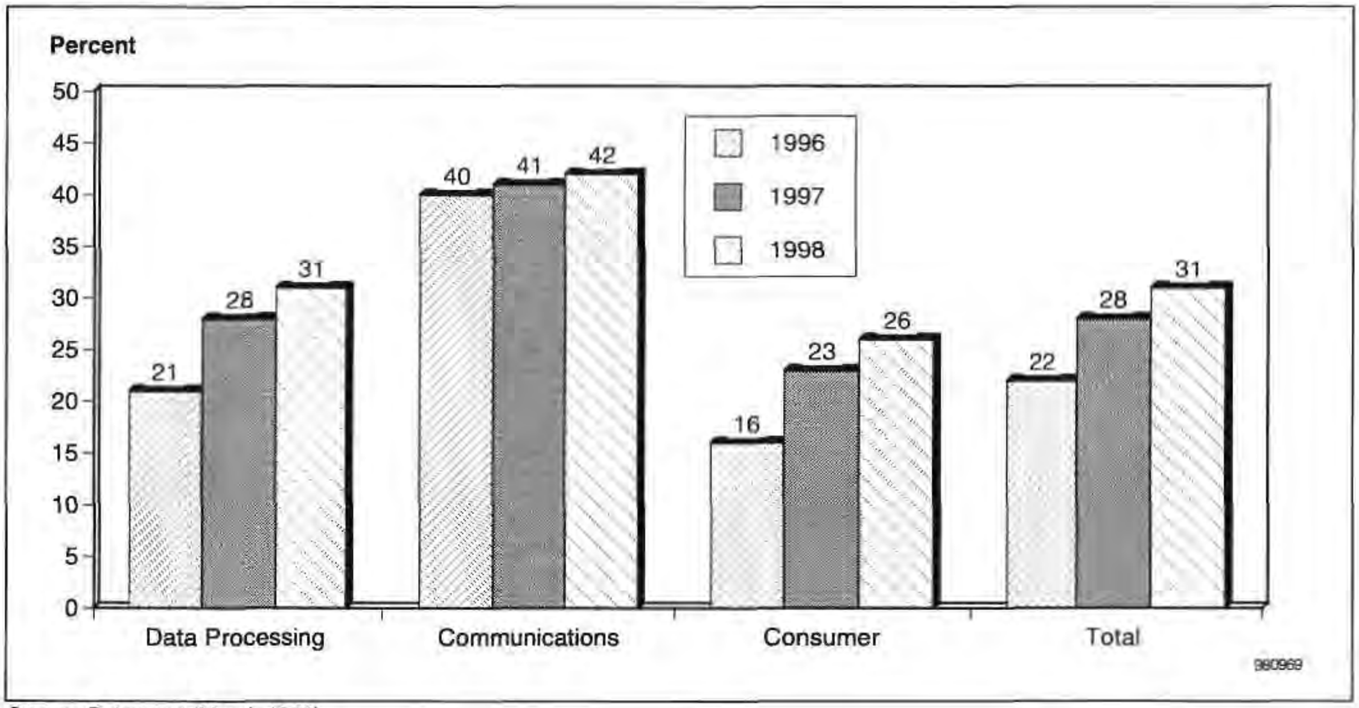
reasons, Dataquest's sample group is outpacing the overall industry average (see Figure 2).

Figure 1
Surveyed Companies' Share of Electronic Equipment Production by Segment in China/Hong Kong, Revenue



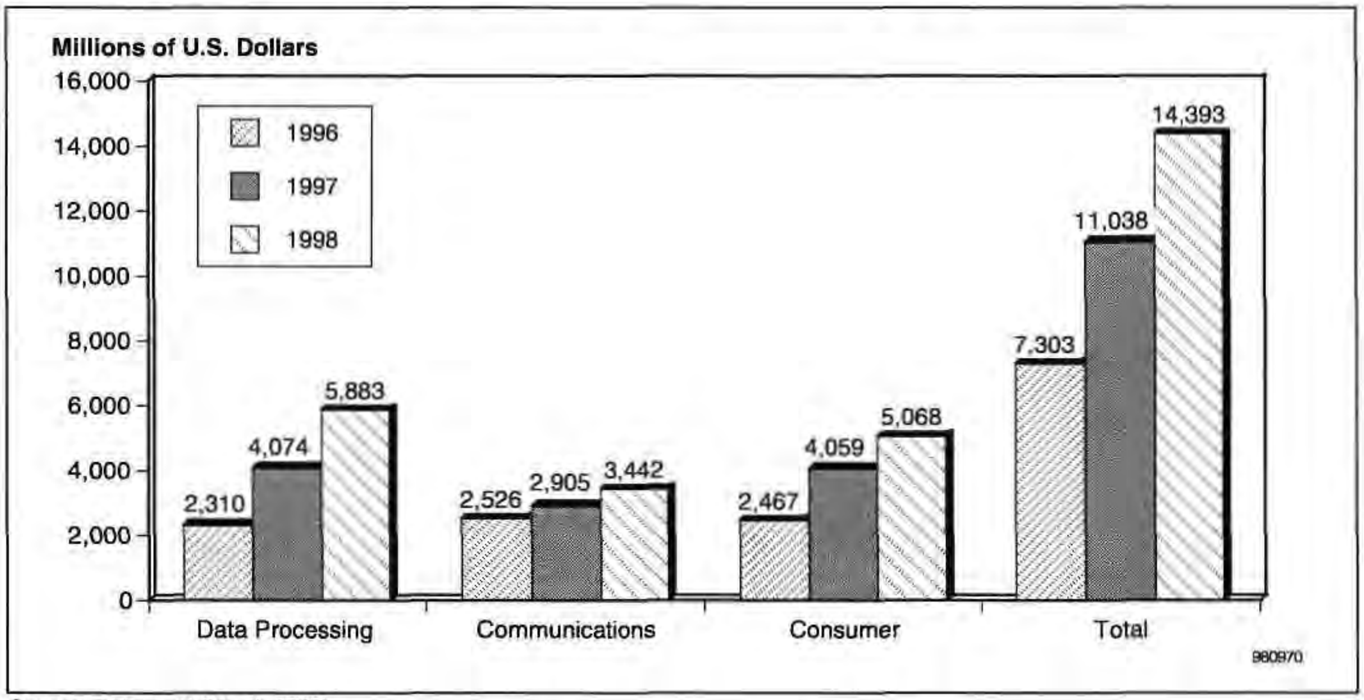
Source: Dataquest (March 1998)

Computer and Peripheral Manufacturers

The overall computer market has yet to show signs of decline, which have been felt elsewhere in the region. Dataquest's survey of 28 percent of the data processing equipment producers indicates that manufacturers did not meet their 1997 production plans in revenue terms and are slowing production expansion in 1998 (see Figure 3). Although the outlook indicates an impressive 44 percent production growth, this is much lower than 1997's 76 percent growth. (Dataquest's methodology for calculating production revenue growth includes surveying companies for unit production and growth, then applying a standard per-unit average selling price across all companies.)

Dataquest observes increased competitive pressure by foreign suppliers that are attempting to counter weak markets in Southeast Asia by focusing on the Chinese market. It appears that manufacturers are expecting increased competition in the domestic market and have lowered their expansion growth for 1998. It is also valid that the near-doubling of industry expansion will be unable to be replicated as it reaches a critical mass.

Figure 2
Production Plans of Surveyed Manufacturers in China/Hong Kong, 1996 to 1998 (Millions of U.S. Dollars)



Source: Dataquest (March 1998)

Personal Computers

The most aggressive and optimistic of the PC manufacturers is Beijing Legend Computer Company. Legend manufactured approximately 420,000 PCs in 1997 and is sticking to its plans of reaching 760,000 units in 1998. Most manufacturers have maintained their expectations for a healthy 1998. The joint venture between China Great Wall Computer Group and IBM, which produces both brands, grew 58 percent in 1997 and is expected to grow 104 percent in 1998 to 615,000 units. The Beida Founder Group did not meet its projections of producing 178,000 PCs in 1997. It plans to grow from 134,000 units in 1997 to 182,000 units in 1998. Acer Computer International Ltd.'s Beijing Minji Computer Company did not convert its mouse and keyboard manufacturing plant into a PC plant, as originally anticipated in 1997. The company expects to assemble about 105,000 units in 1998 and claims to be assembling PCs already at this location.

There are exceptions to aggressive planning and expansion, however. Nanjing Power Computer Co., a joint venture with Motorola Incorporated, decided to discontinue its Power PC computer business plans. Compaq Computer Corporation's assembly plant in Shenzhen will not be scaled up to export PCs but, instead, will service only the Hong Kong and China markets by assembling about 10,000 PCs per month. Its facility will emphasize power supplies for global export, a more labor-intensive industry.

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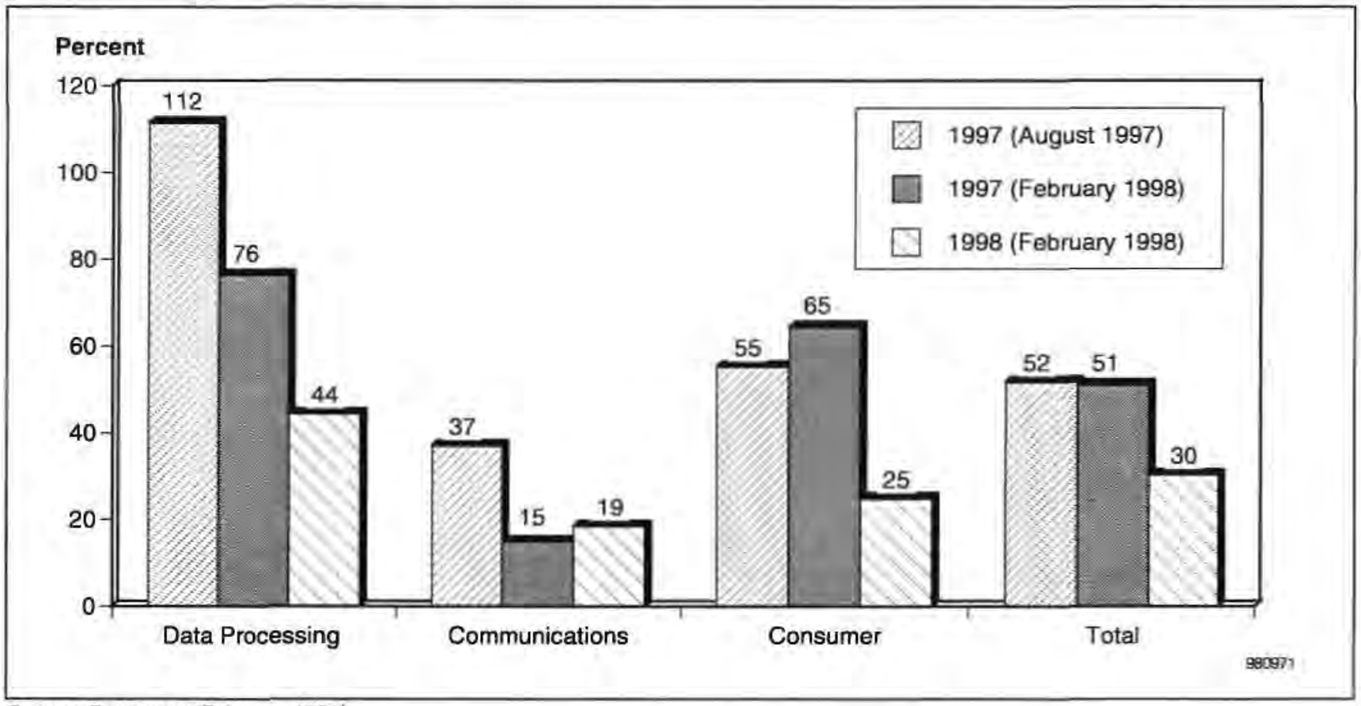
Figure 3
Production Plans of Surveyed Electronic Equipment Companies in China/Hong Kong, 1997 to 1998 (Percent Growth)



Source: Dataquest (February 1998)

PC manufacturers express optimism about China's domestic market, which grew by about 50 percent in 1997. The rate of shipments had slowed in the second half of 1997, which was factored into Dataquest's 1998 forecast of approximately 40 percent growth. The main impetus for this growth forecast appears to be continued growth in the government and business sectors, which will account for the majority of shipments. If companies meet or come close to their current plans, PC production will expand by about 55 percent to 2.9 million units in 1998. From Dataquest's survey, the top 10 vendors are expanding by 70 percent.

Motherboards

Dataquest has revised its motherboard production estimates in 1997 from 8.3 million to 15.2 million because of the inclusion of PC Chip Manufacturing Company Limited (Taiwan) in the survey. Located in Dongguan, Guangdong, this manufacturer produced about 6.9 million motherboards in 1997 and is the largest motherboard manufacturing in China. However, less than 5 percent of its production is shipped to the China market; the remainder is exported globally. This company epitomizes "low-cost strategy." PC Chip does little advertising, has minimal customer support, and cuts administration and sales to the bare bones. Its business philosophy is survival by price and price alone. For example, PC Chip's socket-7 motherboard, with VIA Technologies Inc.'s accelerated graphics port (AGP) averaging less than U.S.$70 in Hong Kong in February, compared to an Asus Company's board that sells for U.S.$125.

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China's own and largest vendor, Legend, is now capable of producing approximately 300,000 motherboards per month. Legend's production is likely to expand 30 percent from 2.3 million in 1997 to 3 million in 1998. Expansion plans for most major vendors in 1998 are more conservative than 1997 after experiencing spectacular growth of 128 percent. Dataquest estimates its unit growth to be 32 percent in 1998. The top five manufacturers will expand by 23 percent to 8.7 million units. Dataquest notes that a formidable group of small and medium-size companies exist in this segment. Dataquest estimates total motherboard production at 15 million units in 1997, growing to 18 million units in 1998.

Monitors

This sector is not slowing in growth. Dataquest forecasts monitors' unit production to grow 50 percent. Leading the sector is Acer Group, which plans to double its production at its Suzhou Minji facility from 600,000 units in 1997 to about 1.3 million in 1998. China's own Great Wall and Founder are keeping pace with Acer Suzhou, and they expect to produce about 500,000 units each in 1998. Although Founder initiated production at a new facility in 1997, Founder Likang Technology Co., its major facility is in Dongguan. The company expects to ramp Likang quickly and match Dongguan in unit output in 1998. LG Electronics Inc. will move away from monitor production at its Shenyang facility and produce consumer products, presumably TV monitors. Samsung Electronics Company Ltd., also in Shenyang, plans to utilize its operations for more sales and distribution rather than monitor production.

Rigid Disk Drives

Seagate (Shenzhen) International Technology Company Ltd.'s 1997 production fell short of its projection but reached 2.5 million units in 1997 and is expected to reach 3 million units in 1998. Production at Seagate (Wuxi) International Technology Company Ltd. met expectations with 2.8 million drives in 1997. It raised its target for 1998 to 4 million units. Combined production is expected grow 32 percent to 7 million units in 1998.

Page Printers

China's 51,100-unit page printer industry is small and has yet to experience a boom many have been waiting for following the computer boom. Dataquest forecasts 45 percent growth, or 74,200 units, in 1998. Imported products are strongly preferred by Chinese users, and formidable competition by any local companies has yet to emerge because of tight technology controls by foreign manufacturers.

Consumer Electronics Manufacturers

Dataquest's survey covered approximately 23 percent of China/Hong Kong's consumer electronic production revenue, as shown in Figure 1. This is the only segment that outperformed its August 1997 expectations for annual growth. In August, surveyed manufacturers of eight products (camcorders, color televisions, stereos, radios, video compact disc players, VCRs, and video games), indicated a 55 percent average growth for 1997. However, since that time, a flurry of VCD manufacturers have entered the market. Dataquest surveyed and estimated these companies in February, which explains the production increase.

But from VCDs to color televisions, there is a wide variance of opinion among consumer electronics manufacturers. As the oldest sector, a large number of companies are inefficient, state-owned enterprises that are going through major restructuring. On the other hand, economic growth has raised disposable income levels and spurred spending on stereos, televisions, and appliances—even in remote rural areas. And still, opportunities for new technologies and standards are ripe, irrespective of worldwide standards, making the case for the VCD-consumption boom in China.

Color Televisions

Color television production, the pillar of China's consumer electronics, expanded by about 10 percent in 1997. Based on manufacturers' input, the color TV industry will accelerate to 15 percent. The top 10 producers' expansion plans remain aggressive. However, such growth will be difficult to achieve because of high inventory levels, inexpensive Korean imports that are beginning to enter the Chinese market, and an anticipated economic slowdown in 1998 to between 7 percent and 8 percent, relative to 1997 levels of 8 percent to 9 percent.

Leading the optimists in 1998 is Sichuan Changhong Electric Appliances Company Ltd., which boasts that it will expand production by 31 percent to reach 8 million units. Dataquest's China research staff believes that inventories have risen dramatically in recent months to as high as 1 million units. What could potentially exacerbate the problem is the fact that Korean-made television prices are falling. If these TV sets start to meet Chinese-made price points, then consumers could gradually start to buy Korean. Until now, the market has been strongly segmented with Japanese-made brands dominating the high-end market and Chinese-made products popular with the value-conscious buyers.

Video Compact Discs

Dataquest estimates the VCD industry to produce 15 million to 16 million units in 1998, which is equal to two-thirds of the number of TV sets produced in China. Production is concentrated in the top 10 manufacturers that account for about 75 percent of production, and it is expected to grow 61 percent over 1997. Changhong has recently entered the foray of manufacturers and has made significant investments in an attempt to lead this industry by the end of 1998. It expects to expand output from 400,000 units in 1997 to 3 million sets in 1998. Last year, Changhong had forecast 2.2 million sets for 1998 and has raised its forecast to 3 million units, apparently becoming increasingly optimistic about its prospects for success. The company has been working closely with C-Cube Microsystems Inc. Competition is fierce in this cut-throat, price-sensitive business. The VCD system designs are readily available and mechanical parts are readily copied by competitors. Electronics technologies are also readily available from the plethora of foreign partners with facilities such as LG Electronics, Philips Electronics NV, Samsung, and Sharp Electronics Corporation.

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Videocassette/Tape Recorders

There was little good news from VCR manufacturers that sell products in China mainly because of the adoption of VCDs. Dataquest expects consolidation among local manufacturers. But because this industry is dominated by five manufacturers that export most of their production, the overall industry appears to be growing. The combined production of Shanghai Lejing Guangdian Electronics Company, Hualu Matsushita VCR Co. Ltd., Xiaxin Electronics Co. Ltd., Tianjin Samsung Electronics Ltd., and Shenzhen Huangqiang Sanyo Electronics Co. Ltd. reached 1.9 million units in 1997 and is expected to reach 2.2 million units in 1998.

Communications Equipment Manufacturers

The communications segment did not meet manufacturers' expectations in 1997. The companies surveyed accounted for 41 percent of communications production revenue in 1997. After several years of impressive growth, these companies' average expected growth in production was 37 percent. The February estimates indicate only 15 percent growth in revenue as shown in Figure 3. Central-office equipment and mobile-communications-infrastructure equipment are two categories that met expectations, expanding about 41 percent and 40 percent, respectively. In 1997, all other sectors grew less than was forecast. The most dramatic surprise to the market was the falloff in the pager market.

Pagers

Motorola, Matsushita Communications Industry Co. Ltd., and TCL/NEC, for example, had planned to expand production from 5.5 million units in 1996 to 7.8 million pagers in 1997. Dataquest's preliminary estimates show the actual 1997 number to be 6.1 million units, a meager 10 percent growth. As the largest producer, Motorola's two plans were impacted the hardest. The Motorola (China) Electronics Ltd. in Tianjin expanded by about 11 percent, while Shanghai Motorola Paging Products Co. Ltd. remained flat at about 1 million units. The manufacturers' goal is to expand production by more than 17 percent, and they are presumably looking to an export-demand boost. One of the main reasons for the pager-production decline was the widespread adoption of cellular phones in China as a substitute product.

Cellular Handsets

Dataquest estimates that China's top six cellular phone manufacturers produced about 500,000 more phones than originally planned in 1997. Total production of Ericsson, Matsushita, Motorola, NEC Corporation, Nokia Telecommunications, and Siemens AG reached 2.2 million sets in 1997, a growth of 70 percent over 1996. Motorola's Hangzhou and Tianjin plants accounted for approximately 1.2 million units according to company reports; the company plans to reach 1.5 million units in 1998. These six manufacturers plan to expand production of cellular handsets by 21 percent in 1998.

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Party Congress Meeting in March Contributes to Short-Term Uncertainty in the Electronics Industry

We hear and read about government's and large manufacturers' optimism on China's electronics industry. However, the uncertainty as to how the government's vision will play out in practice is causing widespread concern, especially among the Chinese companies. The government is showing signs that it will accelerate its ambitious plans to adopt information technology to modernize public and business sectors and to support "localization" of technology. There is no major slowdown in telecommunications deals being signed at central and provincial levels of government. In February, the Guangdong Post and Telecommunications Authority (GPTA) signed a $34 million networking deal with Newbridge Networks Corp. In other areas relating to manufacturing, however, projects appear to be more carefully viewed and delayed as the state-run enterprises are being restructured. The Communist Party Congress meeting in March further raises the prospects of change and short-term uncertainty, contributing to the very cautious business environment.

Large Chinese manufacturers also express optimism, echoing the government's advocates of IT spending. But information from component suppliers tells a different story. Planning managers are also cutting inventories and planning conservatively. This caution is partly attributed to uncertainty in how government restructuring of state-owned enterprises will affect the specific industry. Adding to business planners' concerns are the Asian financial crisis' effects on exports and the Chinese economy's performance in 1998. As discussed earlier, one immediate effect of the financial crisis has been the inexpensive Korean televisions competing with Chinese products in the low-cost segment of the market.

Manufacturing Trends: Subcontracting Reconsidered

Because foreign-owned manufacturers tend to export the majority of their production and, in general, do not procure semiconductors locally, this sector continues to expand. These entities tend to export the majority of their production and do not have localized procurement.

Dataquest has yet to see any sign that foreign manufacturers are abandoning or changing their investment strategy radically in China. Most of their existing plans are long-term and are unlikely to be affected by the Asian financial crisis. As for new investments—whether to invest in new plants in China or Southeast Asia—the uncertainty within China's political systems poses significant risk. Investment policies and the financial system are undergoing radical change, so new investors in the region are reticent. On the other hand, companies with existing facilities and capital are able to expand production and benefit from the lower exchange rates.

Dataquest believes the foreign investors' tactical changes within China to be more significant. Foreign manufacturers are faced with various investment model options when setting up operations in China. The once-popular model to fully localize management and operations has proved less effective than hybrid variations that are now evolving. Cost controls, intellectual property, and material costs are key business concerns for foreign manufacturers in China. In new technology areas such as PCs and VCDs, intellectual property is the foreign manufacturers' only competitive advantage because manufacturing costs are comparable in each sector. How to control these assets is increasingly important. Therefore, foreign companies once believed that operating their own facility would give them maximum control and, therefore, the biggest cost advantage.

Dataquest believes that a more cost-effective model will emerge, and that this model is subcontracting. Multinational companies (MNCs) can avoid huge setup costs, government regulations, and heavy taxation by using a subcontractor. And the long-term advantage is increased competition among local manufacturers, which benefits the original equipment manufacturers (OEMs). The possibility of losing intellectual property to one's subcontractor was feared previously, and that was the reason for setting up a fully owned operation. However, MNCs are finding that full ownership does not guarantee full control because there is a high turnover of key, senior staff and company-critical information often goes with these departing staff.

The OEMs appear to be devising better ways to control intellectual property (IP), which is making subcontracting an increasingly viable alternative to full-ownership production in China. Both full ownership and subcontracting have risks, but the risk/benefit of subcontracting is improving. A beneficial approach is through inventory management.

In a fully owned subsidiary or joint-venture company, oftentimes, operational, financial, R&D, and supplier information are divulged to the management team in China. When middle and upper managers leave, they not only have the OEM's board designs and manufacturing processes, but speedy access to key components and support. In a subcontractor relationship, the power shifts back to the OEM, which can negotiate for the lowest-possible cost between competitors. Key components and access to suppliers is controlled by the OEM that centrally purchases and warehouses components. Each component can be accounted for with each unit of finished good that is shipped. This may not halt the loss of IP but it may lengthen the time necessary for competitors to reverse engineer, produce, and mass market. With total control of parts and purchasing, a subcontractor in China is impaired long enough for the OEM to phase out its product and start producing its next generation of products.

Dataquest Perspective

Dataquest's survey of manufacturers in China represented 30 percent of electronic equipment production, 28 percent of data processing, 41 percent of communications, and 23 percent of consumer electronics. At an aggregate level, companies surveyed met their expected growth of 51 percent in 1997. The high level of growth, spurred primarily by foreign manufacturers, had begun to slow prior to the Asian financial crisis. Despite the recent turmoil, these companies anticipate a healthy average 30 percent growth in 1998. The manufacturing of many products will far exceed the average, but that will struggle to match 1997's production levels. The manufacturing environment, like the market, is very dynamic. Companies continue to change and adopt new operation models to deal with these forces. At the same time, the central government will continue to exert a huge influence on industry growth until the state-owned sector can begin to stand on its own.

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Perspective

Semiconductors China

Market Analysis

China's Economic Outlook: Assessing Asia/Pacific's Financial Crisis on Growth

Abstract: *Watching the unfolding of Asia/Pacific's economic events, Dataquest sees China weathering the storm better than its neighbors. But to what extent will cheaper exports from the rest of Asia/Pacific impact semiconductor consumption in China? Dataquest highlights its economic assumptions for 1998 as the baseline for the formal forecast of China's electronic equipment production. Dataquest also assesses the impact of this financial crisis on China.*
By Daniel Heyler

An Outlook

In this Perspective, Dataquest presents its economic assumptions for China, prior to the formal electronics production and semiconductor consumption forecasts scheduled in March and April. The recent rise of risk and uncertainty as a result of Asia's financial crisis (AFC) has led to questions and concerns from clients about China. In this Perspective, Dataquest analyzes the effect of the currency crisis and discusses China's key economic indicators and growth outlook as they relate to electronics production. Dataquest then provides a qualitative analysis of electronics and semiconductors production, in addition to providing a qualitative analysis of the currency crisis's potential impact on electronic equipment production in China. But first, several key conclusions of this Perspective are summarized as follows:

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- China has been immune from the Asian currency crisis because of the structural difference of its economy and immaturity of its financial markets. While exports have been falling in Southeast Asia, China's exports have surged. China's trade strength also contributes to this crisis.

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- Problems with bad loans in China are *not* as serious as elsewhere in Asia because China's loans are made by Chinese banks to Chinese companies within a nonconvertible monetary system. By staying on the current course of economic growth and reform, the Chinese government is capable of working through its financial problems. In addition, China's financial markets are too small and tightly controlled to become a target of international speculators, who are busy elsewhere. So China's U.S.$120 billion foreign reserves are available to the government to assist local banks and continue the rapid pace of reforms, albeit now more cautiously.
- Dataquest expects new foreign investments in China to decline in 1998 due to the both Asia's financial crisis and production overcapacity in 1997. Investments from foreign companies have been the key driver to growth in China's electronic equipment industry, especially in the past four years. These investments have resulted in high export growth that represented more than 70 percent of electronics output in 1995. In 1997, Dataquest estimates electronic equipment exports reached $26 billion, or 62 percent of total production. Large investments continued in 1997, which boosted multinational companies' electronic production capacity by more than 40 percent. With plentiful capacity and the threat of goods from other countries flooding the global market, multinationals have little need or incentive to expand capacity in China.
- Dataquest does not expect a slowdown in strategic investments that are the primary purpose of developing the Chinese markets. Investments targeting market expansion within China may, in fact, increase as multinational equipment vendors turn to China to compensate for market losses in Southeast Asia and Korea. In January, one of the most unstable months in Asia, Motorola Incorporated announced an integrated smart card system development/manufacturing joint venture. In semiconductors, Dataquest sees that MEMC Electronic Materials Inc. is planning to build a silicon plant in China.
- Dataquest expects the impact of weaker exports from China to reduce electronic equipment production by $1.2 billion in 1998 and $2.8 billion by 1999.
- Assuming semiconductor contents of 15.8 percent in 1998 and 17.5 percent in 1999, weaker exports translate into $189 million and $496 million in lower semiconductor consumption, respectively. The top-line growth would then be 20 percent in 1998 and 27 percent in 1999. Dataquest's last formal forecast estimated 23 percent growth in 1998 and 31 percent in 1999, respectively—a loss of 3 percentage points in 1998 and 4 percentage points in 1999.

Year of the Tiger: A Meow or a Roar for GDP?

Key economic data suggests that China will be able to sustain strong economic growth, although its Asian neighbors will face a downturn caused by high interest rates and a weak consumer purchasing power. Dataquest presents the economic assumptions for China and its view of the Asian financial crisis on China following the forecast.

China is the only major economy in Asia/Pacific that has not been hurt by the Asian financial turmoil during the past five months. However, economic growth slowed to about 8 percent during the second half of 1997 from 9.5 percent in the first half, due in part to slower industrial output and domestic consumption. Industrial production declined from 15 percent in 1996 to 10 percent in 1997 because of the consolidation of money-losing, state-run enterprises. The good news for the economy was that inflation dropped from an expected 10 percent to 3.8 percent (see Table 1).

Another factor behind the slowdown was that direct foreign investments increased only 8 percent in 1997. The planned, approved investments for 1998 dropped by about 40 percent. The slowdown in economic growth, combined with declining investments, has caused Beijing to cut or extend import tariffs on equipment. The second initiative in 1998 is to finance state-owned enterprise reform through government treasury bonds and to relax their tax burden. These factors also have resulted in a lower consensus forecast for gross domestic product (GDP) growth in 1998 and 1999. Previous expectations for 1998 GDP growth has been lowered from 11 percent (with high inflation) to 8.7 percent (with low inflation), with an 8.5 percent (with low inflation) in 1999.

Exports Face Threat in the Second Half of 1998

Although China is a large country and its economy has exhibited remarkable change and growth, the role of exports has been a critical element of growth. China's largest trading partner is the United States, which accounts for

Table 1
Key Economic Data and Forecast Assumptions for China, 1995 to 1999

	1995	1996	1997	Forecast 1998	Forecast 1999
GDP Growth Rate (%)	13.5	10.5	9.3	8.7	8.5
Industrial Production Growth (%)	16.1	15.0	11.2	10.0	10.0
Consumer Price Change (%)	17.1	8.3	3.8	5.2	5.7
RMB to Dollar Exchange Rate	NA	8.3	8.3	8.4	8.5
Merchandised Exports (U.S.$B)	148.8	151.1	150.0	159.9	172.0
Merchandised Imports	132.1	138.8	127.0	142.6	159.7
Trade Surplus	16.7	12.3	23.0	17.3	12.3
Electronics Domestic Exports	20.9	24.0	30.0	27.5	25.0
Real GDP (U.S.$B)	555.0	654	767.0	842.0	921.0
Current Accounts Balance (U.S.$B)	1.6	3.2	7.8	7.9	7.8
International Reserves (U.S.$B)	80.3	110.7	120.0	128.0	137.0
Population (M)	1,221.0	1,236.0	1,250.0	1,264.0	1,278.0
Gross Domestic Investment (% of GDP)	41.2	40.4	40.4	39.5	NA
Gross Domestic Savings (% of GDP)	41.5	39.5	38.5	38.5	NA

Source: Dataquest (February 1998) and several banks

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approximately 15 percent of China's total worldwide trade. Trade with the United States increased by a healthy 14 percent in 1997.

There is good news and bad news for China on the export front in 1998. The good news is that exports were much higher than anticipated in 1997. The bad news is that China will be negatively impacted by the currency crisis in other Asian countries. Many of the goods produced in Southeast Asia are also produced in China, so devaluation directly affects the overall trade. Dataquest had forecast a smaller trade surplus than China achieved in 1997, but China's strong performance was related to a fall in imports rather than a surge in exports. Merchandised export growth was flat in 1996 (at 1.5 percent) but accelerated to 15 percent in 1997. At the same time, Chinese imports did not rise as quickly; they grew 5 percent in 1996 and declined by 8.5 percent in 1997.

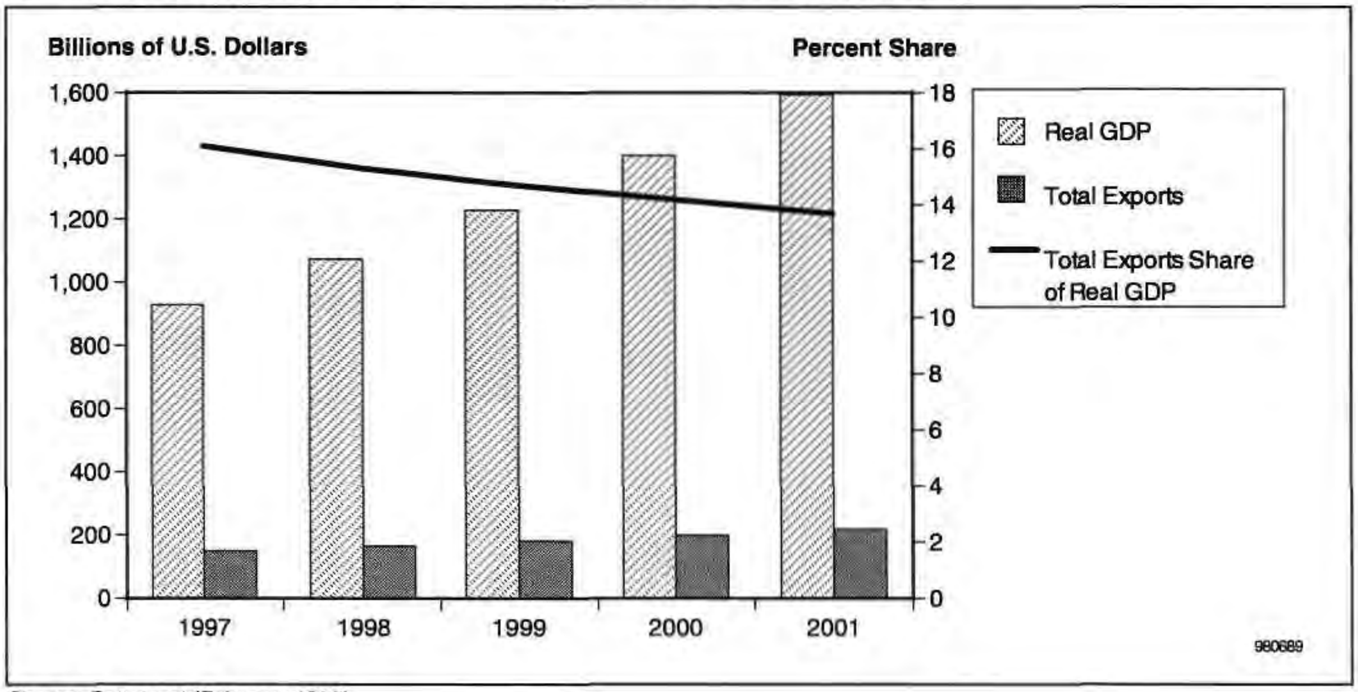
As shown in Figure 1, exports represent about 16 percent of China's GDP. Unlike most other Asian economic "miracles," China's growth has been a balance of domestic consumption and export growth, as previously mentioned. This balance will give China an advantage over the long run, especially since the sheer size of the economy is expected double in real terms to $1.6 trillion in 2001. Consistent with Dataquest's views of electronic production, economists also believe that exports will fall as a percent of GDP due to robust domestic consumption. In short, currency devaluation in other parts of Asia will affect economic growth in China, but the country is far less vulnerable than other Asia/Pacific countries. Figure 2 illustrates China's trade balance from 1995 to 1999.

Asia's Financial Crisis: Is China the Next Prey?

At a worldwide level, the pause in the Asia/Pacific region's breakneck economic growth is assumed by Dataquest to have a direct impact on consumer and business electronics purchases within Asia/Pacific. This situation will directly impact equipment companies selling in Asia/Pacific. For this main reason, Dataquest anticipates a lower semiconductor consumption at a worldwide level than was forecast in October 1997, since Asia/Pacific accounts for approximately one-fifth of all electronics consumed in the world. Asia/Pacific's electronic companies have the most to lose from a market slowdown because they have the largest share of production sold within the region.

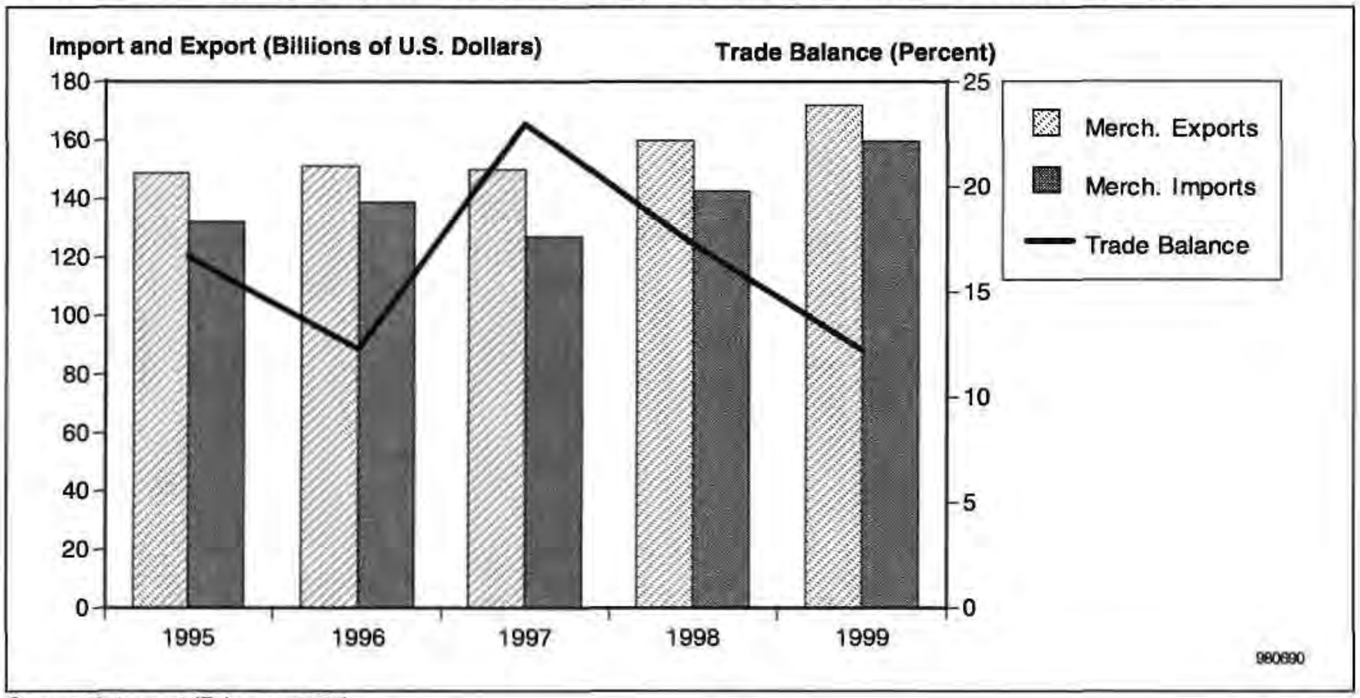
However, what has been dubbed the "Asian financial crisis" has yet to include China, which accounts for half of Asia's population, one-fifth of electronic equipment production, and one-fourth of semiconductor consumption. (Dataquest uses the term "Asia's financial crisis" for simplicity

Figure 1
China's Real GDP and Merchandise Exports (Billions of U.S. Dollars)



Source: Dataquest (February 1998)

Figure 2
China's Imports, Exports, and Trade Balance, 1995 to 1999 (Billions of U.S. Dollars)



Source: Dataquest (February 1998)

sake to describe the recent fall in once-pegged currencies that have weakened Asia's financial systems and economic growth.) Chinese manufacturers still benefit from the robust local market and are negligibly affected by decreased exports to Asia/Pacific countries. To what extent multinational companies that export most of their products may reduce expenditures in China is also examined in this Perspective.

The question is not whether China will devalue its currency, but when. Currently, the government adamantly denies any inclination to devalue its currency (such words would put more devaluation pressure on other Asian currencies, thus impacting the Hong Kong peg). China is not immune from currency speculators, but its lack of large financial markets makes it unattractive to speculators. It is not yet relevant to compare China to other Asian countries. China has a completely different set of economic and financial issues because the Chinese economy is still at an early stage of economic development (at least 10 years behind Thailand and Malaysia and 20 years behind Taiwan, South Korea, and Singapore). China may not follow the same pattern as other countries in the near term. Because China does not have a convertible currency, it is more difficult to ascertain whether the currency is overvalued or undervalued. One can look to the black market to see what traders are charging for U.S. dollars; the current rate has been edging up to RMB 8.8 to the dollar, compared to the official rate of RMB 8.32.

There is little doubt that China's exports will be hurt by devalued currencies in the rest of Asia, but from which consequence and to what extend is less clear. China's largest investors are from within Asia/Pacific itself. Companies have been accelerating investments due to rising costs in their own countries and inexpensive operating costs in China. There is less reason to invest in China other than for the local market. So Dataquest believes that China's RMB will be devalued, but when the government does this depends whether exports can continue to grow and how critical exports are to maintaining strong economic growth. If local consumption continues its lackluster growth, for instance, then unemployment could rise, causing the government to emphasize export-driven economic growth. China has shown restraint in exacerbating the current crisis and is treading carefully in the early stages of this crisis.

AFC's Effects on Electronic Equipment Production

Dataquest believes that the key issues of the crisis are as follows:

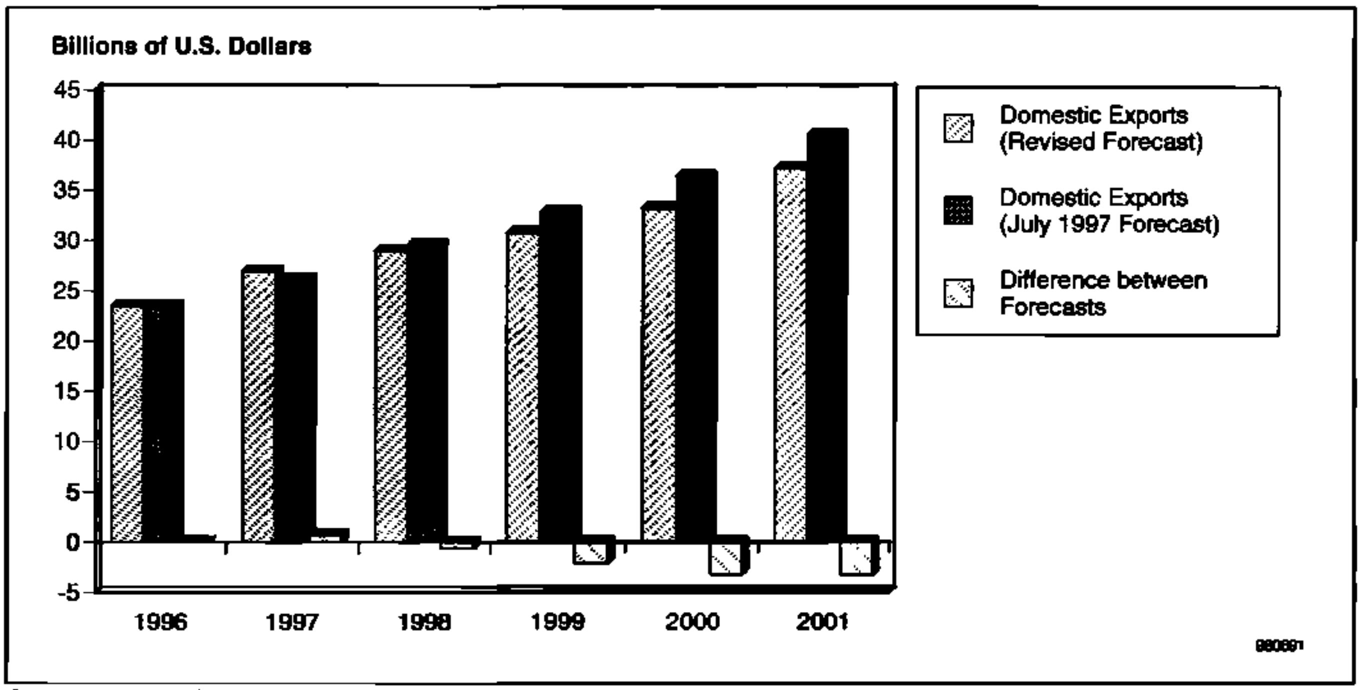
- As a competitor, will China's cost advantage be overtaken by Southeast Asian countries' lower exchange rates?
- To what extend will Southeast Asia's slower economic growth and weaker currencies negatively affect China's exports?
- Investments to China have outpaced all other regions within Asia/Pacific the past few years. Will China lose factory investments to Southeast Asia?

The lion's share of China's electronic equipment exports are produced by the multinational corporations (MNCs) or joint ventures within China and shipped to Europe, Japan, the United States, and Southeast Asia. Dataquest does not anticipate MNCs making a radical shift in production to other facilities in Southeast Asia and displace China-based production in the short term. Manufacturers are taking a wait-and-see attitude because China could easily devalue its currency to make exports more competitive. In the short run, it is not feasible from a logistics standpoint to shift production quickly to other facilities. Additionally, the majority of production costs for MNCs is fixed costs (such as plant and equipment) rather than variable costs (such as labor). Since the largest portion of costs is components that are predominantly imported by Asian countries, Southeast Asia's cheaper export currency means higher import costs (as well as debt-servicing costs). In sum, Southeast Asian manufacturers may gain from weaker currencies, but this likelihood should not be overstated because costs may also rise.

Since currency devaluation's short-term effects are not likely to be huge, one needs to examine its potential long-term consequences for China. Export growth in 1999 will be impacted more severely (see Figure 3). However, Dataquest can be sure that China will do what it has to do to maintain a steady economic growth, foreign investments, and manageable unemployment levels. If some Asian countries do not reform their economies and adopt an "export-or-die" mentality, China has the option to devalue its currency. The size and strength of China's export industries warrant caution among its Asian neighbors. Indeed, everyone will be watching Asia's export picture with great concern throughout 1998.

These costs can best be recovered by operating at the maximum capacity. Furthermore, most products and facilities were put in China in the first place

Figure 3
China's Electronic Equipment Exports (with AFC Effect)



Source: Dataquest (February 1998)

to take advantage of the potential or current local market opportunities. Based on these new numbers, Dataquest does not foresee a major revision in the short-term assumptions of electronic equipment exports for regional or macroeconomic reasons.

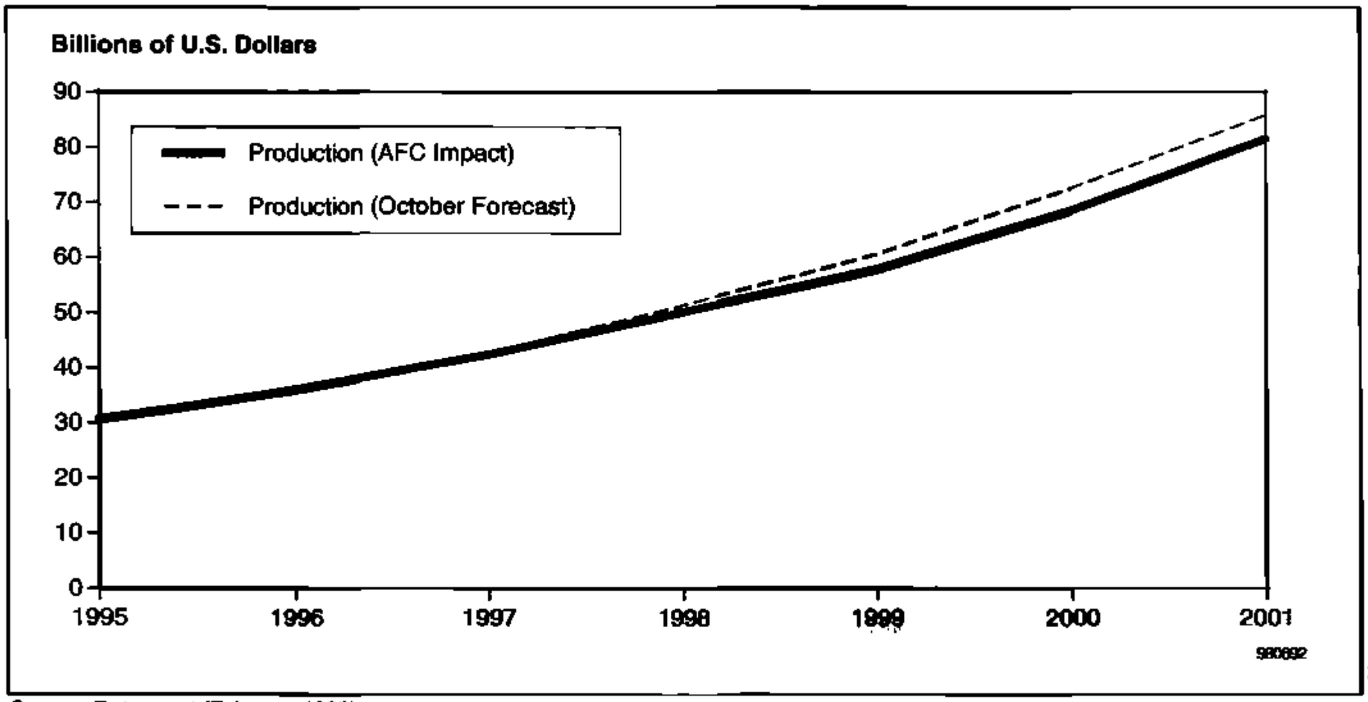
As shown in Figure 4, Dataquest expects the impact of weaker exports from China to reduce electronic equipment production by $1.2 billion in 1998 and $2.8 billion by 1999. Assuming a semiconductor content of 15.8 percent in 1998 and 17.5 percent in 1999, weaker exports translate into $189 million and $496 million in lower semiconductor consumption, respectively. The top-line growth would then be 20 percent in 1998 and 27 percent in 1999. Dataquest's last formal forecast estimated a 23 percent growth in 1998 and 31 percent in 1999, respectively—a loss of 3 percentage points in 1998 and 4 percentage points in 1999.

Dataquest's research shows that electronic equipment production's overcapacity became apparent in 1997. Dataquest does not view this situation as a high risk for these investments because some investors may believe that Southeast Asia can easily ramp up capacity. The region's local companies are in no financial position to make large capital equipment purchases to steal market share from the Chinese companies. Chinese companies are impacted only as far as their exports to Southeast Asia will be reduced due to lower economic growth there.

Multinational Investments Cut in 1998

On another level, comparing multinational companies in China with those in Southeast Asia is appropriate to developing some conclusions on this

Figure 4
China's Electronic Production (with AFC Effect)



Source: Dataquest (February 1998)

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segment. To conclude that this market segment will be hurt by the financial crisis is to assume that multinationals will reduce production in China and increase production of the same goods in other facilities. There may be cases when this situation occurs, but various factors make such moves impractical.

The investments made in China are strategically different from those made in Southeast Asia. Shifting production from China to Southeast Asia as a currency hedge does not conclusively lower costs, assuming that such a logistical move is even feasible in the first place. Many companies that target global exports invest in Southeast Asia instead of China. Southeast Asia has offered much more transparent investment regulations, tax holidays, and government support than China during the past two decades. Worldwide capital-intensive investments have tended to migrate to Southeast Asia due to its securer infrastructure than in China. While there have been high-end, globally exporting facilities in China (for example, Motorola Incorporated's pagers, and Seagate Technology Inc.'s disk drives), the overwhelming majority of production facilities is located in Southeast Asia.

Multinational companies' (that is, electronic equipment companies) still look to China as a production site either exclusively or primarily to develop sales channels and relationships within China's complex socialist economy. (Data shows that companies with production facilities in China are more successful and sell more.) For this reason, joint-venture agreements between foreign and Chinese partners represent the lion's share of electronic equipment production.

Dataquest highlights China as the beneficiary of an emerging domestic market as well as export competitiveness that provides a strong economic base over the long term, compared to the export-dependent economies in Asia. China's rapid electronics consumption growth has been tied to strong business growth and to the development of a middle class in urban areas. Disposable income is rising faster in China than in any other Asian countries. Average annual income for urban families has increase fivefold since 1985 to nearly RMB 5,000 (about 300 million Chinese live in cities). These are long-term manufacturing strategies that will not be abandoned in an attempt to gain from short-term currency gains. Furthermore, the Chinese government could devalue its currency any day to compete with Southeast Asia. It has done so in the past and is expected to do so in 1999. Dataquest believes that multinational electronic equipment companies in China will ride out the crisis. Market-focused investments will continue in line with rapid market growth. However, the short-term ride will be bumpy because export-oriented investments will stall until the Southeast Asian economies stabilize.

Chinese Electronics Companies Face Export Challenges

Dataquest turns the assessment of potential market threats to Chinese companies. Dataquest's research indicates that approximately 40 percent of semiconductor consumption (in revenue terms) comes from Chinese-owned enterprises. The currency crisis in Asia is likely to cause Beijing to reassess either its goals or its strategies to build Chinese electronic conglomerates from export prowess.

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After years of failed government policies and protectionism, a flurry of successful domestic companies have emerged in the areas of computers, consumer electronics, and telecommunications. A new model for development has emerged from Beijing as a result, and that is to consolidate smaller, unprofitable companies or allow them to be merged by these leading companies. The next step is to support these manufacturers and motivate them to export globally. For example, the Legend Group has moved its headquarters to Hong Kong to implement this strategy. Konka successfully exported color televisions from its facility in southern China.

Countless others were aggressively following their government's lead by developing strategies to boost their exports. The rationale is that for China to enter the World Trade Organization (WTO), it will have to open its markets. If companies cannot compete in foreign markets, then how will they be able to compete against these same companies in China? Dataquest believes that the currency crisis did not seriously hurt the leading manufacturers because they, as a whole, rely on their domestic market. The crisis will, however, slow the implementation of this initiative until new competitive dynamics emerge. For now, the Ministry of Electronics has placed public emphasis on companies to maintaining strong share in the domestic markets, presumably in preparing for weakened export growth this year.

Government Response

One cannot forecast government policy. Dataquest can make some educated guesses based on past behavior and understand the issues facing policymakers. Already, Dataquest hears about a change in emphasis from China's influential Ministry of Electronics (MEI) due to this currency turmoil.

Several months before the Asian currency crisis, MEI officials expressed a need for China's large domestic companies to position themselves for export competitiveness. The thinking was that if domestic companies could compete internationally, then they could complete domestically. Domestic competitiveness will be a necessity if China begins to open its markets with the intention of entering the WTO.

Led by the electronics, China's manufacturing sector has been expanding by 15 percent during the past several years, primarily because of economic reforms and foreign investments. However, inefficiencies in the unreformed, state-owned enterprises have plagued the economy, exacerbating corruption and income disparities. Accelerating growth in electronics production has come from foreign manufacturers that export the majority of production as well as domestic manufacturers that now compete against foreign brands within China. Exporters benefited when China devalued its currency several years ago, taking away the market share from Southeast Asia and spurring investments from Taiwan, Korea, and elsewhere.

In 1997, China's exports soared 20 percent. However, with Asian currencies now cheaper, Dataquest expects a slowdown in investments from the multinationals and a diversion of investments to southeast Asia during the

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next few years. China's currency is nonconvertible and the government *could* conveniently take this opportunity to devalue to help exports. But China is showing restraint and is avoiding the aggravation of Southeast Asia's problems. If China can continue to grow its domestic economy and reform its industries, it can delay or even avoid devaluing the Renminbi, which will positively impact the rest of Asia. However, a domestic consumption slowdown and a serious unemployment rise will cause the leadership to turn to the export front to save the economy.

What about Hong Kong?

The cost of Hong Kong maintaining its pegged currency will be higher interest rates and slower economic growth. The upside will be the lower costs of doing business in Hong Kong and southern China. As China's main semiconductor supply channel, lower costs in Hong Kong benefit almost all semiconductor suppliers over the long run (rents alone have declined 20 percent to 30 percent in three months and are still falling). Labor markets have loosened and inflation is down, and salary pressures have been relaxed. Hong Kong's GDP is expected to increase 4.5 percent in 1998 compared to 5.6 percent in 1997. Consumer prices' increases are expected to decelerate from 6 percent in 1997 to 5.5 percent in 1998. And, Dataquest agrees with the consensus that the Hong Kong peg will remain in place through 1999.

Dataquest Perspective

The "Year of the Tiger" will indeed be one of the most interesting since China's Tiananmen Square incident shocked Asia and the rest of the world. The currency crisis's influences on electronic equipment companies in China is multifaceted. The largest and the most important segment of semiconductor demand comes from foreign companies operating in China. Dataquest estimates that nearly 60 percent of China's semiconductor demand (in dollar terms) came from multinational and joint-venture enterprises in 1997. Multinational companies' investments in China have been the main impetus to high semiconductor demand growth. China has outpaced the rest of Asia during the past five years and surpassed Taiwan to become the largest semiconductor market in Asia/Pacific in 1996.

Dataquest's discussion of economic factors and the effect of Asia's currency crisis centers on two main issues affecting semiconductor demand. First, multinationals have invested in production facilities within China primarily for export or domestic shipment. Second, Chinese-owned (domestic) companies have the largest stake in the local markets and, conversely, export a smaller share of their output than the multinationals. For these companies, local demand is important because the majority of production is shipped locally rather than exported globally.

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Perspective

Semiconductors China

Market Analysis

Movers, Shakers, and Key Events in China and Hong Kong in 1997

Abstract: *The year 1997 proved to be pivotal for China and Hong Kong from several perspectives. Dataquest has compiled key events' summary and perspective of their effects on the semiconductor markets and industries in China and Hong Kong.*
By Daniel Heyler

Overview

Dataquest sees 1997 as a year of impressive achievements but is uncertain as to how 1997 will affect 1998 and the years ahead.

The smooth handover of Hong Kong from British to Chinese rule enabled both economies to maintain impressive growth with record-low inflation and ensured foreign investments continue to flow into the region, outpacing most other Asian countries. Multinational investments in electronic equipment production continued to surge after explosive growth in 1996, and end-equipment markets such as PCs and VCDs exceeded expectations while pagers missed the mark, and numerous semiconductor companies restructured their business strategies in China with the establishment of assembly/text, wafer fab, design, or direct sales operations. Most companies across the entire semiconductor food chain expressed a strong intent to ensure their long-term position in Asia/Pacific's largest, fastest-growing semiconductor market. Dataquest has summarized companies or branches of the Chinese bureaucracy that made significant announcements in 1997.

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First Quarter

Shenzhen Government Promotes Its Own VLSI Project, Countering Shanghai's Recent Moves

In January, sources in China reported that Zhongxingxin Telecom Equipment Ltd. and Kaifa Group have formed a consortium to raise U.S.$1.2 billion to U.S.$1.4 billion to establish a semiconductor wafer fab in Shenzhen's Futian Free Trade Zone. The project aims to establish a production base for 0.25-to-0.5-micron technology with an estimated monthly capacity of 20,000 8-inch wafers per month.

The Shenzhen/HK VLSI project was actually approved in 1991 by the Central Government's State Planning Commission (SPC), but the project continued to take many twists and turns. Phase 1 of the project was to establish a back-end facility and Phase 2 aimed at setting up a front-end fab. The main objective was to raise the ratio of domestically produced integrated circuits (ICs) used in telecommunications switching and computers. SGS-Thomson Microelectronics B.V. (owning 60 percent) and the Shenzhen local government (owning 40 percent) have cooperated to establish an assembly test facility (now in pilot production) and design center. This latest announcement raises the price tag and technology level of Phase 2 in an attempt to hasten the project, especially because Shanghai's front-end project (also sanctioned by SPC) is progressing faster. The main barrier in both project remains which side, foreign partner or Chinese government, will control the operations, finance, and management of the semiconductor company.

C-Cube Enters Alliance with Subcor (China) to Mass-Produce VCDs

C-Cube Microsystems Inc. announced that it entered a strategic alliance with one of China's largest consumer electronics manufacturer, Subor Video and Audeo Equipment Co. Ltd. Subor will use C-Cube's decoder technology in its line of video compact disc (VCD) players and will stamp C-Cube's brand name on every VCD to be sold.

Subor was the third-major Chinese manufacturer to enter a branding and manufacturing agreement with C-Cube in China. Two other Chinese partners included Idall and Changhong Electronics Group Co. Other Asian manufacturers included Hyundai Electronics Company Ltd. in Korea and Aiwa in Japan. C-Cube's high level of integration and advanced feature-set has translated into surging sales growth within China, which Dataquest estimates to be the largest VCDs market currently in the world in 1997.

This recent alliance was prompted by an opportunity for high-growth demand in China for VCD players. The quick attraction to the VCD in China has been its low cost, high quality (C-Cube's ClearView technology based on MPEG1), the ability to read all VCD titles universally, and the availability of cheap VCD titles.

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Sino-Lucent Technologies' Joint Venture Receives DNV ISO9001 Quality Certification: Company Agrees to Transfers 5ESS-2000 Technology

One of the major international quality system certification agencies, DNV, certified Lucent Technologies Qingdao Telecom Equipment Ltd. as an ISO9001 factory. The facility's capacity is approximately 1.5 million lines per year. The joint venture was founded in 1995 and has sold more than 2 million lines of its 5ESS-2000 switch gears in China, according to Lucent. Located in a high-technology zone in Qingdao, the venture involves a joint investment of $100 million from Lucent Technologies and four other Chinese partners.

Qingdao may become famous now for more things than its world renowned export of "Tsingdao Beer." Lucent is the city's largest joint venture so far and a first-rate facility. This is the largest manufacturing center for program-controlled switch gears for Lucent outside the United States. This joint venture offers two points for all industry observers to consider: (1) It is a misnomer to think of "Made in China" as necessarily poor quality. Progress through effective management and training is being made quickly and multinational companies are leading the way. In fact, Motorola Incorporated's Tianjin Pager facility received the 6-Sigma Gold Metal in 1995 as the best of all Motorola pager facilities worldwide. (2) This venture's sales success is due largely to Lucent's ability to transfer technology to China, which is always a necessary but difficult balancing act in this market. Lucent recently signed a memorandum of understanding with the State Planning Commission to transfer 5ESS-2000 technology through this joint venture.

Texas Instruments Establishes DSP Partnership

Texas Instruments Inc. of the United States said that it has agreed with Shanghai Computer Application & Industry Development Leadership Group, a municipal agency, to establish four technology centers in Shanghai.

Three of the centers will focus on digital signal processing (DSP) solutions and the fourth will handle DSP training, TI said. The centers will use TI technology to develop products suitable for the China market, including servers, switches for automatic teller machines (ATM), modems, digital cameras, and other advanced electronic products, the company said. The value of the agreement wasn't disclosed.

Second Quarter

Project 909 Announced to Bolster China's Semiconductor Industry

The Chinese government is proceeding with a national semiconductor project named the "909 Project" under its ninth five-year economics plan (1996 to 2000). This project's total investment will be 9.6 billion yuan, making it one of the biggest projects for China's electronics industry so far. A new facility is under construction in Shanghai involving 93,700 square meters of land, 62,700 square meters of building space, and 5,000 square meters of clean room. The total employees in this plant will be 700 at full operation.

The initial capital investment will be shared by the Chinese government and Shanghai City, at 52 percent and 48 percent, percent, respectively. The plant will have 20,000 8-inch wafers per month starting capacity and could handle 0.5-micron processes in the future. The new plant will produce smart card ICs, microcontrollers (MCUs), memories, and various kinds of ICs for communications equipment for OEMs or foundry. Plant construction started November 1996.

At present, China has more than 10 semiconductor production lines, which produce mostly consumer ICs, logic ICs, entry-level MCUs, and MPUs, and memory ICs. However, most of the products are not competitive in the global market. In general, production lines in China are not as well modernized as the facilities in advanced countries. The Chinese government is aware of this fact, and to improve this situation, the government has decided to invest in building the modernized plant in Shanghai.

Through this project, China will be capable of mastering the 0.5-micron process technology, and thus should be able to be involved in the 0.5-micron foundry business, which is the major requirement for foundry business in 1997. China might need to invest more to have 0.35-micron process capacity, however, which is be expected to be a major part of the foundry business in 1998. With China's participation in semiconductor competition added to Korea's and Taiwan's, the Asia/Pacific region will have three strong semiconductor countries.

Rockwell Signs Agreement with M.E.I. in China, Targets Microelectronics

Rockwell International Corporation signed an agreement with China's Ministry of Electronics to increase technical cooperation as part of the U.S. company's drive to secure a large contract for microelectronics. The agreement provides for the establishment of design centers across China to facilitate cooperation in modem and wireless communications. Rockwell's chairman said in the memorandum of understanding (MOU) with the Ministry of Electronics will "lead to greater cooperation between the Chinese government and several of Rockwell's areas."

Rockwell has invested only $50 million in China to date this year and is jockeying to expand its business in several areas in China. It would appear that Rockwell's modem chipsets for computers and faxes have potentially huge gains in China. In addition to setting up design centers to help sell Rockwell modems, Rockwell, sources in China say, is one of several companies discussing technology transfer to Huahong Semiconductor or "Project 909." The Chinese government has big goals and dollars behind Huahong (already under construction), but it lacks a partner/source of technology and management expertise. Dataquest believes that it will not be a viable semiconductor business until a long-term partner is secured.

To what other areas does the Rockwell chairman refer? A potential opportunity for Rockwell in China will be to sell its factory automation equipment that could modernize China's money-losing and bankrupt state-owned factories. Also, China's rapidly growing avionics market has influenced government officials to build a nascent aircraft industry, which is another potentially lucrative area for Rockwell. Rockwell generated about $200 million in revenue in China in 1996 and forecast sales to exceed $1 billion by 2000. To reach this business level and achieve this nationwide expansion level, Dataquest believes that Rockwell will have to increase its investments at least 10 times to $500 million and transfer technology (probably microelectronics) by the end of 1998.

HP Accelerated Joint-Venture Investments in China—Its Latest Venture to Ramp Production in May

China Hewlett-Packard Company's newest joint venture, Hewlett-Packard (China) Shanghai Jinqiao Computer Company, announced that production will begin in May. In the announcement, a U.S.-based HP vice-president stated that China had been elevated to "the most important market for Hewlett-Packard."

HP's strategy in China has been relatively successful because of its ability to secure partnership with China's central government. The China Electronic Import and Export Company, a company under the Ministry of Electronics, has a minority stake in China Hewlett-Packard. China HP reports total business revenue of $550 million in 1996 sales, primarily from HP's computer hardware businesses, such as scanners, servers, printers, and personal computers. Furthermore, CHP has aggressively invested in manufacturing joint ventures throughout China and has garnered more than 6 percent of the computer market, in part because of the success of its five joint ventures. The company has invested about $200 million during the past 18 months, but these ventures are understandably not expected to turn a profit this year. China is HP's third-largest market in Asia/Pacific, which represents about 20 percent of worldwide revenue. China is the fastest-growing market for HP in Asia/Pacific and is planned soon to become the largest.

Seagate Expected to Double Disk Drive Production in China

Seagate Technology Inc. is expanding production in China and has recently announced plans to inject $32 million into its Wuxi facility, bringing total direct investment to $52 million. Aggregate production in Wuxi was reported to be 3 million units in 1996, with about 3,300 workers employed. This investment level adds about 1,600 workers and doubles Seagate's capacity in China, which serves both local and export markets.

The new Wuxi facility is Seagate's second rigid disk drive (RDD) plant in China. The first is its Shenzhen plant that Seagate has operated for more than two years. Seagate's acquisition of Conner Peripherals Inc. enabled it to buy market share in China by acquiring Conner's Shenzhen RDD plant. It also enabled Seagate to adopt Conner's successful business model for selling in China, which Seagate has successfully expanded. Since then, the combined efforts have proved to be effective for Seagate, which now controls more than 50 percent of the market and exports for RDDs from China.

China's PC breakneck market growth has resulted in a huge increase in rigid disk drives demand. However, RDD competition is increasing for Seagate, which is attempting to hang onto its position in China's computer mass storage market. By expanding production, Seagate is leveraging its current competitive advantage in the market to combat the new market entrants. For this reason, Dataquest's current electronic equipment production forecast indicates RDD production outpacing PC production. This is because of locally produced RDDs taking market share from more expensive imported ones. By locating facilities in both southern and, now, central China, Seagate is well-positioned for serving China's high-growth coastal provinces. Another advantage of Shenzhen and Wuxi is their proximity to major shipping ports, enabling Seagate to effectively export to global markets. Both of these industry-intensive regions have relatively good infrastructures and have succeeded in attracting electronics and component suppliers.

ASMC Receives QS-9000 and Targets China's Automotive Market

Advanced Semiconductor Mfg. Corp. (ASMC), a wafer foundry company in Shanghai, announced that it had received registration under QS-9000 quality standards. QS-9000 is a comprehensive quality system developed by Chrysler, Ford, and General Motors that goes beyond ISO 9000 by requiring use of specific technical and managerial practices. ASMC is a joint venture of Philips Electronics NV (owns 38 percent), Northern Telecom Inc. or Nortel (34 percent), and Chinese institutional investors, which was set up in 1995. ASMC, which employs 470 people, now functions as a pure-play independent foundry providing subcontract manufacturing to companies outside China, mainly to Philips and Nortel.

This operation dates back to 1988, when Philips Semiconductor established a joint venture to provide semiconductors to government-run TV and radio factories in China. But the initial goals were not met, and Philips became the major customer. Less than 1 percent of ASMC's 1996 business was from mainland-based companies. However, the situation for ASMC and other component suppliers is gradually changing. (For further discussion of this issue, see the Dataquest Perspective "The Growing Importance of Electronics to China's Economy," SEMI-CH-DP-9702, in June 1997). The Chinese government is pushing companies to localize procurement rather than rely on imports, in part because of rising unemployment from unprofitable state-owned enterprises. Semiconductor companies with production in China will be the first to benefit, for two main reasons: China's electronics industry is growing at more than 20 percent per year, and semiconductors represent a high percentage of total materials costs. Dataquest expects a continuation of the current trend to set up assembly and test or wafer fabrication in China.

Also, most multinationals are aware of the long-term strategic benefits of building a reliable, local supplier base in China. As the first QS-9000 fab in China, the opportunity for ASMC to provide foundry service for General Motors, Ford, Chrysler, and other major automakers in China will be greatly increased as the big three automakers localize sourcing. ASMC plans to leverage its CMOS and bipolar production capabilities to enter the bipolar analog business. And, as ASMC expands capabilities this year, it also plans to ship direct to Nortel in China, a company that is also significantly expanding localization.

Mitsubishi Establishes Its First Direct Sales Company in China: A New Trend in China?

Mitsubishi Corporation announced the establishment of its first-direct semiconductor sales company, called Keling Electric and Machinery (Shanghai), which is part of Mitsubishi's plan to more than double its semiconductor business by 2000. In 1996, Mitsubishi shipped most of its U.S.$100 million in semiconductor products through Hong Kong into China. The company plans to ship more than $250 million by 2000 as a result of its aggressive expansion plans.

This is another sign supporting Dataquest's prediction that strong market growth in 1997 will cause semiconductor companies to expand distribution further north into China. The past five years of booming semiconductor consumption growth in China (except 1996) stemmed largely from southern provinces like Guangdong and Fujian and spread north. Consequently, the overall Chinese market for an increasing number of companies has reached high enough revenue levels to warrant the establishment of direct sales channels in China. Most foreign electronics companies initially moved to China to lower production costs, and the south provided the best cost, quality, and investment conditions for exported products. However, the high consumption growth of end equipment, particularly communications equipment, in the coastal middle and northern provinces is quickly increasing and expanding inland. Semiconductor demand is following this trend, which will result in more announcements relating to direct business. A related Mitsubishi announcement indicates the company's intention of setting up semiconductor design centers next.

As for Hong Kong's role, Dataquest believes semiconductor vendors will continue to rely heavily on Hong Kong as a key distribution point because of the continued growth in southern China, which would be fostered by the establishment of the Hong Kong Special Administrative Region (SAR) on July 1. Furthermore, for practical reasons, using Hong Kong distributors ensures payment, which often eludes mainland companies that are strapped for cash, and ensures their access to the largest semiconductor consuming region in southern China.

Third Quarter

Hong Kong Electronics Industry after the Handover

As expected, there was a wide range of reports on Hong Kong's future coming from the more than 8,000 reporters who visited Hong Kong (many for the first time) looking for a unique angle. To clarify Dataquest's position, this excerpt presents Dataquest's statistics and analysis, which were published in a Dataquest report titled "Hong Kong's Electronics Industry after the Handover" and which Dataquest hopes would provide a reality check.

To forecast Hong Kong's economic and electronics prospects, it is necessary to understand and forecast China's, because these economies have become inextricably connected through Hong Kong's investment in China. To put this point into perspective, consider that Hong Kong companies have invested some $25 billion into Chinese companies (mostly state-owned companies), compared to the United States' $13 billion investment.

With Hong Kong playing a critical role, China's economy grew by an average annual rate of 12.8 percent from 1990 to 1995, compared to the worldwide growth of only 2 percent, according to the World Bank. Hong Kong's economy expanded by 5.6 percent during the same period. In three blistering growth years, China's nominal gross domestic product (GDP) doubled from $426 billion in 1993 to an estimated $840 billion in 1996. Dataquest's research of more than 20 reputable economic forecasters shows a broad range of estimates, from 9 percent to 12 percent, for 1997 and 1998. Indeed, recent statistics confirm a modest GDP acceleration in 1997. With the current favorable global and local economic and trade conditions, this growth momentum is likely to carry into 1998. Although such growth figures are impressive, a closer look at 1996 per capita GDP by urban area illustrates that the pivotal role of Hong Kong on China's growth has moved from south to north:

- Hong Kong: U.S.$25,000
- Shenzhen: U.S.$3,400
- Shanghai: U.S.$2,100
- Beijing: U.S.$1,400
- China: U.S.$700

Recent World Bank statistics indicate that Hong Kong's economy expanded by 4.6 percent in 1996. Because of the increasing economic interdependence between China and Hong Kong, Hong Kong's growth is also forecast to accelerate to 5.6 percent in 1997 and 1998. The service sector continues to fuel Hong Kong's economy and increase its share, but manufacturing is the largest and the fastest-growing part of the mainland's economy. By no accident, China's economic expansion in the past decade has broadened Hong Kong's service sector that now supports China's industrialization. Hong Kong-based companies have provided critical links among Chinese manufacturers and imported technology and components. Hong Kong is now the source of more than two-thirds of the semiconductor components on which China depends. The Hong Kong distributors, traders, assemblers, and manufacturers have maintained the following competitive advantages in China:

- Hong Kong is Asia/Pacific's financial center and multinational bankers' China headquarters (and this is likely to be the case for at least 30 to 50 more years).
- An elaborate network and strong relationships within China's layers of red tape has developed during the past 10 years. Newcomers to the

region face barriers in directly entering the mainland and thus must go through Hong Kong companies to gain a foothold.

- Hong Kong offers timely access to global product and technology information because of its position as Asia/Pacific's media center.
- Accurate, daily semiconductor and equipment pricing data allows Hong Kong companies to supply components to China at bargain-basement prices.
- Flexible, efficient, and decentralized management allows quick market response and adaptability to China's changeable business environment.
- Varied global sourcing networks serve China's diverse and expanding telecommunications, computer, and consumer markets.

Hong Kong offers the ability to get paid. This art eludes many multinational vendors trying to sell directly to China. Most multinational vendors have neither the internal structure nor the will to work in China's high-risk, sometimes chaotic distribution systems.

China's electronic equipment production will continue to grow by an annual average of 20 percent in the next five years, and exports are playing a vital role in its expansion. Guangdong Province, which borders Hong Kong, is the largest electronics-producing region in China and is increasingly an export powerhouse of multinational factories. The trend of continuing migration of Hong Kong electronics companies to southern China will also continue to boost Guangdong's electronics production and, consequently, Hong Kong re-exports. Hong Kong's economy is more knowledge-based than any economy in Asia/Pacific, and its services sector continues to grow.

Whether Hong Kong continues its current path or takes a radically new course (which is not likely) will depend heavily on the new Hong Kong government and Beijing. With the advent of the new Hong Kong Special Administrative Region (SAR), there has been hope among industry leaders of a government-led electronics industry strategy to prevent Hong Kong's losing its manufacturing base completely to China.

Hong Kong has moved ahead of many Asian countries because of its knowledge-based economy with high numbers of valued-added businesses. It would be unwise to change this unique dynamism to a centralized model that may have suited Singapore well but has less relevance to Hong Kong. Hong Kong has thrived on its flexibility to meet China's dynamic growth. Its superb infrastructure, legal and financial system, and professional workforce make it an ideal place to set up capital-intensive, export-driven industries such as semiconductor manufacturing. However, Hong Kong has no semiconductor industry (it has only a few low-end fabs) because of the lack of government industrial planning and strategy. With other governments eagerly courting foreign investors and providing long-term policy and vision, companies are unlikely to consider Hong Kong and its laissez-faire approach to industrial development. There is hope on the horizon, and the majority of multinational electronic companies are maintaining a wait-and-

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see posture, wondering what SAR chief executive Tung Chee-hwa and Beijing will do in Hong Kong.

The Tung government will be working on a 21st-century vision of Hong Kong, which many sources believe will incorporate an information technology strategy. Dataquest expects to hear parts of this vision in an October speech. Nevertheless, Hong Kong will remain vital to growth of electronic equipment production and semiconductor supply to China. Hong Kong's and southern China's electronics industries are already inseparably linked. Hong Kong's rising growth in re-exports is attributed mainly to its ability to supply components, technology, financing, expertise, information, and global market channels.

Therefore, talking about Hong Kong in isolation presents a skewed picture of its integration with southern China during the past 10 years. For this reason, the handover is largely a nonevent in view of the speed, scope, and scale of Southern China's electronics industrialization.

Mitsubishi Participates in First Foreign Trade Joint Venture in China

One of Japan's major trading houses, Mitsubishi Corporation, Continental Grain of the United States, and the local Oriental International Group have formed one of the first two joint venture (JV) foreign trade companies in Shanghai Pudong New Zone last week. The JV company can take advantage of its local and foreign partners' existing channels to import and export machinery, electronics, and high-tech products in China. The newly formed Dongling Trading has a registered capital of $12.5 million, 51 percent of which comes from Oriental International, 27 percent from Mitsubishi, and 22 percent from Continental Grain.

Another JV foreign trade company called Shanghai Lansheng-Daewoo was formed between Daewoo Group and local Shanghai Lansheng. Both JV companies have obtained import/export licenses from the Ministry of Foreign Trade and Economic Cooperation (MOFTEC) and will soon go into operation.

The establishment of JV foreign trade companies, which allows foreign companies to participate in China's import and export trade, marks a breakthrough in China's existing and conservative foreign trade system. Before the establishment of these JV foreign trade companies, all imports and exports must be handled by the government-authorized foreign trade corporations that are state-owned companies. Foreign companies are not allowed to do import and export trade on their own. Foreign vendors lacking local relationship usually have difficulties in getting access to China's potential market because of this restriction. That is why many foreign vendors complain that China market is "big in sight but small in touch."

The tentative procedures issued by the MOFTEC on September 30, 1996, allow JV foreign trade companies to be set up in two trial areas: the Shanghai Pudong New Zone and the Shenzhen Special Economic Zone. Dataquest expects such JV companies will also soon be set up in Shenzhen, which will

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serve southern China, following the first two JV foreign trade companies in Pudong.

As driven by the strong market demand in high-technology areas, especially in telecommunications, the JV foreign trade companies will mainly handle foreign trade of high-technology products. Foreign vendors of electronic equipment and semiconductors may benefit most from the establishment of these JV companies but the benefits will only be gradual.

The establishment of JV foreign trade companies is a result of China's fast expanding economy that requires the reform of low-efficiency foreign trade system currently monopolized by state-run companies. It is unlikely, however, that Chinese government will fully open up its foreign trade in the foreseeable future because protectionism still exists. Dataquest believes that semiconductor vendors will still have to rely on Hong Kong as a key distribution center for southern China where most of export-oriented manufacturing companies are based.

Changhong Plans International Sales and Listing on Hong Kong Stock Market

China's largest color television producer, Changhong Electronics Group Co., plans to begin exporting color televisions by 1999 and to open its first overseas production site to cater for foreign markets. The United States is the first country Changhong will target for international sales as the company hopes to develop a reputation as a low-cost, reliable brand name. Changhong is listed on the Shanghai Stock Exchange and reported posttax profits of RMB 1.67 billion (U.S.$200.2 million), but the company plans to raise money for its expansion plans on the Hong Kong stock market.

China's color television industry continues to undergo consolidation. Changhong is looking for ways to expand beyond the domestic market in China. This overcapacity is the result of central planning in the late 1980s that supported national color television industrial development. With the increase in imports or locally assembled foreign brands in China, these factories have had difficulty competing in China.

Changhong has been able to complete in a market that is flooded with foreign-brand goods and is taking the lead in the consolidation by acquiring smaller, less successful companies in China. Consequently, the company will have increased market share from about 23 percent to a forecast 33 percent by the end of 1997, primarily through acquisitions and aggressive marketing. The acquisition of regional television producers in Nantong (in Jiangsu province), and in Changchun (in Jilin province), is expected to be completed by the end of August. Dataquest expects, as does Changhong, that competition in China's electronics market will increase as the country moves to enter the World Trade Organization. China's major electronics companies realize they must prepare to compete on a global basis because import tariffs will continue to be reduced and the privatization pace will quicken.

Lexmark Opens Two World-Class Ink Jet Printer Plants in China

Lexmark International Inc. has begun high-volume production of ink jet printers at two new manufacturing plants in the People's Republic of China. These facilities, established with partners in Shanghai and Shenzhen, will export about 75 percent to Europe and the United States, while about 25 percent will be shipped to China and other Asia/Pacific countries. Full capacity of both ink jet facilities is expected to be reached by first quarter 1998. The second announcement indicated that Hong Kong would become the company's distribution center servicing the entire Asia/Pacific region.

A number of relevant details were not provided by Lexmark, such as its joint-venture partner, investment amount, or plant capacity. However, the trends are clear. Dataquest's quarterly PC shipment statistics show China growing by 41 percent in second quarter 1997 over second quarter 1996, becoming Asia/Pacific's largest consumer of PCs. Similarly, the printer market is booming in China, and Lexmark is attempting to create a competitive advantage in the dynamic, competitive mainland market. Lexmark has recently extended relationships with two distributors—China Great Wall Computer Group and Stone Computing Group—as another aspect of its market development effort. The relationship with Stone has included a joint effort to develop China-specific printer products, such as a low-cost ink jet (CJ1000). Great Wall will focus on sales of networked laser printers in China. Confident or not, the importance of Hong Kong increases each day. The SAR is now a vital artery of electronic equipment and technology flowing from low-cost production in China to global markets and from Asian neighbors (particularly for key components) into the Chinese market.

AMD Demonstrates Commitment to the China and Hong Kong Microprocessor Markets

At press conferences in Beijing and Hong Kong, Advanced Micro Devices Inc. (AMD) affirmed its commitment to the China/Hong Kong semiconductor market by announcing various initiatives to develop its presence in the Chinese markets. ADM took three actual steps, including the construction of Suzhou Limited, an AMD subsidiary, which will assemble and test integrated circuits; opening a telecommunications laboratory at Qinghua University; and the recent opening of three sales offices in China. Company spokesmen explained other initiatives to (1) work closely with switching manufacturers; (2) develop programs for government, industry, and academic associations; (3) provide silicon technology and applications support to "empower local companies to compete with foreign manufacturers;" and (4) provide low-cost microprocessors to low-cost PC suppliers in China, such as Legend Group, Acer Computer International Ltd., and First International Computer Inc. (FIC). Acer and FIC have recently announced PC products between U.S.$500 and U.S.$1,000, respectively.

Behind the words spoken at AMD's press conferences are messages that attempt to address some important concerns on the minds of mainland government and industry leaders. Dataquest believes these issues to be the following:

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- Chinese government-run electronics equipment manufacturers are, generally speaking, not succeeding in China, while foreign products are gaining appeal and increasing market share. AMD's effort to support the end users in China at the systems level is important to both government and already-privatized mainland companies. Switching, in particular, is a huge immediate opportunity.
- Assembling and testing in China demonstrates a manufacturing commitment to Chinese officials and will enable AMD to establish operations and training programs.
- Relationships with universities and government associations attempt to provide long-term sources of much-needed engineers with applied rather than just theoretical engineering experience.
- If sub-$1,000 PCs are available to the Chinese home, Dataquest believes that demand will surge due to current pent-up demand in Chinese families wishing to educate their child(ren). Dataquest PC analysts estimated that the government and industry markets are already growing between 40 percent and 50 percent each year.

Fourth Quarter

Asian Currency Crisis on Semiconductor Demand in the Rest of Asia/Pacific

Dataquest believes the currency devaluation in some of the countries within the Asia/Pacific region will have varying positive and negative effects on semiconductor consumption in the region. The countries primarily affected and discussed here are Korea, Taiwan, Singapore, Thailand, Malaysia, Indonesia, and the Philippines. Dataquest would like to note that the Hong Kong dollar remains the least vulnerable currency, although it was attacked by speculators only after the Southeast Asian devaluation. Dataquest also believes that Taiwan's electronics industry will fare well in this crisis, primarily because a larger percentage of components is supplied locally and because its financial sector is stronger than in these other countries.

In the short run, numerous companies selling equipment or semiconductor components to these countries report difficulty in getting payment from their channels. Consumption of end equipment such as PCs, cellular phones, and color televisions will be affected, but these markets are small, developing markets relative to worldwide consumption. Since last year, Dataquest has observed a deceleration of growth in Southeast Asia and an acceleration in China. China's electronics equipment production will grow at nearly 20 percent this year and is now the largest semiconductor market in Asia/Pacific. China also represents a huge consumer of communications and computer equipment, representing 25 percent of all personal computers purchased in Asia/Pacific, with growth exceeding 40 percent. Although electronics consumption may be lower than previously expected in selected countries, the region as a whole will continue to enjoy the fastest growth rates in the world.

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The long-term impact on overall semiconductor consumption in Asia/Pacific is better understood from a company-level view. Companies in the affected Asian countries, which rely primarily on imported components, are experiencing increased costs because of their weaker local currency. However, if their finished products are exported, then this cost increase can be reversed, because more local currency is received for the same U.S. dollar price. If an electronics manufacturer receives components through internal transfer or global sourcing agreements (billed out of headquarters) and exports its finished product, then it benefits significantly—it has no cost increase yet does have increased revenue (in local currency).

So which situation is more common in Southeast Asia? The majority of production in these countries is exported rather than shipped locally. However, most components are imported from Europe, Japan, or North America. And the lion's share of these semiconductors is imported by multinational companies that either have global procurement agreements or receive large amounts of transshipments from other subsidiaries. Although recent trends show increased shipments to Southeast Asia from manufacturers based there, this output represents less than 15 percent of total production. Exports have and will continue to drive electronics production in Asia/Pacific and, therefore, strong semiconductor demand. Weaker currency means more expensive parts for some, but all will have more competitive exports. Although certain companies may be hurt, aggregate demand will not be damaged and could well be helped in the long run.

Texas Instruments Announces Its Fourth DSP Development Center in China

Texas Instruments Inc. announced that it will jointly build a digital signal processing (DSP) research center at the Changed Electronic Science & Technology University, located in central China's Sichuan Province. The university will provide facilities, while TI agrees to provide workstations, development tools, system software and hardware, and training. The center will not only provide a laboratory for students to learn about DSPs, but, more importantly, enable students and industry to develop DSP applications.

TI's quick success in China/Hong Kong's DSP market has warranted a rapid response to harness potential long-term market growth. The China/Hong Kong DSP market grew threefold in 1996 and continues its remarkable momentum attributable to China's burgeoning communications markets. TI's initial success is attributed to the rapidly expanding, foreign-invested manufacturers of wireless local loop, digital switching, and digital cellular handsets. However, local Chinese companies are adapting the technology quickly and represent a significant long-term market. New opportunities also are emerging in China's sizable consumer electronics industry, in which TI plans to be a major player.

TI has clearly targeted the top universities across China—others including Beijing's Qinghua University, Shanghai's Jiaotong University, and

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Guangdong's Zhongshan University. This latest partnership is TI's fourth center in China. At least six more centers are planned to be established in China and Hong Kong in the near future. Their long-term goal is to accelerate the commercialization of DSP technologies to China's electronics industry. Universities in Singapore and Taiwan have started similar programs several years ago. However, the number of professors trained in DSP technology in China exceeds those in other Asian countries. Where China is falling behind is in commercialization of this and other semiconductor technologies.

The university program enables TI to disperse DSP technology to China's local industries at an accelerated rate. For nearly a decade, China has been trying to reform its education system from theoretical to applied science. There is no shortage of bright engineering students in China, but there is huge vacuum of application engineers. Signal processing studies in some cases has existed for nearly a decade. TI's partner schools are among the best electrical engineering universities in China and are, by no coincidence, located in thriving electronic industry centers. These technology transfers are not restricted to academic use but, conversely, strongly encouraged to be shared with the commercial community.

Currency Crisis: The Market Impact

Dataquest believes that the currency and financial market problems in Asia/Pacific have a lot to do with speculative investment "bubbles" in property, construction, semiconductors, and other industries, rather than to fundamental manufacturing efficiencies. Asia/Pacific will continue to be a high-growth, efficient exporter of electronic equipment. But it is clear what will happen when rapid economic growth goes unchecked by a transparent financial system and clean government regulation: overcapacity and irrational loans. These bubbles can become so serious as to bring down entire financial systems and impair international confidence, and hence, future economic growth. This situation is what people are witnessing in Korea and Thailand. The impact of electronics production will be weakened by local consumption of information technology products. But electronics exports, the mainstay of semiconductor consumption in Asia/Pacific, will be less effected—a good news for semiconductor suppliers.

China and Hong Kong appear to be weathering the financial turmoil sweeping Asia. As the largest electronics-producing and semiconductor-consuming region, China/Hong Kong's strong export growth and local consumption are proving positive to the region. However, China and Hong Kong are not immune to these problems, although they seemed to be dealing with these bubbles more effectively by proactively popping them before they get too big. China's economic "czar," Zhu Rongji, successfully burst the stock market bubble, property bubble, and construction bubble in 1996 and 1997. After the October Party Congress, he was more empowered than ever to pop the next speculative runs, whatever they may be. In 1998, he will be promoted to prime minister. Zhu's charter is to fix the state-owned enterprises to avoid overwhelming the financial system with bad loans.

If China slacks off, its financial system will face serious problems, potentially worse than that that of Korea. China is learning to avoid Korea's expensive lesson—although having $200 billion in combined reserves with Hong Kong will help, too. A strong economic growth in North America and Europe will be critical to China and the region because Japanese consumption is weakening with its own economic malaise.

As was the case with Russia, the nonconvertibility of China's currency may help in the short run, although it does not necessarily insulate China from the possibility of a major depreciation. In 1994, the Chinese government significantly devalued its renminbi. It may have to do the same in the near future because of the mounting pressure in the region, as well as competition from Asian neighbors on the export front. However, because the government's stated long-term goal is to merge the renminbi with the Hong Kong dollar, it is not likely that the Hong Kong dollar will lose its U.S. dollar peg. Hong Kong's financial systems have remained fundamentally strong and safe from speculators.

Currency depreciation has lowered production costs in various Southeast Asian countries. So, will China become less competitive for its vital export markets? Currency depreciation will lower export costs in numerous Asia/Pacific countries, but only to the extent that they do not need imported components (most do, though).

This means that short-term competition with China for exports and possible long-term competition for foreign investment. However, there are even broader issues affecting China, which are highlighted as follows, including the currencies and economies in neighboring countries:

- Raising the competitiveness of its faltering domestic companies, especially state-owned enterprises before entering the World Trade Organization (WTO)
- Countering the serious slowdown in foreign investments because of rising costs of doing business in China
- Maintaining 7 percent to 10 percent GDP growth and raising the rate of domestic consumption to absorb excess capacity and over dependence on exports
- A slowdown in Japanese imports of consumer electronics and PCs from Asia/Pacific. China may be hurt the most because its currency has not depreciated and therefore its costs are increasing relative to other countries
- Korea and other affected countries will rely heavily on exports to try to pull themselves out of their economic turmoil

The following factors will help China to counter these major challenges and maintain relatively strong electronic industry growth:

- A large proportion of Chinese electronics companies are successfully competing against major multinational corporations (MNS), particularly in computer and consumer equipment markets. Dataquest believes that

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the Chinese government will continue to support these companies before and after entry into the WTO because their international competitiveness will be imperative to their future survival. The government's priority lies in improving efficiencies and quality and, therefore, information technology will continue to be rapidly deployed as an infrastructure necessity.

- Although total investment is down in 1997, production capacity of the large MNC and local electronics manufacturers has increased by more than 50 percent. Although business costs are rising in China, the two main reasons for investing remain to (1) develop the long-term potential of the domestic market and (2) take advantage of an abundant, inexpensive labor force. Note that efficiencies and quality are increasing faster than costs. Investment from Taiwan to China increased by nearly 30 percent in 1997, despite R.O.C. government's attempt to slow the flow of business to China. China will continue to attract investments as a necessary requirement for foreign companies to develop long-term market share there.
- Inflation was the major concern last year at this time; now deflation is the top priority of the government. Interest rates are likely to fall to stimulate growth. However, the demand for information technology continues to boom in China.
- Japanese manufacturers are shipping goods worldwide from China. China's electronics exports to Japan represent 10 percent to 15 percent of China's total electronic exports. Therefore, Japan's consumption slowdown has a minor effect on Chinese production.
- Korean and other affected Asia/Pacific electronics and semiconductor companies may have an increasing currency advantage for exports relative to China in the short term. However, these companies are seriously hurt by increase debt-service costs. With depreciation, there is a debt-service ratio increase of one-to-one, while exports cannot possibly expand enough to counter such costs. Major cost-cutting measures may be necessary to service foreign and local debt that impairs the level of export expansion necessary for recovery. Certainly, capacity expansion is not viable at this point.

All five issues impact the electronics industry in China and Hong Kong. In light of these challenges and Dataquest's survey of producers in China and Hong Kong, Dataquest believes 20 percent growth in electronic production is achievable in 1998, decelerating to 18 percent in 1999. Although Dataquest expects China to maintain a relatively high-level growth, Dataquest has also lowered its 1996-to-2001 forecast for China/Hong Kong's electronic equipment production from a CAGR of 26 percent to 24 percent in light of recent deflationary industry developments in the region.

Dataquest expects the electronics industry of China/Hong Kong to reach $70 billion by 2000 and $85 billion by 2001, rather than $90 billion as previously forecast in August 1997. From 1996 to 2001, China/Hong Kong is expected to exceed Asia/Pacific growth in electronics production by 6.8 percent and semiconductor market growth by 9.6 percent. Consequently, its share of

Asia/Pacific semiconductor market revenue will grow from 20 percent in 1997 to 26 percent.

Cautious business planning is required at this time because the volatile financial markets will take another three to six months to begin to stabilize. The situation requires rapid and extreme government action in Korea and Japan before the downward financial slide in the region reverses course.

Dataquest Perspective

It is clear that never has China's electronics industry experienced such breadth of significant developments in a single year, which included significant semiconductor assembly expansion, major fab announcement, electronic equipment production expansion, design centers, and an unprecedented domestic consumption of PCs, and communications and consumer equipment. Dataquest believes that China will remain an attractive destination for investments in 1998 because of its relative stability of currency markets and financial system compared to most other Asian countries.

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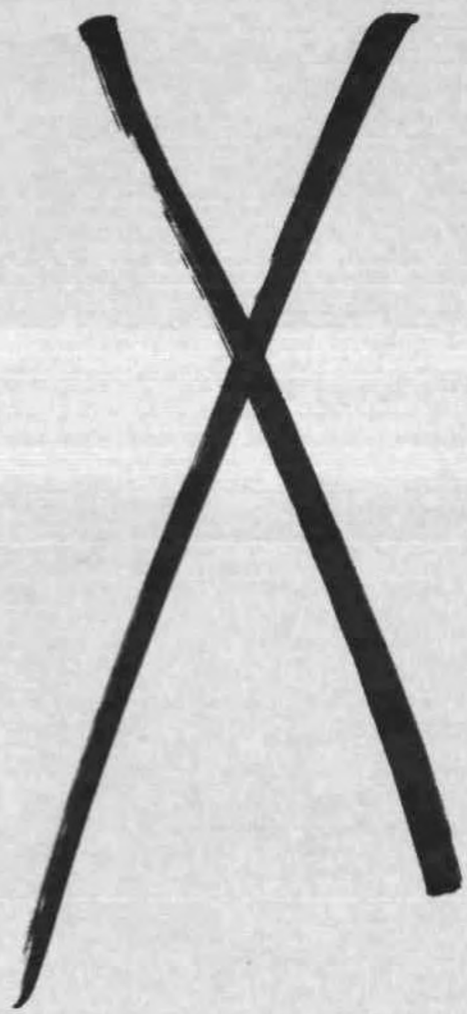

Market Statistics

Market Trends

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August 20, 1998

Dear Semiconductors China Client:

In Dataquest's Semiconductors China Market Trends report, "An Analysis of the China/Hong Kong Semiconductor Market: Suppliers, Drivers, and Forecasts" (SEMI-CH-MT-9801, August 10, 1998), the titles for Figures 4-13 and 4-14 were incorrect.

Please replace Figures 4-13 and 4-14 with the attached figures because the title was mislabeled "Analog-Monolithic" rather than "Discretes." The company names and market share data remain the same, only the titles have been renamed.

Dataquest regrets the error and apologizes for any inconvenience. For further information, contact industry analyst Daniel Heyler at daniel.heyler@dataquest.com.

Sincerely,

Randolph F. Frey

Randolph F. Frey
Director, Editing and Graphics Services

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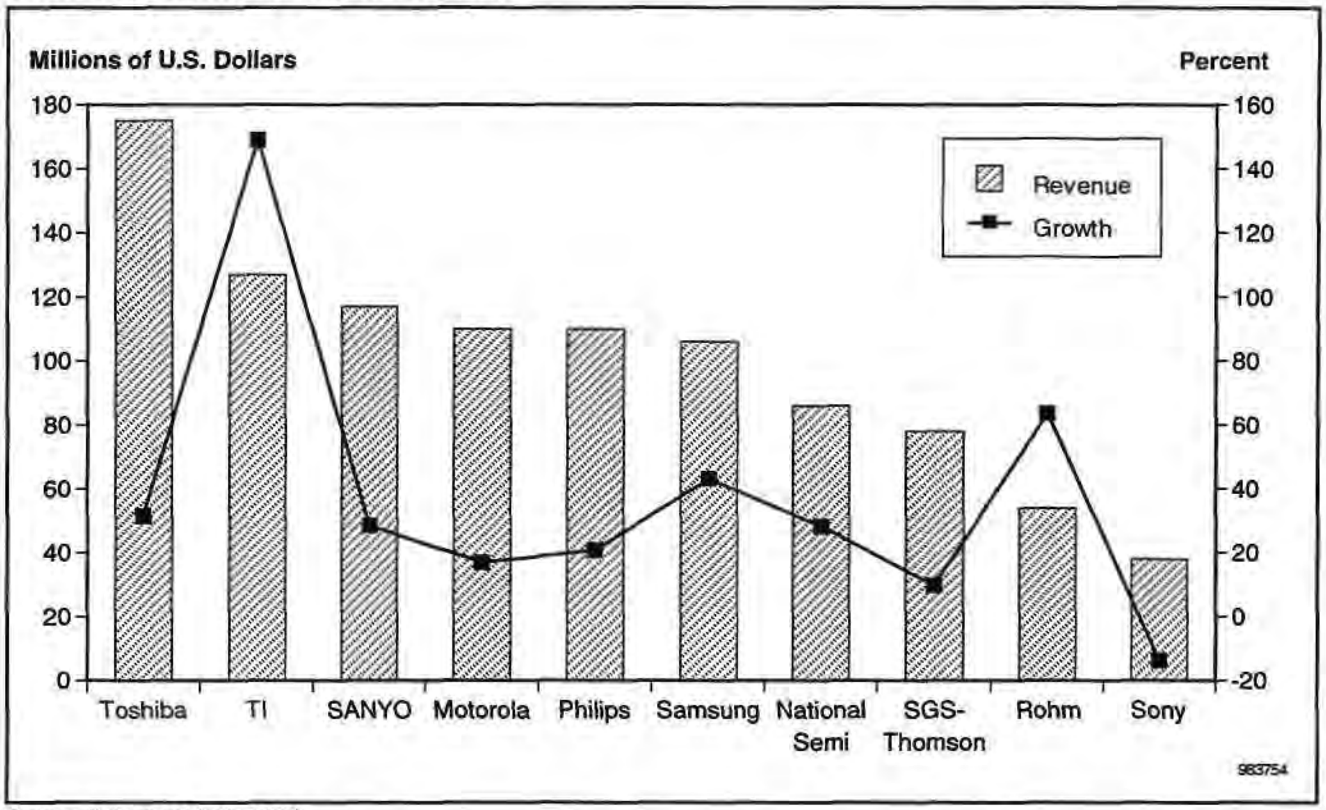
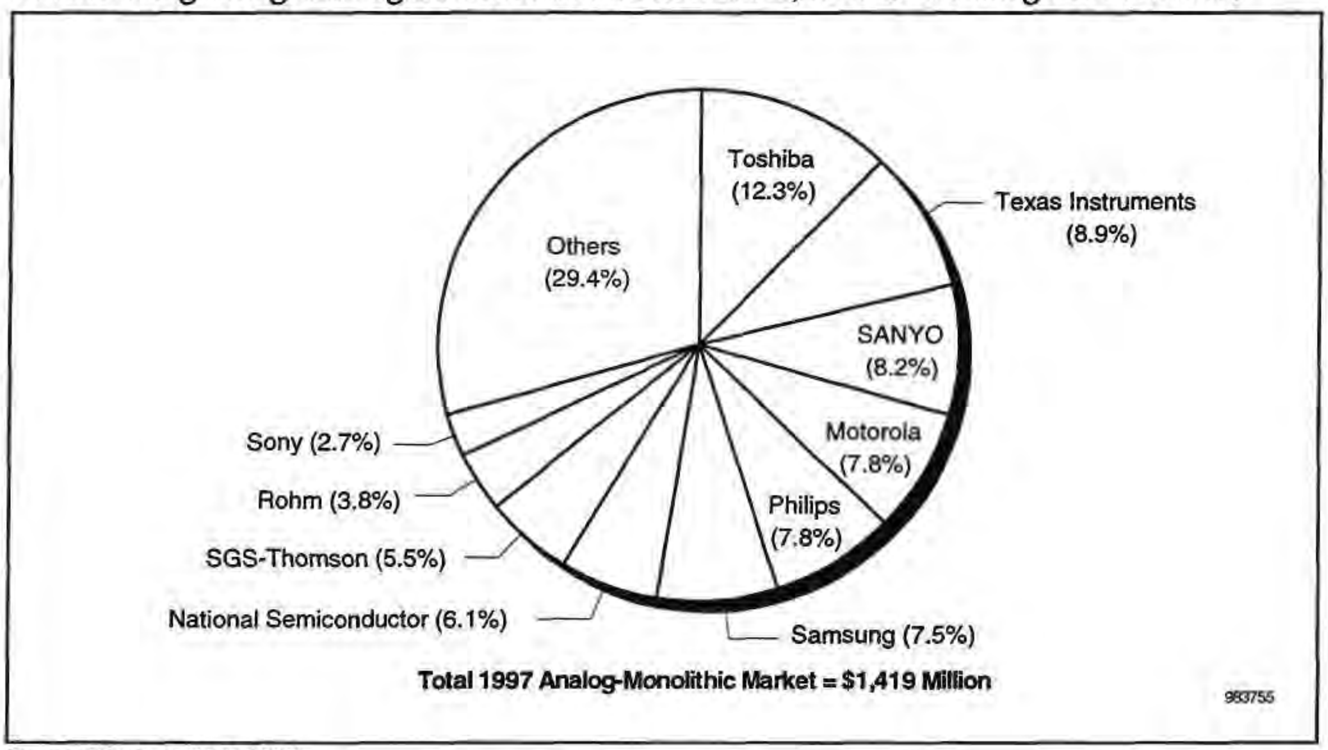
Figure 4-11
China/Hong Kong 1997 Top 10 Analog-Monolithic Suppliers' Revenue and Percentage Growth (Millions of U.S. Dollars)



Source: Dataquest (July 1998)

Figure 4-12
China/Hong Kong Analog-Monolithic Market Share, 1997 (Percentage of Revenue)

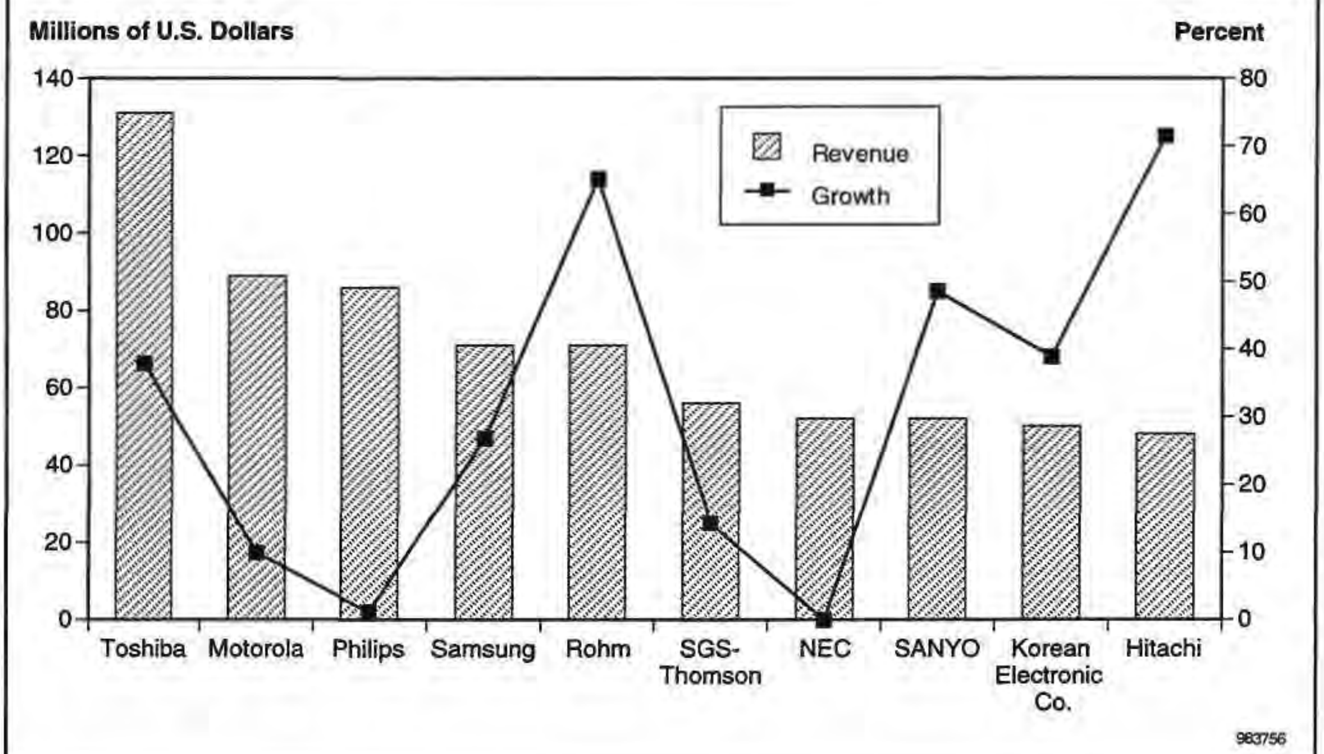


Source: Dataquest (July 1998)

Discrete Market Share Rankings

Dataquest estimates that in 1997, the value of China/Hong Kong's discrete devices reached $859 million. The discrete market represents a 12.7 percent share of China's total semiconductor consumption, but it continues to undergo steady growth year after year. In 1997, the market expanded 22.1 percent. The surveyed companies increased shipments to China by 25.8 percent and gained market share over less competitive domestic manufacturers. This segment's consumer applications are relatively close to discrete devices, as Dataquest observes the vendors' shipment performance. Toshiba, SANYO, Rohm, and Philips are able to leverage their consumer market presence to ship analog and discrete products to the same customers. Among the top 10 discrete suppliers to China, only NEC, Korea Electronic Company Ltd., and Hitachi are not among the top 10 analog suppliers (see Figures 4-13 and 4-14).

Figure 4-13
China/Hong Kong 1997 Top 10 Discrete Suppliers' Revenue and Percentage Growth (Millions of U.S. Dollars)



Source: Dataquest (July 1998)

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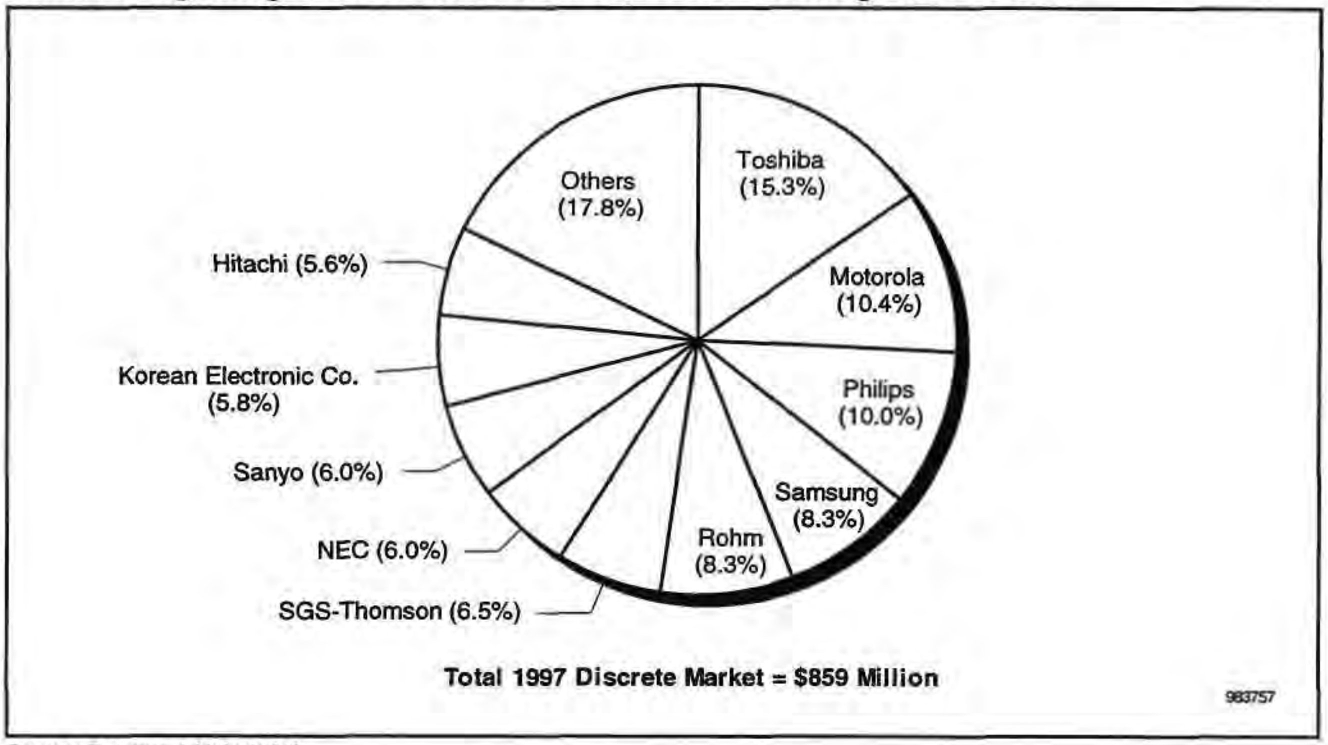
Figure 4-14
China/Hong Kong Discrete Market Share, 1997 (Percentage of Revenue)



Source: Dataquest (July 1998)

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Asia/Pacific Fab Database

Market Statistics

Program: Semiconductors China
Product Code: SEMI-CH-MS-9807
Publication Date: February 8, 1999
Filing: Market Statistics

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Asia/Pacific Fab Database

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Chapter 1
Asia/Pacific Fab Database

Background and Methodology

This report contains the Asia/Pacific portion of Dataquest's wafer fab database. The records in these tables are fabs located in the Asia/Pacific region. The Semiconductor Equipment, Materials, and Manufacturing Worldwide (SEMM) program conducts extensive annual surveys, complemented with quarterly secondary research to maintain this database. Published once a year, this document represents Dataquest's best insights and estimates into the end market of semiconductor equipment.

The tables in this report cover planned and existing merchant, captive, and foundry fab lines. A fab line is a series of equipment to do front-end (from initial oxide through wafer probe) semiconductor manufacturing. Occasionally, two or more separate product-specific fab lines or wafer sizes operate in a single clean room or physical plant. In this situation, Dataquest divides the clean room as separate fab lines if the company dedicates equipment to each wafer size or product line. If a company installs substantially different equipment during an expansion (for example, equipment to increase its maximum wafer diameter), again Dataquest divides the clean room and creates two entries into the database. Therefore, a company may operate many fab lines at one location.

Worldwide Geographic Region Definitions and Regional Roll-Ups

Americas

Includes Central America (all nations), Canada, Mexico, United States, Puerto Rico, and South America (all nations).

Japan

Japan is the only single-country region.

Europe, Africa, and Middle East

Includes Africa (all nations), Albania, Andorra, Armenia, Azerbaijan, Belarus, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Gibraltar, Hungary, Iceland, Israel, Italy, Kazakhstan, Kyrgyzstan, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Middle East (all nations), Moldova, Monaco, Netherlands, Norway, Poland, Romania, Russia, San Marino, Scandinavia, Slovakia, Spain, Sweden, Sweden, Switzerland, Tajikistan, Turkey, Turkmenistan, Ukraine, United Kingdom, Uzbekistan, Vatican City, and all nations within the former Yugoslavia.

Asia/Pacific

Includes Australia, Bangladesh, Cambodia, China, Hong Kong, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, New Zealand, Pakistan, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, and Vietnam.

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Field Definitions

The Company field indicates the operator of the fab line. For contract manufacturers that trade capacity for capital investment in the fab, Dataquest lists the contract manufacturer. For incorporated joint ventures, Dataquest lists either the incorporated entity or the major investors, separated with slashes.

The City field displays the most detailed location information. This reference is usually a city or town, but could be an often-used district name (for example, Science Park in the city of Hsinchu, Taiwan). If this field lists a district, Dataquest will list the city in the State or Province field. In some cases, a reference to a state or province will be included in the City or District field to create a unique identifier for this location.

The Prefecture field denotes the second most detailed location. This reference is usually a state (for the United States), province (for Canada and many European and Asian countries), or a prefecture (for Japan). For countries within the United Kingdom, Dataquest lists the country name (for example, "Scotland") in this field so Dataquest can list the descriptor "U.K." in the Country field.

The Country field indicates the broadest location identifier in this report. This reference is usually a country, except in the case of the United Kingdom (see "State or Province" above). Because Japan is a single-country region, there is no regional qualifier for fabs in Japan.

The Fab Name field provides a reference to a particular fab or fab line to distinguish it from other fabs or lines owned by that company. Although Dataquest makes every attempt to match the nomenclature used by the company, occasionally some additional qualifiers (for example, "Phase 1") will appear to provide insight to the facility's history or organization.

The Products field lists the products manufactured at this site. The listings generally fall into five product groups, with the following nomenclature and definitions (when warranted):

- MOS memory
  - DRAM: Dynamic RAM
  - EEPROM: Electrically erasable PROM
  - EPROM: Ultraviolet erasable PROM
  - FERRAM: Ferroelectric RAM
  - FIFO: First-in/first-out memory
  - Flash: Flash memory
  - Mem: Memory
  - NV Mem: Nonvolatile memory (ROM, PROM, EPROM, EEPROM, and FERRAM)
  - PROM: Programmable ROM
  - RAM: Random-access memory

- ROM: Read-only memory
- SGRAM: Synchronous graphics RAM
- Sp Mem: Other specialty memory (such as dual-port, shift-register, or color lookup)
- SRAM: Static RAM
- VRAM: Video RAM

■ MOS microcomponent/digital logic

- Array: Gate array
- ASIC: Application-specific IC
- ASSP: Application-specific standard product
- Bit: Bit slice (subset of MPU functions)
- CBIC: Cell-based IC
- Custom: Full-custom IC (single user)
- DSP: Digital signal processor
- FPGA: Field-programmable gate array
- LISP: 32-bit list instruction set processor for AI
- Logic: Standard logic
- LSI: Large-scale integration
- MCU: Microcontroller unit
- MixSig ASIC: Mixed-signal ASIC
- MPR: Microperipheral
- MPRCom: MPR digital communication (ISDN, LAN, UART, or modem)
- MPU: Microprocessor unit
- PLD: Programmable logic device
- RISC: Reduced-instruction-set computation 32-bit MPU
- Telecom: Telecommunications chip

■ Power/discrete/analog (including bipolar power)

- A/D D/A: Analog-to-digital, digital-to-analog converter
- Automotive: Dedicated to automobile applications
- CODEC: Coder/decoder
- Diode
- Discrete
- FET: Field-effect transistor
- GTO: Gate turn-off thyristor
- HEMT: High-electron-mobility transistor
- IGBT: Insulated-gate bipolar transistor

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- Interface: Interface IC
- Linear: Linear/analog device
- MDiode: Microwave diode
- MESFET: Metal semiconductor field-effect transistor
- MFET: Microwave field-effect transistor
- Modem: Modulator/demodulator
- MMIC: Monolithic Microwave IC
- MOSFET: MOS-based field-effect transistor
- Op Amp: Operational amplifier
- Pwr IC: Power IC
- Pwr Tran: Power transistor
- Rectifier
- Reg: Voltage regulator
- RF: Radio frequency
- SCR: Schottky rectifier
- Sensor
- Smart Pwr: Smart power
- SST: Small-signal transistor
- Switches: Switching device
- Thyristor
- Tran: Transistor
- Zener Diode

- Optoelectronic
  - CCD: Charge-coupled device (imaging)
  - Coupler: Photocoupler
  - IED: Infrared-emitting diode
  - Image Sensor
  - Laser: Semiconductor laser or laser IC
  - LED: Light-emitting diode
  - Opto: Optoelectronic
  - PDiode: Photo diode
  - PTran: Photo transistor
  - SAW: Surface acoustic wave device
  - SIT Image Sensor: Static induction transistor image sensor

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- Bipolar Digital and Other Devices (includes all digital ICs using a bipolar process)
  - Darlington
  - Micromachining sensors
  - MilStd: Military Standard Logic
  - RadHard: Radiation hardened

The Process Technology field indicates each fab's use of five major types of processes. The process grouping is as follows:

- P/CMOS: P-channel metal-oxide semiconductor (PMOS) or complementary metal-oxide semiconductor (CMOS)
- NMOS: N-channel metal-oxide semiconductor (NMOS)
- BiCMOS: Bipolar and CMOS combined on a chip
- Bipolar
- III-V: Gallium arsenide and other compound semiconductor processes

The Estimated Minimum Geometry is the smallest linewidth feature size, measured in microns, attainable in production volume.

The Wafer Diameter represents the maximum wafer size that the fab or fab line can process. Wafer diameters, although expressed colloquially in inches, conform to metric specifications. For wafers greater than 3 inches in diameter, expression in inches becomes inaccurate. When calculating square inches, Dataquest uses the following approximations:

- Stated diameter of 4 inches (100mm) = Approximate diameter of 3.938 inches
- Stated diameter of 5 inches (125mm) = Approximate diameter of 4.922 inches
- Stated diameter of 6 inches (150mm) = Approximate diameter of 5.906 inches
- Stated diameter of 8 inches (200mm) = Approximate diameter of 7.87 inches
- Stated diameter of 12 inches (300 mm) = Approximate diameter of 11.84 inches.

The Year and Quarter of Initial Production displays the year (and quarter, if available) in which this line, having completed all qualifications, began manufacturing in production volumes. The format for this reference is "year.quarter" (for example, 1994.3 translates to the third calendar quarter of 1994).

The Initial Monthly Wafer Starts field indicates the initial monthly volume of production wafer throughput.

The Estimated Maximum Monthly Wafer Starts field contains the equipment-limited wafer start capacity per four-week period. Only the throughput of the installed equipment and the process complexity limits the maximum starts. Dataquest does not consider current staffing or the number of shifts operating in determining this metric.

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The Fab Type field shows the types of semiconductor manufacturing performed at this location. The fab types include the following:

- "F" indicates that this is a production-based fab.
- "R" indicates a semiconductor R&D and/or trial production facility.
- "P" means that this location produces a pilot line.
- "T" means that this location performs assembly or testing.
- "N" indicates that this location performs foundry production, or contract manufacturing.
- "VD" means that this location performs VHDL design.
- "PD" means that this location performs IC place and route design.

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Chapter 2
Market Statistics Tables

Tables 2-1 and 2-2 provide information on fabs located in the Asia/Pacific region.

Table 2-1
Asia/Pacific's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Advanced Semiconductor Mfg (ASMC)	Shanghai	Suzhou	China	-	Foundry	-	0.50	200	1998.0	4,500	18,100	FN
Advanced Semiconductor Mfg (ASMC)	Shanghai	Suzhou	China	Fab 1	Foundry Linear Automotive	P/CMOS	0.80	150	1997.0	1,000	4,500	FN
Advanced Semiconductor Mfg (ASMC)	Shanghai	Suzhou	China	CMOS 6	Foundry Telecom Consumer ASSP	NMOS	2.00	125	1992.0	2,800	19,000	FN
Alcatel-China Gov't (Shanghai Belling)	Shanghai	Suzhou	China	Shanghai Belling Fab 1	Linear Discrete Power	P/CMOS	3.00	100	1988.0	3,500	10,000	FTRVD-PDN
Amkor/Anam	Buchon-City	Kyungki-Do	Korea	Fab II	DSP, Foundry	-	0.21	200		8,700	10,000	FT
Ankor/Anam	Buchon-City	Kyungki-Do	Korea	Fab 1	Foundry DSP ASIC	-	0.25	200	1997.4	3,700	15,000	FTN
Changzhou Semiconductor	Changzhou	Jiangsu	China	Changzhou Semiconductor Fab	Consumer ICs ASICs	Bipolar	1.00	75	1986.0	200	1,000	FT
Chartered Group	Singapore	Woodlands Industrial Park	Singapore	Fab 3A	Foundry	-	0.25	200	1997.2	4,800	32,000	FN
Chartered Group	Singapore	Woodlands Industrial Park	Singapore	Fab II	Logic MixSig ASIC SRAM ROM	P/CMOS	0.35	200	1996.0	500	50,000	FTN
Chartered Group	Singapore	Woodlands Industrial Park	Singapore	Fab I	Logic MixSig ASIC ROM EEPROM	P/CMOS	0.60	150	1989.2	500	26,000	FN
Daewoo	Guro-Dong	Seoul	Korea	MOS	Custom ASIC	-	1.00	100	1988.3	2,500	10,000	FT
Daewoo	Guro-Dong	Seoul	Korea	Bipolar	Analog	Bipolar	2.00	100	1986.3	3,000	10,000	FT
Daewoo	Kyungki-Do	Kyungki-Do	Korea	Bipolar	Diode Rectifier	Bipolar	5.00	100	1983.0	10,500	30,000	F
Dongsung	Umsung	-	Korea	Bipolar	Diode Rectifier	-	5.00	100	1996.0	10,500	30,000	FT
Government of China	Beijing	-	China	Fab 5	ASIC	-	1.20	100	1994.0	500	2,000	FTRVD
Government of China	Lintong	Shanxi	China	MAI No. 771 Institution	ASIC	Bipolar	1.20	150	1992.0	1,000	4,000	FTRVDN
Government of China	Chongqing	-	China	MEI No. 24 Institution	ASIC	Bipolar	1.20	150	1992.0	1,000	4,000	FTRVD
Government of China	Beijing	-	China	Factory No. 878	ASIC	Bipolar	5.00	75	1988.0	200	1,000	FTRVD
Government of China	Chongqing	-	China	MEI No. 25 Institution	Discrete		2.50	75	1982.0	500	1,500	FTRVD
Hua Ko Electronics	Tai Po	-	Hong Kong	-	MPU Lin ASIC Log SRAM ROM	P/CMOS	2.50	100	1982.0	2,400	8,000	FTP
Hua Yue Microelectronics	Shaoxing	Zhejiang	China	Fab 4	Consumer ICs ASIC		2.00	100	1998.0	3,500	-	FTR
Hua Yue Microelectronics	Shaoxing	Zhejiang	China	Fab 3	Consumer ICs ASIC	Bipolar	5.00	125	1995.4	6,200	12,500	FTR

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Table 2-1 (Continued)
Asia/Pacific's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Hua Yue Microelectronics	Shaoxing	Zhejiang	China	Fab 1	Consumer ICs ASIC	P/CMOS	3.00	75	1993.0	7,000	20,000	F
Hua Yue Microelectronics	Shaoxing	Zhejiang	China	Fab 2	Consumer ICs ASIC	Bipolar	5.00	125	1984.4	7,000	8,000	FTR
Huajing Electronics Group	Wuxi	Jiangsu	China	Fab 1-C	Consumer ICs	P/CMOS	0.80	150	1997.0	6,000	10,000	FTRVDN
Huajing Electronics Group	Wuxi	Jiangsu	China	MOS-I	4-bit MCU	P/CMOS	2.00	125	1993.0	8,000	8,000	FTRVDN
Huajing Electronics Group	Wuxi	Jiangsu	China	Fab 1-A	Audio Visual ICs	Bipolar	2.00	125	1984.0	15,000	15,000	FTRVDN
Hualon Microelectronics	Science Park	Hsinchu	Taiwan	Fab 1	Logic ASIC MPU SRAM	P/CMOS	0.55	125	1988.4	4,500	35,000	FTVD-PDN
Hyundai	Ichon	Kyoungki-Do	Korea	Fab 7	16Mb 64Mb DRAM		0.35	200	1997.0	15,000	30,000	FR
Hyundai	Ichon	Kyoungki-Do	Korea	Fab 6	64M DRAM	P/CMOS	0.25	200	1996.0	7,500	21,000	FTPD
Hyundai	Ichon	Kyoungki-Do	Korea	Fab 5	1-2M SRAM	P/CMOS	0.35	200	1994.0	18,000	23,000	FTPD
Hyundai	Ichon	Kyoungki-Do	Korea	Fab 4	16Mb DRAM	P/CMOS	0.28	200	1993.0	8,000	9,000	FTPD
Hyundai	Ichon	Kyoungki-Do	Korea	Fab 3	4M DRAM ASIC/ASSP Foundry	P/CMOS	0.50	150	1989.0	16,000	18,000	FTPDN
Hyundai	Ichon	Kyoungki-Do	Korea	MOS R&D	DRAM	P/CMOS	0.25	150	1989.0	1,500	3,000	FRP
Hyundai	Ichon	Kyoungki-Do	Korea	MOS Fab 2-A	1Mb 4Mb DRAM	P/CMOS	0.65	150	1986.0	7,500	15,000	FR
Hyundai	Ichon	Kyoungki-Do	Korea	Fab 2	ASIC/ASSP	P/CMOS	0.50	150	1986.0	28,000	30,000	FTPDN
Hyundai	Ichon	Kyoungki-Do	Korea	MOS Fab 1-A	256K DRAM SRAM	P/CMOS	1.00	125	1985.0	7,500	15,000	F
Hyundai	Ichon	Kyoungki-Do	Korea	Fab 1	64-256 SRAM	P/CMOS	0.80	125	1985.0	18,000	20,000	FTPD
Integrated Device Technology	Carlubang	Laguna	Philippines	IDT Philippines	SRAM Logic		0.50	150	1996.2	8,000	20,000	NO
Integrated Device Technology	Penang	Penang	Malaysia	IDT Malaysia	Logic SRAM SMP FIFO MPR		0.80	150	1988.1	8,000	20,000	NO
Korea Diode Company	Buchon-City	Kyoungki-Do	Korea	Bip Line 1	Analog Trans	Bipolar	1.50	100	1975.0	7,000	20,000	FT
Korean Electronic Company	Gumi-City	Kyungbuk	Korea	Bip Line 2	Analog ICs ASIC	Bipolar	1.20	125	1986.0	4,500	15,000	FT
Kukje	Shihung	-	Korea	-	Optoelectronics	GaAs	5.00	51	1992.0	1,400	4,000	FT
LG Semicon	Chongju-City	Chung-cheong-buk-do	Korea	C2-Fab 5	16Mb 64Mb DRAM	P/CMOS	0.25	200	1997.0	20,000	40,000	FTVD-PDN

Table 2-1 (Continued)
Asia/Pacific's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
LG Semicon	Chongju-City	Chung-cheong-buk-do	Korea	C3-Fab 7	64Mb 128Mb 256Mb DRAM	P/CMOS	0.22	200	1997.0	20,000	30,000	FTVD
LG Semicon	Gumi-City	Kyeong-sansbuk-do	Korea	G2/G3	16MB 64MB DRAM	P/CMOS	0.35	200	1997.0	3,000	9,000	FTVD-PDN
LG Semicon	Gumi-City	Kyeong-sansbuk-do	Korea	G3	16M DRAM	P/CMOS	0.35	200	1995.0	16,000	23,000	FTVDPD
LG Semicon	Chongju-City	Chung-cheong-buk-do	Korea	C2-Fab 4	16Mb 64Mb DRAM SRAM Flash SGRAM ASIC	P/CMOS	0.30	200	1993.0	11,000	30,000	FTRVD PD
LG Semicon	Chongju-City	Chung-cheong-buk-do	Korea	C1-Fab 2	1M 4Mb DRAM SRAM ROM	P/CMOS	0.50	150	1991.0	24,000	28,000	FTVDPD
LG Semicon	Chongju-City	Chung-cheong-buk-do	Korea	C1-Fab 1	1Mb 4Mb DRAM SRAM ROM	P/CMOS	0.50	150	1990.0	24,000	28,000	FTVDPD
LG Semicon	Gumi-City	Kyeong-sansbuk-do	Korea	G3	SRAM ROM Logic	P/CMOS	1.20	125	1984.0	11,300	20,000	FTVDPD
LG Semicon	Gumi-City	Kyeong-sansbuk-do	Korea	Gumi Bipolar	Analog Logic	Bipolar	1.20	125	1980.0	17,500	21,000	FTVDPD
Macronix	Science Park	Hsinchu	Taiwan	Fab 2	DRAM, Flash Logic	P/CMOS	0.35	200	1997.2	5,000	15,000	FVDPD
Macronix	Science Park	Hsinchu	Taiwan	Fab 1-A	Foundry	P/CMOS	0.45	150	1994.0	3,700	25,000	FVDPDN
Macronix	Science Park	Hsinchu	Taiwan	Fab 1	ROM EPROM Flash Logic	P/CMOS	0.45	150	1992.3	12,200	35,000	FVDPD
Malaysian Institute of Microelectronic Systems (MIMOS)	Kuala Lumpur	Johor Baru	Malaysia	Mimos Phase 1	ASICS; MCU	P/CMOS	0.50	150	1997.3	300	600	FRVDP-DNP
Maxim	Philippines	-	Philippines	Assembly	Analog & Mixed Signal		1.20	200	1997.0	5,600	18,900	NOT
Micron-Acer	Science Park	Hsinchu	Taiwan	Fab 1B	16Mb 64Mb DRAM	P/CMOS	0.35	200	1996.3	5,000	30,000	FRN
Micron-Acer	Science Park	Hsinchu	Taiwan	Fab 1A	16Mb DRAM	P/CMOS	0.45	150	1991.4	5,000	22,000	FRN
Micron-Singapore EDB (Tech)	Singapore	-	Singapore	Tech Semiconductor Fab 2	16Mb DRAM	P/CMOS	0.18	200	1996.3	10,000	14,000	FN
Micron-Singapore EDB (Tech)	Singapore	-	Singapore	Tech Semiconductor Fab 1	16Mb DRAM	P/CMOS	0.28	200	1993.2	6,000	10,000	FN
Mitsubishi	Nagano	-	Japan		64Mb DRAM	P/CMOS	0.35	200	1998.2	10,000	20,000	F
Mitsubishi	Science Park	Hsinchu	Taiwan	PSC	16Mb 64Mb DRAM	P/CMOS	0.35	200	1996.0	6,000	12,000	FT
Mitsubishi-UMAX (Powerchip)	Science Park	Hsinchu	Taiwan	Powerchip	16Mb DRAM 64Mb DRAM	P/CMOS	0.30	200	1996.2	5,000	25,000	FTRVD-PDN
Mosel Vitalic (JV) ProMos Technologies	Science Park	Hsinchu	Taiwan	Fab 1	64Mb 256Mb DRAM	P/CMOS	0.35	200	1998.1	5,000	20,000	FRVD-PDN

Table 2-1 (Continued)
Asia/Pacific's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Mosel Vitelic	Science Park	Hsinchu	Taiwan	Fab 1B (Mosel Vitelic)	4M, 8M, SDRAM, SRAM, VROM, Logic	P/CMOS	0.34	150	1995.4	2,000	30,000	FRVDN
Mosel Vitelic	Hong Kong	-	Hong Kong	Vitelic Hong Kong Fab 1	Discrete Consumer ICs	-	2.20	100	1982.0	6,100	17,600	FN
Motorola	Seremban	-	Malaysia	ISMF	Small Signal Opto	Bipolar	1.25	100	1988.0	4,000	20,000	F
Motorola	Chengdu	Sichuan	China	LeShan-Phoenix	Packaging	-	-	-	1983.0	-	-	NOT
Nan Ya Technology	Tao Yuan	-	Taiwan	Fab 1 Phase 2	16M 64M DRAM Logic	P/CMOS	0.30	200	1996.4	2,000	35,000	FRVD-PDN
NEC	Shanghai	Shanghai	China	-	DRAM	P/CMOS	0.35	200	1994.4	-	-	F
Photronics	(Taiwan)	-	Taiwan	-	Opto	-	1.70	75	1984.0	3,500	10,000	FT
Quality Semiconductor	Sydney	-	Australia	-	16-bit 32-bit MCU FIFO ASIC Foundry	P/CMOS	0.60	150	1989.2	2,500	7,000	FN
RCL Semiconducors	Tai Po	-	Hong Kong	-	-	P/CMOS	2.50	125	1993.0	2,100	6,000	FT
RCL Semiconducors	Tai Po	-	Hong Kong	-	Memory MPU Log Lin Tran	P/CMOS	2.50	100	1982.0	1,200	4,000	FTP
Sammi	Yongin	Kyungki-Do	Korea	III-V	LED Ld Hemt	GaAs	5.00	51	1992.0	1,400	4,000	FT
Samsung	Kiheung-Up	Kyungki-Do	Korea	Fab 8	64Mb DRAM	P/CMOS	0.30	200	1998.0	12,500	25,000	FTVDPD
Samsung	Kiheung-Up	Kyungki-Do	Korea	Fab 7	16Mb 64Mb DRAM	P/CMOS	0.35	200	1996.0	15,000	20,000	FTVDPD
Samsung	Kiheung-Up	Kyungki-Do	Korea	Fab 6	16Mb 64Mb DRAM	P/CMOS	0.26	200	1995.1	23,000	37,000	FTVDPD
Samsung	Kiheung-Up	Kyungki-Do	Korea	Fab 5	Alpha MPU ASIC ASSP E DRAM	P/CMOS	0.35	200	1993.0	19,000	24,000	FTVDPD
Samsung	Kiheung-Up	Kyungki-Do	Korea	Fab 4	4Mb DRAM SRAM Embed DRAM	P/CMOS	0.48	150	1990.0	25,000	42,000	FTVDPD
Samsung	Kiheung-Up	Kyungki-Do	Korea	R&D	R&D	P/CMOS	0.30	300	1989.2	1,500	3,000	FTRVD-PDP
Samsung	Kiheung-Up	Kyungki-Do	Korea	Fab 3	ASIC MCRO	P/CMOS	0.48	150	1988.3	24,000	55,000	FTVDPD
Samsung	Kiheung-Up	Kyungki-Do	Korea	Fab 2	ASIC	P/CMOS	0.45	150	1985.1	25,000	46,000	FTVDPD
Samsung	Buchon-City	Kyungki-Do	Korea	Bucheon C	Analog	Bipolar	3.00	100	1985.0	23,000	68,000	FTVDPD
Samsung	Kiheung-Up	Kyungki-Do	Korea	Fab 1	ASIC	P/CMOS	1.00	100	1984.1	21,000	35,000	FTVDPD
Samsung	Buchon-City	Kyungki-Do	Korea	MOS	MICRO Logic	P/CMOSNMOS	2.00	125	1974.0	15,000	30,000	FTRVD PD
Semiconductor Complex Ltd. (SCL)	Nagar-Chandigarh	SAS Nagar Punjab	India	VLSI Fab	Telecom ICs, ASICs	P/CMOS	0.80	200	1997.0	1,000	2,000	FTRVDP-DNP

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Table 2-1 (Continued)
Asia/Pacific's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Shanghai Industrial Complex	Shanghai	Suzhou	China	Fab No. 2	ASIC		1.00	100	1985.0	4,100	16,600	F
Shanghai Industrial Complex	Shanghai	Suzhou	China	Fab No. 1	Tran Lin Log Mem	NMOS	3.00	100	1983.0	300	1,200	FRP
STMicroelectronics	Singapore	-	Singapore	Fab 4 #7	MPU CPU	GaAs	1.5	125	1996	8000	23000	FVDPD
STMicroelectronics	Singapore	-	Singapore	Fab 1 # 4	MPU CPU	BiCMOSBipolar	2	125	1988	12000	28000	FVDPD
STMicroelectronics	Singapore	-	Singapore	Fab 3 # 6	MPU CPU	GaAs	2.5	125	1984	16000	37000	FVDPD
STMicroelectronics	Singapore	-	Singapore	Fab 2 # 5	MPU CPU	GaAs	2.5	125	1984	14700	42000	FVDPDP
Suzhou Complex	Suzhou	-	China	Suzhou Semiconductor Fab	Opto Telecom Consumer ICs	Bipolar	0.80	75	1990.0	300	1,000	FTRVD
Taijin No. 1	Taijin	-	China	-	Audio ICs	-	5.00	75	1983.0	3,000	10,000	F
TSMC Group	Science Park	Hsinchu	Taiwan	Fab 5	Foundry	P/CMOS	0.18	200	1998.0	5,000	30,000	FTN
TSMC Group	Science Park	Hsinchu	Taiwan	Fab 4	Foundry	P/CMOS	0.25	200	1997.1	5,000	31,000	FTRN
TSMC Group	Science Park	Hsinchu	Taiwan	Fab 3	Foundry	P/CMOS	0.25	200	1995.3	5,000	41,000	FTN
TSMC Group	Science Park	Hsinchu	Taiwan	Fab 2-B	Foundry	P/CMOS	0.50	150	1992.4	6,000	80,000	FTX PDN
TSMC Group	Science Park	Hsinchu	Taiwan	Fab 1	Foundry	P/CMOS	0.80	150	1988.0	3,000	21,000	FN
UMC Group	Science Park	Hsinchu	Taiwan	USI	Foundry	P/CMOS	0.25	200	1998.1	5,000	8,000	FPDN
UMC Group	Science Park	Hsinchu	Taiwan	USC	Foundry	P/CMOS	0.25	200	1996.4	5,000	30,000	FN
UMC Group	Science Park	Hsinchu	Taiwan	Fab 3-A	Foundry	P/CMOS	0.25	200	1995.0	5,000	30,000	FRN
UMC Group	Science Park	Hsinchu	Taiwan	Fab 2	Foundry	P/CMOS	0.50	150	1989.0	6,000	48,000	FN
UTEK	Science Park	Hsinchu	Taiwan	Fab 2	MCU ASIC Non Vol	P/CMOS	0.25	200	1998.2	5,000	8,000	FTVD-PDN
UTEK	Science Park	Hsinchu	Taiwan	Fab 1	MCU ASIC Non Vol	P/CMOS	0.80	125	1990.4	2,000	35,000	FTVD-PDN
Vanguard International	Science Park	Hsinchu	Taiwan	Fab 1B	16Mb 64Mb SDRAM; 8M SGRAM	P/CMOS	0.35	200	1996.4	5,000	25,000	FTRVD PD
Vanguard International	Science Park	Hsinchu	Taiwan	Fab 1A	4Mb DRAM	P/CMOS	0.35	200	1995.2	5,000	15,000	FTRVD-PDN
Vanguard International	Science Park	Hsinchu	Taiwan	Fab 1	4Mb DRAM	P/CMOS	0.50	150	1991.0	2,000	4,000	FRP
Winbond Group	Science Park	Hsinchu	Taiwan	Fab 4	64Mb DRAM	P/CMOS	0.25	200	1998.3	5,000	10,000	FVDPDN
Winbond Group	Science Park	Hsinchu	Taiwan	WSMC 1	Flash, SRAM, Logic	P/CMOS	0.25	200	1998.3	5,000	5,000	FTRNP
Winbond Group	Science Park	Hsinchu	Taiwan	Fab 2	Logic, SRAM	P/CMOS	0.50	150	1992.4	5,000	35,000	FVDPDN
Winbond Group	Science Park	Hsinchu	Taiwan	Fab 1	Analog, Logic	P/CMOS	0.80	125	1988.3	6,000	22,000	FVDPDN
Xin Whey Guafon Microelectronics	Xinhui	Guangzhou	China	-	Telecom ICs	-	1.40	100	1990.0	1,500	5,000	FTRPDN

Source: Dataquest (December 1998)

Table 2-2
Asia/Pacific's Future Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Advanced Semiconductor Mfg (ASMC)	Shanghai	Suzhou	China	-	Foundry	-	0.50	200	1998.0	4,500	18,100	FN
Arcus Technology (fabless)	Bangalore	-	India	-	MixSig ASIC 16 32-bit RISC MPU	-	1.40	100	2000.0	5,200	17,400	
Chartered Group	Singapore	-	Singapore	Chartered Silicon Partners	Foundry	P/CMOS	0.25	200	2000.0	4,500		FN
Chartered Group	Singapore	Woodlands Industrial Park	Singapore	Fab IV	Foundry	-	0.25	200	2001.0	7,200	48,000	FN
DongBu Electronics	Eumsung	ChungBuk	Korea	-	64 Mb 256Mb DRAM	P/CMOS	0.25	200	1999.0	15,000	30,000	F
First Silicon	Kuching	Sarawak	Malaysia	Kuching	Foundry	-	0.25	200	1999.4	3,700	20,000	FN
Hitachi-Nippon Steel Semiconductor	Singapore	-	Singapore	Hitachi-Nippon Steel Semiconductor	64Mb DRAM	P/CMOS	0.18	200	1999.0	10,000	20,000	F
Hua Hong Microelectronics (NEC)	Poudong	Shanghai	China	Fab 1	EEPROM SRAM MCU DRAM Foundry	-	0.35	200	1999.3	3,000	20,000	FN
Hua Yue Microelectronics	Shaoxing	Zhejiang	China	Fab 4	Consumer ICs ASIC	-	2.00	100	1998.0	3,500		FTR
Macronix	Science Park	Hsinchu	Taiwan	Fab 3	ROM EPROM Flash Logic	P/CMOS	0.25	200	2000.0	10,500	30,000	FVDPD
Malaysian Institute of Microelectronic Systems (MIMOS)	Johor Baru	-	Malaysia	Phase II	ASIC	P/CMOS	0.50	200	1999.4	1,500	6,000	FRP
Micron-Acer	Science Park	Hsinchu	Taiwan	Fab 2	64Mb DRAM	P/CMOS	0.25	200	1999.2	10,000	20,000	FN
Mitsubishi	Nagano	-	Japan	-	64Mb DRAM	P/CMOS	0.35	200	1998.2	10,000	20,000	F
Mosel Vitalic (JV) ProMos Technologies	Science Park	Hsinchu	Taiwan	Fab 1	64Mb 256Mb DRAM	P/CMOS	0.35	200	1998.1	5,000	20,000	FRVD-PDN
Motorola	Tianjin	-	China	MOS-17	Telecom ASIC RF SmartMOS	-	0.50	200	1999.0	14,000	20,000	FVDPD
Nan Ya Technology	Tao Yuan	-	Taiwan	Fab 1 Phase 3	64Mb 256Mb DRAM	P/CMOS	0.25	200	1999.3	5,000	-	FRVD-PDN
NEC	Beijing	-	China	Shougang Phase 3	16Mb DRAM	P/CMOS	0.40	150	2000.0	1,500	6,000	FT
Philips-TSMC Group	Singapore	-	Singapore	8	SOC ICs for Consumer and Communications	-	0.25		2000.3			F
Samsung	Kiheung-Up	Kyungki-Do	Korea	Fab 8	64Mb DRAM	P/CMOS	0.30	200	1998.0	12,500	25,000	FTVDPD
Silicon Manufacturing Partners	Singapore	Woodlands Industrial Park	Singapore	Silicon Manufacturing Partners	ASIC MPU Foundry	P/CMOS	0.25	200	1999.0	2,000	2,000	FRP
STMicroelectronics	Singapore	-	Singapore	Fab 5	Logic	-	0.5	200	1999	4000	20000	FR
SubMicron Technology	Bangkok	Chachaersao	Thailand	Fab 1	Foundry	P/CMOS	0.35	200	1999.4	3,000	20,000	FN
TSMC Group	Science Park	Hsinchu	Taiwan	Fab 5	Foundry	P/CMOS	0.18	200	1998.0	5,000	30,000	FTN

Table 2-2 (Continued)
Asia/Pacific's Future Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year and Quarter of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
TSMC Group	Science Park	Hsinchu	Taiwan	Fab 7	Foundry	-	0.18	200	2000.0	5,000	-	FN
TSMC Group	Tainan	Tainan	Taiwan	Fab 6	Foundry	P/CMOS	0.25	200	2001.0	9,000	60,000	FN
TSMC Group	Tainan	Tainan	Taiwan	Tainan 8 #1	Foundry	P/CMOS	0.25	200	2001.0	5,000	15,900	FN
UMC Group	Science Park	Hsinchu	Taiwan	USI	Foundry	P/CMOS	0.25	200	1998.1	5,000	8,000	FPDN
UMC Group	Science Park	Hsinchu	Taiwan	Fab 5	Foundry	P/CMOS	0.25	200	1999.0	5,000	-	FRPDN
UMC Group	Science Park	Hsinchu	Taiwan	Fab 2	Foundry	P/CMOS	0.25	200	1999.4	5,000		FN
UMC Group	Science Park	Hsinchu	Taiwan	UICC	Foundry	P/CMOS	0.25	200	1999.4	5,000	30,000	FPDN
UMC Group	Tainan Industrial Park	Tainan	Taiwan	Fab IV	Foundry 256Mb DRAM	P/CMOS	0.16	200	2000.0	7,500	50,000	FN
UTEK	Science Park	Hsinchu	Taiwan	Fab 2	MCU ASIC Non Vol	P/CMOS	0.25	200	1998.2	5,000	8,000	FTVD-PDN
Vanguard International	Science Park	Hsinchu	Taiwan	Fab 2	64M 128M SDRAM	P/CMOS	0.25	200	2000.1	8,000		FTRVD
Wafer Technology Malaysia (VLSI and Atmel)	Penang	-	Malaysia	-	Arrays CBIC MPU Telecom ICs Foundry	P/CMOS	0.25	200	2000.0	14,000	27,000	F
Winbond Group	Science Park	Hsinchu	Taiwan	Fab 4	64Mb DRAM	P/CMOS	0.25	200	1998.3	5,000	10,000	FVDPDN
Winbond Group	Science Park	Hsinchu	Taiwan	WSMC 1	Flash, SRAM, Logic	P/CMOS	0.25	200	1998.3	5,000	5,000	FTRNP
Winbond Group	Science Park	Hsinchu	Taiwan	WSMC 2	Logic	P/CMOS	0.18	200	1999.3	5,000	-	FTRN

Source: Dataquest (December 1998)

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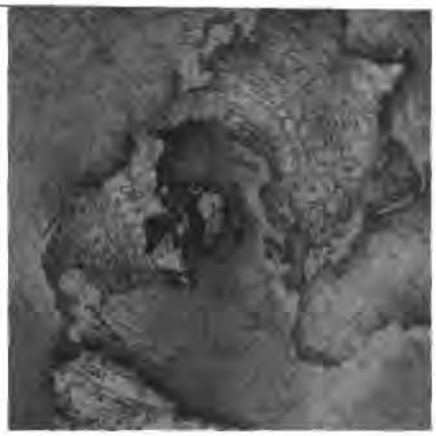

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China/Hong Kong Semiconductor Consumption Forecast by Electronics Application: Winter 1998

Market Statistics

Program: Semiconductors China
Product Code: SEMI-CH-MS-9806
Publication Date: December 21, 1998
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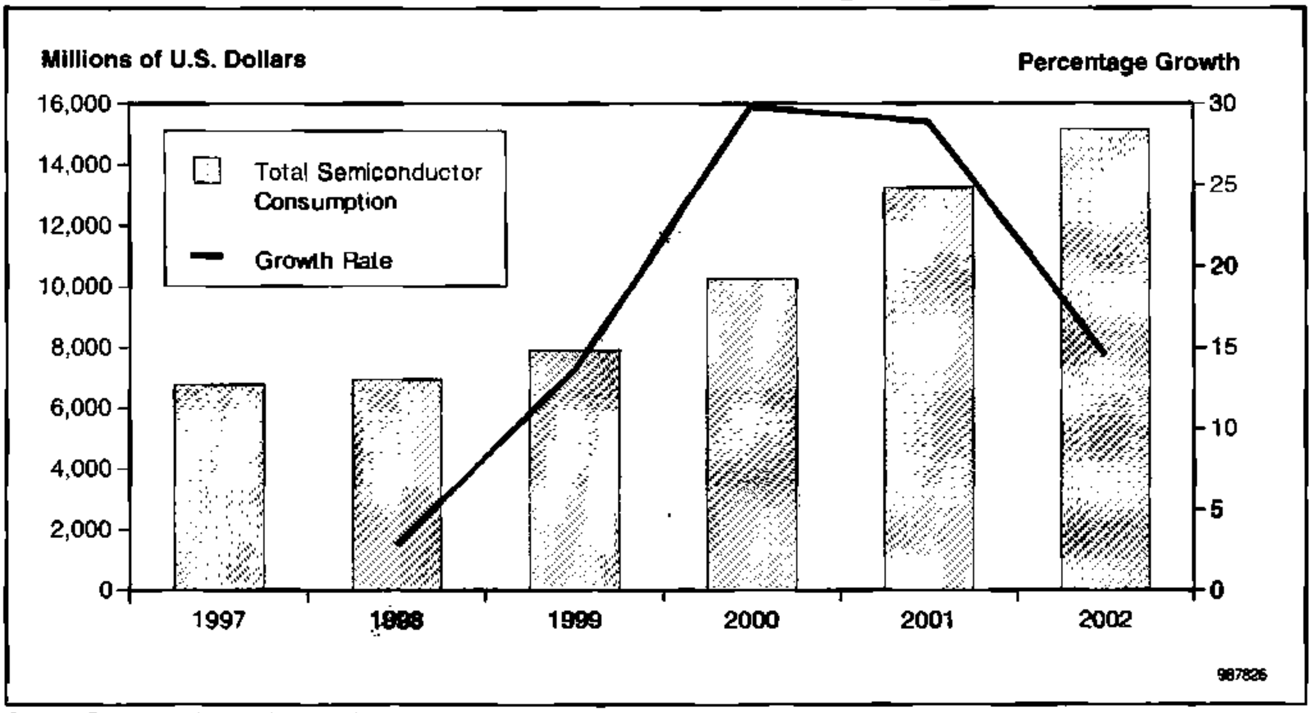
Chapter 1
Introduction

China/Hong Kong's Semiconductor Market Forecast Summary

While most Asia/Pacific countries will experience a market contraction in 1998, Dataquest predicts that China/Hong Kong's semiconductor market will grow by 2.8 percent and reach U.S.$7 billion. Dataquest expects that it will sustain growth, despite the current Asian financial crisis, because China has a relatively better economic health than other Asian nations, particularly steady growth with low inflation. By 2002, China/Hong Kong's semiconductor market will total $15 billion, which marks a 17.5 percent compound annual growth rate (CAGR) from 1997 to 2002. Figures 1-1 to 1-3 illustrate China/Hong Kong's semiconductor consumption forecast.

Figure 1-1
Total Value of Semiconductors Consumed in China/Hong Kong, 1997 to 2002



Source: Dataquest (November 1998)

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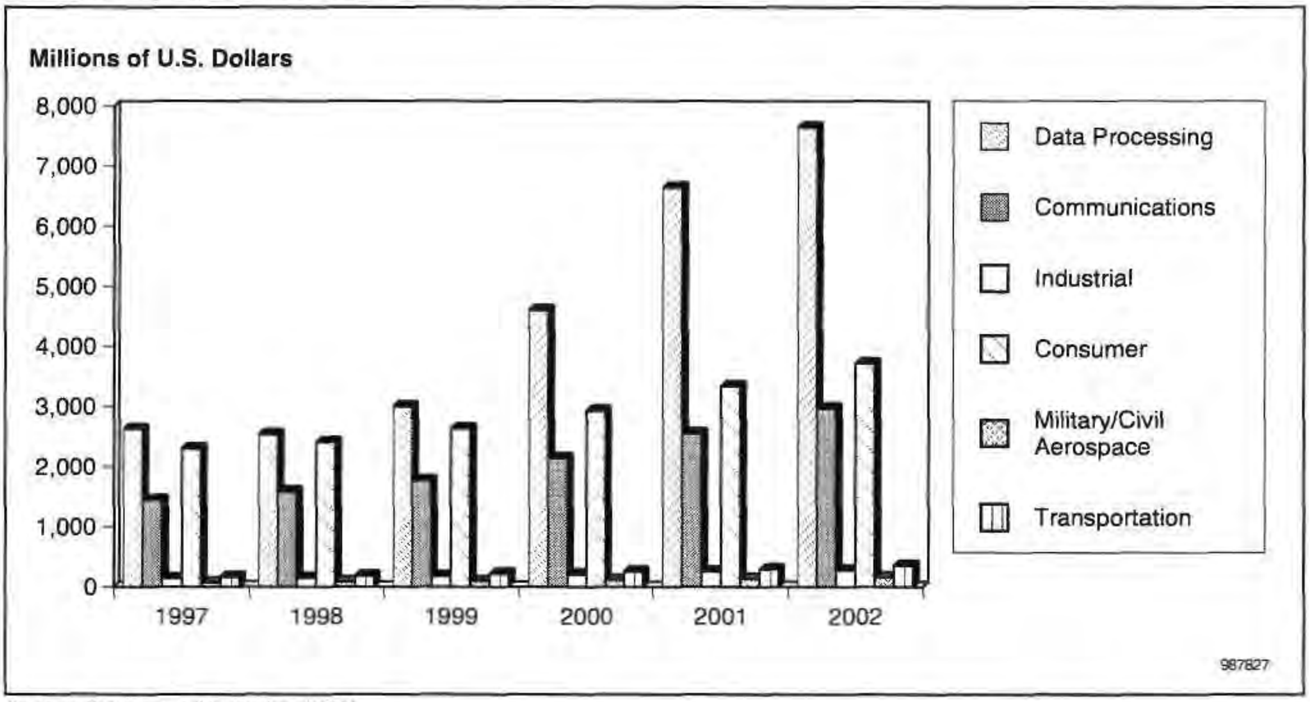
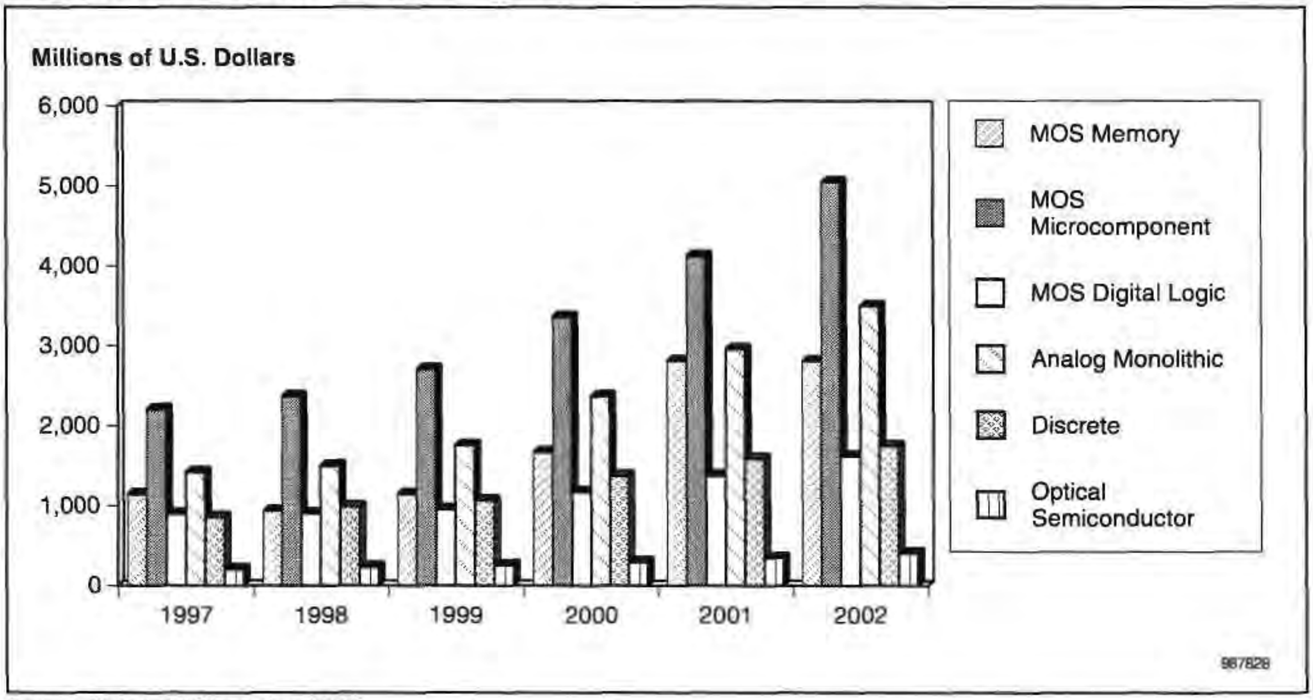
Figure 1-2
Value of Semiconductors Consumed in China/Hong Kong by Electronic Product Group, 1997 to 2002 (Millions of U.S. Dollars)



Source: Dataquest (November 1998)

Figure 1-3
Value of Semiconductors Consumed in China/Hong Kong by Device Group, 1997 to 2002 (Millions of U.S. Dollars)



Source: Dataquest (November 1998)

Forecast Highlights and Assumptions

The following are key assumptions and highlights of this forecast:

- China's economy is expected to grow by an estimated 7 percent, while Hong Kong's economy will shrink by 4 percent in 1998. The Asia/Pacific region should begin to recover from the economic turmoil in 1999.
- China's electronics equipment production will grow 12.6 percent this year, and its semiconductor market by 2.8 percent. China is now the largest semiconductor consumer in Asia/Pacific. It represents the largest consumer of computer equipment, accounting for a quarter of all PC shipments in the region. China's PC unit shipments are expected to reach 3 million units, a 53 percent increase over the 1997 level.
- China/Hong Kong's semiconductor market will expand from $6.8 billion in 1997 to $15 billion in 2002, at a 17.5 percent CAGR, far higher than the region's 13.3 percent CAGR. In 1998, China/Hong Kong's semiconductor market is forecast to grow 2.8 percent, reaching nearly $7 billion.
- Computers will be the dominant driving force for the semiconductor consumption in China/Hong Kong, especially PCs, whose semiconductor use is expected to growth at a 35.2 percent CAGR from 1997 to 2002.
- PCs represent the largest semiconductor consumption application in China, which account for 26 percent of the total semiconductor consumption in computers. However, because of the fast downward pricing of component prices (especially in DRAM and CPU), although the unit growth will be substantial, the revenue terms may still show a flat trend. The serious component price drop will probably hinder the semiconductor consumption growth.
- Memory devices are estimated to decline in 1998 because of the sluggish DRAM price in 1998. DRAM alone is expected to shrink 27.5 percent in 1998, which is a result of vendors' cutthroat price competition, but it will recover gradually from 1999 after vendors' concerted efforts to reduce production. DRAM prices will have a direct impact on the prices of PCs, whose DRAM contents are expected to increase over time.
- China/Hong Kong's MOS microcomponent market is forecast to grow at an 18 percent CAGR from 1997 to 2002, primarily driven by use in PCs and increasing usage of microcontrollers (MCUs) and digital signal processors (DSPs).
- The semiconductor market for optical disk drives will become stagnant in 1999, as the demand of CD-ROM drives reaches saturation and semiconductor prices fall in a downward trend. However, this market will recover in 2000 when high-content digital video disc (DVD) ROM drives will become more popular, gradually replacing CD-ROM drives.
- CRT monitors will be gradually replaced by thin film transistor (TFT) displays in the coming years. The demand for TFT displays will be the main growth driver of semiconductor market of monitors.

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- The average growth of semiconductors used in communications equipment manufacturing will be 9.9 percent this year and is forecast at 11.1 percent in 1999. Digital cordless phones and digital mobile phones will be the sector's key growth drivers. The analog cordless phones will be replaced by digital cordless, while digital cellular phones have already taken the dominant position over analog cellular.
- Semiconductors used in pager manufacturing will show a flat growth of less than 4 percent in 1999, as the market is eroded by the popularity of cellular phones.
- The other area of high growth in communications equipment production is broadcast and studio, which will be driven by the digitalization in broadcasting. As China plans to start its first digital broadcast station in 2000, the related applications are expected to start booming at that time. The high semiconductor content in digital products will make the market attractive.
- China's unemployment rate increases because of the nationwide restructuring of state-owned enterprises (SOEs) and employee layoffs. Because of rising unemployment, the consumer price index (CPI) deflated by 2 percent in the second quarter, suggesting that the consumer consumption was low. The lack of internal consumption will probably bring down the economy and, ultimately, the consumption of semiconductor chips.
- The average growth of semiconductor consumption in consumer electronics will be at a stagnant 4.5 percent this year. The slow growth is attributed to several factors—such as poor export performance, large layoffs of SOE employees, and the disastrous floods in August 1998. The consumer electronics market is forecast to recover gradually and peak in 2001, driven by the global trend of digitalization.
- Digital consumer electronics will be the future growth driver. As the government plans to start its first digital broadcast station in 2000 and to produce fully digital high-definition television (HDTV) in 2004 with a target capacity of 600,000 per year, digitalization will revive the slow growth of consumer electronics.
- Color TV will be one of the applications to benefit from the digitalization. With China's first digital broadcast station to be established in 2000, digital color TV and analog set-top boxes for converting the digital signals will be growing fast, with an expected 23 percent CAGR and 66 percent CAGR, respectively. In addition to local demand, the growth will also be driven by exports as digitalization becomes a global trend.
- China is currently the largest VCD player production base and consumption center. In October 1998, the Ministry of Information Industry (MII) announced a new extended standard for super video compact disc (VCD). VCD players are expected to dominate until 2000 when DVD players become popular and more affordable.
- The home appliance market will be flat this year because of the unfavorable environment for consumers to make purchases. However, the growth is expected to recover from 1999, as the market is still unsaturated in some segments and there is room for replacement purchases.

Electronic Equipment Production in China/Hong Kong

China/Hong Kong's electronic equipment manufacturing is expected to continue growing at a 15.1 percent CAGR to 2002, reaching $92.2 billion. This growth is driven by emerging applications in the data processing equipment, communications equipment, and consumer electronics segments.

Electronic equipment manufacturing is forecast to grow 12.6 percent in 1998, in contrast to 18.6 percent in 1997. The dollar value is expected to reach $51.3 billion in 1998, compared to $45.6 billion in 1997. Its slower growth in 1998 is attributed to the impacts of the Asian financial crisis and the nationwide restructuring of SOEs, which suppress the export growth and internal consumption.

However, given the encouraging macroeconomic developments and continued favorable government policy, China's equipment production will remain on an upward curve through the end of the decade, at 15.1 percent CAGR, to reach $92.2 billion by 2002.

The Market Statistics Report Format

This Market Statistics report contains Dataquest's forecast of China/Hong Kong's semiconductor consumption by electronics application from 1997 to 2002. Readers will note these two forecasts were previously published in separate reports. This is the second of two semiannual forecasts that Dataquest publishes this year. This second forecast reflects changes in Dataquest's view of semiconductor consumption by electronic equipment in China/Hong Kong since spring. It incorporates changes suggested by Dataquest's recently updated forecasts of electronic equipment production and semiconductor shipments.

In contrast to previous forecasts, Dataquest is only reporting its forecast for the 1997-to-2002 period. More significantly, Dataquest has greatly expanded the electronic equipment details to support its forecast of the total semiconductor consumption. These changes are related to a fundamental change in Dataquest's forecast methodology. Whereas Dataquest's previous semiconductor consumption forecasts represent a top-down mathematical reconciliation of its updated electronic equipment production and semiconductor shipment forecasts, this forecast is an effort at a bottom-up estimate of the semiconductor consumption generated by Dataquest's forecast of electronics production. As such, this forecast no longer attempts to specify how Dataquest's forecast of semiconductor shipments will distribute themselves across electronic applications. Instead, it attempts to estimate semiconductor consumption separately by electronic systems unconstrained by the requirement that semiconductor consumption equal semiconductor shipments. Thus, it leaves open the possibility that estimated semiconductor consumption may differ from estimated semiconductor shipments. Unfortunately, this is not the forum to discuss the consequences of the semiconductor demand-supply imbalance implied by persistent differences between estimated semiconductor consumption and estimated semiconductor shipments. Dataquest leaves that task for other publications.

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This report's tables present data that is intended to answer the following questions:

- What is the estimated semiconductor consumption of various broad categories of electronic equipment?
- What is the estimated semiconductor consumption of the key individual electronic systems that make up these broad categories?

The estimates offered here are intended to provide very general answers to these questions. They are meant as a broad guide to semiconductor consumption by electronic equipment production. Dataquest publishes several reports concerning semiconductor applications in specific electronic equipment categories. Readers interested in more detailed information about estimated semiconductor consumption by individual electronic systems are encouraged to consult these publications.

The semiconductor consumption forecasts presented here complement Dataquest's recently updated forecasts of electronic equipment production and semiconductor shipments. A summary of these forecasts down to the individual electronic systems level appears in Chapter 3. Regional forecasts for the Americas, Japan, and Europe, Middle East, and Africa may be requested through Dataquest's inquiry service. Additional regional and semiconductor device detail for this forecast may also be requested through Dataquest's inquiry service.

This report contains tables organized as follows:

- Tables 2-1 to 2-2 summarize Dataquest's China/Hong Kong semiconductor consumption forecast by electronic product group.
- Tables 2-3 to 2-10 detail China/Hong Kong's semiconductor consumption by individual electronic system grouped by equipment type.
- Tables 2-11 to 2-12 summarize the China/Hong Kong semiconductor consumption forecast by device.
- Tables 3-1 to 3-12 detail the China/Hong Kong electronic equipment production forecast.

Segmentation of Semiconductor Applications

Dataquest forecasts semiconductor consumption by end-use electronic application. We divide electronic applications into six broad groups in accordance with our segmentation of electronic equipment production. These groups are, in turn, disaggregated into narrower electronic systems categories, as follows:

- Data processing equipment
  - Computers
  - Data storage equipment
  - Input/output devices
  - Dedicated systems
  - Other data processing equipment

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- Communications equipment
  - Premise telecom equipment
  - Public telecom equipment
  - Mobile communications equipment
  - Broadcast and studio equipment
  - Other communications equipment
- Industrial electronic equipment
  - Security and energy management systems
  - Manufacturing systems and instruments
  - Medical equipment
  - Other industrial equipment
- Consumer electronics
  - Audio equipment
  - Video equipment
  - Personal electronics
  - Appliances
  - Other consumer equipment
- Military/civil aerospace systems
- Transportation electronic equipment

As part of our forecast process, we develop forecasts for roughly 40 individual electronic systems within these various categories and subcategories. These include the following:

- Data processing equipment
  - Mainframe/supercomputers (computers)
  - Midrange computers (computers)
  - Workstations (computers)
  - PCs (computers)
  - PC motherboards (computers)
  - Rigid disk drives (data storage)
  - Optical disk drives (data storage)
  - Removable magnetic storage (data storage)
  - Page printers (input/output devices)
  - Serial printers (input/output devices)
  - Monitors (input/output devices)

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- Communications equipment
  - LAN cards (premise telecom equipment)
  - Premise line cards (premise telecom equipment)
  - Fax machines (premise telecom equipment)
  - Modems (premise telecom equipment)
  - Corded telephones (premise telecom equipment)
  - Analog cordless phones (premise telecom equipment)
  - Digital cordless phones (premise telecom equipment)
  - Central office line cards (public telecom equipment)
  - Analog cellular phones (mobile telecom equipment)
  - Digital cellular phones (mobile telecom equipment)
  - Mobile telecom infrastructure (mobile telecom equipment)
  - Other mobile telecom products (mobile telecom equipment)
- Consumer electronics
  - Personal/portable stereo (audio systems)
  - Color TVs (video devices)
  - VCRs (video devices)
  - Analog camcorders (video devices)
  - Digital camcorders (video devices)
  - DVDs (video devices)
  - Analog set-top boxes (video devices)
  - Digital set-top boxes (video devices)
  - Digital still cameras (personal electronics)
  - Video game controllers (personal electronics)
  - Video game cartridges (personal electronics)
- Transportation electronic equipment
  - Automotive stereos
  - Automotive engine control units (ECUs)
  - Antilock braking systems
  - Air bags
  - Automotive navigation systems

Readers interested in more detailed discussion of our applications segmentation are encouraged to consult the Dataquest publication guide, *Semiconductor Application Market Definitions Guide,* which may also be requested through Dataquest's inquiry service.

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Geographic Segmentation

Dataquest's worldwide electronic equipment production forecast is aggregated from individual forecasts for the four following principal geographic regions:

- Americas
- Japan
- Europe, Middle East, and Africa
- Asia/Pacific

Detailed discussion of these regions and their composition may be found in the Dataquest publication, *Semiconductor Application Market Definitions Guide*.

Exchange Rates

Dataquest's worldwide electronic equipment forecast aggregates data from many countries, each of which uses a currency that has a different and fluctuating exchange rate relative to the U.S. dollar. Because we compile our worldwide forecast from individual regional forecasts, we use the U.S. dollar as a common currency for comparisons and aggregation. As a rule, Dataquest calculates forecasts in local currencies and then converts them to U.S. dollars using projected average annual exchange rates. Dataquest does not forecast exchange rates per se. Instead, we calculate projected average annual exchange rates from current exchange rates. Our projections are based on estimates of the latest available monthly exchange rate at the time the forecast is developed. Table 1-1 presents the average annual exchange rates incorporated in this forecast. These rates are based on monthly exchange rates observed through October 1998. Additional information about historical exchange rates and Dataquest's method of calculating future average exchange rates may be requested through Dataquest's client inquiry service.

Forecast Methodology

When discussing semiconductor consumption, it is critical to remember that semiconductors are not end products consumed for their own sake. Instead, they are intermediate products used as inputs for electronic end products which, in turn, are eventually consumed by individuals and businesses for the services and utility they provide. Implicit in the concept of semiconductor consumption is the notion that one can specify the electronic end products in which semiconductors will be incorporated or consumed. A semiconductor forecast which does not or cannot specify this is not a forecast of semiconductor consumption. At best, it is merely a forecast of semiconductor shipments.

Dataquest's semiconductor consumption by electronic application forecast grew out of the recognition that a truly complete semiconductor forecast must specify the electronic end uses of semiconductors. However, specifying semiconductor end uses has proven far more difficult than recognizing that it must be done. Although it appears possible to specify semiconductor consumption by the variety of electronics produced, it is, in fact, virtually impossible to do this. There are simply too many different types of semiconductor devices consumed in too large a variety of electronic products.

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Table 1-1
Asia/Pacific Exchange Rates against the U.S. Dollar, 1997 to 1999

	Annual Average 1997	Estimated Annual Average 1998	Forecast Annual Rate 1999 and Beyond
Australia (Dollar)	1.35	1.58	1.62
China (Renminbi)	8.32	8.31	8.31
Hong Kong (Dollar)	7.74	7.75	7.75
India (Rupee)	36.36	41.35	42.61
Indonesia (Rupiah)	2,872.61	11,997.24	13,995.87
Japan (Yen)	121.10	136.35	140.79
Malaysia (Ringgit)	2.82	4.04	4.16
New Zealand (Dollar)	1.51	1.86	1.93
Philippines (Peso)	29.47	40.77	41.67
Singapore (Dollar)	1.49	1.68	1.71
South Africa (Rand)	4.61	5.65	6.23
South Korea (Won)	954.14	1,398.99	1,295.76
Sri Lanka (Rupee)	59.02	64.54	65.91
Taiwan (Dollar)	28.79	33.91	34.39
Thailand (Baht)	31.07	42.44	41.30

Source: Dataquest (November 1998)

As a result, semiconductor consumption must invariably be estimated. This can be done in any number of ways. Previous to this forecast, Dataquest used a mathematical model to estimate semiconductor consumption by various electronic end uses. Taking Dataquest's electronic equipment production and semiconductor shipments forecasts as inputs, this model allocated estimated semiconductor shipments across forecast electronics production subject to various assumptions about the semiconductor content of electronic products. The model also imposed several balancing conditions intended to guarantee that estimated semiconductor shipments were totally and completely allocated across all forecast electronics production.

The model applied a decidedly "top-down" approach to estimating semiconductor consumption. In effect, it calculated estimates of semiconductor consumption by compelling agreement between the details of Dataquest's electronics production and semiconductor shipment forecast. As a result, Dataquest's estimates of semiconductor consumption were more an artifact of a mathematical process than truly independent estimates of semiconductor consumption. Although the model offered considerable flexibility to produce reasonable results, it was, nonetheless, limited by the validity of its semiconductor content assumptions and the balancing requirement that semiconductor consumption equal semiconductor shipments. Despite its potential drawbacks, the model provided the best estimates Dataquest could offer given a paucity of knowledge about semiconductor applications in specific electronic systems.

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Fortunately, Dataquest has been able to greatly expand its knowledge of semiconductor uses in specific electronic systems in recent years. During past few years, Dataquest's semiconductor applications research has been concentrated on the study of semiconductor use in specific individual electronic systems. Dataquest has successfully developed models to track and forecast the production and semiconductor consumption of some 40 different individual electronic systems. These include PCs and PC motherboards, rigid disk drives (RDDs), LAN cards, modems, digital cellular phones, digital set-top boxes, and automotive navigation systems, among others. All told, the electronic systems encompassed by Dataquest's models account for roughly one-half of all electronics production and nearly two-thirds of estimated semiconductor consumption.

These models have not only allowed us to codify our knowledge about individual electronic systems but also to approach the task of estimating semiconductor consumption using a "bottom-up" forecast method. This is the method Dataquest has used for this forecast and intend to use from now on for future forecasts. The method essentially involves building up a forecast of semiconductor consumption for all electronics production by leveraging the estimates of semiconductor consumption for individual electronic systems. Specially, Dataquest uses individual systems estimates as a forecast base and augments it with estimates of semiconductor consumption for the various other electronic equipment categories it currently does not track on an individual systems basis. Precisely because the method uses well-researched knowledge about individual electronics systems that dominate semiconductor consumption, we believe it is capable of providing far better forecasts of semiconductor consumption than Dataquest's former top-down method, especially for those electronic equipment categories (such as computers) where our individual systems forecasts account for virtually all of the category.

Naturally, Dataquest's change to a new method has several important consequences. First, Dataquest has, at least temporarily, eliminated the forecasts of specific semiconductor device consumption by electronic application it used to provide. Although informative, these forecasts were largely an artifact of Dataquest's old top-down method. Recent research indicates that these forecasts were especially sensitive to the assumptions and balancing conditions of our top-down method. Unfortunately, we are still in the process of developing semiconductor device detail for many of the individual systems forecasts, which now serve as the basis for our new bottom-up method. Consequently, our systems forecasts have yet to reach the point where they can be leveraged to provide reasonable consumption forecasts for specific semiconductor devices. We hope to reinstate device consumption forecasts, as soon as they are possible, according to our new bottom-up method. In the meantime, we trust that readers will find the added electronics system detail Dataquest can now offer in its forecast adequate compensation.

More importantly, we no longer insist that estimated semiconductor consumption equal Dataquest's forecast of semiconductor shipments. This is actually as it should be. In truth, our long-standing insistence that estimated semiconductor consumption equal forecast semiconductor shipments was more a matter of mathematical necessity for the sake of our old top-down forecast method than a reflection of market realities. There are, in fact, several reasons why semiconductor consumption as we estimate it may differ from a forecast of semiconductor shipments.

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First, there can be significant slippage between semiconductor shipments and semiconductor consumption by electronics producers over short periods because of changes in the semiconductor inventories held by electronic producers. Electronics producers naturally adjust their semiconductor inventories in response to expected changes in their level of production. Although just-in-time practices are reducing the volume of inventories producers hold, the continued existence of inventories means semiconductor shipments and consumption may differ.

Second, not all semiconductor shipments are consumed by electronics producers manufacturing new electronics. Indeed, some find their way into so-called "aftermarkets" where they are eventually "consumed" by existing electronics. We exclude aftermarket activity from our estimates of semiconductor consumption. Aftermarket consumption is virtually impossible to track and in any event, and it appears small relative to the consumption generated by electronics producers.

Finally, Dataquest's estimates of both electronics production and semiconductor consumption, no doubt, suffer from errors of omission. We know that our estimates are likely to exclude at least some current semiconductor applications and most certainly exclude more than a few future applications that cannot be anticipated here and now. In our defense, we have good reason to believe these omissions are minor. Still, they represent yet another reason why estimated semiconductor consumption may differ from forecast semiconductor shipments.

That said, nonetheless, it seems reasonable to expect that estimated semiconductor consumption and forecast semiconductor shipments will closely parallel one another, especially over the long term. As already noted, semiconductors are first and foremost intermediate inputs to electronics production. As such, semiconductor shipment growth is ultimately fueled by growth in the semiconductor consumption generated by electronics production. Growth in electronics manufacturers' semiconductor consumption is, in turn, fueled by growth in both the volume and semiconductor content of electronics production. In the end, all growth in semiconductor shipments can and must be attributed to growth in one or the other of these key consumption drivers. Estimation errors aside, persistent differences between estimated semiconductor consumption growth and forecast semiconductor shipments growth prefigure a demand-supply imbalance in the semiconductor market. In the past, Dataquest's top-down research method obscured the potential semiconductor market imbalances by assuming that estimated semiconductor consumption must equal forecast semiconductor shipments. The beauty of Dataquest's new bottom-up method is that in forsaking this assumption, it can offer important insights into the future of the semiconductor market. Dataquest realizes that separate forecasts of semiconductor consumption and semiconductor shipments have the potential to create some confusion. By the same token, however, Dataquest believes that separate forecasts may actually help clarify future semiconductor market movements by revealing potential market imbalances.

Project Analyst: Kelvin Fu

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Chapter 2

China/Hong Kong's Semiconductor Consumption Forecasts

Tables 2-1 to 2-12 represent Dataquest's forecast of China/Hong Kong semiconductor consumption by electronics application.

Table 2-1
Value of Semiconductors Consumed in China/Hong Kong by Electronic Product Group, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
All Electronic Products	**6,769**	**6,957**	**7,906**	**10,262**	**13,226**	**15,143**
Data Processing Products	**2,631**	**2,539**	**3,002**	**4,605**	**6,643**	**7,649**
Computers	1,001	1,150	1,453	2,467	3,441	3,917
Data Storage	357	386	467	636	856	982
Input/Output	413	402	480	670	1,031	1,269
Dedicated System	699	473	501	700	1,105	1,257
Other Data Processing	161	127	102	131	210	224
Communications Products	**1,446**	**1,589**	**1,767**	**2,145**	**2,555**	**2,977**
Premise Telecom	874	967	1,067	1,294	1,485	1,645
Public Telecom	209	232	261	298	345	396
Mobile Communications	314	340	379	475	611	772
Broadcast and Studio	40	41	48	65	99	148
Other Communications Equipment	9	9	12	14	16	17
Industrial Products	**143**	**152**	**178**	**211**	**255**	**280**
Security/Energy Management	59	61	74	90	106	119
Manufacturing System/Instruments	74	79	90	104	128	138
Medical Equipment	6	7	8	10	11	13
Other Industrial Equipment	5	5	6	7	9	11
Consumer Products	**2,304**	**2,408**	**2,636**	**2,927**	**3,340**	**3,720**
Audio	861	812	884	970	1,066	1,135
Video	866	1,041	1,095	1,210	1,432	1,632
Personal Electronics	346	313	371	402	434	474
Appliances	223	234	278	336	397	464
Other Consumer Electronics	8	8	9	10	11	13
Military/Civil Aerospace Products	**78**	**86**	**100**	**117**	**139**	**164**
Transportation Products	**167**	**184**	**222**	**256**	**295**	**354**

Source: Dataquest (November 1998)

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Table 2-2
Growth in Value of Semiconductors Consumed in China/Hong Kong by Electronic Product Group, 1997 to 2002 (Percent)

	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
All Electronic Products	**2.8**	**13.6**	**29.8**	**28.9**	**14.5**	**17.5**
Data Processing Products	**-3.5**	**18.3**	**53.4**	**44.3**	**15.1**	**23.8**
Computers	15.0	26.3	69.9	39.4	13.8	31.4
Data Storage	8.2	20.9	36.2	34.5	14.7	22.4
Input/Output	-2.8	19.5	39.6	53.8	23.1	25.2
Dedicated System	-32.4	5.9	39.7	58.0	13.8	12.4
Other Data Processing	-21.1	-20.0	28.9	60.7	6.5	6.9
Communications Products	**9.9**	**11.2**	**21.4**	**19.1**	**16.5**	**15.5**
Premise Telecom	10.6	10.4	21.2	14.8	10.8	13.5
Public Telecom	11.4	12.3	14.1	15.8	14.7	13.7
Mobile Communications	8.1	11.6	25.3	28.6	26.4	19.7
Broadcast and Studio	3.4	16.5	36.2	52.3	49.6	30.2
Other Communications Equipment	-2.0	27.5	14.4	17.1	4.4	11.8
Industrial Products	**6.0**	**17.6**	**18.6**	**20.5**	**9.9**	**14.4**
Security/Energy Management	3.8	20.9	22.1	17.5	12.1	15.1
Manufacturing System/Instruments	7.3	14.1	15.6	23.1	7.6	13.4
Medical Equipment	12.1	25.6	13.9	15.4	12.9	15.9
Other Industrial Equipment	4.2	21.1	27.4	27.5	13.1	18.3
Consumer Products	**4.5**	**9.5**	**11.0**	**14.1**	**11.4**	**10.1**
Audio	-5.7	8.8	9.7	9.9	6.5	5.7
Video	20.3	5.2	10.5	18.4	14.0	13.5
Personal Electronics	-9.6	18.6	8.4	7.8	9.3	6.5
Appliances	5.1	18.6	21.0	18.1	17.1	15.8
Other Consumer Electronics	-9.8	12.7	10.3	20.0	18.1	9.7
Military/Civil Aerospace Products	**10.1**	**16.8**	**16.9**	**18.8**	**17.6**	**16.0**
Transportation Products	**10.5**	**20.4**	**15.5**	**15.0**	**19.9**	**16.2**

Source: Dataquest (November 1998)

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Table 2-3
Value of Semiconductors Consumed in China/Hong Kong by Individual Data Processing Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Computers	**1,001**	**1,150**	**1,453**	**2,467**	**3,441**	**3,917**
Mainframe/Supercomputers	52	55	63	70	79	85
Midrange Computers	-	-	3	5	11	15
Workstations	3	4	8	11	15	19
PCs	550	654	887	1,595	2,234	2,485
Motherboards	397	437	493	787	1,102	1,313
Data Storage	**357**	**386**	**467**	**636**	**856**	**982**
Rigid Disk Drives	159	170	228	298	348	380
Optical Disk Drives	120	131	135	194	325	394
Removable Magnetic Storage	78	85	104	145	183	208
Input/Output	**413**	**402**	**480**	**670**	**1,031**	**1,269**
Page Printers	3	5	8	12	19	29
Serial Printers	15	36	40	43	47	51
Monitors	125	154	223	298	395	495
Other Input/Output	269	207	209	317	569	694
Dedicated Systems	**699**	**473**	**501**	**700**	**1,105**	**1,257**
Other Data Processing	**161**	**127**	**102**	**131**	**210**	**224**
All Data Processing Products	**2,631**	**2,539**	**3,002**	**4,605**	**6,643**	**7,649**

Source: Dataquest (November 1998)

Table 2-4
Growth in Value of Semiconductors Consumed in China/Hong Kong by Individual Data Processing Product, 1997 to 2002 (Percent)

	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Computers	**15.0**	**26.3**	**69.9**	**39.4**	**13.8**	**31.4**
Mainframe/Supercomputers	7.3	12.9	12.6	12.3	7.1	10.4
Midrange Computers	NA	NA	100.5	122.7	28.3	NA
Workstations	52.2	89.8	40.5	37.0	27.6	48.0
PC	18.9	35.7	79.7	40.1	11.3	35.2
Motherboards	10.3	12.6	59.7	40.0	19.2	27.1
Data Storage	**8.2**	**20.9**	**36.2**	**34.5**	**14.7**	**22.4**
Rigid Disk Drives	6.9	34.1	30.7	16.8	9.2	19.0
Optical Disk Drives	9.1	3.1	43.1	67.8	21.4	26.8
Removable Magnetic Storage	9.6	21.7	39.2	26.6	13.5	21.7
Input/Output	**-2.8**	**19.5**	**39.6**	**53.8**	**23.1**	**25.2**
Page Printers	42.5	57.1	60.3	60.1	47.5	53.3
Serial Printers	139.5	10.5	9.0	9.6	8.0	27.8
Monitors	22.6	45.4	33.5	32.6	25.2	31.6
Other Input/Output	-23.1	1.1	51.3	79.5	22.0	20.8
Dedicated Systems	**-32.4**	**5.9**	**39.7**	**58.0**	**13.8**	**12.4**
Other Data Processing	**-21.1**	**-20.0**	**28.9**	**60.7**	**6.5**	**6.9**
All Data Processing Products	**-3.5**	**18.3**	**53.4**	**44.3**	**15.1**	**23.8**

NA = Not applicable
Source: Dataquest (November 1998)

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Table 2-5
Value of Semiconductors Consumed in China/Hong Kong by Individual Communications Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Premise Telecom	**874.4**	**967.0**	**1,067.5**	**1,293.7**	**1,484.6**	**1,644.7**
LAN Cards	28.0	40.6	49.1	64.7	68.4	70.7
Premise Line Cards	9.2	11.3	14.1	17.9	20.1	23.0
Answering Machines	83.2	95.8	114.8	136.9	159.0	193.5
Fax Machines	51.3	53.4	50.1	50.5	48.4	51.1
Modems	14.2	16.7	18.7	20.6	23.3	26.1
Corded Telephones	240.2	258.3	281.4	302.5	321.9	349.4
Analog Cordless Telephones	325.9	269.1	223.6	216.7	185.6	156.2
Digital Cordless Telephones	33.1	117.6	172.2	244.4	325.2	349.2
Other Premise Telecom	89.1	104.3	143.6	239.6	332.8	425.5
Public Telecom	**208.6**	**232.4**	**261.0**	**297.9**	**344.9**	**395.7**
Central Office Line Cards	192.6	216.1	241.7	274.4	317.0	364.5
Other Public Telecom	16.0	16.4	19.4	23.4	27.9	31.2
Mobile Communications	**314.1**	**339.7**	**377.9**	**475.0**	**610.7**	**772.2**
Analog Cellular Telephones	16.5	14.6	9.3	6.7	4.6	3.5
Digital Cellular Telephones	204.8	213.9	251.9	337.4	465.5	618.1
Pagers	79.5	93.2	96.7	106.6	114.0	121.6
Mobile Communications Infrastructure	13.3	18.0	21.0	24.2	26.6	28.9
Broadcast and Studio	**39.6**	**40.9**	**47.7**	**64.9**	**98.8**	**147.9**
Other Communications Equipment	**9.4**	**9.3**	**11.8**	**13.5**	**15.8**	**16.5**
All Communications Products	**1,446.1**	**1,589.3**	**1,765.9**	**2,145.0**	**2,554.8**	**2,977.0**

Source: Dataquest (November 1998)

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Table 2-6
Growth in Value of Semiconductors Consumed in China/Hong Kong by Individual Communications Product, 1997 to 2002 (Percent)

	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Premise Telecom	**10.6**	**10.4**	**21.2**	**14.8**	**10.8**	**13.5**
LAN Cards	44.8	21.1	31.8	5.6	3.4	20.3
Premise Line Cards	21.9	24.8	27.1	12.6	14.2	20.0
Answering Machines	15.1	19.8	19.3	16.1	21.7	18.4
Fax Machines	4.1	-6.3	1.0	-4.1	5.5	-0.1
Modems	17.2	11.8	10.2	13.2	12.1	12.9
Corded Telephones	7.5	8.9	7.5	6.4	8.6	7.8
Analog Cordless Telephones	-17.4	-16.9	-3.1	-14.3	-15.9	-13.7
Digital Cordless Telephones	255.1	46.5	41.9	33.1	7.4	60.2
Other Premise Telecom	17.0	37.7	66.8	38.9	27.9	36.7
Public Telecom	**11.4**	**12.3**	**14.1**	**15.8**	**14.7**	**13.7**
Central Office Line Cards	12.2	11.8	13.6	15.5	15.0	13.6
Other Public Telecom	2.3	18.4	21.1	19.2	11.8	14.3
Mobile Communications	**8.1**	**11.3**	**25.7**	**28.6**	**26.4**	**19.7**
Analog Cellular Telephones	-11.7	-36.2	-28.3	-30.4	-23.9	-26.5
Digital Cellular Telephones	4.4	17.8	34.0	37.9	32.8	24.7
Pagers	17.3	3.7	10.3	6.9	6.7	8.9
Mobile Communications Infrastructure	35.0	16.9	15.1	9.8	8.7	16.7
Broadcast and Studio	**3.4**	**16.5**	**36.2**	**52.3**	**49.6**	**30.2**
Other Communications Equipment	**-2.0**	**27.5**	**14.4**	**17.1**	**4.4**	**11.8**
All Communications Products	**9.9**	**11.1**	**21.5**	**19.1**	**16.5**	**15.5**

Source: Dataquest (November 1998)

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Table 2-7
Value of Semiconductors Consumed in China/Hong Kong by Individual Consumer Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Audio	**860.9**	**811.9**	**883.7**	**969.5**	**1,066.0**	**1,135.4**
Personal/Portable Stereo	199.2	204.6	201.1	213.4	224.0	232.5
Other Audio	661.6	607.3	682.6	756.1	842.0	902.9
Video	**865.8**	**1,041.3**	**1,095.2**	**1,210.1**	**1,432.2**	**1,632.4**
Color TVs	411.5	545.7	652.1	783.2	985.8	1,176.1
VCRs	148.8	179.9	185.4	185.0	181.1	166.1
Analog Camcorders	26.0	27.4	30.1	33.7	38.8	42.3
Digital Camcorders	0	0	0.2	0.4	1.2	1.6
DVD	0	2.4	4.6	8.4	48.0	109.3
VCD	276.7	272.4	201.7	164.4	121.1	74.0
Analog Set-Top Boxes	2.8	13.6	18.9	25.1	32.0	35.8
Digital Set-Top Boxes	0	0	2.3	9.8	24.2	27.1
Personal Electronics	**346.0**	**312.8**	**371.0**	**402.0**	**433.5**	**474.0**
Digital Still Cameras	0	0.6	1.5	3.2	4.3	6.3
Video Game Controllers	31.3	33.4	30.8	30.5	31.9	32.6
Other Personal Electronics (including Game Cartridges)	314.6	278.8	338.6	368.4	397.3	435.2
Appliances	**222.7**	**234.2**	**277.7**	**336.0**	**396.7**	**464.5**
Other Consumer Electronics	**8.5**	**7.6**	**8.6**	**9.5**	**11.4**	**13.5**
All Consumer Products	**2,303.8**	**2,407.8**	**2,636.2**	**2,927.2**	**3,339.9**	**3,719.8**

Source: Dataquest (November 1998)

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Table 2-8
Growth in Value of Semiconductors Consumed in China/Hong Kong by Individual Consumer Product, 1997 to 2002 (Percent)

	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Audio	**-5.7**	**8.8**	**9.7**	**9.9**	**6.5**	**5.7**
Personal/Portable Stereo	2.7	-1.7	6.1	4.9	3.8	3.1
Other Audio	-8.2	12.4	10.8	11.4	7.2	6.4
Video	**20.3**	**5.2**	**10.5**	**18.4**	**14.0**	**13.5**
Color TVs	32.6	19.5	20.1	25.9	19.3	23.4
VCRs	20.9	3.1	-0.2	-2.1	-8.3	2.2
Analog Camcorders	5.3	9.9	12.2	15.1	9.0	10.2
Digital Camcorders	NA	NA	137.3	191.6	36.8	NA
DVD	NA	92.5	83.3	471.1	127.7	NA
VCD	-1.5	-26.0	-18.5	-26.3	-38.8	-23.2
Analog Set-Top Boxes	381.9	39.2	33.2	27.2	12.0	66.3
Digital Set-Top Boxes	NA	NA	323.6	145.7	12.2	NA
Personal Electronics	**-9.6**	**18.6**	**8.4**	**7.8**	**9.3**	**6.5**
Digital Still Cameras	NA	170.9	106.1	35.6	46.4	NA
Video Game Controllers	6.6	-7.8	-1.2	4.9	2.0	0.8
Other Personal Electronics (incl. Game Cartridges)	-11.4	21.4	8.8	7.8	9.5	6.7
Appliances	**5.1**	**18.6**	**21.0**	**18.1**	**17.1**	**15.8**
Other Consumer Electronics	**-9.8**	**12.7**	**10.3**	**20.0**	**18.1**	**9.7**
All Consumer Products	**4.5**	**9.5**	**11.0**	**14.1**	**11.4**	**10.1**

NA = Not applicable
Source: Dataquest (November 1998)

Table 2-9
Value of Semiconductors Consumed in China/Hong Kong by Individual Transportation Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Auto Stereo	78.6	84.9	103.6	120.7	138.3	156.1
Auto Engine Control Unit (ECU)	0.1	0.1	0.2	0.3	0.8	1.5
Antilock Braking System	7.6	14.5	25.9	30.0	39.5	69.9
Air Bags	0	0	0	0.1	0.3	0.9
Other Transportation Electronics	80.6	84.8	92.1	105.3	116.0	125.2
All Transportation Products	**166.9**	**184.3**	**221.9**	**256.5**	**295.0**	**353.7**

Source: Dataquest (November 1998)

Table 2-10
Growth in the Value of Semiconductors Consumed in China/Hong Kong by Individual Transportation Product, 1997 to 2002 (Percent)

	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Auto Stereo	8.0	22.1	16.5	14.6	12.9	14.7
Auto Engine Control Unit (ECU)	134.8	104.3	38.9	144.8	84.7	97.6
Antilock Braking System	90.7	78.4	15.9	31.6	77.0	55.8
Air Bags	74.7	128.2	218.7	176.8	200.0	153.9
Other Transportation Electronics	5.2	8.7	14.3	10.2	7.9	9.2
All Transportation Products	**10.5**	**20.4**	**15.5**	**15.0**	**19.9**	**16.2**

Source: Dataquest (November 1998)

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Table 2-11
Value of Semiconductors Consumed in China/Hong Kong by Device Group, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Total Semiconductor	**6,769**	**6,957**	**7,906**	**10,262**	**13,226**	**15,143**
Bipolar Digital	42	35	29	23	18	14
MOS Memory	1,142	933	1,144	1,667	2,812	2,807
Dynamic RAM	800	580	725	1,132	2,157	2,022
Static RAM	87	96	122	171	202	235
Nonvolatile Memory	239	240	279	344	432	531
Other MOS Memory	15	16	18	20	21	20
MOS Microcomponent	2,206	2,370	2,705	3,361	4,123	5,052
Microprocessor	881	1,015	1,245	1,539	1,853	2,270
Microcontroller	680	652	675	836	1,049	1,297
Microperipheral	480	502	533	663	798	948
Digital Signal Processor	165	201	252	323	423	537
MOS Digital Logic	895	901	950	1,171	1,376	1,620
ASICs	253	250	281	385	497	663
Custom IC	78	68	54	43	30	20
MOS Standard Logic	197	178	186	197	205	216
Total Other MOS Logic	368	405	429	546	644	721
Analog-Monolithic	1,419	1,499	1,756	2,369	2,957	3,496
Total Discrete	859	988	1,065	1,375	1,592	1,746
Total Optical Semiconductor	205	231	256	295	348	407

Source: Dataquest (November 1998)

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Table 2-12
Growth in Value of Semiconductors Consumed in China/Hong Kong by Device Group, 1997 to 2002 (Percent)

	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Semiconductor	**2.8**	**13.6**	**29.8**	**28.9**	**14.5**	**17.5**
Bipolar Digital	-16.3	-18.0	-19.5	-21.4	-21.4	-19.3
MOS Memory	-18.3	22.7	45.7	68.7	-0.2	19.7
Dynamic RAM	-27.5	25.0	56.1	90.5	-6.3	20.4
Static RAM	10.3	26.6	40.0	18.4	16.2	21.9
Nonvolatile Memory	0.3	16.3	23.3	25.5	22.8	17.2
Other MOS Memory	6.0	10.0	11.0	4.0	-4.0	5.3
MOS Microcomponent	7.4	14.1	24.3	22.7	22.5	18.0
Microprocessor	15.2	22.7	23.6	20.4	22.5	20.8
Microcontroller	-4.1	3.5	23.9	25.5	23.6	13.8
Microperipheral	4.6	6.2	24.4	20.4	18.8	14.6
Digital Signal Processor	21.8	25.4	28.2	31.0	27.0	26.6
MOS Digital Logic	0.6	5.4	23.3	17.5	17.7	12.6
ASICs	-1.3	12.4	37.0	29.1	33.4	21.2
Custom IC	-12.3	-20.6	-20.4	-30.2	-33.3	-23.7
MOS Standard Logic	-9.6	4.5	5.9	4.1	5.4	1.9
Total Other MOS Logic	10.1	5.9	27.3	17.9	12.0	14.4
Analog-Monolithic	5.6	17.1	34.9	24.8	18.2	19.8
Total Discrete	15.0	7.8	29.1	15.8	9.7	15.2
Total Optical Semiconductor	12.8	11.0	15.0	18.0	17.0	14.7

Source: Dataquest (November 1998)

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Chapter 3

China/Hong Kong's Electronic Equipment Production Forecasts

Tables 3-1 to 3-12 present Dataquest's China/Hong Kong production revenue forecast for electronic equipment.

Table 3-1
China/Hong Kong's Revenue from Data Processing Equipment Production, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Computers	**3,554**	**4,992**	**6,668**	**8,362**	**10,013**	**12,099**
Mainframe/Supercomputers	707	666	724	741	810	890
Midrange Computers	-	-	11	21	42	51
Workstations	13	21	41	59	82	103
PCs	1,708	2,707	4,127	5,214	6,252	7,594
Motherboards	1,127	1,598	1,766	2,328	2,827	3,460
Data Storage	**1,985**	**2,374**	**2,688**	**3,254**	**4,083**	**4,992**
Rigid Disk Drives	946	1,005	1,019	1,123	1,251	1,604
Optical Disk Drives	495	698	693	958	1,350	1,572
Removable Magnetic Storage	545	671	976	1,172	1,482	1,815
Input/Output	**2,331**	**3,466**	**4,509**	**6,118**	**7,885**	**9,654**
Page Printers	24	34	54	87	139	205
Serial Printers	136	327	361	393	431	465
Monitors	1,253	1,991	2,576	3,616	4,793	5,995
Other Input/Output	918	1,114	1,518	2,021	2,522	2,989
Dedicated Systems	**3,926**	**4,224**	**4,769**	**5,528**	**6,488**	**7,391**
Other Data Processing	**656**	**725**	**861**	**1,048**	**1,122**	**1,207**
All Data Processing Products	**12,454**	**15,781**	**19,495**	**24,310**	**29,591**	**35,343**

Source: Dataquest (November 1998)

Table 3-2
Growth in China/Hong Kong's Revenue from Data Processing Equipment Production, 1997 to 2002 (Percent)

	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Computers	**40.5**	**33.6**	**25.4**	**19.7**	**20.8**	**27.8**
Mainframe/Supercomputers	-5.8	8.7	2.2	9.3	9.9	4.7
Midrange Computers	NA	NA	99.3	98.1	20.7	NA
Workstations	66.2	92.2	44.5	39.6	26.3	52.1
PCs	58.5	52.4	26.3	19.9	21.5	34.8
Motherboards	41.8	10.5	31.8	21.5	22.4	25.2
Data Storage	**19.6**	**13.2**	**21.0**	**25.5**	**22.3**	**20.2**
Rigid Disk Drives	6.3	1.4	10.2	11.4	28.3	11.2
Optical Disk Drives	41.0	-0.7	38.4	40.9	16.4	26.0
Removable Magnetic Storage	23.2	45.4	20.1	26.4	22.5	27.2
Input/Output	**48.7**	**30.1**	**35.7**	**28.9**	**22.4**	**32.9**
Page Printers	42.5	57.1	60.3	60.1	47.5	53.3
Serial Printers	139.5	10.5	9.0	9.6	8.0	27.8
Monitors	58.9	29.4	40.4	32.6	25.1	36.8
Other Input/Output	21.4	36.3	33.1	24.8	18.5	26.6
Dedicated Systems	**7.6**	**12.9**	**15.9**	**17.4**	**13.9**	**13.5**
Other Data Processing	**10.5**	**18.7**	**21.7**	**7.1**	**7.6**	**13.0**
All Data Processing Products	**26.7**	**23.5**	**24.7**	**21.7**	**19.4**	**23.2**

NA = Not applicable
Source: Dataquest (November 1998)

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Table 3-3
China/Hong Kong's Revenue from Communications Equipment Production, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Premise Telecom	**4,259.1**	**4,591.2**	**5,093.6**	**5,943.8**	**6,686.7**	**7,335.3**
LAN Cards	76.8	100.9	116.3	143.8	148.1	145.7
Premise Line Cards	63.2	86.9	110.2	132.7	149.0	166.0
Answering Machines	263.8	275.9	325.9	388.3	435.0	472.8
Fax Machines	196.9	204.9	201.7	204.0	205.5	204.7
Modems	42.4	47.8	51.9	55.6	60.5	65.3
Corded Telephones	2,051.4	2,033.8	2,046.5	2,064.5	2,072.1	2,078.3
Analog Cordless Telephones	953.0	841.1	740.3	646.7	518.4	423.2
Digital Cordless Telephones	94.6	377.0	591.9	801.2	985.3	1,055.0
Other Premise Telecom	517.0	623.0	908.9	1,507.0	2,112.7	2,724.4
Public Telecom	**1,363.8**	**1,581.6**	**1,798.1**	**2,054.9**	**2,350.2**	**2,658.6**
Central Office Line Cards	1,212.5	1,421.3	1,611.1	1,829.4	2,082.8	2,360.5
Other Public Telecom	151.4	160.3	187.1	225.4	267.4	298.1
Mobile Communications	**1,508.0**	**1,616.9**	**1,770.0**	**2,085.6**	**2,514.1**	**2,926.2**
Analog Cellular Telephones	105.8	102.5	63.2	43.7	32.7	20.7
Digital Cellular Telephones	820.8	832.5	999.0	1,295.2	1,714.9	2,112.0
Pagers	398.8	438.8	427.3	432.2	425.6	427.7
Mobile Communications Infrastructure	182.6	243.1	280.5	314.5	340.9	365.8
Broadcast and Studio	**230.1**	**252.2**	**291.5**	**395.0**	**602.3**	**896.3**
Other Communications Equipment	**72.0**	**74.0**	**102.0**	**108.0**	**125.0**	**130.0**
All Communications Products	**7,433.0**	**8,115.9**	**90,55.3**	**10,587.3**	**12,278.3**	**13,946.5**

Source: Dataquest (November 1998)

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Table 3-4
Growth in China/Hong Kong's Revenue from Communications Equipment Production, 1997 to 2002 (Percent)

	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Premise Telecom	**7.8**	**10.9**	**16.7**	**12.5**	**9.7**	**11.5**
LAN Cards	31.4	15.3	23.6	3.0	-1.6	13.7
Premise Line Cards	37.5	26.7	20.5	12.3	11.4	21.3
Answering Machines	4.6	18.1	19.1	12.0	8.7	12.4
Fax Machines	4.1	-1.6	1.1	0.7	-0.4	0.8
Modems	12.9	8.5	7.2	8.7	7.9	9.0
Corded Telephones	-0.9	0.6	0.9	0.4	0.3	0.3
Analog Cordless Telephones	-11.7	-12.0	-12.6	-19.8	-18.4	-15.0
Digital Cordless Telephones	298.3	57.0	35.4	23.0	7.1	62.0
Other Premise Telecom	20.5	45.9	65.8	40.2	29.0	39.4
Public Telecom	**16.0**	**13.7**	**14.3**	**14.4**	**13.1**	**14.3**
Central Office Line Cards	17.2	13.4	13.6	13.9	13.3	14.3
Other Public Telecom	5.9	16.7	20.5	18.6	11.5	14.5
Mobile Communications	**7.2**	**9.5**	**17.8**	**20.5**	**16.4**	**14.2**
Analog Cellular Telephones	-3.1	-38.3	-30.9	-25.1	-36.7	-27.8
Digital Cellular Telephones	1.4	20.0	29.6	32.4	23.2	20.8
Pagers	10.0	-2.6	1.1	-1.5	0.5	1.4
Mobile Communications Infrastructure	33.1	15.4	12.1	8.4	7.3	14.9
Broadcast and Studio	**9.6**	**15.6**	**35.5**	**52.5**	**48.8**	**31.3**
Other Communications Equipment	**2.8**	**37.8**	**5.9**	**15.7**	**4.0**	**12.5**
All Communications Products	**9.2**	**11.6**	**16.9**	**16.0**	**13.6**	**13.4**

Source: Dataquest (November 1998)

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Table 3-5
China/Hong Kong's Revenue from Consumer Electronic Equipment Production, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Audio	**7,445.3**	**7,766.9**	**8,601.3**	**9,481.5**	**10,354.2**	**11,125.2**
Personal/Portable Stereo	1,036.0	1,093.0	1,182.3	1,262.9	1,348.7	1,437.2
Other Audio	6,409.3	6,673.9	7,419.1	8,218.6	9,005.5	9,688.0
Video	**5,943.9**	**6,604.2**	**6,846.6**	**7,497.3**	**8,352.3**	**9,231.0**
Color TVs	3,246.5	3,744.9	4,443.2	5,297.9	6,265.3	7,152.2
VCRs	665.5	773.3	792.2	776.7	722.1	648.0
Analog Camcorders	106.7	110.0	125.8	150.8	177.5	199.8
Digital Camcorders	0	0	0.7	1.8	5.3	7.3
DVD	0	9.9	21.6	41.3	204.2	555.5
VCD	1,921	1,946	1,426	1,159	853	524
Analog Set-Top Boxes	3.8	20.3	31.4	41.7	50.4	54.6
Digital Set-Top Boxes	0	0	6.1	27.9	74.9	89.3
Personal Electronics	**3,492.7**	**3,366.0**	**3,934.7**	**4,221.8**	**4,510.6**	**4,940.7**
Digital Still Cameras	0	1.0	2.8	5.9	8.8	13.0
Video Game Controllers	73.0	84.6	83.7	76.0	87.2	92.3
Other Personal Electronics (incl. Game Cartridges)	3,419.7	3,280.5	3,848.2	4,139.9	4,414.6	4,835.5
Appliances	**5,431.6**	**6,004.2**	**6,941.7**	**8,196.2**	**9,676.3**	**11,192.6**
Other Consumer Electronics	**116.0**	**123.2**	**136.7**	**149.9**	**173.3**	**200.9**
All Consumer Products	**22,429.5**	**23,864.5**	**26,460.9**	**29,546.6**	**33,066.6**	**36,690.5**

Source: Dataquest (November 1998)

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Table 3-6
Growth in China/Hong Kong's Revenue from Consumer Electronic Equipment Production, 1997 to 2002 (Percent)

	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Audio	**4.3**	**10.7**	**10.2**	**9.2**	7.4	**8.4**
Personal/Portable Stereo	5.5	8.2	6.8	6.8	6.6	6.8
Other Audio	4.1	11.2	10.8	9.6	7.6	8.6
Video	**11.1**	**3.7**	**9.5**	**11.4**	**10.5**	**9.2**
Color TVs	15.4	18.6	19.2	18.3	14.2	17.1
VCRs	16.2	2.4	-2.0	-7.0	-10.3	-0.5
Analog Camcorders	3.1	14.4	19.8	17.7	12.6	13.4
Digital Camcorders	NA	NA	147.4	187.0	38.6	NA
DVD	NA	119.2	90.6	394.9	172.1	NA
VCD	1.3	-26.7	-18.7	-26.4	-38.5	-22.9
Analog Set-Top Boxes	430.3	54.9	32.8	21.0	8.3	70.2
Digital Set-Top Boxes	NA	NA	360.7	168.7	19.2	NA
Personal Electronics	**-3.6**	**16.9**	**7.3**	**6.8**	**9.5**	**7.2**
Digital Still Cameras	NA	190.6	110.3	50.2	47.5	NA
Video Game Controllers	15.9	-1.1	-9.1	14.6	5.8	4.8
Other Personal Electronics (incl. Game Cartridges)	-4.1	17.3	7.6	6.6	9.5	7.2
Appliances	**10.5**	**15.6**	**18.1**	**18.1**	**15.7**	**15.6**
Other Consumer Electronics	**6.2**	**10.9**	**9.6**	**15.6**	**15.9**	**11.6**
All Consumer Products	**6.4**	**10.9**	**11.7**	**11.9**	**11.0**	**10.3**

NA = Not applicable
Source: Dataquest (November 1998)

Table 3-7
China/Hong Kong's Revenue from Transportation Equipment Production, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Auto Stereo	355.8	354.9	379.1	409.5	455.5	516.8
Auto Engine Control Unit (ECU)	0.2	0.3	0.7	0.9	2.3	4.3
Antilock Braking System	31.5	58.5	101.5	114.1	145.8	251.1
Air Bags	0	0	0.1	0.3	0.8	2.2
Other Transportation Electronics	691.8	737.3	804.6	903.6	987.0	1,088.3
All Transportation Products	**1,079.3**	**1,151.1**	**1,286.0**	**1,428.4**	**15,91.4**	**1,862.8**

Source: Dataquest (November 1998)

Table 3-8
Growth in China/Hong Kong's Revenue from Transportation Equipment Production, 1997 to 2002 (Percent)

	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Auto Stereo	-0.2	6.8	8.0	11.2	13.5	7.8
Auto Engine Control Unit (ECU)	112.2	96.9	41.1	142.7	90.0	93.6
Antilock Braking System	85.6	73.5	12.4	27.8	72.2	51.4
Air Bags	65.8	113.0	201.3	171.5	177.7	140.4
Other Transportation Electronics	6.6	9.1	12.3	9.2	10.3	9.5
All Transportation Products	**6.7**	**11.7**	**11.1**	**11.4**	**17.1**	**11.5**

Source: Dataquest (November 1998)

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Table 3-9
Value of Semiconductors Consumed as a Percentage of China/Hong Kong Production Revenue from Data Processing Equipment, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002
Computers	**28.2**	**23.0**	**21.8**	**29.5**	**34.4**	**32.4**
Mainframe/Supercomputers	7.3	8.3	8.6	9.5	9.8	9.5
Midrange Computers	NA	NA	23.8	24.0	27.0	28.7
Workstations	20.8	19.1	18.9	18.3	18.0	18.2
PCs	32.2	24.1	21.5	30.6	35.7	32.7
Motherboards	35.2	27.4	27.9	33.8	39.0	38.0
Data Storage	**18.0**	**16.3**	**17.4**	**19.6**	**21.0**	**19.7**
Rigid Disk Drives	16.8	16.9	22.4	26.5	27.8	23.7
Optical Disk Drives	24.3	18.8	19.5	20.2	24.1	25.1
Removable Magnetic Storage	14.3	12.7	10.6	12.3	12.3	11.4
Input/Output	**17.7**	**11.6**	**10.6**	**11.0**	**13.1**	**13.1**
Page Printers	14.0	14.0	14.0	14.0	14.0	14.0
Serial Printers	11.0	11.0	11.0	11.0	11.0	11.0
Monitors	10.0	7.7	8.7	8.2	8.2	8.3
Other Input/Output	29.4	18.6	13.8	15.7	22.6	23.2
Dedicated Systems	**17.8**	**11.2**	**10.5**	**12.7**	**17.0**	**17.0**
Other Data Processing	**24.5**	**17.5**	**11.8**	**12.5**	**18.8**	**18.6**
All Data Processing Products	**21.1**	**16.1**	**15.4**	**18.9**	**22.4**	**21.6**

NA = Not applicable
Source: Dataquest (November 1998)

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Table 3-10
Value of Semiconductors Consumed as a Percentage of China/Hong Kong Production Revenue from Communications Equipment, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002
Premise Telecom	**20.5**	**21.1**	**21.0**	**21.8**	**22.2**	**22.4**
LAN Cards	36.5	40.2	42.2	45.0	46.2	48.5
Premise Line Cards	14.6	12.9	12.8	13.5	13.5	13.8
Answering Machines	31.6	34.7	35.2	35.3	36.5	40.9
Fax Machines	26.1	26.1	24.8	24.8	23.6	25.0
Modems	33.6	34.9	36.0	37.0	38.5	40.0
Corded Telephones	11.7	12.7	13.7	14.7	15.5	16.8
Analog Cordless Telephones	34.2	32.0	30.2	33.5	35.8	36.9
Digital Cordless Telephones	35.0	31.2	29.1	30.5	33.0	33.1
Other Premise Telecom	17.2	16.7	15.8	15.9	15.8	15.6
Public Telecom	**15.3**	**14.7**	**14.5**	**14.5**	**14.7**	**14.9**
Central Office Line Cards	15.9	15.2	15.0	15.0	15.2	15.4
Other Public Telecom	10.6	10.2	10.4	10.4	10.5	10.5
Mobile Communications	**20.8**	**21.0**	**21.3**	**22.8**	**24.3**	**26.4**
Analog Cellular Telephones	15.6	14.2	14.7	15.3	14.2	17.1
Digital Cellular Telephones	25.0	25.7	25.2	26.1	27.1	29.3
Pagers	19.9	21.2	22.6	24.7	26.8	28.4
Mobile Communications Infrastructure	7.3	7.4	7.5	7.7	7.8	7.9
Broadcast and Studio	**17.2**	**16.2**	**16.4**	**16.4**	**16.4**	**16.5**
Other Communications Equipment	**13.1**	**12.5**	**11.6**	**12.5**	**12.7**	**12.7**
All Communications Products	**19.5**	**19.6**	**19.5**	**20.3**	**20.8**	**21.3**

Source: Dataquest (November 1998)

Table 3-11
Value of Semiconductors Consumed as a Percentage of China/Hong Kong Production Revenue from Consumer Electronic Equipment, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002
Audio	**11.6**	**10.5**	**10.3**	**10.2**	**10.3**	**10.2**
Personal/Portable Stereo	19.2	18.7	17.0	16.9	16.6	16.2
Other Audio	10.3	9.1	9.2	9.2	9.4	9.3
Video	**14.6**	**15.8**	**16.0**	**16.1**	**17.1**	**17.7**
Color TVs	12.7	14.6	14.7	14.8	15.7	16.4
VCRs	22.4	23.3	23.4	23.8	25.1	25.6
Analog Camcorders	24.4	24.9	23.9	22.4	21.9	21.2
Digital Camcorders	NA	NA	22.5	21.5	21.9	21.6
DVD	NA	24.1	21.2	20.4	23.5	19.7
VCD	0.1	0.7	1.3	2.2	3.8	6.8
Analog Set-Top Boxes	73.6	66.9	60.1	60.3	63.4	65.6
Digital Set-Top Boxes	NA	NA	38.4	35.3	32.3	30.4
Personal Electronics	**9.9**	**9.3**	**9.4**	**9.5**	**9.6**	**9.6**
Digital Still Cameras	NA	58.9	54.9	53.8	48.6	48.3
Video Game Controllers	42.9	39.5	36.8	40.0	36.6	35.3
Other Personal Electronics (incl. Game Cartridges)	9.2	8.5	8.8	8.9	9.0	9.0
Appliances	**4.1**	**3.9**	**4.0**	**4.1**	**4.1**	**4.2**
Other Consumer Electronics	**7.3**	**6.2**	**6.3**	**6.3**	**6.6**	**6.7**
All Consumer Products	**10.3**	**10.1**	**10.0**	**9.9**	**10.1**	**10.1**

NA = Not applicable
Source: Dataquest (November 1998)

Table 3-12
Value of Semiconductors Consumed as a Percentage of China/Hong Kong Production Revenue from Transportation Equipment, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002
Auto Stereo	22.1	23.9	27.3	29.5	30.4	30.2
Auto Engine Control Unit (ECU)	32.3	35.8	37.1	36.5	36.9	35.8
Antilock Braking System	24.2	24.8	25.5	26.3	27.1	27.8
Air Bags	32.2	33.9	36.4	38.5	39.2	42.4
Other Transportation Electronics	11.7	11.5	11.5	11.7	11.8	11.5
All Transportation Products	**15.5**	**16.0**	**17.3**	**18.0**	**18.5**	**19.0**

Source: Dataquest (November 1998)

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1998 Company-Level Electronics Production and Semiconductor Consumption in China/Hong Kong

Market Statistics

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MARIA VALENZUELA

Program: Semiconductors China
Product Code: SEMI-CH-MS-9805
Publication Date: August 10, 1998
Filing: Market Statistics

1998 Company-Level Electronics Production and Semiconductor Consumption in China/Hong Kong

Market Statistics

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Chapter 1
Introduction and Definitions

This Market Statistics report represents findings of Dataquest's primary research of China's electronic equipment manufacturers. Dataquest has selected 62 major high-volume electronic equipment manufacturers with more than 108 factories in China. These companies are top representing companies of U.S., Chinese, European, Hong Kong, Japanese, Korean, and Taiwanese capital.

In addition to Dataquest's *High-Volume Electronic Equipment Unit Production Forecast and Semiconductor Consumption: China/Hong Kong* document, this report publishes company-level information for such details as company locations, products, production units, export ratios, and retail average selling prices (ASPs). This report offers a better understanding of consumption trends by end-application market.

The 62 leading companies selected by Dataquest are as follows:

- United States
  - AST Research Inc.
  - Compaq Computer Corporation
  - IBM
  - Motorola Incorporated
  - Seagate Technology Inc.
- China
  - The Beida Founder Group
  - Beijing International Switching System Company
  - Beijing Aerospace Gold Card Company
  - Changke International Electronics Company Ltd.
  - China Electronic Info. Industry Company
  - Chongqing HuiLiDa Electronic Company
  - Dongguan Zhenglong Technology Company Ltd.
  - Fujian Malata Company Ltd.
  - Guangdong Idall Company Ltd.
  - HuaFei Color Monitor System Company Ltd.
  - HuaXu Gold Card Company
  - Huizhou Wangpai AV Electronic Company Ltd.
  - Jiangsu Shinco Electronic Group Company
  - Konka Electronic Group Company
  - LangChao Electronic Group Company
  - Legend Group

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- Panda Electronics Group
- QingDao Hisense Computer Company
- Rainbow Electronic Group Company
- Shanghai Automotive Brake System Company Ltd.
- Shanghai Bell Telephone Equipment Company
- Shanghai Fudian Automotive Electronics Company Ltd.
- Shanghai Guang Dian Group Company
- Shenzhen Huawei Technology Company Ltd.
- Shenzhen Phone Star Comm. Company Ltd.
- Shenzhen Shentong Printing Equipment Co Ltd.
- Sichuan Changhong Electronic Group Company Ltd.
- Stone Group Corporation
- TCL Group Corporation
- Tontru Information Industry Group
- WeiFang HuaGuang Technology LTD Company
- Xiamen HuaQio Electronic Company
- Xiamen Xiaxin Company Ltd.
- Xian DaTang Telecom Company Ltd.

- Europe
  - Ericsson
  - Nokia Corporation
  - Philips Electronics NV
  - Siemens AG
- Hong Kong
  - Vtech Holdings Ltd.
- Japan
  - Fujitsu Ltd.
  - Hitachi Ltd.
  - Matsushita Electric Industrial Company Ltd.
  - NEC Corporation
  - SANYO Electric Company Ltd.
  - Sharp Electronics Corporation
  - Sony Corporation
  - Toshiba Corporation
  - Uniden Corporation

- Korea
    - Hyundai Electronics Company Ltd.
    - LG Electronics Inc.
    - Samsung Electronics Company Ltd.
- Taiwan
    - Acer Group
    - Dataexpert Inc.
    - First International Computer Inc. (FIC)
    - Hsin Ming Electronic Company Ltd.
    - PC Chips Group

Economic Assumptions and Exchange Rates

Actual exchange rates for the major countries in Asia/Pacific are detailed in Table 1-1. The exchange rates are applied to all historical figures. Dataquest does not forecast currency fluctuations. In looking at our historical numbers, it is important to note fluctuations in currencies. The Chinese renminbi was stable in 1995 and 1996, compared to its fluctuation in 1994. The Korean won appreciated 4.49 percent in 1996. In conducting market forecasts, Dataquest uses constant exchange rates across technologies and regions.

Dataquest has included the gross domestic product forecast by the WEFA Group. As shown in Table 1-2, Asia/Pacific has the fastest-growing economies in the world. The regional expansion has been led by manufacturing, which has in turn been led by the electronics sector in Korea, Singapore, Taiwan, and, more recently, China and Malaysia. These economies have not only sustained growth since the late 1980s but have diversified their regional export markets, which has reduced dependence on North American or European consumers. The increased importance of intra-Asian trade and integration is the key reason for the long-term growth expected. It is noteworthy that China led other Asia/Pacific countries in gross domestic product (GDP) growth, and this is expected to continue until 2001.

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Table 1-1
Asia/Pacific Currency Exchange Rates against the U.S. Dollar, 1996 to 1999

	1996	1997	1998*	1998* U.S. Dollar Appreciation (%)	1999* U.S. Dollar Appreciation
China (Renminbi)	8.34	8.32	8.31	-0.16	8.31
Hong Kong (Dollar)	7.73	7.74	7.75	0.07	7.75
India (Rupee)	35.52	36.36	39.61	8.92	39.70
Japan (Yen)	108.81	121.10	130.85	8.05	131.75
Malaysia (Ringgit)	2.52	2.82	3.80	34.88	3.74
Singapore (Dollar)	1.41	1.49	1.62	8.95	1.60
South Korea (Won)	805.16	954.14	1,445.74	51.52	1,391.55
Taiwan (Dollar)	27.47	28.79	33.06	14.83	33.02
Thailand (Baht)	25.36	31.07	41.43	33.35	39.65

* Estimated average
Source: Dataquest (June 1998)

Table 1-2
Asia/Pacific GDP Growth Rates (Percent)

	1996	1997	1998	1999	2000	2001	2002
Indonesia	8.0	4.6	-6.4	-1.7	4.2	6.4	6.5
Malaysia	8.6	7.8	2.0	3.0	5.5	6.8	7.0
Philippines	5.7	5.1	3.0	4.5	5.5	6.0	6.1
Singapore	6.9	7.8	2.5	4.0	6.8	6.8	6.8
Thailand	6.0	-0.5	-3.5	1.5	3.7	4.1	5.9
China	9.7	8.8	8.0	8.6	8.7	8.7	8.9
Hong Kong	4.9	5.2	2.7	4.2	5.2	5.2	5.0
Taiwan	5.7	6.8	5.2	5.6	6.0	6.0	5.8
South Korea	7.1	5.5	-1.8	2.2	5.7	5.6	5.6
India	7.5	5.0	5.4	5.8	6.3	6.9	6.7

Source: Dataquest (June 1998)

Regional Definitions

Dataquest has revised its regional definitions effective this year. The region formerly known as "Rest of World" has been eliminated and its components have been redistributed across the remaining regions. The remaining regions, in turn, have been redefined in response to this change. Former Rest of World constituents Central America, South America, and the Caribbean have been combined with North America in a new region redefined as "Americas." The Middle East (including Israel) and Africa have been combined with Europe in the redefined region "Europe, Middle East, and Africa." The Pacific Island nations of Oceania, formerly considered Rest of World, have been included with Asia/Pacific to create a larger redefined region still called "Asia/Pacific."

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Americas

- North America: Includes Canada, Mexico, and the United States (50 states)
- Central America
- South America
- Caribbean

Japan

Japan is the only single-country region.

Europe, Middle East, and Africa

Europe

Western Europe. Includes Austria, Belgium, Denmark, Eire (Ireland), Finland, France, Germany (including former East Germany), Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and rest of western Europe (Andorra, Cypress, Gibraltar, Iceland, Liechtenstein, Malta, Monaco, San Marino, Turkey, and Vatican City).

Eastern Europe. Includes Albania, Bulgaria, the Czech Republic and Slovakia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the republics of the former Yugoslavia, and the republics of the former USSR (including Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan).

Middle East (Includes Israel)

Africa

Asia/Pacific

Includes Asia/Pacific's newly industrialized economies (NIEs) and the remainder of Asia/Pacific including Oceania. Asia/Pacific NIEs include Hong Kong, South Korea, Singapore, and Taiwan. The remainder of Asia/Pacific includes Australia, Bangladesh, Brunei, Cambodia, China, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, New Zealand, Pakistan, the Philippines, Sri Lanka, Thailand, and Vietnam, as well as the Pacific Island nations that make up Oceania.

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Product Definitions

The products mentioned in this report will follow the following definitions.

Electronic Data Processing

Personal Computer

A personal computer is a general-purpose computer that is distinguished from other computers by its adherence to hardware and software compatibility. This compatibility drives high unit volumes of commoditylike products that do not require on-site technical support. High-performance features (such as networking, graphics, floating-point coprocessor, and a virtual multiuser/multitasking operating system) are normally optional and not integral system features. IBM/IBM-compatible and Macintosh personal computers are two platforms in this product segment. A single-user PC's resident operating system is typically DOS, OS/2, or Mac OS.

PCs have a performance ceiling that is lower in system compute performance, I/O channel speed, and disk speed than workstations; normally, standard graphics are in the 640 x 480-pixel range, and optional high-end graphics are limited, compared to workstations. Dataquest views a PC system as a single unit that includes a CPU, a monitor, and a keyboard. Furthermore, Dataquest PC shipment data does not include systems assembled from component parts purchased in electronics stores or other outlets.

Motherboard

A motherboard is a PC system board consisting of a printed circuit board with semiconductor and nonsemiconductor components that are all soldered down. The list of semiconductor components will include a minimum of core logic chipset, clock controller, real-time clock, keyboard controller, and any additional glue logic required to interface between the core logic chipset and CPU, cache memory, main memory, and expansion bus (such as PCI). The list of semiconductor components may include a graphics controller, mass storage interface, serial and parallel I/O, voltage converter, or audio controller, as long as they are soldered down.

Workstation

Dataquest classifies workstations by a composite of features, including their hardware and software features. Workstations are typically based on Pentium-class or RISC CPU architectures with a high-performance bus structure, graphics, and operating system. In general, a workstation must come standard with integrated floating-point processing, integrated networking, and a 32-bit multitasking operating system, as well as offer a configuration that has high-resolution graphics capabilities (typically 1-megapixel display). Dataquest does not determine a workstation architecture by its usage (that is, single-user, server, or multiuser).

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Once the system passes these criteria, we examine whether it is designed to be a server or a workstation (that is, if the system is marketed with graphics capabilities). If the system is designed to be a server (examples are the SPARCserver 1000 and RS/6000 POWERserver 900 series), the system is classified in Dataquest's midrange category. If it is marketed with graphics capabilities, we further classify the workstation and its server configuration (for example, SPARCstation 10 and SPARCserver10) into one of three categories: entry-level workstation, midrange workstation, and superworkstation.

Midrange Computer

The midrange product category includes all systems that fall between workstations and mainframes. These are multiuser systems that may or may not run proprietary operating systems. With the evolution of client/server computing and the systems that define this market, traditional midrange product categories are becoming obsolete. The HP 9000 and the HP 3000, Digital's VAX systems, and the IBM AS/400 line are joined by the dedicated server products from vendors such as Auspex, NetFRAME, and Tricord in the midrange product category. Office systems and proprietary turnkey computing solutions, common in Japan, are also included in the midrange category. Systems designed as servers from workstation vendors are also included here.

Midrange-class servers consist of high-end PC server systems that are manufactured and marketed by traditional PC vendors as well as system vendors. A server is a shared computer on a network that can be used for simple and complex tasks. The key distinctions between midrange-class servers and server-marketed PCs are price and the average number of CPUs included in the base system. Midrange-class servers ship with more than one CPU and generally cost more than $15,000. Examples of this segment include the Compaq ProLiant 4000, IBM PC Server 700, and the HP NetServer LM2. The midrange-class server category comprises PC servers that compete with leading symmetric multiprocessing (SMP) and scalable products marketed by dedicated server vendors.

Mainframe/Supercomputer

A supercomputer is a high-performance computer designed for numerically intensive applications; current prices range from $100,000 to $20 million. Typically, these systems run in cool rooms (with or without raised floors), and performance speeds range upward from 50 mflops. Massively parallel systems are defined as machines that have more than 32 relatively inexpensive processors linked together to act as one system.

A mainframe is a general-purpose information system with a starting price of more than $100,000; CPU bit width ranges from 32 bits to 64 bits. Physical environment can be with or without environmental controls.

Page Printer

A page printer prints one page at a time.

Serial Printer

A serial printer prints one character at a time.

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Rigid Disk Drive

The rigid disk drive (RDD) industry is the collective body of companies manufacturing rotating magnetic disk drives for use in storing computer programs and data. Some products are used in noncomputer applications; those are not included in the data presented in these market statistics. A rigid disk drive stores digital information on a round platter made of polished aluminum or a ceramic material. The information is written and read from the platters by recording heads mounted on the end of an arm. The arm is positioned over the desired area of the disk by a sophisticated control circuit that guides an actuator motor's movement. The data is amplified, decoded, and transmitted to the computer by the disk drive electronic circuits. The manner in which the information is presented to the computer is determined by the interface characteristics of the disk drive. Examples of interfaces include the small computer system interface (SCSI) and the PC-AT bus, sometimes called IDE.

Optical Disk Drive

An optical disk drive (ODD) is a data storage device that uses laser technology. Its categories are as follows: CD-ROM drive, 12cm in diameter; CD-Recordable; write-once read-many (WORM) optical drive; rewritable ODD; magneto-optical (MO) multifunction, which has a hidden code read at disk spin-up time; and PC multifunction drive (WORM media that cannot be erased).

Removable Magnetic Storage

Removable magnetic storage comprises FDD and tape.

Monitors

A self-contained video display device that attaches directly to a computer and displays the contents of the computer's video memory. A monitor contains no data formatting or editing capability, nor does it contain any type of networking capability. Included are color monitors, which have interfaces capable of interpreting signals containing separate color components, normally the three primary colors red, green, and blue; and monochrome monitors, which are based on a single-color CRT. These monitors normally display in shades of white, green, or amber. They may or may not have the ability to display multiple shades of a monochromatic color.

Communications

LAN Card

A LAN card is the printed circuit board that plugs into the expansion slots of a PC, workstation, or host terminal to allow connection to a LAN. Network interface cards (NICs) are designed in accordance with either IEEE or ANSI protocol standards; the most common are Ethernet, token ring, and fiber-distributed data interface (FDDI). Workstation and host NICs are segmented only into FDDI, ATM, and others.

Fax

Facsimile machines include those with answering machines and cordless handsets.

Modem

A modem is an electronic device that provides modulation and demodulation functions for data signals transmitted over telephone lines. Modems convert digital data to analog data for transmission over leased lines or the analog public switched telephone network.

Central Office/Premise Line Card

A telecommunications switch used by public carriers.

Corded Telephone

This category includes both standard and feature phones.

PBX

Private branch exchange.

Answering Machine

Answering machines include both standalone and integrated answering machines, including any telephone terminal with an answering machine. To avoid double counting, any corded or home cordless telephone that has an integrated answering machine will be counted in the answering machine category. They are not counted again in the corded or cordless category.

Analog Cordless Telephone

Includes analog (single channel, 10-channel, 24-channel, CT-0, CT-1) cordless telephones and 900 MHz analog cordless telephones. These handsets are usually distinguished by the ability to only communicate with one base station in the home or small business. Therefore, a unit would consist of the combination of a handset and base station. The chip content in both the handset and base station should be added together on the semiconductor content line.

Digital Cordless Telephone

These are cordless handsets that can be used to roam outside the home and can communicate with a service provider's infrastructure or multiple base stations in an office environment. They are usually distinguished from cellular by only being able to communicate at pedestrian speeds. Examples of handsets are PHS, DECT, and CT-2.

Analog Cellular Telephone

This includes all advanced mobile phone service (AMPS), total access communications system (TACS), and Nordic Mobile Telephone (NMT) cellular handsets, among others.

Digital Cellular Telephone

This category covers all digital cellular and broadband personal communications services (PCS) handsets, including handsets that conform to the following standards: Global System for Mobile Communications (GSM), DCS1800, PCS1900, NA-TDMA (IS-54/136), CDMA (IS-95), PDC, and Omnipoint.

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Pager

A pager is a small, pocket-size receiver that can be activated when the pager number is dialed from a telephone. Includes both one-way and two-way pagers.

Mobile Communications Infrastructure

Two components are the base station controller (BSC) and the switch. The BSC controls the voice channels and power controls.

Consumer

Color TV

Color TVs include LCD-based and TV-VCR combinations.

VCR

VCRs do not include TV-VCR combinations.

Personal/Portable Stereo

This category includes headphone stereos, portable CDs, and boom boxes.

Digital Video Player (DVD)

Includes only DVD products that are used with a television for playback of video content. Does not include DVD products targeted at the PC market. These would be included as a subcategory of optical disk drives.

Set-Top Box: Analog

A set-top box that decodes and enables access to analog-based TV services.

Set-Top Box: Digital

Digital cable converter boxes that sit on top of TVs and act as converter devices for digital information over CATV, telephone, or wireless networks to television sets. These boxes contain a general-purpose microprocessor or a high-powered digital signal processor capable of digital transmission, reception, and decompression.

Video Game Controllers

The board with the chips on it that drives the hardware of the game player.

Transportation

Auto Stereo Systems

Includes integrated AM/FM stereo radio receivers; AM/FM radio/cassette combinations; AM/FM radio/cassette/CD combinations, and all in-car audio stereo AM/FM radio-based systems. In the future, this will include terrestrial Digital Audio Broadcast FM receivers (any estimates for DAB radios should become available for inclusion to this category as a separate line item).

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Auto Engine Control Unit

Includes electronic engine control units (ECUs) for petrol (gasoline) and diesel (derv) fuel carburetor/injection engines for cars, trucks, and lorries. Electronic engine control units for petrol engine cars include electronically controlled carburetor systems, single-point injection systems, and multi-point injection systems. Also includes electronic control units where ignition control (breakerless/distributorless, or adaptive/digitally programmed) is integrated with carburetor or injection control unit. Electronic engine control units for diesel engine cars include electronically controlled direct injection systems and indirect injection (distributor) systems. (Please note: Engine control unit excludes standalone electronic ignition control units.) Manages spark or fuel injection, or both.

Antilock Brake System Control Unit

Includes electronic ABS control units for two-wheel ABS systems and four-wheel ABS systems for passenger cars. Includes electronic ABS control units for two-wheel and four-wheel ABS systems for light trucks. Includes electronic ABS control units for commercial-vehicle ABS systems for trailers/juggernauts; and electronic ABS control units for motorcycles. Includes ABS with integrated traction control systems.

Air Bag Control Unit

Includes electronic control units for single and/or dual air bag systems for driver/front passenger. Includes electronic control units for rear-seat air bag systems for rear passengers. Includes electronic control units for side-impact air bag systems for front/rear-seat passengers.

Data Sources

The historical information presented in the production data has been consolidated from a variety of sources, each of which focuses on a specific part of the market. From time to time, Dataquest conducts production surveys for specific types of electronic equipment, and the data gathered is also incorporated into the database. Other sources include the following:

- Dataquest's estimates of systems manufacturers' end-user revenue
- Trade association data
- Various government agency statistics of the countries in Asia/Pacific
- Estimates presented by knowledgeable and reliable industry spokespersons
- Published product literature and prices
- Other Dataquest research groups (including Computer Systems and Peripherals and Telecommunications)

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Forecast Methodology

Dataquest uses a variety of forecasting techniques (both qualitative and quantitative) that vary by technology area. Dataquest follows a three-step process to forecast electronic equipment production. First, current and expected future worldwide and European macroeconomic conditions are assessed and forecast. The Dun & Bradstreet Corporation information is used to develop the macroeconomic forecasts for world's major economies, the Group of Seven (G7) countries. This forecast identifies trends in the economic health of the world's leading consumers and producers of electronic equipment. Using this forecast in conjunction with input from other Dataquest industry sources (as identified earlier), Dataquest estimates the overall business climates in which the electronic systems market will operate.

Second, Dataquest analyzes and forecasts the significant long-range trend and outlook in the various electronic systems research groups (within Dataquest). This analysis establishes a five-year trend growth path for electronic systems production.

The final step in the forecast process is to reconcile expected fluctuations in market trends so that the two do not inexplicably diverge. Dataquest anticipates that in the absence of shocks to the market, market fluctuations converge toward a long-term trend.

Because the time series data contained in this document comprises, in general, annual observations, and it is sparse in terms of the number of observations, the data generally does not satisfy the requirements of quantitative empirical techniques such as econometric or statistical time series models. Therefore, in most cases, we have used judgmental models (that is, intuitive judgments, expert opinions, and subjective probabilities) or technological models (that is, curve fitting and the use of analogous data).

Project Analyst: Kelvin Fu

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Chapter 2
Factory Unit Production

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Table 2-1
Factory Unit Production of U.S. Companies, 1996 to 1999 (Thousands of Units)

Company	Factory	Products	Description	1996	1997	1998	1999
AST	Dongguan AST Hongzhi Computer Co. Ltd.	Motherboard	AST	250	300	-	-
		PC	AST	120	150	-	-
Motorola	Hangzhou Motorola Cellular Systems Co. Ltd.	Cellular phone	GSM	135	200	300	500
	Motorola (China) Electronics Ltd.	Cellular phone	GSM	715	1,000	1,200	1,350
		Pager	Motorola	3,600	3,750	3,800	3,500
	Nanjing Power Co. Ltd.	Power PC	Motorola	8	-	-	-
	Shanghai Motorola Paging Products Co. Ltd.	Pager	Motorola/FLEX	800	1,000	1,300	1,100
Seagate	Seagate (Shenzhen) International Technology Co. Ltd.	Rigid disk drive	Seagate	1,900	2,500	3,000	3,835
	Seagate (Wuxi) International Technology Co. Ltd.	Rigid disk drive	Seagate	783	2,800	4,000	4,950

Source: Dataquest (July 1998)

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Table 2-2
Factory Unit Production of Chinese Companies, 1996 to 1999 (Thousands of Units)

Company	Factory	Products	Description	1996	1997	1998	1999
Beijing Aerospace	Beijing Aerospace Gold Card Co.	Card reader	BJ Aerospace	-	22	30	50
CEC	China Electronic Info. Industry Co.	Smart card	CESC	-	-	5,000	8,000
Chang Hong	Sichuan Changhong Electric Appliances Co. Ltd.	Color television	ChangHong	4,800	6,500	7,000	7,800
		VCD player	CH3000	-	400	800	700
DaTang	Xian DaTang Telecom LTD Co.	CO/PBX	DaTang	-	700	900	1,100
Founder	Dongguan Zhenglong Technology Co Ltd.	Monitor	AONE	145	185	250	500
		PC	Founder	78	135	200	400
	Founder Likang Technology Co. Ltd.	Monitor	AONE	-	25	240	300
Fudian Automotive	Shanghai Fudian Automotive Electronics Co. Ltd.	Auto stereo	-	-	35	45	52
Fujian Malata	Fujian Malata Co. Ltd.	VCD player	Malata	300	1,350	1,500	1,000
Great Wall	Great Wall Hunan Computer Plant	Monitor	Wescom	180	280	456	600
		Terminal	GreatWall	90	120	144	160
Great Wall+IBM	Changke International Electronics Co. Ltd.	Motherboard	IBM OEM, Great Wall	650	850	1,100	1,500
	Great Wall International Information Products Co. Ltd.	PC	Great Wall, IBM	200	400	600	750
Hisense	QingDao Hisense Computer Co.	PC	Hisense	-	50	100	200
HuaFei	HuaFei Color Monitor System Ltd. Co.	Monitor	Philips	-	300	500	800
HuaGuang	WeiFang HuaGuang Technology LTD Co.	CO/PBX	HuanGuang	-	700	1,000	1,200
Huawei	Shenzhen Huawei Technology Company	CO/PBX	C&C08	1,860	2,850	3,420	4,000
HuaXu	HuaXu Gold Card Co.	Card reader	HX series	-	3	15	25
HuaXuTecsun	HuaXu Gold Card Co.	Smart card	HX series	-	5,000	8,000	15,000
HuiLiDa	Chongqing HuiLiDa Electronic Co.	Monitor	HuiLiDa	-	200	350	500
Hunan Computer	Hunan Computer Factory	Card reader	HCC	-	3	10	20
Idall	Guangdong Idall Co. Ltd.	VCD player	Idall	450	1,930	2,000	1,800
	GuangDong Idall Telecom Equipment Co.	Cordless phone	Idall	-	-	500	1,000
		DVD	Idall	-	-	1	5
JiangDu	JiangDu Wire Factory	Corded phone	JiangDu	-	3,000	4,000	5,000
Jiangsu Shinco	Jiangsu Shinco Electronic Group Co.	VCD player	Shinco	900	3,200	2,800	2,000
Konka	Konka Electronic Group Co.	Color television	Konka	-	3,200	4,500	5,500

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Table 2-2 (Continued)
Factory Unit Production of Chinese Companies, 1996 to 1999 (Thousands of Units)

Company	Factory	Products	Description	1996	1997	1998	1999
		VCD player	Konka	-	300	800	950
Langchao	LangChao Electronic Group Co.	PC	Langchao	-	21	80	150
Legend	Beijing Legend Computer Co. Ltd.	PC	Legend	206	320	600	900
	Huiyang Legend Computer Co. Ltd.	Motherboard	QDI	2,100	3,200	4,100	5,000
Panda	Panda Electronics Group	Color television	Panda	-	610	600	700
		DVD	Panda	-	-	1	2
Phone Star	ShenZhen Phone Star Comm. Ltd. Co.	Corded phone	Phone Star	-	3,000	8,000	10,000
		Cordless phone	Phone Star	-	800	1,500	2,000
Rainbow	Rainbow Electronic Group Co.	Corded phone	Rainbow	-	800	1,500	2,000
Rainbow	Rainbow Electronic Group Co.	Monitor	Rainbow	-	300	500	800
Shanghai ABS	Shanghai Automotive Brake System Co. Ltd.	ABS	-	-	150	180	216
Shanghai Bell	Shanghai Bell Telephone Equipment Co.	CO/PBX	S1240	-	5,950	6,800	7,500
Shanghai GuangDian	Shanghai GuangDian Group Co.	Color television	JinXing	-	1,200	1,500	1,800
Stone+Compaq	Compaq Computer Technology (China) Co. Ltd.	PC	Compaq	80	100	150	300
Stone+Fujitsu	Shenzhen Shentong Printing Equipment Co Ltd.	Printer	Stone-Lexmark, Stone OKI	50	67	90	120
TCL	Huizhou Wangpai AV Electronic Co. Ltd.	Color television	TCL	350	400	400	500
	Shenzhen TCL Wangpai Electronics Co. Ltd.	Color television	TCL	300	800	800	1,000
	TCL Communication Equipment Co Ltd.	Corded phone	TCL/Huangpai	5,200	6,000	8,500	12,000
		Cordless phone	TCL Analog cordless phone	795	1,000	1,500	2,000
TCL+NEC	(Huizhou) TCL Mobile Communication Co. Ltd.	Pager	NEC	650	400	1,056	1,000
Tontru	Tontru Information Industry Group	PC	Tontru	18	180	300	500
XiaHua (Xoceco)	Xiamen HuaQio Electronic Co.	Corded phone	Xoceco	-	-	2,000	3,000
		Cordless phone	Xoceco	-	200	500	800
		Color television	Xoceco	-	1,000	1,000	1,500
		Monitor	Xoceco	-	500	1,000	1,200
Xiamen Xiaxin	Xiamen Xiaxin Co. Ltd.	VCD player	Amoisonic	-	820	984	600

Source: Dataquest (July 1998)

Table 2-3
Factory Unit Production of European Companies, 1996 to 1999 (Thousands of Units)

Company	Factory	Products	Description	1996	1997	1998	1999
BISC	Beijing International Switching System Co.	CO/PBX	Siemens	2,540	2,800	3,500	4,000
Ericsson	BEC Beijing Ericsson Communication System Co. Ltd.	CO/PBX	MD110/MD150	350	400	480	600
	BMC Beijing Mobile Communication Co. Ltd.	Cellular phone	GSM	260	320	450	600
	ENC Ericsson (Nanjing) Communication Co. Ltd.	Mobile communications Infrastructure (U.S.$M)	Ericsson	23	34	63	70
	GEC Guangzhou Ericsson Communication Co. Ltd.	Mobile communications Infrastructure (U.S.$M)	Ericsson	18	27	33	45
Nokia	Beijing Nokia Hangxing Communication Co. Ltd.	CO/PBX	Nokia DX200	250	300	360	400
	Beijing Nokia Mobile Communication Co. Ltd.	Cellular phone	GSM	80	150	200	300
		Mobile communications Infrastructure (U.S.$M)	Nokia	63	85	102	110
Philips	Beijing Philips Radio & Video Corp.	Hi-Fi	Philips	80	100	150	170
		Personal stereo	Philips	600	750	900	1,000
	Suzhou Philips Consumer Electronics Co. Ltd.	Monitor	Philips	600	800	1,500	1,800
	Suzhou Philips Consumer Electronics Co. Ltd.	Color television	Philips	250	340	408	550
	Xiaxin Electronics Co. Ltd.	VCD player	Philips	185	820	984	500
		VCR	Philips	65	80	96	80
Siemens	Beijing International Switching System Co. Ltd.	CO/PBX	EWSD	2,540	2,800	3,200	4,000
	Fuzhou Siemens Rixdolf Co. Ltd.	PC	Siemens	8	60	100	100
	Shanghai Siemens Communication Terminals Co. Ltd.	Corded phone	Siemens	250	400	480	650
		Cordless phone	Siemens	-	-	10	100
	Shanghai Siemens Mobile Communication Co. Ltd.	Cellular phone	GSM	45	80	96	250
		Mobile communications Infrastructure (U.S.$M)	Siemens	14	20	24	30
	Siemens Data Communication Co. Ltd.	CO/PBX	HICOM	300	200	250	250

Note: Mobile communications infrastructure is not counted in unit shipments but in revenue.
Source: Dataquest (July 1998)

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Table 2-4
Factory Unit Production of Hong Kong Companies, 1996 to 1999 (Thousands of Units)

Company	Factory	Products	Description	1996	1997	1998	1999
Vtech	Dongguan Vtech Electronics Factory	Cordless phone	Vtech/OEM	1,450	3,350	4,800	5,500
		PC	Vtech	48	50	-	-
		Set-top box	Vtech	-	50	285	380
	Dongguan Vtech Satellite Instrument Co. Ltd.	Satellite receiver	Vtech	100	140	160	180

Source: Dataquest (July 1998)

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Table 2-5
Factory Unit Production of Japanese Companies, 1996 to 1999 (Thousands of Units)

Company	Factory	Products	Description	1996	1997	1998	1999
Fujitsu	Nanjing Fujitsu Computer Instrument Co. Ltd.	Printer	Fujitsu	80	90	160	220
Hitachi	Fujian Hitachi Television Co. Ltd.	Analog camcorder	Hitachi 8mm	18	25	30	45
	Shenzhen Saige Hitachi Color Monitor System Co. Ltd.	Analog camcorder	Hitachi 8mm	25	50	60	75
Hitachi (FuRi)	Fujian Hitachi Television Co. Ltd.	Color television	Hitachi	750	960	1,200	1,500
	Shenzhen Saige Hitachi Color Monitor System Co. Ltd.	Color television	Hitachi	800	1,200	1,200	1,400
Matsushita	Beijing Matsushita Communication Instrument Co. Ltd.	Cellular phone	Panasonic	120	140	180	200
		Pager	Panasonic	540	950	1,000	1,000
	Dalian Matsushita Communication Industry Co. Ltd.	Auto stereo	Panasonic	612	800	960	1,100
		Hi-Fi	Panasonic	300	300	320	400
	Hualu Matsushita VCR Co. Ltd.	Color television	Panasonic	120	-	-	-
		VCR	Panasonic	124	150	165	150
	Xiamen Matsushita Stereo Co. Ltd.	Personal stereo	Panasonic	1,958	2,310	2,772	2,800
NEC	(Benxi) NEC Communication Co Ltd.	CO/PBX	NEAX	180	250	300	300
	Shanghai NEC Computer Co. Ltd.	PC	NEC	24	55	80	150
	Tianjin NEC Telecommunications Co. Ltd.	CO/PBX	NEAX (61)	800	1,200	1,500	1,500
	Wuhan NEC Zhongyuan Mobile Communication Co. Ltd.	Cellular phone	NEC	80	400	480	650
SANYO	SANYO Electric Appliances (Shekou) Co. Ltd.	Personal stereo	SANYO	545	650	780	850
		Radio	SANYO	125	204	245	350
		Video game	SANYO	658	845	1,014	1,200
	Shenzhen Huanqiang SANYO Electronics Co. Ltd.	Color television	SANYO	740	1,000	1,200	1,500
		Hi-Fi	SANYO	38	56	67	90
		VCR	SANYO	75	85	102	128
	Tianjin SANYO Communication Co. Ltd.	Cordless phone	SANYO	28	38	100	350
Sharp	Nanjing Sharp Electronic Co. Ltd.	Color television	Sharp	-	20	150	250
		Hi-Fi	Sharp	-	10	50	80
		VCD player	Sharp	-	50	150	100
	Sharp Office Equipment (Changshu) Co. Ltd.	Printer	Sharp	25	32	38	50
Sony	Beijing Suohong Electronics Co. Ltd.	Cordless phone	Sony	-	800	1,000	1,000

Table 2-5 (Continued)
Factory Unit Production of Japanese Companies, 1996 to 1999 (Thousands of Units)

Company	Factory	Products	Description	1996	1997	1998	1999
	Shanghai Suoguang Electronics Co. Ltd.	Analog camcorder	Sony 8mm	35	200	220	250
	Shanghai Suoguang Yingxiang Co. Ltd.	Color television	Sony	-	50	90	150
		Monitor	Sony	-	90	150	250
Toshiba	Hangzhi Electric Instrument Co. Ltd.	CO/PBX	Toshiba	258	354	425	500
	Toshiba Dalian Co. Ltd.	Color television	Toshiba	550	650	760	850
Uniden	Uniden Electronics Products (Shenzhen) Co. Ltd.	Cordless phone	Uniden/OEM	5,400	5,800	7,100	8,250

Source: Dataquest (July 1998)

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Table 2-6
Factory Unit Production of Korean Companies, 1996 to 1999 (Thousands of Units)

Company	Factory	Products	Description	1996	1997	1998	1999
Hyundai	Hyundai Electronics (Tianjin) Co. Ltd.	Auto stereo	Hyundai	200	450	540	650
LG	LG Electronics (Huizhou) Co. Ltd.	Hi-Fi	LG	70	200	300	380
		Personal stereo	LG	450	650	780	850
	LG Electronics (Shenyang) Co. Ltd.	Monitor	LG	150	-	-	-
	Shanghai Lejin Guangdian Electronics Co. Ltd.	VCD player	LG	56	650	800	500
		VCR	LG	580	650	700	750
Samsung	Huizhou Samsung Electronics Co. Ltd.	Hi-Fi	Samsung	80	300	450	480
		VCD player	Samsung	150	420	460	500
	Shandong Samsung Telecommunications Co. Ltd.	CO/PBX	Samsung	200	250	300	400
		Fax machine	Samsung	315	360	420	500
	Shenyang Samsung Electronic Co. Ltd.	Color television	Samsung	6	-	-	-
		Monitor	Samsung	100	-	-	-
	Tianjin Samsung Electric Instrument Co. Ltd.	Color television	Samsung	150	400	480	500
	Tianjin Samsung Electronics Co. Ltd.	VCR	Samsung	750	980	1,176	800
	Tianjin Tongguang Samsung Electronics Co. Ltd.	Color television	Samsung	900	1,200	1,440	1,650

Source: Dataquest (July 1998)

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Table 2-7
Factory Unit Production of Taiwanese Companies, 1996 to 1999 (Thousands of Units)

Company	Factory	Products	Description	1996	1997	1998	1999
Acer	Beijing Mingji	PC	Acer	-	5	105	150
	Suzhou Mingji Computer Co. Ltd.	Monitor	Acer	350	600	1,350	2,000
Dataexpert	Zhaoqing Dataexpert Computer Co. Ltd.	Motherboard	Dataexpert	480	1,200	1,500	1,800
FIC	Caizhong Plant	Motherboard	LEO	110	1,000	1,125	1,200
		PC	LEO	25	60	72	100
	Changzhong Plant	PC	LEO	80	150	180	200
	Shangzhong Plant	Monitor	LEO	200	500	600	800
	Taizhong Plant	Motherboard	LEO	230	1,500	1,650	1,800
Hsin Ming	Weijia Technology Co. Ltd.	Plug-in card	OEM	800	1,000	1,200	1,500
PC Chips	PC Chips Manufacturing Limited	Motherboard	PC Chips/Asia Gate	5,500	6,900	7,650	8,500

Source: Dataquest (July 1998)

Chapter 3
Factory Unit Production by Electronics Application

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Table 3-1
Factory Unit Production of Personal Computers, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Acer	Beijing Mingji	Acer	Units (K)	-	5.0	105.0	150.0
			Factory Revenue (U.S.$M)	-	6.8	137.0	187.1
			Export Ratio	0.1	0.1	0.1	0.1
AST	Dongguan AST Hongzhi Computer Co. Ltd.	AST	Units (K)	120.0	150.0	-	-
			Factory Revenue (U.S.$M)	173.4	204.5	-	-
			Export Ratio	0.8	0.8	0.8	0.8
FIC	Caizhong Plant	LEO	Units (K)	25.0	60.0	72.0	100.0
			Factory Revenue (U.S.$M)	36.1	81.8	93.9	124.7
			Export Ratio	0.7	0.7	0.7	0.7
	Changzhong Plant	LEO	Units (K)	80.0	150.0	180.0	200.0
			Factory Revenue (U.S.$M)	115.6	204.5	234.8	249.5
			Export Ratio	0.7	0.7	0.7	0.7
Founder	Dongguan Zhenglong Technology Co. Ltd.	Founder	Units (K)	78.0	135.0	200.0	400.0
			Factory Revenue (U.S.$M)	112.7	184.0	260.9	498.9
			Export Ratio	0.1	0.1	0.1	0.1
Great Wall + IBM	Great Wall International Information Products Co. Ltd.	Great Wall, IBM	Units (K)	200.0	400.0	600.0	750.0
			Factory Revenue (U.S.$M)	289.0	545.2	782.8	935.5
			Export Ratio	-	0.1	0.1	0.1
Hisense	QingDao Hisense Computer Co.	Hisense	Units (K)	-	50.0	100.0	200.0
			Factory Revenue (U.S.$M)	-	68.2	130.5	249.5
			Export Ratio	-	-	-	-
LangChao	LangChao Electronic Group Co.	LangChao	Units (K)	-	21.0	80.0	150.0
			Factory Revenue (U.S.$M)	-	28.6	104.4	187.1
			Export Ratio	-	-	-	-
Legend	Beijing Legend Computer Co. Ltd.	Legend	Units (K)	206.0	320.0	600.0	900.0
			Factory Revenue (U.S.$M)	297.7	436.2	782.8	1,122.6
			Export Ratio	-	-	0.1	0.1
NEC	Shanghai NEC Computer Co. Ltd.	NEC	Units (K)	24.0	55.0	80.0	150.0

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Table 3-1 (Continued)
Factory Unit Production of Personal Computers, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
			Factory Revenue (U.S.$M)	34.7	75.0	104.4	187.1
			Export Ratio	-	0.2	0.2	0.2
Siemens	Fuzhou Siemens Rixdolf Co. Ltd.	Siemens	Units (K)	8.0	60.0	100.0	100.0
			Factory Revenue (U.S.$M)	11.6	81.8	130.5	124.7
			Export Ratio	-	0.8	0.8	0.8
Stone + Compaq	Compaq Computer Technology (China) Co. Ltd.	Compaq	Units (K)	80.0	100.0	150.0	300.0
			Factory Revenue (U.S.$M)	115.6	136.3	195.7	374.2
			Export Ratio	0.5	0.5	0.5	0.5
Tontru	Tontru Information Industry Group	Tontru	Units (K)	17.6	180.0	300.0	500.0
			Factory Revenue (U.S.$M)	25.4	245.4	391.4	623.7
			Export Ratio	-	-	0.2	0.2
Vtech	Dongguan Vtech Electronics Factory	Vtech	Units (K)	48.0	50.0	-	-
			Factory Revenue (U.S.$M)	69.4	68.2	-	-
			Export Ratio	0.9	0.9	0.9	0.9

Source: Dataquest (July 1998)

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Table 3-2
Factory Unit Production of Motherboards, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
AST	Dongguan AST Hongzhi Computer Co. Ltd.	AST	Units (K)	250.0	300.0	-	-
			Factory Revenue (U.S.$M)	15.0	21.6	-	-
			Export Ratio	0.8	0.8	-	-
Dataexpert	Zhaoqing Dataexpert Computer Co. Ltd.	Dataexpert	Units (K)	480.0	1,200.0	1,500.0	1,800.0
			Factory Revenue (U.S.$M)	28.8	86.4	123.0	137.1
			Export Ratio	0.6	0.8	0.8	0.8
FIC	Caizhong Plant	LEO	Units (K)	110.0	1,000.0	1,125.0	1,200.0
			Factory Revenue (U.S.$M)	6.6	72.0	92.3	91.4
			Export Ratio	0.9	1.0	1.0	1.0
	Taizhong Plant	LEO	Units (K)	230.0	1,500.0	1,650.0	1,800.0
			Factory Revenue (U.S.$M)	13.8	108.0	135.3	137.1
			Export Ratio	0.9	1.0	1.0	1.0
Great Wall + IBM	Changke International Electronics Co. Ltd.	IBM OEM, Great Wall	Units (K)	650.0	850.0	1,100.0	1,500.0
			Factory Revenue (U.S.$M)	39.0	61.2	90.2	114.2
			Export Ratio	0.9	0.5	0.6	0.6
Legend	Huiyang Legend Computer Co. Ltd.	QDI	Units (K)	2,100.0	3,200.0	4,100.0	5,000.0
			Factory Revenue (U.S.$M)	126.0	230.4	336.2	380.8
			Export Ratio	0.9	0.9	0.9	0.9
PC Chips	PC Chips Manufacturing Limited	PC Chips/Asia Gate	Units (K)	5,500.0	6,900.0	7,650.0	8,500.0
			Factory Revenue (U.S.$M)	330.0	496.8	627.3	647.4
			Export Ratio	1.0	1.0	1.0	1.0

Source: Dataquest (July 1998)

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Table 3-3
Factory Unit Production of Monitors, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Acer	Suzhou Mingji Computer Co. Ltd.	Acer	Units (K)	350.0	600.0	1,350.0	2,000.0
			Factory Revenue (U.S.$M)	61.1	99.6	215.1	312.9
			Export Ratio	0.9	0.9	0.9	0.8
FIC	Shangzhong Plant	LEO	Units (K)	200.0	500.0	600.0	800.0
			Factory Revenue (U.S.$M)	34.9	83.0	95.6	125.2
			Export Ratio	0.8	0.8	0.8	0.8
Founder	Dongguan Zhenglong Technology Co. Ltd.	AONE	Units (K)	145.0	185.0	250.0	500.0
			Factory Revenue (U.S.$M)	25.3	30.7	39.8	78.2
			Export Ratio	0.6	0.6	0.6	0.6
	Founder Likang Technology Co. Ltd.	AONE	Units (K)	-	25.0	240.0	300.0
			Factory Revenue (U.S.$M)	-	4.1	38.2	46.9
			Export Ratio	0.6	0.6	0.6	0.6
Great Wall	Great Wall Hunan Computer Plant	Wescom	Units (K)	180.0	280.0	456.0	600.0
			Factory Revenue (U.S.$M)	31.4	46.5	72.7	93.9
			Export Ratio	-	-	0.1	0.1
HuaFei	HuaFei Color Monitor System Ltd. Co.	Philips	Units (K)	-	300.0	500.0	800.0
			Factory Revenue (U.S.$M)	-	49.8	79.7	125.2
			Export Ratio	-	0.7	0.7	0.7
HuiLiDa	Chongqing HuiLiDa Electronic Co.	HuiLiDa	Units (K)	-	200.0	350.0	500.0
			Factory Revenue (U.S.$M)	-	33.2	55.8	78.2
			Export Ratio	-	0.9	0.9	0.9
LG	LG Electronics (Shenyang) Co. Ltd.	LG	Units (K)	150.0	-	-	-
			Factory Revenue (U.S.$M)	26.2	-	-	-
			Export Ratio	0.8	0.8	0.8	0.8
Philips	Suzhou Philips Consumer Electronics Co. Ltd.	Philips	Units (K)	600.0	800.0	1,500.0	1,800.0
			Factory Revenue (U.S.$M)	104.8	132.8	239.0	281.6
			Export Ratio	0.6	0.6	0.6	0.6
Rainbow	Rainbow Electronic Group Co.	Rainbow	Units (K)	-	300.0	500.0	800.0

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Table 3-3 (Continued)
Factory Unit Production of Monitors, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
			Factory Revenue (U.S.$M)	-	49.8	79.7	125.2
			Export Ratio	-	0.2	0.2	0.2
Samsung	Shenyang Samsung Electronic Co. Ltd.	Samsung	Units (K)	100.0	-	-	-
			Factory Revenue (U.S.$M)	17.5	-	-	-
			Export Ratio	0.8	0.8	0.8	0.8
Sony	Shanghai Suoguang Yingxiang Co. Ltd.	Sony	Units (K)	-	90.0	150.0	250.0
			Factory Revenue (U.S.$M)	-	14.9	23.9	39.1
			Export Ratio	0.8	0.8	0.8	0.8
XiaHua (Xoceco)	Xiamen HuaQio Electronic Co.	Xoceco	Units (K)	-	500.0	1,000.0	1,200.0
			Factory Revenue (U.S.$M)	-	83.0	159.3	187.7
			Export Ratio	-	0.2	0.3	0.4

Source: Dataquest (July 1998)

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Table 3-4
Factory Unit Production of Printers, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Fujitsu	Nanjing Fujitsu Computer Instrument Co. Ltd.	Fujitsu	Units (K)	80.0	90.0	160.0	220.0
			Factory Revenue (U.S.$M)	16.6	18.0	31.1	40.7
			Export Ratio	0.4	0.4	0.4	0.4
Sharp	Sharp Office Equipment (Changshu) Co. Ltd.	Sharp	Units (K)	25.0	32.0	38.0	50.0
			Factory Revenue (U.S.$M)	5.2	6.4	7.4	9.3
			Export Ratio	1.0	1.0	1.0	1.0
Stone + Fujitsu	Shenzhen Shentong Printing Equipment Co. Ltd.	Stone-Lexmark, Stone OKI	Units (K)	50.0	67.0	90.0	120.0
			Factory Revenue (U.S.$M)	10.4	13.4	17.5	22.2
			Export Ratio	0.8	0.7	0.7	0.7

Source: Dataquest (July 1998)

Table 3-5
Factory Unit Production of Rigid Disk Drives, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Seagate	Seagate (Shenzhen) International Technology Co. Ltd.	Seagate	Units (K)	1,900.0	2,500.0	3,000.0	3,835.0
			Factory Revenue (U.S.$M)	380.0	495.0	510.0	559.9
			Export Ratio	0.9	0.9	0.9	0.9
	Seagate (Wuxi) International Technology Co. Ltd.	Seagate	Units (K)	783.0	2,800.0	4,000.0	4,950.0
			Factory Revenue (U.S.$M)	156.6	554.4	680.0	722.7
			Export Ratio	0.9	0.9	0.9	0.9

Source: Dataquest (July 1998)

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Table 3-6
Factory Unit Production of Plug-In Cards, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Hsin Ming	Weijia Technology Co. Ltd.	OEM	Units (K)	800.0	1,000.0	1,200.0	1,500.0
			Factory Revenue (U.S.$M)	28.0	32.1	36.5	43.5
			Export Ratio	1.0	1.0	1.0	1.0

Source: Dataquest (July 1998)

Table 3-7
Factory Unit Production of Power PCs, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Motorola	Nanjing Power Co. Ltd.	Motorola	Units (K)	8.0	-	-	-
			Factory Revenue (U.S.$M)	11.6	-	-	-
			Export Ratio	0.5	-	-	-

Source: Dataquest (July 1998)

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Table 3-8
Factory Unit Production of Central Office/PBX, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
BISC	Beijing International Switching System Co.	Siemens	Units (K)	2,540.0	2,800.0	3,500.0	4,000.0
			Factory Revenue (U.S.$M)	196.9	211.4	259.0	288.0
			Export Ratio	-	-	-	-
DaTang	Xian DaTang Telecom LTD Co.	DaTang	Units (K)	-	700.0	900.0	1,100.0
			Factory Revenue (U.S.$M)	-	52.9	66.6	79.2
			Export Ratio	-	-	-	-
Ericsson	BEC Beijing Ericsson Communication System Co. Ltd.	MD110/MD150	Units (K)	350.0	400.0	480.0	600.0
			Factory Revenue (U.S.$M)	27.1	30.2	35.5	43.2
			Export Ratio	-	-	-	-
HuaGuang	WeiFang HuaGuang Technology LTD Co.	HuanGuang	Units (K)	-	700.0	1,000.0	1,200.0
			Factory Revenue (U.S.$M)	-	52.9	74.0	86.4
			Export Ratio	-	-	-	-
Huawei	Shenzhen Huawei Technology Company	C&C08	Units (K)	1,860.0	2,850.0	3,420.0	4,000.0
			Factory Revenue (U.S.$M)	144.2	215.2	253.1	288.0
			Export Ratio	0.1	0.1	0.1	0.1
NEC	(Benxi) NEC Communication Co. Ltd.	NEAX	Units (K)	180.0	250.0	300.0	300.0
			Factory Revenue (U.S.$M)	14.0	18.9	22.2	21.6
			Export Ratio	0.2	0.2	0.2	0.2
	Tianjin NEC Telecommunications Co. Ltd.	NEAX (61)	Units (K)	800.0	1,200.0	1,500.0	1,500.0
			Factory Revenue (U.S.$M)	62.0	90.6	111.0	108.0
			Export Ratio	0.2	0.2	0.2	0.2
Nokia	Beijing Nokia Hangxing Communication Co. Ltd.	Nokia DX200	Units (K)	250.0	300.0	360.0	400.0
			Factory Revenue (U.S.$M)	19.4	22.7	26.6	28.8
			Export Ratio	-	-	-	-
Samsung	Shandong Samsung Telecommunications Co. Ltd.	Samsung	Units (K)	200.0	250.0	300.0	400.0
			Factory Revenue (U.S.$M)	15.5	18.9	22.2	28.8
			Export Ratio	0.4	0.4	0.4	0.4
Shanghai Bell	Shanghai Bell Telephone Equipment Co.	S1240	Units (K)	-	5,950.0	6,800.0	7,500.0

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Table 3-8 (Continued)
Factory Unit Production of Central Office/PBX, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
			Factory Revenue (U.S.$M)	-	449.2	503.2	540.0
			Export Ratio	-	0.2	0.2	0.2
Siemens	Beijing International Switching System Co. Ltd.	EWSD	Units (K)	2,540.0	2,800.0	3,200.0	4,000.0
			Factory Revenue (U.S.$M)	196.9	211.4	236.8	288.0
			Export Ratio	0.2	0.2	0.2	0.2
	Siemens Data Communication Co. Ltd.	HICOM	Units (K)	300.0	200.0	250.0	250.0
			Factory Revenue (U.S.$M)	23.3	15.1	18.5	18.0
			Export Ratio	-	-	-	-
Toshiba	Hangzhi Electric Instrument Co. Ltd.	Toshiba	Units (K)	258.0	354.0	425.0	500.0
			Factory Revenue (U.S.$M)	20.0	26.7	31.5	36.0
			Export Ratio	0.4	0.4	0.4	0.4

Source: Dataquest (July 1998)

Table 3-9
Factory Unit Production of Corded Phones, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
JiangDu	JiangDu Wire Factory	JiangDu	Units (K)	-	3,000.0	4,000.0	5,000.0
			Factory Revenue (U.S.$M)	-	65.3	81.9	96.4
			Export Ratio	-	0.8	0.8	0.8
Phone Star	ShenZhen Phone Star Comm. Ltd. Co.	Phone Star	Units (K)	-	3,000.0	8,000.0	10,000.0
			Factory Revenue (U.S.$M)	-	65.3	163.8	192.7
			Export Ratio	-	0.5	0.5	0.5
Rainbow	Rainbow Electronic Group Co.	Rainbow	Units (K)	-	800.0	1,500.0	2,000.0
			Factory Revenue (U.S.$M)	-	17.4	30.7	38.5
			Export Ratio	-	0.4	0.4	0.4
Siemens	Shanghai Siemens Communication Terminals Co. Ltd.	Siemens	Units (K)	250.0	400.0	480.0	650.0
			Factory Revenue (U.S.$M)	5.9	8.7	9.8	12.5
			Export Ratio	0.4	0.4	0.4	0.4
TCL	TCL Communication Equipment Co. Ltd.	TCL/Huangpai	Units (K)	5,200.0	6,000.0	8,500.0	12,000.0
			Factory Revenue (U.S.$M)	122.4	130.7	174.0	231.3
			Export Ratio	0.3	0.4	0.4	0.4
XiaHua (Xoceco)	Xiamen HuaQio Electronic Co.	Xoceco	Units (K)	-	-	2,000.0	3,000.0
			Factory Revenue (U.S.$M)	-	-	40.9	57.8
			Export Ratio	-	-	0.4	0.4

Source: Dataquest (July 1998)

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Table 3-10
Factory Unit Production of Cordless Phones, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Idall	GuangDong Idall Telecom Equipment Co.	Idall	Units (K)	-	-	500.0	1,000.0
			Factory Revenue (U.S.$M)	-	-	22.1	42.1
			Export Ratio	-	-	0.6	0.7
Phone Star	ShenZhen Phone Star Comm. Ltd. Co.	Phone Star	Units (K)	-	800.0	1,500.0	2,000.0
			Factory Revenue (U.S.$M)	-	38.4	66.2	84.2
			Export Ratio	-	0.7	0.7	0.7
SANYO	Tianjin SANYO Communication Co. Ltd.	SANYO	Units (K)	28.0	38.0	100.0	350.0
			Factory Revenue (U.S.$M)	1.4	1.8	4.4	14.7
			Export Ratio	0.8	0.8	0.8	0.8
Siemens	Shanghai Siemens Communication Terminals Co. Ltd.	Siemens	Units (K)	-	-	10.0	100.0
			Factory Revenue (U.S.$M)	-	-	0.4	4.2
			Export Ratio	0.8	0.8	0.8	0.8
Sony	Beijing Suohong Electronics Co. Ltd.	Sony	Units (K)	-	800.0	1,000.0	1,000.0
			Factory Revenue (U.S.$M)	-	38.4	44.1	42.1
			Export Ratio	0.7	0.7	0.7	0.7
TCL	TCL Communication Equipment Co. Ltd.	TCL Analog cordless phone	Units (K)	795.0	1,000.0	1,500.0	2,000.0
			Factory Revenue (U.S.$M)	39.0	48.0	66.2	84.2
			Export Ratio	0.5	0.6	0.6	0.6
Uniden	Uniden Electronics Products (Shenzhen) Co. Ltd.	Uniden/OEM	Units (K)	5,400.0	5,800.0	7,100.0	8,250.0
			Factory Revenue (U.S.$M)	264.6	278.4	313.1	347.3
			Export Ratio	1.0	1.0	1.0	1.0
Vtech	Dongguan Vtech Electronics Factory	Vtech/OEM	Units (K)	1,450.0	3,350.0	4,800.0	5,500.0
			Factory Revenue (U.S.$M)	71.1	160.8	211.7	231.6
			Export Ratio	1.0	1.0	1.0	1.0
XiaHua (Xoceco)	Xiamen HuaQio Electronic Co.	Xoceco	Units (K)	-	200.0	500.0	800.0
			Factory Revenue (U.S.$M)	-	9.6	22.1	33.7
			Export Ratio	-	0.4	0.4	0.4

Source: Dataquest (July 1998)

Table 3-11
Factory Unit Production of Cellular Phones, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Ericsson	BMC Beijing Mobile Communication Co. Ltd.	GSM	Units (K)	260.0	320.0	450.0	600.0
			Factory Revenue (U.S.$M)	98.8	104.0	113.9	129.0
			Export Ratio	0.2	0.2	0.2	0.2
Matsushita	Beijing Matsushita Communication Instrument Co. Ltd.	Panasonic	Units (K)	120.0	140.0	180.0	200.0
			Factory Revenue (U.S.$M)	45.6	45.5	45.5	43.0
			Export Ratio	0.9	0.9	0.9	0.9
Motorola	Hangzhou Motorola Cellular Systems Co. Ltd.	GSM	Units (K)	135.0	200.0	300.0	500.0
			Factory Revenue (U.S.$M)	51.3	65.0	75.9	107.5
			Export Ratio	0.2	0.2	0.2	0.2
	Motorola (China) Electronics Ltd.	GSM	Units (K)	715.0	1,000.0	1,200.0	1,350.0
			Factory Revenue (U.S.$M)	271.7	325.0	303.6	290.3
			Export Ratio	0.6	0.6	0.6	0.6
NEC	Wuhan NEC Zhongyuan Mobile Communication Co. Ltd.	NEC	Units (K)	80.0	400.0	480.0	650.0
			Factory Revenue (U.S.$M)	30.4	130.0	121.4	139.8
			Export Ratio	0.7	0.7	0.7	0.7
Nokia	Beijing Nokia Mobile Communication Co. Ltd.	GSM	Units (K)	80.0	150.0	200.0	300.0
			Factory Revenue (U.S.$M)	30.4	48.8	50.6	64.5
			Export Ratio	-	-	-	0.1
Siemens	Shanghai Siemens Mobile Communication Co. Ltd.	GSM	Units (K)	45.0	80.0	96.0	250.0
			Factory Revenue (U.S.$M)	17.1	26.0	24.3	53.8
			Export Ratio	-	-	-	-

Source: Dataquest (July 1998)

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Table 3-12
Factory Unit Production of Pagers, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Matsushita	Beijing Matsushita Communication Instrument Co. Ltd.	Panasonic	Units (K)	540.0	950.0	1,000.0	1,000.0
			Factory Revenue (U.S.$M)	40.5	54.1	54.1	51.8
			Export Ratio	0.9	0.9	0.9	0.9
Motorola	Motorola (China) Electronics Ltd.	Motorola	Units (K)	3,600.0	3,750.0	3,800.0	3,500.0
			Factory Revenue (U.S.$M)	270.0	213.7	205.6	181.3
			Export Ratio	0.4	0.4	0.4	0.4
	Shanghai Motorola Paging Products Co. Ltd.	Motorola/FLEX	Units (K)	800.0	1,000.0	1,300.0	1,100.0
			Factory Revenue (U.S.$M)	60.0	57.0	70.3	57.0
			Export Ratio	0.5	0.5	0.5	0.5
TCL + NEC	(Huizhou) TCL Mobile Communication Co. Ltd.	NEC	Units (K)	650.0	400.0	1,056.0	1,000.0
			Factory Revenue (U.S.$M)	48.8	22.8	57.1	51.8
			Export Ratio	0.3	0.3	0.3	0.3

Source: Dataquest (July 1998)

Table 3-13
Factory Unit Production of Mobile Communications Infrastructure, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Ericsson	ENC Ericsson (Nanjing) Communication Co. Ltd.	Ericsson	Units (K)	23.1	34.2	62.9	70.0
			Factory Revenue (U.S.$M)	23.1	34.2	62.9	70.0
			Export Ratio	0.4	0.4	0.4	0.4
	GEC Guangzhou Ericsson Communication Co. Ltd.	Ericsson	Units (K)	18.3	27.1	32.5	45.0
			Factory Revenue (U.S.$M)	18.3	27.1	32.5	45.0
			Export Ratio	-	-	-	-
Nokia	Beijing Nokia Mobile Communication Co. Ltd.	Nokia	Units (K)	62.7	84.7	101.7	110.0
			Factory Revenue (U.S.$M)	62.7	84.7	101.7	110.0
			Export Ratio	-	-	-	-
Siemens	Shanghai Siemens Mobile Communication Co. Ltd.	Siemens	Units (K)	14.5	20.0	24.0	30.0
			Factory Revenue (U.S.$M)	14.5	20.0	24.0	30.0
			Export Ratio	-	-	-	-

Note: Mobile communications infrastructure is not counted in unit shipments but in revenue.
Source: Dataquest (July 1998)

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Table 3-14
Factory Unit Production of Color Televisions, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Chang Hong	Sichuan Changhong Electric Appliances Co. Ltd.	ChangHong	Units (K)	4,800.0	6,500.0	7,000.0	7,800.0
			Factory Revenue (U.S.$M)	696.0	923.0	980.0	1,084.2
			Export Ratio	0.2	0.02	0.02	0.05
Hitachi (FuRi)	Fujian Hitachi Television Co. Ltd.	Hitachi	Units (K)	750.0	960.0	1,200.0	1,500.0
			Factory Revenue (U.S.$M)	108.8	136.3	168.0	208.5
			Export Ratio	0.8	0.8	0.8	0.8
	Shenzhen Saige Hitachi Color Monitor System Co. Ltd.	Hitachi	Units (K)	800.0	1,200.0	1,200.0	1,400.0
			Factory Revenue (U.S.$M)	116.0	170.4	168.0	194.6
			Export Ratio	0.6	0.6	0.6	0.6
Konka	Konka Electronic Group Co.	Konka	Units (K)	-	3,200.0	4,500.0	5,500.0
			Factory Revenue (U.S.$M)	-	454.4	630.0	764.5
			Export Ratio	-	0.2	0.2	0.2
Matsushita	Hualu Matsushita VCR Co. Ltd.	Panasonic	Units (K)	120.0	-	-	-
			Factory Revenue (U.S.$M)	17.4	-	-	-
			Export Ratio	0.8	0.8	0.8	0.8
Panda	Panda Electronics Group	Panda	Units (K)	-	610.0	600.0	700.0
			Factory Revenue (U.S.$M)	-	86.6	84.0	97.3
			Export Ratio	-	-	-	-
Philips	Suzhou Philips Consumer Electronics Co. Ltd.	Philips	Units (K)	250.0	340.0	408.0	550.0
			Factory Revenue (U.S.$M)	36.3	48.3	57.1	76.5
			Export Ratio	0.6	0.6	0.6	0.6
Samsung	Shenyang Samsung Electronic Co. Ltd.	Samsung	Units (K)	6.0	-	-	-

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Table 3-14 (Continued)
Factory Unit Production of Color Televisions, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
			Factory Revenue (U.S.$M)	0.9	-	-	-
			Export Ratio	0.8	0.8	0.8	0.8
	Tianjin Samsung Electric Instrument Co. Ltd.	Samsung	Units (K)	150.0	400.0	480.0	500.0
			Factory Revenue (U.S.$M)	21.8	56.8	67.2	69.5
			Export Ratio	0.8	0.8	0.8	0.8
	Tianjin Tongguang Samsung Electronics Co. Ltd.	Samsung	Units (K)	900.0	1,200.0	1,440.0	1,650.0
			Factory Revenue (U.S.$M)	130.5	170.4	201.6	229.4
			Export Ratio	0.7	0.7	0.7	0.7
SANYO	Shenzhen Huanqiang SANYO Electronics Co. Ltd.	SANYO	Units (K)	740.0	1,000.0	1,200.0	1,500.0
			Factory Revenue (U.S.$M)	107.3	142.0	168.0	208.5
			Export Ratio	0.2	0.2	0.2	0.2
Shanghai GuangDian	Shanghai GuangDian Group Co.	JinXing	Units (K)	-	1,200.0	1,500.0	1,800.0
			Factory Revenue (U.S.$M)	-	170.4	210.0	250.2
			Export Ratio	-	0.1	0.1	0.2
Sharp	Nanjing Sharp Electronic Co. Ltd.	Sharp	Units (K)	-	20.0	150.0	250.0
			Factory Revenue (U.S.$M)	-	2.8	21.0	34.8
			Export Ratio	0.9	0.9	0.9	0.9
Sony	Shanghai Suoguang Yingxiang Co. Ltd.	Sony	Units (K)	-	50.0	90.0	150.0
			Factory Revenue (U.S.$M)	-	7.1	12.6	20.9
			Export Ratio	0.8	0.8	0.8	0.8
TCL	Huizhou Wangpai AV Electronic Co. Ltd.	TCL	Units (K)	350.0	400.0	400.0	500.0
			Factory Revenue (U.S.$M)	50.8	56.8	56.0	69.5

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Table 3-14 (Continued)
Factory Unit Production of Color Televisions, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
			Export Ratio	0.2	0.3	0.3	0.3
	Shenzhen TCL Wangpai Electronics Co. Ltd.	TCL	Units (K)	300.0	800.0	800.0	1,000.0
			Factory Revenue (U.S.$M)	43.5	113.6	112.0	139.0
			Export Ratio	0.1	0.4	0.4	0.4
Toshiba	Toshiba Dalian Co. Ltd.	Toshiba	Units (K)	550.0	650.0	760.0	850.0
			Factory Revenue (U.S.$M)	79.8	92.3	106.4	118.2
			Export Ratio	0.8	0.8	0.8	0.8
XiaHua (Xoceco)	Xiamen HuaQio Electronic Co.	Xoceco	Units (K)	-	1,000.0	1,000.0	1,500.0
			Factory Revenue (U.S.$M)	-	142.0	140.0	208.5
			Export Ratio	-	0.3	0.3	0.3

Source: Dataquest (July 1998)

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Table 3-15
Factory Unit Production of Video CD Players, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Chang Hong	Sichuan Changhong Electric Appliances Co. Ltd.	CH3000	Units (K)	-	400.0	800.0	700.0
			Factory Revenue (U.S.$M)	-	50.4	80.8	53.9
			Export Ratio	-	-	-	-
Fujian Malata	Fujian Malata Co. Ltd.	Malata	Units (K)	300.0	1,350.0	1,500.0	1,000.0
			Factory Revenue (U.S.$M)	63.0	170.1	151.5	77.0
			Export Ratio	-	-	-	-
Idall	Guangdong Idall Co. Ltd.	Idall	Units (K)	450.0	1,930.0	2,000.0	1,800.0
			Factory Revenue (U.S.$M)	94.5	243.2	202.0	138.6
			Export Ratio	-	-	-	0.05
Jiangsu Shinco	Jiangsu Shinco Electronic Group Co.	Shinco	Units (K)	900.0	3,200.0	2,800.0	2,000.0
			Factory Revenue (U.S.$M)	189.0	403.2	282.8	154.0
			Export Ratio	0.1	0.1	0.1	0.1
Konka	Konka Electronic Group Co.	Konka	Units (K)	-	300.0	800.0	950.0
			Factory Revenue (U.S.$M)	-	63.0	100.8	96.0
			Export Ratio	-	0.2	0.2	0.2
LG	Shanghai Lejin Guangdian Electronics Co. Ltd.	LG	Units (K)	56.0	650.0	800.0	500.0
			Factory Revenue (U.S.$M)	11.8	81.9	80.8	38.5
			Export Ratio	0.8	0.8	0.8	0.8
Philips	Xiaxin Electronics Co. Ltd.	Philips	Units (K)	185.0	820.0	984.0	500.0
			Factory Revenue (U.S.$M)	38.9	103.3	99.4	38.5
			Export Ratio	0.7	0.2	0.2	0.2
Samsung	Huizhou Samsung Electronics Co. Ltd.	Samsung	Units (K)	150.0	420.0	460.0	500.0
			Factory Revenue (U.S.$M)	31.5	52.9	46.5	38.5
			Export Ratio	0.8	0.8	0.8	0.8
Sharp	Nanjing Sharp Electronic Co. Ltd.	Sharp	Units (K)	-	50.0	150.0	100.0
			Factory Revenue (U.S.$M)	-	6.3	15.2	7.7
			Export Ratio	0.6	0.6	0.6	0.6
Xiamen Xiaxin	Xiamen Xiaxin Co. Ltd.	Amoisonic	Units (K)	-	820.0	984.0	600.0
			Factory Revenue (U.S.$M)	-	103.3	99.4	46.2
			Export Ratio	0.2	0.2	0.2	0.2

Source: Dataquest (July 1998)

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Table 3-16
Factory Unit Production of VCRs, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
LG	Shanghai Lejin Guangdian Electronics Co. Ltd.	LG	Units (K)	580.0	650.0	700.0	750.0
			Factory Revenue (U.S.$M)	88.4	94.2	96.3	99.8
			Export Ratio	1.0	1.0	1.0	1.0
Matsushita	Hualu Matsushita VCR Co. Ltd.	Panasonic	Units (K)	124.0	150.0	165.0	150.0
			Factory Revenue (U.S.$M)	18.9	21.7	22.7	20.0
			Export Ratio	0.4	0.4	0.4	0.5
Philips	Xiaxin Electronics Co. Ltd.	Philips	Units (K)	65.0	80.0	96.0	80.0
			Factory Revenue (U.S.$M)	9.9	11.6	13.2	10.7
			Export Ratio	0.7	0.7	0.7	0.7
Samsung	Tianjin Samsung Electronics Co. Ltd.	Samsung	Units (K)	750.0	980.0	1,176.0	800.0
			Factory Revenue (U.S.$M)	114.3	142.0	161.7	106.5
			Export Ratio	0.8	0.8	0.8	0.8
SANYO	Shenzhen Huanqiang SANYO Electronics Co. Ltd.	SANYO	Units (K)	75.0	85.0	102.0	128.0
			Factory Revenue (U.S.$M)	11.4	12.3	14.0	17.0
			Export Ratio	0.4	0.4	0.4	0.4

Source: Dataquest (July 1998)

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Table 3-17
Factory Unit Production of Analog Camcorders, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Hitachi	Fujian Hitachi Television Co. Ltd.	Hitachi 8mm	Units (K)	18.0	25.0	30.0	45.0
			Factory Revenue (U.S.$M)	7.0	9.1	9.8	14.1
			Export Ratio	0.7	0.7	0.7	0.7
	Shenzhen Saige Hitachi Color Monitor System Co. Ltd.	Hitachi 8mm	Units (K)	25.0	50.0	60.0	75.0
			Factory Revenue (U.S.$M)	9.7	18.3	19.6	23.4
			Export Ratio	0.8	0.8	0.8	0.8
Sony	Shanghai Suoguang Electronics Co. Ltd.	Sony 8mm	Units (K)	35.0	200.0	220.0	250.0
			Factory Revenue (U.S.$M)	13.6	73.0	71.7	78.1
			Export Ratio	0.6	0.6	0.6	0.6

Source: Dataquest (July 1998)

Table 3-18
Factory Unit Production of Personal Stereos, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
LG	LG Electronics (Huizhou) Co. Ltd.	LG	Units (K)	450.0	650.0	780.0	850.0
			Factory Revenue (U.S.$M)	14.0	20.3	25.0	27.6
			Export Ratio	0.8	0.8	0.8	0.9
Matsushita	Xiamen Matsushita Stereo Co. Ltd.	Panasonic	Units (K)	1,958.0	2,310.0	2,772.0	2,800.0
			Factory Revenue (U.S.$M)	60.9	72.3	88.7	91.0
			Export Ratio	0.7	0.7	0.7	0.7
Philips	Beijing Philips Radio & Video Corp.	Philips	Units (K)	600.0	750.0	900.0	1,000.0
			Factory Revenue (U.S.$M)	18.7	23.5	28.8	32.5
			Export Ratio	0.6	0.6	0.6	0.6
SANYO	SANYO Electric Appliances (Shekou) Co. Ltd.	SANYO	Units (K)	545.0	650.0	780.0	850.0
			Factory Revenue (U.S.$M)	16.9	20.3	25.0	27.6
			Export Ratio	0.8	0.8	0.8	0.8

Source: Dataquest (July 1998)

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Table 3-19
Factory Unit Production of Smart Cards, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
CEC	China Electronic Info. Industry Co.	CESC	Units (K)	-	-	5,000.0	8,000.0
			Factory Revenue (U.S.$M)	-	-	3.6	5.8
			Export Ratio	-	-	-	-
HuaXuTecsun	HuaXu Gold Card Co.	HX series	Units (K)	-	5,000.0	8,000.0	15,000.0
			Factory Revenue (U.S.$M)	-	3.9	6.3	11.7
			Export Ratio	-	-	-	-

Source: Dataquest (July 1998)

Table 3-20
Factory Unit Production of Card Readers, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Beijing Aerospace	Beijing Aerospace Gold Card Co.	BJ Aerospace	Units (K)	-	22.0	30.0	50.0
			Factory Revenue (U.S.$M)	-	4.2	5.4	8.6
			Export Ratio	-	-	-	-
HuaXu	HuaXu Gold Card Co.	HX series	Units (K)	-	3.0	15.0	25.0
			Factory Revenue (U.S.$M)	-	0.6	2.7	4.3
			Export Ratio	-	-	-	-
Hunan Computer	Hunan Computer Factory	HCC	Units (K)	-	3.0	10.0	20.0
			Factory Revenue (U.S.$M)	-	0.6	1.8	3.4
			Export Ratio	-	-	-	-

Source: Dataquest (July 1998)

Table 3-21
Factory Unit Production of Hi-Fi Systems, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
LG	LG Electronics (Huizhou) Co. Ltd.	LG	Units (K)	70.0	200.0	300.0	380.0
			Factory Revenue (U.S.$M)	14.6	39.6	55.5	68.4
			Export Ratio	0.8	0.8	0.8	0.8
Matsushita	Dalian Matsushita Communication Industry Co. Ltd.	Panasonic	Units (K)	300.0	300.0	320.0	400.0
			Factory Revenue (U.S.$M)	62.7	59.4	59.2	72.0
			Export Ratio	0.8	0.8	0.8	0.8
Philips	Beijing Philips Radio & Video Corp.	Philips	Units (K)	80.0	100.0	150.0	170.0
			Factory Revenue (U.S.$M)	16.7	19.8	27.8	30.6
			Export Ratio	0.4	0.4	0.4	0.4
Samsung	Huizhou Samsung Electronics Co. Ltd.	Samsung	Units (K)	80.0	300.0	450.0	480.0
			Factory Revenue (U.S.$M)	16.7	59.4	83.3	86.4
			Export Ratio	0.8	0.8	0.8	0.8
SANYO	Shenzhen Huanqiang SANYO Electronics Co. Ltd.	SANYO	Units (K)	38.0	56.0	67.0	90.0
			Factory Revenue (U.S.$M)	7.9	11.1	12.4	16.2
			Export Ratio	0.2	0.2	0.2	0.2
Sharp	Nanjing Sharp Electronic Co. Ltd.	Sharp	Units (K)	-	10.0	50.0	80.0
			Factory Revenue (U.S.$M)	-	2.0	9.3	14.4
			Export Ratio	0.9	0.9	0.9	0.9

Source: Dataquest (July 1998)

Table 3-22
Factory Unit Production of Set-Top Boxes, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Vtech	Dongguan Vtech Electronics Factory	Vtech	Units (K)	-	50.0	285.0	380.0
			Factory Revenue (U.S.$M)	-	2.5	14.3	18.8
			Export Ratio	-	1.0	1.0	1.0

Source: Dataquest (July 1998)

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Table 3-23
Factory Unit Production of Satellite Receivers, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Vtech	Dongguan Vtech Satellite Instrument Co. Ltd.	Vtech	Units (K)	100.0	140.0	160.0	180.0
			Factory Revenue (U.S.$M)	NA	NA	NA	NA
			Export Ratio	-	1.0	1.0	1.0

NA = Not applicable
Source: Dataquest (July 1998)

Table 3-24
Factory Unit Production of DVD Players, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Idall	GuangDong Idall Telecom Equipment Co.	Idall	Units (K)	-	-	0.5	5.0
			Factory Revenue (U.S.$M)	-	-	0.2	1.8
			Export Ratio	-	-	0.6	0.7
Panda	Panda Electronics Group	Panda	Units (K)	-	-	1.0	2.0
			Factory Revenue (U.S.$M)	-	-	0.4	0.7
			Export Ratio	-	-	-	-

Source: Dataquest (July 1998)

Table 3-25
Factory Unit Production of Auto Stereo Systems, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Fudian Automotive	Shanghai Fudian Automotive Electronics Co. Ltd.	Fute	Units (K)	-	34.7	45.0	52.0
			Factory Revenue (U.S.$M)	-	2.0	2.6	3.0
			Export Ratio	-	1.0	1.0	1.0
Hyundai	Hyundai Electronics (Tianjin) Co. Ltd.	Hyundai	Units (K)	200.0	450.0	540.0	650.0
			Factory Revenue (U.S.$M)	12.0	26.6	31.3	37.1
			Export Ratio	0.9	0.9	0.9	0.9
Matsushita	Dalian Matsushita Communication Industry Co. Ltd.	Panasonic	Units (K)	612.0	800.0	960.0	1,100.0
			Factory Revenue (U.S.$M)	36.7	47.2	55.7	62.7
			Export Ratio	0.8	0.8	0.8	0.8

Source: Dataquest (July 1998)

Table 3-26
Factory Unit Production of Auto Brake Systems, 1996 to 1999

Company	Factory	Description	Data	1996	1997	1998	1999
Shanghai ABS	Shanghai Automotive Brake System Co. Ltd.	-	Units (K)	-	150.0	180.0	216.0
		-	Factory Revenue (U.S.$M)	-	23.6	27.0	31.3
		-	Export Ratio	-	0.1	0.1	0.1

Source: Dataquest (July 1998)

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Chapter 4

Factory Semiconductor Consumption

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Table 4-1
Factory Semiconductor Consumption by Data Processing Equipment, 1996 to 1999 (Millions of U.S. Dollars)

Products	Company	Factory	1996	1997	1998	1999
Monitor	Acer	Suzhou Mingji Computer Co. Ltd.	6.3	10.2	22.9	32.0
	FIC	Shangzhong Plant	3.6	8.5	10.2	12.8
	Founder	Dongguan Zhenglong Technology Co. Ltd.	2.6	3.1	4.2	8.0
		Founder Likang Technology Co. Ltd.	-	0.4	4.1	4.8
	Great Wall	Great Wall Hunan Computer Plant	3.2	4.8	7.8	9.6
	HuaFei	HuaFei Color Monitor System Ltd. Co.	-	5.1	8.5	12.8
	HuiLiDa	Chongqing HuiLiDa Electronic Co.	-	3.4	5.9	8.0
	LG	LG Electronics (Shenyang) Co. Ltd.	2.7	-	-	-
	Philips	Suzhou Philips Consumer Electronics Co. Ltd.	10.8	13.6	25.5	28.8
	Rainbow	Rainbow Electronic Group Co.	-	5.1	8.5	12.8
	Samsung	Shenyang Samsung Electronic Co. Ltd.	1.8	-	-	-
	Sony	Shanghai Suoguang Yingxiang Co. Ltd.	-	1.5	2.5	4.0
	XiaHua (Xoceco)	Xiamen HuaQio Electronic Co.	-	8.5	17.0	19.2
Motherboard	AST	Dongguan AST Hongzhi Computer Co. Ltd.	8.7	10.7	-	-
	Dataexpert	Zhaoqing Dataexpert Computer Co. Ltd.	16.8	42.7	58.2	67.7
	FIC	Caizhong Plant	3.8	35.6	43.7	45.1
		Taizhong Plant	8.0	53.4	64.0	67.7
	Great Wall + IBM	Changke International Electronics Co. Ltd.	22.7	30.3	42.7	56.4
	Legend	Huiyang Legend Computer Co. Ltd.	73.3	113.9	159.1	188.0
	PC Chips	PC Chips Manufacturing Limited	192.0	245.6	296.8	319.6
PC	Acer	Beijing Mingji	-	2.0	41.1	56.0
	AST	Dongguan AST Hongzhi Computer Co. Ltd.	49.6	59.8	-	-
	FIC	Caizhong Plant	10.3	23.9	28.2	37.3
		Changzhong Plant	33.1	59.8	70.5	74.7
	Founder	Dongguan Zhenglong Technology Co. Ltd.	32.3	53.8	78.3	149.3
	Great Wall + IBM	Great Wall International Information Products Co. Ltd.	82.7	159.5	234.8	280.0
	Hisense	QingDao Hisense Computer Co.	-	19.9	39.1	74.7
	LangChao	LangChao Electronic Group Co.	-	8.4	31.3	56.0

Table 4-1 (Continued)
Factory Semiconductor Consumption by Data Processing Equipment, 1996 to 1999 (Millions of U.S. Dollars)

Products	Company	Factory	1996	1997	1998	1999
	Legend	Beijing Legend Computer Co. Ltd.	85.2	127.6	234.8	336.0
	NEC	Shanghai NEC Computer Co. Ltd.	9.9	21.9	31.3	56.0
	Siemens	Fuzhou Siemens Rixdolf Co. Ltd.	3.3	23.9	39.1	37.3
	Stone + Compaq	Compaq Computer Technology (China) Co. Ltd.	33.1	39.9	58.7	112.0
	Tontru	Tontru Information Industry Group	7.3	71.8	117.4	186.7
	Vtech	Dongguan Vtech Electronics Factory	19.8	19.9	-	-
Plug-In Card	Hsin Ming	Weijia Technology Co. Ltd.	10.1	11.4	12.2	14.7
Printer	Fujitsu	Nanjing Fujitsu Computer Instrument Co. Ltd.	1.9	2.2	4.3	6.3
	Sharp	Sharp Office Equipment (Changshu) Co. Ltd.	0.6	0.8	1.0	1.4
	Stone + Fujitsu	Shenzhen Shentong Printing Equipment Co. Ltd.	1.2	1.7	2.4	3.4
Rigid Disk Drive	Seagate	Seagate (Shenzhen) International Technology Co. Ltd.	57.2	75.3	87.3	106.3
		Seagate (Wuxi) International Technology Co. Ltd.	23.6	84.4	116.4	137.2
Terminal	Great Wall	Great Wall Hunan Computer Plant	2.3	3.1	3.5	3.7
Power PC	Motorola	Nanjing Power Co. Ltd.	3.3	-	-	-
Total			**823.1**	**1,467.7**	**2,013.5**	**2,626.2**

Source: Dataquest (July 1998)

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Table 4-2
Factory Semiconductor Consumption by Communications Equipment, 1996 to 1999 (Millions of U.S. Dollars)

Products	Company	Factory	1996	1997	1998	1999
Cellular Phone	Ericsson	BMC Beijing Mobile Communication Co. Ltd.	23.1	25.6	31.3	37.6
	Matsushita	Beijing Matsushita Communication Instrument Co. Ltd.	10.6	11.2	12.5	12.5
	Motorola	Hangzhou Motorola Cellular Systems Co. Ltd.	12.0	16.0	20.9	31.4
		Motorola (China) Electronics Ltd.	63.4	80.1	83.4	84.6
	NEC	Wuhan NEC Zhongyuan Mobile Communication Co. Ltd.	7.1	32.0	33.4	40.8
	Nokia	Beijing Nokia Mobile Communication Co. Ltd.	7.1	12.0	13.9	18.8
	Siemens	Shanghai Siemens Mobile Communication Co. Ltd.	4.0	6.4	6.7	15.7
CO/PBX	BISC	Beijing International Switching System Co.	29.6	33.6	39.4	43.2
	DaTang	Xian DaTang Telecom LTD Co.	-	8.4	10.1	11.9
	Ericsson	BEC Beijing Ericsson Communication System Co. Ltd.	4.1	4.8	5.4	6.5
	HuaGuang	WeiFang HuaGuang Technology LTD Co.	-	8.4	11.3	13.0
	Huawei	Shenzhen Huawei Technology Company	21.7	34.2	38.5	43.2
	NEC	(Benxi) NEC Communication Co. Ltd.	2.1	3.0	3.4	3.2
		Tianjin NEC Telecommunications Co. Ltd.	9.3	14.4	16.9	16.2
	Nokia	Beijing Nokia Hangxing Communication Co. Ltd.	2.9	3.6	4.1	4.3
	Samsung	Shandong Samsung Telecommunications Co. Ltd.	2.3	3.0	3.4	4.3
	Shanghai Bell	Shanghai Bell Telephone Equipment Co.	-	71.4	76.5	81.0
	Siemens	Beijing International Switching System Co. Ltd.	29.6	33.6	36.0	43.2
		Siemens Data Communication Co. Ltd.	3.5	2.4	2.8	2.7
	Toshiba	Hangzhi Electric Instrument Co. Ltd.	3.0	4.2	4.8	5.4
Corded Phone	JiangDu	JiangDu Wire Factory	-	7.7	10.4	13.3
	Phone Star	ShenZhen Phone Star Comm. Ltd. Co.	-	7.7	20.8	26.5
	Rainbow	Rainbow Electronic Group Co.	-	2.0	3.9	5.3
	Siemens	Shanghai Siemens Communication Terminals Co. Ltd.	0.6	1.0	1.2	1.7
	TCL	TCL Communication Equipment Co. Ltd.	5.7	15.3	22.1	31.8
		TCL Huangpai Telecommunication Co. Ltd.	7.4	-	-	-
	XiaHua (Xoceco)	Xiamen HuaQio Electronic Co.	-	-	5.2	8.0
Cordless Phone	Idall	GuangDong Idall Telecom Equipment Co.	-	-	6.5	13.5

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Table 4-2 (Continued)
Factory Semiconductor Consumption by Communications Equipment, 1996 to 1999 (Millions of U.S. Dollars)

Products	Company	Factory	1996	1997	1998	1999
	Phone Star	ShenZhen Phone Star Comm. Ltd. Co.	-	10.6	19.5	27.0
	SANYO	Tianjin SANYO Communication Co. Ltd.	0.4	0.5	1.3	4.7
	Siemens	Shanghai Siemens Communication Terminals Co. Ltd.	-	-	0.1	1.4
	Sony	Beijing Suohong Electronics Co. Ltd.	-	10.6	13.0	13.5
	TCL	TCL Communication Equipment Co. Ltd.	6.1	13.2	19.5	27.0
		TCL Huangpai Telecommunication Co. Ltd.	5.4	-	-	-
	Uniden	Uniden Electronics Products (Shenzhen) Co. Ltd.	78.3	76.6	92.3	111.4
	Vtech	Dongguan Vtech Electronics Factory	21.0	44.2	62.4	74.3
	XiaHua (Xoceco)	Xiamen HuaQio Electronic Co.	-	2.6	6.5	10.8
Fax Machine	Samsung	Shandong Samsung Telecommunications Co. Ltd.	21.3	22.0	24.4	26.0
Pager	Matsushita	Beijing Matsushita Communication Instrument Co. Ltd.	6.8	11.8	13.1	13.6
	Motorola	Motorola (China) Electronics Ltd.	45.2	46.7	49.7	47.6
		Shanghai Motorola Paging Products Co. Ltd.	10.0	12.4	17.0	15.0
	TCL + NEC	(Huizhou) TCL Mobile Communication Co. Ltd.	8.2	5.0	13.8	13.6
Total			**451.9**	**698.3**	**857.1**	**1,005.3**

Source: Dataquest (July 1998)

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Table 4-3
Factory Semiconductor Consumption by Consumer Electronic Equipment, 1996 to 1999 (Millions of U.S. Dollars)

Products	Company	Factory	1996	1997	1998	1999
Analog Camcorder	Hitachi	Fujian Hitachi Television Co. Ltd.	2.2	2.2	2.4	3.4
		Shenzhen Saige Hitachi Color Monitor System Co. Ltd.	3.0	4.4	4.9	5.6
	Sony	Shanghai Suoguang Electronics Co. Ltd.	4.2	17.8	17.9	18.7
Card Reader	Beijing Aerospace	Beijing Aerospace Gold Card Co.	-	1.3	1.6	2.6
	HuaXu	HuaXu Gold Card Co.	-	0.2	0.8	1.3
	Hunan Computer	Hunan Computer Factory	-	0.2	0.5	1.0
Color Television	Chang Hong	Sichuan Changhong Electric Appliances Co. Ltd.	83.5	117.0	142.8	159.1
	Hitachi (FuRi)	Fujian Hitachi Television Co. Ltd.	13.1	17.3	24.5	30.6
		Shenzhen Saige Hitachi Color Monitor System Co. Ltd.	13.9	21.6	24.5	28.6
	Konka	Konka Electronic Group Co.	-	57.6	91.8	112.2
	Matsushita	Hualu Matsushita VCR Co. Ltd.	2.1	-	-	-
	Panda	Panda Electronics Group	-	11.0	12.2	14.3
	Philips	Suzhou Philips Consumer Electronics Co. Ltd.	4.4	6.1	8.3	11.2
	Samsung	Shenyang Samsung Electronic Co. Ltd.	0.1	-	-	-
		Tianjin Samsung Electric Instrument Co. Ltd.	2.6	7.2	9.8	10.2
		Tianjin Tongguang Samsung Electronics Co. Ltd.	15.7	21.6	29.4	33.7
	SANYO	Shenzhen Huanqiang SANYO Electronics Co. Ltd.	12.9	18.0	24.5	30.6
	Shanghai GuangDian	Shanghai GuangDian Group Co.	-	21.6	30.6	36.7
	Sharp	Nanjing Sharp Electronic Co. Ltd.	-	0.4	3.1	5.1
	Sony	Shanghai Suoguang Yingxiang Co. Ltd.	-	0.9	1.8	3.1
	TCL	Huizhou Wangpai AV Electronic Co. Ltd.	6.1	7.2	8.2	10.2
		Shenzhen TCL Wangpai Electronics Co. Ltd.	5.2	14.4	16.3	20.4
	Toshiba	Toshiba Dalian Co. Ltd.	9.6	11.7	15.5	17.3
	XiaHua (Xoceco)	Xiamen HuaQio Electronic Co.	-	18.0	20.4	30.6
DVD	Idall	GuangDong Idall Telecom Equipment Co.	-	-	0.1	0.6
	Panda	Panda Electronics Group	-	-	0.1	0.2
Hi-Fi	LG	LG Electronics (Huizhou) Co. Ltd.	3.0	8.3	12.2	14.7
	Matsushita	Dalian Matsushita Communication Industry Co. Ltd.	13.1	12.5	13.0	15.4
	Philips	Beijing Philips Radio & Video Corp.	3.5	4.2	6.1	6.6

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Table 4-3 (Continued)
Factory Semiconductor Consumption by Consumer Electronic Equipment, 1996 to 1999 (Millions of U.S. Dollars)

Products	Company	Factory	1996	1997	1998	1999
	Samsung	Huizhou Samsung Electronics Co. Ltd.	3.5	12.5	18.2	18.5
	SANYO	Shenzhen Huanqiang SANYO Electronics Co. Ltd.	1.7	2.3	2.7	3.5
	Sharp	Nanjing Sharp Electronic Co. Ltd.	-	0.4	2.0	3.1
Personal Stereo	LG	LG Electronics (Huizhou) Co. Ltd.	2.7	3.9	4.7	4.7
	Matsushita	Xiamen Matsushita Stereo Co. Ltd.	11.8	13.9	16.6	15.5
	Philips	Beijing Philips Radio & Video Corp.	3.6	4.5	5.4	5.5
	SANYO	SANYO Electric Appliances (Shekou) Co. Ltd.	3.3	3.9	4.7	4.7
Radio	SANYO	SANYO Electric Appliances (Shekou) Co. Ltd.	0.3	0.4	0.5	0.7
Satellite Receiver	Vtech	Dongguan Vtech Satellite Instrument Co. Ltd.	-	-	-	-
Set-Top Box	Vtech	Dongguan Vtech Electronics Factory	-	1.9	9.5	11.3
Smart Card	CEC	China Electronic Info. Industry Co.	-	-	1.8	2.9
	HuaXuTecsun	HuaXu Gold Card Co.	-	2.0	3.1	5.9
VCD Player	Chang Hong	Sichuan Changhong Electric Appliances Co. Ltd.	-	11.9	19.2	13.1
	Fujian Malata	Fujian Malata Co. Ltd.	17.6	40.2	36.0	18.7
	Idall	Guangdong Idall Co. Ltd.	26.3	57.5	48.0	33.6
	Jiangsu Shinco	Jiangsu Shinco Electronic Group Co.	52.7	95.4	67.2	37.3
	Konka	Konka Electronic Group Co.	-	17.6	23.8	22.8
	LG	Shanghai Lejin Guangdian Electronics Co. Ltd.	3.3	19.4	19.2	9.3
	Philips	Xiaxin Electronics Co. Ltd.	10.8	24.4	23.6	9.3
	Samsung	Huizhou Samsung Electronics Co. Ltd.	8.8	12.5	11.0	9.3
	Sharp	Nanjing Sharp Electronic Co. Ltd.	-	1.5	3.6	1.9
	Xiamen Xiaxin	Xiamen Xiaxin Co. Ltd.	-	24.4	23.6	11.2
VCR	LG	Shanghai Lejin Guangdian Electronics Co. Ltd.	17.7	21.1	22.4	23.4
	Matsushita	Hualu Matsushita VCR Co. Ltd.	3.8	4.9	5.3	4.7
	Philips	Xiaxin Electronics Co. Ltd.	2.0	2.6	3.1	2.5
	Samsung	Tianjin Samsung Electronics Co. Ltd.	22.8	31.8	37.6	24.9
	SANYO	Shenzhen Huanqiang SANYO Electronics Co. Ltd.	2.3	2.8	3.3	4.0
Video Game	SANYO	SANYO Electric Appliances (Shekou) Co. Ltd.	3.8	4.7	5.3	6.0
Total			**396.5**	**820.8**	**944.6**	**932.1**

Source: Dataquest (July 1998)

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Table 4-4
Factory Semiconductor Consumption by Transportation Equipment, 1996 to 1999 (Millions of U.S. Dollars)

Products	Company	Factory	1996	1997	1998	1999
Antilock Brake System Control Unit	Shanghai ABS	Shanghai Automotive Brake System Co. Ltd.	-	5.7	6.7	8.0
Auto Stereo	Fudian Automotive	Shanghai Fudian Automotive Electronics Co. Ltd.	-	0.5	0.6	0.7
	Hyundai	Hyundai Electronics (Tianjin) Co. Ltd.	2.5	6.0	7.2	9.0
	Matsushita	Dalian Matsushita Communication Industry Co. Ltd.	7.7	10.6	12.8	15.2
Total			**10.2**	**22.7**	**27.3**	**32.8**

Source: Dataquest (July 1998)

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Chapter 5
Factory Location

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Table 5-1
Factory Location of Multinational Companies' Plants in China

Origin	Company	Factory	Province	Address
U.S. Companies	AST	Dongguan AST Hongzhi Computer Co. Ltd.	Guangdong	Shiji Computer Zone, Houjie Zhen
	Motorola	Hangzhou Motorola Cellular Systems Co. Ltd.	Zhejiang	Technological & Economic Development Area (TEDA), Xiasha
		Motorola (China) Electronics Ltd.	Tianjin	No. 10, 4th Avenue, TEDA
		Nanjing Power Co. Ltd.	Jiangsu	Jiangning Development Zone
		Shanghai Motorola Paging Products Co. Ltd.	Shanghai	Zhangjiang Hi-Tech Park, Pudong
	Seagate	Seagate (Shenzhen) International Technology Co. Ltd.	Guangdong	Kaifa Complex, Caitian Road, Futian Industrial District
		Seagate (Wuxi) International Technology Co. Ltd.	Jiangsu	No. 106, Singapore Industry Park
Chinese Companies	Beijing Aerospace	Beijing Aerospace Gold Card Co.	Beijing	No. 4 FeiTi North Road, FeiTai District, Beijing
	CEC	China Electronic Info. Industry Co.	Beijing	No. 58 LuGu Road, ShiJing Mountain District, Beijing
	Chang Hong	Sichuan Changhong Electric Appliances Co. Ltd.	Sichuan	No. 4, Yuejin Road
	DaTang	Xian DaTang Telecom LTD Co.	ShanXi	No. 6 HongZhuan East Road, YanTa District, XiAn
	Founder	Dongguan Zhenglong Technology Co. Ltd.	Guangdong	Shilong District
	Fudian Automotive	Shanghai Fudian Automotive Electronics Co. Ltd.	Shanghai	The 3rd Floor Yinhai Building, No. 250 Caoxi Road,
	Fujian Malata	Fujian Malata Co. Ltd.	Fujian	No. 8, Jianshe Road, Shancheng Town
	Great Wall	Great Wall Hunan Computer Plant	Hunan	No. 21, Yuhua Road
	Great Wall + IBM	Changke International Electronics Co. Ltd.	Guangdong	Hi-Tech Park, Nanshan Zone
		Great Wall International Information Products Co. Ltd.	Guangdong	Hi-Tech Park, Nanshan Zone
	Hisense	QingDao Hisense Computer Co.	ShanDong	No. 11 JiangXi Road, QingDao
	HuaFei	HuaFei Color Monitor System Ltd. Co.	Jiangsu	MaiGao Bridge ZhongYang Gate, Nanjing

Table 5-1 (Continued)
Factory Location of Multinational Companies' Plants in China

Origin	Company	Factory	Province	Address
	HuaGuang	WeiFang HuaGuangTtechnology LTD Co.	ShanDong	No. 272 East Street, DongFeng KuiWen District, WeiFang
	Huawei	Shenzhen Huawei Technology Company	Guangdong	Kefa Road, Hi-Tech Zone
	HuaXu	HuaXu Gold Card Co.	Beijing	Westside JianXiang Bridge HanDian District, Beijing
	HuaXuTecsun	HuaXu Gold Card Co.	Beijing	Westside JianXiang Bridge HanDian District, Beijing
	HuiLiDa	Chongqing HuiLiDa Electronic Co.	ChongQing	No. B-4 JiaZhou Garden, YuBei District, ChongQing
	Hunan Computer	Hunan Computer Factory	Hunan	No. 21, Yuhua Road, ChangSha
	Idall	Guangdong Idall Co. Ltd.	Guangdong	Aiduo Dianqi Building
		GuangDong Idall Telecom Equipment Co.	Guangdong	Idall Electricity Building DongShen Town, Zhongshan
	JiangDu	JiangDu Wire Factory	Jiangsu	No. 32 South Road, SanYuan Bridge, JiangDu
	Jiangsu Shinco	Jiangsu Shinco Electronic Group Co.	Jiangsu	Luoyang Road
	Konka	Konka Electronic Group Co.	Guangdong	Huaqiao City South Mountain District, ShenZhen
	LangChao	LangChao Electronic Group Co.	ShanDong	No. 224 South Mountain Road, JiNan
	Legend	Beijing Legend Computer Co. Ltd.	Beijing	Shangdi Hi-Tech Zone, Haidian District
		Huiyang Legend Computer Co. Ltd.	Guangdong	Sun Park
	Panda	Panda Electronics Group	Jiangsu	No. 301, Zhongshan East Road
	Phone Star	ShenZhen Phone Star Comm. Ltd. Co.	Guangdong	No. 213 Building Industry Town, CheGongMiao, ShenZhen
	Rainbow	Rainbow Electronic Group Co.	Beijing	No. 9 ShangDi Four Street, HaiDian District, Beijing
	Shanghai ABS	Shanghai Automotive Brake System Co. Ltd.	Shanghai	No. 2281 Jianchuam Road
	Shanghai Bell	Shanghai Bell Telephone Equipment Co.	Shanghai	No. 188-189 Bell Road, Gold Bridge, PuDong, Shanghai

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Table 5-1 (Continued)
Factory Location of Multinational Companies' Plants in China

Origin	Company	Factory	Province	Address
	Shanghai GuangDian	Shanghai GuangDian Group Co.	Shanghai	No.140 TianLin Road, XuHui District, Shanghai
	Stone + Compaq	Compaq Computer Technology (China) Co. Ltd.	Guangdong	D East Overseas Chinese Park
	Stone + Fujitsu	Shenzhen Shentong Printing Equipment Co. Ltd.	Guangdong	Fl 2, SOTEC Building, Baguasilu Road, Bagua District, Shenzhen
	TCL	Huizhou Wangpai AV Electronic Co. Ltd.	Guangdong	Shouhua Science Park, Zhennanshan, Huizhou
		Shenzhen TCL Wangpai Electronics Co. Ltd.	Guangdong	No. 33, Shekou Industry Avenue, Nanshan District
		TCL Communication Equipment Co. Ltd.	Guangdong	Shangpaidaling Road, Huizhou
		TCL Huangpai Telecommunication Co. Ltd.	Guangdong	No. 14, Jiangbei District, Huizhou
	TCL + NEC	(Huizhou) TCL Mobile Communication Co. Ltd.	Guangdong	Yuantian Industry Zone, Yuanshan East Road, Jiangbei District
	Tontru	Tontru Information Industry Group	JiangShu	No. 99 ChangJiang Road, Nanjing
	XiaHua (Xoceco)	Xiamen HuaQio Electronic Co.	Fujian	No. 22 HuLi Road, XiaMen
	Xiamen Xiaxin	Xiamen Xiaxin Co. Ltd.	Fujian	No. 45, Tiyu Road
European Companies	BISC	Beijing International Switching System Co.	Beijing	No. 14, Jiuxian Bridge
	Ericsson	BEC Beijing Ericsson Communication System Co. Ltd.	Beijing	No. 1, Jiuxian Bridge
		BMC Beijing Mobile Communication Co. Ltd.	Beijing	No. 28, Xinjiekouwai
		ENC Ericsson (Nanjing) Communication Co. Ltd.	Jiangsu	No. 32, Chitian Road, Jiangning Zone
		GEC Guangzhou Ericsson Communication Co. Ltd.	Guangdong	No. 6, Yiheng Road
	Nokia	Beijing Nokia Hangxing Communication Co. Ltd.	Beijing	No. 11, Hepingli East Road
		Beijing Nokia Mobile Communication Co. Ltd.	Beijing	No. 5, Jiangtai Road

Table 5-1 (Continued)
Factory Location of Multinational Companies' Plants in China

Origin	Company	Factory	Province	Address
	Philips	Beijing Philips Radio & Video Corp.	Beijing	No. 4, Beiwa Road
		Suzhou Philips Consumer Electronics Co. Ltd.	Jiangsu	No. 88, Shishan Road
		Suzhou Philips Consumer Electronics Co. Ltd.	Jiangsu	No. 88, Shishan Road
		Xiaxin Electronics Co. Ltd.	Fujian	No. 45, Tiyu Road
	Siemens	Beijing International Switching System Co. Ltd.	Beijing	No. 14, Jiuxian Bridge
		Fuzhou Siemens Rixdolf Co. Ltd.	Fujian	Shangzhengyuanhong Road
		Shanghai Siemens Communication Terminals Co. Ltd.	Shanghai	No. 778, Siemens Road, Pudong District
		Shanghai Siemens Mobile Communication Co. Ltd.	Shanghai	No. 777, Siemens Road, Pudong District
		Siemens Data Communication Co. Ltd.	Shanghai	No. 199, Liangji Road, Pudong District
Hong Kong Companies	Vtech	Dongguan Vtech Electronics Factory	Guangdong	Santun, Houjie District
		Dongguan Vtech Satellite Instrument Co. Ltd.	Guangdong	Santun, Houjie District
Japanese Companies	Fujitsu	Nanjing Fujitsu Computer Instrument Co. Ltd.	Jiangsu	No. 100, Dongjingting, Zhongyangmenwai
	Hitachi	Fujian Hitachi Television Co. Ltd.	Fujian	No. 32, Wangnan Road
		Shenzhen Saige Hitachi Color Monitor System Co. Ltd.	Guangdong	Lianhua Industry Zone, Huanggang Road, Futian District
	Hitachi (FuRi)	Fujian Hitachi Television Co. Ltd.	Fujian	No. 32, Wangnan Road
		Shenzhen Saige Hitachi Color Monitor System Co. Ltd.	Guangdong	Lianhua Industry Zone, Huanggang Road, Futian District
	Matsushita	Beijing Matsushita Communication Instrument Co. Ltd.	Beijing	No. 28, Xinjiekou Road, Westcity District
		Dalian Matsushita Communication Industry Co. Ltd.	Liaoning	No. 43, Xinzhaizi, Ganjingzi District
		Hualu Matsushita VCR Co. Ltd.	Liaoning	No. 1, Hualu Road

Table 5-1 (Continued)
Factory Location of Multinational Companies' Plants in China

Origin	Company	Factory	Province	Address
		Xiamen Matsushita Stereo Co. Ltd.	Fujian	Huoju Hi-Tech Zone
	NEC	(Benxi) NEC Communication Co. Ltd.	Liaoning	No. 26, Zijin Road, Mingshan District
		Shanghai NEC Computer Co. Ltd.	Shanghai	No. 120, Laohuming Road
		Tianjin NEC Telecommunications Co. Ltd.	Tianjin	No. 226, Hongqi Road, Nankai
		Wuhan NEC Zhongyuan Mobile Communication Co. Ltd.	Hubei	No. 2, Industry Zone, Guandong Tech Park
	SANYO	SANYO Electric Appliances (Shekou) Co. Ltd.	Guangdong	No. 3, Huajian Industrial Bldg., Shekou
		Shenzhen Huanqiang SANYO Electronics Co. Ltd.	Guangdong	No. 34, Shennan Zhong Road
		Tianjin SANYO Communication Co. Ltd.	Tianjin	No. 3, Fukang Road, Nankai District
	Sharp	Nanjing Sharp Electronic Co. Ltd.	Jiangsu	Hi-Tech Zone
		Sharp Office Equipment (Changshu) Co. Ltd.	Jiangsu	Huanghe Road, Yanjiang Economical Development Zone
	Sony	Beijing Suohong Electronics Co. Ltd.	Beijing	No. 10, West Tucheng Road, Haidian District
		Shanghai Suoguang Electronics Co. Ltd.	Shanghai	No. 930, Jinachuan Road, Minhang District
		Shanghai Suoguang Yingxiang Co. Ltd.	Shanghai	No. 925, Shangchuan Road, Pudong
	Toshiba	Hangzhi Electric Instrument Co. Ltd.	Zhejiang	No. 6, Jiaogong Road
	Uniden	Uniden Electronics Products (Shenzhen) Co. Ltd.	Guangdong	Fuyong, Baoan District, Shenzhen
Korean Companies	Hyundai	Hyundai Electronics (Tianjin) Co. Ltd.	Tianjin	No. 46, 6th Hi-Tech Park
	LG	LG Electronics (Huizhou) Co. Ltd.	Guangdong	Zhongkai Hi-Tech Zone
		LG Electronics (Shenyang) Co. Ltd.	Liaoning	No. 28, Beiling Street, Huanggu District

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Table 5-1 (Continued)
Factory Location of Multinational Companies' Plants in China

Origin	Company	Factory	Province	Address
		Shanghai Lejin Guangdian Electronics Co. Ltd.	Shanghai	No. 230, Jinqiao Road, Pudong
	Samsung	Huizhou Samsung Electronics Co. Ltd.	Guangdong	Huizhang Road, Chenjiang District
		Shandong Samsung Telecommunications Co. Ltd.	ShanDong	Jinzhou Road, Huoju Hi-Tech Zone
		Shenyang Samsung Electronic Co. Ltd.	Liaoning	No. 262, Shifu Road, Shenhe District
		Tianjin Samsung Electric Instrument Co. Ltd.	Tianjin	No. 133, Donging Road
		Tianjin Samsung Electronics Co. Ltd.	Tianjin	4th Avenue, Dongting Road
		Tianjin Tongguang Samsung Electronics Co. Ltd.	Tianjin	No. 185, Xinda Road, Hebei District
Taiwanese Companies	Acer	Suzhou Mingji Computer Co. Ltd.	Jiangsu	Shishan Road, Xin Zone
	Dataexpert	Zhaoqing Dataexpert Computer Co. Ltd.	Guangdong	Dachong Guojing East Road
	FIC	Caizhong Plant	Guangdong	No. 17/19, Shaojian Road, Shatoujiao
		Changzhong Plant	Guangdong	No. 3, Industry Zone Section Teo, Xinan
		Shangzhong Plant	Shanghai	Pengzhao Road, Mulu Zhen, Jiading District
		Taizhong Plant	Guangdong	No. 22, Industry Zone Section Three, Bao'an
	Hsin Ming	Weijia Technology Co. Ltd.	Guangdong	Shenshan Industry Zone, Hengli Zhen
	PC Chips	PC Chips Manufacturing Limited	Hong Kong	Unit 9, 2/F, Fook Hong Industrial Building, Kowloon Bay

Source: Dataquest (July 1998)

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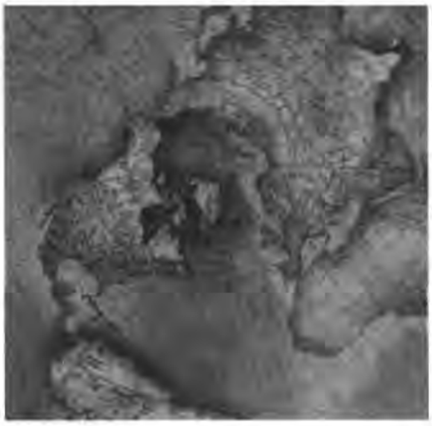

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China/Hong Kong Semiconductor Consumption by Electronic Application Forecasts, Spring 1998

Market Statistics

FILE COPY:
MARIA VALENZUELA

Program: Semiconductors China
Product Code: SEMI-CH-MS-9804
Publication Date: July 6, 1998
Filing: Market Statistics

China/Hong Kong Semiconductor Consumption by Electronic Application Forecasts, Spring 1998

Market Statistics

Program: Semiconductors China
Product Code: SEMI-CH-MS-9804
Publication Date: July 6, 1998
Filing: Market Statistics

Table of Contents

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List of Tables

Chapter 1
Introduction and Discussion

Introduction

This Market Statistics report contains Dataquest's forecast of China/Hong Kong semiconductor consumption by electronic application from 1997 to 2002. Long-time readers will note these two forecasts were previously published in separate documents. This is the first of two semiannual forecasts that Dataquest will publish this year; the second will be published this coming fall. This first forecast reflects changes in Dataquest's view of semiconductor consumption by electronic equipment in China/Hong Kong since the fall of 1997. It incorporates changes suggested by Dataquest's recently updated forecasts of electronic equipment production and semiconductor shipments.

Long-time readers will note significant changes in the focus and format of this forecast, compared to previous forecasts. In contrast to previous forecasts, Dataquest is reporting only its 1997-to-2002 forecast. More significantly, Dataquest has greatly expanded the electronic systems detail supporting its total semiconductor consumption forecast. At the same time, Dataquest has eliminated our semiconductor device consumption forecasts by electronic application. These changes are related to a fundamental change in Dataquest's forecast methodology.

Whereas Dataquest's previous semiconductor consumption forecasts were a top-down mathematical reconciliation of its updated electronic equipment production and semiconductor shipment forecasts, the forecast presented here represents an effort to make an independently "bottom-up" estimate of the semiconductor consumption generated by Dataquest's forecast of electronics production. As such, the forecast no longer attempts to specify how Dataquest's forecast semiconductor shipments will distribute themselves across electronic applications. Instead, it attempts to estimate semiconductor consumption separately by electronic system, unconstrained by the requirement that semiconductor consumption equals semiconductor shipments. It thus leaves open the possibility that estimated semiconductor consumption may differ from estimated semiconductor shipments. Unfortunately, this is not the forum to discuss the consequences of the semiconductor demand-supply imbalance implied by persistent differences between estimated semiconductor consumption and estimated semiconductor shipments. Dataquest leaves that task for other publications.

This report's tables present data that is intended to answer the following questions:

- What is the estimated semiconductor consumption of various broad categories of electronic equipment?
- What is the estimated semiconductor consumption of the key individual electronic systems that make up these broad categories?

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The semiconductor consumption forecasts presented here complement Dataquest's recently updated forecasts of electronic equipment production and semiconductor shipments. Dataquest's updated China/Hong Kong electronic equipment forecasts may be found in *1998 China/Hong Kong Detailed Electronic Equipment Production Forecast* (SEMI-CH-MS-9801, May 1998). A summary of these forecasts down to the individual electronic systems level appears in Appendix A. Regional forecasts of the Americas, Japan, and Europe, Middle East, and Africa may be requested through Dataquest's inquiry service. Additional regional and semiconductor device detail for this forecast may also be requested through Dataquest's inquiry service.

The tables in this document are organized as follows:

- Tables 2-1 to 2-2 summarize Dataquest's China/Hong Kong semiconductor consumption forecast.
- Tables 2-3 to 2-4 summarize Dataquest's Asia/Pacific semiconductor consumption forecast, which provides the big picture and a contrast to China/Hong Kong's forecast.
- Tables 2-5 to 2-12 detail China/Hong Kong's semiconductor consumption by individual electronic systems grouped by equipment type.

Segmentation of Semiconductor Applications

Dataquest forecasts semiconductor consumption by end-use electronic application. We divide electronic applications into six broad groups in accordance with our segmentation of electronic equipment production. These groups are, in turn, disaggregated into narrower electronic systems categories, as follows:

- Data processing
  - Computers
  - Data storage
  - Input/output devices
  - Dedicated systems
  - Other data processing
- Communications
  - Premise telecom
  - Public telecom
  - Mobile communications
  - Broadcast and studio equipment
  - Other communications
- Industrial
  - Security and energy-management systems
  - Manufacturing systems and instruments
  - Medical equipment
  - Other industrial equipment

- Consumer
  - Audio
  - Video
  - Personal electronics
  - Appliances
  - Other consumer equipment
- Military/civil aerospace
- Transportation

As part of Dataquest's forecast process, forecasts for roughly 40 individual electronic systems within these various categories and subcategories are developed. These include the following:

- Data processing
  - Mainframe/supercomputers (Computers)
  - Midrange computers (Computers)
  - Workstations (Computers)
  - PCs (Computers)
  - PC motherboards (Computers)
  - Rigid disk drives (Data storage)
  - Optical disk drives (Data storage)
  - Removable magnetic storage (Data storage)
  - Page printers (Input/output)
  - Serial printers (Input/output)
  - Monitors (Input/output)
- Communications
  - LAN cards (Premise telecom)
  - Premise line cards (Premise telecom)
  - Fax (Premise telecom)
  - Modems (Premise telecom)
  - Corded telephones (Premise telecom)
  - Analog cordless phones (Premise telecom)
  - Digital cordless phones (Premise telecom)
  - Central-office line cards (Public telecom)
  - Analog cellular phones (Mobile telecom)
  - Digital cellular phones (Mobile telecom)
  - Mobile telecom infrastructure (Mobile telecom)
  - Other mobile telecom products (Mobile telecom)

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- Consumer
  - Personal/portable stereo (Audio)
  - Color TVs (Video)
  - VCRs (Video)
  - Analog camcorders (Video)
  - Digital camcorders (Video)
  - DVD players (Video)
  - Analog set-top boxes (Video)
  - Digital set-top boxes (Video)
  - Digital still cameras (Personal electronics)
  - Video game controllers (Personal electronics)
  - Video game cartridges (Personal electronics)
- Transportation
  - Automotive stereos
  - Automotive engine control units (ECUs)
  - Antilock braking systems
  - Air bags
  - Automotive navigation systems

Readers interested in a more detailed discussion of Dataquest's applications segmentation are encouraged to consult *Semiconductor Application Market Definitions Guide* (SAMM-WW-GU-9701), which may also be requested through Dataquest's inquiry service.

Geographic Segmentation

Dataquest's worldwide electronic equipment production forecast is aggregated from individual forecasts for the following four principal geographic regions:

- Americas
- Japan
- Europe, Middle East, and Africa
- Asia/Pacific

Detailed discussion of these regions and their composition may be found in the Dataquest publication, *Semiconductor Application Market Definitions Guide* (SAMM-WW-GU-9701).

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Exchange Rates

Dataquest's worldwide electronic equipment forecast aggregates data from many countries, each of which uses a currency that has a different and fluctuating exchange rate relative to the U.S. dollar. Because we compile our worldwide forecast from individual regional forecasts, we use the U.S. dollar as a common currency for comparisons and aggregation. As a rule, Dataquest calculates forecasts in local currencies and then converts them to U.S. dollars using projected average annual exchange rates. Dataquest does not forecast exchange rates per se. Instead, we calculate projected average annual exchange rates from current exchange rates. Dataquest's projections are based on estimates of the latest-available monthly exchange rate at the time the forecast is developed. Table 1-1 presents the average annual exchange rates incorporated in this forecast. These rates are based on monthly exchange rates observed through February 1998. Additional information about historical exchange rates and Dataquest's method of calculating future average exchange rates may be requested through Dataquest's client inquiry service.

Table 1-1
Foreign Currency to U.S. Dollar Exchange Rate, 1997 to 2002

	1997	1998	1999 to 2002	U.S. Dollar Appreciation versus Foreign Currency (%) 1997 to 1998	Foreign Currency Appreciation versus U.S. Dollar (%) 1997 to 1998
Americas					
Brazil (Real)	1.08	1.12	1.12	3.9	-3.7
Canada (Dollar)	1.38	1.44	1.44	4.0	-3.9
Mexico (Peso)	7.92	8.23	8.23	3.9	-3.7
Japan					
Japan (Yen)	121.10	129.55	129.55	7.0	-6.5
Europe, Middle East, and Africa					
ECU/Euro	0.89	0.92	0.92	3.9	-3.8
France (Franc)	5.84	6.08	6.08	4.2	-4.1
Germany (Mark)	1.73	1.82	1.82	4.8	-4.5
Italy (Lira)	1,703.02	1,787.87	1,787.87	5.0	-4.7
Netherlands (Guilder)	1.95	2.05	2.05	4.9	-4.7
United Kingdom (Pound)	0.61	0.61	0.61	0.2	-0.2
Asia/Pacific					
China (Renminbi)	8.32	8.31	8.31	-0.1	0.1
Hong Kong (Dollar)	7.74	7.74	7.74	0	0
India (Rupee)	36.36	39.39	39.39	8.3	-7.7
Indonesia (Rupiah)	2,872.61	9,743.04	9,743.04	239.2	-70.5
Malaysia (Ringgit)	2.82	4.41	4.41	56.5	-36.1
Philippines (Peso)	29.47	42.66	42.66	44.8	-30.9
Singapore (Dollar)	1.49	1.75	1.75	17.6	-15.0
South Korea (Won)	954.14	1,707.30	1,707.30	78.9	-44.1
Taiwan (Dollar)	28.79	34.12	34.12	18.5	-15.6
Thailand (Baht)	31.07	52.98	52.98	70.5	-41.4

Source: Dataquest (June 1998)

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Forecast Methodology

When discussing semiconductor consumption, it is critical to remember that semiconductors are not end products consumed for their own sake. Instead, they are intermediate products used as electronic end-products inputs that, in turn, are eventually consumed by individuals and businesses for the services and utility they provide. Implicit in the concept of semiconductor consumption is the notion that one can specify the electronic end products in which semiconductors will be incorporated or consumed. A semiconductor forecast that does not or can not specify this aspect is not a forecast of semiconductor consumption. At best, it is merely a forecast of semiconductor shipments.

Dataquest's semiconductor consumption by electronic application forecast grew out of the recognition that a truly complete semiconductor forecast must specify the electronic end uses of semiconductors. However, specifying semiconductor end uses has proved far more difficult than recognizing that it must be done. Although it appears possible to specify semiconductor consumption by the variety of electronics produced, it is, in fact, virtually impossible to do this. There are simply too many different types of semiconductor devices consumed in too large a variety of electronic products. As a result, semiconductor consumption must invariably be estimated. This can be done in any number of ways. Previous to this forecast, Dataquest used a mathematical model to estimate semiconductor consumption by various electronic end uses. Taking Dataquest's electronic equipment production and semiconductor shipments forecasts as inputs, this model allocated estimated semiconductor shipments across forecast electronics production subject to various assumptions about the semiconductor content of electronic products. The model also imposed several balancing conditions intended to guarantee that estimated semiconductor shipments were totally and completely allocated across all forecast electronics production.

The model applied a decidedly top-down approach to estimating semiconductor consumption. In effect, it calculated estimates of semiconductor consumption by compelling agreement between the details of Dataquest's electronics production and semiconductor shipments forecast. As a result, Dataquest's estimates of semiconductor consumption were more an artifact of a mathematical process than truly independent estimates of semiconductor consumption. Although the model offered considerable flexibility to produce reasonable results, it was, nonetheless, limited by the validity of its semiconductor content assumptions and the balancing requirement that semiconductor consumption equal semiconductor shipments. Despite its potential drawbacks, the model provided the best estimates Dataquest could offer, given a paucity of knowledge about semiconductor applications in specific electronic systems.

Fortunately, Dataquest has been able to expand greatly its knowledge of semiconductor uses in specific electronic systems in recent years. During the past several years, Dataquest's semiconductor applications research has been concentrated on the study of semiconductor use in specific individual electronic systems. We have successfully developed models to track and forecast the production and semiconductor consumption of some 40 different individual electronic systems.

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These include PCs and PC motherboards, rigid disk drives, LAN cards, modems, digital cellular phones, digital set-top boxes, and automotive navigation systems, among others. All told, the electronic systems encompassed by Dataquest's models account for roughly one-half of all electronics production and nearly two-thirds of estimated semiconductor consumption.

These models have not only allowed us to codify our knowledge about individual electronic systems but also to approach the task of estimating semiconductor consumption using a bottom-up forecast method. This is the method Dataquest has used for this forecast and intends to use from now on for future forecasts. The method essentially involves building up a semiconductor consumption forecast for all electronics production by leveraging our semiconductor consumption estimates for individual electronic systems. Dataquest uses individual systems estimates as a forecast base and augments it with semiconductor consumption estimates for the various other electronic equipment categories that are currently tracked on an individual systems basis. Precisely because the method uses well-researched knowledge about individual electronics systems that dominate semiconductor consumption, we believe it is capable of providing far better semiconductor consumption forecasts than our former top-down method, especially for those electronic equipment categories, such as computers, in which our individual systems forecasts account for virtually all of the category.

Naturally, Dataquest's switch to a new method has several important consequences. First, we have, at least temporarily, eliminated the specific semiconductor device consumption forecasts by electronic application we used to provide. Although informative, these forecasts were largely an artifact of our old top-down method. Recent research indicates these forecasts were especially sensitive to the assumptions and balancing conditions of our top-down method. Unfortunately, we are still in the process of developing semiconductor device detail for many of the individual systems forecasts that now serve as the basis for our new bottom-up method. Consequently, Dataquest's systems forecasts have yet to reach the point where they can be leveraged to provide reasonable consumption forecasts for specific semiconductor devices. We hope to reinstate device consumption forecasts as soon as they are possible, according to our new bottom-up method. In the mean time, we trust that readers will find the added electronics system detail we can now offer in our forecast an adequate compensation.

More importantly, Dataquest no longer insists that estimated semiconductor consumption equal semiconductor shipment forecast. This is actually as it should be. In truth, our long-standing insistence that estimated semiconductor consumption equal forecast semiconductor shipments, was more a matter of mathematical necessity for the sake of our old top-down forecast method than a reflection of market realities. There are, in fact, several reasons why semiconductor consumption, as we estimate it, may differ from a semiconductor shipment forecast. First, there can be significant slippage between semiconductor shipments and semiconductor consumption by electronics producers over short periods because of semiconductor inventory changes held by electronic producers.

Electronics producers naturally adjust their semiconductor inventories in response to expected changes in their production level. Although "just-in-time" practices are reducing the inventory volume producers hold, the continued existence of inventories means semiconductor shipments and consumption may differ.

Second, not all semiconductor shipments are consumed by electronics producers manufacturing new electronics. Indeed, some find their way into so-called "aftermarkets" where they are eventually "consumed" by existing electronics. Dataquest excludes aftermarket activity from its semiconductor consumption estimates. Aftermarket consumption is virtually impossible to track, and in any event, appears small relative to the consumption generated by electronics producers. Finally, Dataquest's estimates of both electronics production and semiconductor consumption no doubt suffer from errors of omission. We know our estimates are likely to exclude at least some current semiconductor applications and most certainly exclude more than a few future applications that cannot be anticipated here and now. In Dataquest's defense, there is a good reason to believe that these omissions are minor. Still, they represent yet another reason why estimated semiconductor consumption may differ from forecast semiconductor shipments.

Nonetheless, it seems reasonable to expect that estimated semiconductor consumption and forecast semiconductor shipments will closely parallel one another, especially over the long term. As already noted, semiconductors are first and foremost intermediate inputs to electronic equipment production. As such, semiconductor shipment growth is ultimately fueled by the semiconductor consumption growth generated by electronics production. Electronics producers' semiconductor consumption growth is, in turn, fueled by growth in both the volume and semiconductor content of electronics production. In the end, all growth in semiconductor shipments can and must be attributed to growth in one or the other of these key consumption drivers.

Estimation errors aside, persistent differences between estimated semiconductor consumption growth and forecast semiconductor shipments growth prefigure a demand-supply imbalance in the semiconductor market. In the past, Dataquest's top-down method obscured potential semiconductor market imbalances by assuming that estimated semiconductor consumption must equal forecast semiconductor shipments. The beauty of Dataquest's new bottom-up method is that in forsaking this assumption, Dataquest can offer important insights into the future of the semiconductor market. We realize separate forecasts of semiconductor consumption and semiconductor shipments have the potential to create some confusion. By the same token, however, we believe separate forecasts may actually help clarify future semiconductor market movements by revealing potential market imbalances.

Project Analysts: Kelvin Fu and Daniel Heyler

Chapter 2
Semiconductor Consumption Forecasts

Tables 2-1 to 2-12 present Dataquest's forecast of China/Hong Kong's semiconductor consumption by electronic application.

Table 2-1
Value of Semiconductors Consumed in China/Hong Kong by Electronic Product Group, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
All Electronic Products	**6,769**	**7,819**	**9,429**	**12,098**	**15,951**	**17,593**
Data Processing Products	2,748	3,514	4,678	6,370	8,706	9,730
Computers	1,367	1,811	2,426	3,413	4,560	5,146
Data Storage	344	450	638	812	1,202	1,299
Input/Output	312	422	591	890	1,246	1,379
Dedicated System	592	676	829	997	1,377	1,533
Other Data Processing	133	154	194	257	321	373
Communications Products	2,468	2,564	2,791	3,310	4,046	4,294
Premise Telecom	1,586	1,600	1,718	2,030	2,342	2,432
Public Telecom	376	376	398	436	512	553
Mobile Communications	390	472	563	722	1,049	1,153
Broadcast and Studio	90	89	83	91	107	115
Other Communications	26	27	29	31	37	40
Industrial Products	121	133	149	180	240	263
Security/Energy Management	41	45	50	60	77	85
Manufacturing System/Instruments	70	75	83	101	135	148
Medical Equipment	6	7	8	10	15	15
Other Industrial	5	6	8	9	13	14
Consumer Products	1,232	1,386	1,545	1,890	2,496	2,792
Audio	363	393	435	537	700	787
Video	309	397	456	594	760	862
Personal Electronics	254	266	262	297	376	429
Appliances	297	319	380	449	645	696
Other Consumer	10	11	12	13	15	18
Military/Civil Aerospace Products	66	75	89	118	167	179
Transportation Products	133	147	177	231	295	335

Source: Dataquest (June 1998)

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Table 2-2
Growth in the Value of Semiconductors Consumed in China/Hong Kong by Electronic Product Group, 1997 to 2002 (Percent)

	1998	1999	2000	2001	2002
All Electronic Products	**15.5**	**20.6**	**28.3**	**31.8**	**10.3**
Data Processing Products	27.8	33.2	36.2	36.7	11.8
Computers	32.5	34.0	40.7	33.6	12.9
Data Storage	31.0	41.6	27.3	48.0	8.1
Input/Output	35.3	39.9	50.6	40.1	10.6
Dedicated System	14.1	22.7	20.4	38.1	11.3
Other Data Processing	15.6	25.9	32.3	24.7	16.3
Communications Products	3.9	8.8	18.6	22.3	6.1
Premise Telecom	0.9	7.4	18.2	15.4	3.9
Public Telecom	0.1	5.8	9.5	17.4	8.1
Mobile Communications	20.9	19.3	28.4	45.1	10.0
Broadcast and Studio	-1.3	-6.3	9.2	17.3	8.2
Other Communications	6.8	7.5	4.4	21.9	6.2
Industrial Products	10.3	11.6	21.2	33.2	9.8
Security/Energy Management	9.9	11.2	19.8	28.6	11.5
Manufacturing System/Instruments	7.9	10.5	22.1	33.5	9.7
Medical Equipment	33.4	13.2	17.4	47.4	5.2
Other Industrial	21.9	27.0	23.4	44.4	6.1
Consumer Products	12.5	11.5	22.3	32.1	11.9
Audio	8.3	10.7	23.5	30.4	12.5
Video	28.8	14.7	30.2	28.0	13.4
Personal Electronics	4.7	-1.2	13.3	26.4	14.0
Appliances	7.3	19.1	18.1	43.8	7.9
Other Consumer	12.2	5.7	13.1	12.7	20.2
Military/Civil Aerospace Products	13.5	18.1	32.4	42.4	6.7
Transportation Products	10.1	20.9	30.3	27.6	13.7

Source: Dataquest (June 1998)

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Table 2-3
Value of Semiconductors Consumed in Asia/Pacific by Electronic Product Group, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
All Electronic Products	**31,293**	**36,787**	**43,174**	**52,014**	**58,823**	**66,460**
Data Processing Products	15,880	19,075	22,976	28,371	32,045	36,459
Computers	7,298	8,662	10,658	12,991	14,954	17,403
Data Storage	4,029	5,075	5,642	6,883	7,952	9,157
Input/Output	3,158	3,679	4,527	5,630	5,913	6,414
Other Data Processing	573	652	806	1,026	1,113	1,174
Communications Products	6,116	7,096	8,162	9,693	11,193	12,965
Premise Telecom	3,227	3,567	3,912	4,412	4,884	5,206
Public Telecom	561	657	806	959	1,020	1,127
Mobile Communications	1,602	1,987	2,272	2,746	3,441	4,488
Broadcast and Studio	332	397	537	746	905	1,065
Other Communications	394	488	635	829	942	1,078
Industrial Products	668	767	908	1,141	1,342	1,467
Security/Energy Management	154	178	221	261	314	347
Manufacturing System/Instruments	337	385	448	587	689	758
Medical Equipment	59	72	89	112	136	150
Other Industrial	118	133	149	181	203	212
Consumer Products	7,800	8,937	10,095	11,605	12,881	14,079
Audio	1,807	1,980	2,331	2,996	3,043	3,129
Video	3,254	3,758	4,246	4,598	5,319	5,942
Personal Electronics	1,592	1,903	1,985	2,067	2,301	2,518
Appliances	517	586	678	790	926	1,061
Other Consumer	630	710	855	1,154	1,293	1,429
Military/Civil Aerospace Products	304	350	414	483	561	642
Transportation Products	526	561	619	722	801	847
Semiconductor Shipments	**32,534**	**35,899**	**42,754**	**51,751**	**64,483**	**67,561**

Source: Dataquest (June 1998)

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Table 2-4
Growth in the Value of Semiconductors Consumed in Asia/Pacific by Electronic Product Group, 1997 to 2002 (Percent)

	1998	1999	2000	2001	2002	CAGR (%) 1996 to 2002
All Electronic Products	**17.6**	**17.4**	**20.5**	**13.1**	**13.0**	**16.3**
Data Processing Products	20.1	20.4	23.5	12.9	13.8	18.1
Computers	18.7	23.0	21.9	15.1	16.4	19.0
Data Storage	26.0	11.2	22.0	15.5	15.1	17.8
Input/Output	16.5	23.0	24.4	5.0	8.5	15.2
Other Data Processing	13.8	23.6	27.4	8.4	5.5	15.4
Communications Products	16.0	15.0	18.8	15.5	15.8	16.2
Premise Telecom	10.5	9.7	12.8	10.7	6.6	10.0
Public Telecom	17.0	22.6	19.1	6.4	10.5	15.0
Mobile Communications	24.1	14.3	20.9	25.3	30.4	22.9
Broadcast and Studio	19.4	35.5	39.0	21.3	17.7	26.2
Other Communications	23.9	30.0	30.6	13.6	14.5	22.3
Industrial Products	14.9	18.3	25.6	17.7	9.3	17.0
Security and Energy Management	15.2	24.6	17.9	20.5	10.4	17.6
Manufacturing System/Instruments	14.3	16.4	31.1	17.4	10.0	17.6
Medical Equipment	22.3	24.1	24.9	21.4	10.2	20.5
Other Industrial	12.5	12.2	21.2	12.2	4.5	12.4
Consumer Products	14.6	13.0	15.0	11.0	9.3	12.5
Audio	9.6	17.7	28.5	1.6	2.8	11.6
Video	15.5	13.0	8.3	15.7	11.7	12.8
Personal Electronics	19.5	4.4	4.1	11.3	9.4	9.6
Appliances	13.2	15.7	16.6	17.1	14.6	15.5
Other Consumer	12.7	20.3	35.0	12.0	10.6	17.8
Military/Civil Aerospace Products	15.3	18.4	16.5	16.2	14.5	16.1
Transportation Products	6.7	10.5	16.6	10.9	5.8	10.0
Semiconductor Shipments	**10.3**	**19.1**	**21.0**	**24.6**	**4.8**	**15.7**

Source: Dataquest (June 1998)

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Table 2-5
Value of Semiconductors Consumed in in China/Hong Kong by Individual Data Processing Products, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Mainframe/Supercomputer	56	51	51	61	54	53
Midrange Computer	-	-	1	2	5	6
Monitor	128	206	242	315	354	418
Motherboard	541	730	916	1,097	1,341	1,566
Optical Disk Drive	36	55	57	63	70	77
Page Printer	7	10	17	30	51	84
Personal Computer	608	913	1,377	1,899	2,604	3,365
Rigid Disk Drive	160	204	260	327	372	435
Serial Printer	13	15	19	22	26	29
Workstation	3	3	3	3	4	4
Other Data Processing Products	1,197	1,327	1,736	2,551	3,825	3,693
All Data Processing Products	2,748	3,514	4,678	6,370	8,706	9,730

Source: Dataquest (June 1998)

Table 2-6
Growth in the Value of Semiconductors Consumed in China/Hong Kong by Individual Data Processing Products, 1997 to 2002 (Percent)

	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Mainframe/Supercomputer	-8.8	0	19.1	-10.4	-3.0	-1.1
Midrange Computer	NA	NA	100.5	122.7	28.3	NA
Monitor	60.5	17.7	30.0	12.5	18.0	26.7
Motherboard	34.8	25.6	19.7	22.3	16.7	23.7
Optical Disk Drive	52.1	3.8	10.4	11.6	9.7	16.4
Page Printer	47.1	65.4	76.4	66.2	65.8	63.9
Personal Computer	50.1	50.8	37.9	37.1	29.2	40.8
Rigid Disk Drive	27.6	27.6	25.6	13.9	16.9	22.2
Serial Printer	21.5	20.5	18.9	17.2	12.7	18.1
Workstation	0.2	9.5	11.4	13.9	19.7	10.8
Other Data Processing Products	10.9	30.8	47.0	49.9	-3.5	25.3
All Data Processing Products	27.8	33.2	36.2	36.7	11.8	28.8

NA = Not available
Source: Dataquest (June 1998)

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Table 2-7
Value of Semiconductors Consumed in China/Hong Kong by Individual Communications Products, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Analog Cellular Telephone	18.9	17.7	15.5	13.9	12.5	11.2
Analog Cordless Telephone	516.2	460.0	450.2	426.2	418.9	384.8
Answering Machine	83.2	108.1	129.5	154.4	179.3	218.3
Central-Office Line Card	192.6	213.0	228.5	260.4	297.9	369.6
Corded Telephone	255.0	274.2	298.7	321.2	341.8	371.0
Digital Cellular Telephone	204.2	263.1	333.7	454.1	615.3	838.8
Digital Cordless Telephone	58.5	68.6	86.2	109.4	138.2	175.4
Fax Machine	51.3	44.2	41.4	41.8	40.0	42.2
LAN Card	7.0	10.5	12.3	14.9	17.8	20.7
Mobile Communications Infrastructure	19.8	21.1	22.5	24.1	25.9	28.1
Modem	0.7	1.5	3.4	6.7	12.5	22.8
Pager	80.0	94.6	110.1	128.0	135.8	144.4
Premise Switching	16.9	19.3	23.6	29.2	32.7	37.0
Other Communications Products	963	969	1,036	1,326	1,778	1,630
All Communications Products	2,468	2,564	2,791	3,310	4,046	4,294

Source: Dataquest (June 1998)

Table 2-8
Growth in the Value of Semiconductors Consumed in China/Hong Kong by Individual Communications Products, 1997 to 2002 (Percent)

	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Analog Cellular Telephone	-6.0	-12.6	-10.2	-10.4	-10.0	-9.9
Analog Cordless Telephone	-10.9	-2.1	-5.3	-1.7	-8.1	-5.7
Answering Machine	29.9	19.8	19.3	16.1	21.7	21.3
Central-Office Line Card	10.6	7.3	13.9	14.4	24.1	13.9
Corded Telephone	7.5	8.9	7.5	6.4	8.6	7.8
Digital Cellular Telephone	28.8	26.8	36.1	35.5	36.3	32.6
Digital Cordless Telephone	17.1	25.8	26.8	26.3	27.0	24.5
Fax Machine	-14.0	-6.3	1.0	-4.1	5.5	-3.8
LAN Card	49.8	17.5	20.5	20.0	16.3	24.3
Mobile Communications Infrastructure	6.5	6.5	7.5	7.3	8.4	7.2
Modem	127.2	126.9	97.7	85.0	82.6	102.9
Pager	18.2	16.4	16.3	6.1	6.3	12.5
Premise Switching	14.4	22.4	23.4	12.0	13.4	17.0
Other Communications Products	0.5	6.9	28.0	34.1	-8.3	11.1
All Communications Products	3.9	8.8	18.6	22.3	6.1	11.7

Source: Dataquest (June 1998)

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Table 2-9
Value of Semiconductors Consumed in China/Hong Kong by Individual Consumer Products, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Analog Camcorder	26.0	26.8	28.9	32.4	37.3	40.7
Analog Set-Top Box	0.6	2.4	5.9	9.2	11.7	13.1
Color Television	411.5	536.3	636.1	764.0	961.7	1,231.4
Digital Camcorder	0	0	0.2	0.4	1.2	1.6
Digital Set-Top Box	0	0.3	2.8	13.5	37.3	43.6
Digital Still Camera	0	0.5	1.5	3.2	4.3	6.3
DVD Player	0	0.6	4.1	7.6	39.9	98.4
Personal/Portable Stereo	162.5	169.8	160.7	170.2	178.3	176.3
VCR	74.8	80.6	83.1	82.9	79.8	75.7
Video Game Controller	46.4	45.2	48.5	49.8	48.0	45.4
Other Consumer Products	510	523	573	757	1,097	1,060
All Consumer Products	1,232	1,386	1,545	1,890	2,496	2,792

Source: Dataquest (June 1998)

Table 2-10
Growth in the Value of Semiconductors Consumed in China/Hong Kong by Individual Consumer Products, 1997 to 2002 (Percent)

	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Analog Camcorder	3.1	7.8	12.2	15.1	9.0	9.4
Analog Set-Top Box	306.4	149.1	56.5	27.2	12.0	86.5
Color Television	30.3	18.6	20.1	25.9	28.0	24.5
Digital Camcorder	NA	NA	137.3	191.6	36.8	NA
Digital Set-Top Box	NA	940.6	380.1	176.1	16.9	NA
Digital Still Camera	NA	238.7	106.1	35.6	46.4	NA
DVD Player	NA	566.9	85.5	427.4	146.7	NA
Personal / Portable Stereo	4.5	-5.3	5.9	4.7	-1.1	1.6
VCR	7.7	3.1	-0.2	-3.7	-5.2	0.2
Video Game Controller	-2.5	7.4	2.7	-3.6	-5.5	-0.4
Other Consumer Products	2.6	9.5	32.1	44.9	-3.4	15.7
All Consumer Products	12.5	11.5	22.3	32.1	11.9	17.8

NA = Not available
Source: Dataquest (June 1998)

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Table 2-11
Value of Semiconductors Consumed in China/Hong Kong by Individual Transportation Products, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
ABS Control Unit	0	0.1	0.2	0.4	0.8	1.4
Air Bag Control Unit	0	0	0	0.1	0.3	0.9
Auto ECU	0	0.1	0.1	0.2	0.5	0.9
Auto Stereo	78.0	91.1	111.1	137.7	163.7	204.8
Other Transportation Products	55	55	66	93	130	127
All Transportation Products	133	147	177	231	295	335

Source: Dataquest (June 1998)

Table 2-12
Growth in the Value of Semiconductors Consumed in China/Hong Kong by Individual Transportation Products, 1997 to 2002 (Percent)

	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
ABS Control Unit	145.4	165.1	138.8	85.4	75.0	119.0
Air Bag Control Unit	74.7	128.2	218.7	176.8	197.2	153.4
Auto ECU	138.0	109.1	42.6	144.8	84.7	100.1
Auto Stereo	16.8	22.0	23.9	18.8	25.1	21.3
Other Transportation Products	0.4	18.7	40.7	40.0	-1.7	18.2
All Transportation Products	10.1	20.9	30.3	27.6	13.7	20.3

Source: Dataquest (June 1998)

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Appendix A
Electronics Systems Production Forecasts

Table A-1 presents Dataquest's China/Hong Kong production forecasts for selected individual electronics systems.

Table A-1
Value of Electronics Produced in China/Hong Kong by Individual Products, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Mainframe/Supercomputers (Computers)	587	509	509	577	502	487	-3.7
Midrange Computers (Computers)	-	-	5	9	18	22	NA
Workstation (Computers)	18	20	24	30	36	45	19.5
PC (Computers)	1,227	1,829	2,722	3,779	5,171	6,741	40.6
Motherboards (Computers)	1,094	1,542	1,852	2,306	2,775	3,357	25.1
Rigid Disk Drive (Data Storage)	1,308	1,753	2,384	2,960	3,782	4,414	27.5
Optical Disk Drive (Data Storage)	144	183	237	273	292	311	16.6
Page Printer (Input/Output)	26	37	58	93	149	238	55.5
Serial Printer (Input/Output)	102	113	124	136	149	160	9.4
Monitors (Input/Output)	1,319	2,117	2,533	3,243	3,871	4,510	27.9
LAN Cards (Premise Telecom)	20	29	33	33	32	33	10.9
Premise Switching	119	157	193	228	253	275	18.3
Answering Machines (Premise Telecom)	264	311	368	438	491	533	15.1
Fax (Premise Telecom)	197	169	167	169	170	169	-3.0
Modem (Premise Telecom)	2	4	9	18	32	57	96.0
Corded Telephones (Premise Telecom)	2,178	2,159	2,173	2,192	2,200	2,206	0.3
Analog Cordless (Premise Telecom)	953	779	677	626	578	481	-12.8
Digital Cordless (Premise Telecom)	95	113	132	155	174	202	16.4
Central-Office Line Cards (Public Telecom)	1,212	1,401	1,524	1,736	1,958	2,394	14.6
Analog Cellular (Mobile Telecom)	106	90	75	59	52	43	-16.5
Digital Cellular (Mobile Telecom)	829	958	1,144	1,404	1,759	2,206	21.6
Pagers (Mobile Telecom)	559	608	662	743	769	809	7.7
Mobile Telecom Infrastructure (Mobile Telecom)	165	176	187	201	216	234	7.2
Personal/Portable Stereo (Audio)	845	907	945	1,007	1,074	1,090	5.2
Color TV (Video)	3,429	4,207	5,020	6,067	7,505	9,391	22.3
VCR (Video)	335	347	355	348	318	295	-2.5
Analog Camcorder (Video)	107	108	121	145	170	192	12.5
Digital Camcorder (Video)	-	-	1	2	5	7	NA
DVD Player(Video)	-	2	12	22	110	260	NA
Analog Set-Top Box (Video)	1	4	10	15	18	20	90.9
Digital Set-Top Box (Video)	-	1	6	28	75	89	NA
Digital Still Camera (Personal Electronics)	-	1	3	6	9	13	NA
Video Game Controllers (Personal Electronics)	91	85	87	89	89	87	-0.9
Automotive Stereo (Transportation)	347	396	459	542	638	773	17.4
Automotive ECU (Transportation)	0	0	0	0	1	2	98.6
Antilock Braking System (Transportation)	0	0	1	2	3	5	112.9
Air Bags (Transportation)	0	0	0	0	1	2	140.4
Other Products	28,815	32,974	37,987	43,092	49,443	55,885	14.2
All Electronic Equipment	46,496	54,087	62,798	72,773	84,888	98,041	16.1

NA = Not available
Source: Dataquest (June 1998)

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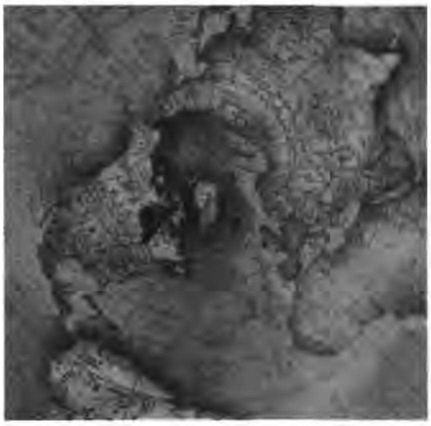

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Final 1997 Asia/Pacific Semiconductor Market Share by Country

Market Statistics

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MARIA VALENZUELA

Program: Semiconductors China
Product Code: SEMI-CH-MS-9803
Publication Date: July 6, 1998
Filing: Market Statistics

Final 1997 Asia/Pacific Semiconductor Market Share by Country

Market Statistics

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Chapter 1
Final 1997 Asia/Pacific Semiconductor Market Share

Introduction

This document contains detailed information on Dataquest's view of the semiconductor market. Included in this document are 1996 and 1997 market share rankings.

Asia/Pacific market share estimates combine data from many countries, each of which has a different and fluctuating exchange rate. Estimates of non-U.S. market consumption or revenue are based on the average exchange rate for the given year. The section titled "Exchange Rates" gives more information on these average rates. As a rule, Dataquest's estimates are calculated in local currencies and then converted to U.S. dollars.

More detailed data on this market may be requested through Dataquest's client inquiry service. Qualitative analysis of this data is provided in Dataquest Perspectives.

Segmentation and Definitions

A detailed explanation of device segmentation and related definitions is contained in *Semiconductor Market Definitions, 1997* (SCND-WW-GU-9801).

Market Share Methodology

Dataquest uses both primary and secondary sources to produce market statistics data. In the fourth quarter of each year, Dataquest surveys all major participants within each industry. Selected companies are resurveyed during the first quarter of the following year to verify final annual results. This primary research is supplemented with additional primary research and secondary research to verify market size, shipment totals, and pricing information. Sources of data used by Dataquest include the following:

- Information published by major industry participants
- Estimates made by knowledgeable and reliable industry spokespersons
- Government data or trade association data (such as WSTS, MITI, and U.S. DOC)
- Published product literature and price lists
- Interviews with knowledgeable manufacturers, distributors, and users
- Relevant economic data
- Information and data from online and CD-ROM data banks
- Articles in both the general and trade press
- Reports from financial analysts
- End-user surveys

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Dataquest believes that the estimates presented in this document are the most accurate and meaningful statistics available.

Despite the care taken in gathering, analyzing, and categorizing the data in a meaningful way, careful attention must be paid to the definitions and assumptions used when interpreting the estimates presented in this document. Various companies, government agencies, and trade associations may use slightly different definitions of product categories and regional groupings, or they may include different companies in their summaries. These differences should be kept in mind when making comparisons between data and numbers provided by Dataquest and those provided by other sources.

Notes on Market Share

In the process of conducting data collection and preparing market statistics information, Dataquest will sometimes consolidate or revise a particular company, model, series, or industry's numbers. In this section, we explain any such changes contained within this document for your reference.

Notes to Market Share Tables

- All rank tables in this document include only the top 30 semiconductor companies' revenue into the Asia/Pacific region. The total Asia/Pacific market in 1996 was U.S.$29,735 billion and included many more than those 30 companies.
- "Other Asia" refers to Asia/Pacific countries excluding Korea, China, Hong Kong, Singapore, and Taiwan.
- Cyrix was acquired by National Semiconductor in 1997.
- National Semiconductor divested itself of Fairchild in 1997.
- National Semiconductor's 1997 revenue includes all of Cyrix's 1997 revenue and part of Fairchild's calendar first quarter revenue.
- Power Innovations was formed through the acquisition of the Power Semiconductor interests of Texas Instruments.
- Melexis was formerly known as Elex.
- Micronas acquired ITT in 1997.
- The following companies were added to the market share database in 1997:
  - Fairchild
  - Vitesse
  - TriQuint
  - Power Innovations
  - Robert Bosch
  - Stanley

- Toko is now tracked in other Japanese companies.
- IBM's 1996 revenue was restated in 1997.
- Singapore revenue includes "as to" billings, some of which are re-exported from Singapore.

Exchange Rates

Dataquest uses an average annual exchange rate in converting revenue to U.S. dollar amounts. Table 1-1 outlines these rates for 1996 through 1997.

Table 1-1
Exchange Rates

	1996	1997
China (Renminbi/U.S.$)	8.34	8.32
Hong Kong (Dollar/U.S.$)	7.73	7.75
Singapore (Dollar/U.S.$)	1.41	1.99
South Korea (Won/U.S.$)	805.16	954.14
Taiwan (Dollar/U.S.$)	27.47	28.79

Source: Dataquest (August 1997)

Project Analysts: Ellie Babaie, Ron Bohn, Sabrina Chiou, Marilyn David, Kelvin Fu, Dan Heyler, C.S. Kim, Kevin McClure, Yoshihiro Shimada, J.H. Son, Erwin Wong, Jerry Yeh, and Sun-Ah Yeom

Chapter 2
Asia/Pacific Market Statistics Tables

Table 2-1
Vendor Revenue from Shipments of Total Semiconductors by Country (Millions of U.S. Dollars)

	Korea	China/ Hong Kong	Singapore	Taiwan	Other Asia	Asia/ Pacific
Intel	559	684	1,437	941	456	4,077
Samsung	620	405	482	299	116	1,922
Texas Instruments	160	281	989	290	132	1,852
Toshiba	196	637	510	426	38	1,807
Motorola	199	414	608	266	195	1,682
Philips	404	359	338	288	191	1,580
NEC	85	353	498	374	16	1,326
SGS-Thomson	141	176	542	160	58	1,077
Hitachi	144	166	322	209	165	1,006
LG Semicon	270	280	170	223	49	992
SANYO	176	268	211	109	137	901
Rohm	100	230	302	98	96	826
National Semiconductor	171	146	199	116	74	706
Hyundai	78	179	244	173	30	704
Mitsubishi	61	107	277	215	29	689
Lucent Technologies	80	135	175	192	50	632
Siemens	51	116	193	158	33	551
Fujitsu	54	68	149	69	137	477
Advanced Micro Devices	42	121	85	221	3	472
Matsushita	49	92	103	76	120	440
Sharp	105	69	136	75	48	433
Sony	58	102	121	52	41	374
United Microelectronics Corp.	-	90	10	153	91	344
Cirrus Logic	11	6	126	123	31	297
Atmel	45	92	84	69	2	292
S3	1	59	32	159	18	269
Winbond Electronics	5	32	6	130	88	261
Korean Electronic Co.	103	75	41	28	8	255
IBM	10	39	142	50	7	248
Vanguard	55	50	87	25	20	237
Sanken	89	34	34	29	4	190
Mosel Vitelic	-	12	3	157	4	176
All Other Companies	NA	NA	NA	NA	NA	5,439
Total Market	**NA**	**NA**	**NA**	**NA**	**NA**	**32,534**

NA = Not available
Source: Dataquest (June 1998)

Table 2-2
Top 30 Worldwide Vendors' Revenue from Shipments of Total Semiconductors to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	3,250	4,077	25.4	15.0
2	2	Samsung	1,828	1,922	5.1	7.1
3	4	Texas Instruments	1,735	1,852	6.7	6.8
4	3	Toshiba	1,805	1,807	0.1	6.7
5	6	Motorola	1,424	1,682	18.1	6.2
6	5	Philips	1,473	1,580	7.3	5.8
7	7	NEC	1,284	1,326	3.3	4.9
8	10	SGS-Thomson	1,128	1,077	-4.5	4.0
9	9	Hitachi	1,170	1,006	-14.0	3.7
10	8	LG Semicon	1,178	992	-15.8	3.7
11	11	SANYO	913	901	-1.3	3.3
12	17	Rohm	471	826	75.4	3.0
13	14	National Semiconductor	560	706	26.1	2.6
14	12	Hyundai	763	704	-7.7	2.6
15	13	Mitsubishi	729	689	-5.5	2.5
16	22	Lucent Technologies	355	632	78.0	2.3
17	18	Siemens	454	551	21.4	2.0
18	16	Fujitsu	476	477	0.2	1.8
19	25	Advanced Micro Devices	268	472	76.1	1.7
20	15	Matsushita	500	440	-12.0	1.6
21	20	Sharp	408	433	6.1	1.6
22	23	Sony	286	374	30.8	1.4
23	19	United Microelectronics Corp.	430	344	-20.0	1.3
24	24	Cirrus Logic	283	297	4.9	1.1
25	30	Atmel	209	292	39.7	1.1
26	116	S3	0	269	NA	1.0
27	26	Winbond Electronics	261	261	0	1.0
28	28	Korean Electronic Co.	228	255	11.8	0.9
29	21	IBM	382	248	-35.1	0.9
30	253	Vanguard	0	237	NA	0.9
		All Others	456	366	-19.7	1.4
		Americas Companies	8,466	10,527	24.3	38.9
		Japanese Companies	8,257	8,469	2.6	31.3
		European Companies	3,055	3,208	5.0	11.8
		Asia/Pacific Companies	4,929	4,891	-0.8	18.1
		Included Companies Total	**24,707**	**27,095**	**9.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-3
Top 30 Worldwide Vendors' Revenue from Shipments of Total Integrated Circuits to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	3,250	4,077	25.4	17.5
2	2	Texas Instruments	1,732	1,852	6.9	7.9
3	3	Samsung	1,568	1,615	3.0	6.9
4	7	Motorola	1,141	1,372	20.2	5.9
5	6	Philips	1,175	1,285	9.4	5.5
6	4	Toshiba	1,331	1,263	-5.1	5.4
7	8	NEC	1,093	1,083	-0.9	4.6
8	5	LG Semicon	1,178	992	-15.8	4.3
9	9	SGS-Thomson	996	934	-6.2	4.0
10	10	Hitachi	933	724	-22.4	3.1
11	12	SANYO	699	711	1.7	3.1
12	11	Hyundai	763	704	-7.7	3.0
13	14	National Semiconductor	494	673	36.2	2.9
14	19	Lucent Technologies	345	604	75.1	2.6
15	13	Mitsubishi	648	600	-7.4	2.6
16	23	Advanced Micro Devices	268	472	76.1	2.0
17	18	Siemens	375	459	22.4	2.0
18	15	Fujitsu	454	458	0.9	2.0
19	28	Rohm	199	380	91.0	1.6
20	16	United Microelectronics Corp.	430	344	-20.0	1.5
21	26	Sony	235	321	36.6	1.4
22	21	Cirrus Logic	283	297	4.9	1.3
23	27	Atmel	209	292	39.7	1.3
24	20	Matsushita	303	274	-9.6	1.2
25	30	S3	0	269	NA	1.2
26	24	Winbond Electronics	261	261	0	1.1
27	22	Sharp	277	260	-6.1	1.1
28	17	IBM	382	248	-35.1	1.1
29	31	Vanguard	0	237	NA	1.0
30	25	Mosel Vitelic	241	176	-27.0	0.8
		All Others	44	74	68.2	0.3
		Americas Companies	8,104	10,156	25.3	43.6
		Japanese Companies	6,172	6,099	-1.2	26.2
		European Companies	2,546	2,678	5.2	11.5
		Asia/Pacific Companies	4,485	4,378	-2.4	18.8
		Included Companies Total	**21,307**	**23,311**	**9.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-4
Top 13 Worldwide Vendors' Revenue from Shipments of Bipolar Digital to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Hitachi	53	54	1.9	28.9
2	1	Texas Instruments	54	49	-9.3	26.2
3	4	Motorola	31	29	-6.5	15.5
4	6	Philips	12	13	8.3	7.0
5	9	Matsushita	4	11	175.0	5.9
6	30	Mosel Vitelic	0	10	NA	5.3
7	7	LG Semicon	8	7	-12.5	3.7
8	8	Advanced Micro Devices	4	4	0	2.1
9	5	Toshiba	19	3	-84.2	1.6
10	10	Mitsubishi	3	3	0	1.6
11	11	NEC	2	2	0	1.1
12	3	National Semiconductor	45	1	-97.8	0.5
13	12	Fujitsu	1	1	0	0.5
		All Others	-	-	NA	0
		Americas Companies	134	83	-38.1	44.4
		Japanese Companies	82	74	-9.8	39.6
		European Companies	12	13	8.3	7.0
		Asia/Pacific Companies	8	17	112.5	9.1
		Included Companies Total	**236**	**187**	**-20.8**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-5
Top 30 Worldwide Vendors' Revenue from Shipments of MOS Digital ICs to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	3,250	4,077	25.4	22.8
2	2	Samsung	1,361	1,321	-2.9	7.4
3	4	Texas Instruments	1,104	1,055	-4.4	5.9
4	8	Motorola	783	947	20.9	5.3
5	3	LG Semicon	1,134	940	-17.1	5.3
6	5	NEC	951	935	-1.7	5.2
7	6	Toshiba	939	818	-12.9	4.6
8	9	Hyundai	762	701	-8.0	3.9
9	10	Philips	656	660	0.6	3.7
10	16	Lucent Technologies	313	594	89.8	3.3
11	7	Hitachi	788	543	-31.1	3.0
12	11	Mitsubishi	533	491	-7.9	2.8
13	12	Fujitsu	440	440	0	2.5
14	20	Advanced Micro Devices	243	423	74.1	2.4
15	17	Siemens	311	380	22.2	2.1
16	13	United Microelectronics Corp.	430	344	-20.0	1.9
17	15	SANYO	338	309	-8.6	1.7
18	24	Atmel	209	292	39.7	1.6
19	25	National Semiconductor	202	278	37.6	1.6
20	29	S3	0	269	NA	1.5
21	22	SGS-Thomson	237	251	5.9	1.4
22	14	IBM	382	248	-35.1	1.4
23	30	Vanguard	0	237	NA	1.3
24	19	Sharp	250	228	-8.8	1.3
25	18	Cirrus Logic	258	216	-16.3	1.2
26	23	Winbond Electronics	211	200	-5.2	1.1
27	27	Sony	146	197	34.9	1.1
28	21	Mosel Vitelic	241	166	-31.1	0.9
29	28	Rohm	101	153	51.5	0.9
30	26	Matsushita	158	134	-15.2	0.8
		All Others	-	-	NA	0
		Americas Companies	6,744	8,399	24.5	47.1
		Japanese Companies	4,644	4,248	-8.5	23.8
		European Companies	1,204	1,291	7.2	7.2
		Asia/Pacific Companies	4,139	3,909	-5.6	21.9
		Included Companies Total	**16,731**	**17,847**	**6.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-6
Top 27 Worldwide Vendors' Revenue from Shipments of MOS Memory to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	1,074	892	-16.9	15.3
2	2	LG Semicon	979	731	-25.3	12.5
3	3	Hyundai	755	697	-7.7	12.0
4	5	NEC	541	432	-20.1	7.4
5	10	Siemens	298	352	18.1	6.0
6	4	Texas Instruments	567	321	-43.4	5.5
7	8	Mitsubishi	344	305	-11.3	5.2
8	9	Fujitsu	311	279	-10.3	4.8
9	12	Atmel	179	238	33.0	4.1
10	29	Vanguard	0	237	NA	4.1
11	6	Hitachi	469	195	-58.4	3.3
12	13	Intel	163	183	12.3	3.1
13	11	Mosel Vitelic	241	166	-31.1	2.8
14	7	Toshiba	403	154	-61.8	2.6
15	15	Winbond Electronics	131	110	-16.0	1.9
16	17	SGS-Thomson	103	103	0	1.8
17	19	Advanced Micro Devices	70	93	32.9	1.6
18	16	Sharp	108	87	-19.4	1.5
19	23	Matsushita	37	59	59.5	1.0
20	18	Motorola	94	50	-46.8	0.9
21	21	IBM	52	50	-3.8	0.9
22	20	SANYO	57	32	-43.9	0.5
23	24	Sony	33	27	-18.2	0.5
24	14	United Microelectronics Corp.	140	18	-87.1	0.3
25	25	Rohm	11	10	-9.1	0.2
26	26	Philips	0	6	NA	0.1
27	22	National Semiconductor	39	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	1,164	935	-19.7	16.0
		Japanese Companies	2,314	1,580	-31.7	27.1
		European Companies	401	461	15.0	7.9
		Asia/Pacific Companies	3,320	2,851	-14.1	48.9
		Included Companies Total	**7,199**	**5,827**	**-19.1**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-7
Top 17 Worldwide Vendors' Revenue from Shipments of DRAM to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Samsung	852	724	-15.0	16.6
2	3	Hyundai	712	669	-6.0	15.3
3	1	LG Semicon	883	650	-26.4	14.9
4	5	NEC	504	402	-20.2	9.2
5	8	Siemens	298	352	18.1	8.1
6	4	Texas Instruments	536	294	-45.1	6.7
7	9	Mitsubishi	291	262	-10.0	6.0
8	18	Vanguard	0	237	NA	5.4
9	11	Fujitsu	208	181	-13.0	4.2
10	10	Mosel Vitelic	233	165	-29.2	3.8
11	6	Hitachi	391	163	-58.3	3.7
12	7	Toshiba	343	106	-69.1	2.4
13	13	Matsushita	34	57	67.6	1.3
14	15	Motorola	33	37	12.1	0.8
15	12	IBM	42	29	-31.0	0.7
16	14	SANYO	34	28	-17.6	0.6
17	16	Sharp	8	4	-50.0	0
		All Others	-	-	NA	0
		Americas Companies	611	360	-41.1	8.3
		Japanese Companies	1,813	1,203	-33.6	27.6
		European Companies	298	352	18.1	8.1
		Asia/Pacific Companies	2,680	2,445	-8.8	56.1
		Included Companies Total	**5,402**	**4,360**	**-19.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-8
Top 19 Worldwide Vendors' Revenue from Shipments of SRAM to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	162	126	-22.2	25.2
2	3	Winbond Electronics	121	102	-15.7	20.4
3	6	LG Semicon	49	41	-16.3	8.2
4	7	Toshiba	46	36	-21.7	7.2
5	8	Hyundai	43	28	-34.9	5.6
6	9	Mitsubishi	39	27	-30.8	5.4
7	10	Sony	33	27	-18.2	5.4
8	5	Hitachi	57	25	-56.1	5.0
9	14	IBM	10	21	110.0	4.2
10	2	United Microelectronics Corp.	125	17	-86.4	3.4
11	11	NEC	20	15	-25.0	3.0
12	13	Sharp	18	14	-22.2	2.8
13	4	Motorola	59	12	-79.7	2.4
14	16	Fujitsu	4	3	-25.0	0.6
15	17	Rohm	4	3	-25.0	0.6
16	12	SANYO	19	2	-89.5	0.4
17	15	Mosel Vitelic	8	1	-87.5	0.2
18	18	Matsushita	2	0	-100.0	0
19	19	SGS-Thomson	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	69	33	-52.2	6.6
		Japanese Companies	242	152	-37.2	30.4
		European Companies	1	-	-100.0	0
		Asia/Pacific Companies	508	315	-38.0	63.0
		Included Companies Total	**820**	**500**	**-39.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-9
Top 20 Worldwide Vendors' Revenue from Shipments of Nonvolatile Memory to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Atmel	179	238	33.0	24.9
2	2	Intel	163	183	12.3	19.2
3	3	SGS-Thomson	100	100	0	10.5
4	4	Fujitsu	99	95	-4.0	10.0
5	6	Advanced Micro Devices	70	93	32.9	9.7
6	5	Sharp	82	69	-15.9	7.2
7	7	Samsung	60	42	-30.0	4.4
8	8	LG Semicon	47	40	-14.9	4.2
9	10	Texas Instruments	31	27	-12.9	2.8
10	15	Mitsubishi	13	15	15.4	1.6
11	13	Toshiba	14	12	-14.3	1.3
12	14	NEC	14	12	-14.3	1.3
13	16	Winbond Electronics	10	8	-20.0	0.8
14	11	Hitachi	21	7	-66.7	0.7
15	17	Rohm	7	7	0	0.7
16	18	SANYO	4	2	-50.0	0.2
17	20	Matsushita	1	2	100.0	0.2
18	12	United Microelectronics Corp.	15	1	-93.3	0.1
19	19	Motorola	1	1	0	0.1
20	9	National Semiconductor	39	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	483	542	12.2	56.8
		Japanese Companies	255	221	-13.3	23.2
		European Companies	100	100	0	10.5
		Asia/Pacific Companies	132	91	-31.1	9.5
		Included Companies Total	**970**	**954**	**-1.6**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-10
Top Five Worldwide Vendors' Revenue from Shipments of Other MOS Memory to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	27	Philips	0	6	NA	46.2
2	1	NEC	3	3	0	23.1
3	2	SGS-Thomson	2	3	50.0	23.1
4	3	Mitsubishi	1	1	0	7.7
5	4	Motorola	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	1	-	-100.0	0
		Japanese Companies	4	4	0	30.8
		European Companies	2	9	350.0	69.2
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**7**	**13**	**85.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-11
Top 28 Worldwide Vendors' Revenue from Shipments of MOS Microcomponents to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	3,087	3,894	26.1	43.4
2	2	Motorola	558	685	22.8	7.6
3	4	Toshiba	301	395	31.2	4.4
4	5	Texas Instruments	290	382	31.7	4.3
5	6	United Microelectronics Corp.	290	326	12.4	3.6
6	8	NEC	254	307	20.9	3.4
7	10	Hitachi	237	303	27.8	3.4
8	3	Philips	385	286	-25.7	3.2
9	14	Advanced Micro Devices	122	284	132.8	3.2
10	12	National Semiconductor	136	274	101.5	3.1
11	30	S3	0	269	NA	3.0
12	13	Lucent Technologies	125	225	80.0	2.5
13	7	Cirrus Logic	258	216	-16.3	2.4
14	16	Samsung	80	207	158.8	2.3
15	11	Mitsubishi	179	173	-3.4	1.9
16	9	IBM	247	145	-41.3	1.6
17	20	LG Semicon	61	107	75.4	1.2
18	18	Winbond Electronics	76	86	13.2	1.0
19	17	SANYO	78	85	9.0	0.9
20	15	SGS-Thomson	94	80	-14.9	0.9
21	19	Fujitsu	63	75	19.0	0.8
22	21	Sharp	47	53	12.8	0.6
23	22	Matsushita	43	33	-23.3	0.4
24	24	Atmel	19	29	52.6	0.3
25	23	Sony	30	28	-6.7	0.3
26	26	Siemens	13	28	115.4	0.3
27	25	Rohm	15	6	-60.0	0
28	27	Hyundai	1	1	0	0
		All Others	-	-	NA	0
		Americas Companies	4,842	6,403	32.2	71.3
		Japanese Companies	1,247	1,458	16.9	16.2
		European Companies	492	394	-19.9	4.4
		Asia/Pacific Companies	508	727	43.1	8.1
		Included Companies Total	**7,089**	**8,982**	**26.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-12
Top 12 Worldwide Vendors' Revenue from Shipments of Microprocessors to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	2,734	3,525	28.9	82.2
2	3	Motorola	152	253	66.4	5.9
3	4	Advanced Micro Devices	87	204	134.5	4.8
4	2	IBM	241	139	-42.3	3.2
5	7	National Semiconductor	14	97	592.9	2.3
6	9	NEC	12	32	166.7	0.7
7	5	Toshiba	25	29	16.0	0.7
8	11	SGS-Thomson	3	5	66.7	0.1
9	10	Fujitsu	5	3	-40.0	0
10	6	Texas Instruments	16	1	-93.8	0
11	12	Mitsubishi	1	1	0	0
12	8	LG Semicon	13	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	3,244	4,219	30.1	98.4
		Japanese Companies	43	65	51.2	1.5
		European Companies	3	5	66.7	0.1
		Asia/Pacific Companies	13	-	-100.0	0
		Included Companies Total	**3,303**	**4,289**	**29.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-13
Top 23 Worldwide Vendors' Revenue from Shipments of Microcontrollers to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Motorola	368	384	4.3	18.0
2	3	NEC	202	212	5.0	10.0
3	8	Samsung	78	205	162.8	9.6
4	6	Philips	150	197	31.3	9.3
5	4	Hitachi	155	194	25.2	9.1
6	2	Toshiba	203	175	-13.8	8.2
7	5	Mitsubishi	153	152	-0.7	7.1
8	7	Intel	111	109	-1.8	5.1
9	9	SANYO	78	85	9.0	4.0
10	10	SGS-Thomson	68	68	0	3.2
11	15	LG Semicon	26	56	115.4	2.6
12	11	Sharp	47	53	12.8	2.5
13	12	Fujitsu	36	52	44.4	2.4
14	18	Atmel	19	29	52.6	1.4
15	13	Sony	30	28	-6.7	1.3
16	19	Siemens	13	28	115.4	1.3
17	14	Texas Instruments	29	23	-20.7	1.1
18	17	United Microelectronics Corp.	20	21	5.0	1.0
19	16	Matsushita	23	16	-30.4	0.8
20	20	National Semiconductor	12	15	25.0	0.7
21	23	Advanced Micro Devices	0	15	NA	0.7
22	21	Winbond Electronics	10	10	0	0.5
23	22	Rohm	9	2	-77.8	0
		All Others	-	-	NA	0
		Americas Companies	539	575	6.7	27.0
		Japanese Companies	936	969	3.5	45.5
		European Companies	231	293	26.8	13.8
		Asia/Pacific Companies	134	292	117.9	13.7
		Included Companies Total	**1,840**	**2,129**	**15.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-14
Top 21 Worldwide Vendors' Revenue from Shipments of Microperipherals to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	United Microelectronics Corp.	270	305	13.0	16.7
2	27	S3	0	269	NA	14.8
3	3	Intel	242	260	7.4	14.3
4	2	Cirrus Logic	258	216	-16.3	11.8
5	5	National Semiconductor	110	162	47.3	8.9
6	6	Hitachi	80	106	32.5	5.8
7	8	Toshiba	62	87	40.3	4.8
8	7	Winbond Electronics	66	76	15.2	4.2
9	10	Advanced Micro Devices	35	65	85.7	3.6
10	9	Texas Instruments	40	58	45.0	3.2
11	4	Philips	235	54	-77.0	3.0
12	15	LG Semicon	22	51	131.8	2.8
13	11	NEC	32	39	21.9	2.1
14	13	Mitsubishi	25	20	-20.0	1.1
15	12	Motorola	29	16	-44.8	0.9
16	16	Fujitsu	17	16	-5.9	0.9
17	17	Matsushita	10	9	-10.0	0.5
18	14	SGS-Thomson	23	7	-69.6	0.4
19	18	Rohm	6	4	-33.3	0.2
20	19	Samsung	2	2	0	0.1
21	20	Hyundai	1	1	0	0
		All Others	-	-	NA	0
		Americas Companies	714	1,046	46.5	57.4
		Japanese Companies	232	281	21.1	15.4
		European Companies	258	61	-76.4	3.3
		Asia/Pacific Companies	361	435	20.5	23.9
		Included Companies Total	**1,565**	**1,823**	**16.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-15
Top 10 Worldwide Vendors' Revenue from Shipments of Digital Signal Processors to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Texas Instruments	205	300	46.3	40.5
2	2	Lucent Technologies	125	225	80.0	30.4
3	3	Toshiba	11	104	845.5	14.0
4	17	Philips	0	35	NA	4.7
5	5	Motorola	9	32	255.6	4.3
6	6	NEC	8	24	200.0	3.2
7	4	Matsushita	10	8	-20.0	1.1
8	7	IBM	6	6	0	0.8
9	8	Fujitsu	5	4	-20.0	0.5
10	9	Hitachi	2	3	50.0	0.4
		All Others	-	-	NA	0
		Americas Companies	345	563	63.2	76.0
		Japanese Companies	36	143	297.2	19.3
		European Companies	-	35	NA	4.7
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**381**	**741**	**94.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-16
Top 23 Worldwide Vendors' Revenue from Shipments of MOS Digital Logic to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	6	Lucent Technologies	188	369	96.3	12.1
2	1	Philips	271	368	35.8	12.1
3	2	Texas Instruments	247	352	42.5	11.6
4	3	Toshiba	235	269	14.5	8.9
5	4	Samsung	207	222	7.2	7.3
6	8	Motorola	131	212	61.8	7.0
7	7	NEC	156	196	25.6	6.5
8	5	SANYO	203	192	-5.4	6.3
9	12	Sony	83	142	71.1	4.7
10	15	Rohm	75	137	82.7	4.5
11	10	LG Semicon	94	102	8.5	3.4
12	9	Sharp	95	88	-7.4	2.9
13	16	Fujitsu	66	86	30.3	2.8
14	18	SGS-Thomson	40	68	70.0	2.2
15	11	IBM	83	53	-36.1	1.7
16	17	Advanced Micro Devices	51	46	-9.8	1.5
17	13	Hitachi	82	45	-45.1	1.5
18	14	Matsushita	78	42	-46.2	1.4
19	20	Atmel	11	25	127.3	0.8
20	21	Mitsubishi	10	13	30.0	0.4
21	19	National Semiconductor	27	4	-85.2	0.1
22	23	Winbond Electronics	4	4	0	0.1
23	22	Hyundai	6	3	-50.0	0
		All Others	-	-	NA	0
		Americas Companies	738	1,061	43.8	34.9
		Japanese Companies	1,083	1,210	11.7	39.8
		European Companies	311	436	40.2	14.4
		Asia/Pacific Companies	311	331	6.4	10.9
		Included Companies Total	**2,443**	**3,038**	**24.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-17
Top 23 Worldwide Vendors' Revenue from Shipments of ASICs to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Lucent Technologies	188	369	96.3	29.8
2	1	Texas Instruments	196	222	13.3	17.9
3	4	NEC	117	108	-7.7	8.7
4	8	LG Semicon	74	80	8.1	6.5
5	9	Fujitsu	62	79	27.4	6.4
6	3	Samsung	134	71	-47.0	5.7
7	12	SGS-Thomson	36	57	58.3	4.6
8	6	IBM	83	53	-36.1	4.3
9	13	Motorola	35	39	11.4	3.1
10	5	Toshiba	113	37	-67.3	3.0
11	11	Hitachi	48	30	-37.5	2.4
12	10	Matsushita	52	27	-48.1	2.2
13	16	Advanced Micro Devices	22	19	-13.6	1.5
14	18	Atmel	11	15	36.4	1.2
15	7	Sharp	82	12	-85.4	1.0
16	15	Sony	26	8	-69.2	0.6
17	17	SANYO	19	4	-78.9	0.3
18	19	Hyundai	6	3	-50.0	0.2
19	21	National Semiconductor	3	3	0	0.2
20	23	Mitsubishi	2	3	50.0	0.2
21	22	Philips	2	1	-50.0	0
22	14	Rohm	32	0	-100.0	0
23	20	Winbond Electronics	4	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	538	720	33.8	58.1
		Japanese Companies	553	308	-44.3	24.8
		European Companies	38	58	52.6	4.7
		Asia/Pacific Companies	218	154	-29.4	12.4
		Included Companies Total	**1,347**	**1,240**	**-7.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-18
Top 10 Worldwide Vendors' Revenue from Shipments of Custom ICs to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	15	Sharp	0	62	NA	20.9
2	6	Samsung	0	56	NA	18.9
3	9	Motorola	0	52	NA	17.6
4	22	Rohm	0	45	NA	15.2
5	3	NEC	0	33	NA	11.1
6	16	Sony	0	17	NA	5.7
7	12	Matsushita	0	13	NA	4.4
8	14	Atmel	0	10	NA	3.4
9	10	Toshiba	0	4	NA	1.4
10	23	Winbond Electronics	0	4	NA	1.4
		All Others	-	-	NA	0
		Americas Companies	0	62	NA	20.9
		Japanese Companies	0	174	NA	58.8
		European Companies	0	-	NA	0
		Asia/Pacific Companies	0	60	NA	20.3
		Included Companies Total	**0**	**296**	**NA**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-19
Top 15 Worldwide Vendors' Revenue from Shipments of MOS Standard Logic to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	68	130	91.2	28.3
2	3	Texas Instruments	51	95	86.3	20.7
3	2	Toshiba	67	92	37.3	20.0
4	4	Motorola	49	48	-2.0	10.4
5	7	LG Semicon	20	22	10.0	4.8
6	9	Samsung	12	15	25.0	3.3
7	10	NEC	9	13	44.4	2.8
8	11	Rohm	5	13	160.0	2.8
9	13	SGS-Thomson	4	11	175.0	2.4
10	8	Hitachi	13	9	-30.8	2.0
11	12	Fujitsu	4	7	75.0	1.5
12	14	Mitsubishi	3	4	33.3	0.9
13	6	National Semiconductor	23	1	-95.7	0.2
14	5	Matsushita	23	0	-100.0	0
15	15	SANYO	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	123	144	17.1	31.3
		Japanese Companies	126	138	9.5	30.0
		European Companies	72	141	95.8	30.7
		Asia/Pacific Companies	32	37	15.6	8.0
		Included Companies Total	**353**	**460**	**30.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-20
Top 15 Worldwide Vendors' Revenue from Shipments of Total Other MOS Logic to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	201	237	17.9	22.7
2	2	SANYO	182	188	3.3	18.0
3	5	Toshiba	55	136	147.3	13.1
4	4	Sony	57	117	105.3	11.2
5	3	Samsung	61	80	31.1	7.7
6	7	Rohm	38	79	107.9	7.6
7	6	Motorola	47	73	55.3	7.0
8	8	NEC	30	42	40.0	4.0
9	15	Texas Instruments	0	35	NA	3.4
10	9	Advanced Micro Devices	29	27	-6.9	2.6
11	11	Sharp	13	14	7.7	1.3
12	10	Hitachi	21	6	-71.4	0.6
13	12	Mitsubishi	5	6	20.0	0.6
14	13	Matsushita	3	2	-33.3	0.2
15	14	National Semiconductor	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	77	135	75.3	13.0
		Japanese Companies	404	590	46.0	56.6
		European Companies	201	237	17.9	22.7
		Asia/Pacific Companies	61	80	31.1	7.7
		Included Companies Total	**743**	**1,042**	**40.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-21
Top 25 Worldwide Vendors' Revenue from Shipments of Analog-Monolithic to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Texas Instruments	574	748	30.3	14.2
2	1	SGS-Thomson	759	683	-10.0	12.9
3	3	Philips	507	612	20.7	11.6
4	4	Toshiba	373	442	18.5	8.4
5	5	SANYO	361	402	11.4	7.6
6	6	Motorola	327	396	21.1	7.5
7	7	National Semiconductor	247	394	59.5	7.5
8	8	Samsung	207	294	42.0	5.6
9	12	Rohm	98	227	131.6	4.3
10	10	NEC	140	146	4.3	2.8
11	9	Matsushita	141	129	-8.5	2.4
12	13	Hitachi	92	127	38.0	2.4
13	14	Sony	89	124	39.3	2.3
14	11	Mitsubishi	112	106	-5.4	2.0
15	21	Cirrus Logic	25	81	224.0	1.5
16	15	Siemens	64	79	23.4	1.5
17	16	Winbond Electronics	50	61	22.0	1.2
18	17	Korean Electronic Co.	44	49	11.4	0.9
19	18	LG Semicon	36	45	25.0	0.9
20	22	Advanced Micro Devices	21	45	114.3	0.9
21	20	Sharp	27	32	18.5	0.6
22	32	Sanken	0	25	NA	0.5
23	23	Fujitsu	13	17	30.8	0.3
24	19	Lucent Technologies	32	10	-68.8	0.2
25	24	Hyundai	1	3	200.0	0
		All Others	-	-	NA	0
		Americas Companies	1,226	1,674	36.5	31.7
		Japanese Companies	1,446	1,777	22.9	33.7
		European Companies	1,330	1,374	3.3	26.0
		Asia/Pacific Companies	338	452	33.7	8.6
		Included Companies Total	**4,340**	**5,277**	**21.6**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 2-22
Top 18 Worldwide Vendors' Revenue from Shipments of Discrete Semiconductors to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Toshiba	390	454	16.4	14.7
2	6	Rohm	193	335	73.6	10.9
3	3	Motorola	271	297	9.6	9.6
4	2	Philips	291	295	1.4	9.6
5	4	Samsung	252	295	17.1	9.6
6	5	Hitachi	203	252	24.1	8.2
7	7	Korean Electronic Co.	165	191	15.8	6.2
8	10	SANYO	136	165	21.3	5.4
9	12	Sanken	120	161	34.2	5.2
10	9	Matsushita	151	154	2.0	5.0
11	8	NEC	154	151	-1.9	4.9
12	11	SGS-Thomson	132	143	8.3	4.6
13	14	Mitsubishi	64	70	9.4	2.3
14	15	Siemens	44	56	27.3	1.8
15	13	National Semiconductor	66	33	-50.0	1.1
16	16	Fujitsu	14	17	21.4	0.6
17	17	Sony	8	9	12.5	0.3
18	18	Texas Instruments	3	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	340	330	-2.9	10.7
		Japanese Companies	1,433	1,768	23.4	57.4
		European Companies	467	494	5.8	16.0
		Asia/Pacific Companies	417	486	16.5	15.8
		Included Companies Total	**2,657**	**3,078**	**15.8**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 2-23
Top 16 Worldwide Vendors' Revenue from Shipments of Optical Semiconductors to Asia/Pacific (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Sharp	131	173	32.1	24.5
2	3	Rohm	66	111	68.2	15.7
3	5	NEC	35	92	162.9	13.0
4	2	Toshiba	84	90	7.1	12.7
5	7	Sony	33	44	33.3	6.2
6	6	Siemens	35	36	2.9	5.1
7	8	Hitachi	25	30	20.0	4.2
8	13	Lucent Technologies	10	28	180.0	4.0
9	10	SANYO	16	25	56.3	3.5
10	11	Mitsubishi	16	19	18.8	2.7
11	9	Korean Electronic Co.	19	15	-21.1	2.1
12	12	Motorola	12	13	8.3	1.8
13	4	Matsushita	46	12	-73.9	1.7
14	14	Samsung	8	12	50.0	1.7
15	15	Sanken	2	4	100.0	0.6
16	16	Fujitsu	2	2	0	0.3
		All Others	-	-	NA	0
		Americas Companies	22	41	86.4	5.8
		Japanese Companies	456	602	32.0	85.3
		European Companies	35	36	2.9	5.1
		Asia/Pacific Companies	27	27	0	3.8
		Included Companies Total	**540**	**706**	**30.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Chapter 3
Korea Market Statistics Tables

Table 3-1
Top 30 Worldwide Vendors' Revenue from Shipments of Total Semiconductors to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	603	620	2.8	15.0
2	2	Intel	454	559	23.1	13.6
3	3	Philips	345	404	17.1	9.8
4	4	LG Semicon	297	270	-9.1	6.6
5	6	Motorola	188	199	5.9	4.8
6	5	Toshiba	235	196	-16.6	4.8
7	7	SANYO	173	176	1.7	4.3
8	11	National Semiconductor	116	171	47.4	4.1
9	9	Texas Instruments	167	160	-4.2	3.9
10	8	Hitachi	172	144	-16.3	3.5
11	10	SGS-Thomson	130	141	8.5	3.4
12	19	Sharp	52	105	101.9	2.5
13	12	Korean Electronic Co.	116	103	-11.2	2.5
14	16	Rohm	58	100	72.4	2.4
15	28	Sanken	7	89	1,171.4	2.2
16	13	NEC	93	85	-8.6	2.1
17	22	Lucent Technologies	35	80	128.6	1.9
18	14	Hyundai	88	78	-11.4	1.9
19	18	Mitsubishi	52	61	17.3	1.5
20	15	Sony	81	58	-28.4	1.4
21	253	Vanguard	0	55	NA	1.3
22	23	Fujitsu	27	54	100.0	1.3
23	20	Siemens	36	51	41.7	1.2
24	17	Matsushita	52	49	-5.8	1.2
25	21	Atmel	35	45	28.6	1.1
26	24	Advanced Micro Devices	26	42	61.5	1.0
27	27	Cirrus Logic	9	11	22.2	0.3
28	25	IBM	21	10	-52.4	0.2
29	30	Winbond Electronics	3	5	66.7	0.1
30	116	S3	0	1	NA	0
		All Others	16	-	-100.0	0
		Americas Companies	1,051	1,278	21.6	31.0
		Japanese Companies	1,002	1,117	11.5	27.1
		European Companies	511	596	16.6	14.5
		Asia/Pacific Companies	1,123	1,131	0.7	27.4
		Included Companies Total	**3,687**	**4,122**	**11.8**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-2
Top 30 Worldwide Vendors' Revenue from Shipments of Total Integrated Circuits to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Intel	454	559	23.1	16.7
2	1	Samsung	485	491	1.2	14.7
3	4	Philips	250	310	24.0	9.3
4	3	LG Semicon	297	270	-9.1	8.1
5	7	Motorola	157	165	5.1	4.9
6	11	National Semiconductor	102	164	60.8	4.9
7	5	Texas Instruments	167	160	-4.2	4.8
8	9	SANYO	146	153	4.8	4.6
9	6	Toshiba	159	129	-18.9	3.9
10	10	SGS-Thomson	110	127	15.5	3.8
11	8	Hitachi	150	124	-17.3	3.7
12	12	Hyundai	88	78	-11.4	2.3
13	18	Lucent Technologies	33	72	118.2	2.1
14	13	NEC	84	68	-19.0	2.0
15	21	Sharp	21	61	190.5	1.8
16	31	Vanguard	0	55	NA	1.6
17	19	Fujitsu	26	50	92.3	1.5
18	14	Sony	71	47	-33.8	1.4
19	17	Atmel	35	45	28.6	1.3
20	15	Mitsubishi	38	42	10.5	1.3
21	20	Advanced Micro Devices	26	42	61.5	1.3
22	24	Rohm	16	31	93.8	0.9
23	25	Siemens	16	30	87.5	0.9
24	16	Korean Electronic Co.	35	20	-42.9	0.6
25	23	Matsushita	17	15	-11.8	0.4
26	30	Sanken	0	14	NA	0.4
27	27	Cirrus Logic	9	11	22.2	0.3
28	22	IBM	21	10	-52.4	0.3
29	29	Winbond Electronics	3	5	66.7	0.1
30	32	S3	0	1	NA	0
		All Others	16	-	-100.0	0
		Americas Companies	1,004	1,229	22.4	36.7
		Japanese Companies	728	734	0.8	21.9
		European Companies	376	467	24.2	13.9
		Asia/Pacific Companies	924	919	-0.5	27.4
		Included Companies Total	**3,032**	**3,349**	**10.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-3
Top 11 Worldwide Vendors' Revenue from Shipments of Bipolar Digital to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	3	Hitachi	8	8	0	34.8
2	1	Texas Instruments	12	4	-66.7	17.4
3	4	LG Semicon	4	3	-25.0	13.0
4	5	Motorola	3	3	0	13.0
5	6	Philips	2	2	0	8.7
6	7	Toshiba	1	1	0	4.3
7	9	Mitsubishi	1	1	0	4.3
8	10	Advanced Micro Devices	1	1	0	4.3
9	2	National Semiconductor	8	0	-100.0	0
10	8	NEC	1	0	-100.0	0
11	11	Matsushita	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	24	8	-66.7	34.8
		Japanese Companies	12	10	-16.7	43.5
		European Companies	2	2	0	8.7
		Asia/Pacific Companies	4	3	-25.0	13.0
		Included Companies Total	**42**	**23**	**-45.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 3-4
Top 30 Worldwide Vendors' Revenue from Shipments of MOS Digital ICs to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	454	559	23.1	23.0
2	2	Samsung	396	375	-5.3	15.4
3	3	LG Semicon	271	241	-11.1	9.9
4	6	Philips	124	161	29.8	6.6
5	7	Motorola	105	126	20.0	5.2
6	5	Hitachi	128	103	-19.5	4.2
7	4	Texas Instruments	134	96	-28.4	3.9
8	9	Hyundai	88	78	-11.4	3.2
9	16	Lucent Technologies	28	72	157.1	3.0
10	11	SANYO	56	62	10.7	2.5
11	10	NEC	65	59	-9.2	2.4
12	8	Toshiba	92	58	-37.0	2.4
13	13	SGS-Thomson	47	56	19.1	2.3
14	29	Vanguard	0	55	NA	2.3
15	21	Sharp	20	52	160.0	2.1
16	17	Fujitsu	26	48	84.6	2.0
17	14	Atmel	35	45	28.6	1.8
18	18	National Semiconductor	25	39	56.0	1.6
19	15	Mitsubishi	33	37	12.1	1.5
20	19	Advanced Micro Devices	22	35	59.1	1.4
21	12	Sony	50	25	-50.0	1.0
22	25	Siemens	5	15	200.0	0.6
23	23	Cirrus Logic	9	11	22.2	0.5
24	20	IBM	21	10	-52.4	0.4
25	27	Rohm	3	6	100.0	0.2
26	24	Matsushita	7	5	-28.6	0.2
27	28	Winbond Electronics	2	4	100.0	0.2
28	32	S3	0	1	NA	0
29	22	Mosel Vitelic	12	0	-100.0	0
30	26	United Microelectronics Corp.	4	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	833	994	19.3	40.8
		Japanese Companies	480	455	-5.2	18.7
		European Companies	176	232	31.8	9.5
		Asia/Pacific Companies	773	753	-2.6	30.9
		Included Companies Total	**2,262**	**2,434**	**7.6**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 3-5
Top 25 Worldwide Vendors' Revenue from Shipments of MOS Memory to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	271	256	-5.5	37.6
2	2	LG Semicon	217	167	-23.0	24.5
3	3	Hyundai	86	77	-10.5	11.3
4	27	Vanguard	0	55	NA	8.1
5	5	Atmel	30	37	23.3	5.4
6	6	SGS-Thomson	14	20	42.9	2.9
7	4	Texas Instruments	36	15	-58.3	2.2
8	7	Intel	13	15	15.4	2.2
9	11	Advanced Micro Devices	7	8	14.3	1.2
10	14	Fujitsu	4	7	75.0	1.0
11	20	Siemens	2	6	200.0	0.9
12	9	Toshiba	9	3	-66.7	0.4
13	15	IBM	4	3	-25.0	0.4
14	10	NEC	7	2	-71.4	0.3
15	17	Sony	3	2	-33.3	0.3
16	21	Mitsubishi	1	2	100.0	0.3
17	24	Philips	0	2	NA	0.3
18	12	Hitachi	6	1	-83.3	0.1
19	13	Motorola	4	1	-75.0	0.1
20	19	Sharp	2	1	-50.0	0.1
21	23	Winbond Electronics	1	1	0	0.1
22	8	Mosel Vitelic	12	0	-100.0	0
23	16	National Semiconductor	3	0	-100.0	0
24	18	United Microelectronics Corp.	3	0	-100.0	0
25	22	Matsushita	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	97	79	-18.6	11.6
		Japanese Companies	33	18	-45.5	2.6
		European Companies	16	28	75.0	4.1
		Asia/Pacific Companies	590	556	-5.8	81.6
		Included Companies Total	**736**	**681**	**-7.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-6
Top 12 Worldwide Vendors' Revenue from Shipments of DRAM to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	220	201	-8.6	40.8
2	2	LG Semicon	188	140	-25.5	28.4
3	3	Hyundai	80	74	-7.5	15.0
4	11	Vanguard	0	55	NA	11.2
5	4	Texas Instruments	26	7	-73.1	1.4
6	9	Siemens	2	6	200.0	1.2
7	8	IBM	4	3	-25.0	0.6
8	6	Toshiba	8	2	-75.0	0.4
9	7	NEC	5	2	-60.0	0.4
10	16	Fujitsu	0	2	NA	0.4
11	10	Hitachi	2	1	-50.0	0.2
12	5	Mosel Vitelic	12	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	30	10	-66.7	2.0
		Japanese Companies	15	7	-53.3	1.4
		European Companies	2	6	200.0	1.2
		Asia/Pacific Companies	500	470	-6.0	95.3
		Included Companies Total	**547**	**493**	**-9.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-7
Top 11 Worldwide Vendors' Revenue from Shipments of SRAM to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	39	39	0	63.9
2	2	LG Semicon	14	12	-14.3	19.7
3	3	Hyundai	6	3	-50.0	4.9
4	5	Sony	3	2	-33.3	3.3
5	9	Mitsubishi	1	2	100.0	3.3
6	4	Motorola	4	1	-75.0	1.6
7	7	Toshiba	1	1	0	1.6
8	10	Winbond Electronics	1	1	0	1.6
9	6	United Microelectronics Corp.	3	0	-100.0	0
10	8	NEC	1	0	-100.0	0
11	11	Matsushita	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	4	1	-75.0	1.6
		Japanese Companies	7	5	-28.6	8.2
		European Companies	-	-	NA	0
		Asia/Pacific Companies	63	55	-12.7	90.2
		Included Companies Total	**74**	**61**	**-17.6**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 3-8
Top 12 Worldwide Vendors' Revenue from Shipments of Nonvolatile Memory to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Atmel	30	37	23.3	29.6
2	3	SGS-Thomson	14	20	42.9	16.0
3	5	Samsung	12	16	33.3	12.8
4	2	LG Semicon	15	15	0	12.0
5	4	Intel	13	15	15.4	12.0
6	6	Texas Instruments	10	8	-20.0	6.4
7	7	Advanced Micro Devices	7	8	14.3	6.4
8	8	Fujitsu	4	5	25.0	4.0
9	11	Sharp	2	1	-50.0	0.8
10	9	Hitachi	4	0	-100.0	0
11	10	National Semiconductor	3	0	-100.0	0
12	12	NEC	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	63	68	7.9	54.4
		Japanese Companies	11	6	-45.5	4.8
		European Companies	14	20	42.9	16.0
		Asia/Pacific Companies	27	31	14.8	24.8
		Included Companies Total	**115**	**125**	**8.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 3-9
Top 26 Worldwide Vendors' Revenue from Shipments of MOS Microcomponents to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	441	544	23.4	44.0
2	2	Hitachi	107	94	-12.1	7.6
3	4	Philips	61	83	36.1	6.7
4	3	Motorola	76	82	7.9	6.6
5	8	Samsung	33	49	48.5	4.0
6	5	NEC	48	46	-4.2	3.7
7	15	Lucent Technologies	11	45	309.1	3.6
8	11	National Semiconductor	19	39	105.3	3.2
9	6	Toshiba	44	38	-13.6	3.1
10	10	Mitsubishi	30	33	10.0	2.7
11	7	SGS-Thomson	33	28	-15.2	2.3
12	9	Texas Instruments	30	25	-16.7	2.0
13	13	Advanced Micro Devices	12	24	100.0	1.9
14	14	LG Semicon	11	24	118.2	1.9
15	12	SANYO	15	17	13.3	1.4
16	17	Fujitsu	6	17	183.3	1.4
17	19	Sharp	4	14	250.0	1.1
18	16	Cirrus Logic	9	11	22.2	0.9
19	23	Siemens	3	9	200.0	0.7
20	21	Atmel	3	5	66.7	0.4
21	18	Sony	6	3	-50.0	0.2
22	20	IBM	4	3	-25.0	0.2
23	24	Winbond Electronics	1	2	100.0	0.2
24	22	Matsushita	3	1	-66.7	0
25	30	S3	0	1	NA	0
26	25	United Microelectronics Corp.	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	605	779	28.8	63.0
		Japanese Companies	263	263	0	21.3
		European Companies	97	120	23.7	9.7
		Asia/Pacific Companies	46	75	63.0	6.1
		Included Companies Total	**1,011**	**1,237**	**22.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 3-10
Top Nine Worldwide Vendors' Revenue from Shipments of Microprocessors to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	393	494	25.7	90.5
2	2	Motorola	15	23	53.3	4.2
3	5	National Semiconductor	2	14	600.0	2.6
4	3	NEC	4	6	50.0	1.1
5	8	Advanced Micro Devices	2	4	100.0	0.7
6	4	IBM	4	3	-25.0	0.5
7	6	Toshiba	2	2	0	0.4
8	7	Texas Instruments	2	0	-100.0	0
9	9	LG Semicon	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	418	538	28.7	98.5
		Japanese Companies	6	8	33.3	1.5
		European Companies	-	-	NA	0
		Asia/Pacific Companies	2	-	-100.0	0
		Included Companies Total	**426**	**546**	**28.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-11
Top 20 Worldwide Vendors' Revenue from Shipments of Microcontrollers to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Hitachi	85	75	-11.8	16.3
2	3	Philips	54	71	31.5	15.5
3	2	Motorola	57	48	-15.8	10.5
4	6	Samsung	32	48	50.0	10.5
5	4	NEC	41	36	-12.2	7.8
6	8	Mitsubishi	25	28	12.0	6.1
7	7	SGS-Thomson	26	26	0	5.7
8	5	Toshiba	36	21	-41.7	4.6
9	9	Intel	21	21	0	4.6
10	10	SANYO	15	17	13.3	3.7
11	13	Fujitsu	5	15	200.0	3.3
12	12	LG Semicon	5	14	180.0	3.1
13	14	Sharp	4	14	250.0	3.1
14	17	Siemens	3	9	200.0	2.0
15	18	Atmel	3	5	66.7	1.1
16	15	National Semiconductor	3	4	33.3	0.9
17	11	Sony	6	3	-50.0	0.7
18	16	Texas Instruments	3	2	-33.3	0.4
19	19	Matsushita	2	1	-50.0	0.2
20	20	Advanced Micro Devices	0	1	NA	0.2
		All Others	-	-	NA	0
		Americas Companies	87	81	-6.9	17.6
		Japanese Companies	219	210	-4.1	45.8
		European Companies	83	106	27.7	23.1
		Asia/Pacific Companies	37	62	67.6	13.5
		Included Companies Total	**426**	**459**	**7.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-12
Top 19 Worldwide Vendors' Revenue from Shipments of Microperipherals to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	27	29	7.4	21.2
2	3	National Semiconductor	14	21	50.0	15.3
3	4	Advanced Micro Devices	10	19	90.0	13.9
4	2	Hitachi	21	18	-14.3	13.1
5	5	Cirrus Logic	9	11	22.2	8.0
6	10	LG Semicon	4	10	150.0	7.3
7	8	Toshiba	6	7	16.7	5.1
8	9	Mitsubishi	5	5	0	3.6
9	11	Texas Instruments	3	5	66.7	3.6
10	6	Philips	7	2	-71.4	1.5
11	7	SGS-Thomson	7	2	-71.4	1.5
12	12	NEC	2	2	0	1.5
13	15	Fujitsu	1	2	100.0	1.5
14	17	Winbond Electronics	1	2	100.0	1.5
15	14	Samsung	1	1	0	0.7
16	26	S3	0	1	NA	0.7
17	13	Motorola	1	0	-100.0	0
18	16	Matsushita	1	0	-100.0	0
19	18	United Microelectronics Corp.	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	64	86	34.4	62.8
		Japanese Companies	36	34	-5.6	24.8
		European Companies	14	4	-71.4	2.9
		Asia/Pacific Companies	7	13	85.7	9.5
		Included Companies Total	**121**	**137**	**13.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-13
Top Seven Worldwide Vendors' Revenue from Shipments of Digital Signal Processors to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Lucent Technologies	11	45	309.1	47.4
2	1	Texas Instruments	22	18	-18.2	18.9
3	3	Motorola	3	11	266.7	11.6
4	13	Philips	0	10	NA	10.5
5	11	Toshiba	0	8	NA	8.4
6	5	NEC	1	2	100.0	2.1
7	4	Hitachi	1	1	0	1.1
		All Others	-	-	NA	0
		Americas Companies	36	74	105.6	77.9
		Japanese Companies	2	11	450.0	11.6
		European Companies	-	10	NA	10.5
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**38**	**95**	**150.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-14
Top 23 Worldwide Vendors' Revenue from Shipments of MOS Digital Logic to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	3	Philips	63	76	20.6	14.7
2	1	Samsung	92	70	-23.9	13.6
3	2	Texas Instruments	68	56	-17.6	10.9
4	4	LG Semicon	43	50	16.3	9.7
5	5	SANYO	41	45	9.8	8.7
6	8	Motorola	25	43	72.0	8.3
7	12	Sharp	14	37	164.3	7.2
8	9	Lucent Technologies	17	27	58.8	5.2
9	10	Fujitsu	16	24	50.0	4.7
10	6	Sony	41	20	-51.2	3.9
11	7	Toshiba	39	17	-56.4	3.3
12	14	NEC	10	11	10.0	2.1
13	11	Hitachi	15	8	-46.7	1.6
14	24	SGS-Thomson	0	8	NA	1.6
15	18	Rohm	3	6	100.0	1.2
16	13	IBM	13	4	-69.2	0.8
17	17	Matsushita	3	4	33.3	0.8
18	16	Advanced Micro Devices	3	3	0	0.6
19	20	Atmel	2	3	50.0	0.6
20	19	Mitsubishi	2	2	0	0.4
21	21	Hyundai	2	1	-50.0	0.2
22	25	Winbond Electronics	0	1	NA	0.2
23	15	National Semiconductor	3	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	131	136	3.8	26.4
		Japanese Companies	184	174	-5.4	33.7
		European Companies	63	84	33.3	16.3
		Asia/Pacific Companies	137	122	-10.9	23.6
		Included Companies Total	**515**	**516**	**0.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-15
Top 18 Worldwide Vendors' Revenue from Shipments of ASICs to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Texas Instruments	53	40	-24.5	21.7
2	3	LG Semicon	33	38	15.2	20.7
3	5	Lucent Technologies	17	27	58.8	14.7
4	6	Fujitsu	16	21	31.3	11.4
5	2	Samsung	49	11	-77.6	6.0
6	20	SGS-Thomson	0	8	NA	4.3
7	10	Hitachi	10	6	-40.0	3.3
8	4	Toshiba	33	5	-84.8	2.7
9	9	Sharp	12	5	-58.3	2.7
10	11	Motorola	5	5	0	2.7
11	8	IBM	13	4	-69.2	2.2
12	17	Matsushita	1	4	300.0	2.2
13	7	Sony	15	3	-80.0	1.6
14	12	NEC	4	3	-25.0	1.6
15	14	Advanced Micro Devices	2	2	0	1.1
16	15	Atmel	2	1	-50.0	0.5
17	16	Hyundai	2	1	-50.0	0.5
18	13	Rohm	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	92	79	-14.1	42.9
		Japanese Companies	93	47	-49.5	25.5
		European Companies	-	8	NA	4.3
		Asia/Pacific Companies	84	50	-40.5	27.2
		Included Companies Total	**269**	**184**	**-31.6**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 3-16
Top Eight Worldwide Vendors' Revenue from Shipments of Custom ICs to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	9	Sharp	0	28	NA	46.7
2	5	Samsung	0	10	NA	16.7
3	10	Motorola	0	10	NA	16.7
4	13	Sony	0	5	NA	8.3
5	18	Rohm	0	3	NA	5.0
6	16	Atmel	0	2	NA	3.3
7	14	NEC	0	1	NA	1.7
8	22	Winbond Electronics	0	1	NA	1.7
		All Others	-	-	NA	0
		Americas Companies	0	12	NA	20.0
		Japanese Companies	0	37	NA	61.7
		European Companies	0	-	NA	0
		Asia/Pacific Companies	0	11	NA	18.3
		Included Companies Total	**0**	**60**	**NA**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 3-17
Top 13 Worldwide Vendors' Revenue from Shipments of MOS Standard Logic to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	LG Semicon	10	12	20.0	24.5
2	1	Texas Instruments	15	11	-26.7	22.4
3	3	Motorola	5	5	0	10.2
4	5	Toshiba	3	5	66.7	10.2
5	6	Philips	3	5	66.7	10.2
6	4	Samsung	3	3	0	6.1
7	18	Fujitsu	0	3	NA	6.1
8	10	Rohm	1	2	100.0	4.1
9	8	Hitachi	2	1	-50.0	2.0
10	11	NEC	1	1	0	2.0
11	12	Mitsubishi	1	1	0	2.0
12	7	National Semiconductor	3	0	-100.0	0
13	9	Matsushita	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	23	16	-30.4	32.7
		Japanese Companies	10	13	30.0	26.5
		European Companies	3	5	66.7	10.2
		Asia/Pacific Companies	13	15	15.4	30.6
		Included Companies Total	**49**	**49**	**0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 3-18
Top 13 Worldwide Vendors' Revenue from Shipments of Total Other MOS Logic to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	60	71	18.3	31.8
2	3	Samsung	40	46	15.0	20.6
3	2	SANYO	41	45	9.8	20.2
4	5	Motorola	15	23	53.3	10.3
5	4	Sony	26	12	-53.8	5.4
6	7	Toshiba	3	7	133.3	3.1
7	6	NEC	5	6	20.0	2.7
8	13	Texas Instruments	0	5	NA	2.2
9	9	Sharp	2	4	100.0	1.8
10	8	Hitachi	3	1	-66.7	0.4
11	10	Mitsubishi	1	1	0	0.4
12	11	Advanced Micro Devices	1	1	0	0.4
13	15	Rohm	0	1	NA	0.4
		All Others	-	-	NA	0
		Americas Companies	16	29	81.3	13.0
		Japanese Companies	81	77	-4.9	34.5
		European Companies	60	71	18.3	31.8
		Asia/Pacific Companies	40	46	15.0	20.6
		Included Companies Total	**197**	**223**	**13.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-19
Top 23 Worldwide Vendors' Revenue from Shipments of Analog-Monolithic to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	124	147	18.5	16.5
2	4	National Semiconductor	69	125	81.2	14.0
3	3	Samsung	89	116	30.3	13.0
4	2	SANYO	90	91	1.1	10.2
5	6	SGS-Thomson	63	71	12.7	8.0
6	5	Toshiba	66	70	6.1	7.8
7	11	Texas Instruments	21	60	185.7	6.7
8	7	Motorola	49	36	-26.5	4.0
9	9	LG Semicon	22	26	18.2	2.9
10	14	Rohm	13	25	92.3	2.8
11	10	Sony	21	22	4.8	2.5
12	8	Korean Electronic Co.	35	20	-42.9	2.2
13	15	Siemens	11	15	36.4	1.7
14	32	Sanken	0	14	NA	1.6
15	13	Hitachi	14	13	-7.1	1.5
16	16	Matsushita	9	10	11.1	1.1
17	12	NEC	18	9	-50.0	1.0
18	20	Sharp	1	9	800.0	1.0
19	19	Advanced Micro Devices	3	6	100.0	0.7
20	18	Mitsubishi	4	4	0	0.4
21	22	Fujitsu	0	2	NA	0.2
22	21	Winbond Electronics	1	1	0	0.1
23	17	Lucent Technologies	5	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	147	227	54.4	25.4
		Japanese Companies	236	269	14.0	30.2
		European Companies	198	233	17.7	26.1
		Asia/Pacific Companies	147	163	10.9	18.3
		Included Companies Total	**728**	**892**	**22.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-20
Top 17 Worldwide Vendors' Revenue from Shipments of Discrete Semiconductors to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	110	117	6.4	18.4
2	2	Philips	93	94	1.1	14.8
3	3	Korean Electronic Co.	71	75	5.6	11.8
4	15	Sanken	4	72	1,700.0	11.3
5	4	Toshiba	65	58	-10.8	9.1
6	7	Rohm	28	47	67.9	7.4
7	5	Motorola	30	33	10.0	5.2
8	6	Matsushita	30	32	6.7	5.0
9	8	SANYO	20	20	0	3.1
10	13	Mitsubishi	13	18	38.5	2.8
11	10	Siemens	16	17	6.3	2.7
12	11	Hitachi	15	15	0	2.4
13	9	SGS-Thomson	20	14	-30.0	2.2
14	14	NEC	6	12	100.0	1.9
15	12	National Semiconductor	14	7	-50.0	1.1
16	17	Fujitsu	1	3	200.0	0.5
17	16	Sony	2	2	0	0.3
		All Others	-	-	NA	0
		Americas Companies	44	40	-9.1	6.3
		Japanese Companies	184	279	51.6	43.9
		European Companies	129	125	-3.1	19.7
		Asia/Pacific Companies	181	192	6.1	30.2
		Included Companies Total	**538**	**636**	**18.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 3-21
Top 16 Worldwide Vendors' Revenue from Shipments of Optical Semiconductors to Korea (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Sharp	31	44	41.9	32.1
2	2	Rohm	12	22	83.3	16.1
3	5	Samsung	8	12	50.0	8.8
4	3	Toshiba	11	9	-18.2	6.6
5	6	Sony	8	9	12.5	6.6
6	4	Korean Electronic Co.	10	8	-20.0	5.8
7	12	Lucent Technologies	2	8	300.0	5.8
8	8	Hitachi	5	5	0	3.6
9	11	NEC	2	5	150.0	3.6
10	9	Siemens	4	4	0	2.9
11	10	SANYO	3	3	0	2.2
12	16	Sanken	0	3	NA	2.2
13	7	Matsushita	5	2	-60.0	1.5
14	13	Motorola	1	1	0	0.7
15	14	Mitsubishi	1	1	0	0.7
16	19	Fujitsu	0	1	NA	0.7
		All Others	-	-	NA	0
		Americas Companies	3	9	200.0	6.6
		Japanese Companies	78	104	33.3	75.9
		European Companies	4	4	0	2.9
		Asia/Pacific Companies	18	20	11.1	14.6
		Included Companies Total	**103**	**137**	**33.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Chapter 4
China/Hong Kong Market Statistics Tables

Table 4-1
Top 30 Worldwide Vendors' Revenue from Shipments of Total Semiconductors to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	558	684	22.6	11.6
2	2	Toshiba	504	637	26.4	10.8
3	3	Motorola	374	414	10.7	7.0
4	7	Samsung	302	405	34.1	6.9
5	5	Philips	320	359	12.2	6.1
6	4	NEC	363	353	-2.8	6.0
7	9	Texas Instruments	202	281	39.1	4.8
8	6	LG Semicon	306	280	-8.5	4.8
9	8	SANYO	224	268	19.6	4.6
10	13	Rohm	161	230	42.9	3.9
11	10	Hyundai	193	179	-7.3	3.0
12	11	SGS-Thomson	178	176	-1.1	3.0
13	12	Hitachi	164	166	1.2	2.8
14	15	National Semiconductor	131	146	11.5	2.5
15	23	Lucent Technologies	59	135	128.8	2.3
16	22	Advanced Micro Devices	61	121	98.4	2.1
17	20	Siemens	88	116	31.8	2.0
18	17	Mitsubishi	96	107	11.5	1.8
19	18	Sony	93	102	9.7	1.7
20	21	Matsushita	84	92	9.5	1.6
21	25	Atmel	52	92	76.9	1.6
22	19	United Microelectronics Corp.	90	90	0	1.5
23	27	Korean Electronic Co.	43	75	74.4	1.3
24	16	Sharp	120	69	-42.5	1.2
25	14	Fujitsu	134	68	-49.3	1.2
26	116	S3	0	59	NA	1.0
27	253	Vanguard	0	50	NA	0.9
28	24	IBM	57	39	-31.6	0.7
29	26	Sanken	46	34	-26.1	0.6
30	28	Winbond Electronics	26	32	23.1	0.5
		All Others	20	18	-10.0	0.3
		Americas Companies	1,500	1,977	31.8	33.6
		Japanese Companies	1,989	2,126	6.9	36.2
		European Companies	586	651	11.1	11.1
		Asia/Pacific Companies	974	1,123	15.3	19.1
		Included Companies Total	**5,049**	**5,877**	**16.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 4-2
Top 30 Worldwide Vendors' Revenue from Shipments of Total Integrated Circuits to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	558	684	22.6	14.0
2	2	Toshiba	392	487	24.2	10.0
3	6	Samsung	246	334	35.8	6.8
4	5	Motorola	288	320	11.1	6.6
5	4	NEC	304	287	-5.6	5.9
6	8	Texas Instruments	202	281	39.1	5.8
7	3	LG Semicon	306	280	-8.5	5.7
8	7	Philips	235	273	16.2	5.6
9	10	SANYO	181	208	14.9	4.3
10	9	Hyundai	193	179	-7.3	3.7
11	14	National Semiconductor	117	139	18.8	2.8
12	21	Advanced Micro Devices	61	121	98.4	2.5
13	11	SGS-Thomson	129	120	-7.0	2.5
14	23	Lucent Technologies	56	115	105.4	2.4
15	12	Hitachi	129	112	-13.2	2.3
16	18	Rohm	74	99	33.8	2.0
17	19	Sony	74	96	29.7	2.0
18	25	Atmel	52	92	76.9	1.9
19	16	United Microelectronics Corp.	90	90	0	1.8
20	20	Siemens	65	84	29.2	1.7
21	17	Mitsubishi	76	82	7.9	1.7
22	13	Fujitsu	127	66	-48.0	1.4
23	24	Matsushita	55	64	16.4	1.3
24	30	S3	0	59	NA	1.2
25	31	Vanguard	0	50	NA	1.0
26	15	Sharp	95	47	-50.5	1.0
27	22	IBM	57	39	-31.6	0.8
28	26	Winbond Electronics	26	32	23.1	0.7
29	29	Korean Electronic Co.	3	22	633.3	0.5
30	27	Mosel Vitelic	14	12	-14.3	0.2
		All Others	6	9	50.0	0.2
		Americas Companies	1,397	1,856	32.9	38.0
		Japanese Companies	1,507	1,551	2.9	31.8
		European Companies	429	477	11.2	9.8
		Asia/Pacific Companies	878	999	13.8	20.5
		Included Companies Total	**4,211**	**4,883**	**16.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-3
Top 12 Worldwide Vendors' Revenue from Shipments of Bipolar Digital to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Hitachi	11	11	0	30.6
2	1	Texas Instruments	15	10	-33.3	27.8
3	5	Motorola	7	7	0	19.4
4	6	LG Semicon	2	2	0	5.6
5	30	Mosel Vitelic	0	2	NA	5.6
6	4	Toshiba	8	1	-87.5	2.8
7	8	Philips	1	1	0	2.8
8	9	Advanced Micro Devices	1	1	0	2.8
9	10	Mitsubishi	1	1	0	2.8
10	3	National Semiconductor	9	0	-100.0	0
11	7	NEC	1	0	-100.0	0
12	11	Matsushita	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	32	18	-43.8	50.0
		Japanese Companies	22	13	-40.9	36.1
		European Companies	1	1	0	2.8
		Asia/Pacific Companies	2	4	100.0	11.1
		Included Companies Total	**57**	**36**	**-36.8**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-4
Top 30 Worldwide Vendors' Revenue from Shipments of MOS Digital ICs to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	558	684	22.6	18.8
2	4	Toshiba	251	311	23.9	8.5
3	3	NEC	257	267	3.9	7.3
4	2	LG Semicon	296	266	-10.1	7.3
5	7	Samsung	172	228	32.6	6.3
6	6	Motorola	187	203	8.6	5.6
7	5	Hyundai	192	176	-8.3	4.8
8	8	Philips	143	162	13.3	4.4
9	9	Texas Instruments	136	144	5.9	3.9
10	19	Advanced Micro Devices	53	105	98.1	2.9
11	21	Lucent Technologies	51	105	105.9	2.9
12	20	Atmel	52	92	76.9	2.5
13	12	SANYO	90	91	1.1	2.5
14	13	United Microelectronics Corp.	90	90	0	2.5
15	11	Hitachi	103	79	-23.3	2.2
16	15	Mitsubishi	59	63	6.8	1.7
17	10	Fujitsu	122	59	-51.6	1.6
18	17	Siemens	58	59	1.7	1.6
19	29	S3	0	59	NA	1.6
20	25	Sony	30	58	93.3	1.6
21	22	National Semiconductor	41	53	29.3	1.5
22	30	Vanguard	0	50	NA	1.4
23	14	Sharp	87	46	-47.1	1.3
24	23	Rohm	41	45	9.8	1.2
25	16	SGS-Thomson	58	42	-27.6	1.2
26	18	IBM	57	39	-31.6	1.1
27	24	Matsushita	32	38	18.8	1.0
28	27	Winbond Electronics	13	16	23.1	0.4
29	26	Mosel Vitelic	14	10	-28.6	0.3
30	28	Cirrus Logic	6	6	0	0.2
		All Others	-	-	NA	0
		Americas Companies	1,141	1,490	30.6	40.9
		Japanese Companies	1,072	1,057	-1.4	29.0
		European Companies	259	263	1.5	7.2
		Asia/Pacific Companies	777	836	7.6	22.9
		Included Companies Total	**3,249**	**3,646**	**12.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 4-5
Top 27 Worldwide Vendors' Revenue from Shipments of MOS Memory to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	LG Semicon	231	182	-21.2	18.8
2	2	Hyundai	192	176	-8.3	18.2
3	3	NEC	160	103	-35.6	10.6
4	6	Samsung	81	83	2.5	8.6
5	11	Atmel	37	65	75.7	6.7
6	8	Siemens	56	57	1.8	5.9
7	9	Texas Instruments	49	50	2.0	5.2
8	29	Vanguard	0	50	NA	5.2
9	5	Toshiba	83	32	-61.4	3.3
10	7	Hitachi	57	19	-66.7	2.0
11	13	SGS-Thomson	23	19	-17.4	2.0
12	10	Sharp	42	18	-57.1	1.9
13	15	Intel	16	18	12.5	1.9
14	16	Advanced Micro Devices	14	18	28.6	1.9
15	14	Mitsubishi	17	17	0	1.8
16	4	Fujitsu	87	11	-87.4	1.1
17	17	Mosel Vitelic	14	10	-28.6	1.0
18	19	Matsushita	8	9	12.5	0.9
19	20	IBM	7	9	28.6	0.9
20	12	Motorola	31	8	-74.2	0.8
21	21	Sony	5	7	40.0	0.7
22	23	Rohm	3	3	0	0.3
23	18	United Microelectronics Corp.	13	2	-84.6	0.2
24	22	SANYO	4	1	-75.0	0.1
25	25	Winbond Electronics	1	1	0	0.1
26	26	Philips	0	1	NA	0.1
27	24	National Semiconductor	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	156	168	7.7	17.3
		Japanese Companies	466	220	-52.8	22.7
		European Companies	79	77	-2.5	7.9
		Asia/Pacific Companies	532	504	-5.3	52.0
		Included Companies Total	**1,233**	**969**	**-21.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equel the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-6
Top 17 Worldwide Vendors' Revenue from Shipments of DRAM to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Hyundai	180	168	-6.7	23.7
2	1	LG Semicon	206	162	-21.4	22.9
3	3	NEC	145	95	-34.5	13.4
4	5	Samsung	68	58	-14.7	8.2
5	6	Siemens	56	57	1.8	8.1
6	18	Vanguard	0	50	NA	7.1
7	8	Texas Instruments	43	45	4.7	6.4
8	4	Toshiba	70	19	-72.9	2.7
9	9	Hitachi	36	11	-69.4	1.6
10	12	Mitsubishi	12	11	-8.3	1.6
11	10	Mosel Vitelic	14	10	-28.6	1.4
12	7	Fujitsu	55	7	-87.3	1.0
13	13	Matsushita	7	7	0	1.0
14	11	Motorola	13	4	-69.2	0.6
15	14	IBM	4	3	-25.0	0.4
16	16	SANYO	2	1	-50.0	0.1
17	15	Sharp	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	60	52	-13.3	7.3
		Japanese Companies	329	151	-54.1	21.3
		European Companies	56	57	1.8	8.1
		Asia/Pacific Companies	468	448	-4.3	63.3
		Included Companies Total	**913**	**708**	**-22.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-7
Top 15 Worldwide Vendors' Revenue from Shipments of SRAM to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	7	Samsung	7	19	171.4	23.8
2	3	Hyundai	12	8	-33.3	10.0
3	5	LG Semicon	10	8	-20.0	10.0
4	6	Toshiba	10	8	-20.0	10.0
5	9	Sharp	5	7	40.0	8.8
6	10	Sony	5	7	40.0	8.8
7	12	IBM	3	6	100.0	7.5
8	2	Hitachi	14	5	-64.3	6.3
9	1	Motorola	17	3	-82.4	3.8
10	8	NEC	6	3	-50.0	3.8
11	4	United Microelectronics Corp.	12	2	-83.3	2.5
12	11	Mitsubishi	3	2	-33.3	2.5
13	13	Fujitsu	1	1	0	1.3
14	15	Winbond Electronics	1	1	0	1.3
15	14	SANYO	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	20	9	-55.0	11.3
		Japanese Companies	45	33	-26.7	41.3
		European Companies	-	-	NA	0
		Asia/Pacific Companies	42	38	-9.5	47.5
		Included Companies Total	**107**	**80**	**-25.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-8
Top 19 Worldwide Vendors' Revenue from Shipments of Nonvolatile Memory to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Atmel	37	65	75.7	36.1
2	4	SGS-Thomson	23	19	-17.4	10.6
3	5	Intel	16	18	12.5	10.0
4	7	Advanced Micro Devices	14	18	28.6	10.0
5	6	LG Semicon	15	12	-20.0	6.7
6	2	Sharp	35	11	-68.6	6.1
7	10	Samsung	6	6	0	3.3
8	8	NEC	9	5	-44.4	2.8
9	11	Texas Instruments	6	5	-16.7	2.8
10	12	Toshiba	3	5	66.7	2.8
11	14	Mitsubishi	2	4	100.0	2.2
12	3	Fujitsu	31	3	-90.3	1.7
13	9	Hitachi	7	3	-57.1	1.7
14	13	Rohm	3	3	0	1.7
15	19	Matsushita	1	2	100.0	1.1
16	16	Motorola	1	1	0	0.6
17	15	National Semiconductor	2	0	-100.0	0
18	17	United Microelectronics Corp.	1	0	-100.0	0
19	18	SANYO	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	76	107	40.8	59.4
		Japanese Companies	92	36	-60.9	20.0
		European Companies	23	19	-17.4	10.6
		Asia/Pacific Companies	22	18	-18.2	10.0
		Included Companies Total	**213**	**180**	**-15.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 4-9
Top 27 Worldwide Vendors' Revenue from Shipments of MOS Microcomponents to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	542	666	22.9	34.9
2	3	Toshiba	99	136	37.4	7.1
3	2	Motorola	112	131	17.0	6.9
4	7	NEC	66	97	47.0	5.1
5	5	United Microelectronics Corp.	77	88	14.3	4.6
6	19	Samsung	16	77	381.3	4.0
7	15	Advanced Micro Devices	26	76	192.3	4.0
8	4	Philips	79	68	-13.9	3.6
9	6	Texas Instruments	67	62	-7.5	3.2
10	30	S3	0	59	NA	3.1
11	9	LG Semicon	37	56	51.4	2.9
12	12	National Semiconductor	34	53	55.9	2.8
13	13	Hitachi	31	51	64.5	2.7
14	17	Lucent Technologies	23	50	117.4	2.6
15	8	Mitsubishi	41	44	7.3	2.3
16	14	SANYO	30	40	33.3	2.1
17	16	Fujitsu	23	34	47.8	1.8
18	18	Sharp	18	23	27.8	1.2
19	10	IBM	35	20	-42.9	1.0
20	20	Atmel	13	20	53.8	1.0
21	11	SGS-Thomson	34	18	-47.1	0.9
22	22	Winbond Electronics	12	14	16.7	0.7
23	24	Matsushita	8	9	12.5	0.5
24	21	Sony	13	8	-38.5	0.4
25	25	Cirrus Logic	6	6	0	0.3
26	23	Rohm	8	3	-62.5	0.2
27	26	Siemens	2	2	0	0.1
		All Others	-	-	NA	0
		Americas Companies	858	1,143	33.2	59.8
		Japanese Companies	337	445	32.0	23.3
		European Companies	115	88	-23.5	4.6
		Asia/Pacific Companies	142	235	65.5	12.3
		Included Companies Total	**1,452**	**1,911**	**31.6**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-10
Top 11 Worldwide Vendors' Revenue from Shipments of Microprocessors to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	477	599	25.6	77.5
2	4	Advanced Micro Devices	20	62	210.0	8.0
3	2	Motorola	34	56	64.7	7.2
4	3	IBM	34	19	-44.1	2.5
5	9	National Semiconductor	1	15	1,400.0	1.9
6	5	Toshiba	9	11	22.2	1.4
7	8	NEC	3	8	166.7	1.0
8	11	SGS-Thomson	1	2	100.0	0.3
9	10	Fujitsu	1	1	0	0.1
10	6	LG Semicon	9	0	-100.0	0
11	7	Texas Instruments	7	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	573	751	31.1	97.2
		Japanese Companies	13	20	53.8	2.6
		European Companies	1	2	100.0	0.3
		Asia/Pacific Companies	9	-	-100.0	0
		Included Companies Total	**596**	**773**	**29.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-11
Top 21 Worldwide Vendors' Revenue from Shipments of Microcontrollers to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	12	Samsung	16	76	375.0	13.0
2	2	Motorola	61	60	-1.6	10.2
3	3	NEC	47	59	25.5	10.1
4	1	Toshiba	63	55	-12.7	9.4
5	4	Philips	39	51	30.8	8.7
6	5	Mitsubishi	36	40	11.1	6.8
7	7	SANYO	30	40	33.3	6.8
8	9	Hitachi	20	33	65.0	5.6
9	6	Intel	31	31	0	5.3
10	13	LG Semicon	14	27	92.9	4.6
11	11	Fujitsu	16	25	56.3	4.3
12	10	Sharp	18	23	27.8	3.9
13	14	Atmel	13	20	53.8	3.4
14	8	SGS-Thomson	27	16	-40.7	2.7
15	15	Sony	13	8	-38.5	1.4
16	16	Texas Instruments	8	6	-25.0	1.0
17	19	Matsushita	4	5	25.0	0.9
18	18	National Semiconductor	4	4	0	0.7
19	21	Advanced Micro Devices	0	3	NA	0.5
20	17	Rohm	7	2	-71.4	0.3
21	20	Siemens	2	2	0	0.3
		All Others	-	-	NA	0
		Americas Companies	117	124	6.0	21.2
		Japanese Companies	254	290	14.2	49.5
		European Companies	68	69	1.5	11.8
		Asia/Pacific Companies	30	103	243.3	17.6
		Included Companies Total	**469**	**586**	**24.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 4-12
Top 20 Worldwide Vendors' Revenue from Shipments of Microperipherals to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	United Microelectronics Corp.	77	88	14.3	22.6
2	26	S3	0	59	NA	15.1
3	3	Intel	34	36	5.9	9.2
4	4	National Semiconductor	29	34	17.2	8.7
5	5	Toshiba	22	32	45.5	8.2
6	7	LG Semicon	14	29	107.1	7.4
7	8	NEC	12	18	50.0	4.6
8	10	Hitachi	11	18	63.6	4.6
9	9	Winbond Electronics	12	14	16.7	3.6
10	11	Texas Instruments	9	13	44.4	3.3
11	13	Advanced Micro Devices	6	11	83.3	2.8
12	2	Philips	40	9	-77.5	2.3
13	6	Motorola	15	8	-46.7	2.1
14	16	Fujitsu	5	8	60.0	2.1
15	14	Cirrus Logic	6	6	0	1.5
16	15	Mitsubishi	5	4	-20.0	1.0
17	17	Matsushita	2	1	-50.0	0.3
18	18	Rohm	1	1	0	0.3
19	19	Samsung	0	1	NA	0.3
20	12	SGS-Thomson	6	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	99	167	68.7	42.8
		Japanese Companies	58	82	41.4	21.0
		European Companies	46	9	-80.4	2.3
		Asia/Pacific Companies	103	132	28.2	33.8
		Included Companies Total	**306**	**390**	**27.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-13
Top Nine Worldwide Vendors' Revenue from Shipments of Digital Signal Processors to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Lucent Technologies	23	50	117.4	30.9
2	1	Texas Instruments	43	43	0	26.5
3	3	Toshiba	5	38	660.0	23.5
4	4	NEC	4	12	200.0	7.4
5	17	Philips	0	8	NA	4.9
6	5	Motorola	2	7	250.0	4.3
7	6	Matsushita	2	3	50.0	1.9
8	8	IBM	1	1	0	0.6
9	7	Fujitsu	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	69	101	46.4	62.3
		Japanese Companies	12	53	341.7	32.7
		European Companies	-	8	NA	4.9
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**81**	**162**	**100.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-14
Top 22 Worldwide Vendors' Revenue from Shipments of MOS Digital Logic to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Toshiba	69	143	107.2	18.7
2	3	Philips	64	93	45.3	12.1
3	1	Samsung	75	68	-9.3	8.9
4	6	NEC	31	67	116.1	8.7
5	5	Motorola	44	64	45.5	8.4
6	8	Lucent Technologies	28	55	96.4	7.2
7	4	SANYO	56	50	-10.7	6.5
8	17	Sony	12	43	258.3	5.6
9	7	Rohm	30	39	30.0	5.1
10	11	Texas Instruments	20	32	60.0	4.2
11	9	LG Semicon	28	28	0	3.7
12	12	Matsushita	16	20	25.0	2.6
13	16	Fujitsu	12	14	16.7	1.8
14	15	Advanced Micro Devices	13	11	-15.4	1.4
15	13	IBM	15	10	-33.3	1.3
16	14	Hitachi	15	9	-40.0	1.2
17	19	Atmel	2	7	250.0	0.9
18	10	Sharp	27	5	-81.5	0.7
19	21	SGS-Thomson	1	5	400.0	0.7
20	20	Mitsubishi	1	2	100.0	0.3
21	25	Winbond Electronics	0	1	NA	0.1
22	18	National Semiconductor	5	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	127	179	40.9	23.4
		Japanese Companies	269	392	45.7	51.2
		European Companies	65	98	50.8	12.8
		Asia/Pacific Companies	103	97	-5.8	12.7
		Included Companies Total	**564**	**766**	**35.8**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-15
Top 17 Worldwide Vendors' Revenue from Shipments of ASICs to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Lucent Technologies	28	55	96.4	24.8
2	1	Samsung	62	33	-46.8	14.9
3	5	NEC	19	30	57.9	13.5
4	3	LG Semicon	26	26	0	11.7
5	11	Motorola	11	12	9.1	5.4
6	12	Fujitsu	10	11	10.0	5.0
7	6	Texas Instruments	15	10	-33.3	4.5
8	7	IBM	15	10	-33.3	4.5
9	9	Matsushita	12	10	-16.7	4.5
10	10	Toshiba	11	6	-45.5	2.7
11	13	Hitachi	9	5	-44.4	2.3
12	16	Atmel	2	5	150.0	2.3
13	14	Sony	4	3	-25.0	1.4
14	15	Advanced Micro Devices	4	3	-25.0	1.4
15	19	SGS-Thomson	0	2	NA	0.9
16	4	Sharp	25	1	-96.0	0.5
17	8	Rohm	13	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	75	95	26.7	42.8
		Japanese Companies	103	66	-35.9	29.7
		European Companies	-	2	NA	0.9
		Asia/Pacific Companies	88	59	-33.0	26.6
		Included Companies Total	**266**	**222**	**-16.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-16
Top Nine Worldwide Vendors' Revenue from Shipments of Custom ICs to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Samsung	0	18	NA	25.0
2	17	Rohm	0	15	NA	20.8
3	5	Motorola	0	10	NA	13.9
4	3	NEC	0	9	NA	12.5
5	9	Matsushita	0	8	NA	11.1
6	13	Sony	0	7	NA	9.7
7	12	Atmel	0	2	NA	2.8
8	16	Sharp	0	2	NA	2.8
9	21	Winbond Electronics	0	1	NA	1.4
		All Others	-	-	NA	0
		Americas Companies	0	12	NA	16.7
		Japanese Companies	0	41	NA	56.9
		European Companies	0	-	NA	0
		Asia/Pacific Companies	0	19	NA	26.4
		Included Companies Total	**0**	**72**	**NA**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 4-17
Top 14 Worldwide Vendors' Revenue from Shipments of MOS Standard Logic to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	24	46	91.7	31.3
2	3	Toshiba	11	36	227.3	24.5
3	2	Motorola	17	17	0	11.6
4	5	Texas Instruments	5	15	200.0	10.2
5	4	Samsung	6	9	50.0	6.1
6	10	NEC	2	7	250.0	4.8
7	9	Rohm	2	4	100.0	2.7
8	8	Hitachi	4	3	-25.0	2.0
9	12	Fujitsu	2	3	50.0	2.0
10	13	SGS-Thomson	1	3	200.0	2.0
11	11	LG Semicon	2	2	0	1.4
12	14	Mitsubishi	1	2	100.0	1.4
13	6	National Semiconductor	5	0	-100.0	0
14	7	Matsushita	4	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	27	32	18.5	21.8
		Japanese Companies	26	55	111.5	37.4
		European Companies	25	49	96.0	33.3
		Asia/Pacific Companies	8	11	37.5	7.5
		Included Companies Total	**86**	**147**	**70.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-18
Top 13 Worldwide Vendors' Revenue from Shipments of Total Other MOS Logic to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Toshiba	47	101	114.9	31.1
2	1	SANYO	56	50	-10.7	15.4
3	3	Philips	40	47	17.5	14.5
4	8	Sony	8	33	312.5	10.2
5	4	Motorola	16	25	56.3	7.7
6	6	NEC	10	21	110.0	6.5
7	5	Rohm	15	20	33.3	6.2
8	7	Advanced Micro Devices	9	8	-11.1	2.5
9	9	Samsung	7	8	14.3	2.5
10	12	Texas Instruments	0	7	NA	2.2
11	11	Sharp	2	2	0	0.6
12	18	Matsushita	0	2	NA	0.6
13	10	Hitachi	2	1	-50.0	0.3
		All Others	-	-	NA	0
		Americas Companies	25	40	60.0	12.3
		Japanese Companies	140	230	64.3	70.8
		European Companies	40	47	17.5	14.5
		Asia/Pacific Companies	7	8	14.3	2.5
		Included Companies Total	**212**	**325**	**53.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-19
Top 24 Worldwide Vendors' Revenue from Shipments of Analog-Monolithic to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Toshiba	133	175	31.6	14.6
2	8	Texas Instruments	51	127	149.0	10.6
3	3	SANYO	91	117	28.6	9.7
4	2	Motorola	94	110	17.0	9.2
5	4	Philips	91	110	20.9	9.2
6	5	Samsung	74	106	43.2	8.8
7	7	National Semiconductor	67	86	28.4	7.2
8	6	SGS-Thomson	71	78	9.9	6.5
9	11	Rohm	33	54	63.6	4.5
10	10	Sony	44	38	-13.6	3.2
11	12	Matsushita	22	26	18.2	2.2
12	19	Siemens	7	25	257.1	2.1
13	14	Hitachi	15	22	46.7	1.8
14	22	Korean Electronic Co.	3	22	633.3	1.8
15	9	NEC	46	20	-56.5	1.7
16	13	Mitsubishi	16	18	12.5	1.5
17	15	Winbond Electronics	13	16	23.1	1.3
18	18	Advanced Micro Devices	7	15	114.3	1.2
19	17	LG Semicon	8	12	50.0	1.0
20	21	Lucent Technologies	5	10	100.0	0.8
21	20	Fujitsu	5	7	40.0	0.6
22	23	Hyundai	1	3	200.0	0.2
23	32	Sanken	0	3	NA	0.2
24	16	Sharp	8	1	-87.5	0
		All Others	-	-	NA	0
		Americas Companies	224	348	55.4	29.0
		Japanese Companies	413	481	16.5	40.0
		European Companies	169	213	26.0	17.7
		Asia/Pacific Companies	99	159	60.6	13.2
		Included Companies Total	**905**	**1,201**	**32.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 4-20
Top 17 Worldwide Vendors' Revenue from Shipments of Discrete Semiconductors to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Toshiba	95	131	37.9	16.1
2	3	Motorola	81	89	9.9	10.9
3	2	Philips	85	86	1.2	10.6
4	4	Samsung	56	71	26.8	8.7
5	7	Rohm	43	71	65.1	8.7
6	6	SGS-Thomson	49	56	14.3	6.9
7	5	NEC	52	52	0	6.4
8	9	SANYO	35	52	48.6	6.4
9	8	Korean Electronic Co.	36	50	38.9	6.1
10	10	Hitachi	28	48	71.4	5.9
11	11	Sanken	27	31	14.8	3.8
12	12	Matsushita	19	25	31.6	3.1
13	15	Siemens	9	21	133.3	2.6
14	14	Mitsubishi	14	18	28.6	2.2
15	13	National Semiconductor	14	7	-50.0	0.9
16	17	Sony	3	4	33.3	0.5
17	16	Fujitsu	5	2	-60.0	0.2
		All Others	-	-	NA	0
		Americas Companies	95	96	1.1	11.8
		Japanese Companies	321	434	35.2	53.3
		European Companies	143	163	14.0	20.0
		Asia/Pacific Companies	92	121	31.5	14.9
		Included Companies Total	**651**	**814**	**25.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 4-21
Top 13 Worldwide Vendors' Revenue from Shipments of Optical Semiconductors to China/Hong Kong (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Rohm	40	60	50.0	33.3
2	2	Sharp	25	22	-12.0	12.2
3	13	Lucent Technologies	3	20	566.7	11.1
4	3	Toshiba	17	19	11.8	10.6
5	7	NEC	6	14	133.3	7.8
6	4	Siemens	14	11	-21.4	6.1
7	11	SANYO	4	8	100.0	4.4
8	10	Mitsubishi	5	7	40.0	3.9
9	9	Hitachi	5	6	20.0	3.3
10	8	Motorola	5	5	0	2.8
11	6	Matsushita	10	3	-70.0	1.7
12	12	Korean Electronic Co.	4	3	-25.0	1.7
13	5	Sony	14	2	-85.7	1.1
		All Others	-	-	NA	0
		Americas Companies	8	25	212.5	13.9
		Japanese Companies	126	141	11.9	78.3
		European Companies	14	11	-21.4	6.1
		Asia/Pacific Companies	4	3	-25.0	1.7
		Included Companies Total	**152**	**180**	18.4	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Chapter 5
Singapore Market Statistics Tables

Table 5-1
Top 30 Worldwide Vendors' Revenue from Shipments of Total Semiconductors to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	1,134	1,437	26.7	16.6
2	2	Texas Instruments	779	989	27.0	11.4
3	5	Motorola	519	608	17.1	7.0
4	3	SGS-Thomson	564	542	-3.9	6.3
5	4	Toshiba	554	510	-7.9	5.9
6	7	NEC	451	498	10.4	5.8
7	6	Samsung	505	482	-4.6	5.6
8	10	Philips	267	338	26.6	3.9
9	8	Hitachi	314	322	2.5	3.7
10	17	Rohm	153	302	97.4	3.5
11	9	Mitsubishi	310	277	-10.6	3.2
12	11	Hyundai	267	244	-8.6	2.8
13	12	SANYO	235	211	-10.2	2.4
14	15	National Semiconductor	156	199	27.6	2.3
15	19	Siemens	141	193	36.9	2.2
16	20	Lucent Technologies	135	175	29.6	2.0
17	13	LG Semicon	222	170	-23.4	2.0
18	16	Fujitsu	156	149	-4.5	1.7
19	14	IBM	161	142	-11.8	1.6
20	18	Sharp	153	136	-11.1	1.6
21	22	Cirrus Logic	97	126	29.9	1.5
22	25	Sony	65	121	86.2	1.4
23	21	Matsushita	122	103	-15.6	1.2
24	253	Vanguard	0	87	NA	1.0
25	26	Advanced Micro Devices	52	85	63.5	1.0
26	23	Atmel	74	84	13.5	1.0
27	27	Korean Electronic Co.	37	41	10.8	0.5
28	24	Sanken	68	34	-50.0	0.4
29	116	S3	0	32	NA	0.4
30	29	United Microelectronics Corp.	21	10	-52.4	0.1
		All Others	38	9	-76.3	0.1
		Americas Companies	3,107	3,877	24.8	44.8
		Japanese Companies	2,581	2,663	3.2	30.8
		European Companies	972	1,073	10.4	12.4
		Asia/Pacific Companies	1,090	1,043	-4.3	12.0
		Included Companies Total	**7,750**	**8,656**	**11.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-2
Top 30 Worldwide Vendors' Revenue from Shipments of Total Integrated Circuits to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	1,134	1,437	26.7	18.6
2	2	Texas Instruments	779	989	27.0	12.8
3	3	SGS-Thomson	546	512	-6.2	6.6
4	5	Motorola	428	508	18.7	6.6
5	7	NEC	372	455	22.3	5.9
6	4	Samsung	463	429	-7.3	5.6
7	6	Toshiba	404	354	-12.4	4.6
8	12	Philips	216	291	34.7	3.8
9	8	Mitsubishi	298	265	-11.1	3.4
10	9	Hitachi	272	249	-8.5	3.2
11	10	Hyundai	267	244	-8.6	3.2
12	16	National Semiconductor	142	192	35.2	2.5
13	18	Siemens	123	180	46.3	2.3
14	17	Lucent Technologies	132	175	32.6	2.3
15	13	SANYO	189	172	-9.0	2.2
16	11	LG Semicon	222	170	-23.4	2.2
17	15	Fujitsu	147	143	-2.7	1.9
18	14	IBM	161	142	-11.8	1.8
19	23	Rohm	54	134	148.1	1.7
20	20	Cirrus Logic	97	126	29.9	1.6
21	24	Sony	53	106	100.0	1.4
22	30	Vanguard	0	87	NA	1.1
23	25	Advanced Micro Devices	52	85	63.5	1.1
24	22	Atmel	74	84	13.5	1.1
25	21	Matsushita	84	71	-15.5	0.9
26	19	Sharp	105	57	-45.7	0.7
27	32	S3	0	32	NA	0.4
28	27	United Microelectronics Corp.	21	10	-52.4	0.1
29	28	Winbond Electronics	6	6	0	0
30	29	Korean Electronic Co.	4	4	0	0
		All Others	32	7	-78.1	0
		Americas Companies	2,999	3,770	25.7	48.9
		Japanese Companies	1,978	2,010	1.6	26.0
		European Companies	885	983	11.1	12.7
		Asia/Pacific Companies	1,015	953	-6.1	12.4
		Included Companies Total	**6,877**	**7,716**	**12.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 5-3
Top 10 Worldwide Vendors' Revenue from Shipments of Bipolar Digital to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Hitachi	17	20	17.6	30.3
2	2	Texas Instruments	14	12	-14.3	18.2
3	3	Motorola	13	12	-7.7	18.2
4	25	Matsushita	0	11	NA	16.7
5	6	Philips	5	5	0	7.6
6	32	Mosel Vitelic	0	3	NA	4.5
7	5	Toshiba	8	1	-87.5	1.5
8	7	LG Semicon	1	1	0	1.5
9	8	Advanced Micro Devices	1	1	0	1.5
10	4	National Semiconductor	13	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	41	25	-39.0	37.9
		Japanese Companies	25	32	28.0	48.5
		European Companies	5	5	0	7.6
		Asia/Pacific Companies	1	4	300.0	6.1
		Included Companies Total	**72**	**66**	**-8.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 5-4
Top 30 Worldwide Vendors' Revenue from Shipments of MOS Digital ICs to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	1,134	1,437	26.7	25.9
2	3	Texas Instruments	409	543	32.8	9.8
3	2	Samsung	447	403	-9.8	7.3
4	5	Motorola	306	362	18.3	6.5
5	4	NEC	332	360	8.4	6.5
6	6	Hyundai	267	244	-8.6	4.4
7	8	Mitsubishi	225	200	-11.1	3.6
8	7	Toshiba	250	195	-22.0	3.5
9	13	Lucent Technologies	119	175	47.1	3.2
10	14	Siemens	118	170	44.1	3.1
11	9	LG Semicon	221	169	-23.5	3.1
12	10	Hitachi	214	166	-22.4	3.0
13	11	IBM	161	142	-11.8	2.6
14	12	Fujitsu	142	139	-2.1	2.5
15	19	Philips	55	96	74.5	1.7
16	20	SGS-Thomson	52	95	82.7	1.7
17	29	Vanguard	0	87	NA	1.6
18	18	Atmel	74	84	13.5	1.5
19	15	SANYO	117	81	-30.8	1.5
20	21	Advanced Micro Devices	43	67	55.8	1.2
21	24	Sony	38	63	65.8	1.1
22	26	Rohm	28	54	92.9	1.0
23	17	Sharp	93	50	-46.2	0.9
24	23	National Semiconductor	41	50	22.0	0.9
25	16	Cirrus Logic	94	45	-52.1	0.8
26	30	S3	0	32	NA	0.6
27	22	Matsushita	42	16	-61.9	0.3
28	27	United Microelectronics Corp.	21	10	-52.4	0.2
29	28	Winbond Electronics	5	5	0	0
30	25	Mosel Vitelic	32	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	2,381	2,937	23.4	53.0
		Japanese Companies	1,481	1,324	-10.6	23.9
		European Companies	225	361	60.4	6.5
		Asia/Pacific Companies	993	918	-7.6	16.6
		Included Companies Total	**5,080**	**5,540**	**9.1**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 5-5
Top 27 Worldwide Vendors' Revenue from Shipments of MOS Memory to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	414	326	-21.3	17.0
2	2	Hyundai	267	244	-8.6	12.7
3	8	Siemens	113	158	39.8	8.2
4	3	LG Semicon	213	154	-27.7	8.0
5	7	NEC	136	142	4.4	7.4
6	4	Mitsubishi	158	135	-14.6	7.0
7	6	Texas Instruments	142	117	-17.6	6.1
8	9	Fujitsu	103	110	6.8	5.7
9	28	Vanguard	0	87	NA	4.5
10	11	Atmel	70	76	8.6	4.0
11	5	Hitachi	149	72	-51.7	3.7
12	12	Intel	53	60	13.2	3.1
13	10	Toshiba	102	44	-56.9	2.3
14	15	SGS-Thomson	35	44	25.7	2.3
15	14	Sharp	41	41	0	2.1
16	13	SANYO	48	27	-43.8	1.4
17	18	IBM	17	27	58.8	1.4
18	19	Advanced Micro Devices	16	19	18.8	1.0
19	21	Sony	10	14	40.0	0.7
20	17	Motorola	31	12	-61.3	0.6
21	23	Rohm	5	4	-20.0	0.2
22	24	Matsushita	2	4	100.0	0.2
23	25	Winbond Electronics	2	2	0	0.1
24	20	United Microelectronics Corp.	12	1	-91.7	0
25	27	Philips	0	1	NA	0
26	16	Mosel Vitelic	32	0	-100.0	0
27	22	National Semiconductor	9	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	338	311	-8.0	16.2
		Japanese Companies	754	593	-21.4	30.9
		European Companies	148	203	37.2	10.6
		Asia/Pacific Companies	940	814	-13.4	42.4
		Included Companies Total	**2,180**	**1,921**	**-11.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-6
Top 17 Worldwide Vendors' Revenue from Shipments of DRAM to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	310	265	-14.5	18.3
2	2	Hyundai	249	233	-6.4	16.1
3	8	Siemens	113	158	39.8	10.9
4	3	LG Semicon	203	146	-28.1	10.1
5	7	NEC	122	124	1.6	8.6
6	6	Mitsubishi	131	115	-12.2	8.0
7	5	Texas Instruments	137	114	-16.8	7.9
8	17	Vanguard	0	87	NA	6.0
9	10	Fujitsu	61	72	18.0	5.0
10	4	Hitachi	143	65	-54.5	4.5
11	11	SANYO	30	24	-20.0	1.7
12	9	Toshiba	70	17	-75.7	1.2
13	13	IBM	17	12	-29.4	0.8
14	14	Motorola	6	7	16.7	0.5
15	15	Matsushita	2	4	100.0	0.3
16	16	Sharp	1	3	200.0	0.2
17	12	Mosel Vitelic	29	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	160	133	-16.9	9.2
		Japanese Companies	560	424	-24.3	29.3
		European Companies	113	158	39.8	10.9
		Asia/Pacific Companies	791	731	-7.6	50.6
		Included Companies Total	**1,624**	**1,446**	**-11.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 5-7
Top 18 Worldwide Vendors' Revenue from Shipments of SRAM to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Samsung	83	47	-43.4	29.6
2	2	Toshiba	25	22	-12.0	13.8
3	21	IBM	0	15	NA	9.4
4	8	Sony	10	14	40.0	8.8
5	4	Hyundai	18	11	-38.9	6.9
6	5	Mitsubishi	18	11	-38.9	6.9
7	7	LG Semicon	10	8	-20.0	5.0
8	10	NEC	8	8	0	5.0
9	11	Sharp	6	6	0	3.8
10	3	Motorola	25	5	-80.0	3.1
11	12	Hitachi	3	5	66.7	3.1
12	6	SANYO	17	2	-88.2	1.3
13	15	Winbond Electronics	2	2	0	1.3
14	9	United Microelectronics Corp.	10	1	-90.0	0.6
15	14	Rohm	2	1	-50.0	0.6
16	16	Fujitsu	1	1	0	0.6
17	13	Mosel Vitelic	3	0	-100.0	0
18	17	SGS-Thomson	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	25	20	-20.0	12.6
		Japanese Companies	90	70	-22.2	44.0
		European Companies	1	-	-100.0	0
		Asia/Pacific Companies	126	69	-45.2	43.4
		Included Companies Total	**242**	**159**	**-34.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-8
Top 16 Worldwide Vendors' Revenue from Shipments of Nonvolatile Memory to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Atmel	70	76	8.6	24.4
2	2	Intel	53	60	13.2	19.3
3	5	SGS-Thomson	34	43	26.5	13.8
4	3	Fujitsu	41	37	-9.8	11.9
5	4	Sharp	34	32	-5.9	10.3
6	7	Advanced Micro Devices	16	19	18.8	6.1
7	6	Samsung	21	14	-33.3	4.5
8	8	Mitsubishi	9	9	0	2.9
9	12	NEC	3	7	133.3	2.3
10	10	Toshiba	7	5	-28.6	1.6
11	11	Texas Instruments	5	3	-40.0	1.0
12	14	Rohm	3	3	0	1.0
13	13	Hitachi	3	2	-33.3	0.6
14	16	SANYO	1	1	0	0.3
15	9	National Semiconductor	9	0	-100.0	0
16	15	United Microelectronics Corp.	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	153	158	3.3	50.8
		Japanese Companies	101	96	-5.0	30.9
		European Companies	34	43	26.5	13.8
		Asia/Pacific Companies	23	14	-39.1	4.5
		Included Companies Total	**311**	**311**	**0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-9
Top 27 Worldwide Vendors' Revenue from Shipments of MOS Microcomponents to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	1,081	1,377	27.4	50.4
2	2	Motorola	238	299	25.6	10.9
3	3	Texas Instruments	149	222	49.0	8.1
4	5	NEC	106	138	30.2	5.1
5	7	Toshiba	89	111	24.7	4.1
6	4	IBM	117	89	-23.9	3.3
7	9	Hitachi	46	84	82.6	3.1
8	8	Mitsubishi	62	58	-6.5	2.1
9	11	National Semiconductor	27	50	85.2	1.8
10	6	Cirrus Logic	94	45	-52.1	1.6
11	12	Samsung	21	41	95.2	1.5
12	16	Advanced Micro Devices	15	37	146.7	1.4
13	30	S3	0	32	NA	1.2
14	13	Philips	20	30	50.0	1.1
15	10	Lucent Technologies	45	20	-55.6	0.7
16	20	SGS-Thomson	6	20	233.3	0.7
17	21	Sony	6	15	150.0	0.5
18	17	SANYO	15	12	-20.0	0.4
19	22	Siemens	5	12	140.0	0.4
20	23	LG Semicon	3	10	233.3	0.4
21	19	United Microelectronics Corp.	9	9	0	0.3
22	18	Matsushita	14	8	-42.9	0.3
23	14	Fujitsu	16	5	-68.8	0.2
24	15	Sharp	16	5	-68.8	0.2
25	25	Winbond Electronics	1	2	100.0	0
26	26	Atmel	0	1	NA	0
27	24	Rohm	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	1,766	2,172	23.0	79.5
		Japanese Companies	372	436	17.2	16.0
		European Companies	31	62	100.0	2.3
		Asia/Pacific Companies	34	62	82.4	2.3
		Included Companies Total	**2,203**	**2,732**	**24.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-10
Top 10 Worldwide Vendors' Revenue from Shipments of Microprocessors to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	944	1,234	30.7	82.5
2	3	Motorola	59	101	71.2	6.8
3	2	IBM	114	86	-24.6	5.7
4	4	Advanced Micro Devices	13	31	138.5	2.1
5	7	NEC	3	17	466.7	1.1
6	8	National Semiconductor	2	14	600.0	0.9
7	5	Toshiba	10	11	10.0	0.7
8	9	Mitsubishi	1	1	0	0
9	10	SGS-Thomson	1	1	0	0
10	6	Texas Instruments	5	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	1,137	1,466	28.9	98.0
		Japanese Companies	14	29	107.1	1.9
		European Companies	1	1	0	0
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**1,152**	**1,496**	**29.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 5-11
Top 21 Worldwide Vendors' Revenue from Shipments of Microcontrollers to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Motorola	175	184	5.1	28.9
2	2	NEC	94	101	7.4	15.9
3	4	Mitsubishi	57	54	-5.3	8.5
4	3	Toshiba	59	51	-13.6	8.0
5	6	Hitachi	30	48	60.0	7.5
6	7	Samsung	20	41	105.0	6.4
7	5	Intel	40	39	-2.5	6.1
8	8	Philips	20	26	30.0	4.1
9	16	SGS-Thomson	4	18	350.0	2.8
10	14	Sony	6	15	150.0	2.4
11	10	SANYO	15	12	-20.0	1.9
12	15	Siemens	5	12	140.0	1.9
13	11	Texas Instruments	14	11	-21.4	1.7
14	18	LG Semicon	2	6	200.0	0.9
15	9	Sharp	16	5	-68.8	0.8
16	17	National Semiconductor	3	4	33.3	0.6
17	12	Matsushita	9	3	-66.7	0.5
18	13	Fujitsu	7	3	-57.1	0.5
19	21	Advanced Micro Devices	0	2	NA	0.3
20	27	Atmel	0	1	NA	0.2
21	19	Rohm	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	232	241	3.9	37.9
		Japanese Companies	295	292	-1.0	45.9
		European Companies	29	56	93.1	8.8
		Asia/Pacific Companies	22	47	113.6	7.4
		Included Companies Total	**578**	**636**	**10.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-12
Top 17 Worldwide Vendors' Revenue from Shipments of Microperipherals to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	97	104	7.2	30.4
2	2	Cirrus Logic	94	45	-52.1	13.2
3	5	Hitachi	16	35	118.8	10.2
4	3	Texas Instruments	22	32	45.5	9.4
5	4	National Semiconductor	22	32	45.5	9.4
6	26	S3	0	32	NA	9.4
7	6	Toshiba	15	22	46.7	6.4
8	8	NEC	8	12	50.0	3.5
9	7	United Microelectronics Corp.	9	9	0	2.6
10	12	Advanced Micro Devices	2	4	100.0	1.2
11	15	LG Semicon	1	4	300.0	1.2
12	10	Mitsubishi	4	3	-25.0	0.9
13	11	Matsushita	3	3	0	0.9
14	9	Fujitsu	6	2	-66.7	0.6
15	16	Winbond Electronics	1	2	100.0	0.6
16	14	SGS-Thomson	1	1	0	0.3
17	13	Samsung	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	237	249	5.1	72.8
		Japanese Companies	52	77	48.1	22.5
		European Companies	1	1	0	0.3
		Asia/Pacific Companies	12	15	25.0	4.4
		Included Companies Total	**302**	**342**	**13.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 5-13
Top 10 Worldwide Vendors' Revenue from Shipments of Digital Signal Processors to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Texas Instruments	108	179	65.7	69.4
2	3	Toshiba	5	27	440.0	10.5
3	2	Lucent Technologies	45	20	-55.6	7.8
4	4	Motorola	4	14	250.0	5.4
5	8	NEC	1	8	700.0	3.1
6	21	Philips	0	4	NA	1.6
7	6	IBM	3	3	0	1.2
8	7	Matsushita	2	2	0	0.8
9	11	Hitachi	0	1	NA	0.4
10	5	Fujitsu	3	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	160	216	35.0	83.7
		Japanese Companies	11	38	245.5	14.7
		European Companies	-	4	NA	1.6
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**171**	**258**	**50.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-14
Top 22 Worldwide Vendors' Revenue from Shipments of MOS Digital Logic to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Texas Instruments	118	204	72.9	23.0
2	3	Lucent Technologies	74	155	109.5	17.5
3	2	NEC	90	80	-11.1	9.0
4	8	Philips	35	65	85.7	7.3
5	6	Motorola	37	51	37.8	5.7
6	13	Rohm	21	50	138.1	5.6
7	5	SANYO	54	42	-22.2	4.7
8	4	Toshiba	59	40	-32.2	4.5
9	16	Samsung	12	36	200.0	4.1
10	12	Sony	22	34	54.5	3.8
11	17	SGS-Thomson	11	31	181.8	3.5
12	9	IBM	27	26	-3.7	2.9
13	11	Fujitsu	23	24	4.3	2.7
14	15	Advanced Micro Devices	12	11	-8.3	1.2
15	14	Hitachi	19	10	-47.4	1.1
16	20	Mitsubishi	5	7	40.0	0.8
17	21	Atmel	4	7	75.0	0.8
18	19	LG Semicon	5	5	0	0.6
19	7	Sharp	36	4	-88.9	0.5
20	10	Matsushita	26	4	-84.6	0.5
21	22	Winbond Electronics	2	1	-50.0	0.1
22	18	National Semiconductor	5	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	277	454	63.9	51.2
		Japanese Companies	355	295	-16.9	33.3
		European Companies	46	96	108.7	10.8
		Asia/Pacific Companies	19	42	121.1	4.7
		Included Companies Total	**697**	**887**	**27.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-15
Top 20 Worldwide Vendors' Revenue from Shipments of ASICs to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Lucent Technologies	74	155	109.5	31.4
2	1	Texas Instruments	104	152	46.2	30.8
3	3	NEC	74	51	-31.1	10.3
4	10	SGS-Thomson	10	29	190.0	5.9
5	6	IBM	27	26	-3.7	5.3
6	7	Fujitsu	21	23	9.5	4.7
7	14	Samsung	6	14	133.3	2.8
8	11	Motorola	9	10	11.1	2.0
9	4	Toshiba	33	9	-72.7	1.8
10	13	Advanced Micro Devices	7	6	-14.3	1.2
11	17	Atmel	4	5	25.0	1.0
12	9	SANYO	16	3	-81.3	0.6
13	16	Hitachi	4	3	-25.0	0.6
14	19	Mitsubishi	2	3	50.0	0.6
15	8	Matsushita	18	2	-88.9	0.4
16	15	Sony	4	2	-50.0	0.4
17	18	Philips	2	1	-50.0	0.2
18	5	Sharp	28	0	-100.0	0
19	12	Rohm	7	0	-100.0	0
20	20	Winbond Electronics	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	225	354	57.3	71.7
		Japanese Companies	207	96	-53.6	19.4
		European Companies	12	30	150.0	6.1
		Asia/Pacific Companies	8	14	75.0	2.8
		Included Companies Total	**452**	**494**	**9.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-16
Top Nine Worldwide Vendors' Revenue from Shipments of Custom ICs to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	3	NEC	0	19	NA	30.2
2	19	Rohm	0	13	NA	20.6
3	7	Samsung	0	11	NA	17.5
4	8	Motorola	0	10	NA	15.9
5	16	Sony	0	4	NA	6.3
6	11	Atmel	0	2	NA	3.2
7	15	Matsushita	0	2	NA	3.2
8	9	Toshiba	0	1	NA	1.6
9	20	Winbond Electronics	0	1	NA	1.6
		All Others	-	-	NA	0
		Americas Companies	0	12	NA	19.0
		Japanese Companies	0	39	NA	61.9
		European Companies	0	-	NA	0
		Asia/Pacific Companies	0	12	NA	19.0
		Included Companies Total	**0**	**63**	**NA**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 5-17
Top 15 Worldwide Vendors' Revenue from Shipments of MOS Standard Logic to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	33	64	93.9	38.6
2	4	Texas Instruments	14	32	128.6	19.3
3	2	Toshiba	26	25	-3.8	15.1
4	3	Motorola	20	19	-5.0	11.4
5	10	Rohm	2	7	250.0	4.2
6	6	Hitachi	7	5	-28.6	3.0
7	8	LG Semicon	5	5	0	3.0
8	7	NEC	6	4	-33.3	2.4
9	13	SGS-Thomson	1	2	100.0	1.2
10	11	Fujitsu	2	1	-50.0	0.6
11	12	Samsung	1	1	0	0.6
12	15	Mitsubishi	1	1	0	0.6
13	5	Matsushita	7	0	-100.0	0
14	9	National Semiconductor	5	0	-100.0	0
15	14	SANYO	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	39	51	30.8	30.7
		Japanese Companies	52	43	-17.3	25.9
		European Companies	34	66	94.1	39.8
		Asia/Pacific Companies	6	6	0	3.6
		Included Companies Total	**131**	**166**	**26.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-18
Top 13 Worldwide Vendors' Revenue from Shipments of Total Other MOS Logic to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	SANYO	37	39	5.4	23.8
2	3	Rohm	12	30	150.0	18.3
3	2	Sony	18	28	55.6	17.1
4	13	Texas Instruments	0	20	NA	12.2
5	5	Motorola	8	12	50.0	7.3
6	8	Samsung	5	10	100.0	6.1
7	4	NEC	10	6	-40.0	3.7
8	9	Advanced Micro Devices	5	5	0	3.0
9	14	Toshiba	0	5	NA	3.0
10	7	Sharp	8	4	-50.0	2.4
11	10	Mitsubishi	2	3	50.0	1.8
12	6	Hitachi	8	2	-75.0	1.2
13	11	Matsushita	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	13	37	184.6	22.6
		Japanese Companies	96	117	21.9	71.3
		European Companies	-	-	NA	0
		Asia/Pacific Companies	5	10	100.0	6.1
		Included Companies Total	**114**	**164**	**43.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 5-19
Top 23 Worldwide Vendors' Revenue from Shipments of Analog-Monolithic to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Texas Instruments	356	434	21.9	20.6
2	1	SGS-Thomson	494	417	-15.6	19.8
3	3	Philips	156	190	21.8	9.0
4	4	Toshiba	146	158	8.2	7.5
5	6	National Semiconductor	88	142	61.4	6.7
6	5	Motorola	109	134	22.9	6.4
7	11	NEC	40	95	137.5	4.5
8	8	SANYO	72	91	26.4	4.3
9	21	Cirrus Logic	3	81	2,600.0	3.8
10	12	Rohm	26	80	207.7	3.8
11	7	Mitsubishi	73	65	-11.0	3.1
12	10	Hitachi	41	63	53.7	3.0
13	9	Matsushita	42	44	4.8	2.1
14	14	Sony	15	43	186.7	2.0
15	13	Samsung	16	26	62.5	1.2
16	17	Advanced Micro Devices	8	17	112.5	0.8
17	19	Siemens	5	10	100.0	0.5
18	16	Sharp	12	7	-41.7	0.3
19	18	Fujitsu	5	4	-20.0	0.2
20	20	Korean Electronic Co.	4	4	0	0.2
21	32	Sanken	0	4	NA	0.2
22	22	Winbond Electronics	1	1	0	0
23	15	Lucent Technologies	13	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	577	808	40.0	38.3
		Japanese Companies	472	654	38.6	31.0
		European Companies	655	617	-5.8	29.2
		Asia/Pacific Companies	21	31	47.6	1.5
		Included Companies Total	**1,725**	**2,110**	**22.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 5-20
Top 17 Worldwide Vendors' Revenue from Shipments of Discrete Semiconductors to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	3	Rohm	89	156	75.3	20.7
2	1	Toshiba	115	120	4.3	15.9
3	2	Motorola	89	98	10.1	13.0
4	8	Hitachi	33	64	93.9	8.5
5	6	Samsung	42	53	26.2	7.0
6	5	Philips	48	47	-2.1	6.2
7	10	Korean Electronic Co.	32	36	12.5	4.8
8	11	SANYO	27	34	25.9	4.5
9	7	Sanken	36	30	-16.7	4.0
10	9	Matsushita	32	30	-6.3	4.0
11	12	SGS-Thomson	18	30	66.7	4.0
12	4	NEC	60	27	-55.0	3.6
13	14	Mitsubishi	11	10	-9.1	1.3
14	13	National Semiconductor	14	7	-50.0	0.9
15	15	Siemens	9	5	-44.4	0.7
16	16	Fujitsu	5	5	0	0.7
17	17	Sony	2	1	-50.0	0.1
		All Others	-	-	NA	0
		Americas Companies	103	105	1.9	13.9
		Japanese Companies	410	477	16.3	63.3
		European Companies	75	82	9.3	10.9
		Asia/Pacific Companies	74	89	20.3	11.8
		Included Companies Total	**662**	**753**	**13.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 5-21
Top 15 Worldwide Vendors' Revenue from Shipments of Optical Semiconductors to Singapore (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Sharp	48	79	64.6	42.2
2	2	Toshiba	35	36	2.9	19.3
3	3	NEC	19	16	-15.8	8.6
4	8	Sony	6	14	133.3	7.5
5	6	Rohm	6	12	100.0	6.4
6	5	Hitachi	8	9	12.5	4.8
7	4	Siemens	9	8	-11.1	4.3
8	9	SANYO	3	5	66.7	2.7
9	7	Matsushita	6	2	-66.7	1.1
10	11	Motorola	2	2	0	1.1
11	14	Mitsubishi	1	2	100.0	1.1
12	12	Korean Electronic Co.	1	1	0	0.5
13	15	Fujitsu	1	1	0	0.5
14	10	Lucent Technologies	3	0	-100.0	0
15	13	Sanken	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	5	2	-60.0	1.1
		Japanese Companies	134	176	31.3	94.1
		European Companies	9	8	-11.1	4.3
		Asia/Pacific Companies	1	1	0	0.5
		Included Companies Total	**149**	**187**	**25.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Chapter 6

Taiwan Market Statistics Tables

Table 6-1
Top 30 Worldwide Vendors' Revenue from Shipments of Total Semiconductors to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	741	941	27.0	15.8
2	2	Toshiba	422	426	0.9	7.2
3	4	NEC	359	374	4.2	6.3
4	5	Samsung	311	299	-3.9	5.0
5	3	Texas Instruments	374	290	-22.5	4.9
6	7	Philips	252	288	14.3	4.8
7	8	Motorola	247	266	7.7	4.5
8	6	LG Semicon	267	223	-16.5	3.7
9	17	Advanced Micro Devices	127	221	74.0	3.7
10	12	Mitsubishi	180	215	19.4	3.6
11	10	Hitachi	205	209	2.0	3.5
12	22	Lucent Technologies	103	192	86.4	3.2
13	11	Hyundai	184	173	-6.0	2.9
14	14	SGS-Thomson	154	160	3.9	2.7
15	116	S3	0	159	NA	2.7
16	15	Siemens	145	158	9.0	2.7
17	21	Mosel Vitelic	106	157	48.1	2.6
18	9	United Microelectronics Corp.	221	153	-30.8	2.6
19	16	Winbond Electronics	134	130	-3.0	2.2
20	13	Cirrus Logic	156	123	-21.2	2.1
21	23	National Semiconductor	103	116	12.6	1.9
22	20	SANYO	109	109	0	1.8
23	27	Rohm	35	98	180.0	1.6
24	24	Matsushita	70	76	8.6	1.3
25	25	Sharp	51	75	47.1	1.3
26	19	Fujitsu	121	69	-43.0	1.2
27	26	Atmel	48	69	43.8	1.2
28	29	Sony	26	52	100.0	0.9
29	18	IBM	125	50	-60.0	0.8
30	28	Sanken	34	29	-14.7	0.5
		All Others	26	53	103.8	0.9
		Americas Companies	2,024	2,427	19.9	40.8
		Japanese Companies	1,612	1,732	7.4	29.1
		European Companies	551	606	10.0	10.2
		Asia/Pacific Companies	1,249	1,188	-4.9	20.0
		Included Companies Total	**5,436**	**5,953**	**9.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-2
Top 30 Worldwide Vendors' Revenue from Shipments of Total Integrated Circuits to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	741	941	27.0	18.0
2	2	Texas Instruments	374	290	-22.5	5.6
3	4	Toshiba	304	265	-12.8	5.1
4	5	Samsung	276	263	-4.7	5.0
5	7	Philips	225	261	16.0	5.0
6	3	NEC	315	257	-18.4	4.9
7	9	Motorola	211	227	7.6	4.3
8	6	LG Semicon	267	223	-16.5	4.3
9	16	Advanced Micro Devices	127	221	74.0	4.2
10	21	Lucent Technologies	102	192	88.2	3.7
11	12	Mitsubishi	162	189	16.7	3.6
12	10	Hyundai	184	173	-6.0	3.3
13	30	S3	0	159	NA	3.0
14	20	Mosel Vitelic	106	157	48.1	3.0
15	8	United Microelectronics Corp.	221	153	-30.8	2.9
16	14	Siemens	135	144	6.7	2.8
17	11	Hitachi	164	141	-14.0	2.7
18	15	Winbond Electronics	134	130	-3.0	2.5
19	13	Cirrus Logic	156	123	-21.2	2.4
20	18	SGS-Thomson	122	123	0.8	2.4
21	22	National Semiconductor	92	110	19.6	2.1
22	24	Atmel	48	69	43.8	1.3
23	23	SANYO	67	66	-1.5	1.3
24	19	Fujitsu	118	64	-45.8	1.2
25	28	Rohm	18	59	227.8	1.1
26	25	Matsushita	39	55	41.0	1.1
27	26	Sharp	31	52	67.7	1.0
28	17	IBM	125	50	-60.0	1.0
29	27	Sony	22	32	45.5	0.6
30	32	Vanguard	0	25	NA	0.5
		All Others	2	5	150.0	0
		Americas Companies	1,976	2,382	20.5	45.6
		Japanese Companies	1,240	1,183	-4.6	22.7
		European Companies	482	528	9.5	10.1
		Asia/Pacific Companies	1,190	1,126	-5.4	21.6
		Included Companies Total	**4,888**	**5,219**	**6.8**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-3
Top 12 Worldwide Vendors' Revenue from Shipments of Bipolar Digital to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Texas Instruments	11	19	72.7	46.3
2	2	Hitachi	10	12	20.0	29.3
3	4	Philips	2	2	0	4.9
4	5	Motorola	2	2	0	4.9
5	14	NEC	0	2	NA	4.9
6	7	LG Semicon	1	1	0	2.4
7	8	Advanced Micro Devices	1	1	0	2.4
8	9	Mitsubishi	1	1	0	2.4
9	18	Mosel Vitelic	0	1	NA	2.4
10	3	National Semiconductor	6	0	-100.0	0
11	6	Matsushita	2	0	-100.0	0
12	10	Fujitsu	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	20	22	10.0	53.7
		Japanese Companies	14	15	7.1	36.6
		European Companies	2	2	0	4.9
		Asia/Pacific Companies	1	2	100.0	4.9
		Included Companies Total	**37**	**41**	**10.8**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-4
Top 30 Worldwide Vendors' Revenue from Shipments of MOS Digital ICs to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	741	941	27.0	21.0
2	4	NEC	280	234	-16.4	5.2
3	6	Samsung	252	232	-7.9	5.2
4	3	Toshiba	285	230	-19.3	5.1
5	5	LG Semicon	260	215	-17.3	4.8
6	15	Advanced Micro Devices	123	214	74.0	4.8
7	2	Texas Instruments	292	211	-27.7	4.7
8	20	Lucent Technologies	96	192	100.0	4.3
9	8	Hyundai	184	173	-6.0	3.9
10	9	Mitsubishi	148	170	14.9	3.8
11	29	S3	0	159	NA	3.5
12	12	Motorola	138	158	14.5	3.5
13	17	Mosel Vitelic	106	156	47.2	3.5
14	7	United Microelectronics Corp.	221	153	-30.8	3.4
15	13	Siemens	126	133	5.6	3.0
16	10	Cirrus Logic	148	123	-16.9	2.7
17	18	Philips	102	112	9.8	2.5
18	11	Hitachi	140	107	-23.6	2.4
19	19	Winbond Electronics	100	89	-11.0	2.0
20	21	National Semiconductor	63	75	19.0	1.7
21	23	Atmel	48	69	43.8	1.5
22	16	Fujitsu	115	61	-47.0	1.4
23	14	IBM	125	50	-60.0	1.1
24	22	SGS-Thomson	59	48	-18.6	1.1
25	24	Matsushita	34	48	41.2	1.1
26	26	Sharp	29	40	37.9	0.9
27	25	SANYO	31	35	12.9	0.8
28	30	Vanguard	0	25	NA	0.6
29	28	Rohm	6	18	200.0	0.4
30	27	Sony	16	14	-12.5	0.3
		All Others	-	-	NA	0
		Americas Companies	1,774	2,192	23.6	48.9
		Japanese Companies	1,084	957	-11.7	21.3
		European Companies	287	293	2.1	6.5
		Asia/Pacific Companies	1,123	1,043	-7.1	23.3
		Included Companies Total	**4,268**	**4,485**	**5.1**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-5
Top 27 Worldwide Vendors' Revenue from Shipments of MOS Memory to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	LG Semicon	247	196	-20.6	11.1
2	3	Samsung	231	176	-23.8	10.0
3	4	NEC	225	176	-21.8	10.0
4	5	Hyundai	181	171	-5.5	9.7
5	10	Mosel Vitelic	106	156	47.2	8.8
6	8	Mitsubishi	115	133	15.7	7.5
7	7	Siemens	124	131	5.6	7.4
8	2	Texas Instruments	246	120	-51.2	6.8
9	6	Toshiba	180	69	-61.7	3.9
10	13	Winbond Electronics	74	62	-16.2	3.5
11	9	Hitachi	115	61	-47.0	3.5
12	14	Atmel	42	60	42.9	3.4
13	15	Advanced Micro Devices	33	48	45.5	2.7
14	11	Fujitsu	103	46	-55.3	2.6
15	19	Matsushita	22	42	90.9	2.4
16	17	Intel	23	26	13.0	1.5
17	30	Vanguard	0	25	NA	1.4
18	18	SGS-Thomson	23	14	-39.1	0.8
19	12	United Microelectronics Corp.	95	13	-86.3	0.7
20	21	Sharp	16	10	-37.5	0.6
21	22	IBM	14	10	-28.6	0.6
22	20	Motorola	17	9	-47.1	0.5
23	23	Sony	12	4	-66.7	0.2
24	25	Rohm	3	3	0	0.2
25	24	SANYO	4	2	-50.0	0.1
26	29	Philips	0	1	NA	0
27	16	National Semiconductor	25	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	400	273	-31.8	15.5
		Japanese Companies	795	546	-31.3	31.0
		European Companies	147	146	-0.7	8.3
		Asia/Pacific Companies	934	799	-14.5	45.3
		Included Companies Total	**2,276**	**1,764**	**-22.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-6
Top 17 Worldwide Vendors' Revenue from Shipments of DRAM to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	NEC	219	172	-21.5	12.1
2	3	LG Semicon	218	172	-21.1	12.1
3	6	Hyundai	175	166	-5.1	11.7
4	9	Mosel Vitelic	102	155	52.0	10.9
5	4	Samsung	190	149	-21.6	10.5
6	7	Siemens	124	131	5.6	9.2
7	10	Mitsubishi	98	120	22.4	8.5
8	1	Texas Instruments	238	112	-52.9	7.9
9	5	Toshiba	178	65	-63.5	4.6
10	8	Hitachi	105	55	-47.6	3.9
11	12	Matsushita	21	42	100.0	3.0
12	11	Fujitsu	86	35	-59.3	2.5
13	21	Vanguard	0	25	NA	1.8
14	13	IBM	14	10	-28.6	0.7
15	14	Motorola	6	7	16.7	0.5
16	15	Sharp	5	1	-80.0	0
17	16	SANYO	2	1	-50.0	0
		All Others	-	-	NA	0
		Americas Companies	258	129	-50.0	9.1
		Japanese Companies	714	491	-31.2	34.6
		European Companies	124	131	5.6	9.2
		Asia/Pacific Companies	685	667	-2.6	47.0
		Included Companies Total	**1,781**	**1,418**	**-20.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-7
Top 16 Worldwide Vendors' Revenue from Shipments of SRAM to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Winbond Electronics	67	56	-16.4	40.0
2	3	Samsung	30	21	-30.0	15.0
3	4	LG Semicon	15	13	-13.3	9.3
4	1	United Microelectronics Corp.	85	12	-85.9	8.6
5	5	Mitsubishi	15	12	-20.0	8.6
6	8	Hitachi	8	5	-37.5	3.6
7	9	Hyundai	6	5	-16.7	3.6
8	6	Sony	12	4	-66.7	2.9
9	10	NEC	5	4	-20.0	2.9
10	12	Toshiba	2	3	50.0	2.1
11	7	Motorola	11	2	-81.8	1.4
12	13	Rohm	2	2	0	1.4
13	11	Mosel Vitelic	4	1	-75.0	0.7
14	14	Matsushita	1	0	-100.0	0
15	15	Fujitsu	1	0	-100.0	0
16	16	SANYO	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	11	2	-81.8	1.4
		Japanese Companies	47	30	-36.2	21.4
		European Companies	-	-	NA	0
		Asia/Pacific Companies	207	108	-47.8	77.1
		Included Companies Total	**265**	**140**	**-47.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-8
Top 18 Worldwide Vendors' Revenue from Shipments of Nonvolatile Memory to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Atmel	42	60	42.9	29.7
2	2	Advanced Micro Devices	33	48	45.5	23.8
3	4	Intel	23	26	13.0	12.9
4	5	SGS-Thomson	22	12	-45.5	5.9
5	6	Fujitsu	16	11	-31.3	5.4
6	7	LG Semicon	14	11	-21.4	5.4
7	9	Sharp	11	9	-18.2	4.5
8	11	Texas Instruments	8	8	0	4.0
9	8	Samsung	11	6	-45.5	3.0
10	12	Winbond Electronics	7	6	-14.3	3.0
11	10	United Microelectronics Corp.	10	1	-90.0	0.5
12	13	Hitachi	2	1	-50.0	0.5
13	16	Rohm	1	1	0	0.5
14	17	SANYO	1	1	0	0.5
15	20	Toshiba	0	1	NA	0.5
16	3	National Semiconductor	25	0	-100.0	0
17	14	Mitsubishi	1	0	-100.0	0
18	15	NEC	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	131	142	8.4	70.3
		Japanese Companies	33	24	-27.3	11.9
		European Companies	22	12	-45.5	5.9
		Asia/Pacific Companies	42	24	-42.9	11.9
		Included Companies Total	**228**	**202**	**-11.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-9
Top 27 Worldwide Vendors' Revenue from Shipments of MOS Microcomponents to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	718	915	27.4	41.4
2	30	S3	0	159	NA	7.2
3	6	Advanced Micro Devices	68	146	114.7	6.6
4	3	United Microelectronics Corp.	126	140	11.1	6.3
5	2	Cirrus Logic	148	123	-16.9	5.6
6	4	Motorola	100	113	13.0	5.1
7	7	Toshiba	57	104	82.5	4.7
8	9	Lucent Technologies	38	90	136.8	4.1
9	12	National Semiconductor	27	74	174.1	3.3
10	8	Philips	55	52	-5.5	2.4
11	13	Texas Instruments	24	48	100.0	2.2
12	15	Hitachi	20	43	115.0	1.9
13	11	Mitsubishi	31	35	12.9	1.6
14	20	Samsung	7	31	342.9	1.4
15	5	IBM	87	30	-65.5	1.4
16	14	Winbond Electronics	24	26	8.3	1.2
17	10	NEC	32	23	-28.1	1.0
18	17	LG Semicon	10	16	60.0	0.7
19	18	SANYO	8	13	62.5	0.6
20	16	SGS-Thomson	11	10	-9.1	0.5
21	19	Fujitsu	7	7	0	0.3
22	23	Sharp	3	4	33.3	0.2
23	22	Atmel	3	3	0	0.1
24	21	Matsushita	5	2	-60.0	0
25	25	Siemens	2	2	0	0
26	26	Hyundai	1	1	0	0
27	24	Sony	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	1,213	1,701	40.2	77.0
		Japanese Companies	165	231	40.0	10.5
		European Companies	68	64	-5.9	2.9
		Asia/Pacific Companies	168	214	27.4	9.7
		Included Companies Total	**1,614**	**2,210**	**36.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-10
Top 11 Worldwide Vendors' Revenue from Shipments of Microprocessors to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	685	881	28.6	79.0
2	3	Advanced Micro Devices	52	107	105.8	9.6
3	4	Motorola	35	58	65.7	5.2
4	7	National Semiconductor	3	31	933.3	2.8
5	2	IBM	85	28	-67.1	2.5
6	5	Toshiba	4	5	25.0	0.4
7	6	Fujitsu	4	2	-50.0	0.2
8	11	SGS-Thomson	1	2	100.0	0.2
9	9	NEC	2	1	-50.0	0
10	8	Texas Instruments	2	0	-100.0	0
11	10	LG Semicon	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	862	1,105	28.2	99.1
		Japanese Companies	10	8	-20.0	0.7
		European Companies	1	2	100.0	0.2
		Asia/Pacific Companies	2	-	-100.0	0
		Included Companies Total	**875**	**1,115**	**27.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-11
Top 22 Worldwide Vendors' Revenue from Shipments of Microcontrollers to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Motorola	55	50	-9.1	14.7
2	2	Toshiba	37	45	21.6	13.3
3	3	Philips	32	41	28.1	12.1
4	8	Hitachi	16	33	106.3	9.7
5	11	Samsung	7	31	342.9	9.1
6	4	Mitsubishi	21	27	28.6	8.0
7	5	United Microelectronics Corp.	20	21	5.0	6.2
8	7	Intel	17	16	-5.9	4.7
9	6	NEC	18	13	-27.8	3.8
10	10	SANYO	8	13	62.5	3.8
11	9	Winbond Electronics	10	10	0	2.9
12	22	Advanced Micro Devices	0	9	NA	2.7
13	12	LG Semicon	5	8	60.0	2.4
14	13	SGS-Thomson	3	4	33.3	1.2
15	14	Sharp	3	4	33.3	1.2
16	20	Fujitsu	1	4	300.0	1.2
17	15	Atmel	3	3	0	0.9
18	16	National Semiconductor	2	3	50.0	0.9
19	18	Siemens	2	2	0	0.6
20	17	Matsushita	2	1	-50.0	0.3
21	21	Texas Instruments	1	1	0	0.3
22	19	Sony	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	78	82	5.1	24.2
		Japanese Companies	108	140	29.6	41.3
		European Companies	37	47	27.0	13.9
		Asia/Pacific Companies	42	70	66.7	20.6
		Included Companies Total	**265**	**339**	**27.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-12
Top 19 Worldwide Vendors' Revenue from Shipments of Microperipherals to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	26	S3	0	159	NA	27.4
2	1	Cirrus Logic	148	123	-16.9	21.2
3	2	United Microelectronics Corp.	106	119	12.3	20.5
4	4	National Semiconductor	22	40	81.8	6.9
5	7	Advanced Micro Devices	16	30	87.5	5.2
6	5	Toshiba	16	25	56.3	4.3
7	6	Intel	16	18	12.5	3.1
8	8	Winbond Electronics	14	16	14.3	2.8
9	13	Hitachi	4	10	150.0	1.7
10	10	Mitsubishi	10	8	-20.0	1.4
11	14	LG Semicon	3	8	166.7	1.4
12	11	NEC	10	7	-30.0	1.2
13	3	Philips	23	5	-78.3	0.9
14	9	Motorola	10	5	-50.0	0.9
15	12	SGS-Thomson	7	4	-42.9	0.7
16	17	Texas Instruments	1	2	100.0	0.3
17	15	Fujitsu	1	1	0	0.2
18	18	Hyundai	1	1	0	0.2
19	16	Matsushita	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	213	377	77.0	64.9
		Japanese Companies	42	51	21.4	8.8
		European Companies	30	9	-70.0	1.5
		Asia/Pacific Companies	124	144	16.1	24.8
		Included Companies Total	**409**	**581**	**42.1**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-13
Top Eight Worldwide Vendors' Revenue from Shipments of Digital Signal Processors to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Lucent Technologies	38	90	136.8	51.4
2	2	Texas Instruments	20	45	125.0	25.7
3	12	Toshiba	0	29	NA	16.6
4	18	Philips	0	6	NA	3.4
5	3	NEC	2	2	0	1.1
6	5	IBM	2	2	0	1.1
7	4	Matsushita	2	1	-50.0	0.6
8	6	Fujitsu	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	60	137	128.3	78.3
		Japanese Companies	5	32	540.0	18.3
		European Companies	-	6	NA	3.4
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**65**	**175**	**169.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-14
Top 23 Worldwide Vendors' Revenue from Shipments of MOS Digital Logic to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Lucent Technologies	58	102	75.9	20.0
2	3	Philips	47	59	25.5	11.5
3	2	Toshiba	48	57	18.8	11.2
4	7	Texas Instruments	22	43	95.5	8.4
5	9	Motorola	21	36	71.4	7.0
6	6	NEC	23	35	52.2	6.8
7	13	Sharp	10	26	160.0	5.1
8	11	Samsung	14	25	78.6	4.9
9	4	SGS-Thomson	25	24	-4.0	4.7
10	8	Advanced Micro Devices	22	20	-9.1	3.9
11	10	SANYO	19	20	5.3	3.9
12	19	Rohm	3	15	400.0	2.9
13	5	IBM	24	10	-58.3	2.0
14	23	Sony	2	10	400.0	2.0
15	15	Fujitsu	5	8	60.0	1.6
16	18	Atmel	3	6	100.0	1.2
17	14	Matsushita	7	4	-42.9	0.8
18	16	Hitachi	5	3	-40.0	0.6
19	17	LG Semicon	3	3	0	0.6
20	21	Mitsubishi	2	2	0	0.4
21	12	National Semiconductor	11	1	-90.9	0.2
22	20	Winbond Electronics	2	1	-50.0	0.2
23	22	Hyundai	2	1	-50.0	0.2
		All Others	-	-	NA	0
		Americas Companies	161	218	35.4	42.7
		Japanese Companies	124	180	45.2	35.2
		European Companies	72	83	15.3	16.2
		Asia/Pacific Companies	21	30	42.9	5.9
		Included Companies Total	**378**	**511**	**35.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-15
Top 19 Worldwide Vendors' Revenue from Shipments of ASICs to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Lucent Technologies	58	102	75.9	43.8
2	5	NEC	18	22	22.2	9.4
3	6	Texas Instruments	17	20	17.6	8.6
4	4	SGS-Thomson	23	18	-21.7	7.7
5	2	Toshiba	31	16	-48.4	6.9
6	3	IBM	24	10	-58.3	4.3
7	8	Advanced Micro Devices	9	8	-11.1	3.4
8	11	Fujitsu	5	8	60.0	3.4
9	10	Motorola	6	7	16.7	3.0
10	9	Samsung	7	5	-28.6	2.1
11	7	Sharp	10	4	-60.0	1.7
12	12	Matsushita	5	4	-20.0	1.7
13	14	Atmel	3	4	33.3	1.7
14	13	Hitachi	5	3	-40.0	1.3
15	17	Hyundai	2	1	-50.0	0.4
16	19	National Semiconductor	1	1	0	0.4
17	15	Rohm	2	0	-100.0	0
18	16	Winbond Electronics	2	0	-100.0	0
19	18	Sony	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	118	152	28.8	65.2
		Japanese Companies	77	57	-26.0	24.5
		European Companies	23	18	-21.7	7.7
		Asia/Pacific Companies	11	6	-45.5	2.6
		Included Companies Total	**229**	**233**	**1.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-16
Top Nine Worldwide Vendors' Revenue from Shipments of Custom ICs to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	11	Sharp	0	18	NA	34.6
2	9	Motorola	0	10	NA	19.2
3	10	Samsung	0	9	NA	17.3
4	17	Rohm	0	5	NA	9.6
5	2	NEC	0	3	NA	5.8
6	5	Toshiba	0	3	NA	5.8
7	13	Atmel	0	2	NA	3.8
8	18	Winbond Electronics	0	1	NA	1.9
9	19	Sony	0	1	NA	1.9
		All Others	-	-	NA	0
		Americas Companies	0	12	NA	23.1
		Japanese Companies	0	30	NA	57.7
		European Companies	0	-	NA	0
		Asia/Pacific Companies	0	10	NA	19.2
		Included Companies Total	**0**	**52**	**NA**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-17
Top 10 Worldwide Vendors' Revenue from Shipments of MOS Standard Logic to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	4	Texas Instruments	5	20	300.0	30.3
2	1	Toshiba	16	18	12.5	27.3
3	5	Philips	5	9	80.0	13.6
4	3	Motorola	7	7	0	10.6
5	8	SGS-Thomson	2	6	200.0	9.1
6	6	LG Semicon	3	3	0	4.5
7	7	Samsung	2	2	0	3.0
8	12	NEC	0	1	NA	1.5
9	2	National Semiconductor	10	0	-100.0	0
10	9	Matsushita	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	22	27	22.7	40.9
		Japanese Companies	18	19	5.6	28.8
		European Companies	7	15	114.3	22.7
		Asia/Pacific Companies	5	5	0	7.6
		Included Companies Total	**52**	**66**	**26.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-18
Top 12 Worldwide Vendors' Revenue from Shipments of Total Other MOS Logic to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	42	50	19.0	31.3
2	2	SANYO	19	20	5.3	12.5
3	8	Toshiba	1	20	1,900.0	12.5
4	3	Advanced Micro Devices	13	12	-7.7	7.5
5	4	Motorola	8	12	50.0	7.5
6	9	Rohm	1	10	900.0	6.3
7	5	Samsung	5	9	80.0	5.6
8	6	NEC	5	9	80.0	5.6
9	10	Sony	1	9	800.0	5.6
10	16	Sharp	0	4	NA	2.5
11	11	Texas Instruments	0	3	NA	1.9
12	7	Mitsubishi	2	2	0	1.3
		All Others	-	-	NA	0
		Americas Companies	21	27	28.6	16.9
		Japanese Companies	29	74	155.2	46.3
		European Companies	42	50	19.0	31.3
		Asia/Pacific Companies	5	9	80.0	5.6
		Included Companies Total	**97**	**160**	**64.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-19
Top 24 Worldwide Vendors' Revenue from Shipments of Analog-Monolithic to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	121	147	21.5	21.2
2	4	SGS-Thomson	63	75	19.0	10.8
3	2	Motorola	71	67	-5.6	9.7
4	3	Texas Instruments	71	60	-15.5	8.7
5	7	Winbond Electronics	34	41	20.6	5.9
6	13	Rohm	12	41	241.7	5.9
7	9	National Semiconductor	23	35	52.2	5.1
8	10	Toshiba	19	35	84.2	5.1
9	5	SANYO	36	31	-13.9	4.5
10	8	Samsung	24	31	29.2	4.5
11	11	Hitachi	14	22	57.1	3.2
12	6	NEC	35	21	-40.0	3.0
13	12	Mitsubishi	13	18	38.5	2.6
14	16	Sony	6	18	200.0	2.6
15	21	Sharp	2	12	500.0	1.7
16	14	Siemens	9	11	22.2	1.6
17	17	LG Semicon	6	7	16.7	1.0
18	20	Matsushita	3	7	133.3	1.0
19	19	Advanced Micro Devices	3	6	100.0	0.9
20	22	Fujitsu	2	3	50.0	0.4
21	32	Sanken	0	3	NA	0.4
22	23	Korean Electronic Co.	2	2	0	0.3
23	15	Cirrus Logic	8	0	-100.0	0
24	18	Lucent Technologies	6	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	182	168	-7.7	24.2
		Japanese Companies	142	211	48.6	30.4
		European Companies	193	233	20.7	33.6
		Asia/Pacific Companies	66	81	22.7	11.7
		Included Companies Total	**583**	**693**	**18.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 6-20
Top 17 Worldwide Vendors' Revenue from Shipments of Discrete Semiconductors to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Toshiba	104	140	34.6	24.3
2	2	NEC	36	60	66.7	10.4
3	6	Hitachi	33	60	81.8	10.4
4	4	SANYO	34	38	11.8	6.6
5	7	SGS-Thomson	32	37	15.6	6.4
6	3	Samsung	35	36	2.9	6.2
7	5	Motorola	33	36	9.1	6.2
8	12	Rohm	15	33	120.0	5.7
9	8	Philips	25	27	8.0	4.7
10	10	Sanken	21	26	23.8	4.5
11	9	Korean Electronic Co.	22	24	9.1	4.2
12	13	Mitsubishi	15	21	40.0	3.6
13	11	Matsushita	19	18	-5.3	3.1
14	15	Siemens	5	8	60.0	1.4
15	14	National Semiconductor	11	6	-45.5	1.0
16	16	Fujitsu	2	5	150.0	0.9
17	17	Sony	1	2	100.0	0.3
		All Others	-	-	NA	0
		Americas Companies	44	42	-4.5	7.3
		Japanese Companies	280	403	43.9	69.8
		European Companies	62	72	16.1	12.5
		Asia/Pacific Companies	57	60	5.3	10.4
		Included Companies Total	**443**	**577**	**30.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 6-21
Top 14 Worldwide Vendors' Revenue from Shipments of Optical Semiconductors to Taiwan (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	4	NEC	8	57	612.5	36.3
2	1	Sharp	20	23	15.0	14.6
3	2	Toshiba	14	21	50.0	13.4
4	11	Sony	2	18	800.0	11.5
5	5	Hitachi	6	8	33.3	5.1
6	6	Siemens	5	6	20.0	3.8
7	12	Rohm	1	6	500.0	3.8
8	7	SANYO	4	5	25.0	3.2
9	9	Mitsubishi	3	5	66.7	3.2
10	3	Matsushita	12	3	-75.0	1.9
11	8	Motorola	3	3	0	1.9
12	10	Korean Electronic Co.	2	2	0	1.3
13	13	Fujitsu	1	0	-100.0	0
14	14	Lucent Technologies	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	4	3	-25.0	1.9
		Japanese Companies	71	146	105.6	93.0
		European Companies	5	6	20.0	3.8
		Asia/Pacific Companies	2	2	0	1.3
		Included Companies Total	**82**	**157**	**91.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Chapter 7
Other Asian Countries Market Statistics Tables

Table 7-1
Top 30 Worldwide Vendors' Revenue from Shipments of Total Semiconductors to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	363	456	25.6	18.3
2	9	Motorola	96	195	103.1	7.8
3	3	Philips	289	191	-33.9	7.7
4	2	Hitachi	315	165	-47.6	6.6
5	6	SANYO	172	137	-20.3	5.5
6	20	Fujitsu	38	137	260.5	5.5
7	4	Texas Instruments	213	132	-38.0	5.3
8	5	Matsushita	172	120	-30.2	4.8
9	7	Samsung	107	116	8.4	4.7
10	16	Rohm	64	96	50.0	3.9
11	10	United Microelectronics Corp.	94	91	-3.2	3.7
12	11	Winbond Electronics	92	88	-4.3	3.5
13	18	National Semiconductor	54	74	37.0	3.0
14	8	SGS-Thomson	102	58	-43.1	2.3
15	23	Lucent Technologies	23	50	117.4	2.0
16	14	LG Semicon	86	49	-43.0	2.0
17	21	Sharp	32	48	50.0	1.9
18	24	Sony	21	41	95.2	1.6
19	13	Toshiba	90	38	-57.8	1.5
20	19	Siemens	44	33	-25.0	1.3
21	27	Cirrus Logic	15	31	106.7	1.2
22	22	Hyundai	31	30	-3.2	1.2
23	12	Mitsubishi	91	29	-68.1	1.2
24	253	Vanguard	0	20	NA	0.8
25	116	S3	0	18	NA	0.7
26	26	NEC	18	16	-11.1	0.6
27	28	Korean Electronic Co.	6	8	33.3	0.3
28	25	IBM	18	7	-61.1	0.3
29	15	Mosel Vitelic	77	4	-94.8	0.2
30	17	Sanken	60	4	-93.3	0.2
		All Others	2	5	150.0	0.2
		Americas Companies	784	968	23.5	38.9
		Japanese Companies	1,073	831	-22.6	33.4
		European Companies	435	282	-35.2	11.3
		Asia/Pacific Companies	493	406	-17.6	16.3
		Included Companies Total	**2,785**	**2,487**	**-10.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-2
Top 30 Worldwide Vendors' Revenue from Shipments of Total Integrated Circuits to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	363	456	25.6	21.3
2	15	Motorola	57	152	166.7	7.1
3	2	Philips	249	150	-39.8	7.0
4	18	Fujitsu	36	135	275.0	6.3
5	4	Texas Instruments	210	132	-37.1	6.2
6	5	SANYO	116	112	-3.4	5.2
7	3	Hitachi	218	98	-55.0	4.6
8	7	Samsung	98	98	0	4.6
9	8	United Microelectronics Corp.	94	91	-3.2	4.2
10	9	Winbond Electronics	92	88	-4.3	4.1
11	6	Matsushita	108	69	-36.1	3.2
12	16	National Semiconductor	41	68	65.9	3.2
13	17	Rohm	37	57	54.1	2.7
14	10	SGS-Thomson	89	52	-41.6	2.4
15	22	Lucent Technologies	22	50	127.3	2.3
16	11	LG Semicon	86	49	-43.0	2.3
17	21	Sharp	25	43	72.0	2.0
18	25	Sony	15	40	166.7	1.9
19	26	Cirrus Logic	15	31	106.7	1.4
20	20	Hyundai	31	30	-3.2	1.4
21	14	Toshiba	72	28	-61.1	1.3
22	13	Mitsubishi	74	22	-70.3	1.0
23	19	Siemens	36	21	-41.7	1.0
24	28	Vanguard	0	20	NA	0.9
25	29	S3	0	18	NA	0.8
26	23	NEC	18	16	-11.1	0.7
27	24	IBM	18	7	-61.1	0.3
28	12	Mosel Vitelic	77	4	-94.8	0.2
29	27	Advanced Micro Devices	2	3	50.0	0.1
30	32	Atmel	0	2	NA	0
		All Others	-	2	NA	0
		Americas Companies	728	919	26.2	42.9
		Japanese Companies	719	621	-13.6	29.0
		European Companies	374	223	-40.4	10.4
		Asia/Pacific Companies	478	381	-20.3	17.8
		Included Companies Total	**2,299**	**2,144**	**-6.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-3
Top Eight Worldwide Vendors' Revenue from Shipments of Bipolar Digital to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	3	Motorola	6	5	-16.7	23.8
2	5	Texas Instruments	2	4	100.0	19.0
3	28	Mosel Vitelic	0	4	NA	19.0
4	2	Hitachi	7	3	-57.1	14.3
5	4	Philips	2	3	50.0	14.3
6	1	National Semiconductor	9	1	-88.9	4.8
7	8	Fujitsu	0	1	NA	4.8
8	6	Toshiba	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	17	10	-41.2	47.6
		Japanese Companies	9	4	-55.6	19.0
		European Companies	2	3	50.0	14.3
		Asia/Pacific Companies	-	4	NA	19.0
		Included Companies Total	**28**	**21**	**-25.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-4
Top 30 Worldwide Vendors' Revenue from Shipments of MOS Digital ICs to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	363	456	25.6	26.2
2	15	Fujitsu	35	133	280.0	7.6
3	2	Philips	232	129	-44.4	7.4
4	12	Motorola	47	98	108.5	5.6
5	6	United Microelectronics Corp.	94	91	-3.2	5.2
6	3	Hitachi	203	88	-56.7	5.1
7	7	Winbond Electronics	91	86	-5.5	4.9
8	5	Samsung	94	83	-11.7	4.8
9	4	Texas Instruments	133	61	-54.1	3.5
10	16	National Semiconductor	32	61	90.6	3.5
11	21	Lucent Technologies	19	50	163.2	2.9
12	8	LG Semicon	86	49	-43.0	2.8
13	13	SANYO	44	40	-9.1	2.3
14	20	Sharp	21	40	90.5	2.3
15	24	Sony	12	37	208.3	2.1
16	27	Cirrus Logic	1	31	3,000.0	1.8
17	17	Hyundai	31	30	-3.2	1.7
18	18	Rohm	23	30	30.4	1.7
19	14	Matsushita	43	27	-37.2	1.5
20	11	Toshiba	61	24	-60.7	1.4
21	10	Mitsubishi	68	21	-69.1	1.2
22	28	Vanguard	0	20	NA	1.1
23	29	S3	0	18	NA	1.0
24	23	NEC	17	15	-11.8	0.9
25	19	SGS-Thomson	21	10	-52.4	0.6
26	22	IBM	18	7	-61.1	0.4
27	25	Siemens	4	3	-25.0	0.2
28	26	Advanced Micro Devices	2	2	0	0.1
29	30	Atmel	0	2	NA	0.1
30	9	Mosel Vitelic	77	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	615	786	27.8	45.1
		Japanese Companies	527	455	-13.7	26.1
		European Companies	257	142	-44.7	8.2
		Asia/Pacific Companies	473	359	-24.1	20.6
		Included Companies Total	**1,872**	**1,742**	**-6.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-5
Top 23 Worldwide Vendors' Revenue from Shipments of MOS Memory to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	12	Fujitsu	14	105	650.0	21.3
2	6	Intel	58	64	10.3	13.0
3	3	Samsung	77	51	-33.8	10.4
4	7	Winbond Electronics	53	44	-17.0	8.9
5	1	Hitachi	142	42	-70.4	8.5
6	5	LG Semicon	71	32	-54.9	6.5
7	9	Hyundai	29	29	0	5.9
8	14	Motorola	11	20	81.8	4.1
9	27	Vanguard	0	20	NA	4.1
10	2	Texas Instruments	94	19	-79.8	3.9
11	8	Mitsubishi	53	18	-66.0	3.7
12	17	Sharp	7	17	142.9	3.5
13	13	NEC	13	9	-30.8	1.8
14	10	Toshiba	29	6	-79.3	1.2
15	16	SGS-Thomson	8	6	-25.0	1.2
16	18	Matsushita	4	4	0	0.8
17	11	United Microelectronics Corp.	17	2	-88.2	0.4
18	21	SANYO	1	2	100.0	0.4
19	15	IBM	10	1	-90.0	0.2
20	22	Philips	0	1	NA	0.2
21	4	Mosel Vitelic	77	0	-100.0	0
22	19	Sony	3	0	-100.0	0
23	20	Siemens	3	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	173	104	-39.9	21.1
		Japanese Companies	266	203	-23.7	41.3
		European Companies	11	7	-36.4	1.4
		Asia/Pacific Companies	324	178	-45.1	36.2
		Included Companies Total	**774**	**492**	**-36.4**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-6
Top 16 Worldwide Vendors' Revenue from Shipments of DRAM to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	11	Fujitsu	6	65	983.3	22.0
2	5	Samsung	64	51	-20.3	17.3
3	1	Hitachi	105	31	-70.5	10.5
4	4	LG Semicon	68	30	-55.9	10.2
5	7	Hyundai	28	28	0	9.5
6	17	Vanguard	0	20	NA	6.8
7	10	Motorola	8	19	137.5	6.4
8	2	Texas Instruments	92	16	-82.6	5.4
9	6	Mitsubishi	50	16	-68.0	5.4
10	9	NEC	13	9	-30.8	3.1
11	12	Matsushita	4	4	0	1.4
12	8	Toshiba	17	3	-82.4	1.0
13	21	SANYO	0	2	NA	0.7
14	13	IBM	3	1	-66.7	0.3
15	3	Mosel Vitelic	76	0	-100.0	0
16	14	Siemens	3	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	103	36	-65.0	12.2
		Japanese Companies	195	130	-33.3	44.1
		European Companies	3	-	-100.0	0
		Asia/Pacific Companies	236	129	-45.3	43.7
		Included Companies Total	**537**	**295**	**-45.1**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-7
Top 13 Worldwide Vendors' Revenue from Shipments of SRAM to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Winbond Electronics	50	42	-16.0	70.0
2	2	Hitachi	32	10	-68.8	16.7
3	3	United Microelectronics Corp.	15	2	-86.7	3.3
4	4	Toshiba	8	2	-75.0	3.3
5	6	Sharp	7	1	-85.7	1.7
6	9	Motorola	2	1	-50.0	1.7
7	11	Fujitsu	1	1	0	1.7
8	12	Hyundai	1	1	0	1.7
9	5	IBM	7	0	-100.0	0
10	7	Samsung	3	0	-100.0	0
11	8	Sony	3	0	-100.0	0
12	10	Mitsubishi	2	0	-100.0	0
13	13	Mosel Vitelic	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	9	1	-88.9	1.7
		Japanese Companies	53	14	-73.6	23.3
		European Companies	-	-	NA	0
		Asia/Pacific Companies	70	45	-35.7	75.0
		Included Companies Total	**132**	**60**	**-54.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-8
Top 13 Worldwide Vendors' Revenue from Shipments of Nonvolatile Memory to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	58	64	10.3	47.1
2	3	Fujitsu	7	39	457.1	28.7
3	13	Sharp	0	16	NA	11.8
4	4	SGS-Thomson	7	6	-14.3	4.4
5	10	Texas Instruments	2	3	50.0	2.2
6	7	Winbond Electronics	3	2	-33.3	1.5
7	8	LG Semicon	3	2	-33.3	1.5
8	11	Mitsubishi	1	2	100.0	1.5
9	5	Hitachi	5	1	-80.0	0.7
10	6	Toshiba	4	1	-75.0	0.7
11	2	Samsung	10	0	-100.0	0
12	9	United Microelectronics Corp.	2	0	-100.0	0
13	12	SANYO	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	60	67	11.7	49.3
		Japanese Companies	18	59	227.8	43.4
		European Companies	7	6	-14.3	4.4
		Asia/Pacific Companies	18	4	-77.8	2.9
		Included Companies Total	**103**	**136**	**32.0**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-9
Top 26 Worldwide Vendors' Revenue from Shipments of MOS Microcomponents to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	305	392	28.5	43.9
2	3	United Microelectronics Corp.	77	89	15.6	10.0
3	6	Motorola	32	60	87.5	6.7
4	7	National Semiconductor	29	58	100.0	6.5
5	2	Philips	170	53	-68.8	5.9
6	4	Winbond Electronics	38	42	10.5	4.7
7	5	Hitachi	33	31	-6.1	3.5
8	23	Cirrus Logic	1	31	3,000.0	3.5
9	8	Texas Instruments	20	25	25.0	2.8
10	15	Lucent Technologies	8	20	150.0	2.2
11	29	S3	0	18	NA	2.0
12	10	Matsushita	13	13	0	1.5
13	12	Fujitsu	11	12	9.1	1.3
14	19	Samsung	3	9	200.0	1.0
15	16	Sharp	6	7	16.7	0.8
16	11	Toshiba	12	6	-50.0	0.7
17	13	SGS-Thomson	10	4	-60.0	0.4
18	9	Mitsubishi	15	3	-80.0	0.3
19	14	SANYO	10	3	-70.0	0.3
20	17	Rohm	5	3	-40.0	0.3
21	18	IBM	4	3	-25.0	0.3
22	21	NEC	2	3	50.0	0.3
23	22	Siemens	1	3	200.0	0.3
24	20	Sony	3	2	-33.3	0.2
25	24	Advanced Micro Devices	1	1	0	0.1
26	25	LG Semicon	0	1	NA	0.1
		All Others	-	-	NA	0
		Americas Companies	400	608	52.0	68.2
		Japanese Companies	110	83	-24.5	9.3
		European Companies	181	60	-66.9	6.7
		Asia/Pacific Companies	118	141	19.5	15.8
		Included Companies Total	**809**	**892**	**10.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-10
Top Five Worldwide Vendors' Revenue from Shipments of Microprocessors to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Intel	235	317	34.9	88.3
2	3	National Semiconductor	6	23	283.3	6.4
3	2	Motorola	9	15	66.7	4.2
4	4	IBM	4	3	-25.0	0.8
5	10	Texas Instruments	0	1	NA	0.3
		All Others	-	-	NA	0
		Americas Companies	254	359	41.3	100.0
		Japanese Companies	-	-	NA	0
		European Companies	-	-	NA	0
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**254**	**359**	**41.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-11
Top 17 Worldwide Vendors' Revenue from Shipments of Microcontrollers to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Motorola	20	42	110.0	38.5
2	12	Samsung	3	9	200.0	8.3
3	9	Philips	5	8	60.0	7.3
4	8	Sharp	6	7	16.7	6.4
5	7	Matsushita	6	6	0	5.5
6	6	Fujitsu	7	5	-28.6	4.6
7	10	Hitachi	4	5	25.0	4.6
8	5	SGS-Thomson	8	4	-50.0	3.7
9	2	Mitsubishi	14	3	-78.6	2.8
10	3	SANYO	10	3	-70.0	2.8
11	4	Toshiba	8	3	-62.5	2.8
12	11	Texas Instruments	3	3	0	2.8
13	15	NEC	2	3	50.0	2.8
14	16	Siemens	1	3	200.0	2.8
15	13	Sony	3	2	-33.3	1.8
16	14	Intel	2	2	0	1.8
17	26	LG Semicon	0	1	NA	0.9
		All Others	-	-	NA	0
		Americas Companies	25	47	88.0	43.1
		Japanese Companies	60	37	-38.3	33.9
		European Companies	14	15	7.1	13.8
		Asia/Pacific Companies	3	10	233.3	9.2
		Included Companies Total	**102**	**109**	**6.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-12
Top 17 Worldwide Vendors' Revenue from Shipments of Microperipherals to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	United Microelectronics Corp.	77	89	15.6	23.9
2	3	Intel	68	73	7.4	19.6
3	4	Winbond Electronics	38	42	10.5	11.3
4	1	Philips	165	38	-77.0	10.2
5	6	National Semiconductor	23	35	52.2	9.4
6	15	Cirrus Logic	1	31	3,000.0	8.3
7	5	Hitachi	28	25	-10.7	6.7
8	26	S3	0	18	NA	4.8
9	7	Texas Instruments	5	6	20.0	1.6
10	11	Matsushita	3	5	66.7	1.3
11	8	Rohm	5	3	-40.0	0.8
12	9	Fujitsu	4	3	-25.0	0.8
13	10	Motorola	3	3	0	0.8
14	12	Toshiba	3	1	-66.7	0.3
15	16	Advanced Micro Devices	1	1	0	0.3
16	13	SGS-Thomson	2	0	-100.0	0
17	14	Mitsubishi	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	101	167	65.3	44.8
		Japanese Companies	44	37	-15.9	9.9
		European Companies	167	38	-77.2	10.2
		Asia/Pacific Companies	115	131	13.9	35.1
		Included Companies Total	**427**	**373**	**-12.6**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-13
Top Seven Worldwide Vendors' Revenue from Shipments of Digital Signal Processors to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Lucent Technologies	8	20	150.0	39.2
2	1	Texas Instruments	12	15	25.0	29.4
3	9	Philips	0	7	NA	13.7
4	14	Fujitsu	0	4	NA	7.8
5	3	Matsushita	4	2	-50.0	3.9
6	5	Toshiba	1	2	100.0	3.9
7	4	Hitachi	1	1	0	2.0
		All Others	-	-	NA	0
		Americas Companies	20	35	75.0	68.6
		Japanese Companies	6	9	50.0	17.6
		European Companies	-	7	NA	13.7
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**26**	**51**	**96.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-14
Top 21 Worldwide Vendors' Revenue from Shipments of MOS Digital Logic to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	62	75	21.0	20.9
2	2	SANYO	33	35	6.1	9.8
3	13	Sony	6	35	483.3	9.8
4	10	Lucent Technologies	11	30	172.7	8.4
5	7	Rohm	18	27	50.0	7.5
6	9	Samsung	14	23	64.3	6.4
7	14	Motorola	4	18	350.0	5.0
8	6	Texas Instruments	19	17	-10.5	4.7
9	8	LG Semicon	15	16	6.7	4.5
10	11	Fujitsu	10	16	60.0	4.5
11	12	Sharp	8	16	100.0	4.5
12	3	Hitachi	28	15	-46.4	4.2
13	5	Toshiba	20	12	-40.0	3.4
14	4	Matsushita	26	10	-61.5	2.8
15	15	IBM	4	3	-25.0	0.8
16	16	National Semiconductor	3	3	0	0.8
17	18	NEC	2	3	50.0	0.8
18	30	Atmel	0	2	NA	0.6
19	19	Hyundai	2	1	-50.0	0.3
20	20	Advanced Micro Devices	1	1	0	0.3
21	17	SGS-Thomson	3	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	42	74	76.2	20.7
		Japanese Companies	151	169	11.9	47.2
		European Companies	65	75	15.4	20.9
		Asia/Pacific Companies	31	40	29.0	11.2
		Included Companies Total	**289**	**358**	**23.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-15
Top 18 Worldwide Vendors' Revenue from Shipments of ASICs to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	4	Lucent Technologies	11	30	172.7	28.0
2	3	LG Semicon	15	16	6.7	15.0
3	6	Fujitsu	10	16	60.0	15.0
4	1	Hitachi	20	13	-35.0	12.1
5	5	Samsung	10	8	-20.0	7.5
6	2	Matsushita	16	7	-56.3	6.5
7	11	Motorola	4	5	25.0	4.7
8	12	IBM	4	3	-25.0	2.8
9	9	Sharp	7	2	-71.4	1.9
10	16	National Semiconductor	2	2	0	1.9
11	17	NEC	2	2	0	1.9
12	10	Toshiba	5	1	-80.0	0.9
13	13	SANYO	3	1	-66.7	0.9
14	18	Hyundai	2	1	-50.0	0.9
15	7	Rohm	8	0	-100.0	0
16	8	Texas Instruments	7	0	-100.0	0
17	14	SGS-Thomson	3	0	-100.0	0
18	15	Sony	2	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	28	40	42.9	37.4
		Japanese Companies	73	42	-42.5	39.3
		European Companies	3	-	-100.0	0
		Asia/Pacific Companies	27	25	-7.4	23.4
		Included Companies Total	**131**	**107**	**-18.3**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-16
Top Seven Worldwide Vendors' Revenue from Shipments of Custom ICs to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	9	Sharp	0	14	NA	28.6
2	7	Motorola	0	12	NA	24.5
3	15	Rohm	0	9	NA	18.4
4	5	Samsung	0	8	NA	16.3
5	6	Matsushita	0	3	NA	6.1
6	20	Atmel	0	2	NA	4.1
7	11	NEC	0	1	NA	2.0
		All Others	-	-	NA	0
		Americas Companies	0	14	NA	28.6
		Japanese Companies	0	27	NA	55.1
		European Companies	0	-	NA	0
		Asia/Pacific Companies	0	8	NA	16.3
		Included Companies Total	**0**	**49**	NA	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-17
Top Six Worldwide Vendors' Revenue from Shipments of MOS Standard Logic to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Texas Instruments	12	17	41.7	53.1
2	2	Toshiba	11	8	-27.3	25.0
3	4	Philips	3	6	100.0	18.8
4	17	National Semiconductor	0	1	NA	3.1
5	3	Matsushita	8	0	-100.0	0
6	5	SANYO	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	12	18	50.0	56.3
		Japanese Companies	20	8	-60.0	25.0
		European Companies	3	6	100.0	18.8
		Asia/Pacific Companies	-	-	NA	0
		Included Companies Total	**35**	**32**	**-8.6**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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Table 7-18
Top 12 Worldwide Vendors' Revenue from Shipments of Total Other MOS Logic to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Philips	59	69	16.9	40.6
2	7	Sony	4	35	775.0	20.6
3	2	SANYO	29	34	17.2	20.0
4	3	Rohm	10	18	80.0	10.6
5	6	Samsung	4	7	75.0	4.1
6	5	Toshiba	4	3	-25.0	1.8
7	4	Hitachi	8	2	-75.0	1.2
8	11	Advanced Micro Devices	1	1	0	0.6
9	13	Motorola	0	1	NA	0.6
10	8	Matsushita	2	0	-100.0	0
11	9	National Semiconductor	1	0	-100.0	0
12	10	Sharp	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	2	2	0	1.2
		Japanese Companies	58	92	58.6	54.1
		European Companies	59	69	16.9	40.6
		Asia/Pacific Companies	4	7	75.0	4.1
		Included Companies Total	**123**	**170**	**38.2**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-19
Top 23 Worldwide Vendors' Revenue from Shipments of Analog-Monolithic to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	SANYO	72	72	0	18.9
2	1	Texas Instruments	75	67	-10.7	17.6
3	13	Motorola	4	49	1,125.0	12.9
4	3	SGS-Thomson	68	42	-38.2	11.0
5	4	Matsushita	65	42	-35.4	11.0
6	7	Rohm	14	27	92.9	7.1
7	5	Siemens	32	18	-43.8	4.7
8	6	Philips	15	18	20.0	4.7
9	12	Samsung	4	15	275.0	3.9
10	10	Hitachi	8	7	-12.5	1.8
11	21	National Semiconductor	0	6	NA	1.6
12	9	Toshiba	9	4	-55.6	1.0
13	14	Sharp	4	3	-25.0	0.8
14	15	Sony	3	3	0	0.8
15	19	Winbond Electronics	1	2	100.0	0.5
16	11	Mitsubishi	6	1	-83.3	0.3
17	17	NEC	1	1	0	0.3
18	18	Fujitsu	1	1	0	0.3
19	20	Advanced Micro Devices	0	1	NA	0.3
20	31	Korean Electronic Co.	0	1	NA	0.3
21	32	Sanken	0	1	NA	0.3
22	8	Cirrus Logic	14	0	-100.0	0
23	16	Lucent Technologies	3	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	96	123	28.1	32.3
		Japanese Companies	183	162	-11.5	42.5
		European Companies	115	78	-32.2	20.5
		Asia/Pacific Companies	5	18	260.0	4.7
		Included Companies Total	**399**	**381**	**-4.5**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-20
Top 16 Worldwide Vendors' Revenue from Shipments of Discrete Semiconductors to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	1	Hitachi	94	65	-30.9	21.8
2	2	Matsushita	51	49	-3.9	16.4
3	3	Philips	40	41	2.5	13.8
4	4	Motorola	38	41	7.9	13.8
5	7	Rohm	18	28	55.6	9.4
6	6	SANYO	20	21	5.0	7.0
7	12	Samsung	9	18	100.0	6.0
8	8	SGS-Thomson	13	6	-53.8	2.0
9	9	National Semiconductor	13	6	-53.8	2.0
10	14	Korean Electronic Co.	4	6	50.0	2.0
11	10	Toshiba	11	5	-54.5	1.7
12	13	Siemens	5	5	0	1.7
13	11	Mitsubishi	11	3	-72.7	1.0
14	5	Sanken	32	2	-93.8	0.7
15	16	Fujitsu	1	2	100.0	0.7
16	15	Texas Instruments	3	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	54	47	-13.0	15.8
		Japanese Companies	238	175	-26.5	58.7
		European Companies	58	52	-10.3	17.4
		Asia/Pacific Companies	13	24	84.6	8.1
		Included Companies Total	**363**	**298**	**-17.9**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

Table 7-21
Top 13 Worldwide Vendors' Revenue from Shipments of Optical Semiconductors to Other Asian Countries (Millions of U.S. Dollars)

1997 Rank	1996 Rank	Company	1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share of Included Companies (%)*
1	2	Rohm	7	11	57.1	24.4
2	6	Siemens	3	7	133.3	15.6
3	3	Toshiba	7	5	-28.6	11.1
4	4	Sharp	7	5	-28.6	11.1
5	5	Mitsubishi	6	4	-33.3	8.9
6	8	SANYO	2	4	100.0	8.9
7	1	Matsushita	13	2	-84.6	4.4
8	10	Hitachi	1	2	100.0	4.4
9	11	Motorola	1	2	100.0	4.4
10	7	Sony	3	1	-66.7	2.2
11	9	Korean Electronic Co.	2	1	-50.0	2.2
12	12	Sanken	1	1	0	2.2
13	13	Lucent Technologies	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	2	2	0	4.4
		Japanese Companies	47	35	-25.5	77.8
		European Companies	3	7	133.3	15.6
		Asia/Pacific Companies	2	1	-50.0	2.2
		Included Companies Total	**54**	**45**	**-16.7**	**100.0**

*The total includes only the top 32 companies by shipments into Asia/Pacific; it does not equal the total Asia/Pacific market.
NA = Not available
Source: Dataquest (June 1998)

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High-Volume Electronic Equipment Unit Production Forecast and Semiconductor Consumption Analysis: China/Hong Kong, 1998

Market Statistics

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MARIA VALENZUELA

Program: Semiconductors China
Product Code: SEMI-CH-MS-9802
Publication Date: June 22, 1998
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High-Volume Electronic Equipment Unit Production Forecast and Semiconductor Consumption Analysis: China/Hong Kong, 1998

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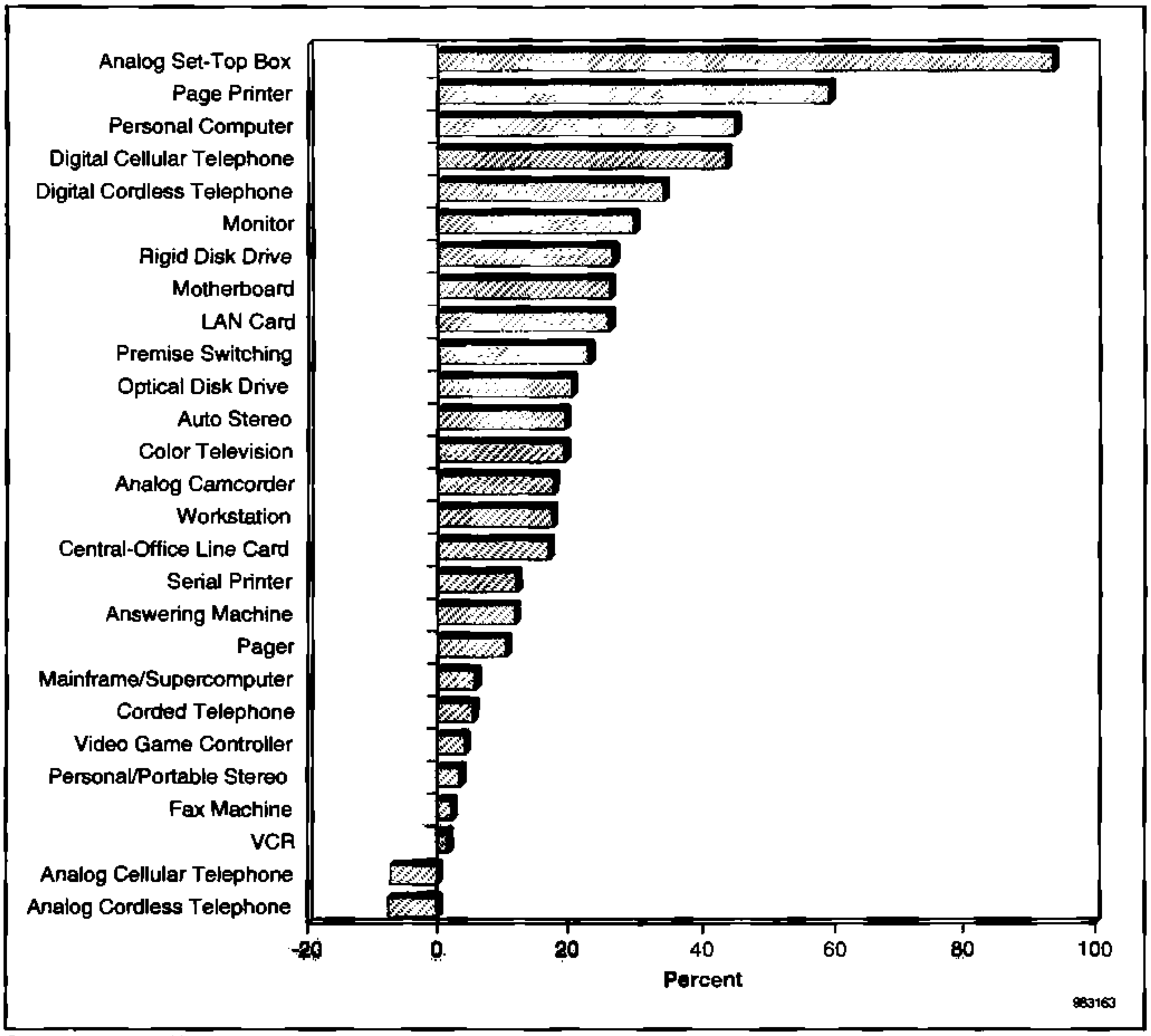
Chapter 1
Introduction

This Market Statistics report represents Dataquest's forecast for China/Hong Kong electronic equipment production in units, revenue, semiconductor content, and available markets for semiconductors. Dataquest has selected 37 key application systems that have high-volume production in China/Hong Kong. These key systems are identified by Dataquest as the leading indicators of semiconductor consumption trends by end-application market segment.

Figure 1-1
China/Hong Kong's Electronic Equipment Unit Compound Annual Growth Rates, 1997 to 2002



Source: Dataquest (June 1998)

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The 37 leading indicators selected by Dataquest are as follows:

- Electronic data processing
  - Personal computer
  - Motherboard
  - Workstation
  - Midrange computer
  - Mainframe/supercomputer
  - Page printer
  - Serial printer
  - Rigid disk drive
  - Optical disk drive
  - Monitor
- Communications
  - LAN card
  - Fax
  - Modem
  - Central office/premise line card
  - Corded telephone
  - PBX
  - Answering machine
  - Analog cordless telephone
  - Digital cordless telephone
  - Analog cellular telephone
  - Digital cellular telephone
  - Pager
  - Mobile communications infrastructure
- Consumer
  - Color TV
  - VCR
  - Analog camcorder
  - Digital camcorder
  - Digital still camera
  - Personal/portable stereo
  - Digital video disc (DVD) player
  - Set-top box—analog
  - Set-top box—digital
  - Video game controller

- Transportation
  - Auto stereo system
  - Auto engine control unit
  - Antilock brake system (ABS) control unit
  - Air bag control unit

This Market Statistics report contains detailed information on Dataquest's view of China/Hong Kong's electronic equipment production. Electronic equipment production is an important determinant of semiconductor market activity because semiconductor demand is derived, in part, from the underlying demand for the systems that use semiconductors. Therefore, the forecast of electronic equipment production is an essential component to assessing future semiconductor market activity. China/Hong Kong production is estimated for the years 1996 to 2001.

Economic Assumptions and Exchange Rates

Actual exchange rates for the major countries in Asia/Pacific are contained in Table 1-1. The exchange rates are applied to all historical figures. Dataquest does not forecast currency fluctuations. In looking at Dataquest's historical numbers, it is important to note fluctuations in currencies. The Chinese renminbi was quite stable in 1995 and 1996, compared with its fluctuation in 1994. The Korean won appreciated 4.49 percent in 1996. In conducting market forecasts, Dataquest uses constant exchange rates across technologies and regions.

Table 1-1
Asia/Pacific Exchange Rate against the U.S. Dollar, 1993 to 1997

Currency	1993	1994	1995	1996	1997	U.S. Dollar Appreciation (%) 1996 to 1997
China (Renminbi)	5.76	8.54	8.35	8.34	8.32	-0.24
Hong Kong (Dollar)	7.74	7.73	7.74	7.73	7.74	0.13
India (Rupee)	30.84	31.15	32.38	35.52	36.36	2.36
Malaysia (Ringgit)	2.58	2.62	2.51	2.52	2.82	11.90
Singapore (Dollar)	1.62	1.53	1.43	1.41	1.49	5.67
South Korea (Won)	799.52	802.84	770.57	805.16	954.14	18.50
Taiwan (Dollar)	26.16	26.45	26.48	27.47	28.79	4.81
Thailand (Baht)	25.31	25.36	24.91	25.36	31.07	22.52

Source: Dataquest (February 1998)

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Regional Definitions

Dataquest has revised its regional definitions effective this year. The region formerly known as "Rest of World" has been eliminated and its components have been redistributed across the remaining regions. The remaining regions, in turn, have been redefined in response to this change. Former Rest of World constituents Central America, South America, and the Caribbean have been combined with North America in a new region redefined as "Americas." The Middle East (including Israel) and Africa have been combined with Europe in the redefined region "Europe, Middle East, and Africa." The Pacific Island nations of Oceania, formerly considered Rest of World, have been rolled into Asia/Pacific to create a larger redefined region still called "Asia/Pacific."

The Americas

- North America: Includes Canada, Mexico, and the United States (50 states)
- Central America
- South America
- Caribbean

Japan

- Japan is the only single-country region.

Europe, Middle East, and Africa

- Europe
  - Western Europe—Includes Austria, Belgium, Denmark, Eire (Ireland), Finland, France, Germany (including former East Germany), Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and rest of western Europe (Andorra, Cypress, Gibraltar, Iceland, Liechtenstein, Malta, Monaco, San Marino, Turkey, and Vatican City)
  - Eastern Europe—Includes Albania, Bulgaria, the Czech Republic and Slovakia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, the republics of the former Yugoslavia, and the republics of the former USSR (including Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan)
- Middle East (Includes Israel)
- Africa

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Asia/Pacific

Includes Asia/Pacific's newly industrialized economies (NIEs) and the remainder of Asia/Pacific, including Oceania. Asia/Pacific NIEs include Hong Kong, Korea, Singapore, and Taiwan. The remainder of Asia/Pacific includes Australia, Bangladesh, Brunei, Cambodia, China, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, New Zealand, Pakistan, the Philippines, Sri Lanka, Thailand, and Vietnam as well as the Pacific Island nations that make up Oceania.

Line Item Definitions

The objective of analyzing electronic systems production is to estimate its important implications for semiconductor consumption. Therefore, general economic concepts such as production and consumption are tailored to best isolate these implications.

The value of production is estimated as factory revenue. For the purposes of this report, Dataquest defines factory revenue as the money exchange value of the commodity transaction between the original equipment manufacturer and the point of entry into distribution. In the case of a direct sale that involves no distribution—as is the case with military systems—factory revenue is equal to the final user cost, net of sales taxes.

Production is the value-adding process by which the factors of production (labor and capital) and material inputs are transformed into the finished goods that are desired for consumption and investment. As such, production can and increasingly does span both time and geography. For example, a North American-owned disk drive company may minimize its cost of production by manufacturing (that is, consuming chips) its products in Taiwan, for eventual sale in Europe.

We would classify this as Asia/Pacific data storage device production, because we are interested in that stage of the production process that relates particularly to semiconductor consumption. Production would be valued as the exchange value of the transaction between the North American company's Taiwanese operation (which is factory revenue) and the European distributor or final user.

Product Definitions

Electronic Data Processing

The key application systems under this category are discussed in the following sections.

Personal Computer

A personal computer is a general-purpose computer that is distinguished from other computers by its adherence to hardware and software compatibility. This compatibility drives high unit volumes of commodity-like products that do not require on-site technical support. High-performance features (such as networking, graphics, floating-point coprocessor, and a virtual multiuser/multitasking operating system) are normally optional and not integral system features. IBM/IBM-compatible and Macintosh personal computers are two platforms in this product segment. A single-user PC's resident operating system is typically DOS, OS/2, or Mac OS. PCs have a performance ceiling that is lower in system

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compute performance, I/O channel speed, and disk speed than workstations; normally, standard graphics are in the 640 x 480-pixel range and optional high-end graphics are limited, compared to workstations. Dataquest views a PC system as a single unit that includes a CPU, a monitor, and a keyboard. Furthermore, Dataquest PC shipment data does not include systems assembled from component parts purchased in electronic stores or other outlets.

Motherboard

A motherboard is a PC system board consisting of a printed circuit board with semiconductor and nonsemiconductor components that are all soldered down. The list of semiconductor components will include a minimum of core logic chipset, clock controller, real-time clock, keyboard controller, and any additional glue logic required to interface between the core logic chipset and CPU, cache memory, main memory, and expansion bus (such as PCI). The list of semiconductor components may include a graphics controller, mass storage interface, serial and parallel I/O, voltage converter, or audio controller, as long as they are soldered down.

Workstation

Dataquest classifies workstations by a composite of features, including their hardware and software features. Workstations are typically based on RISC CPU architecture with a high-performance bus structure, graphics, and operating system. In general, a workstation must come standard with integrated floating-point processing, integrated networking, and a 32-bit multitasking operating system, as well as offer a configuration that has high-resolution graphics capabilities (typically 1-megapixel display). We do not determine a workstation architecture by its usage (that is, single user, server, or multiuser).

Once the system passes these criteria, we examine whether it is designed to be a server or a workstation (that is, if the system is marketed with graphics capabilities). If it is designed to be a server (examples are the SPARCserver 1000 and RS/6000 POWERserver 900 series), the system is classified in Dataquest's midrange category. If it is marketed with graphics capabilities, we further classify the workstation and its server configuration (for example, SPARCstation 10 and SPARCserver10) into one of three categories: entry-level workstation, midrange workstation, and superworkstation.

Midrange Computer

The midrange product category includes all systems that fall between workstations and mainframes. These are multiuser systems that may or may not run proprietary operating systems. With the evolution of client/server computing and the systems that define this market, traditional midrange product categories are becoming obsolete. The HP 9000 and the HP 3000, Digital's VAX systems, and the IBM AS/400 line are joined by the dedicated server products from vendors such as Auspex, NetFRAME, and Tricord to make up the midrange product category. Office systems, proprietary turnkey computing solutions common in Japan, are also included in the midrange category. Systems designed as servers from workstation vendors are also included here. Midrange-class servers consist of high-end PC server systems that are manufactured and marketed by traditional PC vendors as well as system vendors. A server is

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a shared computer on a network that can be used for simple and complex tasks. The key distinction between midrange-class servers and server-marketed PCs is price and the average number of CPUs included in the base system. Midrange class servers ship with more than one CPU and generally cost more than $15,000. Examples of this segment include the Compaq ProLiant 4000, IBM PC Server 700, and the HP NetServer LM2. The midrange-class server category comprises PC servers that compete with leading symmetric multiprocessing (SMP) and scalable products marketed by dedicated server vendors.

Mainframe/Supercomputer
A supercomputer is a high-performance computer designed for numerically intensive applications; current prices range from $100,000 to $20 million. Typically, these systems run in cool rooms (with or without raised floors); performance speeds range upward from 50 mflops. Massively parallel systems are defined as machines that have more than 32 relatively inexpensive processors linked together to act as one system.

A mainframe is a general-purpose information system with a starting price of over $100,000; CPU bit width ranges from 32 to 64 bits. Physical environment can be with or without environmental controls.

Page Printer
A page printer prints one page at a time.

Serial Printer
A serial printer prints one character at a time.

Rigid Disk Drive
The rigid disk drive (RDD) industry is the collective body of companies manufacturing rotating magnetic disk drives for use in storing computer programs and data. Some products are used in noncomputer applications; those are not included in the data presented in these market statistics. A rigid disk drive stores digital information on a round platter made of polished aluminum or a ceramic material. The information is written and read from the platters by recording heads mounted on the end of an arm. The arm is positioned over the desired area of the disk by a sophisticated control circuit that guides an actuator motor's movement. The data is amplified, decoded, and transmitted to the computer by the disk drive electronic circuits. The manner in which the information is presented to the computer is determined by the interface characteristics of the disk drive. Examples of interfaces include the small computer system interface (SCSI) and the PC-AT bus, sometimes called IDE.

Optical Disk Drive
An optical disk drive (ODD) is a data storage device that uses laser technology. Its categories are as follows: CD ROM drive, 12cm in diameter; CD-Recordable; write-once read-many (WORM) optical drive; rewritable ODD; magneto-optical (MO) multifunction, which has a hidden code read at disk spin-up time; and PC multifunction drive (WORM media that cannot be erased).

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Removable Magnetic Storage

Removable magnetic storage comprises floppy disk drives (FDDs) and tape.

Monitors

A self-contained video display device that attaches directly to a computer and displays the contents of the computer's video memory. A monitor contains no data formatting or editing capability, nor does it contain any type of networking capability. Included are: color monitors that have interfaces capable of interpreting signals containing separate color components, normally the three primary colors red, green, and blue, and monochrome monitors that are based on a single color CRT. These monitors normally display in shades of white, green, or amber. They may or may not have the ability to display multiple shades of a monochromatic color.

Communications

The key application systems under this category are discussed in the following sections.

LAN Card

A LAN card is the printed circuit board that plugs into the expansion slots of a PC, workstation, or host terminal to allow connection to a LAN. Network interface cards (NICs) are designed in accordance with either IEEE or ANSI protocol standards; the most common are Ethernet, token ring, and fiber-distributed data interface (FDDI). Workstation and host NICs are segmented only into FDDI, ATM, and Others.

Fax

Facsimile machines include those with answering machines and cordless handsets.

Modem

A modem is an electronic device that provides modulation and demodulation functions for data signals transmitted over telephone lines. Modems convert digital data to analog data for transmission over leased lines or the analog public switched telephone network.

Central Office/Premise Line Card

A telecommunications switch used by public carriers

Corded Telephone

This category includes both standard and feature phones.

PBX

Private branch exchange

Answering Machine

Answering machines include both standalone and integrated answering machines, including any telephone terminal with an answering machine. To avoid double counting, any corded or home cordless telephone that has an integrated answering machine will be counted in the answering machine category. They are not counted again in the corded or cordless category.

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Analog Cordless Telephone
Telephone-home cordless handsets and base stations include analog (single-channel, 10-channel, 24-channel, CT-0, CT-1) cordless telephones and 900-MHz analog cordless telephones. These handsets are usually distinguished by the ability to communicate with only one base station in the home or small business. Therefore, a unit would consist of the combination of a handset and base station. The chip content in both the handset and base station should be added together on the semiconductor content line.

Digital Cordless Telephone
These are cordless handsets that can be used to roam outside the home and can communicate with a service provider's infrastructure or multiple base stations in an office environment. They are usually distinguished from cellular by being able to communicate only at pedestrian speeds. Examples of handsets are PHS, DECT, and CT-2.

Analog Cellular Telephone
This includes all Advanced Mobile Phone Service (AMPS), Total Access Communications System (TACS), and Nordic Mobile Telephone (NMT) cellular handsets, among others.

Digital Cellular Telephone
This includes all digital cellular and broadband Personal Communications Services (PCS) handsets, including handsets that conform to the following standards: GSM, DCS1800, PCS1900, NA-TDMA (IS-54/136), CDMA (IS-95), PDC, and Omnipoint.

Pager
A pager is a small, pocket-size receiver that can be activated when the pager number is dialed from a telephone. Includes both one-way and two-way pagers.

Mobile Communications Infrastructure
Two components are the base station controller (BSC) and the switch. The BSC controls the voice channels and power controls.

Consumer
The key application systems under this category are discussed in the following sections.

Color TV
Color TVs include LCD-based and TV-VCR combinations.

VCR
VCRs do not include TV-VCR combinations.

Personal/Portable Stereo
This category includes headphone stereos, portable CDs, and boom boxes.

Digital Video Disc (DVD) Player
Includes only DVD products that are used with a television for playback of video content. Does not include DVD products targeted at the PC market. These would be included as a subcategory of optical disk drives.

Set-Top Box—Analog

A set-top box that decodes and enables access to analog-based TV services

Set-Top Box—Digital

Digital cable converter boxes that sit on top of TVs and act as converter devices for digital information over CATV, telephone, or wireless networks to television sets. These boxes contain a general-purpose microprocessor or a high-powered digital signal processor capable of digital transmission, reception, and decompression.

Video Game Controllers

The board with the chips on it that drives the hardware of the game player

Transportation

The key application systems under this category are discussed in the following sections.

Auto Stereo Systems

Includes integrated AM/FM stereo radio receivers; includes AM/FM radio/cassette combinations, AM/FM radio/cassette/CD combinations, and all in-car audio stereo AM/FM radio-based systems. In the future, this will include terrestrial Digital Audio Broadcast FM receivers (any estimates for DAB radios should become available for inclusion to this category as a separate line item).

Auto Engine Control Unit

Includes electronic engine control units (ECUs) for gasoline (petrol) and diesel (derv) fuel carburetor/injection engines for cars, trucks, and lorries. Electronic engine control units for gasoline engine cars include electronically controlled carburetor systems, single-point injection systems, and multipoint injection systems. Also includes electronic control units where ignition control (breakerless/distributorless, or adaptive/digitally programmed) is integrated with carburetor or injection control unit. Electronic engine control units for diesel engine cars include electronically controlled direct injection systems and indirect injection (distributor) systems. (Please note: Engine control unit excludes standalone electronic ignition control units.) Manages spark or fuel injection or both.

Antilock Brake System Control Unit

Includes electronic ABS control units for two-wheel ABS systems, and four-wheel ABS systems for passenger cars; includes electronic ABS control units for two-wheel and four-wheel ABS systems for light trucks. Includes electronic ABS control units for commercial vehicles, ABS systems for trailers/juggernauts, and electronic ABS control units for motorcycles. Includes ABS with integrated traction control systems

Air Bag Control Unit

Includes electronic control units for single and/or dual air bag systems for driver/front passenger, electronic control units for rear-seat air bag systems for rear passengers, electronic control units for side-impact air bag systems for front-/rear-seat passengers.

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Data Sources

The historical information presented in the production data has been consolidated from a variety of sources, each of which focuses on a specific part of the market. From time to time, Dataquest conducts production surveys for specific types of electronic equipment, and the data gathered is also incorporated into the database. Other sources include the following:

- Dataquest's estimates of systems manufacturers' end-user revenue
- Trade association data
- Various government agency statistics of the countries in Asia/Pacific
- Estimates presented by knowledgeable and reliable industry spokespersons
- Published product literature and prices
- Other Dataquest research groups (including Computer Systems and Peripherals and Telecommunications)

Forecast Methodology

Dataquest uses a variety of forecasting techniques (both qualitative and quantitative) that vary by technology area. Dataquest follows a three-step process to forecast electronic equipment production. First, current and expected future worldwide and European macroeconomic conditions are assessed and forecast.

This forecast identifies trends in the economic health of the world-leading consumers and producers of electronic equipment. Using this forecast in conjunction with input from other Dataquest industry sources (as identified earlier), Dataquest estimates the overall business climates in which the electronic systems market will operate.

Second, Dataquest analyzes and forecasts the significant long-range trend and outlook in the various electronic system research groups (within Dataquest). This establishes a five-year trend growth path for electronic system production.

The final step in the forecast process is to reconcile expected fluctuations about market trends so that the two do not inexplicably diverge. Dataquest anticipates that in the absence of shocks to the market, market fluctuations converge toward a long-term trend.

Because the time series data contained in this document comprises, in general, annual observations and is sparse in terms of the number of observations, the data generally does not satisfy the requirements of quantitative empirical techniques such as econometric or statistical time series models. Therefore, in most cases, we have used judgmental models (that is, intuitive judgments, expert opinions, and subjective probabilities) or technological models (that is, curve fitting and the use of analogous data).

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Chapter 2
Electronic Data Processing Equipment

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Table 2-1
China/Hong Kong's Personal Computer Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	1,147.5	2,096.0	3,230.0	5,028.0	7,159.8	10,038.0	13,400.8	-
Manufacturing ASP (U.S.$)	590.0	585.5	566.2	541.4	527.8	515.2	503.1	-
Manufacturing Revenue (U.S.$M)	677.0	1,227.2	1,828.8	2,722.0	3,779.2	5,171.3	6,741.4	-
Semiconductor Content (U.S.$)	300.5	290.2	282.7	273.8	265.2	259.4	251.1	-
Semiconductor TAM (U.S.$M)	344.8	608.3	913.1	1,376.7	1,898.8	2,603.9	3,364.9	-
Growth (%)								
Units	-	82.66	54.10	55.66	42.40	40.20	33.50	44.93
Manufacturing ASP	-	-0.76	-3.30	-4.39	-2.50	-2.40	-2.35	-2.99
Manufacturing Revenue	-	81.27	49.02	48.84	38.84	36.83	30.36	40.59
Semiconductor Content	-	-3.42	-2.59	-3.15	-3.14	-2.19	-3.20	-2.85
Semiconductor TAM	-	76.41	50.11	50.76	37.93	37.13	29.23	40.79

Source: Dataquest (February 1998)

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Table 2-2
China/Hong Kong's Motherboard Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	9,476.3	15,200.0	18,802.4	24,367.9	31,166.6	39,082.9	48,658.2	-
Manufacturing ASP (U.S.$)	60.0	72.0	82.0	76.0	74.0	71.0	69.0	-
Manufacturing Revenue (U.S.$M)	568.6	1,094.4	1,541.8	1,852.0	2,306.3	2,774.9	3,357.4	-
Semiconductor Content (U.S.$)	34.9	35.6	38.8	37.6	35.2	34.3	32.2	-
Semiconductor TAM (U.S.$M)	330.7	541.1	729.5	916.2	1,097.1	1,341.3	1,565.8	-
Growth (%)								
Units	-	60.40	23.70	29.60	27.90	25.40	24.50	26.20
Manufacturing ASP	-	20.00	13.89	-7.32	-2.63	-4.05	-2.82	-0.85
Manufacturing Revenue	-	92.48	40.88	20.12	24.53	20.32	20.99	25.13
Semiconductor Content	-	2.01	8.99	-3.09	-6.38	-2.50	-6.24	-2.00
Semiconductor TAM	-	63.62	34.82	25.59	19.74	22.27	16.74	23.68

Source: Dataquest (February 1998)

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Table 2-3
China/Hong Kong's Workstation Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	1.5	1.7	1.9	2.2	2.6	3.1	3.8	-
Manufacturing ASP (U.S.$)	7,531.2	7,520.3	7,014.6	7,364.1	6,923.3	6,642.9	6,732.0	-
Manufacturing Revenue (U.S.$M)	11.5	12.7	13.4	16.2	18.0	20.7	25.5	-
Semiconductor Content (U.S.$)	1,651.5	1,567.2	1,389.2	1,322.8	1,249.0	1,185.3	1,165.2	-
Semiconductor TAM (U.S.$M)	2.5	2.7	2.7	2.9	3.2	3.7	4.4	-
Growth (%)								
Units	-	10.96	13.01	15.02	17.97	20.02	21.79	17.52
Manufacturing ASP	-	-0.14	-6.72	4.98	-5.99	-4.05	1.34	-2.19
Manufacturing Revenue	-	10.80	5.41	20.75	10.91	15.15	23.42	14.94
Semiconductor Content	-	-5.10	-11.36	-4.77	-5.59	-5.09	-1.70	-5.76
Semiconductor TAM	-	5.29	0.17	9.53	11.38	13.90	19.72	10.75

Source: Dataquest (February 1998)

Table 2-4
China/Hong Kong's Midrange Computer Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	-	-	-	0.1	0.2	0.4	0.5	-
Manufacturing ASP (U.S.$)	-	-	-	46,305.0	46,140.3	45,701.1	44,121.7	-
Manufacturing Revenue (U.S.$M)	-	-	-	4.6	9.2	18.3	22.1	-
Semiconductor Content (U.S.$)	11,028.8	11,040.4	11,067.5	12,325.7	12,650.1	13,089.3	13,125.6	-
Semiconductor TAM (U.S.$M)	-	-	-	1.2	2.5	5.2	6.6	-
Growth (%)								
Units	-	NM	NM	NM	100.00	100.00	25.00	NM
Manufacturing ASP	-	NM	NM	NM	-0.36	-0.95	-3.46	NM
Manufacturing Revenue	-	NM	NM	NM	99.29	98.10	20.68	NM
Semiconductor Content	-	0.10	0.25	11.37	2.63	3.47	0.28	3.52
Semiconductor TAM	-	NM	NM	NM	105.26	106.94	25.35	NM

NM = Not meaningful
Source: Dataquest (February 1998)

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Table 2-5
China/Hong Kong's Mainframe/Supercomputer Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	0.8	0.9	0.9	0.9	1.2	1.1	1.2	-
Manufacturing ASP (U.S.$)	751,584.0	665,648.0	579,622.9	544,978.5	496,030.0	460,571.2	417,770.5	-
Manufacturing Revenue (U.S.$M)	570.6	586.8	508.6	508.5	576.8	502.3	487.2	-
Semiconductor Content (U.S.$)	67,642.6	63,236.6	57,962.3	54,497.8	52,083.2	49,741.7	45,119.2	-
Semiconductor TAM (U.S.$M)	51.4	55.7	50.9	50.9	60.6	54.2	52.6	-
Growth (%)								
Units	-	16.10	-0.45	6.33	24.62	-6.22	6.94	5.76
Manufacturing ASP	-	-11.43	-12.92	-5.98	-8.98	-7.15	-9.29	-8.90
Manufacturing Revenue	-	2.83	-13.32	-0.02	13.43	-12.92	-3.00	-3.65
Semiconductor Content	-	-6.51	-8.34	-5.98	-4.43	-4.50	-9.29	-6.53
Semiconductor TAM	-	8.54	-8.75	-0.02	19.10	-10.43	-3.00	-1.15

Source: Dataquest (February 1998)

Table 2-6
China/Hong Kong's Page Printer Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	35.3	51.1	74.2	118.6	194.6	319.1	522.7	-
Manufacturing ASP (U.S.$)	530.0	512.0	503.0	490.0	479.0	467.0	455.2	-
Manufacturing Revenue (U.S.$M)	18.7	26.2	37.3	58.1	93.2	149.0	238.0	-
Semiconductor Content (U.S.$)	139.2	138.5	140.5	145.2	156.2	162.8	168.9	-
Semiconductor TAM (U.S.$M)	4.9	7.1	10.4	17.2	30.4	52.0	88.3	-
Growth (%)								
Units	-	45.00	45.00	60.00	64.00	64.00	63.81	59.19
Manufacturing ASP	-	-3.40	-1.76	-2.58	-2.24	-2.51	-2.53	-2.32
Manufacturing Revenue	-	40.08	42.45	55.86	60.32	59.89	59.67	55.49
Semiconductor Content	-	-0.50	1.44	3.37	7.55	4.23	3.75	4.05
Semiconductor TAM	-	44.27	47.09	65.39	76.39	70.93	69.95	65.63

Source: Dataquest (February 1998)

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Table 2-7
China/Hong Kong's Serial Printer Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	454.0	510.8	579.2	653.3	731.1	815.1	898.5	-
Manufacturing ASP (U.S.$)	207.4	200.0	194.4	190.5	185.5	182.3	178.6	-
Manufacturing Revenue (U.S.$M)	94.2	102.2	112.6	124.4	135.6	148.6	160.5	-
Semiconductor Content (U.S.$)	24.2	24.8	26.6	28.4	30.2	31.8	32.5	-
Semiconductor TAM (U.S.$M)	11.0	12.7	15.4	18.6	22.1	25.9	29.2	-
Growth (%)								
Units	-	12.50	13.40	12.80	11.90	11.50	10.22	11.96
Manufacturing ASP	-	-3.56	-2.80	-2.04	-2.63	-1.72	-2.02	-2.24
Manufacturing Revenue	-	8.50	10.23	10.50	8.96	9.59	7.99	9.45
Semiconductor Content	-	2.48	7.15	6.83	6.25	5.14	2.28	5.52
Semiconductor TAM	-	15.29	21.51	20.51	18.89	17.23	12.73	18.13

Source: Dataquest (February 1998)

Table 2-8
China/Hong Kong's Rigid Disk Drive Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	2,683.1	5,300.0	7,000.0	9,377.4	12,368.8	14,842.6	17,324.6	-
Manufacturing ASP (U.S.$)	220.0	246.9	250.4	254.2	239.3	254.8	254.8	-
Manufacturing Revenue (U.S.$M)	590.3	1,308.3	1,752.6	2,383.6	2,960.0	3,781.6	4,414.3	-
Semiconductor Content (U.S.$)	30.1	30.1	29.1	27.7	26.4	25.1	25.1	-
Semiconductor TAM (U.S.$M)	80.7	159.7	203.7	259.9	326.5	372.0	434.8	-
Growth (%)								
Units	-	97.53	32.08	33.96	31.90	20.00	16.72	26.73
Manufacturing ASP	-	12.21	1.43	1.52	-5.85	6.46	0.01	0.64
Manufacturing Revenue	-	121.64	33.96	36.00	24.18	27.76	16.73	27.54
Semiconductor Content	-	0.15	-3.43	-4.75	-4.75	-5.07	0.16	-3.59
Semiconductor TAM	-	97.82	27.55	27.59	25.64	13.91	16.91	22.18

Source: Dataquest (February 1998)

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Table 2-9
China/Hong Kong's Optical Disk Drive Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	1,500.0	1,800.0	2,340.0	3,159.0	3,790.8	4,169.9	4,575.5	-
Manufacturing ASP (U.S.$)	81.4	80.0	78.0	75.0	72.0	70.0	67.9	-
Manufacturing Revenue (U.S.$M)	122.1	144.0	182.5	236.9	272.9	291.9	310.7	-
Semiconductor Content (U.S.$)	20.4	20.0	23.4	18.0	16.6	16.8	16.8	-
Semiconductor TAM (U.S.$M)	30.5	36.0	54.8	56.9	62.8	70.1	76.9	-
Growth (%)								
Units	-	20.00	30.00	35.00	20.00	10.00	9.73	20.51
Manufacturing ASP	-	-1.72	-2.50	-3.85	-4.00	-2.78	-3.00	-3.23
Manufacturing Revenue	-	17.94	26.75	29.81	15.20	6.94	6.44	16.62
Semiconductor Content	-	-1.72	17.00	-23.08	-8.00	1.45	0	-3.43
Semiconductor TAM	-	17.94	52.10	3.85	10.40	11.59	9.73	16.38

Source: Dataquest (February 1998)

Table 2-10
China/Hong Kong's Monitor Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	5,426.1	7,550.0	12,117.8	15,147.2	19,691.3	23,629.6	27,882.9	-
Manufacturing ASP (U.S.$)	174.7	174.7	174.7	167.2	164.7	163.8	161.8	-
Manufacturing Revenue (U.S.$M)	947.9	1,319.0	2,116.9	2,532.8	3,242.9	3,871.2	4,510.2	-
Semiconductor Content (U.S.$)	18.0	17.0	17.0	16.0	16.0	15.0	15.0	-
Semiconductor TAM (U.S.$M)	97.7	128.4	206.0	242.4	315.1	354.4	418.2	-
Growth (%)								
Units	-	39.14	60.50	25.00	30.00	20.00	18.00	29.86
Manufacturing ASP	-	0	0	-4.28	-1.51	-0.52	-1.26	-1.53
Manufacturing Revenue	-	39.14	60.49	19.65	28.04	19.37	16.51	27.88
Semiconductor Content	-	-5.56	0	-5.88	0	-6.25	0	-2.47
Semiconductor TAM	-	31.41	60.49	17.65	30.00	12.50	18.00	26.65

Source: Dataquest (February 1998)

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Chapter 3
Communications Equipment

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Table 3-1
China/Hong Kong's LAN Card Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	600.0	1,000.0	1,500.0	1,800.0	2,200.0	2,700.0	3,189.4	-
Manufacturing ASP (U.S.$)	21.7	20.0	19.0	18.5	15.0	12.0	10.5	-
Manufacturing Revenue (U.S.$M)	13.0	20.0	28.5	33.3	33.0	32.4	33.5	-
Semiconductor Content (U.S.$)	9.0	7.0	7.0	6.8	6.8	6.6	6.5	-
Semiconductor TAM (U.S.$M)	5.4	7.0	10.5	12.3	14.9	17.8	20.7	-
Growth (%)								
Units	-	66.67	50.00	20.00	22.22	22.73	18.12	26.11
Manufacturing ASP	-	-8.00	-5.00	-2.63	-18.92	-20.00	-12.50	-12.09
Manufacturing Revenue	-	53.33	42.50	16.84	-0.90	-1.82	3.36	10.86
Semiconductor Content	-	-22.41	-0.11	-2.10	-1.39	-2.22	-1.52	-1.47
Semiconductor TAM	-	29.31	49.83	17.48	20.53	20.00	16.33	24.25

Source: Dataquest (February 1998)

Table 3-2
China/Hong Kong's Fax Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	790.7	841.2	761.3	795.5	835.3	889.6	938.5	-
Manufacturing ASP (U.S.$)	244.5	234.0	222.5	209.5	201.8	190.9	180.3	-
Manufacturing Revenue (U.S.$M)	193.3	196.9	169.4	166.7	168.6	169.8	169.2	-
Semiconductor Content (U.S.$)	67.5	61.0	58.0	52.0	50.0	45.0	45.0	-
Semiconductor TAM (U.S.$M)	53.4	51.3	44.2	41.4	41.8	40.0	42.2	-
Growth (%)								
Units	-	6.39	-9.50	4.50	5.00	6.50	5.49	2.21
Manufacturing ASP	-	-4.28	-4.95	-5.80	-3.69	-5.41	-5.56	-5.09
Manufacturing Revenue	-	1.83	-13.98	-1.56	1.12	0.74	-0.37	-2.99
Semiconductor Content	-	-9.63	-4.92	-10.34	-3.85	-10.00	0	-5.90
Semiconductor TAM	-	-3.86	-13.95	-6.31	0.96	-4.15	5.49	-3.82

Source: Dataquest (February 1998)

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Table 3-3
China/Hong Kong's Modem Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	17.0	22.0	51.8	121.7	249.4	461.5	849.1	-
Manufacturing ASP (U.S.$)	94.1	89.2	83.1	77.9	73.0	70.1	67.0	-
Manufacturing Revenue (U.S.$M)	1.6	2.0	4.3	9.5	18.2	32.4	56.9	-
Semiconductor Content (U.S.$)	32.0	30.0	29.0	28.0	27.0	27.0	26.8	-
Semiconductor TAM (U.S.$M)	0.5	0.7	1.5	3.4	6.7	12.5	22.8	-
Growth (%)								
Units	-	29.50	135.01	135.00	105.00	85.00	84.00	107.58
Manufacturing ASP	-	-5.19	-6.85	-6.29	-6.20	-3.96	-4.49	-5.56
Manufacturing Revenue	-	22.78	118.90	120.22	92.30	77.67	75.74	96.02
Semiconductor Content	-	-6.23	-3.32	-3.45	-3.58	0.02	-0.77	-2.23
Semiconductor TAM	-	21.43	127.21	126.90	97.66	85.04	82.59	102.95

Source: Dataquest (February 1998)

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Table 3-4
China/Hong Kong's Central-Office/Premise Line Card Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	13,668.3	16,059.0	18,930.8	21,162.0	24,796.4	28,375.0	35,200.8	-
Manufacturing ASP (U.S.$)	77.5	75.5	74.0	72.0	70.0	69.0	68.0	-
Manufacturing Revenue (U.S.$M)	1,059.3	1,212.5	1,400.9	1,523.7	1,735.7	1,957.9	2,393.7	-
Semiconductor Content (U.S.$)	11.7	12.0	11.3	10.8	10.5	10.5	10.5	-
Semiconductor TAM (U.S.$M)	159.5	192.6	213.0	228.5	260.4	297.9	369.6	-
Growth (%)								
Units	-	17.49	17.88	11.79	17.17	14.43	24.06	16.99
Manufacturing ASP	-	-2.58	-1.99	-2.70	-2.78	-1.43	-1.45	-2.07
Manufacturing Revenue	-	14.46	15.54	8.76	13.92	12.80	22.26	14.57
Semiconductor Content	-	2.79	-6.22	-4.00	-2.78	0	0	-2.63
Semiconductor TAM	-	20.77	10.55	7.31	13.92	14.43	24.06	13.92

Source: Dataquest (February 1998)

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Table 3-5
China/Hong Kong's Corded Telephone Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	89,504.8	99,995.1	105,457.9	112,725.6	118,950.0	124,272.9	130,166.0	-
Manufacturing ASP (U.S.$)	23.5	21.8	20.5	19.3	18.4	17.7	17.0	-
Manufacturing Revenue (U.S.$M)	2,107.0	2,177.9	2,159.2	2,172.7	2,191.8	2,199.9	2,206.4	-
Semiconductor Content (U.S.$)	2.5	2.6	2.6	2.7	2.7	2.8	2.9	-
Semiconductor TAM (U.S.$M)	225.6	255.0	274.2	298.7	321.2	341.8	371.0	-
Growth (%)								
Units	-	11.72	5.46	6.89	5.52	4.47	4.74	5.42
Manufacturing ASP	-	-7.48	-5.99	-5.86	-4.40	-3.93	-4.24	-4.89
Manufacturing Revenue	-	3.37	-0.86	0.62	0.88	0.37	0.30	0.26
Semiconductor Content	-	1.19	1.96	1.92	1.89	1.85	3.64	2.25
Semiconductor TAM	-	13.05	7.53	8.95	7.51	6.41	8.55	7.79

Source: Dataquest (February 1998)

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Table 3-6
China/Hong Kong's Answering Machine Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	5,197.5	6,756.7	8,445.9	9,712.8	10,684.1	11,218.3	11,798.6	-
Manufacturing ASP (U.S.$)	41.0	39.0	36.9	37.9	41.0	43.8	45.2	-
Manufacturing Revenue (U.S.$M)	213.3	263.8	311.2	367.6	438.0	490.8	533.4	-
Semiconductor Content (U.S.$)	11.9	12.3	12.8	13.3	14.5	16.0	18.5	-
Semiconductor TAM (U.S.$M)	62.0	83.2	108.1	129.5	154.4	179.3	218.3	-
Growth (%)								
Units	-	30.00	25.00	15.00	10.00	5.00	5.17	11.79
Manufacturing ASP	-	-4.87	-5.62	2.71	8.32	6.71	3.33	2.97
Manufacturing Revenue	-	23.67	17.98	18.12	19.15	12.04	8.67	15.12
Semiconductor Content	-	3.30	3.88	4.14	8.44	10.61	15.72	8.47
Semiconductor TAM	-	34.29	29.85	19.76	19.28	16.14	21.70	21.26

Source: Dataquest (February 1998)

Table 3-7
China/Hong Kong's Analog Cordless Phone Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	14,342.0	19,853.8	17,690.6	16,079.1	15,224.7	14,590.3	13,500.7	-
Manufacturing ASP (U.S.$)	49.0	48.0	44.1	42.1	41.1	39.6	35.6	-
Manufacturing Revenue (U.S.$M)	702.8	953.0	779.4	677.4	626.3	577.6	480.7	-
Semiconductor Content (U.S.$)	25.0	26.0	26.0	28.0	28.0	28.7	28.5	-
Semiconductor TAM (U.S.$M)	358.6	516.2	460.0	450.2	426.2	418.9	384.8	-
Growth (%)								
Units	-	38.43	-10.90	-9.11	-5.31	-4.17	-7.47	-7.42
Manufacturing ASP	-	-2.04	-8.22	-4.37	-2.35	-3.77	-10.06	-5.80
Manufacturing Revenue	-	35.61	-18.22	-13.09	-7.54	-7.78	-16.78	-12.79
Semiconductor Content	-	4.00	0	7.69	-0.01	2.54	-0.73	1.85
Semiconductor TAM	-	43.97	-10.89	-2.12	-5.33	-1.73	-8.14	-5.71

Source: Dataquest (February 1998)

Table 3-8
China/Hong Kong's Digital Cordless Telephone Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	325.0	802.1	1,203.1	1,612.1	2,095.8	2,682.6	3,487.3	-
Manufacturing ASP (U.S.$)	151.3	118.0	94.0	82.0	74.0	65.0	58.0	-
Manufacturing Revenue (U.S.$M)	49.2	94.6	113.1	132.2	155.1	174.4	202.3	-
Semiconductor Content (U.S.$)	92.0	73.0	57.0	53.5	52.2	51.5	50.3	-
Semiconductor TAM (U.S.$M)	29.9	58.5	68.6	86.2	109.4	138.2	175.4	-
Growth (%)								
Units	-	146.79	50.00	34.00	30.00	28.00	30.00	34.17
Manufacturing ASP	-	-22.02	-20.34	-12.77	-9.76	-12.16	-10.77	-13.24
Manufacturing Revenue	-	92.43	19.49	16.89	17.32	12.43	16.00	16.40
Semiconductor Content	-	-20.65	-21.92	-6.14	-2.43	-1.34	-2.33	-7.18
Semiconductor TAM	-	95.82	17.12	25.77	26.84	26.28	26.97	24.54

Source: Dataquest (February 1998)

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Table 3-9
China/Hong Kong's Analog Cellular Telephone Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	578.8	572.0	537.7	500.0	464.0	429.2	394.9	-
Manufacturing ASP (U.S.$)	243.9	185.0	168.0	150.0	128.0	120.0	108.5	-
Manufacturing Revenue (U.S.$M)	141.2	105.8	90.3	75.0	59.4	51.5	42.8	-
Semiconductor Content (U.S.$)	36.0	33.0	33.0	31.0	30.0	29.1	28.5	-
Semiconductor TAM (U.S.$M)	20.8	18.9	17.7	15.5	13.9	12.5	11.2	-
Growth (%)								
Units	-	-1.18	-6.00	-7.00	-7.20	-7.50	-8.00	-7.14
Manufacturing ASP	-	-24.14	-9.19	-10.71	-14.67	-6.25	-9.58	-10.12
Manufacturing Revenue	-	-25.04	-14.64	-16.96	-20.81	-13.28	-16.82	-16.54
Semiconductor Content	-	-8.35	0	-6.02	-3.23	-3.09	-2.16	-2.92
Semiconductor TAM	-	-9.43	-6.00	-12.60	-10.20	-10.35	-9.99	-9.85

Source: Dataquest (February 1998)

Table 3-10
China/Hong Kong's Digital Cellular Telephone Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	961.6	2,550.0	3,786.8	5,320.4	7,714.6	10,993.2	15,533.1	-
Manufacturing ASP (U.S.$)	380.0	325.0	253.0	215.0	182.0	160.0	142.0	-
Manufacturing Revenue (U.S.$M)	365.4	828.8	958.0	1,143.9	1,404.0	1,758.9	2,205.7	-
Semiconductor Content (U.S.$)	88.7	80.1	69.5	62.7	58.9	56.0	54.0	-
Semiconductor TAM (U.S.$M)	85.3	204.2	263.1	333.7	454.1	615.3	838.8	-
Growth (%)								
Units	-	165.17	48.50	40.50	45.00	42.50	41.30	43.53
Manufacturing ASP	-	-14.47	-22.15	-15.02	-15.35	-12.09	-11.25	-15.26
Manufacturing Revenue	-	126.79	15.60	19.40	22.74	25.27	25.40	21.63
Semiconductor Content	-	-9.71	-13.24	-9.73	-6.16	-4.91	-3.52	-7.58
Semiconductor TAM	-	139.43	28.84	26.83	36.06	35.50	36.32	32.65

Source: Dataquest (February 1998)

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Table 3-11
China/Hong Kong's Pager Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	5,874.5	6,430.0	7,233.8	8,089.5	9,192.1	9,829.1	10,537.8	-
Manufacturing ASP (U.S.$)	93.6	87.0	84.1	81.8	80.8	78.2	76.8	-
Manufacturing Revenue (U.S.$M)	549.8	559.3	608.1	661.7	742.8	769.0	809.1	-
Semiconductor Content (U.S.$)	12.5	12.4	13.1	13.6	13.9	13.8	13.7	-
Semiconductor TAM (U.S.$M)	73.7	80.0	94.6	110.1	128.0	135.8	144.4	-
Growth (%)								
Units	-	9.46	12.50	11.83	13.63	6.93	7.21	10.38
Manufacturing ASP	-	-7.06	-3.35	-2.70	-1.20	-3.19	-1.87	-2.46
Manufacturing Revenue	-	1.73	8.73	8.81	12.27	3.52	5.21	7.66
Semiconductor Content	-	-0.80	5.07	4.05	2.32	-0.77	-0.84	1.94
Semiconductor TAM	-	8.58	18.20	16.36	16.27	6.10	6.31	12.52

Source: Dataquest (February 1998)

Table 3-12
China/Hong Kong's Mobile Communications Infrastructure Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	-	-	-	-	-	-	-	-
Manufacturing ASP (U.S.$)	-	-	-	-	-	-	-	-
Manufacturing Revenue (U.S.$M)	128.3	165.0	175.7	187.1	201.2	215.9	234.0	-
Semiconductor Content (U.S.$)	-	-	-	-	-	-	-	-
Growth (%)								
Units	-	NM	NM	NM	NM	NM	NM	NM
Manufacturing ASP	-	NM	NM	NM	NM	NM	NM	NM
Manufacturing Revenue	-	28.59	6.50	6.50	7.50	7.30	8.40	7.24
Semiconductor Content	-	NM	NM	NM	NM	NM	NM	NM
Semiconductor TAM	-	28.59	6.50	6.50	7.50	7.30	8.40	7.24

NM = Not meaningful
Source: Dataquest (February 1998)

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Table 3-13
China/Hong Kong's Premise Switching Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	983.8	1,288.4	1,738.9	2,211.3	2,681.2	3,156.3	3,630.9	-
Manufacturing ASP (U.S.$)	98.6	92.1	90.4	87.2	85.0	80.2	75.7	-
Manufacturing Revenue (U.S.$M)	97.0	118.6	157.2	192.9	227.8	253.1	274.8	-
Semiconductor Content (U.S.$)	14.5	13.1	11.1	10.7	10.9	10.4	10.2	-
Growth (%)								
Units	-	30.96	34.97	27.16	21.25	17.72	15.04	23.03
Manufacturing ASP	-	-6.61	-1.81	-3.51	-2.61	-5.61	-5.63	-3.85
Manufacturing Revenue	-	22.31	32.53	22.70	18.09	11.11	8.56	18.29
Semiconductor Content	-	-9.40	-15.26	-3.78	1.78	-4.87	-1.45	-4.90
Semiconductor TAM	-	18.65	14.38	22.35	23.41	11.98	13.37	17.00

Source: Dataquest (February 1998)

Chapter 4

Consumer Electronic Equipment

Table 4-1
China/Hong Kong's Color TV Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	20,784.3	22,862.7	26,292.1	31,182.5	37,450.1	44,940.2	55,469.4	-
Manufacturing ASP (U.S.$)	140.0	150.0	160.0	161.0	162.0	167.0	169.3	-
Manufacturing Revenue (U.S.$M)	2,909.8	3,429.4	4,206.7	5,020.4	6,066.9	7,505.0	9,390.8	-
Semiconductor Content (U.S.$)	17.4	18.0	20.4	20.4	20.4	21.4	22.2	-
Semiconductor TAM (U.S.$M)	361.6	411.5	536.3	636.1	764.0	961.7	1,231.4	-
Growth (%)								
Units	-	10.00	15.00	18.60	20.10	20.00	23.43	19.39
Manufacturing ASP	-	7.14	6.67	0.63	0.62	3.09	1.38	2.45
Manufacturing Revenue	-	17.86	22.67	19.34	20.85	23.70	25.13	22.32
Semiconductor Content	-	3.45	13.32	0	0	4.90	3.74	4.28
Semiconductor TAM	-	13.80	30.32	18.60	20.10	25.87	28.05	24.51

Source: Dataquest (February 1998)

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Table 4-2
China/Hong Kong's VCR Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	1,941.2	2,310.0	2,521.0	2,667.4	2,725.3	2,591.1	2,506.2	-
Manufacturing ASP (U.S.$)	152.4	144.9	137.5	133.1	127.7	122.8	117.9	-
Manufacturing Revenue (U.S.$M)	295.9	334.8	346.6	355.1	348.1	318.2	295.4	-
Semiconductor Content (U.S.$)	30.5	32.4	32.0	31.1	30.4	30.8	30.2	-
Semiconductor TAM (U.S.$M)	59.1	74.8	80.6	83.1	82.9	79.8	75.7	-
Growth (%)								
Units	-	19.00	9.13	5.81	2.17	-4.93	-3.27	1.64
Manufacturing ASP	-	-4.91	-5.15	-3.16	-4.06	-3.86	-4.02	-4.05
Manufacturing Revenue	-	13.15	3.51	2.46	-1.98	-8.60	-7.16	-2.48
Semiconductor Content	-	6.37	-1.30	-2.60	-2.37	1.28	-1.95	-1.40
Semiconductor TAM	-	26.58	7.71	3.06	-0.25	-3.71	-5.17	0.22

Source: Dataquest (February 1998)

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Table 4-3
China/Hong Kong's Analog Camcorder Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	82.2	292.4	330.3	386.9	478.8	576.9	661.3	-
Manufacturing ASP (U.S.$)	387.6	365.0	326.0	312.4	302.5	295.5	290.2	-
Manufacturing Revenue (U.S.$M)	31.9	106.7	107.7	120.9	144.8	170.5	191.9	-
Semiconductor Content (U.S.$)	120.3	88.9	81.1	74.7	67.7	64.7	61.5	-
Semiconductor TAM (U.S.$M)	9.9	26.0	26.8	28.9	32.4	37.3	40.7	-
Growth (%)								
Units	-	255.69	12.96	17.16	23.73	20.50	14.62	17.73
Manufacturing ASP	-	-5.83	-10.69	-4.18	-3.16	-2.31	-1.79	-4.48
Manufacturing Revenue	-	234.95	0.88	12.27	19.83	17.72	12.57	12.45
Semiconductor Content	-	-26.08	-8.75	-7.98	-9.34	-4.47	-4.90	-7.11
Semiconductor TAM	-	162.93	3.08	7.81	12.17	15.12	9.01	9.36

Source: Dataquest (February 1998)

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Table 4-4
China/Hong Kong's Digital Camcorder Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	-	-	-	1.0	3.0	10.0	15.0	-
Manufacturing ASP (U.S.$)	-	-	834.4	740.2	610.5	525.6	485.8	-
Manufacturing Revenue (U.S.$M)	-	-	-	0.7	1.8	5.3	7.3	-
Semiconductor Content (U.S.$)	-	-	207.7	166.3	131.6	115.1	105.0	-
Semiconductor TAM (U.S.$M)	-	-	-	0.2	0.4	1.2	1.6	-
Growth (%)								
Units	-	NM	NM	NM	200.00	233.33	50.00	NM
Manufacturing ASP	-	NM	NM	-11.29	-17.52	-13.91	-7.57	NM
Manufacturing Revenue	-	NM	NM	NM	147.43	186.98	38.65	NM
Semiconductor Content	-	NM	NM	-19.92	-20.90	-12.51	-8.78	NM
Semiconductor TAM	-	NM	NM	NM	137.30	191.63	36.84	NM

NM = Not meaningful
Source: Dataquest (February 1998)

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Table 4-5
China/Hong Kong's Digital Still Camera Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	-	-	4.0	15.5	35.2	60.2	95.5	-
Manufacturing ASP (U.S.$)	-	-	191.5	179.5	166.2	146.0	135.7	-
Manufacturing Revenue (U.S.$M)	-	-	0.8	2.8	5.9	8.8	13.0	-
Semiconductor Content (U.S.$)	-	-	112.9	98.6	89.5	71.0	65.5	-
Semiconductor TAM (U.S.$M)	-	-	0.5	1.5	3.2	4.3	6.3	-
Growth (%)								
Units	-	NM	NM	287.50	127.10	71.02	58.64	NM
Manufacturing ASP	-	NM	NM	-6.25	-7.39	-12.18	-7.02	NM
Manufacturing Revenue	-	NM	NM	263.30	110.32	50.19	47.51	NM
Semiconductor Content	-	NM	NM	-12.60	-9.26	-20.70	-7.71	NM
Semiconductor TAM	-	NM	NM	238.67	106.07	35.61	46.41	NM

NM = Not meaningful
Source: Dataquest (February 1998)

Table 4-6
China/Hong Kong's Personal/Portable Stereo Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	30,875.0	27,000.0	28,350.0	29,067.5	30,520.9	32,046.9	32,046.9	-
Manufacturing ASP (U.S.$)	31.1	31.3	32.0	32.5	33.0	33.5	34.0	-
Manufacturing Revenue (U.S.$M)	960.0	845.1	907.2	944.7	1,007.2	1,073.6	1,089.6	-
Semiconductor Content (U.S.$)	6.0	6.0	6.0	5.5	5.6	5.6	5.5	-
Semiconductor TAM (U.S.$M)	185.8	162.5	169.8	160.7	170.2	178.3	176.3	-
Growth (%)								
Units	-	-12.55	5.00	2.53	5.00	5.00	0	3.49
Manufacturing ASP	-	0.67	2.24	1.56	1.54	1.52	1.49	1.67
Manufacturing Revenue	-	-11.97	7.35	4.13	6.62	6.59	1.49	5.21
Semiconductor Content	-	0.06	-0.51	-7.68	0.86	-0.26	-1.13	-1.79
Semiconductor TAM	-	-12.50	4.46	-5.34	5.90	4.73	-1.13	1.63

Source: Dataquest (February 1998)

Table 4-7
China/Hong Kong's Digital Video Player Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	-	-	4.9	35.2	80.0	450.0	1,325.0	-
Manufacturing ASP (U.S.$)	-	-	425.0	350.5	275.0	245.2	196.0	-
Manufacturing Revenue (U.S.$M)	-	-	2.1	12.3	22.0	110.3	259.8	-
Semiconductor Content (U.S.$)	-	-	125.0	115.8	94.5	88.6	74.2	-
Semiconductor TAM (U.S.$M)	-	-	0.6	4.1	7.6	39.9	98.4	-
Growth (%)								
Units	-	NM	NM	619.84	127.27	462.50	194.44	NM
Manufacturing ASP	-	NM	NM	-17.53	-21.54	-10.83	-20.05	NM
Manufacturing Revenue	-	NM	NM	493.65	78.31	401.58	135.41	NM
Semiconductor Content	-	NM	NM	-7.36	-18.39	-6.24	-16.22	NM
Semiconductor TAM	-	NM	NM	566.86	85.47	427.38	146.69	NM

NM = Not meaningful
Source: Dataquest (February 1998)

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Table 4-8
China/Hong Kong's Set-Top Box—Analog Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	5.9	15.6	70.5	198.0	310.5	385.0	425.0	-
Manufacturing ASP (U.S.$)	52.8	50.5	50.0	50.4	49.2	48.0	47.1	-
Manufacturing Revenue (U.S.$M)	0.3	0.8	3.5	10.0	15.3	18.5	20.0	-
Semiconductor Content (U.S.$)	40.8	37.2	33.5	29.7	29.7	30.4	30.9	-
Semiconductor TAM (U.S.$M)	0.2	0.6	2.4	5.9	9.2	11.7	13.1	-
Growth (%)								
Units	-	164.22	351.71	180.71	56.82	23.99	10.39	93.63
Manufacturing ASP	-	-4.27	-1.00	0.78	-2.44	-2.44	-1.87	-1.40
Manufacturing Revenue	-	152.93	347.22	182.89	52.99	20.97	8.32	90.91
Semiconductor Content	-	-8.78	-10.03	-11.25	-0.18	2.61	1.49	-3.66
Semiconductor TAM	-	141.01	306.42	149.13	56.54	27.23	12.04	86.55

Source: Dataquest (February 1998)

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Table 4-9
China/Hong Kong's Set-Top Box—Digital Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	-	-	2.5	25.0	125.0	350.0	425.0	-
Manufacturing ASP (U.S.$)	292.0	283.5	260.8	242.0	223.0	214.0	210.0	-
Manufacturing Revenue (U.S.$M)	-	-	0.7	6.1	27.9	74.9	89.3	-
Semiconductor Content (U.S.$)	140.8	125.1	108.1	112.5	108.0	106.5	102.5	-
Semiconductor TAM (U.S.$M)	-	-	0.3	2.8	13.5	37.3	43.6	-
Growth (%)								
Units	-	NM	NM	900.00	400.00	180.00	21.43	NM
Manufacturing ASP	-	-2.91	-8.01	-7.21	-7.85	-4.04	-1.87	-5.83
Manufacturing Revenue	-	NM	NM	827.91	360.74	168.70	19.16	NM
Semiconductor Content	-	-11.09	-13.63	4.06	-3.99	-1.39	-3.76	-3.91
Semiconductor TAM	-	NM	NM	940.64	380.07	176.11	16.87	NM

NM = Not meaningful
Source: Dataquest (February 1998)

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Table 4-10
China/Hong Kong's Video Game Controller Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	317.7	552.0	579.6	614.4	639.0	658.1	677.9	-
Manufacturing ASP (U.S.$)	170.0	165.2	145.8	142.3	139.7	135.6	128.8	-
Manufacturing Revenue (U.S.$M)	54.0	91.2	84.5	87.4	89.2	89.2	87.3	-
Semiconductor Content (U.S.$)	94.0	84.0	78.0	79.0	78.0	73.0	67.0	-
Semiconductor TAM (U.S.$M)	29.9	46.4	45.2	48.5	49.8	48.0	45.4	-
Growth (%)								
Units	-	73.77	5.00	6.00	4.00	3.00	3.00	4.19
Manufacturing ASP	-	-2.82	-11.74	-2.40	-1.86	-2.90	-5.03	-4.86
Manufacturing Revenue	-	68.86	-7.33	3.46	2.06	0.01	-2.18	-0.87
Semiconductor Content	-	-10.64	-7.14	1.28	-1.27	-6.41	-8.22	-4.42
Semiconductor TAM	-	55.28	-2.50	7.36	2.68	-3.60	-5.47	-0.41

Source: Dataquest (February 1998)

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Chapter 5
Transportation Electronic Equipment

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Table 5-1
China/Hong Kong's Auto Stereo System Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	5,032.7	5,887.8	6,829.9	8,059.2	9,671.1	11,605.3	14,321.2	-
Manufacturing ASP (U.S.$)	60.0	59.0	58.0	57.0	56.0	55.0	54.0	-
Manufacturing Revenue (U.S.$M)	302.0	347.4	396.1	459.4	541.6	638.3	773.3	-
Semiconductor Content (U.S.$)	12.5	13.2	13.3	13.8	14.2	14.1	14.3	-
Semiconductor TAM (U.S.$M)	63.0	78.0	91.1	111.1	137.7	163.7	204.8	-
Growth (%)								
Units	-	16.99	16.00	18.00	20.00	20.00	23.40	19.46
Manufacturing ASP	-	-1.67	-1.69	-1.72	-1.75	-1.79	-1.82	-1.76
Manufacturing Revenue	-	15.04	14.03	15.97	17.89	17.86	21.16	17.36
Semiconductor Content	-	5.74	0.72	3.38	3.28	-0.98	1.40	1.55
Semiconductor TAM	-	23.71	16.83	21.99	23.93	18.83	25.13	21.30

Source: Dataquest (February 1998)

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Table 5-2
China/Hong Kong's Auto Engine Control Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	0.5	2.0	4.5	9.0	12.0	28.0	50.3	-
Manufacturing ASP (U.S.$)	28.3	28.9	29.7	31.0	32.3	33.7	35.5	-
Manufacturing Revenue (U.S.$M)	0	0.1	0.1	0.3	0.4	0.9	1.8	-
Semiconductor Content (U.S.$)	12.9	13.5	14.3	14.9	15.9	16.7	17.2	-
Semiconductor TAM (U.S.$M)	0	0	0.1	0.1	0.2	0.5	0.9	-
Growth (%)								
Units	-	280.95	125.00	100.00	33.33	133.33	79.61	90.59
Manufacturing ASP	-	2.27	2.78	4.21	4.32	4.39	5.22	4.18
Manufacturing Revenue	-	289.59	131.25	108.42	39.09	143.58	88.99	98.55
Semiconductor Content	-	4.17	5.77	4.56	6.94	4.90	2.81	4.99
Semiconductor TAM	-	296.83	137.99	109.13	42.59	144.77	84.66	100.09

Source: Dataquest (February 1998)

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Table 5-3
China/Hong Kong's Antilock Brake System Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	0.4	0.8	1.9	5.0	12.0	22.4	39.6	-
Manufacturing ASP (U.S.$)	160.0	157.0	150.0	145.0	140.0	135.0	130.0	-
Manufacturing Revenue (U.S.$M)	0.1	0.1	0.3	0.7	1.7	3.0	5.1	-
Semiconductor Content (U.S.$)	37.9	37.9	37.2	37.0	36.8	36.6	36.2	-
Semiconductor TAM (U.S.$M)	0	0	0.1	0.2	0.4	0.8	1.4	-
Growth (%)								
Units	-	114.29	150.00	166.67	140.00	86.67	76.84	121.08
Manufacturing ASP	-	-1.88	-4.46	-3.33	-3.45	-3.57	-3.70	-3.70
Manufacturing Revenue	-	110.27	138.85	157.78	131.72	80.00	70.29	112.89
Semiconductor Content	-	0.10	-1.82	-0.59	-0.48	-0.70	-1.05	-0.93
Semiconductor TAM	-	114.50	145.44	165.09	138.84	85.36	74.98	119.02

Source: Dataquest (February 1998)

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Table 5-4
China/Hong Kong's Air Bag Control Unit Production and Growth Rate Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	0.2	0.4	0.7	1.5	4.8	13.7	41.2	-
Manufacturing ASP (U.S.$)	70.0	68.8	67.6	64.8	61.0	57.9	53.6	-
Manufacturing Revenue (U.S.$M)	0	0	0	0.1	0.3	0.8	2.2	-
Semiconductor Content (U.S.$)	20.7	22.2	22.9	23.6	23.5	22.7	22.5	-
Semiconductor TAM (U.S.$M)	0	0	0	0	0.1	0.3	0.9	-
Growth (%)								
Units	-	128.57	68.75	122.22	220.00	185.83	200.04	152.64
Manufacturing ASP	-	-1.74	-1.74	-4.17	-5.83	-5.00	-7.45	-4.86
Manufacturing Revenue	-	124.60	65.82	112.96	201.33	171.54	177.69	140.37
Semiconductor Content	-	7.24	3.52	2.71	-0.40	-3.18	-0.94	0.31
Semiconductor TAM	-	145.11	74.70	128.25	218.72	176.76	197.22	153.43

Source: Dataquest (February 1998)

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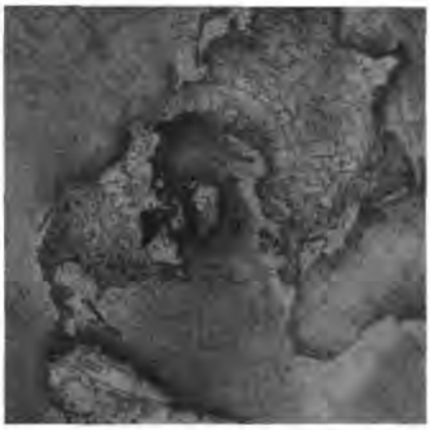

Dataquest

1998 China/Hong Kong Detailed Electronic Equipment Production Forecast

Market Statistics

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MARIA VALENZUELA

Program: Semiconductors China
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1998 China/Hong Kong Detailed Electronic Equipment Production Forecast

Market Statistics

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Chapter 1
Introduction

Electronic equipment production is an important determinant of semiconductor market activity because semiconductor demand is derived, in large part, from the underlying demand for the systems that use semiconductors. Therefore, the forecast of expected future electronics system production is an essential tool to assess expected future semiconductor market activity.

This Market Statistics report contains detailed information on Dataquest's view of the electronic equipment markets in which semiconductors are used. This is the fall forecast that Dataquest will publish this year; the first forecast was published in spring. This second forecast reflects changes in China/Hong Kong production and worldwide consumption outlooks since spring. It also incorporates data revisions and updates suggested by Dataquest's continuing research of the world's dynamic electronic equipment markets. Two key databases previously published on China/Hong Kong are incorporated into this forecast.

The market statistics in this report include the following databases:

- High-volume electronic equipment unit production forecast and semiconductor consumption estimates (1996 to 2001)
- Company-level electronic equipment production and semiconductor consumption estimates (1996 and 1997)

Production is aggregated into one geographic region, China/Hong Kong. Because the majority of semiconductors consumed in China are billed in Hong Kong or shipped by multinationals, Dataquest treats China and Hong Kong as one single market. For regional estimates within China/Hong Kong, Dataquest refers to the recent company-level equipment research. The list of tables details the type of production data by region, application market, and unit of measure.

Segmentation

Dataquest's objective is to provide data along the lines of segmentation that are logical, appropriate to the industry in question, and immediately useful to clients. Dataquest's segmentation for China/Hong Kong is applied across Asia/Pacific and the rest of the world.

Dataquest defines the electronic equipment industry as the group of competing companies primarily engaged in manufacturing electronic goods. For the purposes of this report, important products of the electronics industry include data processing equipment, communications equipment, selected types of industrial equipment, consumer electronics, selected types of military and civilian aerospace and defense-oriented electronics, and automotive electronics.

For forecasting purposes, Dataquest segments the electronics industry into six broad semiconductor application markets, disaggregated into narrower electronic system groups, as follows:

- Data Processing
  - Computers
  - Data storage
  - Input/output sevices
  - Dedicated systems
  - Other data processing
- Communications
  - Premise telecom
  - Public telecom
  - Mobile communications
  - Broadcast and studio equipment
  - Other communications
- Industrial
  - Security and energy management systems
  - Manufacturing systems and instruments
  - Medical equipment
  - Other industrial equipment
- Consumer
  - Audio
  - Video
  - Personal electronics
  - Appliances
  - Other consumer equipment
- Military/Civilian Aerospace
- Transportation

Electronic Equipment Definitions

Electronic system groups comprise the specific electronic equipment types described in the following sections.

Data Processing

Data processing definitions are as follows:

- **Computer systems**: Includes supercomputers, mainframe computers, midrange computers (also known as superminicomputers and minicomputers), workstations, and PC/motherboard upgrades (including portable computers). Computer systems estimate does not include the

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value of the following systems: rigid disk drives, flexible disk drives, keyboards, and displays. Computer systems estimate does include the value of aftermarket sales of the following: graphic boards, motherboards, memory cards-SIMMs, storage host adapters, and serial and parallel I/O boards.

- **Data storage**: Includes rigid disk drives, flexible disk drives, optical disk drives, and tape drives.
- **Input/output devices**: Includes alphanumeric terminals and graphics terminals (for example, X terminals), monitors, funds transfer terminals, printers, media-to-media data conversion, magnetic ink character recognition, optical scanning equipment, plotters, mice, keyboards, and digitizers.
- **Dedicated systems**: Includes electronic copiers, electronic calculators and personal organizers, smart cards (IC cards), dictation/transcribing equipment, electronic typewriters and dedicated word processors, point-of sale terminals and electronic cash registers, and mailing/letter-handling/addressing equipment.
- **Other data processing**: Includes sound/audio boards, digital video boards, accelerator boards, and embedded CPU boards.

Note: The category PC/motherboard upgrades has been revalued and revised from 1995 onward to better reflect the geographic distribution of PC production adjusted for PC motherboard production (see "Line Item Definitions" section for further discussion).

Communications

Communications definitions are as follows:

- **Premise telecom equipment**: Includes image and text communication, such as facsimile and facsimile cards, and video teleconferencing; data communications equipment such as modems and modem cards, digital WAN systems, front-end processors, (local area) network interface cards, LAN hubs and internetworking equipment, remote access systems and VSAT terminals; premise voice systems, such as premise switching equipment (PBX telephone equipment and key telephone systems) and call processing equipment (voice messaging, interactive voice response systems, and automatic call distributors); and desktop terminal equipment, such as telephone sets/pay telephones and cordless telephones, and teleprinters.
- **Public telecom equipment**: Includes transmission equipment, such as multiplexers, carrier systems, microwave radio, laser and infrared transmission equipment, and satellite communications equipment; and central office switching equipment.
- **Mobile communications equipment**: Includes cellular terminals (digital and analog), pagers (one- and two-way), mobile communications infrastructure, and other mobile communications equipment such as mobile radio systems.
- **Broadcast and studio equipment**: Includes audio equipment, video equipment, transmitters and RF power amplifiers, studio transmitter links, cable TV (headend) equipment, closed-circuit TV equipment, and other equipment, such as studio and theater equipment.

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- **Other telecom equipment**: Includes intercom equipment and electrical amplifiers, and communications equipment not elsewhere classified.

Note: "Remote access systems" and "VSAT terminals" are new categories introduced to the forecast this year. Also note that mobile communications has been resegmented to better reflect the realities of this rapidly growing market segment.

Industrial

Industrial definitions are as follows:

- **Security/energy management**: Includes alarm systems, such as intrusion detection and fire detection systems, and energy management systems.
- **Manufacturing systems/instruments**: Includes semiconductor production equipment, controls, process controls, control and processing displays, and robots; and test and measuring equipment such as semiconductor-dedicated automatic test equipment (ATE), other test and measurement equipment, and nuclear electronics.
- **Medical equipment**: Includes diagnostic equipment, therapeutic equipment, patient monitoring equipment, surgical support systems, and irradiation equipment.
- **Other industrial equipment**: Includes vending machines, power supplies, traffic control equipment, and industrial equipment not elsewhere classified.

Consumer

Consumer definitions are as follows:

- **Audio equipment**: Includes compact disc players, radios, portable/personal stereos, stereo components, musical instruments, and tape recorders.
- **Video equipment**: Includes VCRs and VTRs, video cameras and camcorders, video disc players (including video CD and DVD), color and monochrome TVs, and cable/satellite set-top decoders.
- **Personal electronics**: Includes electronic games and toys (systems and cartridges), cameras (traditional and digital), watches, and clocks.
- **Appliances**: Includes air conditioners, microwave ovens, washers and dryers, refrigerators, dishwashers, and ranges and ovens.
- **Other consumer equipment**: Includes automatic garage door openers, and consumer equipment not elsewhere classified.

Military/Civil Aerospace

Military/civil aerospace definitions are as follows:

- **Military/civil aerospace**: Includes radar/sonar/reconnaissance systems, missile/space-related electronics, navigation equipment, electronic warfare, aircraft flight systems, and command and control systems.

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Transportation

Transportation definitions are as follows:

- **Transportation electronics**: Includes in-car entertainment systems such as AM/FM radios, cassette and compact disc players, and radio/cassette combination systems; body control electronics such as four-wheel steering control, 2WD/4WD control; multiplex systems such as driver's door, door locks, windshield wipers, heated rear windows, memory seats, memory steering wheel, remote security systems, and suspension control and traction control systems; lighting controls including automatic headlight systems, timers, reminders, and sequential signal controls; and other body control electronics including aerodynamic aid control and power roof/window controls; driver information systems including electronic dashboard/instrument clusters, analog or digital clusters, electronic analog/digital clocks and compasses, electronic thermometers, head-up displays, navigation and location systems, signal and warning lights, and trip computers; powertrain systems including engine management systems, powertrain sensors, ignition control, fuel injection systems, fuel flow, engine temperature, air temperature, coolant level, wheel speed sensors, and transmission control; and safety and convenience systems including climate control systems (air conditioning/heating), air purifier systems, air bag control systems, antilock braking systems, collision warning systems, and cruise control.

Worldwide Geographic Regions

Dataquest segments the world into four principal geographic regions: Americas; Japan; Europe, Middle East, and Africa; and Asia/Pacific. These regions are further subdivided into various subregions. Dataquest collects and forecasts market data for various subsets of these regions and subregions. Dataquest's worldwide electronic equipment forecast is an aggregate of forecasts for the four principal world geographic regions delineated. Subregional forecast detail for Dataquest's regional forecasts is not developed. The following outlines and defines Dataquest's Asia/Pacific geographic segmentation.

Asia/Pacific

Includes mainland China, Hong Kong Special Administrative Region (SAR), Korea, Singapore, and Taiwan. The rest of Asia/Pacific includes Australia, Bangladesh, Brunei, Cambodia, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, New Zealand, Pakistan, the Philippines, Sri Lanka, Thailand, and Vietnam, as well as the Pacific Island nations that make up Oceania.

Line Item Definitions

The objective of analyzing electronic systems production is to estimate its implications for semiconductor consumption. Therefore, general economic concepts such as production and consumption are tailored to best isolate these implications.

The value of production is estimated as factory revenue. For the purposes of this report, Dataquest defines factory revenue as the money value of the commodity transaction between the original equipment manufacturer

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(OEM) and the point of entry into distribution. In the case of a direct sale that involves no distribution—as is the case with military systems—factory revenue is equal to the final user cost, net of sales taxes.

Production is the value-adding process by which the factors of production (labor and capital) are combined to transform material inputs into the finished goods that are desired for consumption and investment. As such, production can and increasingly does span both time and geography. For example, a North America-owned disk drive company may minimize cost of production by manufacturing products in Singapore (where semiconductors are used as one of many material inputs), for eventual sale in Europe. Dataquest would classify this activity as Asia/Pacific data storage device production, because Dataquest is interested in that stage of the production process that relates particularly to semiconductor consumption. Production would be valued as the money value of the transaction between the North American company's Singapore operation (which is factory revenue) and the European distributor or final user.

Personal computers (PCs) are a particularly challenging example of an electronic product whose production increasingly spans both time and geography. Today, it is not at all uncommon for PCs to be assembled from components manufactured throughout the world. Moreover, the final assembly of a PC often occurs at a locale far removed from the source of its semiconductors. This is true largely because the geographic distribution of PC motherboard production differs substantially from the distribution of final PC assembly and production. Large numbers of PC motherboards are produced in Asia/Pacific. However, the vast majority are incorporated into PCs produced elsewhere in the world. Dataquest has developed a unique methodology to handle the challenge presented by PCs and PC motherboards. Dataquest's forecast for the category PC/Motherboard Upgrades reflects the geographic distribution of PC production adjusted for PC motherboard production. Dataquest does this by estimating the value of PCs produced in each region, exclusive of their motherboards. Dataquest also estimates separately the value of motherboards produced in each region. Dataquest's regional forecasts for the category PC/Motherboard Upgrades is then developed by summing these separate estimates. Dataquest reports a combined value for PCs and PC motherboards because the two products are so closely linked in the minds of consumers, distributors, and producers. Dataquest's separate treatment of PC and PC motherboard production guarantees that the value reported for the category PC/Motherboard Upgrades conforms to the concept of factory revenue applied elsewhere in the forecast.

Data Sources

The historical information presented in the production data has been consolidated from a variety of sources, each of which focuses on a specific part of the market. These sources include the following:

- Dataquest's estimates of systems manufacturers' factory revenue
- U.S. Department of Commerce estimates of manufacturers' shipments
- Japanese production statistics compiled and published by the Ministry of International Trade and Industry (MITI)

- Various European and Asian nations' government agency statistics
- Trade associations
- Estimates presented by knowledgeable and reliable industry spokespersons
- Published product literature and prices

Dataquest believes that the estimates presented here represent the most accurate and meaningful generally available today.

Forecast Methodology for China/Hong Kong

Dataquest feels strongly that quantifying and forecasting electronic equipment production in China/Hong Kong is best achieved in a worldwide collaborative process. Our statistics include surveys of actual manufacturers in China/Hong Kong, as well as worldwide consumption inputs in the key regions consuming China-made products. Dataquest applies a "bottom-up" and "top-down" approach to China/Hong Kong forecasting. Dataquest's knowledge of worldwide semiconductor technologies also enables the assessment of growth potentional of new products, such as DVDs and set-top boxes.

Dataquest uses a variety of forecasting techniques (both qualitative and quantitative) that vary by technology area. An overview of Dataquest forecasting techniques can be found in the *Dataquest Research Methodology* report.

Dataquest follows a three-step process to forecast electronic equipment production. First, current and expected future worldwide macroeconomic conditions are assessed and forecast. Economic information from various public and private sources is used to develop macroeconomic forecasts for the world's major economies. These forecasts identify trends in the economic health of the world's leading consumers and producers of electronic equipment. Using this forecast in conjunction with input from Dataquest's regional offices, Dataquest estimates the overall business climate in which the electronic systems markets will operate.

Second, Dataquest analyzes and forecasts the significant long-range trends and outlook in the various electronic system groups. This analysis establishes a five-year trend growth path or "envelope" for electronic system production.

The final step in the forecast process is to reconcile expected fluctuations about the market trends so that the two do not inexplicably diverge. Dataquest anticipates that, in the absence of shocks to the market, market fluctuations converge toward a long-term trend.

Because the time-series data contained in this document in general is composed of annual observations and is sparse in terms of the number of observations, the data generally does not satisfy the requirements of quantitative empirical techniques such as econometric or statistical time-series models. Therefore, in most cases, Dataquest has used judgmental models (that is, intuitive judgments, expert opinions, and subjective probabilities) or technological models (that is, curve fitting and the use of analogous data).

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Macroeconomic Outlook: Third Quarter 1997

Global Outlook: Prospects Remain Bright despite Pessimism about Transition Economies

The latest forecast for global economic growth from the WEFA Group indicates that the real world gross domestic product (GDP) is expected to grow 3.1 percent in 1997, comparing to 2.7 percent in 1996. Beyond 1997, global real GDP growth is expected to average 3.3 percent. (Note: These figures are dollar-based growth rates that assume 1990 prices and exchange rates). Although the new forecast reflects little change in WEFA's overall outlook for the global economy as a whole, WEFA has changed to the outlooks for several individual countries, especially for the near-term period from 1997 to 1998. WEFA's near-term forecast for the United States has been significantly revised upward in response to continued strong economic growth. In contrast, the near-term outlooks for Eastern Europe and the economies of the former Soviet Union have been substantially downgraded in response to continuing economic difficulties. WEFA has also downgraded its outlook for Latin America's near-term prospects.

Among advanced economies, WEFA now anticipates aggregate real GDP growth for 1997 to average 2.7 percent. Growth is forecast to range from a torrid 3.5 percent in the United States to a tepid 0.9 percent in Italy. Beyond 1997, aggregate real GDP of the world's advanced economies is forecast to average 2.5 percent as U.S. growth returns to more sustainable levels. Canada is expected to average the most rapid economic growth between 1997 and 2001, roughly 3.6 percent, while Italy is forecast to average the slowest, roughly 2.1 percent. Although slight accelerations of inflation are forecast for most advanced economies, WEFA generally expects inflation to remain subdued across developed economies. For advanced economies as a group, inflation is forecast to average 2.5 percent by 2001. Among individual advanced economies, forecast inflation for 2001 ranges from a paltry 3.0 percent in the United States to a mere 1.1 percent in Canada.

WEFA continues to expect the world's developing or emerging economies to outperform their developed counterparts, at least for real GDP growth. Based on WEFA's forecast, Dataquest estimates aggregate emerging economy growth will be at 4.3 percent in 1997. Dataquest estimates that the emerging economy's growth will average even higher between 1997 and 2001, roughly 5.4 percent. Both these averages, however, mask considerable variation in both the near-term and long-term outlooks for individual economies. Once again, WEFA expects China to experience the greatest real GDP growth among emerging nations in 1997. China's 1997 real GDP is forecast to grow 9.8 percent. In contrast, the economies that make up the former Soviet Union are expected to experience the least growth, just 0.1 percent.

Over the longer term, WEFA expects Chinese real GDP growth to slow somewhat, falling to 8.6 percent by 2001. Nonetheless, growth is forecast to average roughly 8.8 percent between 1997 and 2001. This average seems unlikely to be surpassed by any other emerging country or region over the period. As for the economies of the former Soviet Union, WEFA is forecasting a gradual pickup in growth that should raise average real GDP growth among these economies to 4.9 percent by 2001. At this rate, growth among former Soviet economies would rival growth in Latin America and Eastern Europe by 2001. All told, the world's developing economies have significantly reduced inflation in recent years. Nevertheless, inflation across emerging economies is likely to remain above the rates WEFA anticipates for advanced economies.

Regional Outlooks: Americas Temporarily Buoyed by Surging U.S. Growth; Asia/Pacific Braces for Fallout from Currency Crisis

WEFA is continuing to forecast marked differences in regional economic performance. Based on WEFA's forecast, Dataquest estimates that real GDP growth in 1997 will be the fastest in Asia/Pacific (6.8 percent), and the slowest in Europe, Middle East, and Africa (2.1 percent). Americas is expected to experience especially strong growth on account of surging U.S. real GDP at an estimated 3.7 percent, while Japan is forecast to experience a 2.1 percent growth. Generally speaking, WEFA expects these patterns to hold through the longer term. Asia/Pacific should continue to spearhead world economic growth between 1997 and 2001 with an estimated average growth rate of 6.8 percent. Americas' growth is expected to decline somewhat as U.S. real GDP returns to more sustainable levels; Dataquest estimates that Americas' growth will average 2.8 percent between 1997 and 2001. Meanwhile, a general quickening of growth throughout the Europe, Middle East, and Africa region should place that region's average growth on a par with Americas between 1997 and 2001. Finally, Japan is expected to experience a modest pickup in economic activity that should cause Japanese real GDP to average an estimated 2.6 percent growth between 1997 and 2001.

The outlooks for Americas and Asia/Pacific deserve a special comment. As indicated earlier, WEFA's near-term outlook for the Americas has been strongly influenced by bullish GDP growth in the United States. In the first quarter of 1997, U.S. real GDP grew at the whopping annualized rate of 4.9 percent. Recent statistical releases indicate that the annualized real GDP growth in the second quarter of 1997 was more moderate but still a strong 3.3 percent. U.S. real GDP has grown at an annualized rate of 3.4 percent during last year (third quarter 1996 to second quarter 1997). Most economists agree that this rate of economic expansion is not sustainable and must return to more modest levels (between 2.0 percent and 2.5 percent) if an acceleration of inflation is to be avoided. Optimists have been quick to point out that no sign of increased inflation is to be found anywhere in the economy. But for pessimists, this is more like whistling in the dark than anything else because the increased inflation induced by excessive economic growth usually appears with a lag.

WEFA's forecast is based on the assumption that the Fed will increase the Federal Funds Rate, its short-term interest rate target, 25 basis points to 5.75 percent before the end of the year. This assumption also appears to be the expectation currently priced into U.S. financial markets. All told, this expectation may be too optimistic. If annualized, third quarter 1997's real GDP growth equals or is better than the pace of economic expansion set during the past year. A considerably larger boost in interest rates may be necessary to slow the economy to more sustainable levels. Although especially strong real GDP growth in the third quarter of 1997 would certainly raise U.S. growth above WEFA's forecast for 1997, it would, given a likely sharp policy response from the Fed, probably reduce actual growth below WEFA's forecast between 1998 and 2001.

WEFA's Asia/Pacific forecasts may also prove too optimistic. This summer, the region was overwhelmed by a currency crisis that reminded some of Mexico's meltdown in 1994. In retrospect, the crisis had been in the making for sometime. It began to gather steam in late spring when rising concern about Thailand's mounting current account deficit and its means of financing this deficit precipitated devaluation pressure on Thailand's currency, the baht. The Thai government initially responded with a series of policy moves intended to avert devaluation of its currency. Unfortunately, these moves proved unsuccessful and Thailand eventually agreed to devalue the baht nearly 20 percent in July as part of rescue package negotiated with international financial agencies.

As Thailand's troubles progressed, several of its developing neighbors also came under pressure to devalue their currencies. In particular, Malaysia, Indonesia, and the Philippines found their currencies subjected to strong devaluation pressure through June and July. Like Thailand, these countries have experienced rising current account deficits in recent years. However, the size of their deficits relative to GDP have been far smaller than in the case of Thailand, and their means of financing these deficits appear to have been somewhat sounder. Nonetheless, all three countries eventually bowed to devaluation pressures and depreciated their currencies in July.

All the countries involved in the crisis have found it necessary to impose much stricter fiscal and monetary policies. In addition, Thailand will probably have to restructure its financial system significantly. Although the contractionary impacts of these policy moves will be somewhat offset by the effects of currency depreciation, it remains likely that regional growth will be adversely effected, especially over the near term. Several forecasters have already lowered their expectations for the countries impacted by the crisis. Outlooks for Thailand in particular have been sharply curtailed.

Although they have been willing to acknowledge some of Thailand's more egregious sins, several Asia leaders have characterized this summer's currency crisis as an unwarranted speculative attack on their currencies. There have even been calls from some to ban currency trading except where needed to finance trade. No doubt, some of the frenzied currency trading that eventually pressured Thailand and its neighbors to devalue their currencies was speculative. But the initial spark that gave rise to that trading appears to have been quite justified by economic fundamentals. The combination of rising current account deficits, slowing GDP growth, and most especially, greatly extended financial systems served to make all four countries likely candidates for eventual currency devaluation. While it is true that many Asian countries have made great economic strides in recent years, it is equally true that most still have a long way to go on the road to economic maturity. One of the last and most important steps on that road is the development of an independent and mature financial sector fully integrated into world financial markets. The bottom line is that Asian leaders would be best advised to focus attention on their own financial failings rather than pointing blame at speculative bogeymen for this summer's crisis.

WEFA's real GDP growth forecasts for a variety of countries and regions are reported in Table 1-1.

Table 1-1
Forecast Real GDP Growth, 1996 to 2001 (Percent)

	1996	1997	1998	1999	2000	2001
Americas						
United States	2.4	3.5	2.3	2.2	2.3	2.2
Canada	1.5	3.1	3.7	4.0	3.6	3.1
Mexico	5.1	5.4	6.4	6.1	5.4	6.0
Latin America (excluding Mexico)	3.2	4.2	4.2	4.4	4.6	5.0
Europe, Middle East, and Africa						
Germany	1.4	2.2	2.2	2.7	2.7	2.5
France	1.5	2.2	2.7	2.1	2.1	2.3
Italy	0.7	0.9	1.8	2.3	2.2	2.0
United Kingdom	2.3	3.2	2.4	1.9	2.2	2.5
Eastern Europe	3.1	1.9	4.0	4.4	4.5	4.5
Former Soviet Union	-4.7	0.1	2.7	4.9	4.8	4.9
Middle East	4.1	1.8	1.9	3.4	3.3	3.7
Africa	4.7	4.2	4.9	4.9	5.1	5.2
Japan and Asia/Pacific						
Japan	3.7	2.1	3.2	2.6	2.1	2.3
China	9.7	9.8	9.2	8.9	8.6	8.6
Pacific Basin	6.7	6.4	6.6	6.6	6.5	6.4
Other Asia	6.3	6.4	6.5	6.6	6.7	6.6

Source: The WEFA Group

Reported real GDP and consumer price index (CPI) growth rates are taken from the most recently available quarterly world forecast of the WEFA Group contained in Table 1-1, "World Forecast Summary," *World Outlook, Executive Summary,* August 1, 1997, page 3. Economic commentary is based on independent research by Dataquest.

China/Hong Kong Forecast Highlights

The China/Hong Kong semiconductor market is positioned for accelerating growth during the next five years. With electronic equipment industries on an upturn and the worldwide semiconductor industry recovering in 1998, China/Hong Kong will achieve at least 31 percent CAGR from 1996 to 2001. Dataquest foresees the immature personal computer and communications industries in China as leading the broad-based growth during the next silicon cycle. Growth in China during the past five years has been led by consumer electronics, largely because of Japanese electronic equipment investments and local demand within China. With leadership from China's Ministry of Electronics, computers and communications have moved to the center of China's industrial development policy. Furthermore, business applications for computer and communication is swelling in an economy where the gross domestic product (GDP) will expand 9 percent to 12 percent during the next five years.

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The combination of foreign investments plus high market growth will continue to be key drivers to electronics. Dataquest expects varied investments into a variety of electronics products from every major region (Americas, Europe, Japan, Korea, Taiwan, Singapore, and Hong Kong). Efficient manufacturing, unlimited cheap skill labor, currency stability backed by the governments of Hong Kong SAR and China, and rapidly growing demand from blistering economic growth are all reasons for investing in China relative to other Asia/Pacific countries. The combination of these competitive advantages cannot fundamentally change in the short term and are likely to accelerate in the long term.

Worldwide Forecast Highlights

Worldwide electronic equipment production is now forecast to grow 8.2 percent in 1997, compared to 7.1 percent growth in 1996. Continued equipment production growth is forecast through 2001. However, annual growth is expected to slow in the coming years as electronic equipment markets continue to mature. Overall, equipment production growth is now forecast to average 8.0 percent growth between 1996 and 2001. Not surprisingly, production of data processing equipment will continue to fuel growth in electronic equipment production. Dominated by PC and PC motherboard production, data processing equipment is expected to experience average annual growth in excess of 11.5 percent between 1996 and 2001. As a result, its share of total electronic equipment production is expected to rise from a current level of about 33 percent to about 38 percent by 2001.

Worldwide production growth of communications, industrial, and transportation equipment will roughly mirror overall equipment production growth. As a result, their shares of total equipment production are expected to hold more or less steady at about 22 percent, 14.5 percent, and 5 percent, respectively. Consumer and military/civil aerospace electronics production is forecast to experience below-average growth relative to overall equipment. As a result, their shares of total electronic equipment production are expected to decline. By 2001, consumer electronics are expected to account for about 16 percent of total electronics production, while military/civil aerospace electronics will constitute just more than 5 percent of production.

Regionally, total electronic equipment production is still forecast to grow fastest in Asia/Pacific and slowest in Japan during the forecast period. Europe, Middle East, and Africa will experience the second-fastest growth, closely followed by the Americas. Asia/Pacific's electronic equipment production is now forecast to grow 14.9 percent in 1997, compared to 7.7 percent growth in 1996. Production growth is forecast to be strong through 2001 but is expected slow in unison with worldwide growth. Overall, Asia/Pacific electronic equipment production is now forecast to average 13.5 percent annual growth between 1996 and 2001. Europe, Middle East, and Africa's electronic equipment production is now forecast to grow 9 percent in 1997, compared to 8.8 percent growth in 1996. Production growth is forecast to slow beginning next year but remain at healthy levels through 2001. Overall, electronic equipment production in Europe, Middle East, and Asia is now forecast to average 8.4 percent annual growth between 1996 and 2001.

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Americas will actually experience stronger growth than Europe, Middle East, and Africa in 1997. Americas' electronic equipment production is now forecast to grow 11.3 percent in 1997, compared to 12 percent growth in 1996. As in Europe, Middle East, and Africa, however, production growth is expected to slow beginning next year. Dataquest believes that Americas' production growth rates will settle at levels below Europe for the remainder of the decade. Overall, electronic equipment production in Americas is now forecast to average 7.9 percent annual growth between 1996 and 2001. Finally, dollar-valued Japanese electronics equipment production is now forecast to contract 1.8 percent in 1997, comparing to a 1.1 percent dollar-valued contraction in 1996. Unfortunately, these figures are somewhat misleading on account of the yen's continuing movements relative to the dollar.

Dataquest's forecast assumes the yen will depreciate 7.7 percent relative to the dollar in 1997, following a 13.7 percent depreciation in 1996. When expressed in yen, Japanese electronic equipment production is forecast to grow 6.4 percent in 1997, following a 14.7 percent yen-valued growth in 1996. In the longer term, dollar-valued Japanese electronic equipment production growth is expected to revive. Assuming no continued depreciation of the yen beyond that assumed in our forecast, Japanese electronic equipment production is expected to average 3.8 percent annual dollar-valued growth between 1997 and 2001. Growth is forecast to be especially strong in 1998 at 5.5 percent. All told, Dataquest now forecasts Japanese electronic equipment production to average 2.7 percent annual dollar-valued growth between 1996 and 2001.

Still, when all is said and done, Americas should continue to lead all other regions in total electronics equipment production throughout the forecast period. Americas' share of total worldwide production should remain near its current level of roughly 36 percent throughout the forecast period. However, thanks to continued rapid production growth, the gap between Asia/Pacific electronic equipment production and production in other regions will close quickly. Although Asia/Pacific's production is expected to remain well below Americas' production even by 2001, it is now expected to surpass Japanese production in 1999 and then overtake European production in 2001. By 2001, Asia/Pacific is expected to command a 23.1 percent share of total worldwide electronic equipment production. Europe, Middle East, and Africa should garner about a 22 percent share, while Japan's share is forecast to fall to just about 19 percent.

For specific application areas, Dataquest anticipates the following:

- Dataquest now expects worldwide data processing electronics equipment production to grow 12.9 percent in 1997, compared to 9.2 percent in 1996. In the longer term, production growth will remain strong, but it is expected slow somewhat toward the end of the decade. Overall, data processing equipment is expected to average 11.6 percent production growth annually between 1996 and 2001. Not surprisingly, this growth will be fueled by computer production, specifically combined PC and PC motherboard production. Worldwide factory revenue from the production of PCs and PC motherboards is expected to grow 18.6 percent in 1997, compared to 17.3 percent growth in 1996. In the longer term, production growth is expected to average 14.8 percent between 1996 and 2001. Rigid disk and optical disc drives will also contribute significantly to data processing equipment production growth. Worldwide rigid disk drive production is now forecast to grow 27 percent in 1997. In the longer term, rigid disk drives are expected to experience 20.9 percent average growth between 1996 and 2001. Worldwide optical disc drive production is now forecast to grow 28.4 percent in 1997. In the longer term, optical disc drives will experience 13.3 percent growth between 1996 and 2001. Regionally, Americas is expected to retain its lead share of data processing equipment production during the forecast period. However, continued production growth in Asia/Pacific will raise that region's production of data processing equipment to levels approaching Americas by 2001. Strong production growth in Europe, Middle East, and Africa combined with sluggish production growth in Japan will result in Europe overtaking Japan in data processing production by 1999.

- Dataquest now expects worldwide communications electronic equipment production to grow 12.1 percent in 1997, compared with 18.4 percent growth in 1996. In the longer term, production growth is forecast to slow through the end of the decade. Overall, communications equipment is expected to average 6.9 percent production growth annually between 1996 and 2001. Products at the forefront of the digital revolution in communications are anticipated to spur worldwide communications equipment production growth. Digital cellular and digital cordless phones and terminals will make significant contributions to communications equipment production growth. Production of digital cellular phones is forecast to experience 36.9 percent growth in 1997 and to average 13.3 percent growth annually between 1996 and 2001. Production of digital cordless phones is forecast to experience 15.1 percent growth in 1997 and to average 12.8 percent growth annually between 1996 and 2001. Mobile communications infrastructure will also make an important contribution to communications equipment production growth. Production of mobile communications infrastructure equipment is forecast to grow 34.4 percent in 1997 and to average 12.2 percent growth annually between 1996 and 2001. Regionally, Americas is forecast to maintain its lead share of total worldwide communications equipment production over the forecast period. Dataquest estimates that the Americas currently produces about 40.5 percent of all communications electronics. Dataquest expects the Americas to preserve this share of production through 2001. However, production of specific communications equipment in other regions is forecast to rival Americas' production. For example, production of digital cellular phones and mobile communications infrastructure equipment in Europe, Middle East, and Africa will amply exceed Americas production throughout most of the forecast period.

- Dataquest now expects worldwide industrial electronics equipment production to grow 5.3 percent in 1997, compared to 3.6 percent in 1996. In the longer term, production growth is forecast to quicken through the end of the decade. Overall, industrial equipment is expected to average 7.3 percent growth annually between 1996 and 2001. Manufacturing systems and instruments are anticipated to be the lead growing industrial electronics equipment segment. Production of these electronics is expected to grow 6.6 percent in 1997 and to average 7.8 percent annually between 1996 and 2001. Medical electronics are also forecast to sustain solid growth. Medical electronics are expected to experience a 5.2 percent growth in 1997 and to average 7 percent annually between 1996 and 2001. Here again, Dataquest expects the Americas to maintain its lead share of overall worldwide equipment production. Dataquest estimates that the Americas currently produces approximately 47 percent of the world's industrial electronics. The remainder, minus a marginal share for Asia/Pacific, is split fairly evenly between Japan and Europe. Dataquest expects little change in this division over the forecast period. Dataquest also expects little change in the division of individual industrial segments, especially for manufacturing systems and instruments, as well as for medical electronics. Americas' production predominates both these segments and should continue to do so despite respectable growth in Japanese and European production.

- Dataquest now expects worldwide production of consumer electronics equipment to grow just 0.9 percent in 1997, compared to a 1.8 percent contraction in 1996. In the longer term, production growth is forecast to accelerate. Dataquest believes consumer electronic growth to average 4.5 percent annual growth between 1996 and 2001. As with communications electronics, products at the forefront of the digital consumer revolution will make significant contributions to consumer electronics production growth throughout the forecast period. Key products to watch include DVD, digital still cameras, digital camcorders, and digital set-top boxes. DVD is expected to average annual production growth approaching an astounding 270 percent between 1996 and 2001. Dataquest forecasts digital still cameras to average a somewhat more modest 35 percent annual production growth between 1996 and 2001. Digital camcorders and digital set-top boxes are expected to average 22 percent and 21.7 percent annual production growth, respectively, between 1996 and 2001. Regionally, Americas and European consumer electronics production will take a distant backseat to Japan and Asia/Pacific. Japan has developed many of the new digital products commercially expected to spur consumer electronics growth. However, Dataquest believes that once production reaches full gear, it will be migrated to Asia/Pacific. As a result, Asia/Pacific is forecast to consolidate its lead share of worldwide consumer electronics production. One notable exception is the digital set-top boxes. Here, Americas and Europe are expected to retain significant shares of worldwide production. Still, Asia/Pacific is likely to garner an ever-increasing share of digital set-top box production.

- Dataquest now expects worldwide production of military/civil aerospace electronics to grow 3.0 percent in 1997, compared to 1.7 percent growth in 1996. In the longer term, Dataquest forecasts a continued acceleration of aerospace electronics production. Overall, aerospace electronics production is forecast to average 3.3 percent annual production growth between 1996 and 2001. Regionally, Americas and Europe, Middle East, and Africa will continue to dominate aerospace electronics production. Americas' production is forecast to average 3.3 percent annual growth between 1996 and 2001, while European production is expected to average near-zero growth. Still, these two regions combined will continue to account for more than 80 percent of worldwide aerospace electronics production through 2001. Asia/Pacific is forecast to sustain double-digit production growth throughout the forecast period.

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As a result, its share of worldwide production will nearly double by 2001. Japan, however, is expected to experience continued contraction of aerospace electronics production. As a result, Dataquest forecasts Japan to garner about 2.5 percent of worldwide aerospace production by 2001.

- Dataquest now expects worldwide production of transportation/automotive electronics to grow 4.9 percent in 1997, compared to 2.6 percent growth in 1996. In the longer term, Dataquest forecasts higher rates of production through the end of the decade. Overall, automotive electronics production is expected to average 7.8 percent annual growth between 1996 and 2001. Automotive navigation systems will make a significant contribution to transportation electronics growth throughout the forecast period. Dataquest forecasts production of these systems to grow 43 percent in 1997. In the longer term, Dataquest expects production to average 44.6 percent annual growth between 1996 and 2001. Antilock braking systems will also buoy automotive electronics production growth. Dataquest expects production of these systems to grow 13.4 percent in 1997 and to average 7.8 percent annual growth between 1996 and 2001. Not surprisingly, the regional distribution of total automotive electronics production should continue to mirror the distribution of automotive production. Americas and Europe, Middle East, and Africa are forecast to garner the leading shares of production, followed by Japan and then Asia/Pacific. As elsewhere, however, the regional distribution of production for specific products will vary from the pattern for total production. For instance, Dataquest expects Japan to be the principal producer of automotive navigation systems throughout the forecast period. Dataquest also expects Asia/Pacific to rival Japan as the world's leading producer of automotive stereo systems before the end of the forecast period.

Exchange Rates

Dataquest's worldwide electronic equipment forecast combines data from many countries, each of which uses a currency that has a different and fluctuating exchange rate relative to the U.S. dollar. Because Dataquest forecasts electronic equipment production in several regions of the world, Dataquest uses the U.S. dollar as a common currency for comparisons and aggregation. As a rule, Dataquest calculates the forecasts in local currencies and then convert them to U.S. dollars using projected average annual exchange rates. Dataquest does not forecast exchange rates per se. Instead, Dataquest calculates projected average annual exchange rates from the current exchange rate. Dataquest's projections are based on estimates of the latest available monthly exchange rate at the time the forecast is developed. Table 1-2 presents the average annual exchange rates incorporated in this forecast. These rates are based on monthly exchange rates observed through July 1997. Additional information about historical exchange rates and Dataquest's methodology of calculating future average exchange rates may be requested through Dataquest's client inquiry service.

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Table 1-2
Foreign Currency Exchange Rates against the U.S. Dollar, 1996 to 1998

Country	Annual Average 1996	Annual Average 1997	Latest Monthly Average January 1998	Estimated 1998 Quarterly Averages Q1	Q2	Q3	Q4	Estimated Annual Average 1998	Annual Rate 1999 and Beyond
Argentina (Peso)	NA	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Australia (Dollar)	1.28	1.35	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Austria (Schilling)	10.59	12.20	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Belgium (Franc)	30.96	35.79	37.54	37.54	37.54	37.54	37.54	37.54	37.54
Brazil (Real)	NA	1.08	1.12	1.12	1.12	1.12	1.12	1.12	1.12
Canada (Dollar)	1.36	1.38	1.44	1.44	1.44	1.44	1.44	1.44	1.44
Chile (Peso)	NA	419.05	453.49	453.49	453.49	453.49	453.49	453.49	453.49
China (Renminbi)	8.34	8.32	8.31	8.31	8.31	8.31	8.31	8.31	8.31
Czech Republic (Koruna)	NA	31.70	35.43	35.43	35.43	35.43	35.43	35.43	35.43
Denmark (Krone)	5.81	6.61	6.92	6.92	6.92	6.92	6.92	6.92	6.92
European Union (Euro)	0.80	0.89	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Egypt (Pound)	NA	3.39	3.40	3.40	3.40	3.40	3.40	3.40	3.40
Finland (Markka)	4.59	5.19	5.50	5.50	5.50	5.50	5.50	5.50	5.50
France (Franc)	5.12	5.84	6.08	6.08	6.08	6.08	6.08	6.08	6.08
Germany (Mark)	1.50	1.73	1.82	1.82	1.82	1.82	1.82	1.82	1.82
Greece (Drachma)	240.82	273.11	287.24	287.24	287.24	287.24	287.24	287.24	287.24
Hong Kong (Dollar)	7.73	7.74	7.74	7.74	7.74	7.74	7.74	7.74	7.74
Hungary (Forint)	NA	186.84	206.23	206.23	206.23	206.23	206.23	206.23	206.23
Iceland (Krona)	NA	70.82	72.88	72.88	72.88	72.88	72.88	72.88	72.88
India (Rupee)	35.52	36.36	39.39	39.39	39.39	39.39	39.39	39.39	39.39
Indonesia (Rupiah)	NA	2,872.61	9,743.04	9,743.04	9,743.04	9,743.04	9,743.04	9,743.04	9,743.04
Ireland (Punt)	0.63	0.66	0.72	0.72	0.72	0.72	0.72	0.72	0.72
Italy (Lira)	1,542.72	1,703.02	1,787.87	1,787.87	1,787.87	1,787.87	1,787.87	1,787.87	1,787.87
Japan (Yen)	108.81	121.10	129.55	129.55	129.55	129.55	129.55	129.55	129.55
Malaysia (Ringgit)	2.52	2.82	4.41	4.41	4.41	4.41	4.41	4.41	4.41
Mexico (Peso)	7.60	7.92	8.23	8.23	8.23	8.23	8.23	8.23	8.23

Table 1-2 (Continued)
Foreign Currency Exchange Rates against the U.S. Dollar, 1996 to 1998

Country	Annual Average 1996	Annual Average 1997	Latest Monthly Average January 1998	Estimated 1998 Quarterly Averages Q1	Q2	Q3	Q4	Estimated Annual Average 1998	Annual Rate 1999 and Beyond
Netherlands (Guilder)	1.69	1.95	2.05	2.05	2.05	2.05	2.05	2.05	2.05
New Zealand (Dollar)	1.45	1.51	1.73	1.73	1.73	1.73	1.73	1.73	1.73
Norway (Krone)	6.46	7.08	7.50	7.50	7.50	7.50	7.50	7.50	7.50
Philippines (Peso)	NA	29.47	42.66	42.66	42.66	42.66	42.66	42.66	42.66
Poland (Zloty)	NA	3.28	3.53	3.53	3.53	3.53	3.53	3.53	3.53
Portugal (Escudo)	154.27	175.35	185.80	185.80	185.80	185.80	185.80	185.80	185.80
Russia (Ruble)	NA	5,290.28	185.80	185.80	185.80	185.80	185.80	185.80	185.80
Singapore (Dollar)	1.41	1.49	1.75	1.75	1.75	1.75	1.75	1.75	1.75
South Africa (Rand)	4.30	4.61	4.94	4.94	4.94	4.94	4.94	4.94	4.94
South Korea (Won)	805.16	954.14	1,707.30	1,707.30	1,707.30	1,707.30	1,707.30	1,707.30	1,707.30
Spain (Peseta)	126.68	146.45	153.93	153.93	153.93	153.93	153.93	153.93	153.93
Sri Lanka (Rupee)	55.30	59.02	62.28	62.28	62.28	62.28	62.28	62.28	62.28
Sweden (Krona)	6.71	7.64	8.02	8.02	8.02	8.02	8.02	8.02	8.02
Switzerland (Franc)	1.24	1.45	1.47	1.47	1.47	1.47	1.47	1.47	1.47
Taiwan (Dollar)	27.47	28.79	34.12	34.12	34.12	34.12	34.12	34.12	34.12
Thailand (Baht)	25.36	31.07	52.98	52.98	52.98	52.98	52.98	52.98	52.98
Turkey (Lira)	NA	152,692.14	215,443.08	215,443.08	215,443.08	215,443.08	215,443.08	215,443.08	215,443.08
United Kingdom (Pound)	0.64	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
Venezuela (Bolivar)	NA	487.86	506.95	506.95	506.95	506.95	506.95	506.95	506.95

Note: To convert foreign-currency denominated data into dollars, divide the data by the exchange rate reported above for the appropriate country and time period (i.e., divide quarterly data by appropriate quarterly rates, annual data by appropriate annual rates, etc.). Historical monthly, quarterly, and annual rates may be requested as needed.
NA = Not available
Source: Dataquest (February 1998)

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Chapter 2
Market Statistics Tables

Tables 2-1 to 2-13 present the production revenue of electronic equipment manufacturing in China/Hong Kong between 1996 and 2002. Figures 2-1 to 2-10 illustrate production revenue trends of various types of electronic equipment manufacturing in China/Hong during this same time period.

Table 2-1
China/Hong Kong Production Revenue by Electronic Equipment Group, 1996 to 2002 (Millions of U.S. Dollars)

	1996	1997	1998	1999	2000	2001	2002
Total Electronic Equipment	**38,463**	**46,496**	**54,087**	**62,798**	**72,773**	**84,888**	**98,041**
Data Processing	**9,892**	**13,407**	**17,363**	**21,936**	**27,264**	**33,617**	**40,019**
Computers	2,631	3,967	5,217	6,790	8,613	10,736	13,392
Data Storage	1,467	2,415	3,388	4,676	5,879	7,742	9,392
Input/Output	1,715	2,457	3,709	4,779	6,207	7,653	9,035
Dedicated System	3,468	3,911	4,279	4,777	5,454	6,295	6,919
Other Data Processing	610	656	770	913	1,112	1,191	1,282
Communications	**6,457**	**7,540**	**8,398**	**9,593**	**10,638**	**11,674**	**12,978**
Premise Telecom	3,732	4,227	4,691	5,468	5,909	6,262	6,576
Public Telecom	1,198	1,352	1,549	1,696	1,933	2,182	2,644
Mobile Communications	1,185	1,659	1,832	2,068	2,407	2,795	3,292
Broadcast and Studio	252	230	252	260	280	310	337
Others Communications	90	72	74	102	108	125	130
Industrial	**895**	**991**	**1,122**	**1,268**	**1,459**	**1,691**	**1,951**
Security and Energy Management	377	410	462	524	610	698	821
Manufacturing Systems/Instruments	405	456	505	562	638	750	855
Medical Equipment	67	73	91	105	119	137	155
Other Industrial	46	52	64	77	92	106	120
Consumer	**19,218**	**22,266**	**24,592**	**26,972**	**29,867**	**33,743**	**38,177**
Audio	6,951	7,254	7,838	8,414	9,226	10,079	10,778
Video	3,958	5,953	6,770	7,234	7,799	8,984	10,686
Personal Electronics	3,381	3,511	3,665	3,938	4,235	4,513	4,936
Appliances	4,823	5,432	6,192	7,244	8,453	9,989	11,571
Other Consumer	105	116	128	142	154	178	206
Military/Civil Aerospace	**1,019**	**1,162**	**1,325**	**1,536**	**1,782**	**2,085**	**2,451**
Transportation	**982**	**1,129**	**1,287**	**1,493**	**1,762**	**2,079**	**2,465**

Source: Dataquest (May 1998)

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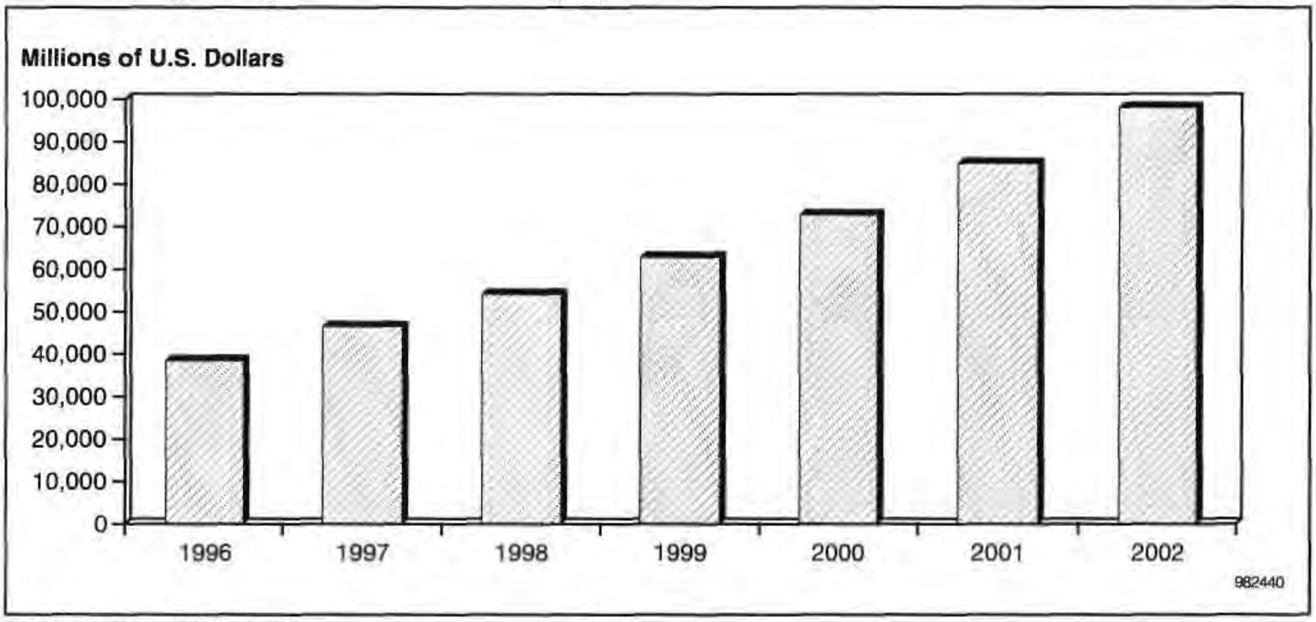
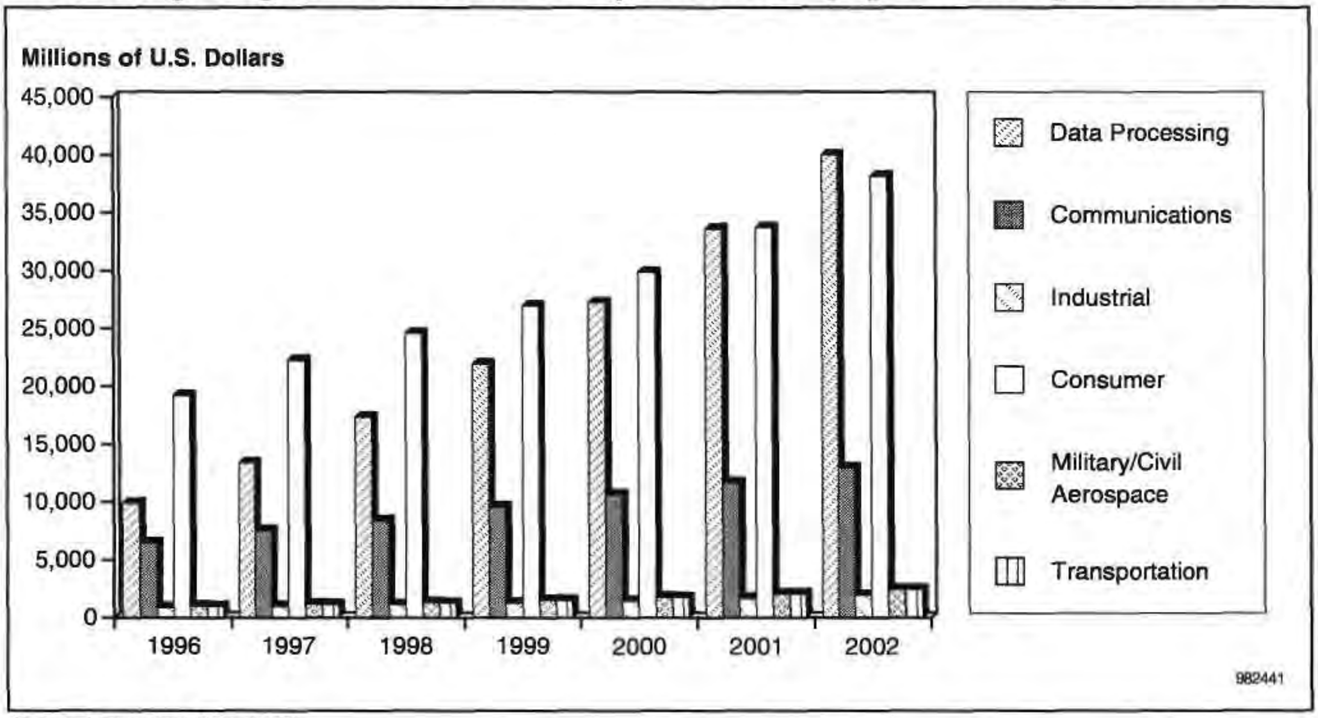
Figure 2-1
China/Hong Kong Total Electronic Equipment Production Revenue, 1996 to 2002



Source: Dataquest (May 1998)

Figure 2-2
China/Hong Kong Production Revenue by Electronic Equipment Group, 1996 to 2002



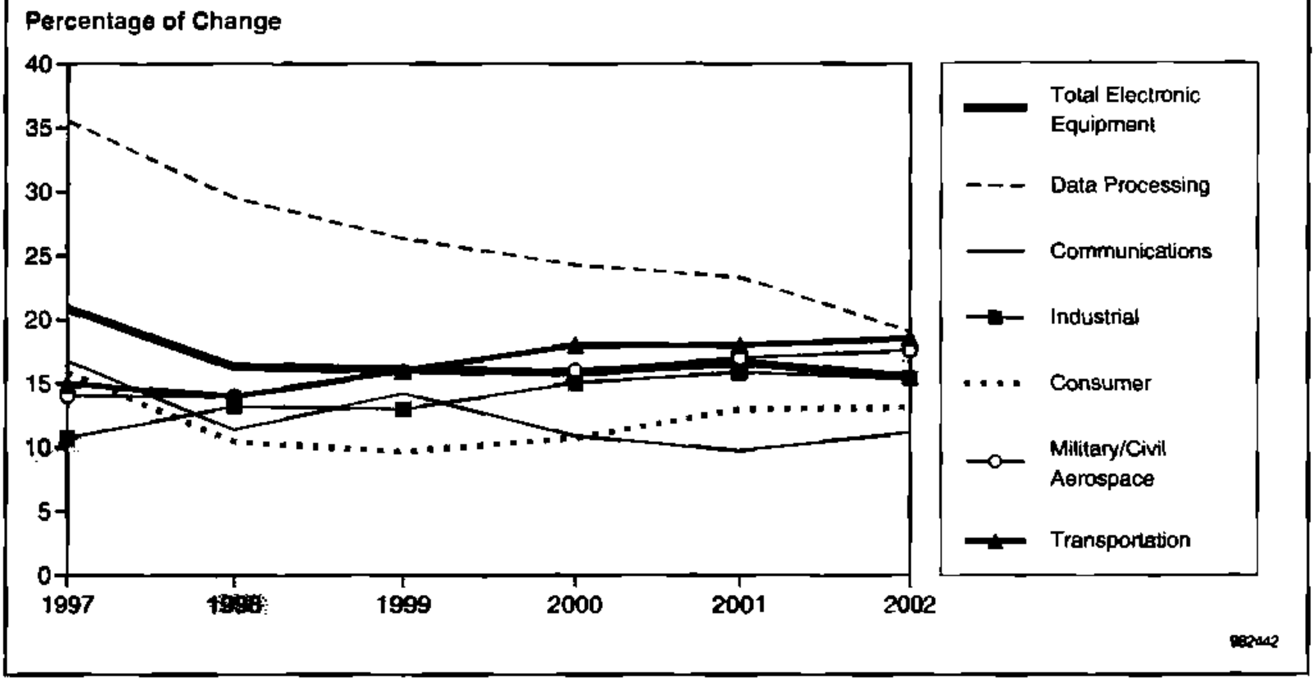
Source: Dataquest (May 1998)

Table 2-2
China/Hong Kong Production Revenue Growth by Electronic Equipment Group, 1997 to 2002 (Percentage Change)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Electronic Equipment	**20.9**	**16.3**	**16.1**	**15.9**	**16.6**	**15.5**	**16.1**
Data Processing	**35.5**	**29.5**	**26.3**	**24.3**	**23.3**	**19.0**	**24.4**
Computers	50.8	31.5	30.2	26.8	24.7	24.7	27.5
Data Storage	64.6	40.3	38.0	25.7	31.7	21.3	31.2
Input/Output	43.3	50.9	28.9	29.9	23.3	18.1	29.7
Dedicated System	12.8	9.4	11.6	14.2	15.4	9.9	12.1
Other Data Processing	7.6	17.3	18.7	21.7	7.1	7.6	14.3
Communications	**16.8**	**11.4**	**14.2**	**10.9**	**9.7**	**11.2**	**11.5**
Premise Telecom	13.3	11.0	16.6	8.1	6.0	5.0	9.2
Public Telecom	12.9	14.5	9.5	14.0	12.9	21.2	14.3
Mobile Communications	40.0	10.4	12.9	16.4	16.1	17.8	14.7
Broadcast and Studio	-8.7	9.6	3.2	7.8	10.6	8.6	7.9
Others Communications	-20.0	2.8	37.8	5.9	15.7	4.0	12.5
Industrial	**10.7**	**13.2**	**13.0**	**15.1**	**15.9**	**15.4**	**14.5**
Security and Energy Management	8.8	12.6	13.4	16.5	14.4	17.6	14.9
Manufacturing Systems/Instruments	12.5	10.7	11.3	13.5	17.4	14.1	13.4
Medical Equipment	9.5	24.6	15.0	13.6	15.3	12.9	16.2
Other Industrial	12.9	23.7	21.1	19.0	15.3	13.4	18.4
Consumer	**15.9**	**10.4**	**9.7**	**10.7**	**13.0**	**13.1**	**11.4**
Audio	4.4	8.0	7.3	9.7	9.2	6.9	8.2
Video	50.4	13.7	6.9	7.8	15.2	18.9	12.4
Personal Electronics	3.8	4.4	7.5	7.5	6.6	9.4	7.0
Appliances	12.6	14.0	17.0	16.7	18.2	15.8	16.3
Other Consumer	10.5	10.3	10.9	8.5	15.6	15.9	12.2
Military/Civil Aerospace	**14.0**	**14.0**	**15.9**	**16.0**	**17.0**	**17.6**	**16.1**
Transportation	**15.0**	**14.0**	**16.0**	**18.0**	**18.0**	**18.5**	**16.9**

Source: Dataquest (May 1998)

Figure 2-3
China/Hong Kong Production Revenue Growth by Electronic Equipment Group, 1997 to 2002



Source: Dataquest (May 1998)

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Table 2-3
Asia/Pacific Production Revenue by Electronic Equipment Group, 1996 to 2002
(Millions of U.S. Dollars)

	1996	1997	1998	1999	2000	2001	2002
Asia/Pacific Total	**156,057**	**175,058**	**196,879**	**220,425**	**239,969**	**271,143**	**302,986**
Data Processing	**66,698**	**77,903**	**91,332**	**106,529**	**118,718**	**138,172**	**157,145**
Computers	17,134	16,838	19,238	22,648	26,452	29,912	34,224
Data Storage	20,866	28,175	35,718	44,434	49,367	61,056	71,765
Input/Output	20,924	24,344	26,802	28,892	31,225	34,247	36,780
Dedicated System	5,395	6,008	6,861	7,677	8,598	9,665	10,851
Other Data Processing	2,378	2,538	2,713	2,878	3,075	3,293	3,525
Communications	**25,163**	**29,332**	**32,589**	**35,235**	**37,995**	**42,280**	**47,270**
Premise Telecom	12,469	12,680	13,255	13,950	13,989	14,410	14,479
Public Telecom	3,618	4,136	4,751	5,403	6,057	6,952	7,870
Mobile Communications	4,886	7,908	9,524	10,335	11,870	14,204	17,521
Broadcast and Studio	1,411	1,604	1,768	1,982	2,168	2,418	2,669
Others Communications	2,779	3,004	3,291	3,565	3,911	4,296	4,729
Industrial	**4,641**	**5,255**	**5,886**	**6,573**	**7,282**	**8,262**	**9,236**
Security and Energy Management	991	1,114	1,237	1,431	1,622	1,915	2,227
Manufacturing Systems/Instruments	1,809	2,088	2,336	2,614	2,938	3,323	3,713
Medical Equipment	630	718	831	918	1,001	1,139	1,278
Other Industrial	1,211	1,335	1,482	1,610	1,721	1,884	2,018
Consumer	**52,090**	**54,561**	**58,314**	**62,414**	**65,432**	**70,758**	**76,475**
Audio	14,009	14,709	15,319	15,910	16,363	16,809	17,369
Video	18,693	18,973	20,216	21,826	22,451	24,626	26,990
Personal Electronics	4,474	4,615	5,003	5,191	5,405	6,024	6,564
Appliances	11,499	12,612	13,943	15,401	16,813	18,512	20,400
Other Consumer	3,415	3,652	3,833	4,087	4,399	4,787	5,152
Military/Civil Aerospace	**4,157**	**4,534**	**5,112**	**5,856**	**6,532**	**7,412**	**8,452**
Transportation	**3,308**	**3,473**	**3,647**	**3,819**	**4,010**	**4,258**	**4,409**

Source: Dataquest (May 1998)

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Table 2-4
Asia/Pacific Production Revenue Growth by Electronic Equipment Group, 1997 to 2002 (Percentage Change)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2001
Asia/Pacific Total	**12.2**	**12.5**	**12.0**	**8.9**	**13.0**	**11.7**	**12.2**
Data Processing	**16.8**	**17.2**	**16.6**	**11.4**	**16.4**	**13.7**	**15.1**
Computers	-1.7	14.3	17.7	16.8	13.1	14.4	15.2
Data Storage	35.0	26.8	24.4	11.1	23.7	17.5	20.6
Input/Output	16.3	10.1	7.8	8.1	9.7	7.4	8.6
Dedicated System	11.4	14.2	11.9	12.0	12.4	12.3	12.6
Other Data Processing	6.7	6.9	6.1	6.8	7.1	7.0	6.8
Communications	**16.6**	**11.1**	**8.1**	**7.8**	**11.3**	**11.8**	**10.0**
Premise Telecom	1.7	4.5	5.2	0.3	3.0	0.5	2.7
Public Telecom	14.3	14.9	13.7	12.1	14.8	13.2	13.7
Mobile Communications	61.8	20.4	8.5	14.9	19.7	23.4	17.2
Broadcast and Studio	13.7	10.2	12.1	9.4	11.5	10.4	10.7
Others Communications	8.1	9.6	8.3	9.7	9.9	10.1	9.5
Industrial	**13.2**	**12.0**	**11.7**	**10.8**	**13.5**	**11.8**	**11.9**
Security and Energy Management	12.4	11.0	15.7	13.3	18.1	16.3	14.9
Manufacturing Systems/Instruments	15.4	11.9	11.9	12.4	13.1	11.7	12.2
Medical Equipment	14.0	15.7	10.5	9.0	13.8	12.2	12.2
Other Industrial	10.2	11.0	8.6	6.9	9.5	7.1	8.6
Consumer	**4.7**	**6.9**	**7.0**	**4.8**	**8.1**	**8.1**	**7.0**
Audio	5.0	4.1	3.9	2.9	2.7	3.3	3.4
Video	1.5	6.5	8.0	2.9	9.7	9.6	7.3
Personal Electronics	3.1	8.4	3.8	4.1	11.5	9.0	7.3
Appliances	9.7	10.6	10.5	9.2	10.1	10.2	10.1
Other Consumer	6.9	5.0	6.6	7.6	8.8	7.6	7.1
Military/Civil Aerospace	**9.1**	**12.7**	**14.6**	**11.5**	**13.5**	**14.0**	**13.3**
Transportation	**5.0**	**5.0**	**4.7**	**5.0**	6.2	3.5	**4.9**

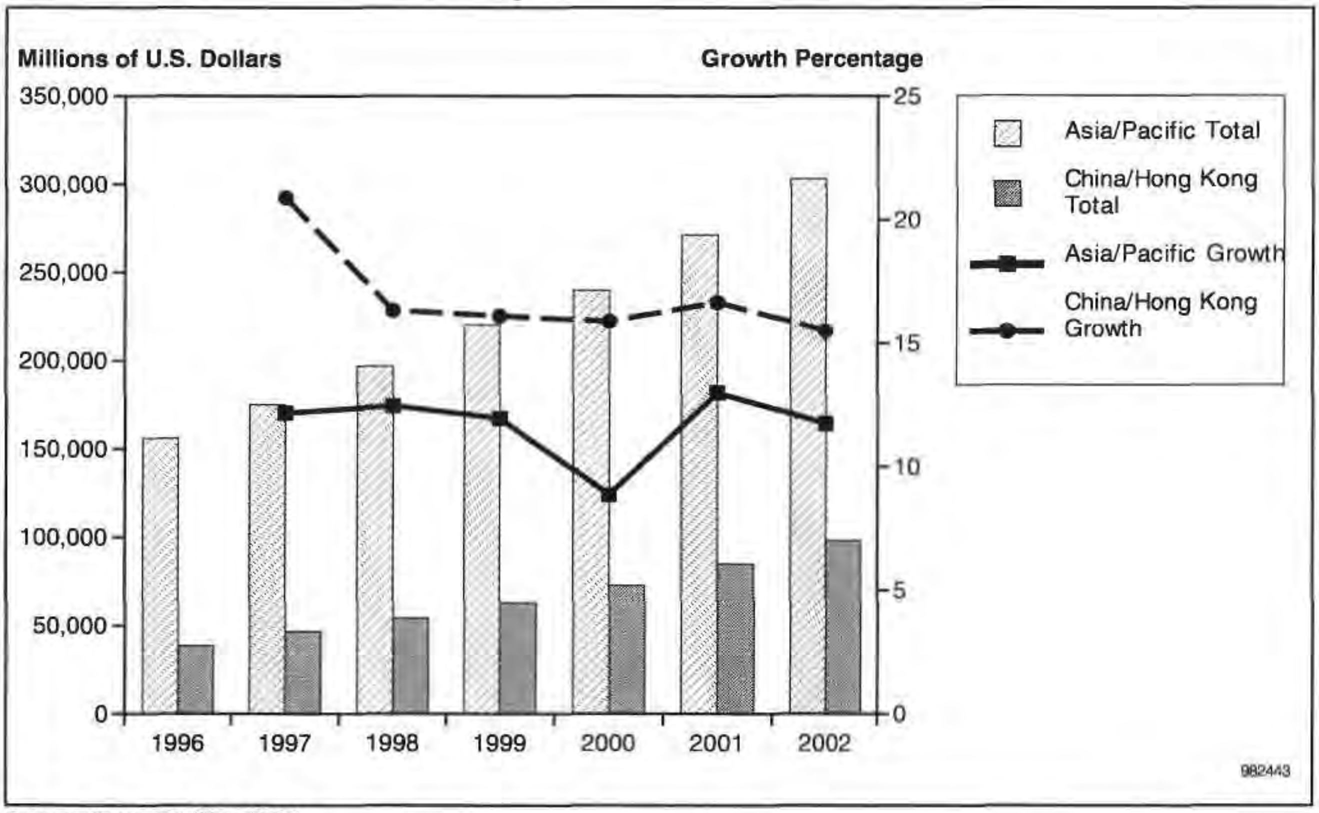
Source: Dataquest (May 1998)

Table 2-5
China/Hong Kong Electronic Equipment Production Revenue as a Percentage of Asia/Pacific, 1996 to 2002 (Percentage)

	1996	1997	1998	1999	2000	2001	2002
China/Hong Kong as a Percentage of Asia/Pacific	**24.6**	**26.6**	**27.5**	**28.5**	**30.3**	**31.3**	**32.4**
Data Processing	**14.8**	**17.2**	**19.0**	**20.6**	**23.0**	**24.3**	**25.5**
Computers	15.4	23.6	27.1	30.0	32.6	35.9	39.1
Data Storage	7.0	8.6	9.5	10.5	11.9	12.7	13.1
Input/Output	8.2	10.1	13.8	16.5	19.9	22.3	24.6
Dedicated System	64.3	65.1	62.4	62.2	63.4	65.1	63.8
Other Data Processing	25.6	25.9	28.4	31.7	36.2	36.2	36.4
Communications	**25.7**	**25.7**	**25.8**	**27.2**	**28.0**	**27.6**	**27.5**
Premise Telecom	29.9	33.3	35.4	39.2	42.2	43.5	45.4
Public Telecom	33.1	32.7	32.6	31.4	31.9	31.4	33.6
Mobile Communications	24.2	21.0	19.2	20.0	20.3	19.7	18.8
Broadcast and Studio	17.9	14.3	14.3	13.1	12.9	12.8	12.6
Others Communications	3.2	2.4	2.2	2.9	2.8	2.9	2.7
Industrial	**19.3**	**18.9**	**19.1**	**19.3**	**20.0**	**20.5**	**21.1**
Security and Energy Management	38.1	36.8	37.3	36.6	37.6	36.5	36.9
Manufacturimg Systems/Instruments	22.4	21.8	21.6	21.5	21.7	22.6	23.0
Medical Equipment	10.6	10.2	10.9	11.4	11.9	12.0	12.1
Other Industrial	3.8	3.9	4.3	4.8	5.3	5.6	6.0
Consumer	**36.9**	**40.8**	**42.2**	**43.2**	**45.6**	**47.7**	**49.9**
Audio	49.6	49.3	51.2	52.9	56.4	60.0	62.1
Video	21.2	31.4	33.5	33.1	34.7	36.5	39.6
Personal Electronics	75.6	76.1	73.3	75.9	78.3	74.9	75.2
Appliances	41.9	43.1	44.4	47.0	50.3	54.0	56.7
Other Consumer	3.1	3.2	3.3	3.5	3.5	3.7	4.0
Military/Civil Aerospace	**24.5**	**25.6**	**25.9**	**26.2**	**27.3**	**28.1**	**29.0**
Transportation	**29.7**	**32.5**	**35.3**	**39.1**	**43.9**	**48.8**	**55.9**

Source: Dataquest (May 1998)

Figure 2-4
Asia/Pacific and China/Hong Kong Production Revenue and Growth, 1996 to 2002



Source: Dataquest (May 1998)

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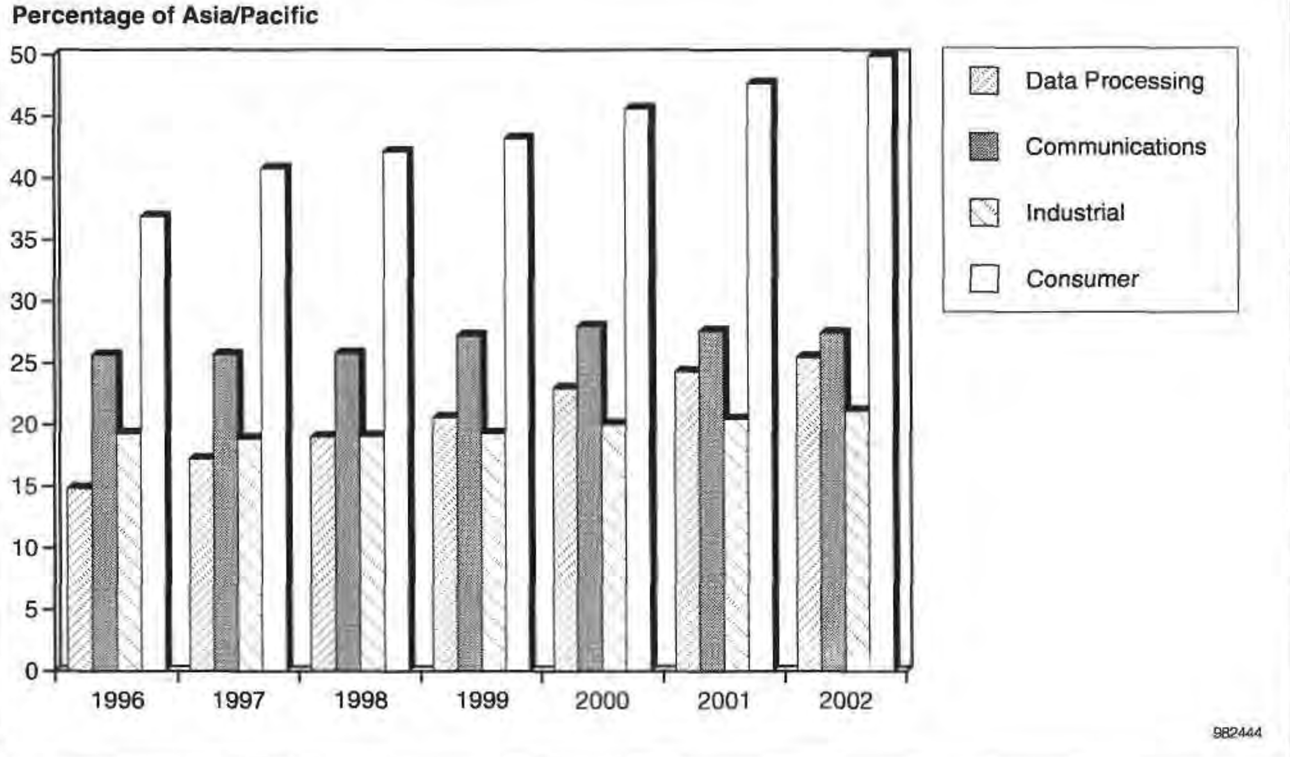
Figure 2-5
China/Hong Kong Electronic Equipment Production Revenue as a Percentage of Total Asia/Pacific Revenue, 1996 to 2002



Source: Dataquest (May 1998)

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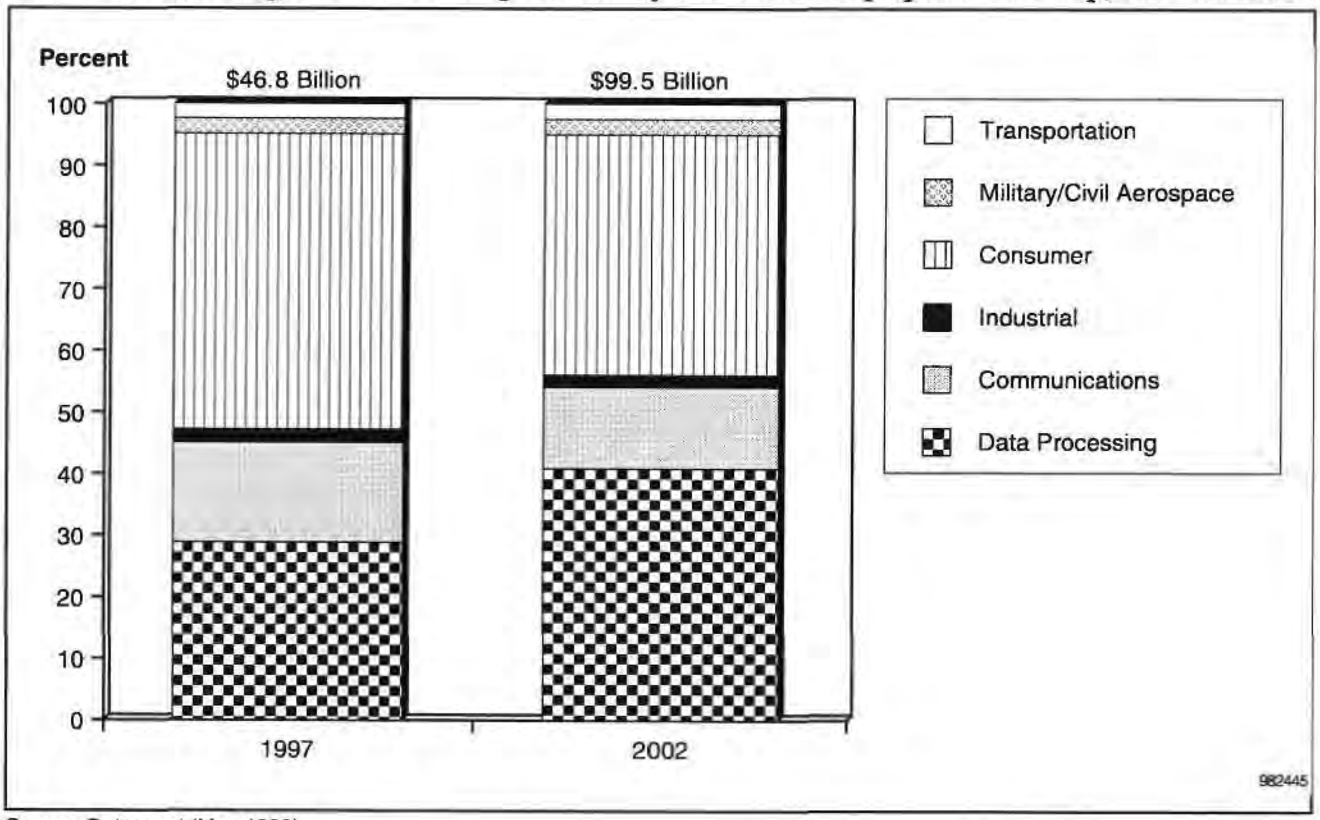
Figure 2-6
China/Hong Kong Revenue Composition by Electronic Equipment Group, 1997 to 2002



Source: Dataquest (May 1998)

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Table 2-6
China/Hong Kong Production Revenue for Data Processing Equipment, 1996 to 2002 (Millions of U.S. Dollars)

	1996	1997	1998	1999	2000	2001	2002
Data Processing Total	**9,892**	**13,407**	**17,363**	**21,936**	**27,264**	**33,617**	**40,019**
Computer	**2,631**	**3,967**	**5,217**	**6,790**	**8,613**	**10,736**	**13,392**
PC	677	1,227	1,829	2,722	3,779	5,171	6,741
Motherboard	569	1,094	1,542	1,852	2,306	2,775	3,357
Mainframe	571	587	509	509	577	502	487
Workstation	14	18	20	24	30	36	45
Other Computer	815	1,059	1,338	1,708	1,950	2,288	2,806
Data Storage Device	**1,467**	**2,415**	**3,388**	**4,676**	**5,879**	**7,742**	**9,392**
Rigid Disk Drive	590	1,308	1,753	2,384	2,960	3,782	4,414
Floppy Disk Drive	453	545	843	1,200	1,441	1,821	2,230
Optical Disk Drive	122	144	183	237	273	292	311
Other Data Storage Device	302	418	610	856	1,205	1,847	2,436
Input/Output Device	**1,715**	**2,457**	**3,709**	**4,779**	**6,207**	**7,653**	**9,035**
Monitor	948	1,319	2,117	2,533	3,243	3,871	4,510
Printer	113	128	150	183	229	298	398
Page Printer	19	26	37	58	93	149	238
Serial Printer	94	102	113	124	136	149	160
Scanner	180	310	432	693	965	1,220	1,461
Other Input/output Device	474	700	1,010	1,370	1,771	2,265	2,666
Dedicated System	**3,468**	**3,911**	**4,279**	**4,777**	**5,454**	**6,295**	**6,919**
Electronic Calculator	925	1,168	1,254	1,349	1,508	1,632	1,781
Personal Organizer	1,848	2,003	2,197	2,503	2,860	3,373	3,571
Other Dedicated System	695	740	828	925	1,086	1,290	1,567
Other Data Processing	**610**	**656**	**770**	**913**	**1,112**	**1,191**	**1,282**

Source: Dataquest (May 1998)

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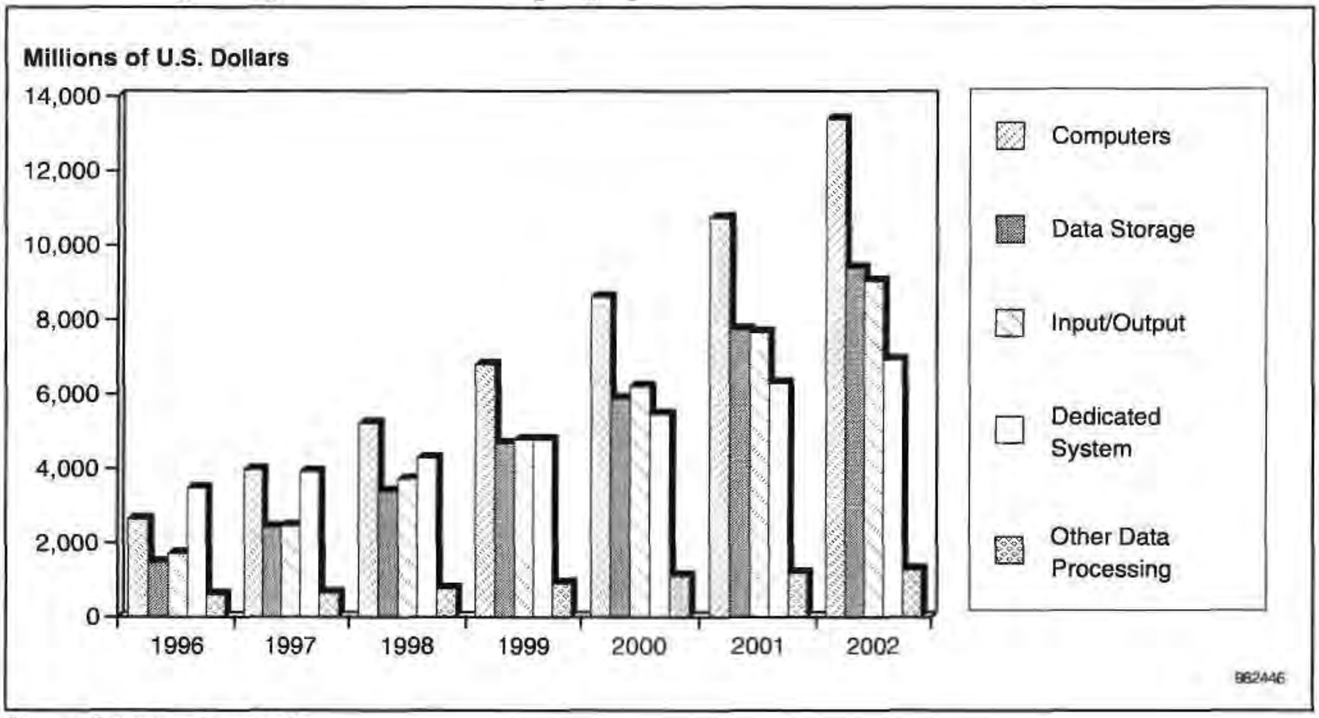
Figure 2-7
China/Hong Kong's Data Processing Equipment Production Revenue, 1996 to 2002



Source: Dataquest (May 1998)

Table 2-7
China/Hong Kong Production Revenue Growth for Data Processing Equipment, 1997 to 2002 (Percentage Change)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2001
Data Processing Total	**35.5**	**29.5**	**26.3**	**24.3**	**23.3**	**19.0**	**24.4**
Computer	**50.8**	**31.5**	**30.2**	**26.8**	**24.7**	**24.7**	**27.5**
PC	81.3	49.0	48.8	38.8	36.8	30.4	40.6
Motherboard	92.5	40.9	20.1	24.5	20.3	21.0	25.1
Mainframe	2.8	-13.3	0.0	13.4	-12.9	-3.0	-3.7
Workstation	34.5	10.3	18.3	24.2	19.7	25.6	19.5
Other Computer	29.9	26.3	27.7	14.2	17.3	22.7	21.5
Data Storage Device	**64.6**	**40.3**	**38.0**	**25.7**	**31.7**	**21.3**	**31.2**
Rigid Disk Drive	121.6	34.0	36.0	24.2	27.8	16.7	27.5
Floppy Disk Drive	20.4	54.7	42.3	20.1	26.4	22.5	32.5
Optical Disk Drive	17.9	26.8	29.8	15.2	6.9	6.4	16.6
Other Data Storage Device	38.4	46.0	40.3	40.7	53.3	31.9	42.3
Input/Output Device	**43.3**	**50.9**	**28.9**	**29.9**	**23.3**	**18.1**	**29.7**
Monitor	39.1	60.5	19.6	28.0	19.4	16.5	27.9
Printer	13.7	16.8	21.8	25.3	30.1	33.9	25.4
Page Printer	40.1	42.5	55.9	60.3	59.9	59.7	55.5
Serial Printer	8.5	10.2	10.5	9.0	9.6	8.0	9.4
Scanner	72.2	39.4	60.4	39.2	26.4	19.8	36.4
Other Input/output Device	47.6	44.3	35.7	29.2	27.9	17.7	30.7
Dedicated System	**12.8**	**9.4**	**11.6**	**14.2**	**15.4**	**9.9**	**12.1**
Electronic Calculator	26.2	7.4	7.6	11.8	8.2	9.1	8.8
Personal Organizer	8.4	9.7	13.9	14.3	17.9	5.9	12.3
Other Dedicated System	6.5	11.9	11.7	17.4	18.8	21.5	16.2
Other Data Processing	**7.6**	**17.3**	**18.7**	**21.7**	**7.1**	**7.6**	**14.3**

Source: Dataquest (May 1998)

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Table 2-8
China/Hong Kong Production Revenue for Communications Equipment, 1996 to 2002 (Millions of U.S. Dollars)

	1996	1997	1998	1999	2000	2001	2002
Communications Total	**6,457**	**7,540**	**8,398**	**9,593**	**10,638**	**11,674**	**12,978**
Premise Telecom	**3,732**	**4,227**	**4,691**	**5,468**	**5,909**	**6,262**	**6,576**
Image and Text Communications	206	212	187	189	196	201	204
Facsimile (Card See Modem)	193	197	169	167	169	170	169
Video Teleconferencing	13	15	18	22	27	31	35
Data Communications Equipment	286	320	885	1,615	1,941	2,215	2,508
LAN	13	20	29	33	33	32	33
Other Data Communications Equipment	273	300	856	1,581	1,908	2,182	2,475
Premise Voice Systems	252	329	441	546	649	787	922
PBX Telephone Equipment	97	119	157	193	228	253	275
Other Premise Voice Systems	155	210	284	353	421	534	648
Desktop Terminal	3,143	3,577	3,462	3,472	3,544	3,593	3,589
Telephone Sets/Answerers	3,072	3,489	3,363	3,350	3,411	3,443	3,423
Corded Phone	2,107	2,178	2,159	2,173	2,192	2,200	2,206
Analog Cordless Phone	703	953	779	677	626	578	481
Digital Cordless Phone	49	95	113	132	155	174	202
Answering m/c	213	264	311	368	438	491	533
Teleprinter	21	24	27	34	41	46	51
Others	50	64	72	88	92	104	115
Public Telecom	**1,198**	**1,352**	**1,549**	**1,696**	**1,933**	**2,182**	**2,644**
Transmission	139	140	148	172	198	224	250
Central Office Switching	1,059	1,212	1,401	1,524	1,736	1,958	2,394
Mobile Communications	**1,185**	**1,659**	**1,832**	**2,068**	**2,407**	**2,795**	**3,292**
Analog Cellular	141	106	90	75	59	52	43
Digital Cellular	365	829	958	1,144	1,404	1,759	2,206
Pager	550	559	608	662	743	769	809
Mobile Communications Infrastructure	128	165	176	187	201	216	234
Broadcast and Studio	**252**	**230**	**252**	**260**	**280**	**310**	**337**
Other Telecom	**90**	**72**	**74**	**102**	**108**	**125**	**130**

Source: Dataquest (May 1998)

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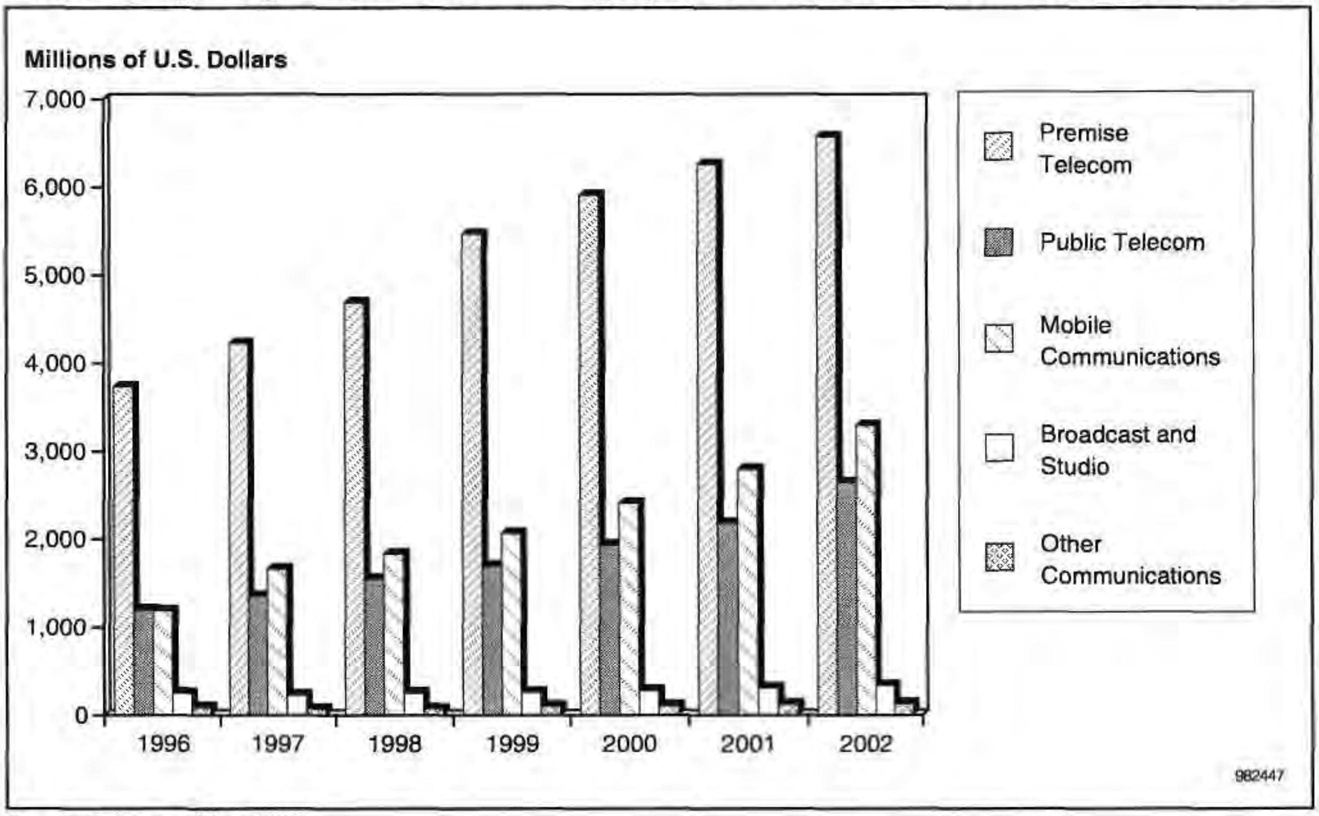
Figure 2-8
China/Hong Kong's Communications Equipment Production Revenue, 1996 to 2002



Source: Dataquest (May 1998)

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Table 2-9
China/Hong Kong Production Revenue Growth for Communications Equipment, 1997 to 2002 (Percentage Change)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2001
Communications Total	**16.8**	**11.4**	**14.2**	**10.9**	**9.7**	**11.2**	**11.5**
Premise Telecom	**13.3**	**11.0**	**16.6**	**8.1**	**6.0**	**5.0**	**9.2**
Image and Text Communications	2.7	-11.7	0.9	3.9	2.5	1.7	-0.7
Facsimile (Card See Modem)	1.8	-14.0	-1.6	1.1	0.7	-0.4	-3.0
Video Teleconferencing	16.4	19.1	24.6	24.9	13.4	12.7	18.8
Data Communications Equipment	11.9	176.5	82.5	20.2	14.1	13.3	51.0
LAN	53.3	42.5	16.8	-0.9	-1.8	3.4	10.9
Other Data Communications Equipment	9.9	185.5	84.7	20.7	14.4	13.4	52.5
Premise Voice Systems	30.4	34.3	23.7	18.8	21.3	17.2	22.9
PBX Telephone Equipment	22.3	32.5	22.7	18.1	11.1	8.6	18.3
Other Premise Voice Systems	35.5	35.2	24.3	19.3	26.8	21.3	25.3
Desktop Terminal	13.8	-3.2	0.3	2.1	1.4	-0.1	0.1
Telephone Sets/Answerers	13.6	-3.6	-0.4	1.8	0.9	-0.6	-0.4
Corded Phone	3.4	-0.9	0.6	0.9	0.4	0.3	0.3
Analog Cordless Phone	35.6	-18.2	-13.1	-7.5	-7.8	-16.8	-12.8
Digital Cordless Phone	92.4	19.5	16.9	17.3	12.4	16.0	16.4
Answering m/c	23.7	18.0	18.1	19.2	12.0	8.7	15.1
Teleprinter	14.0	14.8	25.1	20.1	13.4	11.1	16.8
Others	28.0	12.5	22.2	4.5	13.0	10.6	12.4
Public Telecom	**12.9**	**14.5**	**9.5**	**14.0**	**12.9**	**21.2**	**14.3**
Transmission	0.7	5.9	16.0	15.0	13.4	11.5	12.3
Central Office Switching	14.5	15.5	8.8	13.9	12.8	22.3	14.6
Mobile Communications	**40.0**	**10.4**	**12.9**	**16.4**	**16.1**	**17.8**	**14.7**
Analog Cellular	-25.0	-14.6	-17.0	-20.8	-13.3	-16.8	-16.5
Digital Cellular	126.8	15.6	19.4	22.7	25.3	25.4	21.6
Pager	1.7	8.7	8.8	12.3	3.5	5.2	7.7
Mobile Communications Infrastructure	28.6	6.5	6.5	7.5	7.3	8.4	7.2
Broadcast and Studio	**-8.7**	**9.6**	**3.2**	**7.8**	**10.6**	**8.6**	**7.9**
Other Telecom	**-20.0**	**2.8**	**37.8**	**5.9**	**15.7**	**4.0**	**12.5**

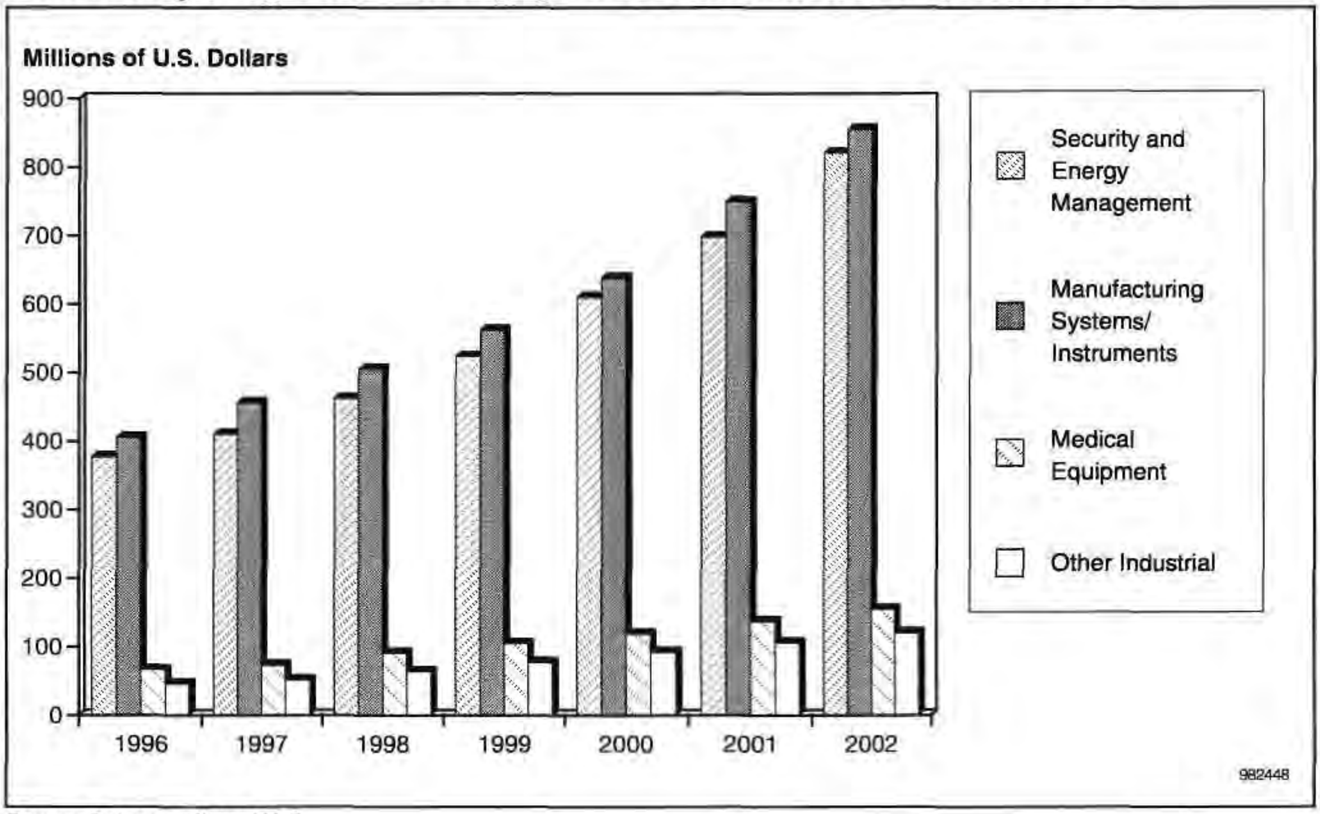
Source: Dataquest (May 1998)

Table 2-10
China/Hong Kong Production Revenue for Industrial Equipment, 1996 to 2002 (Millions of U.S. Dollars)

	1996	1997	1998	1999	2000	2001	2002
Industrial Total	**895**	**991**	**1,122**	**1,268**	**1,459**	**1,691**	**1,951**
Security/Energy Management	**377**	**410**	**462**	**524**	**610**	**698**	**821**
Alarm System	216	229	255	284	323	373	432
Energy Management	161	182	207	239	287	326	389
Manufacturing System	**405**	**456**	**505**	**562**	**638**	**750**	**855**
Semiconductor Production	-	-	6	11	19	22	24
Controls	140	157	173	187	207	246	276
Process Controls	150	172	184	199	220	259	296
Control and Processing Displays	38	40	45	53	61	71	79
Robots	16	17	19	22	26	30	36
Test and Measuring Equipment	61	69	78	91	106	123	144
Medical Equipment	**67**	**73**	**91**	**105**	**119**	**137**	**155**
Other Industrial System	**46**	**52**	**64**	**77**	**92**	**106**	**120**

Source: Dataquest (May 1998)

Figure 2-9
China/Hong Kong's Industrial Equipment Production Revenue, 1996 to 2002



Source: Dataquest (May 1998)

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Table 2-11
China/Hong Kong Production Revenue Growth for Industrial Equipment, 1997 to 2002 (Percentage Change)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2001
Industrial Total	**10.7**	**13.2**	**13.0**	**15.1**	**15.9**	**15.4**	**14.5**
Security/Energy Management	**8.8**	**12.6**	**13.4**	**16.5**	**14.4**	**17.6**	**14.9**
Alarm System	5.6	11.7	11.4	13.7	15.2	16.0	13.6
Energy Management	13.0	13.8	15.8	19.7	13.6	19.4	16.4
Manufacturing System	**12.5**	**10.7**	**11.3**	**13.5**	**17.4**	**14.1**	**13.4**
Semiconductor Production	NA	NA	79.5	77.1	15.3	11.6	NA
Controls	12.4	10.2	8.3	10.2	19.2	12.1	11.9
Process Controls	15.0	6.9	7.9	10.6	17.7	14.6	11.5
Control and Processing Displays	5.5	10.5	17.7	15.4	17.1	10.8	14.3
Robots	6.2	9.2	17.8	16.8	12.4	21.7	15.5
Test and Measuring Equipment	12.8	13.7	15.4	17.5	15.3	17.5	15.9
Medical Equipment	**9.5**	**24.6**	**15.0**	**13.6**	**15.3**	**12.9**	**16.2**
Other Industrial System	**12.9**	**23.7**	**21.1**	**19.0**	**15.3**	**13.4**	**18.4**

NA = Not available
Source: Dataquest (May 1998)

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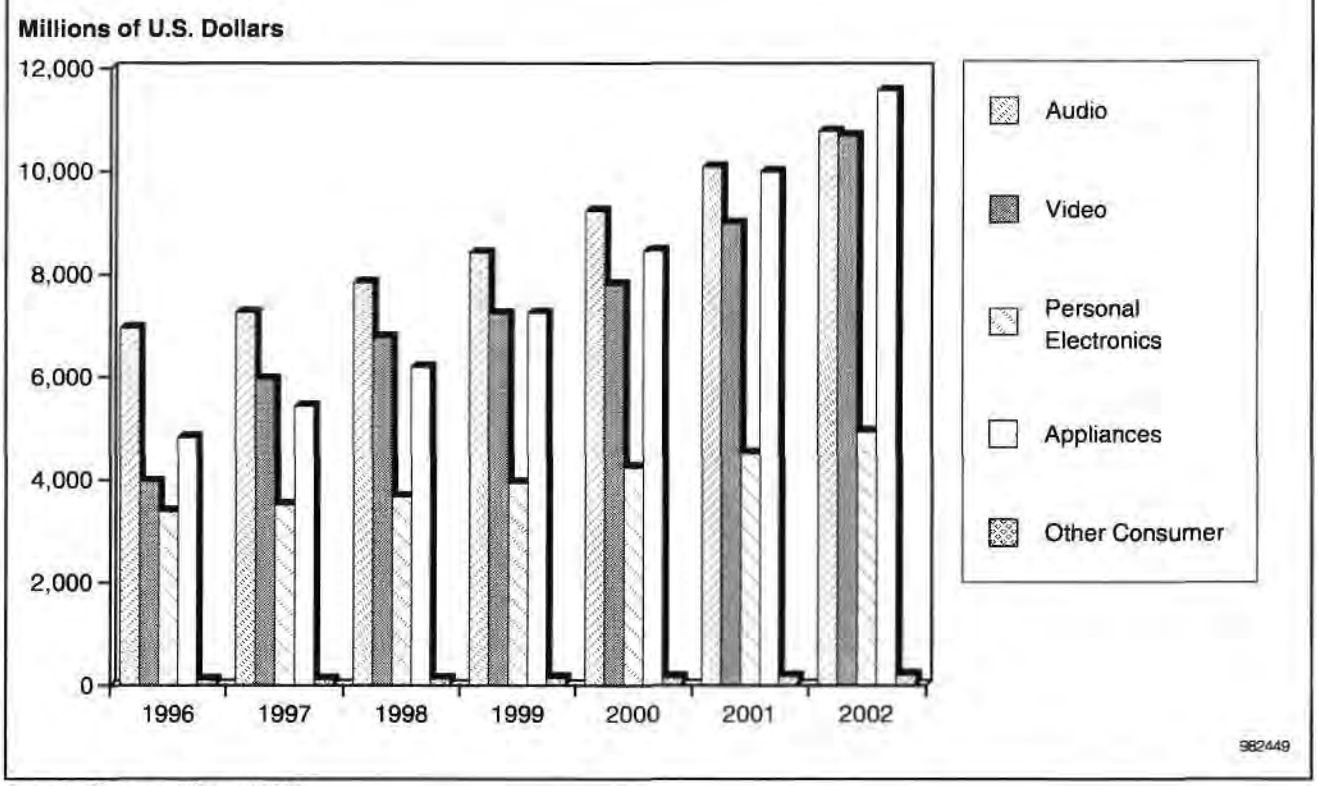
Table 2-12
China/Hong Kong Production Revenue for Consumer Equipment, 1996 to 2002
(Millions of U.S. Dollars)

	1996	1997	1998	1999	2000	2001	2002
Consumer Total	**19,218**	**22,266**	**24,592**	**26,972**	**29,867**	**33,743**	**38,177**
Audio	**6,951**	**7,254**	**7,838**	**8,414**	**9,226**	**10,079**	**10,778**
Compact Disc Player	149	177	208	243	291	338	359
Radio	3,682	3,765	3,895	3,995	4,128	4,246	4,383
Personal/Portable Stereo	960	845	907	945	1,007	1,074	1,090
Stereo Component	832	932	1,074	1,235	1,447	1,683	1,876
Musical Instrument	377	422	484	557	657	765	851
Tape Recorder	951	1,114	1,270	1,439	1,696	1,974	2,219
Video	**3,958**	**5,953**	**6,770**	**7,234**	**7,799**	**8,984**	**10,686**
Analog Camcorder	32	107	108	121	145	170	192
Digital Camcorder	-	-	-	1	2	5	7
Color Televisions	2,910	3,429	4,207	5,020	6,067	7,505	9,391
Analog Cable/Satellite Set-Top Decoder	0.3	0.8	4	10	15	18	20
Digital Cable/Satellite Set-Top Decoder	-	-	1	6	28	75	89
DVD Player	-	-	2.1	12.3	22	110	260
VCD Player	720	2,082	2,103	1,708	1,172	781	431
VCR	296	335	347	355	348	318	295
Personal Electronics	**3,381**	**3,511**	**3,665**	**3,938**	**4,235**	**4,513**	**4,936**
Digital Still Camera	-	-	1	3	6	9	13
Game Controller	54	91	85	87	89	89	87
Others	3,327	3,420	3,580	3,848	4,140	4,415	4,835
Appliances	**4,823**	**5,432**	**6,192**	**7,244**	**8,453**	**9,989**	**11,571**
Air Conditioner	1,832	2,124	2,530	3,111	3,637	4,375	4,948
Microwave Oven	449	568	693	883	1,130	1,410	1,809
Washer and Dryer	334	350	392	442	514	598	721
Refrigerator	1,711	1,751	1,845	1,936	2,134	2,380	2,662
Rice cooker	332	437	483	581	686	801	951
Other Appliances	165	201	248	292	352	425	480
Other Consumer	**105**	**116**	**128**	**142**	**154**	**178**	**206**

Source: Dataquest (May 1998)

Figure 2-10
China/Hong Kong's Consumer Equipment Production Revenue, 1996 to 2002



Source: Dataquest (May 1998)

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Table 2-13
China/Hong Kong Production Revenue Growth for Consumer Equipment, 1997 to 2002 (Percentage Change)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Consumer Total	**15.9**	**10.4**	**9.7**	**10.7**	**13.0**	**13.1**	**11.4**
Audio	**4.4**	**8.0**	**7.3**	**9.7**	**9.2**	**6.9**	**8.2**
Compact Disc Player	18.8	17.8	16.8	19.4	16.4	6.2	15.2
Radio	2.2	3.5	2.6	3.3	2.9	3.2	3.1
Personal/Portable Stereo	-12.0	7.3	4.1	6.6	6.6	1.5	5.2
Stereo Component	12.0	15.2	15.0	17.1	16.4	11.4	15.0
Musical Instrument	12.0	14.8	15.1	18.0	16.4	11.2	15.1
Tape Recorder	17.1	14.0	13.3	17.9	16.4	12.4	14.8
Video	**50.4**	**13.7**	**6.9**	**7.8**	**15.2**	**18.9**	**12.4**
Analog Camcorder	235.0	0.9	12.3	19.8	17.7	12.6	12.5
Digital Camcorder	NA	NA	NA	147.4	187.0	38.6	NA
Color Televisions	17.9	22.7	19.3	20.8	23.7	25.1	22.3
Analog Cable/Satellite Set-Top Decoder	152.9	347.2	182.9	53.0	21.0	8.3	90.9
Digital Cable/Satellite Set-Top Decoder	NA	NA	827.9	360.7	168.7	19.2	NA
DVD Player	NA	NA	493.7	78.3	401.6	135.4	NA
VCD Player	189.1	1.0	-18.8	-31.4	-33.4	-44.8	-27.0
VCR	13.2	3.5	2.5	-2.0	-8.6	-7.2	-2.5
Personal Electronics	**3.8**	**4.4**	**7.5**	**7.5**	**6.6**	**9.4**	**7.0**
Digital Still Camera	NA	NA	263.3	110.3	50.2	47.5	NA
Game Controller	68.9	-7.3	3.5	2.1	0.0	-2.2	-0.9
Others	2.8	4.7	7.5	7.6	6.6	9.5	7.2
Appliances	**12.6**	**14.0**	**17.0**	**16.7**	**18.2**	**15.8**	**16.3**
Air Conditioner	15.9	19.1	23.0	16.9	20.3	13.1	18.4
Microwave Oven	26.4	22.0	27.4	28.0	24.7	28.3	26.1
Washer and Dryer	4.9	12.0	12.5	16.4	16.4	20.6	15.5
Refrigerator	2.4	5.4	4.9	10.2	11.5	11.9	8.7
Rice cooker	31.6	10.4	20.3	18.1	16.8	18.7	16.8
Other Appliances	21.8	23.3	17.7	20.5	20.6	12.9	19.0
Other Consumer	**10.5**	**10.3**	**10.9**	**8.5**	**15.6**	**15.9**	**12.2**

NA = Not available
Source: Dataquest (May 1998)

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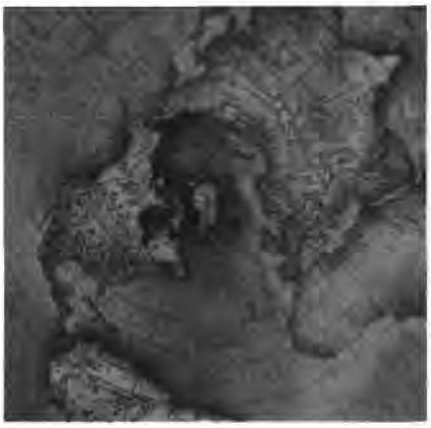
Dear Client:

The enclosed copy of "China/Hong Kong's Leading Electronics Companies: Growth Prospects for 1999," product code SEMI-CH-FR-9801, replaces the copy that we previously mailed to you. Because of a production error, part of the document was inadvertently not printed as part of the previous mailing. We regret this production error and apologize for any inconvenience this may have caused.

Randolph F. Frey

Director, GartnerGroup Editing and Graphics Services



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China/Hong Kong's Leading Electronics Companies: Growth Prospects for 1999

Focus Report

Program: Semiconductors China
Product Code: SEMI-CH-FR-9801
Publication Date: October 19, 1998
Filing: Reports

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China/Hong Kong's Leading Electronics Companies: Growth Prospects for 1999

Focus Report

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Chapter 1
Executive Summary

To what extent will Japanese and Asian currency devaluation affect China's once-insatiable appetite for information technology (IT)? China/Hong Kong has been the main force for IT sales in the Asia/Pacific region, but how long can it sustain this role? Dataquest isolates and discusses the key equipment and companies that have the most impact on China/Hong Kong's semiconductor market. Dataquest also stratifies its analysis across computer, communications, and consumer electronics industries.

Dataquest's goal in publishing this report is to present a concise report of China's electronics industry and its company-level outlook in 1998 and 1999. This Focus Report serves the following four simple research purposes:

- Summarizes key industry trends and lists forecast assumptions
- Presents company-level production units in 1998 and 1999 for high-volume products
- Forecasts long-term, high-volume electronic equipment production growth from 1998 to 2002 in terms of units, revenue, and semiconductor consumption
- Provides semiconductor consumption forecasts for 1998 and 1999 by product, application group, company, and origin of ownership

Format and Scope

This Focus Report emphasizes demand-side analysis of the semiconductor market and focuses on electronic equipment production. For supply-side semiconductor shipment information by product or company (with vendor market share analysis), please see Dataquest's Market Trends report, *An Analysis of China/Hong Kong's Semiconductor Market: Suppliers, Drivers, and Forecasts*. The company data is provided by responsible representatives of those companies or knowledgeable industry contacts.

Key Findings

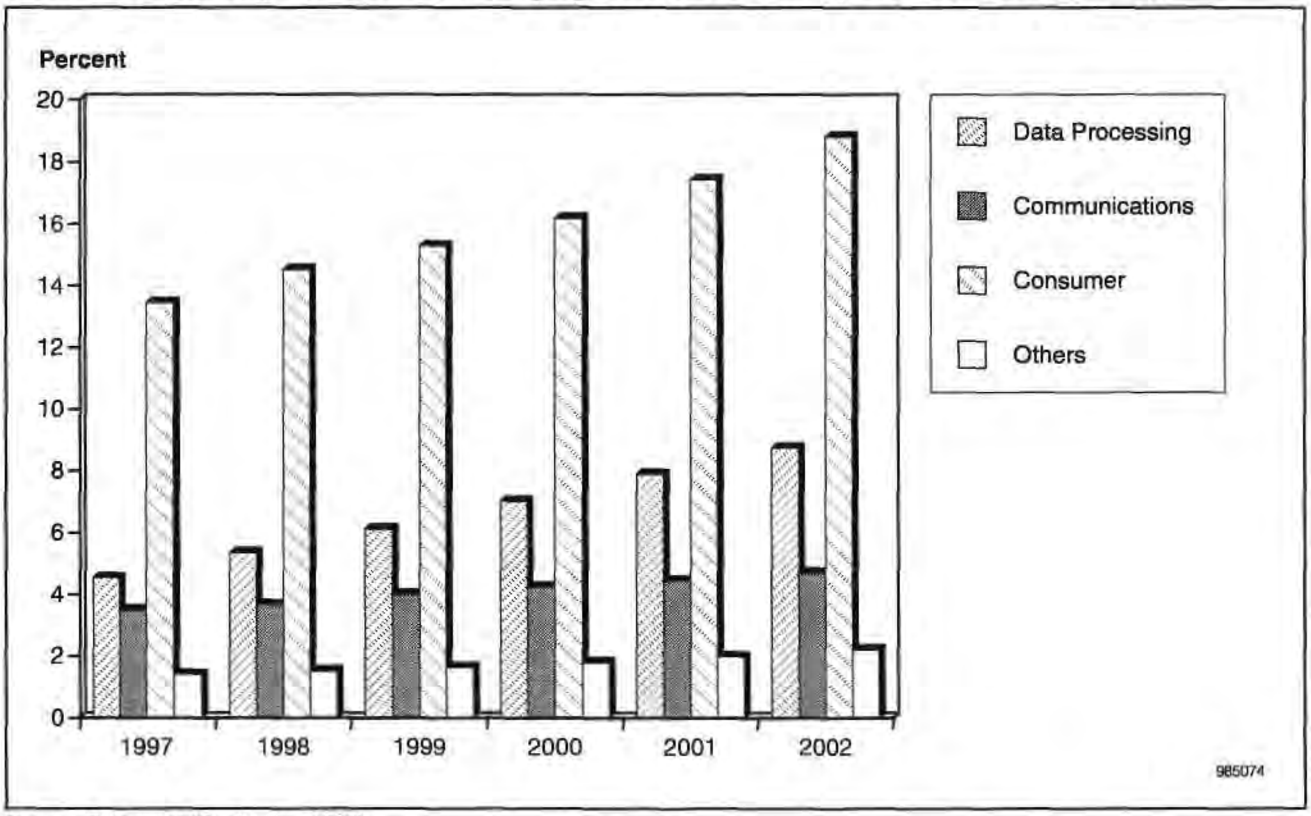
Despite some mature IT segments, Dataquest expects the worldwide IT's overall health to be influenced by emerging communications, Internet, digital consumer, and PC industries' 15 percent average unit growth. Dataquest forecasts an overall IT hardware shipment growth in the next five years of 7 percent. Asia/Pacific's production accounted for only 15 percent of the world's total electronic equipment production in 1993, but reached 19 percent in 1997. By 2002, Dataquest forecasts that 24 percent of worldwide electronic equipment production will take place in Asia/Pacific.

China Now a Global Force

As shown in Figure 1-1, Dataquest concludes that China/Hong Kong will outpace the rest of Asia/Pacific and substantially increase its share of worldwide electronic equipment production from approximately 5 percent in 1997 to 8 percent in 2002. In 1996, it accounted for only 4 percent of output. Dataquest will explain how consumer electronics will represent the largest share of 19 percent of world production, up from 13 percent in 1997. Data processing will increase its market share the fastest, doubling from 4.5 percent in 1997 to 9 percent in 2002. Communications equipment will grow substantially, from a small base of 3.5 percent to 5 percent by 2002.

China/Hong Kong's share of Asia/Pacific production will increase from 27 percent in 1997 to 32 percent in five years. In revenue terms, China/Hong Kong's electronics production will grow from U.S.$37 billion to $98 billion, representing a compound annual growth rate (CAGR) of 16 percent.

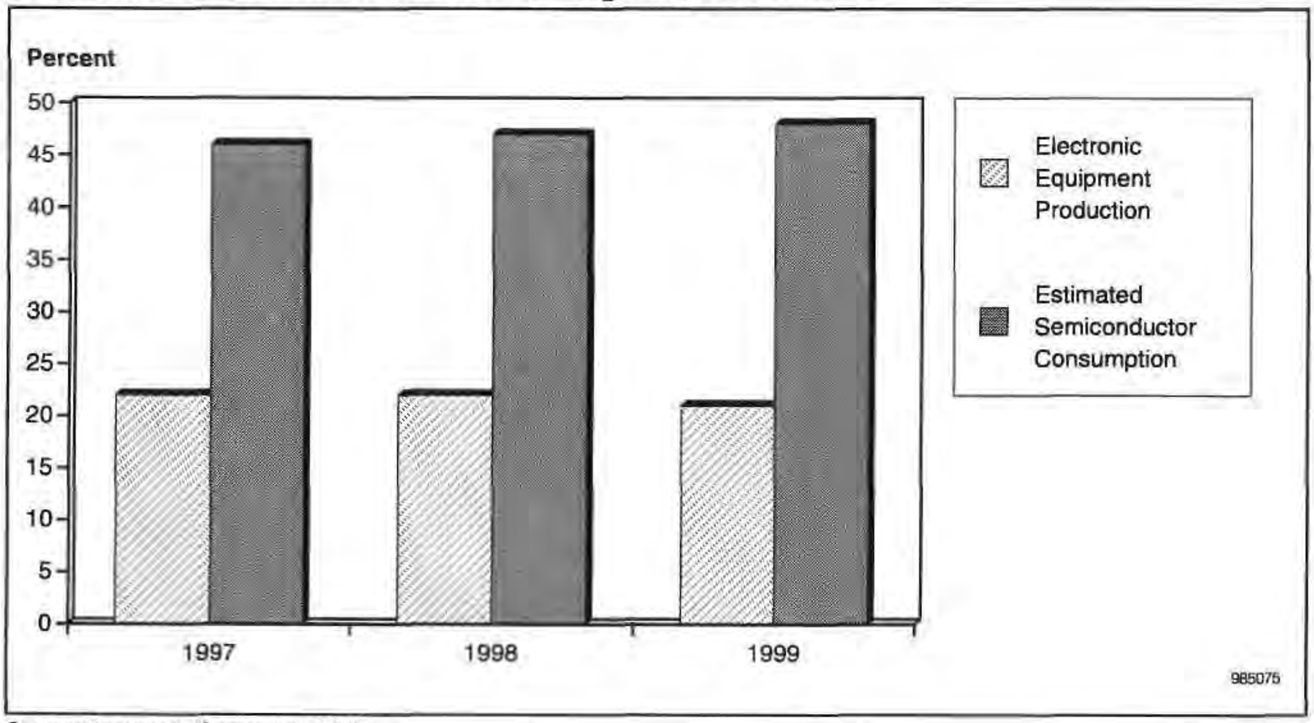
Figure 1-1
China/Hong Kong's Share of Worldwide Total Electronic, Data Processing, Communications, and Consumer Equipment Production, 1997 to 2002 (Percent)



Source: Dataquest (September 1998)

Dataquest conducted a survey of 64 major electronic equipment manufacturers, which are listed throughout this report in respective product discussions. Dataquest has identified the factories, products, and production quantities for 1997 and forecast for 1998 and 1999. Dataquest's basis for selecting these companies was subjective. Clients expressed a high interest in Chinese companies since last year, so we increased our sample size of local manufacturers relative to multinational vendors. Companies that had large production capacity or had aggressive expansion plans were also selected. The main purpose is to support Dataquest's high-volume electronic equipment production forecast that is also included in this report. Upon completing the research, Dataquest discovered that these companies represent approximately 24 percent of the 1998 production. As illustrated in Figure 1-2, the sample size within each application segment varies. These findings indicate that China/Hong Kong's manufacturers are scaling back production in certain areas, but the overall industry will sustain formidable growth in the next few years.

Figure 1-2
Surveyed Companies' Share of Total China/Hong Kong Electronic Equipment Production and Semiconductor Consumption, 1997 to 1999

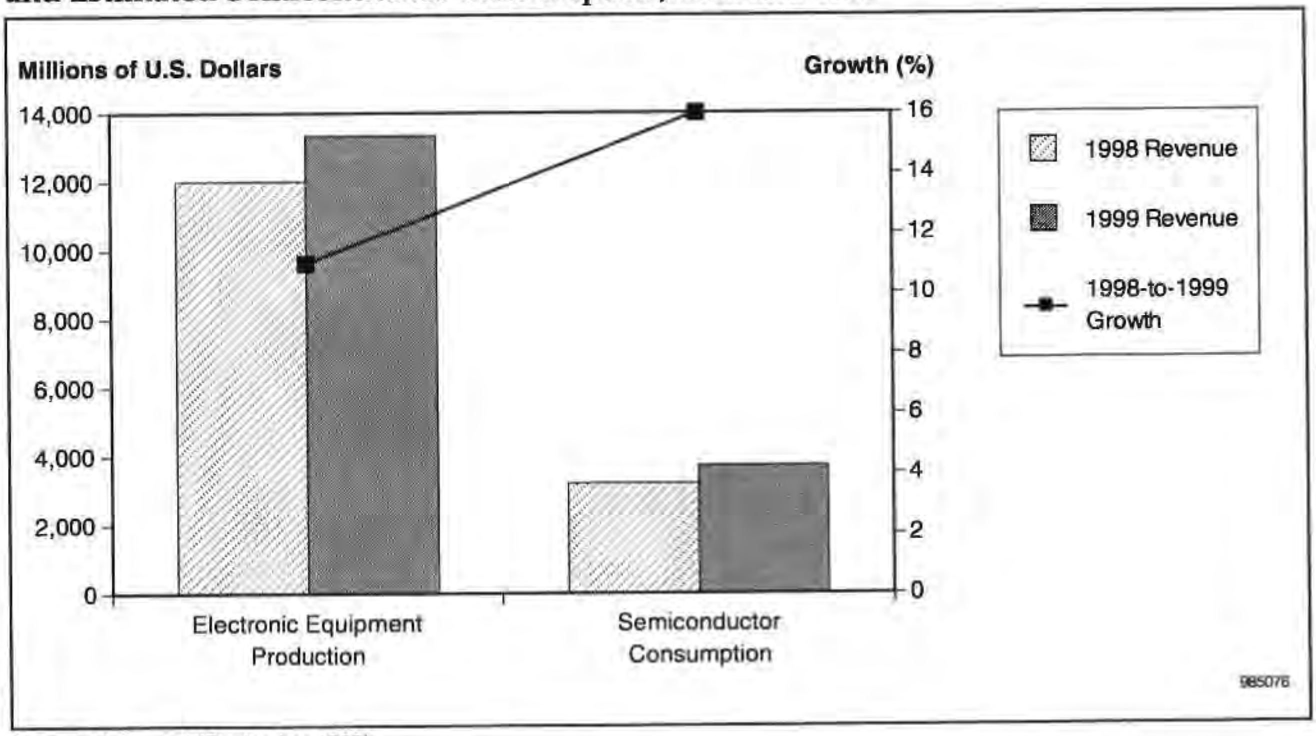


Source: Dataquest (September 1998)

In terms of semiconductor consumption, Dataquest observes that because major manufacturers will expand by 11 percent in revenue terms, their semiconductor consumption will increase by approximately 16 percent (see Figure 1-3). As discussed earlier, Dataquest's survey group will consume an estimated 24 percent of semiconductors consumed in China/Hong Kong in 1998. Note that these semiconductors were either shipped internally by multinational companies, purchased direct from manufacturers, or supplied by distributors. Dataquest forecasts that this same group of companies will consume 48 percent of all 1999 semiconductor shipments. This consumption level reveals the following trends:

- Rising semiconductor richness and technology level of products being manufactured in China/Hong Kong
- Larger multinational and Chinese manufacturers are achieving economies of scale faster and for higher-end products than the smaller companies
- Small and medium-size companies will face further difficulty competing against large companies that have efficient sourcing and distribution systems
- State-owned enterprises (SOEs) are being restructured, merged, or sold

Figure 1-3
Surveyed Companies' China/Hong Kong Electronic Equipment Production Revenue and Estimated Semiconductor Consumption, 1998 and 1999



Source: Dataquest (September 1998)

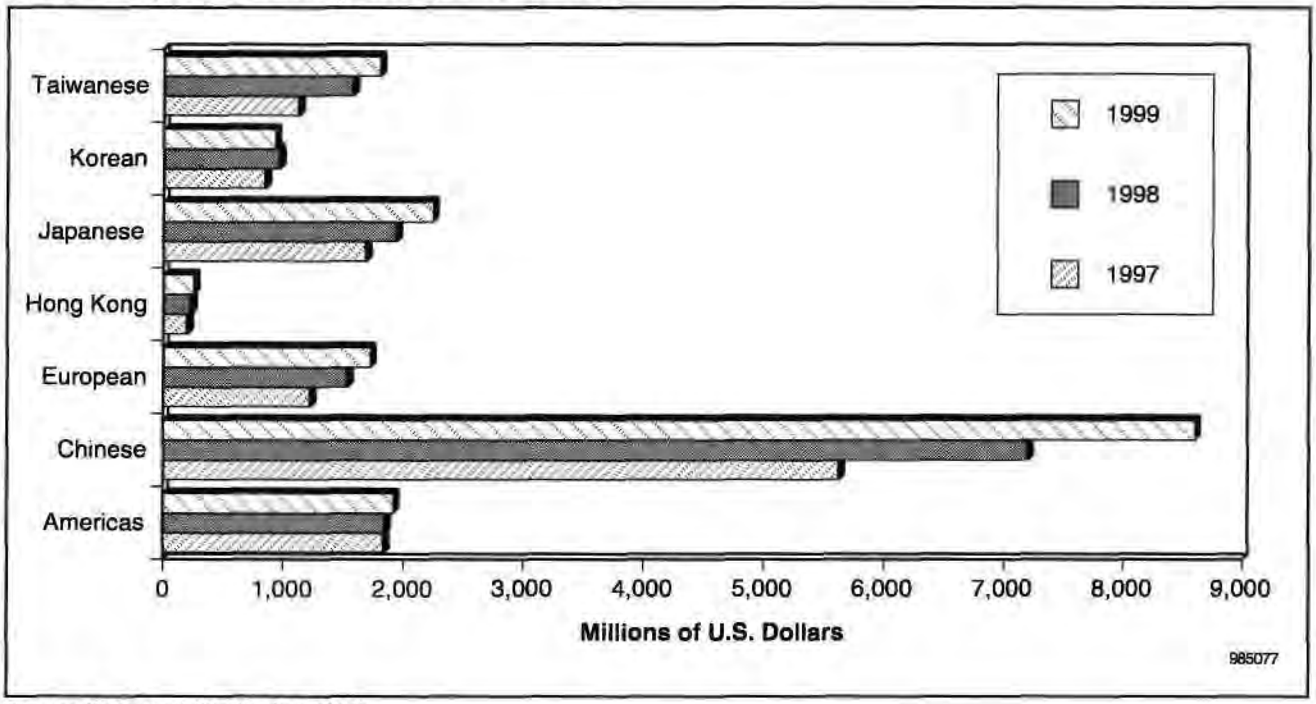
Electronics Production Growth by Ownership

Figure 1-4 lists production revenue of the 64 companies surveyed in China/Hong Kong by grouping their home base ownership. Figure 1-5 illustrates these companies' percentage share. The Americas companies surveyed had doubled production in China/Hong Kong in 1997, after investments made in 1995 and 1996. However, these companies have halted expansion plans in 1998 with about 1 percent growth. Dataquest had expected U.S. manufacturers to surpass Japanese manufacturers in 1997 and 1998, but this will not happen because of investment slowdowns. As discussed in Chapters 3 and 4, computer and communications investments are leading the next wave of growth, while consumer growth is expected to remain modest.

Semiconductor Consumption by Users' Home Base of Ownership

Each manufacturer's semiconductor consumption is derived by multiplying the units of equipment produced by an average semiconductor content per piece. Dataquest estimates each equipment's semiconductor content and manufacturers' semiconductor consumption revenue. The scope of the survey did not include surveys of procurement offices to ascertain total semiconductor purchase by factory. Such a methodology would have had to account for local purchases, internal transfers, and global procurement contracts. Dataquest believes that the methodology used provides a realistic average consumption by product and accurate trend analysis on a year-on-year comparative basis.

Figure 1-4
China/Hong Kong's Electronic Equipment Production Revenue by Home Base of Ownership of 64 Companies, 1997 to 1999



Source: Dataquest (September 1998)

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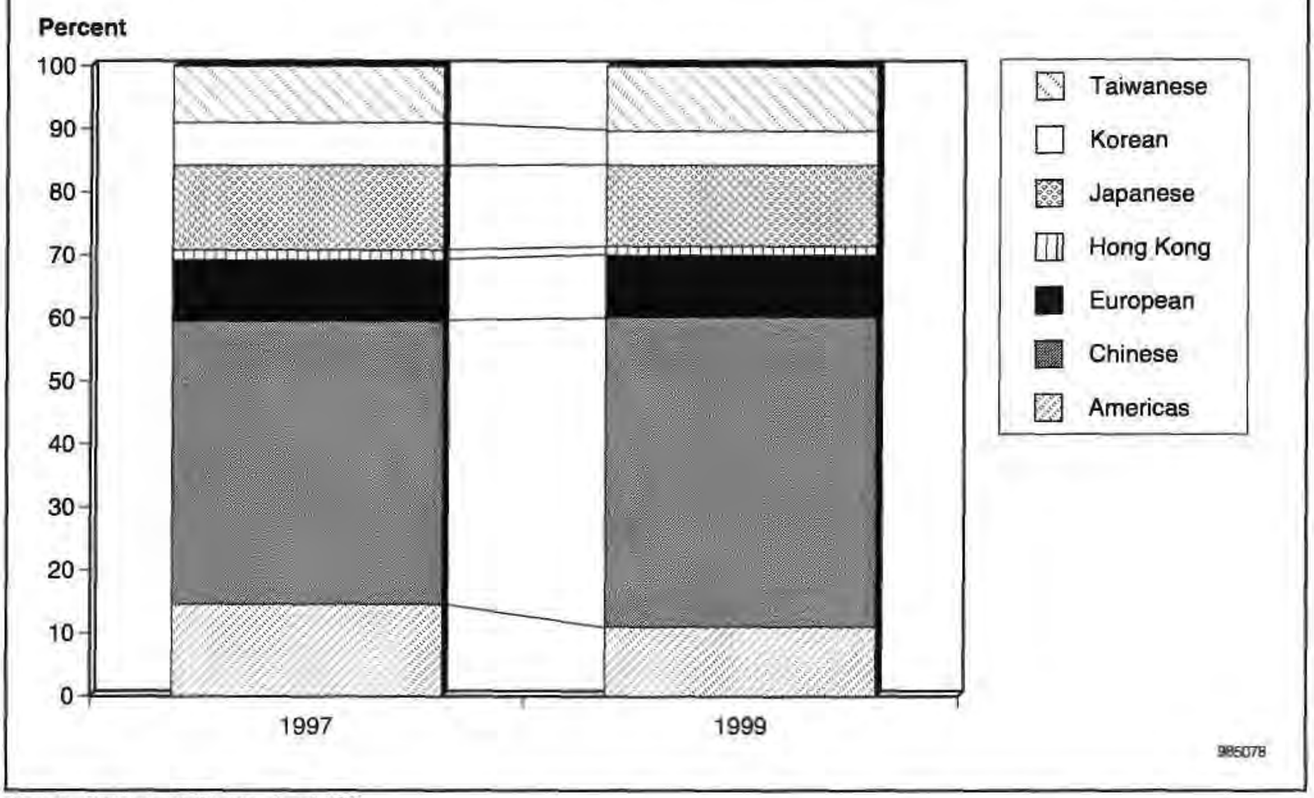
Figure 1-5
China/Hong Kong's Electronic Equipment Production Revenue by Home Base of Ownership of 64 Companies, 1997 and 1999



Source: Dataquest (September 1998)

Figures 1-6 and 1-7 illustrate the revenue and percentage of total semiconductor consumption estimates aggregated for the 64 users. Chinese companies occupy the largest share and are the fastest-growing in equipment production and semiconductor consumption, with 28 percent and 39 percent growth, respectively. Americas companies were the second largest, representing 13 percent of consumption, but they will expand only 1 percent in 1998. These companies expected semiconductor consumption will improve next year, based on a 13 percent growth in the value of semiconductors used. Japanese companies will increase semiconductor consumption by 22 percent in 1998 and 23 percent in 1999. Dataquest believes the main reason for this discrepancy between Chinese and multinational companies' growth is a result of local Chinese manufacturers' particularly strong video compact disc (VCD) and PC production and sales in 1998.

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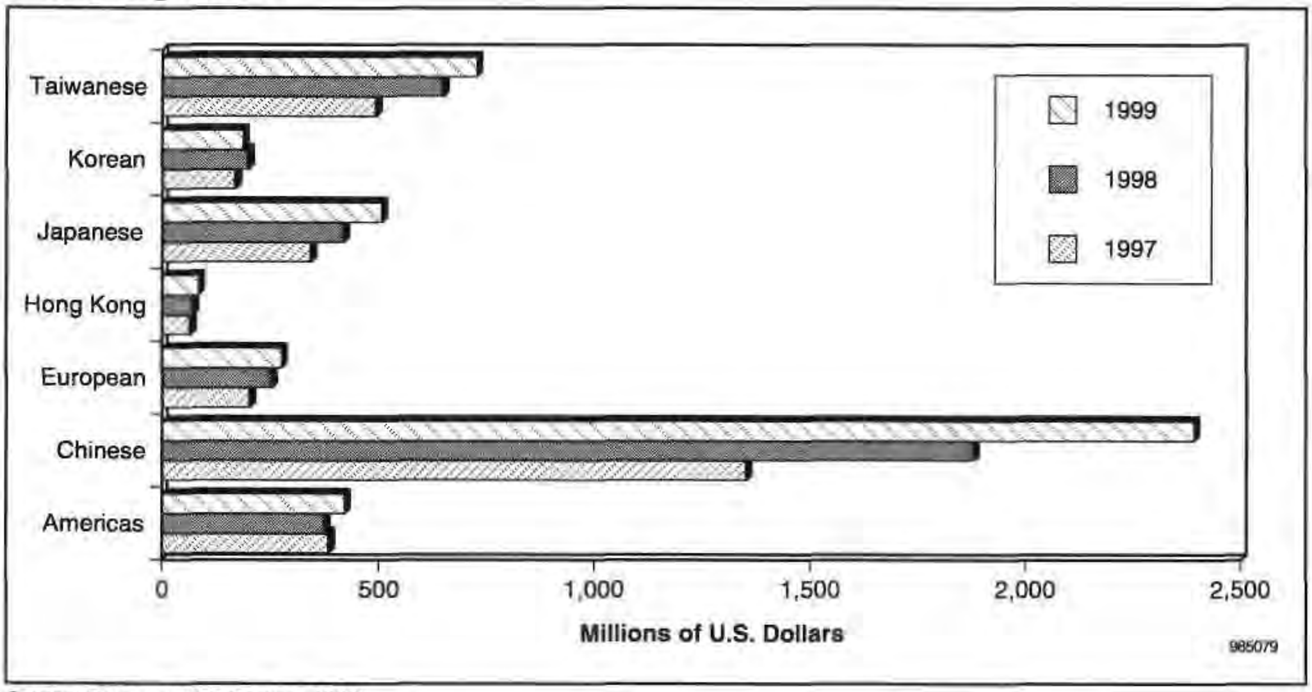
Figure 1-6
China/Hong Kong's Semiconductor Consumption by 64 Company Users' Home Base of Ownership in 1998

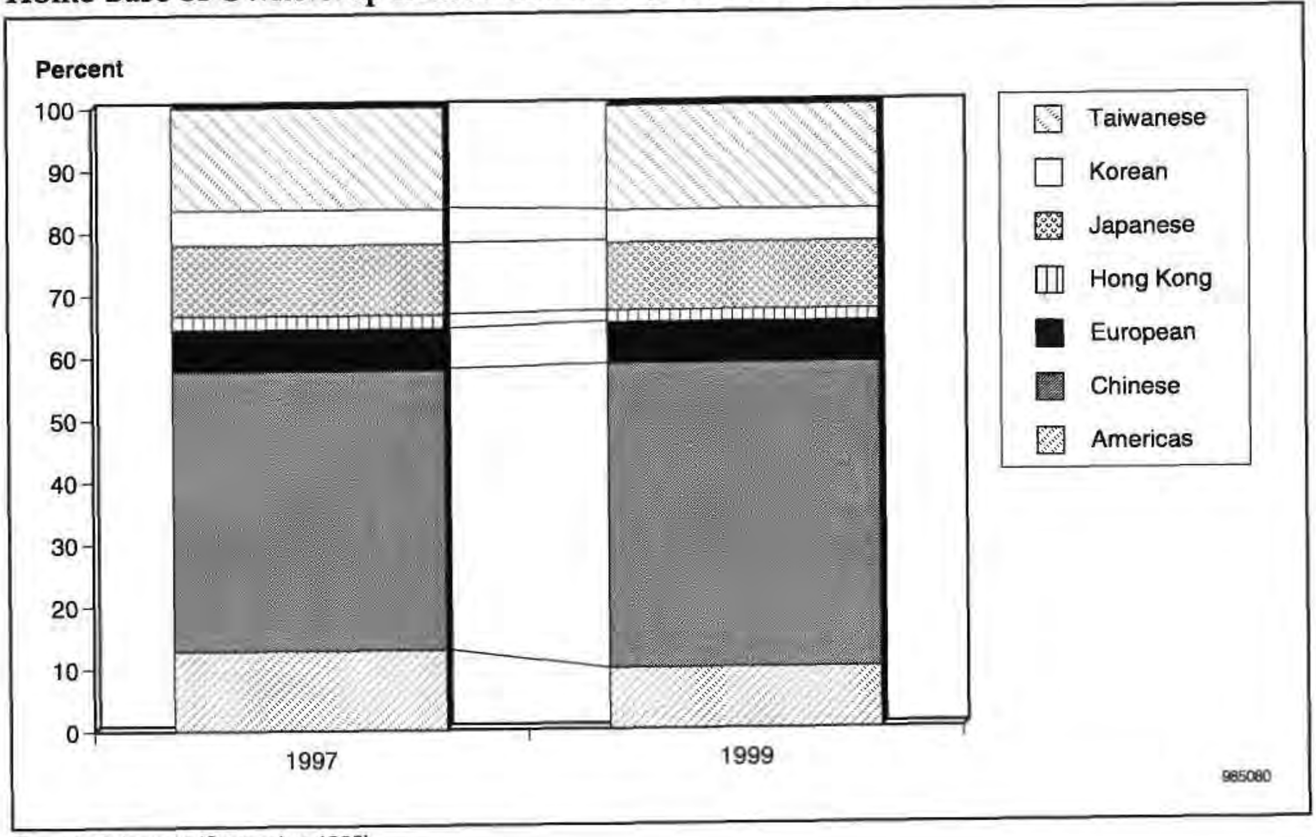


Source: Dataquest (September 1998)

Figure 1-8 summarizes all information by comparing growth rates by ownership for both equipment and semiconductor consumption. Figure 1-9 illustrates China/Hong Kong's electronic equipment production in 1998 and 1999. After the Chinese companies, Taiwanese producers are the fastest-growing consumers of semiconductors. Taiwanese companies, like the Americas, focused on the computer segment in China/Hong Kong. While both experienced rapid electronic equipment production growth, their semiconductor consumption growth is less than equipment factory revenue primarily because of pricing declines of memories, microprocessors, and microperipherals. European companies are the third-fastest-growing semiconductor user group, but they represent only 7 percent of Dataquest's survey group. Japanese companies appear to be maintaining overall semiconductor consumption growth, ranking fourth in consumption growth. Korean companies are ranked fifth in growth, followed by Hong Kong and Americas companies.

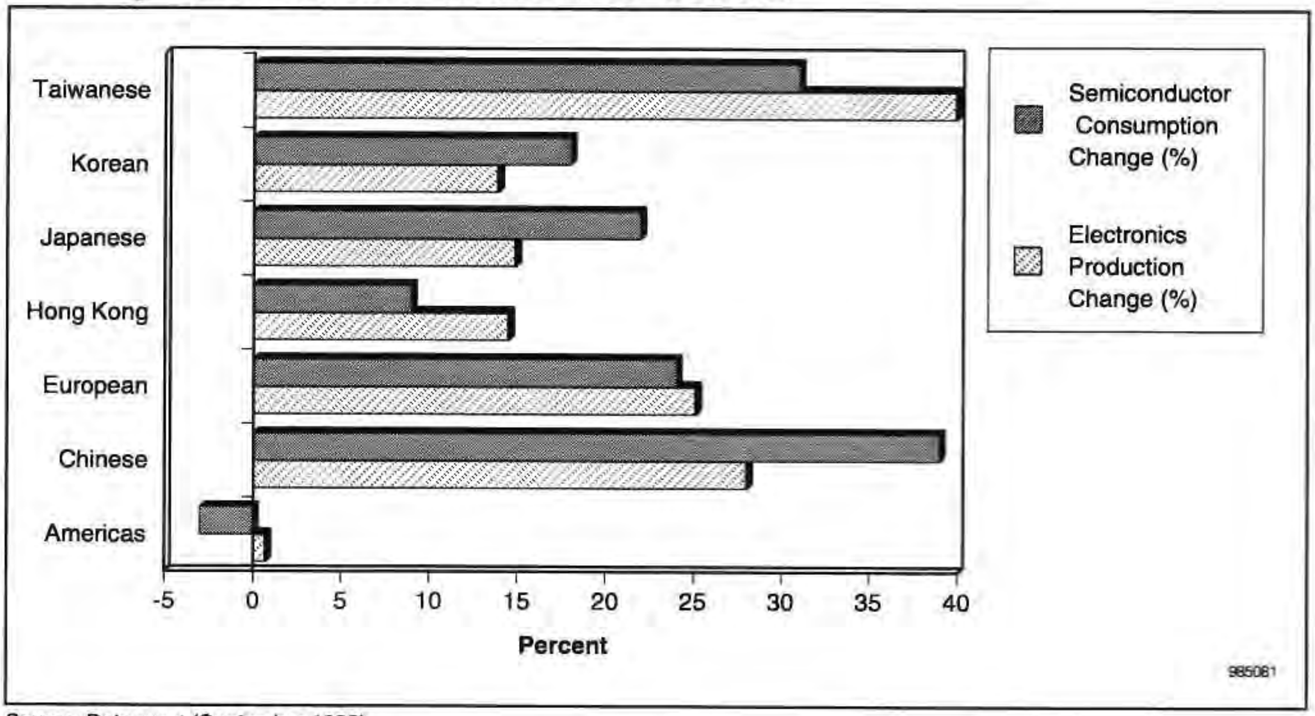
Project Analyst: Daniel Heyler

Figure 1-7
China/Hong Kong's Estimated Semiconductor Consumption by 64 Company Users' Home Base of Ownership in 1997 and 1998 (Percent Share)



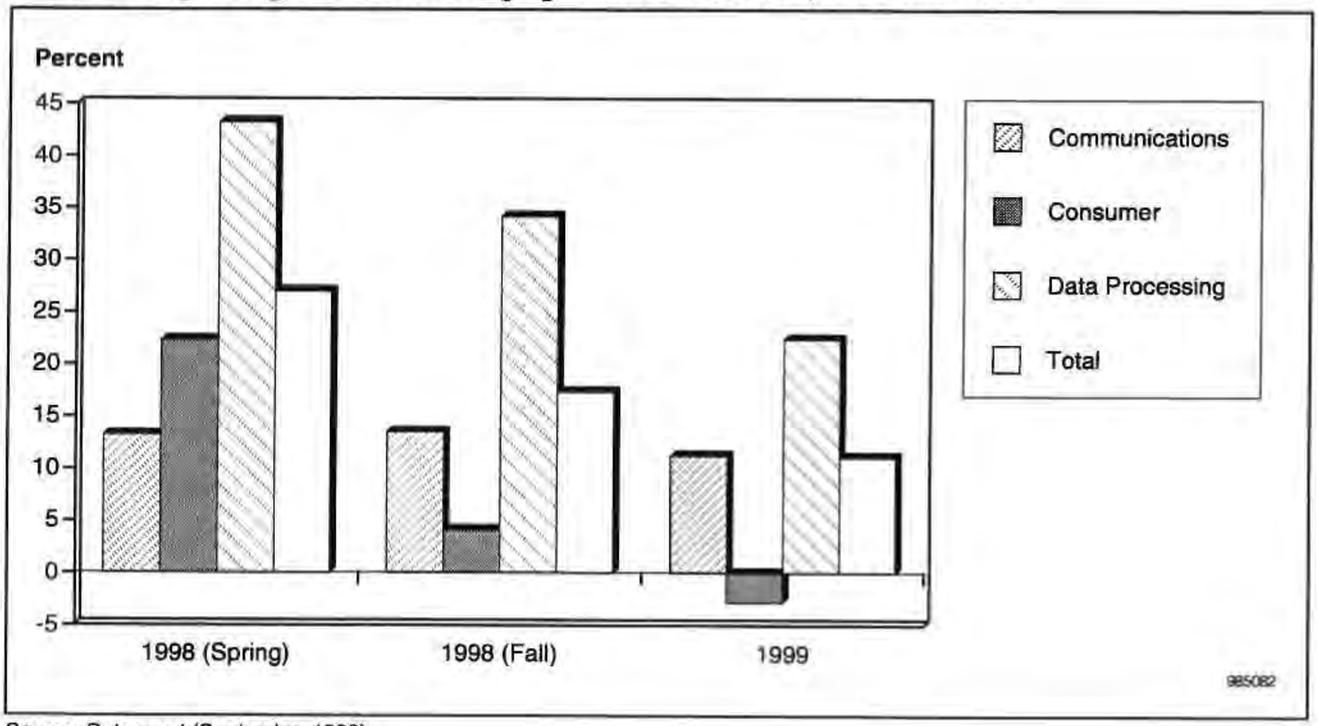
Source: Dataquest (September 1998)

Figure 1-8
Surveyed Companies' Electronic Equipment Production and Semiconductor Consumption Growth Rate Forecast in 1998 (Percent)



Source: Dataquest (September 1998)

Figure 1-9
China/Hong Kong's Electronic Equipment Production, 1998 and 1999



Source: Dataquest (September 1998)

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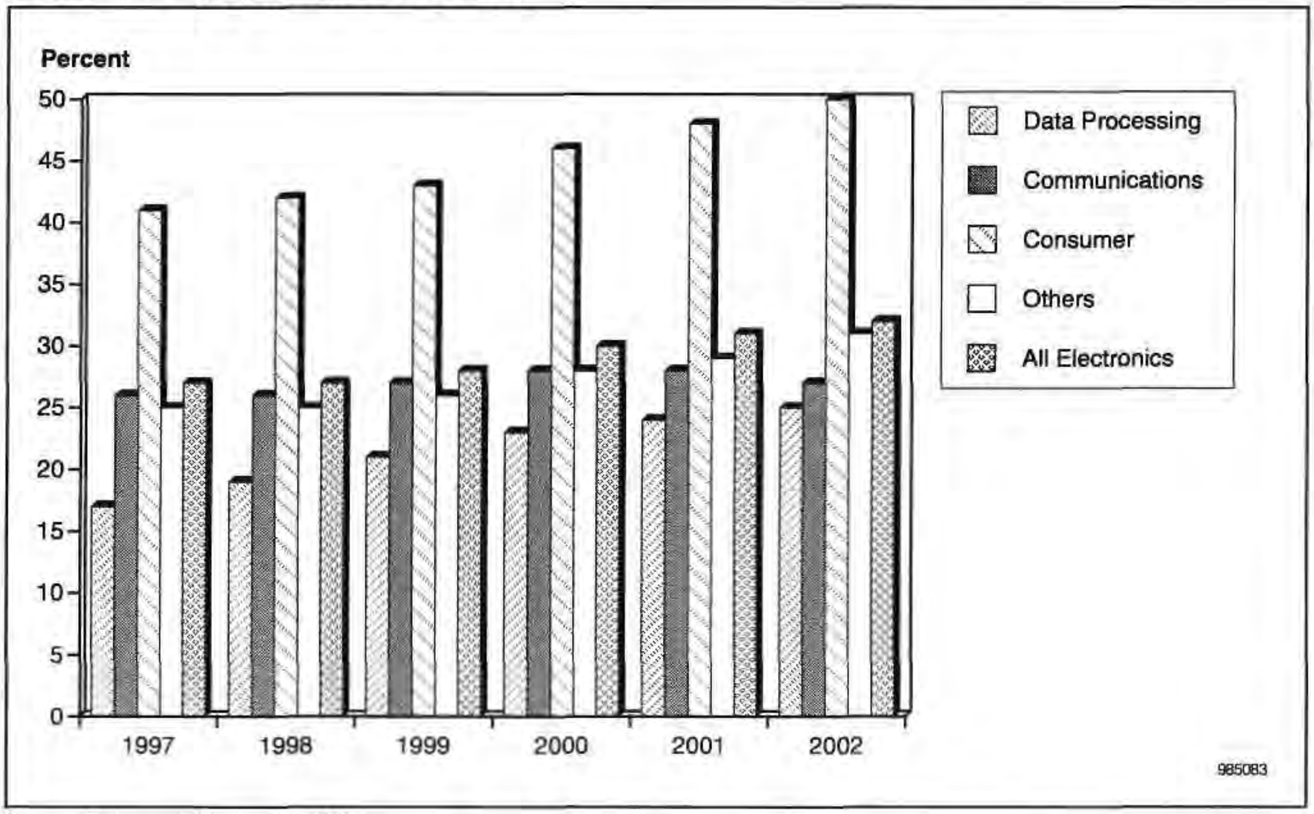
Chapter 2
Electronics Industry Trends

More than 30 Percent of Asia/Pacific Production Will Come from China

China/Hong Kong's share of Asia/Pacific production will rise from approximately 27 percent in 1997 to 32 percent in the next four years. In revenue terms, China/Hong Kong's electronics production will grow from $46 billion to $98 billion, representing an 18 percent CAGR. In a broader context, the worldwide CAGR for this period is about 6 percent to 7 percent, with the Asia/Pacific CAGR more than 10 percent. China/Hong Kong's lectronic equipment production quantity outpaces worldwide averages because of export competitiveness and unsatisfied local demand, especially within the healthier economies such as China and Taiwan. At the same time, semiconductor content is increasing faster in Asia/Pacific than in the rest of the world. This trend suggests that semiconductor consumption will outpace electronics in the next five-year period (taking out cyclicality). Foreign investments to China/Hong Kong are accelerating for the purpose of gaining market access and time-to-market competitive advantage, a necessity in an oversupplied market. Figure 2-1 illustrates China/Hong Kong's share of total data processing, communications, and consumer equipment production.

Figure 2-1
China/Hong Kong's Share of Total Electronic, Data Processing, Communications, and Consumer Equipment, 1997 to 2002



Source: Dataquest (September 1998)

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In comparing the past five years with the next five years, it is clear that revenue in Table 2-1 shows an electronics production deceleration in Asia/Pacific. In relative terms, the region has doubled in revenue and expanded from one-third the size of Japanese electronics industry to more than 90 percent of Japan's 1997 revenue. The region was half the size of Europe's industry in 1991, but it will continue to converge with that of Europe. The region will not sustain this phenomenal growth because of lasting effects of the Asian financial crisis, but it is expected to outpace other regions in the next five years.

Data Processing Electronic Equipment Overview

Although Asia/Pacific succeeded early in consumer electronics manufacturing , its data processing industry has kept pace with worldwide trends, and its revenue is expected to more than double from $78 billion in 1997 to $157 billion in 2002. In the past three years, Asia/Pacific communications markets' and industries' rapid growth has enabled this sector to reach $29 billion in 1997. Dataquest forecasts strong growth in a few key sectors, bringing revenue to $47 million in 2002. Consumer electronics production surged in the early 1990s because of transplanted Japanese manufacturing. Dataquest expects it to remain the second-largest segment in Asia/Pacific. A worldwide consumer electronics consumption slowdown through 1998 has translated into slower growth in Asia/Pacific production, although Dataquest expects Asia/Pacific to grow at double the worldwide production growth rate.

Asia/Pacific countries that bet their industrial development on PCs have reaped the rewards. The impressive manufacturing efficiencies of Singapore and, later, Malaysia, have enabled Asia/Pacific to increase its share of global mass-storage production. Dataquest sees no signs of this trend changing. The combined revenue from monitors, PCs, and motherboards was 65 percent of total data processing revenue. Storage makes up most of the rest of data processing revenue. By 2002, Dataquest believes that these five products will represent 80 percent of data processing revenue, and data processing will represent 52 percent of total Asia/Pacific electronics production.

Table 2-1
Asia/Pacific Electronic Equipment Production Forecast by Sector, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Electronics	**175,058**	**196,879**	**220,425**	**239,969**	**271,143**	**302,986**	**11.6**
Data Processing	77,903	91,332	106,529	118,718	138,172	157,145	15.1
Communications	29,332	32,589	35,235	37,995	42,280	47,270	10.0
Consumer	54,561	58,314	62,414	65,432	70,758	76,475	7.0
Industrial	5,255	5,886	6,573	7,282	8,262	9,236	11.9
Military/Civil Aerospace	4,534	5,112	5,856	6,532	7,412	8,452	13.3
Transportation	3,473	3,647	3,819	4,010	4,258	4,409	4.9

Source: Dataquest (August 1998)

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The PC markets show slower but steady growth worldwide, and Asia/Pacific has proved well-suited to meet those market needs. What will enable the PC to continue to add value to home and private citizens is that it continues to evolve in its functionality and integration into people's lives. Recently, PCs evolve from a productivity tool for spreadsheet, word processing, and other data processing tasks into an information, communications, and entertainment multimedia system. Technology barriers are eventually overcome, and new multimedia PCs now offer 3-D graphics, MPEG-2 video, AC-3 audio, fax/modem, telephony functions, and videophone. The world of system-level integration will engender the next quantum leap in performance and functions.

Consumer Electronics Overview

Asia/Pacific is already a player in the new wave of digital consumer electronics that is now entering the marketplace. These emerging electronics include digital video disks (DVDs), digital cameras, digital camcorders, digital VCR, digital TVs, video CDs, advanced games, and direct broadcast satellite, or set-top boxes.

Asia/Pacific benefits several ways in manufacturing consumer electronics. It receives investments from high-cost production regions, such as Japan, and its broad economic growth provides new growth for old products. China's color television production is an example of an undeveloped market revitalizing a mature industry. In 1997, China manufactured approximately $6 billion in video equipment. Dataquest expects China to experience a two-year slowdown in consumer electronics, but the five-year future of digital consumer equipment production is bright. New products, such as set-top boxes and DVDs, will find a way into these huge potential markets in inexpensive ways. Governments are eager to establish digital broadcast standards that will pave the way for broadcasting after 2000.

Communications Electronics Overview

Communications electronics are the third-largest sector in China/Hong Kong and Asia/Pacific. In China/Hong Kong, communications equipment production dominates consumer products such as phones, cordless handsets, answering machines, and analog cellular equipment. Furthermore, digital cellular products are now playing a pivotal role in communications semiconductor market growth. In 1995, digital cellular shipments accounted for only 38 percent of the total analog and digital cellular unit market, but in 1998, it will account for more than 80 percent of the 123 million phones shipped.

Unlike data processing and consumer electronic equipment production Asia/Pacific's communications production is significantly less than it consumes. These are market opportunities that the local companies are exploring, and multinational companies are starting to invest in this area. In the short term, most of the advanced infrastructure equipment will be imported. For many other products, Dataquest sees production continuing to expand in the region because this is where the world's fastest market growth is expected for the next 10 years. Central office/premises and cellular phones will surpass cordless phones to become the second- and third-largest markets.

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China/Hong Kong a Critical Growth Source for Asia/Pacific

The following key factors enable China/Hong Kong electronics to avoid dramatic production swings as these sectors fell in most other parts of Asia/Pacific, except Taiwan:

- China, unlike the other regions, is showing growth in all three electronics sectors. The net consequence is an impressive overall growth.
- China's domestic market attracts investors from all major regions.
- China's industry is balanced between exports and local consumption, each representing about one-half of total output.
- Economic planners are focusing on sustaining macroeconomic stability vis-à-vis microeconomic policy. Without floating its currency, China has maintained control of its economy without suffering the economic woes seen in the Russian republics.

As shown in Table 2-2, Dataquest expects strong growth in China's three major electronics sectors, but with data processing leading the growth, while communications and consumer sectors followed.

Dataquest's Electronic Equipment Producers Survey Results: The Big Are Getting Bigger—and a Lot Faster, Too

China/Hong Kong has become the No. 1 investment destination by electronic equipment companies in Asia/Pacific. The currency and economic woes in several Southeast Asian countries may further depress their long-term growth. China's rapid reforms, strong economy, growing consumption, and advancing production base continue to attract major investments from various sectors.

Table 2-3 lists major multinational and Chinese companies that were surveyed for production quantities detailed in this report. Dataquest surveyed 38 manufacturers and has itemized the top 20. Note that the revenue was derived from estimated unit production of major electronic equipment and applying a factory ASP.

Table 2-2
China/Hong Electronics Equipment Production Forecast by Sector, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Electronics	**46,496**	**54,087**	**62,798**	**72,773**	**84,888**	**98,341**	**16.2**
Data Processing	13,407	17,363	21,936	27,264	33,617	40,019	24.4
Communications	7,540	8,398	9,593	10,638	11,674	12,978	11.5
Consumer	22,266	24,592	26,972	29,867	33,743	38,477	11.6
Industrial	991	1,122	1,268	1,459	1,691	1,951	14.5
Military/Civil Aerospace	1,162	1,325	1,536	1,782	2,085	2,451	16.1
Transportation	1,129	1,287	1,493	1,762	2,079	2,465	16.9

Source: Dataquest (August 1998)

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Table 2-3
Manufacturing Joint Ventures' Sampler in China

Company	Products	Chinese Partner
Ericsson	Cellular phone	China National Posts and Telecommunications Industry Corporation
	Mobile communications infrastructure	Guangdong Mobile Communications Co. Ltd.
	Parts of AXE system	Nanjing Panda Electronics Enterprise Group
	Central office	Beijing Wire Communications Plant
FIC	Motherboard	Hong Kong Taizhong Co. Ltd.
	PC	Changbai Computer Enterprises Group
Fujitsu	Printer	Nanjing Zhongshan Enterprise Group
	Printer	Beijing Stone Group
IBM	Motherboard	China Great Wall Computer Group
	PC	China Great Wall Computer Group
Hitachi	Color television	Shenzhen Saige Enterprise Group
	Analog camcorder	Shenzhen Saige Enterprise Group
LG	VCD	Shanghai Huangdian Enterprises Group
Matsushita	Color television	Hualu Enterprises Group
	Pager	China National Posts & Telecoms Industry Corporation
	Videocassette recorder (VCR)	Hualu Enterprises Group
Motorola	Cellular phone	China National Posts & Telecoms Industrial Corp., Eastern Communications Co. Ltd.
	Pager	Shanghai Radio Communications Equipment Manufacturing Company Limited
NEC	Cellular phone	Wuhan Zhongyuan Radio Factory
	PC	Changjiang Computer Enterprises Group
	Central office	Benxi Communications & Electronical Appliance Industry Co. Ltd.
		Tianjing Zhonghuan Electronics & Computer Corp.
	Pager	TCL
Nokia	Cellular phone	Beijing Communications Instrument Factory
	Mobile communications infrastructure	Beijing Communications Instrument Factory
	Central office	Beijing Hangxing Communications Co. Ltd.
Philips	Color television	Suzhou Peacock TV Plant
	HiFi	Beijing No 1 Radio Company
	Personal stereo	Beijing No 1 Radio Company
SANYO	Analog cordless phone	China National Posts and Telecommunications Industrial Corp.
Sharp	Color television	Nanjing Panda Electronics Group
	HiFi	Nanjing Panda Electronics Group
Siemens	PC	Hongkong Top Victory Investment Co. Ltd., Fuzhou Tianye Enterprise Group
	Central office	Shanghai Xinguang Factory
		State-owned Beijing 239 Factory

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Table 2-3 (Continued)
Manufacturing Joint Ventures' Sampler in China

Company	Products	Chinese Partner
Sony	Color television	Shanghai Guangdian Enterprise Group
	Monitor	Shanghai Guangdian Enterprise Group
	Analog cordless phone	Technology development Co. Ltd. of Post and Telecommunications Institution
	Analog camcorder	Shanghai Guangdian Enterprise Group
Compaq	PC	Beijing Stone Group

Source: Dataquest (September 1998)

Dataquest lists 31 major manufacturing companies, representing 20 percent (or $11 billion) of electronics production in China/Hong Kong. Dataquest's analysis of these manufacturers indicates a rapid expansion of production capacity for both local consumption and export, but that this expansion is decelarating, particularly in the consumer electronics area. These 31 companies are expected to increase revenue by about 13 percent in 1999 after growing approximately 22 percent in 1998 (see Table 2-4).

Company-Level Semiconductor Consumption Ranking Forecast

As expected,China's semiconductor consumption is rising even faster for the major manufacturers. However, semiconductor consumption rankings differ from electronics production rankings. Legend Group will become the largest consumer of semiconductors in China/Hong Kong in 1998, after surpassing PC Chips Manufacturing Limited, a low-end motherboard manufacturer based in Taiwan (see Table 2-5). The combined consumption of these companies will be more than 30 percent of semiconductors used in China/Hong Kong. Dataquest's total sample group of 64 will consume 42 percent of semiconductors used in China/Hong Kong.

Electronics Equipment Production Assumptions

China's growth in exports, local consumption, foreign investment, and government support are some basic positive factors behind its electronics production growth. Underlying and supporting all these trends is the fact that local production is becoming more efficient, and economies of scale are being achieved.

Does China Need to Devalue Its Currency?

The currency devaluation created critical problems for Asia/Pacific semiconductor suppliers and users that are almost entirely dependent on imports. Although most vendors denominate their prices in dollars, cash-flow problems—attributed to rising credit costs and falling sales—have resulted in weakened demand from local manufacturers. Indonesia's currency devalued more than 80 percent during the past six months, and its equity market dropped by more than 80 percent. As a result of the financial turmoil, stock markets in Korea, Thailand, the Philippines, and Malaysia declined by more than 60 percent. Equity markets in China and Hong Kong have also dropped, but their strong cash account reserves have enabled them to support the Hong Kong dollar and the Chinese renminbi.

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Table 2-4
Forecast of 31 Major Electronic Manufacturers' Factory Revenue from Electronic Equipment Production Ranking in China/Hong Kong, 1997 to 1999 (Millions of U.S. Dollars)

Rank 1998	Company	Final 1997	Forecast 1998	Change (%) 1997 to 1998	Forecast Change (%) 1998 to 1999
1	Seagate	1,049	1,190	13.4	7.8
2	Chang Hong	973	1,061	9.0	7.3
3	Legend	447	751	67.9	31.7
4	Konka	517	731	41.2	17.7
5	Samsung	585	676	15.6	-1.8
6	Motorola	661	655	-0.8	-3.0
7	PC Chips	497	627	26.3	3.2
8	Great Wall/IBM	333	505	51.9	23.0
9	Shanghai Bell	449	503	12.0	7.3
10	FIC	405	497	22.7	11.9
11	Philips	339	465	37.1	1.1
12	TCL	349	408	16.9	28.4
13	Siemens	322	383	19.0	23.8
14	Xia Hua	235	362	54.5	34.6
15	Hitachi	307	336	9.5	20.0
16	Matsushita	300	326	8.5	4.5
17	Uniden	278	313	12.5	10.9
18	NEC	277	310	12.0	19.6
19	Acer	103	288	179.4	44.0
20	Jiangsu Shinco	403	283	-29.9	-45.5
21	BISC	211	259	22.5	11.2
22	LG	236	258	9.1	-9.0
23	Huawei	215	253	17.6	13.8
24	Sanyo	205	245	19.4	26.1
25	Ericsson	196	245	25.2	17.3
26	Phone Star	104	230	121.7	20.4
27	Vtech	197	226	14.5	10.8
28	Idall	243	224	-7.8	-18.6
29	Founder	126	216	71.1	82.8
30	Shanghai Guangdian	170	210	23.2	19.1
31	Tontru	122	207	69.9	62.9
	Top 31 Total	**10,857**	**13,245**	**22.0**	**13.4**
	Top 60 Total	**12,537**	**15,276**	**21.9**	**14.4**
	Total China/Hong Kong	**54,087**	**62,798**	-	-

Source: Dataquest (August 1998)

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Table 2-5
Estimated Semiconductor Consumption for 20 Major Electronics Companies in China/Hong Kong, 1997 to 1999 (Millions of U.S. Dollars)

Rank 1997	Rank 1998	Company	1997	1998	Forecast Growth (%) 1997 to 1998	Forecast Growth (%) 1998 to 1999	1999
2	1	Legend	242	394	63.1	33.0	524
1	2	PC Chips	246	297	20.8	7.7	320
3	3	Great Wall/IBM	190	278	46.2	21.2	336
4	4	FIC	181	217	19.5	9.7	238
5	5	Seagate	160	204	27.6	19.5	243
6	6	Motorola	155	171	10.1	4.5	179
7	7	Chang Hong	129	162	25.7	6.3	172
8	8	Samsung	111	134	21.1	-5.1	127
12	9	Tontru	72	117	63.6	59.0	187
11	10	Konka	75	116	53.9	16.7	135
10	11	Uniden	77	92	20.6	20.7	111
20	12	Founder	57	87	50.9	87.2	162
16	13	Siemens	67	86	27.7	18.6	102
14	14	NEC	71	85	19.0	36.8	116
13	15	Shanghai Bell	71	77	7.1	5.9	81
18	16	Matsushita	65	73	12.9	5.0	77
21	17	Philips	55	72	29.9	-11.2	64
17	18	Vtech	66	72	9.0	18.9	86
9	19	Jiangsu Shinco	95	67	-29.5	-44.4	37
23	20	TCL	50	66	31.9	35.3	89
		Top 20 Total	**2,235**	**2,865**	**28.2**	**18.2**	-
		Top 63 Total	**3,009**	**3,842**	**27.7**	**19.6**	-

Source: Dataquest (August 1998)

Few economists expect a renminbi devaluation in 1998, but there are concerns in the region that falling exports and a slowing economy will force China to devalue, potentially sparking another round of disastrous currency depreciation in Asia. It is a question of time. For sure, China will devalue, but whether it is before or after the region has recovered is the issue. In 1998, the Chinese government is under extreme pressure to maintain strong economic growth and create new jobs because of the dismantling of state-owned industries, which is creating millions of surplus workers. So far, the Chinese leadership has responsibly held its currency at the expense of economic growth, in addition to committing U.S.$250 billion in infrastructure spending projects to increase its gross domestic product (GDP) vis-à-vis domestic consumption.

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Gross Domestic Product Remains Robust

China's economic growth has slowed substantially since March of 1998. Data from the Organization of Economic Cooperation and Development (OECD) had forecast China's economy to grow between 7.5 percent to 8.0 percent in 1998. However, because of the region's worsening economies and slowing exports, GDP is expected by numerous sources in Hong Kong to fall between 6.5 percent and 7.5 percent. GDP in the first quarter of 1998 had slowed to 7.2 percent, and it is expected to slow to 7.0 percent in the second quarter. The trend is expected to continue, with the second half of 1998 averaging less than 7 percent. One of the advantages China has over the rest of Asia/Pacific is that its economy is far more diversified, with economic expansion taking place in heavy industries, manufacturing, electronics, services, and agriculture. This broad-based growth, including electronics, buffered it from Asia's economic woes. In fact, the major growth burden has been from the SOEs that account for about 60 percent the economy. Prime Minister Zhu Rongji is in the process of structuring SOEs, which is the main factor behind slower growth and rising unemployment. However, China depends heavily on foreign capital and markets to sustain its current growth rate.

Foreign Investment Will Not Dry Up

In addition to increased efficiencies in Chinese companies, economic growth has been boosted by direct foreign investment. Foreign investments need to continue to flow into China for it to achieve a 7 percent GDP growth. Hong Kong, which has been hurt financially by its falling stock market, accounted for 59 percent of foreign-invested capital in China from 1980 to 1997. In the past few years, contracted investments in China had declined from $88 billion in 1994 to $72 billion in 1997. However, the actual utilized investment increased from $33 billion to $44 billion during this period. There is uncertainty in 1998, and most forecasts indicate a decline in utilized investments to $35 billion for the first time in at least five years.

Dataquest also expects contracted investments to decline because of the investor uncertainty that is the short-term outcome of China's aggressive reforms to be undertaken in 1998. However, once the dust settles, investment flow is expected to resume in 1999 because the current slowdown is macroeconomic rather than microeconomic in nature. In the first quarter of 1998, figures show more than 10 percent growth over 1997, but the second quarter is expected to decline. However, Dataquest continues to see communications, computer, and consumer electronic companies maintain a high strategic interest in investing in manufacturing in China for long-term needs: to increase market access, reduce distribution costs, and improve time to the market.

Exports Still Competitive, Southeast Asian Companies Face Cash-Flow Problems

China's GDP will exceed $900 billion in 1998, yet its total trade is nearly $400 billion. China's export machine has proved to be a formidable global force, particularly in the past three years. The economy's trade surplus was expected to increase beyond $50 billion in 1998 prior to the financial crisis; but as result of the financial crisis, it is expected to decrease to the $30 billion range. The first two months of 1998 show exports to the United States to be at the same levels as 1997, while imports are slightly down.

China is exposed to the Asian financial crisis by about 11 percent because 11 percent of its exports go to Southeast Asia and Korea. In the past few years, China's exports to Japan have declined to about 15 percent of total exports, but exports to Europe, North America, and Taiwan increased to more than 60 percent. Based on export exposure, a dramatic trade downturn as experienced by the rest of Asia is not likely. The free-falling yen was clearly a threat, but China still holds a (dangerous) wild card: devaluing the renminbi.

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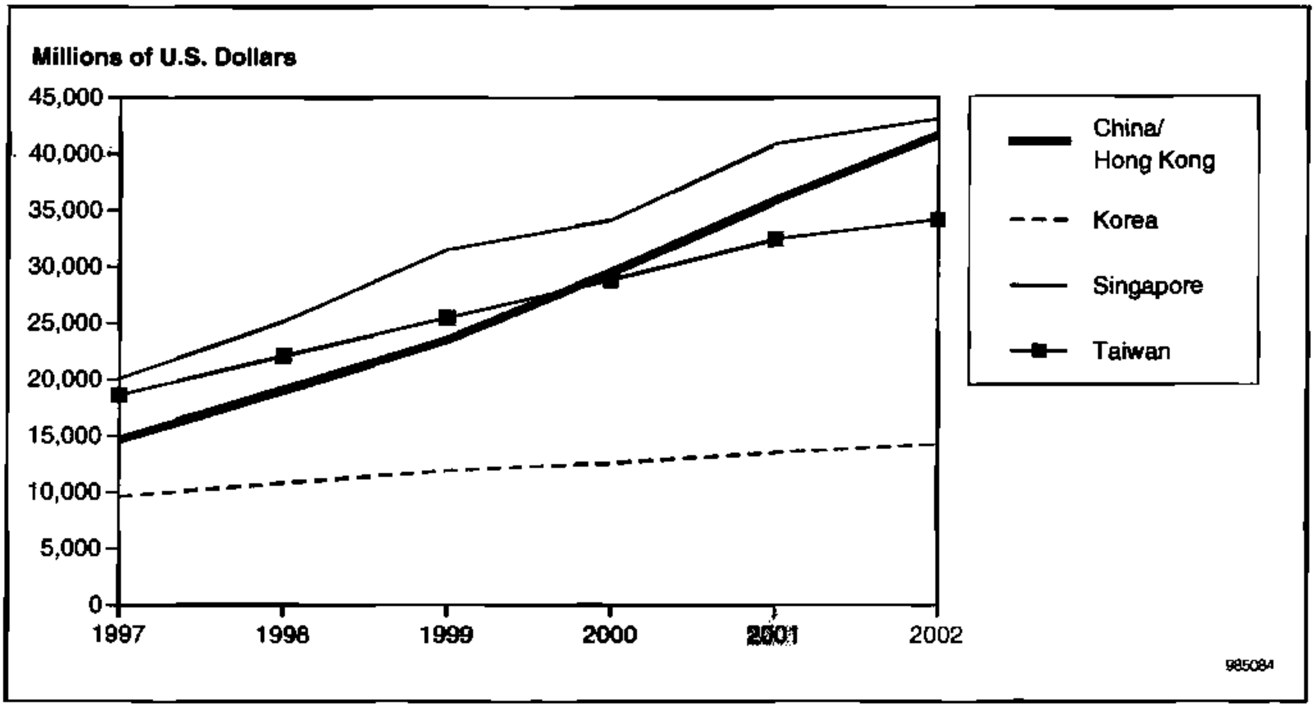
Chapter 3
Computers and Peripherals Industry Trends

Dataquest forecasts that data processing-related electronic equipment production revenue will grow from $19 billion in 1998 to $42 billion in 2002. In 1998, PC production will increase 55 percent to 4 million units, representing a semiconductor opportunity of approximately $900 million. Dataquest expects data processing, led by strong PC industry and market growth, to undergo an average annual growth rate of 36 percent during this period for reasons discussed later in this chapter. During this period, China will surpass Taiwan to become the second-largest data processing equipment producer in Asia/Pacific (see Figure 3-1).

Data Processing Segment Analysis

Dataquest expects data storage to become the fastest-growing sector during the 1997-to-2002 forecast period, although it was the smallest sector in 1997. Dataquest expects that most of the 1998 production will be exported. Seagate Technology Inc. is the sole manufacturer of rigid disk drives (RDDs) in China, operating two major facilities. Dataquest believes that this $2.4 billion industry in 1998 will grow fivefold to $9.4 billion by 2002, based on Seagate's plans, and new entrants are likely in the 1999-to-2000 time frame.

Figure 3-1
Data Processing Equipment Production in China/Hong Kong, Korea, Singapore, and Taiwan: 1997 to 2002 (Millions of U.S. Dollars)



Source: Dataquest (September 1998)

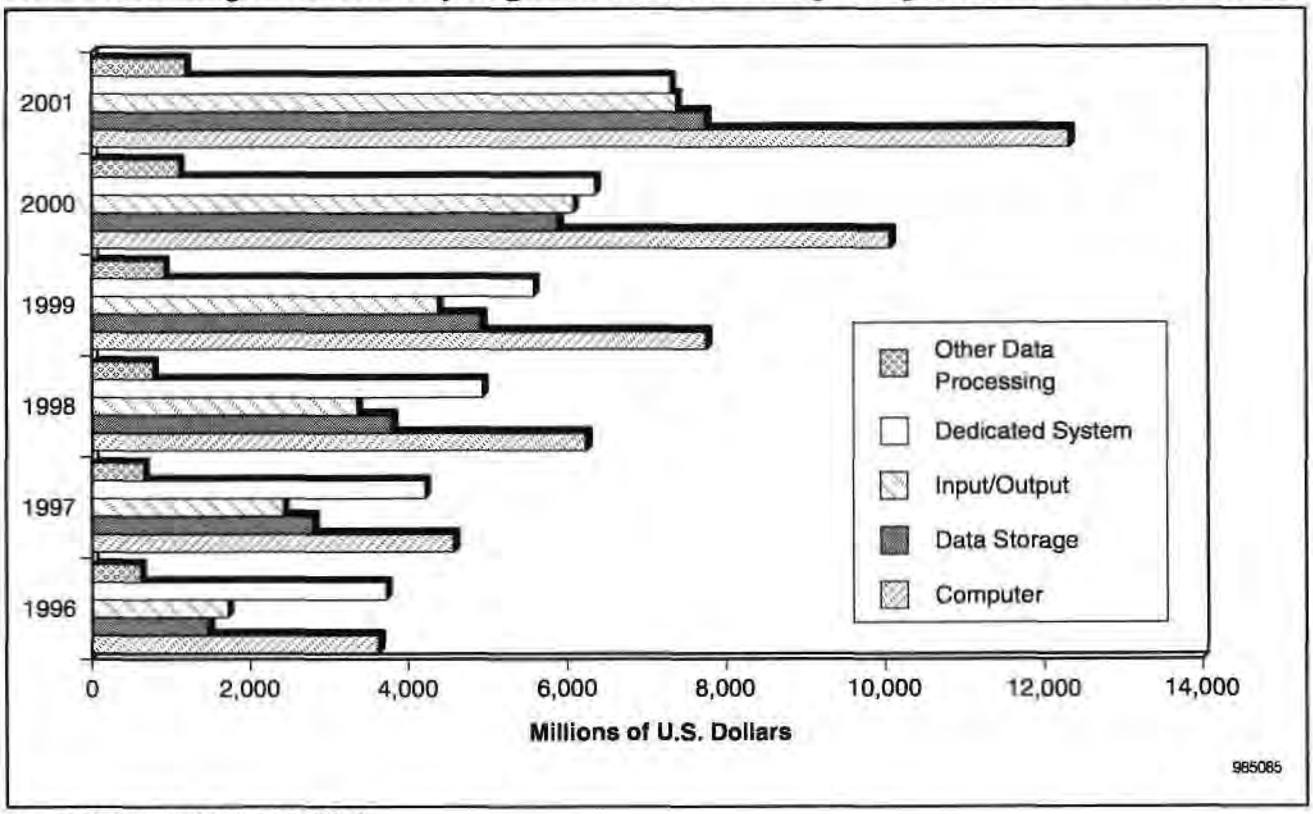
Computer peripherals, defined as input/output devices, will expand at an average annual growth rate of 30 percent to reach $9 billion, up from $2.4 billion in 1997. Monitors represent about 54 percent of this category.

The largest data processing sector is the computers, which is expected to grow 32 percent in 1998 and average 28 percent in the next four years, reaching a $13.3 billion revenue level in 2002. PCs and motherboards will increase in importance from 21 percent to 28 percent share of data processing production (see Figure 3-2). PCs and motherboards represent about 71 percent of computer revenue in 1998.

Computer Production

Computer equipment production in China is being driven first and foremost by consumption. However, improved quality and competitiveness now mean that foreign and Chinese companies are also exporting from China. China's growing computer demand will support the country's economic modernization. Chinese banks, insurance companies, and tax agencies are in the rudimentary stages of computer use, and they lack networks for information sharing. For the future convertibility of the renminbi (or Chinese yuan), Chinese officials are integrating banks with better computing systems. The State Bureau of Taxation is looking to connect 30,000 offices across the country.

Figure 3-2
Data Processing Production by Segment in China/Hong Kong (Millions of U.S. Dollars)



Source: Dataquest (September 1998)

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Computer and computer peripheral sales in China are expected to increase by more than 30 percent in 1997. Domestic demand for PCs this year is expected to approach 3 million units in 1997. China's domestic computer manufacturers currently account for about 25 percent of domestic sales. Most leading foreign PC vendors have already established manufacturing facilities in China to anticipate this growing domestic demand. Among other forecasts, China's annual demand for high-powered computer workstations is expected to grow to about 5,000 units this year.

PC Production Spurred by Domestic Market's Pull

Furthering PC production growth is the parts and components production in major production centers: Shenzhen, Shanghai, and Beijing. Time-to-market concerns, familiarity with local distribution channels and customer concerns, lower tariffs, and locally produced parts translate into competitive advantages and lower costs for Chinese producers. In addition to small-scale producers, major brands—such as Legend Group, the Beida Founder Group, China Great Wall Computer Group, Beijing Stone Group, Donghai Co., and others—have emerged in China's booming retail markets. Legend Group's recent initiatives indicate that the company is trying to duplicate its newfound success in the international markets. Legend moved its PC division headquarters to Hong Kong to break into the global PC market, which was Legend's first step to become one of the top five vendors in Asia/Pacific, while maintaining domestic market leadership by 2000. Legend forecasts its sales to reach 1 million units annually by 2000. Table 3-1 shows China/Hong Kong's PC production forecast.

Table 3-2 provides a ranking of China/Hong Kong's PC manufacturers in terms of 1996 and 1997 production units ranking. The top manufacturers correspond closely with the top vendors in terms of market share because of the above advantages. Table 3-3 provides company production trend lines and a forecast for 1999 production.

Table 3-1
PC Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	1,147.5	2,549.8	3,949.4	6,119.2	7,999.9	9,910.1	11,993.2	36
Manufacturing Revenue ($M)	745.9	1,707.7	2,707.2	4,126.9	5,213.9	6,252.2	7,594.3	35
Manufacturing ASP ($)	650.0	669.8	685.5	674.4	651.8	630.9	633.2	-1
Semiconductor Content ($)	196.5	218.9	228.6	245.1	273.8	252.3	249.0	3
Semiconductor TAM ($M)	225.5	558.3	903.0	1,500.0	2,190.4	2,500.7	2,986.6	40
Growth Rate of Unit (%)	-	122.2	54.9	54.9	30.7	23.9	21.0	-
Rate of Manufacturing ASP (%)	-	3.0	2.3	-1.6	-3.4	-3.2	0.4	-
Growth Rate of Manufacturing Revenue (%)	-	129.0	58.5	52.4	26.3	19.9	21.5	-
Growth Rate of Semiconductor Content (%)	-	11.4	4.4	7.2	11.7	-7.8	-1.3	-
Growth Rate of Semiconductor TAM (%)	-	147.6	61.8	66.1	46.0	14.2	19.4	-

TAM = Total available market
Source: Dataquest (August 1998)

Table 3-2
PC Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

Rank 1996	Rank 1997	Company	1996	1997	Production Share (%) 1996	Production Share (%) 1997	Accumulated Share (%) 1996	Accumulated Share (%) 1997
2	1	Great Wall + IBM	200	400	17.4	15.7	17.4	15.7
1	2	Legend	206	320	18.0	12.6	35.4	28.2
4	3	FIC	105	210	9.2	8.2	44.5	36.5
9	4	Tontru	18	180	1.5	7.1	46.1	43.5
3	5	AST	120	150	10.5	5.9	56.5	49.4
6	6	Founder	78	135	6.8	5.3	63.3	54.7
5	7	Stone + Compaq	80	100	7.0	3.9	70.3	58.6
10	8	Siemens	8	60	0.7	2.4	71.0	61.0
8	9	NEC	24	55	2.1	2.2	73.1	63.1
7	10	Vtech Holdings Ltd.	48	50	4.2	2.0	77.3	65.1
11	10	Hisense	0	50	0	2.0	77.3	67.1
11	12	Langchao	0	21	0	0.8	77.3	67.9
11	13	Acer	0	5	0	0.2	77.3	68.1
		Others	**261**	**814**	**22.7**	**31.9**	-	-
		Total	**1,147**	**2,550**	**100**	**100**	-	-

Source: Dataquest (August 1998)

Table 3-3
PC Company Production Unit Forecast, 1998 to 1999

Company	Units (K) 1996	Units (K) 1997	Units (K) 1998	Units (K) 1999	Growth (%) 1997	Growth (%) 1998	Growth (%) 1999
Great Wall + IBM	200	400	600	750	100.0	50.0	25.0
Legend	206	320	600	900	55.3	87.5	50.0
FIC	105	210	252	300	100.0	20.0	19.0
Tontru	18	180	300	500	923.9	66.7	66.7
AST	120	150	0	0	25.0	-100.0	
Founder	78	135	200	400	73.1	48.1	100.0
Stone + Compaq	80	100	150	300	25.0	50.0	100.0
Siemens	8	60	100	100	650.0	66.7	0
NEC	24	55	80	150	129.2	45.5	87.5
Vtech Holdings Ltd.	48	50	0	0	4.2	-100.0	
Hisense	0	50	100	200		100.0	100.0
Langchao	0	21	80	150		281.0	87.5
Acer	0	5	105	150		2,000.0	42.9
Total Surveyed Companies	**887**	**1,736**	**2,567**	**3,900**	**95.8**	**47.9**	**51.9**
Others (Estimated)	261	814	1,382	2,219	211.9	69.9	60.5
Total China/Hong Kong	**1,147**	**2,550**	**3,949**	**6,119**	**122.2**	**54.9**	**54.9**
Surveyed Companies' Share of Total (%)	77	68	65	64	-	-	-

Source: Dataquest (August 1998)

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Over the long run, Dataquest expects China/Hong Kong's PC production to reach 35 percent CAGR. China's PC market represents about one-third of all shipments to the Asia/Pacific region (excluding Japan) in 1998. At the same time, its unit growth will likely double the regional average.

Business Markets Dominate and Still Show High Growth

China's PC market continues to show strong growth and attract multinational investors and domestic suppliers. Table 3-4 ranks all major vendors according to PC units shipped in 1997.

Table 3-4
Worldwide PC Vendor Shipment Ranking to China, 1997 (Units)

Ranking	Total	1997 Shipments	1997 Market Share (%)
1	Legend	235,535	10.7
2	IBM	175,169	7.9
3	Compaq Computer Corp.	172,773	7.8
4	Hewlett-Packard	151,012	6.8
5	Tontru	114,996	5.2
6	Founder	69,124	3.1
7	AST Research	65,730	3.0
8	Acer	63,619	2.9
9	Great Wall	55,474	2.5
10	Dell Computer Corp.	46,733	2.1
11	Digital Equipment	44,947	2.0
12	Packard Bell NEC	42,095	1.9
13	Toshiba	27,842	1.3
14	Philips	25,732	1.2
15	LangChao	20,453	0.9
16	Fujitsu	19,918	0.9
17	Twinhead	17,607	0.8
18	MAX	16,584	0.8
19	FIC	11,088	0.5
20	Apple Computer	10,330	0.5
21	Hisense	9,310	0.4
22	IPC	8,652	0.4
23	Tulip	8,279	0.4
24	Unisys	4,737	0.2
25	Hyundai Electronics	4,020	0.2
26	Siemens Nixdorf Informationssysteme	3,260	0.1
27	Texas Instruments	2,349	0.1
28	Olivetti	1,419	0.1
	White Box PC	**694,580**	**31.4**
	Other PC Vendors	**85,781**	**3.9**

Source: Dataquest (August 1998)

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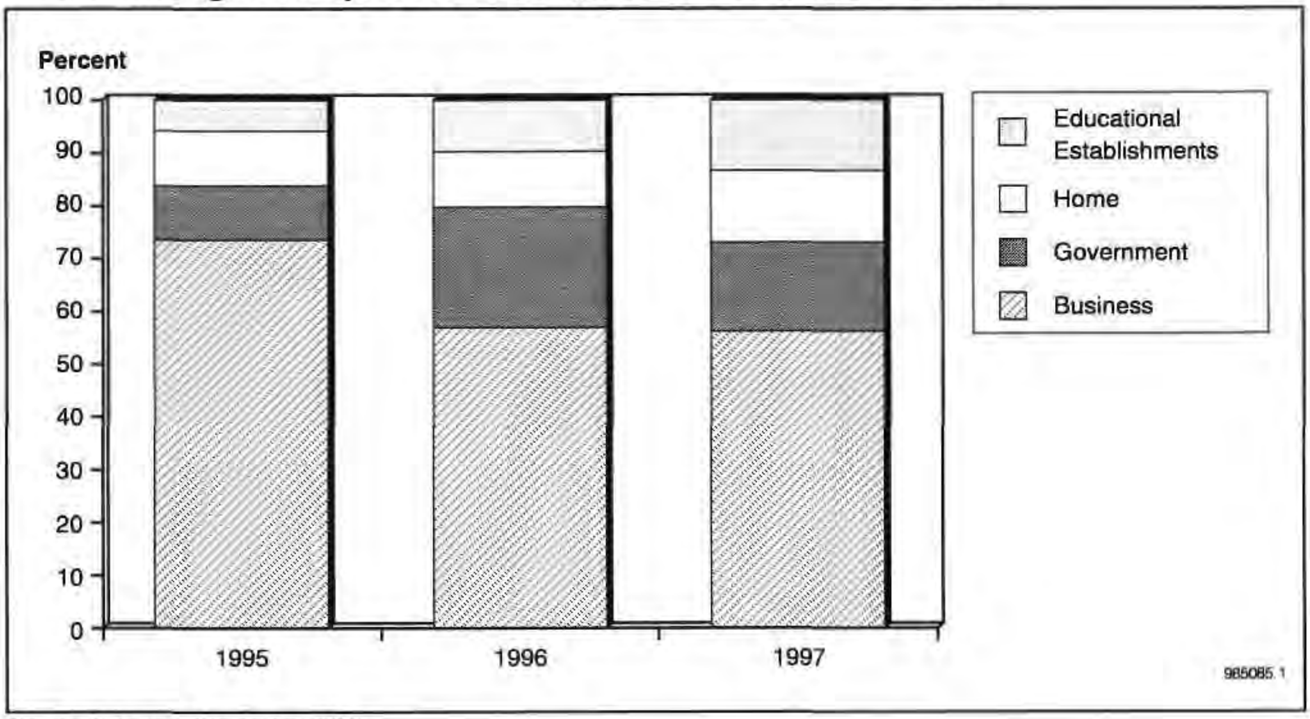
To understand the source of the business markets' growth, Dataquest segments the market by customer, form factor, and processor class. China's business market was the first to adopt PCs in the country. In 1995, the business segment absorbed nearly three-fourths of all PCs shipped in China (see Figure 3-3). Strong demand from foreign businesses in China later spilled over into local export-oriented companies. Foreign brands will not be the automatic product of choice because many local vendors now produce credible quality and are learning to provide aftersales service. The private sector remains China's engine for economic growth, and PCs will be rapidly deployed in this large and booming sector. However, the emergence of government, home, and education markets lowered business segment's share to 56 percent in 1997. But the PC market more than doubled, so PCs for business use still grew from 700,000 units to 1.2 million units from 1995 to 1997.

Government Sector Shows Strength

The government market accounted for about 10 percent of the PC market in 1995 and nearly doubled in share to 17 percent by 1997. The government and home markets each purchased only about 100,000 units in 1995. But the government segment grew faster, reaching 372,000 units in 1997. The government's recent initiative to streamline government, reduce ministries, and cut red tape will necessitate the computerization of administrative functions across China's central government. However, the pace at which China can achieve such a mammoth task will be slow, and the funds available will be increasingly scarce.

Figure 3-3
PC Market Segments by User in China, 1995 to 1997 (Percent Share)



Source: Dataquest (September 1998)

Home Market Awakes

There are few reasons to believe that the Chinese will have any less of a desire for home PCs than is seen in the United States, where approximately 40 percent of homes have PCs. This is another example of high nascent demand, because urban families have shown a high interest in PCs to educate their children to get ahead in China's competitive education system. In China, about 0.05 percent of the population own PCs, and only about 0.25 percent of 1 percent of families own PCs (assuming an average family size of five persons). The current economic growth rate, resulting in higher disposable incomes, would suggest that it takes about 10 years for 20 percent of Chinese families to own PCs. Another way to look at this trend is as follows: If an average of 5 percent of PCs are retired per year in the next decade, and the home market grows by 50 percent per year, then 85 million PCs would be sold just to families in China between now and 2008.

Education Users Surge

China's education market was the fastest-growing PC market segment during the past three years. Only 6 percent of PCs sold in 1995 went to educational establishments, but by 1997, this more than doubled to 13 percent. The university environment is the heaviest user on a per-PC basis, with hundreds of students sharing one or two PCs. But it is also the least funded. Vendors are wise to develop market share in this segment (providing discounts) as an efficient means of building brand recognition with China's next generation of business and government leaders.

Form-Factor Trends

In addition to market segmentation by end user, Dataquest segments PC shipments by form factor. The Chinese market has been dominated by desktop computers. But in 1997, the notebook computer market doubled to 173,000 units after several years of slow growth. Dataquest forecasts the market to continue this growth level through 1999, and then settle to a 50 percent average growth from 2000 to 2002. Dataquest has yet to see a local notebook computer manufacturer in China, but it expects volume production to begin in 1999. Significant semiconductor opportunities will emerge as portables grow from a mere 9 percent in 1997 to 26 percent in 2002. Desktop PCs remain the "bread and butter" of the industry. Desktop PC shipments will grow from 1.7 million units in 1997 to 6.5 million units in 2002. The overall PC shipment share will fall from a high of 88 percent in 1997 to 68 percent in 2002.

Long-Term PC Production and Semiconductor Consumption Forecast

PC manufacturers surveyed by Dataquest expect a significant production expansion slowdown in 1998 relative to 1997—from 97 percent in 1997 to 46 percent in 1998. Approximately 84 percent of China/Hong Kong-based PC manufacturers' unit output was surveyed in both periods. These manufacturers, as a group, had exceeded their production plans of 88 percent growth in September 1997 and reported their final 1997 growth to be 97 percent. This performance is consistent with local Chinese companies' local market share gains, which expanded by 44 percent to 2.2 million units in 1997.

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Dataquest estimates that total PC production in 1998 will reach 4 million units, a 55 percent increase over 1997. The estimated factory average selling price (ASP) of PCs (excluding motherboard, monitor, keyboard and disk drive) in 1998 will reach $686, up from was about $670 in 1997 (see Table 3-5).

Motherboard Production to Drop in 1999

Table 3-6 lists Dataquest's 1996 and 1997 PC motherboard manufacturer ranking and production share for the surveyed companies. The largest manufacturer in terms of units was PC Chips, a low-end, volume-driven motherboard manufacturer based in Taiwan. Dataquest believes that this group of manufacturers represents 96 percent of total motherboard production in China/Hong Kong.

The production forecast of these manufacturers is presented in Table 3-7, which shows 1998 and 1999 unit production by company. As stated earlier, these manufacturers are cautious with their expansion plans. Dataquest's surveys of these companies indicate that growth will fall off from 60 percent in 1998 to 15 percent in 1999, because of few new investments.

Table 3-5
PC Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	1,147	2,550	3,949	6,119	8,000	9,910	11,993	36
Manufacturing Revenue ($M)	746	1,708	2,707	4,127	5,214	6,252	7,594	35
Manufacturing ASP ($)	650	670	685	674	652	631	633	-1
Semiconductor Content ($)	196	219	229	245	274	252	249	3
Semiconductor TAM ($M)	225	558	903	1,500	2,190	2,501	2,987	40
Growth Rate of Unit (%)	0	122.2	54.9	54.9	30.7	23.9	21.0	-
Rate of Manufacturing ASP (%)	0	3.0	2.3	-1.6	-3.4	-3.2	0.4	-
Growth Rate of Manufacturing Revenue (%)	0	129.0	58.5	52.4	26.3	19.9	21.5	-
Growth Rate of Semiconductor Content (%)	0	11.4	4.4	7.2	11.7	-7.8	-1.3	-
Growth Rate of Semiconductor TAM (%)	0	147.6	61.8	66.1	46.0	14.2	19.4	-

TAM = Total available market
Source: Dataquest (August 1998)

Table 3-6
PC Motherboard Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	PC Chips	5,500	6,900	58.0	44.1	58.0	44.1
2	2	Legend	2,100	3,200	22.2	20.5	80.2	64.5
5	3	FIC	340	2,500	3.6	16.0	83.8	80.5
4	4	Dataexpert	480	1,200	5.1	7.7	88.9	88.2
3	5	Great Wall+IBM	650	850	6.9	5.4	95.7	93.6
6	6	AST	250	300	2.6	1.9	98.4	95.5
		Others	156	698	1.6	4.5	-	-
		Total	**9,476**	**15,648**	**100**	**100**	-	-

Source: Dataquest (August 1998)

Table 3-7
PC Motherboard Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	1996	1997	1998	1999	1997	1998	1999
Great Wall + IBM	650	850	1,100	1,500	30.8	29.4	36.4
Legend	2,100	3,200	4,100	5,000	52.4	28.1	22.0
FIC	340	2,500	2,775	3,000	635.3	11.0	8.1
AST	250	300	0	0	20.0	-100.0	
PC Chips	5,500	6,900	7,650	8,500	25.5	10.9	11.1
Dataexpert	480	1,200	1,500	1,800	150.0	25.0	20.0
Total Surveyed Companies	**9,320**	**14,950**	**17,125**	**19,800**	**60.4**	**14.5**	**15.6**
Others (Estimated)	156	698	2,357	3,383	346.3	237.9	43.6
Total China/Hong Kong	**9,476**	**15,648**	**19,482**	**23,183**	**65.1**	**24.5**	**19.0**
Surveyed Companies' Share of Total (%)	98	96	88	85	-	-	-

Source: Dataquest (August 1998)

Dataquest's long-term outlook is presented in Table 3-8, which indicates a recovery caused by underinvesting during these next two years. Dataquest forecasts China/Hong Kong's motherboard production to expand by 32 percent CAGR from 1997 to 2002. PCs are growing at a faster rate because Dataquest believes that some of China's market will continue to be served effectively by drop shipments of motherboards to assemblers in China. The semiconductor opportunity of $760 million in 1998 is approximately the same size as the $900 million shipped to the PC market. Combined semiconductor consumption of PC and motherboard vendors will exceed $1.6 billion in 1998 and will grow to more than $5 billion in 2002. This amount is nearly 20 percent of the entire semiconductor market in 2002 (see Table 3-8).

Table 3-8
PC Motherboard Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	9,476	15,648	19,482	23,183	31,359	39,573	49,645	26
Manufacturing Revenue ($M)	569	1,127	1,598	1,766	2,328	2,827	3,460	25
Manufacturing ASP ($)	60	72	82	76	74	71	70	-1
Semiconductor Content ($)	34	37	39	37	37	37	36	0
Semiconductor TAM ($M)	326	579	759	866	1,168	1,481	1,801	25
Growth Rate of Unit (%)		65.1	24.5	19.0	35.3	26.2	25.5	-
Rate of Manufacturing ASP (%)		98.1	41.8	10.5	31.8	21.5	22.4	-
Growth Rate of Manufacturing Revenue (%)		20.0	13.9	-7.1	-2.5	-3.8	-2.5	-
Growth Rate of Semiconductor Content (%)		7.6	5.3	-4.1	-0.3	0.5	-3.1	-
Growth Rate of Semiconductor TAM (%)		77.6	31.0	14.1	34.9	26.8	21.6	-

TAM = Total available market
Source: Dataquest (August 1998)

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Computer Monitors

Domestic monitor shipments to the Chinese market has been growing at 40 percent during the past several years. Production expanded by 39 percent in 1997 and accelerated to 65 percent in 1998 because of new investments. Table 3-9 ranks the top manufacturers that account for about 50 percent of total production. As indicated, Chinese companies have rapidly entered this market, but the multinational vendors still dominate.

As shown in Table 3-10, the growth Dataquest had forecast is attributed to increased capacity by the large three producers, Philips Electronics NV, Acer Computer International Ltd., and First International Computer Inc. (FIC). These three companies occupied 25 percent of the industry in 1997. Dataquest segments monitors in the input/output equipment market, which is part of the overall data processing market. Monitors will remain the primary growth driver and have the largest share of input/output production. Dataquest forecasts this segment to expand by 30 percent from $2.5 billion in 1997 to $9 billion in 2002. Monitors' 1998 revenue of $2 billion will represent 54 percent of all 1998 input/output revenue.

Table 3-11 presents Dataquest's history and forecast of total computer monitor production in China/Hong Kong. Dataquest's survey of monitor production in China/Hong Kong covered one-half of the region's total monitor production, which is a large sample size. Dataquest estimates the total production in 1998 to reach 12.5 million units, compared to 7.6 million units in 1997.

Table 3-9
Computer Monitor Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Philips	600	800	11.1	10.6	11.1	10.6
2	2	Acer	350	600	6.5	7.9	17.5	18.5
3	3	FIC	200	500	3.7	6.6	21.2	25.2
8	3	XiaHua (Xoceco)	0	500	0	6.6	21.2	31.8
8	5	HuaFei	0	300	0	4.0	21.2	35.8
8	5	Rainbow	0	300	0	4.0	21.2	39.7
4	7	Great Wall	180	280	3.3	3.7	24.5	43.4
6	8	Founder	145	210	2.7	2.8	27.2	46.2
8	9	HuiLiDa	0	200	0	2.6	27.2	48.9
8	10	Sony	0	90	0	1.2	27.2	50.1
7	11	Samsung	100	0	1.8	0	29.0	50.1
5	11	LG	150	0	2.8	0	31.8	50.1
		Others	3,701	3,770	68.2	49.9	100.0	100.0
		Total	**5,426**	**7,550**	**100**	**100**	-	-

Source: Dataquest (August 1998)

Table 3-10
Computer Monitor Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	1996	1997	1998	1999	1997	1998	1999
Philips	600	800	1,500	1,800	33.3	87.5	20.0
Acer	350	600	1,350	2,000	71.4	125.0	48.1
XiaHua (Xoceco)	0	500	1,000	1,200	-	100.0	20.0
FIC	200	500	600	800	150.0	20.0	33.3
HuaFei	0	300	500	800	-	66.7	60.0
Rainbow	0	300	500	800	-	66.7	60.0
Founder	145	210	490	800	44.8	133.3	63.3
Great Wall	180	280	456	600	55.6	62.9	31.6
HuiLiDa	0	200	350	500	-	75.0	42.9
Sony	0	90	150	250	-	66.7	66.7
LG	150	0	0	0	-100.0	-	-
Samsung	100	0	0	0	-100.0	-	-
Total Surveyed Companies	**1,725**	**3,780**	**6,896**	**9,550**	**119.1**	**82.4**	**38.5**
Others (Estimated)	3,701	3,770	5,599	6,912	1.9	48.5	23.5
Total China/Hong Kong	**5,426**	**7,550**	**12,495**	**16,462**	**39.1**	**65.5**	**31.8**
Surveyed Companies' Share of Total (%)	32	50	55	58	-	-	-

Source: Dataquest (August 1998)

Table 3-11
Computer Monitor Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	5,426	7,550	12,495	16,462	21,401	25,681	30,304	32
Manufacturing Revenue ($M)	948	1,253	1,991	2,576	3,616	4,274	4,928	32
Manufacturing ASP ($)	175	166	159	156	169	166	163	0
Semiconductor Content ($)	18	17	17	16	16	15	15	-2
Semiconductor TAM ($M)	98	128	212	263	342	385	455	29
Growth Rate of Unit (%)	-	39.1	65.5	31.8	30.0	20.0	18.0	-
Rate of Manufacturing ASP (%)	-	32.2	58.9	29.4	40.4	18.2	15.3	-
Growth Rate of Manufacturing Revenue (%)	-	-5.0	-4.0	-1.8	8.0	-1.5	-2.3	-
Growth Rate of Semiconductor Content (%)	-	-5.6	0	-5.9	0	-6.3	0	-
Growth Rate of Semiconductor TAM (%)	-	31.4	65.5	24.0	30.0	12.5	18.0	-

TAM = Total available market
Source: Dataquest (August 1998)

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Storage Equipment

Seagate is the sole producer of RDDs in China/Hong Kong. Most components are internally transferred from Singapore; however, Dataquest has estimated Seagate's semiconductor consumption at two facilities. Table 3-12 provides Seagate's historical units and growth, while Table 3-13 provides Dataquest's forecast for 1998 and 1999.

Dataquest expects data storage to be a major semiconductor growth source for the next four years. We expect that at least 90 percent production will continue to be exported by Seagate for global export because of the nature of these facilities. Dataquest believes that the $1.6 billion storage industry in 1998 will grow fivefold to reach $3.9 billion in 2002, with Seagate leading the way. This 19 percent CAGR is lower than unit growth of 24 percent, as price erosion continues, but at a slower rate (see Table 3-14).

Table 3-12
Rigid Disk Drivers Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Seagate	2,683	5300	100	100	100	100
		Others	0	0	0	0	-	-
		Total	**2,683**	**5300**	**100**	**100**	-	-

Source: Dataquest (August 1998)

Table 3-13
Rigid Disk Driver Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	1996	1997	1998	1999	1997	1998	1999
Seagate	2,683	5,300	7,000	8,785	97.5	32.1	25.5
Total Surveyed Companies	**2,683**	**5,300**	**7,000**	**8,785**	**97.5**	**32.1**	**25.5**
Others (Estimated)	0	0	0	0	-100.0	-	-
Total China/Hong Kong	**2,683**	**5,300**	**7,000**	**8,785**	**97.5**	**32.1**	**25.5**
Surveyed Companies' Share of Total (%)	100	100	100	100	-	-	-

Source: Dataquest (August 1998)

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Table 3-14
Rigid Disk Drive Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	2,683	5,300	7,000	8,785	11,139	13,367	15,603	24
Manufacturing Revenue ($M)	590	1,238	1,554	1,891	2,258	2,578	2,904	19
Manufacturing ASP ($)	220	234	222	215	203	193	186	-4
Semiconductor Content ($)	30	30	29	28	26	25	25	-4
Semiconductor TAM ($M)	81	160	204	243	294	335	392	20
Growth Rate of Unit (%)		97.5	32.1	25.5	26.8	20.0	16.7	-
Rate of Manufacturing ASP (%)		109.8	25.5	21.7	19.4	14.2	12.6	-
Growth Rate of Manufacturing Revenue (%)		6.2	-5.0	-3.0	-5.9	-4.9	-3.5	-
Growth Rate of Semiconductor Content (%)		0.1	-3.4	-4.8	-4.7	-5.1	0.2	-
Growth Rate of Semiconductor TAM (%)		97.8	27.6	19.5	20.8	13.9	16.9	-

TAM = Total available market
Source: Dataquest (August 1998)

Seagate Technology Inc.

Seagate has been expanding production in China and will inject $32 million into its Wuxi facility, bringing total direct investment to more than $52 million. Total investment in China was reported to be $90 million, including the Wuxi plant. Employing about 3,300 workers, the Wuxi plant's aggregate production reached 3 million units in 1996. This investment adds about 1,600 workers and doubles Seagate's capacity in China, which serves both local and export markets. It is said that the production line for magnetic disk drivers, which is now in the old building, will be shifted to the new one, and the old one will be used mainly for the production of E-BIKS, with an expected daily capacity of 25,000 units.

The new Wuxi facility is Seagate's second RDD plant in China, after operating the Shenzhen plant for more than two years. The acquisition of Conner Peripherals Inc. by Seagate enabled it to buy market share in China by acquiring Conner's Shenzhen RDD plant. It also enabled Seagate to adopt a successful business model for selling in China, which Seagate has successfully expanded upon. Since then, the combined efforts have proved effective for Seagate, which now controls more than 50 percent of the market and exports RDDs from China.

Dataquest estimates the PC production growth rates to keep pace with China's breakneck PC market growth. This rapid growth resulted in a voracious demand for RDDs. However, RDD competition is increasing for Seagate as it is attempting to hang on to its reign of China's computers mass-storage market. By expanding production, Seagate is leveraging its current competitive advantage in the market to combat the new market entrants.

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Printers

Dataquest researched production for Fujitsu Ltd., Stone/Fujitsu, and Sharp Electronics Corporation, but we did not include Hewlett-Packard, which also manufactures printers in China. From Dataquest's research, these four companies represent almost the entire page printer production industry in China/Hong Kong. Fujitsu and its joint venture, Fujitsu/Stone, together represented about 22 percent of production in 1997 (see Table 3-15). Sharp produces a small quantity that represents only approximately 4 percent of overall production.

Table 3-16 provides production forecasts for these three companies in 1998 and 1999. Dataquest observes aggressive expansion in 1998 because of investments that were made in 1997. However, as Dataquest observes in many segments, investments have become somewhat cautious in 1998, hence unit production is expected to expand by a slower, but robust, 35 percent.

The long-term printer production outlook growth and semiconductor consumption is quantified in Table 3-17. In general, the 33 percent CAGR should not be a surprise here because printer production is keeping track with PC production and electronics market growth. Semiconductor content is increasing because of expectations that higher-end printers will be built in China and because of increasing demand from business, government, and even personal users.

Table 3-15
Printer Manufacturers Production Share and Ranking, 1996 and 1997(Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Fujitsu	80	90	16.4	12.3	16.4	12.3
2	2	Stone + Fujitsu	50	67	10.2	9.2	26.6	21.5
3	3	Sharp	25	32	5.1	4.4	31.7	25.9
		Others	334	540	68.3	74.1	-	-
		Total	**489**	**729**	**100**	**100**	-	-

Source: Dataquest (August 1998)

Table 3-16
Printer Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	1996	1997	1998	1999	1997	1998	1999
Sharp	25	32	38	50	28.0	18.8	31.6
Fujitsu	80	90	160	220	12.5	77.8	37.5
Stone + Fujitsu	50	67	90	120	34.0	34.3	33.3
Total Surveyed Companies	**155**	**189**	**288**	**390**	**21.9**	**52.4**	**35.4**
Others (Estimated)	334	540	1,461	1,616	61.5	170.5	10.6
Total China/Hong Kong	**489**	**729**	**1,749**	**2,006**	**49.0**	**139.9**	**14.7**
Surveyed Companie's Share of Total (%)	32	26	16	19	-	-	-

Source: Dataquest (August 1998)

Table 3-17
Printer Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	489	729	1,749	2,006	2,302	2,662	3,057	33
Manufacturing Revenue ($M)	113	161	361	415	480	570	671	33
Manufacturing ASP ($)	737	712	697	680	664	649	634	-2
Semiconductor Content ($)	163	163	167	174	186	190	193	3
Semiconductor TAM ($M)	16	23	54	70	92	122	157	46
Growth Rate of Unit (%)		49.0	139.9	14.7	14.8	15.7	14.8	-
Rate of Manufacturing ASP (%)		42.3	124.9	14.9	15.7	18.7	17.6	-
Growth Rate of Manufacturing Revenue (%)		-3.4	-2.1	-2.4	-2.4	-2.3	-2.4	-
Growth Rate of Semiconductor Content (%)		-0.1	2.3	3.9	7.3	2.0	1.4	-
Growth Rate of Semiconductor TAM (%)		47.5	131.5	28.7	32.1	32.3	28.3	-

TAM = Total available market
Source: Dataquest (August 1998)

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Chapter 4
Communications Electronics Equipment

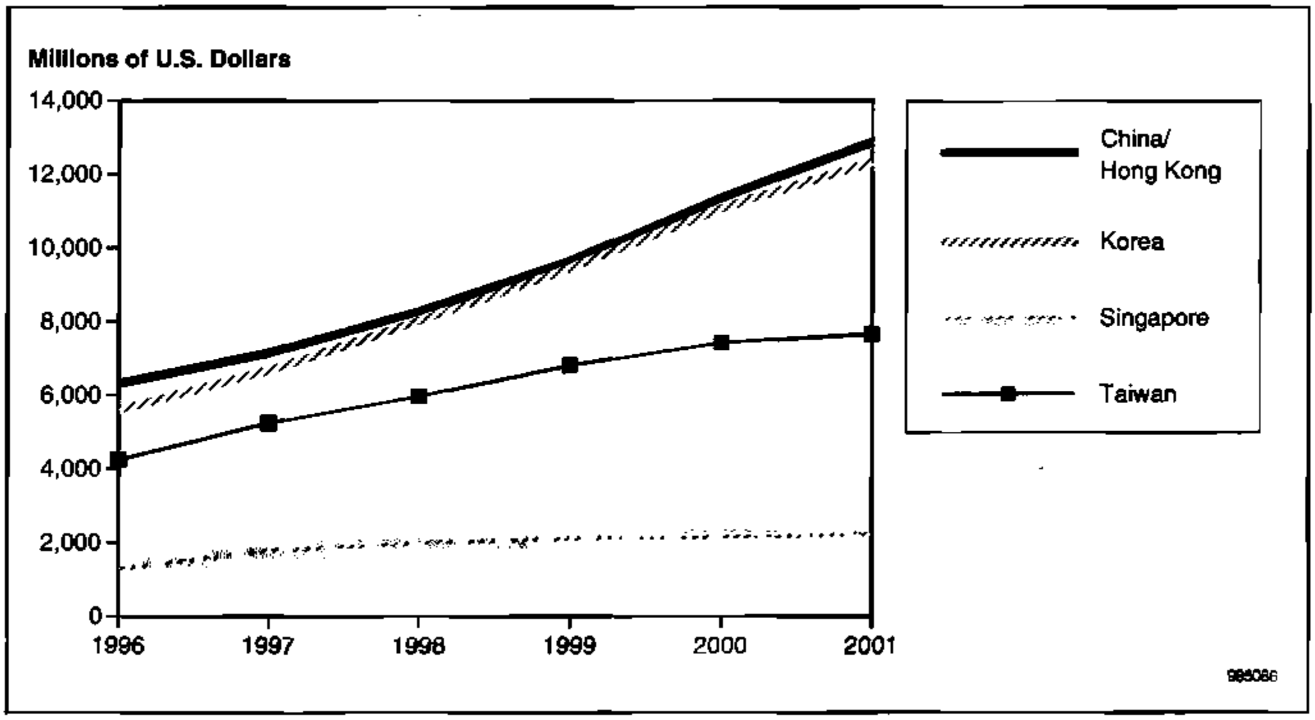
Introduction

Dataquest assesses the communications equipment production in 1998 and 1999 with an up close look at key manufacturers. Dataquest also assesses each product's semiconductor usage from 1997 to 2002. Because of the importance of communications market to driving investments in local production, Dataquest has provided additional market-related information as part of its baseline assumptions.

Communications Sector Trends

China/Hong Kong has become Asia/Pacific's largest manufacturer of communications equipment because of its rapid rise in premises and, more recently, mobile communications production. Dataquest expects communications production to maintain its current pace because of broad-based products that are both exported and shipped locally in China. The Chinese government continues to provide significant support and investments in developing its telecommunications infrastructure, which will lead to increases in local content and foreign investment. Figure 4-1 illustrates Dataquest's forecast by Asia/Pacific country, which shows that China/Hong Kong and Korea both maintain dominance of Asia/Pacific's communications production.

Figure 4-1
Communications Production Revenue Forecast in China/Hong Kong, Korea, Singapore, and Taiwan: 1997 to 2002 (Millions of U.S. Dollars)



Source: Dataquest (September 1998)

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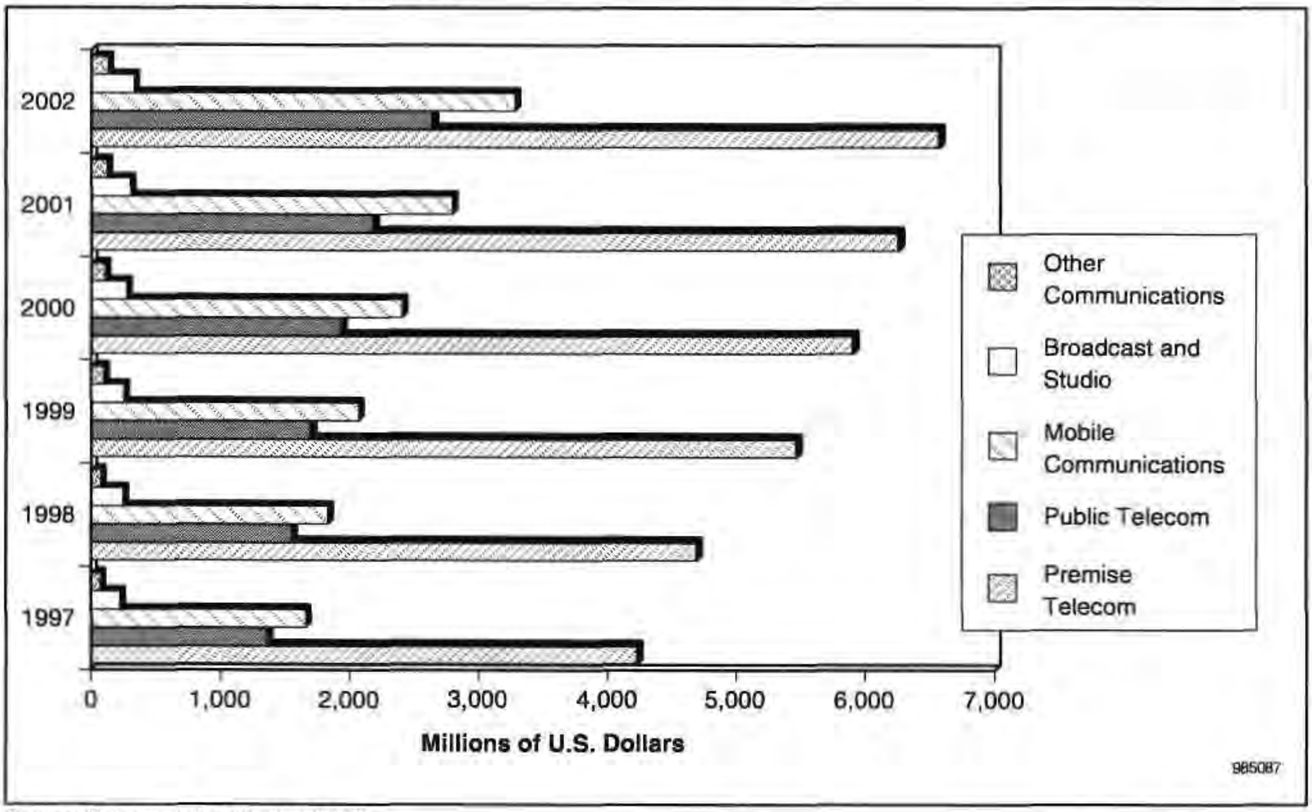
Communications equipment production will generate $8.3 billion in China/Hong Kong in 1998, which represented 4 percent of Asia/Pacific's total electronics production. China/Hong's production represented 27 percent of all communications-related production (revenue) in Asia/Pacific. Dataquest forecasts that China/Hong Kong's communications production will grow at an 11 percent CAGR from 1997 to 2002. At its current growth trajectory, China/Hong Kong will maintain its share of Asia/Pacific communications production despite its high consumption growth of communications equipment. Dataquest believes that China/Hong Kong will still have to import the majority of its infrastructure equipment because of technological complexity and the need for turnkey solutions. Some standardized systems, such as Global System for Mobile Communications (GSM), can lead to local production but new technologies, such as xDSL, will continue to be imported in entirety (and probably from only a few vendors).

As illustrated in Figure 4-2, which splits China/Hong Kong's communication production by major market segment, Dataquest forecasts that premises will continue to dominate in production share, while mobile leads the industry growth. Substantial production volume, particularly in southern China, of corded and cordless telephone handsets will enable premises production to sustain more than 50 percent of production. It will account for 55 percent of production in 1998 but will fall to 50 percent because of mobile's faster growth. Premises are followed by mobile with 21 percent share, public telecom (18 percent), broadcast/studio (3 percent), and others (0.8 percent).

Figure 4-2
China/Hong Kong's Communications Production Revenue Forecast by Sector, 1997 to 2002 (Millions of U.S. Dollars)



Source: Dataquest (September 1998)

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Digital Cellular

Table 4-1 presents Dataquest's list of major mobile cellular phone producers in China/Hong Kong, their production units, and production share. Dataquest includes all cellular handset production in this segment, including digital cellular and broadband PCS handsets to include handsets that conform to the following standards: GSM, Digital Cellular System (DCS) 1800, personal communications services (PCS) 1900, NA-TDMA (IS-54/136), code division multiple access or CDMA (IS-95), Personal Data Cartridge (PDC), and Omnipoint.

Dataquest's sample survey of six major multinational manufacturers included about 74 percent of cellular phone production in China. Motorola Incorporated is a Goliath and overshadows all other manufacturers with 39 percent production share in 1997. Despite its 41 percent increase in output, Motorola still lost 3 percentage points production share because of NEC Corporation's rapid expansion, which enabled NEC to move from No. 4 to No. 2 in production ranking.

Table 4-2 presents production plans of these major six manufacturers in 1998 and 1999. As shown, there is a dramatic deceleration from 60 percent growth in 1997 to 27 percent in 1998 among these top producers. Consequently, the overall industry will only grow 25 percent, which is high by global standards but slow for China/Hong Kong. One would expect this slowdown to occur in 1998 because all manufacturers have expanded production. It appears this slowdown is temporary because production among these companies is expected to accelerate to 33 percent in 1999. Dataquest expects the next year to see new entrants to the market attributed to turnkey GSM technology transfers that are taking place this year. Dataquest expects to see one or two Chinese companies start producing cellular phones by 1999. Hence, overall cellular phone production will jump to 39 percent according to Dataquest's forecast.

Table 4-1
Cellular Phone Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Motorola	850	1,200	43.8	38.7	43.8	38.7
4	2	NEC	80	400	4.1	12.9	47.9	51.7
2	3	Ericsson	260	320	13.4	10.3	61.3	62.0
4	4	Nokia	80	150	4.1	4.8	65.5	66.8
3	5	Matsushita	120	140	6.2	4.5	71.7	71.3
6	6	Siemens	45	80	2.3	2.6	74.0	73.9
		Others	505	807	26.0	26.1	-	-
		Total	**1940**	**3097**	**100**	**100**	-	-

Source: Dataquest (August 1998)

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Table 4-2
Cellular Telephone Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	**1996**	**1997**	**1998**	**1999**	**1997**	**1998**	**1999**
Siemens	45	80	96	250	77.8	20.0	160.4
NEC	80	400	480	650	400.0	20.0	35.4
Motorola	850	1,200	1,500	1,850	41.2	25.0	23.3
Ericsson	260	320	450	600	23.1	40.6	33.3
Nokia	80	150	200	300	87.5	33.3	50.0
Matsushita	120	140	180	200	16.7	28.6	11.1
Total Surveyed Companies	**1,435**	**2,290**	**2,906**	**3,850**	**59.6**	**26.9**	**32.5**
Others (Estimated)	505	807	956	1,509	60.0	18.4	57.8
Total China/Hong Kong	**1,940**	**3,097**	**3,862**	**5,359**	**59.7**	**24.7**	**38.8**
Surveyed Companies' Share of Total (%)	74	74	75	72	-	-	-

Source: Dataquest (August 1998)

Table 4-3 presents Dataquest's long-term perspective on cellular phone production and semiconductor consumption. Dataquest forecasts a significant production growth of 39 percent CAGR from 1997 to 2002. This growth level translates into a production capacity of 16 million cellular phones by 2002 in China/Hong Kong.

Mobile telecommunications business has developed rapidly in China, but with faster expansion in the eastern coastal areas than the central and western areas. Competition is sizzling in the mobile telecommunications service market between China Telecom, under the Ministry of Posts and Telecommunications (MPT), and its main rival, China Unicom.

Table 4-3
Cellular Telephone Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	1,940	3,097	3,862	5,359	7,807	11,645	16,002	39
Manufacturing Revenue ($M)	675	927	935	1,062	1,339	1,748	2,133	18
Manufacturing ASP ($)	636	510	432	355	304	274	241	-14
Semiconductor Content ($)	137	110	91	73	65	59	56	-13
Semiconductor TAM ($M)	158	221	228	260	344	470	621	23
Growth Rate of Unit (%)	-	84.4	30.2	22.6	31.8	32.0	11.7	-
Rate of Manufacturing ASP (%)	-	-41.2	-25.2	-34.9	-28.5	-19.1	-24.4	-
Growth Rate of Manufacturing Revenue (%)	-	28.9	-1.7	-18.3	-1.2	7.3	-13.5	-
Growth Rate of Semiconductor Content (%)	-	-39.0	-31.9	-33.7	-22.1	-19.4	-10.0	-
Growth Rate of Semiconductor TAM (%)	-	28.8	-7.7	-18.9	6.2	9.7	1.6	-

TAM = Total available market
Source: Dataquest (August 1998)

China's mobile phone subscribers in 1997 reached nearly 10 million. The Chinese government predicted last year that the number of mobile phone subscribers would reach 7 million by the end of 1997. Recent estimates put the 1997 figure closer to 10 million. But most of them are still based on the analog system because of its earlier introduction in the 1980s. Cellular phone subscribers in 1997 are estimated to be 4 million by MPT. In Shanghai alone, the number of cellular phone subscribers were 600,000 in 1997, from about 360,000 in 1996.

Major players in the mobile telecommunications market include China Telecom, Telecom United, Motorola, Nokia Telecommunications, Oki Telecom, Ericsson, and Siemens AG.

With the addition of 130 GSM networks run by China Unicom, the GSM networks increased to about 5 million. This addition will add an estimated 250,000 to 300,000 radio channels. Mobile phones made by the world's three leading telecommunications companies, Ericsson, Nokia, and Motorola, have captured about 95 percent of Beijing's GSM mobile phone market. The remaining 5 percent of the market is shared by a mixture of products from other companies, including Siemens and NEC.

China is one of the world's most underserved telecommunications markets today. It had a cellular phone penetration rate of only 0.6 percent last year. But the market is expected to quadruple to 28 million subscribers by 2000. Even with this increase, it is still a tiny percent of the 1.3 billion people in China today. If Taiwan is an indicator, then this rate is only about 4 percent of Taiwan's 21 million mobile telephones subscribers today. Provincial governments are taking many initiatives to expand their mobile markets, as detailed below. For example, the economically vibrant coast province of Shandong has an estimated 750,000 mobile phone and 800,000 pager customers in 1997. The number of mobile subscribers in Henan Province is not in line with the size of its population. Henan had 95 million people, but had only 121,708 cellular phone subscribers in 1995.

GSM Developments in China

China is going mobile to meet the growing demands of the country's telecommunications explosion. GSM continues to build momentum in China as digital technology provides high-traffic-carrying capacity.

In the face of rapidly growing public demand, the MPT has decided to expand its sophisticated digital mobile communications systems dramatically in China in the next few years. MPT officials say that foreign telecommunications companies will be allowed to market their own digital or GSM mobile phones in China if their products are found to be of high quality, which, the officials say, will help increase market competition and force prices of GSM mobile phones here to fall.

CDMA Developments

China is now building several trial code division multiple access (CDMA) networks in populous cities such as Guangzhou, Beijing, and Shanghai. The handling capacity of the CDMA networks is reported to be 10 times higher than the present analog mobile telecommunications standard.

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Representatives of Lucent Technologies (China) Ltd.—one of the global telecommunications giants leading the CDMA trend—said that China dialed the first CDMA call on the trial network launched by Lucent Technologies in Guangzhou on December 31, 1996. It is the first commercial CDMA system operational in China.

Lucent said that China—the fastest-growing market in the Asia/Pacific region and in which the company has won CDMA contracts worth $250 million—is now technically qualified to adopt the CDMA technology countrywide.

Motorola, another major CDMA supplier from the United States, is also accelerating the construction work on two trial networks in Beijing and Fujian Province. It made the first CDMA call in Beijing early this month. Meanwhile, other CDMA manufacturers, including Canada's Northern Telecom Inc., Samsung Electronics Company Ltd., and, to a lesser extent, LG Electronics Inc., are entering the Chinese CDMA marketplace.

Once the country decides to open the market to foreign CDMA suppliers, the telecommunications administrative body will encourage the foreign companies to make technical transfer. China has always adhered to the principle of trading market for technology. Therefore, the earlier the CDMA technology is transferred, the easier it will be for the company to make its way into the Chinese market.

Lucent Technologies (China) Ltd.

In September, Lucent's CDMA system was successfully tested to roam between two different networks in Guangdong and Beijing. The tests were conducted with China Telecom Greatwall Network, a cooperative entity between China's MPT and China Electronic System Engineering Co. Lucent's CDMA system passed both the C7 signaling tests and the IS-41B tests, in addition to also achieving successful roaming between the networks in Guangdong and Shanghai. LG is a latecomer in the booming China market for wireless handheld phones and is constructing an assembly plant, like the other major vendors. LG will be bucking up against CDMA phone suppliers that already have assembly plants in China.

Samsung Electronics Company Ltd.

China is also showing interest in Korea's experience in the commercial use of CDMA mobile telecommunications. Korea's Samsung Electronics signed a contract in June to supply CDMA digital mobile telecommunications equipment to China's Shanghai Great Wall Mobile Communications Co. Under the contract, Samsung will supply one switch station with a capacity of 68,000 lines, 67 base stations, and services on a turnkey basis. The CDMA digital cellular phone services are expected to go into commercial operation in Shanghai beginning in 1998.

Samsung bid against foreign rivals that included Lucent Technologies, Motorola, and QUALCOMM Incorporated. Samsung plans to use Shanghai as its regional base for communications equipment because of high market potential, with the number of cellular phone subscribers expecting to reach 600,000 in 1997 from 380,000 in 1996.

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Thus, Samsung plans to explore the market in Shanghai for PCS, wireless local loop (WLL), and asynchronous transfer mode (ATM). Samsung operates a joint-venture company in Shanghai for WLL operation. In 1996, it supplied wireless paging systems capable of accommodating 1 million subscribers.

CDMA Production Developments

Major CDMA market players, including Lucent, Motorola, Samsung, and LG all have assembly plants in China. LG is a latecomer in the booming China market for wireless handheld phones. LG will be bucking up against CDMA phone suppliers that already have assembly plants in China.

In April, China Samsung Electronics has been selected as the official CDMA hardware provider for Shanghai. The turnkey contract calls for the company to provide China Shanghai Changcheng Mobile Communications Co. Ltd. with a switching station that has the capacity to handle 68,000 subscribers, as well as 67 base stations and follow-up services. Installation is scheduled to begin in the first half of this year, and the system will be fully operational within the second half of the year.

Mitsubishi Electric Corporation announced plans to set up a digital mobile phone production base in China and to increase Mitsubishi's share in the world mobile phone market from present 6.5 percent to more than 10 percent by 2000. So far, Mitsubishi has established production bases in the United States and France, with annual output reaching 1 million units in 1996. Because China forms an increasing demand for mobile phones, Mitsubishi predicted that Asia/Pacific will represent 40 percent in the world digital cellular market.

Personal Communications Services (PCS) Developments

The changeover of Hong Kong sovereignty also could have a positive impact on PCS implementation in China. PCS licenses in Hong Kong are on track to generate an estimated $700 million in the next two years and as much as $5 billion in total revenue in the next 10 years. In underdeveloped countries where limited wireline infrastructure is installed, the existing infrastructure may not support the growing population or their service needs. The large cost and projected scope of laying more wireline networks suggest a wireless solution such as a PCS network. A PCS microcell base station that will support 100 people is estimated to cost somewhere between $60,000 and $65,000. By 2001, the number of cellular and PCS users in China, for example, could reach 12 million, representing $20 billion in revenue. The current worldwide wait for phone service for an estimated 40 million to 50 million people is 1.2 years. The average density of phone lines for the world is about 10 percent (or 10 lines per 100 people), with industrialized nations averaging about 50 percent. A key challenge will be for GSM, CDMA, and PCS companies to ensure that Chinese government understands the relationships among the cost of regulation and the speed of approvals, and the affordability of services with its effect on universal service.

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Pagers

Dataquest's survey of China/Hong Kong's pager producers represented about 90 percent of production in 1997. Table 4-4 presents Dataquest's ranking of the three major pager manufacturers in China/Hong Kong. Dataquest estimates that China produced 7 million pagers in 1997, led by Motorola, Matsushita, and the joint venture, TCL/NEC (between Huizhou TCL Mobile Communication Co. Ltd. and NEC). Motorola dominates pager production with 67 percent of production share or 4.8 million sets in 1997. Matsushita's production quantity increased 76 percent in 1997 to 95,000. This expansion enables Matsushita to move to rank second and capture 14 percent production share, at the expense of Motorola that lost 7 percentage points production share. TCL/NEC cut production from 650,000 to 400,000, as the industry suffered overcapacity in 1997.

Table 4-5 presents the unit production forecasts for TCL/NEC, Motorola, and Matsushita in 1998 and 1999. Production expansion by Motorola and Matsushita appears to be coming to a standstill to better align with slowing demand. However, TCL/NEC plans to boost production from 400,000 units in 1997 to 1 million units in 1998. This expansion will further exacerbate ASP declines, as Dataquest forecasts in Table 4-6.

Table 4-4
Pager Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Motorola	4,400	4,750	74.9	67.9	74.9	67.9
3	2	Matsushita	540	950	9.2	13.6	84.1	81.5
2	3	TCL/NEC	650	400	11.1	5.7	95.2	87.2
		Others	285	897	4.8	12.8	-	-
		Total	**5,875**	**6,997**	**100**	**100**	-	-

Source: Dataquest (August 1998)

Table 4-5
Pager Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	1996	1997	1998	1999	1997	1998	1999
Motorola	4,400	4,750	5,100	4,600	8.0	7.4	-9.8
Matsushita	540	950	1,000	1,000	75.9	5.3	0
TCL + NEC	650	400	1,056	1,000	-38.5	164.0	-5.3
Total Surveyed Companies	**5,590**	**6,100**	**7,156**	**6,600**	**9.1**	**17.3**	**-7.8**
Others (Estimated)	285	897	954	1,650	215.1	6.4	73.0
Total China/Hong Kong	**5,875**	**6,997**	**8,110**	**8,250**	**19.1**	**15.9**	**1.7**
Surveyed Companies' Share of Total (%)	95	87	88	80	-	-	-

Source: Dataquest (August 1998)

Table 4-6
Pager Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	5,875	6,997	8,110	8,250	8,507	8,830	9,139	5
Manufacturing Revenue ($M)	441	399	439	427	432	426	428	1
Manufacturing ASP ($)	75	57	54	52	51	48	47	-4
Semiconductor Content ($)	11	11	11	12	13	13	13	3
Semiconductor TAM ($M)	66	79	93	97	107	114	122	9
Growth Rate of Unit (%)	-	19.1	15.9	1.7	3.1	3.8	3.5	-
Rate of Manufacturing ASP (%)	-	-24.0	-5.1	-4.3	-1.9	-5.1	-2.9	-
Growth Rate of Manufacturing Revenue (%)	-	-9.5	10.0	-2.6	1.1	-1.5	0.5	-
Growth Rate of Semiconductor Content (%)	-	0.4	1.2	1.9	7.0	3.0	3.1	-
Growth Rate of Semiconductor TAM (%)	-	19.6	17.3	3.7	10.3	6.9	6.7	-

TAM = Total available market
Source: Dataquest (August 1998)

Dataquest believes that pager unit production will grow at only 5 percent CAGR from 1997 to 2002. This growth represents a semiconductor market expansion of 9 percent, from $93 million in 1998 to $122 million in 2002.

At the end of 1997, there were 8 million new subscribers. But MPT's projections showed paging subscriptions to reach 117 million by 2000, which Dataquest believes to be overstated. By the end of 1996, MPT had started national paging networks in 22 Chinese cities. The new systems have adopted FLEX/multifrequency roaming modules, as well as VSAT interconnection technology. ChinaSat has contracted Hughes Network System to provide VSAT equipment in more than 300 subnetworks across China. MPT has experimented with new frequencies, particularly the 150 MHz.

Dataquest believes that paging services may continue to be a major means of communications, but the falling cellular phone service prices make pagers obsolete for many consumers.

Paging Companies and Developments

China Unicom and other non-MPT paging service providers have merged or sought vertically integrated networks under other ministries. Other strategies adopted include seeking foreign partners for direct investment or new technologies. Beijing Jingxin Electronics Co. Ltd. and HP signed a cooperative agreement in December 1996 for codeveloping wireless, high-speed beeping coding system. The project received support from the State Science and Technology Commission. China's wireless, high-speed beeping business was projected to develop rapidly in 1997.

Tianjin Municipal Posts and Telecommunications Administration in the north China's Tianjin started two new paging services in cooperation with independent paging service centers in May. Tianjin now has more than 70 separate paging services with 1.2 million subscribers. A majority of the services are small in scale, except for the local posts and telecommunications departments, which are financially and technically stronger.

A dozen of these paging centers have more than 10,000 subscribers each, but some have only about 2,000 subscribers. To woo more subscribers, paging service operators have been competing by cutting costs, a move that has put some operators in a tough situation. A total of 37 other separate paging services have also agreed to join the unified new paging services and are now making preparations, according to local sources.

Samsung said it has completed construction of a $1 million paging system in Shanghai, which can handle 1.2 million subscribers in 1997. The company said it delivered the turnkey project to Shanghai Guomai Communications Co. Ltd. Samsung estimates that the paging networks will cover 20 percent of China's 30 million citizens by the turn of the century.

NEC had acquired an additional 35 percent in a Guangdong-based pager manufacturing and marketing joint venture, established in 1993 by a Hong Kong company and a local Chinese entity. NEC purchased all holdings of the Hong Kong partner with about $1.75 million investment.

Central Office Line Cards

Dataquest surveyed 11 major central office/PBX switching suppliers in Table 4-7. Dataquest typically tracks central office by number of line cards, but data available from manufacturers is in the form of number of lines. Furthermore, companies are less comfortable splitting PBX and central office numbers, so Dataquest has combined the figures into one category. A central office line cards is typically defined as a telecommunications switch by public carriers, excluding PBX—a private branch exchange—but Dataquest's company figures include PBXs. Dataquest has estimated pure central office line cards, exclusive of PBXs later in this section.

As shown in Table 4-7, leading central office/PBX manufacturers in China/Hong Kong are a mix of foreign and domestic manufacturers. These companies more than doubled output as measured in lines in 1997 because of China's rapid infrastructure expansion. Shanghai Bell Telephone Equipment Manufacturing Co. Ltd. is the dominant player with a formidable 37 percent production share. The top five companies are market makers because they control about 85 percent of the market. Table 4-8 indicates that these market makers will lose market share caused by several rapid-growth competitors gaining share in 1998 and 1999.

Dataquest's long-term outlook for central office/premises line card production and semiconductor consumption in China/Hong Kong is presented in Table 4-9. Dataquest expects 1997's output of 16 million line cards to expand at a 17 percent CAGR to 35 million units in 2002. Dataquest believes that this will generate semiconductor consumption growth in this segment of 14 percent, from about $200 million in 1998 to $360 million 2002. This market's high competition level is resulting in semiconductor ASP erosion.

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Table 4-7
Central Office/PBX Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
9	1	Shanghai Bell	NA	5950	0	37.1	0	37.1
1	2	Siemens	2840	3000	20.8	18.7	20.8	55.7
3	3	Huawei	1860	2850	13.6	17.7	34.4	73.5
2	4	BISC	2540	2800	18.6	17.4	53.0	90.9
4	5	NEC	980	1450	7.2	9.0	60.1	99.9
9	6	HuaGuang	NA	700	0	4.4	60.1	104.3
9	6	DaTang	NA	700	0	4.4	60.1	108.7
5	8	Ericsson	350	400	2.6	2.5	62.7	111.2
6	9	Toshiba	258	354	1.9	2.2	64.6	113.4
7	10	Nokia	250	300	1.8	1.9	66.4	115.2
8	11	Samsung	200	250	1.5	1.6	67.9	116.8
		Others	NA	NA	NA	NA	-	-
		Total	**9,278**	**18,754**	**100**	**100**	-	-

NA = Not available
Source: Dataquest (August 1998)

Table 4-8
Central Office/PBX Manufacturers Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	1996	1997	1998	1999	1997	1998	1999
Shanghai Bell	NA	5,950	6,800	7,500	NA	14.3	10.3
Siemens	2,840	3,000	3,450	4,250	5.6	15.0	23.2
Huawei	1,860	2,850	3,420	4,000	53.2	20.0	17.0
BISC	2,540	2,800	3,500	4,000	10.2	25.0	14.3
NEC	980	1,450	1,800	1,800	48.0	24.1	0
HuaGuang	NA	700	1,000	1,200	NA	42.9	20.0
DaTang	NA	700	900	1,100	NA	28.6	22.2
Ericsson	350	400	480	600	14.3	20.0	25.0
Toshiba	258	354	425	500	37.2	20.1	17.6
Samsung	200	250	300	400	25.0	20.0	33.3
Nokia	250	300	360	400	20.0	20.0	11.1
Total Surveyed Companies	**9,278**	**18,754**	**22,435**	**25,750**	**102.1**	**19.6**	**14.8**
Others (Estimated)	NA	NA	NA	NA	-	-	-
Total China/Hong Kong	**9,278**	**18,754**	**22,435**	**25,750**	**17.5**	**19.6**	**16.5**
Surveyed Companies' Share of Total (%)	NA	NA	NA	NA	-	-	-

NA = Not available
Source: Dataquest (August 1998)

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Table 4-9
Central Office Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	13,668	16,059	19,207	22,376	26,135	30,186	34,714	17
Manufacturing Revenue ($M)	1,059	1,212	1,421	1,611	1,829	2,083	2,361	14
Manufacturing ASP ($)	78	76	74	72	70	69	68	-2
Semiconductor Content ($)	12	12	11	11	11	11	11	-3
Semiconductor TAM ($M)	160	193	216	242	274	317	364	14
Growth Rate of Unit (%)	-	17.5	19.6	16.5	16.8	15.5	15.0	-
Rate of Manufacturing ASP (%)	-	-2.6	-2.0	-2.7	-2.8	-1.4	-1.4	-
Growth Rate of Manufacturing Revenue (%)	-	14.5	17.2	13.4	13.6	13.9	13.3	-
Growth Rate of Semiconductor Content (%)	-	2.8	-6.2	-4.0	-2.8	0	0	-
Growth Rate of Semiconductor TAM (%)	-	20.8	12.2	11.8	13.6	15.5	15.0	-

TAM = Total available market
Source: Dataquest (August 1998)

Switching Competitive Environment

As of 1997, China had approved more than 43 manufacturers of commercial switching equipment, of which 12 were joint ventures with foreign suppliers. The number has continued to grow. Estimated capacity of the industry is more than 24 million lines per year. China's MPT plans to expand China's switching capacity to more than 200 million lines by 2002. The ninth five-year plan aimed at increasing program-controlled switching by 84 million by 2000. Long-distance switching is planned to reach 6 million accesses with customers exceeding 130 million. These figures represent a penetration rate of about 10 percent nationwide and between 30 percent and 40 percent in urban areas.

Huawei Technology Ltd.

Shenzhen-based Huawei Technology Ltd. is one of China's leading switching equipment manufacturers. The company has supplied switching equipment throughout China. In February, the company supplied 24,000 lines of switches attributed, in part, to China's efforts to localize exchange systems. China's ability to supply switching equipment has improved because of government's support, increased access to technology, and improved manufacturing productivity, as evidenced by Huawei's success.

Shandong Province

There are plans to build telephone exchanges with combined capacity of 1.5 million lines and 20,000-terminal long distance automatic telephone exchanges in the economically booming coastal Shandong province. The number of telephone customers will increase at least 1 million this year, thus providing an average of 6.5 telephones per 100 people in the province.

PBX Telephone Exchanges

Oki Electric Industry Company Limited announced in 1997 that it would set up its first joint venture in China with a telecommunications manufacturer, Guoguang Electronic Corp. Oki Electric has set up a joint venture, Changzhou OKI-GEG Telecoms Ltd., which makes PBX telephone

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exchanges and key telephone systems. Markets would include China, Europe, Oceania, Japan, and Southeast Asia. Oki Electric would hold a 70 percent stake in the venture, with Guoguang Electric holding the balance, and the Changzhou-based joint venture would be capitalized at $7.3 million. Guoguang Electric has been making key telephone and PBX systems for Oki Electric since 1995 and is the local distributor for PBXs.

Cordless Telephones

Southern China is the world's largest production base for cordless telephone. China/Hong Kong's cordless telephone industry will ship 23 million telephones in 1998, a 12 percent increase. Dataquest's survey of seven major manufacturers covered approximately 42 percent of China/Hong Kong's total cordless phone production in 1998. Table 4-10 lists the major manufacturers of cordless phones, their units, ranking, and production share. Uniden Electronics Products (Shenzhen) Co. Ltd. is the largest manufacturer of cordless phones in China/Hong Kong, with 28 percent share of production in 1998. Vtech Holdings Ltd. is the fastest-growing manufacturer in 1998 since it doubled production volume from 1.5 million units to 3.3 million units. Its production market share expanded from 10 percent to 16 percent.

Table 4-11 provides Dataquest's outlook on these manufacturers in 1998 and 1999. These manufacturers' strong growth is likely to continue in 1998, but it is expected to slow in 1999. These seven major manufacturers will expand by 42 percent in 1998, but they will slow to 24 percent in 1999. Uniden and Vtech will remain in their respective ranking and slow their expansion to about 16 percent in 1999 after growing an estimated 22 percent in 1998. Several new second-tier companies are adding significant capacity, which will take production share from the top two producers. Table 4-12 shows a forecast of China/Hong Kong's cordless telephone production forecast.

Table 4-10
Cordless Telephone Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

Rank 1996	Rank 1997	Company	1996	1997	Production Share (%) 1996	Production Share (%) 1997	Accumulated Share (%) 1996	Accumulated Share (%) 1997
1	1	Uniden	5400	5800	36.8	28.1	36.8	28.1
2	2	Vtech Holdings Ltd.	1450	3350	9.9	16.2	46.7	44.3
3	3	TCL	795	1000	5.4	4.8	52.1	49.1
5	4	Phone Star	NA	800	0	3.9	52.1	53.0
5	4	Sony	NA	800	0	3.9	52.1	56.9
5	6	XiaHua (Xoceco)	NA	200	0	1.0	52.1	57.9
4	7	Sanyo	28	38	0.2	0.2	52.3	58.0
		Others	6,994	8,668	47.7	42.0	-	-
		Total	14,667	20,656	100	100	-	-

Source: Dataquest (August 1998)

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Table 4-11
Cordless Telephone Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	1996	1997	1998	1999	1997	1998	1999
Uniden	5,400	5,800	7,100	8,250	7.4	22.4	16.2
Vtech Holdings Ltd.	1,450	3,350	4,800	5,500	131.0	43.3	14.6
TCL	795	1,000	1,500	2,000	25.8	50.0	33.3
Phone Star	NA	800	1,500	2,000	NA	87.5	33.3
Sony	NA	800	1,000	1,000	NA	25.0	0
Idall	NA	NA	500	1,000	NA	NA	100.0
XiaHua (Xoceco)	NA	200	500	800	NA	150.0	60.0
Sanyo	28	38	100	350	35.7	163.2	250.0
Siemens	NA	NA	10	100	NA	NA	900.0
Total Surveyed Companies	**7,673**	**11,988**	**17,010**	**21,000**	**56.2**	**41.9**	**23.5**
Others (Estimated)	6,994	8,668	6,072	3,804	23.9	-29.9	-37.4
Total China/Hong Kong	**14,667**	**20,656**	**23,082**	**24,804**	**40.8**	**11.7**	**7.5**
Surveyed Companies' Share of Total (%)	52	58	74	85	-	-	-

NA = Not available
Source: Dataquest (August 1998)

Table 4-12
Cordless Telephone Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	14,667	20,656	23,082	24,804	26,563	28,251	30,078	8
Manufacturing Revenue ($M)	752	1,048	1,218	1,332	1,448	1,504	1,478	7
Manufacturing ASP ($)	200	166	138	124	115	105	94	-11
Semiconductor Content ($)	117	99	83	82	80	80	79	-4
Semiconductor TAM ($M)	388	575	724	879	1,006	1,157	1,254	17
Growth Rate of Unit (%)	-	40.8	11.7	7.5	7.1	6.4	6.5	-
Rate of Manufacturing ASP (%)	-	39.3	16.3	9.4	8.7	3.9	-1.7	-
Growth Rate of Manufacturing Revenue (%)	-	-17.1	-16.8	-10.1	-7.3	-9.1	-10.5	-
Growth Rate of Semiconductor Content (%)	-	-15.4	-16.2	-1.8	-1.6	0	-1.8	-
Growth Rate of Semiconductor TAM (%)	-	48.0	26.0	21.3	14.5	15.0	8.4	-

TAM = Total available market
Source: Dataquest (August 1998)

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The deceleration observed from Dataquest's company survey will continue after 1999 because of persistent overcapacity from overinvestments in 1996 and 1997. Dataquest's 1997-to-2002 CAGR is expected to reach 8 percent unit growth and 7 percent revenue increase. This semiconductor market segment will, however, experience substantial revenue growth, outpacing equipment unit and revenue growth by a large margin. Dataquest forecasts the cordless telephone semiconductor market to expand from $724 million in 1998 to $1.3 billion in 2002, which is a 17 percent CAGR. This is a highly competitive market in which manufacturers will differentiate their product on functionality, and thereby requiring higher-performance digital signal processors (DSPs), memory, and microcontrollers. Cordless phone customers have a particularly high expectation of performance, quality, and functionality.

Mobile Communications Infrastructure

Dataquest presents revenue estimates on three mobile communications infrastructure equipment manufacturers in Table 4-13. Nokia, Ericsson, and Siemens manufacture approximately 90 percent of the mobile communications equipment produced in China/Hong Kong. Nokia is the largest maker, with a 46 percent production market share. Table 4-14 provides production forecasts for these three manufacturers in 1998 and 1999. While 1997 and 1998 showed substantial growth—similar to cellular and pager trends—mobile communications equipment manufacturing expansion is expected to decelerate in 1999. Dataquest expects this segment's revenue to grow by 15 percent in 1999, after growing by 33 percent in 1998 and 40 percent in 1997.

Table 4-14 provides a forecast of these three manufacturers in 1998 and 1999. Both Nokia and Ericsson are slowing expansion growth in 1999 after several years of rapid expansion. Siemens is accelerating expansion from 20 percent in 1998 to 25 percent in 1999, but from a small revenue base of $24 million.

Table 4-15 presents Dataquest's 1997-to-2002 forecast for all of China/Hong Kong production and semiconductor consumption in this segment. Dataquest estimates that China/Hong Kong's $243 million production revenue in 1998 represents approximately $20 million in semiconductor consumption. By 2002, Dataquest forecasts revenue to reach a modest $366 million, which represents a semiconductor market of $28 million. At this time, most design wins are outside of China/Hong Kong, but by 2002, Dataquest expects most production and design wins to occur within China/Hong Kong.

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Table 4-13
Mobile Communications Infrastructure Equipment Manufacturers Production Share and Ranking, 1996 and 1997 (Millions of U.S. Dollars)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Nokia	63	85	48.8	46.4	48.8	46.4
2	2	Ericsson	41	61	32.3	33.6	81.1	80.0
3	3	Siemens	14	20	11.3	11.0	92.4	90.9
		Others	10	17	7.6	9.1	-	-
		Total	**128**	**183**	**100**	**100**	-	-

Source: Dataquest (August 1998)

Table 4-14
Mobile Infrastructure Equipment Manufacturers Production Revenue Forecast, 1996 to 1999

	Revenue ($M)				Growth (%)		
Company	1996	1997	1998	1999	1997	1998	1999
Ericsson	41	61	95	115	47.9	55.6	20.5
Nokia	63	85	102	110	35.2	20.1	8.2
Siemens	14	20	24	30	38.3	19.9	25.1
Total Surveyed Companies	**119**	**166**	**221**	**255**	**40.0**	**33.2**	**15.3**
Others (Estimated)	10	17	22	26	70.1	32.8	15.8
Total China/Hong Kong	**128**	**183**	**243**	**281**	**42.3**	**33.1**	**15.4**
Surveyed Companies' Share of Total (%)	92	91	91	91	-	-	-

Source: Dataquest (August 1998)

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Table 4-15
Mobile Communication Infrastructure Equipment Production Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	NA	NA	NA	NA	NA	NA	NA	NA
Manufacturing Revenue ($M)	128	183	243	281	315	341	366	15
Manufacturing ASP ($)	NA	NA	NA	NA	NA	NA	NA	NA
Semiconductor Content ($)	NA	NA	NA	NA	NA	NA	NA	NA
Semiconductor TAM ($M)	15	20	21	22	24	26	28	7
Growth Rate of Unit (%)	0	42.3	33.1	15.4	12.1	8.4	7.3	-
Rate of Manufacturing ASP (%)	NA	NA	NA	NA	NA	NA	NA	-
Growth Rate of Manufacturing Revenue (%)	0	42.3	33.1	15.4	12.1	8.4	7.3	-
Growth Rate of Semiconductor Content (%)	NA	NA	NA	NA	NA	NA	NA	-
Growth Rate of Semiconductor TAM (%)	0	28.6	6.5	6.5	7.5	7.3	8.4	-

NA = Not available
TAM = Total available market
Source: Dataquest (August 1998)

Corded Telephones

Dataquest sizes the corded phone industry at 99 million units in 1998, a 5 percent growth. Dataquest believes that China/Hong Kong will produce about 123 million corded telephones by 2002, which is a 5 percent CAGR from 1997 to 2002. This is a $349 million semiconductor opportunity (see Table 4-16). There are several hundred telephone manufacturers in China, and competition is acute. Telecommunications infrastructure in the vast rural areas of the country remains poor. Most of the telephones will be produced in Shanghai, Fujian province, and Guangdong province, with annual output in Guangdong's Huizhou city alone at 30 million in 1997.

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Table 4-16
Corded Telephone Production and Semiconductor Consumption Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	89,505	94,186	99,331	106,177	112,040	117,053	122,604	5
Manufacturing Revenue ($M)	2,107	2,051	2,034	2,046	2,064	2,072	2,078	0
Manufacturing ASP ($)	24	22	20	19	18	18	17	-5
Semiconductor Content ($)	3	3	3	3	3	3	3	2
Semiconductor TAM ($M)	226	240	258	281	303	322	349	8
Growth Rate of Unit (%)	-	5.2	5.5	6.9	5.5	4.5	4.7	-
Rate of Manufacturing ASP (%)	-	-7.5	-6.0	-5.9	-4.4	-3.9	-4.2	-
Growth Rate of Manufacturing Revenue (%)	-	-2.6	-0.9	0.6	0.9	0.4	0.3	-
Growth Rate of Semiconductor Content (%)	-	1.2	2.0	1.9	1.9	1.9	3.6	-
Growth Rate of Semiconductor TAM (%)	-	6.5	7.5	8.9	7.5	6.4	8.6	-

TAM = Total available market
Source: Dataquest (August 1998)

The Ministry of Posts of Telecommunications (MPT) predicted that 10 out of every 100 people will become telephone subscribers by the turn of the century. However, only about six out of every 100 people had a telephone services at the end of 1997. China's serious plans to raise its national telecommunications network capacity are formidable. To increase subscribers and meet a government plan, China will need 85 million telephone lines before 2000. China is on its way to achieving this goal, since about 17 million new telephone lines were installed in 1997. With more than 130 million telephones to be connected, 30 percent to 40 percent of urban residents are targeted to have a phone by 2000. China's urban population is estimated at 300 million to 400 million people, depending on whether or not suburbs are counted.

All Chinese rural villages are planned to be connected by phones during the Ninth Five-Year Plan period (1996 to 2000). The number of rural telephone customers is expected to increase annually by 6 million to 7 million, according to China's telecommunications departments. Because of high priority given to rural areas, China's rural telecommunications business—with a generally poorer economic base—has not been ignored. In fact, the rural installation rate has been steadily increasing in recent years (at a rate higher than in urban areas in 1995). In some economically thriving eastern regions, the number of customers in rural areas is increasing faster than in urban areas. However, in much of China's central and western regions, almost half of the villages still have no access to a telephone.

Fax Machines

Table 4-17 provides Dataquest's long-term forecast of facsimile machine production and semiconductor consumption. Like corded phones, fax machines are a mature market with overproduction and severe competition. Dataquest forecasts production to grow at a 6 percent CAGR from 841,000 units in 1997 to 1.1 million units in 2002. There are more than

20 fax machine manufacturers in China, but domestically made fax machines are of poor quality, compared with imported products. Hence, the domestic manufacturers import the fax thermal reading heads, scanners, and high-speed modems. The demand for fax machines has increased, as more telephones are installed and the switch capacity expands. Japanese products have dominated China's fax machine market and account for 80 percent of the imported fax machines, which occupy 90 percent of the domestic market. Demand for fax machines is expected to stand at 300,000 units in 1997.

Popular fax machine brands in China include Panasonic Communications and Systems Company, Canon Inc., and Oki Telecom. In 1997, more than 200,000 machines were approved in government projects, and about half were Panasonic products. Oki products have been widely used in railways, electronics, and public security sectors. Fax machines from Korean companies such as Samsung and Daewoo Telecommunications Company Ltd. have also expanded their market share in China with an edge on prices.

LAN Cards

China/Hong Kong's PC market boom has recently increased LAN market growth. Local manufacturers are entering the market and expanding production capacity. Table 4-18 presents Dataquest's 1997-to-2002 production and semiconductor consumption forecast for LAN cards. Of the 2.2 million PCs sold in China in 1997, nearly 100,000 units, or 40 percent, were sold as part of networks. Production in 1998 increased by 45 percent to 5.8 million units, representing a $41 million semiconductor market. Dataquest forecasts LAN card production to grow at a 22 percent CAGR from 4 million units in 1997 to 11 million units in 2002. Semiconductor consumption in LAN cards will reach $71 million by 2002.

Table 4-17
Facsimile Production and Semiconductor Consumption Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	791	841	921	963	1,011	1,076	1,136	6
Manufacturing Revenue ($M)	193	197	205	202	204	205	205	1
Manufacturing ASP ($)	245	234	222	210	202	191	180	-5
Semiconductor Content ($)	68	61	58	52	50	45	45	-6
Semiconductor TAM ($M)	53	51	53	50	51	48	51	0
Growth Rate of Unit (%)	0	6.4	9.5	4.5	5.0	6.5	5.5	-
Rate of Manufacturing ASP (%)	0	-4.3	-5.0	-5.8	-3.7	-5.4	-5.6	-
Growth Rate of Manufacturing Revenue (%)	0	1.8	4.1	-1.6	1.1	0.7	-0.4	-
Growth Rate of Semiconductor Content (%)	0	-9.6	-4.9	-10.3	-3.8	-10.0	0	-
Growth Rate of Semiconductor TAM (%)	0	-3.9	4.1	-6.3	1.0	-4.1	5.5	-

TAM = Total available market
Source: Dataquest (August 1998)

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Table 4-18
Local Area Network Card Production and Semiconductor Consumption Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	600.0	4,000.0	5,800.3	7,177.0	9,589.0	10,356.1	10,873.9	22
Manufacturing Revenue ($M)	12.9	76.8	100.9	116.3	143.8	148.1	145.7	14
Manufacturing ASP ($)	21.5	19.2	17.4	16.2	15.0	14.3	13.4	-7
Semiconductor Content ($)	9.0	7.0	7.0	6.8	6.8	6.6	6.5	-1
Semiconductor TAM ($M)	5.4	28.0	40.6	49.1	64.7	68.4	70.7	20
Growth Rate of Unit (%)	0	566.7	45.0	23.7	33.6	8.0	5.0	-
Rate of Manufacturing ASP (%)	0	-10.7	-9.4	-6.8	-7.5	-4.6	-6.3	-
Growth Rate of Manufacturing Revenue (%)	0	495.3	31.4	15.3	23.6	3.0	-1.6	-
Growth Rate of Semiconductor Content (%)	0	-22.4	-0.1	-2.1	-1.4	-2.2	-1.5	-
Growth Rate of Semiconductor TAM (%)	0	417.2	44.8	21.1	31.8	5.6	3.4	-

TAM = Total available market
Source: Dataquest (August 1998)

On the networking market front, networking companies are making a convincing case that China's attention has turned to networking equipment. Greater China—which includes China, Hong Kong, and Taiwan—emerged as the Cisco System Inc.'s largest market in Asia/Pacific (excluding Japan) as the fastest-growing sales region worldwide. Cisco's sales to greater China in fiscal 1997 climbed 120 percent over the previous fiscal year, with sales in mainland China jumping almost 280 percent.

In a multimillion dollar deal, Hong Kong-based China Internet Corp. (CIC) and the U.S. networking giant Bay Networks Inc. joined forces to set up a network of powerful Web servers that bring vital information to businesses in China. In January 1998, Bay Networks was chosen to provide the infrastructure for the project, dubbed the China Wide Web (CWW), which will place servers strategically located in more than 50 major cities across China. The first phase of the network, covering five major cities, is now being installed and was operational in the first quarter of 1997. Network control centers will be set up in Beijing and Hong Kong. The first CWW branch nodes will be in Shanghai, Shenyang, and Guangzhou. CIC has plans to add an additional five cities to the network each quarter, reaching a minimum of 20 cities by the end of the year. The Bay Networks System 5000 hubs are now shipping to the CWW's phase-one sites in Beijing, Hong Kong, Shanghai, and Guangzhou.

Following desktop computers and notebook computers, Philips Electronics NV recently announced to enter network market in Beijing. It also designated the Beijing Yasuo Network Technology Ltd. its general agent in mainland China. The first-released products include 10/100M PnP ISA/PCI/PCMCIA network card (NIC), 10M PnP PCMCIA FAX/MODEM/NIC card, 10M/100M concentrators (HUB), and exchangers.

China has leaped to become Digital Equipment Corporation's fastest-increasing market. Digital expected to expand its network market by 60 percent in China in 1997. Digital's network products will further tap the Chinese market, particularly the banking and financial market.

Talking about exchange systems, Digital will put stress on school net exchange systems and long distance net systems. In addition, Digital will engage itself in developing new technology suitable for China's condition.

Modems

China's modem production in 1997 reached 575,000 units and is expected to grow 21 percent in 1998. Production is decelerating to 16 percent in 1999 and 14 percent in 2000. Semiconductor consumption is forecast to grow from $17 million in 1998 to $26 million in 2002, a 13 percent CAGR. Table 4-19 provides Dataquest's modem production and semiconductor consumption unit and revenue forecasts from 1997 to 2002.

Table 4-19
Local Area Network Card Production and Semiconductor Consumption Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	350	475	575	666	762	862	974	15
Manufacturing Revenue ($M)	33	42	48	52	56	60	65	9
Manufacturing ASP ($)	94	89	83	78	73	70	67	-6
Semiconductor Content ($)	32	30	29	28	27	27	27	-2
Semiconductor TAM ($M)	11	14	17	19	21	23	26	13
Growth Rate of Unit (%)	0	35.7	21.2	15.8	14.3	13.2	13.0	-
Rate of Manufacturing ASP (%)	0	-5.2	-6.9	-6.3	-6.2	-4.0	-4.5	-
Growth Rate of Manufacturing Revenue (%)	0	28.6	12.9	8.5	7.2	8.7	7.9	-
Growth Rate of Semiconductor Content (%)	0	-6.2	-3.3	-3.4	-3.6	-0.2	-0.4	-
Growth Rate of Semiconductor TAM (%)	0	27.2	17.2	11.8	10.2	13.0	12.5	-

TAM = Total available market
Source: Dataquest (August 1998)

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Chapter 5

Consumer Electronics Equipment

China/Hong Kong produced approximately 40 percent of Asia/Pacific's consumer electronic equipment in 1997 and approximately 13 percent of worldwide consumer electronics. Dataquest forecasts China/Hong Kong's consumer electronics production share in Asia/Pacific's to increase to 50 percent by 2002, and its share in the worldwide production to reach 19 percent 2002. However, this growth will need to come after a slowdown in 1998 and 1999. If digital consumer expands at a worldwide level as expected, then China/Hong Kong will meet this forecast. Otherwise, Dataquest expects a worst-case scenario in which production will grow at an 8 percent CAGR rather than the 12 percent Dataquest forecasts.

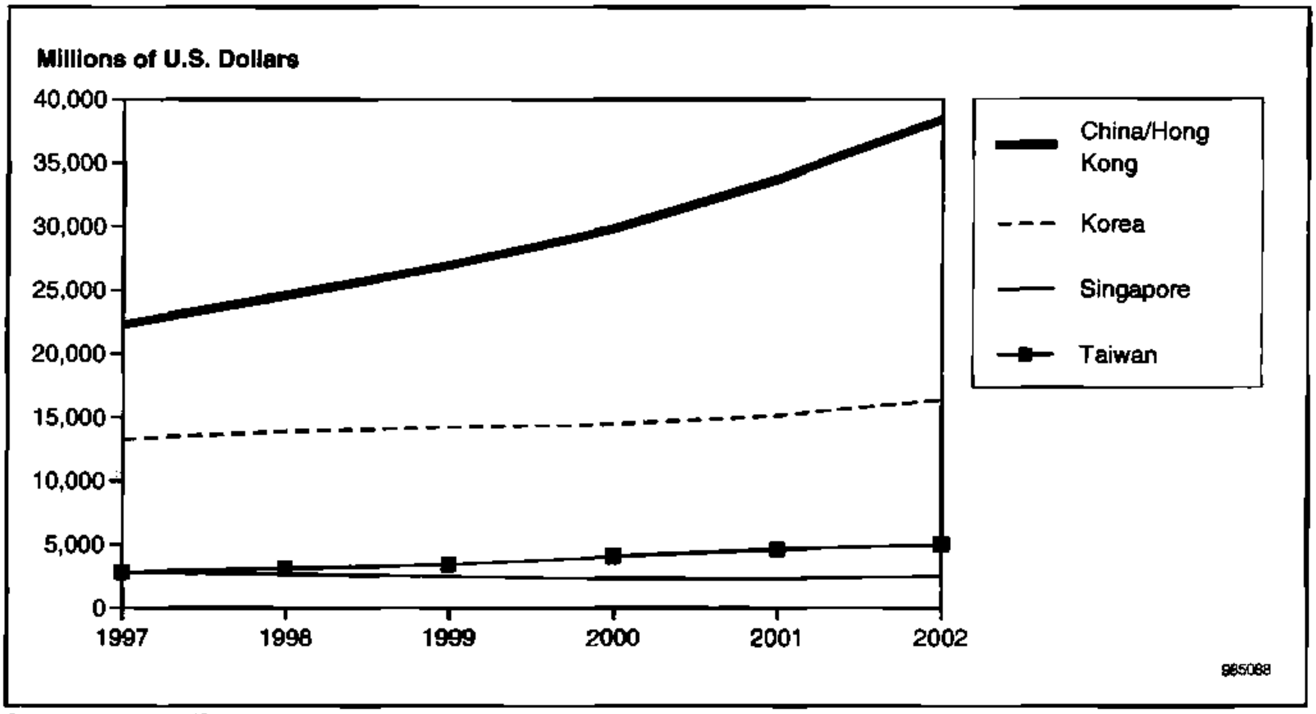
China/Hong Kong's large and rapidly-growing domestic market is the main factor behind China's high production level relative to other Asia/Pacific countries. Moreover, Japanese and Korean consumer manufacturers continue to shift production to China faster than to any other Asia/Pacific country. Dataquest expects China/Hong Kong to remain the main destination for these investments in the next five years. As discussed in Chapter 2, China/Hong Kong is now the Asia/Pacific growth center because of stronger economic fundamentals. Both exports and domestic consumption are maintaining reasonable growth even after the Asian financial crisis. However, Dataquest has observed that, at the same time, the new era of digital consumer is already showing up in China in the form of digital broadcasting and digital video compact disc (VCD) players. Figure 5-1 illustrates consumer electronics equipment production forecast for four major Asian countries.

Production Growth Sectors in Consumer Electronics

Figure 5-2 illustrates each market segment of China/Hong Kong's consumer electronics industry. Audio equipment is the largest of the five major segments with a $7.8 million revenue in 1998. Dataquest expects video equipment production to match or surpass audio by 2002 because of China's imminent expansion into digital consumer equipment and broadcast. In addition to audio's slow growth, Dataquest expects a personal electronics maturation on a revenue basis in China/Hong Kong. Personal electronics and audio equipment will expand at a 7 percent to 8 percent CAGR from 1997 to 2002, while video will expand by 12 percent.

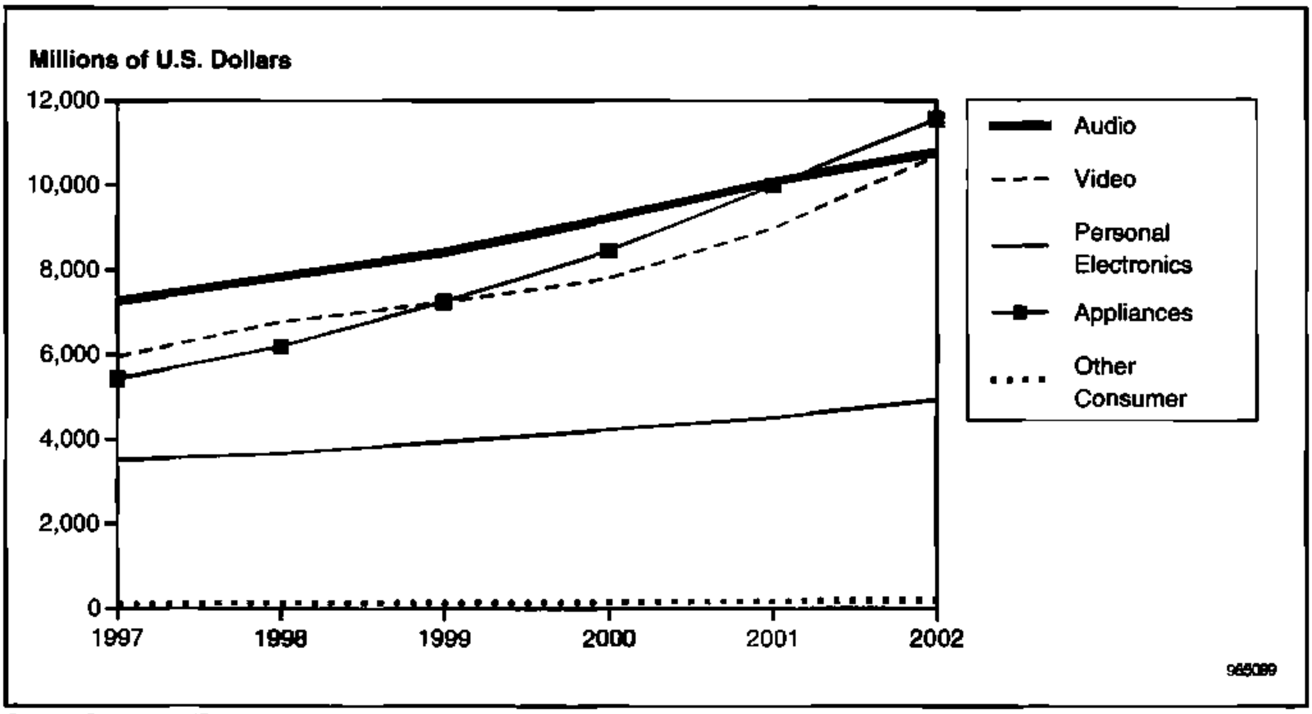
Home appliance production is the fastest-growing segment of the consumer electronics industry. Production will reach $6.2 billion in 1998 and will expand at a 16 percent CAGR at $10 billion by 2002. Dataquest's outlook for continuous and expanding growth is tied mainly to the belief that the economy, as indicated by GDP, will average 6 percent to 8 percent growth during this period. New areas of economic development will absorb local production. Wealthier urban areas will continue to upgrade their to new gadgets, such as air conditioners, heaters, or dehumidifiers. Furthermore, Dataquest's survey of producers discovered a high percentage of exported consumer electronics production by multinational companies, as discussed later in the chapter.

Figure 5-1
Consumer Electronic Equipment Production Forecast for China/Hong Kong, Korea, Singapore, and Taiwan: 1997 to 2002



Source: Dataquest (September 1998)

Figure 5-2
China/Hong Kong's Consumer Electronics Equipment Production Forecast by Segment, 1997 to 2002 (Millions of U.S. Dollars)



Source: Dataquest (September 1998)

Color Television Production Forecast

Dataquest's survey covered 14 major color television (CTV) manufacturers in China/Hong Kong, which combined to account for 85 percent of total production in 1997.

Table 5-1 lists these companies' unit output in ranking order according to production share. Changhong Electric Appliances Company is, by far, the industry leader, accounting for a whopping 28 percent of all China/Hong Kong CTV production. The company is the technology and manufacturing leader in China/Hong Kong, which is why it continues to gain production share as well as local market share. In China/Hong Kong, as elsewhere in the world, the large manufacturers are consolidating their leadership through superior operational efficiency from production to marketing and distribution. The top five manufacturers in China/Hong Kong control 64 percent of total production.

Table 5-2 provides Dataquest's company-level forecast for CTVs in 1998 and 1999. Dataquest sees a clear drop in industry output in 1998 and 1999 primarily attributed to worsening economic conditions in China/Hong Kong, rising unemployment, and consumer pessimism about future employment and the economic growth of China. Because Dataquest does not have 1997 data for all 14 companies, a comparison of the seven companies surveyed in 1996 and 1997 will be done instead. These seven manufacturers are estimated to have a combined annual production expansion of 40 percent in 1997. In 1998, these same seven companies are forecast to have only a 10 percent production, but Dataquest expects improvement in 1999 and forecasts a 15 percent year-on-year unit growth.

Table 5-1
Color Television Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Chang Hong	4,800	6,500	23.1	28.4	23.1	28.4
9	2	Konka	NA	3,200	0	14.0	23.1	42.4
2	3	Hitachi (FuRi)	1,550	2,160	7.5	9.4	30.6	51.9
3	4	Samsung	1,056	1,600	5.1	7.0	35.6	58.9
5	5	TCL	650	1,200	3.1	5.2	38.8	64.1
9	5	Shanghai GuangDian	NA	1,200	NA	5.2	38.8	69.4
4	7	Sanyo	740	1,000	3.6	4.4	42.3	73.7
9	7	XiaHua (Xoceco)	NA	1,000	NA	4.4	42.3	78.1
6	9	Toshiba	550	650	2.6	2.8	45.0	81.0
9	10	Panda	NA	610	NA	2.7	45.0	83.6
7	11	Philips	250	340	1.2	1.5	46.2	85.1
9	12	Sony	NA	50	NA	0.2	46.2	85.3
9	13	Sharp	NA	20	NA	0.1	46.2	85.4
8	14	Matsushita	120	NA	0.6	0	46.7	85.4
		Others	11,068	3,333	53.3	14.6	-	-
		Total	**20,784**	**22,863**	**100**	**100**	-	-

Source: Dataquest (August 1998)

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Table 5-2
Color Television Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	**1996**	**1997**	**1998**	**1999**	**1997**	**1998**	**1999**
Chang Hong	4,800	6,500	7,000	7,800	35.4	7.7	11.4
Konka	NA	3,200	4,500	5,500	NA	40.6	22.2
Hitachi (FuRi)	1,550	2,160	2,400	2,900	39.4	11.1	20.8
Samsung	1,056	1,600	1,920	2,150	51.5	20.0	12.0
Shanghai GuangDian	NA	1,200	1,500	1,800	NA	25.0	20.0
TCL	650	1,200	1,200	1,500	84.6	0	25.0
Sanyo	740	1,000	1,200	1,500	35.1	20.0	25.0
XiaHua (Xoceco)	NA	1,000	1,000	1,500	NA	0	50.0
Toshiba	550	650	760	850	18.2	16.9	11.8
Panda	NA	610	600	700	NA	-1.6	16.7
Philips	250	340	408	550	36.0	20.0	34.8
Sharp	NA	20	150	250	NA	650.0	66.7
Sony	NA	50	90	150	NA	80.0	66.7
Matsushita	120	NA	NA	NA	-100.0	NA	NA
Total Surveyed Companies	**9,716**	**19,530**	**22,728**	**27,150**	**101.0**	**16.4**	**19.5**
Others (Estimated)	11,068	3,333	4,021	4,816	-69.9	20.7	19.7
Total China/Hong Kong	**20,784**	**22,863**	**26,749**	**31,966**	**10.0**	**17.0**	**19.5**
Surveyed Companies' Share of Total (%)	47	85	85	85	-	-	-

NA = Not available
Source: Dataquest (August 1998)

Color television production represented approximately 55 percent of the consumer video segment (as illustrated in Figure 5-2) in 1997 and will grow to a 67 percent share by 2002. Dataquest has mentioned that consumer video is forecast to grow by 12 percent from $6 billion in 1997 to $11 billion in 2002. Color television factory revenue is forecast to grow at a 17 percent CAGR, from $3 billion in 1997 to $7.1 billion in 2002. Semiconductor consumption in the CTV market segment will grow from $400 million in 1997 to $1.2 billion in 2002, a 23 percent CAGR (see Table 5-3).

The relatively large proportion of multinational manufacturers, with the exception of Changhong, adds to China's production prowess in that a large percent of CTVs are exported. Dataquest expects export success to help boost the industries' long-term growth, and the government will likely support about five major manufacturers by providing export incentives.

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Table 5-3
Color Television Production and Semiconductor Consumption Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	20,784	22,863	26,749	31,966	38,391	46,069	52,979	18
Manufacturing Revenue ($M)	3,014	3,247	3,745	4,443	5,298	6,265	7,152	17
Manufacturing ASP ($)	145	142	140	139	138	136	135	-1
Semiconductor Content ($)	17	18	20	20	20	21	22	4
Semiconductor TAM ($M)	362	412	546	652	783	986	1,176	23
Growth Rate of Unit (%)	-	10.0	17.0	19.5	20.1	20.0	15.0	-
Rate of Manufacturing ASP (%)	-	-2.1	-1.4	-0.7	-0.7	-1.4	-0.7	-
Growth Rate of Manufacturing Revenue (%)	-	7.7	15.4	18.6	19.2	18.3	14.2	-
Growth Rate of Semiconductor Content (%)	-	3.5	13.3	0	0	4.9	3.7	-
Growth Rate of Semiconductor TAM (%)	-	13.8	32.6	19.5	20.1	25.9	19.3	-

TAM = Total available market
Source: Dataquest (August 1998)

Video Compact Disc Players (VCDs)

Table 5-4 presents the 10 large VCD manufacturers' units and production share in 1996 and 1997, which combined to account for 68 percent of China's total unit output in 1997.

China's VCD player market follows a typical product life cycle: It has gone through the introduction stage and high-growth stage and is now approaching the maturity stage. The declining stage will start in 1999 when DVD players begin to penetrate the market.

Table 5-4
Video Compact Disk (VCD) Player Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Jiangsu Shinco	900	3,200	15.7	21.8	15.7	21.8
2	2	Idall	450	1,930	7.8	13.2	23.5	35.0
3	3	Fujian Malata	300	1,350	5.2	9.2	28.7	44.2
4	4	Philips	185	820	3.2	5.6	31.9	49.8
7	4	Xiamen Xiaxin	-	820	0	5.6	31.9	55.4
6	6	LG	56	650	1.0	4.4	32.9	59.8
5	7	Samsung	150	420	2.6	2.9	35.5	62.7
7	8	Chang Hong	-	400	0	2.7	35.5	65.4
7	9	Konka	-	300	0	2.0	35.5	67.5
7	10	Sharp	-	50	0	0.3	35.5	67.8
		Others	3,709	4,720	64.5	32.2	-	-
		Total	**5,750**	**14,660**	**100**	**100**	-	-

Source: Dataquest (August 1998)

At the current maturity stage, manufacturers are competing on prices to achieve volume and fighting for market shares. Efforts are being put into efficiency and cost reduction. Meanwhile, market leaders such as Jiangsu province's Jiangsu Shinco Electronic Group Company and Guangdong Idall Co. Ltd. are advertising heavily to emphasize brand differentiation and special product features. Manufacturers extend the product life by means of incorporating more functions into their VCD players. Built-in karaoke functions are now a standard. Other choices are integrated VCD hi-fi systems, multidisk changers, and two-in-one TV/VCD sets. There are also many manufacturers that are concerned with improving the picture quality. Table 5-5 presents China/Hong Kong's VCD production forecast by vendor.

The top five VCD player makers are all Chinese brands; they combine to account for 53.6 percent of the total VCD player market. About one-fifth of this market is occupied by the largest market leader, Jiangsu Province's Shinco. The top three manufacturers occupy nearly half of the overall player market.

In view of the VCD player market's explosive growth, many manufacturers want to share the piece of the pie that belongs to the leading manufacturers. The television giant, Changhong Electronic Group Co., has planned to expand its VCD player production capacity from 400,000 units to 3 million units in 1998.

Taiwanese makers are also eyeing China's VCD player market. The Acer Group and Sampo Corporation are both supplying VCD technology and OEM kits to their Chinese partner for assembly. Their ultimate goal, however, is to make and distribute DVD players to this market.

Table 5-5
VCD Player Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	**1996**	**1997**	**1998**	**1999**	**1997**	**1998**	**1999**
Chang Hong	0	400	800	700	-	100.0	-12.5
Konka	0	300	800	950	-	166.7	18.8
Samsung	150	420	460	500	180.0	9.5	8.7
Philips	185	820	984	500	343.2	20.0	-49.2
Sharp	0	50	150	100	-	200.0	-33.3
LG	56	650	800	500	1,060.7	23.1	-37.5
Jiangsu Shinco	900	3,200	2,800	2,000	255.6	-12.5	-28.6
Idall	450	1,930	2,000	1,800	328.9	3.6	-10.0
Fujian Malata	300	1,350	1,500	1,000	350.0	11.1	-33.3
Xiamen Xiaxin	0	820	984	600	-	20.0	-39.0
Total Surveyed Companies	**2,041**	**9,940**	**11,278**	**8,650**	**387.0**	**13.5**	**-23.3**
Others (Estimated)	3,709	4,720	7,206	8,750	27.3	52.7	21.4
Total China/Hong Kong	**5,750**	**14,660**	**18,484**	**17,400**	**155.0**	**26.1**	**-5.9**
Surveyed Companies' Share of Total (%)	35	68	61	50	-	-	-

Source: Dataquest (August 1998)

Table 5-6 presents Dataquest's long-term forecast of China/Hong Kong's VCD production, which shows accelerating growth and then decline because of maturation and the introduction of DVD replacement technology. CCD players have been proliferating in the Chinese market for some simple reasons. The hardware is cheap and simple in technology. VCD players combine CD players with a MPEG decoder to produce acceptable video-playing capabilities. The majority of manufacturers get key components from a few suppliers: Sony Corporation and Philips for CD mechanisms, and C-Cube Microsystems Inc. and ESS Technology Inc. for decoding chips.

The proliferation of private software has fueled the demand for China's VCD market. The intellectual-copyright concept is still weakly understood among Chinese consumers. They can easily get low-cost pirate software or even rent VCD movies at a cost below U.S.$1 in some cities. The third reason is the lack of an installed base of VCRs and audio CDs in China. The popularity of color TV and karaoke among the Chinese has also contributed to the strong demand of VCD players.

In terms of the substitution by DVD players, the price and software gap will lengthen the time needed for DVD players to take off in the market. Although DVD players provide consumers with high-quality pictures and sounds, better performance, and a wider range of features, Chinese consumers do not currently have the purchasing power to buy them. The higher price is not the only barrier for DVD players to enter the China market. Consumers are concerned about the limited availability of DVD titles that cost much more than VCD titles. Also, the existing color television sets, limited by 350-line, cannot produce a high-resolution effect required by DVD players.

On the other hand, the DVD player emergence will encourage VCD player manufacturers to improve the quality of their VCD products. Because of the backward compatibility of DVD players, VCD software will still prevail, unless DVD titles' prices can match. VCD players will be able to survive in the presence of DVD players until 2001 when a precipitous decline is expected.

Table 5-6
VCD Player Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	5,750	14,660	18,484	17,400	15,200	11,050	5,690	-17
Manufacturing Revenue ($M)	1,208	1,847	1,867	1,340	1,064	751	415	-26
Manufacturing ASP ($)	210	126	101	77	70	68	73	-10
Semiconductor Content ($)	59	30	24	19	17	15	17	-11
Semiconductor TAM ($M)	336	437	444	325	255	168	94	-26
Growth Rate of Unit (%)	-	155.0	26.1	-5.9	-12.6	-27.3	-48.5	-
Rate of Manufacturing ASP (%)	-	-40.0	-19.8	-23.8	-9.1	-2.9	7.4	-
Growth Rate of Manufacturing Revenue (%)	-	53.0	1.1	-28.2	-20.6	-29.4	-44.7	-
Growth Rate of Semiconductor Content (%)	-	-49.1	-19.5	-22.2	-10.0	-9.5	8.6	-
Growth Rate of Semiconductor TAM (%)	-	29.9	1.5	-26.8	-21.4	-34.2	-44.1	-

TAM = Total available market
Source: Dataquest (August 1998)

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Video Cassette Recorders (VCR)

Table 5-7 presents Dataquest's list of surveyed VCR manufacturers and their respective production volume and industry share. Dataquest's survey of five manufacturers represents 42 percent of combined production units. These companies appear to be increasing production share, while smaller manufacturers are exiting the market.

Table 5-8 presents these five manufacturers' 1998 and 1999 production plans. The VCR industry is a mature but lingering market. Slow growth but large-scale production is sustained by a large infrastructure of inexpensive tapes and demand from remote regions where VCDs and media are not readily available. Nevertheless, because of China's population advantage, there will be growth, but less than 4 percent in units for the next five years. In addition, revenue is expected to contract (see Table 5-9).

Table 5-7
VCR Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Samsung	750	980	19.4	21.3	19.4	21.3
2	2	LG	580	650	15.0	14.2	34.5	35.5
3	3	Matsushita	124	150	3.2	3.3	37.7	38.8
4	4	Sanyo	75	85	1.9	1.9	39.6	40.6
5	5	Philips	65	80	1.7	1.7	41.3	42.4
		Others	2,264	2,646	58.7	57.6	-	-
		Total	**3,858**	**4,591**	**100**	**100**	-	-

Source: Dataquest (August 1998)

Table 5-8
VCR Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	1996	1997	1998	1999	1997	1998	1999
Samsung	750	980	1,176	800	30.7	20.0	-32.0
Sanyo	75	85	102	128	13.3	20.0	25.5
Philips	65	80	96	80	23.1	20.0	-16.7
Matsushita	124	150	165	150	21.0	10.0	-9.1
LG	580	650	700	750	12.1	7.7	7.1
Total Surveyed Companies	**1,594**	**1,945**	**2,239**	**1,908**	**22.0**	**15.1**	**-14.8**
Others (Estimated)	2,264	2,646	3,385	4,042	16.9	27.9	19.4
Total China/Hong Kong	**3,858**	**4,591**	**5,624**	**5,950**	**19.0**	**22.5**	**5.8**
Surveyed Companies' Share of Total (%)	41	42	40	32	-	-	-

Source: Dataquest (August 1998)

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Table 5-9
VCR Camcorder Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	3,858	4,591	5,624	5,950	6,081	5,881	5,498	4
Manufacturing Revenue ($M)	588	665	773	792	777	722	648	-1
Manufacturing ASP ($)	152	145	137	133	128	123	118	-4
Semiconductor Content ($)	30	32	32	31	30	31	30	-1
Semiconductor TAM ($M)	118	149	180	185	185	181	166	2
Growth Rate of Unit (%)	0	19.0	22.5	5.8	2.2	-3.3	-6.5	-
Rate of Manufacturing ASP (%)	0	-4.9	-5.2	-3.2	-4.1	-3.9	-4.0	-
Growth Rate of Manufacturing Revenue (%)	0	13.2	16.2	2.5	-2.0	-7.0	-10.3	-
Growth Rate of Semiconductor Content (%)	0	6.4	-1.3	-2.6	-2.4	1.3	-2.0	-
Growth Rate of Semiconductor TAM (%)	0	26.6	20.9	3.1	-0.2	-2.1	-8.3	-

TAM = Total available market
Source: Dataquest (August 1998)

Personal Stereo

Personal/portable stereo production of $655 million in 1997 accounted for only 9 percent of total audio equipment production in China/Hong Kong. Dataquest's survey of personal stereo manufacturers represented only 2.9 percent of total personal/portable stereo equipment production in this highly dispersed market segment. Personal stereo was one of the earliest consumer electronics markets to grow since China's economic reform and "open door" policy took hold in mid-1980s. Now this market is plagued by overcapacity and efficient state-owned enterprises that will undergo consolidation in the next five years. Table 5-10 shows personal/portable stereo manufacturers' ranking and market share in China/Hong Kong.

Table 5-10
Personal / Portable Stereo Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
2	1	Samsung	80	300	0.3	0.9	0.3	0.9
1	1	Matsushita	300	300	1.0	0.9	1.2	1.8
4	3	LG	70	200	0.2	0.6	1.5	2.4
2	4	Philips	80	100	0.3	0.3	1.7	2.7
5	5	Sanyo	38	56	0.1	0.2	1.8	2.9
6	6	Sharp	-	10	0	0	1.8	2.9
		Others	30,307	32,132	98.2	97.1	-	-
		Total	**30,875**	**33,098**	**100**	**100**	-	-

Source: Dataquest (August 1998)

Table 5-11 presents 1998 and 1999 forecasts for these major multinational vendors. Samsung and LG Electronics are the only two companies that expanded in 1997, while the others' production remained flat. Most manufacturers show a clear slowing trend in 1998 and 1999 because of difficult market conditions.

Dataquest's long-term industry outlook is shown in Table 5-12. Dataquest expects personal and portable stereo shipments to grow approximately 5 percent in the next five years, like other mature electronics equipment markets in China. China/Hong Kong's estimated 33 million units will increase at a rate slower than GDP growth to 42 million units in 2002. Semiconductor consumption in this segment will climb only 3 percent from $200 million in 1998 to $260 million in 2002.

Camcorders

Analog camcorders are providing new growth opportunities for consumer electronic equipment manufacturers in China/Hong Kong. Dataquest's survey of Sony and Hitachi Ltd. found that these multinational manufacturers are rapidly expanding production capacity in China/Hong Kong and are taking advantage of the local market to absorb their production. As shown in Table 5-13, both companies rapidly expanded production in 1997, by a whopping 350 percent, from 78,000 units in 1996 to 275,000 in 1997. Dataquest estimates that this combined production volume represents 94 percent of total personal and portable stereo production.

Table 5-11
Personal/Portable Stereo Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	1996	1997	1998	1999	1997	1998	1999
Matsushita	1,958	2,310	2,772	2,800	18.0	20.0	1.0
Philips	600	750	900	1,000	25.0	20.0	11.1
Sanyo	545	650	780	850	19.3	20.0	9.0
LG	450	650	780	850	44.4	20.0	9.0
Total Surveyed Companies	**3,553**	**4,360**	**5,232**	**5,500**	**22.7**	**20.0**	**5.1**
Others (Estimated)	27,322	28,738	28,925	30,877	5.2	0.7	6.7
Total China/Hong Kong	**30,875**	**33,098**	**34,157**	**36,377**	**7.2**	**3.2**	**6.5**
Surveyed Companies' Share of Total (%)	12	13	15	15	-	-	-

Source: Dataquest (August 1998)

Table 5-12
Personal/Portable Stereo Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	30,875	33,098	34,157	36,377	38,269	40,259	42,272	5
Manufacturing Revenue ($M)	960	1,036	1,093	1,182	1,263	1,349	1,437	7
Manufacturing ASP ($)	31	31	32	33	33	34	34	2
Semiconductor Content ($)	6	6	6	6	6	6	6	-2
Semiconductor TAM ($M)	186	199	205	201	213	224	232	3
Growth Rate of Unit (%)	-	7.2	3.2	6.5	5.2	5.2	5.0	-
Rate of Manufacturing ASP (%)	-	0.7	2.2	1.6	1.5	1.5	1.5	-
Growth Rate of Manufacturing Revenue (%)	-	7.9	5.5	8.2	6.8	6.8	6.6	-
Growth Rate of Semiconductor Content (%)	-	0.1	-0.5	-7.7	0.9	-0.3	-1.1	-
Growth Rate of Semiconductor TAM (%)	-	7.3	2.7	-1.7	6.1	4.9	3.8	-

TAM = Total available market
Source: Dataquest (August 1998)

Table 5-13
Analog Camcorder Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
2	1	Sony	35	200	42.6	68.4	42.6	68.4
1	2	Hitachi	43	75	52.3	25.7	94.9	94.1
		Others	4	17	5.1	5.9	-	-
		Total	**82**	**292**	**100**	**100**	-	-

Source: Dataquest (August 1998)

Table 5-14 provides Sony's and Hitachi's production outlook in 1998 and 1999, which is leveling off after 1997's surge in capacity. Sony will expand unit production from 220,000 units per year to 260,000 units per year in 1999, a 14 percent growth rate. Hitachi will expand from 90,000 units in 1998 to about 120,000 units in 1999, a 33 percent growth rate.

For the long term, China/Hong Kong's camcorder production will surge because of a strong market demand, and Dataquest expects new manufacturers to enter this industry after technology becomes readily available. Table 5-15 provides Dataquest's long-term forecast of camcorder production and semiconductor consumption from 1997 to 2002.

Table 5-14
Analog Camcorder Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	**1996**	**1997**	**1998**	**1999**	**1997**	**1998**	**1999**
Sony	35	200	220	250	471.4	10.0	13.6
Hitachi	43	75	90	120	74.4	20.0	33.3
Total Surveyed Companies	**78**	**275**	**310**	**370**	**252.6**	**12.7**	**19.4**
Others (Estimated)	4	17	27	33	313.8	57.7	19.9
Total China/Hong Kong	**82**	**292**	**337**	**403**	**255.7**	**15.4**	**19.4**
Surveyed Companies' Share of Total (%)	95	94	92	92	-	-	-

Source: Dataquest (August 1998)

Table 5-15
Analog Camcorder Production Forecast in China/Hong Kong, 1996 to 2002

	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**CAGR (%) 1997 to 2002**
Units (K)	82	292	337	403	498	601	688	19
Manufacturing Revenue ($M)	32	107	110	126	151	177	200	13
Manufacturing ASP ($)	388	365	326	312	303	296	290	-4
Semiconductor Content ($)	120	89	81	75	68	65	62	-7
Semiconductor TAM ($M)	10	26	27	30	34	39	42	10
Growth Rate of Unit (%)	-	255.7	15.4	19.4	23.7	20.5	14.6	-
Rate of Manufacturing ASP (%)	-	-5.8	-10.7	-4.2	-3.2	-2.3	-1.8	-
Growth Rate of Manufacturing Revenue (%)	-	235.0	3.1	14.4	19.8	17.7	12.6	-
Growth Rate of Semiconductor Content (%)	-	-26.1	-8.7	-8.0	-9.3	-4.5	-4.9	-
Growth Rate of Semiconductor TAM (%)	-	162.9	5.3	9.9	12.2	15.1	9.0	-

TAM = Total available market
Source: Dataquest (August 1998)

Appendix A
Exchange Rates

Table A-1
Foreign Currency per U.S. Dollar, 1997 and 1998

Country	Annual Average 1997	Preliminary Annual Average 1998	U.S. $ Appreciation (%) 1998	Projected Rate 1999+
Country	1997	1998	1998	1999+
Australia (Dollar)	1.35	1.58	17.31	1.62
Austria (Schilling)	12.20	12.68	3.91	12.65
Belgium (Franc)	35.79	37.18	3.88	37.07
Canada (Dollar)	1.38	1.46	5.62	1.49
China (Renminbi)	8.32	8.31	-0.12	8.31
Denmark (Krone)	6.61	6.87	3.96	6.85
European Monetary Union (ECU)	0.89	0.91	3.01	0.91
Finland (Markka)	5.19	5.47	5.42	5.47
France (Franc)	5.84	6.04	3.51	6.03
Germany (Mark)	1.73	1.80	3.92	1.80
Great Britain (Pound)	0.61	0.61	-0.55	0.61
Greece (Drachma)	273.11	300.28	9.95	299.35
Hong Kong (Dollar)	7.74	7.75	0.05	7.75
India (Rupee)	36.36	41.35	13.70	42.61
Ireland (Punt)	0.66	0.72	8.69	0.71
Italy (Lira)	1,703.02	1,776.50	4.31	1,772.42
Japan (Yen)	121.10	136.35	12.59	140.79
Malaysia (Ringgit)	2.82	4.04	43.38	4.16
Mexico (Peso)	7.92	8.72	10.16	8.90
Netherlands (Guilder)	1.95	2.03	4.08	2.03
New Zealand (Dollar)	1.51	1.86	23.19	1.93
Norway (Krone)	7.08	7.58	7.05	7.62
Portugal (Escudo)	175.35	184.43	5.18	183.93
Singapore (Dollar)	1.49	1.68	13.30	1.71
South Africa (Rand)	4.61	5.65	22.52	6.23
South Korea (Won)	954.14	1,398.99	46.62	1,295.76
Spain (Peseta)	146.45	152.91	4.41	152.58
Sri Lanka (Rupee)	59.02	64.54	9.35	65.91
Sweden (Krona)	7.64	7.96	4.12	7.99
Switzerland (Franc)	1.45	1.50	3.33	1.51
Taiwan (Dollar)	28.79	33.91	17.79	34.39
Thailand (Baht)	31.07	42.44	36.59	41.30

NA = Not tracked until 1996
NM = Not meaningful
Source: Dataquest (August 1998)

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Appendix B
Telephone Manufacturing

Table B-1
Telephone Manufacturing Sino-Foreign Joint Ventures: Initial Capital, Partner, Products, and Start Date

Foreign-China Joint Ventures	Initial Investment, Partners, and Products
Alcatel Telecom	
Alcatel Shenyang Telecommunications Co. Ltd.	$4.8 million, set up on December 28, 1993; Shenyang Telecom Bureau and Hong Kong Alcatel (China) Co. Ltd.; wired and wireless telephones.
Fujian Alcatel Communications Technology Co. Ltd.	$4.5 million, established on March 28, 1996; Fujian Bamin Telecom Liability Ltd. Co. and Alcatel (China) Co. Ltd.; wired and wireless telephones.
Shanghai Bell Alcatel Mobile Communications System Co. Ltd.	$8 million, set up on December 21, 1994; Shanghai Bell Telephone Equipment Manufacturing Co. Ltd. and Alcatel (China) Co. Ltd.; GSM telephone handsets.
AT&T Corporation	
AT&T Consumer Telecom Products Beijing Ltd.	$4 million, established in December 1994; PTIC's Zhongxun P&T Technology Service Center and AT&T International Corp.; wired and cordless Telephones, answering machines, facsimile, and video phones.
Casio Computer Company Ltd.	
Casio-Langchao Communications & Electronics Co. Ltd.	$7.5 million, set up on December 16, 1993; Langchao Electronics Information Industry Group Corp. and Casio Computer Corp.; numeric and Chinese display pagers.
Shanghai Guomai-Casio Telecommunications Co. Ltd.	$1.54 million, set up on February 1, 1994; Shanghai Guomai United Co. Ltd. and Casio Computer Corp.; numeric and Chinese display paging equipment.
Ericsson	
Beijing Ericsson Mobile Communications Co. Ltd.	$13 million, established on August 8, 1995; PTIC and Ericsson; TACS, GSM, and DECT handsets.
Guangzhou Ericsson Communications Co. Ltd.	$7 million, set up on March 18, 1993; Guangzhou Radio Group Corp. and Ericsson Wireless System Corp.; wireless telephone handsets.
Nanjing Ericsson Communications Co. Ltd.	$20.9 million, set up on September 3, 1992; Nanjing Radio Factory and Ericsson; TACS telephones.
Fujitsu Ltd.	
Nanjing Fujitsu Telecommunications Equipment Co. Ltd.	$9 million, established on March 18, 1992; Nanjing Wire Telecom Plant and Fujitsu Corp.; analog and digital mobile telephones.
Matsushita Communications Industry Co. Ltd.	
Beijing Matsushita Communications Equipment Co. Ltd.	$9.43 million, established on May 30, 1992; PTIC, PTIC Beijing Company, Beijing Telecom Components Factory and Matsushita Corp.; TACS, GSM, CDMA, PHS, cordless telephones and pagers.

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Table B-1 (Continued)
Telephone Manufacturing Sino-Foreign Joint Ventures: Initial Capital, Partner, Products, and Start Date

Foreign-China Joint Ventures	Initial Investment, Partners, and Products
Motorola Incorporated	
Motorola (China) Electronics Co. Ltd.—Tianjin	$120 million, established on June 9, 1992; TACS, GSM, CDMA, wireless trunk mobile telephone handsets, and pagers.
Hangzhou Telecommunications Equipment Factory of the MPT	Technology transfers from Motorola in 1992; analog and digital mobile telephone handsets.
Hangzhou Motorola Cellular Systems Co. Ltd.	Started production on January 20, 1997; MPT's Hangzhou Telecom Equipment Factory and Motorola's Asia/Pacific Cellular Infrastructure Group; CDMA telephones.
NEC Corporation	
TCL Mobile Communications Equipment Co. Ltd.	$5 million, set up on December 31, 1993; TCL Telecom Equipment Liability Ltd. Co. and NEC Hong Kong Co. Ltd.; NEC series pager.
Tianjin NEC Telecommunications Engineering Co. Ltd.	$6.5 million, established on December 7, 1989; Tianjin Urban Telephone Bureau, Tianjin Long-Distance Telecom Bureau, Tianjin P&T Appliance Corp. and NEC; PHS customer premises equipment.
Wuhan NEC Zhongyuan Mobile Communications Co. Ltd.	$7 million, set up in December 1993; Zhongyuan Radio Factory, Yangtze Optical Telecom Industry Group and NEC; TACS and GSM handsets.
Nokia Telecommunications	
Beijing Nokia Mobile Communications Co. Ltd.	$20 million, established on March 13, 1995; MPT's Beijing Telecom Equipment Factory and Nokia Mobile Telephone Co. Ltd.; E-TACS, GSM, and CDMA telephone handsets.
Dongguan Nokia Mobile Phones Co. Ltd.	$10 million, set up on May 8, 1995; Dongguan Telecom Development General Corp. and Nokia Mobile Telephone Co. Ltd.; mobile telephone handsets.
Samsung	
Shanghai Samsung Kangcheng Communications Equipment Co. Ltd.	$9.5 million, established in December 1995; Shanghai Kangcheng Telecom Equipment Co. Ltd. and Samsung Electronics Corp.; CDMA telephone handsets.
Siemens AG	
Siemens Shanghai Communications Terminals Ltd.	6 million marks, set up on May 11, 1995; Shanghai Guangdian Liability Ltd. Co. and Siemens Corp.; wired, wireless, and cordless telephones.
Siemens Shanghai Mobile Communications Co. Ltd.	60 million marks, established on May 11, 1993; Shanghai Guangdian Liability Ltd. Co., Shanghai P&T Administration Bureau, MPT's No. 1 Research Institute and Siemens Corp.; GSM S4 Series telephone handsets.
Others	
Changchun Jida Telecommunications Technology Co. Ltd.	$12 million, set up on October 12, 1992; Jilin Experimental Technology Development Co. Ltd. Co. and US Suda International Resources Co.; wireless telephones.
Shanghai MTC Telecommunications Equipment Co. Ltd.	$4 million, established in March 1993; Shanghai Broadcasting Appliance Factory. PTIC Shanghai Company, Shanghai Shenhang Import and Export Co. and Canada MTC; wireless telephone handsets.
Tianjin SANYO Telecommunications Equipment Co. Ltd.	$1 million, established in April 1995; Tianjin Telephone Equipment Factory and SANYO Electronics and Machines Corp.; wired and wireless telephones.

Source: China's Ministry of Posts and Telecommunications (MPT) and Dataquest (August 1998)

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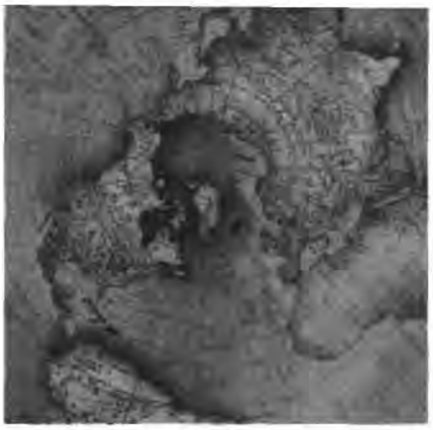

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China/Hong Kong's Leading Electronics Companies: Growth Prospects for 1999

Focus Report

FILE COPY:
MARIA VALENZUELA

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China/Hong Kong's Leading Electronics Companies: Growth Prospects for 1999

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Chapter 1

Executive Summary

To what extent will Japanese and Asian currency devaluation affect China's once-insatiable appetite for information technology (IT)? China/Hong Kong has been the main force for IT sales in the Asia/Pacific region, but how long can it sustain this role? Dataquest isolates and discusses the key equipment and companies that have the most impact on China/Hong Kong's semiconductor market. Dataquest also stratifies its analysis across computer, communications, and consumer electronics industries.

Dataquest's goal in publishing this report is to present a concise report of China's electronics industry and its company-level outlook in 1998 and 1999. This Focus Report serves the following four simple research purposes:

- Summarizes key industry trends and lists forecast assumptions
- Presents company-level production units in 1998 and 1999 for high-volume products
- Forecasts long-term, high-volume electronic equipment production growth from 1998 to 2002 in terms of units, revenue, and semiconductor consumption
- Provides semiconductor consumption forecasts for 1998 and 1999 by product, application group, company, and origin of ownership

Format and Scope

This Focus Report emphasizes demand-side analysis of the semiconductor market and focuses on electronic equipment production. For supply-side semiconductor shipment information by product or company (with vendor market share analysis), please see Dataquest's Market Trends report, *An Analysis of China/Hong Kong's Semiconductor Market: Suppliers, Drivers, and Forecasts*. The company data is provided by responsible representatives of those companies or knowledgeable industry contacts.

Key Findings

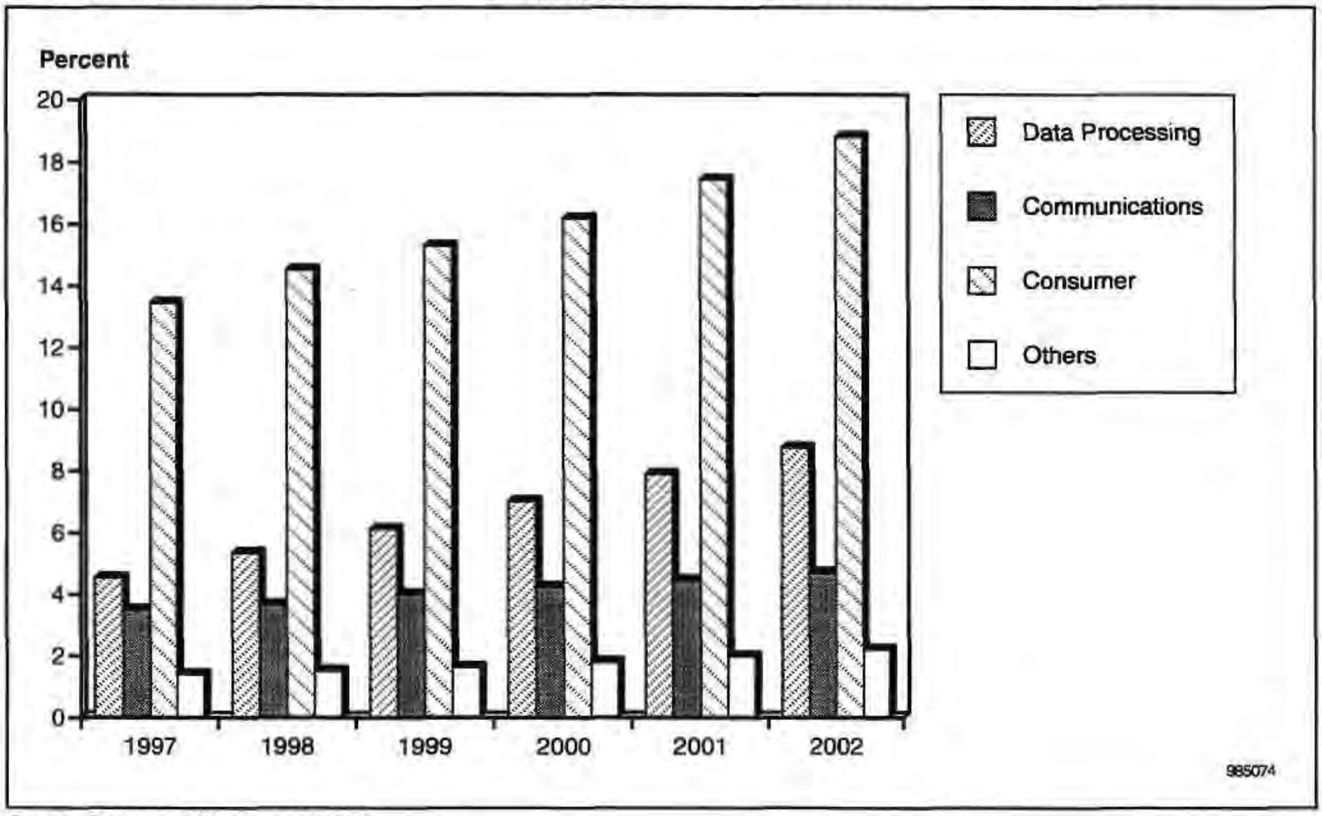
Despite some mature IT segments, Dataquest expects the worldwide IT's overall health to be influenced by emerging communications, Internet, digital consumer, and PC industries' 15 percent average unit growth. Dataquest forecasts an overall IT hardware shipment growth in the next five years of 7 percent. Asia/Pacific's production accounted for only 15 percent of the world's total electronic equipment production in 1993, but reached 19 percent in 1997. By 2002, Dataquest forecasts that 24 percent of worldwide electronic equipment production will take place in Asia/Pacific.

China Now a Global Force

As shown in Figure 1-1, Dataquest concludes that China/Hong Kong will outpace the rest of Asia/Pacific and substantially increase its share of worldwide electronic equipment production from approximately 5 percent in 1997 to 8 percent in 2002. In 1996, it accounted for only 4 percent of output. Dataquest will explain how consumer electronics will represent the largest share of 19 percent of world production, up from 13 percent in 1997. Data processing will increase its market share the fastest, doubling from 4.5 percent in 1997 to 9 percent in 2002. Communications equipment will grow substantially, from a small base of 3.5 percent to 5 percent by 2002.

China/Hong Kong's share of Asia/Pacific production will increase from 27 percent in 1997 to 32 percent in five years. In revenue terms, China/Hong Kong's electronics production will grow from U.S.$37 billion to $98 billion, representing a compound annual growth rate (CAGR) of 16 percent.

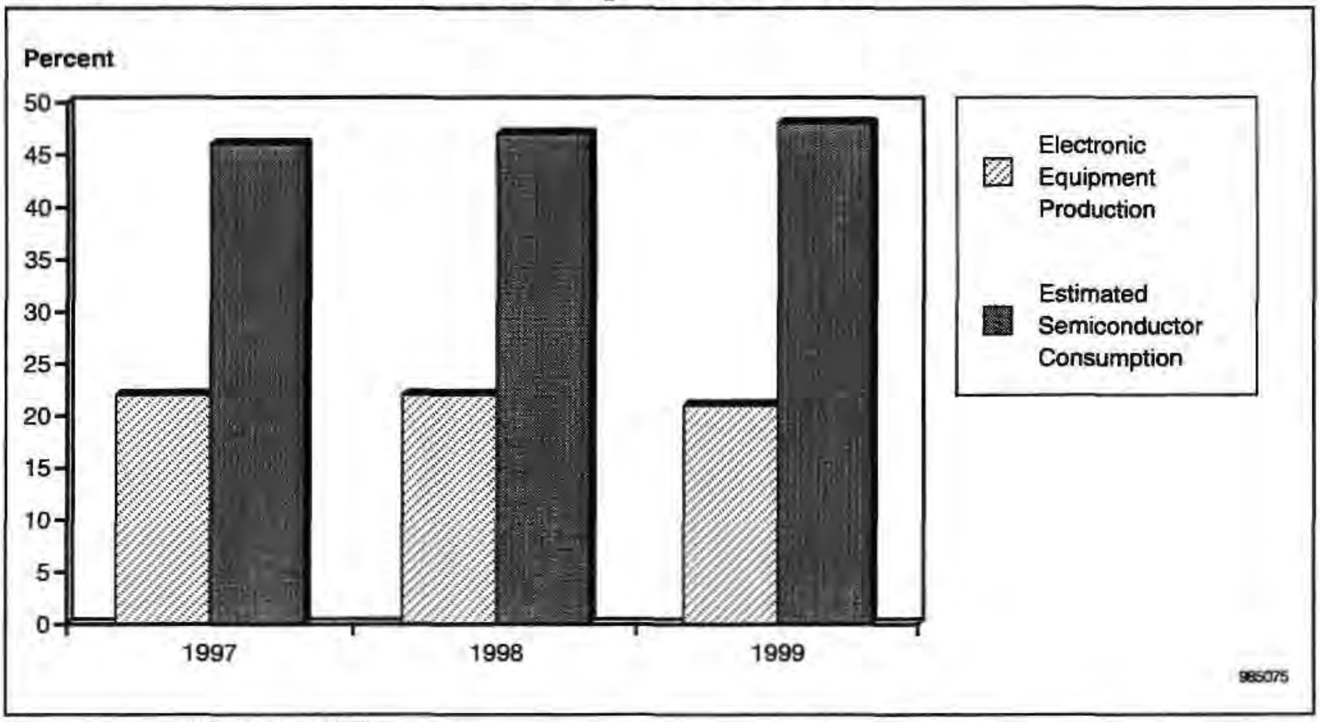
Figure 1-1
China/Hong Kong's Share of Worldwide Total Electronic, Data Processing, Communications, and Consumer Equipment Production, 1997 to 2002 (Percent)



Source: Dataquest (September 1998)

Dataquest conducted a survey of 64 major electronic equipment manufacturers, which are listed throughout this report in respective product discussions. Dataquest has identified the factories, products, and production quantities for 1997 and forecast for 1998 and 1999. Dataquest's basis for selecting these companies was subjective. Clients expressed a high interest in Chinese companies since last year, so we increased our sample size of local manufacturers relative to multinational vendors. Companies that had large production capacity or had aggressive expansion plans were also selected. The main purpose is to support Dataquest's high-volume electronic equipment production forecast that is also included in this report. Upon completing the research, Dataquest discovered that these companies represent approximately 24 percent of the 1998 production. As illustrated in Figure 1-2, the sample size within each application segment varies. These findings indicate that China/Hong Kong's manufacturers are scaling back production in certain areas, but the overall industry will sustain formidable growth in the next few years.

Figure 1-2
Surveyed Companies' Share of Total China/Hong Kong Electronic Equipment Production and Semiconductor Consumption, 1997 to 1999



Source: Dataquest (September 1998)

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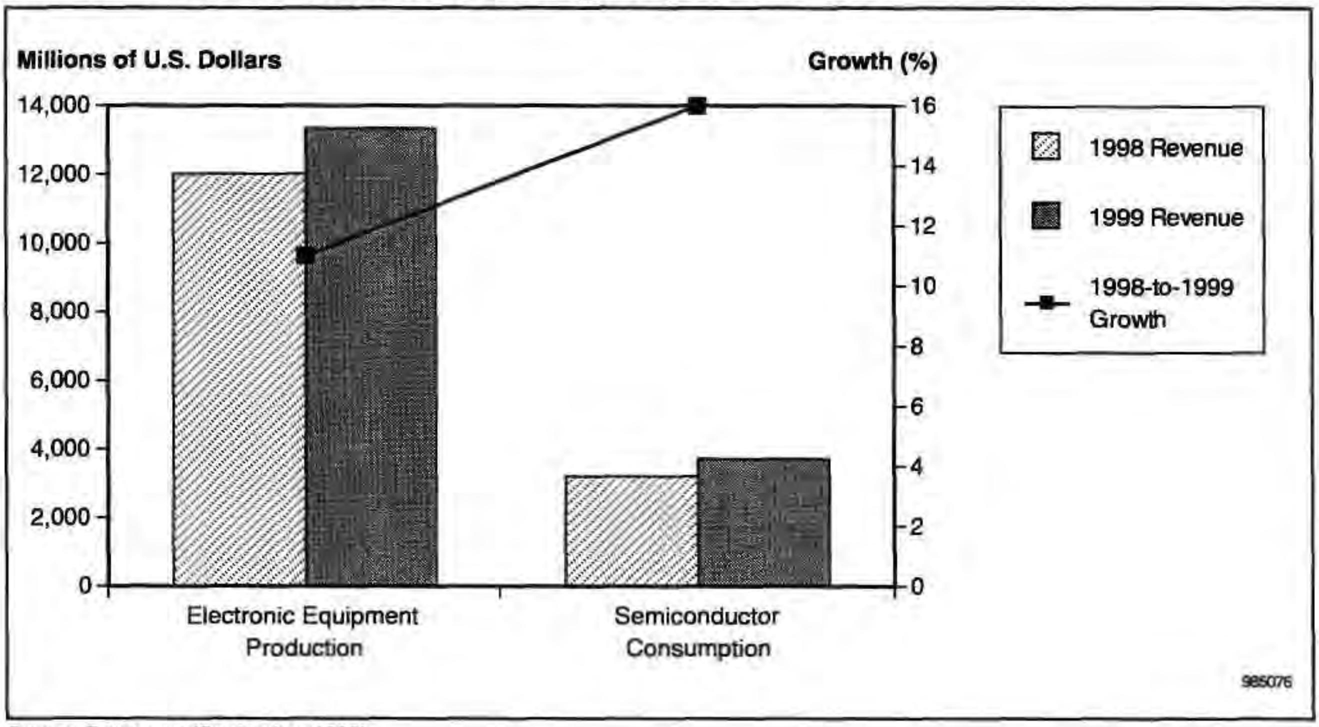
In terms of semiconductor consumption, Dataquest observes that because major manufacturers will expand by 11 percent in revenue terms, their semiconductor consumption will increase by approximately 16 percent (see Figure 1-3). As discussed earlier, Dataquest's survey group will consume an estimated 24 percent of semiconductors consumed in China/Hong Kong in 1998. Note that these semiconductors were either shipped internally by multinational companies, purchased direct from manufacturers, or supplied by distributors. Dataquest forecasts that this same group of companies will consume 48 percent of all 1999 semiconductor shipments. This consumption level reveals the following trends:

- Rising semiconductor richness and technology level of products being manufactured in China/Hong Kong
- Larger multinational and Chinese manufacturers are achieving economies of scale faster and for higher-end products than the smaller companies
- Small and medium-size companies will face further difficulty competing against large companies that have efficient sourcing and distribution systems
- State-owned enterprises (SOEs) are being restructured, merged, or sold

Figure 1-3
Surveyed Companies' China/Hong Kong Electronic Equipment Production Revenue and Estimated Semiconductor Consumption, 1998 and 1999



Source: Dataquest (September 1998)

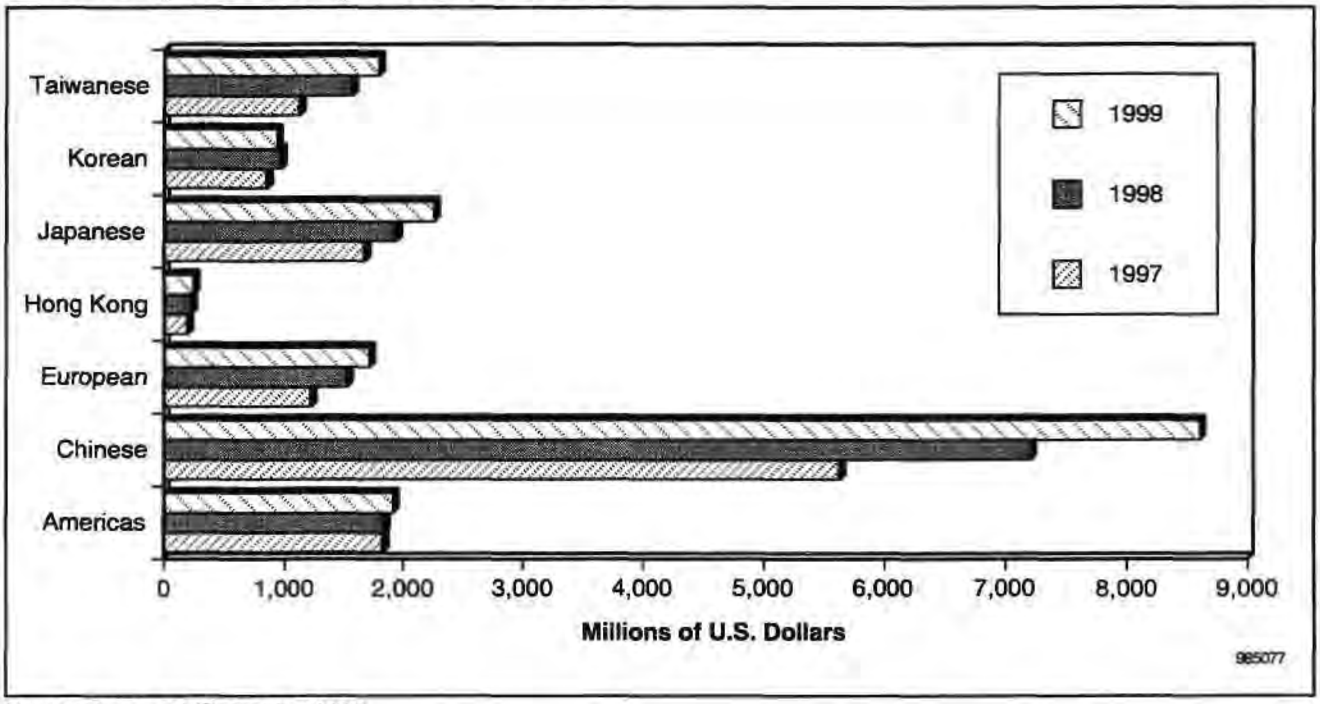
Electronics Production Growth by Ownership

Figure 1-4 lists production revenue of the 64 companies surveyed in China/Hong Kong by grouping their home base ownership. Figure 1-5 illustrates these companies' percentage share. The Americas companies surveyed had doubled production in China/Hong Kong in 1997, after investments made in 1995 and 1996. However, these companies have halted expansion plans in 1998 with about 1 percent growth. Dataquest had expected U.S. manufacturers to surpass Japanese manufacturers in 1997 and 1998, but this will not happen because of investment slowdowns. As discussed in Chapters 3 and 4, computer and communications investments are leading the next wave of growth, while consumer growth is expected to remain modest.

Semiconductor Consumption by Users' Home Base of Ownership

Each manufacturer's semiconductor consumption is derived by multiplying the units of equipment produced by an average semiconductor content per piece. Dataquest estimates each equipment's semiconductor content and manufacturers' semiconductor consumption revenue. The scope of the survey did not include surveys of procurement offices to ascertain total semiconductor purchase by factory. Such a methodology would have had to account for local purchases, internal transfers, and global procurement contracts. Dataquest believes that the methodology used provides a realistic average consumption by product and accurate trend analysis on a year-on-year comparative basis.

Figure 1-4
China/Hong Kong's Electronic Equipment Production Revenue by Home Base of Ownership of 64 Companies, 1997 to 1999



Source: Dataquest (September 1998)

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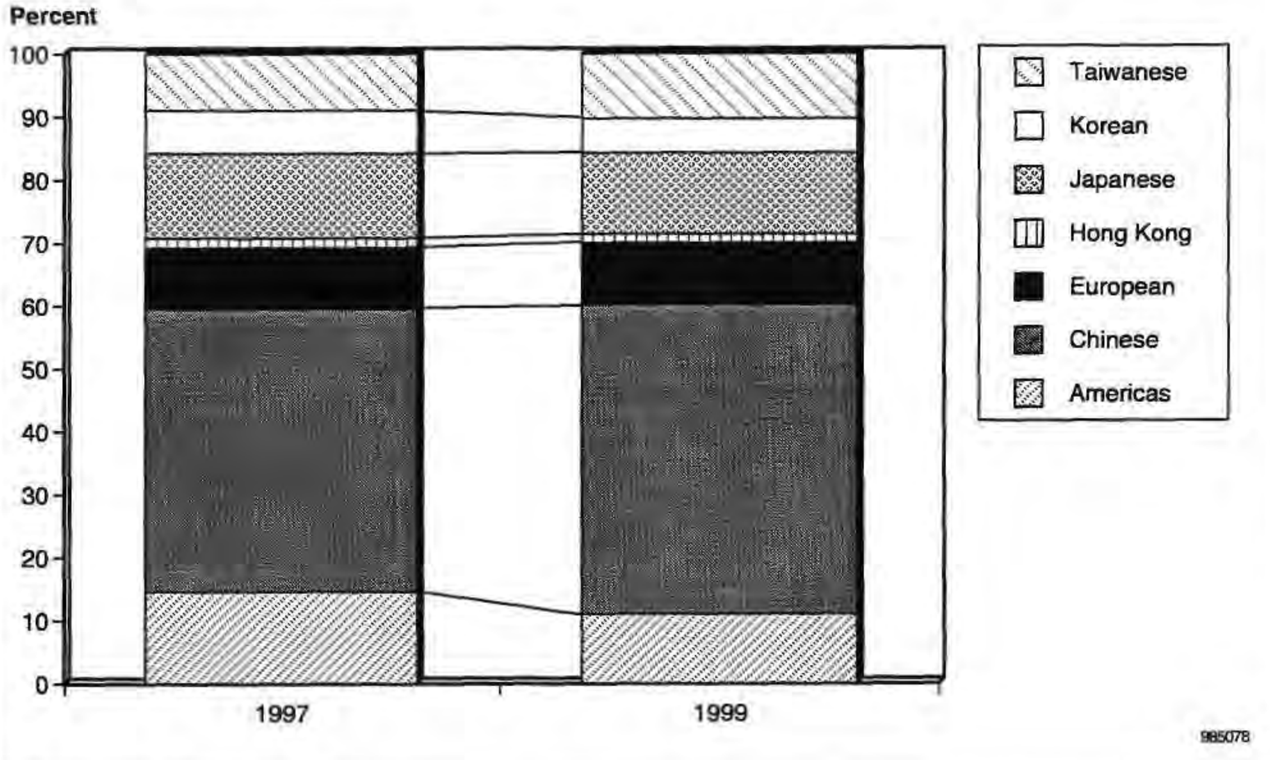
Figure 1-5
China/Hong Kong's Electronic Equipment Production Revenue by Home Base of Ownership of 64 Companies, 1997 and 1999



Source: Dataquest (September 1998)

Figures 1-6 and 1-7 illustrate the revenue and percentage of total semiconductor consumption estimates aggregated for the 64 users. Chinese companies occupy the largest share and are the fastest-growing in equipment production and semiconductor consumption, with 28 percent and 39 percent growth, respectively. Americas companies were the second largest, representing 13 percent of consumption, but they will expand only 1 percent in 1998. These companies expected semiconductor consumption will improve next year, based on a 13 percent growth in the value of semiconductors used. Japanese companies will increase semiconductor consumption by 22 percent in 1998 and 23 percent in 1999. Dataquest believes the main reason for this discrepancy between Chinese and multinational companies' growth is a result of local Chinese manufacturers' particularly strong video compact disc (VCD) and PC production and sales in 1998.

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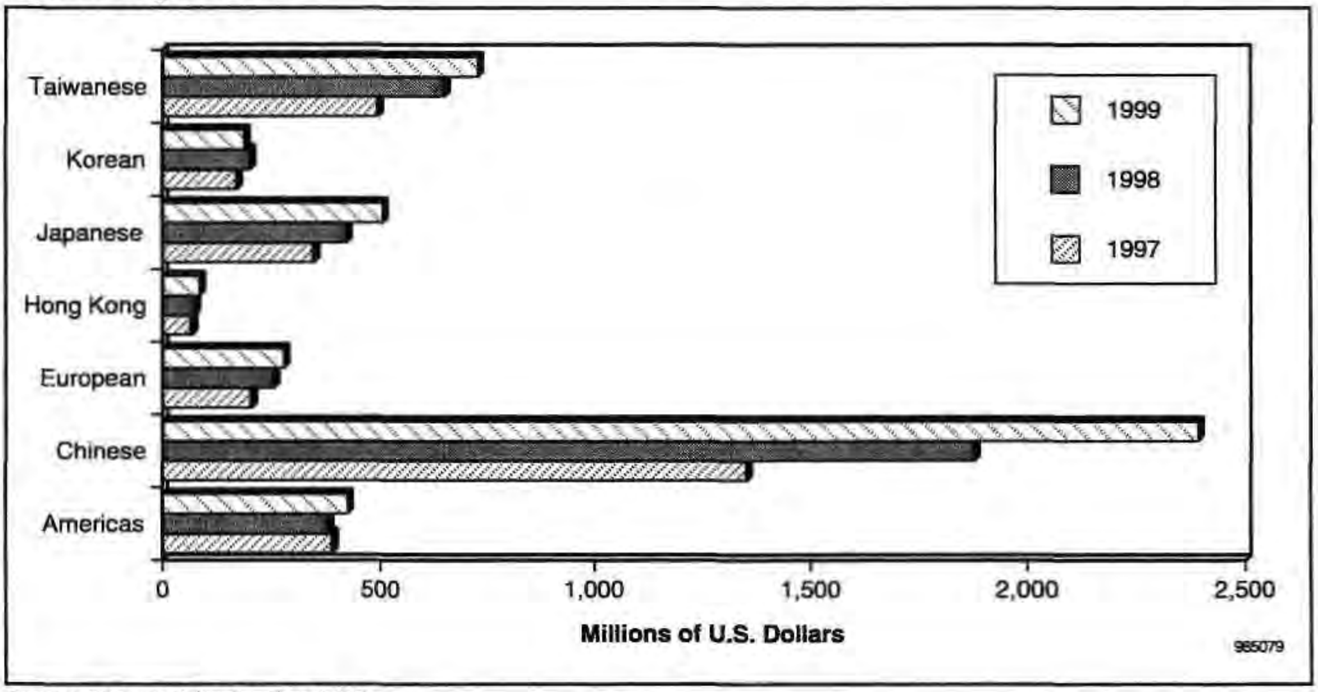
Figure 1-6
China/Hong Kong's Semiconductor Consumption by 64 Company Users' Home Base of Ownership in 1998



Source: Dataquest (September 1998)

Figure 1-8 summarizes all information by comparing growth rates by ownership for both equipment and semiconductor consumption. Figure 1-9 illustrates China/Hong Kong's electronic equipment production in 1998 and 1999. After the Chinese companies, Taiwanese producers are the fastest-growing consumers of semiconductors. Taiwanese companies, like the Americas, focused on the computer segment in China/Hong Kong. While both experienced rapid electronic equipment production growth, their semiconductor consumption growth is less than equipment factory revenue primarily because of pricing declines of memories, microprocessors, and microperipherals. European companies are the third-fastest-growing semiconductor user group, but they represent only 7 percent of Dataquest's survey group. Japanese companies appear to be maintaining overall semiconductor consumption growth, ranking fourth in consumption growth. Korean companies are ranked fifth in growth, followed by Hong Kong and Americas companies.

Project Analyst: Daniel Heyler

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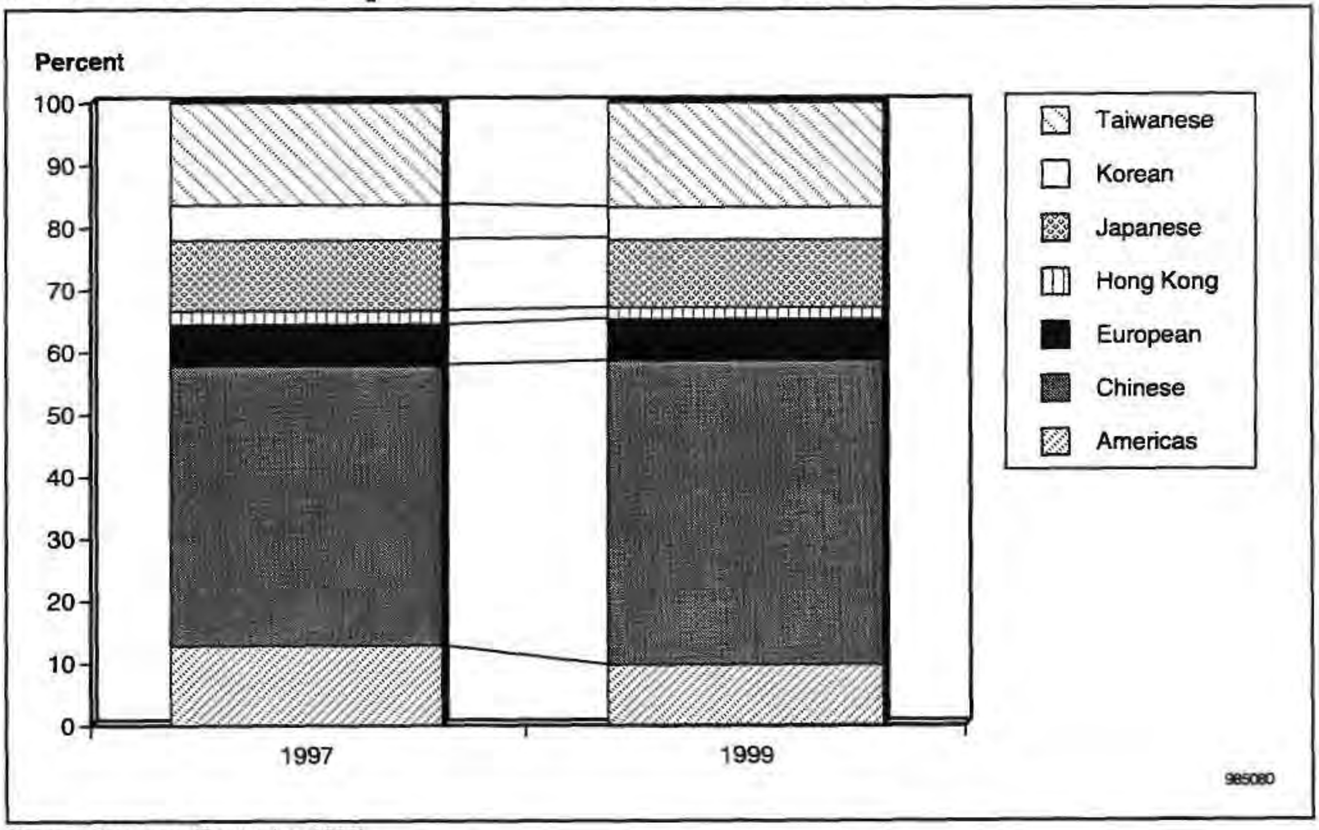
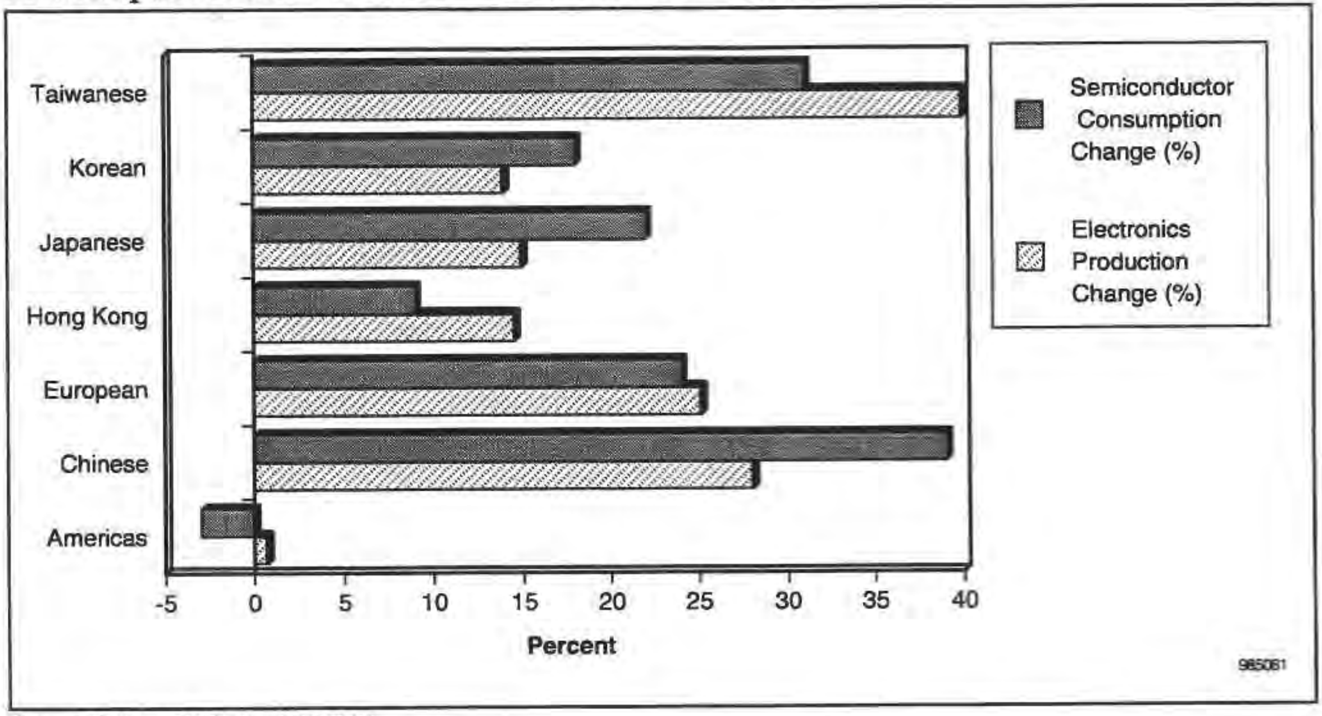
Figure 1-7
China/Hong Kong's Estimated Semiconductor Consumption by 64 Company Users' Home Base of Ownership in 1997 and 1998 (Percent Share)



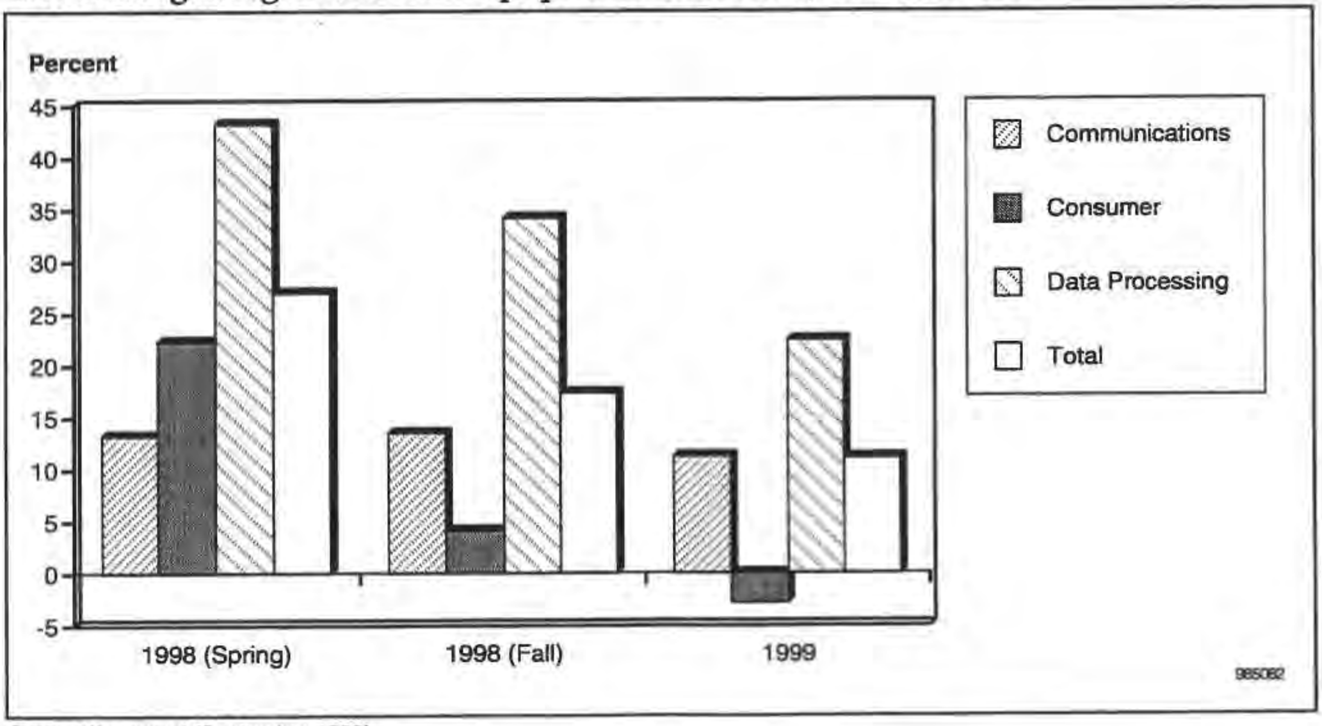
Source: Dataquest (September 1998)

Figure 1-8
Surveyed Companies' Electronic Equipment Production and Semiconductor Consumption Growth Rate Forecast in 1998 (Percent)



Source: Dataquest (September 1998)

Figure 1-9
China/Hong Kong's Electronic Equipment Production, 1998 and 1999



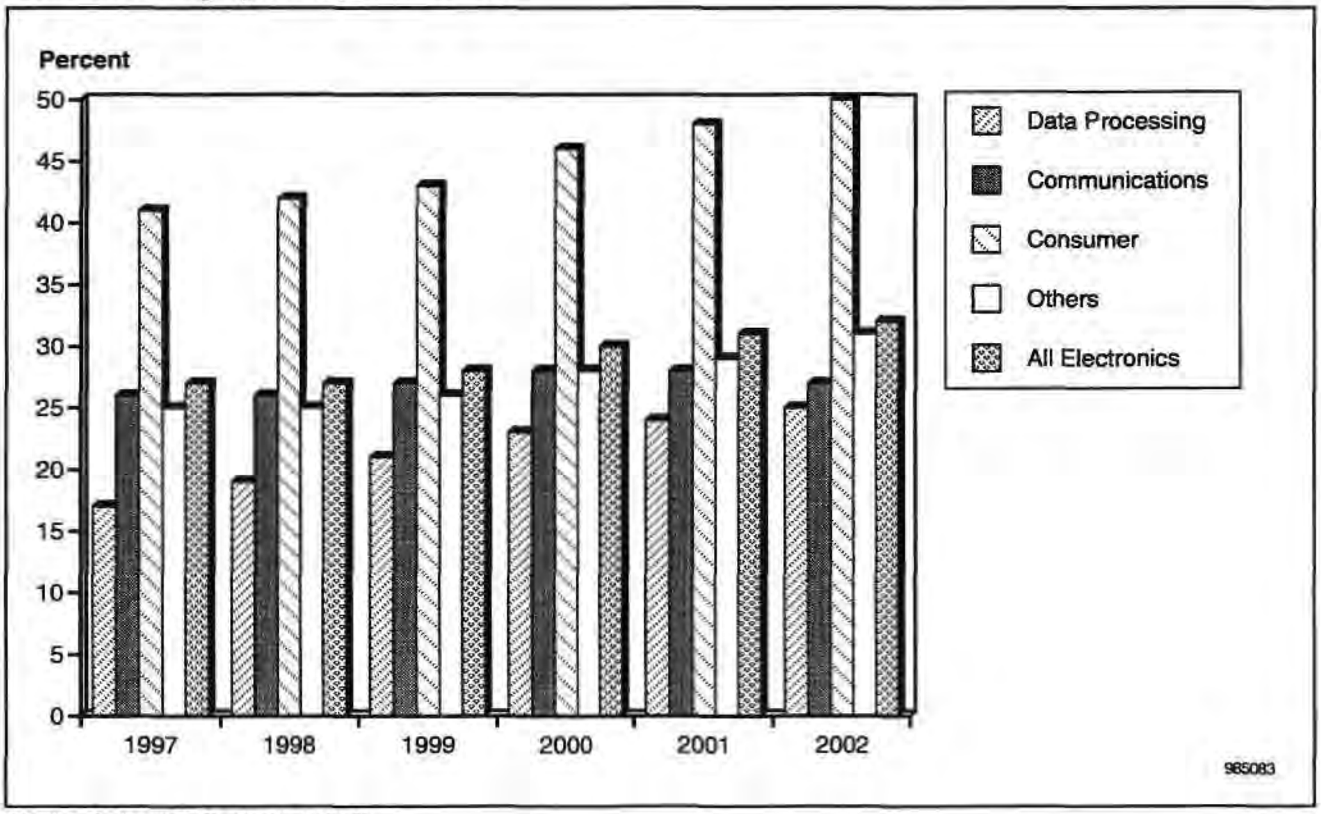
Source: Dataquest (September 1998)

Chapter 2
Electronics Industry Trends

More than 30 Percent of Asia/Pacific Production Will Come from China

China/Hong Kong's share of Asia/Pacific production will rise from approximately 27 percent in 1997 to 32 percent in the next four years. In revenue terms, China/Hong Kong's electronics production will grow from $46 billion to $98 billion, representing an 18 percent CAGR. In a broader context, the worldwide CAGR for this period is about 6 percent to 7 percent, with the Asia/Pacific CAGR more than 10 percent. China/Hong Kong's lectronic equipment production quantity outpaces worldwide averages because of export competitiveness and unsatisfied local demand, especially within the healthier economies such as China and Taiwan. At the same time, semiconductor content is increasing faster in Asia/Pacific than in the rest of the world. This trend suggests that semiconductor consumption will outpace electronics in the next five-year period (taking out cyclicality). Foreign investments to China/Hong Kong are accelerating for the purpose of gaining market access and time-to-market competitive advantage, a necessity in an oversupplied market. Figure 2-1 illustrates China/Hong Kong's share of total data processing, communications, and consumer equipment production.

Figure 2-1
China/Hong Kong's Share of Total Electronic, Data Processing, Communications, and Consumer Equipment, 1997 to 2002



Source: Dataquest (September 1998)

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In comparing the past five years with the next five years, it is clear that revenue in Table 2-1 shows an electronics production deceleration in Asia/Pacific. In relative terms, the region has doubled in revenue and expanded from one-third the size of Japanese electronics industry to more than 90 percent of Japan's 1997 revenue. The region was half the size of Europe's industry in 1991, but it will continue to converge with that of Europe. The region will not sustain this phenomenal growth because of lasting effects of the Asian financial crisis, but it is expected to outpace other regions in the next five years.

Data Processing Electronic Equipment Overview

Although Asia/Pacific succeeded early in consumer electronics manufacturing , its data processing industry has kept pace with worldwide trends, and its revenue is expected to more than double from $78 billion in 1997 to $157 billion in 2002. In the past three years, Asia/Pacific communications markets' and industries' rapid growth has enabled this sector to reach $29 billion in 1997. Dataquest forecasts strong growth in a few key sectors, bringing revenue to $47 million in 2002. Consumer electronics production surged in the early 1990s because of transplanted Japanese manufacturing. Dataquest expects it to remain the second-largest segment in Asia/Pacific. A worldwide consumer electronics consumption slowdown through 1998 has translated into slower growth in Asia/Pacific production, although Dataquest expects Asia/Pacific to grow at double the worldwide production growth rate.

Asia/Pacific countries that bet their industrial development on PCs have reaped the rewards. The impressive manufacturing efficiencies of Singapore and, later, Malaysia, have enabled Asia/Pacific to increase its share of global mass-storage production. Dataquest sees no signs of this trend changing. The combined revenue from monitors, PCs, and motherboards was 65 percent of total data processing revenue. Storage makes up most of the rest of data processing revenue. By 2002, Dataquest believes that these five products will represent 80 percent of data processing revenue, and data processing will represent 52 percent of total Asia/Pacific electronics production.

Table 2-1
Asia/Pacific Electronic Equipment Production Forecast by Sector, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Electronics	**175,058**	**196,879**	**220,425**	**239,969**	**271,143**	**302,986**	**11.6**
Data Processing	77,903	91,332	106,529	118,718	138,172	157,145	15.1
Communications	29,332	32,589	35,235	37,995	42,280	47,270	10.0
Consumer	54,561	58,314	62,414	65,432	70,758	76,475	7.0
Industrial	5,255	5,886	6,573	7,282	8,262	9,236	11.9
Military/Civil Aerospace	4,534	5,112	5,856	6,532	7,412	8,452	13.3
Transportation	3,473	3,647	3,819	4,010	4,258	4,409	4.9

Source: Dataquest (August 1998)

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The PC markets show slower but steady growth worldwide, and Asia/Pacific has proved well-suited to meet those market needs. What will enable the PC to continue to add value to home and private citizens is that it continues to evolve in its functionality and integration into people's lives. Recently, PCs evolve from a productivity tool for spreadsheet, word processing, and other data processing tasks into an information, communications, and entertainment multimedia system. Technology barriers are eventually overcome, and new multimedia PCs now offer 3-D graphics, MPEG-2 video, AC-3 audio, fax/modem, telephony functions, and videophone. The world of system-level integration will engender the next quantum leap in performance and functions.

Consumer Electronics Overview

Asia/Pacific is already a player in the new wave of digital consumer electronics that is now entering the marketplace. These emerging electronics include digital video disks (DVDs), digital cameras, digital camcorders, digital VCR, digital TVs, video CDs, advanced games, and direct broadcast satellite, or set-top boxes.

Asia/Pacific benefits several ways in manufacturing consumer electronics. It receives investments from high-cost production regions, such as Japan, and its broad economic growth provides new growth for old products. China's color television production is an example of an undeveloped market revitalizing a mature industry. In 1997, China manufactured approximately $6 billion in video equipment. Dataquest expects China to experience a two-year slowdown in consumer electronics, but the five-year future of digital consumer equipment production is bright. New products, such as set-top boxes and DVDs, will find a way into these huge potential markets in inexpensive ways. Governments are eager to establish digital broadcast standards that will pave the way for broadcasting after 2000.

Communications Electronics Overview

Communications electronics are the third-largest sector in China/Hong Kong and Asia/Pacific. In China/Hong Kong, communications equipment production dominates consumer products such as phones, cordless handsets, answering machines, and analog cellular equipment. Furthermore, digital cellular products are now playing a pivotal role in communications semiconductor market growth. In 1995, digital cellular shipments accounted for only 38 percent of the total analog and digital cellular unit market, but in 1998, it will account for more than 80 percent of the 123 million phones shipped.

Unlike data processing and consumer electronic equipment production Asia/Pacific's communications production is significantly less than it consumes. These are market opportunities that the local companies are exploring, and multinational companies are starting to invest in this area. In the short term, most of the advanced infrastructure equipment will be imported. For many other products, Dataquest sees production continuing to expand in the region because this is where the world's fastest market growth is expected for the next 10 years. Central office/premises and cellular phones will surpass cordless phones to become the second- and third-largest markets.

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China/Hong Kong a Critical Growth Source for Asia/Pacific

The following key factors enable China/Hong Kong electronics to avoid dramatic production swings as these sectors fell in most other parts of Asia/Pacific, except Taiwan:

- China, unlike the other regions, is showing growth in all three electronics sectors. The net consequence is an impressive overall growth.
- China's domestic market attracts investors from all major regions.
- China's industry is balanced between exports and local consumption, each representing about one-half of total output.
- Economic planners are focusing on sustaining macroeconomic stability vis-à-vis microeconomic policy. Without floating its currency, China has maintained control of its economy without suffering the economic woes seen in the Russian republics.

As shown in Table 2-2, Dataquest expects strong growth in China's three major electronics sectors, but with data processing leading the growth, while communications and consumer sectors followed.

Dataquest's Electronic Equipment Producers Survey Results: The Big Are Getting Bigger—and a Lot Faster, Too

China/Hong Kong has become the No. 1 investment destination by electronic equipment companies in Asia/Pacific. The currency and economic woes in several Southeast Asian countries may further depress their long-term growth. China's rapid reforms, strong economy, growing consumption, and advancing production base continue to attract major investments from various sectors.

Table 2-3 lists major multinational and Chinese companies that were surveyed for production quantities detailed in this report. Dataquest surveyed 38 manufacturers and has itemized the top 20. Note that the revenue was derived from estimated unit production of major electronic equipment and applying a factory ASP.

Table 2-2
China/Hong Electronics Equipment Production Forecast by Sector, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Electronics	**46,496**	**54,087**	**62,798**	**72,773**	**84,888**	**98,341**	**16.2**
Data Processing	13,407	17,363	21,936	27,264	33,617	40,019	24.4
Communications	7,540	8,398	9,593	10,638	11,674	12,978	11.5
Consumer	22,266	24,592	26,972	29,867	33,743	38,477	11.6
Industrial	991	1,122	1,268	1,459	1,691	1,951	14.5
Military/Civil Aerospace	1,162	1,325	1,536	1,782	2,085	2,451	16.1
Transportation	1,129	1,287	1,493	1,762	2,079	2,465	16.9

Source: Dataquest (August 1998)

Table 2-3
Manufacturing Joint Ventures' Sampler in China

Company	Products	Chinese Partner
Ericsson	Cellular phone	China National Posts and Telecommunications Industry Corporation
	Mobile communications infrastructure	Guangdong Mobile Communications Co. Ltd.
	Parts of AXE system	Nanjing Panda Electronics Enterprise Group
	Central office	Beijing Wire Communications Plant
FIC	Motherboard	Hong Kong Taizhong Co. Ltd.
	PC	Changbai Computer Enterprises Group
Fujitsu	Printer	Nanjing Zhongshan Enterprise Group
	Printer	Beijing Stone Group
IBM	Motherboard	China Great Wall Computer Group
	PC	China Great Wall Computer Group
Hitachi	Color television	Shenzhen Saige Enterprise Group
	Analog camcorder	Shenzhen Saige Enterprise Group
LG	VCD	Shanghai Huangdian Enterprises Group
Matsushita	Color television	Hualu Enterprises Group
	Pager	China National Posts & Telecoms Industry Corporation
	Videocassette recorder (VCR)	Hualu Enterprises Group
Motorola	Cellular phone	China National Posts & Telecoms Industrial Corp., Eastern Communications Co. Ltd.
	Pager	Shanghai Radio Communications Equipment Manufacturing Company Limited
NEC	Cellular phone	Wuhan Zhongyuan Radio Factory
	PC	Changjiang Computer Enterprises Group
	Central office	Benxi Communications & Electronical Appliance Industry Co. Ltd.
		Tianjing Zhonghuan Electronics & Computer Corp.
	Pager	TCL
Nokia	Cellular phone	Beijing Communications Instrument Factory
	Mobile communications infrastructure	Beijing Communications Instrument Factory
	Central office	Beijing Hangxing Communications Co. Ltd.
Philips	Color television	Suzhou Peacock TV Plant
	HiFi	Beijing No 1 Radio Company
	Personal stereo	Beijing No 1 Radio Company
SANYO	Analog cordless phone	China National Posts and Telecommunications Industrial Corp.
Sharp	Color television	Nanjing Panda Electronics Group
	HiFi	Nanjing Panda Electronics Group
Siemens	PC	Hongkong Top Victory Investment Co. Ltd., Fuzhou Tianye Enterprise Group
	Central office	Shanghai Xinguang Factory
		State-owned Beijing 239 Factory

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Table 2-3 (Continued)
Manufacturing Joint Ventures' Sampler in China

Company	Products	Chinese Partner
Sony	Color television	Shanghai Guangdian Enterprise Group
	Monitor	Shanghai Guangdian Enterprise Group
	Analog cordless phone	Technology development Co. Ltd. of Post and Telecommunications Institution
	Analog camcorder	Shanghai Guangdian Enterprise Group
Compaq	PC	Beijing Stone Group

Source: Dataquest (September 1998)

Dataquest lists 31 major manufacturing companies, representing 20 percent (or $11 billion) of electronics production in China/Hong Kong. Dataquest's analysis of these manufacturers indicates a rapid expansion of production capacity for both local consumption and export, but that this expansion is decelarating, particularly in the consumer electronics area. These 31 companies are expected to increase revenue by about 13 percent in 1999 after growing approximately 22 percent in 1998 (see Table 2-4).

Company-Level Semiconductor Consumption Ranking Forecast

As expected,China's semiconductor consumption is rising even faster for the major manufacturers. However, semiconductor consumption rankings differ from electronics production rankings. Legend Group will become the largest consumer of semiconductors in China/Hong Kong in 1998, after surpassing PC Chips Manufacturing Limited, a low-end motherboard manufacturer based in Taiwan (see Table 2-5). The combined consumption of these companies will be more than 30 percent of semiconductors used in China/Hong Kong. Dataquest's total sample group of 64 will consume 42 percent of semiconductors used in China/Hong Kong.

Electronics Equipment Preduction Assumptions

China's growth in exports, local consumption, foreign investment, and government support are some basic positive factors behind its electronics production growth. Underlying and supporting all these trends is the fact that local production is becoming more efficient, and economies of scale are being achieved.

Does China Need to Devalue Its Currency?

The currency devaluation created critical problems for Asia/Pacific semiconductor suppliers and users that are almost entirely dependent on imports. Although most vendors denominate their prices in dollars, cashflow problems—attributed to rising credit costs and falling sales—have resulted in weakened demand from local manufacturers. Indonesia's currency devalued more than 80 percent during the past six months, and its equity market dropped by more than 80 percent. As a result of the financial turmoil, stock markets in Korea, Thailand, the Philippines, and Malaysia declined by more than 60 percent. Equity markets in China and Hong Kong have also dropped, but their strong cash account reserves have enabled them to support the Hong Kong dollar and the Chinese renminbi.

Table 2-4
Forecast of 31 Major Electronic Manufacturers' Factory Revenue from Electronic Equipment Production Ranking in China/Hong Kong, 1997 to 1999 (Millions of U.S. Dollars)

Rank 1998	Company	Final 1997	Forecast 1998	Change (%) 1997 to 1998	Forecast Change (%) 1998 to 1999
1	Seagate	1,049	1,190	13.4	7.8
2	Chang Hong	973	1,061	9.0	7.3
3	Legend	447	751	67.9	31.7
4	Konka	517	731	41.2	17.7
5	Samsung	585	676	15.6	-1.8
6	Motorola	661	655	-0.8	-3.0
7	PC Chips	497	627	26.3	3.2
8	Great Wall/IBM	333	505	51.9	23.0
9	Shanghai Bell	449	503	12.0	7.3
10	FIC	405	497	22.7	11.9
11	Philips	339	465	37.1	1.1
12	TCL	349	408	16.9	28.4
13	Siemens	322	383	19.0	23.8
14	Xia Hua	235	362	54.5	34.6
15	Hitachi	307	336	9.5	20.0
16	Matsushita	300	326	8.5	4.5
17	Uniden	278	313	12.5	10.9
18	NEC	277	310	12.0	19.6
19	Acer	103	288	179.4	44.0
20	Jiangsu Shinco	403	283	-29.9	-45.5
21	BISC	211	259	22.5	11.2
22	LG	236	258	9.1	-9.0
23	Huawei	215	253	17.6	13.8
24	Sanyo	205	245	19.4	26.1
25	Ericsson	196	245	25.2	17.3
26	Phone Star	104	230	121.7	20.4
27	Vtech	197	226	14.5	10.8
28	Idall	243	224	-7.8	-18.6
29	Founder	126	216	71.1	82.8
30	Shanghai Guangdian	170	210	23.2	19.1
31	Tontru	122	207	69.9	62.9
	Top 31 Total	**10,857**	**13,245**	**22.0**	**13.4**
	Top 60 Total	**12,537**	**15,276**	**21.9**	**14.4**
	Total China/Hong Kong	**54,087**	**62,798**	**-**	**-**

Source: Dataquest (August 1998)

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Table 2-5
Estimated Semiconductor Consumption for 20 Major Electronics Companies in China/Hong Kong, 1997 to 1999 (Millions of U.S. Dollars)

Rank 1997	Rank 1998	Company	1997	1998	Forecast Growth (%) 1997 to 1998	Forecast Growth (%) 1998 to 1999	1999
2	1	Legend	242	394	63.1	33.0	524
1	2	PC Chips	246	297	20.8	7.7	320
3	3	Great Wall/IBM	190	278	46.2	21.2	336
4	4	FIC	181	217	19.5	9.7	238
5	5	Seagate	160	204	27.6	19.5	243
6	6	Motorola	155	171	10.1	4.5	179
7	7	Chang Hong	129	162	25.7	6.3	172
8	8	Samsung	111	134	21.1	-5.1	127
12	9	Tontru	72	117	63.6	59.0	187
11	10	Konka	75	116	53.9	16.7	135
10	11	Uniden	77	92	20.6	20.7	111
20	12	Founder	57	87	50.9	87.2	162
16	13	Siemens	67	86	27.7	18.6	102
14	14	NEC	71	85	19.0	36.8	116
13	15	Shanghai Bell	71	77	7.1	5.9	81
18	16	Matsushita	65	73	12.9	5.0	77
21	17	Philips	55	72	29.9	-11.2	64
17	18	Vtech	66	72	9.0	18.9	86
9	19	Jiangsu Shinco	95	67	-29.5	-44.4	37
23	20	TCL	50	66	31.9	35.3	89
		Top 20 Total	**2,235**	**2,865**	**28.2**	**18.2**	-
		Top 63 Total	**3,009**	**3,842**	**27.7**	**19.6**	-

Source: Dataquest (August 1998)

Few economists expect a renminbi devaluation in 1998, but there are concerns in the region that falling exports and a slowing economy will force China to devalue, potentially sparking another round of disastrous currency depreciation in Asia. It is a question of time. For sure, China will devalue, but whether it is before or after the region has recovered is the issue. In 1998, the Chinese government is under extreme pressure to maintain strong economic growth and create new jobs because of the dismantling of state-owned industries, which is creating millions of surplus workers. So far, the Chinese leadership has responsibly held its currency at the expense of economic growth, in addition to committing U.S.$250 billion in infrastructure spending projects to increase its gross domestic product (GDP) vis-à-vis domestic consumption.

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Gross Domestic Product Remains Robust

China's economic growth has slowed substantially since March of 1998. Data from the Organization of Economic Cooperation and Development (OECD) had forecast China's economy to grow between 7.5 percent to 8.0 percent in 1998. However, because of the region's worsening economies and slowing exports, GDP is expected by numerous sources in Hong Kong to fall between 6.5 percent and 7.5 percent. GDP in the first quarter of 1998 had slowed to 7.2 percent, and it is expected to slow to 7.0 percent in the second quarter. The trend is expected to continue, with the second half of 1998 averaging less than 7 percent. One of the advantages China has over the rest of Asia/Pacific is that its economy is far more diversified, with economic expansion taking place in heavy industries, manufacturing, electronics, services, and agriculture. This broad-based growth, including electronics, buffered it from Asia's economic woes. In fact, the major growth burden has been from the SOEs that account for about 60 percent the economy. Prime Minister Zhu Rongji is in the process of structuring SOEs, which is the main factor behind slower growth and rising unemployment. However, China depends heavily on foreign capital and markets to sustain its current growth rate.

Foreign Investment Will Not Dry Up

In addition to increased efficiencies in Chinese companies, economic growth has been boosted by direct foreign investment. Foreign investments need to continue to flow into China for it to achieve a 7 percent GDP growth. Hong Kong, which has been hurt financially by its falling stock market, accounted for 59 percent of foreign-invested capital in China from 1980 to 1997. In the past few years, contracted investments in China had declined from $88 billion in 1994 to $72 billion in 1997. However, the actual utilized investment increased from $33 billion to $44 billion during this period. There is uncertainty in 1998, and most forecasts indicate a decline in utilized investments to $35 billion for the first time in at least five years.

Dataquest also expects contracted investments to decline because of the investor uncertainty that is the short-term outcome of China's aggressive reforms to be undertaken in 1998. However, once the dust settles, investment flow is expected to resume in 1999 because the current slowdown is macroeconomic rather than microeconomic in nature. In the first quarter of 1998, figures show more than 10 percent growth over 1997, but the second quarter is expected to decline. However, Dataquest continues to see communications, computer, and consumer electronic companies maintain a high strategic interest in investing in manufacturing in China for long-term needs: to increase market access, reduce distribution costs, and improve time to the market.

Exports Still Competitive, Southeast Asian Companies Face Cash-Flow Problems

China's GDP will exceed $900 billion in 1998, yet its total trade is nearly $400 billion. China's export machine has proved to be a formidable global force, particularly in the past three years. The economy's trade surplus was expected to increase beyond $50 billion in 1998 prior to the financial crisis; but as result of the financial crisis, it is expected to decrease to the $30 billion range. The first two months of 1998 show exports to the United States to be at the same levels as 1997, while imports are slightly down.

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China is exposed to the Asian financial crisis by about 11 percent because 11 percent of its exports go to Southeast Asia and Korea. In the past few years, China's exports to Japan have declined to about 15 percent of total exports, but exports to Europe, North America, and Taiwan increased to more than 60 percent. Based on export exposure, a dramatic trade downturn as experienced by the rest of Asia is not likely. The free-falling yen was clearly a threat, but China still holds a (dangerous) wild card: devaluing the renminbi.

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Chapter 3

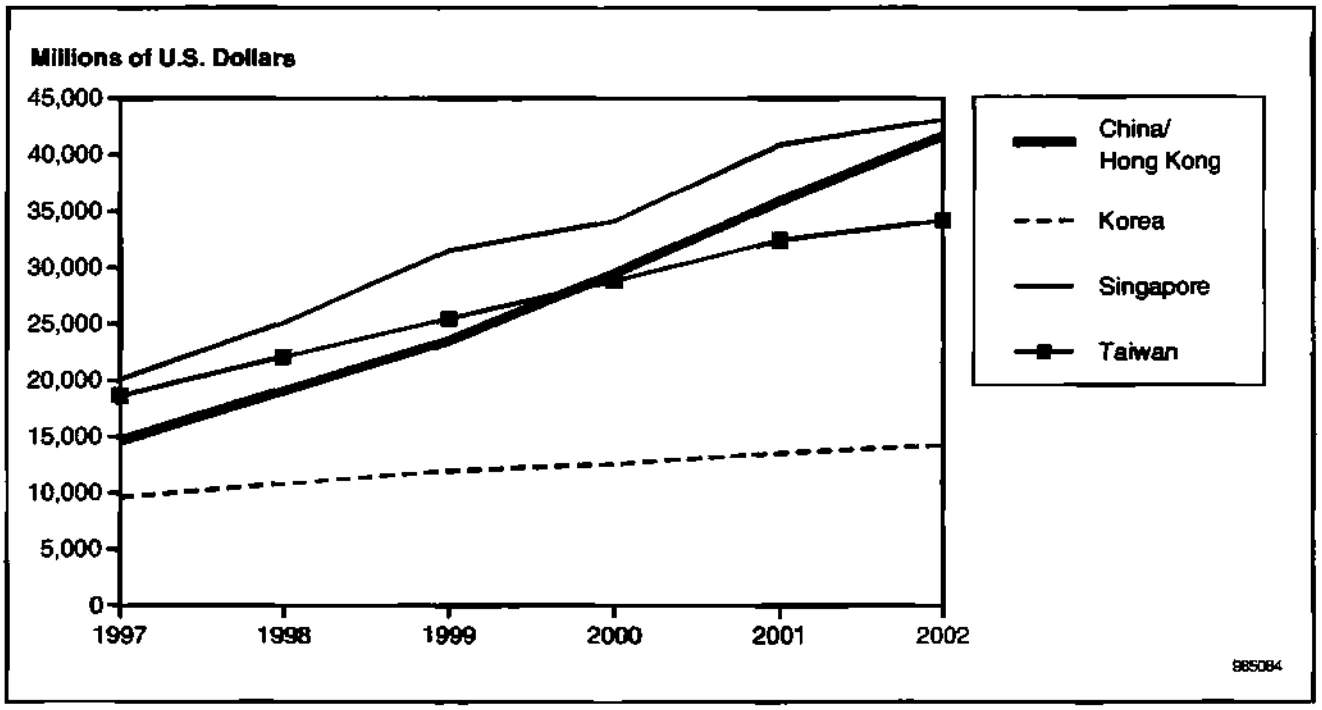
Computers and Peripherals Industry Trends

Dataquest forecasts that data processing-related electronic equipment production revenue will grow from $19 billion in 1998 to $42 billion in 2002. In 1998, PC production will increase 55 percent to 4 million units, representing a semiconductor opportunity of approximately $900 million. Dataquest expects data processing, led by strong PC industry and market growth, to undergo an average annual growth rate of 36 percent during this period for reasons discussed later in this chapter. During this period, China will surpass Taiwan to become the second-largest data processing equipment producer in Asia/Pacific (see Figure 3-1).

Data Processing Segment Analysis

Dataquest expects data storage to become the fastest-growing sector during the 1997-to-2002 forecast period, although it was the smallest sector in 1997. Dataquest expects that most of the 1998 production will be exported. Seagate Technology Inc. is the sole manufacturer of rigid disk drives (RDDs) in China, operating two major facilities. Dataquest believes that this $2.4 billion industry in 1998 will grow fivefold to $9.4 billion by 2002, based on Seagate's plans, and new entrants are likely in the 1999-to-2000 time frame.

Figure 3-1
Data Processing Equipment Production in China/Hong Kong, Korea, Singapore, and Taiwan: 1997 to 2002 (Millions of U.S. Dollars)



Source: Dataquest (September 1998)

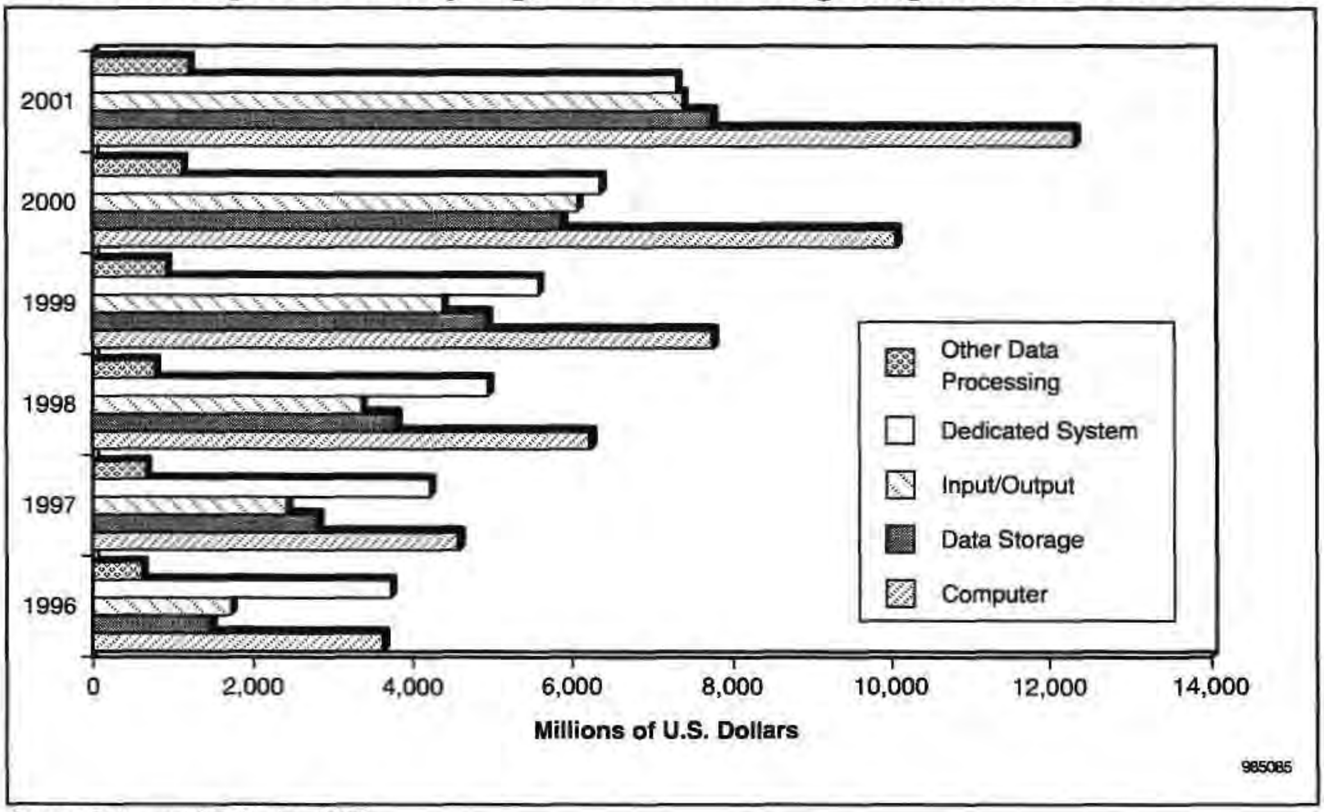
Computer peripherals, defined as input/output devices, will expand at an average annual growth rate of 30 percent to reach $9 billion, up from $2.4 billion in 1997. Monitors represent about 54 percent of this category.

The largest data processing sector is the computers, which is expected to grow 32 percent in 1998 and average 28 percent in the next four years, reaching a $13.3 billion revenue level in 2002. PCs and motherboards will increase in importance from 21 percent to 28 percent share of data processing production (see Figure 3-2). PCs and motherboards represent about 71 percent of computer revenue in 1998.

Computer Production

Computer equipment production in China is being driven first and foremost by consumption. However, improved quality and competitiveness now mean that foreign and Chinese companies are also exporting from China. China's growing computer demand will support the country's economic modernization. Chinese banks, insurance companies, and tax agencies are in the rudimentary stages of computer use, and they lack networks for information sharing. For the future convertibility of the renminbi (or Chinese yuan), Chinese officials are integrating banks with better computing systems. The State Bureau of Taxation is looking to connect 30,000 offices across the country.

Figure 3-2
Data Processing Production by Segment in China/Hong Kong (Millions of U.S. Dollars)



Source: Dataquest (September 1998)

Computer and computer peripheral sales in China are expected to increase by more than 30 percent in 1997. Domestic demand for PCs this year is expected to approach 3 million units in 1997. China's domestic computer manufacturers currently account for about 25 percent of domestic sales. Most leading foreign PC vendors have already established manufacturing facilities in China to anticipate this growing domestic demand. Among other forecasts, China's annual demand for high-powered computer workstations is expected to grow to about 5,000 units this year.

PC Production Spurred by Domestic Market's Pull

Furthering PC production growth is the parts and components production in major production centers: Shenzhen, Shanghai, and Beijing. Time-to-market concerns, familiarity with local distribution channels and customer concerns, lower tariffs, and locally produced parts translate into competitive advantages and lower costs for Chinese producers. In addition to small-scale producers, major brands—such as Legend Group, the Beida Founder Group, China Great Wall Computer Group, Beijing Stone Group, Donghai Co., and others—have emerged in China's booming retail markets. Legend Group's recent initiatives indicate that the company is trying to duplicate its newfound success in the international markets. Legend moved its PC division headquarters to Hong Kong to break into the global PC market, which was Legend's first step to become one of the top five vendors in Asia/Pacific, while maintaining domestic market leadership by 2000. Legend forecasts its sales to reach 1 million units annually by 2000. Table 3-1 shows China/Hong Kong's PC production forecast.

Table 3-2 provides a ranking of China/Hong Kong's PC manufacturers in terms of 1996 and 1997 production units ranking. The top manufacturers correspond closely with the top vendors in terms of market share because of the above advantages. Table 3-3 provides company production trend lines and a forecast for 1999 production.

Table 3-1
PC Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	1,147.5	2,549.8	3,949.4	6,119.2	7,999.9	9,910.1	11,993.2	36
Manufacturing Revenue ($M)	745.9	1,707.7	2,707.2	4,126.9	5,213.9	6,252.2	7,594.3	35
Manufacturing ASP ($)	650.0	669.8	685.5	674.4	651.8	630.9	633.2	-1
Semiconductor Content ($)	196.5	218.9	228.6	245.1	273.8	252.3	249.0	3
Semiconductor TAM ($M)	225.5	558.3	903.0	1,500.0	2,190.4	2,500.7	2,986.6	40
Growth Rate of Unit (%)	-	122.2	54.9	54.9	30.7	23.9	21.0	-
Rate of Manufacturing ASP (%)	-	3.0	2.3	-1.6	-3.4	-3.2	0.4	-
Growth Rate of Manufacturing Revenue (%)	-	129.0	58.5	52.4	26.3	19.9	21.5	-
Growth Rate of Semiconductor Content (%)	-	11.4	4.4	7.2	11.7	-7.8	-1.3	-
Growth Rate of Semiconductor TAM (%)	-	147.6	61.8	66.1	46.0	14.2	19.4	-

TAM = Total available market
Source: Dataquest (August 1998)

Table 3-2
PC Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

Rank 1996	Rank 1997	Company	1996	1997	Production Share (%) 1996	Production Share (%) 1997	Accumulated Share (%) 1996	Accumulated Share (%) 1997
2	1	Great Wall + IBM	200	400	17.4	15.7	17.4	15.7
1	2	Legend	206	320	18.0	12.6	35.4	28.2
4	3	FIC	105	210	9.2	8.2	44.5	36.5
9	4	Tontru	18	180	1.5	7.1	46.1	43.5
3	5	AST	120	150	10.5	5.9	56.5	49.4
6	6	Founder	78	135	6.8	5.3	63.3	54.7
5	7	Stone + Compaq	80	100	7.0	3.9	70.3	58.6
10	8	Siemens	8	60	0.7	2.4	71.0	61.0
8	9	NEC	24	55	2.1	2.2	73.1	63.1
7	10	Vtech Holdings Ltd.	48	50	4.2	2.0	77.3	65.1
11	10	Hisense	0	50	0	2.0	77.3	67.1
11	12	Langchao	0	21	0	0.8	77.3	67.9
11	13	Acer	0	5	0	0.2	77.3	68.1
		Others	**261**	**814**	**22.7**	**31.9**	-	-
		Total	**1,147**	**2,550**	**100**	**100**	-	-

Source: Dataquest (August 1998)

Table 3-3
PC Company Production Unit Forecast, 1998 to 1999

Company	Units (K) 1996	Units (K) 1997	Units (K) 1998	Units (K) 1999	Growth (%) 1997	Growth (%) 1998	Growth (%) 1999
Great Wall + IBM	200	400	600	750	100.0	50.0	25.0
Legend	206	320	600	900	55.3	87.5	50.0
FIC	105	210	252	300	100.0	20.0	19.0
Tontru	18	180	300	500	923.9	66.7	66.7
AST	120	150	0	0	25.0	-100.0	
Founder	78	135	200	400	73.1	48.1	100.0
Stone + Compaq	80	100	150	300	25.0	50.0	100.0
Siemens	8	60	100	100	650.0	66.7	0
NEC	24	55	80	150	129.2	45.5	87.5
Vtech Holdings Ltd.	48	50	0	0	4.2	-100.0	
Hisense	0	50	100	200		100.0	100.0
Langchao	0	21	80	150		281.0	87.5
Acer	0	5	105	150		2,000.0	42.9
Total Surveyed Companies	**887**	**1,736**	**2,567**	**3,900**	**95.8**	**47.9**	**51.9**
Others (Estimated)	261	814	1,382	2,219	211.9	69.9	60.5
Total China/Hong Kong	**1,147**	**2,550**	**3,949**	**6,119**	**122.2**	**54.9**	**54.9**
Surveyed Companies' Share of Total (%)	77	68	65	64	-	-	-

Source: Dataquest (August 1998)

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Over the long run, Dataquest expects China/Hong Kong's PC production to reach 35 percent CAGR. China's PC market represents about one-third of all shipments to the Asia/Pacific region (excluding Japan) in 1998. At the same time, its unit growth will likely double the regional average.

Business Markets Dominate and Still Show High Growth

China's PC market continues to show strong growth and attract multinational investors and domestic suppliers. Table 3-4 ranks all major vendors according to PC units shipped in 1997.

Table 3-4
Worldwide PC Vendor Shipment Ranking to China, 1997 (Units)

Ranking	Total	1997 Shipments	1997 Market Share (%)
1	Legend	235,535	10.7
2	IBM	175,169	7.9
3	Compaq Computer Corp.	172,773	7.8
4	Hewlett-Packard	151,012	6.8
5	Tontru	114,996	5.2
6	Founder	69,124	3.1
7	AST Research	65,730	3.0
8	Acer	63,619	2.9
9	Great Wall	55,474	2.5
10	Dell Computer Corp.	46,733	2.1
11	Digital Equipment	44,947	2.0
12	Packard Bell NEC	42,095	1.9
13	Toshiba	27,842	1.3
14	Philips	25,732	1.2
15	LangChao	20,453	0.9
16	Fujitsu	19,918	0.9
17	Twinhead	17,607	0.8
18	MAX	16,584	0.8
19	FIC	11,088	0.5
20	Apple Computer	10,330	0.5
21	Hisense	9,310	0.4
22	IPC	8,652	0.4
23	Tulip	8,279	0.4
24	Unisys	4,737	0.2
25	Hyundai Electronics	4,020	0.2
26	Siemens Nixdorf Informationssysteme	3,260	0.1
27	Texas Instruments	2,349	0.1
28	Olivetti	1,419	0.1
	White Box PC	**694,580**	**31.4**
	Other PC Vendors	**85,781**	**3.9**

Source: Dataquest (August 1998)

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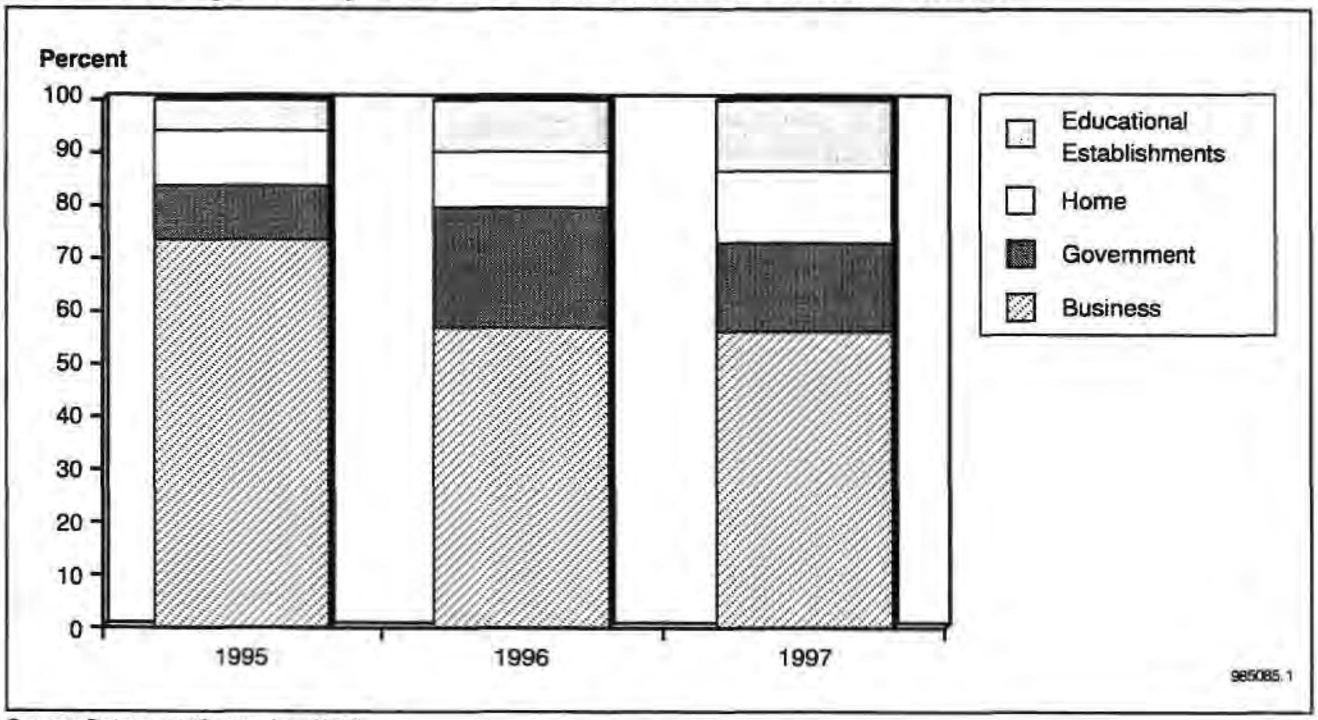
To understand the source of the business markets' growth, Dataquest segments the market by customer, form factor, and processor class. China's business market was the first to adopt PCs in the country. In 1995, the business segment absorbed nearly three-fourths of all PCs shipped in China (see Figure 3-3). Strong demand from foreign businesses in China later spilled over into local export-oriented companies. Foreign brands will not be the automatic product of choice because many local vendors now produce credible quality and are learning to provide aftersales service. The private sector remains China's engine for economic growth, and PCs will be rapidly deployed in this large and booming sector. However, the emergence of government, home, and education markets lowered business segment's share to 56 percent in 1997. But the PC market more than doubled, so PCs for business use still grew from 700,000 units to 1.2 million units from 1995 to 1997.

Government Sector Shows Strength

The government market accounted for about 10 percent of the PC market in 1995 and nearly doubled in share to 17 percent by 1997. The government and home markets each purchased only about 100,000 units in 1995. But the government segment grew faster, reaching 372,000 units in 1997. The government's recent initiative to streamline government, reduce ministries, and cut red tape will necessitate the computerization of administrative functions across China's central government. However, the pace at which China can achieve such a mammoth task will be slow, and the funds available will be increasingly scarce.

Figure 3-3
PC Market Segments by User in China, 1995 to 1997 (Percent Share)



Source: Dataquest (September 1998)

Home Market Awakes

There are few reasons to believe that the Chinese will have any less of a desire for home PCs than is seen in the United States, where approximately 40 percent of homes have PCs. This is another example of high nascent demand, because urban families have shown a high interest in PCs to educate their children to get ahead in China's competitive education system. In China, about 0.05 percent of the population own PCs, and only about 0.25 percent of 1 percent of families own PCs (assuming an average family size of five persons). The current economic growth rate, resulting in higher disposable incomes, would suggest that it takes about 10 years for 20 percent of Chinese families to own PCs. Another way to look at this trend is as follows: If an average of 5 percent of PCs are retired per year in the next decade, and the home market grows by 50 percent per year, then 85 million PCs would be sold just to families in China between now and 2008.

Education Users Surge

China's education market was the fastest-growing PC market segment during the past three years. Only 6 percent of PCs sold in 1995 went to educational establishments, but by 1997, this more than doubled to 13 percent. The university environment is the heaviest user on a per-PC basis, with hundreds of students sharing one or two PCs. But it is also the least funded. Vendors are wise to develop market share in this segment (providing discounts) as an efficient means of building brand recognition with China's next generation of business and government leaders.

Form-Factor Trends

In addition to market segmentation by end user, Dataquest segments PC shipments by form factor. The Chinese market has been dominated by desktop computers. But in 1997, the notebook computer market doubled to 173,000 units after several years of slow growth. Dataquest forecasts the market to continue this growth level through 1999, and then settle to a 50 percent average growth from 2000 to 2002. Dataquest has yet to see a local notebook computer manufacturer in China, but it expects volume production to begin in 1999. Significant semiconductor opportunities will emerge as portables grow from a mere 9 percent in 1997 to 26 percent in 2002. Desktop PCs remain the "bread and butter" of the industry. Desktop PC shipments will grow from 1.7 million units in 1997 to 6.5 million units in 2002. The overall PC shipment share will fall from a high of 88 percent in 1997 to 68 percent in 2002.

Long-Term PC Production and Semiconductor Consumption Forecast

PC manufacturers surveyed by Dataquest expect a significant production expansion slowdown in 1998 relative to 1997—from 97 percent in 1997 to 46 percent in 1998. Approximately 84 percent of China/Hong Kong-based PC manufacturers' unit output was surveyed in both periods. These manufacturers, as a group, had exceeded their production plans of 88 percent growth in September 1997 and reported their final 1997 growth to be 97 percent. This performance is consistent with local Chinese companies' local market share gains, which expanded by 44 percent to 2.2 million units in 1997.

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Dataquest estimates that total PC production in 1998 will reach 4 million units, a 55 percent increase over 1997. The estimated factory average selling price (ASP) of PCs (excluding motherboard, monitor, keyboard and disk drive) in 1998 will reach $686, up from was about $670 in 1997 (see Table 3-5).

Motherboard Production to Drop in 1999

Table 3-6 lists Dataquest's 1996 and 1997 PC motherboard manufacturer ranking and production share for the surveyed companies. The largest manufacturer in terms of units was PC Chips, a low-end, volume-driven motherboard manufacturer based in Taiwan. Dataquest believes that this group of manufacturers represents 96 percent of total motherboard production in China/Hong Kong.

The production forecast of these manufacturers is presented in Table 3-7, which shows 1998 and 1999 unit production by company. As stated earlier, these manufacturers are cautious with their expansion plans. Dataquest's surveys of these companies indicate that growth will fall off from 60 percent in 1998 to 15 percent in 1999, because of few new investments.

Table 3-5
PC Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	1,147	2,550	3,949	6,119	8,000	9,910	11,993	36
Manufacturing Revenue ($M)	746	1,708	2,707	4,127	5,214	6,252	7,594	35
Manufacturing ASP ($)	650	670	685	674	652	631	633	-1
Semiconductor Content ($)	196	219	229	245	274	252	249	3
Semiconductor TAM ($M)	225	558	903	1,500	2,190	2,501	2,987	40
Growth Rate of Unit (%)	0	122.2	54.9	54.9	30.7	23.9	21.0	-
Rate of Manufacturing ASP (%)	0	3.0	2.3	-1.6	-3.4	-3.2	0.4	-
Growth Rate of Manufacturing Revenue (%)	0	129.0	58.5	52.4	26.3	19.9	21.5	-
Growth Rate of Semiconductor Content (%)	0	11.4	4.4	7.2	11.7	-7.8	-1.3	-
Growth Rate of Semiconductor TAM (%)	0	147.6	61.8	66.1	46.0	14.2	19.4	-

TAM = Total available market
Source: Dataquest (August 1998)

Table 3-6
PC Motherboard Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	PC Chips	5,500	6,900	58.0	44.1	58.0	44.1
2	2	Legend	2,100	3,200	22.2	20.5	80.2	64.5
5	3	FIC	340	2,500	3.6	16.0	83.8	80.5
4	4	Dataexpert	480	1,200	5.1	7.7	88.9	88.2
3	5	Great Wall+IBM	650	850	6.9	5.4	95.7	93.6
6	6	AST	250	300	2.6	1.9	98.4	95.5
		Others	156	698	1.6	4.5	-	-
		Total	**9,476**	**15,648**	**100**	**100**	-	-

Source: Dataquest (August 1998)

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Table 3-7
PC Motherboard Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	**1996**	**1997**	**1998**	**1999**	**1997**	**1998**	**1999**
Great Wall + IBM	650	850	1,100	1,500	30.8	29.4	36.4
Legend	2,100	3,200	4,100	5,000	52.4	28.1	22.0
FIC	340	2,500	2,775	3,000	635.3	11.0	8.1
AST	250	300	0	0	20.0	-100.0	
PC Chips	5,500	6,900	7,650	8,500	25.5	10.9	11.1
Dataexpert	480	1,200	1,500	1,800	150.0	25.0	20.0
Total Surveyed Companies	**9,320**	**14,950**	**17,125**	**19,800**	**60.4**	**14.5**	**15.6**
Others (Estimated)	156	698	2,357	3,383	346.3	237.9	43.6
Total China/Hong Kong	**9,476**	**15,648**	**19,482**	**23,183**	**65.1**	**24.5**	**19.0**
Surveyed Companies' Share of Total (%)	98	96	88	85	-	-	-

Source: Dataquest (August 1998)

Dataquest's long-term outlook is presented in Table 3-8, which indicates a recovery caused by underinvesting during these next two years. Dataquest forecasts China/Hong Kong's motherboard production to expand by 32 percent CAGR from 1997 to 2002. PCs are growing at a faster rate because Dataquest believes that some of China's market will continue to be served effectively by drop shipments of motherboards to assemblers in China. The semiconductor opportunity of $760 million in 1998 is approximately the same size as the $900 million shipped to the PC market. Combined semiconductor consumption of PC and motherboard vendors will exceed $1.6 billion in 1998 and will grow to more than $5 billion in 2002. This amount is nearly 20 percent of the entire semiconductor market in 2002 (see Table 3-8).

Table 3-8
PC Motherboard Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	9,476	15,648	19,482	23,183	31,359	39,573	49,645	26
Manufacturing Revenue ($M)	569	1,127	1,598	1,766	2,328	2,827	3,460	25
Manufacturing ASP ($)	60	72	82	76	74	71	70	-1
Semiconductor Content ($)	34	37	39	37	37	37	36	0
Semiconductor TAM ($M)	326	579	759	866	1,168	1,481	1,801	25
Growth Rate of Unit (%)		65.1	24.5	19.0	35.3	26.2	25.5	-
Rate of Manufacturing ASP (%)		98.1	41.8	10.5	31.8	21.5	22.4	-
Growth Rate of Manufacturing Revenue (%)		20.0	13.9	-7.1	-2.5	-3.8	-2.5	-
Growth Rate of Semiconductor Content (%)		7.6	5.3	-4.1	-0.3	0.5	-3.1	-
Growth Rate of Semiconductor TAM (%)		77.6	31.0	14.1	34.9	26.8	21.6	-

TAM = Total available market
Source: Dataquest (August 1998)

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Computer Monitors

Domestic monitor shipments to the Chinese market has been growing at 40 percent during the past several years. Production expanded by 39 percent in 1997 and accelerated to 65 percent in 1998 because of new investments. Table 3-9 ranks the top manufacturers that account for about 50 percent of total production. As indicated, Chinese companies have rapidly entered this market, but the multinational vendors still dominate.

As shown in Table 3-10, the growth Dataquest had forecast is attributed to increased capacity by the large three producers, Philips Electronics NV, Acer Computer International Ltd., and First International Computer Inc. (FIC). These three companies occupied 25 percent of the industry in 1997. Dataquest segments monitors in the input/output equipment market, which is part of the overall data processing market. Monitors will remain the primary growth driver and have the largest share of input/output production. Dataquest forecasts this segment to expand by 30 percent from $2.5 billion in 1997 to $9 billion in 2002. Monitors' 1998 revenue of $2 billion will represent 54 percent of all 1998 input/output revenue.

Table 3-11 presents Dataquest's history and forecast of total computer monitor production in China/Hong Kong. Dataquest's survey of monitor production in China/Hong Kong covered one-half of the region's total monitor production, which is a large sample size. Dataquest estimates the total production in 1998 to reach 12.5 million units, compared to 7.6 million units in 1997.

Table 3-9
Computer Monitor Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Philips	600	800	11.1	10.6	11.1	10.6
2	2	Acer	350	600	6.5	7.9	17.5	18.5
3	3	FIC	200	500	3.7	6.6	21.2	25.2
8	3	XiaHua (Xoceco)	0	500	0	6.6	21.2	31.8
8	5	HuaFei	0	300	0	4.0	21.2	35.8
8	5	Rainbow	0	300	0	4.0	21.2	39.7
4	7	Great Wall	180	280	3.3	3.7	24.5	43.4
6	8	Founder	145	210	2.7	2.8	27.2	46.2
8	9	HuiLiDa	0	200	0	2.6	27.2	48.9
8	10	Sony	0	90	0	1.2	27.2	50.1
7	11	Samsung	100	0	1.8	0	29.0	50.1
5	11	LG	150	0	2.8	0	31.8	50.1
		Others	3,701	3,770	68.2	49.9	100.0	100.0
		Total	**5,426**	**7,550**	**100**	**100**	-	-

Source: Dataquest (August 1998)

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Table 3-10
Computer Monitor Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	**1996**	**1997**	**1998**	**1999**	**1997**	**1998**	**1999**
Philips	600	800	1,500	1,800	33.3	87.5	20.0
Acer	350	600	1,350	2,000	71.4	125.0	48.1
XiaHua (Xoceco)	0	500	1,000	1,200	-	100.0	20.0
FIC	200	500	600	800	150.0	20.0	33.3
HuaFei	0	300	500	800	-	66.7	60.0
Rainbow	0	300	500	800	-	66.7	60.0
Founder	145	210	490	800	44.8	133.3	63.3
Great Wall	180	280	456	600	55.6	62.9	31.6
HuiLiDa	0	200	350	500	-	75.0	42.9
Sony	0	90	150	250	-	66.7	66.7
LG	150	0	0	0	-100.0	-	-
Samsung	100	0	0	0	-100.0	-	-
Total Surveyed Companies	**1,725**	**3,780**	**6,896**	**9,550**	**119.1**	**82.4**	**38.5**
Others (Estimated)	3,701	3,770	5,599	6,912	1.9	48.5	23.5
Total China/Hong Kong	**5,426**	**7,550**	**12,495**	**16,462**	**39.1**	**65.5**	**31.8**
Surveyed Companies' Share of Total (%)	32	50	55	58	-	-	-

Source: Dataquest (August 1998)

Table 3-11
Computer Monitor Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	5,426	7,550	12,495	16,462	21,401	25,681	30,304	32
Manufacturing Revenue ($M)	948	1,253	1,991	2,576	3,616	4,274	4,928	32
Manufacturing ASP ($)	175	166	159	156	169	166	163	0
Semiconductor Content ($)	18	17	17	16	16	15	15	-2
Semiconductor TAM ($M)	98	128	212	263	342	385	455	29
Growth Rate of Unit (%)	-	39.1	65.5	31.8	30.0	20.0	18.0	-
Rate of Manufacturing ASP (%)	-	32.2	58.9	29.4	40.4	18.2	15.3	-
Growth Rate of Manufacturing Revenue (%)	-	-5.0	-4.0	-1.8	8.0	-1.5	-2.3	-
Growth Rate of Semiconductor Content (%)	-	-5.6	0	-5.9	0	-6.3	0	-
Growth Rate of Semiconductor TAM (%)	-	31.4	65.5	24.0	30.0	12.5	18.0	-

TAM = Total available market
Source: Dataquest (August 1998)

Storage Equipment

Seagate is the sole producer of RDDs in China/Hong Kong. Most components are internally transferred from Singapore; however, Dataquest has estimated Seagate's semiconductor consumption at two facilities.
Table 3-12 provides Seagate's historical units and growth, while Table 3-13 provides Dataquest's forecast for 1998 and 1999.

Dataquest expects data storage to be a major semiconductor growth source for the next four years. We expect that at least 90 percent production will continue to be exported by Seagate for global export because of the nature of these facilities. Dataquest believes that the $1.6 billion storage industry in 1998 will grow fivefold to reach $3.9 billion in 2002, with Seagate leading the way. This 19 percent CAGR is lower than unit growth of 24 percent, as price erosion continues, but at a slower rate (see Table 3-14).

Table 3-12
Rigid Disk Drivers Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Seagate	2,683	5300	100	100	100	100
		Others	0	0	0	0	-	-
		Total	**2,683**	**5300**	**100**	**100**	-	-

Source: Dataquest (August 1998)

Table 3-13
Rigid Disk Driver Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	1996	1997	1998	1999	1997	1998	1999
Seagate	2,683	5,300	7,000	8,785	97.5	32.1	25.5
Total Surveyed Companies	**2,683**	**5,300**	**7,000**	**8,785**	**97.5**	**32.1**	**25.5**
Others (Estimated)	0	0	0	0	-100.0	-	-
Total China/Hong Kong	**2,683**	**5,300**	**7,000**	**8,785**	**97.5**	**32.1**	**25.5**
Surveyed Companies' Share of Total (%)	100	100	100	100	-	-	-

Source: Dataquest (August 1998)

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Table 3-14
Rigid Disk Drive Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	2,683	5,300	7,000	8,785	11,139	13,367	15,603	24
Manufacturing Revenue ($M)	590	1,238	1,554	1,891	2,258	2,578	2,904	19
Manufacturing ASP ($)	220	234	222	215	203	193	186	-4
Semiconductor Content ($)	30	30	29	28	26	25	25	-4
Semiconductor TAM ($M)	81	160	204	243	294	335	392	20
Growth Rate of Unit (%)		97.5	32.1	25.5	26.8	20.0	16.7	-
Rate of Manufacturing ASP (%)		109.8	25.5	21.7	19.4	14.2	12.6	-
Growth Rate of Manufacturing Revenue (%)		6.2	-5.0	-3.0	-5.9	-4.9	-3.5	-
Growth Rate of Semiconductor Content (%)		0.1	-3.4	-4.8	-4.7	-5.1	0.2	-
Growth Rate of Semiconductor TAM (%)		97.8	27.6	19.5	20.8	13.9	16.9	-

TAM = Total available market
Source: Dataquest (August 1998)

Seagate Technology Inc.

Seagate has been expanding production in China and will inject $32 million into its Wuxi facility, bringing total direct investment to more than $52 million. Total investment in China was reported to be $90 million, including the Wuxi plant. Employing about 3,300 workers, the Wuxi plant's aggregate production reached 3 million units in 1996. This investment adds about 1,600 workers and doubles Seagate's capacity in China, which serves both local and export markets. It is said that the production line for magnetic disk drivers, which is now in the old building, will be shifted to the new one, and the old one will be used mainly for the production of E-BIKS, with an expected daily capacity of 25,000 units.

The new Wuxi facility is Seagate's second RDD plant in China, after operating the Shenzhen plant for more than two years. The acquisition of Conner Peripherals Inc. by Seagate enabled it to buy market share in China by acquiring Conner's Shenzhen RDD plant. It also enabled Seagate to adopt a successful business model for selling in China, which Seagate has successfully expanded upon. Since then, the combined efforts have proved effective for Seagate, which now controls more than 50 percent of the market and exports RDDs from China.

Dataquest estimates the PC production growth rates to keep pace with China's breakneck PC market growth. This rapid growth resulted in a voracious demand for RDDs. However, RDD competition is increasing for Seagate as it is attempting to hang on to its reign of China's computers mass-storage market. By expanding production, Seagate is leveraging its current competitive advantage in the market to combat the new market entrants.

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Printers

Dataquest researched production for Fujitsu Ltd., Stone/Fujitsu, and Sharp Electronics Corporation, but we did not include Hewlett-Packard, which also manufactures printers in China. From Dataquest's research, these four companies represent almost the entire page printer production industry in China/Hong Kong. Fujitsu and its joint venture, Fujitsu/Stone, together represented about 22 percent of production in 1997 (see Table 3-15). Sharp produces a small quantity that represents only approximately 4 percent of overall production.

Table 3-16 provides production forecasts for these three companies in 1998 and 1999. Dataquest observes aggressive expansion in 1998 because of investments that were made in 1997. However, as Dataquest observes in many segments, investments have become somewhat cautious in 1998, hence unit production is expected to expand by a slower, but robust, 35 percent.

The long-term printer production outlook growth and semiconductor consumption is quantified in Table 3-17. In general, the 33 percent CAGR should not be a surprise here because printer production is keeping track with PC production and electronics market growth. Semiconductor content is increasing because of expectations that higher-end printers will be built in China and because of increasing demand from business, government, and even personal users.

Table 3-15
Printer Manufacturers Production Share and Ranking, 1996 and 1997(Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Fujitsu	80	90	16.4	12.3	16.4	12.3
2	2	Stone + Fujitsu	50	67	10.2	9.2	26.6	21.5
3	3	Sharp	25	32	5.1	4.4	31.7	25.9
		Others	334	540	68.3	74.1	-	-
		Total	**489**	**729**	**100**	**100**	-	-

Source: Dataquest (August 1998)

Table 3-16
Printer Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	1996	1997	1998	1999	1997	1998	1999
Sharp	25	32	38	50	28.0	18.8	31.6
Fujitsu	80	90	160	220	12.5	77.8	37.5
Stone + Fujitsu	50	67	90	120	34.0	34.3	33.3
Total Surveyed Companies	**155**	**189**	**288**	**390**	**21.9**	**52.4**	**35.4**
Others (Estimated)	334	540	1,461	1,616	61.5	170.5	10.6
Total China/Hong Kong	**489**	**729**	**1,749**	**2,006**	**49.0**	**139.9**	**14.7**
Surveyed Companie's Share of Total (%)	32	26	16	19	-	-	-

Source: Dataquest (August 1998)

Table 3-17
Printer Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	489	729	1,749	2,006	2,302	2,662	3,057	33
Manufacturing Revenue ($M)	113	161	361	415	480	570	671	33
Manufacturing ASP ($)	737	712	697	680	664	649	634	-2
Semiconductor Content ($)	163	163	167	174	186	190	193	3
Semiconductor TAM ($M)	16	23	54	70	92	122	157	46
Growth Rate of Unit (%)		49.0	139.9	14.7	14.8	15.7	14.8	-
Rate of Manufacturing ASP (%)		42.3	124.9	14.9	15.7	18.7	17.6	-
Growth Rate of Manufacturing Revenue (%)		-3.4	-2.1	-2.4	-2.4	-2.3	-2.4	-
Growth Rate of Semiconductor Content (%)		-0.1	2.3	3.9	7.3	2.0	1.4	-
Growth Rate of Semiconductor TAM (%)		47.5	131.5	28.7	32.1	32.3	28.3	-

TAM = Total available market
Source: Dataquest (August 1998)

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Chapter 4

Communications Electronics Equipment

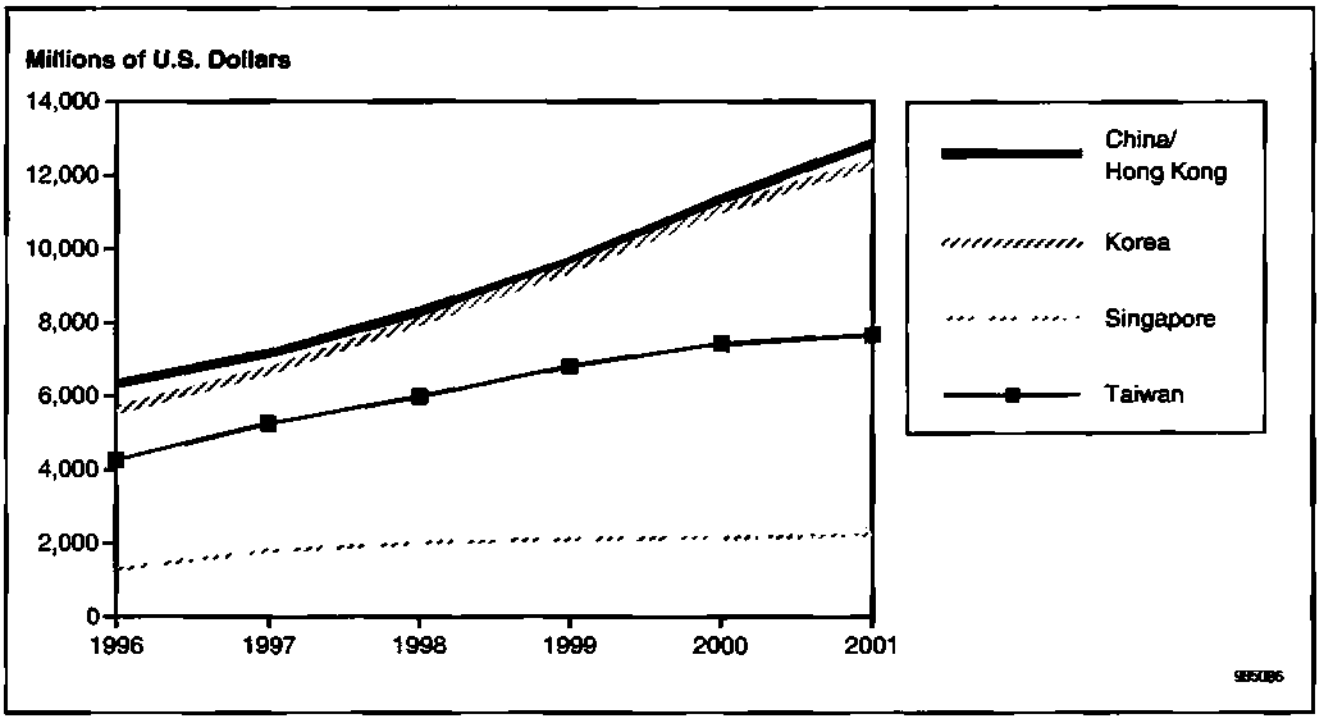
Introduction

Dataquest assesses the communications equipment production in 1998 and 1999 with an up close look at key manufacturers. Dataquest also assesses each product's semiconductor usage from 1997 to 2002. Because of the importance of communications market to driving investments in local production, Dataquest has provided additional market-related information as part of its baseline assumptions.

Communications Sector Trends

China/Hong Kong has become Asia/Pacific's largest manufacturer of communications equipment because of its rapid rise in premises and, more recently, mobile communications production. Dataquest expects communications production to maintain its current pace because of broad-based products that are both exported and shipped locally in China. The Chinese government continues to provide significant support and investments in developing its telecommunications infrastructure, which will lead to increases in local content and foreign investment. Figure 4-1 illustrates Dataquest's forecast by Asia/Pacific country, which shows that China/Hong Kong and Korea both maintain dominance of Asia/Pacific's communications production.

Figure 4-1
Communications Production Revenue Forecast in China/Hong Kong, Korea, Singapore, and Taiwan: 1997 to 2002 (Millions of U.S. Dollars)



Source: Dataquest (September 1998)

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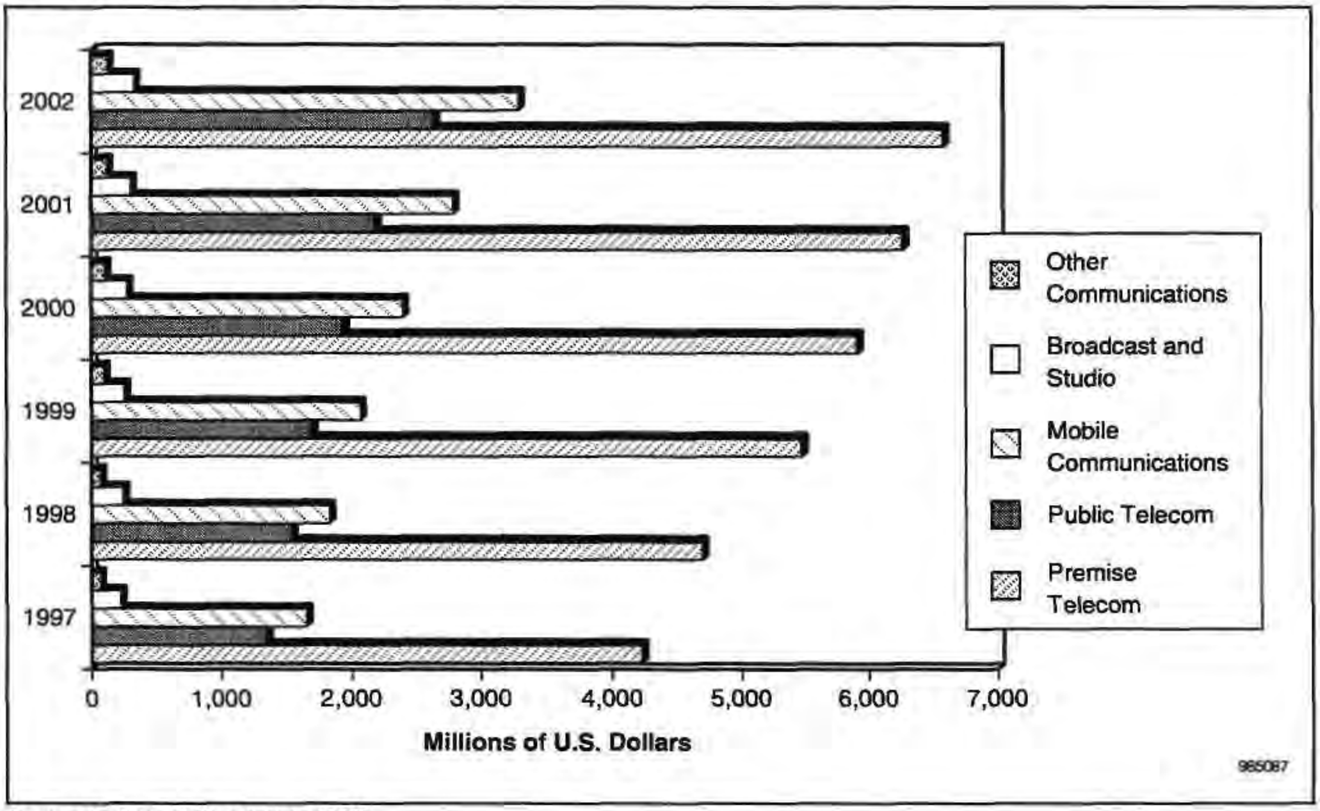
Communications equipment production will generate $8.3 billion in China/Hong Kong in 1998, which represented 4 percent of Asia/Pacific's total electronics production. China/Hong's production represented 27 percent of all communications-related production (revenue) in Asia/ Pacific. Dataquest forecasts that China/Hong Kong's communications production will grow at an 11 percent CAGR from 1997 to 2002. At its current growth trajectory, China/Hong Kong will maintain its share of Asia/ Pacific communications production despite its high consumption growth of communications equipment. Dataquest believes that China/Hong Kong will still have to import the majority of its infrastructure equipment because of technological complexity and the need for turnkey solutions. Some standardized systems, such as Global System for Mobile Communications (GSM), can lead to local production but new technologies, such as xDSL, will continue to be imported in entirety (and probably from only a few vendors).

As illustrated in Figure 4-2, which splits China/Hong Kong's communication production by major market segment, Dataquest forecasts that premises will continue to dominate in production share, while mobile leads the industry growth. Substantial production volume, particularly in southern China, of corded and cordless telephone handsets will enable premises production to sustain more than 50 percent of production. It will account for 55 percent of production in 1998 but will fall to 50 percent because of mobile's faster growth. Premises are followed by mobile with 21 percent share, public telecom (18 percent), broadcast/studio (3 percent), and others (0.8 percent).

Figure 4-2
China/Hong Kong's Communications Production Revenue Forecast by Sector, 1997 to 2002 (Millions of U.S. Dollars)



Source: Dataquest (September 1998)

Digital Cellular

Table 4-1 presents Dataquest's list of major mobile cellular phone producers in China/Hong Kong, their production units, and production share. Dataquest includes all cellular handset production in this segment, including digital cellular and broadband PCS handsets to include handsets that conform to the following standards: GSM, Digital Cellular System (DCS) 1800, personal communications services (PCS) 1900, NA-TDMA (IS-54/136), code division multiple access or CDMA (IS-95), Personal Data Cartridge (PDC), and Omnipoint.

Dataquest's sample survey of six major multinational manufacturers included about 74 percent of cellular phone production in China. Motorola Incorporated is a Goliath and overshadows all other manufacturers with 39 percent production share in 1997. Despite its 41 percent increase in output, Motorola still lost 3 percentage points production share because of NEC Corporation's rapid expansion, which enabled NEC to move from No. 4 to No. 2 in production ranking.

Table 4-2 presents production plans of these major six manufacturers in 1998 and 1999. As shown, there is a dramatic deceleration from 60 percent growth in 1997 to 27 percent in 1998 among these top producers. Consequently, the overall industry will only grow 25 percent, which is high by global standards but slow for China/Hong Kong. One would expect this slowdown to occur in 1998 because all manufacturers have expanded production. It appears this slowdown is temporary because production among these companies is expected to accelerate to 33 percent in 1999. Dataquest expects the next year to see new entrants to the market attributed to turnkey GSM technology transfers that are taking place this year. Dataquest expects to see one or two Chinese companies start producing cellular phones by 1999. Hence, overall cellular phone production will jump to 39 percent according to Dataquest's forecast.

Table 4-1
Cellular Phone Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Motorola	850	1,200	43.8	38.7	43.8	38.7
4	2	NEC	80	400	4.1	12.9	47.9	51.7
2	3	Ericsson	260	320	13.4	10.3	61.3	62.0
4	4	Nokia	80	150	4.1	4.8	65.5	66.8
3	5	Matsushita	120	140	6.2	4.5	71.7	71.3
6	6	Siemens	45	80	2.3	2.6	74.0	73.9
		Others	505	807	26.0	26.1	-	-
		Total	**1940**	**3097**	**100**	**100**	-	-

Source: Dataquest (August 1998)

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Table 4-2
Cellular Telephone Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	**1996**	**1997**	**1998**	**1999**	**1997**	**1998**	**1999**
Siemens	45	80	96	250	77.8	20.0	160.4
NEC	80	400	480	650	400.0	20.0	35.4
Motorola	850	1,200	1,500	1,850	41.2	25.0	23.3
Ericsson	260	320	450	600	23.1	40.6	33.3
Nokia	80	150	200	300	87.5	33.3	50.0
Matsushita	120	140	180	200	16.7	28.6	11.1
Total Surveyed Companies	**1,435**	**2,290**	**2,906**	**3,850**	**59.6**	**26.9**	**32.5**
Others (Estimated)	505	807	956	1,509	60.0	18.4	57.8
Total China/Hong Kong	**1,940**	**3,097**	**3,862**	**5,359**	**59.7**	**24.7**	**38.8**
Surveyed Companies' Share of Total (%)	74	74	75	72	-	-	-

Source: Dataquest (August 1998)

Table 4-3 presents Dataquest's long-term perspective on cellular phone production and semiconductor consumption. Dataquest forecasts a significant production growth of 39 percent CAGR from 1997 to 2002. This growth level translates into a production capacity of 16 million cellular phones by 2002 in China/Hong Kong.

Mobile telecommunications business has developed rapidly in China, but with faster expansion in the eastern coastal areas than the central and western areas. Competition is sizzling in the mobile telecommunications service market between China Telecom, under the Ministry of Posts and Telecommunications (MPT), and its main rival, China Unicom.

Table 4-3
Cellular Telephone Production Forecast in China/Hong Kong, 1996 to 2002

	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**CAGR (%) 1997 to 2002**
Units (K)	1,940	3,097	3,862	5,359	7,807	11,645	16,002	39
Manufacturing Revenue ($M)	675	927	935	1,062	1,339	1,748	2,133	18
Manufacturing ASP ($)	636	510	432	355	304	274	241	-14
Semiconductor Content ($)	137	110	91	73	65	59	56	-13
Semiconductor TAM ($M)	158	221	228	260	344	470	621	23
Growth Rate of Unit (%)	-	84.4	30.2	22.6	31.8	32.0	11.7	-
Rate of Manufacturing ASP (%)	-	-41.2	-25.2	-34.9	-28.5	-19.1	-24.4	-
Growth Rate of Manufacturing Revenue (%)	-	28.9	-1.7	-18.3	-1.2	7.3	-13.5	-
Growth Rate of Semiconductor Content (%)	-	-39.0	-31.9	-33.7	-22.1	-19.4	-10.0	-
Growth Rate of Semiconductor TAM (%)	-	28.8	-7.7	-18.9	6.2	9.7	1.6	-

TAM = Total available market
Source: Dataquest (August 1998)

China's mobile phone subscribers in 1997 reached nearly 10 million. The Chinese government predicted last year that the number of mobile phone subscribers would reach 7 million by the end of 1997. Recent estimates put the 1997 figure closer to 10 million. But most of them are still based on the analog system because of its earlier introduction in the 1980s. Cellular phone subscribers in 1997 are estimated to be 4 million by MPT. In Shanghai alone, the number of cellular phone subscribers were 600,000 in 1997, from about 360,000 in 1996.

Major players in the mobile telecommunications market include China Telecom, Telecom United, Motorola, Nokia Telecommunications, Oki Telecom, Ericsson, and Siemens AG.

With the addition of 130 GSM networks run by China Unicom, the GSM networks increased to about 5 million. This addition will add an estimated 250,000 to 300,000 radio channels. Mobile phones made by the world's three leading telecommunications companies, Ericsson, Nokia, and Motorola, have captured about 95 percent of Beijing's GSM mobile phone market. The remaining 5 percent of the market is shared by a mixture of products from other companies, including Siemens and NEC.

China is one of the world's most underserved telecommunications markets today. It had a cellular phone penetration rate of only 0.6 percent last year. But the market is expected to quadruple to 28 million subscribers by 2000. Even with this increase, it is still a tiny percent of the 1.3 billion people in China today. If Taiwan is an indicator, then this rate is only about 4 percent of Taiwan's 21 million mobile telephones subscribers today. Provincial governments are taking many initiatives to expand their mobile markets, as detailed below. For example, the economically vibrant coast province of Shandong has an estimated 750,000 mobile phone and 800,000 pager customers in 1997. The number of mobile subscribers in Henan Province is not in line with the size of its population. Henan had 95 million people, but had only 121,708 cellular phone subscribers in 1995.

GSM Developments in China

China is going mobile to meet the growing demands of the country's telecommunications explosion. GSM continues to build momentum in China as digital technology provides high-traffic-carrying capacity.

In the face of rapidly growing public demand, the MPT has decided to expand its sophisticated digital mobile communications systems dramatically in China in the next few years. MPT officials say that foreign telecommunications companies will be allowed to market their own digital or GSM mobile phones in China if their products are found to be of high quality, which, the officials say, will help increase market competition and force prices of GSM mobile phones here to fall.

CDMA Developments

China is now building several trial code division multiple access (CDMA) networks in populous cities such as Guangzhou, Beijing, and Shanghai. The handling capacity of the CDMA networks is reported to be 10 times higher than the present analog mobile telecommunications standard.

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Representatives of Lucent Technologies (China) Ltd.—one of the global telecommunications giants leading the CDMA trend—said that China dialed the first CDMA call on the trial network launched by Lucent Technologies in Guangzhou on December 31, 1996. It is the first commercial CDMA system operational in China.

Lucent said that China—the fastest-growing market in the Asia/Pacific region and in which the company has won CDMA contracts worth $250 million—is now technically qualified to adopt the CDMA technology countrywide.

Motorola, another major CDMA supplier from the United States, is also accelerating the construction work on two trial networks in Beijing and Fujian Province. It made the first CDMA call in Beijing early this month. Meanwhile, other CDMA manufacturers, including Canada's Northern Telecom Inc., Samsung Electronics Company Ltd., and, to a lesser extent, LG Electronics Inc., are entering the Chinese CDMA marketplace.

Once the country decides to open the market to foreign CDMA suppliers, the telecommunications administrative body will encourage the foreign companies to make technical transfer. China has always adhered to the principle of trading market for technology. Therefore, the earlier the CDMA technology is transferred, the easier it will be for the company to make its way into the Chinese market.

Lucent Technologies (China) Ltd.

In September, Lucent's CDMA system was successfully tested to roam between two different networks in Guangdong and Beijing. The tests were conducted with China Telecom Greatwall Network, a cooperative entity between China's MPT and China Electronic System Engineering Co. Lucent's CDMA system passed both the C7 signaling tests and the IS-41B tests, in addition to also achieving successful roaming between the networks in Guangdong and Shanghai. LG is a latecomer in the booming China market for wireless handheld phones and is constructing an assembly plant, like the other major vendors. LG will be bucking up against CDMA phone suppliers that already have assembly plants in China.

Samsung Electronics Company Ltd.

China is also showing interest in Korea's experience in the commercial use of CDMA mobile telecommunications. Korea's Samsung Electronics signed a contract in June to supply CDMA digital mobile telecommunications equipment to China's Shanghai Great Wall Mobile Communications Co. Under the contract, Samsung will supply one switch station with a capacity of 68,000 lines, 67 base stations, and services on a turnkey basis. The CDMA digital cellular phone services are expected to go into commercial operation in Shanghai beginning in 1998.

Samsung bid against foreign rivals that included Lucent Technologies, Motorola, and QUALCOMM Incorporated. Samsung plans to use Shanghai as its regional base for communications equipment because of high market potential, with the number of cellular phone subscribers expecting to reach 600,000 in 1997 from 380,000 in 1996.

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Thus, Samsung plans to explore the market in Shanghai for PCS, wireless local loop (WLL), and asynchronous transfer mode (ATM). Samsung operates a joint-venture company in Shanghai for WLL operation. In 1996, it supplied wireless paging systems capable of accommodating 1 million subscribers.

CDMA Production Developments

Major CDMA market players, including Lucent, Motorola, Samsung, and LG all have assembly plants in China. LG is a latecomer in the booming China market for wireless handheld phones. LG will be bucking up against CDMA phone suppliers that already have assembly plants in China.

In April, China Samsung Electronics has been selected as the official CDMA hardware provider for Shanghai. The turnkey contract calls for the company to provide China Shanghai Changcheng Mobile Communications Co. Ltd. with a switching station that has the capacity to handle 68,000 subscribers, as well as 67 base stations and follow-up services. Installation is scheduled to begin in the first half of this year, and the system will be fully operational within the second half of the year.

Mitsubishi Electric Corporation announced plans to set up a digital mobile phone production base in China and to increase Mitsubishi's share in the world mobile phone market from present 6.5 percent to more than 10 percent by 2000. So far, Mitsubishi has established production bases in the United States and France, with annual output reaching 1 million units in 1996. Because China forms an increasing demand for mobile phones, Mitsubishi predicted that Asia/Pacific will represent 40 percent in the world digital cellular market.

Personal Communications Services (PCS) Developments

The changeover of Hong Kong sovereignty also could have a positive impact on PCS implementation in China. PCS licenses in Hong Kong are on track to generate an estimated $700 million in the next two years and as much as $5 billion in total revenue in the next 10 years. In underdeveloped countries where limited wireline infrastructure is installed, the existing infrastructure may not support the growing population or their service needs. The large cost and projected scope of laying more wireline networks suggest a wireless solution such as a PCS network. A PCS microcell base station that will support 100 people is estimated to cost somewhere between $60,000 and $65,000. By 2001, the number of cellular and PCS users in China, for example, could reach 12 million, representing $20 billion in revenue. The current worldwide wait for phone service for an estimated 40 million to 50 million people is 1.2 years. The average density of phone lines for the world is about 10 percent (or 10 lines per 100 people), with industrialized nations averaging about 50 percent. A key challenge will be for GSM, CDMA, and PCS companies to ensure that Chinese government understands the relationships among the cost of regulation and the speed of approvals, and the affordability of services with its effect on universal service.

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Pagers

Dataquest's survey of China/Hong Kong's pager producers represented about 90 percent of production in 1997. Table 4-4 presents Dataquest's ranking of the three major pager manufacturers in China/Hong Kong. Dataquest estimates that China produced 7 million pagers in 1997, led by Motorola, Matsushita, and the joint venture, TCL/NEC (between Huizhou TCL Mobile Communication Co. Ltd. and NEC). Motorola dominates pager production with 67 percent of production share or 4.8 million sets in 1997. Matsushita's production quantity increased 76 percent in 1997 to 95,000. This expansion enables Matsushita to move to rank second and capture 14 percent production share, at the expense of Motorola that lost 7 percentage points production share. TCL/NEC cut production from 650,000 to 400,000, as the industry suffered overcapacity in 1997.

Table 4-5 presents the unit production forecasts for TCL/NEC, Motorola, and Matsushita in 1998 and 1999. Production expansion by Motorola and Matsushita appears to be coming to a standstill to better align with slowing demand. However, TCL/NEC plans to boost production from 400,000 units in 1997 to 1 million units in 1998. This expansion will further exacerbate ASP declines, as Dataquest forecasts in Table 4-6.

Table 4-4
Pager Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Motorola	4,400	4,750	74.9	67.9	74.9	67.9
3	2	Matsushita	540	950	9.2	13.6	84.1	81.5
2	3	TCL/NEC	650	400	11.1	5.7	95.2	87.2
		Others	285	897	4.8	12.8	-	-
		Total	**5,875**	**6,997**	**100**	**100**	-	-

Source: Dataquest (August 1998)

Table 4-5
Pager Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	1996	1997	1998	1999	1997	1998	1999
Motorola	4,400	4,750	5,100	4,600	8.0	7.4	-9.8
Matsushita	540	950	1,000	1,000	75.9	5.3	0
TCL + NEC	650	400	1,056	1,000	-38.5	164.0	-5.3
Total Surveyed Companies	**5,590**	**6,100**	**7,156**	**6,600**	**9.1**	**17.3**	**-7.8**
Others (Estimated)	285	897	954	1,650	215.1	6.4	73.0
Total China/Hong Kong	**5,875**	**6,997**	**8,110**	**8,250**	**19.1**	**15.9**	**1.7**
Surveyed Companies' Share of Total (%)	95	87	88	80	-	-	-

Source: Dataquest (August 1998)

Table 4-6
Pager Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	5,875	6,997	8,110	8,250	8,507	8,830	9,139	5
Manufacturing Revenue ($M)	441	399	439	427	432	426	428	1
Manufacturing ASP ($)	75	57	54	52	51	48	47	-4
Semiconductor Content ($)	11	11	11	12	13	13	13	3
Semiconductor TAM ($M)	66	79	93	97	107	114	122	9
Growth Rate of Unit (%)	-	19.1	15.9	1.7	3.1	3.8	3.5	-
Rate of Manufacturing ASP (%)	-	-24.0	-5.1	-4.3	-1.9	-5.1	-2.9	-
Growth Rate of Manufacturing Revenue (%)	-	-9.5	10.0	-2.6	1.1	-1.5	0.5	-
Growth Rate of Semiconductor Content (%)	-	0.4	1.2	1.9	7.0	3.0	3.1	-
Growth Rate of Semiconductor TAM (%)	-	19.6	17.3	3.7	10.3	6.9	6.7	-

TAM = Total available market
Source: Dataquest (August 1998)

Dataquest believes that pager unit production will grow at only 5 percent CAGR from 1997 to 2002. This growth represents a semiconductor market expansion of 9 percent, from $93 million in 1998 to $122 million in 2002.

At the end of 1997, there were 8 million new subscribers. But MPT's projections showed paging subscriptions to reach 117 million by 2000, which Dataquest believes to be overstated. By the end of 1996, MPT had started national paging networks in 22 Chinese cities. The new systems have adopted FLEX/multifrequency roaming modules, as well as VSAT interconnection technology. ChinaSat has contracted Hughes Network System to provide VSAT equipment in more than 300 subnetworks across China. MPT has experimented with new frequencies, particularly the 150 MHz.

Dataquest believes that paging services may continue to be a major means of communications, but the falling cellular phone service prices make pagers obsolete for many consumers.

Paging Companies and Developments

China Unicom and other non-MPT paging service providers have merged or sought vertically integrated networks under other ministries. Other strategies adopted include seeking foreign partners for direct investment or new technologies. Beijing Jingxin Electronics Co. Ltd. and HP signed a cooperative agreement in December 1996 for codeveloping wireless, high-speed beeping coding system. The project received support from the State Science and Technology Commission. China's wireless, high-speed beeping business was projected to develop rapidly in 1997.

Tianjin Municipal Posts and Telecommunications Administration in the north China's Tianjin started two new paging services in cooperation with independent paging service centers in May. Tianjin now has more than 70 separate paging services with 1.2 million subscribers. A majority of the services are small in scale, except for the local posts and telecommunications departments, which are financially and technically stronger.

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A dozen of these paging centers have more than 10,000 subscribers each, but some have only about 2,000 subscribers. To woo more subscribers, paging service operators have been competing by cutting costs, a move that has put some operators in a tough situation. A total of 37 other separate paging services have also agreed to join the unified new paging services and are now making preparations, according to local sources.

Samsung said it has completed construction of a $1 million paging system in Shanghai, which can handle 1.2 million subscribers in 1997. The company said it delivered the turnkey project to Shanghai Guomai Communications Co. Ltd. Samsung estimates that the paging networks will cover 20 percent of China's 30 million citizens by the turn of the century.

NEC had acquired an additional 35 percent in a Guangdong-based pager manufacturing and marketing joint venture, established in 1993 by a Hong Kong company and a local Chinese entity. NEC purchased all holdings of the Hong Kong partner with about $1.75 million investment.

Central Office Line Cards

Dataquest surveyed 11 major central office/PBX switching suppliers in Table 4-7. Dataquest typically tracks central office by number of line cards, but data available from manufacturers is in the form of number of lines. Furthermore, companies are less comfortable splitting PBX and central office numbers, so Dataquest has combined the figures into one category. A central office line cards is typically defined as a telecommunications switch by public carriers, excluding PBX—a private branch exchange—but Dataquest's company figures include PBXs. Dataquest has estimated pure central office line cards, exclusive of PBXs later in this section.

As shown in Table 4-7, leading central office/PBX manufacturers in China/Hong Kong are a mix of foreign and domestic manufacturers. These companies more than doubled output as measured in lines in 1997 because of China's rapid infrastructure expansion. Shanghai Bell Telephone Equipment Manufacturing Co. Ltd. is the dominant player with a formidable 37 percent production share. The top five companies are market makers because they control about 85 percent of the market. Table 4-8 indicates that these market makers will lose market share caused by several rapid-growth competitors gaining share in 1998 and 1999.

Dataquest's long-term outlook for central office/premises line card production and semiconductor consumption in China/Hong Kong is presented in Table 4-9. Dataquest expects 1997's output of 16 million line cards to expand at a 17 percent CAGR to 35 million units in 2002. Dataquest believes that this will generate semiconductor consumption growth in this segment of 14 percent, from about $200 million in 1998 to $360 million 2002. This market's high competition level is resulting in semiconductor ASP erosion.

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Table 4-7
Central Office/PBX Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

Rank 1996	Rank 1997	Company	1996	1997	Production Share (%) 1996	Production Share (%) 1997	Accumulated Share (%) 1996	Accumulated Share (%) 1997
9	1	Shanghai Bell	NA	5950	0	37.1	0	37.1
1	2	Siemens	2840	3000	20.8	18.7	20.8	55.7
3	3	Huawei	1860	2850	13.6	17.7	34.4	73.5
2	4	BISC	2540	2800	18.6	17.4	53.0	90.9
4	5	NEC	980	1450	7.2	9.0	60.1	99.9
9	6	HuaGuang	NA	700	0	4.4	60.1	104.3
9	6	DaTang	NA	700	0	4.4	60.1	108.7
5	8	Ericsson	350	400	2.6	2.5	62.7	111.2
6	9	Toshiba	258	354	1.9	2.2	64.6	113.4
7	10	Nokia	250	300	1.8	1.9	66.4	115.2
8	11	Samsung	200	250	1.5	1.6	67.9	116.8
		Others	NA	NA	NA	NA	-	-
		Total	**9,278**	**18,754**	**100**	**100**	-	-

NA = Not available
Source: Dataquest (August 1998)

Table 4-8
Central Office/PBX Manufacturers Forecast, 1996 to 1999

Company	Units (K) 1996	Units (K) 1997	Units (K) 1998	Units (K) 1999	Growth (%) 1997	Growth (%) 1998	Growth (%) 1999
Shanghai Bell	NA	5,950	6,800	7,500	NA	14.3	10.3
Siemens	2,840	3,000	3,450	4,250	5.6	15.0	23.2
Huawei	1,860	2,850	3,420	4,000	53.2	20.0	17.0
BISC	2,540	2,800	3,500	4,000	10.2	25.0	14.3
NEC	980	1,450	1,800	1,800	48.0	24.1	0
HuaGuang	NA	700	1,000	1,200	NA	42.9	20.0
DaTang	NA	700	900	1,100	NA	28.6	22.2
Ericsson	350	400	480	600	14.3	20.0	25.0
Toshiba	258	354	425	500	37.2	20.1	17.6
Samsung	200	250	300	400	25.0	20.0	33.3
Nokia	250	300	360	400	20.0	20.0	11.1
Total Surveyed Companies	**9,278**	**18,754**	**22,435**	**25,750**	**102.1**	**19.6**	**14.8**
Others (Estimated)	NA	NA	NA	NA	-	-	-
Total China/Hong Kong	**9,278**	**18,754**	**22,435**	**25,750**	**17.5**	**19.6**	**16.5**
Surveyed Companies' Share of Total (%)	NA	NA	NA	NA	-	-	-

NA = Not available
Source: Dataquest (August 1998)

Table 4-9
Central Office Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	13,668	16,059	19,207	22,376	26,135	30,186	34,714	17
Manufacturing Revenue ($M)	1,059	1,212	1,421	1,611	1,829	2,083	2,361	14
Manufacturing ASP ($)	78	76	74	72	70	69	68	-2
Semiconductor Content ($)	12	12	11	11	11	11	11	-3
Semiconductor TAM ($M)	160	193	216	242	274	317	364	14
Growth Rate of Unit (%)	-	17.5	19.6	16.5	16.8	15.5	15.0	-
Rate of Manufacturing ASP (%)	-	-2.6	-2.0	-2.7	-2.8	-1.4	-1.4	-
Growth Rate of Manufacturing Revenue (%)	-	14.5	17.2	13.4	13.6	13.9	13.3	-
Growth Rate of Semiconductor Content (%)	-	2.8	-6.2	-4.0	-2.8	0	0	-
Growth Rate of Semiconductor TAM (%)	-	20.8	12.2	11.8	13.6	15.5	15.0	-

TAM = Total available market
Source: Dataquest (August 1998)

Switching Competitive Environment

As of 1997, China had approved more than 43 manufacturers of commercial switching equipment, of which 12 were joint ventures with foreign suppliers. The number has continued to grow. Estimated capacity of the industry is more than 24 million lines per year. China's MPT plans to expand China's switching capacity to more than 200 million lines by 2002. The ninth five-year plan aimed at increasing program-controlled switching by 84 million by 2000. Long-distance switching is planned to reach 6 million accesses with customers exceeding 130 million. These figures represent a penetration rate of about 10 percent nationwide and between 30 percent and 40 percent in urban areas.

Huawei Technology Ltd.

Shenzhen-based Huawei Technology Ltd. is one of China's leading switching equipment manufacturers. The company has supplied switching equipment throughout China. In February, the company supplied 24,000 lines of switches attributed, in part, to China's efforts to localize exchange systems. China's ability to supply switching equipment has improved because of government's support, increased access to technology, and improved manufacturing productivity, as evidenced by Huawei's success.

Shandong Province

There are plans to build telephone exchanges with combined capacity of 1.5 million lines and 20,000-terminal long distance automatic telephone exchanges in the economically booming coastal Shandong province. The number of telephone customers will increase at least 1 million this year, thus providing an average of 6.5 telephones per 100 people in the province.

PBX Telephone Exchanges

Oki Electric Industry Company Limited announced in 1997 that it would set up its first joint venture in China with a telecommunications manufacturer, Guoguang Electronic Corp. Oki Electric has set up a joint venture, Changzhou OKI-GEG Telecoms Ltd., which makes PBX telephone

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exchanges and key telephone systems. Markets would include China, Europe, Oceania, Japan, and Southeast Asia. Oki Electric would hold a 70 percent stake in the venture, with Guoguang Electric holding the balance, and the Changzhou-based joint venture would be capitalized at $7.3 million. Guoguang Electric has been making key telephone and PBX systems for Oki Electric since 1995 and is the local distributor for PBXs.

Cordless Telephones

Southern China is the world's largest production base for cordless telephone. China/Hong Kong's cordless telephone industry will ship 23 million telephones in 1998, a 12 percent increase. Dataquest's survey of seven major manufacturers covered approximately 42 percent of China/Hong Kong's total cordless phone production in 1998. Table 4-10 lists the major manufacturers of cordless phones, their units, ranking, and production share. Uniden Electronics Products (Shenzhen) Co. Ltd. is the largest manufacturer of cordless phones in China/Hong Kong, with 28 percent share of production in 1998. Vtech Holdings Ltd. is the fastest-growing manufacturer in 1998 since it doubled production volume from 1.5 million units to 3.3 million units. Its production market share expanded from 10 percent to 16 percent.

Table 4-11 provides Dataquest's outlook on these manufacturers in 1998 and 1999. These manufacturers' strong growth is likely to continue in 1998, but it is expected to slow in 1999. These seven major manufacturers will expand by 42 percent in 1998, but they will slow to 24 percent in 1999. Uniden and Vtech will remain in their respective ranking and slow their expansion to about 16 percent in 1999 after growing an estimated 22 percent in 1998. Several new second-tier companies are adding significant capacity, which will take production share from the top two producers. Table 4-12 shows a forecast of China/Hong Kong's cordless telephone production forecast.

Table 4-10
Cordless Telephone Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Uniden	5400	5800	36.8	28.1	36.8	28.1
2	2	Vtech Holdings Ltd.	1450	3350	9.9	16.2	46.7	44.3
3	3	TCL	795	1000	5.4	4.8	52.1	49.1
5	4	Phone Star	NA	800	0	3.9	52.1	53.0
5	4	Sony	NA	800	0	3.9	52.1	56.9
5	6	XiaHua (Xoceco)	NA	200	0	1.0	52.1	57.9
4	7	Sanyo	28	38	0.2	0.2	52.3	58.0
		Others	6,994	8,668	47.7	42.0	-	-
		Total	**14,667**	**20,656**	**100**	**100**	-	-

Source: Dataquest (August 1998)

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Table 4-11
Cordless Telephone Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	1996	1997	1998	1999	1997	1998	1999
Uniden	5,400	5,800	7,100	8,250	7.4	22.4	16.2
Vtech Holdings Ltd.	1,450	3,350	4,800	5,500	131.0	43.3	14.6
TCL	795	1,000	1,500	2,000	25.8	50.0	33.3
Phone Star	NA	800	1,500	2,000	NA	87.5	33.3
Sony	NA	800	1,000	1,000	NA	25.0	0
Idall	NA	NA	500	1,000	NA	NA	100.0
XiaHua (Xoceco)	NA	200	500	800	NA	150.0	60.0
Sanyo	28	38	100	350	35.7	163.2	250.0
Siemens	NA	NA	10	100	NA	NA	900.0
Total Surveyed Companies	**7,673**	**11,988**	**17,010**	**21,000**	**56.2**	**41.9**	**23.5**
Others (Estimated)	6,994	8,668	6,072	3,804	23.9	-29.9	-37.4
Total China/Hong Kong	**14,667**	**20,656**	**23,082**	**24,804**	**40.8**	**11.7**	**7.5**
Surveyed Companies' Share of Total (%)	52	58	74	85	-	-	-

NA = Not available
Source: Dataquest (August 1998)

Table 4-12
Cordless Telephone Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	14,667	20,656	23,082	24,804	26,563	28,251	30,078	8
Manufacturing Revenue ($M)	752	1,048	1,218	1,332	1,448	1,504	1,478	7
Manufacturing ASP ($)	200	166	138	124	115	105	94	-11
Semiconductor Content ($)	117	99	83	82	80	80	79	-4
Semiconductor TAM ($M)	388	575	724	879	1,006	1,157	1,254	17
Growth Rate of Unit (%)	-	40.8	11.7	7.5	7.1	6.4	6.5	-
Rate of Manufacturing ASP (%)	-	39.3	16.3	9.4	8.7	3.9	-1.7	-
Growth Rate of Manufacturing Revenue (%)	-	-17.1	-16.8	-10.1	-7.3	-9.1	-10.5	-
Growth Rate of Semiconductor Content (%)	-	-15.4	-16.2	-1.8	-1.6	0	-1.8	-
Growth Rate of Semiconductor TAM (%)	-	48.0	26.0	21.3	14.5	15.0	8.4	-

TAM = Total available market
Source: Dataquest (August 1998)

The deceleration observed from Dataquest's company survey will continue after 1999 because of persistent overcapacity from overinvestments in 1996 and 1997. Dataquest's 1997-to-2002 CAGR is expected to reach 8 percent unit growth and 7 percent revenue increase. This semiconductor market segment will, however, experience substantial revenue growth, outpacing equipment unit and revenue growth by a large margin. Dataquest forecasts the cordless telephone semiconductor market to expand from $724 million in 1998 to $1.3 billion in 2002, which is a 17 percent CAGR. This is a highly competitive market in which manufacturers will differentiate their product on functionality, and thereby requiring higher-performance digital signal processors (DSPs), memory, and microcontrollers. Cordless phone customers have a particularly high expectation of performance, quality, and functionality.

Mobile Communications Infrastructure

Dataquest presents revenue estimates on three mobile communications infrastructure equipment manufacturers in Table 4-13. Nokia, Ericsson, and Siemens manufacture approximately 90 percent of the mobile communications equipment produced in China/Hong Kong. Nokia is the largest maker, with a 46 percent production market share. Table 4-14 provides production forecasts for these three manufacturers in 1998 and 1999. While 1997 and 1998 showed substantial growth—similar to cellular and pager trends—mobile communications equipment manufacturing expansion is expected to decelerate in 1999. Dataquest expects this segment's revenue to grow by 15 percent in 1999, after growing by 33 percent in 1998 and 40 percent in 1997.

Table 4-14 provides a forecast of these three manufacturers in 1998 and 1999. Both Nokia and Ericsson are slowing expansion growth in 1999 after several years of rapid expansion. Siemens is accelerating expansion from 20 percent in 1998 to 25 percent in 1999, but from a small revenue base of $24 million.

Table 4-15 presents Dataquest's 1997-to-2002 forecast for all of China/Hong Kong production and semiconductor consumption in this segment. Dataquest estimates that China/Hong Kong's $243 million production revenue in 1998 represents approximately $20 million in semiconductor consumption. By 2002, Dataquest forecasts revenue to reach a modest $366 million, which represents a semiconductor market of $28 million. At this time, most design wins are outside of China/Hong Kong, but by 2002, Dataquest expects most production and design wins to occur within China/Hong Kong.

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Table 4-13
Mobile Communications Infrastructure Equipment Manufacturers Production Share and Ranking, 1996 and 1997 (Millions of U.S. Dollars)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Nokia	63	85	48.8	46.4	48.8	46.4
2	2	Ericsson	41	61	32.3	33.6	81.1	80.0
3	3	Siemens	14	20	11.3	11.0	92.4	90.9
		Others	10	17	7.6	9.1	-	-
		Total	**128**	**183**	**100**	**100**	-	-

Source: Dataquest (August 1998)

Table 4-14
Mobile Infrastructure Equipment Manufacturers Production Revenue Forecast, 1996 to 1999

	Revenue ($M)				Growth (%)		
Company	1996	1997	1998	1999	1997	1998	1999
Ericsson	41	61	95	115	47.9	55.6	20.5
Nokia	63	85	102	110	35.2	20.1	8.2
Siemens	14	20	24	30	38.3	19.9	25.1
Total Surveyed Companies	**119**	**166**	**221**	**255**	**40.0**	**33.2**	**15.3**
Others (Estimated)	10	17	22	26	70.1	32.8	15.8
Total China/Hong Kong	**128**	**183**	**243**	**281**	**42.3**	**33.1**	**15.4**
Surveyed Companies' Share of Total (%)	92	91	91	91	-	-	-

Source: Dataquest (August 1998)

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Table 4-15
Mobile Communication Infrastructure Equipment Production Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	NA	NA	NA	NA	NA	NA	NA	NA
Manufacturing Revenue ($M)	128	183	243	281	315	341	366	15
Manufacturing ASP ($)	NA	NA	NA	NA	NA	NA	NA	NA
Semiconductor Content ($)	NA	NA	NA	NA	NA	NA	NA	NA
Semiconductor TAM ($M)	15	20	21	22	24	26	28	7
Growth Rate of Unit (%)	0	42.3	33.1	15.4	12.1	8.4	7.3	-
Rate of Manufacturing ASP (%)	NA	NA	NA	NA	NA	NA	NA	-
Growth Rate of Manufacturing Revenue (%)	0	42.3	33.1	15.4	12.1	8.4	7.3	-
Growth Rate of Semiconductor Content (%)	NA	NA	NA	NA	NA	NA	NA	-
Growth Rate of Semiconductor TAM (%)	0	28.6	6.5	6.5	7.5	7.3	8.4	-

NA = Not available
TAM = Total available market
Source: Dataquest (August 1998)

Corded Telephones

Dataquest sizes the corded phone industry at 99 million units in 1998, a 5 percent growth. Dataquest believes that China/Hong Kong will produce about 123 million corded telephones by 2002, which is a 5 percent CAGR from 1997 to 2002. This is a $349 million semiconductor opportunity (see Table 4-16). There are several hundred telephone manufacturers in China, and competition is acute. Telecommunications infrastructure in the vast rural areas of the country remains poor. Most of the telephones will be produced in Shanghai, Fujian province, and Guangdong province, with annual output in Guangdong's Huizhou city alone at 30 million in 1997.

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Table 4-16
Corded Telephone Production and Semiconductor Consumption Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	89,505	94,186	99,331	106,177	112,040	117,053	122,604	5
Manufacturing Revenue ($M)	2,107	2,051	2,034	2,046	2,064	2,072	2,078	0
Manufacturing ASP ($)	24	22	20	19	18	18	17	-5
Semiconductor Content ($)	3	3	3	3	3	3	3	2
Semiconductor TAM ($M)	226	240	258	281	303	322	349	8
Growth Rate of Unit (%)	-	5.2	5.5	6.9	5.5	4.5	4.7	-
Rate of Manufacturing ASP (%)	-	-7.5	-6.0	-5.9	-4.4	-3.9	-4.2	-
Growth Rate of Manufacturing Revenue (%)	-	-2.6	-0.9	0.6	0.9	0.4	0.3	-
Growth Rate of Semiconductor Content (%)	-	1.2	2.0	1.9	1.9	1.9	3.6	-
Growth Rate of Semiconductor TAM (%)	-	6.5	7.5	8.9	7.5	6.4	8.6	-

TAM = Total available market
Source: Dataquest (August 1998)

The Ministry of Posts of Telecommunications (MPT) predicted that 10 out of every 100 people will become telephone subscribers by the turn of the century. However, only about six out of every 100 people had a telephone services at the end of 1997. China's serious plans to raise its national telecommunications network capacity are formidable. To increase subscribers and meet a government plan, China will need 85 million telephone lines before 2000. China is on its way to achieving this goal, since about 17 million new telephone lines were installed in 1997. With more than 130 million telephones to be connected, 30 percent to 40 percent of urban residents are targeted to have a phone by 2000. China's urban population is estimated at 300 million to 400 million people, depending on whether or not suburbs are counted.

All Chinese rural villages are planned to be connected by phones during the Ninth Five-Year Plan period (1996 to 2000). The number of rural telephone customers is expected to increase annually by 6 million to 7 million, according to China's telecommunications departments. Because of high priority given to rural areas, China's rural telecommunications business—with a generally poorer economic base—has not been ignored. In fact, the rural installation rate has been steadily increasing in recent years (at a rate higher than in urban areas in 1995). In some economically thriving eastern regions, the number of customers in rural areas is increasing faster than in urban areas. However, in much of China's central and western regions, almost half of the villages still have no access to a telephone.

Fax Machines

Table 4-17 provides Dataquest's long-term forecast of facsimile machine production and semiconductor consumption. Like corded phones, fax machines are a mature market with overproduction and severe competition. Dataquest forecasts production to grow at a 6 percent CAGR from 841,000 units in 1997 to 1.1 million units in 2002. There are more than

20 fax machine manufacturers in China, but domestically made fax machines are of poor quality, compared with imported products. Hence, the domestic manufacturers import the fax thermal reading heads, scanners, and high-speed modems. The demand for fax machines has increased, as more telephones are installed and the switch capacity expands. Japanese products have dominated China's fax machine market and account for 80 percent of the imported fax machines, which occupy 90 percent of the domestic market. Demand for fax machines is expected to stand at 300,000 units in 1997.

Popular fax machine brands in China include Panasonic Communications and Systems Company, Canon Inc., and Oki Telecom. In 1997, more than 200,000 machines were approved in government projects, and about half were Panasonic products. Oki products have been widely used in railways, electronics, and public security sectors. Fax machines from Korean companies such as Samsung and Daewoo Telecommunications Company Ltd. have also expanded their market share in China with an edge on prices.

LAN Cards

China/Hong Kong's PC market boom has recently increased LAN market growth. Local manufacturers are entering the market and expanding production capacity. Table 4-18 presents Dataquest's 1997-to-2002 production and semiconductor consumption forecast for LAN cards. Of the 2.2 million PCs sold in China in 1997, nearly 100,000 units, or 40 percent, were sold as part of networks. Production in 1998 increased by 45 percent to 5.8 million units, representing a $41 million semiconductor market. Dataquest forecasts LAN card production to grow at a 22 percent CAGR from 4 million units in 1997 to 11 million units in 2002. Semiconductor consumption in LAN cards will reach $71 million by 2002.

Table 4-17
Facsimile Production and Semiconductor Consumption Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	791	841	921	963	1,011	1,076	1,136	6
Manufacturing Revenue ($M)	193	197	205	202	204	205	205	1
Manufacturing ASP ($)	245	234	222	210	202	191	180	-5
Semiconductor Content ($)	68	61	58	52	50	45	45	-6
Semiconductor TAM ($M)	53	51	53	50	51	48	51	0
Growth Rate of Unit (%)	0	6.4	9.5	4.5	5.0	6.5	5.5	-
Rate of Manufacturing ASP (%)	0	-4.3	-5.0	-5.8	-3.7	-5.4	-5.6	-
Growth Rate of Manufacturing Revenue (%)	0	1.8	4.1	-1.6	1.1	0.7	-0.4	-
Growth Rate of Semiconductor Content (%)	0	-9.6	-4.9	-10.3	-3.8	-10.0	0	-
Growth Rate of Semiconductor TAM (%)	0	-3.9	4.1	-6.3	1.0	-4.1	5.5	-

TAM = Total available market
Source: Dataquest (August 1998)

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Table 4-18
Local Area Network Card Production and Semiconductor Consumption Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	600.0	4,000.0	5,800.3	7,177.0	9,589.0	10,356.1	10,873.9	22
Manufacturing Revenue ($M)	12.9	76.8	100.9	116.3	143.8	148.1	145.7	14
Manufacturing ASP ($)	21.5	19.2	17.4	16.2	15.0	14.3	13.4	-7
Semiconductor Content ($)	9.0	7.0	7.0	6.8	6.8	6.6	6.5	-1
Semiconductor TAM ($M)	5.4	28.0	40.6	49.1	64.7	68.4	70.7	20
Growth Rate of Unit (%)	0	566.7	45.0	23.7	33.6	8.0	5.0	-
Rate of Manufacturing ASP (%)	0	-10.7	-9.4	-6.8	-7.5	-4.6	-6.3	-
Growth Rate of Manufacturing Revenue (%)	0	495.3	31.4	15.3	23.6	3.0	-1.6	-
Growth Rate of Semiconductor Content (%)	0	-22.4	-0.1	-2.1	-1.4	-2.2	-1.5	-
Growth Rate of Semiconductor TAM (%)	0	417.2	44.8	21.1	31.8	5.6	3.4	-

TAM = Total available market
Source: Dataquest (August 1998)

On the networking market front, networking companies are making a convincing case that China's attention has turned to networking equipment. Greater China—which includes China, Hong Kong, and Taiwan—emerged as the Cisco System Inc.'s largest market in Asia/Pacific (excluding Japan) as the fastest-growing sales region worldwide. Cisco's sales to greater China in fiscal 1997 climbed 120 percent over the previous fiscal year, with sales in mainland China jumping almost 280 percent.

In a multimillion dollar deal, Hong Kong-based China Internet Corp. (CIC) and the U.S. networking giant Bay Networks Inc. joined forces to set up a network of powerful Web servers that bring vital information to businesses in China. In January 1998, Bay Networks was chosen to provide the infrastructure for the project, dubbed the China Wide Web (CWW), which will place servers strategically located in more than 50 major cities across China. The first phase of the network, covering five major cities, is now being installed and was operational in the first quarter of 1997. Network control centers will be set up in Beijing and Hong Kong. The first CWW branch nodes will be in Shanghai, Shenyang, and Guangzhou. CIC has plans to add an additional five cities to the network each quarter, reaching a minimum of 20 cities by the end of the year. The Bay Networks System 5000 hubs are now shipping to the CWW's phase-one sites in Beijing, Hong Kong, Shanghai, and Guangzhou.

Following desktop computers and notebook computers, Philips Electronics NV recently announced to enter network market in Beijing. It also designated the Beijing Yasuo Network Technology Ltd. its general agent in mainland China. The first-released products include 10/100M PnP ISA/PCI/PCMCIA network card (NIC), 10M PnP PCMCIA FAX/MODEM/NIC card, 10M/100M concentrators (HUB), and exchangers.

China has leaped to become Digital Equipment Corporation's fastest-increasing market. Digital expected to expand its network market by 60 percent in China in 1997. Digital's network products will further tap the Chinese market, particularly the banking and financial market.

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Talking about exchange systems, Digital will put stress on school net exchange systems and long distance net systems. In addition, Digital will engage itself in developing new technology suitable for China's condition.

Modems

China's modem production in 1997 reached 575,000 units and is expected to grow 21 percent in 1998. Production is decelerating to 16 percent in 1999 and 14 percent in 2000. Semiconductor consumption is forecast to grow from $17 million in 1998 to $26 million in 2002, a 13 percent CAGR. Table 4-19 provides Dataquest's modem production and semiconductor consumption unit and revenue forecasts from 1997 to 2002.

Table 4-19
Local Area Network Card Production and Semiconductor Consumption Forecast, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	350	475	575	666	762	862	974	15
Manufacturing Revenue ($M)	33	42	48	52	56	60	65	9
Manufacturing ASP ($)	94	89	83	78	73	70	67	-6
Semiconductor Content ($)	32	30	29	28	27	27	27	-2
Semiconductor TAM ($M)	11	14	17	19	21	23	26	13
Growth Rate of Unit (%)	0	35.7	21.2	15.8	14.3	13.2	13.0	-
Rate of Manufacturing ASP (%)	0	-5.2	-6.9	-6.3	-6.2	-4.0	-4.5	-
Growth Rate of Manufacturing Revenue (%)	0	28.6	12.9	8.5	7.2	8.7	7.9	-
Growth Rate of Semiconductor Content (%)	0	-6.2	-3.3	-3.4	-3.6	-0.2	-0.4	-
Growth Rate of Semiconductor TAM (%)	0	27.2	17.2	11.8	10.2	13.0	12.5	-

TAM = Total available market
Source: Dataquest (August 1998)

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Chapter 5
Consumer Electronics Equipment

China/Hong Kong produced approximately 40 percent of Asia/Pacific's consumer electronic equipment in 1997 and approximately 13 percent of worldwide consumer electronics. Dataquest forecasts China/Hong Kong's consumer electronics production share in Asia/Pacific's to increase to 50 percent by 2002, and its share in the worldwide production to reach 19 percent 2002. However, this growth will need to come after a slowdown in 1998 and 1999. If digital consumer expands at a worldwide level as expected, then China/Hong Kong will meet this forecast. Otherwise, Dataquest expects a worst-case scenario in which production will grow at an 8 percent CAGR rather than the 12 percent Dataquest forecasts.

China/Hong Kong's large and rapidly-growing domestic market is the main factor behind China's high production level relative to other Asia/Pacific countries. Moreover, Japanese and Korean consumer manufacturers continue to shift production to China faster than to any other Asia/Pacific country. Dataquest expects China/Hong Kong to remain the main destination for these investments in the next five years. As discussed in Chapter 2, China/Hong Kong is now the Asia/Pacific growth center because of stronger economic fundamentals. Both exports and domestic consumption are maintaining reasonable growth even after the Asian financial crisis. However, Dataquest has observed that, at the same time, the new era of digital consumer is already showing up in China in the form of digital broadcasting and digital video compact disc (VCD) players. Figure 5-1 illustrates consumer electronics equipment production forecast for four major Asian countries.

Production Growth Sectors in Consumer Electronics

Figure 5-2 illustrates each market segment of China/Hong Kong's consumer electronics industry. Audio equipment is the largest of the five major segments with a $7.8 million revenue in 1998. Dataquest expects video equipment production to match or surpass audio by 2002 because of China's imminent expansion into digital consumer equipment and broadcast. In addition to audio's slow growth, Dataquest expects a personal electronics maturation on a revenue basis in China/Hong Kong. Personal electronics and audio equipment will expand at a 7 percent to 8 percent CAGR from 1997 to 2002, while video will expand by 12 percent.

Home appliance production is the fastest-growing segment of the consumer electronics industry. Production will reach $6.2 billion in 1998 and will expand at a 16 percent CAGR at $10 billion by 2002. Dataquest's outlook for continuous and expanding growth is tied mainly to the belief that the economy, as indicated by GDP, will average 6 percent to 8 percent growth during this period. New areas of economic development will absorb local production. Wealthier urban areas will continue to upgrade their to new gadgets, such as air conditioners, heaters, or dehumidifiers. Furthermore, Dataquest's survey of producers discovered a high percentage of exported consumer electronics production by multinational companies, as discussed later in the chapter.

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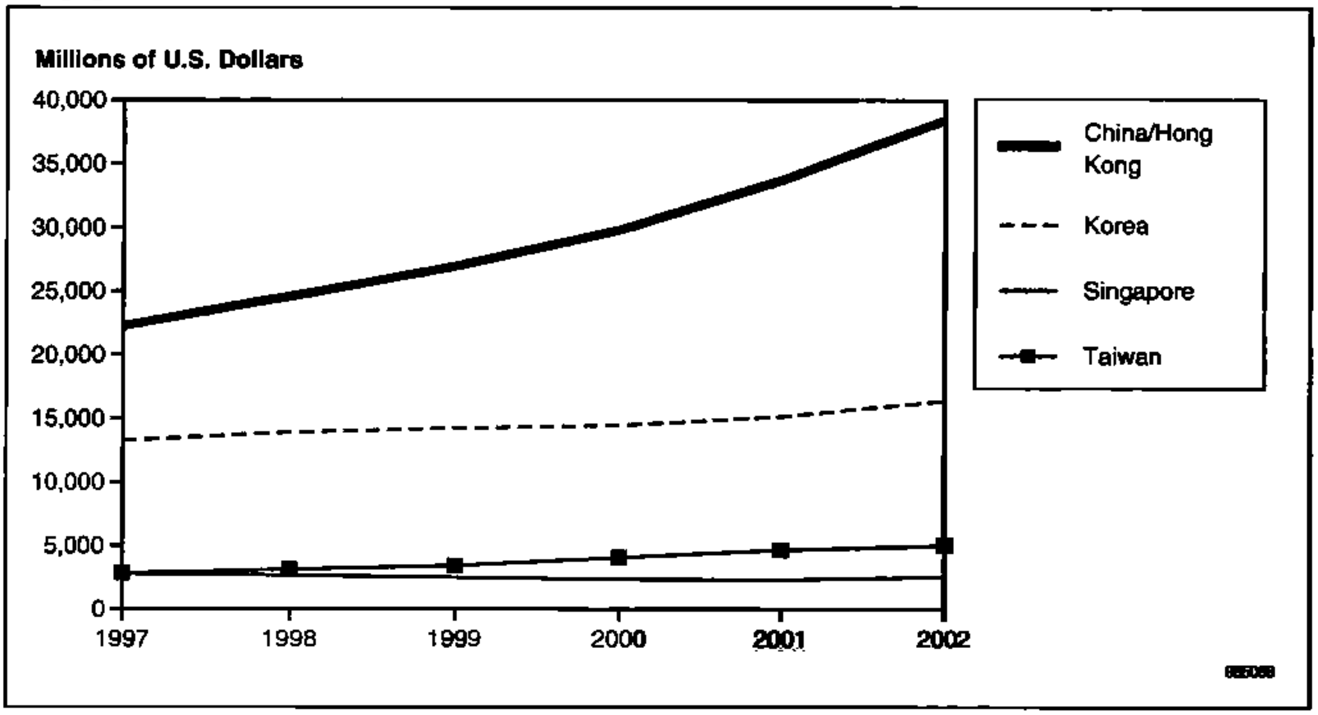
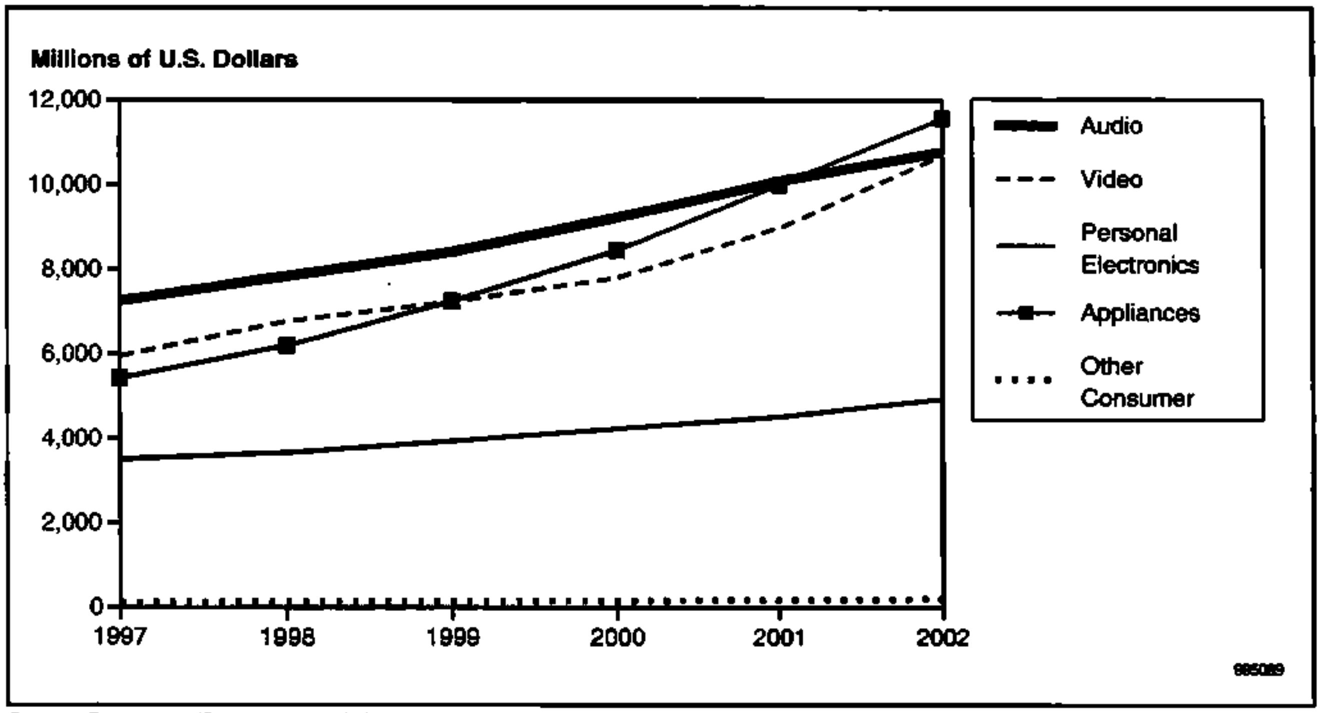
Figure 5-1
Consumer Electronic Equipment Production Forecast for China/Hong Kong, Korea, Singapore, and Taiwan: 1997 to 2002



Source: Dataquest (September 1998)

Figure 5-2
China/Hong Kong's Consumer Electronics Equipment Production Forecast by Segment, 1997 to 2002 (Millions of U.S. Dollars)



Source: Dataquest (September 1998)

Color Television Production Forecast

Dataquest's survey covered 14 major color television (CTV) manufacturers in China/Hong Kong, which combined to account for 85 percent of total production in 1997.

Table 5-1 lists these companies' unit output in ranking order according to production share. Changhong Electric Appliances Company is, by far, the industry leader, accounting for a whopping 28 percent of all China/Hong Kong CTV production. The company is the technology and manufacturing leader in China/Hong Kong, which is why it continues to gain production share as well as local market share. In China/Hong Kong, as elsewhere in the world, the large manufacturers are consolidating their leadership through superior operational efficiency from production to marketing and distribution. The top five manufacturers in China/Hong Kong control 64 percent of total production.

Table 5-2 provides Dataquest's company-level forecast for CTVs in 1998 and 1999. Dataquest sees a clear drop in industry output in 1998 and 1999 primarily attributed to worsening economic conditions in China/Hong Kong, rising unemployment, and consumer pessimism about future employment and the economic growth of China. Because Dataquest does not have 1997 data for all 14 companies, a comparison of the seven companies surveyed in 1996 and 1997 will be done instead. These seven manufacturers are estimated to have a combined annual production expansion of 40 percent in 1997. In 1998, these same seven companies are forecast to have only a 10 percent production, but Dataquest expects improvement in 1999 and forecasts a 15 percent year-on-year unit growth.

Table 5-1
Color Television Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Chang Hong	4,800	6,500	23.1	28.4	23.1	28.4
9	2	Konka	NA	3,200	0	14.0	23.1	42.4
2	3	Hitachi (FuRi)	1,550	2,160	7.5	9.4	30.6	51.9
3	4	Samsung	1,056	1,600	5.1	7.0	35.6	58.9
5	5	TCL	650	1,200	3.1	5.2	38.8	64.1
9	5	Shanghai GuangDian	NA	1,200	NA	5.2	38.8	69.4
4	7	Sanyo	740	1,000	3.6	4.4	42.3	73.7
9	7	XiaHua (Xoceco)	NA	1,000	NA	4.4	42.3	78.1
6	9	Toshiba	550	650	2.6	2.8	45.0	81.0
9	10	Panda	NA	610	NA	2.7	45.0	83.6
7	11	Philips	250	340	1.2	1.5	46.2	85.1
9	12	Sony	NA	50	NA	0.2	46.2	85.3
9	13	Sharp	NA	20	NA	0.1	46.2	85.4
8	14	Matsushita	120	NA	0.6	0	46.7	85.4
		Others	11,068	3,333	53.3	14.6	-	-
		Total	**20,784**	**22,863**	**100**	**100**	-	-

Source: Dataquest (August 1998)

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Table 5-2
Color Television Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	**1996**	**1997**	**1998**	**1999**	**1997**	**1998**	**1999**
Chang Hong	4,800	6,500	7,000	7,800	35.4	7.7	11.4
Konka	NA	3,200	4,500	5,500	NA	40.6	22.2
Hitachi (FuRi)	1,550	2,160	2,400	2,900	39.4	11.1	20.8
Samsung	1,056	1,600	1,920	2,150	51.5	20.0	12.0
Shanghai GuangDian	NA	1,200	1,500	1,800	NA	25.0	20.0
TCL	650	1,200	1,200	1,500	84.6	0	25.0
Sanyo	740	1,000	1,200	1,500	35.1	20.0	25.0
XiaHua (Xoceco)	NA	1,000	1,000	1,500	NA	0	50.0
Toshiba	550	650	760	850	18.2	16.9	11.8
Panda	NA	610	600	700	NA	-1.6	16.7
Philips	250	340	408	550	36.0	20.0	34.8
Sharp	NA	20	150	250	NA	650.0	66.7
Sony	NA	50	90	150	NA	80.0	66.7
Matsushita	120	NA	NA	NA	-100.0	NA	NA
Total Surveyed Companies	**9,716**	**19,530**	**22,728**	**27,150**	**101.0**	**16.4**	**19.5**
Others (Estimated)	11,068	3,333	4,021	4,816	-69.9	20.7	19.7
Total China/Hong Kong	**20,784**	**22,863**	**26,749**	**31,966**	**10.0**	**17.0**	**19.5**
Surveyed Companies' Share of Total (%)	47	85	85	85	-	-	-

NA = Not available
Source: Dataquest (August 1998)

Color television production represented approximately 55 percent of the consumer video segment (as illustrated in Figure 5-2) in 1997 and will grow to a 67 percent share by 2002. Dataquest has mentioned that consumer video is forecast to grow by 12 percent from $6 billion in 1997 to $11 billion in 2002. Color television factory revenue is forecast to grow at a 17 percent CAGR, from $3 billion in 1997 to $7.1 billion in 2002. Semiconductor consumption in the CTV market segment will grow from $400 million in 1997 to $1.2 billion in 2002, a 23 percent CAGR (see Table 5-3).

The relatively large proportion of multinational manufacturers, with the exception of Changhong, adds to China's production prowess in that a large percent of CTVs are exported. Dataquest expects export success to help boost the industries' long-term growth, and the government will likely support about five major manufacturers by providing export incentives.

Table 5-3
Color Television Production and Semiconductor Consumption Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	20,784	22,863	26,749	31,966	38,391	46,069	52,979	18
Manufacturing Revenue ($M)	3,014	3,247	3,745	4,443	5,298	6,265	7,152	17
Manufacturing ASP ($)	145	142	140	139	138	136	135	-1
Semiconductor Content ($)	17	18	20	20	20	21	22	4
Semiconductor TAM ($M)	362	412	546	652	783	986	1,176	23
Growth Rate of Unit (%)	-	10.0	17.0	19.5	20.1	20.0	15.0	-
Rate of Manufacturing ASP (%)	-	-2.1	-1.4	-0.7	-0.7	-1.4	-0.7	-
Growth Rate of Manufacturing Revenue (%)	-	7.7	15.4	18.6	19.2	18.3	14.2	-
Growth Rate of Semiconductor Content (%)	-	3.5	13.3	0	0	4.9	3.7	-
Growth Rate of Semiconductor TAM (%)	-	13.8	32.6	19.5	20.1	25.9	19.3	-

TAM = Total available market
Source: Dataquest (August 1998)

Video Compact Disc Players (VCDs)

Table 5-4 presents the 10 large VCD manufacturers' units and production share in 1996 and 1997, which combined to account for 68 percent of China's total unit output in 1997.

China's VCD player market follows a typical product life cycle: It has gone through the introduction stage and high-growth stage and is now approaching the maturity stage. The declining stage will start in 1999 when DVD players begin to penetrate the market.

Table 5-4
Video Compact Disk (VCD) Player Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Jiangsu Shinco	900	3,200	15.7	21.8	15.7	21.8
2	2	Idall	450	1,930	7.8	13.2	23.5	35.0
3	3	Fujian Malata	300	1,350	5.2	9.2	28.7	44.2
4	4	Philips	185	820	3.2	5.6	31.9	49.8
7	4	Xiamen Xiaxin	-	820	0	5.6	31.9	55.4
6	6	LG	56	650	1.0	4.4	32.9	59.8
5	7	Samsung	150	420	2.6	2.9	35.5	62.7
7	8	Chang Hong	-	400	0	2.7	35.5	65.4
7	9	Konka	-	300	0	2.0	35.5	67.5
7	10	Sharp	-	50	0	0.3	35.5	67.8
		Others	3,709	4,720	64.5	32.2	-	-
		Total	5,750	14,660	100	100	-	-

Source: Dataquest (August 1998)

At the current maturity stage, manufacturers are competing on prices to achieve volume and fighting for market shares. Efforts are being put into efficiency and cost reduction. Meanwhile, market leaders such as Jiangsu province's Jiangsu Shinco Electronic Group Company and Guangdong Idall Co. Ltd. are advertising heavily to emphasize brand differentiation and special product features. Manufacturers extend the product life by means of incorporating more functions into their VCD players. Built-in karaoke functions are now a standard. Other choices are integrated VCD hi-fi systems, multidisk changers, and two-in-one TV/VCD sets. There are also many manufacturers that are concerned with improving the picture quality. Table 5-5 presents China/Hong Kong's VCD production forecast by vendor.

The top five VCD player makers are all Chinese brands; they combine to account for 53.6 percent of the total VCD player market. About one-fifth of this market is occupied by the largest market leader, Jiangsu Province's Shinco. The top three manufacturers occupy nearly half of the overall player market.

In view of the VCD player market's explosive growth, many manufacturers want to share the piece of the pie that belongs to the leading manufacturers. The television giant, Changhong Electronic Group Co., has planned to expand its VCD player production capacity from 400,000 units to 3 million units in 1998.

Taiwanese makers are also eyeing China's VCD player market. The Acer Group and Sampo Corporation are both supplying VCD technology and OEM kits to their Chinese partner for assembly. Their ultimate goal, however, is to make and distribute DVD players to this market.

Table 5-5
VCD Player Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	**1996**	**1997**	**1998**	**1999**	**1997**	**1998**	**1999**
Chang Hong	0	400	800	700	-	100.0	-12.5
Konka	0	300	800	950	-	166.7	18.8
Samsung	150	420	460	500	180.0	9.5	8.7
Philips	185	820	984	500	343.2	20.0	-49.2
Sharp	0	50	150	100	-	200.0	-33.3
LG	56	650	800	500	1,060.7	23.1	-37.5
Jiangsu Shinco	900	3,200	2,800	2,000	255.6	-12.5	-28.6
Idall	450	1,930	2,000	1,800	328.9	3.6	-10.0
Fujian Malata	300	1,350	1,500	1,000	350.0	11.1	-33.3
Xiamen Xiaxin	0	820	984	600	-	20.0	-39.0
Total Surveyed Companies	**2,041**	**9,940**	**11,278**	**8,650**	**387.0**	**13.5**	**-23.3**
Others (Estimated)	3,709	4,720	7,206	8,750	27.3	52.7	21.4
Total China/Hong Kong	**5,750**	**14,660**	**18,484**	**17,400**	**155.0**	**26.1**	**-5.9**
Surveyed Companies' Share of Total (%)	35	68	61	50	-	-	-

Source: Dataquest (August 1998)

Table 5-6 presents Dataquest's long-term forecast of China/Hong Kong's VCD production, which shows accelerating growth and then decline because of maturation and the introduction of DVD replacement technology. CCD players have been proliferating in the Chinese market for some simple reasons. The hardware is cheap and simple in technology. VCD players combine CD players with a MPEG decoder to produce acceptable video-playing capabilities. The majority of manufacturers get key components from a few suppliers: Sony Corporation and Philips for CD mechanisms, and C-Cube Microsystems Inc. and ESS Technology Inc. for decoding chips.

The proliferation of private software has fueled the demand for China's VCD market. The intellectual-copyright concept is still weakly understood among Chinese consumers. They can easily get low-cost pirate software or even rent VCD movies at a cost below U.S.$1 in some cities. The third reason is the lack of an installed base of VCRs and audio CDs in China. The popularity of color TV and karaoke among the Chinese has also contributed to the strong demand of VCD players.

In terms of the substitution by DVD players, the price and software gap will lengthen the time needed for DVD players to take off in the market. Although DVD players provide consumers with high-quality pictures and sounds, better performance, and a wider range of features, Chinese consumers do not currently have the purchasing power to buy them. The higher price is not the only barrier for DVD players to enter the China market. Consumers are concerned about the limited availability of DVD titles that cost much more than VCD titles. Also, the existing color television sets, limited by 350-line, cannot produce a high-resolution effect required by DVD players.

On the other hand, the DVD player emergence will encourage VCD player manufacturers to improve the quality of their VCD products. Because of the backward compatibility of DVD players, VCD software will still prevail, unless DVD titles' prices can match. VCD players will be able to survive in the presence of DVD players until 2001 when a precipitous decline is expected.

Table 5-6
VCD Player Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	5,750	14,660	18,484	17,400	15,200	11,050	5,690	-17
Manufacturing Revenue ($M)	1,208	1,847	1,867	1,340	1,064	751	415	-26
Manufacturing ASP ($)	210	126	101	77	70	68	73	-10
Semiconductor Content ($)	59	30	24	19	17	15	17	-11
Semiconductor TAM ($M)	336	437	444	325	255	168	94	-26
Growth Rate of Unit (%)	-	155.0	26.1	-5.9	-12.6	-27.3	-48.5	-
Rate of Manufacturing ASP (%)	-	-40.0	-19.8	-23.8	-9.1	-2.9	7.4	-
Growth Rate of Manufacturing Revenue (%)	-	53.0	1.1	-28.2	-20.6	-29.4	-44.7	-
Growth Rate of Semiconductor Content (%)	-	-49.1	-19.5	-22.2	-10.0	-9.5	8.6	-
Growth Rate of Semiconductor TAM (%)	-	29.9	1.5	-26.8	-21.4	-34.2	-44.1	-

TAM = Total available market
Source: Dataquest (August 1998)

Video Cassette Recorders (VCR)

Table 5-7 presents Dataquest's list of surveyed VCR manufacturers and their respective production volume and industry share. Dataquest's survey of five manufacturers represents 42 percent of combined production units. These companies appear to be increasing production share, while smaller manufacturers are exiting the market.

Table 5-8 presents these five manufacturers' 1998 and 1999 production plans. The VCR industry is a mature but lingering market. Slow growth but large-scale production is sustained by a large infrastructure of inexpensive tapes and demand from remote regions where VCDs and media are not readily available. Nevertheless, because of China's population advantage, there will be growth, but less than 4 percent in units for the next five years. In addition, revenue is expected to contract (see Table 5-9).

Table 5-7
VCR Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
1	1	Samsung	750	980	19.4	21.3	19.4	21.3
2	2	LG	580	650	15.0	14.2	34.5	35.5
3	3	Matsushita	124	150	3.2	3.3	37.7	38.8
4	4	Sanyo	75	85	1.9	1.9	39.6	40.6
5	5	Philips	65	80	1.7	1.7	41.3	42.4
		Others	2,264	2,646	58.7	57.6	-	-
		Total	**3,858**	**4,591**	**100**	**100**	-	-

Source: Dataquest (August 1998)

Table 5-8
VCR Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	1996	1997	1998	1999	1997	1998	1999
Samsung	750	980	1,176	800	30.7	20.0	-32.0
Sanyo	75	85	102	128	13.3	20.0	25.5
Philips	65	80	96	80	23.1	20.0	-16.7
Matsushita	124	150	165	150	21.0	10.0	-9.1
LG	580	650	700	750	12.1	7.7	7.1
Total Surveyed Companies	**1,594**	**1,945**	**2,239**	**1,908**	**22.0**	**15.1**	**-14.8**
Others (Estimated)	2,264	2,646	3,385	4,042	16.9	27.9	19.4
Total China/Hong Kong	**3,858**	**4,591**	**5,624**	**5,950**	**19.0**	**22.5**	**5.8**
Surveyed Companies' Share of Total (%)	41	42	40	32	-	-	-

Source: Dataquest (August 1998)

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Table 5-9
VCR Camcorder Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	3,858	4,591	5,624	5,950	6,081	5,881	5,498	4
Manufacturing Revenue ($M)	588	665	773	792	777	722	648	-1
Manufacturing ASP ($)	152	145	137	133	128	123	118	-4
Semiconductor Content ($)	30	32	32	31	30	31	30	-1
Semiconductor TAM ($M)	118	149	180	185	185	181	166	2
Growth Rate of Unit (%)	0	19.0	22.5	5.8	2.2	-3.3	-6.5	-
Rate of Manufacturing ASP (%)	0	-4.9	-5.2	-3.2	-4.1	-3.9	-4.0	-
Growth Rate of Manufacturing Revenue (%)	0	13.2	16.2	2.5	-2.0	-7.0	-10.3	-
Growth Rate of Semiconductor Content (%)	0	6.4	-1.3	-2.6	-2.4	1.3	-2.0	-
Growth Rate of Semiconductor TAM (%)	0	26.6	20.9	3.1	-0.2	-2.1	-8.3	-

TAM = Total available market
Source: Dataquest (August 1998)

Personal Stereo

Personal/portable stereo production of $655 million in 1997 accounted for only 9 percent of total audio equipment production in China/Hong Kong. Dataquest's survey of personal stereo manufacturers represented only 2.9 percent of total personal/portable stereo equipment production in this highly dispersed market segment. Personal stereo was one of the earliest consumer electronics markets to grow since China's economic reform and "open door" policy took hold in mid-1980s. Now this market is plagued by overcapacity and efficient state-owned enterprises that will undergo consolidation in the next five years. Table 5-10 shows personal/portable stereo manufacturers' ranking and market share in China/Hong Kong.

Table 5-10
Personal / Portable Stereo Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

Rank 1996	Rank 1997	Company	1996	1997	Production Share (%) 1996	Production Share (%) 1997	Accumulated Share (%) 1996	Accumulated Share (%) 1997
2	1	Samsung	80	300	0.3	0.9	0.3	0.9
1	1	Matsushita	300	300	1.0	0.9	1.2	1.8
4	3	LG	70	200	0.2	0.6	1.5	2.4
2	4	Philips	80	100	0.3	0.3	1.7	2.7
5	5	Sanyo	38	56	0.1	0.2	1.8	2.9
6	6	Sharp	-	10	0	0	1.8	2.9
		Others	30,307	32,132	98.2	97.1	-	-
		Total	**30,875**	**33,098**	**100**	**100**	-	-

Source: Dataquest (August 1998)

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Table 5-11 presents 1998 and 1999 forecasts for these major multinational vendors. Samsung and LG Electronics are the only two companies that expanded in 1997, while the others' production remained flat. Most manufacturers show a clear slowing trend in 1998 and 1999 because of difficult market conditions.

Dataquest's long-term industry outlook is shown in Table 5-12. Dataquest expects personal and portable stereo shipments to grow approximately 5 percent in the next five years, like other mature electronics equipment markets in China. China/Hong Kong's estimated 33 million units will increase at a rate slower than GDP growth to 42 million units in 2002. Semiconductor consumption in this segment will climb only 3 percent from $200 million in 1998 to $260 million in 2002.

Camcorders

Analog camcorders are providing new growth opportunities for consumer electronic equipment manufacturers in China/Hong Kong. Dataquest's survey of Sony and Hitachi Ltd. found that these multinational manufacturers are rapidly expanding production capacity in China/Hong Kong and are taking advantage of the local market to absorb their production. As shown in Table 5-13, both companies rapidly expanded production in 1997, by a whopping 350 percent, from 78,000 units in 1996 to 275,000 in 1997. Dataquest estimates that this combined production volume represents 94 percent of total personal and portable stereo production.

Table 5-11
Personal/Portable Stereo Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	**1996**	**1997**	**1998**	**1999**	**1997**	**1998**	**1999**
Matsushita	1,958	2,310	2,772	2,800	18.0	20.0	1.0
Philips	600	750	900	1,000	25.0	20.0	11.1
Sanyo	545	650	780	850	19.3	20.0	9.0
LG	450	650	780	850	44.4	20.0	9.0
Total Surveyed Companies	**3,553**	**4,360**	**5,232**	**5,500**	**22.7**	**20.0**	**5.1**
Others (Estimated)	27,322	28,738	28,925	30,877	5.2	0.7	6.7
Total China/Hong Kong	**30,875**	**33,098**	**34,157**	**36,377**	**7.2**	**3.2**	**6.5**
Surveyed Companies' Share of Total (%)	12	13	15	15	-	-	-

Source: Dataquest (August 1998)

Table 5-12
Personal/Portable Stereo Production Forecast in China/Hong Kong, 1996 to 2002

	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Units (K)	30,875	33,098	34,157	36,377	38,269	40,259	42,272	5
Manufacturing Revenue ($M)	960	1,036	1,093	1,182	1,263	1,349	1,437	7
Manufacturing ASP ($)	31	31	32	33	33	34	34	2
Semiconductor Content ($)	6	6	6	6	6	6	6	-2
Semiconductor TAM ($M)	186	199	205	201	213	224	232	3
Growth Rate of Unit (%)	-	7.2	3.2	6.5	5.2	5.2	5.0	-
Rate of Manufacturing ASP (%)	-	0.7	2.2	1.6	1.5	1.5	1.5	-
Growth Rate of Manufacturing Revenue (%)	-	7.9	5.5	8.2	6.8	6.8	6.6	-
Growth Rate of Semiconductor Content (%)	-	0.1	-0.5	-7.7	0.9	-0.3	-1.1	-
Growth Rate of Semiconductor TAM (%)	-	7.3	2.7	-1.7	6.1	4.9	3.8	-

TAM = Total available market
Source: Dataquest (August 1998)

Table 5-13
Analog Camcorder Manufacturers Production Share and Ranking, 1996 and 1997 (Thousands of Units)

					Production Share (%)		Accumulated Share (%)	
Rank 1996	Rank 1997	Company	1996	1997	1996	1997	1996	1997
2	1	Sony	35	200	42.6	68.4	42.6	68.4
1	2	Hitachi	43	75	52.3	25.7	94.9	94.1
		Others	4	17	5.1	5.9	-	-
		Total	82	292	100	100	-	-

Source: Dataquest (August 1998)

Table 5-14 provides Sony's and Hitachi's production outlook in 1998 and 1999, which is leveling off after 1997's surge in capacity. Sony will expand unit production from 220,000 units per year to 260,000 units per year in 1999, a 14 percent growth rate. Hitachi will expand from 90,000 units in 1998 to about 120,000 units in 1999, a 33 percent growth rate.

For the long term, China/Hong Kong's camcorder production will surge because of a strong market demand, and Dataquest expects new manufacturers to enter this industry after technology becomes readily available. Table 5-15 provides Dataquest's long-term forecast of camcorder production and semiconductor consumption from 1997 to 2002.

Table 5-14
Analog Camcorder Manufacturers Production Unit Forecast, 1996 to 1999

	Units (K)				Growth (%)		
Company	**1996**	**1997**	**1998**	**1999**	**1997**	**1998**	**1999**
Sony	35	200	220	250	471.4	10.0	13.6
Hitachi	43	75	90	120	74.4	20.0	33.3
Total Surveyed Companies	**78**	**275**	**310**	**370**	**252.6**	**12.7**	**19.4**
Others (Estimated)	4	17	27	33	313.8	57.7	19.9
Total China/Hong Kong	**82**	**292**	**337**	**403**	**255.7**	**15.4**	**19.4**
Surveyed Companies' Share of Total (%)	95	94	92	92	-	-	-

Source: Dataquest (August 1998)

Table 5-15
Analog Camcorder Production Forecast in China/Hong Kong, 1996 to 2002

	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**CAGR (%) 1997 to 2002**
Units (K)	82	292	337	403	498	601	688	19
Manufacturing Revenue ($M)	32	107	110	126	151	177	200	13
Manufacturing ASP ($)	388	365	326	312	303	296	290	-4
Semiconductor Content ($)	120	89	81	75	68	65	62	-7
Semiconductor TAM ($M)	10	26	27	30	34	39	42	10
Growth Rate of Unit (%)	-	255.7	15.4	19.4	23.7	20.5	14.6	-
Rate of Manufacturing ASP (%)	-	-5.8	-10.7	-4.2	-3.2	-2.3	-1.8	-
Growth Rate of Manufacturing Revenue (%)	-	235.0	3.1	14.4	19.8	17.7	12.6	-
Growth Rate of Semiconductor Content (%)	-	-26.1	-8.7	-8.0	-9.3	-4.5	-4.9	-
Growth Rate of Semiconductor TAM (%)	-	162.9	5.3	9.9	12.2	15.1	9.0	-

TAM = Total available market
Source: Dataquest (August 1998)

Appendix A
Exchange Rates

Table A-1
Foreign Currency per U.S. Dollar, 1997 and 1998

Country	Annual Average 1997	Preliminary Annual Average 1998	U.S. $ Appreciation (%) 1998	Projected Rate 1999+
Country	1997	1998	1998	1999+
Australia (Dollar)	1.35	1.58	17.31	1.62
Austria (Schilling)	12.20	12.68	3.91	12.65
Belgium (Franc)	35.79	37.18	3.88	37.07
Canada (Dollar)	1.38	1.46	5.62	1.49
China (Renminbi)	8.32	8.31	-0.12	8.31
Denmark (Krone)	6.61	6.87	3.96	6.85
European Monetary Union (ECU)	0.89	0.91	3.01	0.91
Finland (Markka)	5.19	5.47	5.42	5.47
France (Franc)	5.84	6.04	3.51	6.03
Germany (Mark)	1.73	1.80	3.92	1.80
Great Britain (Pound)	0.61	0.61	-0.55	0.61
Greece (Drachma)	273.11	300.28	9.95	299.35
Hong Kong (Dollar)	7.74	7.75	0.05	7.75
India (Rupee)	36.36	41.35	13.70	42.61
Ireland (Punt)	0.66	0.72	8.69	0.71
Italy (Lira)	1,703.02	1,776.50	4.31	1,772.42
Japan (Yen)	121.10	136.35	12.59	140.79
Malaysia (Ringgit)	2.82	4.04	43.38	4.16
Mexico (Peso)	7.92	8.72	10.16	8.90
Netherlands (Guilder)	1.95	2.03	4.08	2.03
New Zealand (Dollar)	1.51	1.86	23.19	1.93
Norway (Krone)	7.08	7.58	7.05	7.62
Portugal (Escudo)	175.35	184.43	5.18	183.93
Singapore (Dollar)	1.49	1.68	13.30	1.71
South Africa (Rand)	4.61	5.65	22.52	6.23
South Korea (Won)	954.14	1,398.99	46.62	1,295.76
Spain (Peseta)	146.45	152.91	4.41	152.58
Sri Lanka (Rupee)	59.02	64.54	9.35	65.91
Sweden (Krona)	7.64	7.96	4.12	7.99
Switzerland (Franc)	1.45	1.50	3.33	1.51
Taiwan (Dollar)	28.79	33.91	17.79	34.39
Thailand (Baht)	31.07	42.44	36.59	41.30

NA = Not tracked until 1996
NM = Not meaningful
Source: Dataquest (August 1998)

Appendix B
Telephone Manufacturing

Table B-1
Telephone Manufacturing Sino-Foreign Joint Ventures: Initial Capital, Partner, Products, and Start Date

Foreign-China Joint Ventures	Initial Investment, Partners, and Products
Alcatel Telecom	
Alcatel Shenyang Telecommunications Co. Ltd.	$4.8 million, set up on December 28, 1993; Shenyang Telecom Bureau and Hong Kong Alcatel (China) Co. Ltd.; wired and wireless telephones.
Fujian Alcatel Communications Technology Co. Ltd.	$4.5 million, established on March 28, 1996; Fujian Bamin Telecom Liability Ltd. Co. and Alcatel (China) Co. Ltd.; wired and wireless telephones.
Shanghai Bell Alcatel Mobile Communications System Co. Ltd.	$8 million, set up on December 21, 1994; Shanghai Bell Telephone Equipment Manufacturing Co. Ltd. and Alcatel (China) Co. Ltd.; GSM telephone handsets.
AT&T Corporation	
AT&T Consumer Telecom Products Beijing Ltd.	$4 million, established in December 1994; PTIC's Zhongxun P&T Technology Service Center and AT&T International Corp.; wired and cordless Telephones, answering machines, facsimile, and video phones.
Casio Computer Company Ltd.	
Casio-Langchao Communications & Electronics Co. Ltd.	$7.5 million, set up on December 16, 1993; Langchao Electronics Information Industry Group Corp. and Casio Computer Corp.; numeric and Chinese display pagers.
Shanghai Guomai-Casio Telecommunications Co. Ltd.	$1.54 million, set up on February 1, 1994; Shanghai Guomai United Co. Ltd. and Casio Computer Corp.; numeric and Chinese display paging equipment.
Ericsson	
Beijing Ericsson Mobile Communications Co. Ltd.	$13 million, established on August 8, 1995; PTIC and Ericsson; TACS, GSM, and DECT handsets.
Guangzhou Ericsson Communications Co. Ltd.	$7 million, set up on March 18, 1993; Guangzhou Radio Group Corp. and Ericsson Wireless System Corp.; wireless telephone handsets.
Nanjing Ericsson Communications Co. Ltd.	$20.9 million, set up on September 3, 1992; Nanjing Radio Factory and Ericsson; TACS telephones.
Fujitsu Ltd.	
Nanjing Fujitsu Telecommunications Equipment Co. Ltd.	$9 million, established on March 18, 1992; Nanjing Wire Telecom Plant and Fujitsu Corp.; analog and digital mobile telephones.
Matsushita Communications Industry Co. Ltd.	
Beijing Matsushita Communications Equipment Co. Ltd.	$9.43 million, established on May 30, 1992; PTIC, PTIC Beijing Company, Beijing Telecom Components Factory and Matsushita Corp.; TACS, GSM, CDMA, PHS, cordless telephones and pagers.

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Table B-1 (Continued)
Telephone Manufacturing Sino-Foreign Joint Ventures: Initial Capital, Partner, Products, and Start Date

Foreign-China Joint Ventures	Initial Investment, Partners, and Products
Motorola Incorporated	
Motorola (China) Electronics Co. Ltd.—Tianjin	$120 million, established on June 9, 1992; TACS, GSM, CDMA, wireless trunk mobile telephone handsets, and pagers.
Hangzhou Telecommunications Equipment Factory of the MPT	Technology transfers from Motorola in 1992; analog and digital mobile telephone handsets.
Hangzhou Motorola Cellular Systems Co. Ltd.	Started production on January 20, 1997; MPT's Hangzhou Telecom Equipment Factory and Motorola's Asia/Pacific Cellular Infrastructure Group; CDMA telephones.
NEC Corporation	
TCL Mobile Communications Equipment Co. Ltd.	$5 million, set up on December 31, 1993; TCL Telecom Equipment Liability Ltd. Co. and NEC Hong Kong Co. Ltd.; NEC series pager.
Tianjin NEC Telecommunications Engineering Co. Ltd.	$6.5 million, established on December 7, 1989; Tianjin Urban Telephone Bureau, Tianjin Long-Distance Telecom Bureau, Tianjin P&T Appliance Corp. and NEC; PHS customer premises equipment.
Wuhan NEC Zhongyuan Mobile Communications Co. Ltd.	$7 million, set up in December 1993; Zhongyuan Radio Factory, Yangtze Optical Telecom Industry Group and NEC; TACS and GSM handsets.
Nokia Telecommunications	
Beijing Nokia Mobile Communications Co. Ltd.	$20 million, established on March 13, 1995; MPT's Beijing Telecom Equipment Factory and Nokia Mobile Telephone Co. Ltd.; E-TACS, GSM, and CDMA telephone handsets.
Dongguan Nokia Mobile Phones Co. Ltd.	$10 million, set up on May 8, 1995; Dongguan Telecom Development General Corp. and Nokia Mobile Telephone Co. Ltd.; mobile telephone handsets.
Samsung	
Shanghai Samsung Kangcheng Communications Equipment Co. Ltd.	$9.5 million, established in December 1995; Shanghai Kangcheng Telecom Equipment Co. Ltd. and Samsung Electronics Corp.; CDMA telephone handsets.
Siemens AG	
Siemens Shanghai Communications Terminals Ltd.	6 million marks, set up on May 11, 1995; Shanghai Guangdian Liability Ltd. Co. and Siemens Corp.; wired, wireless, and cordless telephones.
Siemens Shanghai Mobile Communications Co. Ltd.	60 million marks, established on May 11, 1993; Shanghai Guangdian Liability Ltd. Co., Shanghai P&T Administration Bureau, MPT's No. 1 Research Institute and Siemens Corp.; GSM S4 Series telephone handsets.
Others	
Changchun Jida Telecommunications Technology Co. Ltd.	$12 million, set up on October 12, 1992; Jilin Experimental Technology Development Co. Ltd. Co. and US Suda International Resources Co.; wireless telephones.
Shanghai MTC Telecommunications Equipment Co. Ltd.	$4 million, established in March 1993; Shanghai Broadcasting Appliance Factory. PTIC Shanghai Company, Shanghai Shenhang Import and Export Co. and Canada MTC; wireless telephone handsets.
Tianjin SANYO Telecommunications Equipment Co. Ltd.	$1 million, established in April 1995; Tianjin Telephone Equipment Factory and SANYO Electronics and Machines Corp.; wired and wireless telephones.

Source: China's Ministry of Posts and Telecommunications (MPT) and Dataquest (August 1998)

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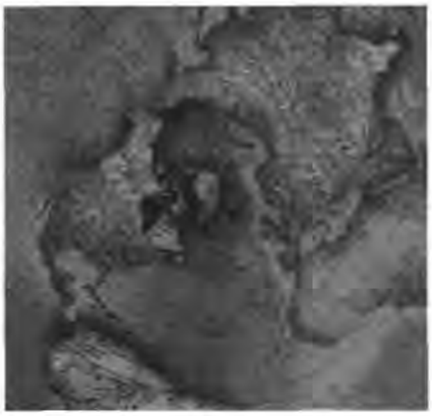

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An Analysis of the China/Hong Kong Semiconductor Markets: Suppliers, Drivers, and Forecasts

Market Trends

FILE COPY:
MARIA VALENZUELA

Program: Semiconductors China
Product Code: SEMI-CH-MT-9801
Publication Date: August 10, 1998
Filing: Market Trends

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Chapter 1
Executive Summary

The purpose of this Market Trends report is to provide a comprehensive view of the semiconductor product markets in China/Hong Kong and their outlook from 1998 to 2002. Dataquest has provided an in-depth analysis of key market trends from 1993 to 1997, including its final 1997 market share ranking.

Dataquest believes that the major conclusions of this China/Hong Kong semiconductor market study are as follows:

- Final vendor and market estimates indicate that the China/Hong Kong semiconductor market grew 19.5 percent to $6,769 million in 1997, for a growth rate nearly double that of Asia/Pacific.
- Texas Instruments Inc. (TI) was the fastest-growing company among the top 10 vendors because of its strength in digital signal processor (DSP) and analog shipments. A 39 percent growth enabled it to move from No. 9 to No. 7 in overall revenue, capturing 4.2 percent of the China/Hong Kong market.
- Intel Corporation and Toshiba Corporation remained the dominant semiconductor suppliers, with 10.1 percent and 9.4 percent of the market. Intel's growth slowed to 23 percent in 1997 because of increased competition, but its growth still outpaced the average market growth. Toshiba's revenue increased by a remarkable 26 percent as the company aggressively marketed non-DRAM products.
- At the positive growth end, the MOS logic market expanded 38 percent, and microcomponents expanded 36 percent. Healthy growth in commodity analog and discrete parts further contributed to the total market rebound.
- China/Hong Kong's MOS memory market further declined 15 percent in 1997 after contracting 26 percent in 1996, but this was less severe than the Asia/Pacific and worldwide contraction, which declined by 19 percent. Memory shipments were surpassed by microcomponents as China/Hong Kong's largest market segment in 1996.
- Growth was led by data processing markets that expanded 24 percent to $2.7 billion, which was 41 percent of total semiconductor consumption in China/Hong Kong. Consumer electronics recovered with a 20 percent growth, after sluggish growth in 1996.
- Personal computer production in China by both foreign and domestic manufacturers nearly doubled to 2.2 million in 1997 and will expand by more than 40 percent in the next two years. China's PC consumption is forecast to grow by more than 40 percent per year for the next three to five years. China (excluding Hong Kong) expanded its lead as the largest PC consumer in Asia/Pacific with a more than 30 percent share of PC shipments.

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- The consumer electronic recovery was led by VCDs, which jumped from 5.8 million to 14.7 million units in 1997. The color TV industry also improved its performance, as production growth had slowed to 8 percent in 1996, but expanded by 10 percent in 1997. Because China produces approximately 20 percent of the world's color televisions, this sector's performance is critical to China's overall consumer electronics growth.
- More mature stereo equipment industries declined 13 percent, but Dataquest expects overall home appliances—such as microwave ovens and air conditioners—to continue to show growth that is consistent elsewhere in the world with economic growth and rising disposable income.
- Consumer electronics will experience a revival in the next five years, as products with high appeal and affordable prices—such as DVDs, digital set-top boxes, and digital cameras—will be produced in China. Already, Dataquest has seen market movement and standards, which, as in the past, led foreign manufacturers to set up production in China.
- Dataquest's varied sources of economic data indicate slower economic growth than previously forecast because of the unexpected Asian financial crisis. The gross domestic product (GDP) growth forecast for 1998 is lowered to 6.5 percent from 8 percent. Unemployment and potential labor unrest are the Chinese government's major concerns, so the reform of money-losing state-owned enterprises will be more cautious, and fiscal policy will become more conservative.
- The domestic market is expanding faster than electronics producers' exports. China exported approximately 65 percent of its electronic equipment output in 1996 and 52 percent in 1997. Exports will continue to play a key role in the electronic industry's growth. But multinational companies manufacturing in China, as a whole, are developing local sales capabilities faster than they are growing exports. Therefore, Dataquest forecasts China to export less than 50 percent of what it produces by 2002.
- Dataquest forecasts the China/Hong Kong semiconductor market to expand at a compound annual growth rate (CAGR) of approximately 21 percent from 1997 to 2002, compared with the forecast Asia/Pacific growth of approximately 16 percent. This represents a reverse from the previous five years when China/Hong Kong underperformed relative to the market.
- China/Hong Kong's semiconductor consumption is led by strength across multiple segments, especially in microcomponents and analog, which are forecast to grow at a 24 percent and 25 percent CAGR, respectively.
- China/Hong Kong's electronic production is expected to rise from $46 billion in 1997 to $98 billion in 2002, with a 16 percent CAGR, leading all Asia/Pacific countries.

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- Suppliers with electronic equipment facilities in China/Hong Kong continue to outperform importers by a significant margin. Consequently, China experienced an unprecedented number of investments from semiconductor companies in 1996 and capacity expansion in 1997. Investments and production capacity growth will slow in 1998 to allow the market to absorb current investnents.
- Current announced investments in wafer fab capacity in China will not alleviate China's dependence on imported semiconductors until after 1999. China/Hong Kong's semiconductor industry produced less than 10 percent of what it consumed in 1997. Further expansion will be moderate because of global overcapacity. With several new capital expenditure plans, China/Hong Kong will probably fabricate or assemble about 15 percent of its semiconductor market's value by 2001.

Project Analyst: Daniel Heyler

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Chapter 2
Introduction

This Market Trends report on China/Hong Kong presents Dataquest's market data, competitive ranking, and forecast analysis of this major semiconductor market.

This report investigates the dynamics behind consumption growth in China/Hong Kong's dynamic and diverse markets. After Dataquest presents an analysis of historical growth and identifies key market trends in Chapter 3, it analyzes suppliers in each major semiconductor segment in Chapter 4. Chapter 5 provides Dataquest's long-term forecast and analysis of each semiconductor device market from 1998 to 2002. The following summarizes this report's structure:

- **Introduction** (Chapter 2)—Introduction, methodologies, and definitions.
- **Market trends** (Chapter 3)—Dataquest assesses the current market and identifies long-term structural trends. We present five years of device and application history and summarize key developments in 1997 and 1998. We also compare and contrast these trends with the rest of Asia/Pacific.
- **Supplier analysis** (Chapter 4)—Dataquest's competitive ranking and analysis of the revenue and market share of the top 30 suppliers worldwide are presented for each major semiconductor product area.
- **Market forecasts** (Chapter 5)—Dataquest forecasts semiconductor devices and key equipment drivers the market.

Economic Assumptions

The section highlights the key economic assumptions and Dataquest's long-term forecast assumptions.

The Next Stage of Economic Restructuring

China's economic transformation, which started 15 years ago, accelerated after the death of reform architect Deng Xiao Ping and the consolidation of power by Jiang Zemin. The focus remains on economic growth to absorb displaced workers from the restructuring or closing of state-owned enterprises. Political reform (within the current single-party system) is also an element of this next stage of reform, which is leading to stronger institutions for a 21st-century, politically practical China. The first and most important move is to build a more efficient bureaucracy, as current administration of vital functions remains backward and inhibits growth.

In March, Beijing said it would abolish or merge 15 ministries and shed 4 million government jobs in a three-year period. The cuts will begin at the central government this year and spread to the provinces next year. The government also intends to reduce the links between bureaucrats and companies. Consequently, analysts believe companies that lose valuable connections in the bureaucracy—those controlled by the central government and those that have their controlling departments dismantled—will become most vulnerable.

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China has failed several times to trim its bureaucracy and cut the links between state enterprises and the government departments, which are their supervisors. But analysts are taking Premier Zhu Rongji's steps to reshape the government more seriously because he has an excellent record in forcing through reforms in other areas, such as taxation.

Increased IT Usage: Privatized Enterprises to Benefit Information Industry

In addition to some major state-run enterprises, Dataquest believes that small, medium-size, and large nonstate ("privatized") enterprises with high technology also play a positive role in China's electronic information industry. Nonstate enterprises usually did not have large amounts of funds when they were founded, but some of them have developed rapidly into major enterprises in the information industry by depending on advanced technology.

Government statistics indicate that 80 percent of the 52 state-level and 58 provincial high-tech development zones grew from nonstate enterprises, many of which are involved in electronic information businesses. The government's vision is promising in that it appears to identify the necessity to build China as a knowledge-based economy and will construct the infrastructure to facilitate this goal.

Growth Engines after the Asian Financial Crises Favor China

Asia will bounce back, slowly and unevenly. But the next boom—and there will be a next boom—won't look like the previous one. The cost of Asia/Pacific's financial and currency crashes of the past 10 months has been extremely great. In fact, according to the latest *World Economic Outlook*, the International Monetary Fund (IMF) looked at what happened before and after nearly 200 currency and banking crises. The news isn't good for Asia's worst-hit countries. In the past, the economic damage was greatest in countries such as South Korea, Indonesia, and Thailand, which were unfortunate enough to have banking, currency, and foreign-debt crises at the same time.

The repair bills in the worst-hit Asian countries—measured in lost output and government spending for bank restructuring—will likely make this crash among the most expensive anywhere in the past 25 years. Economists estimate that bank bailouts will cost taxpayers in Indonesia, Thailand, and South Korea an amount equal to 20 percent or more—perhaps much more—of one year's GDP. Lost economic output could equal another 30 percent of one year's GDP in Indonesia, less in Thailand and South Korea.

Education, for example, is a key concern for a few Asian nations, according to the Asian Development Bank (ADB). Thailand and Malaysia aren't producing the university graduates that at their level of development they need, the ADB says in a special chapter of its latest *Asian Development Outlook*. That's a potentially serious problem because Thailand and Malaysia need to stay one step ahead of the lower-cost countries, such as China, according to the ADB. China's education level is very high and rising faster than elsewhere in the region.

Such weaknesses in numerous countries highlight the likelihood that while boom may come back to Asia, not all Asian countries will necessarily experience the boom. After all, the so-called Asian miracle—the *East Asian* miracle, to be specific—was never a regionwide phenomenon.

Asia caught a couple of lucky breaks in the previous downturn. The Group of Seven industrialized countries decided in 1985 that the Japanese yen was undervalued. The Plaza Accord pushed the yen sharply higher, and the soaring yen, in turn, spawned a rush by Japanese manufacturers to invest in cheaper locales overseas. At roughly the same time, the U.S. personal computer industry was primed for a takeoff. Malaysia, Singapore, and Taiwan reaped the gains as the PC industry accelerated.

But in 1998, Japan's economy became severely impaired and it, in turn, hurts the rest of Asia/Pacific. Falling PC prices are squeezing suppliers in Asia. Asia's richer developing countries face an additional problem that was still over the horizon in 1985 everywhere except Japan: Growing fast gets more difficult the more one grows.

As a region, however, Asia's potential growth rate remains higher than Latin America's and Eastern Europe's largely because Asia is still poorer overall and more populous. Furthermore, China is very much a consumer society, and one needs only look at Taiwan and Hong Kong societies to forecast the future earning power and consumption growth of China. Asia's potential or growth rate "trend" is about 6 percent a year, economists say. (Estimates range from 5 percent to 7 percent.) Latin America's growth rate trend is 5 percent or so, and Eastern Europe's is perhaps a little less.

Currency and Exchange Rates

The currency devaluation created critical problems for Asia/Pacific semiconductor suppliers and users that are almost entirely dependent on imports. Although most vendors denominate their prices in dollars, cash-flow problems—attributed to rising credit costs and falling sales—have resulted in a weakened demand from local manufacturers. Indonesia's currency devalued more than 80 percent during the past six months, and its equity market dropped more than 80 percent. As a result of the financial turmoil, stock markets in Korea, Thailand, the Philippines, and Malaysia declined by more than 60 percent. Equity markets in China and Hong Kong have also shrunk, but their strong cash account reserves have enabled them to support the Hong Kong dollar and the Chinese renminbi.

Few economists expect a devaluation in 1998, but there are concerns in the region that falling exports and a slowing economy will force China to devalue, potentially sparking another round of disastrous currency depreciation in Asia. It is a question of time. For sure, China will devalue, but whether it is before or after the region has recovered is the issue. In 1998, the Chinese government is under extreme pressure to maintain strong economic growth and create new jobs because of the dismantling of state-owned industries, which is creating millions of surplus workers. So far, the Chinese leadership has responsibly held its currency at the expense of economic growth, in addition to committing U.S.$250 billion in infrastructure spending projects to increase GDP vis-à-vis domestic consumption.

Actual exchange rates for the major countries in Asia/Pacific are detailed in Table 2-1. The exchange rates are applied to all historical figures. In conducting worldwide market forecasts, Dataquest uses constant exchange rates across all regions.

Table 2-1
Asia/Pacific Exchange Rate against the U.S. Dollar, 1993 to 1997

Currency	1993	1994	1995	1996	1997	U.S. Dollar Appreciation (%) 1996 to 1997
China (Renminbi)	5.76	8.54	8.35	8.34	8.32	-0.24
Hong Kong (Dollar)	7.74	7.73	7.74	7.73	7.74	0.13
India (Rupee)	30.84	31.15	32.38	35.52	36.36	2.36
Malaysia (Ringgit)	2.58	2.62	2.51	2.52	2.82	11.90
Singapore (Dollar)	1.62	1.53	1.43	1.41	1.49	5.67
South Korea (Won)	799.52	802.84	770.57	805.16	954.14	18.50
Taiwan (Dollar)	26.16	26.45	26.48	27.47	28.79	4.81
Thailand (Baht)	25.31	25.36	24.91	25.36	31.07	22.52

Source: Dataquest (July 1998)

Inflation was also sharply reduced in China since 1996, but economic growth has also slowed from double-digit to single-digit growth, and inflation has increased to double-digit levels according to unofficial estimates. After the international accounts of many countries taking a severe beating in 1996, governments and banks were unable to stop the spiral by drastically underestimating the depth of numerous countries' financial troubles. Moreover, the crisis exposed the financial excesses of overly rapid growth throughout the region. Poor financial judgment and overextension are easily hidden and covered when economies expand rapidly. But when economies face a downturn, poor financial decisions are exposed and can pose a menacing threat to renewed economic growth.

GDP Forecast Lowered

Most banks had forecast China's GDP to grow between 7.5 percent and 8.0 percent in 1998 and 1999. However, because of the region's worsening economies, slowing exports, and yen depreciation, the economy is expected to fall between 6.5 percent and 7.5 percent. China's GDP in the first quarter of 1998 had slowed to 7.2 percent and was expected to slow to 7.0 percent in the second quarter. The trend is expected to continue, with the second half of 1998 averaging less than 7 percent. One of the advantages China has over the rest of Asia/Pacific is that its economy is far more diversified, with economic expansion taking place in heavy industries, manufacturing, electronics, services, and agriculture. This broad-based growth, including within electronics, has come as an important buffer to Asia's economic woes. In fact, the major growth burden has been from the state-owned enterprises (SOEs) that account for about 60 percent of the economy. Prime Minister Zhu Rongji is in the process of structuring SOEs, which is the main factor behind slower growth and rising unemployment. However, China depends heavily on foreign capital and foreign markets to sustain its current growth rate.

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Foreign Investment Affected Moderately

Economic growth and improved output in manufacturing in China will continue to be the result of increased efficiencies within the non-SOEs and direct foreign investment by foreign or joint-venture companies. Foreign investments need to continue to flow into China for it to achieve a 7 percent GDP growth. Hong Kong, which has been hurt financially by its falling stock market, accounted for 59 percent of foreign-invested capital in China from 1980 to 1997. In the past few years, contracted investments in China had declined from $88 billion in 1994 to $72 billion in 1997. However, the actual utilized investment increased from $33 billion to $44 billion during this period. There is uncertainty in 1998, and most forecasts indicate a decline in utilized investments to $35 billion for the first time in at least five years.

Dataquest also expects contracted investments to decline because of the investor uncertainty, a short-term outcome of China's aggressive reforms to be undertaken in 1998. However, once the dust settles, investment flow is expected to resume in 1999 because the current slowdown is macroeconomic rather than microeconomic in nature. In the first quarter of 1998, figures show a growth of more than 10 percent over the 1997 level, but the second quarter is expected to decline. However, Dataquest continues to see communications, computer, and consumer electronic companies maintain a high strategic interest in investing in manufacturing in China for long-term needs: to increase market access, reduce distribution costs, and improve time to the market.

Exports Down but Not Dramatically

China's GDP will exceed $900 billion in 1998, yet its total trade is nearly $400 billion. China's export machine has proved to be a formidable global force, particularly in the past three years. The economy's trade surplus was expected to increase beyond $50 billion in 1998 prior to the financial crisis, but as the result of the financial crisis, it is expected to decrease to the $30 billion range. The first two months of 1998 show exports to the United States to be at the same levels as 1997, while imports are slightly down.

China is exposed to the Asian financial crisis by about 11 percent because 11 percent of its exports go to Southeast Asia and Korea. In the past few years, China's exports to Japan have declined to about 15 percent of total exports, but exports to Europe, North America, and Taiwan increased to more than 60 percent. Based on export exposure, a dramatic trade downturn, as experienced by the rest of Asia, is not likely. The free-falling yen was clearly a threat, but China still holds a (dangerous) wildcard: devaluing the renminbi. So when China hinted at devaluing its currency as the yen collapsed without response, the United States and Japan quietly negotiated overnight to support the yen.

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Semiconductor Market Segmentation and Shipment Definitions

Dataquest publishes a complete set of product, application, and regional definitions for its semiconductor clients. This section provides a synopsis for easy reference.

Dataquest surveys semiconductor vendors to estimate market sizing and growth. The survey covers 151 semiconductor vendors worldwide (this number varies according to mergers, acquisitions, liquidation, start-ups, and so on), by 61 individual semiconductor product categories (excluding subtotals) and five world regions (Asia/Pacific is split into five subregions). This report contains market share rankings for the China/Hong Kong region that were compiled in May 1998. The Asia/Pacific subregional data is published in April.

The categories for which semiconductor revenue is reported are defined comprehensively for the purposes of clarity and guidance to survey participants. These definitions may occasionally be revised, altered, or expanded to reflect changes in the industry. To support these definitions, Dataquest issues an annual survey guide to all participants in its semiconductor market share survey program. Dataquest's definition of shipments are as follows:

- **Sales to customer**—All sales are reported according to customer location—that is, the shipping destination. The four regions that Dataquest recognizes are the Americas; Japan; Europe, the Middle East, and Africa; and Asia/Pacific. Further breakdowns of Asia/Pacific and Europe are also conducted for data verification purposes.
- **Finished semiconductor products**—Assembled and tested semiconductor products. Only count sales of finished semiconductor products to distributors and equipment manufacturers. Do not include sales of finished semiconductors to other semiconductor vendors for value-added resale. Resale revenue will be estimated separately for these companies. Also, only count sales made by an overseas subsidiary to a distributor or equipment manufacturer, as opposed to counting sales from headquarters to an overseas subsidiary.
- **Unfinished semiconductor products**—Wafer and die foundry products. Only count sales of unfinished semiconductor products to distributors and equipment manufacturers. Do not include sales of unfinished semiconductors to other semiconductor vendors for resale. Resale revenue will be estimated separately for these companies. Also, only count sales made by an overseas subsidiary to a distributor or equipment manufacturer as opposed to counting sales from headquarters to an overseas subsidiary.
- **Internal semiconductor sales**—Defined as revenue from finished or unfinished semiconductor products from intracompany (internal) transfers to divisions of the company and/or subsidiaries of the parent company that manufacture end equipment. Internal semiconductor sales are classified as in-house sales or captive sales, depending on whether this company sells semiconductors on the merchant market.

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- **In-house semiconductor sales**—Defined as internal semiconductor sales if the company also sells semiconductors on the merchant market. Count all in-house semiconductor sales at market prices. Market price is defined as the price at which the same or equivalent product is sold to equipment manufacturers.
- **Captive semiconductor sales**—Defined as internal semiconductor sales if the company does not sell semiconductors on the merchant market. Do not include captive semiconductor sales.
- **Hybrid ICs**—Integrated circuits that include a semiconductor die (one or more) with other passive components in a single IC package. Hybrids are so named because they are technology *hybrids*, mixing semiconductor chips with thin/thick film resistors and chip capacitors. Multiple-chip ICs are not considered hybrids and are counted as monolithic ICs.
- **Multichip modules**—Semiconductor-based functions that include more than one semiconductor device. These may be mounted on a silicon printed substrate, polymide multilayer printed substrate, or a printed circuit board (PCB). Only count sales of multichip module (MCM) products and board-level products that conform with the definitions for "finished semiconductor products" or "unfinished semiconductor products." Multichip ICs such as MCMs are not considered hybrids and are counted as monolithic ICs.
- **System-level products**—Products that comprise a number of module and/or board-level products amounting to a single system or subsystem. Examples include development systems, hardware platforms, and box-level products. Do not include any sales from such system-level products.
- **Nonrecurring engineering charges**—Nonrecurring engineering (NRE) charges made to customers as the result of costs incurred during the design or customizing of a semiconductor device for that customer. Only count NRE charges when they occur in the following product areas:
  - Design charges for ASICs including gate arrays, cell-based ICs (CBICs), and full-custom ICs
  - Mask charges that result from the customizing of a programmable array logic (PAL), when the customer's fuse pattern is masked into it to produce a hard-wired array logic (HAL)
  - Mask charges that result from the customizing of ROMs
  - Mask charges that result from the storage of the customer's program in a microcontroller
- Only count revenue from NRE charges on active semiconductor products that conform with the definitions for "finished semiconductor products" or "unfinished semiconductor products." Include these NRE charges as part of the revenue received from associated semiconductor products. Do not include revenue from NRE charges incurred during research, feasibility studies, or facility rental to third parties.

- **Electronic design automation software**—Electronic design automation (EDA) software is used to automate the design of semiconductors. Dataquest includes revenue from ASIC semiconductor vendors that also sell their own EDA software. Include any revenue derived from EDA software in the appropriate ASIC product category. The applicable categories are programmable logic device (PLD), gate array, and CBIC.
- **IPR income**—Intellectual property rights (IPRs) income from royalties, licensing agreements, technology transfers, and dispute settlements. Do not include any such IPR income.

Market Segmentation

This section outlines the market segments that are specific to this document. Dataquest's objective is to provide data along lines of segmentation that are logical, appropriate to the industry in question, and immediately useful to clients.

Dataquest defines the semiconductor industry as the group of competing companies primarily engaged in manufacturing semiconductors and related solid-state devices. Important products of the semiconductor industry include integrated circuits, discrete devices, and optoelectronics devices.

For market share purposes, Dataquest defines the semiconductor market according to the following functional segmentation scheme:

- Total Semiconductor (including Hybrids)
- Total Semiconductor (excluding Hybrids)
  - Total Monolithic Integrated Circuit (including Hybrids)
  - Total Monolithic Integrated Circuit (excluding Hybrids)
    - Bipolar Digital IC
      - Bipolar Logic
      - Other Bipolar Memory/Microcomponent/Logic
  - MOS Digital IC
    - MOS Memory
    - MOS Microcomponent
    - MOS Logic
  - Monolithic Analog IC
  - Hybrid IC
  - Discrete Semiconductor
  - Optoelectronic Semiconductor

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Definitions

This section lists the definitions that are used by Dataquest to present the data in this document. For a complete listing of all semiconductor market segments tracked by Dataquest, please refer to the Dataquest Semiconductor Market Definitions Guide.

Product Definitions

- Total semiconductor (total monolithic integrated circuit + total discrete + total optoelectronic)—An active semiconductor product that contains semiconducting material (such as silicon, germanium, or gallium arsenide, but excluding ceramics) and reacts dynamically to an input signal, either by modifying its shape or adding energy to it. This definition excludes standalone passive components, such as capacitors, resistors, inductors, oscillators, crystals, transformers, and relays.
- Total monolithic integrated circuit (digital monolithic bipolar IC + digital monolithic MOS IC + analog IC)—An IC is defined as a large number of passive and/or active discrete semiconductor circuits integrated into a single package. A monolithic IC is one in which discrete circuits are integrated onto a single die.
- Bipolar digital IC (bipolar digital memory + bipolar digital microcomponent + bipolar digital logic)—A monolithic semiconductor product in which 100 percent of the die area performs digital functions and 100 percent of the die area is manufactured using bipolar semiconductor technology. A digital function is one in which data-carrying signals vary in discrete values.
- Bipolar digital logic (bipolar application-specific IC + bipolar digital standard logic + other bipolar logic)—A bipolar digital semiconductor product in which more than 50 percent of the die area performs logic functions. This definition excludes bipolar digital microcomponent ICs.
- Other bipolar digital memory/microcomponent/logic—A bipolar digital semiconductor product in which binary data is stored and electronically retrieved. This definition includes ECL random-access memory (RAM), read-only memory (ROM), programmable ROM (PROM), last-in/first-out (LIFO) memory, and first-in/first-out (FIFO) memory. Not included are products made with mixed bipolar CMOS (that is, BiCMOS) with transistor-transistor logic (TTL) or emitter-coupled logic (ECL) outputs, which are classified as MOS.
- MOS digital IC (MOS digital memory + MOS digital microcomponent + MOS digital logic)—A monolithic semiconductor product in which 100 percent of the die area performs digital functions, and, concurrently, where any portion of the die area is manufactured using metal oxide semiconductor (MOS) technology. A digital function is one in which data-carrying signals vary in discrete values. This definition includes mixed technology manufacturing, such as BiMOS and BiCMOS, where there is some MOS technology employed.
- MOS digital memory (DRAM + SRAM + EPROM + EEPROM + flash memory + mask ROM + other MOS digital memory)—A MOS digital IC in which binary data is stored and electronically retrieved
- MOS digital microcomponent IC (MOS digital microprocessor + MOS digital microcontroller + MOS digital microperipheral + programmable digital signal processor)—A MOS digital IC that contains a data processing unit or serves as an interface to such a unit

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- MOS digital logic IC (MOS digital logic application-specific IC + MOS digital standard logic IC + other MOS digital logic IC)—A MOS digital IC in which more than 50 percent of the die area performs logic functions. This definition excludes MOS digital microcomponent ICs.
- Total analog IC (amplifier/comparator IC + voltage regulator/reference IC + data converter/switch/multiplexer IC + interface IC + telecom IC + disk drive IC + other special-function IC + linear array/ASIC + mixed-signal ASIC + total special consumer IC + special automotive IC + smart power IC)—A semiconductor product that deals in the realm of electrical signal processing, power control, or electrical drive capability. It is one in which some of the inputs or outputs can be defined in terms of continuously or linearly variable voltages, currents, or frequencies. This definition includes only monolithic analog ICs manufactured using bipolar, MOS, or BiCMOS technologies. A monolithic IC is a single die contained in a single package.
- Hybrid integrated circuit—A semiconductor product consisting of more than one die contained in a single package. A hybrid IC may perform 100-percent linear, 100-percent digital, or mixed-signal (both linear and digital) functions. This definition includes hybrid implementation of all monolithic IC functions described in the following categories, and includes all hybrid ICs manufactured using bipolar, MOS, or BiCMOS technologies.
- Total discrete (transistor + diode + thyristor + other discrete)—A unit building block performing a fundamental semiconductor function
- Total optoelectronic (LED lamp/display + optocoupler + CCD + laser diode + photosensor + other optoelectronic)—A semiconductor product in which photons induce the flow of electrons, or vice versa. Other functions may also be integrated onto the product. This category does not include LCD, incandescent displays, fluorescent displays, cathode ray tubes (CRTs), or plasma displays.

Regional Definitions

Asia/Pacific

Includes Hong Kong, Singapore, South Korea, Taiwan, Australia, Bangladesh, Cambodia, China, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, New Zealand, Pakistan, the Philippines, Sri Lanka, Thailand, and Vietnam

Line Item Definitions

- Factory revenue—The money value received by a semiconductor manufacturer for its products. Revenue from the sale of semiconductors sold either as finished goods, dies, or wafers to another semiconductor vendor for resale is attributed to the semiconductor vendor that sells the product to a distributor or equipment manufacturer.
- Merchant versus captive consumption—All revenue, both merchant and captive, for semiconductor suppliers selling to the merchant market. The data excludes completely captive suppliers where devices are manufactured solely for the company's own use. A product that is used internally is valued at market price rather than at transfer or factory price.

Unless otherwise specified, the amounts given in this report are in U.S. dollars.

Chapter 3
Semiconductor Market Trend Analysis

Last year, Dataquest observed that "Asia/Pacific semiconductor consumption is rapidly changing, and the dynamics are likely to continue to favor China/Hong Kong for the next five years." This statement proved true in 1997, as China/Hong Kong semiconductor consumption exactly matched Dataquest's forecast of approximately 20 percent growth, while the rest of Asia/Pacific grew 8.3 percent. This chapter examines China/Hong Kong's semiconductor market trends and compares this region with the other parts of Asia/Pacific.

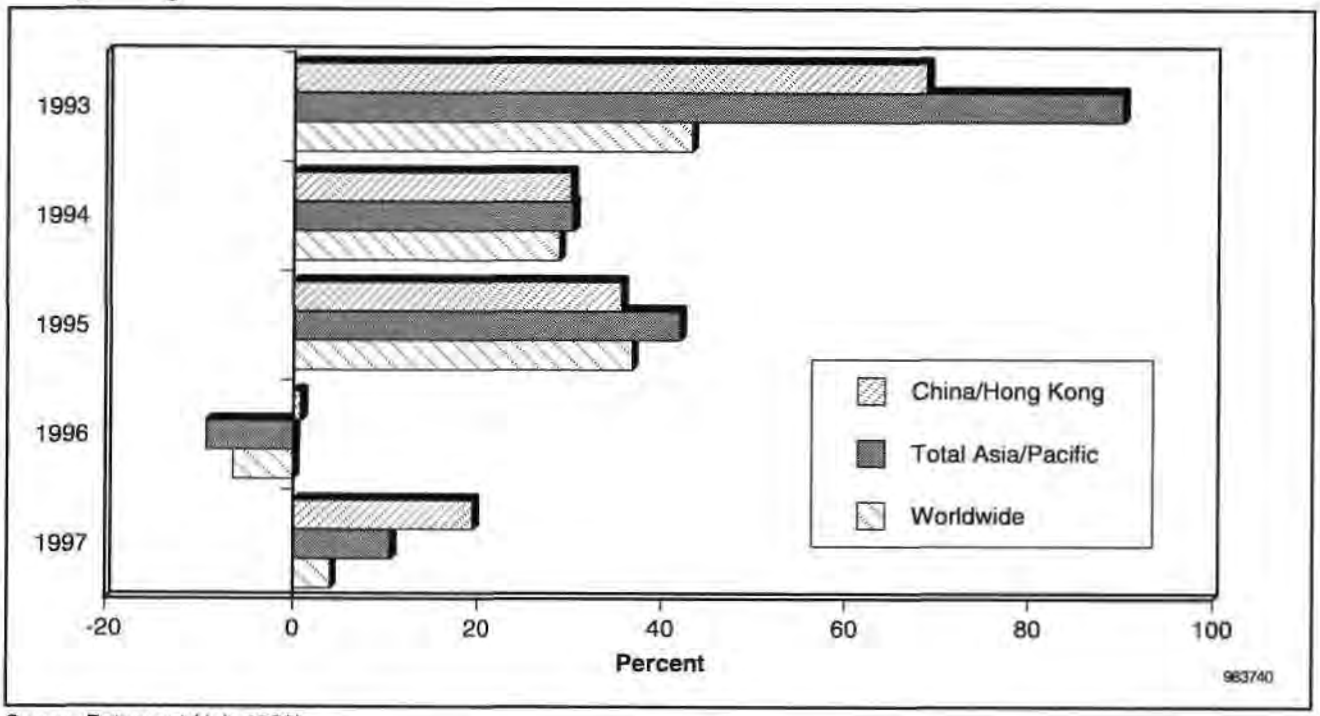
Dataquest's research presented in this report discusses China and Hong Kong as a single market (China/Hong Kong) because most semiconductors are billed in Hong Kong but used in China. It would be a distortion to discuss China without including Hong Kong and vice versa. Dataquest compares this (single) region with other major semiconductor consumption centers in the region—South Korea, Singapore, and Taiwan. Hong Kong's economic integration with China is a reality, with or without official political unification. For all intents and purposes, Hong Kong will continue to be a primary purchasing and trading center for end users throughout China for the next few years, expanding beyond Guangdong Province.

1997 China/Hong Kong, Asia/Pacific, and Worldwide Markets

After the worldwide semiconductor market contraction of 6.3 percent, 1997 experienced a slow growth of 3.5 percent to $147 billion. An unprecedented period of expansion and profits, which peaked in 1995 (36.9 percent in revenue), later collapsed to a protracted three-year downturn caused by overspending in memory capacity—especially DRAMs. The Asia/Pacific was worse off in the decline in 1996 with a 9.2 percent decline, but then returned to worldwide growth leadership in 1997 with 9.6 percent expansion. Asia/Pacific was followed by Europe (5.9 percent), Americas (5.3 percent), and Japan (negative 5 percent).

The Asia/Pacific semiconductor market expanded nearly two and half times from 1991 to the end of 1995, with the regional market growing at a 37.0 percent CAGR, compared with a growth rate of only 26.2 percent for the world semiconductor market. The years 1996, 1997, and 1998 appear to be correction and recovery years after a streak of uninterrupted growth. Figure 3-1 illustrates the comparative growth rates for the worldwide, Asia/Pacific, and China/Hong Kong markets from 1993 to 1997. The China/Hong Kong market was flat in 1996, primarily caused by semiconductor pricing weakness rather than slackening demand. Hence, electronic equipment production expanded 17.5 percent in 1996 and accelerated in 1997 with 20.9 percent growth. The semiconductor market's 19.5 percent growth was almost double the total Asia/Pacific market average of 9.6 percent.

Figure 3-1
Comparative Semiconductor Market Growth Rates, Worldwide, Asia/Pacific, and China/ Hong Kong



Source: Dataquest (July 1998)

It is important to note that China/Hong Kong became the largest semiconductor market in Asia/Pacific in 1996 and extended its lead in 1997, as was predicted. Figure 3-2 illustrates regional semiconductor consumption by Asia/Pacific's five major regions, China/Hong Kong, Singapore, South Korea, Taiwan, and rest of Asia/Pacific (including Australia, Malaysia, Thailand, Indonesia, India, Philippines, and the rest of Southeast Asia and South Pacific).

Dataquest forecasts a 21 percent CAGR growth (1997 to 2002), which is slower than the 24 percent growth rate for the similar-cycle period from 1991 to 1996. The years between 1991 and 1995 were the peak years of the last silicon cycle, and the China/Hong Kong region was able to sustain a 31.3 percent CAGR. When including the 1996 downturn, the growth from 1991 to 1996 was 24 percent. When examining Dataquest's CAGRs, readers must take note of the forecast period with respect to market cycles. Where the base year and final year of the five-year forecast begin can substantially impact the forecast figures.

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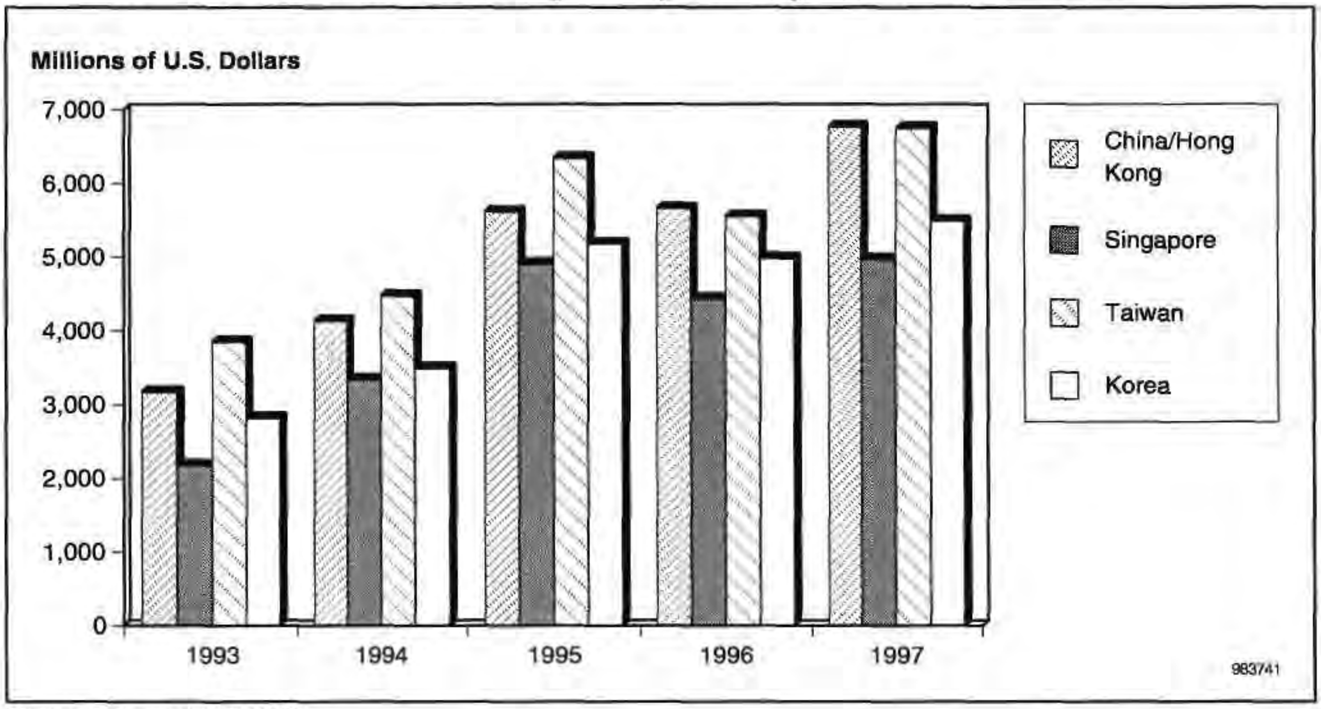
Figure 3-2
Asia/Pacific Semiconductor Consumption by Country, 1993 to 1997



Source: Dataquest (July 1998)

Recent Market Stimulants

Dataquest's historical statistics show that China/Hong Kong performed below the Asia/Pacific average growth until 1995 largely because of Japanese investments in Southeast Asia and Taiwan's PC boom. The effect of previous dynamic RAM (DRAM) undersupply on China/Hong Kong was faster growth for large DRAM consumers Singapore and Taiwan. Overall, China/Hong Kong declined from 20 percent of Asia/Pacific consumption in 1991 to 19 percent in 1996. Singapore and Southeast Asia were the success stories of the early 1990s, increasing their share of the Asia/Pacific total consumption. Led by Malaysia and Thailand, the rest of Asia/Pacific grew from 19 percent to 31 percent of total Asia/Pacific consumption. China/Hong Kong, on the other hand, declined from 20 percent to 19 percent of the total Asia/Pacific market. The story has been changing, and China/Hong Kong is now the growth center through the next forecast period, 1997 to 2002 (as discussed in more detail in Chapter 5). Figure 3-3 illustrates a two-year comparison of China/Hong Kong's semiconductor consumption share in Asia/Pacific in 1996 and 1997.

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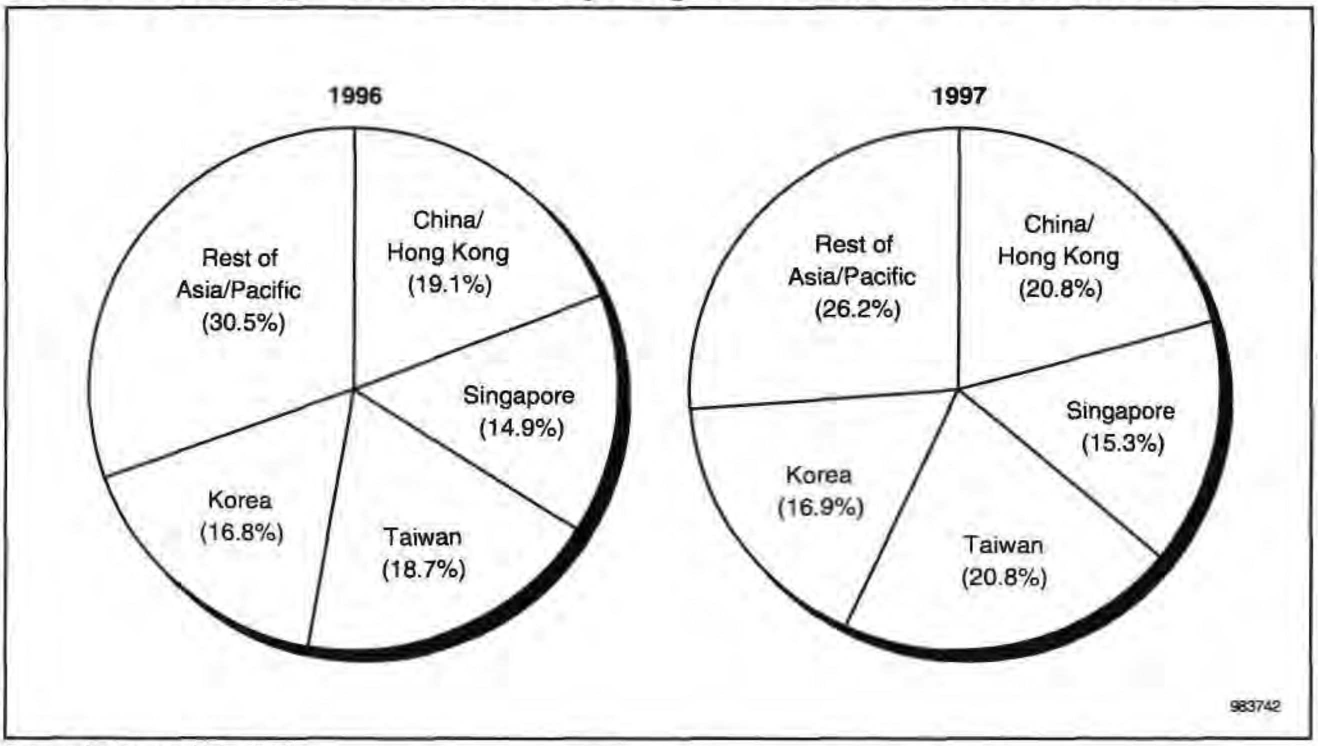
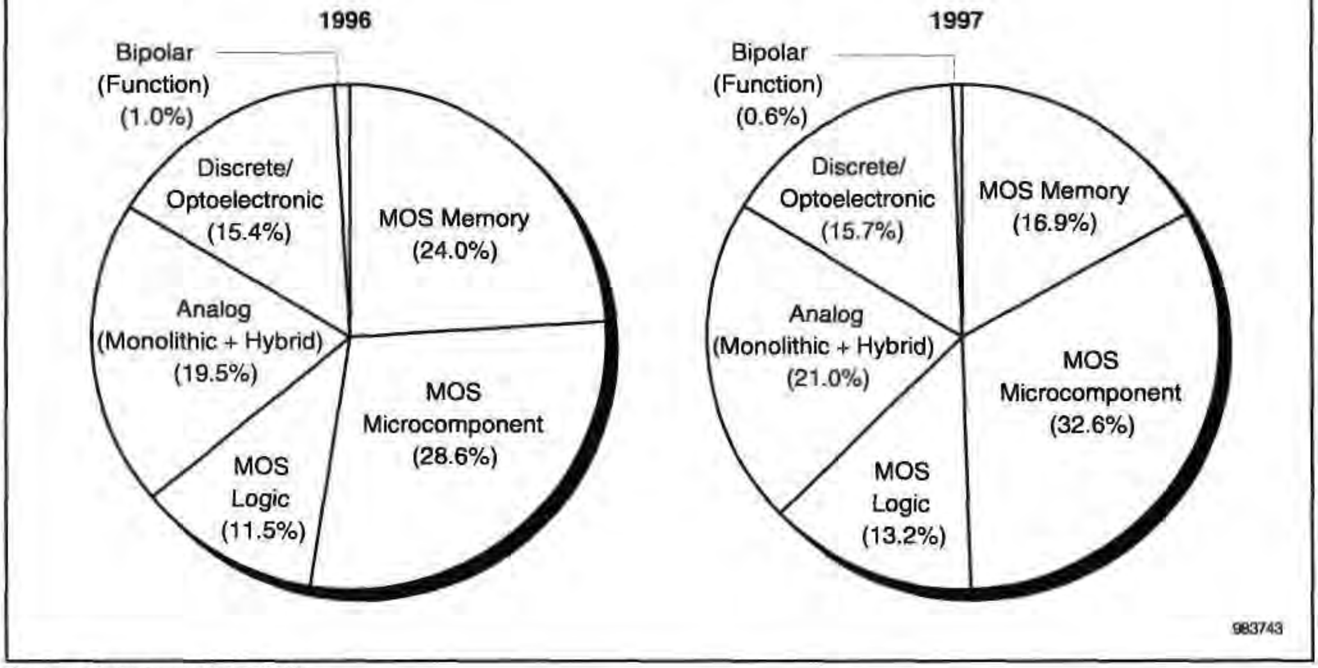
Figure 3-3
1996 and 1997 Comparison: China/Hong Kong Share of the Asia/Pacific Market



Source: Dataquest (July 1998)

Dataquest's data in Figure 3-4 shows the share of China/Hong Kong relative to other countries in Asia/Pacific increased substantially across all device areas. The main drivers for this growth were a shift in foreign investments by multinational corporations (MNCs) to China, strong economic growth, and accelerated use of information technologies in Chinese businesses and the government. For example, China's PC market surged in 1995, and PC manufacturers invested in production within China. Also, local manufacturers emerged to compete with global multinational companies (MNCs). As a result, China's memory, microprocessor, and microperipherals markets surged. Memories would have increased more share if not for the extremely aggressive pricing in the China/Hong Kong market. Furthermore, communication markets and products have surged in the past two years. In 1997, China/Hong Kong consumed a record 20.8 percent share of Asia/Pacific semiconductors. (Dataquest's forecasts of these devices and applications are explained in Chapter 5.)

Figure 3-4
1996 and 1997 Comparison: Semiconductor Segment Changes in China/Hong Kong



Source: Dataquest (July 1998)

Sustainability of Growth Stimulants

Dataquest believes that significant structural changes in China/Hong Kong's electronic equipment industries have enable it to achieve sustainable growth leadership within Asia/Pacific and, of course, worldwide. Table 3-1 quantifies revenue from China/Hong Kong's electronics industries and the value of semiconductors consumed in each end-market segment. Dataquest has revised some historical figures for communications semiconductor markets, which surpassed the consumer segment in 1996. As shown, China/Hong Kong's market growth has been enabled by rapid growth across the three main application areas of consumer, data processing, and communications electronic equipment. Much will depend on the overall health of the global economy, which is influenced by Japan's and Asia's slowdown.

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Table 3-1
China/Hong Kong's Electronic Equipment Production and Semiconductor Consumption by Application, 1992 to 1996 (Millions of U.S. Dollars)

	1993	1994	1995	1996	Final 1997	CAGR (%) 1993 to 1997
Total Electronic Production	**20,981**	**25,591**	**30,616**	**38,463**	**46,496**	**22.01**
Data Processing	5,353	6,393	7,935	9,892	13,407	25.80
Communication	3,124	4,191	5,711	6,457	7,540	24.64
Industrial	536	621	810	895	991	16.62
Consumer	10,767	12,955	14,381	19,218	22,266	19.92
Military/Civil Aerospace	701	762	910	1,019	1,162	13.47
Transportation	500	669	869	982	1,129	22.58
Total Electronic Production (Percent)	**26.1**	**22.0**	**19.6**	**25.6**	**20.9**	-
Data Processing	28.5	19.4	24.1	24.7	35.5	-
Communication	47.8	34.2	36.3	13.1	16.8	-
Industrial	20.1	15.9	30.4	10.5	10.7	-
Consumer	20.2	20.3	11.0	33.6	15.9	-
Military/Civil Aerospace	46.0	8.7	19.4	12.0	14.0	-
Transportation	5.3	33.8	29.9	13.0	15.0	-
Total Semiconductor	**3,173**	**4,137**	**5,620**	**5,664**	**6,769**	**20.85**
Data Processing	906	1,565	2,067	2,216	2,748	31.97
Communication	608	880	1,874	2,147	2,468	41.94
Industrial	55	72	114	102	121	21.70
Consumer	1,507	1,500	1,385	1,031	1,232	-4.91
Military/Civil Aerospace	30	35	54	55	66	21.90
Transportation	67	85	126	113	133	18.74
Total Semiconductor (Percent Growth)	**32.8**	**30.4**	**35.8**	**0.8**	**19.5**	-
Data Processing	30.2	72.7	32.1	7.2	24.0	-
Communication	218.3	44.7	113.0	14.6	14.9	-
Industrial	44.7	30.9	57.8	-10.2	18.3	-
Consumer	8.9	-0.5	-7.6	-25.6	19.5	-
Military/Civil Aerospace	66.7	16.7	55.1	1.3	20.4	-
Transportation	6.3	26.9	47.8	-10.1	17.9	-

Source: Dataquest (July 1998)

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Consumer Electronics Consolidation

Consumer electronics production remained as the equipment revenue leader for China/Hong Kong in 1997, accounting for 48 percent of total electronic equipment production. But the industry is plagued by inefficiencies, has been undergoing consolidation since 1995, and is experiencing a production revenue decline. By contrast, the industry accounted for only 18 percent of semiconductor consumption and has been declining. China's demand for low-end consumer electronics did translate into step-function semiconductor market growth. (As discussed later, this trend may change.)

By contrast, although Southeast Asia's consumer electronics production was slower than China's, it translated into a higher semiconductor market growth than that of China. A 1993-to-1997 CAGR of 17 percent in Southeast Asia's electronic equipment production resulted in a semiconductor market decline because of a market contraction in 1995. When comparing this to Asia/Pacific's 1993-to-1997 CAGR of about 10 percent in electronic equipment production, the result is a 13 percent semiconductor consumption growth.

China/Hong Kong's electronics industry has gone through rapid expansion as well as product technology improvements, leading to higher content per system produced. Consumer electronics has been rapidly declining in importance. In 1993, it accounted for 51 percent of electronic industry output, dropping to 48 percent in 1997. Going back to 1992, the trend is even more clear when consumer applications represented 54 percent, with data processing applications sharing 25 percent of the market.

Semiconductor shipments for consumer applications represented 47 percent of the market in 1993, declining to 18 percent by 1997. Gains were made in computer and communications, which grew on a combined basis from 48 percent of consumption in 1993 to 77 percent. Shipments to data processing applications reached $2.2 billion, or 41 percent of total shipments. As explained in Chapter 4, Intel Corporation and other PC semiconductor suppliers have become major forces in the China/Hong Kong market in 1997.

Communications and Computers Drove Semiconductor Consumption in 1997

In 1997, data processing grew to 29 percent of total electronic equipment output. Communications electronic applications have maintained an average of 15 percent to 16 percent share since 1993, but the market share has migrated from telephones to infrastructure production, thereby accelerating semiconductor consumption in 1997. Shipments of communication semiconductors, on the other hand, increased from 19 percent to 36 percent of the total market in 1997, undergoing a five-year expansion of 42 percent CAGR. The primary growth segments have been semiconductor-rich products—cordless telephones, switching equipment, and pagers.

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This trend will boost this segment. A large growth in communication systems' semiconductor consumption is under way to meet China's infrastructure development. A large portion of this equipment will be imported, but a growing share is being produced by multinationals, because of the pressure from the Chinese government to localize production. Additionally, the government is supporting local Chinese suppliers, which are increasing their communications presence. Semiconductor device technology is enabling Chinese companies, with the support of key vendors, to pursue these lucrative equipment markets. Dataquest thinks that this market will keep pace with data processing during the next five years. Locally produced handsets, pagers, cordless phones, and answering machines, among others, will continue to surge to meet local demand, while semiconductor consumption for public infrastructure is predicted to surge within the next few years.

Broad-Based Semiconductor Growth (except Memories) in 1997

Dataquest continues to emphasize the importance of end-market diversity with the China/Hong Kong market. In 1997, this was truer than ever, as all major sectors experienced revenue growth faster than the rest of Asia/Pacific. But this has been a clear long-term trend. As shown in the detailed breakdown of revenue for total semiconductors shipped to China/Hong Kong in Table 3-2, the total semiconductor market of China/Hong Kong expanded with a 21 percent CAGR from 1993 to 1997. MOS microcomponents became the fastest-growing segment with a 30 percent CAGR from 1993 to 1997. This segment increased from $772 million to $2.2 billion. While MOS memory's 50 percent CAGR from 1991 to 1995 was the fastest-growing segment, its contraction of 26 percent in 1996 severely lowered its five-year average growth to 26 percent from 1992 to 1996. And MOS memories' 1993-to-1997 CAGR dropped to 16 percent—the weakest of all semiconductor products during this period. Traditionally modest-growth markets of analog, discrete, and MOS digital logic grew by 14 percent, 18 percent, and 15 percent during this same period, respectively. Dataquest expects a continuation of these trends in 1998 because of a delayed memory recovery starting in 1999 and accelerating in 2000 and 2001.

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Table 3-2
China/Hong Kong's Semiconductor Consumption by Segment, 1993 to 1997
(Millions of U.S. Dollars)

	1993	1994	1995	1996	1997	CAGR (%) 1993 to 1997
Total Semiconductor	**3,172**	**4,138**	**5,620**	**5,664**	**6,769**	**20.9**
Total IC	2,707	3,518	4,826	4,790	5,705	20.5
Bipolar (Function)	92	93	86	58	42	-17.6
MOS Digital	1,861	2,522	3,688	3,629	4,243	22.9
MOS Memory	636	915	1,589	1,357	1,142	15.8
MOS Microcomponent	772	1005	1,383	1,622	2,206	30.0
MOS Logic	453	602	717	650	895	18.6
Analog (Monolithic + Hybrid)	754	903	1,052	1,104	1,419	17.1
Discrete	379	506	642	704	859	22.7
Optoelectronic	86	114	152	170	205	24.2

Source: Dataquest (July 1998)

Table 3-3
China/Hong Kong's Semiconductor Consumption by Device, 1992 to 1996
(Percentage Growth)

	1993	1994	1995	1996	1997
Total Semiconductor	**32.7**	**30.5**	**35.8**	**0.8**	**19.5**
Total IC	34.1	30.0	37.2	-0.7	19.1
Bipolar (Function)	19.5	1.1	-8.1	-32.6	-26.5
MOS Digital	39.1	35.5	46.2	-1.6	16.9
MOS Memory	42.0	43.9	73.6	-14.6	-15.8
MOS Microcomponent	30.4	30.2	37.6	17.3	36.0
MOS Logic	52.0	32.9	19.0	-9.3	37.8
Analog (Monolithic + Hybrid)	25.0	19.8	16.5	4.9	28.6
Discrete	23.5	33.5	26.9	9.6	22.1
Optoelectronic	32.3	32.6	33.2	12.2	20.2

Source: Dataquest (July 1998)

Consumer Semiconductors

As shown in Table 3-3, the analog IC market expanded by 29 percent and surpassed MOS memories to become the second-largest market after MOS microcomponents in 1997. The discrete market improved from 10 percent in 1996 (because of a general weakness in China's consumer markets) to 22 percent. Consumer electronic equipment production has been China's main application for analog and discrete devices, but the communications markets are providing new life to these products. MOS digital logic market also recovered because of stronger consumer electronics equipment growth in 1997.

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Table 3-4 presents key consumer electronics segments, most of which experienced improved growth after several difficult years. The consumer electronics slump for stereo equipment declined by 12 percent in 1997. After years of consolidation, VCRs showed some improvement because of central China's economic growth. Color TV production growth slowed to 8 percent in 1996 but improved to 10 percent growth in 1997. Consolidation was sorely needed after the government had promoted and protected almost 100 manufacturers, most of which were inefficient and lacked supply of key components. Larger, more efficient manufacturers have acquired ailing companies, boosting the overall output. Because China produces approximately 20 percent of the world's color televisions, this sector's performance is critical to China's overall consumer electronics growth. Semiconductor consumption in this sector grew 14 percent in 1997. As China heads for a World Trade Organization (WTO) membership and as import tariffs decline, color television manufacturers have prepared to increase competitiveness and boost exports to exceed 10 percent growth per year.

Table 3-4
Final 1997 Consumer Equipment Production and Semiconductor Consumption in China/Hong Kong (Units and Revenue)

	1996	1997	Growth (%)
Color Television			
Units (K)	20,784	22,863	10.0
Semiconductor TAM (U.S.$M)	362	412	13.8
Personal / Portable Stereo			
Units (K)	30,875	27,000	-12.6
Semiconductor TAM (U.S.$M)	186	163	-12.5
VCR			
Units (K)	1,941	2,310	19.0
Semiconductor TAM (U.S.$M)	59	75	26.6
Video Game Controller			
Units (K)	318	552	73.8
Semiconductor TAM (U.S.$M)	29.9	46.4	55.3
Analog Camcorder			
Units (K)	82	292	255.7
Semiconductor TAM (U.S.$M)	9.9	26.0	162.9
Analog Set-Top Box			
Units (K)	6	16	164.2
Semiconductor TAM (U.S.$M)	0.2	0.6	141.0
Video Compact Disk Player (VCD)			
Units (K)	5,750	14,660	155.0
Semiconductor TAM (U.S.$M)	336	437	30.1
Total Semiconductor TAM (U.S.$M), Without VCDs	**647**	**722**	**11.7**
Total Semiconductor TAM (U.S.$M), With VCDs	**983**	**1159**	**17.9**

Source: Dataquest (July 1998)

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Certain home appliances, such as microwave ovens and air conditioners, experienced double-digit growth. High local demand for key commodities such as color televisions, VCRs, audio equipment, and other home appliances (refrigerators, washing machines, and rice cookers, among others) were the key to China's market growth from 1991 to 1995. As elsewhere in the world, the market is in need of new applications. However, a continued economic growth and the per-capita-income growth will, predictably, boost consumer electronic purchases. A key initiative of the Chinese government is to expand economic growth to China's heartland. Rising economic disparity between coastal versus inland, as well as urban versus rural regions, will lead to the breakup of the country unless dealt with immediately. Consequently, the government continues to implement ways to accelerate growth throughout China. For instance, special regions that report directly to Beijing have been established. So far, there are 32 Economic and Technology Development Zones, 14 Single-Planned Cities, five Special Economic Zones, and three Coastal Economic Zones. These policies enable central control, facilitate foreign investments, and accelerate economic expansion.

Aside from products tied to economic fundamentals and rising income, Dataquest expects applications that are unique to China. Dataquest's recently published report on video compact disk players (VCD) indicated that production increased eightfold, from 210,000 in 1995 to nearly 5.8 million in 1996. In 1997, Dataquest estimates the VCD production to have reached 14.7 million units. Excluding VCD semiconductors, the main markets would have expanded only 12 percent. The VCD semiconductor consumption of $437 million enabled the semiconductor total available market (TAM) to increase by 18 percent (see Table 3-4).

As elsewhere in the world, this segment's future will depend on new and affordable products, such as DVDs, set-top boxes, and digital cameras. Once there is any movement in the local market activity, Dataquest expects at least a few foreign manufacturers to set up production in China. Already, Dataquest hears of several manufacturers establishing set-top box production facilities for original equipment manufacturers (OEMs) in the United States and Europe.

Figure 3-4 illustrates a revenue comparison between 1996 and 1997. Analog and discrete both increased in share of total consumption after declining in 1996. These two sectors represent 37 percent of semiconductor consumption in China/Hong Kong.

Memories: Segment Shrank to Historic Lows

The MOS memory market experienced its second year of negative growth, falling 16 percent in 1997 after declining 14 percent in 1996. The MOS memory market segment shank to 17 percent of total semiconductor shipments to China/Hong Kong. This is the lowest level in history and even lower than 1992's share of 19 percent. At its peak in 1995, MOS memories were 28 percent of total semiconductor shipments.

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Memories achieve number one segment status in 1995 after expanding by a CAGR of 49.8 percent from 1991 to 1995. Demand for MOS memory devices surged because of another large increase in local PC and motherboard production, which, in turn, caused a huge rise in the DRAM consumption level (DRAM chips constituted 74 percent of the MOS memory consumption). Despite a very strong unit growth in China/Hong Kong, falling average selling prices resulted in a revenue decline. But because of strength in demand, the overall decline in China/Hong Kong was less severe than that of Asia/Pacific's memory markets, which declined by 36 percent and 19 percent in 1996 and 1997, respectively.

All major memory subsegments contributed to decrease memory revenue in 1996. Dataquest's final market share estimates indicate that the DRAM market in China/Hong Kong declined from $1.1 billion to $0.8 billion in 1996. SRAM shipments experienced slow growth, and nonvolatile memories contracted (see Table 3-5).

Table 3-5
China/Hong Kong Semiconductor Market by Device, 1996 and 1997 (Revenue and Percentage Growth)

	1996	Growth (%) 1996	Final 1997	Growth (%) 1997
Total Semiconductor	**5,664**	**0.8**	**6,769**	**19.5**
Total IC	4,790	-0.7	5,705	19.1
Bipolar Digital	58	-32.6	42	-26.5
MOS Digital	3,629	-1.6	4,243	16.9
MOS Memory	1,357	-14.6	1,142	-15.8
DRAM	968	-16.7	800	-17.3
SRAM	103	-27.9	87	-15.0
Nonvolatile	263	7.1	239	-9.0
EPROM	44	10.0	45	2.0
EEPROM	65	120.3	55	-15.0
Flash	86	200.7	92	6.6
Mask ROM	68	-53.9	48	-30.0
Other Memory	24	-40.0	15	-35.5
MOS Microcomponent	1,622	17.3	2,206	36.0
Microprocessor	671	49.5	881	31.2
Microcontroller	532	-15.1	680	27.7
Microperipheral	343	19.1	480	40.0
Digital Signal Processor	75	294.7	165	120.0
MOS Logic	650	-9.3	895	37.8
ASIC	277	5.1	253	-8.6
Custom IC	31	24.0	78	150.0
Standard Logic	97	-54.7	197	103.1
Other Standard Logic	245	14.5	368	50.1
Analog (Monolithic + Hybrid)	1,104	4.9	1,419	28.6
Total Discrete	**704**	**9.6**	**859**	**22.1**
Total Optoelectronic	**170**	**12.2**	**205**	**20.2**

Source: Dataquest (July 1998)

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Microcomponents: Every Sector Surged in 1997

The market for MOS microcomponent devices in China/Hong Kong moved from the second largest (after MOS memory) to become the largest segment in 1996. In 1997, the market grew to $2.2 billion from $772 million in 1993, a 23 percent CAGR. This segment is defined by Dataquest to include microprocessors (MPUs), microcontrollers (MCUs), microperipherals (MPRs), and digital signal processors (DSPs).

As shown in Table 3-4, Dataquest's final market share figures indicate that microprocessor growth remained robust in 1997, but decelerated from 50 percent growth in 1996 to 31 percent in 1997. This $881 million market represents 20 percent of the MPU consumption in Asia/Pacific. Because China/Hong Kong consumes about one-third of PCs shipped in Asia/Pacific, this sector is clearly positioned for continued growth. After a soft MCU and MPR market, these markets bounced back with 28 percent and 40 percent growth, respectively. About 30 percent of MCUs shipped to Asia/Pacific are used in China/Hong Kong. Microprocessors dominate this consumption with 40 percent of microcomponent revenue, followed by MCUs (31 percent), MPRs (22 percent), and DSPs (7 percent).

PC production in China by both foreign and domestic manufacturers grew from 1.1 million units in 1996 to 2.2 million units in 1997. China's PC consumption is forecast to grow by more than 40 percent per year for the next five years, while the production will expand by 45 percent. China (excluding Hong Kong) became the largest consumer of PCs in Asia/Pacific during the second quarter of 1997. With the introduction of sub-$1,000 PCs, as well as improved distribution in China, the market is positioned for continuous long-term growth stimulated by a large, nascent demand.

MOS Digital Logic: A Growth Leader in 1997 Stimulated by the Standard Logic Growth, but ASICs Yet to Gain Share

MOS digital logic, comprising primarily standard logic in the China/Hong Kong market, achieved a 39 percent growth, outpacing all semiconductor segments. The market had contracted by 9.3 percent in 1996. The 1997 market reached $895 million, according to Dataquest's final market share analysis. This number represented a 1993-to-1997 CAGR of 15 percent, thereby performing below the market, which grew 16 percent during the same period. On a worldwide level, ASICs accounted for about 72 percent of MOS logic revenue in 1997, up from 70 percent in 1996. In Asia/Pacific, ASICs shared only 43 percent in 1997, down from 48 percent. In China/Hong Kong, the ASIC market comprised only 28 percent of MOS digital logic products.

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China/Hong Kong Device Markets' Share of Asia/Pacific

Table 3-5 shows each semiconductor segment's long-term changing share of the Asia/Pacific market. It can be seen that from 1992 to 1995, the China/Hong Kong subregion declined in its share of the overall Asia/Pacific semiconductor consumption, for reasons previously discussed. China/Hong Kong's consumption share dropped from 20 percent in 1992 to 17.2 percent in 1995. The trend reversed itself in 1996 when the share increased to 19.2 percent. Dataquest's prediction that this was a long-term trend, rather than a cyclical anomaly, was confirmed as the market increased by 2.6 percentage points to 20.8 percent share of the Asia/Pacific consumption.

In Table 3-6, we constructed a detailed device comparison for 1996 and 1997. This table indicates in real terms the significant differences in consumption patterns between China/Hong Kong and Asia/Pacific. The most significant aspect of this comparison is not that the region outpaces the rest of the region and, of course, worldwide growth, but that it achieves this result across every product market. Tables 3-7 and 3-8 present China/Hong Kong's share of the Asia/Pacific semiconductor market by segment and by device.

Table 3-6
Final 1997 Computer Equipment Production and Semiconductor Consumption in China/Hong Kong (Units and Revenue)

	1996	1997	Annual Growth (%)
Monitor			
Units (K)	5,426	7,550	39.1
Semiconductor TAM (U.S.$M)	98	128	31.4
Motherboard			
Units (K)	9,476	15,200	60.4
Semiconductor TAM (U.S.$M)	331	541	63.6
Optical Disk Drive			
Units (K)	1,500	1,800	20.0
Semiconductor TAM (U.S.$M)	31	36	17.9
Page Printer			
Units (K)	35	51	45.0
Semiconductor TAM (U.S.$M)	5	7	44.3
Personal Computer			
Units (K)	1,147	2,096	82.7
Semiconductor TAM (U.S.$M)	345	608	76.4
Rigid Disk Drive			
Units (K)	2,683	5,300	97.5
Semiconductor TAM (U.S.$M)	81	160	97.8
Serial Printer			
Units (K)	454	511	12.5
Semiconductor TAM (U.S.$M)	11	13	15.3
Total Semiconductor TAM (U.S.$M)	**900**	**1,493**	**65.8**

Source: Dataquest (July 1998)

Table 3-7
China/Hong Kong's Share of Asia/Pacific by Device, 1992 to 1997 (Percentage Share)

	1992	1993	1994	1995	1996	1997
Total Semiconductor	**19.9**	**18.1**	**18.1**	**17.3**	**19.1**	**20.8**
Total Integrated Circuit	20.0	18.1	17.8	17.1	18.8	20.5
Bipolar (Function)	20.2	23.7	25.0	26.6	24.4	23.0
MOS Digital	18.4	16.6	16.7	16.1	18.1	19.9
MOS Memory	16.0	13.0	12.7	12.6	16.9	17.5
MOS Microcomponent	19.2	17.9	18.1	19.1	18.5	20.3
MOS Logic	21.7	22.5	25.5	23.1	19.5	22.9
Analog (Monolithic + Hybrid)	24.5	22.4	21.1	20.9	21.7	22.5
Discrete	18.6	18.2	20.0	18.8	21.4	22.5
Optoelectronic	23.6	20.6	21.9	20.6	23.1	22.4

Source: Dataquest (July 1998)

Table 3-8
China/Hong Kong's Semiconductor Market as Percentage Share of the Asia/Pacific Semiconductor Market, 1996 and 1997

	1996	1997	Change (%) 1996 to 1997	China/Hong Kong (U.S.$M) 1996	1997	Asia/Pacific (U.S.$M) 1996
Total Semiconductor	**19.2**	**20.8**	**1.6**	**5,664**	**6,769**	**29,451**
Total Integrated Circuit	18.8	20.5	1.7	4,790	5,705	25,418
Total Bipolar Digital	24.4	23.0	-1.4	58	42	236
MOS Memory	16.9	17.5	0.6	1,357	1,142	8,017
Dynamic RAM	16.5	17.2	0.8	968	800	5,878
Static RAM (80/0.93)	11.1	14.6	3.5	103	87	926
Nonvolatile Memory	22.3	19.6	-2.8	263	239	1,177
EPROM	19.0	21.9	2.8	44	45	231
EEPROM	38.2	26.2	-12.1	65	55	170
Flash Memory	17.6	15.2	-2.4	86	92	489
Mask ROM	23.7	23.2	-0.5	68	48	287
Other MOS Memory	66.0	30.0	-36.0	24	15	36
MOS Microcomponent	18.5	20.3	1.7	1,622	2,206	8,744
Microprocessor	19.8	19.8	0	671	881	3,392
Microcontroller	26.0	29.4	3.4	532	680	2,050
Microperipheral	12.1	14.5	2.4	343	480	2,834
Digital Signal Processor	16.0	20.6	4.6	75	165	468
MOS Digital Logic	19.5	22.9	3.4	650	895	3,336
Total ASIC	17.4	15.2	-2.2	277	253	1,588
Custom IC	7.0	18.2	11.3	31	78	445
MOS Standard Logic	20.6	32.0	11.4	97	197	472
Total Other MOS Logic	29.5	30.5	1.0	245	368	831
Analog Monolithic	21.7	22.5	0.8	1,104	1,419	5,085
Total Discrete	**21.4**	**22.5**	**1.1**	**704**	**859**	**3,294**
Total Optical Semiconductor	**23.1**	**22.4**	**-0.6**	**170**	**205**	**739**

Source: Dataquest (July 1998)

Chapter 4
Semiconductor Vendor Supply Trends

Introduction

Dataquest publishes market share statistics twice per year. Our survey of all merchant market suppliers to Asia/Pacific is released in April, and the China/Hong Kong statistics for the top 32 Asia/Pacific suppliers are published in July. This survey covers five major Asia/Pacific markets and publishes these results: China/Hong Kong, Korea, Singapore, Taiwan, and the rest of Asia/Pacific. The analysis of this chapter is based on survey results.

This survey is a worldwide effort by Dataquest research analysts located in Asia/Pacific, Europe, Japan, and North America. After finalizing each company's Asia/Pacific shipments, Dataquest's market share team conducts primary and secondary research to estimate country-level shipments for the largest vendors. Direct surveys are conducted with either the country or regional manager, or the responsible representative based in the headquarters of the companies surveyed. Therefore, every company has an opportunity to review, revise, or comment on these estimates. In rare cases, both headquarters and country/regional offices are surveyed to improve accuracy. Companies with large captive semiconductor markets are certainly surveyed at headquarters to ensure that all revenue is counted.

This section of Dataquest's report combines the company revenue into one China/Hong number because vendor business operations also do so. Whether a multinational transfers semiconductors to subsidiaries in China or ships semiconductors direct to distributors or end users, Dataquest counts all revenue as "shipments" to China/Hong Kong. Dataquest's definition for this China/Hong Kong survey is consistent with worldwide market share definitions and methodology.

Dataquest hopes that the estimates data will function as a benchmark to measure the future performance of semiconductor suppliers and to monitor semiconductor allocation dynamics within Asia/Pacific.

Total Semiconductor Market Share Ranking: A Year of Turmoil

As expected, China's overall market recovered in 1997 after a slowdown across most major segments. Some products, such as memories, were still plagued by price declines as a result of a worldwide oversupply. Exceptional growth-volume products included microperipherals and MOS standard logic. DSPs represented the fastest-growing emerging product. Revenue grew 120 percent to $295 million. In major segments, Dataquest sees shipments of MOS memories declined by 16 percent at the negative extreme.

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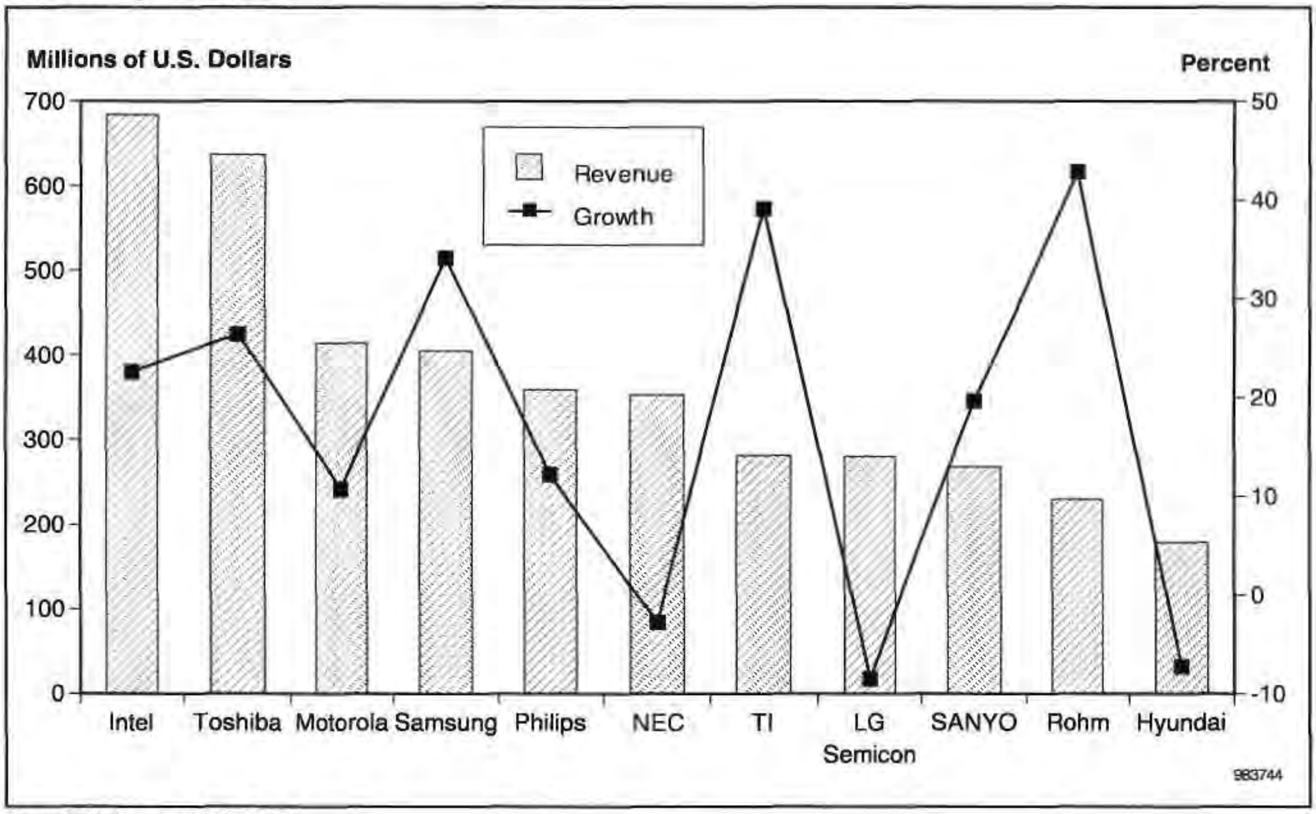
Segment growth leaders included the MOS digital logic market, with 38 percent growth, and microcomponents, with 36 percent growth. Furthermore, strength in analog and discrete parts contributed significantly to the market rebound. As analyzed in later sections, the combination of mature and new products being introduced within the China/Hong Kong market resulted in wide disparity in company performances. This trend would be expected in a memory downturn, but nonmemory growth segments of the markets also experienced a wide shipment variance (see Figure 4-1).

Figure 4-1
China/Hong Kong's 1997 Top 10 Total Semiconductor Suppliers (Revenue and Percentage Growth)



Source: Dataquest (July 1998)

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A Product Overview

Memory suppliers dealt with the downturn differently. Japanese companies either seemed to pull back from the market or lacked the ability to compete and lost market share. Japanese companies' memory shipments to China/Hong Kong consequently declined by 54 percent, while American companies gained by 7.7 percent. The DRAM market went from bad to worse as the worldwide oversupply flooded even China's elaborate distribution channels. Even the emerging flash memories increased by only 6 percent to $92 million.

Nevertheless, China's diverse semiconductor market was able to buffer the memory slump in its third year of contraction. In addition to microcomponents and MOS logic, analog and discrete enjoyed a strong price stability. MOS logic contracted 9 percent in 1996, and analog and discrete grew less than 10 percent. However, both bounced back in 1997, with analog and discrete growing 29 percent and 22 percent, respectively. Microcomponents remained the growth pillar in China. Even with microprocessor revenue slowing to 36 percent from a 50 percent growth in 1996, the overall microcomponent segment was still able to expand by 36 percent from 17 percent in 1996, because of a strong MPR, MCU, and DSP demand.

Dataquest's company-level market share statistics and demand analysis concludes that total the semiconductor market reached $6.8 billion in 1997. Excluding Rohm Company Ltd. and SANYO Semiconductor Corporation, the other eight suppliers in China's top 10 list rank within Asia/Pacific's top 10 semiconductor suppliers. China's top 10 suppliers lost share from 59 percent in 1996 to 57 percent in 1997 (see Figure 4-2). Similarly, the top 32 companies in Asia/Pacific controlled 87 percent of China's semiconductor market in 1997, as opposed to 89 percent in 1996. In Asia/Pacific, however, the top 32 companies gained market share from 83.0 percent to 83.2 percent. In China, established vendors had greater difficulty maintaining market share than other markets in the region. The top 32 companies expanded by 16.4 percent, while the overall semiconductor market grew only a few percentage points faster (19.5 percent). In previous years, these companies were controlling more and more of the market, but the following two factors explain this trend reversal:

- Major DRAM suppliers (all within the top 32) lost significant overall market share because of revenue erosion.
- Other microcomponent and MOS logic vendors entered the Chinese market either to develop entirely new segments, such as in video compact disks (VCDs), or to seek new demand for mature products, such as microcontrollers (for example, Samsung Electronics Company Ltd.) or microprocessors (for example, Advanced Micro Devices Inc.).

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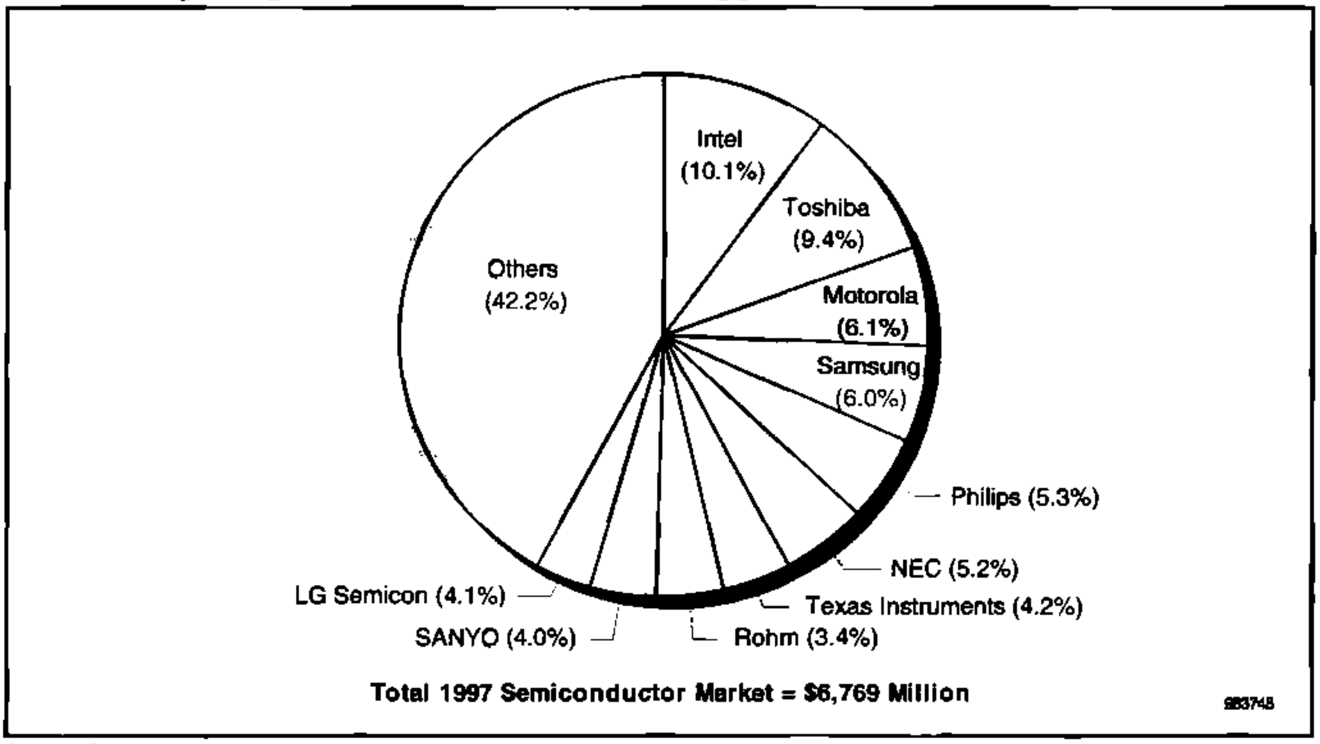
Figure 4-2
China/Hong Kong 1997 Total Semiconductor Suppliers' Market Share (Percent)



Source: Dataquest (July 1998)

No. 1, Intel Corporation

Despite increased competition and loss of market share, Intel Corporation remained the largest semiconductor supplier to China in 1997. Demand for non-Intel microprocessors increased because of AMD's aggressive marketing and pricing. Intel's revenue growth dropped sharply to 25.6 percent in 1997, compared with 48.8 percent in the previous year. Intel's share of Asia/Pacific sales to China remained at approximately 17 percent. Intel has adopted a strategy of mass-marketing and large advertising campaigns, which is difficult for any company other than Intel to match. However, the fragmented nature of the market enables a company such as AMD to gain market share through tactical wins in the marketplace. AMD doubled its revenue in China to $121 million, moving up six ranks to No. 16.

No. 2, Toshiba Corporation

Toshiba Corporation, although exiting the DRAM market, experienced a strong growth by broadened penetration into communications, monitors, and even home appliances. Exiting the DRAM market represented a critical strategic decision that quickly paid off. Toshiba's overall 26.4 percent growth exceeded Intel's 22.6 percent growth, and if the company has another good year, it could regain its No. 1 ranking after losing it in 1996. Toshiba was able to diversify its end-market applications markets. For example, its expansion in cordless phone (CT0 and 900 MHz) markets boosted the bottom line. In addition, Toshiba's flexibility further paid off as it was able to provide design support and kit solutions (MCU and combo chip) to Chinese manufacturers. This strategy had been a key to its success in China's television markets in the 1980s, and the company applied this concept to the communications electronic equipment market.

No. 3, Motorola Incorporated

Toshiba was able to exit losing markets and expand market penetration from its mainstream products. In contrast, Motorola Incorporated's growth slowed, while its own product market accelerated. There was no change in product focus or broadened end markets, hence sales penetration decline. While all of the major markets Motorola participates in recovered in 1997, Motorola's shipments expanded at half its 1996 growth rate. Semiconductor shipments, including transfer shipments, grew 10.7 percent in 1997, about half of the overall market rate. In addition to missing merchant market opportunities, Motorola's semiconductor division has been unable to capitalize on its strong communication equipment sales since the pager market slumped in 1996. In short, the company lost market share in almost every major sector in which it competes. Its 1997 worldwide restructuring process evidently impeded the company's ability to compete. The lost business and opportunity costs will take years to recover, if it recovers at all.

China was once the cornerstone of Motorola's Asian strategy, occupying about 26 percent of Asia/Pacific semiconductor sales. Now, China's share is on a declining slope, with only a 24 percent share in 1997. When one considers the fact that China increased its share of regional consumption from 19 percent to 21 percent in 1997, this decline in relative revenue is actually 5 percentage points.

No. 4, Samsung Electronics Company Ltd.

In the worst memory downturn in China's semiconductor history, Samsung still emerged from the dust with a 34 percent revenue growth and improved its market share ranking from No. 7 to No. 4. China was at the center of Samsung's Asia/Pacific sales growth. Regional sales expanded only 5 percent, while China expanded seven times faster. Samsung's decision to diversify into MCU seemed risky given the 1996 market decline. However, the company was able to expand its regional sales from $78 million to $205 million largely because of its success in China, which accounted for more than one-third of MCU sales in the region. Samsung moved from No. 12 to No. 1, replacing Motorola as the No. 1 MCU supplier in China. This shift happened because of Samsung's expanding sales from $16 million to $76 million, an impressive 375 percent growth rate. In addition to product diversification, Samsung was able to maintain or increase its market position in other key markets in which it participates (such as analog, discrete, and memories). MOS logic was the only area in which the company lost market share.

Total Integrated Circuit Market Share Rankings

For those who do not consider discrete devices to be an important business, they should think again. As shown in this section, when discrete and optoelectronics are excluded, the top 10 ranking changes significantly (see the IC rankings in Figures 4-3 and 4-4).

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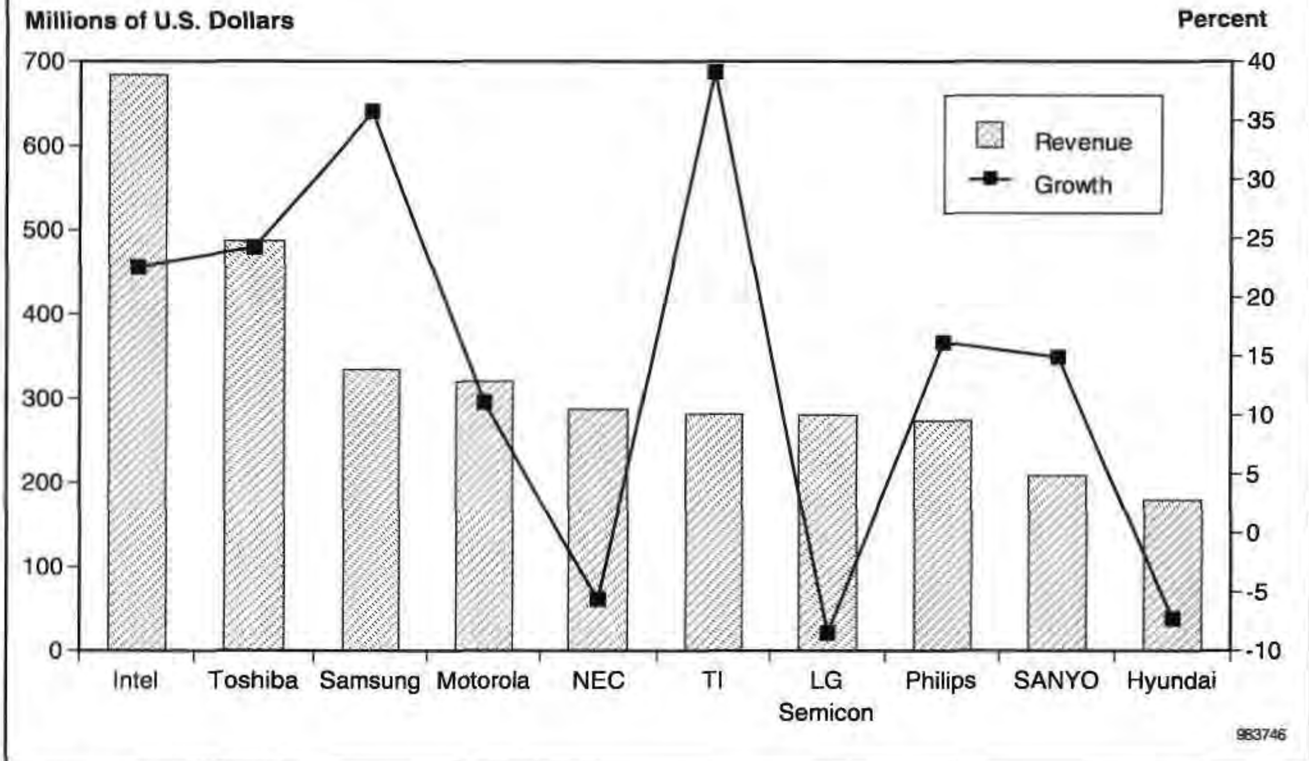
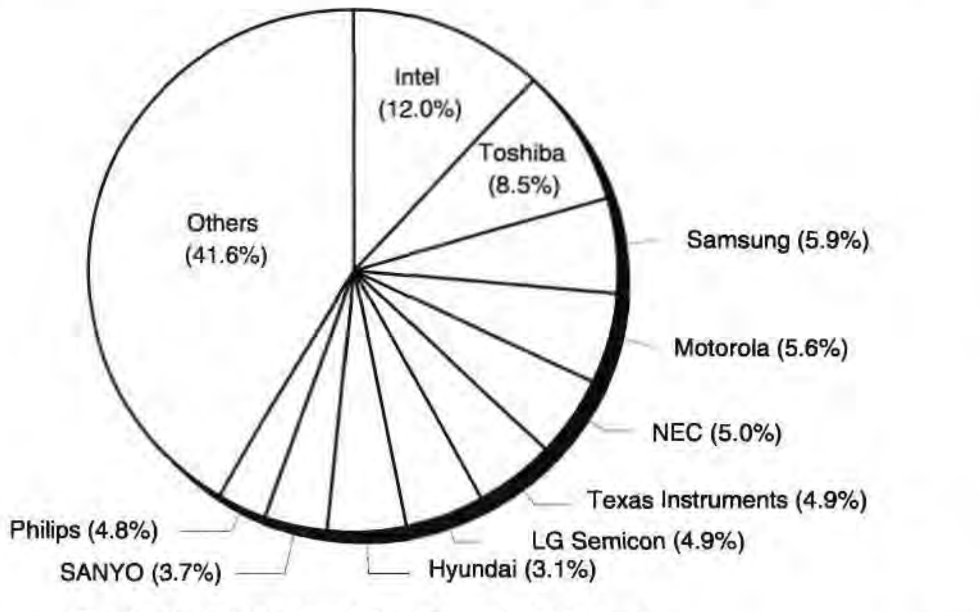
Figure 4-3
China/Hong Kong 1997 Top 10 Integrated Circuit Suppliers' Revenue and Percentage Growth (Millions of U.S. Dollars)



Source: Dataquest (July 1998)

Figure 4-4
China/Hong Kong Total Integrated Circuit Market Share, 1997 (Percentage of Revenue)



Total Integrated Circuit Market = $5,705 Million

Source: Dataquest (July 1998)

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China/Hong Kong's IC market grew 19.1 percent to $5.7 billion in 1997. Although Intel and Toshiba remained the top two suppliers, Samsung replaced Motorola as the No. 3 semiconductor supplier, in part, because of its 27 percent revenue growth in discrete devices. Philips Electronics NV can increase its ranking position from No. 8 (in ICs) to No. 5 in total semiconductors because of its strong position (ranked third) in discrete sales. A recovery in MCUs has enabled Motorola to move up its IC ranking from fifth to fourth place. Nevertheless, Motorola increased its IC revenue by 11 percent, much slower than the market average (see Figure 4-3). TI had a strong year in DSPs and surpassed Philips to become the sixth-largest IC supplier in China/Hong Kong. In 1997, TI ranked eighth. Philips experienced a 16 percent growth in ICs and only 12 percent in semiconductors, attributed to its mere 1.2 percent growth in discrete sales in a market that grew 22 percent.

MOS Memory Market Share

This section summarizes MOS memory market trends and analyses the top 10 suppliers.

After MOS memory devices surpassed MOS microcomponents in 1995, the two devices switched positions again in 1996, and memories further lost market share to microcomponents in 1997. As Dataquest stated in 1997, the trend is expected to hold. In other words, microcomponents will reign as king until beyond 2000.

China/Hong Kong survived, but was not immune from the region's first major downturn, while Taiwan and Singapore sustained a strong bias toward PC, peripherals, and storage manufacturing. This was the single-largest factor behind China/Hong Kong's rise to the lead in Asia/Pacific. In 1995, nearly 39 percent of all semiconductor revenue was derived from memories in Asia/Pacific. After the market correction in 1996, only 27 percent of the market was from memories. Then, the semiconductor market suffered further declines in 1997: Only 20 percent of semiconductor revenue is derived from MOS memories in Asia/Pacific. To put this downward trend in perspective, memory suppliers to Asia/Pacific, as a whole, lost a net $4.6 billion in revenue, from $12.6 billion in 1995 to $8.0 billion in 1996. In 1997, memory suppliers lost another $1.5 billion as the market declined to $6.5 billion.

These same suppliers lost less in China/Hong Kong, where the market declined from $1.6 billion to $1.3 billion in 1996. In 1997, this market hit the $1.1 billion level. The year 1997 experienced a 16 percent decline, compared to Asia/Pacific's 19 percent fall. China/Hong Kong is increasingly being impacted by the worldwide overcapacity because the market is unprotected from semiconductor dumping, in contrast to Europe and North America. China lacks the regulatory bodies of the European Economic Commission (EEC) and the International Trade Commission (ITC), which have been known to slap tariffs on alleged memory dumpers. China/Hong Kong's MOS memory market was about 28 percent of total semiconductors in 1995 but declined to just 20 percent in 1996. In 1997, the share declined to 17 percent. Although, high PC production expansion counteracted some of the ill effects of price erosion, aggressive Taiwanese and Korean pricing inhibited revenue recovery.

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In no other segment do company performances vary as widely among the top 10 suppliers. The market leader Atmel Corporation moved from No. 11 to No. 5 on a 76 percent sales growth. At the other extreme, Hitachi Ltd.'s sales dropped 67 percent. Toshiba was not too far behind, with a 61 percent revenue decline. NEC Corporation also faced a 35 percent revenue decline.

Taiwanese vendor Vanguard International Semiconductor Corp. was able to increase its DRAM revenue to $50 million after negligible sales in 1996. China proved to be a prime market for cheap 16Mb DRAMs, as well as a place to dump outdated 4Mb parts. Prices for most memory parts in China's major computer markets reached price points comparable with Taipei. Pressure from the U.S. ITC on Taiwan's memory resulted in manufacturers and traders focusing more on China to shed excess inventories. Consequently, the DRAM market declined 17 percent and SRAMs declined 15 percent. The capacity and marketing might of Samsung was too powerful for most SRAM vendors to match. Samsung was able to double its revenue in a declining market. Sony Corporation and Sharp Electronics Corporation were the only two other companies able to raise revenue—but only by $2 million—while Samsung dramatically extended its SRAM market share to an impressive 23.8 percent.

Memory Vendors' Company Ranking

Figure 4-5 illustrates the revenue and growth rates of the top 10 MOS memory suppliers in China/Hong Kong. Figure 4-6 illustrates the total 1997 market sizing and company market share of ranking for the top 10 MOS memory semiconductor suppliers in China/Hong Kong during 1997. The following section analyzes the top five vendors' memory business.

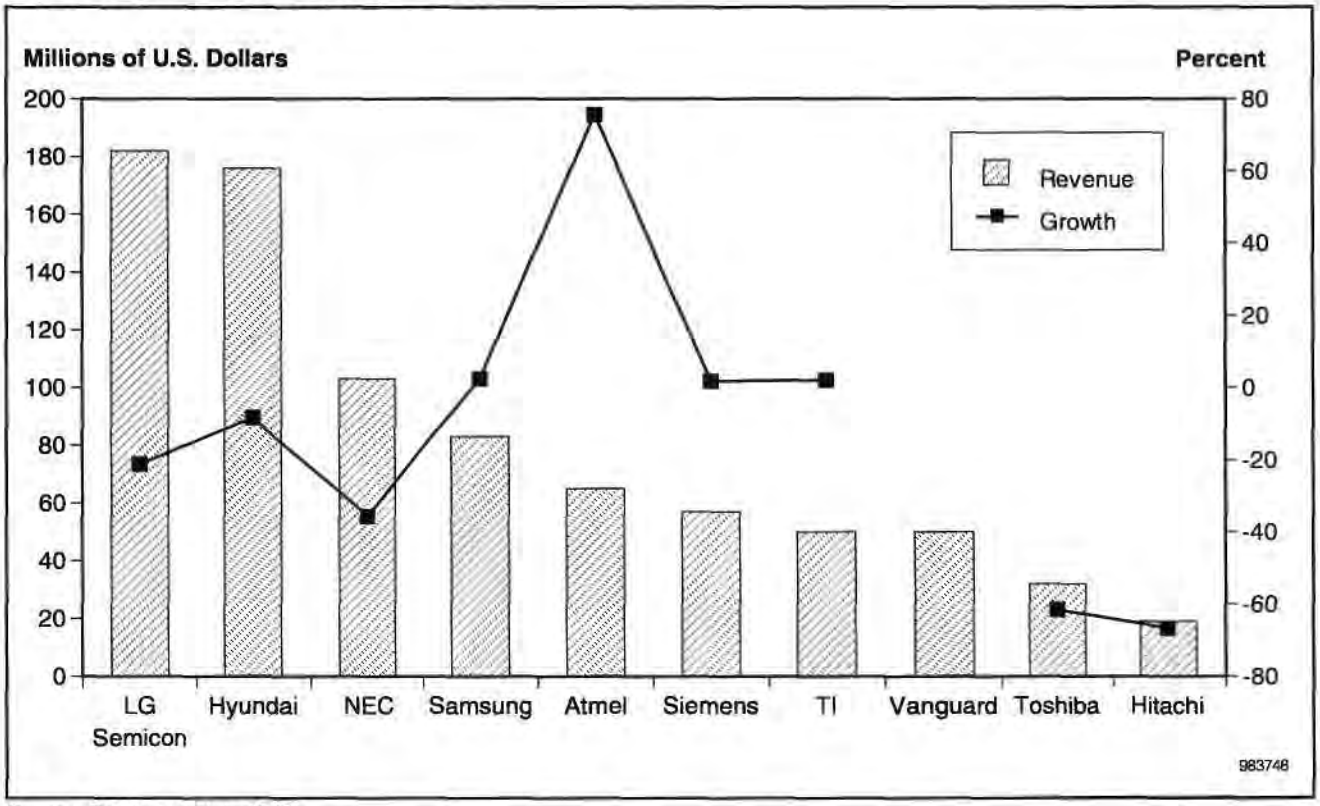
No. 1, LG Semicon Co. Ltd.

LG Semicon Co. Ltd. sustained its top spot in this category, claiming 16 percent of the memory market. This is 4 percentage points less than 1996's 20 percent share. Its DRAM share of total memory revenue declined from 74 percent in 1996 to 70 percent in 1997, indicating that the DRAM overcapacity was the main market inhibitor. LG Semicon's DRAM sales accounted for 72 percent of its semiconductor sales in China/Hong Kong in 1996, which dropped to 58 percent in 1997. As a share of Asia/Pacific total revenue, China/Hong Kong dropped from 30 percent to 28 percent of LG's total regional revenue. Even at this level, this ratio is much higher than other major memory players' ratios.

No. 2, Hyundai Electronics Company Ltd.

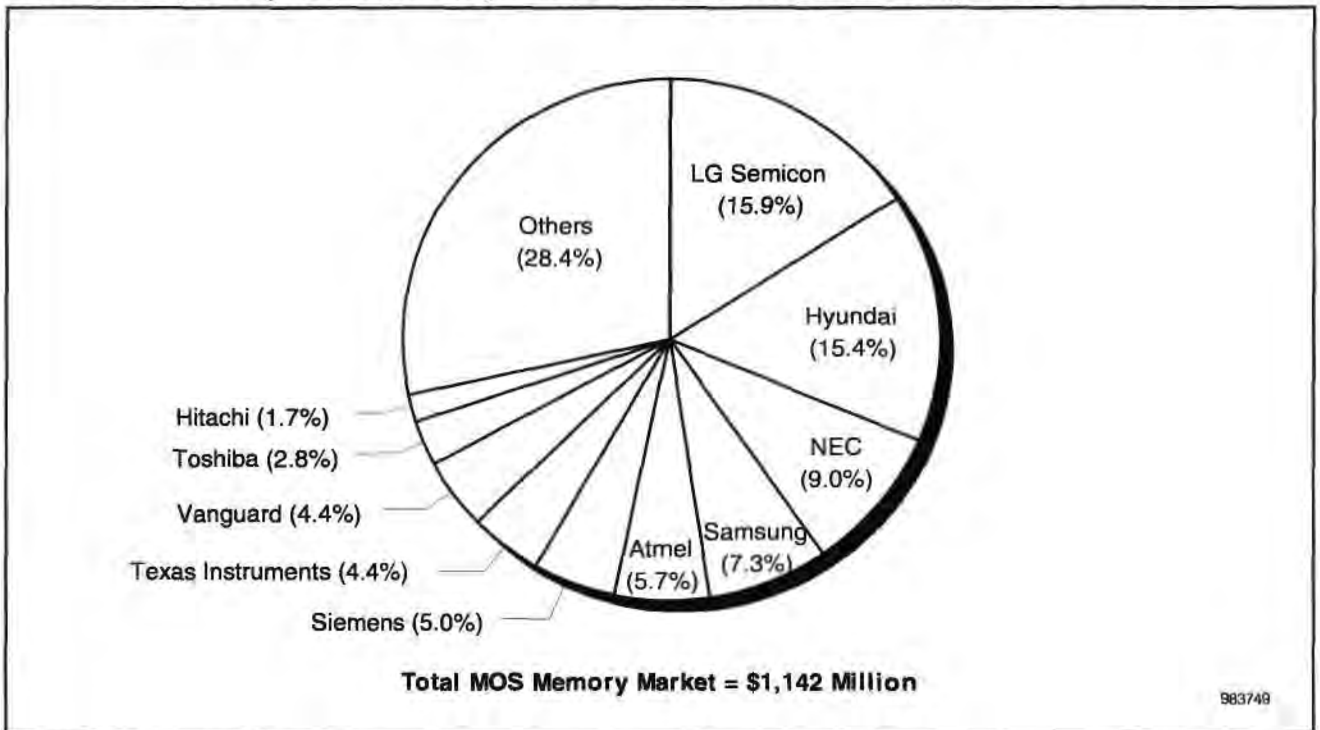
Hyundai's Electronics Company Ltd.'s revenue in China/Hong Kong increased from 23 percent of its total Asia/Pacific sales in 1996 to 25 percent in 1997. This number is between LG's 28 percent and Samsung's 21 percent concentration. For memories, China/Hong Kong also represented 23 percent of Asia/Pacific sales. This result is expected because almost all revenue comes from DRAMs and SRAMs, and these markets did not decline as fast as they did China/Hong Kong.

Figure 4-5
China/Hong Kong 1997 Top 10 MOS Memory Suppliers' Revenue and Percentage Growth (Millions of U.S. Dollars)



Source: Dataquest (July 1998)

Figure 4-6
China/Hong Kong MOS Memory Market Share, 1997 (Percentage of Revenue)



Source: Dataquest (July 1998)

No. 3, Samsung Electronics Company Ltd.

Approximately 19 percent of Samsung's Asia/Pacific revenue came from sales to China/Hong Kong in 1996, which climbed to 21 percent in 1997. Only 20 percent of Samsung's China/Hong Kong business was generated by memory in 1997. The memory shipments declined 16 percent in 1996 and grew 2 percent in 1997. Samsung was able to increase its memory market share for the second consecutive year. Its market share ranking for memories increased from No. 6 to No. 4 as a result. Yet, China/Hong Kong has not been a high-priority market for Samsung's memory division because only 9 percent of Asia/Pacific MOS memory sales are shipped to China/Hong Kong. Because of Samsung's size and the company's sizable volume in microcomponents, analog, and discrete, it jumped from No. 7 to No. 4 in overall semiconductor ranking.

No. 4, NEC Corporation

China/Hong Kong is NEC Corporation's most important Asia/Pacific market, constituting 27 percent of its total regional revenue in 1997. This number was 1 percent less than 1996's share. In recent years, increasing memory market share was an important factor behind NEC's overall success in the China/Hong Kong market (moving in total ranking from sixth to fourth). Approximately 44 percent of NEC's total semiconductor sales in China/Hong Kong came from memory products in 1996. This number declined to 29 percent in 1997. NEC's relative success in DRAM enabled it to increase memory market share from 13.8 percent in 1995 to 14.1 in 1996, thereby ranking third in memories after LG and Samsung, respectively. In 1997, the company lost significant market share because of its 35 percent decline in memory shipments, compared to only 16 percent for the overall market. But the company did not lose its third-ranking position as a result.

No. 5, Hitachi Ltd.

China/Hong Kong increased in importance to Hitachi's Asia/Pacific revenue from 14 percent to 17 percent in 1997. Hitachi has been losing memory market share in China/Hong Kong for several years and almost exited the market completely in 1997. In 1996, Hitachi moved from fourth rank to fifth rank, and its memory revenue declined from $136 million to $57 million in 1996. Market share decreased from 8.6 to 5.0 percent. Hitachi's memory shipments to China/Hong Kong represented 12 percent of all Asia/Pacific memory shipments. Within its China/Hong Kong sales, memories were 35 percent of total sales. Nevertheless, memory shipments declined 67 percent in 1997 to a meager $19 million. As a result, Hitachi's memory ranking slid from No. 8 to No. 10. Hitachi's total semiconductor ranking grew only 1.2 percent, and its ranking declined from No. 12 to No. 13.

Microcomponent Market Share Rankings

Microcomponent shipments increased 17 percent in 1996 to $1.6 billion and another 36 percent in 1997. Microcomponents' share of the semiconductor market in China/Hong Kong increased substantially, from 29 percent in 1996 to 33 percent in 1997. MPUs and microperipherals (MPRs) led the growth, with 31 percent and 40 percent growth, respectively, while MCUs expanded by 27 percent. Intel's dominance of the MPU market distorts this ranking, but a further analysis is discussed later.

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Microprocessors

Intel's revenue from MPU shipments to China/Hong Kong as a percentage share of Asia/Pacific decreased from 17.5 percent in 1996 to 17 percent in 1997. In 1996, more than 85 percent of Intel's semiconductor business came from MPUs, totaling $477 million, compared with $558 million for the company's semiconductor shipments as a whole. In 1997, MPU sales increased 25 percent to $599 million, a slowdown from 1996's growth. Intel's next largest segment was MPRs, which totaled approximately $34 million in 1996 and only $36 million in 1997. Dataquest estimates Intel's MCU sales at approximately $31 million, experiencing a flat growth.

Intel dominates this sector, but if one deducts its $599 million in MPU sales, then only $67 million remains, which is split equally between MCUs and MPRs. Intel's 22.9 percent growth is attributed to a 25.6 percent growth in MPRs, rather than to MCUs and MPRs, which were relatively flat products.

The overall MPU market expanded 31.2 percent, and Intel lost market share, with non-Intel parts expanding by 75 percent. Non-Intel x86 MPU vendors, including AMD, National Semiconductor, STMicroelectronics BV (formerly SGS-Thomson), and IBM, accounted for 14.1 percent of x86 MPU shipments to China in 1997. However, this 14.1 percent share is having a significant impact on Intel's pricing and product strategy in China. In 1998, tightened budgets in business and home result in a price-conscious buying behavior that has benefited the non-Intel camp. Additional challenges lie ahead for Intel, as the market's move to the sub-$1,000 PC is diminishing brand association, which is likely to benefit non-Intel vendors. At the same time, diminished margins make retail-level marketing all the more expensive and difficult to rationalize—but perhaps, all the more necessary. Figure 4-7 illustrates China/Hong Kong's top 10 MOS microcomponent suppliers' revenue and growth in 1997. Figure 4-8 shows MOS microcomponent vendors' market share in China/Hong Kong for the same year.

Microperipherals

The MPR market was bolstered by VCDs, communications, and a continued strength in PC production. The market growth accelerated from 22.7 percent to 40 percent in 1997. S3 Incorporated moved from insignificant sales to a 15 percent market share within one year, ranking No. 2 behind United Microelectronics Corporation (UMC) in 1997. UMC remained the dominant MPR vendor because of its dominance in the PC motherboard segment. Only a few major PC vendors rely on Intel core logic chipsets, and Intel's MPR revenue is only one-third of UMC's.

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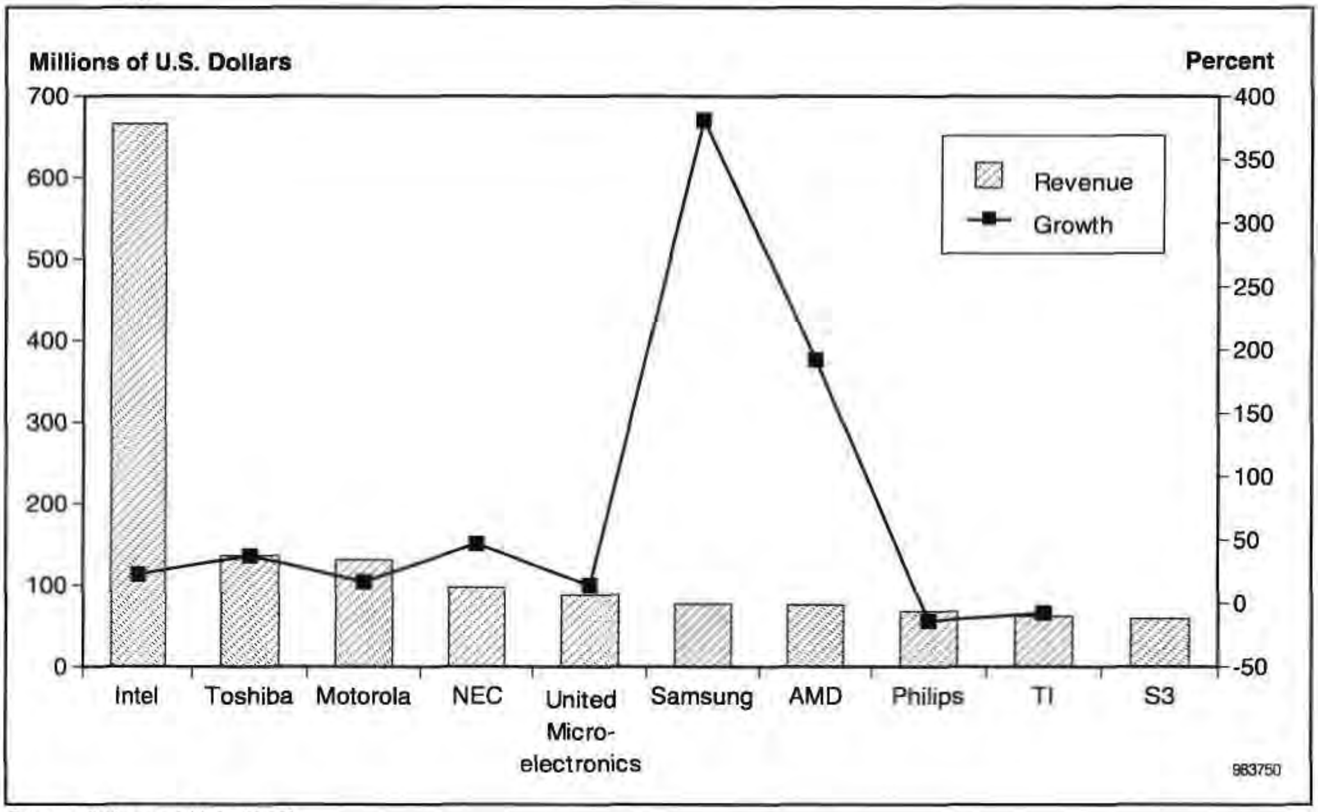
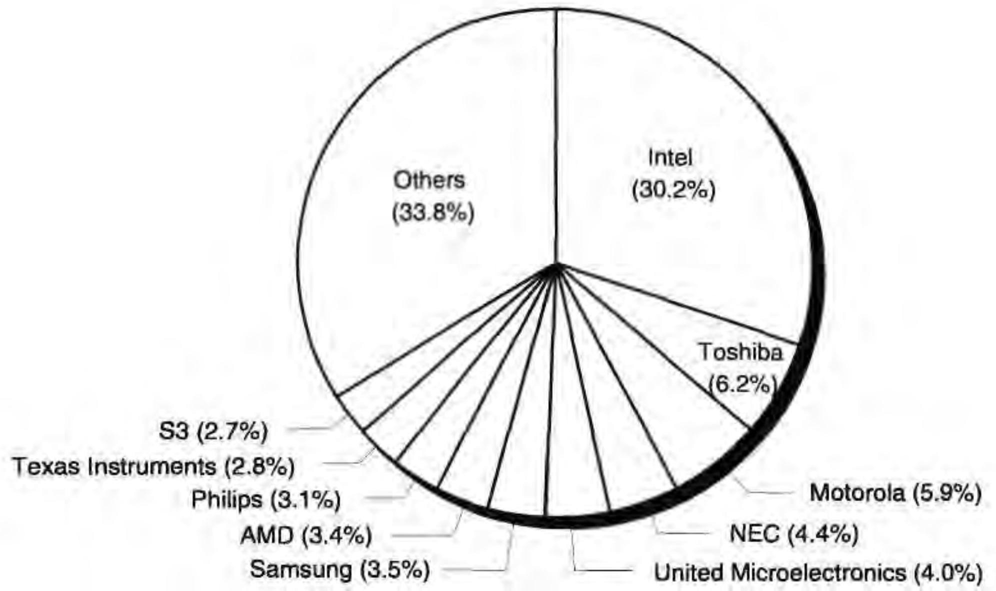
Figure 4-7
China/Hong Kong 1997 Top 10 MOS Microcomponent Suppliers' Revenue and Percentage Growth (Millions of U.S. Dollars)



Source: Dataquest (July 1998)

Figure 4-8
China/Hong Kong MOS Microcomponent Vendors' Market Share, 1997 (Percentage of Revenue)



Source: Dataquest (July 1998)

Microcontrollers

The MCU market also accelerated, recovering with a 27.7 percent growth after experiencing a decline in 1996. The primary growth areas were communications and home appliance markets. As previously discussed, Samsung aggressively and successful tackled this market. Because of the diversity of applications, the success stories vary. Companies in the communications sector generally outperformed those in the consumer sector. Toshiba had made strong gains in the home appliance sector, but the low average selling prices (ASPs) resulted in a below-average market performance.

Motorola, which ranked second overall in the microcomponents market (because of its high revenue levels in MCUs), trailed far behind Intel in MPU revenue. More than 23 percent of Motorola's Asia/Pacific microcomponent revenue came from China/Hong Kong in 1996. In 1997, this number declined to 19 percent. About 33 percent of Motorola's China/Hong Kong semiconductor revenue came from microcomponents in 1996. In 1997, similarly, 32 percent of revenue came from microcomponents. MCUs occupied 20 percent of China/Hong Kong's semicon-ductor business in 1996. But this figure dropped to 14 percent, and the company lost significant market share at the same time. MCUs were the slowest sector of microcomponents in 1996, growing at just 6 percent (this slow growth was attributed, in part, to a market slowdown). The MCU market recovered with a 28 percent growth, yet Motorola's revenue was flat.

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Digital Signal Processors

The fourth segment in microcomponent is digital signal processors (DSPs), which doubled from $81 million to $162 million in 1997. Lucent Technologies usurped the No. 1 position from TI by doubling its sales, while TI experienced a flat growth. Philips Electronics NV's market presence was felt as its sales rose from zero to $8 million in 1997, securing a top five position. Toshiba promoted its DSPs in the communications markets and expanded revenue nearly sixfold to approximately $40 million.

MOS Digital Logic Market Share Rankings

Dataquest's estimates indicate that China/Hong Kong's MOS digital logic market grew from $650 million in 1996 to $895 million in 1997, with an annual growth rate of 40 percent. In 1996, the demand for MOS digital logic comprised mainly ASICs (43 percent), and standard logic products (15 percent), while another 38 percent of MOS logic consumption in China consisted of other logic devices. In 1997, the market makeup was ASICs (28 percent), standard logic products (22 percent), and other logic devices (41 percent). MOS custom ICs increased from 5 percent to 9 percent of MOS digital logic revenue in this period.

Toshiba became the No. 1 supplier with 16 percent of this market. Its 1997 sales increased 107 percent to $143 million (see Figure 4-9).

In 1997, the overall market growth of MOS digital logic was 37.8 percent from negative 9.3 percent a year earlier, which was a sharp turnaround in the MOS logic market. However, the range of vendor performance was more dramatic than in most years. The main reason for these variances is the volatility within various end markets. Although ASIC consumption declined 8.6 percent in 1997, standard logic kept pace with the broad-based growth within communication, consumer, and computer sectors in China. Lucent, NEC, Motorola, and Fujitsu are exceptions among the top 10 in that they generated a positive revenue growth in ASICs. The rest, Samsung, TI, Matsushita Electric Industrial Company Ltd., IBM, Toshiba, and LG Semicon, suffered declines. The MOS logic market was helped by a strengthening in standard logic and other MOS logic, which grew by 103 percent and 50 percent, respectively. Figure 4-10 illustrates China/Hong Kong's MOS digital logic market share in 1997.

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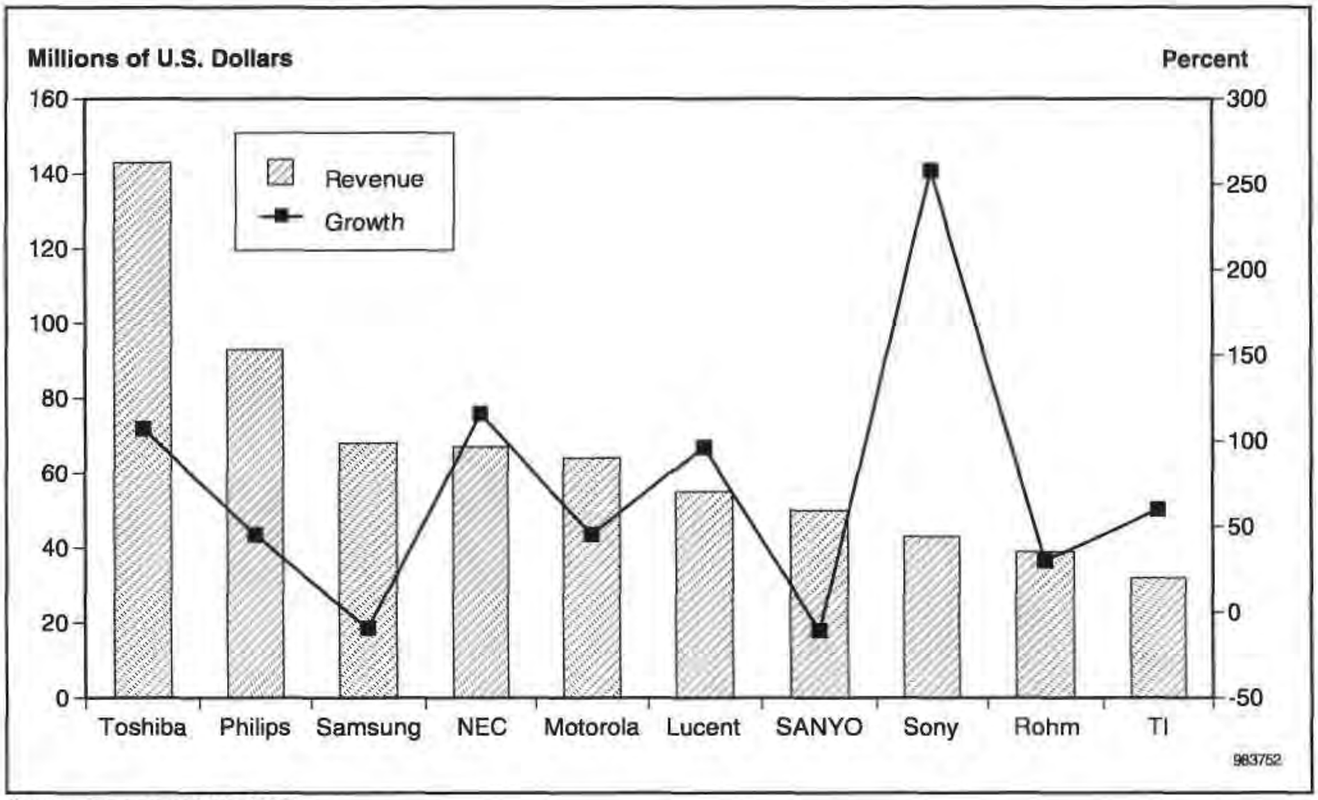
Figure 4-9
China/Hong Kong 1997 Top 10 MOS Digital Logic Suppliers' Revenue and Percentage Growth (Millions of U.S. Dollars)



Source: Dataquest (July 1998)

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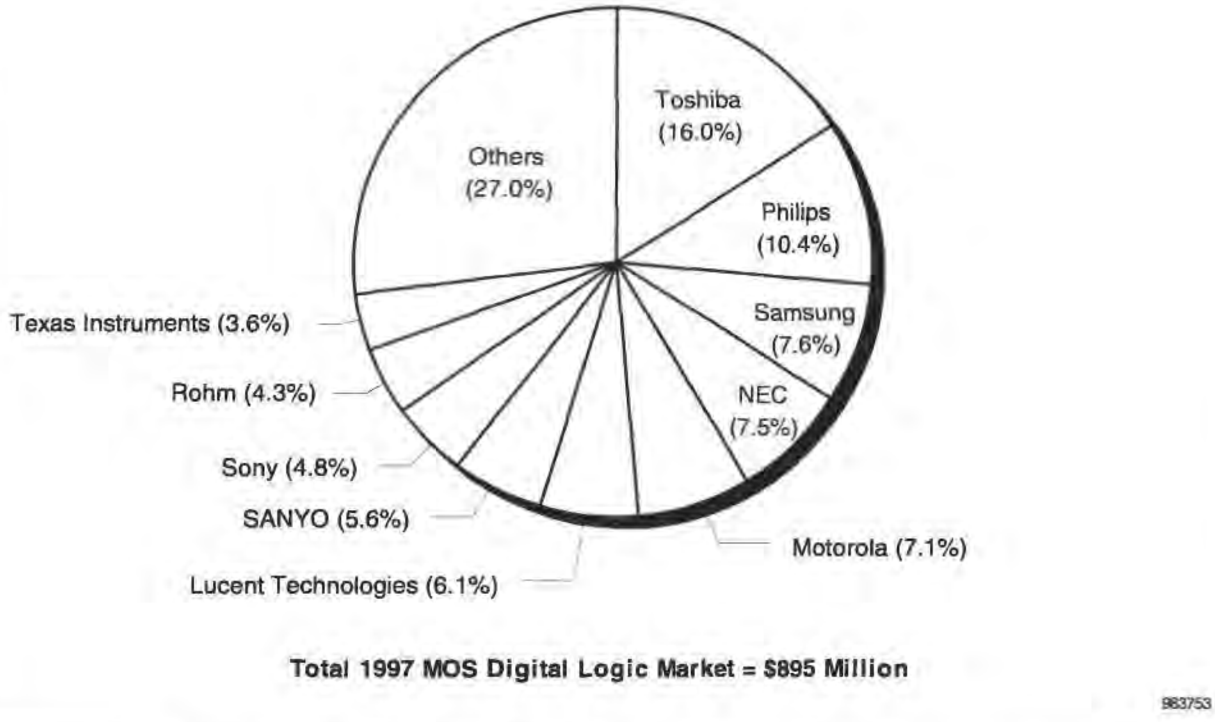
Figure 4-10
China/Hong Kong MOS Digital Logic Market Share, 1997 (Percentage of Revenue)



Source: Dataquest (July 1998)

Analog IC Market Share Rankings

The $1.4 billion analog-monolithic market has a diverse supplier base with minor differences among the companies' market share but a wide variance in the 1997 growth rates (see Figures 4-11 and 4-12).

The total analog market in China expanded 28.6 percent in 1997 because of a surprisingly strong growth in China's communication markets. The large, dispersed monolithic-analog IC market represents a formidable 21 percent of China's total semiconductor consumption. The 32 companies surveyed increased sales by 32.7 percent and, therefore, gained market share. TI jumped from No. 8 to No. 2 because of an impressive 149 percent revenue growth. Market leader Toshiba maintained its lead with an above-average growth of 31.6 percent. The consumer analog market also performed well in 1997, and vendors—such as SANYO and Rohm—expanded their market share.

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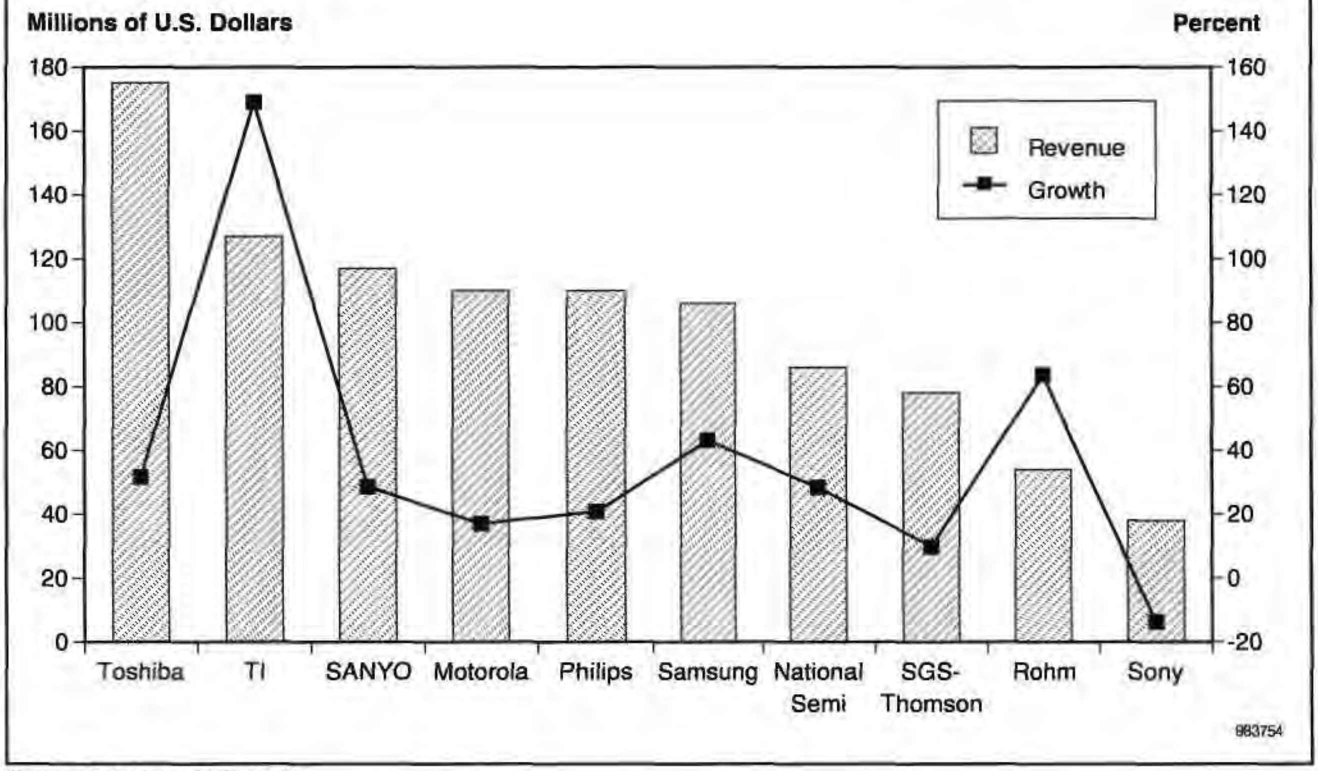
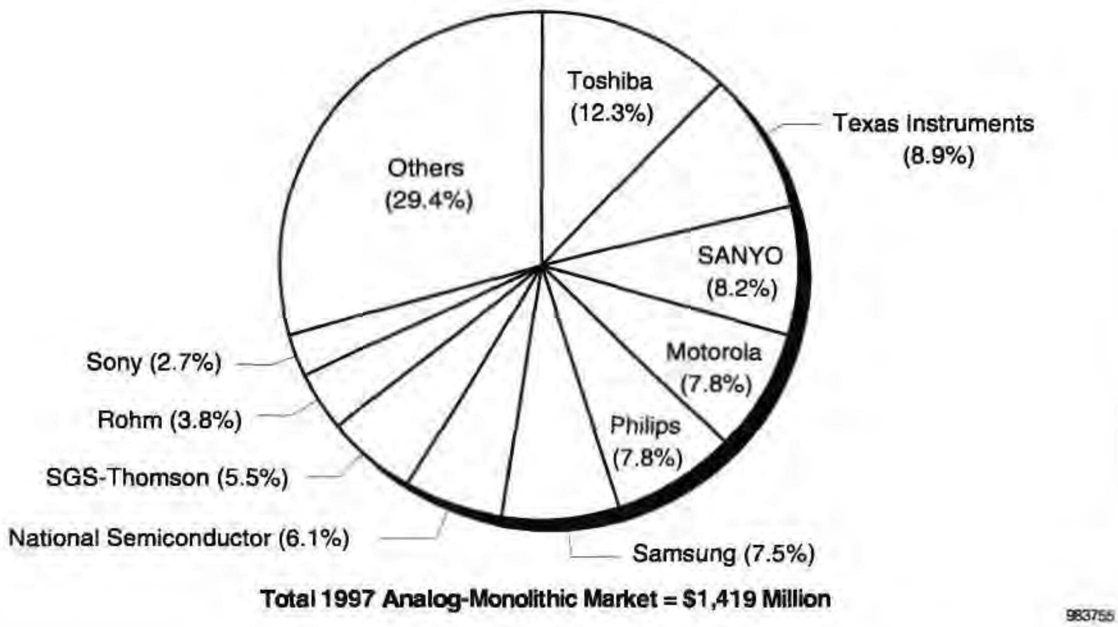
Figure 4-11
China/Hong Kong 1997 Top 10 Analog-Monolithic Suppliers' Revenue and Percentage Growth (Millions of U.S. Dollars)



Source: Dataquest (July 1998)

Figure 4-12
China/Hong Kong Analog-Monolithic Market Share, 1997 (Percentage of Revenue)



Source: Dataquest (July 1998)

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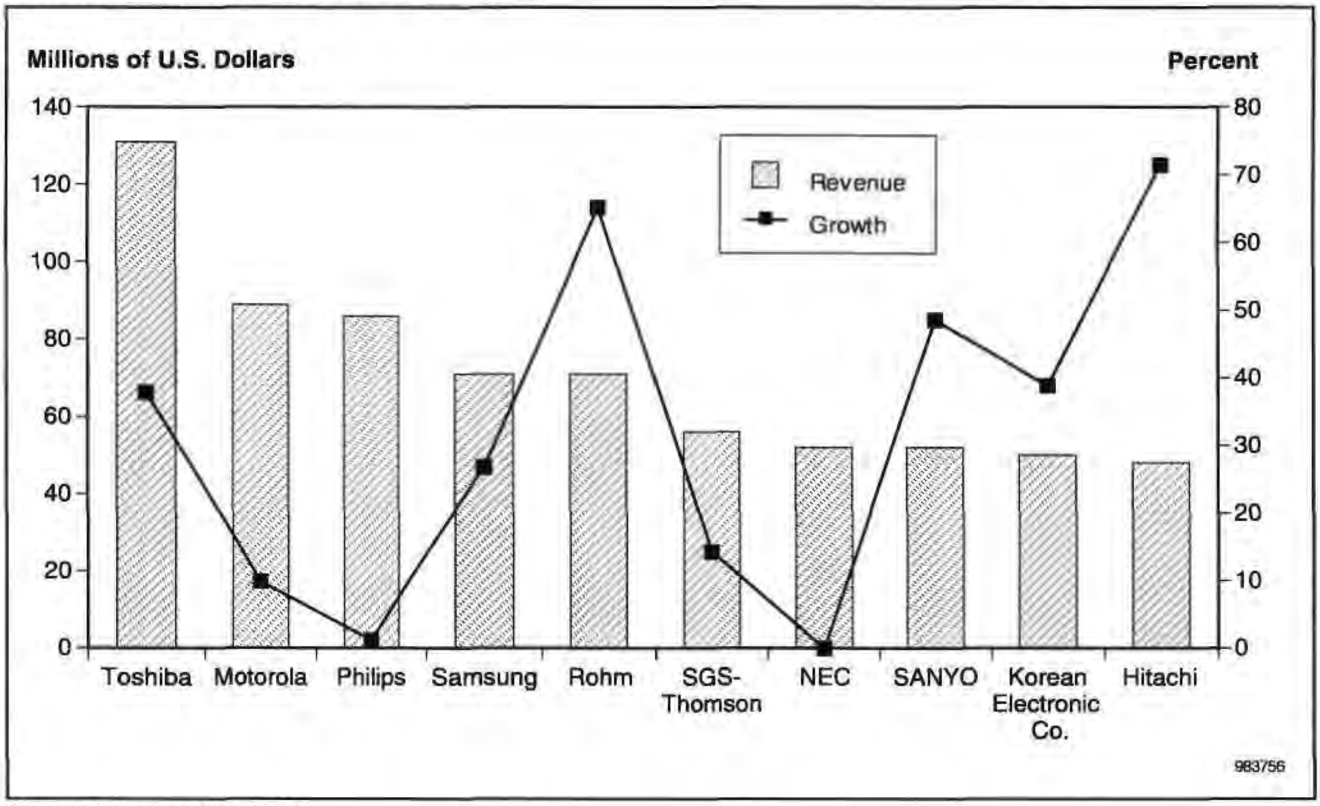
Discrete Market Share Rankings

Dataquest estimates that in 1997, the value of China/Hong Kong's discrete devices reached $859 million. The discrete market represents a 12.7 percent share of China's total semiconductor consumption, but it continues to undergo steady growth year after year. In 1997, the market expanded 22.1 percent. The surveyed companies increased shipments to China by 25.8 percent and gained market share over less competitive domestic manufacturers. This segment's consumer applications are relatively close to discrete devices, as Dataquest observes the vendors' shipment performance. Toshiba, SANYO, Rohm, and Philips are able to leverage their consumer market presence to ship analog and discrete products to the same customers. Among the top 10 discrete suppliers to China, only NEC, Korea Electronic Company Ltd., and Hitachi are not among the top 10 analog suppliers (see Figures 4-13 and 4-14).

Figure 4-13
China/Hong Kong 1997 Top 10 Analog-Monolithic Suppliers' Revenue and Percentage Growth (Millions of U.S. Dollars)



Source: Dataquest (July 1998)

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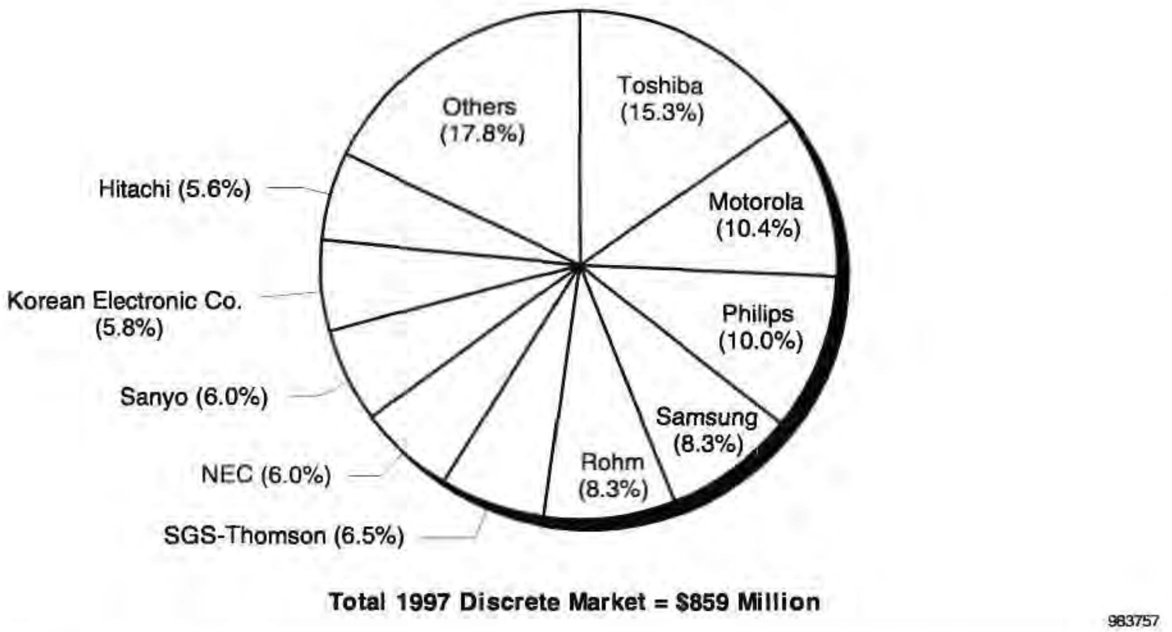
Figure 4-14
China/Hong Kong Analog-Monolithic Market Share, 1997 (Percentage of Revenue)



Source: Dataquest (July 1998)

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Chapter 5
Drivers of Future Semiconductor Demand

Forecast Synopsis

Global overcapacity—particularly in MOS memories—in the Asia/Pacific and China semiconductor markets will result in a lower overall revenue growth than forecast in May 1998.

The financial crises and economic recessions across Asia/Pacific are expected to recover in the next two to three years. Despite China's mammoth economic challenges, its management of the economy, thus far, has allowed it to avoid Southeast Asia's fate. As always, there is a on-going balance between the divergent forces. The electronics industry is helped by its product and market diversity, foreign investors' continued confidence, long-term market prospects, strong government support in communications and computer infrastructure projects, and rising equipment exports to the United States and Europe, which accounted for more than 31 percent of China's total production.

Dataquest's economic assumptions for this forecast are described in Chapter 2. The key assumptions for 1998 are as follows:

- The growth of China's GDP has been revised down to 6.5 percent by several economists. Hong Kong's economic growth is expected to contract by 1 percent to 2 percent in 1998.
- The effect of the Asian financial crisis and Japan's economic quagmire on China's economy is not apparent.
- Dataquest has lowered its electronic equipment production forecast from 20 percent to 16 percent in 1998. Some of the key high-level assumptions behind this change are as follows:
    - A slowdown in domestic consumption, including the following:
        - Weaker consumer spending attributed to slower economic growth and rising unemployment
        - A delay in purchases by state-owned enterprises (SOEs)
        - Conservative fiscal policy and lending to businesses
        - Restructuring of SOEs
    - A slowdown in electronics exports, which represent more than 50 percent of electronic equipment production, including the following:
        - China's exports to Japan, Korea, and Southeast Asia represent 25 percent of total exports and will be drastically affected.
        - Continued strength in exports to Europe and the Americas, which represent more than 65 percent of total exports, will help counter the effect of Asia's economic slowdown.
        - Foreign investment in production capacity has slowed somewhat but not dramatically.

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- Semiconductor consumption will have difficulty achieving a 15.5 percent growth because of the following factors:
  - DRAM revenue could decline by 27 percent.
  - The memory market shows a widespread weakness.
  - Nonmemory market forecasts in this report have not changed.

A Long-Term Forecast Overview

Table 5-1 shows that Asia/Pacific will grow by an estimated 15.7 percent CAGR from 1997 to 2002, which is slower than Dataquest's 1996-to-2001 forecast of 19 percent. This projected growth is only 2 percentage points faster than the worldwide forecast of 14 percent in this period. Dataquest expects a worsening of the current semiconductor slowdown in Asia/Pacific. The long-term growth is likely to be slower than in North America.

The Asia/Pacific market consumed 21 percent of all semiconductors shipped worldwide in 1996, which rose to 22.1 percent in 1997. China/Hong Kong consumed 19 percent of shipments to the Asia/Pacific region in 1996, or 4 percent of the worldwide market. This share rose to a 21 percent share of Asia/Pacific and 5 percent of the worldwide market in 1997. Dataquest expects that share to reach 26 percent of Asia/Pacific and 7 percent of worldwide consumption by 2002, representing a $17.6 billion semiconductor opportunity.

Table 5-1
Worldwide Semiconductor Consumption Forecast by Region, 1997 to 2002
(Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
North America	48,086	53,326	64,133	78,388	95,782	99,906	15.7
Japan	36,499	37,397	42,943	49,988	58,610	61,093	10.9
Europe	30,046	32,627	38,425	46,927	56,152	59,335	14.6
Asia/Pacific	32,534	35,899	42,754	51,751	64,483	67,561	15.7
Worldwide	147,165	159,249	188,255	227,054	275,027	287,895	14.4

Source: Dataquest (July 1998)

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China/Hong Kong: The Largest and Fastest-Growing Market in Asia/Pacific

Dataquest believes that China/Hong Kong will continue to expand its manufacturing scope capabilities faster than any other region in Asia/Pacific. This is because of strong government support for numerous large manufacturers and significant foreign investments, which have showed no signs of slowing. China is learning and improving its manufacturing capabilities at a faster rate than its Asian predecessors. Dataquest continues to observe quality and efficiency rising across consumer, communications, and data processing industries. For this reason, foreign investment confidence continues to rise, although China has long way to go to improve its investment environment. Semiconductor content will consequently rise as production quality and capacity expand to suit overseas market and China's quality-conscious consumers. The shift of factories to China/Hong Kong from Japan, Europe, America, and Taiwan makes China of central importance to semiconductor suppliers' strategies in the region.

Figure 5-1 shows that China/Hong Kong is expected to remain the fastest-growing country in the Asia/Pacific region from 1997 to 2002. Dataquest believes that the China/Hong Kong market will expand about 7 percentage points faster than the rest of the region and 4 percentage points faster than Taiwan. It is noteworthy that China/Hong Kong was only the third-fastest-growing market in this region from 1991 to 1995, at a 31.3 percent CAGR, after Singapore and Southeast Asia. As explained in Chapter 3, Dataquest asserts that structural changes in China's electronics industries and end markets from 1995 to 1997—in addition to Korea's and Southeast Asia's economic troubles—will result in China's long-term growth leadership in the region. For sure, China and Hong Kong have challenges of their own, but not nearly to the extent of most of the region (see Chapter 2).

Semiconductor Market Forecast Drivers

The China/Hong Kong semiconductor market is positioned for accelerating growth in the next five years, but it is not immune from the prolonged worldwide slowdown. Dataquest has lowered its long-term electronic equipment production forecast because of the weaker worldwide consumption forecast by GartnerGroup and Dataquest systems market research divisions. Because China exports about half of its semiconductor production, global consumption trends play an important part in Dataquest's forecast assumptions. Additionally, Dataquest believes that domestic consumption will slow because of massive restructuring and rising unemployment. However, the overall disposable income and domestic consumption will show significant gains, thereby boosting local production.

Time to market has become the fundamental competitive advantage of electronics companies in all major markets in the world. Production will accelerate in China as companies seeking growth markets in an increasingly competitive global marketplace attempt to steal or protect market share from competitors.

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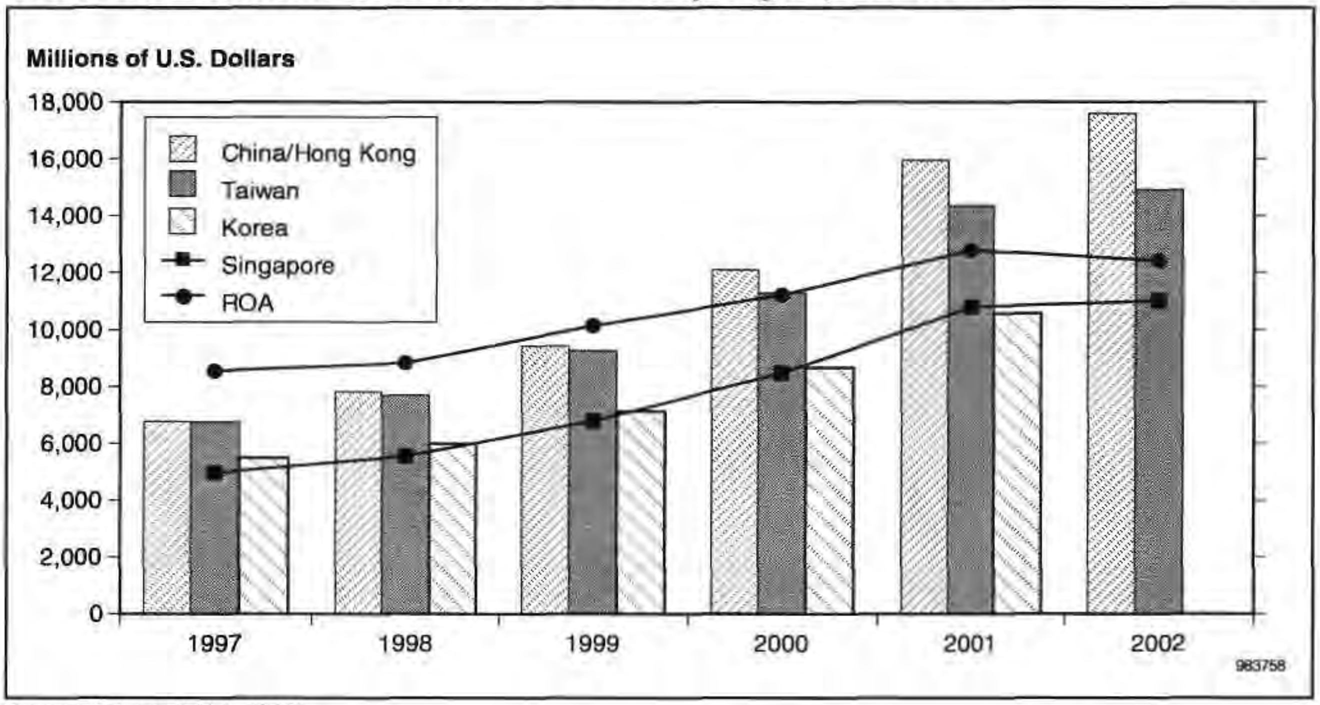
Figure 5-1
Asia/Pacific Semiconductor Market Forecast by Region, 1997 to 2002



Source: Dataquest (July 1998)

Dataquest expects a worldwide electronic equipment market upturn in 2000, which will be driven by digital consumer electronics and convergent computer-communication technologies. At the same time, the worldwide semiconductor industry will have recovered by 2000 because of two years of slow capital spending.

In this scenario, Dataquest's forecast shows that China/Hong Kong will achieve electronic production growth of 16 percent CAGR from 1997 to 2002. Dataquest foresees the immature PC and communications industries in China as leading the broad-based growth in the next silicon cycle. Growth in China during the past two years has been led by computers and communications. Now the American and European companies, rather than the Japanese, are the most aggressive investors in China's IT industries. With leadership from China's newly formed Ministry of Information Industry, computers and communications have moved to the center of China's industrial development policy. Furthermore, business applications for computers and communications are swelling in an economy with a GDP that will expand by 7 percent in the next five years.

Market Forecast by End Equipment

Table 5-2 shows China/Hong Kong's electronic equipment production forecast and semiconductor consumption by application from 1997 to 2002. Dataquest publishes information on detailed electronic equipment production and semiconductor consumption by device in other reports. The intent of this section is to provide a top-line summary of these production and consumption databases. Dataquest publishes detailed unit and company-level production forecasts, which provide the quantitative basis of these figures.

Table 5-2
China/Hong Kong's Electronics Production Forecast and Semiconductor Consumption by Segment, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Electronics Production	**46,496**	**54,087**	**62,798**	**72,773**	**84,888**	**98,041**	**16.1**
Data Processing	13,407	17,363	21,936	27,264	33,617	40,019	24.4
Communication	7,540	8,398	9,593	10,638	11,674	12,978	11.5
Industrial	991	1,122	1,268	1,459	1,691	1,951	14.5
Consumer	22,266	24,592	26,972	29,867	33,743	38,177	11.4
Military/Civil Aerospace	1,162	1,325	1,536	1,782	2,085	2,451	16.1
Transportation	1,129	1,287	1,493	1,762	2,079	2,465	16.9
Total Electronics Production (% Growth)	**20.9**	**16.3**	**16.1**	**15.9**	**16.6**	**15.5**	-
Data Processing	35.5	29.5	26.3	24.3	23.3	19.0	-
Communication	16.8	11.4	14.2	10.9	9.7	11.2	-
Industrial	10.7	13.2	13.0	15.1	15.9	15.4	-
Consumer	15.9	10.4	9.7	10.7	13.0	13.1	-
Military/Civil Aerospace	14.0	14.0	15.9	16.0	17.0	17.6	-
Transportation	15.0	14.0	16.0	18.0	18.0	18.5	-
Total Semiconductor	**6,769**	**7,819**	**9,429**	**12,098**	**15,951**	**17,593**	**21.1**
Data Processing	2,748	3,514	4,678	6,370	8,706	9,730	28.8
Communication	2,468	2,564	2,791	3,310	4,046	4,294	11.7
Industrial	121	133	149	180	240	263	16.9
Consumer	1,232	1,386	1,545	1,890	2,496	2,792	17.8
Military/Civil Aerospace	66	75	89	118	167	179	22.0
Transportation	133	147	177	231	295	335	20.3
Total Semiconductor (Percent Growth)	**19.5**	**15.5**	**20.6**	**28.3**	**31.8**	**10.3**	-
Data Processing	24.0	27.8	33.2	36.2	36.7	11.8	-
Communication	14.9	3.9	8.8	18.6	22.3	6.1	-
Industrial	18.3	10.3	11.6	21.2	33.2	9.8	-
Consumer	19.5	12.5	11.5	22.3	32.1	11.9	-
Military/Civil Aerospace	20.4	13.5	18.1	32.4	42.4	6.7	-
Transportation	17.9	10.1	20.9	30.3	27.6	13.7	-
Semiconductor Content (%)							
Total Electronics	**14.6**	**14.5**	**15.0**	**16.6**	**18.8**	**17.9**	-
Data Processing	20.5	20.2	21.3	23.4	25.9	24.3	-
Communication	32.7	30.5	29.1	31.1	34.7	33.1	-
Industrial	12.2	11.9	11.7	12.3	14.2	13.5	-
Consumer	5.5	5.6	5.7	6.3	7.4	7.3	-
Military/Civil Aerospace	5.7	5.7	5.8	6.6	8.0	7.3	-
Transportation	11.8	11.4	11.9	13.1	14.2	13.6	-

Source: Dataquest (July 1998)

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Data Processing: To Become the Application Leader in Size and Growth

Data processing was the fastest-growing equipment and market segment in 1997. Dataquest has not changed its views from 1997 that data processing will be the fastest-growing electronics production and semiconductor consumption segment from 1997 to 2002. Production is expected to grow at a 24 percent CAGR, engendering a semiconductor market growth of 28 percent—driven by strong domestic demand and continued export prowess. Data processing did not achieve the No. 1 ranking in production in 1998 as Dataquest forecast because of a strong year for VCDs. But Dataquest expects it to become the largest industry by the end of 1998. Data processing was the largest semiconductor market in China/Hong Kong in 1997, despite the memory market, decline because of its volume growth. With data processing equipment production forecast to grow by a 24 percent CAGR, data processing semiconductors will grow by 28 percent from 1997 to 2002. Data processing was and will continue to be the fastest-growing application of the China/Hong Kong semiconductor market for the decade (see Table 5-3).

Table 5-3
Data Processing Unit Production Forecast and Semiconductor Consumption in China/Hong Kong, 1997 to 2002

	1997	1998	2002	CAGR (%) 1997 to 2002
Monitor				
Units (K)	7,550	12,118	27,883	29.9
Semiconductor TAM (U.S.$M)	128	206	418	26.7
Motherboard				
Units (K)	15,200	18,802	48,658	26.2
Semiconductor TAM (U.S.$M)	541	730	1,566	23.7
Optical Disk Drive				
Units (K)	1,800	2,340	4,576	20.5
Semiconductor TAM (U.S.$M)	36	55	77	16.4
Page Printer				
Units (K)	51	74	523	59.2
Semiconductor TAM (U.S.$M)	7	10	84	63.9
Personal Computer				
Units (K)	2,096	3,230	13,401	44.9
Semiconductor TAM (U.S.$M)	608	913	3,365	40.8
Rigid Disk Drive				
Units (K)	5,300	7,000	17,325	26.7
Semiconductor TAM (U.S.$M)	160	204	435	22.2
Serial Printer				
Units (K)	511	579	898	12.0
Semiconductor TAM (U.S.$M)	13	15	29	18.1
Total Semiconductor TAM (U.S.$M)	**1,493**	**2,133**	**5,974**	**32.0**

Source: Dataquest (July 1998)

Consumer: Benefiting from Strong Domestic Consumption

Consumer electronics production will be the slowest segment with a 12 percent CAGR from 1997 to 2002. The year 1997 was a good year because of VCDs' phenomenal growth. Semiconductor shipments to this segment will grow by 18 percent because of digitally enhanced products that are expected to be introduced worldwide in this period. Dataquest expects digital television broadcasting to begin after 2000, and the Chinese government is formulating policies and plans to keep pace with the world in this arena. Chinese and Hong Kong consumer electronics manufacturers are moving into set-top boxes, and Dataquest expects a strong OEM production growth in 1999 (see Table 5-4).

Table 5-4
Consumer Unit Production Forecast and Semiconductor Consumption in China/Hong Kong: 1997, 1998, and 2002

	1997	1998	2002	CAGR (%) 1997 to 2002
Analog Camcorder				
Units (K)	292	330	661	17.7
Semiconductor TAM (U.S.$M)	26	27	41	9.4
Analog Set-Top Box				
Units (K)	16	71	425	93.6
Semiconductor TAM (U.S.$M)	1	2	13	86.5
Color Television				
Units (K)	22,863	26,292	55,469	19.4
Semiconductor TAM (U.S.$M)	412	536	1,231	24.5
Digital Set-Top Box				
Units (K)	0	3	425	NM
Semiconductor TAM (U.S.$M)	0	0	44	NM
DVD Player				
Units (K)	0	5	1,325	NM
Semiconductor TAM (U.S.$M)	0	1	98	NM
Personal / Portable Stereo				
Units (K)	27,000	28,350	32,047	3.5
Semiconductor TAM (U.S.$M)	163	170	176	1.6
VCR				
Units (K)	2,310	2,521	2,506	1.6
Semiconductor TAM (U.S.$M)	75	81	76	0.2
Video Game Controller				
Units (K)	552	580	678	4.2
Semiconductor TAM (U.S.$M)	46	45	45	-0.4
VCD Player				
Units (K)	14,660	18,484	5,690	-17.2
Semiconductor TAM (U.S.$M)	437	444	94	-26.5
Total Semiconductor TAM (U.S.$M)	**1,159**	**1,306**	**1,818**	**9.4**

NM = Not meaningful
Source: Dataquest (July 1998)

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Communications: Large Markets with a Steady Growth

Communications is the third-largest electronics equipment industry and the second-largest semiconductor market in China/Hong Kong. Dataquest forecasts communications equipment production and semiconductor consumption to grow at a 12 percent CAGR. Because communications production consisted predominantly of price-sensitive retail products—such as handsets, pagers, cordless phones, and answering machines—production revenue growth will lag communication systems' market expansion (see Table 5-5). These products are exported and shipped locally. Dataquest believes that the majority of China's purchases of public infrastructure and premises equipment, which are semiconductor-rich equipment, will continue to be imported rather than produced locally for the next few years. But there, the government is achieving increased localization of production by encouraging multinationals in the market to invest in production or by supporting local Chinese companies.

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Table 5-5
Communications Unit Production Forecast and Semiconductor Consumption in China/ Hong Kong: 1997, 1998, and 2002

Product	1997	1998	2002	CAGR (%) 1997 to 2002
Analog Cellular Telephone				
Units (K)	572	538	395	-7.1
Semiconductor TAM (U.S.$M)	19	18	11	-9.9
Analog Cordless Telephone				
Units (K)	19,854	17,691	13,501	-7.4
Semiconductor TAM (U.S.$M)	516	460	385	-5.7
Answering Machine				
Units (K)	6,757	8,446	11,799	11.8
Semiconductor TAM (U.S.$M)	83	108	218	21.3
Central Office Line Card				
Units (K)	16,059	18,931	35,201	17.0
Semiconductor TAM (U.S.$M)	193	213	370	13.9
Corded Telephone				
Units (K)	99,995	105,458	130,166	5.4
Semiconductor TAM (U.S.$M)	255	274	371	7.8
Digital Cellular Telephone				
Units (K)	2,550	3,787	15,533	43.5
Semiconductor TAM (U.S.$M)	204	263	839	32.6
Digital Cordless Telephone				
Units (K)	802	1,203	3,487	34.2
Semiconductor TAM (U.S.$M)	59	69	175	24.5
Fax Machine				
Units (K)	841	761	939	2.2
Semiconductor TAM (U.S.$M)	51	44	42	-3.8
LAN Card				
Units (K)	1,000	1,500	3,189	26.1
Semiconductor TAM (U.S.$M)	7	10	21	24.3
Modem				
Units (K)	22	52	849	107.6
Semiconductor TAM (U.S.$M)	1	2	23	102.9
Pager				
Units (K)	6,430	7,234	10,538	10.4
Semiconductor TAM (U.S.$M)	80	95	144	12.5
Premise Switching				
Units (K)	1,288	1,739	3,631	23.0
Semiconductor TAM (U.S.$M)	17	19	37	17.0
Total Semiconductor TAM (U.S.$M)	1,485	1,575	2,636	12.2

Source: Dataquest (July 1998)

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Semiconductor Device Forecast Trends

The DRAM market growth from 1991 to 1995 was a remarkable 50 percent CAGR. But these good days are gone. Dataquest's five-year projection of 16 percent represents a dramatically slower cycle that is pulling down the overall semiconductor forecast. As shown in Table 5-3, the total China/Hong Kong semiconductor market will decelerate to 21 percent CAGR from 1997 to 2002. The severe price drop of MOS memory that began in 1996 will hamper the market growth in 1998 and part of 1999. MOS memory growth will experience an 18 percent CAGR from the contraction year of 1997 to the next contraction beginning in 2002. This is a much lower forecast than expected in 1997 because of the delayed DRAM recovery. Table 5-6 presents China/Hong Kong's semiconductor forecast by device type in the 1997-to-2002 forecast period.

Figures 5-2 and 5-3 illustrate China/Hong Kong's semiconductor consumption forecast by device type in revenue and percentage, respectively. Figure 5-4 depicts China/Hong Kong's semiconductor forecast by main application market.

Table 5-6
China/Hong Kong's Semiconductor Consumption Forecast by Device Type, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2002
Total Semiconductor	**6,769**	**7,819**	**9,429**	**12,098**	**15,951**	**17,593**	**21.1**
Total Integrated Circuit	5,705	6,600	8,007	10,404	13,994	15,320	21.8
Total Bipolar Digital	42	35	29	23	18	14	-19.3
MOS Memory	1,142	1,178	1,433	2,066	3,476	2,586	17.8
Dynamic RAM	800	817	981	1,471	2,721	1,687	16.1
Static RAM	87	92	138	213	277	308	28.6
Nonvolatile Memory	239	253	297	361	456	571	19.0
EPROM	45	43	38	35	33	31	-7.0
EEPROM	55	59	64	73	91	107	14.2
Flash Memory	92	107	142	196	271	366	31.9
Mask ROM	48	45	52	57	62	67	7.0
Other MOS Memory	15	16	18	20	21	20	5.3
MOS Microcomponent	2,206	2,676	3,256	4,182	5,343	6,543	24.3
Microprocessor	881	1,092	1,376	1,789	2,290	2,863	26.6
Microcontroller	680	775	891	1,114	1,411	1,693	20.0
Microperipheral	480	560	652	842	1,095	1,304	22.1
Digital Signal Processor	165	249	336	437	547	683	32.9
MOS Digital Logic	895	978	1,128	1,310	1,548	1,838	15.5
Total ASIC	253	266	346	467	634	850	27.4
Custom IC	78	74	63	50	35	23	-21.7
MOS Standard Logic	197	223	254	262	285	300	8.8
Total Other MOS Logic	368	416	465	531	594	666	12.6
Analog Monolithic	1,419	1,731	2,161	2,824	3,609	4,339	25.0
Total Discrete	**859**	**988**	**1,166**	**1,399**	**1,609**	**1,866**	**16.8**
Total Optical Semiconductor	**205**	**231**	**256**	**295**	**348**	**407**	**14.7**

Source: Dataquest (July 1998)

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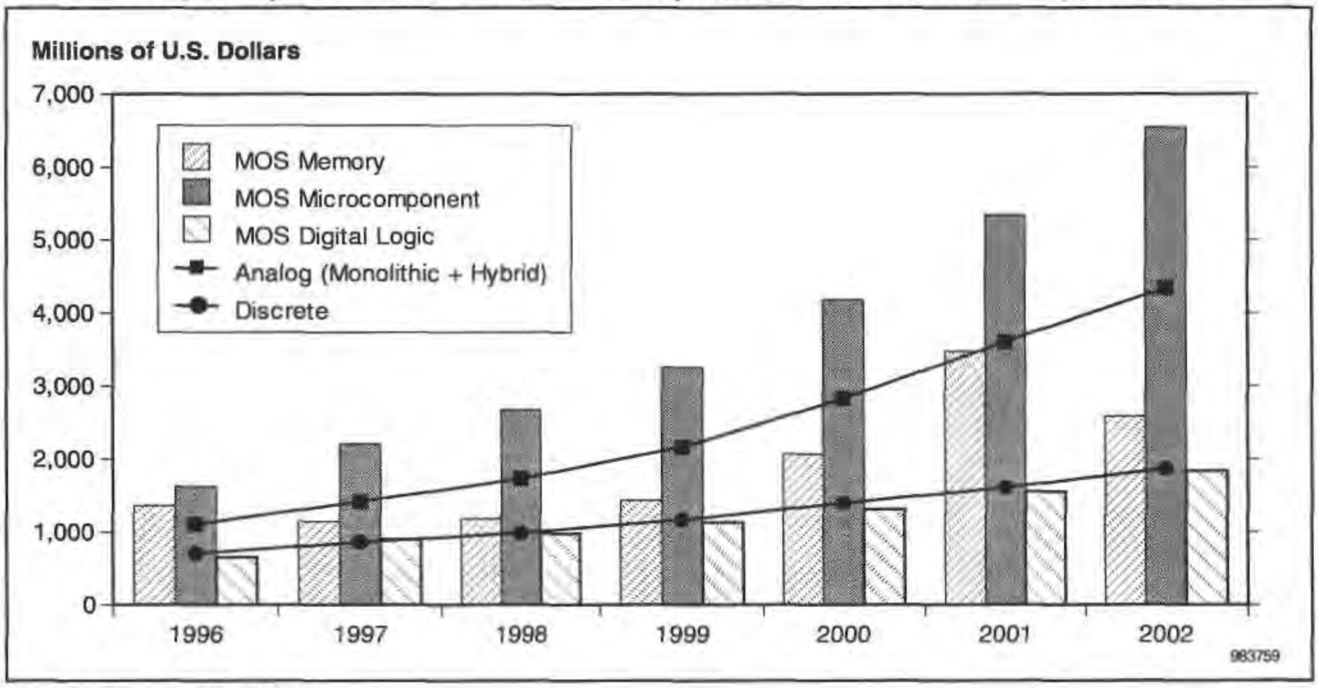
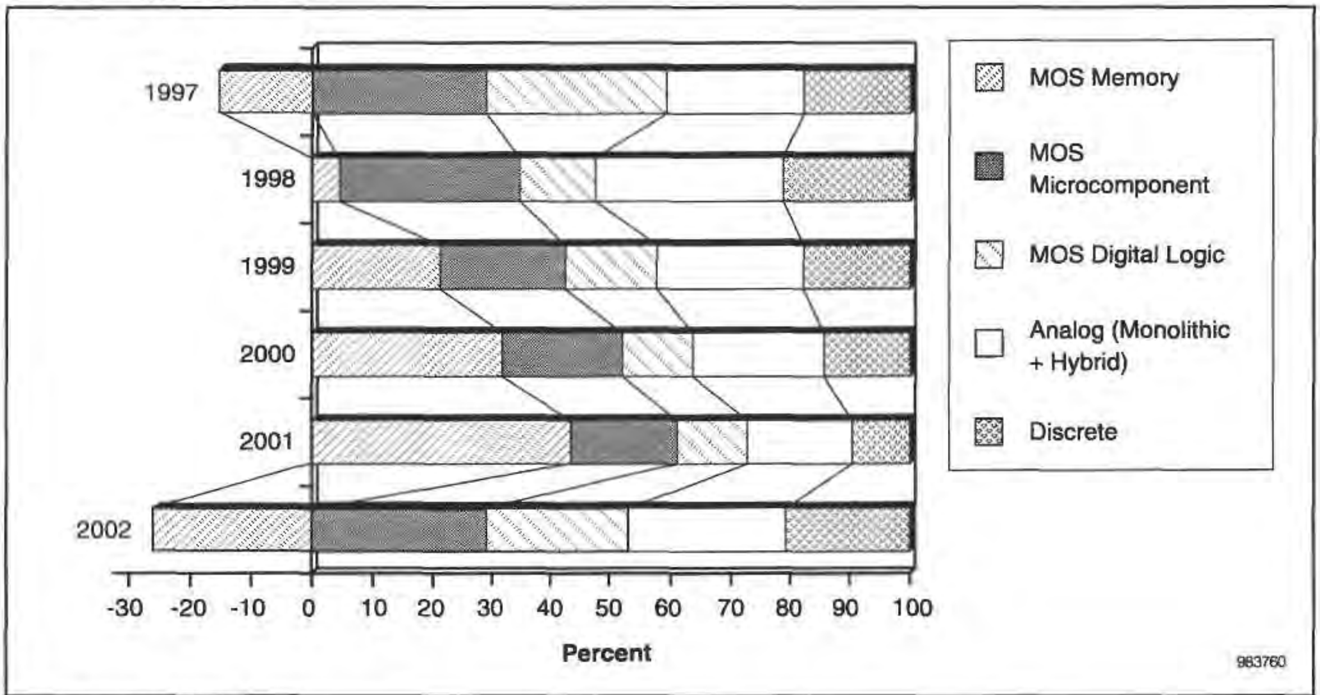
Figure 5-2
China/Hong Kong's Semiconductor Consumption Forecast by Device Type, 1997 to 2002



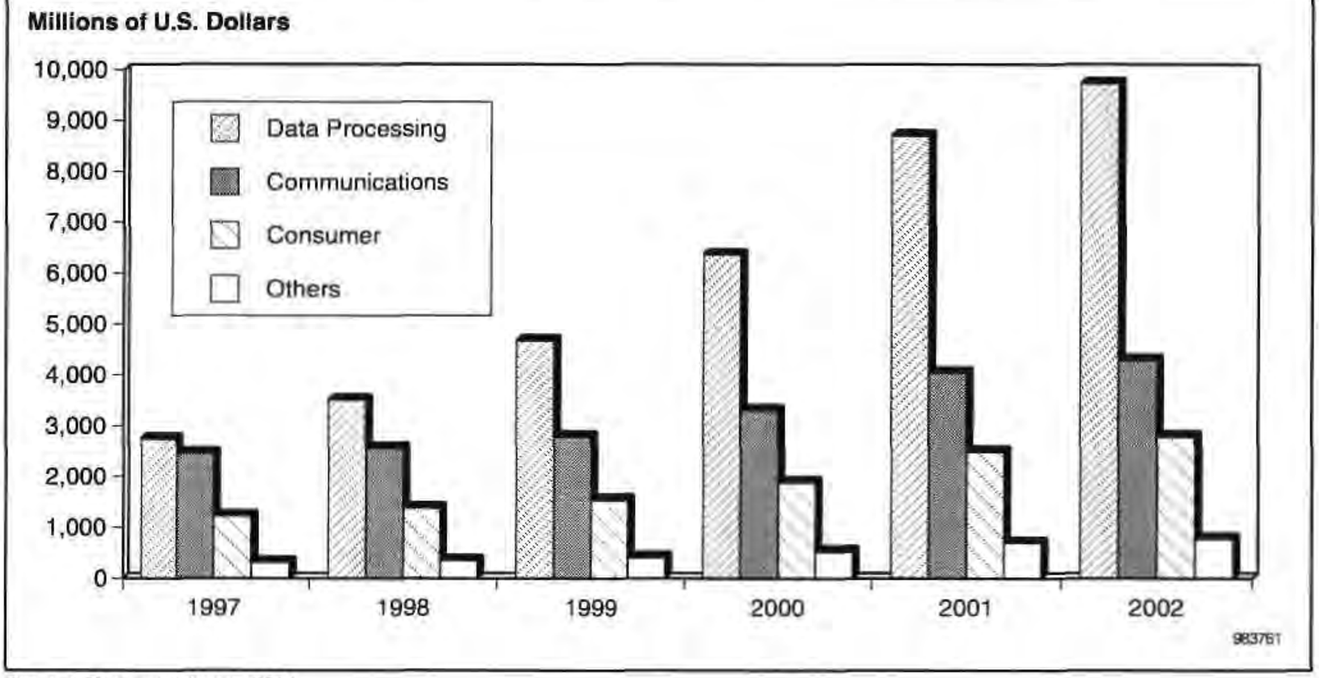
Source: Dataquest (July 1998)

Figure 5-3
China/Hong Kong Semiconductor Consumption Forecast by Device Type, 1997 to 2002 (Percentage Growth)



Source: Dataquest (July 1998)

Figure 5-4
China/Hong Kong Semiconductor Consumption Forecast by Application, 1997 to 2002



Source: Dataquest (July 1998)

Leading this 21 percent CAGR from 1997 to 2002 are MOS microcomponents, growing by a 23 percent CAGR. The next growth category is expected to be MOS microcomponents in terms of size and growth. This growth is enabled by strong MPU demand that will carry the microcomponent market to $5.3 billion in 2002. MOS logic devices lost relative share in this period, but expanded in absolute terms to $1.8 billion. Dataquest expects a stronger growth toward the end of the forecast period because ASIC capabilities will increase after three years. Similarly, analog, discrete, and optoelectronics devices will occupy 38 percent of China/Hong Kong's market by 2002, compared to 37 percent in 1996. Nevertheless, these will grow from $2.4 billion in 1997 to $6.6 billion to 2002. Much of this growth is the result of continued economic expansion into China's new regions. That is, demand for appliances, radios, color televisions, and communications equipment has slowed in coastal provinces, but it is increasing in the second-tier markets of inland provinces (such as Henan, Hubei, Shanxi, and Hunan).

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Overall Memory Forecast

Dataquest expects MOS memories to lag the market expansion in China/Hong Kong in the next five years. The problem of falling memory average selling prices is ameliorated by rapid bit growth resulting in an 18 percent CAGR. Demand is coming from a strong electronic sector, which thrives on exports, but is being further bolstered by local demand. Dataquest's five-year CAGR for electronic equipment production is forecast to be more than 16 percent. PC production, forecast to expand at a 40 percent CAGR, is expected to generate a growth in semiconductor consumption at about an 18 percent CAGR. This result is very achievable. Dataquest expects China to accelerate is migration to high-content systems that are already mainstream or mature in Europe, Japan, and North America, but just starting to be manufactured in volume in China. These mainstream products—such as PCs, peripherals, and mobile and premise communications equipment—will represent high-growth opportunities because they are much richer in semiconductor content than China's current production base. In addition to existing high-content products, Dataquest sees new products already emerging in the Chinese market. The case in point is the DVDs that will be rapidly introduced in the China market as an extension of the current VCD craze.

As discussed in greater detail in later sections, Dataquest expects the market to be further supported by nonmemory parts that will experience more steady but accelerated growth in the next five years. Nonmemory products are forecast to grow at a 22 percent CAGR from 1997 to 2002 in China/Hong Kong.

DRAMs

Memory pricing will continue to be the most volatile and pivotal segment of the market. A sluggish growth in 1998 is expected to give way to greater growth in 2000. The CAGR for the next five years is 48 percent, which is more than double the worldwide growth rate. This forecast is consistent with Dataquest's view that PC production will grow by more than 40 percent in this period, which is more than double worldwide production growth.

Microcomponent Market Forecast

MOS microcomponents will be the fastest-growing market in China/Hong Kong from 1997 to 2002. The microcomponent market surpassed memories in 1996 to become the largest market segment in China/Hong Kong, reaching $1.6 billion. In 1997, the market experienced growth across MPU, MCU, MPR, and DSP products, enabling a 36 percent growth to $2.2 billion. In the next five years, Dataquest does not expect memories to surpass microcomponents again. By 2002, microcomponents will represent a $6.5 billion market, which will constitute a 37 percent share of China/Hong Kong's semiconductor consumption, compared to only a 15 percent share for MOS memories.

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Microprocessors

MPUs are the largest and fastest-growing microcomponent market in China/Hong Kong. MPUs sustained market dominance with a 39 percent market share in 1997. After MPU shipments rose by 48 percent in 1996 to $0.7 billion, they decelerated to 31 percent in 1997, as competitors entered the China market and ASPs declined. The 32-bit-and-above CISC processors occupy more than 80 percent of the China/Hong Kong MPU market. The 8- and 16-bit processors and below represent less than 10 percent of the market, while the 32-bit-and-above RISC processors represent about 10 percent of the total China/Hong Kong MPU market.

If not for a near monopoly in MPUs, Dataquest might even see a decline in semiconductor content per system. Table 5-2 presents Dataquest's estimates of PC production by MPU type in each quarter of 1997. Pentium II and AMD's K6 were the only other non-Pentium, x86 products to experience growth in the fourth quarter of 1997. The success of China's domestic manufacturers is attributed to their ability to introduce next-generation products before technically superior foreign brands could import and distribute their products in China. Their proximity to their channels and ability to source locally buy critical time to market.

Chinese companies are accelerating their rate of technology adoption and surpassing their foreign counterparts in Pentium II consumption in the fourth quarter of 1997, as illustrated in Figure 5-6. For the year, foreign-versus-local Pentium-class processor consumption was proportional to total PC production. In short, there was no marked difference between foreign and local manufacturers' technology level relative to the Chinese market.

Microperipherals

MPRs were the fastest-growing microcomponent segment in 1997, with a 40 percent growth. MPRs will almost keep pace with MPU revenue growth in the next five years with a 22 percent CAGR, compared to a 27 percent CAGR for MPUs. As always, there will be more competition and pricing pressure in this sector. However, the broad range of audio/video, graphics, core logic, communication controllers, and mass storage, which are in high demand in China/Hong Kong, will support growth. The year 1997 was a recovery year with 40 percent growth. Dataquest believes that two high-growth sectors include communication controllers and mass-storage controllers. Because of the pricing pressure, the MPR segment will experience a revenue decline from a 22 percent to 20 percent share of the microcomponent revenue from 1997 to 2002.

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Microcontrollers

The MCU market represented 31 percent of the microcomponent market in China/Hong Kong in 1997. The overall share has been declining as the consumer segment represents a smaller and smaller share of overall applications. After a sluggish 5 percent growth in 1996, MCUs improved in 1997 as Dataquest forecast. Dataquest saw a firming of worldwide prices and a recovery in consumer electronics production in China, fueled by new applications, expanding demand, and a healthy communications sector growth. Dataquest's five-year forecast calls for approximately 20 percent CAGR from 1997 to 2002, which is about 3 percentage points faster than for Asia/Pacific.

Digital Signal Processors

The digital signal processor market is a small but rapidly developing market in China. Current DSP consumption is predominantly in systems that are designed in Europe, North America, or Japan, and shipped to China. The largest market in 1997 was rigid disk drives. TI's DSP strategy focuses on delivering solutions, and its DSP part of the solution includes analog ICs such as drivers. As shown in Chapter 4, TI's market share increased in both DSPs and analog ICs.

DSP shipments to assemblers and manufacturers was only about $20 million in 1996, but jumped to $165 million in 1997. From a local design standpoint, the DSP market will not develop for another two years when local manufacturers have the capabilities to utilize DSP technology to differentiate or enhance the performance of a wide range of mobile and base-station communication equipment. TI is leading the way in China by setting up design centers that will play a role in providing turnkey solutions and support to local manufacturers. Dataquest has raised its market forecast to exceed $683 million by 2002, growing at a 33 percent CAGR.

MOS Digital Logic Market Forecast

The MOS digital logic market in China/Hong Kong comprised four segments, including ASICs, standard logic, custom ICs, and other digital logic ICs. The largest logic market, the other MOS digital logic device market, was approximately $368 million in 1997, sharing 41 percent of the MOS digital logic market.

Asia/Pacific's 17 percent growth and China/Hong Kong's 38 percent growth exceeded worldwide consumption of 9.2 percent significantly. Dataquest expects China/Hong Kong to decelerate to 9 percent in 1998 but maintain a five-year 16 percent CAGR. The main opportunity for ASIC vendors to emerge will be to provide ASIC solutions and reference designs to China's local electronic equipment industry that competes for local market share against multinational companies. The most lucrative opportunity for ASIC growth will be in systems-level integration (SLI), which will be prominent in low-power, portable computing and communication devices. Currently, mobile computing is not a high-growth PC market in China.

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Standard logic consumption doubled in 1997 to $197 million after expanding only about 5 percent in 1996. Dataquest expects standard logic devices to reach $300 million in 2002, but to decline in share of the MOS logic market from 22 percent to 16 percent. This is a 9 percent CAGR, compared to MOS logic's 16 percent. Dataquest's other logic category is forecast to grow faster than standard logic from 1997 to 2002, with a 13 percent CAGR. Total other MOS logic will still decline in overall share from 41 percent to 36 percent because of the rising market share of ASICs.

Analog Market Forecast

The analog market (including monolithic and hybrid analog) in China/Hong Kong maintained its 21 percent of total semiconductor consumption in 1996 and 1997. Dataquest forecasts that analog will become increasingly important from 1997 to 2002, rising in overall share to 25 percent of total semiconductor consumption. China's communications markets have been booming in the past five years, but Dataquest did not see comparable growth in communications equipment production. Dataquest saw the same phenomenon with PCs—PC production has only surged in the past three years but still lags the rate of PC market growth. In the next two years, Dataquest expects computer applications to outpace consumer and communications electronics significantly as production capacity comes online. Analog is benefiting from its wide applications in these sectors and will, therefore, grow by 25 percent CAGR from 1997 to 2002. The introduction of several new major consumer electronics products will bolster consumer electronic production in the next few years. However, it will require a wider application of digital consumer devices in China before consumer will be able to keep pace with computer production.

Discrete and Optoelectronic

Discrete semiconductors and optoelectronic semiconductors have an even wider base of applications than analog, but they are more price sensitive—especially because local companies supply the Chinese market. In revenue terms, these markets are smaller than analog, however. These devices are also linked primarily to China's consumer applications market growth, as described previously. Dataquest's forecast for discrete shows a healthy growth of 17 percent CAGR, but this market will decline slightly in overall revenue share from 13 percent to 11 percent of total semiconductor consumption.

China/Hong Kong's Increased Share of Asia/Pacific Device Markets

Dataquest's forecast of China/Hong Kong's share of the Asia/Pacific semiconductor market is shown in Tables 5-7 and 5-8. All devices will increase their total share of the Asia/Pacific market. China/Hong Kong will account for 26 percent of the total Asia/Pacific semiconductor market in 2002, from 19 percent in 1996. China/Hong Kong's analog market will grow from 20 percent to 31 percent of Asia/Pacific consumption, discrete will expand from 21 percent to 30 percent, and optoelectronic will increase from 23 percent to 28 percent share of Asia/Pacific consumption. China/Hong Kong's MOS digital market, which is driven mainly by data processing and accounted for only 18 percent of the total Asia/Pacific market in 1996, is less than analog, discrete, or optoelectronic.

However, the China/Hong Kong MOS digital market's share of Asia/Pacific consumption will increase at a faster rate, rising to 21 percent by 2002. Specifically, the MOS microcomponents' segment will be the key driver as it increases its share from 19 percent to 26 percent. Table 5-9 presents China/Hong Kong's share of Asia/Pacific semicon-ductor consumption by semiconductor product from 1997 to 2002. Tables 5-10 and 5-11 show the dollar and percentage value of China/Hong Kong's semiconductor consumption by application subsegment in this forecast period.

Table 5-7
China/Hong Kong Semiconductor Consumption Forecast by Device Type, 1997 to 2002 (Percentage Growth)

	1997	1998	1999	2000	2001	2002
Total Semiconductor	**19.5**	**15.5**	**20.6**	**28.3**	**31.8**	**10.3**
Total Integrated Circuit	19.1	15.7	21.3	29.9	34.5	9.5
Total Bipolar Digital	-26.5	-16.3	-18.0	-19.5	-21.4	-21.4
MOS Memory	-15.8	3.2	21.6	44.1	68.3	-25.6
Dynamic RAM	-17.3	2.1	20.0	50.0	85.0	-38.0
Static RAM	-15.0	5.0	50.0	55.0	30.0	11.0
Nonvolatile Memory	-9.0	5.8	17.2	21.7	26.2	25.1
EPROM	2.0	-5.0	-10.0	-8.0	-7.0	-5.0
EEPROM	-15.0	6.0	10.0	13.0	25.0	18.0
Flash Memory	6.6	16.6	33.0	38.0	38.0	35.0
Mask ROM	-30.0	-5.0	15.0	10.0	8.0	8.0
Other MOS Memory	-35.5	6.0	10.0	11.0	4.0	-4.0
MOS Microcomponent	36.0	21.3	21.7	28.4	27.8	22.5
Microprocessor	31.2	24.0	26.0	30.0	28.0	25.0
Microcontroller	27.7	14.0	15.0	25.0	26.6	20.0
Microperipheral	39.9	16.7	16.5	29.0	30.1	19.1
Digital Signal Processor	120.0	51.0	34.9	30.1	25.2	24.9
MOS Digital Logic	37.8	9.2	15.3	16.1	18.2	18.7
Total ASIC	-8.6	5.0	30.2	35.0	35.8	34.1
Custom IC	150.0	-5.0	-15.0	-20.0	-30.0	-35.0
MOS Standard Logic	103.1	13.2	13.9	3.1	8.8	5.3
Total Other MOS Logic	50.1	13.0	12.0	14.0	12.0	12.0
Analog Monolithic	28.6	22.0	24.8	30.7	27.8	20.2
Total Discrete	**22.1**	**15.0**	**18.0**	**20.0**	**15.0**	**16.0**
Total Optical Semiconductor	**20.2**	**12.8**	**11.0**	**15.0**	**18.0**	**17.0**

Source: Dataquest (July 1998)

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Table 5-8
China/Hong Kong Share of Asia/Pacific by Semiconductor Segment, 1996 to 2002 (Percent)

	1996	1997	1998	1999	2000	2001	2002
Total Semiconductor	**19.2**	**20.8**	**21.8**	**22.1**	**23.4**	**24.7**	**26.0**
Total Integrated Circuit	18.8	20.5	21.4	21.5	22.9	24.3	25.6
Bipolar (Function)	24.4	23.0	20.9	19.1	18.3	17.8	17.2
MOS Digital	18.1	19.9	20.7	20.5	21.8	23.0	24.0
MOS Memory	16.9	17.5	17.9	17.7	19.8	21.0	20.6
MOS Microcomponent	18.5	20.3	21.2	21.2	22.9	24.6	26.0
MOS Digital Logic	19.5	22.9	23.4	22.8	22.0	22.9	23.2
Analog	21.7	22.5	23.9	25.1	26.6	28.9	30.6
Discrete	21.4	22.5	23.8	25.5	27.0	28.9	30.1
Optoelectronic	23.1	22.4	24.5	25.1	25.1	26.7	27.5

Source: Dataquest (July 1998)

Table 5-9
China/Hong Kong Share of Asia/Pacific by Semiconductor Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002
Total Semiconductor	**20.8**	**21.8**	**22.1**	**23.4**	**24.7**	**26.0**
Total Integrated Circuit	20.5	21.4	21.5	22.9	24.3	25.6
Bipolar Digital	23.0	20.9	19.1	18.3	17.8	17.2
MOS Memory	17.5	17.9	17.7	19.8	21.0	20.6
Dynamic RAM	17.2	17.7	17.2	19.9	20.9	19.8
Static RAM	14.6	14.7	15.4	16.5	18.2	18.3
Nonvolatile Memory	19.6	19.7	20.5	21.7	23.6	25.2
EPROM	21.9	28.1	30.0	31.5	32.8	33.9
EEPROM	26.2	25.8	25.7	25.6	25.8	25.6
Flash Memory	15.2	14.6	16.1	18.3	21.0	23.4
Mask ROM	23.2	25.7	27.2	28.7	32.5	35.5
Other MOS Memory	30.0	30.7	27.5	24.5	24.0	24.2
MOS Microcomponent	20.3	21.2	21.2	22.9	24.6	26.0
Microprocessor	19.8	20.4	20.9	22.7	24.4	26.3
Microcontroller	29.4	29.5	29.1	30.0	31.8	33.3
Microperipheral	14.5	15.3	14.4	16.2	18.2	19.2
Digital Signal Processor	20.6	24.7	27.8	29.9	28.8	28.6
MOS Digital Logic	22.9	23.4	22.8	22.0	22.9	23.2
Total ASIC	15.2	14.0	14.5	15.5	17.5	19.1
Custom IC	18.2	21.6	24.4	28.0	30.2	32.5
MOS Standard Logic	32.0	33.3	34.2	32.3	34.5	35.6
Total Other MOS Logic	30.5	32.8	29.8	27.2	26.9	25.8
Analog Monolithic	22.5	23.9	25.1	26.6	28.9	30.6
Total Discrete	**22.5**	**23.8**	**25.5**	**27.0**	**28.9**	**30.1**
Total Optical Semiconductor	**22.4**	**24.5**	**25.1**	**25.1**	**26.7**	**27.5**

Source: Dataquest (July 1998)

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Table 5-10
Value of Semiconductors Consumed by Application Subsegment in China/Hong Kong, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997 to 2001
All Electronic Products	**6,769**	**7,819**	**9,429**	**12,098**	**15,951**	**17,593**	**21.1**
Data Processing Products	2,748	3,514	4,678	6,370	8,706	9,730	28.8
Computers	1,367	1,811	2,426	3,413	4,560	5,146	30.4
Data Storage	344	450	638	812	1,202	1,299	30.5
Input/Output	312	422	591	890	1,246	1,379	34.6
Dedicated System	592	676	829	997	1,377	1,533	21.0
Other Data Processing	133	154	194	257	321	373	22.8
Communications Products	2,468	2,564	2,791	3,310	4,046	4,294	11.7
Premise Telecom	1,586	1,600	1,718	2,030	2,342	2,552	10.0
Public Telecom	376	376	398	436	512	553	8.0
Mobile Communications	390	472	563	722	1,049	1,033	21.5
Broadcast and Studio	90	89	83	91	107	115	5.1
Other Communications	26	27	29	31	37	40	9.2
Industrial Products	121	133	149	180	240	263	16.9
Security/Energy Management	41	45	50	60	77	85	16.0
Manufacturing System/Instruments	70	75	83	101	135	148	16.4
Medical Equipment	6	7	8	10	15	15	22.4
Other Industrial	5	6	8	9	13	14	24.0
Consumer Products	1,232	1,386	1,545	1,890	2,496	2,792	17.8
Audio	363	393	435	537	700	787	16.8
Video	309	397	456	594	760	862	22.8
Personal Electronics	254	266	262	297	376	429	11.1
Appliances	297	319	380	449	645	696	18.6
Other Consumer	10	11	12	13	15	18	12.7
Military/Civil Aerospace Products	66	75	89	118	167	179	22.0
Transportation Products	133	147	177	231	295	335	20.3

Source: Dataquest (July 1998)

Table 5-11
Value of Semiconductors Consumed by Application Subsegment in China/Hong Kong, 1997 to 2002 (Percentage Growth)

	1998	1999	2000	2001	2002
All Electronic Products	**15.5**	**20.6**	**28.3**	**31.8**	**10.3**
Data Processing Products	27.8	33.2	36.2	36.7	11.8
Computers	32.5	34.0	40.7	33.6	12.9
Data Storage	31.0	41.6	27.3	48.0	8.1
Input/Output	35.3	39.9	50.6	40.1	10.6
Dedicated System	14.1	22.7	20.4	38.1	11.3
Other Data Processing	15.6	25.9	32.3	24.7	16.3
Communications Products	3.9	8.8	18.6	22.3	6.1
Premise Telecom	0.9	7.4	18.2	15.4	9.0
Public Telecom	0.1	5.8	9.5	17.4	8.1
Mobile Communications	20.9	19.3	28.4	45.1	-1.5
Broadcast and Studio	-1.3	-6.3	9.2	17.3	8.2
Other Communications	6.8	7.5	4.4	21.9	6.2
Industrial Products	10.3	11.6	21.2	33.2	9.8
Security/Energy Management	9.9	11.2	19.8	28.6	11.5
Manufacturing System/Instruments	7.9	10.5	22.1	33.5	9.7
Medical Equipment	33.4	13.2	17.4	47.4	5.2
Other Industrial	21.9	27.0	23.4	44.4	6.1
Consumer Products	12.5	11.5	22.3	32.1	11.9
Audio	8.3	10.7	23.5	30.4	12.5
Video	28.6	14.9	30.2	28.0	13.4
Personal Electronics	4.8	-1.3	13.3	26.4	14.0
Appliances	7.3	19.1	18.1	43.8	7.9
Other Consumer	12.2	5.7	13.1	12.7	20.2
Military/Civil Aerospace Products	13.5	18.1	32.4	42.4	6.7
Transportation Products	10.1	20.9	30.3	27.6	13.7

Source: Dataquest (July 1998)

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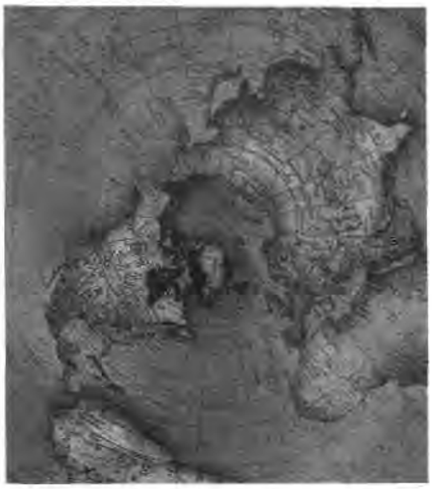

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Semiconductor Market Definitions, 1998

Guides

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Chapter 1
Market Share Survey Overview

Each year, Dataquest surveys semiconductor vendors to estimate their annual sales. The survey currently covers more than 150 semiconductor vendors worldwide (this varies according to mergers, acquisitions, liquidations, start-ups, and so on) by 61 individual semiconductor product categories (excluding subtotals), six application segments, and four world regions (Europe is split into further subregions). This exercise helps Dataquest maintain its dynamic database of semiconductor supply by company and semiconductor vendor revenue by world region and product. The information gained is supplemented by, and cross-checked with, Dataquest's various other information sources.

The semiconductor market share survey process starts during the fourth quarter of each calendar year. The first-phase, top-level estimates for large companies are completed by the end of the calendar year under review, and the results are summarized in several Dataquest reports.

The final detailed survey of all companies starts just after the end of the calendar year under review. These estimates are published in the second quarter of the year following the calendar year under review.

The categories for which semiconductor revenue is reported are defined comprehensively for the purpose of clarity and guidance to survey participants. These definitions may occasionally be revised, altered, or expanded to reflect changes in the industry. To support these definitions, Dataquest will issue an annual survey guide to all participants in its semiconductor market share survey program. This document is the 1997 survey guide.

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Chapter 2
Semiconductor Companies Surveyed Worldwide

In gathering market share data we contact semiconductor companies worldwide.

Americas Companies Surveyed

The following Americas companies were surveyed during 1997:

- ACC Microelectronics
- Actel
- Adaptec
- Advanced Micro Devices
- Allegro MicroSystems
- Altera
- Analog Devices
- Applied Micro Circuits
- AT&T
- Atmel
- Brooktree
- Burr-Brown
- C-Cube Microsystems
- California Micro Devices
- Catalyst
- Cherry Semiconductor
- Chips & Technologies
- Cirrus Logic
- Cypress Semiconductor
- Cyrix
- Dallas Semiconductor
- DSP Semiconductor
- Elantec
- Electronic Designs
- ETEQ Microsystems
- Exar
- General Instrument
- Gennum
- Gould AMI
- Harris
- Hewlett-Packard
- Honeywell
- Hughes

- IBM
- IMI
- Integrated Circuit Systems
- Integrated Device Technology
- Integrated Information Technology
- Integrated Silicon Solution
- Intel
- International CMOS Technology
- International Microelectronic Products
- International Rectifier
- Kulite
- Lattice
- Linear Technology
- Linfinity
- Logic Devices
- LSI Logic
- Maxim
- Micrel
- Micro Linear
- Micro Power Systems
- Microchip Technology
- Micron Technology
- Microsemi
- Mitel
- Motorola
- National Semiconductor
- NCR
- Optek
- OPTi
- Paradigm
- Performance Semiconductor
- Powerex
- Q Logic
- Quality Semiconductor
- Quality Technologies
- QuickLogic
- Ramtron
- Raytheon
- Rockwell

- S3
- Seeq Technology
- Semtech
- Sierra Semiconductor
- Silicon General
- Silicon Systems
- Sipex
- Solitron
- Standard Microsystems
- Supertex
- Symphony Laboratories
- Tektronix
- Telcom
- Texas Instruments
- Trident Microsystems
- TriQuint Semiconductor
- Tseng Labs
- Unitrode
- Universal
- Vitesse
- VLSI Technology
- VTC
- WaferScale Integration
- Weitek
- Western Digital
- Xicor
- Xilinx
- Zilog

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Japanese Companies Surveyed

The following Japanese companies were surveyed in 1997:

- Fuji Electric
- Fujitsu
- Hitachi
- Matsushita Electronics
- Mitsubishi Electric
- NEC
- New Japan Radio
- Nippon Steel
- Oki Electric Industry
- Ricoh
- Rohm
- Sanken Electric
- SANYO Electric
- Seiko Epson
- Sharp
- Shindengen Electric Manufacturing
- Sony
- Toko
- Toshiba
- Yamaha

European Companies Surveyed

The following European companies were surveyed in 1997:

- ABB-Hafo
- ABB-Ixys
- Austria Mikro Systeme
- Elex
- Elmos
- EM Microelectronic
- Ericsson
- Eupec
- European Silicon Structures
- Fagor
- GEC Plessey Semiconductors
- ITT
- Micronas
- Mietec
- Philips Semiconductors

- Semikron
- STMicroelectronics
- Siemens
- TCS (Thomson Composants Spatiaux)
- TEMIC
- Thesys
- Westcode Semiconductors
- Zetex

Asia/Pacific Companies Surveyed

The following Asia/Pacific companies were surveyed in 1997:

- Acer
- Daewoo
- LG Semicon
- Hualon Microelectronics
- Hyundai
- Korean Electronics
- Macronix
- Mosel Vitelic
- Samsung
- Silicon Integrated Systems
- United Microelectronics
- Vanguard
- Winbond Electronics

Summary

The following summarizes the semiconductor companies surveyed in 1997:

- 100 Americas companies
- 20 Japanese companies
- 23 European companies
- 13 Asia/Pacific companies
- 156 companies worldwide

Chapter 3
General Sales Definitions

Dataquest tracks semiconductor vendors' revenue as defined in the following paragraphs.

Revenue

Revenue is the gross sales generated by a vendor or manufacturer, measured in unit currency.

Semiconductor Vendor

A vendor is the last entity in the chain that brands a product and sells it either directly to end users or through a channel. A semiconductor vendor may design and manufacture its own products, in which case it is also an original component manufacturer, or the vendor may procure semiconductors from a component contract manufacturer.

Vendor Revenue

Vendor revenue is defined as the average selling price of a semiconductor product multiplied by the vendor's unit shipments of that product.

Revenue Based on Customer Location

All revenue from sales is reported according to customer location, that is, the shipping destination. The four regions that Dataquest uses for the purpose of this survey are the Americas; Japan; Europe, Africa, and Middle East; and Asia/Pacific.

Manufacturer

A manufacturer is a producer of branded or unbranded finished products. A semiconductor manufacturer could be a contract manufacturer, an original manufacturer, or both.

Original Component Manufacturer

This is a manufacturer that designs and produces components such as semiconductors and design tools either for sale under its brand name or for use internally. An original component manufacturer is also a vendor.

Contract Component Manufacturer

This is a manufacturer that produces components such as semiconductors under an original manufacturer's brand name or that produces components for a semiconductor vendor that brands them. In the semiconductor industry, a contract component manufacturer is sometimes referred to as a "foundry."

Any business done by a semiconductor manufacturer on a contract manufacturing basis is *excluded* as vendor revenue regarding that manufacturer.

Companies that produce exclusively on a contract manufacturing basis are excluded from the list of semiconductor vendors.

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Finished Semiconductor Products

Finished products are assembled and tested semiconductor products. Count only sales of finished semiconductor products to equipment manufacturers and through channels (that is, distributors). Do not include sales of finished semiconductors to other semiconductor vendors for value-added resale. Resale revenue is counted as revenue of the semiconductor vendor to which it is sold. Also, count only sales made by an overseas subsidiary to a equipment manufacturer or distributor, as opposed to counting sales from headquarters to an overseas subsidiary.

Unfinished Semiconductor Products

These are wafer and die foundry products. Count only sales of unfinished semiconductor products to equipment manufacturers or channels (that is, distributors). Do not include sales of unfinished semiconductors to other semiconductor vendors for resale. Resale revenue will be estimated separately for these companies. Also, count only sales made by an overseas subsidiary to equipment manufacturers or distributors, as opposed to counting sales from headquarters to an overseas subsidiary.

Internal Semiconductor Sales

This is defined as revenue from finished or unfinished semiconductor products from intracompany (internal) transfers to divisions of that company or subsidiaries of the parent company that manufactures end equipment. Internal semiconductor sales are classified as in-house sales or captive sales, depending on whether the company sells semiconductors on the merchant market.

In-House Semiconductor Sales

This is defined as internal semiconductor sales if the company also sells semiconductors on the merchant market. Count all in-house semiconductor sales at market prices. Market price is defined as the price at which the same or equivalent product is sold to equipment manufacturers.

Captive Semiconductor Sales

This is defined as internal semiconductor sales if your company does not sell semiconductors on the merchant market. We do not include any captive semiconductor sales.

Multichip Modules

Multichip modules (MCMs) are semiconductor-based functions that include more than one semiconductor device. The multiple dies are arranged either on a thin-film deposited (MCM-D) substrate, a ceramic (MCM-C) substrate, or a polyimide or laminate (MCM-L) substrate. Count only sales of MCM products and board-level products that conform with the definitions for "finished semiconductor products" or "unfinished semiconductor products." MCMs are not considered hybrids or monolithic ICs. MCMs are an advanced form of package interconnect.

System-Level Products

These are products that comprise a number of module or board-level products amounting to a single system or subsystem. Examples include development systems, hardware platforms, and box-level products. Do not include any sales from such system-level products. By contrast, do include application-specific ICs (ASICs) that provide system-level integration into silicon.

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Nonrecurring Engineering Charges

Nonrecurring engineering (NRE) charges are charges made to customers as the result of costs incurred during the design or customizing of a semiconductor device for that customer. Count NRE charges only when they occur in the following product areas:

- Design charges for ASICs, including gate arrays, cell-based ICs, and full-custom ICs
- Mask charges that result from the customizing of a programmable array logic (PAL), when the customer's fuse pattern is masked into it to produce a hard-wired array logic (HAL)
- Mask charges that result from the customizing of ROMs
- Mask charges that result from the storage of the customer's program in a microcontroller

Count revenue from NRE charges only on active semiconductor products that conform with the definitions for "finished semiconductor products" or "unfinished semiconductor products." Include these NRE charges as part of the revenue received from associated semiconductor product. Do not include revenue from NRE charges incurred during research, feasibility studies, or facility rental to third parties.

Electronic Design Automation Software

Electronic design automation (EDA) software is used to automate the design of semiconductors. Dataquest includes revenue from ASIC semiconductor vendors that also sell their own EDA software. Include any revenue derived from EDA software in the appropriate ASIC product category. The applicable categories are programmable logic device (PLD), gate array, and cell-based IC.

Intellectual Property Rights Income

This includes intellectual property rights (IPR) income from royalties, licensing agreements, technology transfers, and dispute settlements. Do not include any IPR income.

Chapter 4
Exchange Rate Definitions

When converting a company's local currency sales into U.S. dollars, or vice versa, it is important to use the 1998 exchange rates provided by Dataquest. This will prevent inconsistencies in the conversion of offshore sales between each company.

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Chapter 5
Semiconductor Product Category Hierarchy

The semiconductor product category hierarchy in Table 5-1 begins with total semiconductor, and indents each subcategory in the left-hand column according to its position in the hierarchy. At each level in the hierarchy, all subcategories that contribute to this level are shown as a subcategory summation in the right-hand column. Any level in the hierarchy that does not depend on any subcategory is marked as a "Data Point."

Table 5-1
Semiconductor Product Category Hierarchy

Category	Description
Total Semiconductor	**Total Monolithic Integrated Circuit + Total Discrete + Total Optical Semiconductor**
Total Monolithic Integrated Circuit	Bipolar Digital IC + MOS Digital IC + Analog IC
Bipolar Digital IC	Bipolar Digital Memory IC + Bipolar Digital Logic IC
Bipolar Digital Memory IC	Data Point
Bipolar Digital Logic IC	Bipolar Digital Logic Application-Specific IC + Bipolar Digital Standard Logic IC + Other Bipolar Digital Logic IC
Bipolar Digital Logic ASIC	Bipolar Digital Gate Array + Bipolar Digital Programmable Logic Device + Bipolar Digital Cell-Based IC/Full-Custom IC
Bipolar Digital GA	Data Point
Bipolar Digital PLD	Data Point
Bipolar Digital Cell-Based IC/ Full-Custom IC	Data Point
Bipolar Digital Standard Logic IC	Data Point
Other Bipolar Digital Logic IC	Data Point
MOS Digital IC	MOS Memory IC + MOS Microcomponent IC + MOS Logic IC
MOS Digital Memory IC	DRAM + SRAM + EPROM + EEPROM + Flash Memory + Mask ROM + Other MOS Digital Memory IC
DRAM	Data Point
SRAM	Data Point
EPROM	Data Point
EEPROM	Data Point
Flash Memory	Data Point
Mask ROM	Data Point
Other MOS Memory IC	Data Point
MOS Digital Microcomponent IC	MOS Digital Microprocessor + MOS Digital Microcontroller + MOS Digital Microperipheral + Programmable Digital Signal Processor
MOS Digital MPU	8- and 16-bit CISC MPU + 32-bit and greater CISC MPU + 32-bit and greater RISC MPU
8- and 16-bit CISC MPU	Data Point
32-bit and greater CISC MPU	Data Point
32-bit and greater RISC MPU	Data Point
MOS Digital MCU	4-bit MCU + 8-bit MCU + 16-bit MCU + 32-bit and greater MCU
4-bit MCU	Data Point
8-bit MCU	Data Point
16-bit MCU	Data Point
32-bit and greater MCU	Data Point

(continued)

Table 5-1 (Continued)
Semiconductor Product Category Hierarchy

Category	Description
MOS Digital MPR	System Core Logic Chipset + Graphics and Imaging Controller + Communications Controller + Mass Storage Controller + Audio/Other Controller
System Core Logic Chipsets	Data Point
Graphics and Imaging Controllers	Data Point
Communications Controllers	Data Point
Mass Storage Controllers	Data Point
Audio/Other Controllers	Data Point
Programmable DSP	Data Point
Logic IC	Total ASIC + Digital Standard Logic IC + Other MOS Digital Logic IC
Total ASIC	Traditional Digital Gate Array + Embedded Gate Array + Digital Programmable Logic Device + Digital Cell-Based IC + Digital Full-Custom IC + Mixed ASIC + Linear Array
Traditional Digital Gate Array	Data Point
Embedded Gate Array	Data Point
Digital Programmable Logic Device	Data Point
Digital Cell-Based IC	Data Point
Digital Full-Custom IC	Data Point
Linear Array/ASIC	Data Point
Mixed-Signal ASIC	Data Point
MOS Digital Standard Logic IC	Data Point
Other MOS Digital Logic IC	LCD Drivers + Other MOS Digital Logic IC
LCD Drivers	Data Point
Other MOS Digital Logic IC	Data Point
Analog IC	Amplifier/Comparator IC + Voltage Regulator/Reference IC + Data Converter/Switch/Multiplexer IC + Interface IC + Telecom IC + Disk Drive IC + Other Special-Function IC + Linear Array/ASIC + Mixed-Signal ASIC + Total Special Consumer IC + Special Automotive IC
Amplifier/Comparator IC	Data Point
Voltage Regulator/Reference IC	Data Point
Data Converter/Switch/Multiplexer IC	Data Point
Interface IC	Data Point
Telecom IC	Data Point
Disk Drive IC	Data Point
Other Special-Function IC	Data Point
Total Special Consumer IC	Video Special Consumer IC + Audio Special Consumer IC + Other Special Consumer IC
Video Special Consumer IC	Data Point
Audio Special Consumer IC	Data Point
Other Special Consumer IC	Data Point
Special Automotive IC	Data Point

(continued)

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Table 5-1 (Continued)
Semiconductor Product Category Hierarchy

Category	Description
Total Discrete	Transistor + Diode + Thyristor + Other Discrete
Transistor	Small-Signal Transistor + Power Transistor
Small-Signal Transistor	Data Point
Power Transistor	Bipolar Power Transistor + MOS Power Transistor + Power Insulated Gate Bipolar Transistor
Bipolar Power Transistor	Data Point
MOS Power Transistor	Data Point
Power IGBT	Data Point
Diode	Small-Signal/Reference Diode + Power Diode/Rectifier
Small-Signal/Reference Diode	Data Point
Power Diode/Rectifier	Data Point
Thyristor	Data Point
Other Discrete	Data Point
Total Optical Semiconductor	Total LED Lamp/Display + Optocoupler + CCD + Laser Diode + Photosensor + Other Optical Semiconductor
Total LED Lamp/Display	Infrared LED + Other LED
Infrared LED	Data Point
Other LED Lamp/Display	Data Point
Optocoupler	Data Point
Charge-Coupled Device	Data Point
Laser Diode	Data Point
Photosensor	Data Point
Other Optical Semiconductor	Data Point

Source: Dataquest (August 1998)

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Chapter 6
Semiconductor Product Category Definitions

The semiconductor product category definitions in Table 6-1 begin with total semiconductor and continue through each subcategory in the same order as shown in the preceding semiconductor product category hierarchy. At each level in the hierarchy, all subcategories that contribute to this level are shown as a subcategory summation in the right-hand column. Comprehensive definitions are given at every level. Table 6-2 shows microcomponent word widths.

Table 6-1
Semiconductor Product Category Definitions

Category	Definition
Total Semiconductor	**(Total Monolithic Integrated Circuit + Total Discrete + Total Optical Semiconductor)** Defined as an active semiconductor product that contains semiconducting material (such as silicon, germanium, or gallium arsenide but excluding ceramics) and reacts dynamically to an input signal, either by modifying its shape or adding energy to it. This definition excludes standalone passive components, such as capacitors, resistors, inductors, oscillators, crystals, transformers, and relays.
Total Monolithic Integrated Circuit	(Digital Monolithic Bipolar IC + Digital Monolithic MOS IC + Analog IC) A monolithic IC is one that is formed on a single chip of semiconducting material. This designation has been applied more broadly to mean any device, even multiple-chip packaged devices, that does not contain other, nonsemiconductor, components. This differentiates monolithic ICs from hybrid ICs that may also be multiple chip, but represent a "hybrid" in the sense of mixing other technologies within the IC package, such as film resistors or chip capacitors.
Digital Bipolar IC	(Bipolar Digital Memory IC + Bipolar Digital Logic IC) A bipolar digital IC is defined as a monolithic semiconductor product in which 100 percent of the die area performs digital functions, and, concurrently, 100 percent of the die area is manufactured using bipolar semiconductor technology. A digital function is one in which data is carried as numerical values, usually in a binary code.
Bipolar Digital Memory IC	A bipolar digital semiconductor product in which binary data is stored and electronically retrieved. Includes emitter-coupled logic (ECL) random-access memory (RAM), read-only memory (ROM), programmable ROM (PROM), last-in/first-out (LIFO) memory, and first-in/first-out (FIFO) memory. Not included are products made with mixed bipolar CMOS (that is, BiCMOS) with transistor-transistor logic (TTL) or ECL outputs, which are classified as Other Bipolar Digital Logic.
Bipolar Digital Logic IC	(Bipolar Digital Logic Application-Specific IC + Bipolar Digital Standard Logic IC + Other Bipolar Digital Logic IC) A bipolar semiconductor product that serves a general-purpose function using bit-processing technology. This bit processing is defined by hardwiring, mask programming, or field programming. Logic ICs also include customer-specific logic ICs.
Bipolar Digital Logic ASIC	(Bipolar Digital Gate Array + Bipolar Digital Programmable Logic Device + Bipolar Digital Cell-Based IC/Bipolar Digital Full-Custom IC) A single-user bipolar digital logic IC that is manufactured using vendor-supplied tools or libraries. Does not include bipolar digital ASICs incorporating microprocessor cells or microcontroller cells; these should be reported in the Other Bipolar Digital Logic IC category.

(continued)

Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
Bipolar Digital Gate Array	A bipolar digital gate array is defined as an ASIC device that is customized by the vendor to end-user specification using layers of interconnect. Included in this category are generic or base wafers with embedded functions, such as static RAM (SRAM) and electrically erasable PROM (EEPROM).
Bipolar Digital Programmable Logic Device	An ASIC device that is customized by the end user after assembly. Included in this category are bipolar field-programmable logic (bipolar FPL), bipolar field-programmable gate array (bipolar FPGA), bipolar programmable array logic (bipolar PAL), bipolar programmable logic array (bipolar PLA), bipolar electrically programmable logic devices (bipolar EPLDs), and bipolar complex PLDs.
Bipolar Digital Cell-Based IC/ Full-Custom IC	A bipolar digital cell-based IC is an ASIC device that is produced from a library of standard circuits/cells to a single-user specification. This process involves automatic routing and placement of cells using a full mask set. Included in this definition are bipolar standard cell ICs. Excluded from this definition are cell-based ICs with processor cores. These should be reported under Other Bipolar Digital Logic IC.
	A full-custom IC is an ASIC device that is produced for a single user using a full set of masks. This manufacturing process involves manual routing and placement of cells.
Bipolar Digital Standard Logic IC	A commodity bipolar family logic with fewer than 150 gates. Sometimes referred to as glue logic. Examples include TTL, ECL, and the following other family logic: TTL-compatible SSI, MSI, and LSI; standard, AS, FAST, LS, and ALS lines; and ECL-compatible SSI, MSI, and LSI. Also included are RTL and DTL.
Other Bipolar Digital Logic IC	All other bipolar digital logic ICs not accounted for in the preceding categories. Includes bipolar commodity family logic with 150 or more gates, bipolar digital general-purpose logic not belonging to any families, and bipolar digital microcomponent ICs.
MOS Digital IC	(MOS Digital Memory IC + MOS Digital Microcomponent IC + MOS Digital Logic IC)
	A monolithic semiconductor product in which 100 percent of the die area performs digital functions, and, concurrently, any portion of the die area that is manufactured using metal-oxide semiconductor (MOS) technology. A digital function is one in which data is carried as numerical values, usually in a binary code. Includes mixed-technology manufacturing, such as BiMOS and BiCMOS, where there is some MOS technology employed.
MOS Digital Memory IC	(DRAM + SRAM + EPROM + EEPROM + Flash Memory + Mask ROM + Other MOS Digital Memory IC)
	A MOS digital IC in which binary data is stored and electronically retrieved.

(continued)

Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
DRAM	Dynamic RAM, multiport-DRAM (M-DRAM), video RAM (V RAM), synchronous DRAM (SDRAM), cached DRAM (CDRAM), and self-refreshed DRAM. DRAMs have memory cells consisting of a single transistor and require regular memory cell refreshes. These are volatile memories, and addressing is multiplexed.
SRAM	Static RAM, multiport-SRAM (M-SRAM), battery backed-up SRAM (BB-SRAM), and pseudo SRAM (PSRAM). SRAMs have memory cells consisting of a minimum of four transistors, except PSRAM, which has a memory cell consisting of a single transistor and is similar to a DRAM with non-multiplexed addresses. SRAMs do not require memory cell refreshes (except in the case of PSRAM). These are volatile memories and addressing is not multiplexed. Note that color palette digital-to-analog converters (DACs) are included in the Data Converter/Switch/Multiplexer IC category of analog ICs.
EPROM	Erasable programmable read-only memory. This product classification includes ultraviolet EPROM (UV EPROM) and one-time programmable read-only memory (OTP ROM). EPROMs have nonvolatile memory cells consisting of a single transistor and do not require any memory cell refreshes. These devices are considered nonvolatile memories.
EEPROM	Electrically erasable programmable read-only memory. Includes serial EEPROM (S-EEPROM), parallel EEPROM (P-EEPROM), and electrically alterable read-only memory (EAROM). EEPROMs have memory cells consisting of a minimum of two transistors and do not require memory cell refreshes. Also includes nonvolatile RAM (NV-RAM), also known as shadow RAM. These semiconductor products are a combination of SRAM and EEPROM technologies in each memory cell. The EEPROM functions as a shadow backup for the SRAM when power is lost. These devices are considered nonvolatile memories.
Flash Memory	Nonvolatile products designed as flash EPROM/EEPROM that incorporate either 5V or 12V programming supplies and one-transistor (1T) or two-transistor (2T) memory cells with electrical programming and fast bulk/block erase. Flash memory can erase data only by bulk/block, not by byte.
Mask ROM	Mask-programmable read-only memory. Mask ROM is a form of memory that is programmed by the manufacturer to a user specification using a mask step. Mask ROM is programmed in hardware rather than software. These devices are considered nonvolatile memories.
Other MOS Digital Memory IC	All other MOS digital memory not already accounted for in the preceding categories. Includes MOS digital content addressable memory (CAM), MOS digital cache-tag RAM, MOS digital first-in/first-out memory (FIFO), MOS digital last-in/first-out (LIFO) memory, and ferroelectric memory.
Microcomponent IC	(Microprocessor + Microcontroller + Digital Signal Processor + Microperipheral) Microcomponents are a category of metal oxide semiconductor (MOS) integrated circuits (ICs), which are mostly digital, made up of the microprocessor (MPU), microcontroller (MCU), programmable digital signal processor (DSP), and microperipheral (MPR) product subcategories.
Microprocessor	(8-Bit MPU +16-Bit MPU + 32-Bit and Greater Computational MPU + 32-Bit and Greater Embedded MPU)

(continued)

Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
	Microprocessor (MPU): An MPU is a MOS digital integrated circuit that includes an instruction decoder, arithmetic logic unit (ALU), registers, and additional logic. It may contain instruction, data, or unified caches, memory management systems, and auxiliary ALUs for floating-point and other special data types. An MPU's functions are determined by fetching and executing instructions and manipulating data held in registers, internal cache, or external memory. MPUs operate out of external memory systems typically ranging from 1MB to 64MB of RAM and often backed by secondary memory systems (such as disks). More highly integrated versions of MPUs may contain on-chip peripherals, interface, and support circuits. The MPU category includes MPUs incorporating or originating from an ASIC design. MPUs are subdivided into 8-bit, 16-bit, or 32-bit and up word width. Beginning in 1997, 32-bit and larger MPUs are further divided into computational and embedded according to the applications into which they are designed. MPUs can be complex-instruction-set-computer (CISC) or reduced-instruction-set computer (RISC) implementations, although Dataquest no longer divides RISC and CISC in favor of architectural family distinctions (68000, x86, MIPS, and SPARC, among others). Similar terms are processor, central processor unit (CPU), and integrated processor.
Microcontroller	(4-Bit MCU + 8-Bit MCU + 16-Bit MCU + 32-Bit and Greater MCU)
	An MCU is a MOS digital integrated circuit designed for standalone operation that includes a programmable processing unit, program memory, read/write data memory, and some input/output capability. The processing unit contains an instruction decoder, arithmetic logic unit, registers, and additional logic. The MCU's functions are determined by fetching and executing instructions and manipulating data held in on-chip program and data memory (not including cache memories). MCU devices must be available with on-chip program store (ROM, EPROM, and flash, among others), typically ranging from 1KB to 64KB. As an option, some MCU devices can be purchased without on-chip memory for use during the debug and development phase of the system. Peripheral circuits are typically included on chip to assist in sophisticated input, output, and control functions. The MCU category includes MCUs incorporating, or originating from, an ASIC design. Standalone digital signal processors are not included with MCUs. MCUs are subdivided into 4-bit, 8-bit, 16-bit, or 32-bit word width. In 1996, Dataquest began separating 32-bit MCUs from 16-bit MCUs. All MCUs are designed into embedded applications. A similar term is microcomputer.

(continued)

Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
Digital Signal Processor	A digital signal processor (DSP) is a programmable MOS digital integrated circuit (IC) designed for standalone operation, constituting a high-speed arithmetic unit (typically a multiplier-accumulator unit) designed to perform complex mathematical operations such as Fourier transforms in real time to generate, manipulate, or interpret digital representations of analog signals. Modern DSPs typically access multiple pieces of data in different locations of on-chip memory over separate data paths using specialized addressing modes. Most DSP functions, such as the multiply-and-accumulate function, complete in a single instruction clock. DSPs usually include peripherals, which may include analog circuits like analog-to-digital converters. DSPs typically operate on 16 or 24 bits of fixed-point data or 32 bits of floating-point data, although Dataquest does not currently subdivide DSPs into these categories. DSPs that have no version that can be reprogrammed by the user in assembly or a higher-level language are not included but are classified as fixed-function application-specific standard products (ASSPs) or microperipherals. DSPs integrated on-chip with an independent microprocessor or microcontroller are classified as either an MPU or an MCU, respectively. All DSPs are designed into embedded applications. A similar term is programmable DSP (pDSP).
Microperipheral	(System Core Logic Chipsets + Graphics and Imaging Controllers + Communications Controllers + Mass Storage Controllers + Audio/Other Controllers) A microperipheral is a MOS digital integrated circuit that serves as a dedicated logical support function to a microprocessor or microcontroller in a system, performing sophisticated input, output, and control functions. Microperipherals are not programmable from assembly language, although they are often highly configurable by software or electrical signals. This definition includes MPRs comprising more than one device, such as PC or core logic chipsets. The MPR category includes MPRs incorporating, or originating from, an ASIC design. MPRs might be implemented using microprocessor, microcontroller, or digital signal processing elements, although this is generally not evident to the user. A similar term is peripheral. Note that this definition may change radically for 1999.
System Core Logic Chipset	Devices dedicated to a particular microprocessor interface that perform some of the basic interface functions such as memory management, DRAM control, cache control, bus interface control, DMA control, and interrupt control.
Graphics and Imaging Controller	Devices that typically interface to some form of systems bus to interpret, control, and display the visual output systems (computer-generated graphics, live video, and other images).
Communications Controller	Devices that control, format, and perform handshaking for the serial transmission and reception of information between systems or intelligent devices, including network controllers, integrated fax/modem chips, serial UARTs, and other communications interfaces.
Mass Storage Controller	Devices that are used to control data storage into and retrieval from all forms of mass storage media (magnetic, optical, and others), which include controllers used within host computers (host-side) and within mass storage drives (device-side).
Audio/Other Controller	Devices used to input or output information through other forms, including audio input/output controllers, keyboard controllers, pen input controllers, parallel port controllers, and various other devices.

(continued)

Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
Word Width	A programmable device's word width is the width, in bits, of one of the inputs to the primary on-chip integer arithmetic and logic unit. This measurement is independent of the data bus width or any other bus associated with the device. Wider and narrower data types might be operated on by the processor, with multiple passes through the ALU or special hardware. The word width classification is not influenced by the existence of additional integer units or of floating point and other special data type processors. A similar term is bit size.
Logic IC	(Total ASIC + MOS Digital Standard Logic IC + Other MOS Digital Logic IC) A MOS semiconductor product that serves a general-purpose function using bit-processing technology. This bit processing is defined by hardwiring, mask programming, or field programming. MOS microcomponents and MOS memory ICs are MOS logic ICs, but are either dedicated to a function (such as MOS microperipherals or MOS memory ICs) or are software programmable (such as MOS microprocessors and MOS microcontrollers). MOS logic ICs also include customer-specific MOS logic ICs.
Total ASIC	(Traditional Digital Gate Array + Embedded Gate Array + Digital Programmable Logic Device + Digital Cell-Based IC + Digital Full-Custom IC + Mixed ASIC + Linear Array) Defined as a single-user digital logic IC that is manufactured using vendor-supplied tools or libraries. Does not include digital ASICs incorporating microprocessor cells or microcontroller cells; these should be reported in the microprocessor IC or microcontroller IC category, respectively.
Traditional Digital Gate Array	Traditional gate arrays are ASICs that contain a configuration of uncommitted elements in a prefabricated base wafer. They are customized by interconnecting these elements with one or more metal routing layers. Included in this category are channeled and sea-of-gates architectures.
Embedded Gate Array	Embedded gate arrays are ASICs with a portion of the chip having traditional gate array architecture (channeled or sea-of-gates) and with megacells such as SRAM diffused into the gate array base wafer.
Digital Programmable Logic Device	An ASIC device that is customized by the end user after assembly. Included in this category are MOS field-programmable logic (MOS FPL), MOS field-programmable gate array (MOS FPGA), MOS programmable array logic (MOS PAL), MOS programmable logic array (MOS PLA), MOS electrically programmable logic device (MOS EPLD), and MOS complex PLDs.
Digital Cell-Based IC	An ASIC device that is produced from a library of standard circuits or cells to a single-user specification. This process involves automatic routing and placement of cells utilizing a full mask set. Included in this definition is MOS standard cell IC.
Digital Full-Custom IC	An ASIC device that is produced for a single user using a full set of masks. This process involves manual routing and placement of cells.

(continued)

Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
Linear Array ASIC	A single-user linear IC that is manufactured using vendor-supplied tools or libraries. Linear arrays fall into one of three types, as follows: 1. Arrays of discrete-level cells such as transistors and diodes 2. Arrays of discrete device combinations, referred to as tiles 3. Arrays of higher-level functional macro cells such as operational amplifiers, comparators, voltage-controlled oscillators (VCOs), references, and other analog functions These arrays are interconnected with a metal mask or by means of some user-programmable interconnect scheme. Unlike cell-based designs, they do not have a unique set of masks for all layers.
Mixed-Signal ASIC	A mixed-signal ASIC that is manufactured for a single user, using vendor-supplied tools or libraries and containing analog in more than 50 percent of the die area. ASICs with analog making up less than 50 percent of the die area should be counted in the appropriate category under digital ASIC.
MOS Digital Standard Logic IC	Commodity MOS family logic with fewer than 150 gates. Sometimes referred to as glue logic. Examples include: HC/HCT, AC/ACT, FACT, and 74BC/BCT BiCMOS family logic.
LCD Driver	Display driver IC designed to control and drive liquid crystal display (LCD) panels. LCD drivers convert digital inputs into the multilevel signals needed to drive liquid crystal displays. Excluded from this category are microperipheral controller/driver ICs that include the LCD drive function and TV LCD drivers that accept analog video inputs. These devices are counted as part of the microcomponent category or analog IC category, respectively.
Other MOS Digital Logic IC	All other MOS digital logic ICs not accounted for in the preceding categories. Includes MOS commodity family logic with 150 or more gates and MOS digital general-purpose logic not belonging to any families.
Total Analog IC	(Amplifier/Comparator IC + Voltage Regulator/Reference IC + Data Converter/Switch/Multiplexer IC + Interface IC + Telecom IC + Disk Drive IC + Other Special-Function IC + Linear Array/ASIC + Mixed-Signal ASIC + Total Special Consumer IC + Special Automotive IC + Smart Power IC) An analog IC is a semiconductor product that deals in the realm of electrical signal processing, power control, or electrical drive capability. It is one in which some of the inputs or outputs can be defined in terms of continuously or linearly variable voltages, currents, or frequencies. Includes only monolithic analog ICs manufactured using bipolar, MOS, or BiCMOS technologies. Includes monolithic linear IC and monolithic mixed-signal IC. A monolithic linear IC is characterized by having 100 percent analog input/output, while a mixed-signal IC carries information in both digital (numeric) and signal/power forms.

(continued)

Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
Amplifier/Comparator IC	An amplifier is a general-purpose linear IC that provides a voltage or current gain to an input signal. Includes operational amplifiers (mono, dual, and quad, among others), instrumentation amplifiers, buffer amplifiers, and power amplifiers. Consumer-dedicated amplifier ICs are counted in special consumer IC. Amplifier ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in linear array ASIC. A comparator IC is defined as a general-purpose linear IC that compares two analog signal inputs and provides a single logic bit output. Although the output could be considered digital, these products are classed as linear ICs because they are specialty high-gain amplifiers, used in an open-loop mode, for which the output is constrained to only two states. By using a comparator, an unknown voltage can be compared with a known reference voltage. Comparator ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in linear array ASIC.
Voltage Regulator/Reference IC	A voltage regulator IC is defined as a general-purpose linear IC that outputs a variable current at a regulated DC voltage to other circuits from a variable current and voltage input. Regulator ICs are either linear regulators, in which the device provides an input-to-output voltage drop, or switching regulators, in which the device provides switched quantities of power to a smoothing circuit to gain higher efficiency and reduce power dissipation. Voltage regulator ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in linear array ASIC. A voltage reference IC is defined as a general-purpose linear IC that outputs a precise reference voltage to other circuits from a variable voltage input. A reference IC differs from a regulator IC in that it is not expected to power other circuits. In fact, voltage regulator ICs incorporate a voltage reference circuit. Voltage reference ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in linear array ASIC.

(continued)

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Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
Data Converter/Switch/Multiplexer IC	A data converter IC is defined as a general-purpose mixed-signal IC that converts an analog signal into a digital signal or vice versa. Includes analog-to-digital converters (ADCs), digital-to-analog converters (DACs), sample-and-hold circuits (SHCs), voltage-to-frequency circuits (VFCs), frequency-to-voltage circuits (FVCs), synchro-to-digital circuits (SDCs), and digital-to-synchro circuits (DSCs). All these are general-purpose data ICs. Also included in this category are color-palette DACs. Consumer-dedicated data converter ICs are counted in special consumer IC, under monolithic linear ICs. Data converter ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in mixed-signal ASIC. A switch/multiplexer IC is defined as a mixed-signal IC that digitally controls analog transmission gates. These products connect or disconnect the analog signal path in analog circuits. Analog switches operate in a mode where each switch is operated independently by a single logic bit. Multiplexers are multiple analog switches that are connected in a dependent manner, where only one signal path is connected through to the output, depending on the state of a digital address word (greater than one bit). Thus, analog multiplexers are really addressable signal selector switches that select one of many signals for further analog processing. Because these addressable analog switches were the key element in time-division multiplexing, the term "multiplexer" has remained. They are an important part of the data conversion product family in that they are used to provide time-division multiplexing of signal inputs to a fast analog-to-digital converter. Switch/multiplexer ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in mixed-signal ASIC.
Interface IC	A general-purpose mixed-signal IC that serves as an interface between a digital system and other external nonsemiconductor systems. Includes line drivers, peripherals drivers, receivers, transmitters, and transceivers. Interface ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in mixed-signal ASIC.
Telecom IC	A general-purpose mixed-signal IC that is used for voice band communication or data communication over voice band media. This category includes codecs, combos and SLACs, subscriber line interface circuits (SLICs), modem and fax/modem ICs, dialer and ringer ICs, repeaters, cellular communications ICs, ISDN ICs, telecom filter ICs, and other telecom-specific circuits. Telecom ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in mixed-signal ASIC.
Disk Drive IC	A mixed-signal IC that is designed specifically for the rotating mass storage market. Applications include the read/write path from preamplifier up to the ENDEC, head-positioning controller, and spindle motor control. Disk drive ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in mixed-signal ASIC.
Other Special-Function IC	An IC that is either a general-purpose IC that does not fit into the other categories or market or application specific ICs for which a category does not yet exist. The main products that fall into this category include timers, phase-locked loops (PLLs), voltage-controlled oscillators, signal- or function-generator ICs, and analog multipliers. Other special-function ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in the linear array/ASIC IC category.

(continued)

Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
Total Special Consumer IC	(Video Special Consumer IC + Audio Special Consumer IC + Other Special Consumer IC) A general-purpose IC that is dedicated to general consumer applications but is not application-specific. Consumer ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in linear array ASIC.
Video Special Consumer IC	An IC implemented for video applications.
Audio Special Consumer IC	An IC implemented for audio applications, including radio and speech synthesis and recognition.
Other Special Consumer IC	An IC implemented in other consumer applications such as electronic games, personal and home appliances, and electronic cameras.
Special Automotive IC	An IC that is used in the following automotive applications: entertainment, engine control, safety, traction, or in-car electrical and suspension systems. Special automotive ICs designed specifically for one customer using vendor-supplied tools or libraries are counted in linear array ASIC.
Total Discrete	(Transistor + Diode + Thyristor + Other Discrete) A discrete semiconductor is defined as a single semiconductor component such as a transistor, diode or thyristor. Although multiple devices may be present in a package, they are still considered discretes if they have no internal functional interconnection and are applied in the same manner as other discrete devices.
Transistor	(Small-Signal Transistor + Power Transistor)
Small-Signal Transistor	Signal transistors, RF microwave transistors, dual transistors, MOS field-effect transistors (MOSFETs), conductivity modulated field-effect transistors (COMFETs), insulated gate bipolar transistors (IGBTs), and MOS-bipolar transistors (MBTs). All rated below 1W power dissipation.
Power Transistor	(Bipolar Power Transistor + MOS Power Transistor + Power IGBT) All are rated at 1W power dissipation and above.
Bipolar Power Transistor	Bipolar Darlington transistor, bipolar microwave transistor, and bipolar radio frequency (RF) transistor.
MOS Power Transistor	MOS field-effect transistor (MOSFET), MOS microwave transistor, and MOS radio frequency (RF) transistor.
IGBT Power Transistor	Insulated gate bipolar transistor (IGBT). Also includes conductivity modulated field-effect transistor (COMFET), MOS-bipolar transistor (MBT), and GEMFET.
Diode	(Small-Signal/Reference Diode + Power Diode/Rectifier)
Small-Signal/Reference Diode	Signal diodes, Schottky diodes, zener diodes, switching diodes, voltage reference diodes, voltage regulator diodes, and rectifier diodes. All are rated below 0.5A.
Power Diode/Rectifier	Zener diodes and rectifier diodes. All are rated 0.5A and above.
Thyristor	Thyristors, silicon-controlled rectifiers (SCRs), diacs, and triacs. Also includes solid-state relays (SSRs) incorporating triacs, thyristors, resistors, and capacitors.
Other Discrete	All other discrete semiconductor products not accounted for in the preceding categories. Includes microwave diodes, varactors, tuning diodes, tunnel effect diodes, and selenium rectifiers. Does not include thermistors and varistors.

(continued)

Table 6-1 (Continued)
Semiconductor Product Category Definitions

Category	Definition
Total Optical Semiconductor	(Total LED Lamp/Display + Optocoupler + CCD + Laser Diode + Photosensor + Other Optical Semiconductor) A semiconductor product in which photons induce the flow of electrons or vice versa. Other functions may also be integrated onto the product. This category does not include LCDs, incandescent displays, fluorescent displays, cathode ray tubes (CRTs), or plasma displays.
Total LED Lamp/Display	(Infrared LED Lamp/Display + Other LED Lamp/Display)
Infrared LED Lamp/Display	Infrared LED lamps/displays are single light-emitting diodes (LEDs) or an array of LEDs consisting of more than one die (in the case of displays) functioning in the invisible infrared range.
Other LED Lamp/Display	Includes visible LEDs and other LED products not included elsewhere. A visible LED lamp is defined as a light-emitting diode for which the light is visible: a semiconductor product consisting of a single die in which photons are emitted at frequencies dependent upon the semiconductor material employed. An LED display is defined as an array of LEDs: a semiconductor product consisting of more than one die in which photons are emitted at frequencies dependent upon the semiconductor material employed and where the light transmission is visible.
Optocoupler	An optocoupler or optoisolator. A semiconductor product consisting of an LED separated from a photosensor by a transparent, insulating, dielectric layer. These are mounted inside an opaque package. Includes optointerrupters, in which the separation between LED and photosensor is large enough to allow external physical systems to influence the device.
Charge-Coupled Device	A charge-coupled device (CCD) is a semiconductor product consisting of an array of photodiodes, an analog CCD shift register, and an output circuit. Includes linear array CCDs with serial shift registers and area array CCDs with parallel shift registers. Includes charge injection device (CID), charge-coupled photodiode (CCP), charge-priming device (CPD), and self-scanning photodiode (SSP).
Laser Diode	A diode that produces coherent light. A semiconductor product in which the heterojunction structure stimulates light amplification by stimulated emission of radiation (laser), resulting in coherent light. Includes Fabrey-Perot laser diodes, pulsed laser diodes, and phase-shifted laser diodes.
Photosensor	(Photodiode + Phototransistor) A diode or transistor in which photons are used to affect current flow or electric potential.
Other Optical Semiconductor	All other optical semiconductor devices not accounted for in the preceding categories. Includes solar cells and optical thermal piles.

Source: Dataquest (August 1998)

Table 6-2
Microcomponent Word Widths

	4-Bit	8-Bit	16-Bit	24-Bit	32-Bit	64-Bit
MPU	-	8-bit	16-bit	-	32-bit and up	32-bit and up
MCU	4-bit	8-bit	16-bit	-	32-bit and up	-
DSP	-	-	DSP	DSP	DSP	-

Source: Dataquest (August 1998)

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Chapter 7
Worldwide Geographic Region Definitions and Regional Roll-Ups

Americas

Includes countries of North America, Central America, and South America.

Dataquest officially treats the countries of South America, Central America, Mexico, and Puerto Rico as the Latin America region.

Japan

Japan is the only single-country region.

Europe, Africa, and Middle East

Europe

Western Europe

Includes Austria, Belgium, Denmark, Finland, France, Germany (including the former East Germany), Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and Rest of Western Europe

Rest of Western Europe: Includes Andorra, Cyprus, Faroe Islands, Gibraltar, Greenland, Guernsey, Iceland, Isle of Man, Jersey, Liechtenstein, Luxembourg, Malta, Monaco, San Marino, and Svalbard

Eastern Europe

Includes Belarus, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Russia, Slovakia, Ukraine, and Rest of Eastern Europe

Rest of Eastern Europe: Includes Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Croatia, Georgia, Kazakhstan, Kyrgyzstan, Macedonia, Moldova, Romania, Slovenia, Tajikistan, Turkmenistan, Uzbekistan, and Yugoslavia (Serbia and Montenegro)

Africa

Middle East

Asia/Pacific

Includes Australia, China, Hong Kong, India, Indonesia, South Korea, Malaysia, Singapore, Taiwan, Thailand, and Rest of Asia/Pacific

Rest of Asia/Pacific: American Samoa, Ashmore and Cartier Islands, Baker Island, Bangladesh, Bhutan, Bouvet Island, Brunei, Cambodia, Christmas Island, Cocos (Keeling) Islands, Cook Islands, Coral Sea Islands, Federated States of Micronesia, Fiji, French Polynesia, Guam, Howland Island, Jarvis Island, Johnston Atoll, Kingman Reef, Kiribati, Laos, Macau, Maldives, Marshall Islands, Midway Islands, Mongolia, Myanmar (Burma), Nauru, Nepal, New Caledonia, New Zealand, Niue, Norfolk Island, Northern Mariana Islands, North Korea, Pakistan, Palau, Palmyra Atoll, Papua New Guinea, Paracel Islands, Philippines, Pitcairn Islands, Solomon Islands, Spratly Islands, Sri Lanka, Tokelau, Tonga, Tuvalu, Vanuatu, Vietnam, Wake Island, Wallis and Futuna, and Western Samoa.

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Chapter 8
Semiconductor Application Segment Definitions

Data Processing

Defined as computer systems, data storage, input/output devices, dedicated systems, and other data processing equipment:

- Computer systems: The computer estimate does not include the value of the following systems: rigid disk drive, flexible disk drive, keyboards, and displays. The computer estimate does include the value of aftermarket sales of the following: graphics boards, motherboards, memory cards or single in-line memory modules (SIMMs), storage host adapters, and serial and parallel I/O boards. Worldwide computer systems production has been re-estimated and revalued to equal the value of worldwide (factory) revenue and shipments of computer systems as estimated by the Dataquest Computer Systems and Peripherals Worldwide group and to eliminate double-counting of system sales of storage devices, keyboards, and displays. Computer systems include supercomputers, mainframe computers, midrange computers (also known as superminicomputers and minicomputers), workstations, and personal computers (including portable computers). This includes the value of central processing units (that is, boxes) only.
- Data storage includes rigid disk drives, flexible disk drives, optical disk drives, and tape drives.
- Input/output devices include alphanumeric terminals and graphics terminals (for example, X terminals), monitors, and funds-transfer terminals; and printers, media-to-media data conversion, magnetic ink character recognition, optical scanning equipment, plotters, mice, keyboards, and digitizers.
- Dedicated systems include electronic copiers, electronic calculators and personal organizers, smart cards (IC cards), dictation and transcribing equipment, electronic typewriters and dedicated word processors, point-of-sale terminals and electronic cash registers, and mailing, letter-handling, and addressing equipment.
- Other data processing includes sound and audio boards, digital video boards, accelerator boards, and embedded CPU boards.

Communications

Defined as premise telecom equipment, public telecom equipment, mobile communications equipment, broadcast and studio equipment, and other telecom equipment:

- Premise telecom equipment includes image and text communication, such as facsimile and facsimile cards, and video teleconferencing; data communications equipment such as modems and modem cards, statistical multiplexers, T1 multiplexers, front-end processors, data service unit/channel service unit (DSU/CSU), protocol converters, (local area) network interface cards, LAN hubs and internetworking equipment, packet data switching systems; premise switching equipment, such as PBX telephone equipment, and key telephone systems; call-processing equipment, such as voice messaging, interactive voice response systems, and automatic call distributors; and desktop terminal equipment, such as telephone sets/pay telephones and cordless telephones, and teleprinters.
- Public telecom equipment includes transmission equipment, such as multiplexers, carrier systems, microwave radio, laser and infrared transmission equipment, and satellite communications equipment; and central office switching equipment.

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- Mobile communications equipment includes mobile radio systems such as cellular telephones, microcellular telephones, mobile radios, mobile radio base station equipment and pagers; portable radio receivers and transmitters; and radio checkout equipment.
- Broadcast and studio equipment includes audio equipment, video equipment, transmitters and RF power amplifiers, studio transmitter links, cable TV (head-end) equipment, closed-circuit TV equipment, and other equipment, such as studio and theater equipment.
- Other telecom equipment includes intercom equipment and electrical amplifiers; and communications equipment not elsewhere classified.

Industrial

Defined as security/energy management systems, manufacturing systems/instruments, medical equipment, and other industrial equipment:

- Security/energy management includes alarm systems, such as intrusion-detection and fire-detection systems, and energy management systems.
- Manufacturing systems/instruments include semiconductor production equipment, controls, process controls, control and processing displays and robots and test and measuring equipment such as semiconductor-dedicated automatic test equipment (ATE), other test and measurement equipment, and nuclear electronics.
- Medical equipment includes diagnostic equipment, therapeutic equipment, patient monitoring equipment, surgical support systems, and irradiation equipment.
- Other industrial equipment includes vending machines, power supplies, traffic-control equipment, and industrial equipment not elsewhere classified.

Consumer

Defined as audio equipment, video equipment, personal electronics, appliances, and other consumer equipment:

- Audio equipment includes compact disc players, radios, stereo components, musical instruments, and tape recorders.
- Video equipment includes VCRs and VTRs, video cameras and camcorders, videodisc players, color and monochrome TVs, and cable/satellite set-top decoders.
- Personal electronics includes electronic games and toys (systems and cartridges), cameras, watches, and clocks.
- Appliances includes air conditioners, microwave ovens, washers and dryers, refrigerators, dishwashers, and ranges and ovens.
- Other consumer equipment includes automatic garage door openers and consumer equipment not elsewhere classified.

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Military and Civil Aerospace

Defined as military electronic equipment and civil aerospace.

- Military/civil aerospace: North American military/civil aerospace production has been re-estimated and revalued to reflect U.S. Department of Commerce estimates of U.S. defense and civil (aerospace) electronics. Military/civil aerospace includes radar/sonar/reconnaissance systems, missile/space-related electronics, navigation equipment, electronic warfare, aircraft flight systems, and command and control systems.

Transportation

Defined as in-car entertainment, body control electronics, power train systems, and safety and convenience systems.

- In-car entertainment includes systems such as AM/FM radios, cassette and compact disc players, and radio/cassette combination systems.
- Body control electronics includes four-wheel steering control, two-wheel drive/four-wheel drive (2WD/4WD) control; multiplex systems such as driver's door console, door locks, windshield wipers, heated rear windows, memory seats, memory steering wheel, remote security systems, and suspension control and traction control systems; lighting controls including automatic headlight systems, timers, reminders, and sequential signal controls; and other body control electronics including aerodynamic aid control and power roof/window controls; driver information systems including electronic dashboard/instrument clusters, analog or digital clusters, electronic analog/digital clocks and compasses, electronic thermometers, head-up displays, navigation and location systems, signal and warning lights, and trip computers.
- Power train systems include engine management systems, power train sensors, ignition control, fuel injection systems, fuel flow, engine temperature, air temperature, coolant level, wheel speed sensors, and transmission control.
- Safety and convenience systems include climate control systems (air conditioning/heating), air purifier systems, air bag control systems, antilock braking systems, collision warning systems, and cruise control.

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Perspectives

Semiconductors Europe

Market Analysis

Water, Water, Everywhere, nor any Drop to Drink

Abstract: *The DRAM market is poised for recovery as demand for PC100 SDRAM increases sharply and vendors struggle to keep up. This Market Analysis updates Dataquest's Europe, Middle East and Africa DRAM forecast, detailing annual unit shipments, average selling prices and revenues from 1992 to 2002.*

By Richard Gordon

Come on in, the Water's Lovely!

It might seem strange that, in a world awash with DRAM production capacity, the market has moved on and is now demanding a type of DRAM that cannot be manufactured in high enough volume. However, this is undoubtedly the case. The industry has moved away from producing asynchronous FPM and EDO DRAM, which are now relegated to the specialist and upgrade sectors of the market, and is struggling to meet demand for DRAM utilizing synchronous interfaces.

As the fundamental demand driver for the DRAM market, the dynamics of the PC market are critical in determining the outlook for the DRAM market. Europe, Middle East and Africa (EMEA) PC production is expected to reach almost 25 million units in 1998 and is forecast to rise to about 41 million units in 2002. With this level of production, together with an increase in the average main memory factory fit from 55MB per system in 1998 to 245MB per system in 2002, the demand-side assumptions in terms of bit shipments are understood. However, bearing in mind that the PC industry is gearing up to fit 100 MHz synchronous DRAM (PC100 SDRAM) to mainstream PCs as a standard, it is by no means certain that the DRAM industry will be able to satisfy this demand for high-performance devices, especially in the short term.

The DRAM industry has entered a new phase based on a shift in demand towards increasingly higher-performance DRAM, driven by a widening gap between microprocessor speed and memory access time. As 1998 draws to a close, demand is firmly established for PC100 SDRAM at densities of 64Mb as minimum. However, although there remains too much DRAM production

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capacity globally, to be able to manufacture this leading-edge product competitively requires 0.25-micron process technology (or better). It is the lack of this leading-edge process technology that is already beginning to constrain the supply of 64Mb or 128Mb PC100 SDRAM and which will fuel the next DRAM market boom.

Short-Term Forecast Highlights and Assumptions

The following are Dataquest's highlights and assumptions for 1998:

- Bit growth of 86 percent, resulting in shipments of more a 900 million 16Mb equivalents into the EMEA region
- Average selling price (ASP) for 1998 of less than $1.50 per megabyte
- Revenues decline by 30 percent over 1997 levels to $2.8 billion

The following are Dataquest's highlights and assumptions for 1999:

- Bit growth at 68 percent returns to a level more consistent with the historic average
- ASPs stabilize at fourth quarter 1998 levels and remain above $1 per megabyte throughout the year
- Revenues increase by 30 percent over 1998 to reach $3.7 billion

Long-Term Forecast Highlights and Assumptions

The following are Dataquest's highlights and assumptions for the long term:

- The current forecast period encompasses the remnants of the last DRAM market downturn, a DRAM boom in 1999 through to 2001 and the start of the next cyclical downturn in 2002.
- Following the return to growth of DRAM revenues in 1999, strong revenue growth of 81 percent in 2000 will be followed by healthy revenue growth of 54 percent in 2001.
- The three growth years of 1999, 2000 and 2001 will be followed by an ASP crash and the next cyclical market downturn in 2002.
- Bit growth is expected to continue at close to 70 percent per annum throughout the forecast period.
- ASPs are expected to remain stable during 1999, 2000 and 2001 at more than $1 per megabyte.
- Continuous developments in DRAM technology are expected during the forecast period. Although PC133 specification DRAM will supersede PC100 and initiatives such as double data rate DRAM and NEC's Virtual Channel DRAM will emerge, by 2002 Dataquest expects Direct Rambus to be firmly established as the DRAM technology of choice in mainstream applications.

Forecast Detail

Table 1 shows the annual history and forecast detail for the EMEA DRAM market for the period 1992 to 2002.

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Table 1
EMEA DRAM Consumption History and Forecast, 1992-2002

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Units (M)												
256Kb	22.0	12.0	8.0	4.0	1.2	0.6	0.2	0.0	0.0	0.0	0.0	-100.0%
1Mb	148.9	117.0	92.4	49.0	35.0	25.8	27.5	22.5	11.6	3.9	2.8	-35.9%
4Mb	70.0	151.0	235.0	294.0	222.0	171.7	122.0	67.5	40.0	12.2	5.9	-49.0%
16Mb	0.2	3.6	21.2	67.9	179.0	377.4	402.0	240.0	140.0	45.5	12.0	-49.8%
64Mb	0.0	0.0	0.0	0.0	1.0	18.9	122.7	307.4	455.0	580.4	520.5	94.1%
128Mb	0.0	0.0	0.0	0.0	0.0	0.0	0.2	4.8	11.4	17.7	8.0	NA
256Mb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	32.0	98.0	299.6	NA
Total	241.1	283.6	356.6	414.9	438.2	594.4	674.6	644.3	690.0	757.7	848.8	7.4%
Terabits	458.9	819.6	1,440.3	2,424.7	4,038.4	8,347.5	15,556.9	26,170.5	43,183.3	68,450.9	116,656.2	69.5%
16Mb Equivalents	27.4	48.9	85.9	144.5	240.7	497.5	927.3	1,559.9	2,573.9	4,080.0	6,953.3	69.5%
Annual Bit Growth	NA	79%	76%	68%	67%	107%	86%	68%	65%	59%	70%	
ASPs ($)												
256Kb	1.70	1.99	2.37	2.50	1.50	1.50	1.60	0.00	0.00	0.00	0.00	-100.0%
1Mb	3.36	3.62	4.40	4.70	2.00	1.40	1.58	1.50	1.50	1.83	1.75	4.5%
4Mb	14.24	12.70	13.54	13.51	5.10	2.41	1.49	1.59	1.72	2.09	1.96	-4.0%
16Mb	112.34	85.18	62.25	54.11	18.42	7.20	2.98	2.08	2.51	2.89	2.75	-17.5%
64Mb	0.00	0.00	0.00	0.00	121.00	45.73	11.38	8.92	9.34	8.54	5.62	-34.2%
128Mb	0.00	0.00	0.00	0.00	0.00	0.00	28.48	18.78	19.50	18.78	11.55	NA
256Mb	0.00	0.00	0.00	0.00	0.00	0.00	300.17	104.43	55.00	49.00	20.66	NA
Revenue ($M)												
256Kb	37	24	19	10	2	1	0	0	0	0	0	-100.0%
1Mb	500	424	407	230	70	36	43	34	17	7	5	-33.0%
4Mb	997	1,918	3,182	3,972	1,132	414	182	107	69	25	12	-51.1%
16Mb	22	307	1,320	3,674	3,297	2,717	1,198	499	351	131	33	-58.6%
64Mb	0	0	0	0	121	864	1,396	2,742	4,250	4,957	2,925	27.6%
128Mb	0	0	0	0	0	0	6	90	222	332	92	NA
256Mb	0	0	0	0	0	0	12	219	1,760	4,802	6,190	NA
Total Revenue ($M)	**1,557**	**2,672**	**4,927**	**7,886**	**4,622**	**4,032**	**2,838**	**3,691**	**6,670**	**10,255**	**9,257**	**18.1%**
Annual Growth Rate	NA	72%	84%	60%	-41%	-13%	-30%	30%	81%	54%	-10%	

NA = not applicable
Source: Dataquest (October 1998 Estimates)

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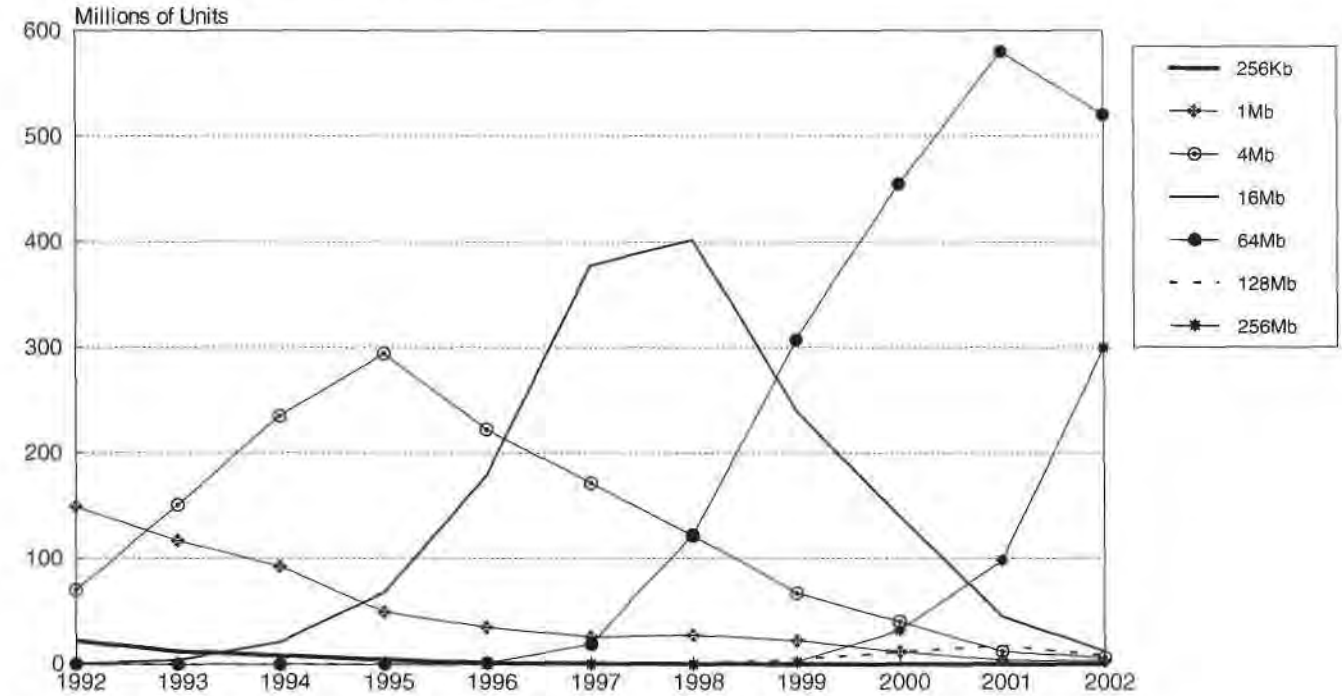
A rapid transition in shipment volume from the 16Mb device density to the 64Mb device density is expected to occur in 1999, so that almost 80 percent of all DRAM bits shipped in the EMEA region will be in the form of 64Mb devices. At this stage, it is expected that the 64Mb device will remain the largest volume shipment device density throughout the forecast period, although it is possible that some cannibalization of 64Mb unit shipments may occur if 128Mb devices gain in popularity. As an "intermediate" device density, there are two schools of thought about 128Mb devices: that they will be restricted to high-end servers and workstations that require a large amount of memory, but have limited space for expansion modules, or, alternatively, that it will actually be more profitable for DRAM vendors to produce a single-chip 128Mb device rather than a pair of 64Mb devices. Dataquest remains to be convinced about the latter argument and the forecast for 128Mb unit shipments reflects our skepticism. Towards the end of the forecast period, shipments of 64Mb devices are expected to begin to reduce in favor of 256Mb devices, as shown in Figure 1.

A period of price stability is forecast for 1999, 2000 and 2001, with the ASP of 64Mb devices remaining above $8 (or $1 per megabyte). At the end of the forecast period, in 2002, the return of DRAM overcapacity is forecast, resulting in a price crash and the next cyclical market downturn. At that time, price parity between 64Mb and 256Mb device densities is expected.

Forecast bit growth of almost 70 percent per annum in parallel with the absence of a decline in ASPs means that spectacular revenue annual growth rates is inevitable during the period from 1999 to 2001, bringing the EMEA DRAM market size to more than $10 billion in 2001. A revenue decline of 10 percent is forecast for 2002, induced by the next cyclical downturn in the DRAM market.

Figure 1
EMEA DRAM Unit Life Cycles, 1992-2002



Source: Dataquest (October 1998 Estimates)

Dataquest Perspective

While many DRAM industry watchers cannot see an end to the era of doom and gloom that has beset the market since 1996, a few, Dataquest included, are convinced that an upturn is just round the corner. There are very good reasons for this optimism, not least of which is a firm belief that the DRAM market will continue to behave as a "closed loop system": the output stage (DRAM revenues) feeding back and influencing the input stage (capital investment), which ultimately dictates the result at the output stage, and so on. This "feedback loop" behavior results in a DRAM market characterized by a cyclicity that, if left unchecked, can result in extreme peaks and troughs.

The last time an end to cyclicity was mooted was in 1995, at the end of a prolonged growth cycle, when it seemed impossible that the market could crash ever again. But crash it did, principally because of a huge buildup of DRAM capacity. Today, many are convinced that something new is going on because the current DRAM recession has resulted in an unprecedented third consecutive year of negative revenue growth in the EMEA region: approximately minus 41 percent in 1996 and minus 13 percent in 1997, with a further decline of 30 percent forecast for 1998. However, it is precisely because the latest trough has been more severe and prolonged than any in the past that the nature of the closed loop system suggests that the corrective action taken to pull the market out of recession (that is, cutbacks in capital investment) is the very action that will cause the next DRAM boom. Aggressive investment in 0.25-micron technology during 1997 exacerbated existing overcapacity in the industry and added another unwelcome pressure to prices already in decline as a result of the currency devaluation caused by the Asian financial crisis. The industry is witnessing very deep capital spending cuts in 1998 caused by overcapacity and financial uncertainty, and it is these cutbacks that ultimately will lead to the return of undersupply and stable prices.

Assuming that the number of DRAM bits shipped continues to increase at a rate consistent with history (about 70 percent for the sake of argument) then it is the level of the right kind of production capacity that will determine whether the DRAM market is over- or undersupplied and whether prices, revenues and margins are low or high respectively. The continuous increase in DRAM bit demand sits uneasily with short, but intensive, bursts of periodic investment and it is this relationship that causes DRAM market cyclicity. As with all commodities, today's investment affects tomorrow's market, and the recent slowdown in DRAM capital investment is already having its effect.

Following the oversupplied DRAM market of the past three years, it is all too easy to continue to predict a gloomy outlook. However, prices have stabilized, demand remains strong and supply is tightening. So, forget all the rational arguments and all the reasons why a recovery may not happen—trust in the industry cycles and look forward to a DRAM boom.

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May 29, 1998
Semiconductors Europe
Market Analysis
Edmund Gemmell

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European Inward Investment Opportunities

In this Market Analysis Dataquest examines what the key factors are in attracting inward investment from the semiconductor industry, and analyzes eight major locations. Funding is no longer the critical factor it once was, while educational infrastructure is playing an increasingly significant role.

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Executive Summary

Most countries in Europe are interested in, and are actively seeking, inward investment from semiconductor manufacturers. With most countries offering broadly similar incentives by way of capital grants and taxation benefits, the battleground to win high-quality inward investment is shifting to skills management. The future winners in this battle will be those that offer a combination of the correct skills in the right numbers, as well as attractive financial packages. This calls for an integrated response by each country to the demands of the semiconductor industry.

Some countries have recognized this and are rising to the challenge of developing methods to meet these demands. These will be the countries that attract the added-value inward investment projects. Some countries or regions will continue to offer large grants, but as this becomes more expensive, and as their competitors become more differentiated, the quality of inward investment that these regions or countries attract will suffer. While the focus of this *Market Analysis* is the semiconductor industry, many of the financial and fiscal incentives described are equally applicable to other industries.

Introduction

The location of a wafer fabrication plant or assembly and test plant is a key decision taken by semiconductor vendors when considering capital expenditure programs. Identifying where sufficient staffing, reliable infrastructure and suitable land can be found is becoming increasingly important. At the same time, many countries within the European Union (EU) have realized the potential benefits of having semiconductor plants located within their borders, in terms of direct employment, indirect employment, enterprise creation and regional regeneration. It is no surprise, therefore, that many countries, and specific regions within countries, are positioning themselves as high-technology centers and competing vigorously for new inward investment proposals. This *Market Analysis* analyzes some of the regions that a semiconductor manufacturer might consider when deciding upon a location within the EU. This *Market Analysis* also provides details of appropriate staffing availability, as well as training infrastructure and an overview of the financial incentives and support available in each location.

The locations covered in this *Market Analysis* are as follows:

- Flanders, Belgium
- Southeast France
- Western France
- Eastern Germany (Saxony)
- Ireland
- Northern England
- Central Scotland
- Central and eastern Spain

Table 1 shows the regions which have been most successful in promoting themselves to the semiconductor vendor community.

Table 1
Semiconductor Inward Investment Projects in Europe Since 1990

Year	Investment Location	Company
1990	Scotland	Motorola
	Scotland	Motorola
	Italy	Texas Instruments
1991	Northern England	Fujitsu
	Sweden	Mitel
	Northern Germany	Philips
	Northern Italy	SGS-Thomson
1993	Southern Germany	Hitachi
	Southern France	SGS-Thomson
1994	Ireland	Intel
1995	Western France	Philips
	Ireland	Analog Devices
1996	Scotland	NEC
	Northern England	Philips
	Netherlands	Philips
	Southern Italy	SGS-Thomson
	Southern France	SGS-Thomson
	Eastern Germany	Siemens
	Italy	Texas Instruments
1997	Southern France	Atmel
	Corbielle-Essomes, France	IBM
	Ireland	Intel
	Northern Italy	International Rectifier
	Germany	Mitsubishi
	Southern Italy	SGS-Thomson
	Northern England	Siemens
1998	Israel	Intel
1999	Eastern Germany	AMD
	Northern England	Fujitsu
	Scotland	Hyundai
	Wales	LG Semicon
Source: Dataquest (May 1998)		

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Flanders

Recently, Flanders has been one of the more proactive regions in Europe trying to attract inward investment. The main focus of activity has been in attempting to attract a semiconductor wafer fabrication facility into the region, which, it is hoped, will act as a catalyst for the further development of the semiconductor industry within the region.

One of the most interesting ideas being investigated by the Flanders Foreign Investment Office (FFIO) is the concept of building its own wafer fabrication plant and leasing this out to semiconductor vendors on a long-term basis. The model would have the Flanders government consortium managing the plant and issues such as chemical, gas and waste handling, while the tenant vendor would be responsible for manufacturing development and core competencies. This business model is still being developed by the

FFIO and Meissner and Wurst, a wafer fab design company.

Flanders is home to two semiconductor fabrication facilities. Alcatel Microelectronics, which is based in Oudenaarde, near Gent and IMEC, which has a smaller-scale facility in the region. IMEC is the largest independent microelectronics R&D center in Europe. IMEC's R&D activities are concentrated on the development of novel design methodologies, the development of processing technologies for the next generation of ULSI chips and the support of the training of VLSI design engineers on behalf of both educational institutes and industry. IMEC also provides training facilities for industrial partners upon request.

However, there are approximately ten other fabrication modules located within 150 km of Brussels. In addition to the semiconductor wafer fabrication plants and IMEC, Flanders has two other universities with specialist electronics faculties. The Flanders region also has 15 industrial engineering colleges which provide four-year electronics courses to degree standard.

The principal financial incentive offered by the Flanders government to inward investors is a series of cumulative direct subsidies. The first is a basic subsidy of 4 percent of total investment, which is available to qualifying investments that are the first operational unit by the company in Flanders. The second is a direct subsidy of up to 8 percent of the total investment, depending on the economic importance of the investment into the region. Given Flanders' eagerness to attract a semiconductor fabrication plant, it would be fair to assume that such an investment would be considered as being of great economic importance and, thus, would attract a significant part of this 8 percent. The third subsidy is based on employment growth, and can be up to 9 percent of the total investment. The combination of these three subsidies means a total direct subsidy of 21 percent of total investments is available to any qualifying inward investment project.

In addition to the direct subsidies that are available as incentives, Flanders also offer several fiscal measures to increase the value of inward investment support packages. These measures include an exemption of real estate tax for the investment site for five years and accelerated depreciation schemes. The FFIO will also participate in site acquisition and preparation.

The Flanders employment agency also participates in the sourcing of staff for any inward investment project. The Flanders employment agency, as part of an incentive package, will meet the expenses of new staff's first six to eight weeks of employment, when they usually will be in training.

France

Within France, the regions of western France and Marseilles-Provence in the southeast are two of France's primary high-technology and IT conurbations. Consequentially, both regions are being given a lot of support from the Invest in France Agency. Philips, Temic Matra (now part of Atmel) and SGS-Thomson have all located wafer fabrication plants within western France. Marseilles-Provence hosts wafer fabrication plants belonging to SGS-Thomson and Atmel. In addition, Motorola is nearby in Toulouse, and SGS-Thomson has more plants close by in Grenoble.

The importance of this high level of wafer fabrication plants is that both regions have been acclimatized to the high levels of service that wafer fabrication investments need in terms of ground preparation requirements, planning permission, waste material management, traffic and customs infrastructure, and supply infrastructure. In addition, the regions also have an existing skill base and orientation towards high-technology industries.

Western France

As well as the wafer fabrication plants located in western France, the region also has a high concentration of R&D facilities, including CNET (applied telecommunications research organization), CCETT (applied audiovisual research) and the microelectronics center for the west of France (CCMO), which is a collaboration between three electronics educational establishments in Rennes together with

SGS-Thomson, Matra and SOREP. CCMO provides R&D facilities as well as further training facilities and courses for workers in the electronics industry.

Western France is also home to more than 50 university- or engineering-school-based laboratories or departments with a high-technology orientation. These laboratories and departments are in 13 universities or engineering schools specializing in electronics, data processing and telecommunications.

The primary financial incentive available to companies investing in western France is the regional development grant (PAT). Most areas within western France qualify for a subsidy of up to FF 50,000 (approximately $8,250) per job created, although some areas within the region qualify for up to FF 70,000 (approximately $11,500) per job created. PAT is available to all companies investing at least FF 20 million (approximately $3.3 million) and creating 20 permanent jobs over three years. Neither of these restrictions would pose much of a problem for a semiconductor vendor considering investing in a new operation. The PAT incentive is limited to 17 percent of total investment. Some exceptional levels of financial assistance are available from PAT in western France, however, because of the restructuring of the French defense industry.

In addition to PAT, other assistance schemes are available for training programs and ensuring that manufacturing facilities are environmentally friendly. Full or partial exemption from business tax (a local tax) is also negotiable for up to five years for inward investment projects. In PAT-qualifying areas, local authorities are also prepared to become involved in land acquisition and preparation, and may provide a discount of up to 25 percent on purchase or lease costs.

Marseilles-Provence

The Marseilles-Provence region in the southeast of France has, as stated earlier, many wafer fabrication plants either in the region or close by. Additionally, the region has several technology parks serving the electronics industry, including Rousset, Aixles-Milles industrial development park, the Chateau-Gombert science park and the Arbois Europole project.

Within these parks and the region's universities there are 30 laboratories carrying out research in various fields of microelectronics. These laboratories are based around the four universities in the Bouches du Rhone region. In addition, Marseilles-Provence is home to the Microelectronics Regional Study Center on Silicon (CREMSI), which has some 40 members, including SGS-Thomson, Atmel, Gemplus and DuPont Photomasks, and 10 R&D laboratories. CREMSI is focused on furthering microelectronics in the Marseilles-Provence region and undertakes joint research for those companies involved. The Marseilles-Provence region also provides training programs and facilities for the technicians and senior technicians required to populate semiconductor fabrication plants.

Financial incentives in the Marseilles-Provence region are structured as those for western France. Marseilles-Provence is one of the few regions in the southeast of France which qualifies for PAT. The PAT rate for Marseilles-Provence is FF 70,000 per job created, subject to a maximum of 25 percent of total investment.

Ireland

Analog Devices' investment in Limerick in 1976 was the catalyst for Ireland's interest in attracting electronics-related investment. Since then, in addition to attracting a prestigious investment from Intel, Ireland has attracted several other semiconductor-related inward investments in the form of design houses.

Ireland has focused its efforts to attract future inward investment by building an infrastructure to supply the key staff for future technology. In addition to the National Microelectronics Research Centre base at University College Cork, which has a 3-inch foundry, IC design group, and interconnect and packaging laboratory, Ireland has eight universities with electronic engineering faculties, which produce between 600 and 700 electronics engineering graduates per year. Also, the Irish government has put in place an

Ir£50 million ($68 million) program aimed at developing additional engineering courses.

As well as its higher education establishments, Ireland also has 12 regional technical colleges offering electronics-related courses. Included in these courses is one codesigned by Hewlett-Packard and Intel to develop a suitably educated pool of technician-level staff.

One of the major financial attractions for investing in Ireland is the level of corporation tax levied against companies. The standard corporate tax rate is set at 10 percent until 2010. From 2010 until 2025 the rate will be 12.5 percent, which is significantly lower than that of most other countries. Surprisingly, other financial incentives aimed at attracting investment are significantly lower than those that some other regions are offering. The Irish Development Agency (IDA) offered Intel approximately IR£30,000 ($40,000) per job, which was significantly below some other offers, for a total commitment of 2,800 jobs, yet it still won the bid. This speaks volumes for the quality of staff on offer.

The IDA tends to work on an investment incentive per job created basis. However, once an amount per job has been fixed, it is broken down into three constituent parts: a capital grant based on the value of fixed assets; an employment grant, which, typically, would not exceed Ir£10,000 ($14,000) per job; and a training grant, which would cover up to 100 percent of agreed training costs.

Saxony, Germany

The former East German state, now one of the new German *Länder*, is positioning itself as the microelectronics center of eastern Germany. Since the reunification of Germany, Siemens has built a new DRAM wafer facility, in which it is planning its new 300-mm pilot line, and AMD is close to completing a new wafer fabrication plant for the manufacture of microprocessors. These developments are on top of the semiconductor infrastructure which existed when Saxony was part of East Germany. Zentrum Mikroelektronik Dresden (ZMD), which produces primarily memory products, has been located in Dresden since 1987. Prereunification, ZMD employed more than 3,000 staff in the microelectronics industry. Today it employs approximately 500, but the supply base for skilled employees, many of which worked in high-technology industries prior to reunification, remains.

Saxony, and Dresden in particular, offers a significant R&D and university infrastructure; Dresden has more than 30 educational and research institutes. Included in this number are the Institute for Semiconductor and Microsystems Technology, the Institute for Communications Systems, the Institute for Information Systems and the Institute for Technical Informatics, all at the Technical University (TU) Dresden, which has 21,000 students. In addition to TU Dresden, TU Chemnitz, FHS Mittweida, FHS Zwickau and FHS Zittau-Goerlitz all have IC design courses. Dresden is also home to the Fraunhofer Institutes for Microelectronic Circuits and Systems, the Fraunhofer Institute for Material Physics and Layer Technology and the Fraunhofer Institute for Integrated Circuits.

The financial incentives offered to inward investors in Saxony, and the new *Länder* of eastern Germany in general, are quite significant. Both Siemens and AMD received funding of approximately DM 800 million (approximately $450 million) to assist in their fabrication plant location decision.

Start up grants can reach 28 percent for large inward investment firms in the surrounding areas of Dresden and Leipzig. In other regions of the new federal states, grants can reach 35 percent of total inward investment. These grants are from the Improvement of Regional Economic Structures Program, which is funded by the Saxony Government, the federal government of Germany and the EU.

In addition to grants, several tax incentives are available to inward investors. Included in these are an investment allowance and a special accelerated depreciation allowance. The investment allowance returns 5 percent of any investment in movable depreciable equipment. Given that the cost of facilitizing a state-of-the-art wafer fabrication plant is now in the region of $1 billion, this allowance on its own is worth approximately $50 million. The special accelerated depreciation allowance allows companies to depreciate their capital equipment by between 20 percent and 40 percent above the normal depreciation rates.

United Kingdom

The United Kingdom has three regions that are focusing their attention on attracting semiconductor inward investment. These regions are the central belt of Scotland, stretching from the east coast around Edinburgh to the west coast around Glasgow, northern England and South Wales.

In 1996, semiconductor companies with manufacturing locations in the United Kingdom, along with the UK government, founded the National Microelectronics Institute (NMI). The NMI's role is to coordinate and enhance the activities of all parts of the UK semiconductor industry's support infrastructure. Included in this is the development of supporting industries and the coordination of further- and higher-education activities related to the microelectronics industry, as well as facilitating cooperation between companies in noncompetitive areas.

The NMI treats the three geographic areas as a single cluster, given their relative geographical proximity, coordinating all its activities to assist each area equally. The NMI has, with semiconductor vendors, developed two further-education courses designed to supply the semiconductor industry with appropriately qualified operators and technicians. To date, four further-education colleges in Scotland, and ten in the United Kingdom, offer these courses. In addition, the NMI has also created and had accredited a microelectronics MSc qualification for the development of engineer-level staff.

The main financial incentives provided to those considering investing in any of the three regions are, in principle, the same, although in the last round of inward investment, which involved Hyundai, the peculiar situation of two regions within the cluster trying to outbid each other occurred. Regional Selective Assistance (RSA) is the main financial incentive and applies to all three regions. Locate in Scotland, the inward investment agency, and the Northern Development Agency say only that RSA is negotiable on an individual basis, but is based on levels of capital expenditure and jobs created. In addition to RSA, all three regions have enterprise zones, which attract additional benefits of exemption from property taxes for 10 years and 100 percent depreciation allowance for buildings in the first year of operation.

Investors into the three regions will also be eligible for training and employment grants. Typically, these grants cover up to 50 percent of training costs, with a maximum of £4,000 ($6,500) per eligible employee.

An example which shows other potential benefits for investors is available in Scotland, where other substantial benefits including site acquisition and preparation, as well as considerable assistance with site management costs have been made available. An example of these is Hyundai's ongoing (and delayed) investment in Dunfermline, where it was reported that in an assistance package which totaled £151 million ($250 million) for a total maximum investment of £2.3 billion ($3.8 billion), amounts of £9.6 million ($16 million) for site acquisition, £23.4 million ($39 million) for site preparation (including new road infrastructure) and £9 million ($15 million) for waste treatment facilities were included.

Central Scotland

Since the mid 1970s, when National Semiconductor opened its first fabrication plant in Greenock, Scotland has recognized the increasing importance of high-technology manufacturing as a driver of national growth and large-scale provider of jobs. Since the 1970s, central Scotland has tried to reposition itself as the high-technology center of Europe, going so far as to coin the term "Silicon Glen."

The central belt of Scotland is home to six semiconductor companies, which have a total of ten wafer fabrication plants between them, and a further two plants are in planning or under construction. Central Scotland is therefore very adept at dealing with the requirements of semiconductor wafer fabrication plants.

In addition to the NMI infrastructure, central Scotland also houses 11 institutes and research centers related to the microelectronic industry. These are based at eight universities throughout the central belt region. Four of these universities are participating in a project with Cadence Design Systems to establish the world's first system-level integration institute. There are also 46 further education colleges, in and around the central belt, offering two-year electronic or electronic engineering courses.

Northern England

In addition to the regions' participation in the NMI, northern England also has a significant electronics-oriented training infrastructure, which produces more than 800 electronics-related graduates per year. In early 1998 the North of England Microelectronics Institute, a joint venture between the region's universities, Siemens and Fujitsu, opened in North Tyneside. The £16.5 million ($26 million) site includes laboratories for testing post-wafer processing reliability and design fault analysis, together with a new interconnection research project.

The region also has two universities: the University of Newcastle upon Tyne and Durham University, which both have a number of research groups related to the microelectronics industry. The University of Newcastle upon Tyne includes the Semiconductor Technology Group, the Microelectronic Systems Design Group and the DSP Group. Durham University includes the Centre for Molecular Electronics and the Centre for Electronic Systems. Durham University also manages a course developed by Fujitsu and continued by Siemens to fulfil the educational needs of both companies.

Spain

Spain appears to be something of an enigma in the field of attracting inward investment from the semiconductor industry. Since attracting Lucent Technologies to Madrid in the late 1980s it has not attracted any other major semiconductor fabrication investment.

Spain has set up two scientific parks focusing on the semiconductor industry. The first is Valles Technology Park located just outside Barcelona, and the second is Tres Cantos Technology park in Madrid, where Lucent Technologies has its wafer fabrication plant. In and around Valles Technology Park are the Spanish National Microelectronics Center, the Regional General Testing and Research Laboratory, and the New Materials Center, which is part of the Higher Center for Scientific Research. The National Microelectronics Center also has a site in the Tres Cantos Technology Park.

The principal financial incentive offered in Spain is for investment in certain regions. This is offered by the state, and varies from 20 percent to 60 percent of a project's capital expenditure. However, neither of the scientific parks mentioned above fall into one of the qualifying regions and, thus, they receive no regional incentive from the Spanish central government. In addition to the central government regional aid, each autonomous region also offers its own smaller-scale investment packages.

Spain has also created a $420 million high-technology fund called the ATYCA initiative, which will run until the end of 1999. The program is financed by the Ministry of Industry and Energy, and can provide funding for the improvement of the technology infrastructure and training.

Dataquest Perspective

Potentially useful manufacturing locations are essentially products for which there is a very small, but valuable, customer base. When Europe started attracting semiconductor inward investment, each country's offerings were essentially commodities, where, typically for commodities, price played the pivotal role in deciding which country won the inward investment. Price in this marketplace was represented by the amount of cash a region or country would pay to convince the prospecting company to move to their location.

However, the market has moved on; in the marketplace of inward investment the emerging key differentiator is the supply chain for appropriate human resources. Those regions or countries that develop a coherent and integrated road map to supply sufficient numbers of appropriate graduates and other technical staff will be the winners in attracting the quality inward investment projects in most cases.

For some, though, location will remain a commodity product and price (in the form of capital grants) will still have a key role to play. It could be argued that AMD's investment in Dresden, Germany was an example where "price" was the determinant factor whereas Intel's investment in Ireland was an occurrence where the differentiator won out over the highest bidder–the differentiating factor being the availability of staff at all levels of engineering expertise.

Some regions are further along the differentiation curve than others. For those lagging behind, price, in the form of subsidies, will continue to be their major attraction. For some companies this may be enough, although the dynamic is changing. Companies are beginning to want more than just a massive cash handout at the beginning of a project. They now want to ensure the long-term future of their plants and maximize the value they add to the company. Equally, countries want more than a cash for jobs equation, especially as the amount of cash required to win becomes unaffordable. They want investment in their communities and participation in their educational infrastructure. We may not have seen the last of the bidding wars that occurred in the fight to attract inward investment in the 1980s and early 1990s, but they will be fewer, as will be the participants involved in the fight. The next step for the inward investment market may well be its segmentation, on both the part of the semiconductor vendor and the regions.

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Perspectives

Semiconductors Europe

Vendor Analysis

ARM: Embraced as a De Facto Standard

Abstract: *Clear winners are emerging as a result of the boom in semiconductor intellectual property. One of these is ARM, a microprocessor architecture that is fast becoming a de facto industry standard in several key volume application areas. This Vendor Analysis examines the UK company behind ARM and why it has been successful.*

By Joe D'Elia

Introduction

In the mid 1980s, when Acorn Computers was looking for a microprocessor to replace the 6502 that had been the basis of its BBC and Electron computers, a group of Acorn engineers were not happy about the available contenders. Dissatisfied with the price/performance of systems built using merchant market products, they decided they could come up with a cheaper, simpler and more elegant solution—luckily their management believed them. Since then, ARM has become one of the leading microprocessor architectures for the embedded environment.

For the first few years of its existence, ARM was used by Acorn primarily as the engine for its RISC PCs. In 1990 Apple Computer was looking for a new processor to power its new Newton PDA product and ARM was a leading contender. ARM Holdings plc was set up as a separate company so that Apple could be serviced and to ensure the development of the architecture on a commercial basis.

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Acorn transferred the ARM design team to the new company and took an equity share, as did Apple and VLSI Technology. VLSI Technology was the semiconductor company that provided the original ARM devices; it was looking to ARM to provide it with a RISC core that it could incorporate in its ASIC libraries. In 1993 these initial investors were joined by Nippon Investment and Finance.

Like other leading third-party IP vendors, such as MIPS Technologies, DSP Group and Rambus Corporation, ARM has found that success in the intellectual property (IP) business takes time. The company was unable to go public until April 1998, its IPO being oversubscribed with shares offered at £5.75 each and selling at £8.38 at the end of the first day of trading.

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Table 1 shows revenue for ARM from 1991 to the first half of 1998; while the company generated revenue from the start, profits did not appear until the third year of its existence. Since then, both revenue and profits have been increasing and, in pound terms, the company has achieved a CAGR of 86.4 percent in revenue over the period 1992 to 1997. This growth rate is slowing down and has been in the region of 60 percent for the past two years. If growth was to continue at 60 percent, 1998 revenue would be in the low £40 millions. However, first-half revenue of £18.6 million would indicate that a more likely number will be in the high £30 millions.

In setting out to be a leading IP provider, ARM realized that it had to supply more than the basic IP. While ARM architecture offered many advantages regarding code density, performance, die size and flexibility in system implementation, this was not enough. The company had to ensure that its cores were supported by all the major EDA vendors, that comprehensive tools were available, that application software was written and that consulting support was on offer.

Through a combination of internal efforts and external partnering the company has successfully built up a comprehensive support network that covers all these items. At any stage, a potential ARM user has a wide choice as to what is available to assist in the project implementation process. In mid 1998 there were more than 20 tools and EDA vendors, almost 50 OS and applications vendors and 20 design services providers. ARM's own participation in these areas has also resulted in a services-based revenue stream for the company to supplement its primary licensing and royalties revenue.

Table 1
Revenue and Profit for ARM, 1991-First Half 1998
(Pounds and Dollars)

	1991	1992	1993	1994	1995	1996	1997	1H 1998	CAGR 1992-1997
Revenue (£K)	959	1,182	2,558	7,215	10,360	16,694	26,580	18,586	86.4%
Net Profit (£K)	-220	-254	147	1,060	2,406	2,660	3,329	3,445	
Revenue ($K)	$1,690	$2,078	$3,835	$11,038	$16,369	$25,850	$43,883	$30,977	84.0%
Net Profit ($K)	-$388	-$446	$221	$1,622	$3,802	$4,119	$5,496	$5,742	
Dollar to Pound Exchange Rate	1.7621	1.7587	1.4997	1.5299	1.5800	1.5485	1.6510	1.6667	

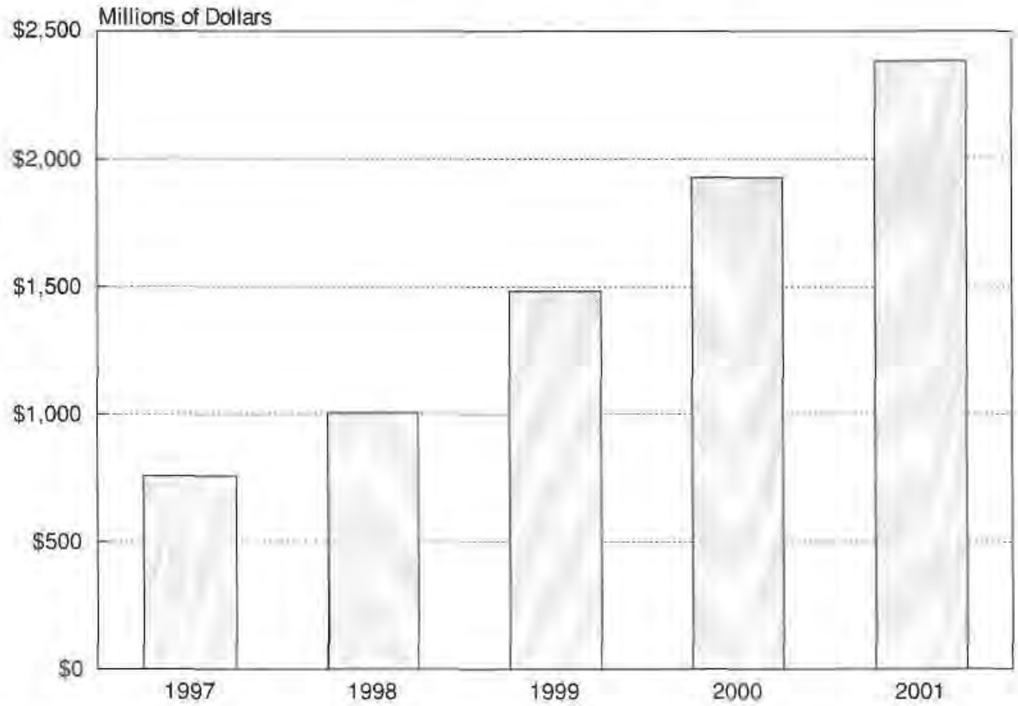
Source: ARM, Dataquest (September 1998 Estimates)

Intellectual Property Market

The supply of semiconductor IP is one of the fastest-developing markets in the world. Dataquest's estimates of how IP value in ASICs will develop is shown in Figure 1, which contains estimates for the period 1997 to 2001. Revenue is estimated at $757 million in 1997 and is expected to exceed $2.3 billion in 2001. For an explanation of how this value was derived, please refer to the *Dataquest Perspective* titled "Evaluating the Market for ASIC Intellectual Property." A comparison of ARM's results for its last financial year against other major third-party IP players shows that its revenue of $43.9 million is lower than MIPS Technologies' result of $56.8 million, but much higher than Rambus' $26 million and DSP Group's $10.7 million. These companies all have different fiscal years, so the results are not directly comparable but do give an indication of scale.

The numerous market players have many different business models, but these can be split into two major categories: direct and indirect. In the direct model, the IP provider designs and supplies cores direct to the end user.

Figure 1
Worldwide Intellectual Property Revenue, 1997-2001



Source: Dataquest (September 1998 Estimates)

Most semiconductor IP is supplied through the direct channel by semiconductor ASIC vendors through their extensive macrocell libraries. These cores are usually proprietary and therefore available from only one vendor; however, this is changing as vendors recognize the need to proliferate their architectures and are therefore slowly starting to cross-license each others' cores.

The drive behind this is the increasing complexity of semiconductor cores, and therefore the cost and effort required to generate and maintain them, together with the need to offer a comprehensive selection. The advance in semiconductor process technology is having as much of an impact on the ability of semiconductor vendors to deliver products to market on time as it is impacting their customers. Tied to the time-to-market issue is the ability to provide comprehensive support on all the complex cores in their libraries. These issues, coupled with customer demands for multisourcing, are driving the trend to cross-licensing and, even more so, the move to providing third-party IP.

In the third-party model, one company designs the IP and licenses it to a second (normally the semiconductor vendor), which sells it on to the end user, usually as a component part of a larger IP group. The licenser derives its revenue from several sources as follows:

- The first source is the license fee paid by the licensee company when it licenses the IP.
- The second is from providing training, engineering resources and tools to the second company during the exercise of porting the IP to that company's process technology.
- The third is through providing training, software and tools to the end user when he incorporates the IP into his design.
- The fourth is the per-unit royalties that the end user will pay indirectly through the silicon vendor.

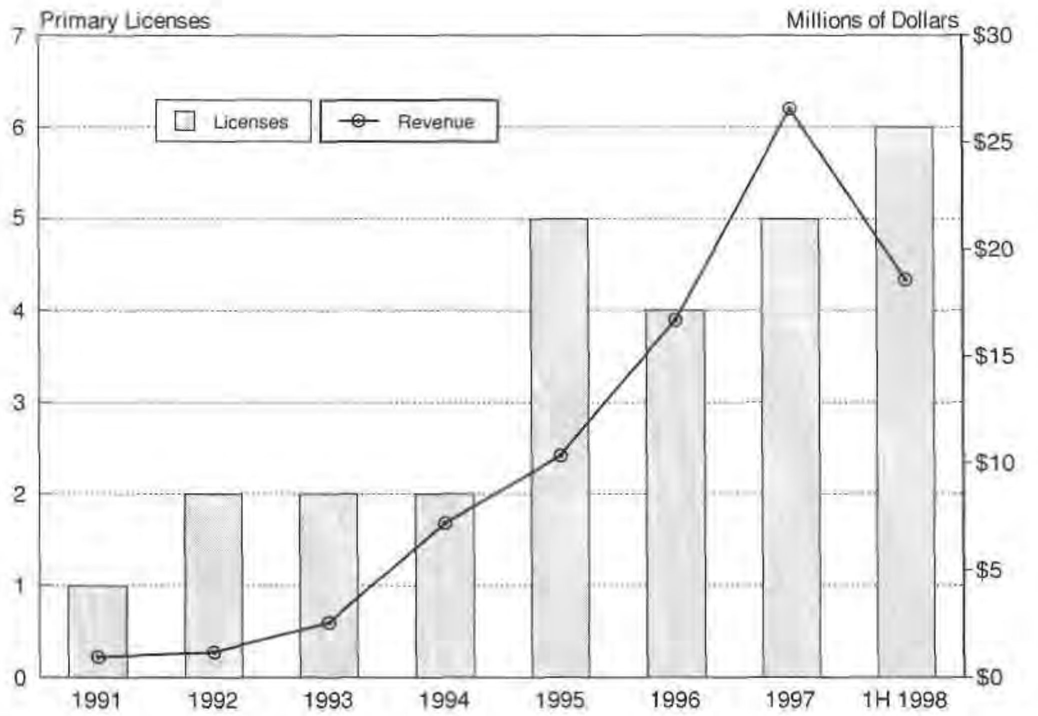
Ultimately, the whole process starts again as further generations of the IP are introduced. The third-party market is growing because it enables all parties in the "food chain" to focus on what they do best: the silicon vendor provides silicon, the IP vendor provides the IP and the end user can focus on adding differentiation to his product through his knowledge of the end market.

ARM is tapping all four sources of income and is going through a transition period as the relative importance of these revenue streams changes. In its few years, ARM survived on licensing and providing porting support services to its licensees. As those licensees grew in number and the architecture started to become accepted by end users, ARM was able to tap into supporting end users' design efforts. Finally, in the past two years, ARM has been starting to tap into the fourth component, the royalty stream, as ARM-based products finally hit volume production.

As well as an increase in royalty streams, ARM is seeing an acceleration in licensees licensing newer cores and therefore starting the process again; to date, 18 of its licensees have already licensed subsequent IP. Figure 2 compares revenue with number of primary licenses, and shows the cumulative effect of these various revenue streams. Clearly, the rate of licenses increasing alone does not explain the revenue increase, even though ARM licenses will have become more expensive as the architecture became more established.

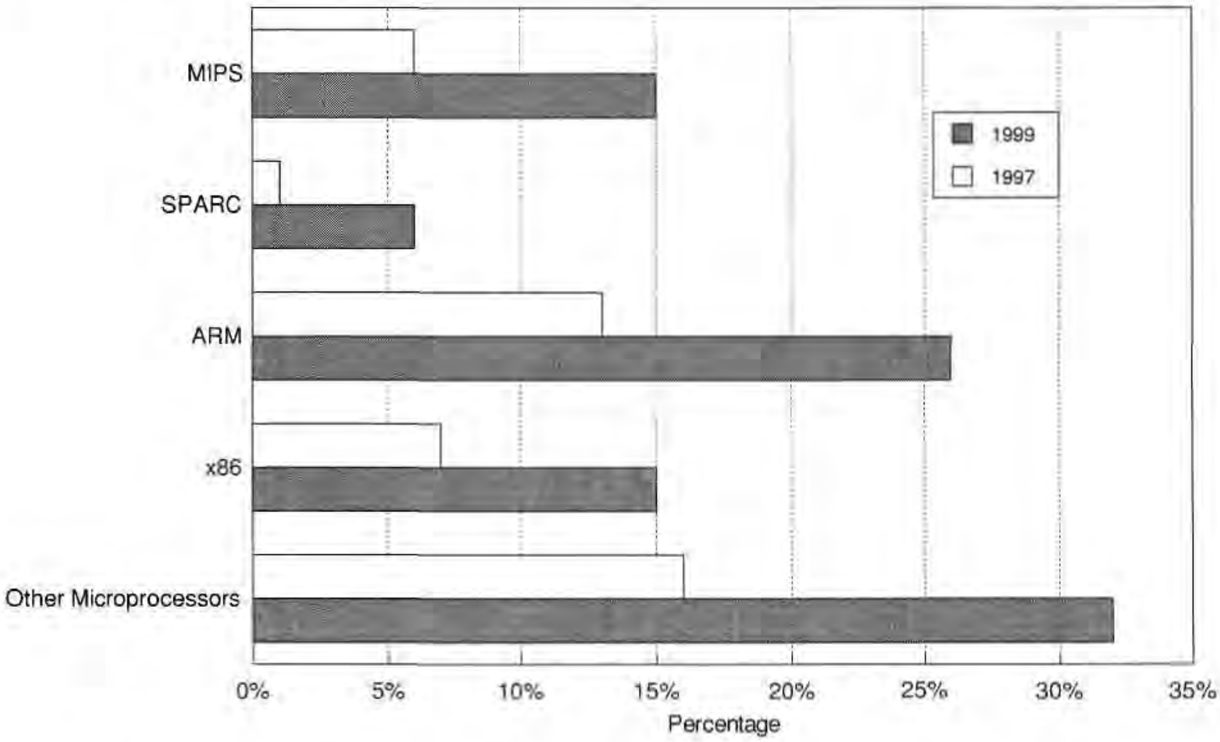
ARM is not alone in providing microprocessor cores, there are many other players, both third-party vendors—for example, MIPS Technologies, ARC, Hyperstone and Lexra—and direct vendors. However, Dataquest research shows that ARM is the architecture with the most design wins and we expect it to maintain this record. Figure 3 shows respondents' replies to Dataquest's 1997 ASIC user survey regarding the use of system-level functions in ASICs. In 1997 ARM was being used in 13 percent of these devices; in 1999 this figure should double to 26 percent.

Figure 2
Revenue versus Primary Licenses, 1991-First Half 1998



Source: ARM, Dataquest (September 1998 Estimates)

Figure 3
Processor Core Preferences, 1997 and 1999



Source: Dataquest (September 1998 Estimates)

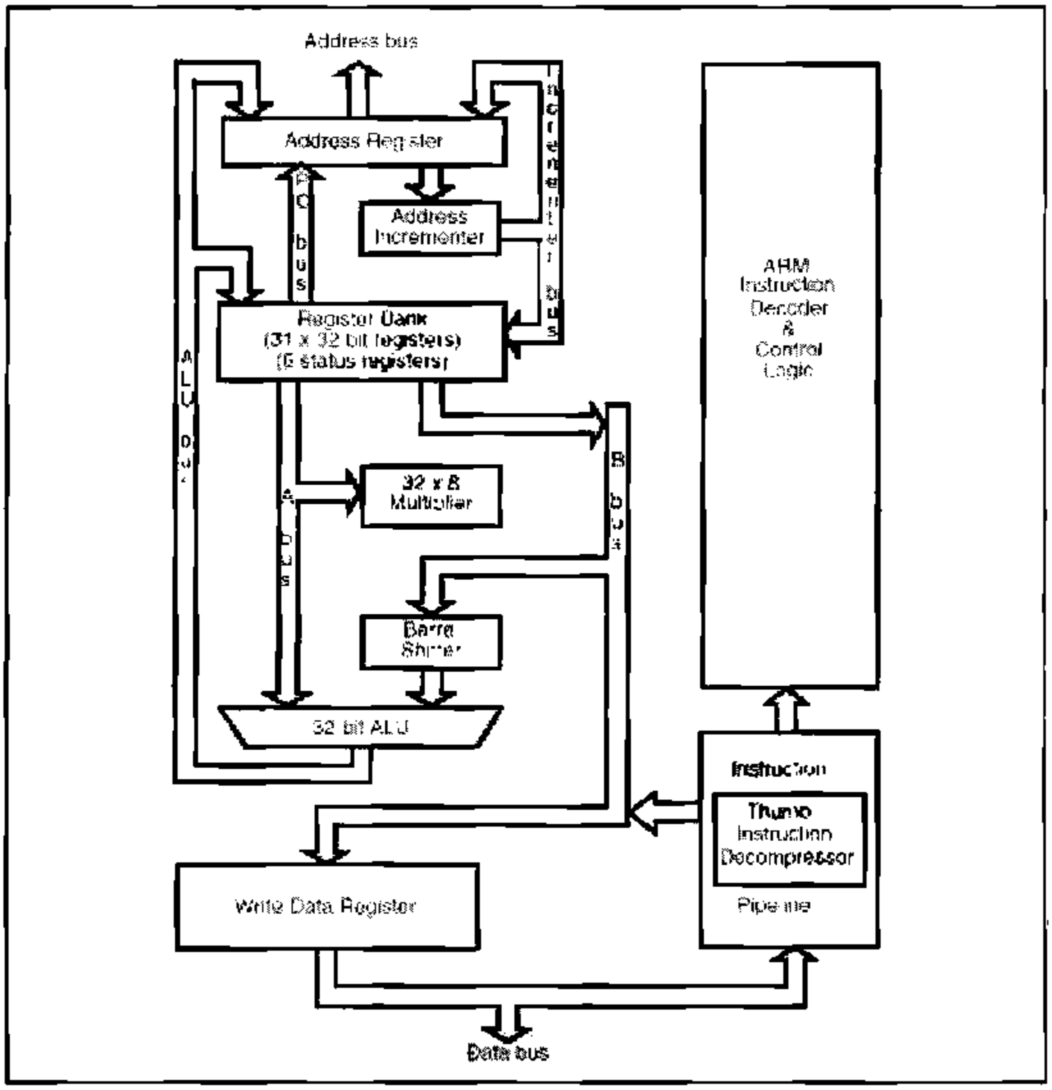
Products

ARM has had several generations of architecture. The one that started its current success is the ARM7D, introduced in 1993. More important is the ATM7TDMI core, introduced in 1995. The difference between the two is that ARM7D is a full 32-bit architecture with 32-bit code and data, while the ARM7TDMI inserts a 32-bit to 16-bit instruction decompression engine between the MPU and memory. This enables the device also to execute with a 16-bit reduced instruction set with only minimal performance degradation, while saving overall silicon area and memory costs in cost-sensitive applications. This "Thumb" extension to the ARM7 has proved so successful that the ARM7TDMI is now the only ARM7 core offered by ARM.

As well as the basic core, three preconfigured macrocells match the core with various peripherals such as cache, write buffers and memory-management functions to offer preconfigured options optimized for different applications. Figure 4 is a block diagram of the ARM7TDMI. It shows that, from an architectural perspective, there is nothing unusual in the RISC architectural implementation of the device; it is the combination of the whole package of products and services that makes ARM successful. The Thumb Instruction Decoder is shown as an integral part of the Instruction Pipeline and Read Data Register block.

In late 1997, ARM announced the ARM9TDMI, a five-stage pipelined core with Harvard buses that provides twice the performance of the ARM7TDMI. Also offered are two preconfigured Cached Processor Macrocells targeted at different applications.

Figure 4
ARM7TDMI Block Diagram



Source: ARM

Table 2 shows ARM's list of licensable cores, macrocells and various architectural extensions. The most interesting of these is the Piccolo DSP coprocessor, which integrates a second DSP-oriented data path and instruction set into a standard ARM system; both the DSP and CPU share the same system bus and memory, thereby minimizing silicon area. The Piccolo core addresses the growing number of applications where there is a need for general purpose processing and DSP functionality. These applications include hard disks, GSM telephony, GPS mapping systems and most of the high-volume digital consumer applications whose growth is just starting. The one disadvantage of this solution is that, as the system bus and memory are shared, only one of the units can be active at a time.

Another component of ARM architecture is StrongARM; this is not offered directly by ARM but by Intel, which acquired it as a result of the settlement of its litigation with Digital Equipment Corporation. With StrongARM, the objective was to offer the best possible performance with the lowest possible power consumption—this StrongARM achieved. Having found application in Apple's Newton resurrection, StrongARM's general acceptance was stalled by the Digital/Intel litigation and the uncertainty about its future after this was resolved. Late July saw Intel give an extremely strong message to the industry: that StrongARM was an integral part of its strategic thrust to obtain market share in those high-volume consumer and communications applications where its x86 architecture had been woefully unsuccessful. To this end, Intel has rebuilt and expanded the StrongARM design teams and is actively pushing to design StrongARM 2 and 3, together with ASSPs targeted at specific applications. This is extremely significant for ARM's overall market acceptance as it brings to the architecture the weight of the world's largest semiconductor manufacturer and microprocessor vendor.

Table 2
Licensable ARM Products

Product Code	Product Type	Product Description
ARM7TDMI	Core	ARM7 32-bit CPU core with Thumb extension
ARM7TDMI S	Core	Synthesizable ARM7 32-bit CPU core with Thumb extension
ARM740T	Macrocell	ARM7TDMI with 8KB cache, write buffer and MPU
ARM710T	Macrocell	ARM7TDMI with 8KB cache, write buffer and full MMU
ARM720T	Macrocell	ARM7TDMI with 8KB cache, write buffer and MMU for Windows CE
ARM9TDMI	Core	5-stage pipelined 32-bit CPU with integral Thumb extensions, giving twice performance of ARM7
ARM910T	Macrocell	ARM9TDMI with peripheral set for deeply embedded applications requiring simple memory management
ARM940T	Macrocell	ARM9TDMI with peripheral set for embedded applications requiring full virtual memory management
Thumb	Architecture Extension	Provides memory compression capibility, enabling 32-bit CPU to run from 16-bit memory
Multiplier	Architecture Extension	DSP-enhanced multiplier
EmbeddedICE debug	Architecture Extension	Provides integral ICE-like debug for CPU cores integrated into ASICs
Piccolo	Architecture Extension	High-performance ARM DSP coprocessor

Source: ARM, Dataquest (September 1998)

Partnerships

Aside from the core products, the single most important factor contributing to ARM's success is the range of partners that it has built up since its inception. While the main interest of this *Vendor Analysis* is the semiconductor partners, the list that ARM has developed in the areas of development tools and services, EDA vendors, RTOS and application software is equally impressive and not to be discounted in the success of the architecture.

Table 3 lists the 27 public semiconductor partners; apart from this list there are two or three other partners that have not made their status public. Examining the participants shows that their regional origin is a good match to the overall semiconductor industry: 13 in the United States, 9 in Japan, 3 in Asia/Pacific and 2 in Europe. Three of the companies—Atmel, Intel and Mitel Semiconductors—were not the original licensees, but inherited their licenses through their acquisition of the original licensees. In all three cases they have maintained the license as a strategic contributor to their product plans.

The range of ARM usage is primarily in three product areas: as cores offered in ASIC vendors' libraries; as standalone microprocessors and microcontrollers, both general purpose and for very targeted applications such as PDAs; and as ASSPs for specific applications. Table 3 lists the application areas for which

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ARM-based ASSPs have been marketed. This gives a good idea of the broad coverage available and indicates where the real volumes of ASIC ARM applications lie. Today, the main areas are electronic data processing and communications, over the next year these will be joined by various major digital consumer applications and within two years by important automotive applications.

ARM's ASIC partners are using the architecture diligently as their path into these major application areas and in certain key areas, such as digital cellular handsets, have established the architecture as the de facto standard. This latter occurrence is important enough to be considered a major reason why companies like LSI Logic and IBM Microelectronics, which have their own competitive offerings in the form of MIPS-based TinyRISC from the former and PowerPC from the latter, have taken on an ARM license. The message they were getting from the major players in the digital cellular market was "Don't call if you can't supply ARM!"

Table 3
Public Semiconductor Partners

Company	Year First Licensed	ARM Offerings	ASSP Application Area
AKM Semiconductor	1994	ASSP	Mobile Communications
Alcatel	1996	ASSP	Telecommunications
Atmel (ES2)	1996 (1995)	MPU/ASIC	NA
Cirrus Logic	1993	MPU/ASSP	PDA, Datacomms
Epson	1998	ASSP	Mobile Communications
Hyundai	1997	ASSP	Mobile Communications
IBM Microelectronics	1998	ASIC	NA
Intel (Digital Equipment Corporation)	1998 (1995)	MPU/ASSP	PDA, Consumer, Mobile Communications
LG Semicon	1995	MCU/ASIC	NA
LSI Logic	1998	ASSP/ASIC	Digital Consumer
Lucent Technologies	1997	ASSP/ASIC	Communications/Datacomms
Mitel Semiconductors (GPS)	1998 (1992)	ASSP/ASIC	Automotive, Communications
National Semiconductor	1998	ASSP	Communications/Consumer
NEC	1995	ASSP/ASIC	Consumer
Oki	1996	MCU/ASIC	NA
Panasonic	1998	ASSP	Consumer Multimedia
Philips	1997	ASSP	Mobile Communications
Qualcomm	1998	ASSP	Mobile Communications
Rockwell	1997	ASSP	Datacomms
Rohm	1996	ASSP	Telecommunications
Samsung	1994	MCU/ASSP	Datacomms
Sharp	1992	ASSP	PDA/Mobile Communications
Sony	1997	ASSP	Consumer
Symbios	1995	ASSP	Datacomms
Texas Instruments	1993	ASSP/ASIC	Consumer
VLSI Technology	1990	MPU/ASSP/ASIC	Consumer, Mobile Communications
Yamaha	1996	ASSP	Consumer

NA = not applicable
Source: Dataquest (September 1998)

The sheer number of ASIC licensees provides evidence of one of ARM's strengths: by using ARM an ASIC customer can choose from a variety of vendors and, if the volumes justify it, can get his product multisourced. While customers increasingly can get this benefit from several other architectures, there is not the same guarantee that what they get will be exactly the same. ARM's use of hard macros has resulted in a guaranteed product that works in exactly the same way and that has well-specified guaranteed parameters, irrespective of which vendor supplies it. A major factor in this strength is that ARM itself is closely involved in each porting effort and has ported the cores so many times and to such a range of processes that it is a well-practiced routine.

Future Directions

With ARM's current penetration of semiconductor vendors, the company has to look both for new products that will enable it to sell more to its existing customers and for products with which to expand its customer base. One initiative addressing the latter issue is the offering of soft macro versions of the architecture. Two of the most recent licensees, IBM Microelectronics and LSI Logic, are offering their own soft versions of the ARM7TDMI core, and now ARM is offering its own version in the form of the ARM7TDMI S. These soft macros will enable those ASIC customers and future licensees whose design flow cannot encompass a hard macro to employ the architecture.

The advantage of ARM's soft macro is that it enables a licensee to use a semiconductor vendor or foundry that is not an ARM licensee, although the downside is that the performance/size of the resulting implementation is entirely the licensee's responsibility. A soft macro will also be of interest to FPGA vendors as the increasing complexity of their devices increasingly demands ASIC-like design methodologies. To be successful, this latter usage would require a radically different business model, as controlling the use of the core would be much more difficult with off-the-shelf FPGAs.

Another initiative that indicates future directions for the company is the recent agreement with Lucent Technologies and Cirrus Logic to codevelop an open ARM-based architecture for hard disk drives. This kind of application-oriented development applied to other vertical markets would enable ARM to sell more to its existing customer base by facilitating its entry into new markets.

Beyond ARM9, the company's design center in Austin, Texas is working on ARM10, which will be introduced at this year's Microprocessor Forum. This shows an obvious acceleration in the introduction of new products: ARM7 was introduced in 1993 and ARM9 was introduced at the same forum in 1997. ARM10 will integrate a floating point unit and take the company into new areas of high-end performance. This combination of the three cores will give ARM a wide spectrum of performance to offer its licensees. The two questions that arise from this product strategy are ARM's ability to support all its customers should they choose to migrate, and the product positioning versus StrongARM, current and future. Figure 5 shows the roadmap for ARM and StrongARM, and shows that there is an overlap of performance as both move forward. However, other factors, such as power dissipation and process technology, will clearly dictate which is the best candidate for a particular application.

Speculation that ARM would extend its product offerings by taking ARM architecture to different word lengths to address areas such as the 8-bit embedded market should be discounted. This avenue was explored and found wanting; the investment required to make ARM successful would not bring the returns necessary to justify it.

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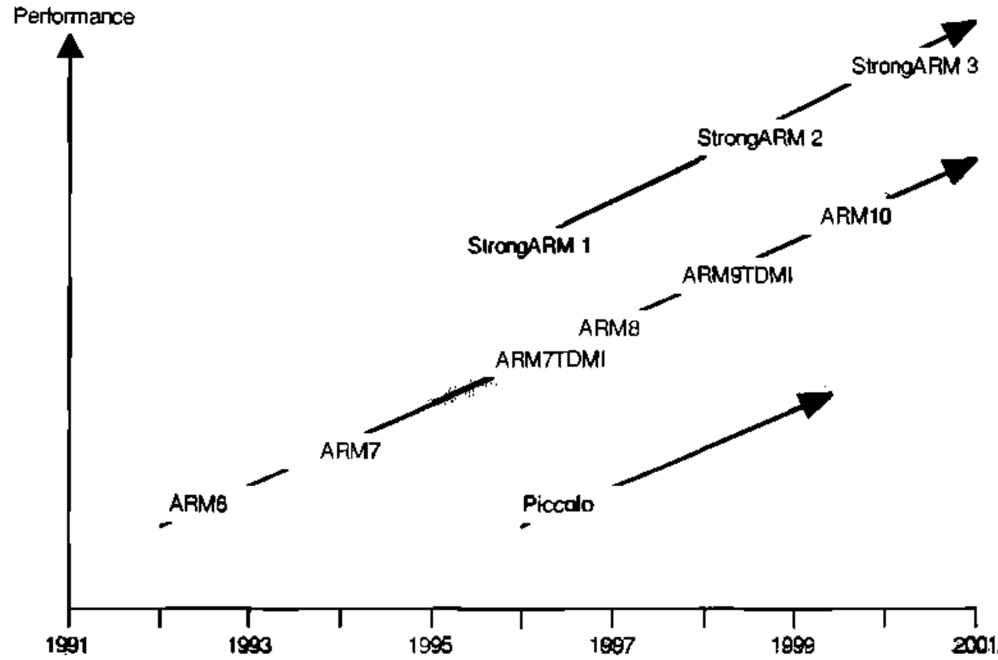
Figure 5
ARM Core Roadmap, 1991-2001



Source: ARM, Dataquest (September 1998)

Dataquest Perspective

The third-party IP market has been a long time coming. ARM has been at the forefront of the campaign and is now enjoying the rewards. It has been able to satisfy the four major issues facing customers looking to implement third-party IP today. These four issues and the ways in which ARM addresses them are listed in Table 4.

With success come new challenges and it is important that the company addresses these to ensure that it continues to grow. ARM's success has encouraged others to enter the third-party microprocessor IP market. The most significant of these new entrants is the revamped MIPS Technologies, which is now refocusing on this market. Beyond MIPS, there are companies like ARC, which has achieved reasonable success in its short existence, and other start-ups such as Lexra with its MIPS clone. These companies are small and flexible, and can use ARM's perceived weaknesses to their advantage. For example, ARC supplies a synthesizable macro and has a business model that minimizes the up-front license fee. Also, its architecture allows customers the flexibility of creating application-specific instructions that can keep code compact and help to minimize peripheral silicon. These three points address some of the major criticisms leveled at ARM; however, they are also cited by other customers as some of the key reasons for ARM's success.

On the same microprocessor IP front, the semiconductor vendors and their proprietary architectures constitute a threat to ARM; again, these competitors are adjusting to make their offerings more competitive. In particular, they are making their architectures more accessible by cross-licensing IP so that a particular architecture is available from several sources. Hitachi is ahead in this respect, having cross-licensed its Super H to four other vendors.

Table 4
Major Issues in the Implementation of Third-Party Intellectual Property

Issue	Resolution
Ease of implementation	Tools, services, software, training, partner programs
Multisourcing	Number of licensees, soft macro
Cost of license and royalty	Flexible business model, transparent end-user royalties
Manufacturability	Proven hard macros

Source: Dataquest (September 1998)

Another major factor for the company is the management of its growth rate, keeping resources in line with revenue. Over the next two years, ARM is due to introduce two major incremental products that require considerable resources to manage all the ports required by its customer base. Coupled with this will be all the necessary internal development for the actual products and tools (for example) needed to support them. ARM is now a public company and no longer has its previous flexibility; it has to meet its forecasts and keep its stockholders happy by maintaining growth in the stock price. ARM's management is aware of this and is learning to manage its revenue flow. If ARM adopts a relentless policy of killing old products, the company should be able to manage its growth successfully into the next millennium.

ARM is in a strong position. The architecture is established, the support infrastructure is in place and well-supported and its revenue streams are starting to be supplemented by royalties generated by the explosive growth of ARM-enabled unit shipments. This makes ARM the target for current and future entries into the microprocessor IP market. Fortunately, the market is growing so fast that there is room for several players. The key for ARM is to maintain its momentum and establish the architecture as a standard across a broad spectrum of applications such that when the market settles it is still in the leading position.

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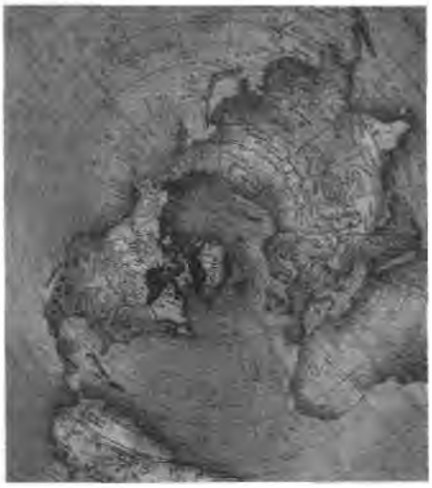
Market Statistics



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EMEA MOS Memory Consumption History and Forecast, 1992-2002

Market Statistics

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Product Code: SEMI-EU-MS-9803
Publication Date: June 30, 1998
Filing: Market Statistics

EMEA MOS Memory Consumption History and Forecast, 1992-2002

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Chapter 1
Total MOS Memory Market Statistics and Analysis

Important Information

When reading this *Market Statistics* report, please bear in mind the contents of the chapter titled "Important Information," which refers specifically to the DRAM market.

Overview

Dataquest's latest market share survey, completed in April 1998, resulted in an estimated market size of $6 billion for Europe, Middle East and Africa (EMEA) MOS memory in 1997. When compared with the market's value of $7 billion in 1996, as shown in Table 1-1, this figure represents a decline of 13 percent. The 1996 figure, represented a 31 percent reduction in revenue from the high of $10 billion in 1995. This continued revenue decline of the MOS memory market further impacted the proportion of the total EMEA semiconductor market accounted for by MOS memory as a product category. The total MOS memory category, which includes DRAM, SRAM and nonvolatile memory, accounted for just 20 percent of the total EMEA semiconductor market last year—down from 24 percent in 1996 and 36 percent in 1995. The MOS microcomponent product category, which includes microprocessors, microcontrollers, microperipherals and digital signal processors, increased its share to 36 percent, while the MOS digital logic product category, which comprises mainly ASICs, grew its share to 14 percent. The share of the three main categories, namely MOS memory, MOS microcomponent and MOS digital logic, which together constitute the MOS digital product category, remained constant at 70 percent of the total EMEA semiconductor market.

The decrease in MOS memory revenue from 1996 to 1997 was driven by a decline in ASPs across all product categories. The only crumb of comfort was that this decline would have been much worse had it not been for healthy increases in bit demand, particularly in DRAM and flash memory. Consequently, the shares of the markets within the total MOS memory market remained largely unchanged. The DRAM market still dominates, retaining 67 percent of 1997 revenue. Similarly, the nonvolatile market held its one-fifth share of the total. However, the significant decline in SRAM revenue resulted in a slight loss of share at less than 11 percent. Making up the total, the other MOS memory market doubled its share from 1 percent to 2 percent, but this was more because a reclassification of revenue by one vendor during the market share reporting process resulted in an artificial fillip rather than a result of any real upsurge in the market.

Dataquest's segmentation for the MOS memory market is shown in Figure 1-1, and a full definition for each device family is included at the end of this document.

Table 1-2 illustrates all of the memory device markets and their relative size in the EMEA region and worldwide in 1997. Overall, the EMEA MOS memory market marginally increased its share of the worldwide total to more than 19 percent compared to the 1996 level of slightly less than 19 percent. This increase in share was driven by the flash and EPROM markets, which each increased worldwide share to 24 percent, along with the DRAM market, which increased its worldwide share to more than 19 percent. The EMEA SRAM market and the ROM market remained pegged at 16 percent and 5 percent respectively worldwide. The sharp decline in the worldwide share of the EMEA EEPROM, as with the apparent increase in the fortunes of the other MOS memory market, owes more to a reclassification of revenue by a vendor during the market share reporting process and is not a true reflection of the market situation.

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Dataquest estimates that the EMEA market for MOS memory will grow at a compound annual growth rate (CAGR) of 15 percent from 1997 to 2002. As expected, MOS memory revenue declined in 1997 compared to the 1996 level, and the hoped-for strong upturn in the market in 1998 is looking less likely as revenue could struggle to maintain the $6 billion level of 1997. This prolonged period without positive market growth has meant that the expected three-year DRAM boom has been pushed out by a year, resulting in a strong growth outlook for 1999, 2000 and 2001. The next capacity-driven downturn is expected in 2002, leading to negative growth which will hold back the CAGR to 15 percent.

1997 Review

The EMEA semiconductor market grew by a modest 6 percent in 1997—a feat made all the more impressive considering the gloom hanging over MOS memory revenue. With the markets for DRAM, SRAM, EPROM, EEPROM and ROM all declining, the only bright spot was the flash memory market, which managed 5 percent growth in spite of severe ASP erosion.

DRAM prices continued to fall throughout 1997 as demand failed to mop up the glut of 16Mb EDO devices that swamped the market. DRAM manufacturing capacity was simply not reigned in, despite public announcements to the contrary. DRAM vendors continued to chase market share by improving production efficiencies and reducing costs to enable further price cuts. For example, the 16Mb contract ASP, which began the year at less than $10, declined by 50 percent to less than $5 by December as vendors shaved margins to the bone and flirted with the specter of antidumping legislation. However, DRAM prices—averaging at $3 to $4 per megabyte—did have a positive effect on the PC market during 1997. By the end of the year, 32MB was a standard PC factory fit and, with EMEA PC production topping 21 million units, a DRAM "bit boom" resulted in more than 100 percent bit growth in 1997 over 1996, compared with the typical level of 70 percent. A year of flat growth is predicted for DRAM revenue in 1998 as prices remain low while the industry is in a lull between DRAM density and technology generations. A very strong growth cycle is expected for the following three years before the cyclical downturn again in 2002.

Weakness in the SRAM market continued throughout 1997, although there were a few "false dawns" for the vendors when prices on selected devices were raised in anticipation of future shortages. These shortages failed to materialize, however, and the market declined by a hefty 19 percent to just $650 million. This decline in revenue meant that the SRAM market was relegated to third place behind the flash memory market, confirming that flash memory has come of age as a memory technology. Dataquest expects the SRAM market to return to low, single-digit growth in 1998 as it continues to shake down following the overcapacity of the past three years. The wide range of SRAM applications is expected to continue to fuel growth throughout the forecast period—especially in the telecommunications area, which is a lucrative market for slow SRAM.

The nonvolatile memory market continues to shape up as expected. The relative strength of the flash market in 1997, albeit at a less spectacular level than in the early 1990s, was achieved at the expense of the EPROM market, where revenue declined by more than 30 percent to less than $200 million. In addition, the removal of a large chunk of EEPROM revenue from the market in 1997 because of a definition change in the reporting of one vendor's memory sales and a residual ROM market that remained stubbornly low meant that the total nonvolatile market declined by 14 percent.

Other MOS memory will continue to be a niche and specialist market, but revenue in the EMEA region is expected to grow at a CAGR of 11 percent for the period 1997 to 2002, putting the market size ahead of that of EPROM and ROM by the end of the forecast period.

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Long-Term Forecast

Table 1-3 shows the complete EMEA MOS memory consumption history and forecast for the period from 1992 to 2002. Included in this table are forecasts for units, ASPs, revenue, bit growth and costs per megabit. The DRAM market is expected to remain the most significant element of the EMEA memory market, rising from 67 percent of the total MOS memory market in 1997 to 76 percent in 2001 before falling back to a 67 percent share in 2002. The SRAM contribution will be maintained at about 10 percent to 12 percent throughout the forecast period, leaving the nonvolatile memory market to account for the remaining portion, a maximum of 20 percent. The dollar value of each of the memory families is illustrated in Figures 1-2 and 1-3. Notably, the flash memory market outgrew the SRAM market in 1997—much earlier than forecast—and these two markets look set to track each other in terms of size over the coming years. Much of this contention is dependent on the PC cache SRAM market, which may disappear in the EMEA region as PC microprocessor solutions migrate to an integrated L2 SRAM cache. Also noteworthy is that the decline in the EPROM market was more aggressive than forecast, primarily because of the emergence of flash technology as a cost-effective, higher-performance alternative. The EPROM market is expected to reach a residual market level of $50 million by the end of the five-year forecast period, and compete with ROM as the smallest EMEA memory market. Steady growth is expected in the EEPROM market following the glitch in 1997, which was caused by the removal of a large portion of "phantom" EEPROM revenue previously attributed to smart cards.

The top ten suppliers of MOS memory to the EMEA region for 1997 are shown in Table 1-4. Samsung retained number-one position by virtue of a steady performance in the declining DRAM market, where it actually managed to post a modest increase in revenue. This growth was coupled with a very good consolidation of its dominant position in SRAM, where the company gained significant market share, especially in the GSM handset arena. Siemens gained one position in the ranking at the expense of NEC; the latter's DRAM revenue declined by almost 20 percent, while the German vendor managed to hold its DRAM revenue reduction to a modest 6 percent. Texas Instruments (TI) and Hyundai both performed well, maintaining their memory revenues at just above 1996 levels. In contrast, heavy declines in DRAM sales pulled Fujitsu and Hitachi down the ranking, although LG Semicon, whose revenue fell at a similar rate, actually climbed a place. Micron Technology made it into the ranking, climbing five places to number seven—a vindication of its strategy of applying aggressive geometry shrinks to the aging 16Mb DRAM density generation to cut costs and prices. Finally, Advanced Micro Devices (AMD), whose flash products are gaining wide acceptance in the EMEA region, entered the top ten at number nine.

Total MOS memory units sold in 1997 grew by 13 percent over 1996. Figure 1-4 shows the forecast unit shipments for each memory family. DRAM unit consumption growth jumped to 35 percent in 1997 as the industry crammed more and more 16Mb devices into the PC. This growth will slow and level off later in the forecast period as the DRAM industry transitions from the 16Mb to the 64Mb device density; similarly, a shift to higher-density devices will result in a stabilization of SRAM unit consumption at about 150 million units per annum. Continued increased bit demand and cannibalization of the EPROM market will ensure that flash unit consumption increases at a CAGR of about 20 percent through 2002, even allowing for a move to higher-density devices. The blip in the EEPROM trend is an anomaly caused by the removal of a significant amount of prepaid telephone card units from the EEPROM category as a result of a definition change by one of the vendors. Unit shipments in this category will therefore be driven by the wide array of applications that use standard EEPROM devices. ROM unit consumption is expected to remain flat at a maximum of 20 million units per year.

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The outlook for MOS memory ASPs is shown in Figure 1-5. The single most notable effect is the across-the-board reduction in ASPs seen in 1997 that affected all memory technologies. Looking ahead, volatile memory ASPs are expected to increase as supply-and-demand dynamics combine with a move to higher-density devices, while those for nonvolatile memories are expected to remain subdued because of the more stable nature of these markets.

The MOS memory application split is shown in Table 1-5. The dominance of DRAM within the memory market and the fact that most DRAM sales are made to the PC industry mean that the electronic data processing (EDP) sector accounted for 67 percent of the MOS memory market in 1997. The next most significant application segments are flash and SRAM; again, this is reflected in the application split where sales of memory chips into communications equipment represented 19 percent of the MOS memory total available market (TAM) in 1997. The EMEA region has a strong market for SRAM and flash in communications end equipment owing to the existence of large OEMs producing both fixed and mobile telephony equipment for the global marketplace. The remaining 14 percent of the EMEA MOS memory market is split between industrial (6 percent), automotive (3 percent), consumer (3 percent), and military and civil aerospace (2 percent).

The largest region for memory continues to be United Kingdom/Ireland with Germany in second place, as illustrated by Table 1-6. The dominance of the EDP and communications markets for MOS memory products in the EMEA region mean that the United Kingdom/Ireland and Germany account for more than 60 percent of the MOS memory TAM. Communications equipment production and strong industrial and automotive sectors mean that France is the third-largest country market for MOS memory in the EMEA region. It is ahead of Italy, where the troubles at Olivetti continue to affect the semiconductor TAM, and the Nordic countries, which are heavily reliant on the communications sector alone.

Figures 1-6, 1-7 and 1-8 show the terabit consumption by all memory products. DRAM bit consumption swamps all other memory types and continues to increase year on year. In spite of wild fluctuations in DRAM ASPs, historical and forecast bit growth remains largely unaffected at about 65 percent per annum on average. This will lead to DRAM bit consumption of 100,000 terabits in 2002. Flash memory is firmly established as the second-largest memory device family in bit terms and is forecast to reach almost 8,000 terabits in 2002, compared with an SRAM bit-consumption forecast of about 1,000 terabits in the same timescale.

Figure 1-9 shows costs per megabit of the various memory technologies. The ASP declines for DRAM in 1996 and 1997 are evident; this trend is expected to continue in 1998 before a leveling in 1999 through 2001, followed by another DRAM ASP crash in 2002. Following the plateau of the early 1990s when flash demand exceeded supply, flash cost per megabit is expected to decline at a steady rate as the technology matures and benefits from economies in manufacture in line with the other more mature memory technologies.

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Table 1-1
EMEA Semiconductor Market Revenue by Product Category, 1995, 1996 and 1997

	1995		1996		1997	
Product Category	**Revenue ($M)**	**Percent Share**	**Revenue ($M)**	**Percent Share**	**Revenue ($M)**	**Percent Share**
MOS Memory	10,074	35.5%	6,918	24.4%	6,041	20.1%
DRAM	7,887	78.3%	4,622	66.8%	4,032	66.7%
SRAM	921	9.1%	797	11.5%	646	10.7%
Nonvolatile	1,180	11.7%	1,414	20.4%	1,216	20.1%
Other MOS Memory	86	0.9%	85	1.2%	147	2.4%
Total		100.0%		100.0%		100.0%
MOS Microcomponent	7,000	24.6%	9,341	32.9%	10,939	36.4%
MOS Digital Logic	2,953	10.4%	3,386	11.9%	4,159	13.8%
Others	8,383	29.5%	8,734	30.8%	8,907	29.6%
Total Semiconductor Market (including Hybrid)	**28,410**	**100.0%**	**28,379**	**100.0%**	**30,046**	**100.0%**

Source: Dataquest (June 1998 Estimates)

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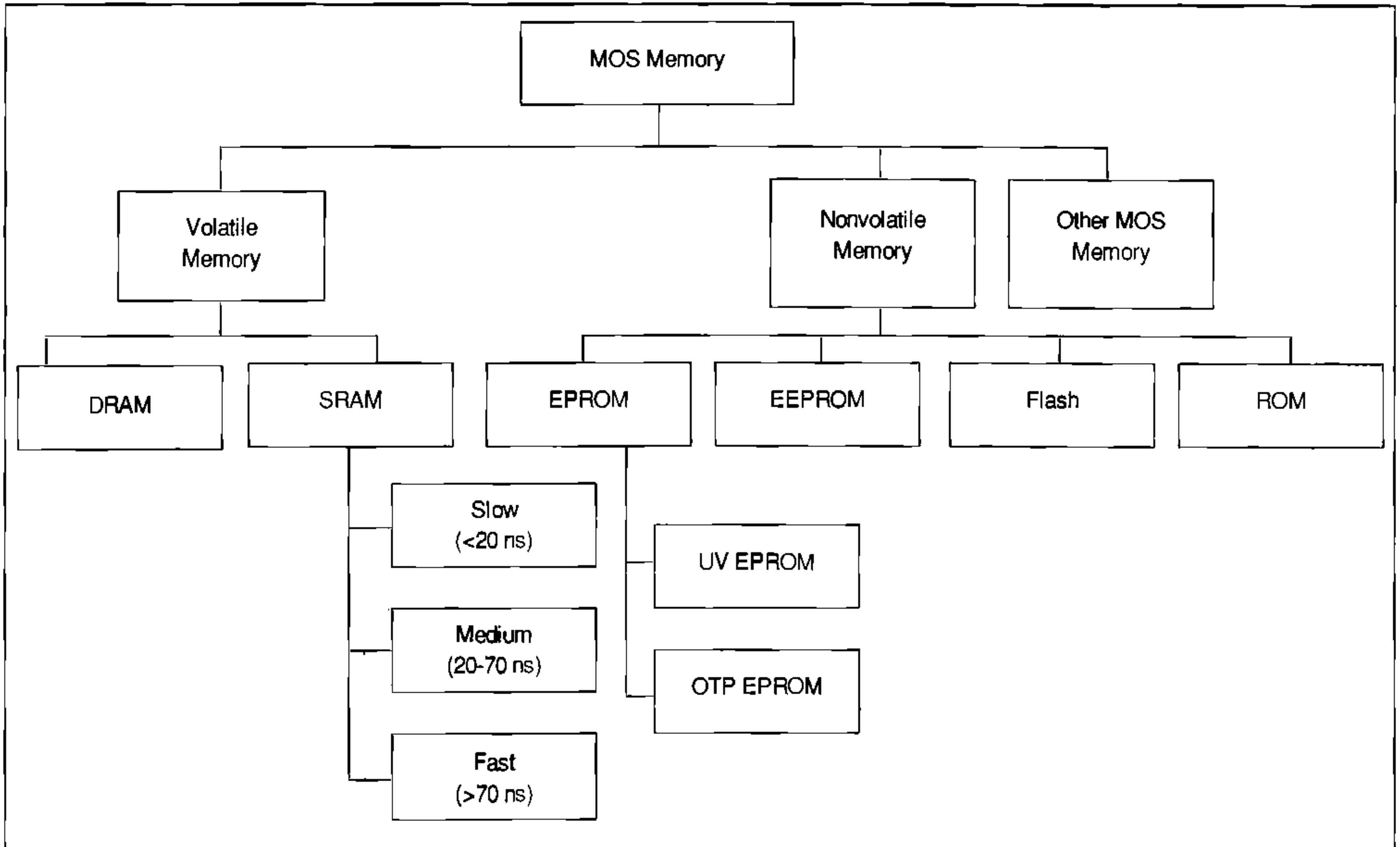
Figure 1-1
MOS Memory Family Tree



Source: Dataquest (June 1998)

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Table 1-2
Comparison of Global MOS Memory Markets, 1997

	Total MOS Memory			DRAM			SRAM			EPROM		
Region	% of EMEA MOS Memory Market	Revenue ($M)	% of Worldwide MOS Memory Market	% of EMEA MOS Memory Market	Revenue ($M)	% of Worldwide MOS Memory Market	% of EMEA MOS Memory Market	Revenue ($M)	% of Worldwide MOS Memory Market	% of EMEA MOS Memory Market	Revenue ($M)	% of Worldwide MOS Memory Market
EMEA	100%	6,041	19.5%	66.7%	4,032	19.4%	10.7%	646	16.1%	3.2%	191	24.3%
Americas		11,898	38.4%		8,233	39.7%		1,852	46.2%		220	28.0%
Japan		6,523	21.1%		3,837	18.5%		911	22.7%		169	21.5%
Asia/Pacific		6,516	21.0%		4,642	22.4%		599	14.9%		205	26.1%
Worldwide		30,978	100.0%		20,744	100.0%		4,008	100.0%		785	100.0%

	EEPROM			Flash Memory			ROM			Other MOS Memory		
Region	% of EMEA MOS Memory Market	Revenue ($M)	% of Worldwide MOS Memory Market	% of EMEA MOS Memory Market	Revenue ($M)	% of Worldwide MOS Memory Market	% of EMEA MOS Memory Market	Revenue ($M)	% of Worldwide MOS Memory Market	% of EMEA MOS Memory Market	Revenue ($M)	% of Worldwide MOS Memory Market
EMEA	5.0%	302	31.2%	11.1%	670	24.1%	0.9%	53	5.1%	2.4%	147	22.4%
Americas		303	31.3%		865	31.2%		131	12.5%		294	44.9%
Japan		151	15.6%		637	23.0%		655	62.7%		163	24.9%
Asia/Pacific		211	21.8%		603	21.7%		205	19.6%		51	7.8%
Worldwide		967	100.0%		2,775	100.0%		1,044	100.0%		655	100.0%

Source: Dataquest (June 1998 Estimates)

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Table 1-3
EMEA MOS Memory Consumption History and Forecast, 1992-2002

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Units (M)												
Total DRAM	241	284	357	415	438	594	698	709	717	688	687	3%
Total Fast SRAM	3	3	7	24	29	39	43	45	43	44	47	3%
Total Medium SRAM	32	40	44	52	43	30	26	27	30	37	48	10%
Total Slow SRAM	81	97	98	107	85	90	85	83	73	73	77	-3%
Total SRAM	116	140	149	183	156	159	154	155	146	154	171	1%
Total EPROM	111	111	117	107	94	83	71	60	51	43	36	-15%
Total Flash	7	19	29	50	78	138	171	216	250	285	326	19%
Total EEPROM	105	131	185	249	473	677	874	1,052	1,216	1,360	1,511	17%
Total ROM	24	22	21	19	17	17	18	18	18	19	20	3%
Total Other MOS Memory	-	-	-	-	-	-	-	-	-	-	-	NA
Total MOS Memory	**603**	**706**	**858**	**1,022**	**1,256**	**1,668**	**1,986**	**2,211**	**2,398**	**2,548**	**2,751**	**11%**
ASPs ($)												
Total DRAM	6.46	9.42	13.82	19.01	10.55	6.78	5.79	7.37	10.83	16.37	11.89	12%
Total Fast SRAM	15.04	12.27	7.76	11.22	8.19	7.10	6.49	8.12	10.81	12.77	13.47	14%
Total Medium SRAM	4.99	3.92	3.81	4.10	3.81	4.30	5.20	8.59	12.07	12.93	9.89	18%
Total Slow SRAM	3.16	3.35	4.09	4.09	4.70	2.66	3.09	3.86	4.93	6.43	6.19	18%
Total SRAM	3.96	3.74	4.17	5.03	5.09	4.06	4.38	5.91	8.12	9.81	9.21	18%
Total EPROM	2.63	2.92	2.96	3.11	2.99	2.29	1.79	1.64	1.56	1.53	1.53	-8%
Total Flash	10.77	9.80	7.09	9.74	8.24	4.86	4.04	3.87	4.06	4.24	4.41	-2%
Total EEPROM	1.63	1.63	1.63	1.10	0.91	0.45	0.40	0.39	0.38	0.38	0.40	-2%
Total ROM	3.06	3.58	5.13	4.86	3.63	3.11	2.34	2.61	2.64	2.43	2.30	-6%
Total Other MOS Memory	-	-	-	-	-	-	-	-	-	-	-	NA
Total MOS Memory	**4.41**	**5.72**	**7.66**	**9.86**	**5.51**	**3.62**	**3.07**	**3.49**	**4.48**	**5.82**	**4.41**	4%

(continued)

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Table 1-3 (Continued)
EMEA MOS Memory Consumption History and Forecast, 1992-2002

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Revenue ($M)												
Total DRAM	1,557	2,672	4,927	7,886	4,622	4,032	4,045	5,229	7,763	11,255	8,169	15%
Total Fast SRAM	42	43	52	272	235	279	277	367	463	567	628	18%
Total Medium SRAM	160	156	169	213	164	128	133	229	364	480	472	30%
Total Slow SRAM	255	325	402	437	398	239	264	322	362	468	474	15%
Total SRAM	457	524	623	921	797	646	674	918	1,189	1,515	1,573	19%
Total EPROM	293	323	346	333	283	191	128	99	80	65	55	-22%
Total Flash	71	181	206	483	641	670	690	837	1,016	1,207	1,439	17%
Total EEPROM	170	214	301	274	431	302	350	407	460	521	601	15%
Total ROM	72	80	109	90	60	53	42	47	49	46	46	-3%
Total Other MOS Memory	38	46	61	87	85	147	163	182	200	221	244	11%
Total MOS Memory	**2,658**	**4,040**	**6,574**	**10,076**	**6,919**	**6,042**	**6,092**	**7,718**	**10,756**	**14,830**	**12,128**	**15%**
Annual Growth Rate	NA	52%	63%	53%	-31%	-13%	1%	27%	39%	38%	-18%	8%
Terabits												
Total DRAM	459	820	1,440	2,425	4,038	8,348	16,638	26,334	43,108	65,848	102,887	65%
Total Fast SRAM	1	1	3	19	26	57	72	105	130	182	241	33%
Total Medium SRAM	9	14	20	26	26	27	40	72	135	238	381	70%
Total Slow SRAM	25	42	62	69	69	76	84	122	175	277	378	38%
Total SRAM	35	57	85	113	122	160	196	298	439	696	1,001	44%
Total EPROM	68	85	111	124	136	111	94	83	71	62	55	-13%
Total Flash	8	24	63	140	326	655	1,122	2,150	3,472	5,212	7,755	64%
Total EEPROM	1	2	3	4	6	5	7	11	15	21	28	40%
Total ROM	66	98	172	201	241	242	296	372	484	616	760	26%
Total Other MOS Memory	-	-	-	-	-	-	-	-	-	-	-	NA
Total MOS Memory	**637**	**1,086**	**1,875**	**3,007**	**4,869**	**9,521**	**18,354**	**29,248**	**47,590**	**72,455**	**112,485**	**64%**

(continued)

Table 1-3 (Continued)
EMEA MOS Memory Consumption History and Forecast, 1992-2002

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Costs per Mb ($)												
Total DRAM	3.24	3.11	3.26	3.10	1.09	0.46	0.23	0.19	0.17	0.16	0.08	-30%
Total Fast SRAM	73.63	43.03	18.84	14.64	8.92	4.90	3.87	3.50	3.56	3.12	2.60	-12%
Total Medium SRAM	17.55	11.35	8.33	8.19	6.32	4.72	3.31	3.19	2.71	2.02	1.24	-23%
Total Slow SRAM	10.02	7.65	6.47	6.34	5.74	3.16	3.14	2.65	2.07	1.69	1.25	-17%
Total SRAM	13.00	9.15	7.32	8.12	6.56	4.04	3.44	3.08	2.71	2.18	1.57	-17%
Total EPROM	4.31	3.80	3.11	2.68	2.07	1.72	1.35	1.19	1.12	1.05	1.00	-10%
Total Flash	9.05	7.55	3.27	3.45	1.97	1.02	0.61	0.39	0.29	0.23	0.19	-29%
Total EEPROM	174.14	124.61	90.93	76.89	73.05	58.00	46.98	38.39	30.51	25.39	21.75	-18%
Total ROM	1.10	0.82	0.63	0.45	0.25	0.22	0.14	0.13	0.10	0.07	0.06	-23%
Total Other MOS Memory	-	-	-	-	-	-	-	-	-	-	-	NA
Total MOS Memory	**4.17**	**3.72**	**3.51**	**3.35**	**1.42**	**0.63**	**0.33**	**0.26**	**0.23**	**0.20**	**0.11**	**-30%**

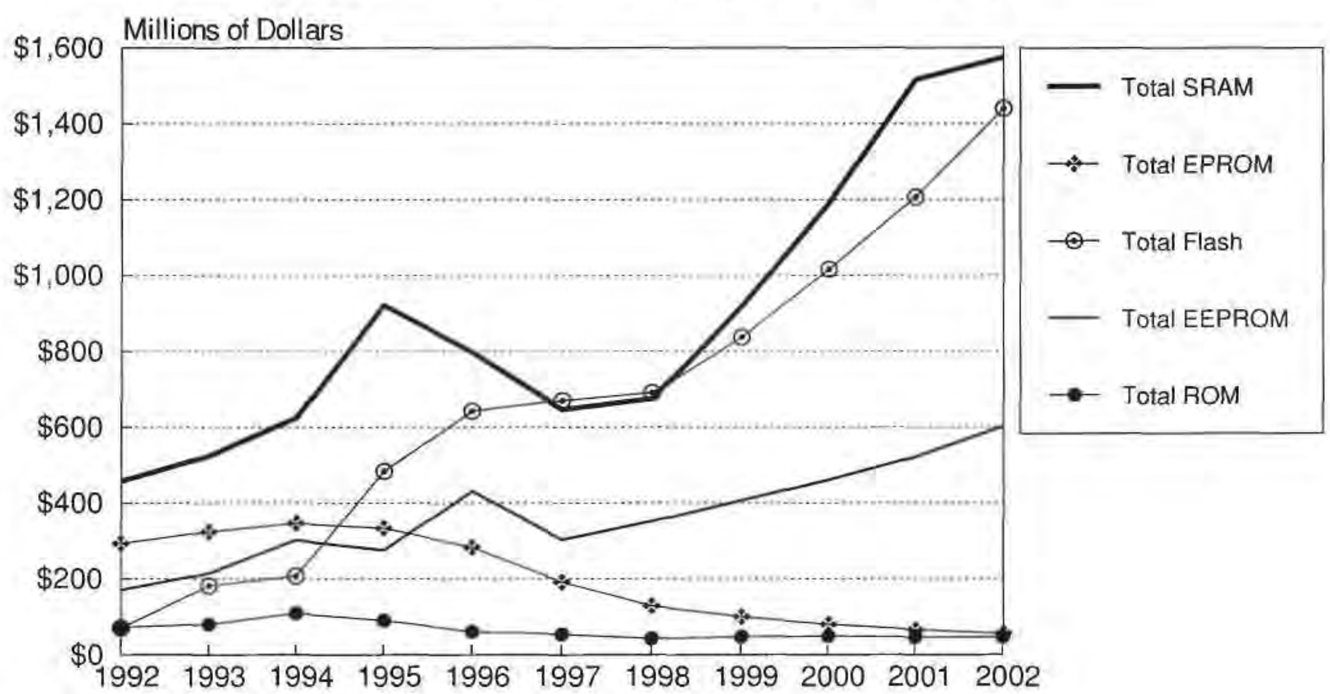
NA = not applicable
Source: Dataquest (June 1998 Estimates)

Table 1-4
EMEA MOS Memory Market Share Rankings, 1997

1997 Rank	1996 Rank		1996 Revenue ($M)	1997 Revenue ($M)	1996-1997 Growth (%)	1997 Market Share (%)
1	1	Samsung	1,090	1,184	8.6%	19.6%
2	3	Siemens	494	479	-3.0%	7.9%
3	2	NEC	540	446	-17.4%	7.4%
4	6	Texas Instruments	409	421	2.9%	7.0%
5	7	Hyundai	395	408	3.3%	6.8%
6	5	Fujitsu	433	341	-21.2%	5.6%
7	12	Micron Technology	259	280	8.1%	4.6%
8	9	LG Semicon	376	267	-29.0%	4.4%
9	14	Advanced Micro Devices	225	253	12.4%	4.2%
10	4	Hitachi	469	236	-49.7%	3.9%
		All Others	2,228	1,726	-22.5%	28.6%
		Total Market	**6,918**	**6,041**	**-12.7%**	**100.0%**

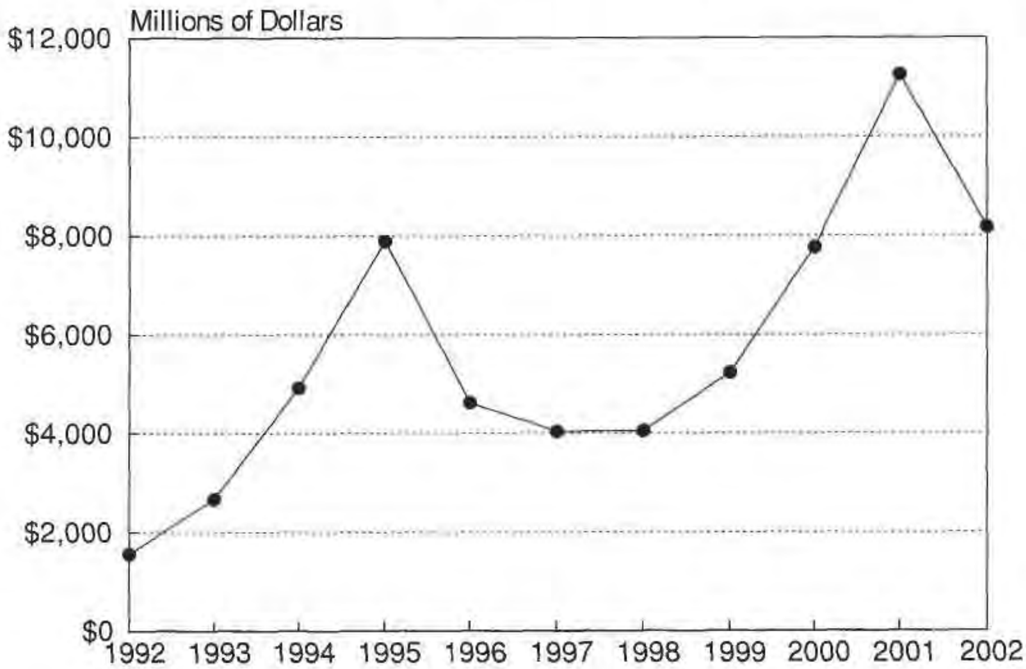
Source: Dataquest (June 1998 Estimates)

Figure 1-2
EMEA MOS Memory Market Revenue (Excluding DRAM), 1992-2002



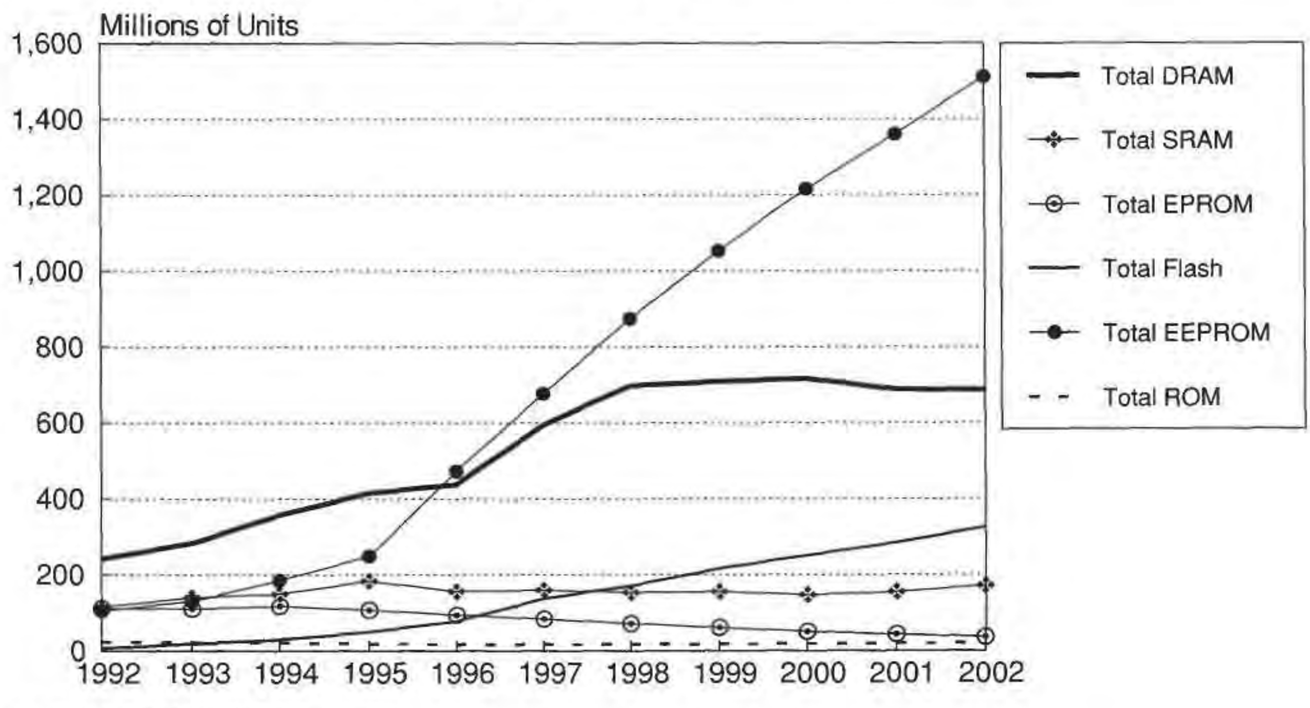
Source: Dataquest (June 1998 Estimates)

Figure 1-3
EMEA MOS Memory Market Revenue (DRAM Only), 1992-2002



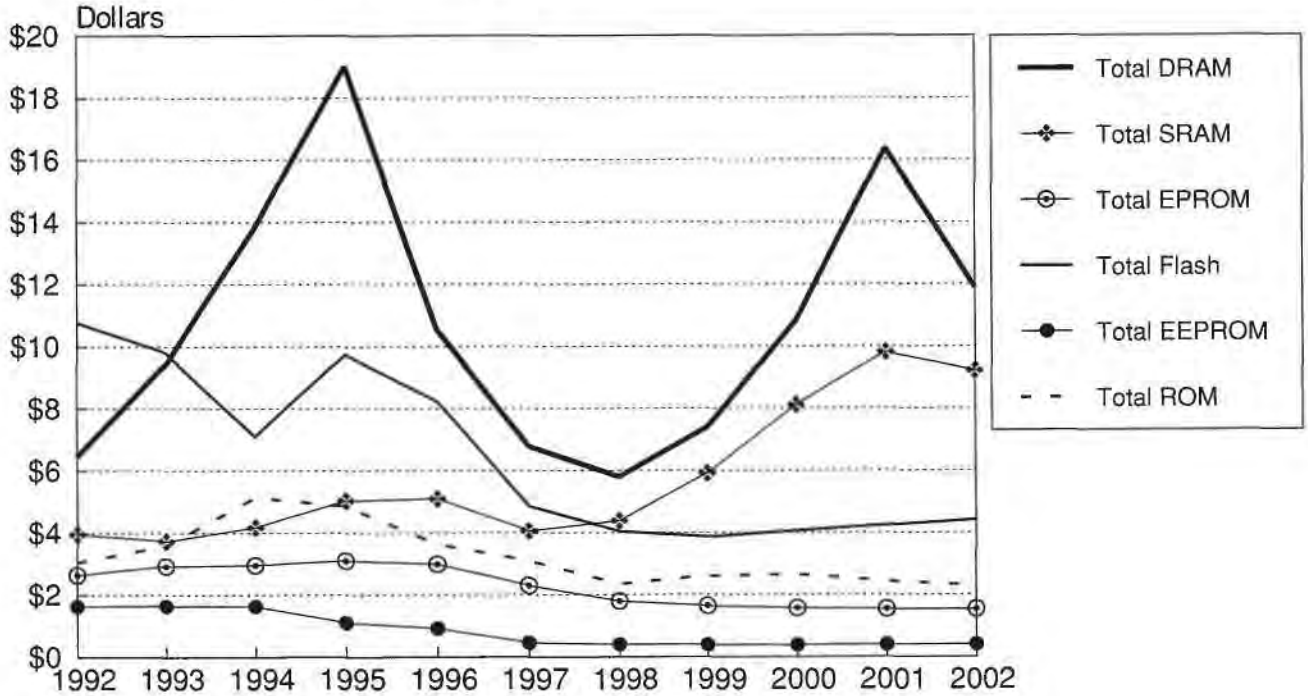
Source: Dataquest (June 1998 Estimates)

Figure 1-4
EMEA MOS Memory Unit Consumption, 1992-2002



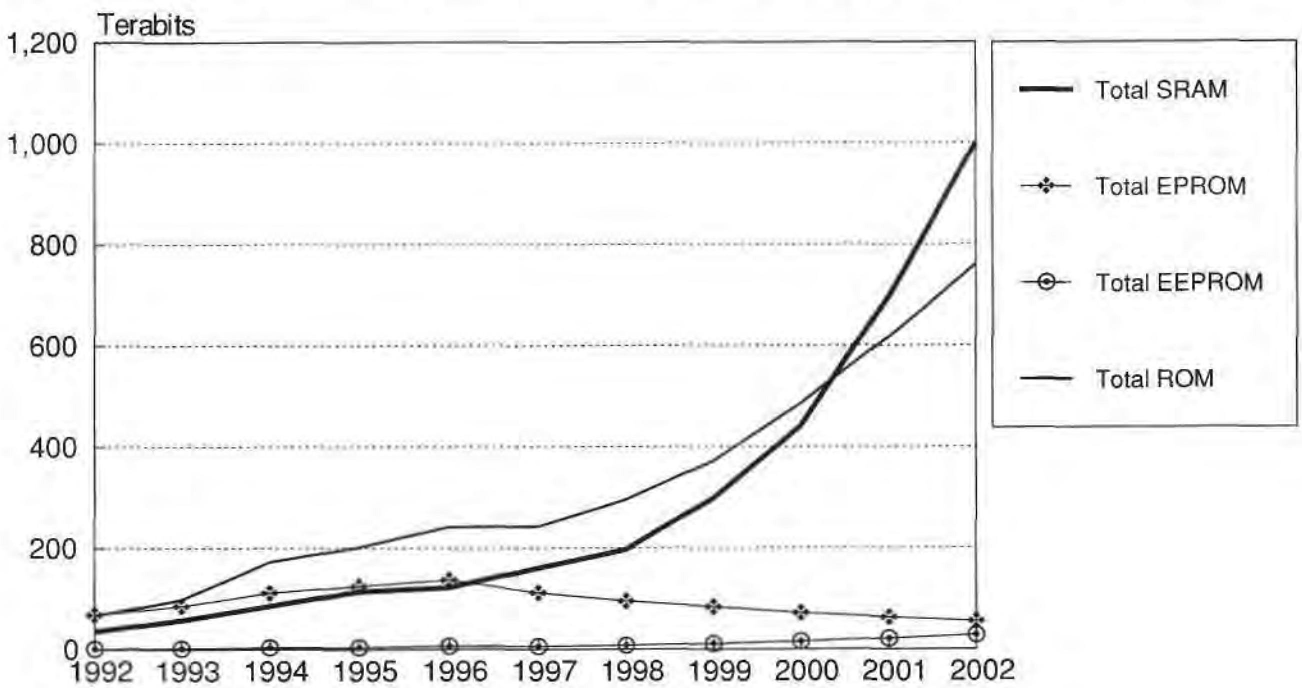
Source: Dataquest (June 1998 Estimates)

Figure 1-5
EMEA MOS Memory ASPs, 1992-2002



Source: Dataquest (June 1998 Estimates)

Figure 1-6
EMEA MOS Memory Terabit Consumption (Excluding DRAM and Flash), 1992-2002



Source: Dataquest (June 1998 Estimates)

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Table 1-5
EMEA MOS Memory Revenue by Application, 1997, 1998 and 2002

	1997 ($M)	1997 (%)	1998 ($M)	1998 (%)	2002 ($M)	2002 (%)	AGR 1997-1998	CAGR 1997-2002
Electronic Data Processing	4,064	67%	4,095	67%	8,255	68%	1%	15%
Communications	1,167	19%	1,173	19%	2,362	19%	0%	15%
Industrial	356	6%	352	6%	661	5%	-1%	13%
Consumer	161	3%	173	3%	334	3%	7%	16%
Military and Civil Aerospace	104	2%	106	2%	175	1%	3%	11%
Automotive	189	3%	194	3%	341	3%	3%	13%
Total	**6,041**	**100%**	**6,092**	**100%**	**12,127**	**100%**		

Source: Dataquest (June 1998 Estimates)

Table 1-6
EMEA MOS Memory by Region, 1997, 1998 and 2002

	1997 ($M)	1997 (%)	1998 ($M)	1998 (%)	2002 ($M)	2002 (%)	AGR 1997-1998	CAGR 1997-2002
Benelux	242	4%	244	4%	485	4%	1%	19%
France	665	11%	670	11%	1,334	11%	1%	22%
Italy	423	7%	426	7%	728	6%	1%	18%
Nordic	483	8%	487	8%	1,091	9%	1%	24%
United Kingdom/Ireland	2,114	35%	2,132	35%	4,123	34%	1%	21%
Germany	1,571	26%	1,584	26%	3,274	27%	1%	22%
Rest of EMEA Region	544	9%	548	9%	1,091	9%	1%	22%
Total	**6,041**	**100%**	**6,092**	**100%**	**12,127**	**100%**		

Source: Dataquest (June 1998 Estimates)

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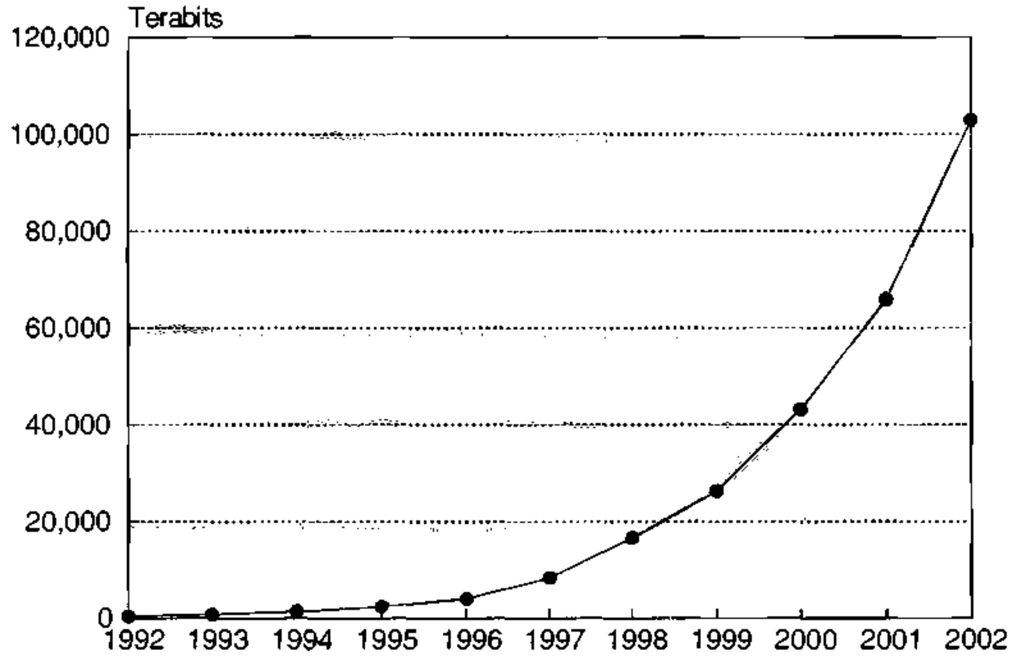
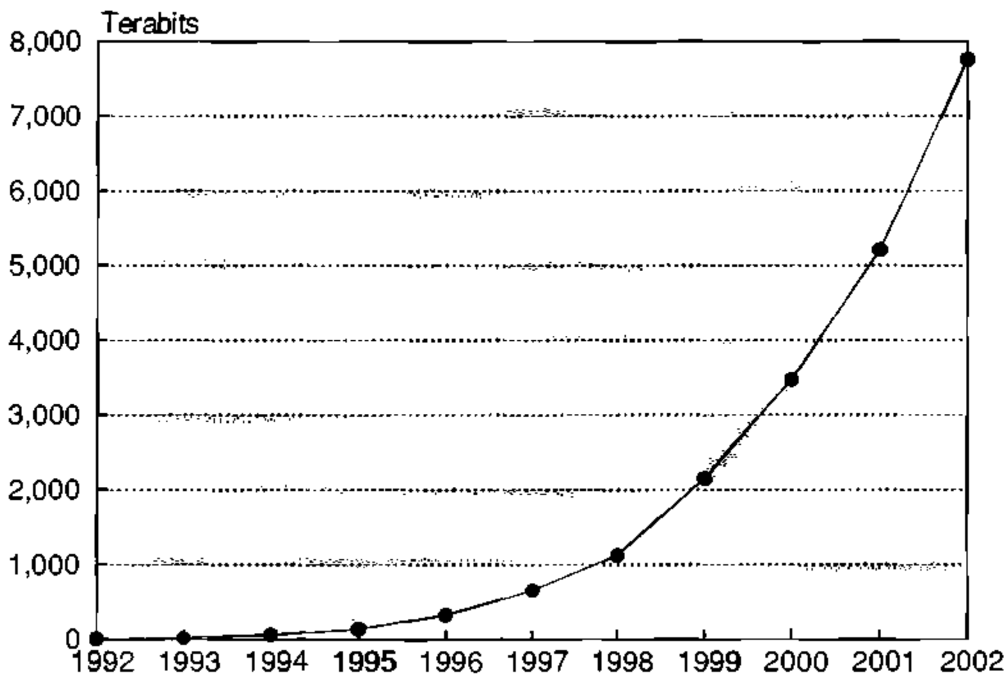
Figure 1-7
EMEA MOS Memory Terabit Consumption (DRAM Only), 1992-2002



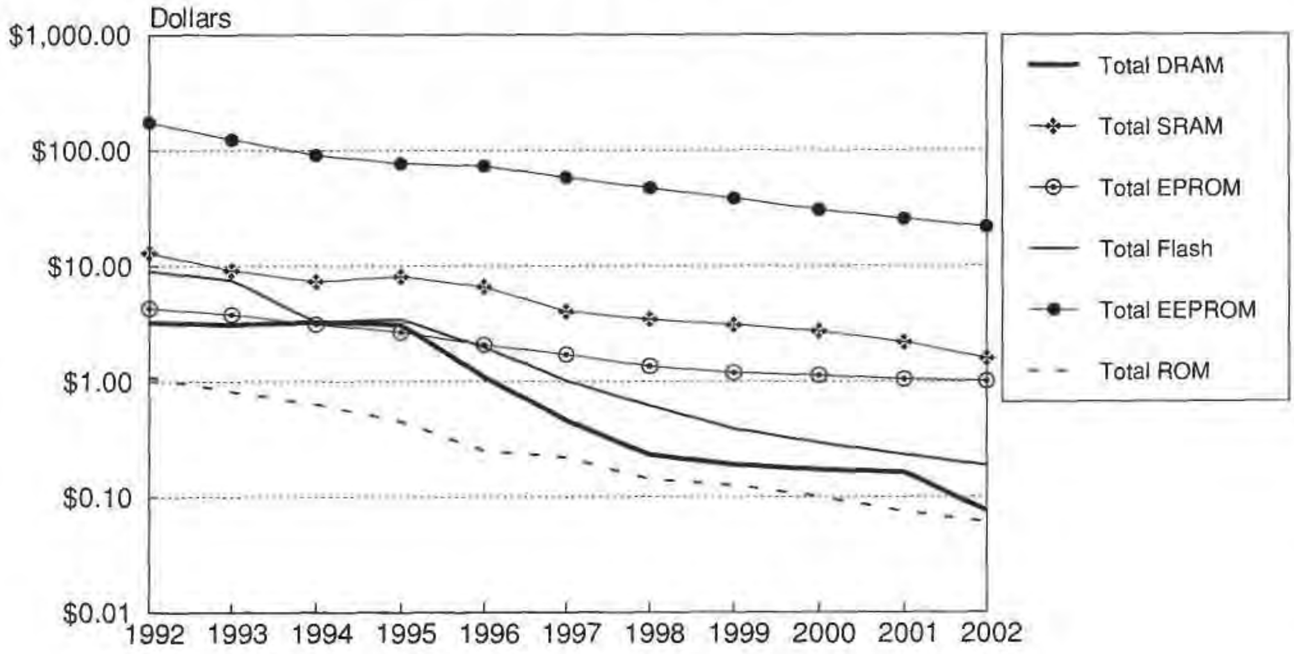
Source: Dataquest (June 1998 Estimates)

Figure 1-8
EMEA MOS Memory Terabit Consumption (Flash Only), 1992-2002



Source: Dataquest (June 1998 Estimates)

Figure 1-9
EMEA MOS Memory Costs per Megabit, 1992-2001



Source: Dataquest (June 1998 Estimates)

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Chapter 2
Total DRAM Market Statistics and Analysis

Important Overview

Please refer to the chapter titled "Important Information," which relates specifically to the DRAM market.

Overview

The long-term forecast for the EMEA DRAM market is shown in Table 2-1. The year 1997 saw a 13 percent fall in EMEA DRAM revenue following the 40 percent revenue decline of 1996. Again, the cause was ASP erosion and it left the EMEA DRAM market worth a fraction above $4 billion in 1997. The outlook for 1998 is just as pessimistic with the most optimistic forecast for revenue growth in the low single digits. Realistically, another decline in revenue is far more likely in 1998, although Dataquest's forecast is for flat revenue growth. Whatever happens in 1998, Dataquest believes that the market will return to strong growth in 1999 through 2001 before falling back in 2002. The long-term outlook forecasts a CAGR of 15 percent for the period 1997 to 2002.

In addition to the long-term forecast, downside and upside forecasts for 1998 are presented in Tables 2-2 and 2-3 respectively. The assumptions behind these upside and downside scenarios are presented later in the text.

1997 Review

Following the DRAM market correction in 1996, ASPs continued to decline throughout 1997, albeit at a less spectacular rate. Overcapacity remained a feature of the global DRAM market and production of the high-volume 16Mb EDO reached new peaks. Vendors produced this device more and more efficiently as they tried to remain ahead of the competition and maintain market share. Talk of regulating production to cut back supply came to nothing and vendors resigned themselves to "slugging it out" while they waited for supply and demand to come back into balance.

The continued and unrelenting reduction in DRAM ASPs finally filtered through to the PC end user as the standard main-memory fit rapidly moved to 32MB in 1997. This, together with growth in PC production to 21 million units, drove unprecedented bit growth of more than 100 percent in 1997 over 1996.

The domination of the 16Mb device density is shown in Figure 2-1. Shipments of the 16Mb density were more than double that of the 4Mb in 1997 as the market switched wholesale to higher-density devices. In revenue terms, the 16Mb density accounted for six times more in sales than the 4Mb. Even sales revenue for the low volume 64Mb was twice that of the 4Mb.

The top ten DRAM suppliers to the EMEA region are shown in Table 2-4. Samsung consolidated its number-one position in the EMEA DRAM market and managed to grow revenue by 7 percent to achieve 25 percent revenue market share with slightly more than $1 billion in DRAM sales. Siemens faired better than most and jumped a place in the ranking to number two with revenue declining by 6 percent. Just behind Siemens, Hyundai also had a good year, growing revenue to almost $400 million to grab third position. The number two in 1996, NEC, suffered a 19 percent DRAM revenue drop which was enough to cause it to fall to number four in 1997. TI and Micron Technology grew their DRAM revenues at a similar rate and both vendors jumped three places in the rankings to fifth and sixth respectively. LG Semicon and Fujitsu both had a poor year with about a 30 percent decline in DRAM revenue, causing both vendors to drop one position in the ranking table. However, the worst performance came from Hitachi: the company's revenue was cut in half in 1997 causing it to drop from number four in 1996 to number nine in 1997. Finally, IBM made up the top ten at number ten.

The application split for DRAM is shown in Table 2-5. Unsurprisingly, a huge proportion of the DRAM shipped in the EMEA region is consumed by EDP applications. The PC accounts for the vast majority of these shipments, taking about three-quarters of the DRAM shipments into the EDP sector. Other compute applications such as workstations and mainframes, together with printers and disk drives among others, account for the remaining 25 percent of the EDP DRAM market. Outside the EDP segment, the communications sector, which is particularly strong in the EMEA region, accounts for a further 8 percent of DRAM sales. The same amount again is split between the application areas of consumer, automotive, industrial, and military and civil aerospace.

Table 2-6 shows the regional split for DRAM in the EMEA region. About two-thirds of DRAM sales are to the main EDP equipment-producing countries of the United Kingdom/Ireland and Germany. France, with its broad applications base, accounts for a further 10 percent of the EMEA DRAM market, with Scandinavia, Benelux and Italy together with the rest of the EMEA region making up the remaining quarter of the market.

Long-Term Forecast

Dataquest's forecast for 1998 assumes an ASP of slightly less than $2 per megabyte for the 16Mb and 64Mb device densities which are expected to account for 80 percent of the units shipped. In addition, a bit growth of 99 percent is forecast—much higher than the historic norm of 65 percent to 70 percent per annum. This high bit-growth assumption is more a recognition of demand elasticity because of continued low prices, rather than the existence of any new software application driver. The upshot of these assumptions is a market size in 1998 comparable to that in 1997.

Dataquest believes that there is plenty of downside opportunity in the DRAM forecast for 1998, as shown in Table 2-2. Because of continued overcapacity in the global DRAM industry—exacerbated by prolonged cost cutting on the aging 16Mb generation of devices—ASPs have declined and are likely to continue to do so. ASPs are forecast to fall month on month throughout the first half of the year, so that by mid 1998 the contract price for a 64Mb device is about the $10 mark. The average ASP assumption factored into the forecast is significantly higher than this figure. Moreover, to anticipate another year of bit growth of about 100 percent would be optimistic to say the least, especially in the absence of any real software application driver. Therefore, Dataquest's downside scenario factors in lower ASPs and lower bit growth to arrive at a DRAM market that could decline by 22 percent in 1998. This would be unprecedented in the history of the DRAM market, but the indications are that it is quite a likely scenario.

If there is any upside, as shown in Table 2-3—Dataquest believes that this scenario is extremely unlikely—it is just possible that an early move to 64Mb synchronous devices could result in device specific shortages and a stabilization in prices. If this ASP stability had a minimal effect on bit growth, there is a remote possibility that single-digit positive growth could return to the DRAM market in 1998.

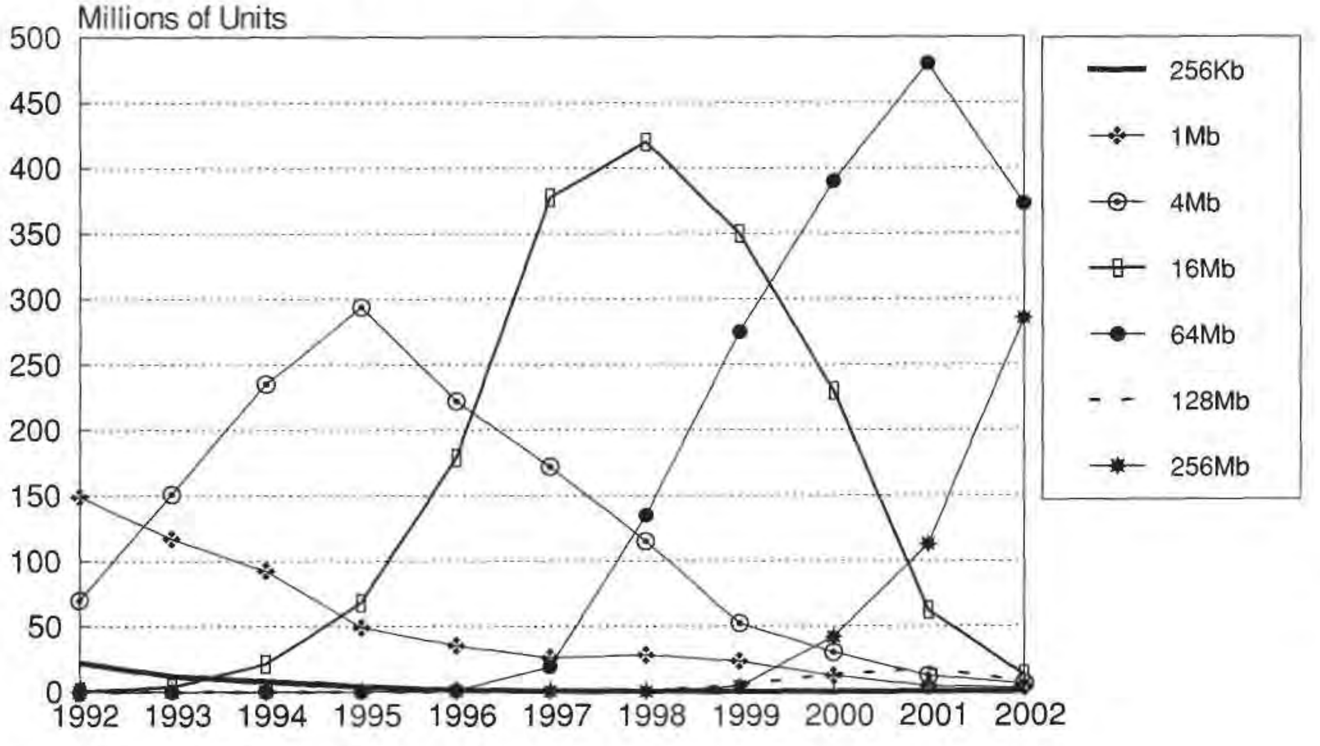
The downturn in the DRAM market that began in 1996 is likely to continue for longer than any previous DRAM bust. The effect of the Asian financial crisis and currency devaluation against the dollar in the short term, particularly in South Korea, has been to reduce manufacturing costs, thus prolonging the lifetime of 16Mb device-density generation by enabling lower prices. Longer term, there is likely to be a supply crisis as the effects of reduced or canceled capital spending ripple through.

The prospects for the recovery of the DRAM market are entirely dependent on the removal of overcapacity from the industry. DRAM capital spending continued to increase during the first half of 1997, fueling the industry's overcapacity. Capital spending has now been reigned in, but Dataquest's projections on the DRAM supply-and-demand situation suggest that a balance between the two will not occur until late 1999 or early 2000, thus keeping prices low. Therefore, individual DRAM vendors are likely to try to persuade their customers to make the switch sooner rather than later from 16Mb EDO devices to 64Mb synchronous devices, believing that there is an edge to be gained in higher market share at the 64Mb density. Although it is currently more profitable for DRAM vendors to manufacture the 16Mb density device, they will be motivated to sacrifice short-term profitability and will attempt to move the market to the 64Mb density device to enable them eventually to reduce cost per bit over time and to achieve higher margins. However, the desire of the DRAM industry to move the PC industry to the 64Mb device density is not enough on its own; there needs to be a demand pull as well and PC vendors will not make the move to the 64Mb device until it reaches bit price parity with the 16Mb. This crossover is unlikely to occur until late 1998 or early 1999.

Longer term, the DRAM market is expected to return to healthy revenue growth in 1999, 2000 and 2001 as prices stabilize. There will be a move to the synchronous DRAM PC100 specification that will gather momentum towards the end of 1998 and, by 1999, it will have become the mainstream DRAM technology for the forthcoming forecast period. The much-talked-about Rambus technology is unlikely to make an appearance in the mainstream DRAM market until early in the next century. As shrinks in process geometry move the industry to feature sizes below 0.25 micron for volume production, the 64Mb device density will become the standard for the PC market and drive the next DRAM upswing. On the demand side, the outlook for PC production in the EMEA region is for continued unit growth at the mid-teens level. PC main-memory fit is expected to continue to increase from an average of 50MB per system in 1998 to an average of 188MB per PC in 2002.

Towards the end of the forecast period, Dataquest expects another DRAM market downturn driven by overcapacity and falling ASPs. Although the exact timing of this downturn is difficult to call, there is no doubt that it will occur unless some new DRAM market dynamics come into play.

Figure 2-1
EMEA DRAM Unit Life Cycles, 1992-2002



Source: Dataquest (June 1998 Estimates)

Table 2-1
EMEA DRAM Consumption History and Forecast, 1992-2002

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Units (M)												
256Kb	22.0	12.0	8.0	4.0	1.2	0.6	0.2	-	-	-	-	-100%
1Mb	148.9	117.0	92.4	49.0	35.0	25.8	28.0	23.0	12.0	4.0	2.8	-36%
4Mb	70.0	151.0	235.0	294.0	222.0	171.7	115.0	52.0	29.9	12.0	5.9	-49%
16Mb	0.2	3.6	21.2	67.9	179.0	377.4	420.0	350.0	230.0	62.0	12.5	-49%
64Mb	-	-	-	-	1.0	18.9	134.9	274.9	390.0	479.9	372.8	82%
128Mb	-	-	-	-	-	-	0.2	5.4	13.0	17.1	8.0	NA
256Mb	-	-	-	-	-	-	-	3.9	41.7	112.7	285.2	NA
Total	**241.1**	**283.6**	**356.6**	**414.9**	**438.2**	**594.4**	**698.3**	**709.2**	**716.6**	**687.7**	**687.2**	**3%**
4Mb equivalents	459	820	1,440	2,425	4,038	8,348	16,638	26,334	43,108	65,848	102,887	65%
16Mb equivalents	27.4	48.9	85.9	144.5	240.7	497.6	991.7	1,569.6	2,569.4	3,924.9	6,132.6	65%
Bit Growth	NA	79%	76%	68%	67%	107%	99%	58%	64%	53%	56%	
ASPs ($)												
256Kb	1.70	1.99	2.37	2.50	1.50	1.50	1.50	-	-	-	-	-100%
1Mb	3.36	3.62	4.40	4.70	2.00	1.40	1.40	1.45	1.47	1.75	1.75	5%
4Mb	14.24	12.70	13.54	13.51	5.10	2.41	2.20	1.86	1.74	1.96	1.96	-4%
16Mb	112.34	85.18	62.25	54.11	18.42	7.20	3.81	3.18	3.13	3.20	3.20	-15%
64Mb	-	-	-	-	121.00	45.73	15.87	11.00	9.50	9.50	4.83	-36%
128Mb	-	-	-	-	-	-	59.24	33.16	20.85	21.48	11.22	NA
256Mb	-	-	-	-	-	-	737.06	200.72	71.88	54.12	21.81	NA
Average	**6.46**	**9.42**	**13.82**	**19.01**	**10.55**	**6.78**	**5.79**	**7.37**	**10.83**	**16.37**	**11.89**	**12%**

(continued)

Table 2-1 (Continued)
EMEA DRAM Consumption History and Forecast, 1992-2002

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Revenue ($M)												
256Kb	37	24	19	10	2	1	-	-	-	-	-	-100%
1Mb	500	424	407	230	70	36	39	33	18	7	5	-33%
4Mb	997	1,918	3,182	3,972	1,132	414	253	97	52	24	12	-51%
16Mb	22	307	1,320	3,674	3,297	2,717	1,600	1,112	720	198	40	-57%
64Mb	-	-	-	-	121	864	2,141	3,025	3,705	4,559	1,802	16%
128Mb	-	-	-	-	-	-	12	179	271	367	90	NA
256Mb	-	-	-	-	-	-	-	783	2,997	6,099	6,221	NA
Total	**1,557**	**2,672**	**4,927**	**7,886**	**4,622**	**4,032**	**4,045**	**5,229**	**7,763**	**11,255**	**8,169**	**15%**
Annual Growth Rate	NA	72%	84%	60%	-41%	-13%	0%	29%	48%	45%	-27%	17%

NA = not applicable
Source: Dataquest (June 1998 Estimates)

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Table 2-2
EMEA DRAM Consumption Forecast Downside, 1992-1998

	1992	1993	1994	1995	1996	1997	1998
Units (M)							
256Kb	22.0	12.0	8.0	4.0	1.2	0.6	0.2
1Mb	148.9	117.0	92.4	49.0	35.0	25.8	26.5
4Mb	70.0	151.0	235.0	294.0	222.0	171.7	101.0
16Mb	0.2	3.6	21.2	67.9	179.0	377.4	414.0
64Mb	-	-	-	-	1.0	18.9	114.0
128Mb	-	-	-	-	-	-	0.2
256Mb	-	-	-	-	-	-	
Total	**241.1**	**283.6**	**356.6**	**414.9**	**438.2**	**594.4**	**655.9**
16Mb equivalents	27.4	48.9	85.9	144.5	240.7	497.6	898.5
Bit Growth	NA	79%	76%	68%	67%	107%	81%
ASPs ($)							
256Kb	1.70	1.99	2.37	2.50	1.50	1.50	1.50
1Mb	3.36	3.62	4.40	4.70	2.00	1.40	1.40
4Mb	14.24	12.70	13.54	13.51	5.10	2.41	2.20
16Mb	112.34	85.18	62.25	54.11	18.42	7.20	3.26
64Mb	-	-	-	-	121.00	45.73	13.35
128Mb	-	-	-	-	-	-	59.24
256Mb	-	-	-	-	-	-	737.06
Average	**6.46**	**9.42**	**13.82**	**19.01**	**10.55**	**6.78**	**4.79**
Revenue ($M)							
256Kb	37	24	19	10	2	1	-
1Mb	500	424	407	230	70	36	37
4Mb	997	1,918	3,182	3,972	1,132	414	222
16Mb	22	307	1,320	3,674	3,297	2,717	1,350
64Mb	-	-	-	-	121	864	1,522
128Mb	-	-	-	-	-	-	12
256Mb	-	-	-	-	-	-	-
Total	**1,557**	**2,672**	**4,927**	**7,886**	**4,622**	**4,032**	**3,143**
Annual Growth Rate	NA	72%	84%	60%	-41%	-13%	-22%

NA = not applicable
Source: Dataquest (June 1998 Estimates)

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Table 2-3
EMEA DRAM Consumption Forecast Upside, 1992-1998

	1992	1993	1994	1995	1996	1997	1998
Units (M)							
256Kb	22.0	12.0	8.0	4.0	1.2	0.6	0.2
1Mb	148.9	117.0	92.4	49.0	35.0	25.8	26.5
4Mb	70.0	151.0	235.0	294.0	222.0	171.7	110.0
16Mb	0.2	3.6	21.2	67.9	179.0	377.4	416.0
64Mb	-	-	-	-	1.0	18.9	124.0
128Mb	-	-	-	-	-	-	0.2
256Mb	-	-	-	-	-	-	0.1
Total	**241.1**	**283.6**	**356.6**	**414.9**	**438.2**	**594.4**	**677.0**
16Mb equivalents	27.4	48.9	85.9	144.5	240.7	497.6	944.4
Bit Growth	NA	79%	76%	68%	67%	107%	90%
ASPs ($)							
256Kb	1.70	1.99	2.37	2.50	1.50	1.50	1.50
1Mb	3.36	3.62	4.40	4.70	2.00	1.40	1.40
4Mb	14.24	12.70	13.54	13.51	5.10	2.41	2.20
16Mb	112.34	85.18	62.25	54.11	18.42	7.20	3.90
64Mb	-	-	-	-	121.00	45.73	17.63
128Mb	-	-	-	-	-	-	59.24
256Mb	-	-	-	-	-	-	737.06
Average	**6.46**	**9.42**	**13.82**	**19.01**	**10.55**	**6.78**	**6.16**
Revenues ($M)							
256Kb	37	24	19	10	2	1	-
1Mb	500	424	407	230	70	36	37
4Mb	997	1,918	3,182	3,972	1,132	414	242
16Mb	22	307	1,320	3,674	3,297	2,717	1,622
64Mb	-	-	-	-	121	864	2,186
128Mb	-	-	-	-	-	-	12
256Mb	-	-	-	-	-	-	74
Total	**1,557**	**2,672**	**4,927**	**7,886**	**4,622**	**4,032**	**4,173**
Annual Growth Rate	NA	72%	84%	60%	-41%	-13%	3%

NA = not applicable
Source: Dataquest (June 1998 Estimates)

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Table 2-4
EMEA DRAM Market Share Rankings, 1997

1997 Rank	1996 Rank		1996 Revenue ($M)	1997 Revenue ($M)	1996-1997 Growth (%)	1997 Market Share (%)
1	1	Samsung	940	1,009	7.3%	25.0%
2	3	Siemens	428	403	-5.8%	10.0%
3	5	Hyundai	387	396	2.3%	9.8%
4	2	NEC	458	369	-19.4%	9.2%
5	8	Texas Instruments	337	350	3.9%	8.7%
6	9	Micron Technology	257	272	5.8%	6.7%
7	6	LG Semicon	361	252	-30.2%	6.3%
8	7	Fujitsu	340	242	-28.8%	6.0%
9	4	Hitachi	392	196	-50.0%	4.9%
10	12	IBM	168	166	-1.2%	4.1%
		All Others	554	377	-31.9%	9.4%
		Total Market	**4,622**	**4,032**	**-12.8%**	**100.0%**

Source: Dataquest (June 1998 Estimates)

Table 2-5
EMEA DRAM Revenue by Application, 1997, 1998 and 2002

	1997 ($M)	1997 (%)	1998 ($M)	1998 (%)	2002 ($M)	2002 (%)	AGR 1997-1998	CAGR 1997-2002
Electronic Data Processing	3,387	84%	3,398	84%	6,862	84%	0%	15%
Communications	323	8%	324	8%	654	8%	0%	15%
Industrial	161	4%	162	4%	327	4%	0%	15%
Consumer	81	2%	81	2%	163	2%	0%	15%
Military and Civil Aerospace	40	1%	40	1%	82	1%	0%	15%
Automotive	40	1%	40	1%	82	1%	0%	15%
Total	**4,032**	**100%**	**4,045**	**100%**	**8,169**	**100%**		

Source: Dataquest (June 1998 Estimates)

Table 2-6
EMEA DRAM Revenue by Region, 1997, 1998 and 2002

	1997 ($M)	1997 (%)	1998 ($M)	1998 (%)	2002 ($M)	2002 (%)	AGR 1997-1998	CAGR 1997-2002
Benelux	161	4.0%	162	4.0%	327	4.0%	0%	15%
France	403	10.0%	405	10.0%	817	10.0%	0%	15%
Italy	282	7.0%	283	7.0%	490	6.0%	0%	12%
Nordic	202	5.0%	202	5.0%	408	5.0%	0%	15%
United Kingdom/Ireland	1,572	39.0%	1,578	39.0%	3,186	39.0%	0%	15%
Germany	1,048	26.0%	1,052	26.0%	2,206	27.0%	0%	16%
Rest of EMEA Region	363	9.0%	364	9.0%	735	9.0%	0%	15%
Total	**4,032**	**100%**	**4,045**	**100%**	**8,169**	**100%**		

Source: Dataquest (June 1998 Estimates)

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Chapter 3
Total SRAM Market Statistics and Analysis

Overview

As shown in Table 3-1, Dataquest's latest forecast estimates that the SRAM market will exceed $1.5 billion by 2002. From a level of $646 million in 1997, the market is forecast to grow at a CAGR of 19 percent during the period 1997 through 2002. Maintaining the proportion seen in 1997 throughout the forecast period, the EMEA SRAM market is expected to continue to represent about 10 percent to 12 percent of the total EMEA MOS memory market.

1997 Review

The EMEA SRAM market declined more sharply than expected in 1997, revenue declining by 19 percent over 1996 levels to $646 million. The decline in 1997 followed a 14 percent decline in 1996 from the high point of $921 million in 1995. The market size is now comparable to that in 1994 in revenue terms, although the number of bits shipped in 1997 was double the number shipped in 1994.

Total unit shipments in 1997 were on a par with those in 1996, as shown in Table 3-1, although there was a 30 percent growth in the number of bits shipped. The average cost per chip declined as prices for higher-density devices such as the 2Mb and 4Mb fell. The attractiveness of these higher-density devices is reflected in the fact that this segment of the market was the only one to show revenue growth in 1997. Revenues in both the 1Mb and the 256Kb market segments declined in 1997 over 1996. From a unit shipment perspective, as shown in Figure 3-1, shipments of the 2Mb and 4Mb device densities increased sharply in 1997, and these higher-density devices are expected to become the highest volume shipment density by 2001.

Table 3-2 illustrates the top ten suppliers of SRAM in the EMEA region. In a difficult year, Samsung consolidated its number-one position and now accounts for 26 percent of the EMEA SRAM market. If the level of Samsung's EMEA SRAM revenue stands head and shoulders above its competition, in a graphic demonstration of the inherent fragmentation of the SRAM market, the companies ranked from number two to number ten in revenue terms each had market shares ranging from about 5 percent to 8 percent in 1997. This increase in Samsung's market share came at the expense of Mitsubishi, Toshiba, Motorola, Sony and Hitachi, all of whose revenues declined by more than 30 percent, resulting in market share losses. NEC and Integrated Device Technology both increased market share and moved up the ranking table in 1997 by limiting their revenue declines to single digits and Cypress Semiconductor held on to 5 percent of the market, even though its revenue declined by almost 20 percent. Surprisingly IBM entered the top ten in 1997, but this can be explained by an improved visibility in the company's reporting of the level of its SRAM sales in the EMEA region.

Table 3-3 shows the application split for SRAM in Europe. Although the SRAM market is fragmented among a multitude of applications, the core markets are in EDP, communications and, to a lesser extent, industrial applications. The EDP sector accounts for about half of SRAM revenue, while the use of SRAM in communications equipment adds another third of the revenue total.

Since half of SRAM revenue comes from the EDP segment, it is not surprising that the key EDP production regions of the United Kingdom/Ireland and Germany together account for more than 50 percent of the SRAM market (see Table 3-4). Communications and industrial equipment production mean that France and the Nordic countries account for about a quarter of SRAM sales by revenue.

Long-Term Forecast

Although Dataquest forecasts steady growth in the EMEA SRAM market throughout the forecast period—driven by existing EDP, communications and industrial markets as well as emerging markets such as digital consumer applications and automotive navigation—there are threats to some of the major SRAM markets that could adversely affect the forecast.

The SRAM market remains fragmented and multifarious applications continue to consume all kinds of device speed and density, but there are common threats to the steady growth forecast for the EMEA SRAM. The trend towards higher integration to reduce costs in high volume consumer-oriented products, such as the PC and the mobile telephone, is leading to a demand for embedded memory in System Level Integration devices. A particular area of concern for SRAM vendors in the short term must be the fate of fast SRAM for the PC L2 cache application. Indeed, many vendors have already exited this market, ostensibly because of the fierce competition but also, no doubt, because of the uncertain future longer term.

The long-term forecast for the EMEA market is heavily dependent on the fortunes of the cache market for fast SRAM. The market for sub-20-ns access time devices accounted for more than one third of EMEA SRAM revenue in 1997, but a large part of this market is expected to disappear over the forecast period because of the accelerating trend towards modular PC microprocessor solutions. The integration of PC SRAM cache memory, either onto the microprocessor module or into the microprocessor device itself, is already underway spearheaded by Intel and its competitors. Intel has chosen a limited number of SRAM vendors as partners to supply cache SRAM for its modular microprocessors so the size and location of the TAM in this segment will be predetermined by the microprocessor vendor. The trend towards modular microprocessors has implications for the EMEA fast SRAM TAM in particular because it is likely that Intel will place its purchase orders for cache SRAM in other global regions such as the Americas. Longer term, the global market for PC cache is likely to disappear altogether as cache becomes incorporated into the microprocessor silicon.

In cellular telephony—a buoyant market for slow SRAM in the EMEA region in recent years—there are emerging threats for the slow SRAM market. Although healthy handset unit growth is expected over the forecast period, it is unlikely to match the 100 percent growth seen in 1997. This is partly because of a growing trend by the major OEMs to shift production to the lower cost manufacturing regions of the Far East and partly because of a slowing in the growth of end-user demand. In addition, there is strong pressure from the OEMs to reduce the handset chip count and this has already resulted in the development of single package multichip flash and SRAM solutions for the handset memory market. Over time, it is likely that the flash and SRAM functions will become truly integrated onto a single piece of silicon, reducing the number of vendors capable of competing in this market.

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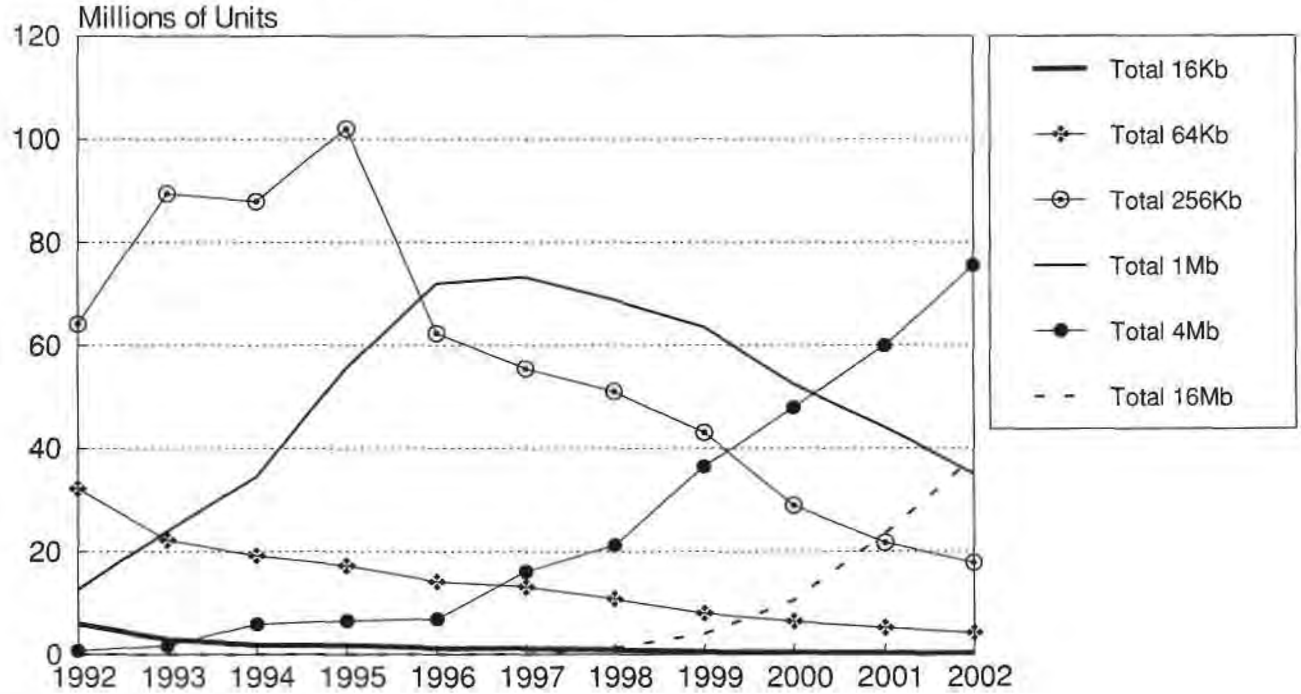
Figure 3-1
EMEA SRAM Unit Life Cycles, 1992-2002



Source: Dataquest (June 1998 Estimates)

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Table 3-1
EMEA SRAM Consumption History and Forecast, 1992-2002

Density	Speed	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Units (M)													
16Kb	<20 ns	0.1	0.1	-	-	-	-	-	-	-	-	-	NA
	20-70 ns	1.8	1.0	0.8	0.8	0.3	0.3	0.3	0.2	0.1	0.1	0.1	-23%
	>70 ns	4.0	1.8	1.0	1.0	0.9	0.8	0.6	0.3	0.2	0.2	0.1	-31%
Total 16Kb		**5.9**	**2.9**	**1.8**	**1.8**	**1.2**	**1.1**	**0.9**	**0.5**	**0.4**	**0.3**	**0.2**	**-28%**
64Kb	<20 ns	1.5	1.0	0.9	0.7	0.6	0.6	0.6	0.4	0.3	0.3	0.2	-17%
	20-70 ns	10.1	7.9	7.1	6.5	5.0	4.5	3.1	2.0	1.6	1.2	1.0	-27%
	>70 ns	20.6	13.3	11.2	10.0	8.5	8.0	7.0	5.5	4.4	3.6	2.9	-18%
Total 64Kb		**32.2**	**22.2**	**19.2**	**17.2**	**14.1**	**13.1**	**10.7**	**7.9**	**6.3**	**5.1**	**4.1**	**-21%**
256Kb	<20 ns	1.0	2.0	4.3	9.0	5.6	8.0	7.0	3.1	1.9	1.1	0.8	-36%
	20-70 ns	16.1	24.4	26.6	31.0	22.0	12.0	8.0	6.8	5.0	3.5	2.7	-26%
	>70 ns	47.0	63.0	57.0	62.0	34.7	35.5	36.0	33.1	22.0	17.1	14.2	-17%
Total 256Kb		**64.1**	**89.4**	**87.9**	**102.0**	**62.3**	**55.5**	**51.0**	**43.0**	**28.9**	**21.7**	**17.8**	**-20%**
512Kb & 1Mb	<20 ns	0.2	0.4	1.5	14.2	22.0	23.5	25.0	24.0	19.0	15.0	12.0	-13%
	20-70 ns	4.0	6.5	9.2	12.6	14.7	9.8	8.6	7.5	5.5	5.0	3.0	-21%
	>70 ns	8.4	17.1	23.8	28.8	35.3	39.9	35.2	32.0	28.0	24.0	20.0	-13%
Total 512Kb & 1Mb		**12.6**	**24.0**	**34.5**	**55.6**	**72.0**	**73.2**	**68.8**	**63.5**	**52.5**	**44.0**	**35.0**	**-14%**
2Mb & 4Mb	<20 ns	-	-	-	0.3	0.4	7.2	10.0	17.3	20.1	24.3	26.5	30%
	20-70 ns	-	-	0.8	1.0	1.1	3.2	5.1	8.6	13.8	18.0	24.7	50%
	>70 ns	0.7	1.7	5.1	5.2	5.4	5.7	6.0	10.5	14.0	17.6	24.3	34%
Total 2Mb & 4Mb		**0.7**	**1.7**	**5.9**	**6.5**	**6.9**	**16.1**	**21.1**	**36.4**	**47.9**	**59.9**	**75.4**	**36%**
16Mb	<20 ns	-	-	-	-	-	-	0.1	0.4	1.5	3.8	7.0	NA
	20-70 ns	-	-	-	-	-	-	0.4	1.5	4.1	9.3	16.3	NA
	>70 ns	-	-	-	-	-	-	0.7	2.1	4.8	10.3	15.0	NA
Total 16Mb		-	-	-	-	-	-	**1.3**	**4.0**	**10.5**	**23.4**	**38.3**	**NA**
Total		**115.5**	**140.2**	**149.3**	**183.1**	**156.5**	**159.0**	**153.7**	**155.3**	**146.4**	**154.4**	**170.8**	**1%**

(continued)

Table 3-1 (Continued)
EMEA SRAM Consumption History and Forecast, 1992-2002

Density	Speed	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
ASPs ($)													
16Kb	<20 ns	2.90	2.40	2.10	2.00	1.50	1.34	1.42	1.50	1.50	1.50	1.50	2%
	20-70 ns	1.65	1.63	1.40	1.42	1.49	1.20	1.12	1.18	1.18	1.18	1.18	0%
	>70 ns	0.81	1.00	1.10	1.05	0.99	1.02	1.05	1.10	1.10	1.10	1.10	1%
Average 16Kb		**1.10**	**1.27**	**1.24**	**1.21**	**1.11**	**1.08**	**1.08**	**1.14**	**1.14**	**1.14**	**1.14**	**1%**
64Kb	<20 ns	5.22	6.26	4.90	3.50	2.60	1.93	1.55	1.55	1.55	1.55	1.55	-4%
	20-70 ns	1.88	1.80	1.74	1.72	1.50	1.25	1.18	1.16	1.21	1.21	1.21	-1%
	>70 ns	1.40	1.31	1.69	1.60	1.50	0.62	0.63	0.61	0.66	0.66	0.66	1%
Average 64Kb		**1.73**	**1.71**	**1.86**	**1.72**	**1.55**	**0.90**	**0.84**	**0.80**	**0.84**	**0.83**	**0.84**	**-1%**
256Kb	<20 ns	21.38	14.29	7.06	6.00	3.82	3.66	2.65	1.87	1.70	1.57	1.57	-16%
	20-70 ns	5.03	3.29	2.60	2.75	1.99	1.46	1.10	1.10	1.10	1.10	1.10	-5%
	>70 ns	3.17	2.92	2.66	2.60	2.55	1.88	1.72	1.76	1.76	1.76	1.76	-1%
Average 256Kb		**3.92**	**3.28**	**2.86**	**2.95**	**2.47**	**2.04**	**1.75**	**1.66**	**1.64**	**1.64**	**1.65**	**-4%**
512Kb & 1Mb	<20 ns	63.00	20.00	11.47	11.45	8.14	4.06	2.95	2.63	2.35	1.90	1.50	-18%
	20-70 ns	14.22	9.22	6.72	6.60	5.50	5.12	3.28	3.24	3.18	3.36	3.36	-8%
	>70 ns	8.00	6.09	5.26	5.20	4.90	2.86	3.37	3.36	3.41	3.50	3.50	4%
Average 512Kb & 1Mb		**10.85**	**7.16**	**5.92**	**7.11**	**6.01**	**3.55**	**3.21**	**3.07**	**3.00**	**2.94**	**2.80**	**-5%**
2Mb & 4Mb	<20 ns	-	-	-	175.00	79.44	21.30	15.24	13.18	11.76	9.96	7.75	-18%
	20-70 ns	-	-	32.25	32.00	29.85	17.02	12.86	12.67	11.50	11.23	7.00	-16%
	>70 ns	10.00	10.38	20.55	21.00	22.80	9.15	8.92	8.75	8.42	8.26	6.25	-7%
Average 2Mb & 4Mb		**10.00**	**10.38**	**22.09**	**29.80**	**27.26**	**16.15**	**12.87**	**11.78**	**10.71**	**9.84**	**7.02**	**-15%**
16Mb	<20 ns	-	-	-	-	-	-	311.89	184.78	118.58	77.50	57.50	NA
	20-70 ns	-	-	-	-	-	-	59.67	55.33	43.56	27.50	17.50	NA
	>70 ns	-	-	-	-	-	-	34.91	29.40	22.20	20.00	15.00	NA
Average 16Mb		-	-	-	-	-	-	**66.01**	**54.07**	**44.48**	**32.31**	**23.83**	**NA**
Average		**3.96**	**3.74**	**4.17**	**5.03**	**5.09**	**4.06**	**4.38**	**5.91**	**8.12**	**9.81**	**9.21**	**18%**

(continued)

Table 3-1 (Continued)
EMEA SRAM Consumption History and Forecast, 1992-2002

Density	Speed	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Revenue ($M)													
16Kb	<20 ns	0.3	0.2	-	-	-	0.1	-	-	-	-	-	-26%
	20-70 ns	3.0	1.6	1.1	1.1	0.4	0.4	0.3	0.2	0.2	0.1	0.1	-24%
	>70 ns	3.2	1.8	1.1	1.1	0.9	0.8	0.6	0.3	0.2	0.2	0.1	-30%
Total 16Kb		**6.5**	**3.7**	**2.2**	**2.2**	**1.3**	**1.2**	**0.9**	**0.6**	**0.4**	**0.3**	**0.2**	**-28%**
64Kb	<20 ns	7.8	6.3	4.4	2.5	1.6	1.2	1.0	0.6	0.5	0.4	0.4	-20%
	20-70 ns	19.0	14.2	12.4	11.2	7.5	5.6	3.6	2.3	1.9	1.5	1.2	-27%
	>70 ns	28.8	17.4	18.9	16.0	12.8	5.0	4.4	3.4	2.9	2.4	1.9	-17%
Total 64Kb		**55.7**	**37.9**	**35.7**	**29.6**	**21.8**	**11.8**	**9.0**	**6.3**	**5.3**	**4.3**	**3.4**	**-22%**
256Kb	<20 ns	21.4	28.6	30.4	54.0	21.5	29.3	18.6	5.9	3.2	1.7	1.3	-46%
	20-70 ns	81.0	80.3	69.2	85.3	43.8	17.5	8.8	7.5	5.5	3.9	3.0	-30%
	>70 ns	149.0	184.0	151.6	161.2	88.5	66.7	61.8	58.2	38.8	30.1	25.0	-18%
Total 256Kb		**251.4**	**292.8**	**251.1**	**300.5**	**153.8**	**113.5**	**89.2**	**71.6**	**47.4**	**35.6**	**29.3**	**-24%**
512Kb & 1Mb	<20 ns	12.6	7.7	17.2	162.6	179.1	95.3	73.9	63.0	44.7	28.5	18.0	-28%
	20-70 ns	56.9	59.9	61.8	83.2	80.9	50.2	28.2	24.3	17.5	16.8	10.1	-27%
	>70 ns	67.2	104.1	125.2	149.8	173.0	114.0	118.6	107.4	95.5	83.9	69.9	-9%
Total 512Kb & 1Mb		**136.7**	**171.7**	**204.2**	**395.5**	**432.9**	**259.5**	**220.7**	**194.6**	**157.7**	**129.2**	**98.0**	**-18%**
2Mb & 4Mb	<20 ns	-	-	-	52.5	32.5	153.4	152.4	228.0	236.4	242.1	205.4	6%
	20-70 ns	-	-	25.0	32.0	31.5	54.5	65.6	109.0	158.8	202.1	172.7	26%
	>70 ns	7.0	17.6	104.8	109.2	123.1	52.2	53.5	91.9	117.9	145.2	151.6	24%
Total 2Mb & 4Mb		**7.0**	**17.6**	**129.8**	**193.7**	**187.2**	**260.0**	**271.5**	**428.9**	**513.0**	**589.4**	**529.8**	**15%**
16Mb	<20 ns	-	-	-	-	-	-	31.6	69.8	177.9	294.5	402.5	NA
	20-70 ns	-	-	-	-	-	-	26.3	85.4	180.3	255.8	285.3	NA
	>70 ns	-	-	-	-	-	-	24.8	61.1	106.9	206.2	225.0	NA
Total 16Mb		**-**	**-**	**-**	**-**	**-**	**-**	**82.7**	**216.2**	**465.2**	**756.4**	**912.8**	**NA**
Total		**457**	**524**	**623**	**921**	**797**	**646**	**674**	**918**	**1,189**	**1,515**	**1,573**	**19%**
Annual Growth Rate		NA	15%	19%	48%	-14%	-19%	4%	36%	29%	27%	4%	

NA = not applicable
Source: Dataquest (June 1998 Estimates)

Table 3-2
EMEA SRAM Market Share Rankings, 1997

1997 Rank	1996 Rank		1996 Revenue ($M)	1997 Revenue ($M)	1996-1997 Growth (%)	1997 Market Share (%)
1	1	Samsung	138	165	19.6%	25.5%
2	3	Mitsubishi	90	55	-38.9%	8.5%
3	7	NEC	55	52	-5.5%	8.0%
4	4	Motorola	86	49	-43.0%	7.6%
5	5	Sony	70	47	-32.9%	7.3%
6	8	Integrated Device Technology	43	40	-7.0%	6.2%
7	2	Toshiba	97	39	-59.8%	6.0%
8	6	Hitachi	66	35	-47.0%	5.4%
9	9	Cypress Semiconductor	41	33	-19.5%	5.1%
10	18	IBM	6	31	416.7%	4.8%
		All Others	105	100	-4.8%	15.5%
		Total Market	**797**	**646**	**-18.9%**	**100.0%**

Source: Dataquest (June 1998 Estimates)

Table 3-3
EMEA SRAM Revenue by Application, 1997, 1998 and 2002

	1997 ($M)	1997 (%)	1998 ($M)	1998 (%)	2002 ($M)	2002 (%)	AGR 1997-1998	CAGR 1997-2002
Electronic Data Processing	317	49%	330	49%	802	51%	4%	20%
Communications	213	33%	222	33%	535	34%	4%	20%
Industrial	78	12%	81	12%	173	11%	4%	17%
Consumer	6	1%	7	1%	16	1%	4%	19%
Military and Civil Aerospace	19	3%	20	3%	31	2%	4%	10%
Automotive	13	2%	13	2%	16	1%	4%	4%
Total	**646**	**100%**	**674**	**100%**	**1,573**	**100%**		

Source: Dataquest (June 1998 Estimates)

Table 3-4
EMEA SRAM Revenue by Region, 1997, 1998 and 2002

	1997 ($M)	1997 (%)	1998 ($M)	1998 (%)	2002 ($M)	2002 (%)	AGR 1997-1998	CAGR 1997-2002
Benelux	26	4.0%	27	4.0%	47	3.0%	4%	13%
France	84	13.0%	88	13.0%	189	12.0%	4%	18%
Italy	45	7.0%	47	7.0%	94	6.0%	4%	16%
Nordic	71	11.0%	74	11.0%	189	12.0%	4%	22%
United Kingdom/Ireland	181	28.0%	189	28.0%	440	28.0%	4%	19%
Germany	181	28.0%	189	28.0%	456	29.0%	4%	20%
Rest of EMEA Region	58	9.0%	61	9.0%	157	10.0%	4%	22%
Total	**646**	**100%**	**674**	**100%**	**1,573**	**100%**		

Source: Dataquest (June 1998 Estimates)

Chapter 4
Total Nonvolatile Memory Market Statistics and Analysis

Overview

Table 4-1 shows Dataquest's latest revenue forecast for the total nonvolatile memory market in Europe up to 2002, broken down into the four constituent product categories of EPROM, flash, EEPROM and ROM. For nonvolatile memory as a whole, a modest CAGR of 12 percent for the period 1997 to 2002 is expected, held back by the declining EPROM market, the static ROM market and the anticipation of continued pressure on flash and EEPROM ASPs.

1997 Review

The decline in the nonvolatile memory market of 14 percent in 1997 over 1996 occurred because of a real decline in the EPROM market and a virtual decline in the EEPROM market. The EPROM market declined much more severely than expected because ASPs were driven down in line with a continued reduction in flash ASPs. In fact, some flash devices were actually priced lower than equivalent density EPROM devices during 1997, which meant that any reason for choosing EPROM over flash disappeared. This effect was a "double whammy" for the nonvolatile market as marginal growth in the flash market failed to compensate for a 32 percent decline in the EPROM market. This real effect was exacerbated by the artificial removal of more than $100 million of EEPROM revenue because of a redefinition of one vendor's smart card sales. Although the ROM market declined by 11 percent in 1997 over 1996, the fact that it continues to account for only about $50 million of revenue meant that it had little effect on the overall growth in EMEA nonvolatile sales.

Long-Term Forecast

The outlook for the EMEA nonvolatile market remains subdued in 1998. No revenue growth is anticipated as the EPROM market continues its slide and low ASPs hold back flash market growth in the short term. Longer term, however, a return to mid-teens growth in both the flash and EEPROM markets will drive a CAGR of 12 percent through 2002. The decline in the EPROM market is expected to continue apace so that by 2002 it will rival ROM as the smallest nonvolatile market in the EMEA region.

Figure 4-1 shows share of the nonvolatile memory market accounted for by EPROM, flash, EEPROM and ROM. In 1997, the flash and EEPROM markets already accounted for 80 percent of the EMEA market. The decline in the EPROM market will mean that, by 2002, 95 percent of nonvolatile sales will be either flash with 67 percent or EEPROM with 28 percent. The remaining 5 percent of the market will comprise either EPROM or ROM sales.

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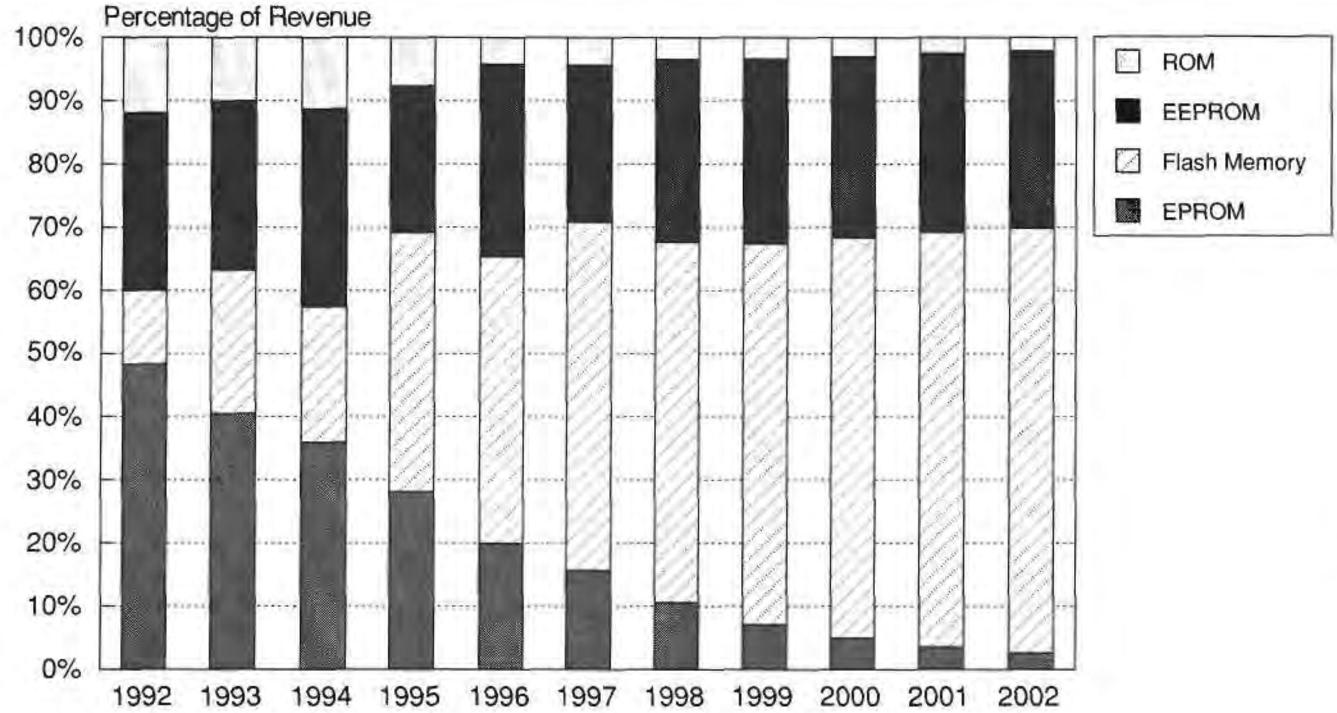
Figure 4-1
Individual Nonvolatile Product Shares of the Total EMEA Nonvolatile Memory Market, 1992-2002



Source: Dataquest (June 1998 Estimates)

Table 4-1
EMEA Nonvolatile Memory Consumption History and Forecast, 1992-2002

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Revenue ($M)												
EPROM	**293**	**323**	**346**	**333**	**282**	**191**	**128**	**99**	**80**	**65**	**55**	**-22%**
Annual Growth Rate	NA	10%	7%	-4%	-15%	-32%	-33%	-23%	-19%	-19%	-15%	
Flash Memory	**71**	**181**	**206**	**483**	**641**	**670**	**690**	**837**	**1,016**	**1,207**	**1,439**	**17%**
Annual Growth Rate	NA	157%	14%	134%	33%	4%	3%	21%	21%	19%	19%	
EEPROM	**170**	**214**	**301**	**274**	**431**	**302**	**350**	**407**	**460**	**521**	**601**	**15%**
Annual Growth Rate	NA	26%	41%	-9%	57%	-30%	16%	16%	13%	13%	15%	
ROM	**72**	**80**	**109**	**90**	**60**	**53**	**42**	**47**	**49**	**46**	**46**	**-3%**
Annual Growth Rate	NA	11%	36%	-17%	-34%	-11%	-21%	12%	4%	-6%	0%	
Total Nonvolatile	**606**	**799**	**963**	**1,181**	**1,414**	**1,216**	**1,210**	**1,390**	**1,605**	**1,839**	**2,141**	**12%**
Annual Growth Rate	NA	32%	21%	23%	20%	-14%	0%	15%	15%	15%	16%	

NA = not applicable
Source: Dataquest (June 1998 Estimates)

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Chapter 5
Total EPROM Market Statistics and Analysis

Overview

Table 5-1 shows the long-term forecast for EPROM in the EMEA region. The market declined by more than 30 percent in 1997 and the outlook is for more of the same. Declining unit sales will lead to an average bit-growth decline of 13 percent per annum over the forecast period. Although ASPs may stabilize as the market transitions towards becoming little more than a residual one, revenue is still expected to decline by a CAGR of 22 percent over the course of the forecast period, leaving the market at the $50 million level by 2002.

1997 Review

The only surprise in the EPROM market in 1997 was the rate at which the market declined. This decline can now be said to be terminal, following a 32 percent drop in revenue in 1997. There no longer appears to be any compelling reason to buy EPROM, other than for products reaching the end of their life cycle. Any new product requiring a nonvolatile code storage device will be using flash now that it is competitively priced and unlikely to be in short supply.

Table 5-2 shows the top ten suppliers of EPROM to the EMEA market in 1997. The top four accounted for more than 90 percent of the EPROM market in 1997. Although it might be a dubious honor, SGS-Thomson continues to dominate the market and accounted for as much EPROM revenue as all the other vendors combined in 1997. Bizarrely, TI jumped to number two in the ranking, growing its EPROM revenue by 10 percent and leapfrogging both AMD and Atmel, whose revenues declined by more than 40 percent. Clearly, these two vendors were concentrating on their flash business in 1997. Judging by the level of sales, the remaining vendors in the ranking had other things on their minds as well.

Figure 5-1 shows the unit volume shipment forecast for all densities of EPROM. The market is concentrated in the lower-density 256Kb to 4Mb range, confirming that EPROMs are now used purely in legacy systems. For this reason, decline in EPROM unit shipments is expected across all these densities.

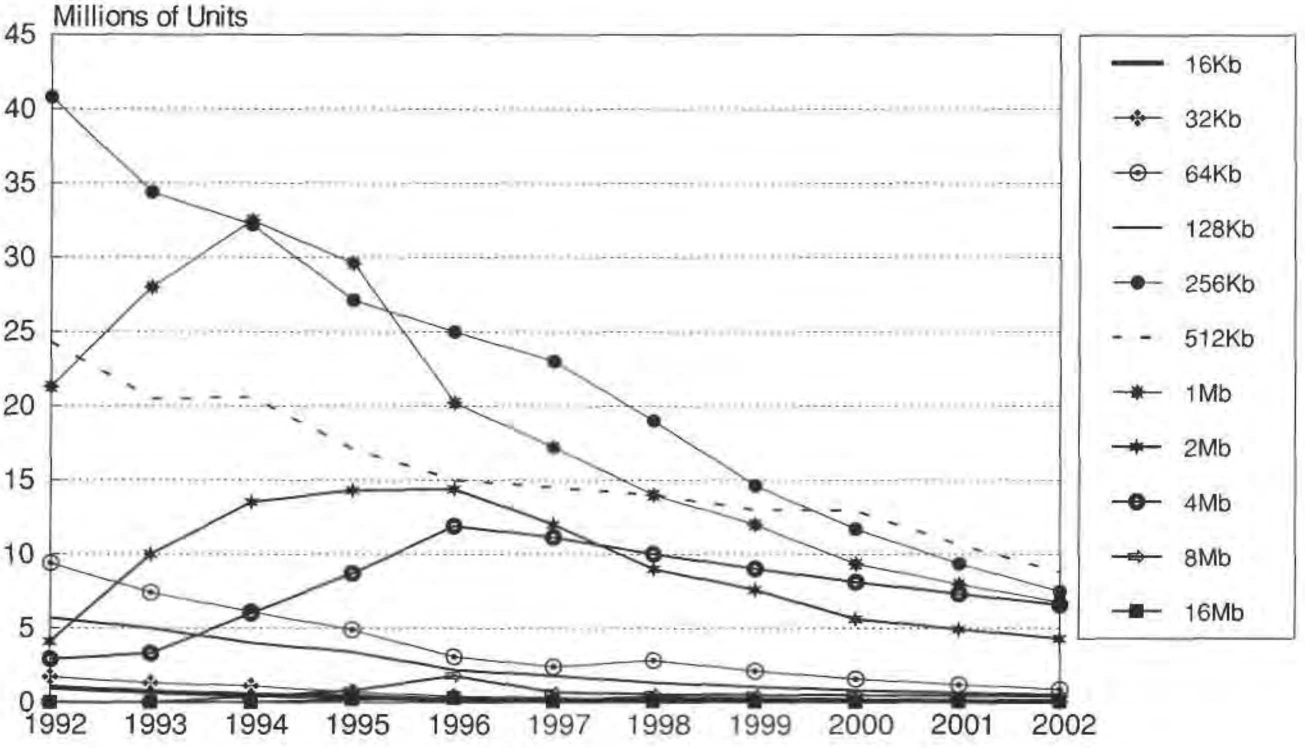
Traditionally EPROM devices find sockets in a wide range of applications as shown in Table 5-3. The EDP and communications sectors each account for about a third of the EPROM market, the remaining third being dominated by the industrial sector.

Since the United Kingdom/Ireland and Germany are the major EDP and communications electronics equipment producers in the EMEA region, more than half of EPROM revenue is derived in these countries, as shown in Table 5-4. France is the next-largest country market for EPROM at 15 percent of the TAM.

Long-Term Forecast

The maturing flash market will push the EPROM market towards an early death. As vendors concentrate investment on flash technology, EPROM devices will become less competitive and relegated to fewer and fewer application areas. With more and more leading-edge flash capacity planned for the coming years, there is no reason to expect a return to the days of flash shortages which may have provided an opportunity for a resurgence in demand for EPROM. With that prospect in mind, Dataquest expects the market level to fall to about $50 million by 2002.

Figure 5-1
EMEA EPROM Unit Life Cycles, 1992-2002



Source: Dataquest (June 1998 Estimates)

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Table 5-1
EMEA EPROM Consumption History and Forecast, 1992-2002

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Units (M)												
16Kb	1.0	0.7	0.5	0.4	0.2	0.1	0.3	0.2	0.1	0.1	0.1	-7%
32Kb	1.7	1.3	1.1	0.7	0.4	0.3	0.2	0.2	0.1	0.1	0.1	-28%
64Kb	9.4	7.4	6.1	4.9	3.1	2.4	2.8	2.1	1.6	1.2	0.9	-18%
128Kb	5.7	5.0	4.0	3.4	2.2	1.8	1.3	1.1	0.8	0.7	0.5	-22%
256Kb	40.8	34.4	32.2	27.1	25.0	23.0	19.0	14.6	11.7	9.4	7.5	-20%
512Kb	24.3	20.5	20.6	17.1	15.0	14.5	14.0	13.0	12.9	10.7	8.8	-10%
1Mb	21.3	28.0	32.5	29.6	20.2	17.2	14.0	12.0	9.4	8.0	6.8	-17%
2Mb	4.1	10.0	13.5	14.3	14.4	12.0	9.0	7.6	5.6	4.9	4.3	-19%
4Mb	2.9	3.3	6.0	8.7	11.9	11.1	10.0	9.0	8.1	7.3	6.6	-10%
8Mb	-	-	0.4	0.8	1.8	0.7	0.6	0.5	0.5	0.5	0.4	-10%
16Mb	-	-	-	0.2	0.3	0.1	0.1	0.1	0.1	0.1	0.1	-5%
Total	**111.2**	**110.6**	**116.9**	**107.2**	**94.4**	**83.2**	**71.4**	**60.4**	**51.0**	**42.8**	**35.9**	**-15%**
ASPs ($)												
16Kb	2.46	2.35	2.24	2.19	2.04	1.84	1.58	1.50	1.47	1.44	1.43	-5%
32Kb	2.70	2.48	2.26	2.46	2.28	2.01	1.49	1.44	1.42	1.38	1.39	-7%
64Kb	1.64	1.55	1.48	1.88	1.55	1.39	1.36	1.36	1.36	1.36	1.36	0%
128Kb	1.47	1.57	1.55	1.66	1.54	1.16	1.13	1.13	1.13	1.13	1.13	0%
256Kb	1.59	1.60	1.58	1.70	1.50	1.45	1.35	1.35	1.35	1.35	1.35	-1%
512Kb	2.56	2.21	2.00	1.99	1.80	1.51	1.40	1.38	1.38	1.35	1.36	-2%
1Mb	3.36	3.60	3.15	2.80	2.25	1.93	1.72	1.58	1.55	1.53	1.51	-5%
2Mb	6.24	5.30	4.28	4.25	4.25	2.93	2.17	1.90	1.77	1.69	1.69	-10%
4Mb	12.99	13.67	10.90	8.60	6.55	4.89	2.96	2.35	2.04	1.91	1.86	-18%
8Mb	-	-	24.00	12.50	9.70	7.42	4.23	3.11	2.63	2.40	2.30	-21%
16Mb	-	-	-	35.00	22.00	16.77	7.60	4.83	3.75	3.28	2.99	-29%
Average	**2.63**	**2.92**	**2.96**	**3.11**	**2.99**	**2.29**	**1.79**	**1.64**	**1.56**	**1.53**	**1.53**	**-8%**

(continued)

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Table 5-1 (Continued)
EMEA EPROM Consumption History and Forecast, 1992-2002

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Revenue ($M)												
16Kb	2.46	1.65	1.12	0.88	0.33	0.18	0.45	0.30	0.21	0.14	0.10	-12%
32Kb	4.59	3.22	2.49	1.72	0.92	0.64	0.34	0.24	0.17	0.12	0.09	-33%
64Kb	15.42	11.47	9.03	9.21	4.77	3.34	3.85	2.88	2.16	1.62	1.22	-18%
128Kb	8.38	7.85	6.20	5.64	3.36	2.08	1.52	1.20	0.94	0.74	0.58	-23%
256Kb	64.87	55.04	50.88	46.07	37.50	33.38	25.65	19.74	15.79	12.63	10.11	-21%
512Kb	62.21	45.31	41.20	34.03	27.00	21.89	19.55	17.90	17.79	14.37	11.94	-11%
1Mb	71.57	100.80	102.38	82.88	45.45	33.13	24.08	19.02	14.53	12.21	10.23	-21%
2Mb	25.58	53.00	57.78	60.78	61.20	35.20	19.51	14.41	9.99	8.35	7.30	-27%
4Mb	37.67	45.11	65.40	74.82	77.95	54.45	29.73	21.20	16.58	13.96	12.25	-26%
8Mb	-	-	9.60	10.00	17.46	5.19	2.41	1.64	1.29	1.08	0.96	-29%
16Mb	-	-	-	7.00	6.60	1.41	0.61	0.37	0.27	0.22	0.19	-33%
Total	**292.7**	**323.4**	**346.1**	**333.0**	**282.5**	**190.9**	**127.7**	**98.9**	**79.7**	**65.4**	**55.0**	**-22%**
Annual Growth Rate	NA	10%	7%	-4%	-15%	-32%	-33%	-23%	-19%	-18%	-16%	

NA = not applicable
Source: Dataquest (June 1998 Estimates)

Table 5-2
EMEA EPROM Market Share Rankings, 1997

1997 Rank	1996 Rank		1996 Revenue ($M)	1997 Revenue ($M)	1996-1997 Growth (%)	1997 Market Share (%)
1	1	SGS-Thomson	128	94	-26.6%	49.2%
2	4	Texas Instruments	31	34	9.7%	17.8%
3	2	Advanced Micro Devices	48	27	-43.8%	14.1%
4	3	Atmel	33	19	-42.4%	9.9%
5	7	NEC	5	5	0.0%	2.6%
6	9	Cypress Semiconductor	5	3	-40.0%	1.6%
7	5	Fairchild	11	3	-72.7%	1.6%
8	8	Hitachi	5	2	-60.0%	1.0%
9	6	Macronix	7	2	-71.4%	1.0%
10	14	Integrated Silicon Solutions	1	1	0.0%	0.5%
		All Others	8	1	-87.5%	0.5%
		Total Market	**282**	**191**	**-32.3%**	**100.0%**

Source: Dataquest (June 1998 Estimates)

Table 5-3
EMEA EPROM Revenue by Application, 1992-2002

	1997 ($M)	1997 (%)	1998 ($M)	1998 (%)	2002 ($M)	2002 (%)	AGR 1997-1998	CAGR 1997-2002
Electronic Data Processing	65	34%	44	34%	20	37%	-33%	-21%
Communications	69	36%	46	36%	21	38%	-33%	-21%
Industrial	27	14%	18	14%	8	14%	-33%	-22%
Consumer	8	4%	5	4%	2	3%	-33%	-26%
Military and Civil Aerospace	6	3%	4	3%	1	2%	-33%	-28%
Automotive	17	9%	12	9%	3	6%	-33%	-28%
Total	**191**	**100%**	**128**	**100%**	**55**	**100%**		

Source: Dataquest (June 1998 Estimates)

Table 5-4
EMEA EPROM Revenue by Region, 1992-2002

	1997 ($M)	1997 (%)	1998 ($M)	1998 (%)	2002 ($M)	2002 (%)	AGR 1997-1998	CAGR 1997-2002
Benelux	8	4.0%	5	4.0%	2	4.0%	-33%	-22%
France	29	15.0%	19	15.0%	8	14.0%	-33%	-23%
Italy	13	7.0%	9	7.0%	3	6.0%	-33%	-24%
Nordic	13	7.0%	9	7.0%	3	6.0%	-33%	-24%
United Kingdom/Ireland	53	28.0%	36	28.0%	16	29.0%	-33%	-21%
Germany	57	30.0%	38	30.0%	18	32.0%	-33%	-21%
Rest of EMEA Region	17	9.0%	12	9.0%	5	9.0%	-33%	-22%
Total	**191**	**100%**	**128**	**100%**	**55**	**100%**		

Source: Dataquest (June 1998 Estimates)

Chapter 6
Total EEPROM Market Statistics and Analysis

Overview

The long-term forecast for EEPROM is shown in Table 6-1. The market size in 1997 suffered an anomalous decline because of a reclassification of its smart card revenue by SGS-Thomson. Although its memory smart card revenue remains included in its EEPROM business, the company now correctly reports its "true" smart card revenue as part of its microcontroller business rather than as part of its memory business, as was previously the case. Although it is difficult to extricate a true EEPROM market growth rate for 1997 because of this definition change by SGS-Thomson, as a rough estimate it appears that the market would have been more or less flat. Removing the effect of SGS-Thomson's true smart card business from the forecast, Dataquest expects a CAGR of 15 percent for the period 1997 to 2002 growing the market to $600 million.

1997 Review

EEPROM continues to be pervasive in all types of electronics equipment, especially in application areas such as communications, automotive and consumer. However, price pressure was again a feature of the market in 1997, as competition for sockets remained intense, so any growth in the non-smart card EEPROM market would have been driven by increased unit volumes. Because of the removal of SGS-Thomson's microcontroller-based smart cards from the EEPROM market, there is a step-function decline in the ASP of 256b EEPROMs to reflect the fact that this category now contains primarily 192b and 272b EEPROM memory-based smart cards.

Table 6-2 shows the 1997 EMEA market share ranking for EEPROM. Siemens is the number-one vendor, overtaking SGS-Thomson, now without the artificial benefit of its microcontroller-based smart card revenue. Atmel, traditionally a stalwart in the EEPROM market, suffered a 19 percent revenue decline in 1997, but managed to retain third spot in the ranking. There was a strong performance by Microchip Technology, which swapped positions with TI and moved into fifth position by increasing revenue by 68 percent. Xicor remained in sixth position, growing revenue slightly, but Fairchild's revenue declined by 41 percent causing it to lose seventh place to Catalyst. Rohm and NEC make up the top ten, but cannot be considered serious EEPROM players.

The unit shipment detail, as illustrated in Figure 6-1, shows the high proportion of unit shipments in the 256b density line which reflects the high volume shipments of 192b and 272b memory-based smart cards. Although there are higher density EEPROM-based smart cards, the 1Kb to 64Kb density range is principally the domain of the standard EEPROM device. A general shift in shipments of standard EEPROM devices is expected towards the higher end of this density range over the forecast period but, in parallel with this shift, EEPROM will face a cannibalization of its market by flash products.

Table 6-3 shows the application split for the EEPROM family. The removal of a significant amount of smart card revenue from the EEPROM market has reduced the proportion of the market accounted for by the EDP sector. It has also left the application split more representative of the traditional EEPROM application areas such as communications, automotive and consumer, each of which accounts for about 15 percent of the overall EEPROM TAM.

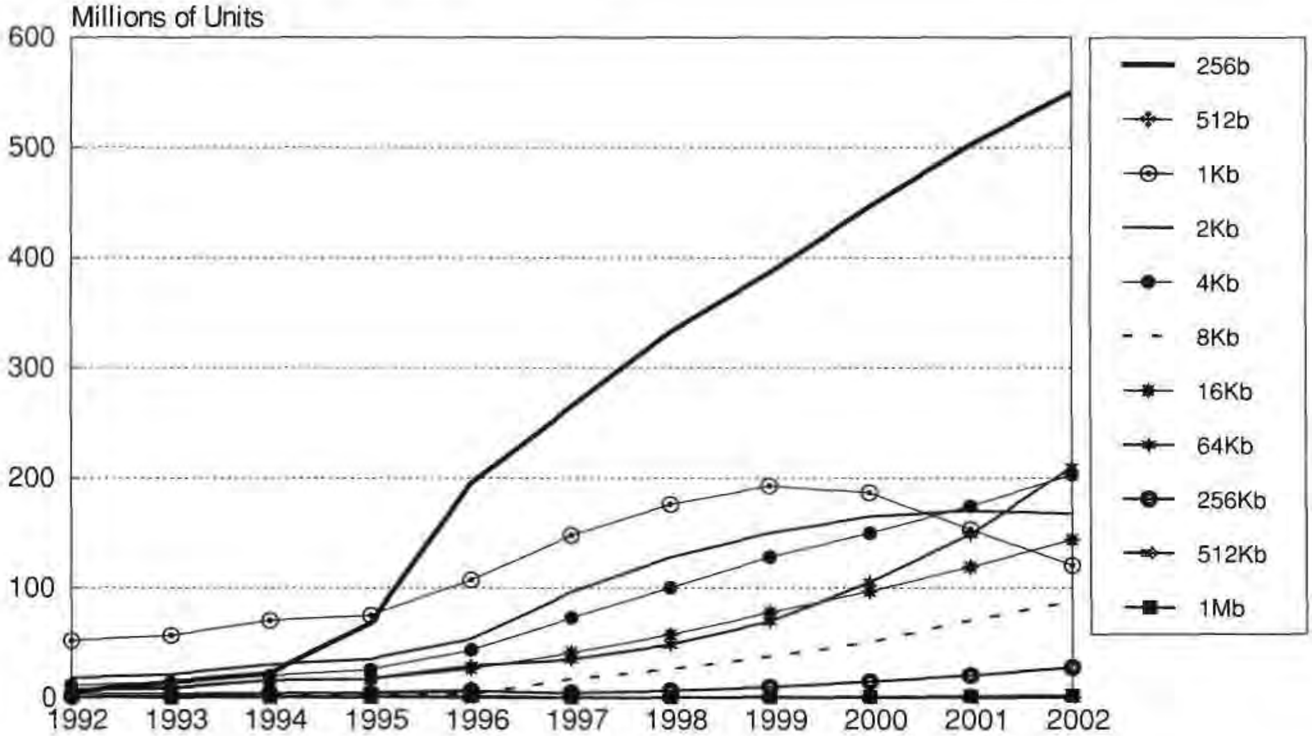
The country split, shown in Table 6-4, confirms the wide usage of EEPROM in many application segments. The importance of Germany, the United Kingdom/Ireland and France as electronics equipment producers is evident, as they take almost 75 percent of the available EEPROM market.

Long-Term Forecast

The restatement of the smart card contribution to the EEPROM market TAM has resulted in a more conservative forecast. Dataquest expects the EEPROM family to grow with a CAGR of 15 percent in revenue terms between 1997 and 2002.

EEPROM will continue to be in demand across a wide range of applications and the market will receive an injection of momentum through the use of EEPROM in synchronous DRAM DIMM modules. However, there are signs that some applications, such as digital cellular handsets, are integrating the EEPROM function into the flash device through the use of EEPROM emulation software techniques. This is a cause for concern for vendors reliant on the EEPROM market, especially as emerging applications such a digital set-top boxes move towards higher levels of integration even before high levels of unit production get underway.

Figure 6-1
EMEA EEPROM Unit Life Cycles, 1992-2002



Source: Dataquest (June 1998 Estimates)

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Table 6-1
EMEA EEPROM Consumption History and Forecast, 1992-2002

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Units (M)												
256b	5.1	14.3	22.0	67.9	195.0	264.0	332.0	386.0	446.0	502.0	550.0	16%
512b	3.3	4.1	4.4	4.9	7.3	-	-	-	-	-	-	NA
1Kb	51.6	56.8	70.5	74.9	107.0	147.6	175.8	192.7	186.4	153.0	120.6	-4%
2Kb	18.1	21.2	30.2	35.2	53.6	95.8	127.7	149.9	164.9	170.2	167.4	12%
4Kb	11.3	13.8	20.1	25.5	43.3	72.6	99.9	128.0	149.9	174.3	202.7	23%
8Kb	0.6	1.6	1.9	2.2	3.5	16.8	26.2	37.5	50.6	70.6	87.4	39%
16Kb	6.0	7.9	15.2	16.5	26.4	40.7	57.2	77.8	96.8	119.0	143.7	29%
64Kb	7.6	9.1	15.9	17.1	29.1	34.6	48.1	69.5	105.1	148.5	209.8	43%
256Kb	0.9	1.7	4.0	4.0	6.1	4.2	6.5	9.8	14.8	20.4	27.5	46%
512Kb	-	-	-	-	-	-	0.1	0.1	0.2	0.2	0.4	48%
1Mb		0.4	0.7	0.8	1.4	0.3	0.5	0.7	0.9	1.4	1.9	45%
4Mb	-	-	-	-	-	-	-	-	-	-	-	NA
Total	**104.5**	**130.9**	**184.9**	**249.0**	**472.8**	**676.7**	**874.0**	**1,051.9**	**1,215.7**	**1,359.6**	**1,511.3**	**17%**
ASPs ($)												
256b	0.64	0.61	0.56	0.36	0.34	0.14	0.14	0.14	0.13	0.13	0.12	-3%
512b	0.74	0.71	0.60	0.45	0.42	-	-	-	-	-	-	NA
1Kb	0.51	0.51	0.41	0.34	0.32	0.21	0.18	0.16	0.16	0.15	0.12	-11%
2Kb	1.08	0.90	0.71	0.56	0.42	0.31	0.28	0.21	0.20	0.19	0.19	-9%
4Kb	2.39	1.85	1.41	1.14	1.04	0.55	0.43	0.39	0.35	0.29	0.28	-13%
8Kb	3.07	2.30	1.99	1.15	1.10	0.80	0.73	0.65	0.60	0.53	0.55	-7%
16Kb	4.77	3.52	2.97	2.10	1.90	1.22	1.17	1.01	0.90	0.87	0.81	-8%
64Kb	5.89	4.92	3.80	3.15	2.80	2.01	1.57	1.42	1.22	1.10	1.02	-13%
256Kb	18.03	14.90	12.15	9.40	8.40	5.29	3.40	2.63	1.91	1.55	1.38	-24%
512Kb	-	-	-	25.36	22.75	12.00	10.00	6.92	5.19	4.11	3.24	-23%
1Mb	-	77.00	71.00	56.16	50.56	32.00	20.00	18.20	13.12	9.55	7.94	-24%
4Mb	-	-	-	-	-	-	-	-	-	-	-	NA
Average	**1.63**	**1.63**	**1.63**	**1.10**	**0.91**	**0.45**	**0.40**	**0.39**	**0.38**	**0.38**	**0.40**	
Revenue ($M)												
256b	3.26	8.72	12.32	24.44	67.18	36.96	46.48	54.04	57.98	65.26	66.00	12%
512b	2.44	2.91	2.64	2.21	3.11	-	-	-	-	-	-	NA
1Kb	26.32	28.97	28.91	25.47	34.76	31.00	31.65	30.84	29.83	22.95	13.86	-15%
2Kb	19.55	19.08	21.44	19.71	22.51	29.71	35.77	31.48	32.98	32.34	31.81	1%
4Kb	27.01	25.53	28.34	29.07	45.08	39.92	42.97	49.94	52.47	50.54	56.75	7%
8Kb	1.84	3.68	3.78	2.53	3.81	13.46	19.15	24.36	30.36	37.41	48.10	29%
16Kb	28.62	27.81	45.14	34.65	50.24	49.64	66.87	78.54	87.13	103.52	116.77	19%
64Kb	44.76	44.77	60.42	53.87	81.49	69.63	75.51	98.65	128.28	163.37	213.69	25%
256Kb	16.23	25.33	48.60	37.60	51.19	21.96	21.94	25.69	28.17	31.63	38.00	12%
512Kb	-	-	-	-	-	0.60	0.77	0.85	0.90	1.01	1.14	14%
1Mb	-	26.95	49.70	44.93	71.19	9.48	9.30	12.24	12.18	13.12	15.05	10%
4Mb	-	-	-	-	-	-	-	-	-	-	-	NA
Total	**170**	**214**	**301**	**274**	**431**	**302**	**350**	**407**	**460**	**521**	**601**	**15%**

NA = not applicable
Source: Dataquest (June 1998 Estimates)

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Table 6-2
EMEA EEPROM Market Share Rankings, 1997

1997 Rank	1996 Rank		1996 Revenue ($M)	1997 Revenue ($M)	1996-1997 Growth (%)	1997 Market Share (%)
1	2	Siemens	66	76	15.2%	25.2%
2	1	SGS-Thomson	199	68	-65.8%	22.5%
3	3	Atmel	52	42	-19.2%	13.9%
4	5	Microchip Technology	22	37	68.2%	12.3%
5	4	Texas Instruments	35	28	-20.0%	9.3%
6	6	Xicor	20	23	15.0%	7.6%
7	8	Catalyst	10	11	10.0%	3.6%
8	7	Fairchild	17	10	-41.2%	3.3%
9	10	Rohm	3	3	0.0%	1.0%
10	11	NEC	2	2	0.0%	0.7%
		All Others	5	2	-60.0%	0.7%
		Total Market	**431**	**302**	**-29.9%**	**100.0%**

Source: Dataquest (June 1998 Estimates)

Table 6-3
EMEA EEPROM Revenue by Application, 1997, 1998 and 2002

	1997 ($M)	1997 (%)	1998 ($M)	1998 (%)	2002 ($M)	2002 (%)	AGR 1997-1998	CAGR 1997-2002
Electronic Data Processing	100	33%	116	33%	198	33%	16%	15%
Communications	54	18%	63	18%	108	18%	16%	15%
Industrial	33	11%	39	11%	66	11%	16%	15%
Consumer	42	14%	49	14%	84	14%	16%	15%
Military and Civil Aerospace	21	7%	25	7%	42	7%	16%	15%
Automotive	51	17%	60	17%	102	17%	16%	15%
Total	**302**	**100%**	**350**	**100%**	**601**	**100%**		

Source: Dataquest (June 1998 Estimates)

Table 6-4
EMEA EEPROM Revenue by Region, 1997, 1998 and 2002

	1997 ($M)	1997 (%)	1998 ($M)	1998 (%)	2002 ($M)	2002 (%)	AGR 1997-1998	CAGR 1997-2002
Benelux	9	3%	11	3%	12	2%	16%	6%
France	51	17%	60	17%	120	20%	16%	19%
Italy	21	7%	25	7%	36	6%	16%	11%
Nordic	24	8%	28	8%	54	9%	16%	17%
United Kingdom/Ireland	82	27%	95	27%	150	25%	16%	13%
Germany	88	29%	102	29%	174	29%	16%	15%
Rest of EMEA Region	27	9%	32	9%	54	9%	16%	15%
Total	**302**	**100%**	**350**	**100%**	**601**	**100%**		

Source: Dataquest (June 1998 Estimates)

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Chapter 7
Total Flash Memory Market Statistics and Analysis

Overview

The long-term forecast for flash memory is shown in Table 7-1. The outlook is for continued growth, although the expectation for 2002 has been reduced to $1.4 billion courtesy of a CAGR of 17 percent for the period 1997 to 2002.

1997 Review

The EMEA market for flash memory was ravaged by fierce competition and heavy ASP erosion. Particularly affected was the price of the 8Mb device, which suffered as the major OEMs played one flash supplier off against another in the face of abundant supply. The 8Mb device ended the year at less than $7 with the ASP slide expected to continue through 1998.

Figure 7-1 shows the unit life cycles for flash memory for the forecast period. The market is expected to be driven by the 1Mb, 4Mb and 8Mb densities in the EMEA region in 1997 and 1998 before the 16Mb takes over in 1999 and 2000 when applications such as digital cellular and digital set-top boxes migrate to the higher density.

Table 7-2 shows the flash market shares for 1997. Here the most notable point is the change in top-ranked vendor in 1997. Following several years of Intel domination, AMD finally gained top spot. This occurrence is particular to the EMEA region because of the importance of two flash application markets: the digital cellular handset market and the automotive market. The technology offered by Fujitsu AMD Semiconductor Ltd. continued to increase its penetration and benefited because of a huge increase in GSM handset production. Because of this and because of its strength in automotive powertrain applications, AMD deposed Intel as the flash market leader in the EMEA region. These two vendors held two-thirds of the EMEA flash market in 1997, although Intel lost market share not only to AMD but also to its partner, Sharp, which entered the ranking at number four. AMD's partner, Fujitsu, the fourth member of the "NOR four" maintained its solid number-three position. The NOR four increased their dominance to account for 89 percent of the market in 1997, up from 81 percent in 1996. Intel was not the only casualty in the market share battle between the top four vendors. Both SGS-Thomson and Atmel, as the only other credible players in the EMEA flash market, lost market share to account for only 7 percent between them, compared with 15 percent the previous year.

Table 7-3 confirms that the dominant flash application area is the communications market, which accounts for 71 percent of the EMEA flash market. The other main application areas are the EDP sector driven by flash PC BIOS, and the automotive electronics sector driven by powertrain applications such as engine control and the emerging application of in-car entertainment and information systems. The consumer segment is set to become an important area for flash memory, particularly as the digital set-top box looks likely to take off during the forecast period.

The regional split for flash is contained in Table 7-4. Surprisingly, although it accounts for a quarter of the flash market, the Nordic region, with its high concentration of digital cellular handset and base station manufacturing, is not the single-largest country market for flash. This honor goes to Germany with its large EDP, telecommunications and automotive industries.

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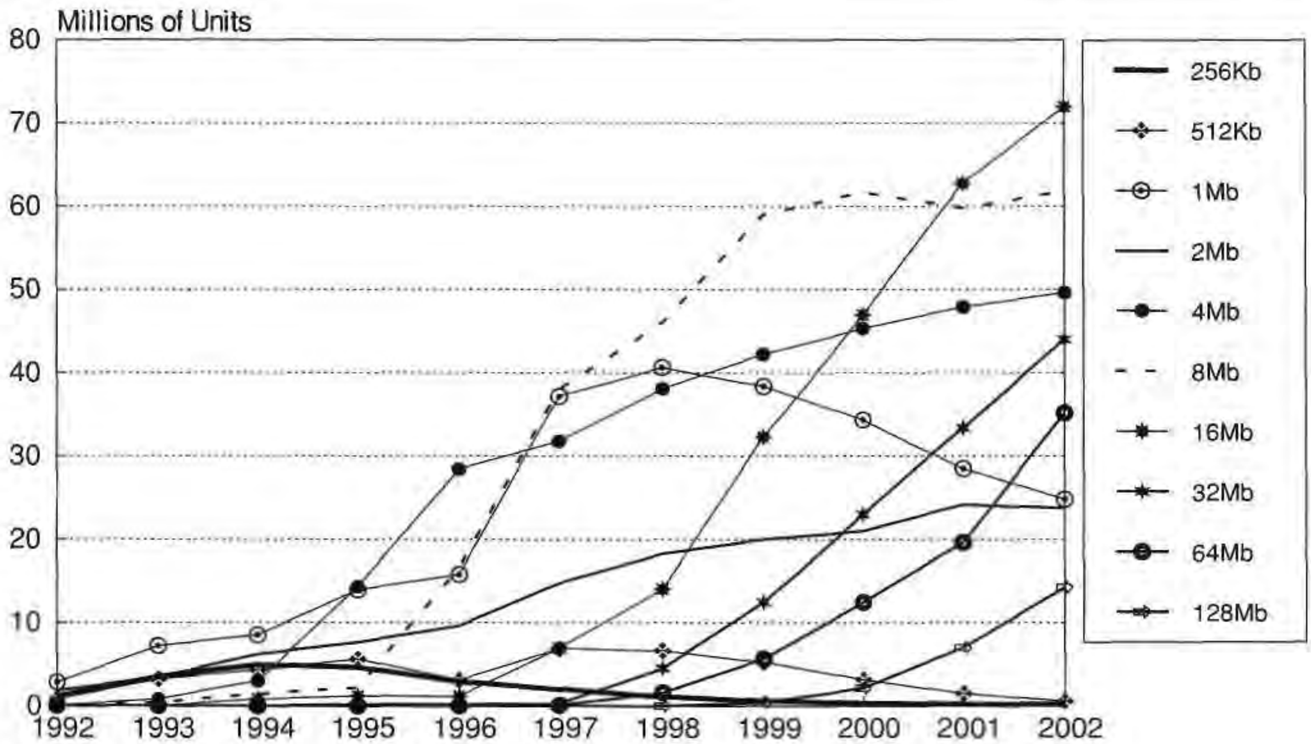
Long-Term Forecast

The low revenue growth seen in 1997 is expected to be repeated in 1998 as the EMEA market remains dominated by the digital cellular handset and its requirement for the 8Mb device density. Higher unit shipments of the 8Mb device will be offset by lower ASPs, and it is not until demand switches to the higher-density 16Mb in 1999 and beyond that healthy growth will return to the EMEA flash market. A more conservative CAGR forecast of 17 percent revenue growth for the period 1997 to 2002 is driven by increased revenue from the 16Mb-and-above device densities later in the forecast window.

ASPs for the 32Mb-and-above device densities are influenced by the fact that NAND-based devices are cheaper on a bit basis than NOR-based devices. In the five-year period, the program code storage market for NOR-based flash will generally require a maximum device density of 32Mb, while the market for the 64Mb and 128Mb will be centered around NAND-based flash and restricted to a limited number of data storage applications.

The flash market has moved into a period of maturity and is showing signs of becoming a commodity market, albeit on a much smaller scale than in the case of DRAM. There are certainly plenty of applications emerging to drive demand, particularly in the digital consumer and automotive segments, but such is the competitive nature of the market that die shrinks and additional fab capacity mean that no supply shortages are on the cards. It remains to be seen whether the NOR four can hold onto their dominant position, but the constant drive to win market share means that they are very lean competitors. Any potential challenger would have to be able to compete at the leading edge of flash technology; it would take a serious commitment to develop a competitive NOR-based flash offering. It is more likely that the NAND-based flash vendors will concentrate on the emerging data storage applications of the Far East markets rather than attempting to enter the EMEA market with its heavy NOR-based technology bias.

Figure 7-1
EMEA Flash Memory Unit Life Cycles, 1992-2002



Source: Dataquest (June 1998 Estimates)

Table 7-1
EMEA Flash Memory Consumption History and Forecast, 1992-2002

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Units (M)												
256Kb	1.1	3.5	4.9	4.6	2.9	2.0	1.1	0.6	0.3	0.2	0.2	-38%
512Kb	0.8	3.2	4.3	5.6	3.1	6.9	6.6	5.2	3.2	1.5	0.6	-39%
1Mb	2.8	7.2	8.5	13.9	15.8	37.2	40.6	38.3	34.3	28.4	24.8	-8%
2Mb	1.8	3.4	6.2	7.6	9.6	14.7	18.2	20.0	21.0	24.1	23.7	10%
4Mb	-	0.8	3.0	14.3	28.4	31.7	38.1	42.2	45.3	47.9	49.6	9%
8Mb	-	0.4	1.4	2.2	16.6	38.0	46.0	59.0	61.7	59.8	61.8	10%
16Mb	-	-	0.8	1.2	1.2	6.9	14.0	32.3	46.9	62.7	72.0	60%
32Mb	-	-	-	0.2	0.2	0.3	4.5	12.4	23.0	33.4	44.0	179%
64Mb	-	-	-	-	-	0.1	1.6	5.6	12.4	19.6	35.2	249%
128Mb	-	-	-	-	-	-	-	0.4	2.2	7.0	14.2	NA
Total	**6.6**	**18.5**	**29.1**	**49.6**	**77.8**	**137.7**	**170.7**	**216.1**	**250.3**	**284.7**	**326.1**	
ASPs ($)												
256Kb	5.30	4.60	2.70	2.50	2.46	2.37	2.12	2.11	2.10	2.10	2.10	-2%
512Kb	6.80	5.90	3.10	3.10	3.19	2.39	2.16	2.15	2.14	2.14	2.14	-2%
1Mb	9.00	7.90	4.00	4.50	3.05	2.26	2.19	2.18	2.17	2.16	2.16	-1%
2Mb	19.00	16.30	6.00	10.00	6.40	3.41	2.65	2.48	2.38	2.32	2.29	-8%
4Mb	-	27.00	13.50	14.69	8.42	4.75	3.46	3.03	2.87	2.69	2.58	-11%
8Mb	-	31.00	30.40	22.50	13.88	6.82	4.65	3.25	3.30	3.28	3.16	-14%
16Mb	-	-	32.00	38.00	29.53	14.25	8.83	6.18	4.90	4.52	4.23	-22%
32Mb	-	-	-	52.00	49.22	15.41	9.16	7.41	6.65	6.07	5.68	-18%
64Mb	-	-	-	-	-	32.94	16.29	12.47	10.33	8.81	7.82	-25%
128Mb	-	-	-	-	-	-	40.93	22.75	18.11	14.62	12.47	NA
Average	**10.77**	**9.80**	**7.09**	**9.74**	**8.24**	**4.86**	**4.04**	**3.87**	**4.06**	**4.24**	**4.41**	**-2%**

(continued)

Table 7-1 (Continued)
EMEA Flash Memory Consumption History and Forecast, 1992-2002

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Revenue ($M)												
256Kb	5.8	16.1	13.2	11.5	7.1	4.7	2.3	1.3	0.7	0.5	0.4	-40%
512Kb	5.4	18.9	13.3	17.4	9.9	16.5	14.3	11.3	6.8	3.2	1.3	-40%
1Mb	25.2	56.9	34.0	62.6	48.2	83.9	88.9	83.6	74.5	61.4	53.6	-9%
2Mb	34.2	55.4	37.2	76.0	61.4	50.2	48.3	49.6	50.0	55.9	54.2	2%
4Mb	-	21.6	40.5	210.1	239.1	150.8	131.7	127.7	130.1	128.5	128.2	-3%
8Mb	-	12.4	42.6	49.5	230.4	259.2	213.7	191.8	203.6	196.1	195.0	-6%
16Mb	-	-	25.6	45.6	35.4	98.3	123.6	199.4	229.8	283.4	304.2	25%
32Mb	-	-	-	10.4	9.8	4.0	41.3	92.0	153.1	202.6	249.7	128%
64Mb	-	-	-	-	-	2.2	25.7	70.3	128.1	172.9	275.1	162%
128Mb	-	-	-	-	-	-	-	9.8	39.2	102.3	177.3	NA
Total	**70.7**	**181.3**	**206.4**	**483.0**	**641.5**	**669.9**	**689.9**	**836.6**	**1,015.9**	**1,206.9**	**1,438.8**	**17%**
Annual Growth Rate	NA	157%	14%	134%	33%	4%	3%	21%	21%	19%	19%	

NA = not applicable
Source: Dataquest (June 1998 Estimates)

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Table 7-2
EMEA Flash Memory Market Share Rankings, 1997

1997 Rank	1996 Rank		1996 Revenue ($M)	1997 Revenue ($M)	1996-1997 Growth (%)	1997 Market Share (%)
1	2	Advanced Micro Devices	177	226	27.7%	33.7%
2	1	Intel	250	222	-11.2%	33.1%
3	3	Fujitsu	93	99	6.5%	14.8%
4	NA	Sharp	0	47	NA	7.0%
5	5	SGS-Thomson	41	25	-39.0%	3.7%
6	4	Atmel	57	24	-57.9%	3.6%
7	7	Texas Instruments	5	8	60.0%	1.2%
8	6	Toshiba	6	4	-33.3%	0.6%
9	14	Samsung	1	3	200.0%	0.4%
10	8	Silicon Storage Technology	4	3	-25.0%	0.4%
		All Others	7	9	28.6%	1.3%
		Total Market	**641**	**670**	**4.5%**	**100.0%**

NA = not applicable
Source: Dataquest (June 1998 Estimates)

Table 7-3
EMEA Flash Memory Revenue by Application, 1997, 1998 and 2002

	1997 ($M)	1997 (%)	1998 ($M)	1998 (%)	2002 ($M)	2002 (%)	AGR 1997-1998	CAGR 1997-2002
Electronic Data Processing	60	9%	69	10%	173	12%	14%	23%
Communications	476	71%	483	70%	993	69%	2%	16%
Industrial	47	7%	41	6%	72	5%	-12%	9%
Consumer	13	2%	21	3%	58	4%	54%	34%
Military and Civil Aerospace	13	2%	14	2%	14	1%	3%	1%
Automotive	60	9%	62	9%	130	9%	3%	17%
Total	**670**	**100%**	**690**	**100%**	**1,439**	**100%**		

Source: Dataquest (June 1998 Estimates)

Table 7-4
EMEA Flash Memory Revenue by Region, 1997, 1998 and 2002

	1997 ($M)	1997 (%)	1998 ($M)	1998 (%)	2002 ($M)	2002 (%)	AGR 1997-1998	CAGR 1997-2002
Benelux	20	3.0%	21	3.0%	29	2.0%	3%	7%
France	80	12.0%	83	12.0%	187	13.0%	3%	18%
Italy	47	7.0%	48	7.0%	86	6.0%	3%	13%
Nordic	168	25.0%	173	25.0%	389	27.0%	3%	18%
United Kingdom/Ireland	107	16.0%	110	16.0%	216	15.0%	3%	15%
Germany	188	28.0%	193	28.0%	403	28.0%	3%	17%
Rest of EMEA Region	60	9.0%	62	9.0%	130	9.0%	3%	17%
Total	**670**	**100%**	**690**	**100%**	**1,439**	**100%**		

Source: Dataquest (June 1998 Estimates)

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Chapter 8
Total ROM Market Statistics and Analysis

Overview

Dataquest's latest long-term outlook for ROM is contained in Table 8-1. The market as a whole is so insignificant in the EMEA region, comprising only 5 percent of global sales, that any growth—positive or negative—fails to have much of an impact in absolute terms. Within the margin of forecasting error, Dataquest expects that the market will neither grow nor shrink significantly but will continue at its present level of about $50 million. A CAGR of minus 3 percent is forecast between 1997 and 2002, resulting in ROM accounting for less and less of a percentage of the total nonvolatile market.

1997 Review

The ROM market is dominated by the printer application and, in the absence of new application drivers, falling ASPs led to a market decline in 1997 of 12 percent over 1996.

The main suppliers of ROM to the EMEA region are illustrated in Table 8-2. Again, this year Dataquest's market share figures have identified only nine vendors active in ROM in this region, reflecting the lack of interest in this area. However, there were some ranking changes compared with the 1996 lineup. The market fell to $53 million with NEC and Toshiba maintaining their top two positions. Samsung and Sharp share third place with Harris, which added $5 million to its sales. The top five vendors in 1997 accounted for 79 percent of the EMEA ROM market compared with 80 percent in 1996. LG Semicon, OKI, Macronix and Hitachi completed the lineup.

As shown in Figure 8-1, unit shipments were concentrated around the 4Mb, 8Mb and 16Mb densities in 1997 with little sign of demand for higher densities even later in the forecast period.

The printer industry is the overriding ROM market in the EMEA region. For this reason, the EDP segment, which contains printers, accounts for about 70 percent of the ROM market, as shown in Table 8-3.

Table 8-4 shows the country split for the EMEA ROM market. The main EDP production regions of the United Kingdom/Ireland and Germany make up 60 percent of the market with another 12 percent going to France.

Long-Term Forecast

The usage of ROM in the EMEA region is limited to applications such as printers which account for approximately half of the market. The possibility that ROM will start to be used more widely as a low-cost alternative to flash, in applications such as budget digital cellular, looks less likely now that flash is so cost competitive. Indeed, the prospect of flash devices replacing ROM in the printer applications seems a more likely scenario.

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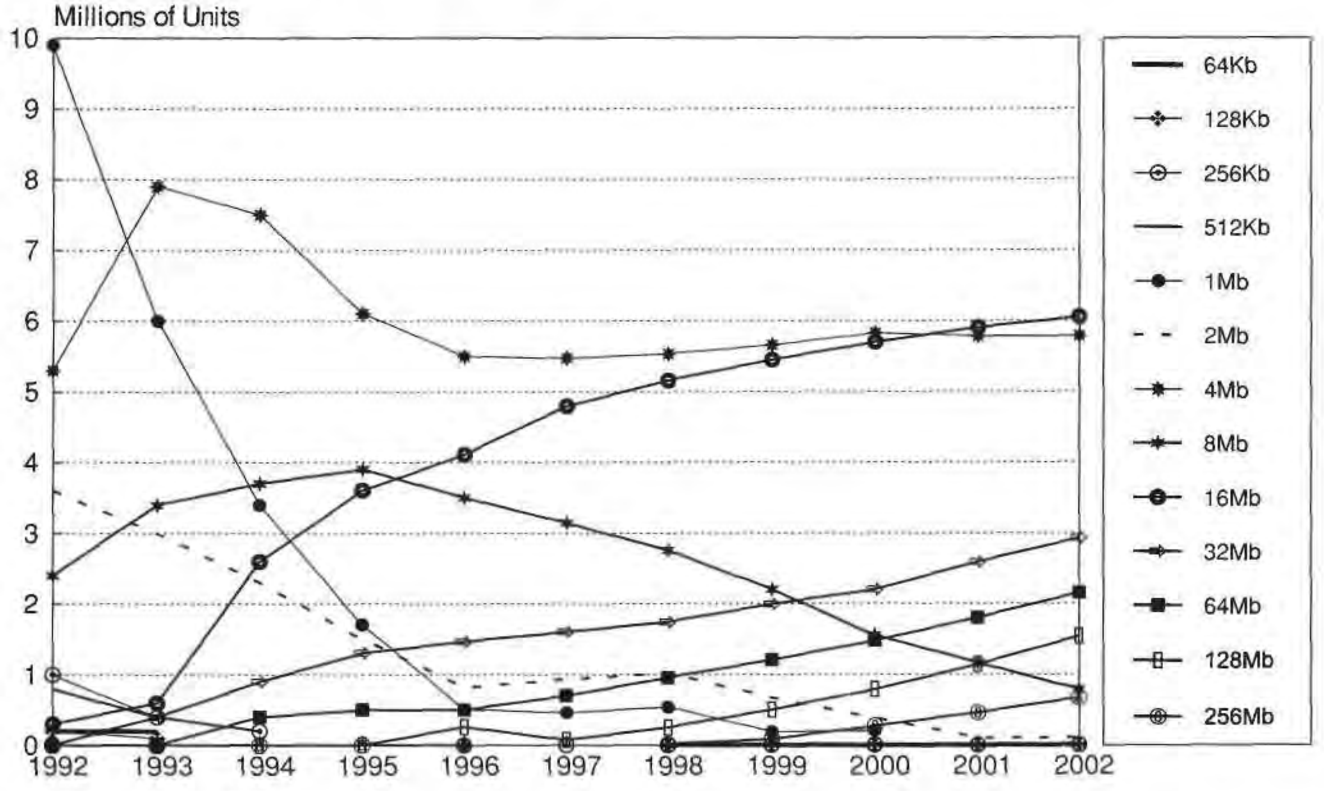
Figure 8-1
EMEA ROM Unit Life Cycles, 1992-2002



Source: Dataquest (June 1998 Estimates)

Table 8-1
EMEA ROM Consumption History and Forecast, 1992-2002

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Units (M)												
64Kb	0.2	0.2	-	-	-	-	-	-	-	-	-	NA
128Kb	0.2	0.1	-	-	-	-	-	-	-	-	-	NA
256Kb	1.0	0.4	0.2	-	-	-	-	-	-	-	-	NA
512Kb	0.8	0.4	0.2	-	-	-	-	-	-	-	-	NA
1Mb	9.9	6.0	3.4	1.7	0.5	0.5	0.5	0.2	0.2	-	-	-100%
2Mb	3.6	3.0	2.3	1.5	0.8	0.9	1.0	0.7	0.4	0.1	0.1	-36%
4Mb	5.3	7.9	7.5	6.1	5.5	5.5	5.5	5.7	5.8	5.8	5.8	1%
8Mb	2.4	3.4	3.7	3.9	3.5	3.1	2.8	2.2	1.6	1.2	0.8	-24%
16Mb	0.3	0.6	2.6	3.6	4.1	4.8	5.2	5.4	5.7	5.9	6.1	5%
32Mb	-	0.4	0.9	1.3	1.5	1.6	1.7	2.0	2.2	2.6	2.9	13%
64Mb	-	-	0.4	0.5	0.5	0.7	1.0	1.2	1.5	1.8	2.2	25%
128Mb	-	-	-	-	0.3	0.1	0.2	0.5	0.8	1.1	1.5	85%
256Mb	-	-	-	-	-	-	-	0.1	0.3	0.5	0.7	NA
Total	**24**	**22**	**21**	**19**	**17**	**17**	**18**	**18**	**18**	**19**	**20**	

(continued)

Table 8-1 (Continued)
EMEA ROM Consumption History and Forecast, 1992-2002

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
ASPs ($)												
64Kb	1.53	1.55	-	-	-	-	-	-	-	-	-	NA
128Kb	1.55	1.46	-	-	-	-	-	-	-	-	-	NA
256Kb	1.55	1.40	1.30	-	-	-	-	-	-	-	-	NA
512Kb	1.94	1.88	1.85	-	-	-	-	-	-	-	-	NA
1Mb	2.30	2.10	1.80	1.90	1.30	1.03	1.01	0.99	0.97	0.95	0.93	-2%
2Mb	2.70	2.50	2.10	2.05	1.60	1.34	1.18	1.14	1.06	1.02	0.99	-6%
4Mb	3.70	3.30	2.85	2.56	2.25	1.72	1.35	1.25	1.20	1.12	1.08	-9%
8Mb	5.30	5.10	3.80	3.15	2.35	2.22	1.69	1.48	1.43	1.35	1.30	-10%
16Mb	12.90	10.20	8.72	6.03	4.10	3.60	2.30	1.99	1.84	1.65	1.52	-16%
32Mb	-	22.00	14.60	7.40	5.75	4.78	3.30	2.63	2.30	2.06	1.91	-17%
64Mb	-	-	65.00	49.68	25.32	10.53	5.35	3.72	3.13	2.74	2.49	-25%
128Mb	-	-	-	76.00	65.00	41.94	21.48	13.21	8.18	5.94	4.68	-36%
256Mb	-	-	-	-	-	-	-	101.52	45.50	24.15	16.83	NA
Average	**3.06**	**3.58**	**5.13**	**4.86**	**3.63**	**3.11**	**2.34**	**2.61**	**2.64**	**2.43**	**2.30**	

(continued)

Table 8-1 (Continued)
EMEA ROM Consumption History and Forecast, 1992-2002

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Revenue ($M)												
64Kb	0.3	0.3	-	-	-	-	-	-	-	-	-	NA
128Kb	0.3	0.1	-	-	-	-	-	-	-	-	-	NA
256Kb	1.6	0.6	0.3	-	-	-	-	-	-	-	-	NA
512Kb	1.6	0.8	0.4	-	-	-	-	-	-	-	-	NA
1Mb	22.8	12.6	6.1	3.2	0.7	0.5	0.5	0.2	0.2	-	-	NA
2Mb	9.7	7.5	4.8	3.1	1.3	1.2	1.2	0.8	0.4	0.1	0.1	-40%
4Mb	19.6	26.1	21.4	15.6	12.4	9.4	7.5	7.1	7.0	6.5	6.2	-8%
8Mb	12.7	17.3	14.1	12.3	8.2	7.0	4.7	3.3	2.2	1.6	1.0	-32%
16Mb	3.9	6.1	22.7	21.7	16.9	17.3	11.9	10.8	10.5	9.7	9.2	-12%
32Mb	-	8.8	13.1	9.6	8.4	7.7	5.8	5.2	5.1	5.3	5.6	-6%
64Mb	-	-	26.0	24.8	12.7	7.4	5.1	4.5	4.6	4.9	5.4	-6%
128Mb	-	-	-	-	-	3.0	5.3	6.6	6.4	6.8	7.2	19%
256Mb	-	-	-	-	-	-	-	8.4	12.2	11.0	11.2	NA
Total	**72**	**80**	**109**	**90**	**60**	**53**	**42**	**47**	**49**	**46**	**46**	**-3%**
Annual Growth Rate	NA	11%	36%	-17%	-33%	-12%	-21%	11%	4%	-5%	0%	

NA = not applicable
Source: Dataquest (June 1998 Estimates)

Table 8-2
EMEA ROM Market Share Rankings, 1997

1997 Rank	1996 Rank		1996 Revenue ($M)	1997 Revenue ($M)	1996-1997 Growth (%)	1997 Market Share (%)
1	1	NEC	14	12	-14.3%	22.6%
2	2	Toshiba	12	9	-25.0%	17.0%
3	3	Samsung	11	7	-36.4%	13.2%
3	4	Sharp	6	7	16.7%	13.2%
3	9	Harris	2	7	250.0%	13.2%
6	5	LG Semicon	5	6	20.0%	11.3%
7	6	Oki	4	2	-50.0%	3.8%
8	8	Macronix	3	2	-33.3%	3.8%
9	7	Hitachi	3	1	-66.7%	1.9%
		All Others	0	0	NA	NA
		Total Market	**60**	**53**	**-11.7%**	**100.0%**

NA = not applicable
Source: Dataquest (June 1998 Estimates)

Table 8-3
EMEA ROM Revenue by Application, 1997, 1998 and 2002

	1997 ($M)	1997 (%)	1998 ($M)	1998 (%)	2002 ($M)	2002 (%)	AGR 1997-1998	CAGR 1997-2002
Electronic Data Processing	37	69%	29	69%	33	72%	-21%	-2%
Communications	4	8%	3	8%	4	9%	-21%	0%
Industrial	2	4%	2	4%	2	4%	-21%	-3%
Consumer	7	13%	5	13%	5	11%	-21%	-6%
Military and Civil Aerospace	1	2%	1	2%	0	1%	-21%	-15%
Automotive	2	4%	2	4%	1	3%	-21%	-8%
Total	**53**	**100%**	**42**	**100%**	**46**	**100%**		

Source: Dataquest (June 1998 Estimates)

Table 8-4
EMEA ROM Revenue by Region, 1997, 1998 and 2002

	1997 ($M)	1997 (%)	1998 ($M)	1998 (%)	2002 ($M)	2002 (%)	AGR 1997-1998	CAGR 1997-2002
Benelux	2	3.0%	1	3.0%	1	2.0%	-21%	-10%
France	6	12.0%	5	12.0%	6	12.0%	-21%	-3%
Italy	4	8.0%	3	8.0%	3	6.0%	-21%	-8%
Nordic	4	7.0%	3	7.0%	4	8.0%	-21%	0%
United Kingdom/Ireland	17	33.0%	14	33.0%	15	33.0%	-21%	-3%
Germany	14	27.0%	11	27.0%	13	28.0%	-21%	-2%
Rest of EMEA Region	5	10.0%	4	10.0%	5	11.0%	-21%	-1%
Total	**53**	**100%**	**42**	**100%**	**46**	**100%**		

Source: Dataquest (June 1998 Estimates)

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Chapter 9
Total Other MOS Memory Market Statistics and Analysis

1997 Review

The EMEA market for other MOS memory devices benefited in 1997 from a windfall gain in the form of additional revenue as a result of a definition change by Philips during the market share reporting process. The market size was $147 million in 1997—a growth of 73 percent—but, if Philips' sales are removed, the growth in the residual market was minus 4 percent. The top suppliers to the EMEA region are shown in Table 9-1. Dataquest's market share figures have managed to identify only six vendors active in the EMEA other MOS memory market in 1997, even after the inclusion of Philips. The introduction of Philips to the category displaced long-term market leader Integrated Device Technology, which now occupies number-two spot. Cypress Semiconductor's revenue in this category increased by 140 percent to $24 million to put it ahead of SGS-Thomson whose revenue declined slightly. NEC and OKI each recorded $5 million in sales, while Xicor and Motorola recorded no sales for this category in 1997.

Long-Term Forecast

For the other MOS memory category, Dataquest expects a modest CAGR of 11 percent for the period 1997 to 2002.

Table 9-1
EMEA Other MOS Memory Market Share Rankings, 1997

1997 Rank	1996 Rank		1996 Revenue ($M)	1997 Revenue ($M)	1996-1997 Growth (%)	1997 Market Share (%)
1	NA	Philips	NA	65	NA	44.2%
2	1	Integrated Device Technology	36	32	-11.1%	21.8%
3	3	Cypress Semiconductor	10	24	140.0%	16.3%
4	2	SGS-Thomson	18	16	-11.1%	10.9%
5	5	NEC	5	5	0.0%	3.4%
6	6	Oki	5	5	0.0%	3.4%
7	4	Xicor	9	0	-100.0%	0.0%
8	7	Motorola	2	0	-100.0%	0.0%
		All Others	0	0	NA	NA
		Total Market	**85**	**147**	**72.9%**	**100.0%**

NA = not applicable
Source: Dataquest (June 1998 Estimates)

Chapter 10
Important Information

DRAM Section

As well as a "most likely" DRAM market forecast for the EMEA region, this *Market Statistics* report contains upside and downside DRAM forecast scenarios. The purpose of this approach was to acknowledge and make clients aware that there was significant risk associated with any set of DRAM forecast numbers published in 1998—such has been the unprecedented volatility in the global DRAM market in recent months.

Two factors have compounded the usual vagaries of the commodity DRAM market. These have led to a reduction in confidence levels in a single DRAM forecast, and the certainty that any forecast is likely to be out of date as soon as it is published. Firstly, the global DRAM oversupply shows no signs of alleviation because of a reluctance on the part of DRAM vendors to reduce production capacity and hence jeopardize their market share position. Secondly, the continuing financial crisis that is affecting the economies of Southeast Asia, particularly that of South Korea (which is heavily dependent on the DRAM market), has made forecasting the DRAM market like "trying to hit a moving target." The most important ramification of this financial crisis for the DRAM market has been the ability of the South Korean vendors to continue to reduce costs because of local currency devaluation. This, in parallel with the continued global DRAM oversupply, has continued to force DRAM ASPs down to levels which are universally acknowledged as below cost throughout the first half of 1998.

When this report was compiled in April 1998, Dataquest was unwilling to forecast that ASPs could be sustained at levels below cost for an extended period. However, as the July publication date loomed, it became clear that this was indeed the case. Therefore, Dataquest believes that the downside forecast for the DRAM market is now the more credible scenario and would advise clients to be guided by it. We are already working on a comprehensive update to the DRAM forecast reflecting this view, and a *Dataquest Perspective* on this subject will be published in the next few weeks.

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Appendix A
Definitions

Devices

Dataquest classifies memory devices in the following categories:

- **DRAM**: Includes dynamic RAM, multiport-DRAM (M-DRAM) and video DRAM (VRAM). DRAMs have memory cells consisting of a single transistor, and require regular externally cycled memory-cell refreshes. This category also includes new-architecture DRAMs (NADs) such as Rambus, cache, enhanced and synchronous DRAMs. These are volatile memories and addressing is multiplexed.
- **SRAM**: Includes static RAM, multiport-SRAM (M-SRAM), battery backed-up SRAM (BB-SRAM), and pseudo SRAM (PSRAM). SRAMs have memory cells consisting of at least four transistors, except a PSRAM, which has a memory cell comprising a single transistor and is similar to a DRAM. SRAMs do not require externally cycled memory-cell refreshes. These are volatile memories and addressing is not multiplexed (except in the case of PSRAM). Note that color-palette DACs are included in the mixed-signal data converter category.
- **EPROM**: Includes erasable programmable read-only memory. This product classification includes ultraviolet EPROM (UV EPROM) and one-time programmable read-only memory (OTPROM). EPROMs have memory cells consisting of a single transistor, and do not require any memory-cell refreshes. These devices are considered nonvolatile memories.
- **EEPROM**: Includes electronically erasable programmable read-only memory, encompassing serial EEPROM (S-EEPROM), parallel EEPROM (P-EEPROM) and electrically alterable read-only memory (EAROM). EEPROMs have memory cells consisting of at least two transistors, and do not require memory-cell refreshes. This category also includes nonvolatile RAM (NV-RAM), alternatively known as shadow RAM, which is a combination of SRAM and EEPROM technologies in each memory cell; the EEPROM acts as a shadow backup for the SRAM when power is lost. These devices are considered nonvolatile memories.
- **Flash Memory**: Includes nonvolatile products designed as flash EPROM/EEPROM that incorporate either 5V or 12V programming supplies and one-transistor (1T) or two-transistor (2T) memory cells with electrical programming and fast chip or sector erase. Flash memory can erase data only by chip or sector, not by byte. These devices are considered nonvolatile memories.
- **ROM**: Defined as mask-programmable read-only memory. ROM is a form of memory that is programmed by the manufacturer to a user specification using a mask step. ROM is programmed in hardware rather than software. These devices are considered nonvolatile memories.
- **Other MOS Digital Memory ICs**: Defined as all other MOS digital memory not already accounted for in the preceding categories. Includes MOS digital content addressable memory (CAM), MOS digital cache-tag RAM, MOS digital first-in/first-out (FIFO) memory, MOS digital last-in/first-out (LIFO) memory and ferroelectric memory.

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EMEA Region

Dataquest defines the EMEA region as follows:

- Benelux: Belgium, the Netherlands and Luxembourg
- France
- Italy
- Nordic Region: Denmark, Norway, Sweden and Finland
- United Kingdom/Ireland
- Germany
- Rest of EMEA region
    - Rest of Western Europe: Andorra, Austria, Cyprus, Faroe Islands, Gibraltar, Greece, Greenland, Guernsey, Iceland, Isle of Man, Jersey, Liechtenstein, Malta, Monaco, Portugal, San Marino, Spain, Svalbard and Switzerland
    - Central/Eastern Europe: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, the Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Macedonia, Moldova, Poland, Romania, Russia, Slovakia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan and Yugoslavia (Serbia and Montenegro)
    - Middle East/Africa: Afghanistan, Algeria, Angola, Bahrain, Bassas da India, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Cote d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Europa Island, Gabon, Gambia, Ghana, Glorioso Islands, Guinea, Guinea-Bissau, Iran, Iraq, Israel, Jordan, Juan de Nova Island, Kenya, Kuwait, Lebanon, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mayotte, Morocco, Mozambique, Namibia, Niger, Nigeria, Oman, Qatar, Reunion, Rwanda, Saint Helena, Sao Tome and Principe, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Syria, Tanzania, Togo, Tromelin Island, Tunisia, Turkey, Uganda, United Arab Emirates, Western Sahara, Yemen, Zaire, Zambia and Zimbabwe

Rounding

Please note that some tables might not add up to totals because of rounding.

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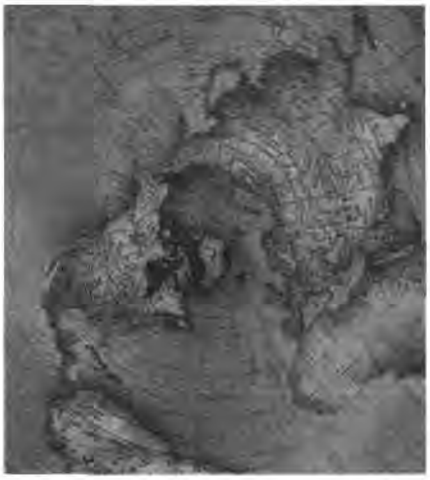

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Final 1997 EMEA Semiconductor Market Share Rankings

Market Statistics

1998

Program: Semiconductors Europe
Product Code: SEMI-EU-MS-9802
Publication Date: May 8, 1998
Filing: Market Statistics

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Final 1997 EMEA Semiconductor Market Share Rankings

Executive Summary

- In 1997 there was a return to growth in the EMEA semiconductor market, with revenue 5.9 percent higher than in 1996, which was 2.4 percent more growth than that of the worldwide market. EMEA companies grew their share of the worldwide market by 0.5 percent, raising it to 10.1 percent.
- The EMEA market still had the lowest worldwide semiconductor total available market (TAM) despite increasing by 0.4 percent to 20.4 percent of worldwide semiconductor TAM in 1997.
- DRAM continued to be the major price driver in 1997, and DRAM revenue continued to shrink even though the market experienced 107 percent DRAM bit growth.
- Intel continued to dominate the rankings at 2.7 times the size of its nearest contender in EMEA. The company accounted for 19.4 percent of the market, a rise of 1.6 percent over 1996.

Project Analysts: Joe D'Elia and Ellie Babaie

Introduction

This *Market Statistics* report contains Dataquest's final estimates of semiconductor vendor market shares in EMEA for 1997.

EMEA semiconductor sales by vendor base region over the past 17 years are shown in Table 1. Some of these figures are plotted in Figure 1, which shows that EMEA companies' share of their home market showed a slight upturn of 0.5 percent in 1997. This follows several years of negative or static growth and may be the precursor of future growth as the market moves to higher integration differentiated products. Japanese companies' share of the market continued the decline started in 1996, as did Asia/Pacific companies, and the Americas companies' continued to grow their share of the market, again a trend started in 1996. These trends are mirrored at the worldwide level, as is shown in Figure 2, where the dramatic reversal of fortunes for Japan and Asia/Pacific companies is evident.

EMEA's diverse mix of applications stood it in good stead in 1997, with the decline of the DRAM market being counteracted by unit growth in the PC market and, therefore, higher sales of microprocessors. The incredible growth in digital cellular handsets also made significant contributions to the microcontroller, ASIC and flash memory segments. The contribution made by these applications resulted in EMEA increasing its share of the worldwide market by 0.4 percent, significantly lower than in 1996 when its share grew by 1.2 percent. However, it should be borne in mind that EMEA's performance relative to worldwide performance in 1996 was much better, as the EMEA market grew when the worldwide market shrank.

Although the EMEA market grew in 1997, this must be put in perspective, it was still the smallest of the four regions comprising the worldwide semiconductor market, with 20.4 percent of the world semiconductor TAM. The Asia/Pacific market, which still grew during 1997, had 22.1 percent share, the declining Japanese market had a 24.8 percent share, and the Americas market had 32.7 percent, having experienced modest growth (see Figure 3).

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Table 1
EMEA Semiconductor Sales by Company Base Region, 1981-1997

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Revenue in EMEA by Company Base Region																	
Americas	1,596	1,656	1,680	2,475	2,377	2,539	2,746	3,664	4,010	4,469	4,780	5,530	7,706	9,928	12,673	14,680	16,184
Japan	160	214	332	609	534	664	845	1,466	1,772	1,643	1,756	2,008	2,607	3,885	5,822	4,554	4,168
EMEA	1,285	1,297	1,358	1,721	1,809	2,323	2,714	3,196	3,478	4,064	4,146	4,157	4,330	5,328	7,105	7,124	7,686
Asia/Pacific & Rest of World	NA	NA	NA	NA	NA	6	50	165	238	239	332	523	807	1,759	2,810	2,021	2,008
Total EMEA	3,041	3,167	3,370	4,805	4,720	5,532	6,355	8,491	9,498	10,415	11,014	12,218	15,450	20,900	28,410	28,379	30,046
Share of Revenue by Company Base Region																	
Americas	52.48%	52.29%	49.85%	51.51%	50.36%	45.90%	43.21%	43.15%	42.22%	42.91%	43.40%	45.26%	49.88%	47.50%	44.61%	51.73%	53.86%
Japan	5.26%	6.76%	9.85%	12.67%	11.31%	12.00%	13.30%	17.27%	18.66%	15.78%	15.94%	16.43%	16.87%	18.59%	20.49%	16.05%	13.87%
EMEA	42.26%	40.95%	40.30%	35.82%	38.33%	41.99%	42.71%	37.64%	36.62%	39.02%	37.64%	34.02%	28.03%	25.49%	25.01%	25.10%	25.58%
Asia/Pacific & Rest of World	0.00%	0.00%	0.00%	0.00%	0.00%	0.11%	0.79%	1.94%	2.51%	2.29%	3.01%	4.28%	5.22%	8.42%	9.89%	7.12%	6.68%
Growth of EMEA Revenue by Company Base Region																	
Americas		3.8%	1.4%	47.3%	-4.0%	6.8%	8.2%	33.4%	9.4%	11.4%	7.0%	15.7%	39.3%	28.8%	27.6%	15.8%	10.2%
Japan		33.8%	55.1%	83.4%	-12.3%	24.3%	27.3%	73.5%	20.9%	-7.3%	6.9%	14.4%	29.8%	49.0%	49.9%	-21.8%	-8.5%
EMEA		0.9%	4.7%	26.7%	5.1%	28.4%	16.8%	17.8%	8.8%	16.8%	2.0%	0.3%	4.2%	23.0%	33.4%	0.3%	7.9%
Asia/Pacific & Rest of World		NA	NA	NA	NA	NA	NA	NA	NA	0.4%	38.9%	57.5%	54.3%	118.0%	59.7%	-28.1%	-0.6%
Total EMEA		4.1%	6.4%	42.6%	-1.8%	17.2%	14.9%	33.6%	11.9%	9.7%	5.8%	10.9%	26.5%	35.3%	35.9%	-0.1%	5.9%

NA = not applicable
Source: Dataquest (May 1998 Estimates)

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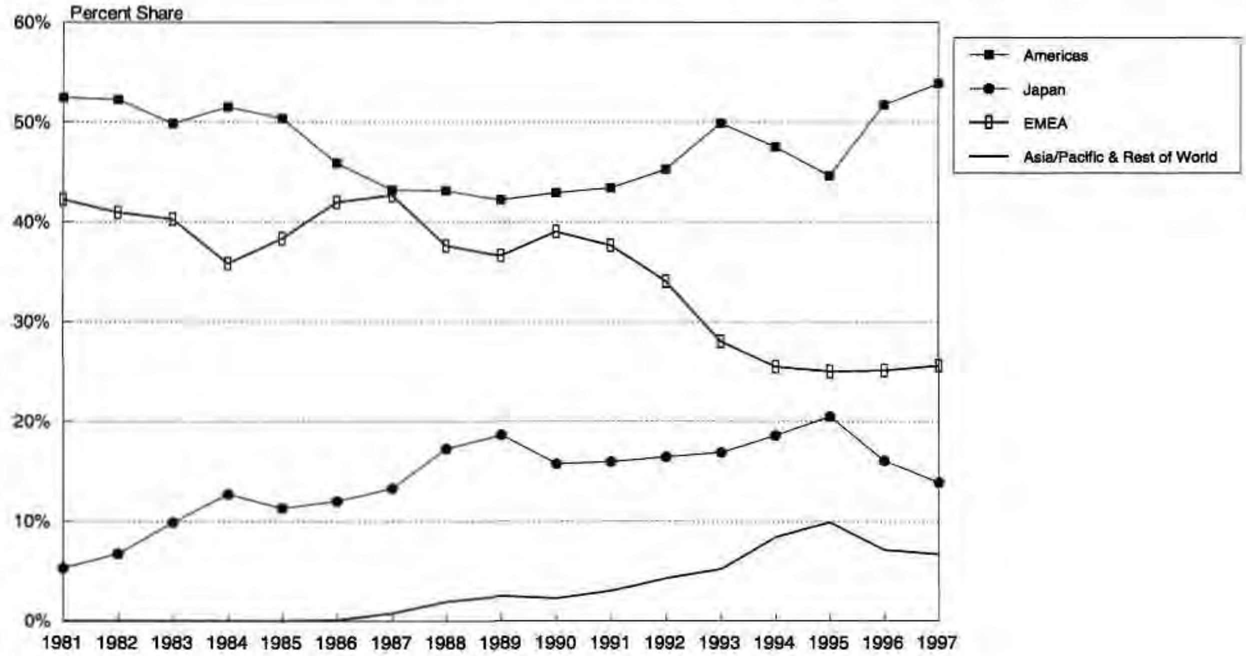
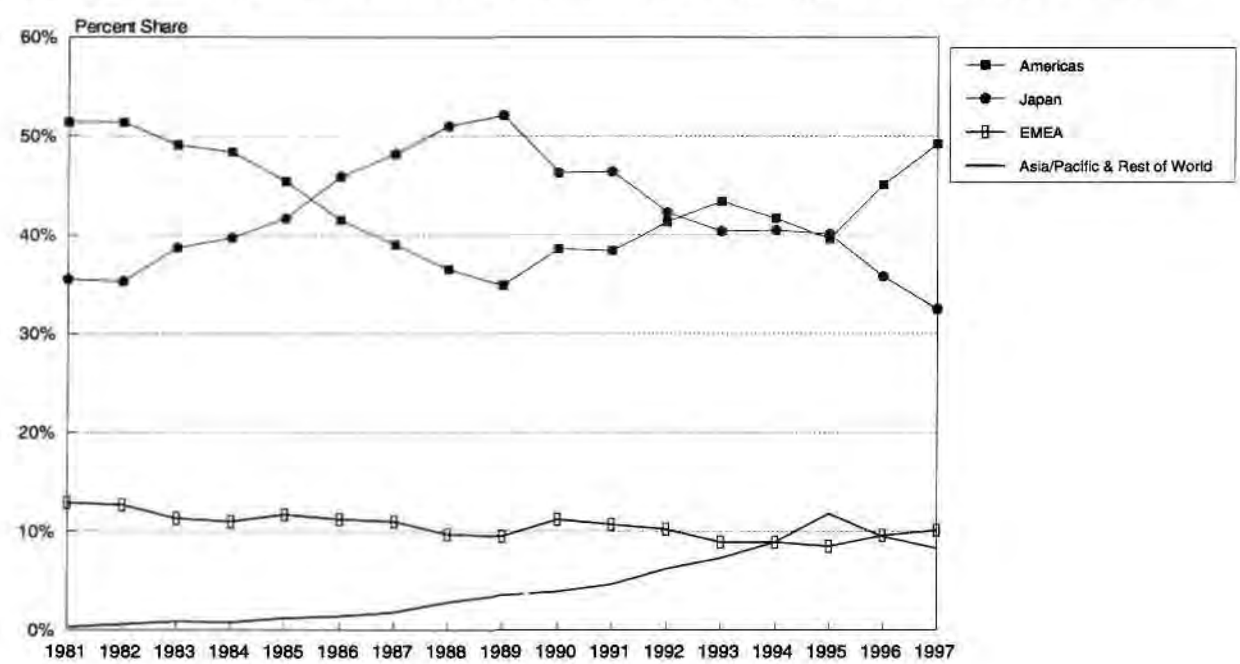
Figure 1
Share of EMEA Semiconductor Revenue by Company Base Region, 1981-1997



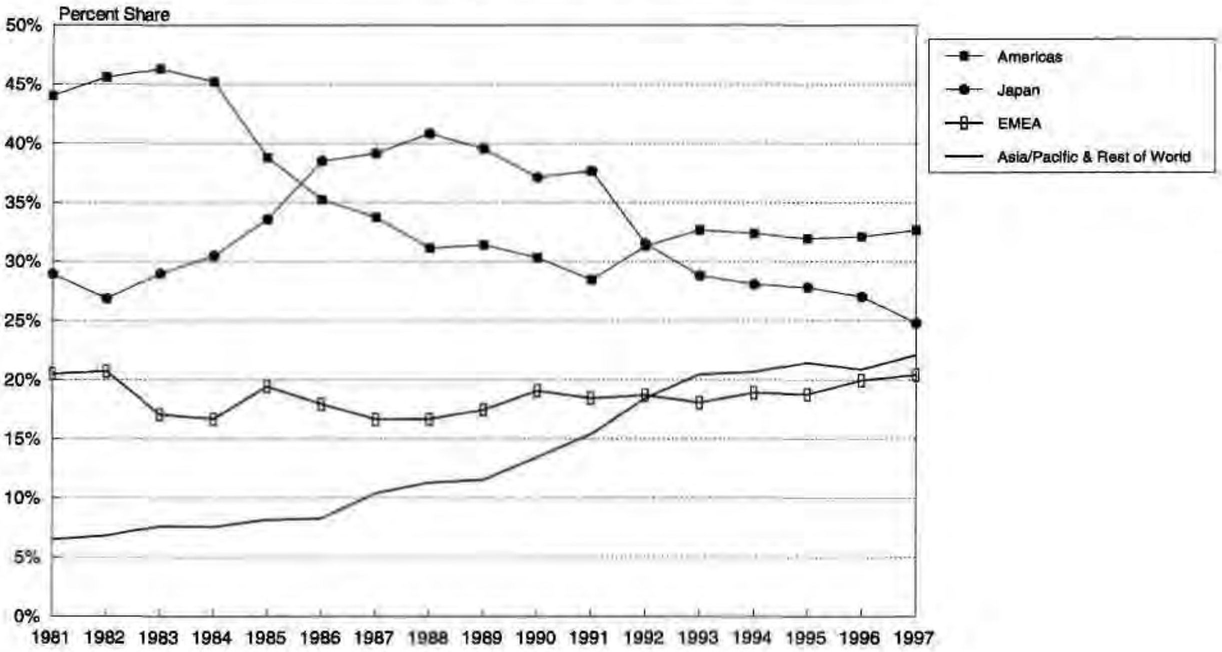
Source: Dataquest (May 1998 Estimates)

Figure 2
Share of Worldwide Semiconductor Revenue by Company Base Region, 1981-1997



Source: Dataquest (May 1998 Estimates)

Figure 3
Share of Worldwide Semiconductor Revenue by Region, 1981-1997



Source: Dataquest (May 1998 Estimates)

Products

The 1997 product categories are not absolutely in line with those of previous years; observant readers will have noticed the omission of the word hybrids in all our product category titles. Because of the decline of this category, the residual hybrids have been absorbed into the appropriate functional category, and will no longer be a category tracked by Dataquest. The 1996 numbers have been restated where necessary to allow comparison with the current year. Other changes have occurred in MOS digital logic and analog, where the mixed-signal ASIC and linear array categories have been switched from analog to MOS digital logic; therefore, the 1997 growth rates for these categories are somewhat artificial.

Table 2 shows the EMEA market split by product category. The largest percentage decline is in bipolar digital, which fell by 31.7 percent; the surprise here is more that the category continues to exist rather than the rate of decline. Compared with the previous year, the decline is accelerating, and by the end of the decade the category will in all probability have disappeared as per hybrid above. The most significant decline is in memory, which declined 12.7 percent, here the guilty party was, as in 1996, DRAM, which declined 12.8 percent. The other category that declined was optoelectronics, which suffered severe erosion of ASPs throughout the year.

Looking at the positive side, MOS microcomponents grew 17.1 percent, making this category by far the largest in EMEA. MOS logic also grew, although the rate is raised artificially by the shift of the two categories discussed above. This correspondingly lowers the increase in analog, with a growth of 3.7 percent, which would have been higher without the reassignment; discretes also grew by 9.6 percent. All these categories are listed in Table 2, and growth is shown in Figure 4. Figure 5 shows EMEA semiconductor product share of revenue for 1997 by region.

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The different regions are prime sources for different product categories, this is illustrated in Figure 5, which shows that the bulk of Asia/Pacific shipments were memory, while the majority of Americas-sourced shipments were micro-components. Japanese shipments used to be more than 50 percent memory, in 1997 that figure dropped to 38 percent of total shipments to EMEA.

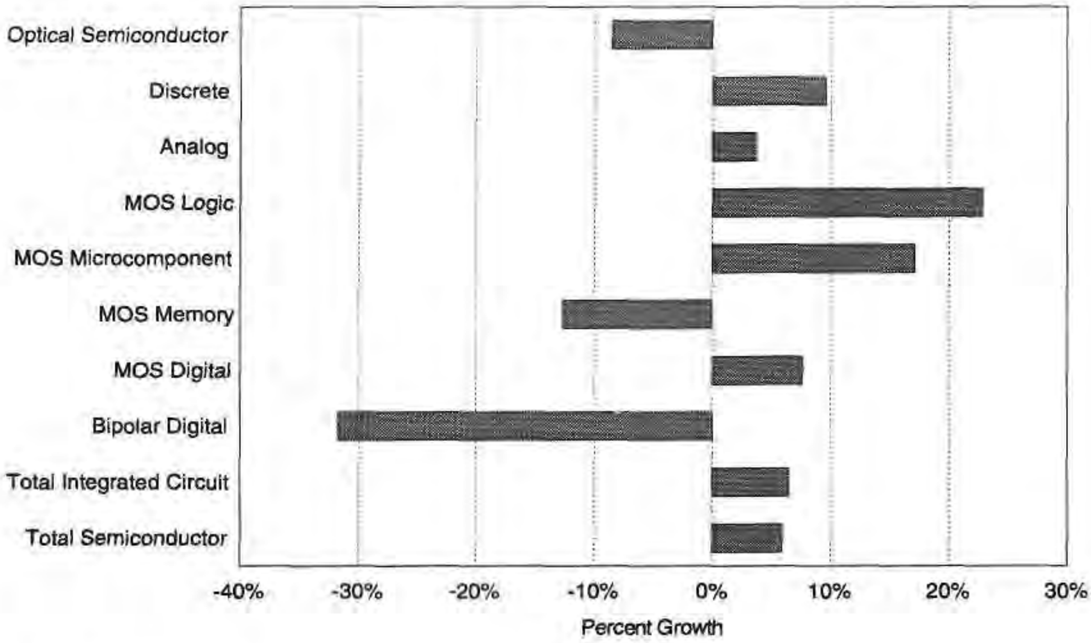
EMEA's strongest product category traditionally has been analog, and this remains the case in 1997, with 34 percent of shipments into EMEA from EMEA companies falling into this category.

Table 2
EMEA Total Available Market by Product Category, 1996 and 1997

Product Category	1996 ($M)	1997 ($M)	Growth (%)	Share (%)
Total Semiconductor	**28,379**	**30,046**	**5.9%**	**100.0%**
Hybrids	126	-	NA	NA
Total Integrated Circuit	24,606	26,195	6.5%	87.2%
Bipolar Digital	246	168	-31.7%	0.6%
MOS Digital	19,645	21,139	7.6%	70.4%
MOS Memory	6,918	6,041	-12.7%	20.1%
MOS Microcomponent	9,341	10,939	17.1%	36.4%
MOS Logic	3,386	4,159	22.8%	13.8%
Analog	4,715	4,888	3.7%	16.3%
Discrete	2,848	3,120	9.6%	10.4%
Optical Semiconductor	799	731	-8.5%	2.4%

NA = not applicable
Source: Dataquest (May 1998 Estimates)

Figure 4
EMEA Semiconductor Product Growth, 1997 over 1996



Source: Dataquest (May 1998 Estimates)

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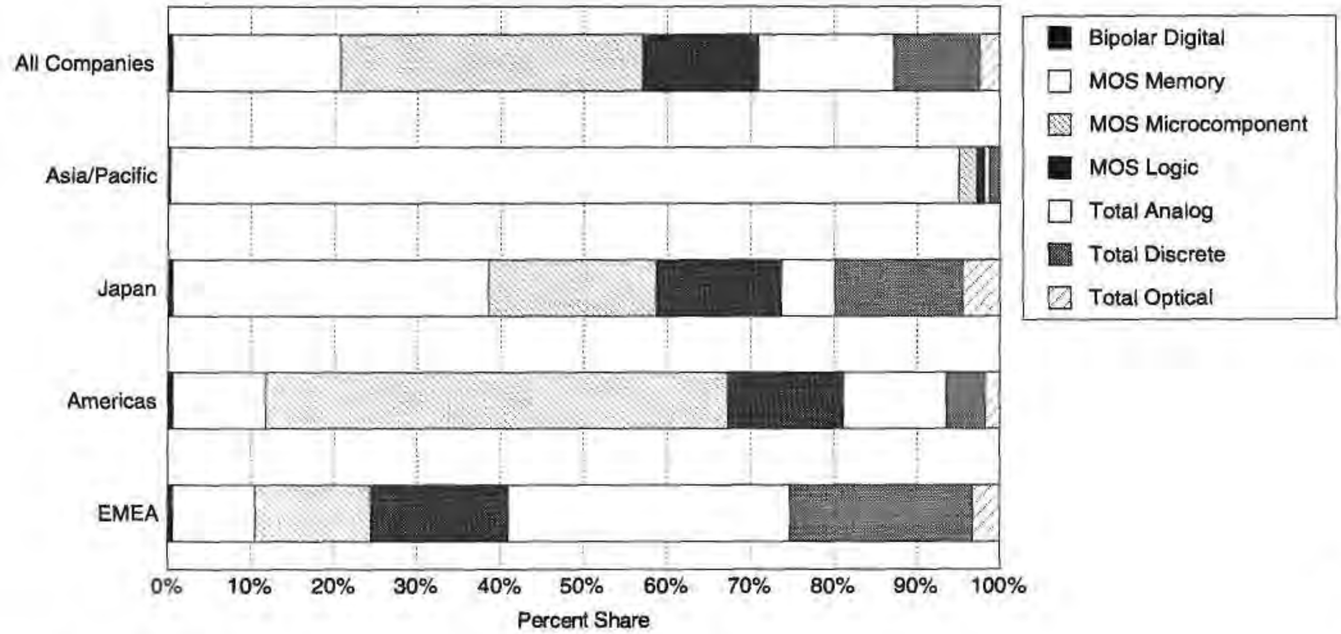
Figure 5
EMEA Semiconductor Product Share of Revenue, 1997



Source: Dataquest (May 1998 Estimates)

Growth of Intel

Intel remains unique, the gap between Intel and the second-place contender, Siemens, grew to $3.6 billion in 1997. Intel's EMEA revenue was $5.8 billion, while Siemens, in second place, had revenue of $2.2 billion. This gap has been growing over the past few years, and Table 3 shows that over the period 1992 to 1997 the ratio grew from 1.2 to 2.7. Also, during this period Intel's share of the EMEA market grew dramatically from 9.3 percent to 19.4 percent of all EMEA shipments. Intel's CAGR for the period 1992 to 1997 was 38.6 percent, while the CAGR for Siemens was 17.5 percent, which was even less than the CAGR of 19.7 percent for the total EMEA market during this period.

Table 3
Intel: Market Share and Ratio to Nearest Contender, 1992 to 1997

	1992	1993	1994	1995	1996	1997	1997/1992 CAGR (%)
Intel Revenue ($M)	1,136	2,056	2,605	3,240	5,044	5,811	38.6%
Second-Place Revenue ($M)	975	1,260	1,380	2,058	2,068	2,182	17.5%
Total Market Revenue ($M)	12,218	15,486	20,900	28,410	28,379	30,002	19.7%
Ratio: Intel/Second Place	1.2	1.6	1.9	1.6	2.4	2.7	
Intel Share of Total Market	9.3%	13.3%	12.5%	11.4%	17.8%	19.4%	

Source: Dataquest (May 1998 Estimates)

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EMEA Companies' Performance Worldwide

EMEA companies are active on the world stage, and are not supplying just to an EMEA customer base. Table 4 shows how they performed on a global basis in 1996 and 1997. Of the big three EMEA players, only Siemens showed any improvement in its ranking, having moved up one place to 12th position. TEMIC, in its last year of existence, remained static, and GEC Plessey, similarly in its last year of existence, dropped seven places, as the uncertainty about its future influenced customers' decisions about whether or not to buy the company's products.

Outside the five top-placed EMEA companies, Micronas was the entity that resulted from the merging of Micronas OY and ITT Intermetall, and, for the first time, we have the commercial market sales of Robert Bosch appearing in the semiconductor rankings. Mietec metamorphosed into Alcatel Microelectronics and lost two places, even though its sales actually increased above the worldwide growth norm of 3.5 percent. Ericsson also grew its sales but remained static in 75th place, while Austrian Mikro Systeme's revenue decreased, resulting in a four-place drop to 89th position.

The single, most significant improvement in rankings was achieved by TCS, which grew its sales by more than 48 percent and jumped 13 places to 93rd position. Further down the rankings are two new names: Power Innovations, which is the management buyout of Texas Instruments' power devices group in the United Kingdom, and Elex, which has been transformed into Melexis.

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Table 4
Top 19 EMEA Companies' Factory Revenue from Shipments of Total Semiconductors to Worldwide, 1996 and 1997

1996 Rank	1997 Rank	Change in Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	1997 AGR (%)	1997 Market Share (%)
9	9	0	Philips	4,220	4,440	5.2%	3.0%
10	10	0	SGS-Thomson	4,112	4,019	-2.3%	2.7%
13	12	1	Siemens	3,029	3,441	13.6%	2.3%
32	32	0	TEMIC	813	856	5.3%	0.6%
52	59	-7	GEC Plessey	338	295	-12.7%	0.2%
-	61	NA	Micronas	307	285	-7.2%	0.2%
-	67	NA	Robert Bosch	NA	240	NA	0.2%
69	71	-2	Alcatel Microelectronics	190	215	13.2%	0.1%
75	75	0	Ericsson	170	180	5.9%	0.1%
85	89	-4	Austria Mikro Systeme	140	130	-7.1%	0.1%
106	93	13	TCS	83	123	48.2%	0.1%
94	100	-6	Semikron	109	116	6.4%	0.1%
78	103	-25	Eupec	160	111	-30.6%	0.1%
118	112	6	Zetex	54	93	72.2%	0.1%
104	114	-10	EM Microelectronics Marin	85	89	4.7%	0.1%
-	145	NA	Fagor	NA	32	NA	0.0%
-	149	NA	Power Innovations	NA	29	NA	0.0%
135	150	-15	Melexis	34	22	-35.3%	0.0%
156	159	-3	Elmos	7	9	28.6%	0.0%
			Other EMEA Companies	105	84	-20.0%	0.1%
			Total EMEA Companies	13,956	14,809	6.1%	10.1%
			Total Worldwide Semiconductor Market	**142,150**	**147,165**	**3.5%**	

NA = not applicable
Source: Dataquest (May 1998 Estimates)

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EMEA's Top Ten Companies

Intel

Intel's growth was driven once again by its dominance in the PC processor market. Of its $5.8 billion total revenue, $4.9 billion was from x86 processors in compute applications. The total compute microprocessor category was $5.5 billion and encompassed Intel's x86 competitors and the use of PowerPCs by Apple in Ireland. Intel lost its flash crown in EMEA during 1997, as not only did its revenue drop, but it also lost the first-place ranking that it had maintained since the creation of this category. Intel's other main product category was microperipherals, where its sales grew from $386 million to $432 million in 1997, thereby strengthening its number-one position in the category.

Siemens

Despite being EMEA's only indigenous DRAM vendor, Siemens managed to increase its worldwide revenue by 13.6 percent and its EMEA revenue by 5.5 percent in 1997. In EMEA the company's DRAM revenue shrank by 9.4 percent, less than the industry average; worldwide, the company managed to grow its DRAM revenue by 12.7 percent—no mean feat when the market was shrinking. Analog products, in particular those for telecommunications and automotive, drove Siemens' success in EMEA, where the company leveraged the systems expertise available in the Siemens equipment manufacturing groups to consolidate its grip on these categories. Also adding to the company's growth were successes in the discrete and microcomponents categories, which benefited from new product acceptance in volume applications.

Motorola

Motorola had a relatively flat year in EMEA, growing semiconductor revenue only 2.2 percent. Memory revenue was clearly down as Motorola exited the DRAM market, but SRAM revenue was also down as fast cache SRAM ASPs collapsed. The areas of growth that counterbalanced declines in logic and memory were microprocessors and DSP, where the company experienced major growth as Apple migrated to higher-performance PowerPC products. DSP revenue was boosted by the huge surge in digital cellular handset production in EMEA. The drop in microcontroller revenue gives cause for concern, as, historically, this has been one of Motorola's strengths.

Philips

Philips grew in line with the industry average in EMEA, and this resulted in it gaining one place in the rankings, moving to fourth position. While microcomponents appear to have declined and analog to have grown, the changes in these categories are more a result of reclassification of some products into more appropriate categories. The area that showed real growth was discretes, where Philips made significant gains on the power transistor front, with increases in both bipolar and MOS devices; being particularly successful in the automotive sector with these latter devices.

SGS-Thomson

Following growth in 1996, 1977 was disappointing for SGS-Thomson, as several markets that were poised to provide good growth for the company either collapsed, as in the form of the hard disk drive market, or failed to materialize because of regulatory interference by the European Union. This regulatory interference impacted the takeoff of digital set-top boxes, an application area in which SGS-Thomson is well placed. Comparison of 1997's numbers with those of previous years will show significant changes in several product categories, as SGS-Thomson moved some product lines to synchronize them with the industry norm.

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Texas Instruments

Texas Instruments managed to grow its EMEA business well above the industry average, and achieved 16.4 percent growth. Significant gains were made in the DSP, MOS digital logic and analog categories in 1997. Some of these gains were as a result of product reclassification, but most were because of the advances that the company has made in supplying products incorporating a high level of system integration to markets such as digital cellular handsets. Aggressive pursuit of available business even allowed the company to grow its DRAM business marginally in the region. The jump in DSP was particularly impressive and heralds the success of the decision to base the company's future on this technology.

Samsung

While successful in growing its business and increasing market share in 1997, Samsung was able to do this only in its traditional product areas of DRAM and SRAM. The strategy to diversify out of these areas has not succeeded yet and took a step backwards in 1997 as memory increased its share of Samsung's EMEA revenue to 95.5 percent, having dropped to 94.0 percent in 1996.

NEC

NEC's revenue in EMEA was flat, with the company showing 0.4 percent growth for the year. The drop in DRAM revenue was compensated for by rises in ASIC, discrete and optoelectronics, while microcomponents remained steady. This result is a vindication of NEC's diversification strategy, as nonmemory products accounted for 59.1 percent of its EMEA revenue in 1997, having been 50.7 percent in 1996.

Hitachi

Hitachi's DRAM revenue dropped significantly from $393 million to $236 million in 1997. Some of this loss was offset by growth in other products; however, this was not enough to stop the company's revenue declining by 13.0 percent. The "star" in Hitachi's nonmemory revenue in previous years had been 16-bit microcontrollers, but this segment showed zero growth in 1997, indicating that the company had failed to find any further significant design wins. The product group with the highest growth proved to be discretes, an area which Hitachi has not been noted for in the past.

National Semiconductor

National Semiconductor's figures are not a direct comparison with any that have been published before; only comparisons between the 1996 and 1997 figures published in this document are valid. The reason for this is that during 1997 the company divested itself of the Fairchild division and acquired Cyrix. This has altered the product mix radically, thus making comparison with past years difficult. National Semiconductor is fast becoming synonymous with the PC through its indigenous peripherals business and the acquisition of Cyrix. These areas were strong for the company in 1997, as it supplied its multi-I/O devices to the remaining EMEA PC motherboard manufacturers, its Ethernet devices to major networking companies and Cyrix processors to the second- and third-tier players in EMEA.

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Product Classification Tables

Tables 5 to 23 show the rankings in all the major product groups together with some subsidiary groups. These subsidiary groups are included where they had a significant impact and where there have been definition changes. By including these extra tables those customers wishing to compare the figures with previous years can extract the data in the format that they desire.

As Dataquest is not publishing a separate ASIC market share report this year, we have also included some of the detail tables that would have appeared in that document.

The hierarchy of the product categories used in the tables included is as follows:

- All Semiconductor
  - Digital Bipolar
  - Memory
    - DRAM
    - Flash
  - Microcomponents
  - Logic
    - ASIC
      - Gate Array
      - Cell Based
        - Linear Arrays
        - Mixed Signal
      - PLD
    - Custom
    - Standard Logic
    - Other Logic
  - Analog
  - Discretes
  - Optoelectronic

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Table 5
Top 150 Worldwide Companies' Factory Revenue from Shipments of Total Semiconductors (Including Hybrids) to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
1	1	Intel	5,044	5,811	15.2	19.3
2	2	Siemens	2,068	2,182	5.5	7.3
3	3	Motorola	1,844	1,885	2.2	6.3
5	4	Philips	1,748	1,847	5.7	6.1
4	5	SGS-Thomson	1,814	1,777	-2.0	5.9
6	6	Texas Instruments	1,502	1,748	16.4	5.8
7	7	Samsung	1,156	1,240	7.3	4.1
8	8	NEC	1,095	1,099	0.4	3.7
9	9	Hitachi	872	759	-13.0	2.5
12	10	National Semiconductor	605	707	16.9	2.4
14	11	Advanced Micro Devices	527	679	28.8	2.3
10	12	Toshiba	810	625	-22.8	2.1
11	13	Fujitsu	636	621	-2.4	2.1
13	14	Lucent Technologies	562	593	5.5	2.0
18	15	Hyundai	395	408	3.3	1.4
16	16	Mitsubishi	415	397	-4.3	1.3
17	17	Analog Devices	396	390	-1.5	1.3
15	18	TEMIC	416	389	-6.5	1.3
20	19	IBM	320	332	3.8	1.1
21	20	Hewlett-Packard	290	283	-2.4	0.9
22	21	Micron Technology	259	280	8.1	0.9
27	22	VLSI Technology	185	277	49.7	0.9
19	23	LG Semicon	377	274	-27.3	0.9
24	24	Rockwell	222	258	16.2	0.9
25	25	LSI Logic	212	242	14.2	0.8
-	26	Robert Bosch	0	210	NA	0.7
28	27	Alcatel Microelectronics	184	207	12.5	0.7
77	28	Micronas	24	197	720.8	0.7
29	29	Harris	175	185	5.7	0.6
23	30	Atmel	238	164	-31.1	0.5
30	31	GEC Plessey	169	139	-17.8	0.5
34	32	Rohm	124	134	8.1	0.4
33	33	Xilink	125	128	2.4	0.4
31	34	International Rectifier	153	126	-17.6	0.4
40	35	Altera	104	126	21.2	0.4
47	36	Microchip Technology	81	125	54.3	0.4
37	37	Ericsson	109	114	4.6	0.4
41	38	Maxim	102	113	10.8	0.4
35	39	Austria Mikro Systeme	117	112	-4.3	0.4
42	40	General Semiconductor	99	101	2.0	0.3

(continued)

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Table 5 (Continued)
Top 150 Worldwide Companies' Factory Revenue from Shipments of Total Semiconductors (Including Hybrids) to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
45	41	Sun Microsystems	85	100	17.6	0.3
38	42	Sanyo	106	99	-6.6	0.3
50	43	TCS	73	99	35.6	0.3
-	44	Fairchild	0	94	NA	0.3
32	45	Sony	126	93	-26.2	0.3
44	46	Linear Technology	85	90	5.9	0.3
46	47	Cypress Semiconductor	82	90	9.8	0.3
64	48	Sharp	34	86	152.9	0.3
36	49	Oki	110	84	-23.6	0.3
43	50	Integrated Device Technology	96	81	-15.6	0.3
39	51	Eupec	106	80	-24.5	0.3
49	52	Semikron	73	76	4.1	0.3
48	53	EM Microelectronics Marin	73	75	2.7	0.2
52	54	Cirrus Logic	63	70	11.1	0.2
55	55	Dallas Semiconductor	51	55	7.8	0.2
67	56	Lattice	30	55	83.3	0.2
51	57	Burr-Brown	64	49	-23.4	0.2
72	58	Zetex	28	48	71.4	0.2
54	59	Mitel	56	47	-16.1	0.2
62	60	C-Cube	35	43	22.9	0.1
60	61	IXYS	39	40	2.6	0.1
-	62	Vitesse	0	38	NA	0.1
59	63	Honeywell	40	37	-7.5	0.1
58	64	Zilog	41	36	-12.2	0.1
68	65	Digital	29	35	20.7	0.1
71	66	Standard Microsystems	28	35	25.0	0.1
-	67	Anadigics	0	35	NA	0.1
-	68	Stanley	0	33	NA	0.1
63	69	Symbios	34	30	-11.8	0
99	70	ATI Technologies	10	30	200.0	0
118	71	Vanguard	5	30	500.0	0
73	72	PMC Sierra Semiconductor	27	29	7.4	0
61	73	Allegro MicroSystems	35	28	-20.0	0
70	74	Sanken	29	27	-6.9	0
57	75	S3	42	26	-38.1	0
66	76	United Microelectronics	31	26	-16.1	0
76	77	Shindengen Electric	24	25	4.2	0
-	78	ESS	0	25	NA	0
75	79	Microsemi	24	24	0	0
69	80	Xicor	29	23	-20.7	0

(continued)

Table 5 (Continued)
Top 150 Worldwide Companies' Factory Revenue from Shipments of Total Semiconductors (Including Hybrids) to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
74	81	Actel	26	23	-11.5	0
79	82	Unitrode	20	20	0	0
85	83	8x8	15	19	26.7	0
-	84	Fagor	0	19	NA	0
-	85	Power Innovations	0	19	NA	0
130	86	Telcom	2	18	800.0	0
-	87	I.S.D.	0	18	NA	0
78	88	Fuji Electric	23	17	-26.1	0
65	89	Melexis	33	16	-51.5	0
81	90	Quality Technologies	18	16	-11.1	0
83	91	Optek	17	16	-5.9	0
84	92	Gennum	16	16	0	0
89	93	DSP Group	13	16	23.1	0
97	94	Integrated Silicon Solutions	10	16	60.0	0
-	95	Triquint	0	16	NA	0
53	96	Matsushita	60	15	-75.0	0
82	97	Raytheon	18	14	-22.2	0
86	98	Exar	14	14	0	0
87	99	Seiko Epson	14	14	0	0
88	100	Level One Communications	13	13	0	0
93	101	Catalyst	11	12	9.1	0
101	102	Alliance Semiconductor	9	12	33.3	0
92	103	Mosel Vitelic	12	11	-8.3	0
96	104	Integrated Circuit Systems	10	11	10.0	0
95	105	Electronic Designs	11	10	-9.1	0
98	106	Semtech	10	10	0	0
106	107	WaferScale Integration	7	9	28.6	0
107	108	Elmos	7	9	28.6	0
103	109	Cherry Semiconductor	7	7	0	0
105	110	Supertex	7	7	0	0
108	111	Winbond Electronics	7	7	0	0
109	112	Q Logic	6	7	16.7	0
110	113	Gould AMI	5	6	20.0	0
113	114	Teccor Electronics	5	6	20.0	0
91	115	VTC	12	5	-58.3	0
94	116	Chips & Technologies	11	5	-54.5	0
112	117	Linfinity	5	5	0	0
115	118	New JRC	5	5	0	0
120	119	Elantec	4	5	25.0	0
123	120	Zoran	4	5	25.0	0

(continued)

Table 5 (Continued)
Top 150 Worldwide Companies' Factory Revenue from Shipments of Total Semiconductors (Including Hybrids) to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
90	121	Macronix	13	4	-69.2	0
111	122	QuickLogic	5	4	-20.0	0
119	123	VIA	5	4	-20.0	0
102	124	Applied Micro Circuits Corp.	7	3	-57.1	0
116	125	Ricoh	5	3	-40.0	0
121	126	Silicon Storage Technology	4	3	-25.0	0
125	127	Quality Semiconductor	3	3	0	0
132	128	Chip Express	1	3	200.0	0
136	129	SEEQ Technology	1	3	200.0	0
124	130	Holtek	4	2	-50.0	0
126	131	Yamaha	3	2	-33.3	0
127	132	Hughes	2	2	0	0
129	133	Micro Linear	2	2	0	0
139	134	Nippon Steel Semiconductor	1	2	100.0	0
104	135	Opti	7	1	-85.7	0
117	136	Acer	5	1	-80.0	0
131	137	ACC Microelectronics	1	1	0	0
133	138	ETEQ Microsystems	1	1	0	0
135	139	Logic Devices	1	1	0	0
137	140	G-Link USA	1	1	0	0
138	141	Paradigm	1	1	0	0
140	142	Korean Electronic Co.	1	1	0	0
26	143	ITT	185	0	-100.0	0
56	144	Cyrix	50	0	-100.0	0
80	145	Oak Technology	19	0	-100.0	0
100	146	Silicon Integrated Systems	10	0	-100.0	0
114	147	Trident Microsystems	5	0	-100.0	0
122	148	Tseng Labs	4	0	-100.0	0
128	149	Micrel	2	0	-100.0	0
134	150	International CMOS Technology	1	0	-100.0	0
		All Others	145	99	-31.7	0.3
		Americas Companies	14,679	16,184	10.3	53.9
		Japanese Companies	4,554	4,168	-8.5	13.9
		EMEA Companies	7,125	7,686	7.9	25.6
		Asia/Pacific Companies	2,021	2,008	-0.6	6.7
		Total Market	**28,379**	**30,046**	**5.9**	**100.0**

NA = not applicable
Source: Dataquest (May 1998 Estimates)

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Table 6
Top 16 Worldwide Companies' Factory Revenue from Shipments of Bipolar Digital to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
1	1	Texas Instruments	60	43	-28.3	25.6
2	2	Motorola	42	40	-4.8	23.8
4	3	Siemens	30	27	-10.0	16.1
5	4	Philips	24	19	-20.8	11.3
7	5	NEC	15	17	13.3	10.1
6	6	Advanced Micro Devices	15	7	-53.3	4.2
-	7	Mosel Vitelic	0	6	NA	3.6
3	8	National Semiconductor	32	3	-90.6	1.8
8	9	Fujitsu	6	2	-66.7	1.2
10	10	Toshiba	5	2	-60.0	1.2
9	11	Hitachi	5	1	-80.0	0.6
15	12	Mitsubishi	1	1	0	0.6
11	13	Applied Micro Circuits Corp.	4	0	-100.0	0
12	14	Raytheon	4	0	-100.0	0
13	15	GEC Plessey	2	0	-100.0	0
14	16	Matsushita	1	0	-100.0	0
		All Others	0	0	NA	0
		Americas Companies	157	93	-40.8	55.4
		Japanese Companies	33	23	-30.3	13.7
		EMEA Companies	56	46	-17.9	27.4
		Asia/Pacific Companies	0	6	NA	3.6
		Total Market	**246**	**168**	**-31.7**	**100.0**

NA = not applicable
Source: Dataquest (May 1998 Estimates)

Table 7
Top 47 Worldwide Companies' Factory Revenue from Shipments of MOS Memory to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
1	1	Samsung	1,090	1,184	8.6	19.6
3	2	Siemens	494	479	-3.0	7.9
2	3	NEC	540	446	-17.4	7.4
6	4	Texas Instruments	409	421	2.9	7.0
7	5	Hyundai	395	408	3.3	6.8
5	6	Fujitsu	433	341	-21.2	5.6
12	7	Micron Technology	259	280	8.1	4.6
9	8	LG Semicon	376	267	-29.0	4.4
14	9	Advanced Micro Devices	225	253	12.4	4.2
4	10	Hitachi	469	236	-49.7	3.9
13	11	Intel	250	222	-11.2	3.7
11	12	Mitsubishi	278	211	-24.1	3.5
8	13	SGS-Thomson	391	203	-48.1	3.4
15	14	IBM	174	197	13.2	3.3
10	15	Toshiba	342	164	-52.0	2.7
16	16	Atmel	142	85	-40.1	1.4
25	17	Sharp	25	77	208.0	1.3
18	18	Integrated Device Technology	79	72	-8.9	1.2
17	19	Motorola	138	71	-48.6	1.2
-	20	Philips	0	65	NA	1.1
21	21	Cypress Semiconductor	56	60	7.1	1.0
19	22	Sony	70	47	-32.9	0.8
20	23	Oki	61	45	-26.2	0.7
24	24	Microchip Technology	25	37	48.0	0.6
36	25	Vanguard	5	30	500.0	0.5
22	26	Xicor	29	23	-20.7	0.4
33	27	Integrated Silicon Solutions	10	16	60.0	0.3
-	28	Fairchild	0	15	NA	0.2
27	29	TEMIC	14	12	-14.3	0.2
31	30	Catalyst	11	12	9.1	0.2
34	31	Alliance Semiconductor	9	12	33.3	0.2
32	32	Electronic Designs	11	10	-9.1	0.2
38	33	Harris	3	8	166.7	0.1
29	34	Mosel Vitelicc	12	5	-58.3	0
28	35	Macronix	13	4	-69.2	0
35	36	Sanyo	7	4	-42.9	0
30	37	United Microelectronics	12	3	-75.0	0
37	38	Silicon Storage Technology	4	3	-25.0	0
39	39	Rohm	3	3	0	0
26	40	Matsushita	18	2	-88.9	0

(continued)

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Table 7 (Continued)
Top 47 Worldwide Companies' Factory Revenue from Shipments of MOS Memory to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
41	41	Seiko Epson	2	2	0	0
44	42	Nippon Steel Semiconductor	1	2	100.0	0
40	43	WaferScale Integration	2	1	-50.0	0
42	44	G-Link USA	1	1	0	0
43	45	Paradigm	1	1	0	0
45	46	Winbond Electronics	1	1	0	0
23	47	National Semiconductor	28	0	-100.0	0
		All Others	0	0	NA	0
		Americas Companies	1,866	1,800	-3.5	29.8
		Japanese Companies	2,249	1,580	-29.7	26.2
		EMEA Companies	899	759	-15.6	12.6
		Asia/Pacific Companies	1,904	1,902	-0.1	31.5
		Total Market	**6,918**	**6,041**	**-12.7**	**100.0**

NA = not applicable
Source: Dataquest (May 1998 Estimates)

Table 8
Top 22 Worldwide Companies' Factory Revenue from Shipments of Dynamic RAM to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
1	1	Samsung	940	1,009	7.3	25.0
3	2	Siemens	428	403	-5.8	10.0
5	3	Hyundai	387	396	2.3	9.8
2	4	NEC	458	369	-19.4	9.2
8	5	Texas Instruments	337	350	3.9	8.7
9	6	Micron Technology	257	272	5.8	6.7
6	7	LG Semicon	361	252	-30.2	6.3
7	8	Fujitsu	340	242	-28.8	6.0
4	9	Hitachi	392	196	-50.0	4.9
12	10	IBM	168	166	-1.2	4.1
11	11	Mitsubishi	186	156	-16.1	3.9
10	12	Toshiba	225	112	-50.2	2.8
13	13	Oki	50	38	-24.0	0.9
18	14	Vanguard	5	30	500.0	0.7
14	15	Motorola	49	21	-57.1	0.5
-	16	Alliance Semiconductor	0	8	NA	0.2
16	17	Mosel Vitelic	12	5	-58.3	0.1
17	18	Sanyo	6	2	-66.7	0
19	19	Sharp	3	2	-33.3	0
21	20	Nippon Steel Semiconductor	1	2	100.0	0
20	21	G-Link USA	1	1	0	0
15	22	Matsushita	16	0	-100.0	0
		All Others	0	0	NA	0
		Americas Companies	812	818	0.7	20.3
		Japanese Companies	1,677	1,119	-33.3	27.8
		EMEA Companies	428	403	-5.8	10.0
		Asia/Pacific Companies	1,705	1,692	-0.8	42.0
		Total Market	**4,622**	**4,032**	**-12.8**	**100.0**

NA = not applicable
Source: Dataquest (May 1998 Estimates)

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Table 9
Top 18 Worldwide Companies' Factory Revenue from Shipments of Flash Memory to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
2	1	Advanced Micro Devices	177	226	27.7	33.7
1	2	Intel	250	222	-11.2	33.1
3	3	Fujitsu	93	99	6.5	14.8
-	4	Sharp	0	47	NA	7.0
5	5	SGS-Thomson	41	25	-39.0	3.7
4	6	Atmel	57	24	-57.9	3.6
7	7	Texas Instruments	5	8	60.0	1.2
6	8	Toshiba	6	4	-33.3	0.6
8	9	Silicon Storage Technology	4	3	-25.0	0.4
14	10	Samsung	1	3	200.0	0.4
12	11	Matsushita	1	2	100.0	0.3
-	12	Fairchild	0	2	NA	0.3
10	13	Catalyst	1	1	0	0.1
11	14	Motorola	1	1	0	0.1
13	15	NEC	1	1	0	0.1
-	16	Micron Technology	0	1	NA	0.1
-	17	Sanyo	0	1	NA	0.1
9	18	Macronix	3	0	-100.0	0
		All Others	0	0	NA	0
		Americas Companies	495	488	-1.4	72.8
		Japanese Companies	101	154	52.5	23.0
		EMEA Companies	41	25	-39.0	3.7
		Asia/Pacific Companies	4	3	-25.0	0.4
		Total Market	**641**	**670**	**4.5**	**100.0**

NA = not applicable
Source: Dataquest (May 1998 Estimates)

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Table 10
Top 71 Worldwide Companies' Factory Revenue from Shipments of MOS Microcomponents to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
1	1	Intel	4,794	5,589	16.6	51.1
2	2	Motorola	814	986	21.1	9.0
3	3	Texas Instruments	487	554	13.8	5.1
8	4	SGS-Thomson	211	387	83.4	3.5
4	5	Philips	384	317	-17.4	2.9
11	6	Advanced Micro Devices	146	303	107.5	2.8
5	7	NEC	292	301	3.1	2.8
7	8	Siemens	248	274	10.5	2.5
6	9	Hitachi	269	270	0.4	2.5
12	10	National Semiconductor	138	262	89.9	2.4
9	11	Lucent Technologies	205	255	24.4	2.3
10	12	Rockwell	204	240	17.6	2.2
13	13	Toshiba	114	100	-12.3	0.9
15	14	Sun Microsystems	85	100	17.6	0.9
18	15	Microchip Technology	56	88	57.1	0.8
14	16	Analog Devices	85	81	-4.7	0.7
25	17	Fujitsu	30	74	146.7	0.7
19	18	Mitsubishi	53	67	26.4	0.6
17	19	IBM	56	65	16.1	0.6
16	20	Cirrus Logic	57	50	-12.3	0.5
24	21	C-Cube	35	43	22.9	0.4
29	22	LSI Logic	24	38	58.3	0.3
-	23	Micronas	0	37	NA	0.3
22	24	Zilog	41	36	-12.2	0.3
26	25	Digital	29	35	20.7	0.3
27	26	Standard Microsystems	28	35	25.0	0.3
43	27	ATI Technologies	10	30	200.0	0.3
21	28	S3	42	26	-38.1	0.2
23	29	TEMIC	36	25	-30.6	0.2
-	30	ESS	0	25	NA	0.2
31	31	Dallas Semiconductor	20	24	20.0	0.2
33	32	United Microelectronics	19	23	21.1	0.2
30	33	Oki	21	19	-9.5	0.2
34	34	8x8	15	19	26.7	0.2
35	35	TCS	15	18	20.0	0.2
37	36	DSP Group	13	16	23.1	0.1
39	37	PMC Sierra Semiconductor	12	14	16.7	0.1
36	38	Harris	13	13	0	0.1
41	39	Atmel	10	9	-10.0	0
46	40	Symbios	8	8	0	0

(continued)

Table 10 (Continued)
Top 71 Worldwide Companies' Factory Revenue from Shipments of MOS Microcomponents to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
47	41	Samsung	8	8	0	0
52	42	WaferScale Integration	5	8	60.0	0
38	43	Melexis	13	7	-46.2	0
49	44	Q Logic	6	7	16.7	0
-	45	LG Semicon	0	6	NA	0
40	46	Chips & Technologies	11	5	-54.5	0
44	47	Matsushita	10	5	-50.0	0
50	48	VLSI Technology	6	5	-16.7	0
56	49	Zoran	4	5	25.0	0
54	50	VIA	5	4	-20.0	0
57	51	EM Microelectronics Marin	4	4	0	0
60	52	GEC Plessey	2	4	100.0	0
42	53	Cypress Semiconductor	10	2	-80.0	0
58	54	Sanyo	2	2	0	0
64	55	SEEQ Technology	1	2	100.0	0
48	56	OPTi	7	1	-85.7	0
53	57	Acer	5	1	-80.0	0
59	58	Yamaha	2	1	-50.0	0
61	59	Holtek	2	1	-50.0	0
62	60	ACC Microelectronics	1	1	0	0
65	61	Rohm	1	1	0	0
66	62	Seiko Epson	1	1	0	0
67	63	Sharp	1	1	0	0
68	64	Winbond Electronics	1	1	0	0
20	65	Cyrix	50	0	-100.0	0
28	66	ITT	25	0	-100.0	0
32	67	Oak Technology	19	0	-100.0	0
45	68	Silicon Integrated Systems	10	0	-100.0	0
51	69	Trident Microsystems	5	0	-100.0	0
55	70	Tseng Labs	4	0	-100.0	0
63	71	Integrated Device Technology	1	0	-100.0	0
		All Others	0	0	NA	0
		Americas Companies	7,582	8,980	18.4	82.1
		Japanese Companies	796	842	5.8	7.7
		EMEA Companies	913	1,073	17.5	9.8
		Asia/Pacific Companies	50	44	-12.0	0.4
		Total Market	**9,341**	**10,939**	**17.1**	**100.0**

NA = not applicable
Source: Dataquest (May 1998 Estimates)

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Table 11
Top 74 Worldwide Companies' Factory Revenue from Shipments of MOS Digital Logic to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
2	1	Texas Instruments	316	358	13.3	8.6
4	2	Lucent Technologies	280	285	1.8	6.9
1	3	Philips	333	278	-16.5	6.7
7	4	VLSI Technology	179	272	52.0	6.5
5	5	SGS-Thomson	193	245	26.9	5.9
9	6	NEC	167	234	40.1	5.6
6	7	LSI Logic	188	204	8.5	4.9
3	8	Motorola	283	197	-30.4	4.7
8	9	Alcatel Microelectronics	173	196	13.3	4.7
11	10	Toshiba	122	138	13.1	3.3
10	11	Xilinx	125	128	2.4	3.1
16	12	Altera	104	126	21.2	3.0
31	13	Micronas	24	120	400.0	2.9
12	14	Austria Mikro Systeme	114	110	-3.5	2.6
17	15	GEC Plessey	103	103	0	2.5
22	16	Fujitsu	68	99	45.6	2.4
23	17	Hewlett-Packard	59	77	30.5	1.9
18	18	IBM	90	70	-22.2	1.7
20	19	TEMIC	80	69	-13.8	1.7
13	20	Advanced Micro Devices	111	66	-40.5	1.6
19	21	Atmel	86	64	-25.6	1.5
15	22	National Semiconductor	107	61	-43.0	1.5
21	23	Hitachi	76	60	-21.1	1.4
-	24	Fairchild	0	57	NA	1.4
26	25	Lattice	30	55	83.3	1.3
27	26	TCS	28	40	42.9	1.0
24	27	Harris Semiconductor	46	31	-32.6	0.7
35	28	Ericsson	19	30	57.9	0.7
37	29	Cypress Semiconductor	16	28	75.0	0.7
25	30	Siemens	31	23	-25.8	0.6
29	31	Actel	26	23	-11.5	0.6
30	32	Symbios	26	22	-15.4	0.5
32	33	Dallas Semiconductor	22	22	0	0.5
51	34	Mitsubishi	3	21	600.0	0.5
28	35	Oki	27	19	-29.6	0.5
33	36	EM Microelectronics Marin	22	18	-18.2	0.4
-	37	I.S.D.	0	18	NA	0.4
-	38	Vitesse	0	17	NA	0.4
41	39	Sanyo	10	16	60.0	0.4
-	40	Robert Bosch	0	15	NA	0.4
36	41	Samsung	17	14	-17.6	0.3

(continued)

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Table 11 (Continued)
Top 74 Worldwide Companies' Factory Revenue from Shipments of MOS Digital Logic to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
34	42	Mitel	20	12	-40.0	0.3
40	43	Seiko Epson	11	11	0	0.3
38	44	Integrated Device Technology	16	9	-43.8	0.2
39	45	Sony	12	9	-25.0	0.2
44	46	Elmos	7	9	28.6	0.2
43	47	Integrated Circuit Systems	7	8	14.3	0.2
42	48	Melexis	8	6	-25.0	0.1
46	49	Gould AMI	5	6	20.0	0.1
45	50	Analog Devices	5	5	0	0.1
48	51	PMC Sierra Semiconductor	5	5	0	0.1
47	52	QuickLogic	5	4	-20.0	0
49	53	Exar	3	4	33.3	0
50	54	Quality Semiconductor	3	3	0	0
52	55	Rohm	3	3	0	0
59	56	Chip Express	1	3	200.0	0
91	57	Gennum	0	3	NA	0
-	58	Applied Micro Circuits Corp.	2	2	0	0
54	59	Hughes	2	2	0	0
57	60	Winbond Electronics	2	2	0	0
64	61	Raytheon	1	2	100.0	0
-	62	Zetex	0	2	NA	0
55	63	New JRC	2	1	-50.0	0
56	64	Holtek	2	1	-50.0	0
58	65	Allegro MicroSystems	1	1	0	0
60	66	ETEQ Microsystems	1	1	0	0
62	67	Logic Devices	1	1	0	0
65	68	Supertex	1	1	0	0
66	69	Sharp	1	1	0	0
67	70	Yamaha	1	1	0	0
68	71	LG Semicon	1	1	0	0
14	72	ITT	107	0	NA	0
61	73	International CMOS Technology	1	0	-100.0	0
63	74	Micrel	1	0	-100.0	0
		All Others	11	11	0	0.3
		Americas Companies	2,282	2,253	-1.3	54.2
		Japanese Companies	514	624	21.4	15.0
		EMEA Companies	1,135	1,264	11.4	30.4
		Asia/Pacific Companies	22	18	-18.2	0.4
		Total Market	**3,953**	**4,159**	**5.2**	**100.0**

NA = not applicable
Source: Dataquest (May 1998 Estimates)

Table 12
Top 59 Worldwide Companies' Factory Revenue from Shipments of Total ASICs to EMEA, 1996 and 1977

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
1	1	Lucent Technologies	280	285	1.8	8.9
4	2	VLSI Technology	179	272	52.0	8.5
2	3	Texas Instruments	195	242	24.1	7.6
7	4	NEC	156	219	40.4	6.9
6	5	SGS-Thomson	167	217	29.9	6.8
3	6	LSI Logic	188	204	8.5	6.4
5	7	Alcatel Microelectronics	173	196	13.3	6.1
8	8	Xilinx	125	128	2.4	4.0
10	9	Altera	104	126	21.2	3.9
11	10	GEC Plessey	103	103	0	3.2
9	11	Austria Mikro Systeme	106	102	-3.8	3.2
17	12	Fujitsu	68	99	45.6	3.1
12	13	Toshiba	94	86	-8.5	2.7
14	14	Motorola	88	80	-9.1	2.5
18	15	Hewlett-Packard	59	77	30.5	2.4
13	16	IBM	90	70	-22.2	2.2
15	17	Atmel	79	60	-24.1	1.9
19	18	Advanced Micro Devices	54	59	9.3	1.8
20	19	TEMIC	53	56	5.7	1.8
16	20	Hitachi	70	55	-21.4	1.7
23	21	Lattice	30	55	83.3	1.7
21	22	National Semiconductor	51	53	3.9	1.7
24	23	TCS	28	40	42.9	1.3
31	24	Ericsson	19	30	57.9	0.9
27	25	Micronas	24	25	4.2	0.8
22	26	Siemens	31	23	-25.8	0.7
25	27	Actel	26	23	-11.5	0.7
26	28	Symbios	26	22	-15.4	0.7
-	29	I.S.D.	0	18	NA	0.6
28	30	EM Microelectronics Marin	22	17	-22.7	0.5
-	31	Vitesse	0	17	NA	0.5
30	32	Mitel	20	12	-40.0	0.4
32	33	Oki	15	11	-26.7	0.3
33	34	Cypress Semiconductor	14	11	-21.4	0.3
29	35	Harris Semiconductor	20	10	-50.0	0.3
36	36	Elmos	7	9	28.6	0.3
34	37	Seiko Epson	8	8	0	0.3
37	38	Integrated Circuit Systems	7	8	14.3	0.3
35	39	Melexis	8	6	-25.0	0.2
39	40	Gould AMI	5	6	20.0	0.2

(continued)

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Table 12 (Continued)
Top 59 Worldwide Companies' Factory Revenue from Shipments of Total ASICs to EMEA, 1996 and 1977

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
45	41	Philips	1	6	500.0	0.2
46	42	Mitsubishi	1	6	500.0	0.2
40	43	Analog Devices	5	5	0	0.2
41	44	PMC Sierra Semiconductor	5	5	0	0.2
38	45	Samsung	5	4	-20.0	0.1
42	46	QuickLogic	5	4	-20.0	0.1
43	47	Exar	2	3	50.0	0
47	48	Chip Express	1	3	200.0	0
-	49	Gennum	0	3	NA	0
44	50	Hughes	2	2	0	0
49	51	Raytheon	1	2	100.0	0
-	52	Zetex	0	2	NA	0
48	53	Applied Micro Circuits Corp.	1	1	0	0
51	54	Allegro MicroSystems	1	1	0	0
52	55	ETEQ Microsystems	1	1	0	0
-	56	Sanyo	0	1	NA	0
-	57	Sony	0	1	NA	0
50	58	Holtek	1	0	-100.0	0
53	59	International CMOS Technology	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	1,665	1,868	12.2	58.6
		Japanese Companies	412	486	18.0	15.2
		EMEA Companies	742	832	12.1	26.1
		Asia/Pacific Companies	6	4	-33.3	0.1
		Total Market	**2,825**	**3,190**	**12.9**	**100.0**

NA = not applicable
Source: Dataquest (May 1998 Estimates)

Table 13
Top 33 Worldwide Companies' Factory Revenue from Shipments of Total Gate Arrays to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
1	1	Texas Instruments	110	131	19.1	17.4
2	2	LSI Logic	87	121	39.1	16.1
5	3	NEC	63	72	14.3	9.6
3	4	GEC Plessey	85	71	-16.5	9.4
6	5	Fujitsu	50	68	36.0	9.0
4	6	Toshiba	77	60	-22.1	8.0
9	7	SGS-Thomson	29	43	48.3	5.7
7	8	Motorola	41	35	-14.6	4.7
10	9	Hitachi	24	21	-12.5	2.8
12	10	National Semiconductor	18	21	16.7	2.8
-	11	Vitesse	0	17	NA	2.3
8	12	TEMIC	34	15	-55.9	2.0
11	13	IBM	21	10	-52.4	1.3
13	14	Oki	10	9	-10.0	1.2
14	15	VLSI Technology	9	8	-11.1	1.1
15	16	Seiko Epson	8	8	0	1.1
16	17	Austria Mikro Systeme	8	7	-12.5	0.9
25	18	TCS	1	5	400.0	0.7
17	19	Atmel	6	4	-33.3	0.5
18	20	Gould AMI	5	4	-20.0	0.5
19	21	Samsung	5	4	-20.0	0.5
24	22	Mitsubishi	1	4	300.0	0.5
21	23	Chip Express	1	3	200.0	0.4
-	24	Gennum	0	3	NA	0.4
-	25	Zetex	0	2	NA	0.3
20	26	Applied Micro Circuits Corp.	1	1	0	0.1
22	27	ETEQ Microsystems	1	1	0	0.1
-	28	Exar	0	1	NA	0.1
-	29	Raytheon	0	1	NA	0.1
-	30	Sanyo	0	1	NA	0.1
-	31	Sony	0	1	NA	0.1
23	32	Harris	1	0	-100.0	0
-	33	Holtek	1	0	-100.0	0
		All Others	0	0	NA	0
		Americas Companies	301	361	19.9	48.0
		Japanese Companies	233	244	4.7	32.4
		EMEA Companies	157	143	-8.9	19.0
		Asia/Pacific Companies	6	4	-33.3	0.5
		Total Market	**697**	**752**	**7.9**	**100.0**

NA = not applicable
Source: Dataquest (May 1998 Estimates)

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Table 14
Top 40 Worldwide Companies' Factory Revenue from Shipments of Total Cell-Based ICs to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
1	1	Lucent Technologies	270	275	1.9	13.7
3	2	VLSI Technology	170	264	55.3	13.1
2	3	Alcatel Microelectronics	173	196	13.3	9.7
4	4	SGS-Thomson	138	174	26.1	8.6
7	5	NEC	93	147	58.1	7.3
8	6	Texas Instruments	85	110	29.4	5.5
6	7	Austria Mikro Systeme	98	95	-3.1	4.7
5	8	LSI Logic	101	83	-17.8	4.1
11	9	Hewlett-Packard	59	77	30.5	3.8
9	10	IBM	69	60	-13.0	3.0
10	11	Atmel	68	49	-27.9	2.4
12	12	Motorola	47	45	-4.3	2.2
21	13	TEMIC	19	41	115.8	2.0
16	14	TCS	27	35	29.6	1.7
13	15	Hitachi	46	34	-26.1	1.7
14	16	National Semiconductor	33	32	-3.0	1.6
24	17	GEC Plessey	18	32	77.8	1.6
25	18	Fujitsu	18	31	72.2	1.5
22	19	Ericsson	19	30	57.9	1.5
26	20	Toshiba	17	26	52.9	1.3
18	21	Micronas	24	25	4.2	1.2
15	22	Siemens	31	23	-25.8	1.1
17	23	Symbios	26	22	-15.4	1.1
-	24	I.S.D.	0	18	NA	0.9
19	25	EM Microelectronics Marin	22	17	-22.7	0.8
20	26	Mitel	20	12	-40.0	0.6
23	27	Harris	19	10	-47.4	0.5
28	28	Elmos	7	9	28.6	0.4
29	29	Integrated Circuit Systems	7	8	14.3	0.4
27	30	Melexis	8	6	-25.0	0.3
31	31	Analog Devices	5	5	0	0.2
32	32	PMC Sierra Semiconductor	5	5	0	0.2
47	33	Philips	0	5	NA	0.2
30	34	Oki	5	2	-60.0	0
33	35	Exar	2	2	0	0
34	36	Hughes	2	2	0	0
-	37	Gould AMI	0	2	NA	0
-	38	Mitsubishi	0	2	NA	0
35	39	Raytheon	1	1	0	0
36	40	Allegro MicroSystems	1	1	0	0

(continued)

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Table 14 (Continued)
Top 40 Worldwide Companies' Factory Revenue from Shipments of Total Cell-Based ICs to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
		All Others	0	0	NA	0
		Americas Companies	990	1,083	9.4	53.8
		Japanese Companies	179	242	35.2	12.0
		EMEA Companies	584	688	17.8	34.2
		Asia/Pacific Companies	0	0	NA	0
		Total Market	**1,753**	**2,013**	**14.8**	**100.0**

NA = not applicable
Source: Dataquest (May 1998 Estimates)

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Table 15
Top 26 Worldwide Companies' Factory Revenue from Shipments of Mixed-Signal ASICs to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
1	1	Alcatel Microelectronics	147	171	16.3	26.5
2	2	SGS-Thomson	93	128	37.6	19.8
3	3	Austria Mikro Systeme	65	65	0	10.1
4	4	Texas Instruments	46	60	30.4	9.3
5	5	Atmel	29	42	44.8	6.5
9	6	TEMIC	19	35	84.2	5.4
6	7	Micronas	24	25	4.2	3.9
10	8	GEC Plessey	15	22	46.7	3.4
-	9	I.S.D.	0	18	NA	2.8
7	10	EM Microelectronics Marin	22	17	-22.7	2.6
8	11	Mitel	20	12	-40.0	1.9
15	12	Symbios	10	9	-10.0	1.4
11	13	Harris	15	8	-46.7	1.2
14	14	National Semiconductor	10	8	-20.0	1.2
16	15	Melexis	8	6	-25.0	0.9
18	16	Analog Devices	5	5	0	0.8
19	17	PMC Sierra Semiconductor	5	5	0	0.8
20	18	Integrated Circuit Systems	3	3	0	0.5
21	19	Exar	2	2	0	0.3
22	20	Hughes	2	2	0	0.3
23	21	Raytheon	1	1	0	0.2
24	22	Allegro MicroSystems	1	1	0	0.2
-	23	Gould AMI	0	1	NA	0.2
12	24	Lucent Technologies	10	0	-100.0	0
13	25	Motorola	10	0	-100.0	0
17	26	TCS	5	0	-100.0	0
		All Others	0	0	NA	0
		Americas Companies	169	177	4.7	27.4
		Japanese Companies	0	0	NA	0
		EMEA Companies	398	469	17.8	72.6
		Asia/Pacific Companies	0	0	NA	0
		Total Market	**567**	**646**	**13.9**	**100.0**

NA = not applicable
Source: Dataquest (May 1998 Estimates)

Table 16
Top 10 Worldwide Companies' Factory Revenue from Shipments of Linear Array ASICs to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
-	1	National Semiconductor	NA	6	NA	21.4
-	2	TCS	NA	5	NA	17.9
-	3	Fujitsu	NA	4	NA	14.3
-	4	Gennum	NA	3	NA	10.7
-	5	NEC	NA	3	NA	10.7
-	6	GEC Plessey	NA	2	NA	7.1
-	7	Zetex	NA	2	NA	7.1
-	8	Exar	NA	1	NA	3.6
-	9	Raytheon	NA	1	NA	3.6
-	10	Sony	NA	1	NA	3.6
		All Others	NA	0	NA	0
		Americas Companies	NA	11	NA	39.3
		Japanese Companies	NA	8	NA	28.6
		EMEA Companies	NA	9	NA	32.1
		Asia/Pacific Companies	NA	0	NA	0
		Total Market	NA	28	NA	100.0

NA = not applicable
Source: Dataquest (May 1998 Estimates)

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Table 17
Top 12 Worldwide Companies' Factory Revenue from Shipments of PLDs to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
1	1	Xilinx	125	128	2.4	30.1
2	2	Altera	104	126	21.2	29.6
3	3	Advanced Micro Devices	54	59	9.3	13.9
4	4	Lattice	30	55	83.3	12.9
5	5	Actel	26	23	-11.5	5.4
6	6	Cypress Semiconductor	14	11	-21.4	2.6
7	7	Lucent Technologies	10	10	0	2.4
8	8	Atmel	5	7	40.0	1.6
9	9	QuickLogic	5	4	-20.0	0.9
11	10	Philips	1	1	0	0.2
-	11	Texas Instruments	0	1	NA	0.2
10	12	International CMOS Technology	1	0	-100.0	0
		All Others	0	0	NA	0
		Americas Companies	374	424	13.4	99.8
		Japanese Companies	0	0	NA	0
		EMEA Companies	1	1	0	0.2
		Asia/Pacific Companies	0	0	NA	0
		Total Market	**375**	**425**	**13.3**	**100.0**

NA = not applicable
Source: Dataquest (May 1998 Estimates)

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Table 18
Top 16 Worldwide Companies' Factory Revenue from Shipments of Custom ICs to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
1	1	Motorola	34	30	-11.8	42.3
5	2	Oki	11	8	-27.3	11.3
4	3	Toshiba	12	7	-41.7	9.9
6	4	Atmel	7	4	-42.9	5.6
8	5	Sony	7	3	-57.1	4.2
9	6	Samsung	3	2	-33.3	2.8
10	7	NEC	2	2	0	2.8
11	8	Seiko Epson	2	2	0	2.8
12	9	Winbond Electronics	2	2	0	2.8
3	10	Texas Instruments	13	1	-92.3	1.4
7	11	Harris	7	1	-85.7	1.4
14	12	Sharp	1	1	0	1.4
15	13	Holtek	1	1	0	1.4
-	14	Yamaha	0	1	NA	1.4
2	15	TEMIC	27	0	-100.0	0
13	16	Micrel	1	0	-100.0	0
		All Others	6	6	0	8.5
		Americas Companies	62	36	-41.9	50.7
		Japanese Companies	41	30	-26.8	42.3
		EMEA Companies	27	0	-100.0	0
		Asia/Pacific Companies	6	5	-16.7	7.0
		Total Market	**136**	**71**	**-47.8**	**100.0**

NA = not applicable
Source: Dataquest (May 1998 Estimates)

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Table 19
Top 17 Worldwide Companies' Factory Revenue from Shipments of MOS Standard Logic to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
1	1	Philips	116	123	6.0	26.4
2	2	Texas Instruments	96	105	9.4	22.5
45	3	Fairchild	0	57	NA	12.2
4	4	Motorola	49	46	-6.1	9.9
10	5	Toshiba	6	32	433.3	6.9
5	6	SGS-Thomson	26	28	7.7	6.0
6	7	Dallas Semiconductor	22	22	0	4.7
7	8	Harris	19	20	5.3	4.3
8	9	Integrated Device Technology	16	9	-43.8	1.9
3	10	National Semiconductor	56	8	-85.7	1.7
9	11	Hitachi	6	5	-16.7	1.1
-	12	TEMIC	0	4	NA	0.9
11	13	Quality Semiconductor	3	3	0	0.6
-	14	Cypress Semiconductor	0	2	NA	0.4
13	15	Exar	1	1	0	0.2
14	16	LG Semicon	1	1	0	0.2
12	17	Rohm	3	0	-100.0	0
		All Others	0	0	NA	0
		Americas Companies	262	273	4.2	58.6
		Japanese Companies	15	37	146.7	7.9
		EMEA Companies	142	155	9.2	33.3
		Asia/Pacific Companies	1	1	0	0.2
		Total Market	**420**	**466**	**11.0**	**100.0**

NA = not applicable
Source: Dataquest (May 1998 Estimates)

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Table 20
Top 25 Worldwide Companies' Factory Revenue from Shipments of Total Other MOS Logic to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
1	1	Philips	216	149	-31.0	34.5
-	2	Micronas	0	95	NA	22.0
2	3	Motorola	112	41	-63.4	9.5
6	4	Sanyo	10	15	50.0	3.5
12	5	Cypress Semiconductor	2	15	650.0	3.5
13	6	Mitsubishi	2	15	650.0	3.5
-	7	Robert Bosch	0	15	NA	3.5
7	8	Toshiba	10	13	30.0	3.0
8	9	NEC	9	13	44.4	3.0
5	10	Texas Instruments	12	10	-16.7	2.3
-	11	TEMIC	0	9	NA	2.1
9	12	Samsung	9	8	-11.1	1.9
10	13	Austria Mikro Systeme	8	8	0	1.9
4	14	Advanced Micro Devices	57	7	-87.7	1.6
11	15	Sony	5	5	0	1.2
-	16	Rohm	0	3	NA	0.7
14	17	New JRC	2	1	-50.0	0.2
15	18	Applied Micro Circuits Corp.	1	1	0	0.2
16	19	Logic Devices	1	1	0	0.2
17	20	Supertex	1	1	0	0.2
19	21	Seiko Epson	1	1	0	0.2
-	22	EM Microelectronics Marin	0	1	NA	0.2
3	23	ITT	107	0	-100.0	0
18	24	Oki	1	0	-100.0	0
20	25	Yamaha	1	0	-100.0	0
		All Others	5	5	0	1.2
		Americas Companies	293	76	-74.1	17.6
		Japanese Companies	46	71	54.3	16.4
		EMEA Companies	224	277	23.7	64.1
		Asia/Pacific Companies	9	8	-11.1	1.9
		Total Market	**572**	**432**	**-24.5**	**100.0**

NA = not applicable
Source: Dataquest (May 1998 Estimates)

Table 21
Top 68 Worldwide Companies' Factory Revenue from Shipments of Analog-Monolithic to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
1	1	Siemens	787	845	7.4	17.3
3	2	Philips	542	671	23.8	13.7
2	3	SGS-Thomson	698	659	-5.6	13.5
7	4	Texas Instruments	199	365	83.4	7.5
5	5	National Semiconductor	277	346	24.9	7.1
4	6	Analog Devices	293	304	3.8	6.2
6	7	Motorola	241	283	17.4	5.8
9	8	TEMIC	90	146	62.2	3.0
-	9	Robert Bosch	0	124	NA	2.5
8	10	Maxim	101	113	11.9	2.3
10	11	Linear Technology	85	90	5.9	1.8
12	12	Harris	52	70	34.6	1.4
11	13	Sanyo	59	64	8.5	1.3
13	14	Ericsson	50	59	18.0	1.2
15	15	EM Microelectronics Marin	47	53	12.8	1.1
21	16	Advanced Micro Devices	30	50	66.7	1.0
14	17	Burr-Brown	49	49	0	1.0
20	18	Toshiba	33	40	21.2	0.8
16	19	Sony	41	37	-9.8	0.8
-	20	Anadigics	0	35	NA	0.7
19	21	NEC	34	31	-8.8	0.6
23	22	Fujitsu	25	30	20.0	0.6
25	23	Mitel	20	28	40.0	0.6
22	24	Allegro MicroSystems	28	27	-3.6	0.6
24	25	Mitsubishi	24	24	0	0.5
-	26	Vitesse	0	21	NA	0.4
26	27	Unitrode	20	20	0	0.4
44	28	Cirrus Logic	6	20	233.3	0.4
30	29	Rohm	14	19	35.7	0.4
27	30	Rockwell	18	18	0	0.4
56	31	Telcom	2	18	800.0	0.4
18	32	GEC Plessey	35	16	-54.3	0.3
-	33	Triquint	0	16	NA	0.3
17	34	Lucent Technologies	40	15	-62.5	0.3
29	35	Gennum	16	13	-18.8	0.3
32	36	Level One Communications	13	13	0	0.3
35	37	Alcatel Microelectronics	11	11	0	0.2
28	38	Samsung	16	10	-37.5	0.2
31	39	Hitachi	13	10	-23.1	0.2
36	40	Exar	11	10	-9.1	0.2

(continued)

Table 21 (Continued)
Top 68 Worldwide Companies' Factory Revenue from Shipments of Analog-Monolithic to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
37	41	PMC Sierra Semiconductor	10	10	0	0.2
39	42	Dallas Semiconductor	9	9	0	0.2
45	43	International Rectifier	6	8	33.3	0.2
-	44	Micronas	0	8	NA	0.2
43	45	Cherry Semiconductor	7	7	0	0.1
50	46	Semtech	4	7	75.0	0.1
41	47	Raytheon	7	6	-14.3	0.1
-	48	Atmel	0	6	NA	0.1
34	49	VTC	12	5	-58.3	0.1
46	50	Honeywell	5	5	0	0.1
47	51	Linfinity	5	5	0	0.1
49	52	Elantec	4	5	25.0	0.1
54	53	New JRC	3	4	33.3	0
-	54	Sanken	0	4	NA	0
33	55	Melexis	12	3	-75.0	0
48	56	Ricoh	5	3	-40.0	0
52	57	Integrated Circuit Systems	3	3	0	0
53	58	Winbond Electronics	3	3	0	0
57	59	Zetex	1	3	200.0	0
38	60	TCS	9	2	-77.8	0
40	61	Matsushita	9	2	-77.8	0
51	62	Austria Mikro Systeme	3	2	-33.3	0
55	63	Micro Linear	2	2	0	0
58	64	Applied Micro Circuits Corp.	1	1	0	0
-	65	Optek	0	1	NA	0
-	66	SEEQ Technology	0	1	NA	0
42	67	ITT	7	0	-100.0	0
59	68	Micrel	1	0	-100.0	0
		All Others	0	0	NA	0
		Americas Companies	1,584	2,005	26.6	41.0
		Japanese Companies	260	268	3.1	5.5
		EMEA Companies	2,285	2,602	13.9	53.2
		Asia/Pacific Companies	19	13	-31.6	0.3
		Total Market	**4,148**	**4,888**	**17.8**	**100.0**

NA = not applicable
Source: Dataquest (May 1998 Estimates)

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Table 22
Top 43 Worldwide Companies' Factory Revenue from Shipments of Total Discretes to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
1	1	Philips	449	497	10.7	15.9
3	2	Siemens	320	373	16.6	12.0
4	3	Motorola	317	302	-4.7	9.7
2	4	SGS-Thomson	321	283	-11.8	9.1
27	5	Hitachi	23	161	600.0	5.2
6	6	Toshiba	140	141	0.7	4.5
5	7	International Rectifier	147	118	-19.7	3.8
9	8	General Semiconductor	99	101	2.0	3.2
10	9	Rohm	85	93	9.4	3.0
7	10	TEMIC	117	81	-30.8	2.6
8	11	Eupec	106	80	-24.5	2.6
11	12	Semikron	73	76	4.1	2.4
-	13	Robert Bosch	0	71	NA	2.3
12	14	Harris	61	63	3.3	2.0
13	15	Fujitsu	49	61	24.5	2.0
16	16	NEC	40	54	35.0	1.7
18	17	Mitsubishi	29	53	82.8	1.7
20	18	Zetex	26	43	65.4	1.4
15	19	Hewlett-Packard	44	40	-9.1	1.3
17	20	IXYS	39	40	2.6	1.3
25	21	National Semiconductor	23	35	52.2	1.1
-	22	Micronas	0	32	NA	1.0
24	23	Shindengen Electric	24	25	4.2	0.8
22	24	Samsung	25	24	-4.0	0.8
23	25	Microsemi	24	24	0	0.8
30	26	Sanken	15	22	46.7	0.7
-	27	Fairchild	0	22	NA	0.7
28	28	Ericsson	19	19	0	0.6
-	29	Fagor	0	19	NA	0.6
-	30	Power Innovations	0	19	NA	0.6
-	31	TCS	0	19	NA	0.6
26	32	Fuji Electric	23	17	-26.1	0.5
19	33	GEC Plessey	27	16	-40.7	0.5
29	34	Sanyo	16	11	-31.3	0.4
32	35	Raytheon	6	6	0	0.2
34	36	Supertex	6	6	0	0.2
35	37	Teccor Electronics	5	6	20.0	0.2
31	38	Matsushita	11	4	-63.6	0.1
33	39	Semtech	6	3	-50.0	0
37	40	Korean Electronic Co.	1	1	0	0

(continued)

Table 22 (Continued)
Top 43 Worldwide Companies' Factory Revenue from Shipments of Total Discretes to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
14	41	ITT	46	0	-100.0	0
21	42	Texas Instruments	25	0	-100.0	0
36	43	Allegro MicroSystems	3	0	-100.0	0
		All Others	58	59	1.7	1.9
		Americas Companies	851	766	-10.0	24.6
		Japanese Companies	455	642	41.1	20.6
		EMEA Companies	1,516	1,687	11.3	54.1
		Asia/Pacific Companies	26	25	-3.8	0.8
		Total Market	**2,848**	**3,120**	**9.6**	**100.0**

NA = not applicable
Source: Dataquest (May 1998 Estimates)

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Table 23
Top 25 Worldwide Companies' Factory Revenue from Shipments of Total Optical Semiconductors to EMEA, 1996 and 1997

1996 Rank	1997 Rank	Company	1996 Revenue ($M)	1997 Revenue ($M)	Percentage Change (%)	1997 Market Share (%)
1	1	Hewlett-Packard	187	166	-11.2	22.7
2	2	Siemens	158	161	1.9	22.0
3	3	TEMIC	79	56	-29.1	7.7
4	4	Toshiba	54	40	-25.9	5.5
5	5	Lucent Technologies	37	38	2.7	5.2
-	6	Stanley	0	33	NA	4.5
6	7	Honeywell	35	32	-8.6	4.4
13	8	Hitachi	12	21	75.0	2.9
7	9	Mitsubishi	21	20	-4.8	2.7
8	10	TCS	21	20	-4.8	2.7
9	11	Quality Technologies	18	16	-11.1	2.2
18	12	NEC	7	16	128.6	2.2
10	13	Optek	17	15	-11.8	2.1
11	14	Rohm	17	15	-11.8	2.1
12	15	Fujitsu	13	14	7.7	1.9
16	16	Mitel	10	7	-30.0	1.0
19	17	Sharp	7	7	0	1.0
20	18	Texas Instruments	6	7	16.7	1.0
15	19	Ericsson	11	6	-45.5	0.8
17	20	Motorola	9	6	-33.3	0.8
14	21	Matsushita	11	2	-81.8	0.3
21	22	Sanyo	2	2	0	0.3
22	23	Oki	1	1	0	0.1
23	24	Sanken	1	1	0	0.1
24	25	Zetex	1	0	-100.0	0
		All Others	64	29	-54.7	4.0
		Americas Companies	319	287	-10.0	39.3
		Japanese Companies	197	189	-4.1	25.9
		EMEA Companies	283	255	-9.9	34.9
		Asia/Pacific Companies	0	0	NA	0
		Total Market	**799**	**731**	**-8.5**	**100.0**

NA = not applicable
Source: Dataquest (May 1998 Estimates)

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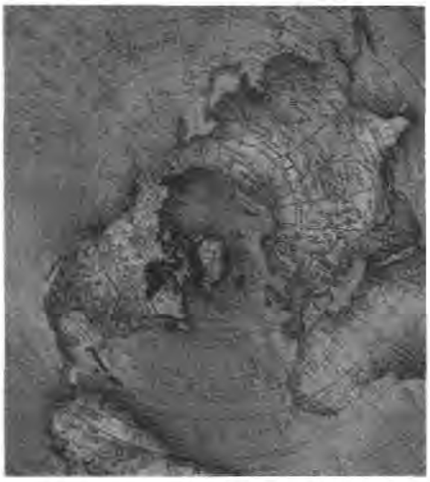

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European Fab Database, 1997

Market Statistics
1998

Program: Semiconductors Europe
Product Code: SEMI-EU-MS-9801
Publication Date: February 5, 1998
Filing: Market Statistics

European Fab Database, 1997

Market Statistics

1998

Program: Semiconductors Europe
Product Code: SEMI-EU-MS-9801
Publication Date: February 5, 1998
Filing: Market Statistics

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Chapter 1
European Fab Database

Background and Methodology

This report contains the European portion of Dataquest's wafer fab database. The records in these tables are fabs located in the Europe, Africa, and Middle East region. The Semiconductor Equipment, Materials, and Manufacturing Worldwide (SEMM) program conducts extensive annual surveys, complemented with quarterly secondary research to maintain this database. Published once a year, this document represents Dataquest's best insights and estimates into the end-market of semiconductor equipment.

The tables in this report cover planned and existing merchant, captive, and foundry fab lines. A fab line is a series of equipment to do front-end (from initial oxide through wafer probe) semiconductor manufacturing. Occasionally, two or more separate product-specific fab lines or wafer sizes operate in a single clean room or physical plant. In this situation, Dataquest divides the clean room as separate fab lines if the company dedicates equipment to each wafer size or product line. If a company installs substantially different equipment during an expansion (for example, equipment to increase its maximum wafer diameter), again Dataquest divides the clean room and creates two entries into the database. Therefore, a company may operate many fab lines at one location.

Worldwide Geographic Region Definitions and Regional Roll-Ups

Americas
Includes Central America (all nations), Canada, Mexico, United States, Puerto Rico, and South America (all nations).

Japan
Japan is the only single-country region.

Europe, Africa, and Middle East
Includes Africa (all nations), Albania, Andorra, Armenia, Azerbaijan, Belarus, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Gibraltar, Hungary, Iceland, Israel, Italy, Kazakhstan, Kyrgyzstan, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Middle East (all nations), Moldova, Monaco, Netherlands, Norway, Poland, Romania, Russia, San Marino, Scandinavia, Slovakia, Spain, Sweden, Sweden, Switzerland, Tajikistan, Turkey, Turkmenistan, Ukraine, United Kingdom, Uzbekistan, Vatican City, and all nations within the former Yugoslavia.

Asia/Pacific
Includes Australia, Bangladesh, Cambodia, China, Hong Kong, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, New Zealand, Pakistan, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, and Vietnam.

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Field Definitions

The Company field indicates the operator of the fab line. For contract manufacturers that trade capacity for capital investment in the fab, Dataquest lists the contract manufacturer. For incorporated joint ventures, Dataquest lists either the incorporated entity or the major investors, separated with slashes.

The Fab Name field provides a reference to a particular fab or fab line to distinguish it from other fabs or lines owned by that company. Although Dataquest makes every attempt to match the nomenclature used by the company, occasionally some additional qualifiers (for example, "Phase 1") will appear to provide insight to the facility's history or organization.

The City field displays the most detailed location information. This reference is usually a city or town, but could be an often-used district name (for example, Science Park in the city of Hsinchu, Taiwan). If this field lists a district, Dataquest will list the city in the State or Province field. In some cases, a reference to a state or province will be included in the City or District field to create a unique identifier for this location.

The State, Province, or Prefecture fields denote the second most detailed location. This reference is usually a state (for the United States), province (for Canada and many European and Asian countries), or a prefecture (for Japan). For countries within the United Kingdom, Dataquest lists the country name (for example, "Scotland") in this field so Dataquest can list the descriptor "U.K." in the Country field.

The Country field indicates the broadest location identifier in this report. This reference is usually a country, except in the case of the United Kingdom (see "State or Province" above). Because Japan is a single-country region, there is no regional qualifier for fabs in Japan.

The Devices Produced field lists the products manufactured at this site. The listings generally fall into five product groups, with the following nomenclature and definitions (when warranted):

- MOS memory
  - DRAM: Dynamic RAM
  - EEPROM: Electrically erasable PROM
  - EPROM: Ultraviolet erasable PROM
  - FERRAM: Ferroelectric RAM
  - FIFO: First-in/first-out memory
  - Flash: Flash memory
  - Mem: Memory
  - NV Mem: Nonvolatile memory (ROM, PROM, EPROM, EEPROM, and FERRAM)
  - PROM: Programmable ROM
  - RAM: Random-access memory
  - ROM: Read-only memory
  - SGRAM: Synchronous graphics RAM
  - Sp Mem: Other specialty memory (such as dual-port, shift-register, or color lookup)
  - SRAM: Static RAM
  - VRAM: Video RAM

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- MOS microcomponent/digital logic
  - Array: Gate array
  - ASIC: Application-specific IC
  - ASSP: Application-specific standard product
  - Bit: Bit slice (subset of MPU functions)
  - CBIC: Cell-based IC
  - Custom: Full-custom IC (single user)
  - DSP: Digital signal processor
  - FPGA: Field-programmable gate array
  - LISP: 32-bit list instruction set processor for AI
  - Logic: Standard logic
  - LSI: Large-scale integration
  - MCU: Microcontroller unit
  - MixSig ASIC: Mixed-signal ASIC
  - MPR: Microperipheral
  - MPRCom: MPR digital communication (ISDN, LAN, UART, or modem)
  - MPU: Microprocessor unit
  - PLD: Programmable logic device
  - RISC: Reduced-instruction-set computation 32-bit MPU
  - Telecom: Telecommunications chip
- Power/discrete/analog (including bipolar power)
  - A/D D/A: Analog-to-digital, digital-to-analog converter
  - Automotive: Dedicated to automobile applications
  - CODEC: Coder/decoder
  - Diode
  - Discrete
  - FET: Field-effect transistor
  - GTO: Gate turn-off thyristor
  - HEMT: High-electron-mobility transistor
  - IGBT: Insulated-gate bipolar transistor
  - Interface: Interface IC
  - Linear: Linear/analog device
  - MDiode: Microwave diode
  - MESFET: Metal semiconductor field-effect transistor
  - MFET: Microwave field-effect transistor
  - Modem: Modulator/demodulator
  - MMIC: Monolithic Microwave IC
  - MOSFET: MOS-based field-effect transistor
  - Op Amp: Operational amplifier
  - Pwr IC: Power IC

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- Pwr Tran: Power transistor
- Rectifier
- Reg: Voltage regulator
- RF: Radio frequency
- SCR: Schottky rectifier
- Sensor
- Smart Pwr: Smart power
- SST: Small-signal transistor
- Switches: Switching device
- Thyristor
- Tran: Transistor
- Zener Diode

- Optoelectronic
  - CCD: Charge-coupled device (imaging)
  - Coupler: Photocoupler
  - IED: Infrared-emitting diode
  - Image Sensor
  - Laser: Semiconductor laser or laser IC
  - LED: Light-emitting diode
  - Opto: Optoelectronic
  - PDiode: Photo diode
  - PTran: Photo transistor
  - SAW: Surface acoustic wave device
  - SIT Image Sensor: Static induction transistor image sensor
- Bipolar Digital and Other Devices (includes all digital ICs using a bipolar process)
  - Darlington
  - Micromachining Sensors
  - MilStd: Military Standard Logic
  - RadHard: Radiation hardened

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The Activities field shows the types of semiconductor manufacturing performed at this location. The activities include:

- "Frnt" means this location performs front-end wafer processing. Front-end wafer processing includes the manufacturing steps from initial oxide through wafer probe test.
- "Rsrch" means the location performs product or process research. Research differs from pilot manufacturing in that research wafers are nonsalable.
- "Dsgn" means this location has a design center.
- "Pilot" means this location performs pilot production. Pilot production means the location produces in small volumes while "debugging" new products or process technologies. The main difference between Research and Pilot is that, unlike Research, Pilot wafers are a salable product.
- "Fndry" means this location performs contract manufacturing. Contract manufacturing is the production, under contract, of another company's branded product. This is also known as foundry production.
- "A/T" means this location performs assembly or testing. Assembly and testing includes the manufacturing steps from E-test through final assembly into a package and final test.
- "Cptiv" means that the company consumes some portion of the fab's output internally.

The Processes field indicates each fab's use of five major types of process. The process groupings are as follows:

- P/CMOS: P-channel metal-oxide semiconductor (PMOS) or complementary metal-oxide semiconductor (CMOS)
- NMOS: N-channel metal-oxide semiconductor (NMOS)
- BiCMOS: Bipolar and CMOS combined on a chip
- Bipolar
- III-V: Gallium arsenide and other compound semiconductor processes

The Year and Quarter of Initial Production displays the year (and quarter, if available) in which this line, having completed all qualifications, began manufacturing in production volumes. The format for this reference is "year.quarter" (for example, 1994.3 translates to the third calendar quarter of 1994).

The Initial Monthly Wafer Starts field indicates the initial monthly volume of production wafer throughput.

The Estimated Maximum Monthly Wafer Starts field contains the equipment-limited wafer start capacity per four-week period. Only the throughput of the installed equipment and the process complexity limits the maximum starts. Dataquest does not consider current staffing or the number of shifts operating in determining this metric.

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The Maximum (Wafer) Diameter represents the maximum wafer size that the fab or fab line can process. Wafer diameters, although expressed colloquially in inches, conform to metric specifications. For wafers greater than 3 inches in diameter, expression in inches becomes inaccurate. When calculating square inches, Dataquest uses the following approximations:

- Stated diameter of 4 inches (100 mm) = Approximate diameter of 3.938 inches
- Stated diameter of 5 inches (125 mm) = Approximate diameter of 4.922 inches
- Stated diameter of 6 inches (150 mm) = Approximate diameter of 5.906 inches
- Stated diameter of 8 inches (200 mm) = Approximate diameter of 7.87 inches

The Minimum Line Width is the smallest feature size, measured in microns, attainable in production volumes.

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Table 2-1
Front-End Production Lines in Operation before 1998

Company	Fab Name	City	Prefecture	Country	Activities	Processes	Products	Initial Production Date	Initial Monthly Wafer Starts	Maximum Monthly Wafer Starts	Maximum Wafer Diameter (mm)	Minimum Line Width (Micron)
AB Vilniaus Venta	Vilniaus Venta	Vilniaus		Lithuania	Frnt A/T Rsrch Fndry		Amplifiers Thyristors	1969	4,000	8,000	100	5
ABB Semiconductor	Lb 1	Lenzburg	Aargau	Switzerland	Frnt A/T Dsgn	Bipolar	High-Power Bipolar Discrete	1981.4	3,000	16,000	100	3
Alcatel Mietec	Fab 1	Oudenaarde	O-VL	Belgium	Frnt A/T Dsgn	P/CMOS N/MOS BiCMOS	Custom MixSig ASIC	1985	6,000	15,000	100	0.6
Alcatel Mietec	Fab 2	Oudenaarde	O-VL	Belgium	Frnt A/T Dsgn Fndry	P/CMOS BiCMOS	Custom MixSig ASIC ASSP	1993.2	2,000	10,000	150	0.3
Analog Devices		Limerick	Ireland	UK	Frnt A/T Rsrch Dsgn Fndry	P/CMOS BiCMOS	Analog Linear A/D D/A DSPs	1986	6,000	20,000	100	2
Analog Devices		Limerick	Ireland	UK	Frnt A/T Rsrch Dsgn Fndry Pilot	P/CMOS BiCMOS	DSPs Analog	1995	1,300	4,400	150	0.35
Ansaldo Transporti SpA	Linita	Genoa		Italy	Frnt A/T Rsrch Dsgn Fndry	Bipolar	Power Discretes	1970	2,100	6,000	100	2
Atmel	Fab 6	Rousset Cedex		France	Frnt A/T Rsrch Dsgn Fndry Pilot	P/CMOS BiCMOS	ASIC MCU EEPROM	1988	500	10,000	150	0.5
Atmel	Fab 7	Rousset Cedex		France	Frnt A/T Rsrch Dsgn	P/CMOS BiCMOS	Flash ASIC	1997	500	30,000	200	0.35
Atmos-Elpol		Warsaw		Poland	Frnt Pilot		ASIC	1985	4,100	16,600	100	2
Austria Mikro Systeme International AG	Unterprem-statten	Unterprem-statten		Austria	Frnt A/T Rsrch Dsgn Fndry Pilot	P/CMOS N/MOS BiCMOS	Digital Analog Mix-Sig ASICs	1983	4,000	16,000	100	0.6
Baneasa SA	Diodes & Thyristors	Bucharest		Romania	Frnt	Bipolar	Discrete Diode Thyristor	1972	100	500	50.8	10
Baneasa SA	Integrated Circuits	Bucharest		Romania	Frnt	Bipolar	Linear IC	1973	100	500	75	5

(continued)

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Table 2-1 (Continued)
Front-End Production Lines in Operation before 1998

Company	Fab Name	City	Prefecture	Country	Activities	Processes	Products	Initial Production Date	Initial Monthly Wafer Starts	Maximum Monthly Wafer Starts	Maximum Wafer Diameter (mm)	Minimum Line Width (Micron)
Baneasa SA	Diodes & Transistors	Bucharest		Romania	Frnt	Bipolar	Discrete Transistor Diode	1975	500	1,000	75	3
CMK Ltd.	CMK	Zarnovica		Slovakia	Frnt A/T Rsrch	III-V	GaAs ICs	1977	1,500	6,000	100	0.25
Diotec Manufacturing Spol SRO	Diotec Mfg.	Radosina		Slovakia	Frnt A/T	Bipolar	Diodes	1993.1	2,000	12,000	100	6
Elmis	SDB Elmis	Zaporozhye		Ukraine	Frnt Rsrch Dsgn Fndry		MCRO ASIC IGBT Diodes Interface Foundry	1991	4,000	5,000	100	3
ELMOS	6	Dortmund		Germany	Frnt A/T Rsrch Dsgn	P/CMOS	EEPROM ASICs 8-Bit MCU	1996	2,000	7,500	150	0.65
ELMOS	4	Dortmund		Germany	Frnt A/T Rsrch Dsgn	P/CMOS	EEPROM ASICs 8-Bit MCU	1985	2,000	7,500	100	1
EM Microelectronics Marin SA	Marin	Marin	2074	Switzerland	Frnt A/T Rsrch Dsgn Fndry	P/CMOS BiCMOS	Hybrid ICs MCU	1992	1,400	6,000	150	0.5
Ericsson Components	5/51	Kista-Stockholm		Sweden	Frnt A/T Rsrch Dsgn	Bipolar	HV Telecom ICs	1972	5,000	12,000	100	1.2
Ericsson Components	Sule-My	Kista-Stockholm		Sweden	Frnt A/T Rsrch Dsgn Pilot	P/CMOS BiCMOS Bipolar	ASICs Telecom ICs RF IC	1994.3	500	1,500	150	0.4
Ericsson Components	3/51	Kista-Stockholm		Sweden	Frnt A/T Rsrch Dsgn	P/CMOS Bipolar	CMOS ASIC Power Discrete RF IC	1982	1,000	3,500	100	1.2
Fraunhofer Institut für Silizium technologie ISIT	Fraunhofer ISIT	Itzehoe		Germany	Frnt A/T Rsrch Dsgn Fndry Cptiv Pilot	P/CMOS	Mem Power MOS	1996	4,500	18,100	200	0.5

(continued)

Table 2-1 (Continued)
Front-End Production Lines in Operation before 1998

Company	Fab Name	City	Prefecture	Country	Activities	Processes	Products	Initial Production Date	Initial Monthly Wafer Starts	Maximum Monthly Wafer Starts	Maximum Wafer Diameter (mm)	Minimum Line Width (Micron)
Fujitsu	Fab 1	Newton Aycliffe	England	UK	Frnt	P/CMOS	4M 16M DRAM	1991	7,500	15,000	150	0.4
Gamma	JSC No. 1	Zaporozhye		Ukraine	Frnt A/T Fndry		ASIC Interface Bipolar Digital	1976	15,000	20,000	100	3
Gamma	JSC No. 2	Zaporozhye		Ukraine	Frnt A/T Fndry		Diode IGBT MOSFET Power Transistors Thyristor	1965	10,000	14,000	75	3
GEC-Marconi Materials Technology Ltd	GaAs	Caswell	England	UK	Frnt A/T Rsrch Dsgn Fndry Pilot	III-V	GaAs Analog MMICs	1993	50	160	75	0.25
GEC Plessey	Doddington	Lincoln	England	UK	Frnt A/T Rsrch Dsgn Pilot	P/CMOS Bipolar Other	Power ICs IGBTs Discrete	1981	4,200	12,000	100	1
GEC Plessey	Cheney Manor	Swindon	Wiltshire, England	UK	Frnt A/T Rsrch Dsgn	Bipolar	Analog	1961	2,400	8,000	150	0.5
GEC Plessey	Chadderton	Oldham	England	UK	Frnt A/T Rsrch Dsgn	Bipolar	MixSig ASIC	1984	3,600	12,000	100	0.8
GEC Plessey	Roborough	Plymouth	England	UK	Frnt A/T Rsrch Dsgn	P/CMOS	ASIC DSPs	1995.4	2,000	24,000	200	0.35
General Instrument		Cricklade	England	UK	Frnt A/T Dsgn	Bipolar	Discrete	1981	3,500	10,000	100	2.2
General Semiconductor		Freiburg		Germany	Frnt A/T Rsrch Dsgn	Bipolar	Discrete			16,800	100	5
Hewlett-Packard	ICO	Ipswich	England	UK	Frnt A/T Rsrch Dsgn	III-V	Opto LED Opto Laser LED Opto Detectors	1987	100	300	50.8	1

(continued)

Table 2-1 (Continued)
Front-End Production Lines in Operation before 1998

Company	Fab Name	City	Prefecture	Country	Activities	Processes	Products	Initial Production Date	Initial Monthly Wafer Starts	Maximum Monthly Wafer Starts	Maximum Wafer Diameter (mm)	Minimum Line Width (Micron)
Hitachi	E2	Landshut	Bavaria	Germany	Frnt A/T	P/CMOS	16Mb DRAM 8-Bit MCU	1993.1	1,500	16,000	200	0.35
Hughes Microelectronics	Semiconductor Products	Glenrothes	Fife, Scotland	UK	Frnt A/T Rsrch Dsgn Fndry	P/CMOS N/MOS Bipolar	EEPROM MixSig ASIC	1971	800	2,800	100	2
IBM Microelectronics		Corbeil-Essonnes		France	Frnt Cptiv	Bipolar	Linear ASIC	1986	10,000	40,000	125	2
IBM Microelectronics		Zurich		Switzerland	Frnt Rsrch Cptiv Pilot	P/CMOS III-V		1986	3,800	11,000	75	1.7
IBM Microelectronics	SGL	Corbeil-Essonnes		France	Frnt Cptiv	P/CMOS	MCU ASIC SRAM Analog	1983	8,200	16,500	125	0.8
IBM Microelectronics		Corbeil-Essonnes		France	Frnt Cptiv Pilot	P/CMOS	DRAM	1989	3,500	7,000	200	0.8
IBM Microelectronics	ACL	Corbeil-Essonnes		France	Frnt	P/CMOS	16Mb DRAM	1981	16,100	30,000	200	0.35
IBM Microelectronics	AMF	Corbeil-Essonnes		France	Frnt	P/CMOS N/MOS	16Mb 64Mb DRAM	1997	5,500	18,000	200	0.2
ICCE		Baneasa		Romania	Frnt Rsrch	Bipolar	Opto Linear	1985	4,400	12,700	100	1.4
ICM Praha		Praha		Czech Republic	Frnt A/T Dsgn Fndry	P/CMOS N/MOS Other	Foundry Sensors Detection	1989.1	200	400	75	3
IMEC	P Line	Leuven	Brabant	Belgium	Frnt A/T Rsrch Dsgn Cptiv Pilot	P/CMOS N/MOS BiCMOS	R&D Prototyping	1987	100	650	150	0.18
Institute of Electron Technology	R&D Silicon	Warsaw		Poland	Frnt A/T Rsrch Dsgn Fndry Cptiv	P/CMOS	Digital ASICs Mem Photodiodes	1976	500	500	100	3
Integral		Minsk City		Russia	Frnt	P/CMOS Bipolar		1986	22,500	75,000	150	0.8
Intel	Fab 8	Migdal Ha'emek	Jerusalem	Israel	Frnt	P/CMOS	x86 MPU MCU MPR	1985	7,000	28,000	150	0.8

(continued)

Table 2-1 (Continued)
Front-End Production Lines in Operation before 1998

Company	Fab Name	City	Prefecture	Country	Activities	Processes	Products	Initial Production Date	Initial Monthly Wafer Starts	Maximum Monthly Wafer Starts	Maximum Wafer Diameter (mm)	Minimum Line Width (Micron)
Intel	Fab 10	Leixlip	Ireland	UK	Frnt	BiCMOS	x86 MPU	1994	8,000	20,000	200	0.5
Intel	Fab 14	Leixlip	Ireland	UK	Frnt	BiCMOS	x86 MPU	1997	9,600	24,000	200	0.35
International Rectifier	Medium Power Fab	Turin	Torino	Italy	Frnt A/T Dsgn		Rectifier Thyristor	1985	5,200	15,000	100	1.6
International Rectifier	High Power Fab	Turin	Torino	Italy	Frnt A/T Dsgn		Rectifier Thyristor	1981.1	3,500	10,000	100	5
International Rectifier	Fab 8/ Schottky	Turin	Torino	Italy	Frnt Dsgn		Schottky Rectifier	1997	400	15,000	125	10
Iskra		Trbovlje		Slovenia	Frnt A/T Dsgn Pilot	Bipolar	Dis	1982	1,700	5,000	75	2.5
Isocom		Hartlepool	England	UK	Frnt A/T	III-V	Opto	1984	4,400	12,700	100	1.4
Italtel		Rome		Italy	Frnt	III-V		1988	5,000	14,400	150	2
IXYS Semiconductor	Edisonstrasse 16	Lampertheim		Germany	Frnt A/T Dsgn	Bipolar Other	MOSFET Bipolar	1971	3,100	15,000	125	2
Kvazar-Micro	Kvazar	Kiev/Ukraine		Ukraine	Frnt A/T Rsrch	P/CMOS N/MOS BiCMOS Bipolar	MPU Analog	1986	2,000	5,000	125	1.6
Kwazar-Joint Stock Company	Kwazar-IC	Kiev		Ukraine	Frnt A/T Rsrch Dsgn Fndry	P/CMOS N/MOS BiCMOS Bipolar	Analog Amplifiers MPU MCU EPROM	1963.1	4,000	10,000	100	1.8
Lucent Technologies	MD-1	Tres Cantos	Madrid	Spain	Frnt A/T Dsgn Fndry	P/CMOS	CBIC Custom DSP	1988.1	3,000	15,400	150	0.32
Microelectronica SA	Microelectron-ica	Bucharest		Romania	Frnt A/T Dsgn	P/CMOS N/MOS Other	ASIC	1983.2	1,000	3,000	100	1
Microelectronics-Ime		Sofia		Bulgaria	Frnt A/T Dsgn Pilot	P/CMOS BiCMOS	Linear	1981	600	2,000	25.4	2
Microelectronics-Ime		Sofia		Bulgaria	Frnt A/T Dsgn Pilot	P/CMOS BiCMOS	Linear	1985	2,700	9,000	125	2

(continued)

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Table 2-1 (Continued)
Front-End Production Lines in Operation before 1998

Company	Fab Name	City	Prefecture	Country	Activities	Processes	Products	Initial Production Date	Initial Monthly Wafer Starts	Maximum Monthly Wafer Starts	Maximum Wafer Diameter (mm)	Minimum Line Width (Micron)
Micronas-Intermetall GmbH	IC Waferfab	Freiburg		Germany	Frnt A/T Rsrch Dsgn Pilot	P/CMOS BiCMOS Bipolar III-V Other	MCU Hybrid MixSig ASIC Controller	1992	1,000	16,500	125	0.5
Micronas OY	Fab 1	Espoo		Finland	Frnt A/T Rsrch Dsgn Fndry Cptiv Pilot	P/CMOS BiCMOS	Linear CBIC Custom	1986.2	3,000	8,000	100	1.2
Micronas SA	Fab	Bevaix	Neuchatel	Switzerland	Frnt A/T Dsgn Pilot Fndry	P/CMOS	Lin CBIC Custom	1986		4,000	100	2
Mikroelektronik & Technologie Ges.	Smd	Dresden		Germany	Frnt Rsrch Cptiv Pilot	P/CMOS	ASIC SRAM DSP	1986	7,700	17,300	100	1.2
Mikron Corporation	Mikron	Zelenograd	Moscow	Russia	Frnt A/T Rsrch Dsgn Fndry	P/CMOS BiCMOS Bipolar III-V	Video Consumer Analog MCU Power ICs Transistors	1964	15,000	60,000	150	0.8
Mitel Semiconductor AB	Fab	Jarfalla		Sweden	Frnt A/T Dsgn Fndry	P/CMOS BiCMOS III-V	Custom MixSig ASIC SOS	1991.1	1,500	4,000	150	1
Mitsubishi	MSE	NRW		Germany	Frnt A/T	P/CMOS	4Mb 16Mb DRAM	1997.2	7,000	14,000	200	0.35
Motorola	Bipolar 4	Toulouse		France	Frnt	P/CMOS Bipolar	Analog Op Amp Telecom Automotive	1979	8,400	28,000	100	2.5
Motorola	MOS 9	East Kilbride	Scotland	UK	Frnt A/T Fndry	P/CMOS	SRAM DSP MCU	1990	8,400	24,000	150	0.35
Motorola	MOS 16	South Queensferry	Scotland	UK	Frnt Cptiv	P/CMOS BiCMOS	MPU Alpha Analog	1990.1	2,800	7,200	150	0.5
Motorola	MOS 1	East Kilbride	Scotland	UK	Frnt A/T	P/CMOS	MCU Logic	1970	14,000	56,000	100	0.8

(continued)

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Table 2-1 (Continued)
Front-End Production Lines in Operation before 1998

Company	Fab Name	City	Prefecture	Country	Activities	Processes	Products	Initial Production Date	Initial Monthly Wafer Starts	Maximum Monthly Wafer Starts	Maximum Wafer Diameter (mm)	Minimum Line Width (Micron)
Motorola	MOS 20	Toulouse		France	Frnt	P/CMOS	Analog Automotive	1987	6,000	20,000	150	1.2
Motorola	BP 6	Toulouse		France	Frnt	P/CMOS Bipolar	Low-Frequency Power	1984	6,300	18,000	125	1.5
Motorola	Rectifier Fab	Toulouse		France	Frnt	Bipolar	High-Voltage Discrete Pwr Diodes	1984	2,400	7,000	75	2.5
National Semiconductor	Fab 1	Greenock	Scotland	UK	Frnt A/T Dsgn Fndry	P/CMOS N/MOS Bipolar	Linear	1977.4	1,000	48,000	100	2
National Semiconductor	Fab 3	Greenock	Scotland	UK	Frnt Dsgn Fndry	P/CMOS Bipolar	Linear	1986.4	1,000	10,000	150	0.8
NEC	1 Phase	Livingston	Scotland	UK	Frnt A/T	P/CMOS	ASIC MCRO Logic 4Mb DRAM	1987	9,000	25,000	150	0.5
NEC	2 Phase	Livingston	Scotland	UK	Frnt A/T	P/CMOS	16Mb 64Mb DRAM	1996.4	10,000	20,000	200	0.25
Newmarket Microsystems		Newmarket	England	UK	Frnt	Bipolar	Linear Discrete	1981	3,500	10,000	100	2.2
Newport Wafer Fab	Fab 2	Newport	Wales	UK	Frnt A/T Rsrch Dsgn Fndry	P/CMOS	Foundry	1996	700	5,000	150	0.5
Newport Wafer Fab	Fab 1	Newport	Wales	UK	Frnt A/T Rsrch Dsgn Fndry	P/CMOS	Foundry	1982	3,000	20,000	150	0.7
Newport Wafer Fab	Fab 3	Newport	Wales	UK	Frnt A/T Rsrch Dsgn Fndry	P/CMOS	Foundry	1997	1,800	12,000	200	0.35
Nuova Mistral SpA	Nuova Mistral	Sermoneta (Latina)		Italy	Frnt A/T	Bipolar	Zener Diode SST and TR-Darlington	1983	1,000	15,000	100	3
Philips	MOS 2	Nijmegen		Netherlands	Frnt A/T Dsgn	P/CMOS	Logic Discretes	1971	7,800	26,000	100	3

(continued)

Table 2-1 (Continued)
Front-End Production Lines in Operation before 1998

Company	Fab Name	City	Prefecture	Country	Activities	Processes	Products	Initial Production Date	Initial Monthly Wafer Starts	Maximum Monthly Wafer Starts	Maximum Wafer Diameter (mm)	Minimum Line Width (Micron)
Philips	Diffusion Centre	Stadskanaal		Netherlands	Frnt A/T Dsgn	Bipolar	Power Rectifier Diodes	1970	24,500	70,000	100	3
Philips	DS Wafer Fab	Hamburg		Germany	Frnt A/T Dsgn	Bipolar	Discrete	1991	6,000	24,000	100	2
Philips	T & D	Nijmegen		Netherlands	Frnt A/T Dsgn	P/CMOS N/MOS Bipolar	SRAM Consumer ICs	1978	4,200	8,400	150	0.8
Philips	PowerMOS	Stockport	Cheshire, England	UK	Frnt Dsgn	N/MOS	Power MOSFETs	1988	10,000	16,000	150	0.8
Philips	AN	Nijmegen		Netherlands	Frnt A/T Dsgn	P/CMOS BiCMOS Bipolar	Consumer ICs	1971	2,000	30,000	125	1.2
Philips	MOS 3	Nijmegen		Netherlands	Frnt A/T Rsrch Dsgn	P/CMOS BiCMOS	ASSP	1987	15,000	25,000	150	0.6
Philips	CIC	Hamburg		Germany	Frnt A/T Dsgn	Bipolar	Consumer ICs	1987	11,000	25,700	150	1
Philips	I & A Wafer Fab	Hamburg		Germany	Frnt A/T Dsgn	P/CMOS N/MOS BiCMOS	MOS BiMOS Logic	1981	2,500	24,000	125	0.6
Philips	Fab 1	Caen		France	Frnt A/T Dsgn	P/CMOS BiCMOS Bipolar	Consumer ICs	1989	2,200	25,000	125	1.2
Philips	Bipolar 1	Stockport	England	UK	Frnt Dsgn	Bipolar	Power Transistors	1996	24,000	40,000	150	3
Philips	MOS4YOU	Nijmegen		Netherlands	Frnt A/T Rsrch Dsgn	P/CMOS	Consumer ICs ASSP	1996.3	10,000	20,000	200	0.35
Philips	Fab 2	Caen		France	Frnt A/T Dsgn	BiCMOS	Analog	1995	2,000	12,500	100	0.8
RIGA Semiconductors	Alfa	Riga		Latvia	Frnt A/T Rsrch Dsgn Fndry	P/CMOS	Power Discrete Analog	1990	400	1,500	100	3

(continued)

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Table 2-1 (Continued)
Front-End Production Lines in Operation before 1998

Company	Fab Name	City	Prefecture	Country	Activities	Processes	Products	Initial Production Date	Initial Monthly Wafer Starts	Maximum Monthly Wafer Starts	Maximum Wafer Diameter (mm)	Minimum Line Width (Micron)
Robert Bosch GmbH	Fab 2	Reutlingen		Germany	Frnt A/T Dsgn Fndry Cptiv	P/CMOS BiCMOS Bipolar Other	ASIC Automotive ICs	1995	6,000	25,000	150	0.8
Romanian Electronics Modules & Semiconductors	ROMES SA	Bucharest		Romania	Frnt A/T Rsrch Dsgn Fndry		Discrete Opto	1979	1,200	800	75	5
Seagate Microelectronics	SME	Livingston	Scotland	UK	Frnt A/T Dsgn Fndry Cptiv	N/MOS BiCMOS Bipolar	Custom ICs Preamp Motor Control ICs	1986.1	2,700	9,000	100	0.8
SEMEFAB	Fab	Glenrothes	Fife, Scotland	UK	Frnt A/T Rsrch Dsgn Fndry Pilot	P/CMOS N/MOS BiCMOS Bipolar	CMOS Linear Discrete MOSFET Bipolar	1987	150	6,000	100	1.5
Semikron		Nurnberg		Germany	Frnt A/T Rsrch Dsgn	Bipolar	Discrete	1989	3,500	10,000	150	2.2
SGS-Thomson	Mesa	Tours		France	Frnt Dsgn	Bipolar	Discrete	1978	21,000	60,000	100	10
SGS-Thomson	Grenoble	Grenoble	Isere	France	Frnt A/T Dsgn	P/CMOS Bipolar	Digital Analog Logic	1980	8,700	25,000	100	1.5
SGS-Thomson	R1 Phase 1	Agrate		Italy	Frnt Rsrch Pilot	P/CMOS	EPROM Flash	1991	8,000	20,000	150	0.6
SGS-Thomson	M5 Phase 3	Catania	Sicily	Italy	Frnt Rsrch	P/CMOS	EPROM Flash	1996	7,000	20,000	200	0.5
SGS-Thomson	M5 Phase 4	Catania	Sicily	Italy	Frnt Rsrch	P/CMOS	EPROM Flash	1997.2	5,600	16,000	200	0.25
SGS-Thomson	Rousset 6	Rousset		France	Frnt A/T Dsgn	P/CMOS N/MOS	EPROM EEPROM MPU MCU	1996	13,000	26,000	150	0.6
SGS-Thomson	Planar	Tours		France	Frnt Dsgn	N/MOS	Discrete	1996	5,200	15,000	125	5

(continued)

Table 2-1 (Continued)
Front-End Production Lines in Operation before 1998

Company	Fab Name	City	Prefecture	Country	Activities	Processes	Products	Initial Production Date	Initial Monthly Wafer Starts	Maximum Monthly Wafer Starts	Maximum Wafer Diameter (mm)	Minimum Line Width (Micron)
SGS-Thomson	R1 Phase 3	Agrate		Italy	Frnt Rsrch Dsgn Pilot	P/CMOS	EPROM Arrays MixSig ASIC	1985	6,200	25,000	150	0.6
SGS-Thomson	Rousset 2000	Rousset		France	Frnt A/T Dsgn	P/CMOS BiCMOS	CMOS BiCMOS ICs	1993	7,700	22,000	200	0.25
Siemens	H15, H16, H17	Regensburg	Bavaria	Germany	Frnt A/T	P/CMOS	4Mb DRAM ASIC ASSP 1Mb DRAM ASIC	1986.3	1,200	50,000	150	0.35
Siemens	H14, H15, H16	Villach Carinthia		Austria	Frnt Rsrch Dsgn	Bipolar	Logic Power	1981	2,000	61,000	150	1
Siemens	SIMEC (Lines 1 & 2)	Dresden	Saxonia	Germany	Frnt A/T Rsrch	P/CMOS	16Mb 64Mb 256Mb DRAM	1996.2	5,000	30,000	200	0.25
Siemens	NTS	North Tyneside	England	UK	Frnt Pilot	P/CMOS	DRAM	1997.3	1,200	25,000	200	0.25
Siemens	Optoelectronics	Regensburg	Bavaria	Germany	Frnt A/T	III-V	LED RED MR Sensors PIN Laser Photo Diodes	1986	2,300	18,000	100	1
Siemens	Mch P	Munich		Germany	Frnt Rsrch		MOS Logic Bipolar Logic	1987	1,000	18,000	150	0.35
Siemens	B	Munich		Germany	Frnt Rsrch		MOS Logic Bipolar Logic	1964	6,200	25,000	125	0.5
South African Microelectronic Systems		Pretoria		South Africa	Frnt A/T Rsrch Fndry Pilot	P/CMOS	CBIC ASIC ASSP	1992	1,000	5,000	150	1

(continued)

Table 2-1 (Continued)
Front-End Production Lines in Operation before 1998

Company	Fab Name	City	Prefecture	Country	Activities	Processes	Products	Initial Production Date	Initial Monthly Wafer Starts	Maximum Monthly Wafer Starts	Maximum Wafer Diameter (mm)	Minimum Line Width (Micron)
SubMicron Semiconductor Technologies (SMST)	Building 31	Boblingen		Germany	Frnt	P/CMOS	DRAM CMOS Processors	1989	9,000	16,000	200	0.4
TEMIC	Fab 150 Phase 1	Nantes		France	Frnt A/T Dsgn Fndry	P/CMOS BiCMOS	256K SRAM MCU ASIC Linear	1986	500	10,500	150	0.5
TEMIC	Fab 4 Phase 1	Heilbronn		Germany	Frnt A/T Dsgn	P/CMOS BiCMOS Bipolar III-V	Analog	1979	200	15,000	100	1
TEMIC	Fab 4 Phase 2	Itzehoe		Germany	Frnt A/T Dsgn		MOSFETs	1994.4	200	20,000	150	1
TEMIC	Fab 6	Heilbronn		Germany	Frnt A/T Dsgn	Bipolar III-V	Analog	1994.4	200	12,000	150	0.7
TEMIC	Fab 150 Phase 2	Nantes		France	Frnt A/T Dsgn Fndry	P/CMOS BiCMOS	SRAM MCU ASIC	1994.4	500	15,000	150	0.35
Tesla Piestany	PAA 0, 1	Piestany		Slovakia	Frnt A/T Dsgn	P/CMOS N/MOS Bipolar	A/D D/A Converters Logic SRAMs DRAMs Trans	1980	400	8,000	100	3.5
Tesla Piestany	PAA 2	Piestany		Slovakia	Frnt			1983	6,100	17,600	100	2.2
Texas Instruments	FFAB	Freising		Germany	Frnt Dsgn	P/CMOS BiCMOS	MPR	1977	6,200	27,000	200	0.4
Texas Instruments	AMOS-1	Avezzano	AQ	Italy	Frnt Rsrch Dsgn	P/CMOS	4Mb 16Mb DRAM 4Mb Flash	1990	8,000	22,000	150	0.4
Texas Instruments	AMOS-2	Avezzano	AQ	Italy	Frnt Rsrch Dsgn	P/CMOS	16Mb DRAM	1996	8,000	15,000	200	0.25
Texet		Nice		France	Frnt A/T Dsgn		Discrete	1981	3,500	10,000	100	2.2

(continued)

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Table 2-1 (Continued)
Front-End Production Lines in Operation before 1998

Company	Fab Name	City	Prefecture	Country	Activities	Processes	Products	Initial Production Date	Initial Monthly Wafer Starts	Maximum Monthly Wafer Starts	Maximum Wafer Diameter (mm)	Minimum Line Width (Micron)
Thesys	ESO-3	Erfurt		Germany	Frnt A/T Rsrch Dsgn Fndry Cptiv	P/CMOS BiCMOS	ASIC	1990	4,500	9,000	150	0.4
Tower Semiconductor	NSMH	Migdal Ha'emek		Israel	Frnt A/T Dsgn Fndry	P/CMOS	EPROM Logic Foundry	1986.3	2,700	18,000	150	0.35
Uniphase Laser Enterprise	Laser-Wafer	Ruschlikon		Switzerland	Frnt A/T Rsrch		Lasers	1985	16	16	75	0.5
Vaisala	Vaisala Clean Room	Vantaa		Finland	Frnt A/T Pilot	P/CMOS	Sensors	1980.4	100	200	100	5
Westcode Semiconductor		Chippenham	England	UK	Frnt A/T Dsgn Cptiv	Bipolar	Discrete	1977	3,500	10,000	50.8	3
X-Fab Wafer Technologies	X-Fab	Erfurt		Germany	Frnt Rsrch Fndry	P/CMOS	CMOS Sensors Power	1987.4	10,000	14,000	150	0.65
Zentrum Mikroelektronik Dresden GmbH	Fab 1	Dresden	01109	Germany	Frnt A/T Rsrch Dsgn Fndry	P/CMOS N/MOS BiCMOS	ASIC Memories Foundries	1987.1	5,000	17,000	125	0.8
Zetex		Chadderton	Lancashire, England	UK	Frnt A/T Rsrch Dsgn	P/CMOS N/MOS Bipolar	Discrete Analog IC Analog	1970	3,100	12,000	100	2

Source: Dataquest (February 1998)

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Table 2-2
Front-End Production Lines Planned for 1998 and After

Company	Fab Name	City	Prefecture	Country	Activities	Processes	Products	Initial Production Date	Initial Monthly Wafer Starts	Maximum Monthly Wafer Starts	Maximum Wafer Diameter (mm)	Minimum Line Width (Micron)
ABB Semiconductor	Lb 2	Lenzburg	Aargau	Switzerland	Frnt A/T Dsgn Fndry	Bipolar	High-Power IGBT Diode Wafer	1998.1	2,100	6,000	125	1
Advanced Micro Devices	Fab 30	Dresden	Saxony	Germany	Frnt Dsgn	P/CMOS	K7 K8 MPU	1999.2	1,000	23,000	200	0.15
Angstrem	Fab 2	Zelenograd	Moscow	Russia	Frnt	P/CMOS	MPU MCU ASIC ASSP SRAM EPROM DRAM	2000	6,000	12,000	200	0.5
Fujitsu	Phase 2	Newton Aycliffe	England	UK	Frnt	P/CMOS	16Mb 64Mb DRAM	1999	10,000	15,000	200	0.25
Hyundai	Fab 1	Halbeath	Dumfermline, Scotland	UK	Frnt	P/CMOS	64Mb 256Mb DRAM	1998.4	500	30,000	200	0.25
Hyundai	Fab 2	Halbeath	Dumfermline, Scotland	UK	Frnt Dsgn	P/CMOS	64Mb 256Mb DRAM	2001	500	30,000	300	0.18
Intel	Fab 18	Kiryat Gat	Jerusalem	Israel	Frnt	BiCMOS	x86 MPU Flash Mem	1998.3	9,600	24,000	200	0.25
LG Semicon	Phase 1	Newport	Wales	UK	Frnt A/T	P/CMOS	64Mb DRAM 256Mb DRAM	1999	15,000	30,000	200	0.25
Micronas-Intermetall GmbH	IC Waferfab	Freiburg		Germany	Frnt A/T Rsrch Dsgn	BiCMOS Bipolar III-V	MCU Hybrid MixSig ASIC Controller	1998.4	4,900	16,500	150	0.5
NEC	2 Phase	Edinburgh	Scotland	UK	Frnt	P/CMOS	64Mb DRAM	2001	10,000	20,000	200	0.35
SGS-Thomson	Rousset 2000	Rousset		France	Frnt A/T Dsgn	P/CMOS	MCU EEPROM NVMem	1999	7,000	20,000	200	0.25
SGS-Thomson	Rennes Fab	Rennes		France	Frnt A/T	P/CMOS BiCMOS Bipolar	Linear Telecom	1998	6,000	20,000	125	1.8
SGS-Thomson	R1 Phase 2	Agrate		Italy	Frnt Rsrch Pilot	P/CMOS	EPROM Flash	1998	7,800	19,700	200	0.35
Siemens	SIMEC (Line 3)	Dresden	Saxony	Germany	Frnt Rsrch Pilot	P/CMOS	64Mb 256Mb 1Gb DRAM	1998.4		2,000	300	0.25
Siemens/ Motorola	Semiconductor 300	Dresden	Saxony	Germany	Pilot Rsrch	P/CMOS	64Mb DRAM	1999		400	300	0.25

Source: Dataquest (February 1998)

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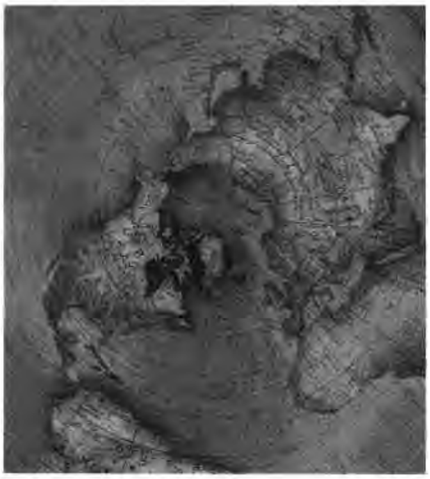

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The European PC Industry: Product Design, Rest in Peace!

Focus Report
1998

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The European PC Industry: Product Design, Rest in Peace!

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SEMI-EU-FR-9802

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Chapter 1
Executive Summary

Key findings of this *Focus Report* include the following:

- The European PC industry is enjoying an excellent year in 1998, with 21.4 shipment growth and 18.2 percent unit production growth.
- The industry is continuing to consolidate, with a greater market share in the hands of large multinationals, the top five of which produced 38.6 percent of all units in Europe in 1997. This figure is forecast to increase to 44.5 percent in 1998.
- Central and Eastern Europe (CEE) will continue to grow faster than Europe as a whole, even though parts of CEE continue to experience economic and social unrest.
- The industry is dominated by transplant manufacturers, which controlled 54.6 percent of regional manufacturing capacity in 1997.
- Growth is forecast at 14.6 percent compound annual growth rate (CAGR) for production and 14.2 percent CAGR for shipments from 1998 to 2002.
- PC workstations will experience strong growth, helping to maintain semiconductor content and unit average selling prices (ASPs).
- Component sourcing decisions are controlled increasingly outside Europe, minimizing design-win opportunities for local semiconductor vendors.
- Intel's dominance as a processor vendor is continuing, although its competitors are beginning to make inroads, finally aided by an increase in sales of sub-$1,000 PCs.
- PC price points are declining, with sub-$1,500 units accounting for 44.5 percent of shipments in the second quarter of 1998.
- The DRAM market is expected to return to strong revenue growth from 1999 to 2001.
- Starting in 1999, a shortage of sub-0.25 micron manufacturing capacity is expected to lead to a tightening of supply of 64Mb PC100 devices.
- 64Mb PC100 pricing levels are expected to stabilize in the fourth quarter of 1998.
- Average PC DRAM fit is expected to be 55MB per system in 1998 and 246MB per system in 2002.
- DRAM fit continues to increase at a historical norm of 65 percent to 70 percent bit growth per annum.
- Worldwide component purchasing agreements are bypassing local vendor offices, establishing virtual total area markets (TAMs) for semiconductor devices.
- Non-DRAM or processor sales of PC-related semiconductors have a minimal impact on the semiconductor design TAM.
- The PC semiconductor TAM over the forecast period will remain about 35 percent of the overall European semiconductor TAM.
- The manufacturing growth rate of motherboards is continuing to decline as the number of locally manufactured motherboards lessens.

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Overview

In contrast with the rest of the world, the PC industry in Europe is set to have another year of strong growth. Following 17.3 percent growth in shipments and 18.4 percent growth in production in 1997 over 1996, Dataquest forecasts 21.4 percent growth in shipments and 18.2 percent growth in production for 1998. This *Focus Report* evaluates the European PC industry, analyzing trends in the market, companies and components and presenting the latest forecasts for the 1998 to 2002 period. The PC manufacturing industry in Western Europe is undergoing a period of major restructuring, and has been transformed almost completely into a production-based industry that focuses on the manufacture and assembly of PCs, with very little product design being undertaken in the region. The serious implications of this change for the semiconductor industry are evaluated, together with recommendations for participating companies. DRAM and microprocessors continue to be the main contributors to the semiconductor TAM in PCs. Accordingly, they are evaluated in detail, together with an overview of other, less important contributors.

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Chapter 2
European PC Manufacturing

Overview

PC manufacturing in Europe is undergoing major restructuring; some companies have been sold, others have shut down capacity. More notably, some major companies are adding significant manufacturing capacity. Certain restructuring efforts have been thwarted, primarily Siemens Nixdorf Informationssysteme's (SNI's) attempt to sell its facility in Augsburg, Bavaria, Germany, to Acer; others, such as Olivetti PCs' attempts to divest itself of capacity at its facility in Scarmango, Italy, seem finally to be coming to fruition. Table 1 shows the most significant activities of the past twelve months as regards local PC production capacity. The overall impact is positive as the major PC manufacturers are continuing to increase their transplant manufacturing capacity in Western Europe. It is, however, only manufacturing capacity, and therefore is vulnerable in times of market downturn when foreign-located facilities are politically easier targets to shut down—a lesson that the UK government is learning the hard way.

The extent of some of the transplant manufacturing expansion is astounding. In particular, Dell has, in the space of a few months, announced two expansions to its Irish facility that will triple the number of employees and its manufacturing space by 1999. Packard Bell NEC's plans to build a new plant in Scotland to double its European capacity causes concern, especially as the company is not experiencing growth comparable with that of Dell. Table 2 shows the final PC production figures for 1997 together with Dataquest's latest estimates for 1998 production. The numbers included in the tables and figures in this *Focus Report* incorporate both PCs and PC workstations (that is, workstations that generally will run Windows NT and that are based on x86 processor architecture). The split between these products is identified in the section titled "Production and Shipment Forecasts" later in this report.

Looking at the current forecast, it becomes apparent that the table will look very different next year—names such as Digital Equipment Corporation and Unisys will have disappeared, and there will be a significant reordering of the ranking positions. New names will creep in to replace those companies that no longer exist and those whose production has shrunk. One immediate result will be that the differential between top and bottom will increase greatly. An increased share of the market will be concentrated in the hands of the top 15 companies: Dataquest forecasts 22.8 percent growth for these companies compared with 18.2 percent growth for the whole sector. The unit ratio between the top company and the bottom company in the top 30 in 1997 was 32.5; in 1998 it is likely to be about 90. Also significant will be the increase in the top 5 companies' market share, which will grow from 38.6 percent to 44.5 percent. Capping it all will be the increase in Compaq's share from 13.1 percent to 16.7 percent. Of this, slightly less than 2 percent will result from the incorporation of Digital's share.

The forecast takes into account the financial and political turmoil that surfaced in Russia in the third quarter of 1997, and the relevant manufacturers' numbers have been reduced to reflect Dataquest's estimation of the impact on the Russian market. Other factors taken into consideration are the impact of Ingram Micro's takeover of the Tulip facility, the sale of Vobis to CHS Electronics and the adoption of Vobis as the exclusive channel for IBM's Aptiva brand in the German market.

Table 1
Major PC Manufacturing Announcements—Europe, Second Half 1997 to Second Half 1998

Company	Action	Comments
Apple	Ceased motherboard assembly in Ireland.	
AST	Ceased Irish assembly activities, except for portables.	Capacity reduction.
Compaq/Digital	Consolidating all production into its facility at Erskine, United Kingdom.	
Dell	Announced that a second Irish assembly plant would start in mid 1998, and a third in late 1999.	Triples Dell's capacity to more than 1 million ft^2 in Europe.
FIC	Opened an assembly facility in the Czech Republic.	OEM build capacity increased.
Fujitsu	Stopped PCB manufacture in Kilo, Finland, and has built up assembly in Germany.	Fujitsu increases screwdriver assembly.
Hewlett-Packard	Started consumer PC production with SCI in the Netherlands.	
IBM	Increased server build in Scotland.	
Packard Bell NEC	Announced major build-to-order assembly facility in Scotland.	To double the company's European capacity by 2002.
Olivetti PCs	Downsizing facility at Scarmango, Italy.	
SNI/Acer	Canceled Acer's takeover of SNI's Augsburg facility.	
Toshiba	Started desktop assembly in Regensburg, Germany.	
Tulip	Sold manufacturing plant to Ingram Micro.	Ingram Micro to channel build.
Unisys	Stopped making PCs and outsourced from a third party.	
Vobis	Sold to CHS Electronics.	Future of Vobis stores uncertain.

Source: Dataquest (October 1998)

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Table 2
PC Production by Major Manufacturer—Europe, 1996-1998 (Thousands of Units)

Rank 1997	Manufacturer	1996	1997	AGR 1996-1997 (%)	Share (%)	Cumulative Share (%)	1998	AGR 1997-1998 (%)
1	Compaq	1,900	2,760	45.3%	13.1%	13.1%	4,150	50.4%
2	IBM	1,880	1,945	3.5%	9.3%	22.4%	2,150	10.5%
3	Hewlett-Packard	950	1,250	31.6%	6.0%	28.4%	1,622	29.8%
4	Dell	780	1,100	41.0%	5.2%	33.6%	1,851	68.3%
5	SNI	750	1,050	40.0%	5.0%	38.6%	1,284	22.3%
6	Packard Bell NEC	750	1,020	36.0%	4.9%	43.5%	1,145	12.3%
7	Vobis Group	650	915	40.8%	4.4%	47.8%	1,200	31.1%
8	Fujitsu	625	810	29.6%	3.9%	51.7%	1,220	50.6%
9	Acer	400	580	45.0%	2.8%	54.4%	665	14.7%
10	Apple	750	545	-27.3%	2.6%	57.0%	610	11.9%
11	Olivetti PCs	660	420	-36.4%	2.0%	59.0%	268	-36.2%
12	Digital	390	410	5.1%	2.0%	61.0%	NA	NA
13	Vist	160	295	84.4%	1.4%	62.4%	270	-8.5%
14	Gateway	240	280	16.7%	1.3%	63.7%	266	-5.0%
15	AST	410	260	-36.6%	1.2%	65.0%	50	-80.8%
16	Toshiba	154	200	29.9%	1.0%	65.9%	275	37.5%
17	Schadt Computertechnik	150	197	31.3%	0.9%	66.8%	175	-11.2%
18	Tulip	190	180	-5.3%	0.9%	67.7%	120	-33.3%
19	R&K	78	180	130.8%	0.9%	68.6%	220	22.2%
20	Actebis	320	150	-53.1%	0.7%	69.3%	201	34.0%
21	OT Computer (Opus/Tiny)	100	145	45.0%	0.7%	70.0%	290	100.0%
22	Unisys	130	140	7.7%	0.7%	70.6%	NA	NA
23	Mitsubishi	140	130	-7.1%	0.6%	71.2%	110	-15.4%
24	PC Spezialist	130	130	0.0%	0.6%	71.9%	122	-6.2%
25	Elonex	115	120	4.3%	0.6%	72.4%	138	15.0%
26	Pacomp	105	120	14.3%	0.6%	73.0%	112	-6.7%
27	Formoza	42	115	173.8%	0.5%	73.6%	180	56.5%
28	Olidata	90	105	16.7%	0.5%	74.1%	120	14.3%
29	Optimus	129	100	-22.5%	0.5%	74.5%	100	0.0%
30	Viglen	80	85	6.3%	0.4%	74.9%	75	-11.8%
	Rest of CEE	1,172	1,310	11.8%	6.2%	81.2%	1,480	13.0%
	Rest of Western Europe	3,310	3,953	19.4%	18.8%	100.0%	4,352	10.1%
	Total	**17,730**	**21,000**	**18.4%**	**100.0%**		**24,821**	**18.2%**
	Top 15 Manufacturers	NA	13,640	NA			16,751	22.8%

NA = not applicable
Source: Dataquest (October 1998 Estimates)

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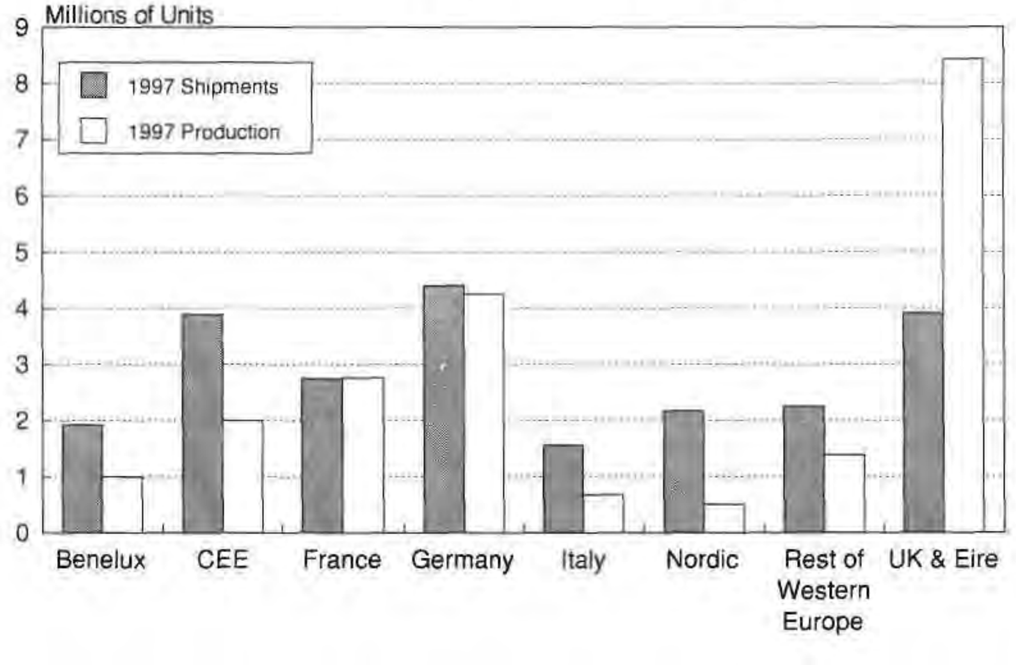
Market Factors

Both the products manufactured and shipped in Europe and their markets are evolving continuously. This section examines various aspects of these products and markets.

The first point to consider is the regional aspect of the total European market—people talk glibly about the "European market," but this market actually comprises many individual markets. For the purpose of data acquisition, Dataquest divides Europe into 20 country markets for PC shipments and 8 regional markets for PC production. For the sake of consistency, this report considers 8 regional markets for both production and shipments. Also for the sake of consistency, this report refers to Europe when talking about the whole market, but uses Western Europe or CEE when referring to these subdivisions. Figure 1 compares PC shipments and PC production by region in 1997, showing that most of the regions were net importers. Only France and the United Kingdom and Eire were net importers: France produced slightly more PCs than were shipped; the United Kingdom and Eire manufactured 2.2 PCs for each PC shipped in the region. This situation will continue, and the dominance of the United Kingdom and Eire region will become even greater as the planned increase in capacity for the major transplant factories is fulfilled.

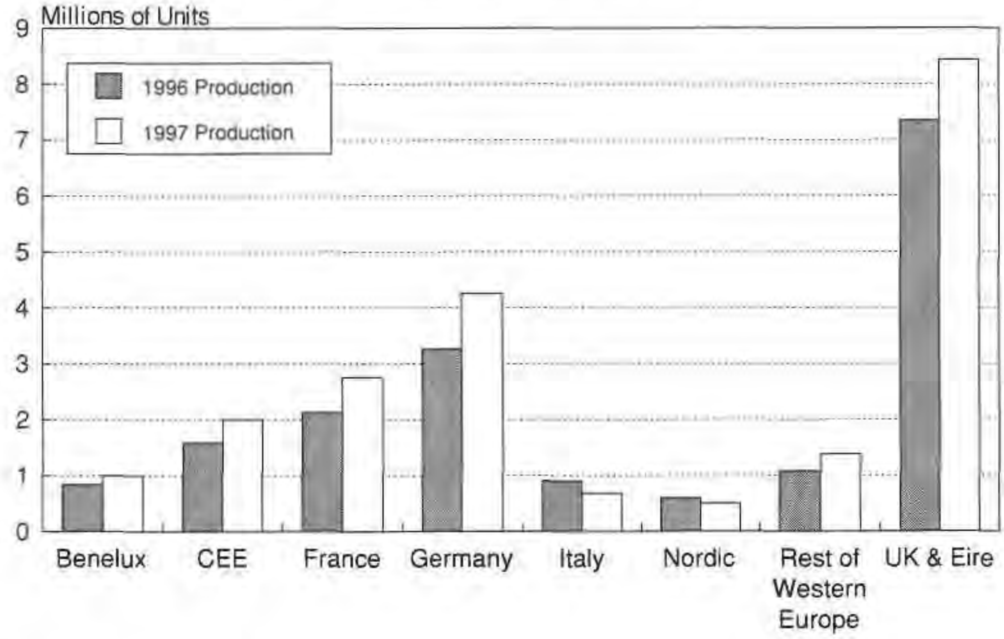
Figure 1
PC Shipments and Production by Region—Europe, 1997



Source: Dataquest (October 1998 Estimates)

Figure 2 shows European PC production by region in 1996 and 1997. All regions increased production during this period with the exception of Italy and the Nordic region. In these two regions the dependence on a single prime player—Olivetti PCs and Fujitsu respectively—reduced the overall regional number as Olivetti PCs continued to shrink and Fujitsu redistributed its production between the Nordic and German regions. CEE continues to grow, and over the five-year period 1997 to 2002 is forecast to have a shipment CAGR of 21.1 percent, compared with 14.2 percent for Europe as a whole. This growth will result in CEE constituting 21.6 percent of the European TAM in 2002.

Figure 2
PC Production by Region—Europe, 1996 and 1997



Source: Dataquest (October 1998 Estimates)

Considerable excitement was generated in 1997 by the advent of the sub-$1,000 PC. Unfortunately, locally, this was nothing but "hot air," as the products in this price band continued to be excess old inventory or local garage shop offerings. Those products designed by major vendors such as Compaq and HP to sell in this price band continued to suffer the inflationary malaise involved in translating dollars into local currencies—in Europe these companies' PCs were priced at well above $1,000. Figure 3 tracks PC price bands in Europe by quarter from 1997 to the second quarter of 1998, showing that only in 1998 has the sub-$1,000 segment begun to be significant. Total 1997 shipments in the sub-$1,000 bracket amounted to only 3.8 percent of the total. The first half of 1998 saw that number jump to 14.2 percent, and the expectation is that by the fourth quarter of 1998 the number will be in the low 20s.

Another clear conclusion to be drawn from Figure 3 is that there is an overall downward migration of price points. The $1,000 to $1,499 bracket is becoming a significantly greater portion of the total—a trend that is apparent over the six quarters—and the higher price brackets are becoming correspondingly smaller. This reduction is very important to the industry because it means that unit growth has to keep increasing to maintain revenue. The magnitude of this shift is evident from the following statistic: in the first quarter of 1997 shipments of units that were priced at less than $1,499 amounted to 18.6 percent of the total, while by the second quarter of 1998 that figure had grown to 44.5 percent.

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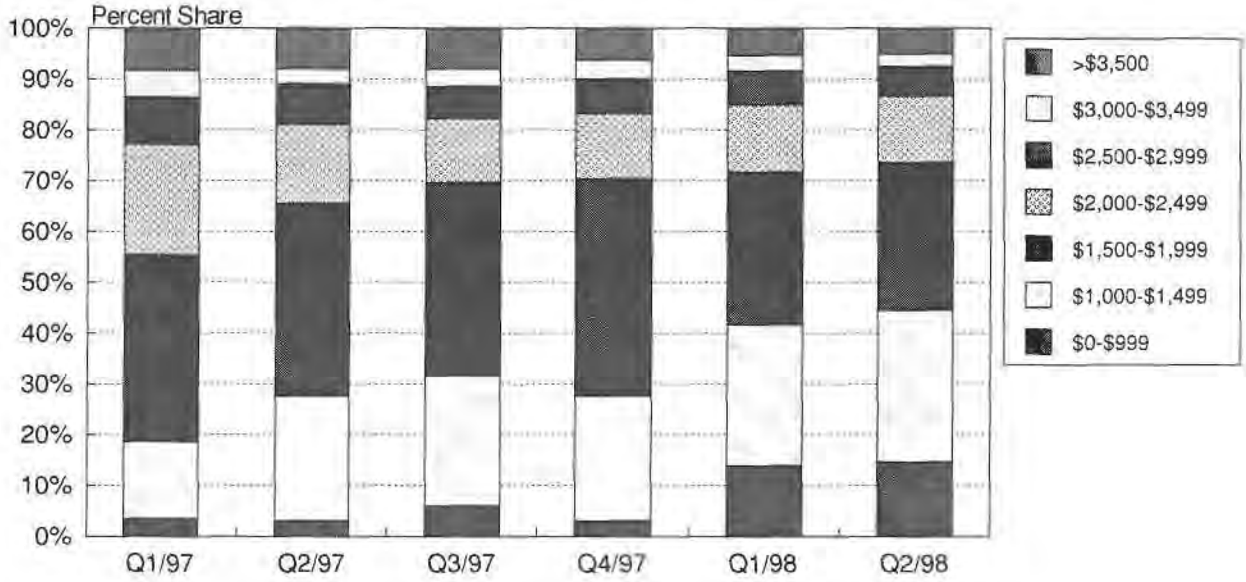
Figure 3
PC Shipments by Price Band—Europe, First Quarter 1997 to Second Quarter 1998

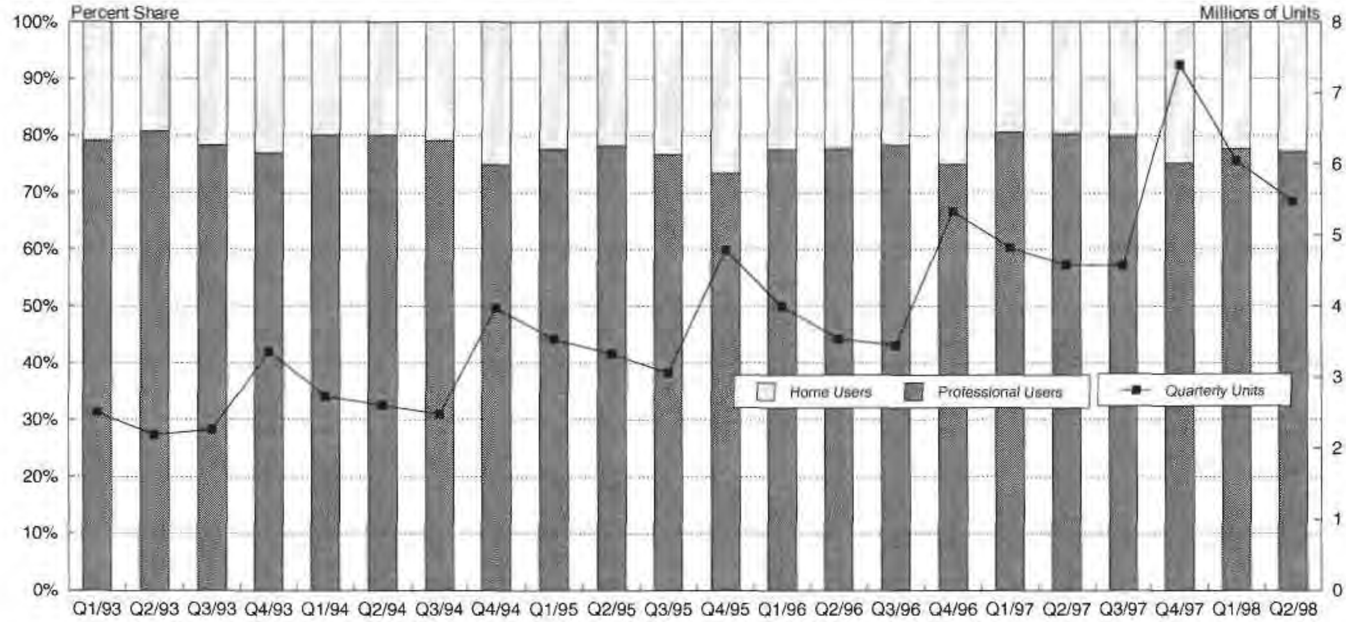


Source: Dataquest (October 1998 Estimates)

The split between professional users and home users is closely monitored in the PC industry. Over the past five years this split has averaged 78 percent for professional users to 22 percent for home users—see Figure 4, which tracks the percentage split from the first quarter of 1993 to the second quarter of 1998. Over this period the range has been from 80.5 percent for professional users and 19.5 percent for home users in the first quarter of 1997 to 73.3 percent for professional users and 26.7 percent for home users in the fourth quarter of 1995. This ratio gives a good indication of whether a year is good or bad—the higher the ratio of home users to professional users the better the year is likely to be for shipments. Different dynamics drive the two sectors. The professional market is steadier and driven by fiscally motivated replacement cycles and business growth. Consumer cycles are more volatile, being driven by consumer confidence and local market conditions. Figure 5 shows the growth rates of the two markets, with the home-user rate showing much wider swings (both positive and negative) compared with the professional sector. This comparison of growth rates also shows that the slowdown from the latter half of 1996 to the first half of 1997 was caused primarily by a lessening of demand from home users. Although European production and consumption in the first half of 1998 was very high (and the second half is showing signs of remaining good), the fact that all three of the growth rates tracked in Figure 5 have begun a downward trend since first quarter of 1998 gives cause for concern for growth in 1999.

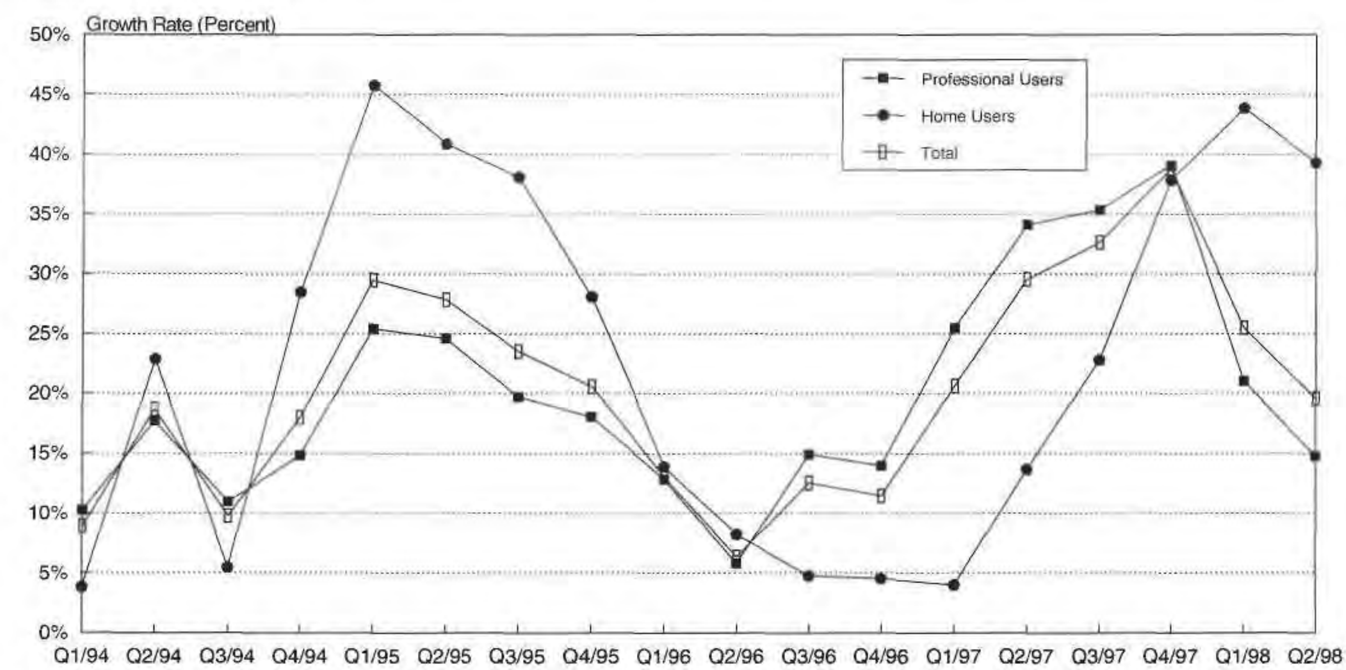
Like many industries, the PC industry is very seasonal. That the ratio of professional users to home users is seasonal is shown clearly in Figure 4, with an average year showing a gradual buildup of home-user sales from the first quarter to the third quarter. This is followed by a major spurt in the fourth quarter, typically adding several percentage points to the home-user segment's share. The overall PC market is also very seasonal—its profile can be seen in the sawtooth line that tracks quarterly shipments in Figure 4. This line shows that the fourth quarter is again the largest quarter for shipments in any year. What is surprising is that the first quarter is the second-biggest quarter, followed by a decline in the second quarter. The third quarter declines again before a huge fourth quarter starts the cycle again. This pattern is sufficiently consistent that a model of quarterly shipment behavior has been built on this basis.

Figure 4
Home and Professional User PC Shipments—Europe, First Quarter 1993 to Second Quarter 1998



Source: Dataquest (October 1998 Estimates)

Figure 5
Home and Professional User PC Shipment Growth Rates—Europe, First Quarter 1994 to Second Quarter 1998



Source: Dataquest (October 1998 Estimates)

European PC Semiconductor Applications

The restructuring that occurred in 1997, and which has continued this year, has reinforced a trend in the European market for semiconductors used in PCs. While overall consumption has increased in line with PC production, the decision-making process involved in component vendor selection has gone increasingly offshore. That 54.6 percent of Europe's PC production was foreign-controlled in 1997—a figure that will continue to rise with the increase in capacity planned by Dell and other companies—means that, increasingly, all sourcing decisions are made elsewhere. That only 5.9 percent of the remaining 45.4 percent was designed in Europe by European-controlled companies means that only 5.9 percent of the non-DRAM and microprocessor TAM was controlled by European decision makers. The remaining 39.6 percent of locally controlled assemblers are merely screwdriver operations and therefore purchase only DRAM and processors locally. This means that, on the DRAM and microprocessor front, European buyers determined all of the 45.4 percent build controlled by European companies. This percentage will continue to decline as foreign-owned companies increase their share of the European market.

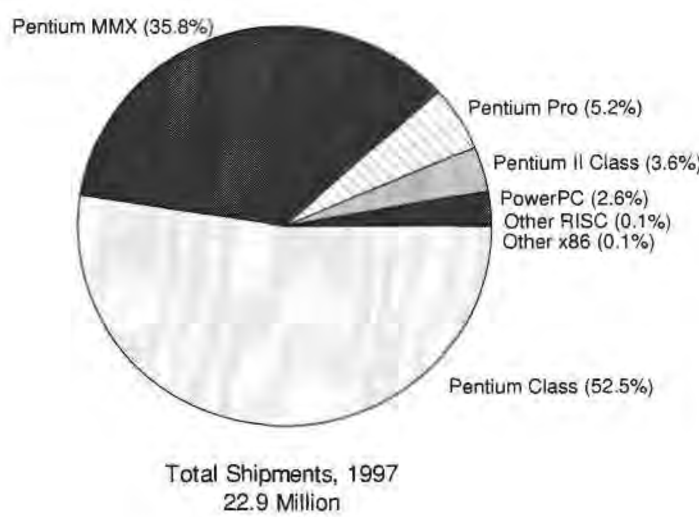
PC design in Europe has been in terminal decline for some years. Since the early 1990s, only a handful of companies has indulged in the luxury of PC design: SNI, Hewlett-Packard (HP), Olivetti PCs, Tulip, Mitsubishi and Fujitsu have held the line, but this is now left to SNI, HP and (for high-end systems only) to Mitsubishi and Fujitsu. The commoditization of the PC has made it uneconomic to design motherboards, especially for budget and mainstream desktops. Portables are brought in from the Far East for local configuration, apart from some transplant builds. SNI and HP are the only companies designing desktop products in Europe. The main difference between these two companies and most other vendors is that SNI and HP have worldwide design centers in Europe. Looking beyond 1998, Dataquest believes that, ultimately, SNI will stop European design and source its PCs from outside Europe. The deal with Acer would have enabled SNI to do this, but, with Acer pulling out, SNI will still be sourcing PCs from within Siemens. The question is: how long before the company stops designing? HP will continue to design in Europe because its facility in Grenoble, France, is its worldwide desktop design center, with products subsequently being manufactured for local markets by contract equipment manufacturers (CEMs) around the world. Although the company's design is undertaken in Europe, HP's centrally organized purchasing is done in the United States—consequently, major sourcing decisions are not controlled locally.

With this discussion in mind, the main focus here will be microprocessors, DRAM and cache SRAM. This *Focus Report* will identify the key players and their market shares, and determine market and product trends. Other products will be touched upon, but only to give an overview of significant trends in any sector.

Microprocessor Trends

The PC microprocessor market was in a state of transition in 1997. On the x86 front, not only was Intel moving forward on two parallel migrations—Pentium to Pentium MMX and Pentium to Pentium II—but Intel's competitors also finally managed to ship competitive products. On the PowerPC front, Apple was completing its migration from first-generation to second-generation products. Figure 6 shows the unit processor split for 1997 and confirms that x86 architectures took all bar 2.7 percent of shipments in Europe. Again on the x86 front, Pentium class devices (that is Pentium, M1 from Cyrix/IBM and K6 from Advanced Micro Devices [AMD]), took the lion's share of the market with 52 percent, followed by Pentium MMX with 36 percent. The rest was taken up by Pentium II (4 percent) and Pentium Pro (5 percent), the bulk of the latter being used in server and PC workstation applications.

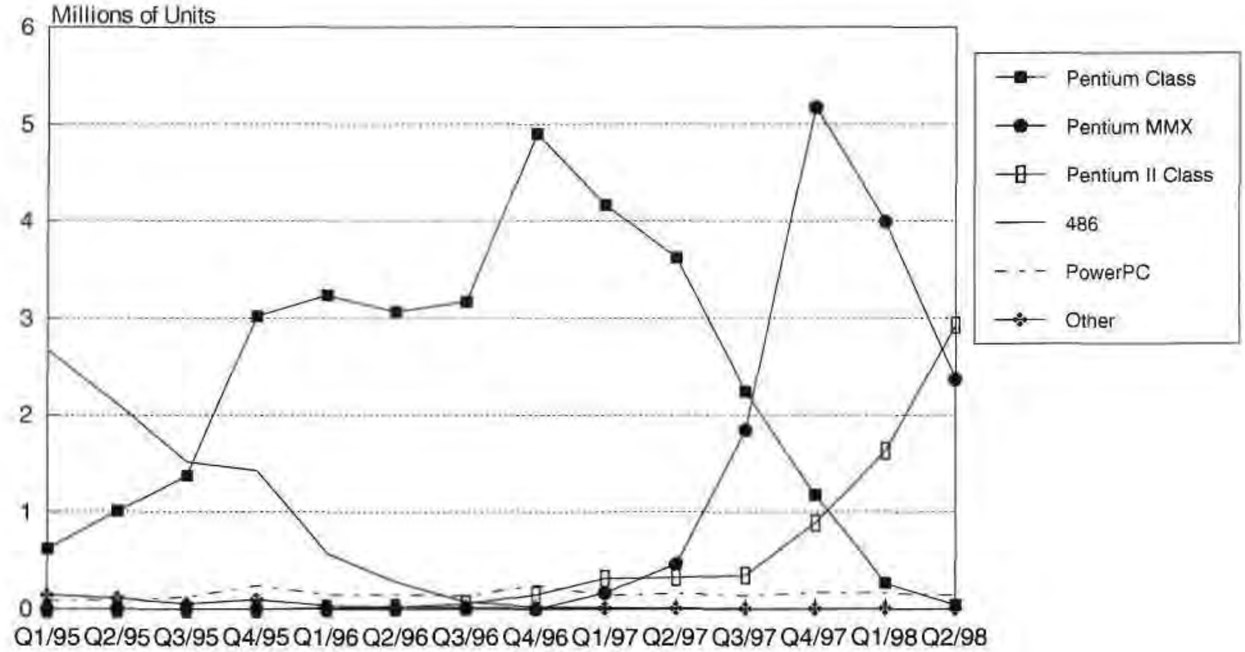
Figure 6
PC Market Processor Shares by Architecture—Europe, 1997



Source: Dataquest (October 1998 Estimates)

Figure 7 shows the migration of major processor families from the first quarter of 1995 to the second quarter of 1998. It shows that the tail end of the 486 generation has been superseded by the Pentium, which is the dominant architecture over the period. The Pentium is shown to have given way to Pentium MMX, which in mid 1998 is already declining rapidly as Pentium II climbs quickly to replace it. Over the whole period all other processors apart from the PowerPC barely registered, and even the PowerPC was barely able to lift itself off the baseline.

Figure 7
Processor Shipment Migration by Architecture—Europe, First Quarter 1995 to Second Quarter 1998



Source: Dataquest (October 1998 Estimates)

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The market revenue shares of the various processor vendors in 1997 are shown in Table 3. Computer processor revenue in the European PC market grew by 18.8 percent in 1997, with total shipments of $5.5 billion. The lion's share of this revenue went to Intel, which shipped $4.9 billion—an increase of 15.6 percent over 1996. Second place went to Motorola, whose revenue rose to $262 million from $120 million in 1996. The main reason for Motorola's 118.3 percent revenue growth was the complete migration of Apple PC production to the PowerPC. The only other non-x86 vendor in the list is VLSI Technology, which continued to supply ARM devices to Acorn for its RISC PC. AMD managed to increase its revenue by 74.8 percent, while National Semiconductor (formerly Cyrix) and IBM made slight gains.

A comparison of Intel's share of the European market in 1997 with its share in 1996 shows that in 1996 Intel had 91.9 percent of the total PC processor market and 94.4 percent of the x86 market, while in 1997 these numbers had dropped to 89.4 percent and 93.9 percent respectively. Evidently, competitive products like AMD's K6 processor can impact Intel. Although AMD's 1997 revenue share was only 3.5 percent, the expectation is that this figure will be considerably higher in 1998—the rise of sub-$1,000 PC shipments shown in Figure 3 is firm evidence to this effect.

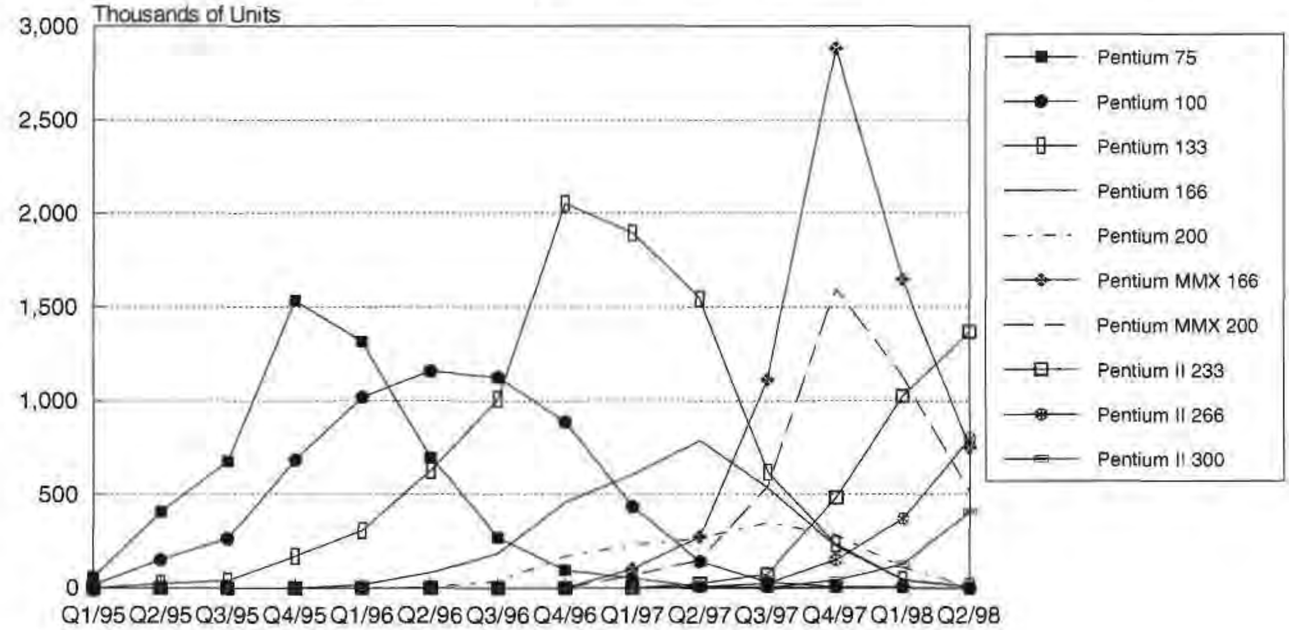
Table 3
PC Processor Vendor Revenue Shares—Europe, 1997

Rank 1996	Rank 1997	Company	Revenue 1996 ($M)	Revenue 1997 ($M)	AGR 1996-1997 (%)	Share 1997 (%)
1	1	Intel	4,282	4,948	15.6%	89.4%
2	2	Motorola	120	262	118.3%	4.7%
3	3	Advanced Micro Devices	111	194	74.8%	3.5%
4	4	National Semiconductor	62	64	3.2%	1.2%
5	5	IBM	49	50	2.0%	0.9%
6	6	SGS-Thomson	34	14	-58.8%	0.3%
7	7	VLSI Technology	2	2	0.0%	0.0%
		Total	**4,660**	**5,534**	**18.8%**	**100.0%**

Source: Dataquest (October 1998 Estimates)

From a situation in 1996 where Intel had almost no competition, 1997 saw the company reacting to the changed situation in two ways, both of which led to a faster acceptance of new processor speeds and architectures. Firstly, Intel announced new products at an increasing rate. Secondly, Intel manipulated its regular price announcements in such a way as to ensure that the market moved to the newer products more quickly than it had in the past. Figure 8 shows how the average time taken for an Intel processor to reach its maximum level of adoption has shortened from six quarters to four quarters. In the period covered by Figure 8, Intel announced 30 speed grades spread over five device families, not counting products specific to portable PCs. For the sake of readability, only the most significant Intel speed/device combinations are plotted.

Figure 8
Intel Processor Speed Adoption—Europe, First Quarter 1995 to Second Quarter 1998



Source: Dataquest (October 1998 Estimates)

Although this abundance of processors might appear to give users more choice, there is a considerable backlash from users against the rapid change because products have increasingly short life cycles. This is felt particularly by corporate IT departments where the decision-making process is long and where it is expected that the products purchased should last for a reasonable period of time. The fast introduction rate of processors and associated technology has meant that customers have had to accept products of entirely different specifications during the life span of their projects. The resulting backlash has induced major PC vendors to introduce product ranges that have life cycles and specifications guaranteed specifically to meet the needs of IT departments.

In 1997, Intel x86 microprocessor pricing was impacted by the arrival of competitive devices. As already noted, Intel was forced to increase the speed with which it reduced its prices, and as a result saw its ASP drop in comparison with that of 1996. Processor ASPs are relatively uniform throughout the world because of the tight control that Intel has over the market. Table 4 shows the worldwide ASPs of Intel and its competitors in 1997 and so far in 1998. The release of 350-MHz and 400-MHz Pentium II products in the first half of 1998 enabled Intel to increase its ASP in the second quarter. This will not continue, however, because the release of Celeron products at a price point that is guaranteed to compete with AMD (among others) will bring down prices in the second half of 1998. Intel plans to maintain its overall ASP by means of Pentium II Xeon products. Pentium II Xeon shipments will start to increase in the second half of 1998, but their full impact will not be felt until 1999.

AMD has suffered the worst ASP fall. This company has publicly tied its pricing at 25 percent less than the nearest comparable-speed Intel product. For the first half of 1998 this meant that AMD's pricing was tied to the Pentium MMX, comparable Intel speeds being available only on this product. With the launch of 300-MHz (and faster) versions of the K6-2, AMD is realigning its pricing at 12.5 percent less than the most comparable Pentium II device. In so doing, AMD hopes to raise its ASP. However, this will only happen if customers accept the resulting price/performance combination when offered an AMD-powered PC.

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Table 4
Worldwide x86 Processor ASPs by Manufacturer, 1997 and 1998

Manufacturer	1997 ($)	Q1/1998 ($)	Q2/1998 ($)	Year-to-Date 1998 ($)
Advanced Micro Devices	84.11	112.67	81.48	92.62
Cyrix	83.78	78.00	77.00	77.50
IBM	88.82	85.00	82.00	83.36
Intel	221.49	191.63	192.83	192.22
All Compute x86	202.49	181.36	175.52	178.39

Source: Dataquest (October 1998 Estimates)

PC Memory Applications

Flash BIOS

Since the advent of the Pentium class PC, all BIOS chips have been of the flash memory type. Although in-system reprogrammability is seldom, if ever, required, the decline in the price of flash memory in recent years has meant that there is now little or no premium over EPROM. In 1997, the vast majority of PC BIOS applications required 1Mb of flash memory, but a rapid shift to 2Mb is underway, and 4Mb will be the norm in coming years.

The European market for flash BIOS is limited by the number of PC and PC workstation motherboards that are manufactured locally. Typically, about 50 percent of the PCs and PC workstations produced in Europe have had locally produced motherboards. In 1997, therefore, about 10 million flash BIOS chips were consumed by the European PC industry. At an ASP of $2.30 per megabit, the TAM was at most $23 million (or less than 3.5 percent of the total flash market). And ASPs have continued to fall, so that the average price of a 1Mb flash device in 1998 is expected to be less than $2, further reducing the attractiveness of this market. In practice, Dataquest has found that the market for flash BIOS in the European region is much smaller than the theoretical maximum because of the number of motherboards produced by CEMs, which to reduce costs procure components centrally, elsewhere in the world.

In Europe, such is the dominance of the GSM handset as an application for flash memory, both in terms of units and of the flash megabits per system requirement, that the major flash vendors—AMD, Intel, Fujitsu and Sharp—have tended to ignore the flash BIOS market, leaving it to emerging vendors such as Macronix and Silicon Storage Technology.

Cache SRAM

By far the most important factor holding back current-generation PC performance is the amount of time taken to store data in, or to retrieve data from, the system main memory. Such has been the acceleration of improvement in microprocessor speed in recent years that system performance remains predominantly limited by the time taken to access the main memory. Although continual progress has been made in developing higher-performance DRAM for system main memory over the years—from asynchronous technologies such as page mode, fast page mode and extended data out (EDO) to the new synchronous DRAM (SDRAM) technologies—a PC's performance can be enhanced greatly by the addition of a relatively small amount of high-speed cache SRAM.

Cache SRAM sits close to the microprocessor and provides high-speed local memory space for recently accessed data, the theory being that the microprocessor is likely to continue to need access to data that it has used recently. The more often the microprocessor achieves a successful "cache hit" the higher the PC system performance will be because the number of times the main memory has to be accessed is reduced.

In fact, there are two levels of cache SRAM. Level 1 cache is located within the microprocessor itself and typically provides 32KB of on-chip memory. Here, memory access time is reduced to a minimum because of the absence of the capacitive loading associated with printed circuit board tracks and chip packages. Historically, level 2 cache has been located off the microprocessor chip, either directly soldered onto, or fitted as a module on, the PC motherboard, or included as part of a microprocessor daughterboard. It is level 2 cache SRAM that this *Focus Report* is concerned with because it utilizes commodity SRAM devices and has therefore been considered a viable end market for semiconductor vendors.

Market Background and Outlook: In the early 1990s the fast SRAM market was buoyant, driven by the PC cache application's demand for the 1Mb (32Kb x 32) synchronous device. Although the product specification required a sub-12 ns access time, the lucrative market attracted many SRAM vendors (particularly new players from Taiwan), which led to a market crash in 1995 as supply exceeded demand.

The market remained competitive up to and including 1997, with demand switching to the 2Mb (64Kb x 32) synchronous device, and access time specifications moving toward sub-5 ns performance. However, 1997 marked a watershed in the PC cache SRAM market—the market situation has changed in 1998. Contemporary PCs are moving rapidly to Pentium II microprocessor technology with SRAM cache incorporated on the microprocessor daughterboard by Intel during assembly. Intel has qualified only a few well-established SRAM vendors, and to date, in Europe, only four vendors (Samsung, NEC, Mitsubishi and Toshiba) are known to be supplying Intel's module assembly plant in Ireland. So, given Intel's dominant position in the microprocessor market, its key fast SRAM suppliers effectively have the European TAM to themselves. Samsung is believed to be the favored supplier with up to 45 percent share, while NEC, Mitsubishi and Toshiba have up to 20 percent each.

More recently, however, as process technology has developed, there has been a move by microprocessor manufacturers to eliminate level 2 cache altogether by increasing the size of the level 1 cache. When this happens—and it is inevitable—the merchant PC cache SRAM market will all but disappear. By the end of 1999, it is expected that the PC cache SRAM market will be restricted to a requirement for sub-5 ns synchronous SRAM in high-end servers and workstations. These machines will be based on Intel's Xeon microprocessor, and it is already clear that Intel will produce the high-speed SRAM for the Xeon's level 2 cache.

Market Statistics: Dataquest estimates that 21 million PCs and PC workstations were manufactured in Europe in 1997. However, only about 10 million motherboards were manufactured locally, and it was the level of motherboard production that effectively determined the size of the European cache SRAM market in 1997. Table 5 gives a breakdown of PC and motherboard production by microprocessor type, with a corresponding estimate of the number of megabits of fast SRAM.

Dataquest estimates that about 28 million cache SRAM 1Mb equivalents were shipped in the European region in 1997, comprising about 14 million 1Mb devices and about 7 million 2Mb devices. At an ASP of $2.50 this puts the 1997 TAM at about $71 million.

The leading PC cache SRAM vendors were Samsung, Mitsubishi, NEC and Toshiba, which shared about half the market equally between them. The remaining half was fought over by multifarious SRAM vendors.

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Dataquest's estimate for PC and PC workstation production in 1998 is almost 25 million units, about 15 million of which will be Pentium II-based machines. Intel will manufacture the Pentium II modules with a fixed 512KB of PC cache SRAM on board at its facility in Ireland. It follows that the cache SRAM TAM at Intel will amount to about 60 million 1Mb equivalents in 1998. As the year progresses, the mix of processor speed will shift from 200/233 MHz to between 300 MHz and 450 MHz; together with this shift will go a requirement for faster specification SRAM devices. Since 1Mb devices are typically specified at 133/150 MHz and 2Mb devices at 183/200 MHz, there will be a corresponding shift in shipments to Intel from 1Mb to 2Mb devices.

Because of this move by Intel to a modular microprocessor with on-board cache, much of the cache SRAM TAM will be "virtual," with only four SRAM vendors qualified by Intel able to participate in this business. This means that the bulk of the cache SRAM market will be shared between the qualified vendors—Samsung, NEC, Mitsubishi and Toshiba—to the exclusion of all others. In addition, the contracts are such that cache SRAM shipments to Intel, although made in Europe, are not necessarily recorded as sales in the region.

Of the remaining 9.4 million machines expected to be produced in Europe, only about 5 million will have their motherboards manufactured locally. These 5 million motherboards effectively determine the size of the PC cache SRAM market available to all SRAM vendors. With an average PC cache SRAM fit of about 600KB, it follows that the maximum available TAM will be about $50 million, comprising 25 million 1Mb equivalent devices at an ASP of $2 each.

Table 5
PC Cache SRAM Consumption—Europe, 1997 and 1998

	PC Production (Units, M)	Local Motherboard Production (Units, M)	Average Cache (KB)	1Mb Equivalents TAM (Units, M)	ASP ($)	TAM ($M)
1997						
Non-Pentium II						
Pentium Pro	1.09	0.00	NA	NA		
Pentium MMX	7.52	4.29	448	15.00	2.50	37.50
Pentium	11.05	5.78	256	11.55	2.50	28.89
PowerPC	0.55	0.55	384	1.64	2.50	4.10
Other RISC	0.02	0.02	384	0.06	2.50	0.16
Other x86	0.02	0.02	384	0.06	2.50	0.16
Total Non-Pentium II	**20.24**	**10.65**		**28.32**		**70.79**
Pentium II	0.76	0.00	NA	NA		
Grand Total	**21.00**	**10.65**		**28.32**		**70.79**
1998						
Non-Pentium II						
Pentium Pro	0.00	0.00	NA	NA	NA	
Pentium MMX	8.68	4.34	640	21.70	2.00	43.40
Pentium	0.00	0.00	NA	NA	NA	
PowerPC	0.74	0.74	512	2.98	2.00	5.95
Other RISC	0.00	0.00	NA	NA	NA	
Other x86	0.00	0.00	NA	NA	NA	
Total Non-Pentium II	**9.42**	**5.08**		**24.68**		**49.35**
Pentium II*	15.38	15.38	512	61.50	2.00	123.01
Grand Total	**24.80**	**20.46**		**86.18**		**172.36**

* It is assumed that all Pentium II motherboards produced in Europe use locally manufactured Pentium II modules. Depending on Intel's global requirements, the number of Pentium II modules manufactured in Europe may be greater or less than the number of locally produced motherboards.
NA = not applicable
Source: Dataquest (October 1998 Estimates)

DRAM

PC system main memory uses DRAM because it is the semiconductor memory technology that offers the optimum price/performance trade-off in this application. The memory performance requirements of the PC are tempered by price-per-megabyte considerations and DRAM offers the lowest price per megabyte of any semiconductor memory technology (excluding mask ROM and EPROM), as shown in Table 6.

Table 6
Semiconductor Average Memory Price Comparison—Europe, 1997

	DRAM	Flash	SRAM	EEPROM
Price per Megabyte ($)	3.68	8.16	32.32	464.00

Source: Dataquest (October 1998 Estimates)

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Although flash memory may be compared with DRAM on a price per megabyte basis, as programmable memory flash memory cannot offer the write-time performance to be viable as PC main memory. SRAM, on the other hand, can offer access times ten times faster than DRAM—but at almost ten times the price. Consequently, DRAM and PC main memory go hand-in-hand—about 73 percent of all DRAM consumption is accounted for by PCs and PC workstations. DRAM's dependence on the PC for its end market means that all drivers of the DRAM industry—cost-per-megabyte reduction, density transitions and bit price crossover, input/output (I/O) configuration and architecture, and cell design—relate directly to the PC. Therefore, generic DRAM technology and trends in the DRAM market automatically apply in the context of the PC more than in any other application.

Market Background and Outlook: DRAM is a true commodity product and, as such, the market is notoriously cyclical and dependent on the precarious balance between supply and demand. From a peak of more than $40 billion in 1995, the global DRAM market declined to about $25 billion in 1996 and to about $20 billion in 1997 as prices crashed because of a glut of products. Overinvestment in DRAM capacity during the early 1990s finally affected the market in 1996 as existing players and new entrants fought for market share.

Although this DRAM market crash was a disaster for the semiconductor industry, it was good news for PC vendors, which were able to increase margins during 1996 by maintaining PC price levels while reducing memory costs. It was not until 1997 that PC end users began to see the benefits, typically in the form of higher-specification machines offered by PC vendors at no additional cost to customers. By 1998, the PC industry was able to offer the so-called "$1,000 PC," which gave the consumer acceptable performance when running contemporaneous software. Continuing DRAM price declines went a long way to making this possible.

The cost of DRAM per megabyte declines by 32 percent per year on average, but imbalances between supply and demand mean that prices do not necessarily follow. While demand for DRAM bits has increased at a relatively predictable 65 percent to 70 percent for more than a decade, fluctuations in the price per megabyte have caused the DRAM market's legendary booms and busts. Contrary to popular belief, DRAM booms are caused by periods of stable rather then increasing prices, while DRAM busts result from a price-per-megabyte correction to the long-term price decline trend. Although the demand side of the DRAM industry equation might be well understood in terms of PC production and main memory fit expectations, it is the supply side—where the timing of the capital investment cycle is critical—that determines future market conditions. Investing in next-generation process technology is fundamental to success in the DRAM market, and the ability to ensure that the right level of capacity is available at the right time in the industry cycle is what distinguishes winners from losers.

Table 7 shows European DRAM vendor market share rankings for 1996 and 1997.

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Table 7
DRAM Vendor Market Share Rankings—Europe, 1996 and 1997

Rank 1996	Rank 1997	Vendor	Region of Origin	Revenue 1996 ($M)	Revenue 1997 ($M)	AGR 1996-1997
1	1	Samsung	Asia/Pacific	940	1,009	7.3%
3	2	Siemens Semiconductor	Europe	428	403	-5.8%
5	3	Hyundai	Asia/Pacific	387	396	2.3%
2	4	NEC	Japan	458	369	-19.4%
8	5	Texas Instruments	Americas	337	350	3.9%
9	6	Micron Technology	Americas	257	272	5.8%
6	7	LG Semicon	Asia/Pacific	361	252	-30.2%
7	8	Fujitsu	Japan	340	242	-28.8%
4	9	Hitachi	Japan	392	196	-50.0%
12	10	IBM	Americas	168	166	-1.2%
11	11	Mitsubishi	Japan	186	156	-16.1%
10	12	Toshiba	Japan	225	112	-50.2%
13	13	Oki	Japan	50	38	-24.0%
18	14	Vanguard International Semiconductor	Asia/Pacific	5	30	500.0%
14	15	Motorola	Americas	49	21	-57.1%
23	16	Alliance Semiconductor	Americas	0	8	NA
16	17	Mosel Vitelic	Asia/Pacific	12	5	-58.3%
17	18	Sanyo	Japan	6	2	-66.7%
19	19	Sharp	Japan	3	2	-33.3%
20	20	Nippon Steel Semiconductor	Japan	1	2	100.0%
21	21	G-Link	Americas	1	1	0.0%
15	22	Matsushita	Japan	16	0	-100.0%
		Total		**4,622**	**4,032**	**-12.8%**

NA = not applicable
Source: Dataquest (October 1998 Estimates)

To the uninitiated, DRAM vendors can be placed in five groups, as follows:

- Committed: Samsung and NEC
- Ambitious: Siemens Semiconductor, Micron Technology and Hyundai/LG Semicon
- Reluctant: Hitachi, Fujitsu, Matsushita, Mitsubishi and Toshiba
- Strategic: IBM, Oki, Sanyo, Sharp and Nippon Steel Semiconductor
- Emerging: Vanguard International Semiconductor, Mosel Vitelic, Alliance Semiconductor and G-Link

The prolonged market downturn has caused many vendors to reappraise their involvement in DRAM. Many names that appeared in the 1997 ranking will disappear in 1998. Motorola pulled out of the DRAM market in late 1997, Micron bought Texas Instruments' DRAM business earlier this year and, at the time of writing, it appears likely that LG Semicon and Hyundai will merge their semiconductor businesses.

Samsung and NEC—long-time DRAM technology and market leaders—are in the unenviable position of having to defend their market shares against aggressive competitors, such as Siemens Semiconductor, Micron Technology and Hyundai/LG Semicon, that are equally committed to the DRAM market. It is interesting to note a geographic trend in the level of commitment to the DRAM market based largely on the maturity of companies as semiconductor vendors. Investing in DRAM has often been the means used by nonsemiconductor companies to enter the semiconductor industry before diversifying into other semiconductor product areas, such as microcontrollers or application-specific ICs (ASICs). This was true of Japanese companies in the 1980s and of South Korean companies in the 1990s. In general, the wider a company's product portfolio the less committed that company will be to any one product. This is especially true of DRAM because of the unpredictable nature of the market. Broadly speaking, Japanese tier-two DRAM vendors (that is, Hitachi, Fujitsu, Matsushita, Mitsubishi and Toshiba) appear to be losing patience with the DRAM market, preferring to concentrate on their wider product portfolios; in contrast, South Korean vendors' product portfolios are not sufficiently diversified for the companies to be anything other than committed to the DRAM market. Continuing this geographic trend, the emergence in recent years of the Taiwanese vendors, Vanguard International Semiconductor and Mosel Vitelic, is noteworthy. It would not be a surprise to see companies from other emerging economies, such as China, follow the same strategy.

The involvement in DRAM of some semiconductor companies, such as IBM, Oki, Sanyo, Sharp and Nippon Steel Semiconductor, is more for strategic business reasons than for a desire to be major DRAM merchant market players. DRAM process technology is often seen as a technology driver for the semiconductor industry as a whole and, with the emergence of system-level integration and embedded memory, many semiconductor companies continue to believe that DRAM capability is important.

Market Statistics: Dataquest's European PC unit production history and forecast data is shown in Table 8.

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Table 8
PC Unit Production—Europe, 1992-2002

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
PC Production (Units, K)	8,145	10,900	13,000	15,885	17,603	20,792	24,450	27,650	31,500	35,792	40,266
PC Workstation Production (Units, K)	N/A	N/A	N/A	N/A	127	208	371	583	837	1,023	1,195
Total PC and PC Workstation Production (Units, K)	8,145	10,900	13,000	15,885	17,730	21,000	24,821	28,233	32,337	36,815	41,461
Total PC and PC Workstation Unit Production Rolling Five-Year Unit CAGR	-	-	-	-	-	20.9%	17.9%	16.8%	15.3%	15.9%	14.6%
Total PC and PC Workstation Average Megabytes per System	5	6	9	13	19	35	55	81	117	162	246
Total PC and PC Workstation Average Megabytes per System Rolling Five-Year CAGR	-	-	-	-	-	49.1%	54.4%	54.2%	55.6%	53.2%	47.9%

N/A = not available
Source: Dataquest (October 1998 Estimates)

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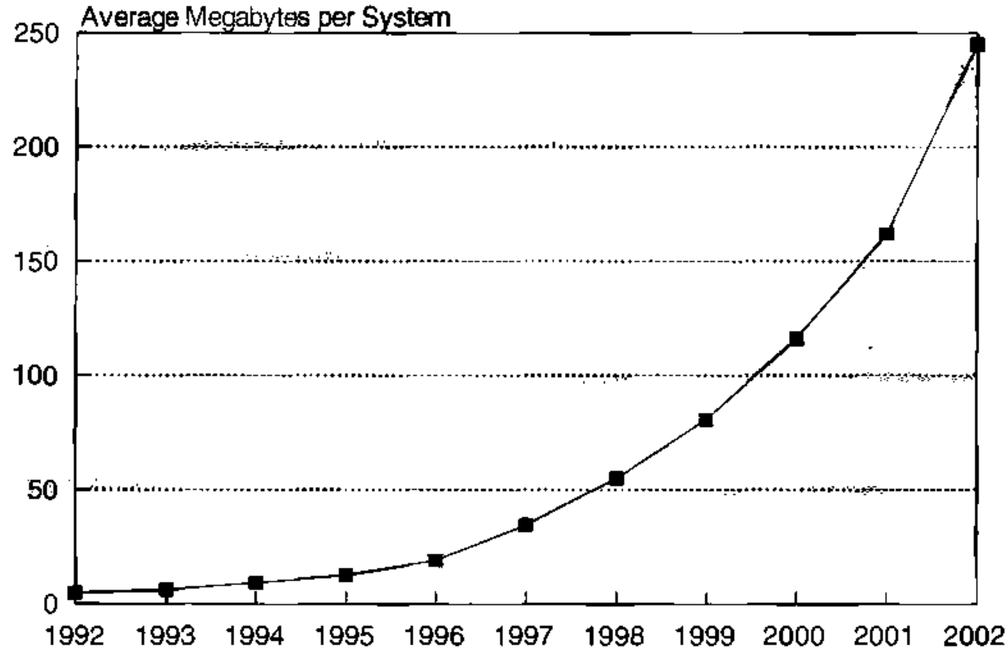
Although growth in PC unit production is expected to decline from a CAGR of 21 percent for the period 1992 to 1997 to 15 percent for the period 1997 to 2002, growth in main memory fit for the same two periods is expected to be maintained at a CAGR of slightly less than 50 percent, resulting in a decline in the bit growth rate for the European PC DRAM market from a CAGR of 79 percent to 69 percent for the same periods. However, this reduction in the bit growth rate is not a cause for concern, but merely a return to historical levels following the "bit boom" of 1997. PC main memory fit (including aftermarket fit) is still expected to increase from an average 35MB in 1997 to an average 246MB in 2002 (see Figure 9).

Figure 9
Total PC Average Megabytes per System—Europe, 1992-2002



Source: Dataquest (October 1998 Estimates)

Table 9 shows Dataquest's most recent forecast for the European PC DRAM market.

 ©1998 Dataquest

Table 9
PC DRAM Market Size—Europe, 1992-2002

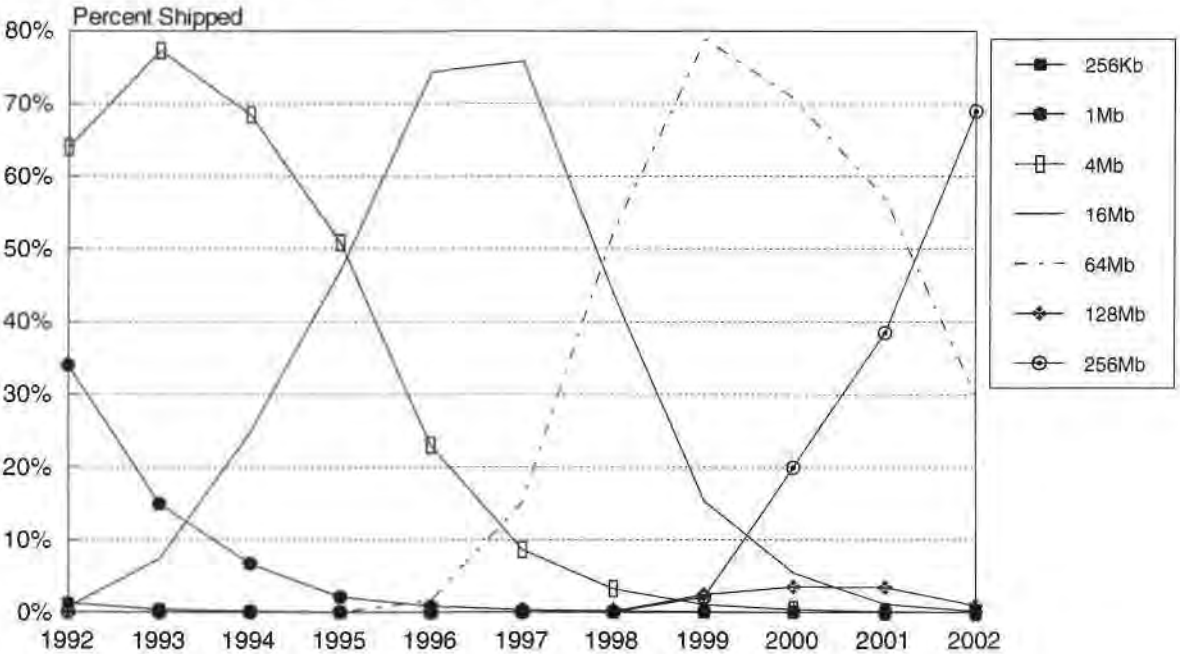
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
PC Production (Units, K)	8,145	10,900	13,000	15,885	17,603	21,000	24,821	28,233	32,337	36,815	41,461
Average PC and PC Workstation Megabytes per System	5	6	9	13	19	35	55	81	117	162	246
Total PC Megabytes (K)	38,290	68,390	120,190	202,335	336,989	727,114	1,369,460	2,281,519	3,767,549	5,972,939	10,181,019
PC 16Mb Equivalents	19	33	59	99	165	355	669	1,114	1,840	2,916	4,971
Price per Megabit ($)	3.56	3.42	3.59	3.41	1.20	0.51	0.19	0.15	0.16	0.16	0.08
PC DRAM Revenue ($M)	1,064	1,826	3,368	5,391	3,160	2,877	2,026	2,637	4,767	7,331	6,618

Source: Dataquest (October 1998 Estimates)

PC DRAM revenue in 1998 is expected to total about $2 billion—about the same level as in 1993 even though the number of megabytes per system is expected to be almost ten times greater this year! With a shortage of PC100 64Mb devices expected because of a lack of sub-0.25 micron fab capacity, the DRAM market is poised to enter an era of price stability. A return to strong growth in DRAM revenue is expected in the period 1999 to 2001 on the assumption that during this time ASPs will stabilize at about the levels of the fourth quarter of 1998.

The period 1999 to 2001 will coincide with the demise of the 16Mb device density in favor of the 64Mb density (see Figure 10). There is a strong body of opinion that advocates the introduction of the 128Mb density as an intermediate density between the 64Mb and 256Mb densities on the grounds that, given the process technologies available, the 128Mb density can be manufactured more cost effectively.

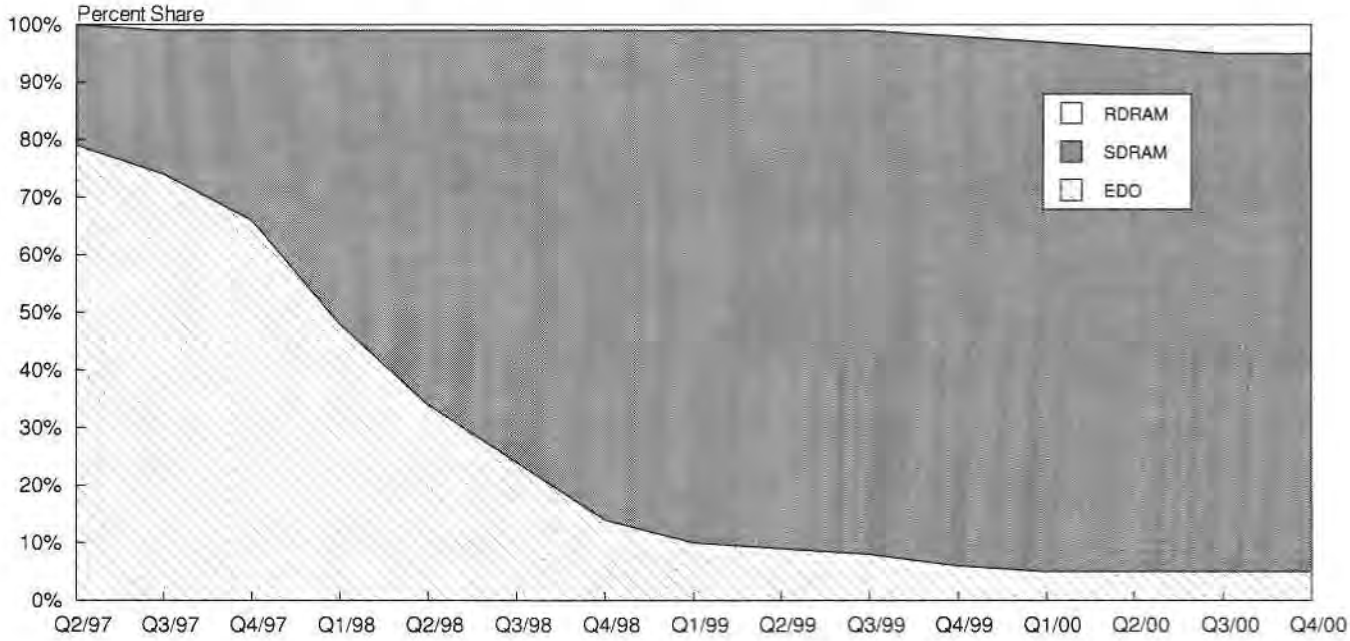
Figure 10
Bits Shipped by Device Density—Europe, 1992-2002



Source: Dataquest (October 1998 Estimates)

Technology transitions will remain as important as density transitions to the development of the DRAM market. Figure 11 shows the rapid shift from EDO technology to synchronous technology that occurred during 1998, when PC66 enjoyed brief popularity. By the first quarter of 1999 about 90 percent of 64Mb DRAM shipments will be SDRAM, and the vast majority of these will be PC100 specification. By the end of 2000, the next generation of DRAM—almost certainly based on proprietary Rambus technology—will have begun to appear, providing yet another quantum leap in DRAM performance.

Figure 11
64Mb DRAM Shipments by Interface Technology—Europe, Second Quarter 1997 to Fourth Quarter 2000



Source: Dataquest (October 1998 Estimates)

Other Devices

The remaining semiconductor components (that is, in addition to microprocessor and DRAM) found on a motherboard fall into several categories (see Table 10), and, of these, SRAM for level 2 cache and flash nonvolatile memory for the BIOS are dealt with in the section titled "PC Memory Applications." These remaining devices are universal to most motherboards and the greatest value is in the chipset, an area where Intel had a virtual monopoly in 1997 as all the transplant fabricators and the European manufacturers used Intel products. Of a market worth $270 million, Intel accounted for $268 million, with the remainder spread between various other companies. In fact, in 1997, more companies left this market than remained. Intel's competitors should gain market share in 1998 because the acceptance of AMD's K6-2 and Cyrix's MII by the major PC vendors will necessitate the use of non-Intel chipsets to get maximum performance from these processors.

The multi-I/O device is the next-largest value item, with European revenue of about $80 million. National Semiconductor has the bulk of this business; Winbond and SMC share about $5 million between them. As we move down the list of devices revenue gets increasingly less and is spread between more players. Because of the small values involved, Dataquest has not done further analysis on these products.

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Table 10
Other Device Categories on PC Motherboards

Device Category	Function	Suppliers
Chipset	Interface between processor and all other functions	Intel, Via Technologies, SIS, Advanced Micro Devices, ALI
Multi-I/O	Floppy, EIDE, Serial, Parallel, USB and so on	National Semiconductor, SMC, Winbond
Interface Drivers	RS232 interface	Various
Clock Chips	System clocks	IC Works, UMC, Cypress Semiconductor
Low Dropout Voltage Regulators	Voltage regulator modules supply core and I/F ring supply for processor	Various
Switch Mode Regulator Controller	As above	Various
Power FETs	As above	Various
Power Rectifiers	As above	Various
Logic Devices	Interface and glue logic	Various

Source: Dataquest (October 1998)

Compaq Deskpro EN Motherboard Analysis

Analysis of a Compaq motherboard for a Deskpro EN as an example of a current high-volume mainstream production unit shows that it has all of the various components previously described. It also has on-board audio, which is increasingly becoming a standard function on motherboards designed by the major PC vendors. Surprisingly, few other functions are migrating to the motherboard—areas like networking are still served mainly by network adapter cards rather than by LAN-on-motherboard (LOM). LOM migration is starting to happen, but the almost religious devotion of network administrators to particular brands of network adapters prevents PC vendors from integrating this function. On the graphics front, the fast rate of innovation plus the targeting of graphics adapters to particular markets (such as games players, electronic design automation and mainstream office users), is also discouraging migration to the motherboard.

Table 11 gives a breakdown by function of the devices on the Compaq Deskpro EN motherboard. A Mitsubishi ASIC M65444 is included on the motherboard. It is believed to carry out functions tied in with administrative security settings and the various interlocks connected to the software-controlled lock that is incorporated inside the chassis. The sound system on this board is based on the ESS1869F, which provides adequate 16-bit stereo sound reproduction. Surprisingly, as well as using a Philips amplifier to drive the internal loudspeaker, Compaq has included a separate headphone driver device.

A device that is beginning to become a standard is the CY2318, which provides clock signal to the SDRAM dual in-line memory modules (DIMMs). Because of 100-MHz DRAM's tight timing, it is necessary to use such a device to ensure the minimum amount of skew between the clock signals applied to each DIMM. The BIOS device on this board is a Fujitsu 2Mb product; this size is fast becoming the standard, having been at 1Mb for several years.

Like so many new-generation motherboards, this one is based on the NLX standard and as such has no slots on it other than an accelerated graphics port slot and a connector for the riser board onto which all expansion boards are plugged. Furthermore, the processor is not fitted vertically on the board, but plugged into a slot 1 socket that is at 90 degrees to the vertical, thereby allowing the processor to lie flat. This keeps down the height of the motherboard and processor combination and allows the board to be used in enclosures of various heights.

Table 11
Compaq Deskpro EN Motherboard Semiconductor Listing

Function	Product	Vendor	Quantity
Processor	400-MHz Pentium II	Intel	1
DRAM (8Mb x 8)	KM48S803BT-GH	Samsung	8
Chipset	440BX-FW82443BX North Bridge	Intel	1
	FW82731EB South Bridge	Intel	1
Multi-I/O	PC 97307-IBY/VUL	National Semiconductor	1
Interface Drivers	SN75185	Texas Instruments	2
Clock Chip	CY2280PVC-IIS	Cypress Semiconductor	1
	CY2318ANZPVC-1	Cypress Semiconductor	1
Bipolar Power	TIP117	ST	1
Power FET	NDP603CL	National Semiconductor	2
Power Rectifier	B40NE 03L-20	ST	1
Regulators/References	Various	Various	4
Analog Devices	Various	Various	2
Logic Devices	Various	Various	14
Flash (2Mb)	29F002T-90	Fujitsu	1
Miscellaneous	M65444-0002FP	Mitsubishi	1
Audio Amp	TDA7056B	Philips	1
Headphone Amp	TDA1308	Philips	1
Sound IC	ESS1869F	ESS	1
Op Amps	LMV324M	National Semiconductor	3
Logic	74HC4066M	National Semiconductor	1

Source: Dataquest (October 1998)

Production and Shipment Forecasts

The future for PC manufacturing in Europe appears relatively secure. The nature of the market will change over the next few years as Western Europe becomes saturated and goes into a replacement mode. However, CEE will continue to grow, albeit with temporary stalls caused by events such as the crisis in Russia. Table 12 gives Dataquest's latest shipment forecast. It shows that from 1998 to 2002 the overall European market will grow at a CAGR of 14.2 percent, with Western Europe growing at 12.4 percent and CEE at 21.1 percent. PC workstations will be the highest-growth format, growing at a CAGR of 32.5 percent. Although PC workstation units are relatively few, they are important because of the impact of their higher ASP on revenue.

Table 12
PC Shipments—Europe, 1996-2002 (Thousands of Units)

	1996	1997	1998	1999	2000	2001	2002	CAGR 1998-2002
Western Europe (PCs)	16,323	18,914	22,860	25,772	29,024	32,685	36,452	12.4%
CEE (PCs)	3,113	3,890	4,678	5,695	6,876	8,337	10,046	21.1%
PC Workstations	21	118	283	474	627	751	870	32.5%
Total	**19,457**	**22,922**	**27,821**	**31,941**	**36,527**	**41,773**	**47,369**	**14.2%**

Source: Dataquest (October 1998 Estimates)

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European PC and PC workstation production is forecast to have a CAGR of 14.6 percent from 1998 to 2002 (see Table 13). Again, the highest growth will be in PC workstations, which will have a CAGR of 41.9 percent over the forecast period. However, when the semiconductor content of ordinary PCs is analyzed, a negative CAGR of 0.7 percent is forecast. This is because Dataquest believes the next DRAM downturn induced by overcapacity will start in 2002 and that DRAM prices will be main factor reducing semiconductor content in 2002. However, the higher semiconductor content of PC workstations will result in a positive (albeit only just) CAGR of 0.6 percent for the total number of PCs manufactured.

Table 13
PC Production Forecast—Europe, 1996-2002

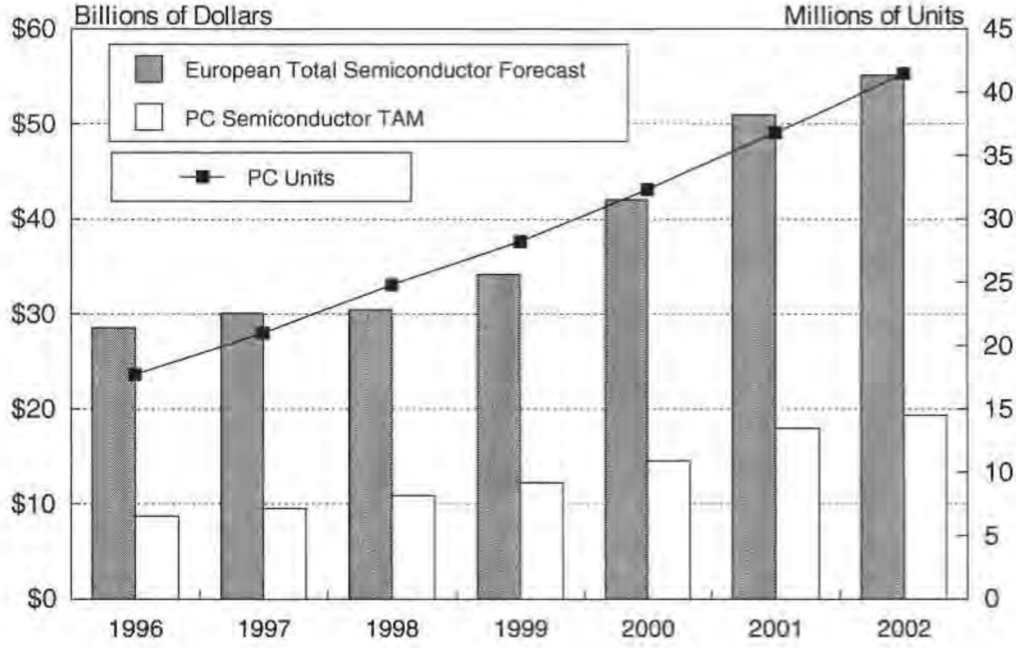
	1996	1997	1998	1999	2000	2001	2002	1998-2002 CAGR
PCs								
Units (K)	17,603	20,792	24,450	27,650	31,500	35,792	40,266	14.1%
Factory ASP ($)	1,320	1,350	1,250	1,190	1,110	1,030	1,005	-5.7%
Factory Revenue ($M)	23,236	28,070	30,563	32,904	34,965	36,866	40,467	7.6%
Semiconductor Content ($)	483	445	422	410	420	455	430	-0.7%
Semiconductor TAM ($M)	8,506	9,253	10,318	11,337	13,230	16,285	17,314	13.4%
I/O Ratio	36.6%	33.0%	33.8%	34.5%	37.8%	44.2%	42.8%	5.4%
PC Workstations								
Units (K)	127	208	371	583	837	1,023	1,195	41.9%
Factory ASP ($)	6,840	5,625	5,050	5,000	5,000	5,000	4,899	-2.7%
Factory Revenue ($M)	867	1,169	1,874	2,913	4,184	5,115	5,854	38.0%
Semiconductor Content ($)	1,570	1,385	1,515	1,548	1,576	1,672	1,714	4.4%
Semiconductor TAM ($M)	199	288	562	902	1,318	1,710	2,049	48.1%
I/O Ratio	23.0%	24.6%	30.0%	31.0%	31.5%	33.4%	35.0%	7.3%
Total								
Units (K)	17,730	21,000	24,821	28,233	32,337	36,815	41,461	14.6%
Factory ASP ($)	1,359	1,392	1,307	1,269	1,211	1,140	1,117	-4.3%
Factory Revenue ($M)	24,103	29,238	32,436	35,816	39,149	41,981	46,322	9.6%
Semiconductor Content ($)	491	454	438	433	450	489	467	0.6%
Semiconductor TAM ($M)	8,705	9,540	10,880	12,238	14,548	17,995	19,363	15.2%
I/O Ratio	36.1%	32.6%	33.5%	34.2%	37.2%	42.9%	41.8%	5.1%

Source: Dataquest (October 1998 Estimates)

Factory ASPs for both PCs and PC workstations are forecast to decline during the period 1998 to 2002 at minus 5.7 percent CAGR and minus 2.7 percent CAGR respectively, resulting in a negative 4.3 percent CAGR for the total PC ASP. Unit growth is forecast to compensate for the decline in ASP, and therefore we see a total factory revenue CAGR of 9.6 percent. Again, this figure will be achieved because of the higher revenue growth rate of PC workstations—38.0 percent CAGR compared with 7.6 percent CAGR for ordinary PCs.

Examination of the PC semiconductor TAM as a percentage of the whole European semiconductor market reveals that over the forecast period this percentage remains relatively constant, being 35.7 percent in 1998 and falling to 35.1 percent in 2002. Interestingly, in 1996 the ratio was 30.5 percent. This increase in value between 1996 and 1998 is attributable primarily to the rise in processor ASP. As the Pentium became the dominant processor family, the corresponding rise in ASP offset the decline in DRAM ASP over the same period and increased the overall PC semiconductor TAM. Figure 12 shows this comparison as well as PC unit growth over the forecast period.

Figure 12
PC Production Units and Semiconductor TAM—Europe, 1996-2002



Source: Dataquest (October 1998 Estimates)

PC motherboard manufacturing in Europe is dominated totally by the transplant manufacturers that continue to produce foreign-designed products in Europe. Table 14 gives Dataquest's forecast for local manufacturing, which is forecast to have a CAGR of 10.2 percent from 1997 to 2002. With the recently accelerating rate at which motherboard production is being transferred to centralized locations in the Far East, this figure may prove to be optimistic in the long term.

Table 14
PC Motherboard Production Forecast—Europe, 1996-2002

	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Units (K)	9,523	10,650	11,834	12,650	14,150	15,200	17,290	10.2%
Factory ASP ($)	135	125	120	117	116	114	114	-1.8%
Factory Revenue ($M)	1,286	1,331	1,420	1,480	1,641	1,733	1,971	8.2%
Semiconductor Content ($)	66	60	62	66	69	71	78	5.4%
Semiconductor TAM ($M)	629	639	734	835	976	1,079	1,349	16.1%
I/O Ratio	48.9%	48.0%	51.7%	56.4%	59.5%	62.3%	68.4%	7.3%

Source: Dataquest (October 1998 Estimates)

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Conclusions

The European PC industry is shoring up growth in the worldwide PC industry in 1998—forecast worldwide shipment growth of 15.6 percent compares badly with the European forecast of 21.1 percent this year. Although the Asian financial crisis is impacting shipments in the Far East, it is having a beneficial impact in Europe because prices for Asian-sourced components are continuing to fall as a result of declining local currency costs, thereby helping to lower PC prices in Europe. Although short-term conditions look good, several issues cloud the future of the European PC industry. The most profound of these is the continuing decline in local ownership and the lack of local intellectual property. The European semiconductor industry is experiencing the impact of being in a similar situation, with local DRAM factories being closed because of worldwide overcapacity, while home region facilities that include research functions and product design centers remain immune.

From the perspective of semiconductor vendors, the key to the European PC manufacturing market is ensuring that they are diligently getting products "designed in" where PCs are being designed, especially in the United States, where most of the multinationals are based. They then have only to service the business on a local basis when production switches to Europe. However, even this is becoming a precarious position because so many deals are being negotiated on a worldwide basis and because products are being drop-shipped into manufacturing facilities around the world without involving semiconductor vendors' local offices. As a result, companies with headquarters in Europe that sell to this market must have strong sales and support presence in the United States and the Far East (especially Taiwan) if they want to be successful.

Processor and memory technology migrations over the next few years will ensure that the PC market remains turbulent. PC prices will continue to decline and most PCs sold will be in the sub-$1,499 price band. This situation will remain as long as the current hiatus in software development continues. There is no convincing candidate on the horizon for the "killer application" that will necessitate much more powerful processors and more memory. Therefore, industry demand for these products will continue to grow at historical growth rates. Various candidates for the killer application have been advocated, but none has yet stood the test of time. The current candidate is speech I/O, but this seems to be making slow progress.

Intel continues to dominate the computer processor arena and has increased its influence further by becoming the dominant player in PC chipsets. The company is also expanding its involvement in networking and graphics. Although Intel's ASPs have declined over the past year, Dataquest expects them to recover as the PC workstation becomes an increasingly important part of the PC market. Pentium II Xeon devices that are targeted specifically at the workstation and server markets are priced at many times the price of a Celeron or Pentium II device. Their cost, however, is only fractionally greater than that of a Pentium II, so their contribution to margins and ASPs will be significant.

Overall, the European market looks healthy. However, analysis of growth rates shows that both the consumer and professional sectors—and therefore the whole market—are slowing. This gives concern for 1999 and beyond. The increase in assembly capacity at such a time means that PC vendors need to keep a close eye on the trend, and ensure that they do not overinvest in production facilities that will become expensive if not running at full capacity.

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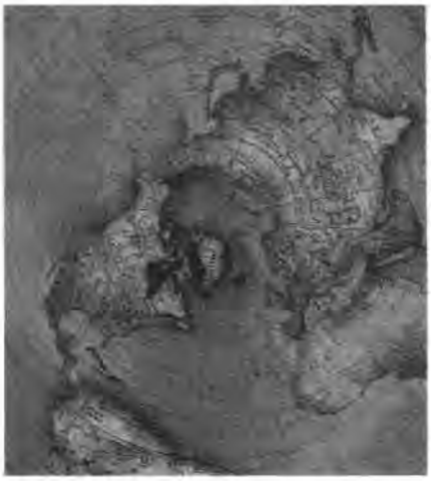

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EMEA Semiconductor Market Forecast and Country Analysis, 1990-2002

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EMEA Semiconductor Market Forecast and Country Analysis, 1990-2002

Executive Summary

Total EMEA

- The market was worth $30.0 billion in 1997—a revenue growth of 5.9 percent over 1996.
- Growth will slow to 2.9 percent in 1998, putting revenue at about $31.0 billion.
- A compound annual growth rate (CAGR) of 15.6 percent is forecast for the period 1997 to 2002.
- Revenue in 2002 is forecast to exceed $62 billion.

Benelux

- Revenue in 1997 was $1.2 billion, up by 4 percent over 1996.
- Benelux is the smallest regional market, accounting for less than 4 percent of total EMEA revenue.
- Growth of about 2 percent is expected in 1998.
- No dramatic change in regional share is anticipated over the forecast period.
- Almost unnoticed, the region is developing as a center of PC production.
- Non-PC markets are declining, holding back the 1997 to 2002 CAGR to 14.5 percent.
- Revenue will exceed $2 billion in 2002.

France

- Average growth of approximately 5.5 percent in 1997 puts revenue at almost $4 billion.
- Above-average growth of 5.8 percent is forecast for 1998.
- A 13 percent share of the total EMEA market is expected to continue through to the end of the forecast period.
- The country has probably the best balance in semiconductor application markets, encompassing healthy communications, automotive, industrial, and military and civil aerospace sectors.
- The wide range of application markets will drive an above-average CAGR of 16.1 percent for the period 1997 to 2002.
- The market will exceed $8 billion in 2002.

Germany

- The market declined by almost 5 percent to $7.5 billion in 1997.
- Germany is no longer the largest single market within the EMEA region in revenue terms, but remains the most important in terms of design-in activity.
- A recovery to 7 percent growth is forecast for 1998.
- Germany has the most broad-based electronics sector of all the EMEA regional markets, so long-term growth goes hand in hand with the EMEA average.
- A CAGR of 15.9 percent is forecast for the period 1997 to 2002.
- Market revenue in excess of $15 billion is forecast for 2002.

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Italy

- Revenue declined by 5.0 percent to $1.7 billion in 1997.
- Revenue of $1.6 billion is forecast for 1998—a further decline.
- Ongoing troubles at Olivetti, the region's most significant OEM, continue to depress the semiconductor total available market (TAM).
- A lack of investment in electronics over many years means that there is no salvation on the horizon.
- Long-term growth at 11.1 percent will continue to lag significantly behind the EMEA average.
- At almost $3 billion in 2002, the market size will be barely above that of Benelux, the smallest EMEA regional market.

Nordic

- Revenue grew by 7.7 percent to $2.7 billion in 1997.
- Forecast growth is 12 percent in 1998, putting the market at $3.0 billion.
- The market has a unique makeup, dominated as it is by Ericsson and Nokia—world leaders in digital cellular handset and infrastructure manufacturing.
- In spite of a move by the major OEMs towards contract electronics manufacturing in low-cost regions and continued pressure to reduce component costs, the region will remain the strongest in growth terms.
- A CAGR of 16.5 percent for the forecast period will drive the market towards $6 billion in 2002.

United Kingdom/Ireland

- At 15.0 percent, the region experienced the highest growth in 1997, putting the market at almost $9 billion.
- The market is now the single largest, ahead of Germany—a situation that will continue throughout the forecast period.
- The large multinational PC companies based in the region have continued to corner the market, providing increased sales for semiconductor vendors.
- The region will benefit most from the anticipated upswing in the DRAM market, which is expected to occur during the forecast period.
- The boom in mobile telephony equipment manufacturing is not restricted to the Nordic region: United Kingdom/Ireland has a lucrative semiconductor market in the sector as well.
- An above-average CAGR of 16.3 percent for the period 1997 to 2002 will put the market at $19 billion by the end of the forecast period.

Rest of EMEA

- Revenue grew by 14.6 percent to $4.1 billion in 1997.
- Many of these countries are still very much immature markets, with much of the electronics equipment manufacturing utilizing subassemblies brought in from outside.
- There are bright spots, such as the Czech Republic and Turkey, but these are the exception.
- Dataquest expects the Rest of EMEA to grow at a slower rate than the industry average over the forecast period to reach $8 billion in 2002.

Scope

This *Market Trends* report analyzes the semiconductor markets that comprise the EMEA region for the period 1990 to 2002. Product level detail is included for the major EMEA market regions: Benelux, France, Germany, Italy, Nordic, United Kingdom/Ireland and Rest of EMEA. Additional breakdown of this latter region gives top-level country market shares and forecasts for Central and Eastern Europe, the Middle East and Africa.

Introduction and Definitions

This *Market Trends* report analyzes the market sizes and outlooks for the major EMEA regions from 1990 to 2002. Dataquest's forecast details the following regional and market definitions.

EMEA

Dataquest defines the EMEA region as follows:

- Benelux: Belgium, the Netherlands and Luxembourg
- France
- Germany
- Italy
- Nordic: Denmark, Finland, Norway and Sweden
- United Kingdom/Ireland
- Rest of Europe, Middle East and Africa: For market analysis purposes, this region is further broken down as follows:
    - Rest of Western Europe: Andorra, Austria, Cyprus, Faroe Islands, Gibraltar, Greece, Greenland, Guernsey, Iceland, Isle of Man, Jersey, Liechtenstein, Malta, Monaco, Portugal, San Marino, Spain, Svalbard and Switzerland
    - Central/Eastern Europe: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, the Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Macedonia, Moldova, Poland, Romania, Russia, Slovakia, Slovenia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan and Yugoslavia (Serbia and Montenegro)
    - Middle East/Africa: Afghanistan, Algeria, Angola, Bahrain, Bassas da India, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Cote d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Europa Island, Gabon, Gambia, Ghana, Glorioso Islands, Guinea, Guinea-Bissau, Iran, Iraq, Israel, Jordan, Juan de Nova Island, Kenya, Kuwait, Lebanon, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mayotte, Morocco, Mozambique, Namibia, Niger, Nigeria, Oman, Qatar, Reunion, Rwanda, Saint Helena, Sao Tome and Principe, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Syria, Tanzania, Togo, Tromelin Island, Tunisia, Turkey, Uganda, United Arab Emirates, Western Sahara, Yemen, Zaire, Zambia and Zimbabwe

Semiconductor Market Definition

Dataquest defines the semiconductor market as representing all merchant market business together with in-house business that exists for those semiconductor manufacturers that also participate in the merchant market. This element of in-house business between a manufacturer and its equipment divisions or subsidiaries is valued at merchant market prices. This gives a true reflection of the TAM to merchant semiconductor suppliers. Figure 1 shows the shipment model used by Dataquest in the definition of the total semiconductor market in EMEA. Table 1 shows, for 1996 and 1997, the market sizes for the seven major EMEA regions, broken down into individual country markets.

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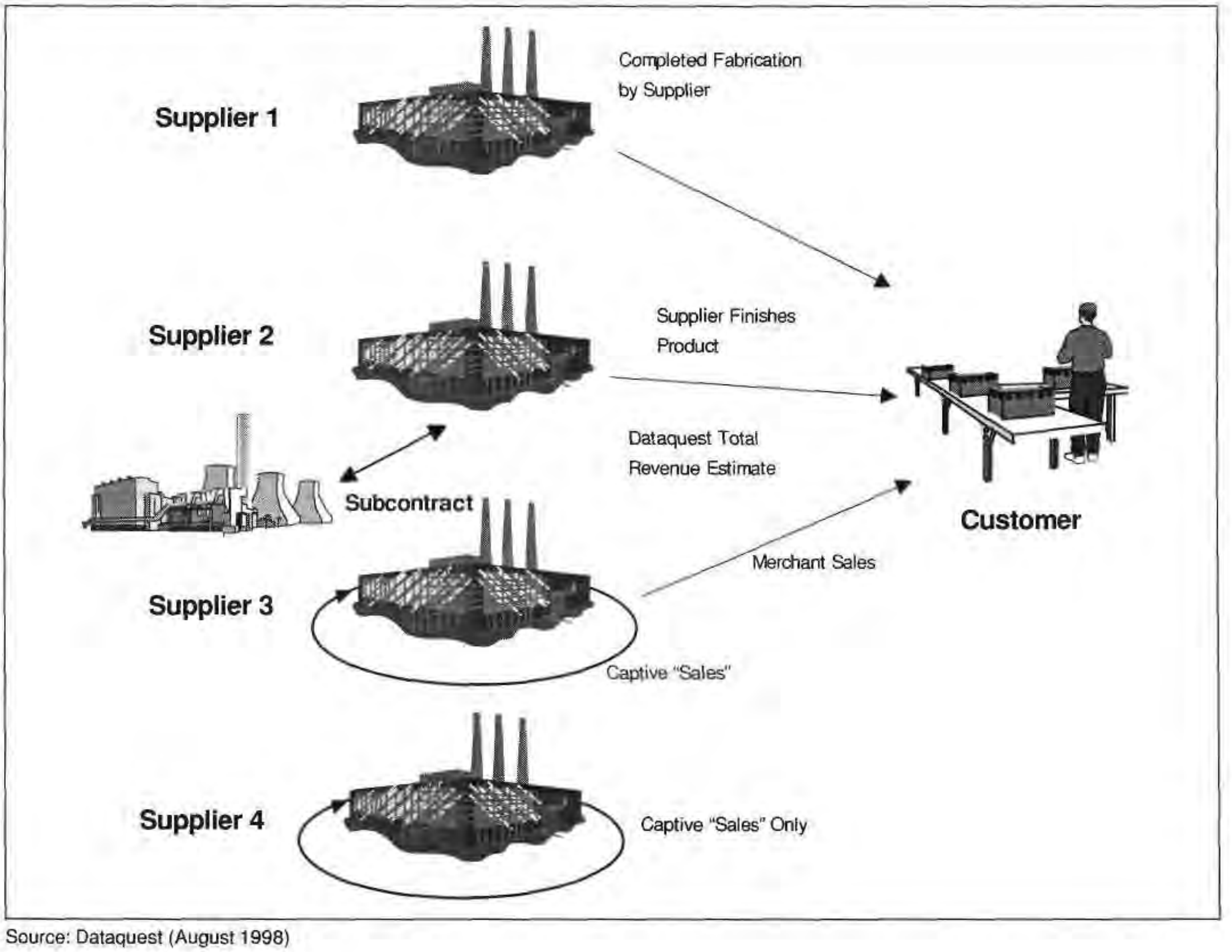
Note that the TAM estimates shown for Central and Eastern Europe, the Middle East and Africa markets are for true end-market consumption and are not the same as for the other regional markets. Dataquest estimates of market sizes are normally based on sales made by semiconductor vendors, that is first-invoice sales. These include sales made to distributors and agents that then sell on to the true end users. In the case of markets such as the Czech Republic or South Africa, the industry chooses to consider their TAM based on surveying the true end users. So, the sales opportunity visible to semiconductor vendors in these new and emerging markets is somewhat smaller than the TAM shown in the particular tables.

Figure 1
Semiconductor Shipments Model



Source: Dataquest (August 1998)

Table 1
EMEA Semiconductor Market by Region, 1996 and 1997

	1996 TAM ($M)	1997 TAM ($M)	1996/1997 Growth (%)	Local Currency	1996 Exchange Rate	1997 Exchange Rate	1996 TAM	1997 TAM	1996/1997 Growth (%)
Benelux	1,105	1,150	4%	Fl	1.69	1.95	1,867	2,243	20.1%
Belgium/Luxembourg	404	430	6%	BF	30.96	35.79	12,508	15,390	23.0%
Netherlands	701	720	3%	Fl	1.69	1.95	1,185	1,404	18.5%
France	3,776	3,981	5%	FF	5.12	5.84	19,333	23,249	20.3%
Germany	7,833	7,451	-5%	DM	1.50	1.73	11,750	12,890	9.7%
Italy	1,816	1,726	-5%	L	1,542.72	1,703.02	2,801,580	2,939,413	4.9%
Nordic	2,492	2,685	8%	SKr	6.71	7.64	16,721	20,513	22.7%
Denmark	274	290	6%	DKr	5.81	6.61	1,592	1,917	20.4%
Finland	871	914	5%	Fmk	4.59	5.19	3,998	4,744	18.7%
Norway	146	161	10%	NKr	6.46	7.08	943	1,140	20.9%
Sweden	1,201	1320	10%	SKr	6.71	7.64	8,059	10,085	25.1%
United Kingdom/Ireland	7,778	8,953	15%	£	0.64	0.61	4,978	5,461	9.7%
Ireland	690	793	15%	Ir£	0.63	0.66	435	523	20.4%
United Kingdom	7,088	8,160	15%	£	0.64	0.61	4,536	4,978	9.7%
Rest of EMEA	3,579	4,100	15%	ECU	0.80	0.89	2,863	3,649	27.4%
Rest of Western Europe	2,004	2,464	23%	ECU	0.80	0.89	1,603	2,193	36.8%
Austria	618	660	7%	Sch	10.59	12.20	6,545	8,052	23.0%
Greece	90	105	17%	Dr	240.82	273.11	21,674	28,677	32.3%
Malta	30	37	23%	LM	0.36	0.39	11	14	32.1%
Portugal	30	41	37%	Esc	154.27	175.35	4,628	7,189	55.3%
Spain	578	675	17%	Pta	126.68	146.45	73,221	98,854	35.0%
Switzerland	519	605	17%	SF	1.24	1.45	644	877	36.3%
Turkey	139	341	145%	Lt	82,813.76	152,958.50	11,511,113	52,158,849	353.1%

(continued)

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Table 1 (Continued)
EMEA Semiconductor Market by Region, 1996 and 1997

	1996 TAM ($M)	1997 TAM ($M)	1996/1997 Growth (%)	Local Currency	1996 Exchange Rate	1997 Exchange Rate	1996 TAM	1997 TAM	1996/1997 Growth (%)
Central and Eastern Europe	724	711	-2%	Rb	5.13	5.79	3,716	4,114	10.7%
Czech Republic	27	100	270%	Kc	27.13	31.73	733	3,173	333.2%
Hungary	57	52	-9%	Ft	149.36	186.85	8,514	9,716	14.1%
Poland	73	142	95%	New Zl	2.70	3.29	197	467	137.0%
Russia	477	291	-39%	Rb	5.13	5.79	2,448	1,684	-31.2%
Other Central and Eastern Europe	90	126	40%	Rb	5.13	5.79	462	729	57.8%
Middle East	635	640	1%	Is	3.20	3.45	2,029	2,208	8.8%
Israel	625	600	-4%	Is	3.20	3.45	1,997	2,070	3.7%
Other Middle East	10	40	300%	Is	3.20	3.45	32	138	331.9%
Africa	216	285	32%	R	4.31	4.61	930	1,227	31.9%
Republic of South Africa	211	250	18%	R	4.31	4.61	908	1,153	26.9%
Other Africa	5	35	600%	R	4.31	4.61	22	161	649.6%
Total EMEA	**28,379**	**30,046**	6%	ECU	**0.80**	**0.89**	**22,703**	**26,741**	**17.8%**

Source: Dataquest (August 1998 Estimates)

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Assumptions

The following are some key assumptions that were used in the forecast model. Significant changes in these assumptions will therefore affect the forecast outlook.

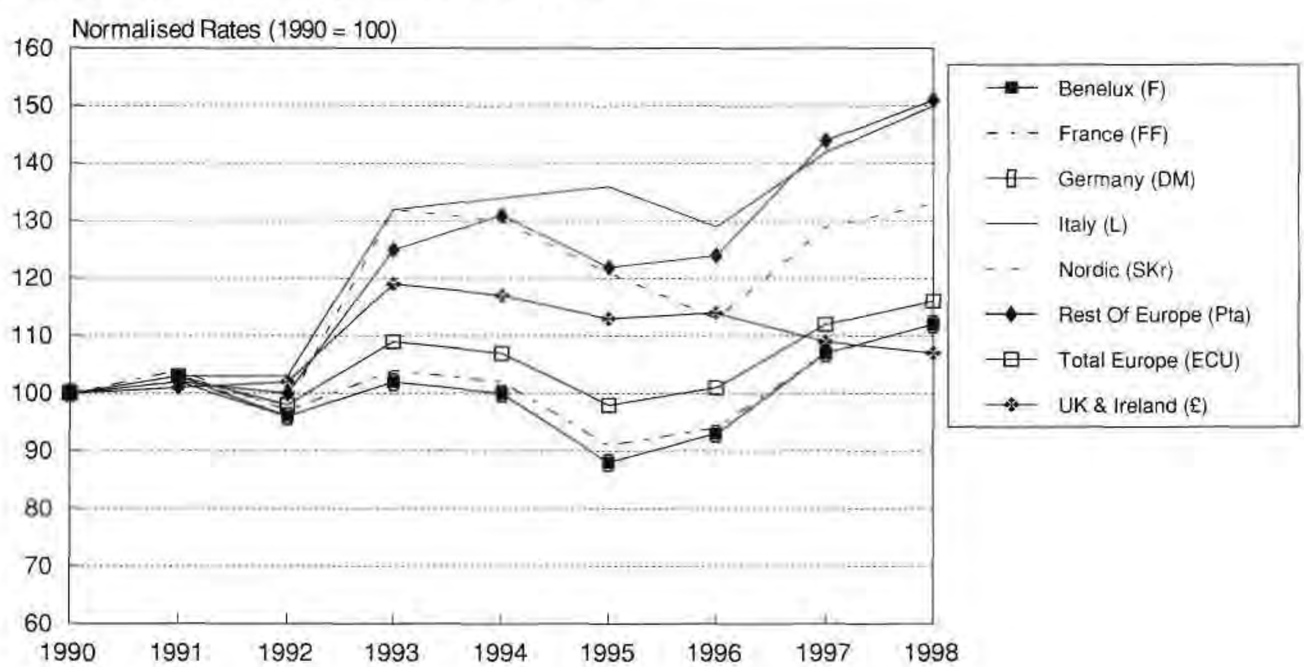
Production Capacity

The global semiconductor industry has been in oversupply since early 1996 and this situation has continued throughout 1997 and into 1998. Dataquest does not see a return to a balance in supply and demand until well into 1999, so prices are expected to continue to decline in the short term. Longer term, the slowdown in capital expenditure witnessed in the later part of 1997 and into 1998 will ripple through, resulting in undercapacity later in the forecast period. For these reasons, Dataquest's forecast semiconductor industry growth rates are below the long-term average of about 15 percent in 1998 and 1999, but higher than the average in 2000, 2001 and 2002. The next cyclical downturn has been pushed out to 2003, outside the current forecast window, because of the effect of reduced capital spending in 1997 and 1998.

Exchange Rates

Actual exchange rates for the EMEA regions covered in this *Market Trends* report are contained in Table 2. Dataquest does not forecast currency fluctuations; therefore, the rate used for 1998 is the average of 1998 year-to-date combined with the latest available month's rates at the time of writing (April) used for the rest of the year. The rate for 1999 onwards is simply the latest rate available for 1998. Figure 2 shows the relative performance of the currencies since 1990.

Figure 2
Relative EMEA Exchange Rates, 1990-1998



Source: Dataquest (August 1998 Estimates)

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Table 2
EMEA Exchange Rates Against the Dollar, 1990-1998

Region	Currency	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Benelux	Gulden	1.82	1.87	1.75	1.86	1.82	1.60	1.69	1.95	2.04	2.04	2.04	2.04	2.04
France	Franc	5.44	5.64	5.27	5.67	5.54	4.97	5.12	5.84	6.08	6.08	6.08	6.08	6.08
Germany	Deutsche Mark	1.62	1.66	1.56	1.66	1.62	1.43	1.50	1.73	1.81	1.81	1.81	1.81	1.81
Italy	Lira (K)	1.20	1.24	1.23	1.58	1.61	1.63	1.54	1.70	1.79	1.79	1.79	1.79	1.79
Nordic	Krona	5.92	6.04	5.81	7.82	7.70	7.15	6.71	7.64	7.87	7.82	7.82	7.82	7.82
United Kingdom/Ireland	Pound	0.56	0.57	0.57	0.67	0.65	0.63	0.64	0.61	0.60	0.60	0.60	0.60	0.60
Rest of EMEA	ECU	0.79	0.81	0.77	0.86	0.84	0.77	0.80	0.89	0.92	0.92	0.92	0.92	0.92
Total EMEA	ECU	0.79	0.81	0.77	0.86	0.84	0.77	0.80	0.89	0.92	0.92	0.92	0.92	0.92

Source: Dataquest (August 1998 Estimates)

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Changes from 1997 Forecast

In a third year of dismal revenue growth in the semiconductor industry, the forecast growth rate for the EMEA region in 1998 has been reduced to less than 3 percent largely because of a continued reduction in DRAM average selling prices (ASPs). The ability of DRAM vendors to continue to reduce costs has been aided by the effects of currency devaluation in the economies of Southeast Asia and Japan and by more aggressive application of leading-edge process technologies on trailing-edge device densities. The constant battle for DRAM market share has ensured that these cost reductions have been passed on to end customers, resulting in reduced revenue for the DRAM industry.

Product Analysis

Tables 3 and 4 detail the overall history and forecast for EMEA by product family. For the period 1997 to 2002, a CAGR of 16 percent is expected, influenced greatly by the MOS memory (22 percent CAGR), MOS microcomponent (14 percent CAGR) and MOS logic (16 percent CAGR) categories. Figures 3 and 4 illustrate the relationship between the MOS memory, MOS microcomponent and MOS logic categories, and their effect on the total semiconductor market in EMEA.

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Table 3
Total EMEA Semiconductor Market History by Product, 1990-1996

Millions of Dollars	1990	1991	1992	1993	1994	1995	1996	CAGR 1991-1996
Total Semiconductor	10,415	11,000	12,218	15,462	20,899	28,410	28,379	20.9%
Total Integrated Circuit	8,115	8,687	9,958	13,319	18,216	24,611	24,732	23.3%
Bipolar Digital	565	486	426	390	357	306	246	-12.7%
MOS Digital	5,224	5,839	7,132	10,014	14,311	20,027	19,645	27.5%
MOS Memory	2,050	2,115	2,660	4,041	6,573	10,074	6,918	26.7%
MOS Microcomponent	1,802	2,082	2,723	4,037	5,408	7,000	9,341	35.0%
MOS Logic	1,372	1,642	1,749	1,936	2,330	2,953	3,386	15.6%
Analog	2,326	2,362	2,400	2,915	3,548	4,278	4,841	15.4%
Discrete	1,895	1,828	1,826	1,769	2,108	3,118	2,848	9.3%
Optoelectronic	405	485	434	374	575	681	799	10.5%
Millions of ECU	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**CAGR 1991-1996**
Total Semiconductor	8,207	8,921	9,408	13,266	17,630	21,978	22,666	20.5%
Total Integrated Circuit	6,395	7,045	7,668	11,428	15,367	19,039	19,753	22.9%
Bipolar Digital	445	394	328	335	301	237	196	-13.0%
MOS Digital	4,117	4,735	5,492	8,592	12,073	15,493	15,690	27.1%
MOS Memory	1,615	1,715	2,048	3,467	5,545	7,793	5,525	26.4%
MOS Microcomponent	1,420	1,689	2,097	3,464	4,562	5,415	7,461	34.6%
MOS Logic	1,081	1,332	1,347	1,661	1,966	2,284	2,704	15.2%
Analog	1,833	1,916	1,848	2,501	2,993	3,309	3,867	15.1%
Discrete	1,493	1,483	1,406	1,518	1,778	2,412	2,275	8.9%
Optoelectronic	319	393	334	321	485	527	638	10.2%
Exchange Rate (Dollars to ECU)	**0.788**	**0.811**	**0.770**	**0.858**	**0.844**	**0.774**	**0.799**	

Source: Dataquest (August 1998 Estimates)

Table 4
Total EMEA Semiconductor Market Forecast by Product, 1996-2002

Millions of Dollars	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Total Semiconductor	28,379	30,046	30,930	35,301	42,599	50,960	62,123	15.6%
Total Integrated Circuit	24,732	26,195	26,624	30,473	36,730	44,758	55,253	16.1%
Bipolar Digital	246	168	141	122	97	78	56	-19.7%
MOS Digital	19,645	21,139	20,733	23,738	29,042	36,132	45,898	16.8%
MOS Memory	6,918	6,041	4,797	5,207	7,221	10,628	16,041	21.6%
MOS Microcomponent	9,341	10,939	11,786	13,586	15,801	18,424	21,298	14.3%
MOS Logic	3,386	4,159	4,150	4,945	6,020	7,080	8,559	15.5%
Analog	4,841	4,888	5,750	6,613	7,591	8,548	9,299	13.7%
Discrete	2,848	3,120	3,500	3,966	4,937	5,204	5,818	13.3%
Optoelectronic	799	731	806	862	932	998	1,052	7.6%
Millions of ECU	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**CAGR 1997-2002**
Total Semiconductor	22,666	26,599	28,341	32,307	38,987	46,639	56,855	16.4%
Total Integrated Circuit	19,753	23,190	24,396	27,889	33,615	40,963	50,568	16.9%
Bipolar Digital	196	149	129	112	89	71	51	-19.3%
MOS Digital	15,690	18,714	18,998	21,725	26,579	33,068	42,006	17.6%
MOS Memory	5,525	5,348	4,395	4,765	6,609	9,727	14,681	22.4%
MOS Microcomponent	7,461	9,684	10,800	12,434	14,461	16,862	19,492	15.0%
MOS Logic	2,704	3,682	3,803	4,526	5,510	6,480	7,833	16.3%
Analog	3,867	4,327	5,269	6,052	6,947	7,823	8,510	14.5%
Discrete	2,275	2,762	3,207	3,630	4,518	4,763	5,325	14.0%
Optoelectronic	638	647	739	789	853	913	963	8.3%
Exchange Rate (Dollars to ECU)	**0.799**	**0.885**	**0.916**	**0.915**	**0.915**	**0.915**	**0.915**	

Source: Dataquest (August 1998 Estimates)

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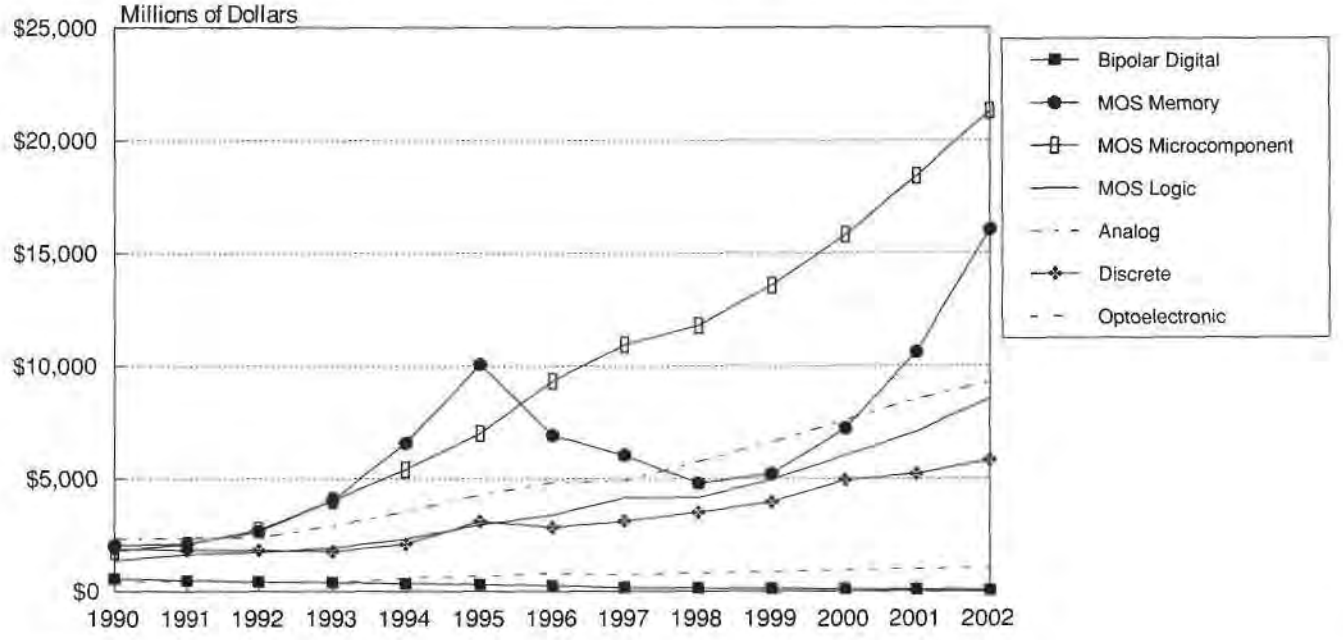
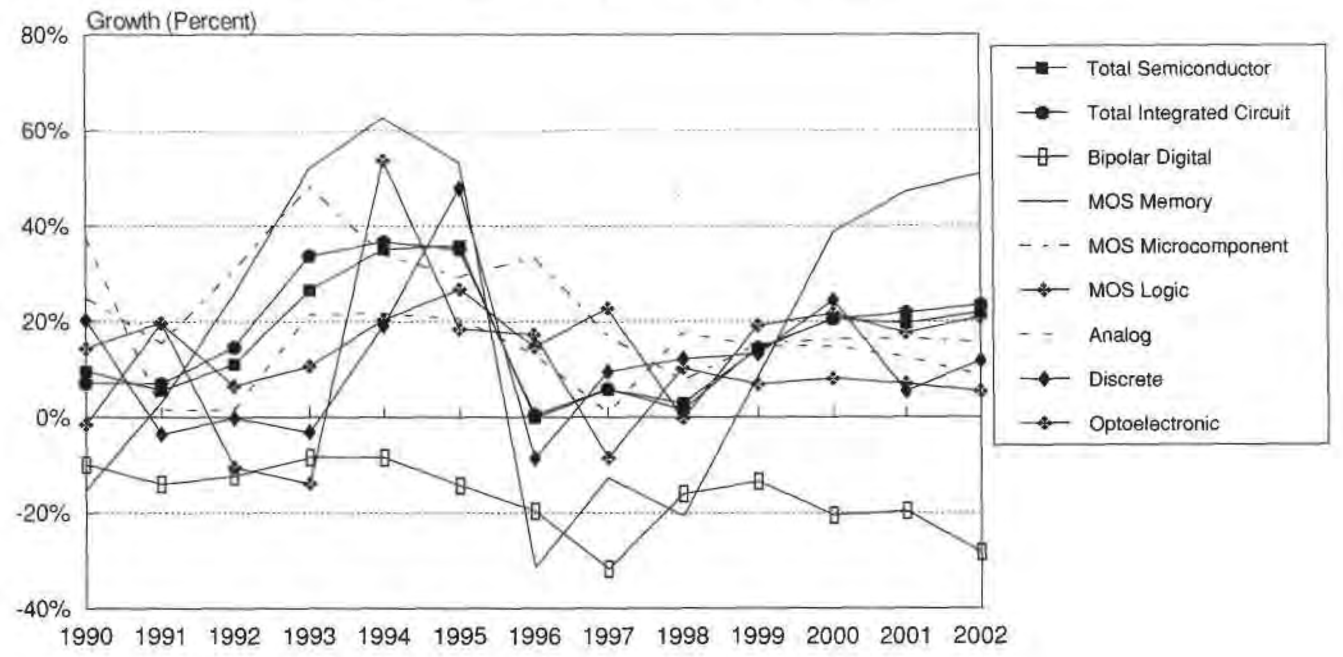
Figure 3
EMEA Semiconductor Product Markets by Revenue, 1990-2002



Source: Dataquest (August 1998 Estimates)

Figure 4
EMEA Semiconductor Product Markets by Growth, 1990-2002



Source: Dataquest (August 1998 Estimates)

Bipolar Digital

There is no sign of an end to the continuing demise of the bipolar digital market. The bipolar digital category is forecast, at about $50 million, to become the smallest single-product category by 2002, accounting for less than 0.1 percent of the total market. However, such is the insignificance of this market segment, it is highly unlikely that the category will survive for analysis until the end of the forecast period.

MOS Digital

Comprising MOS memory, MOS microcomponent and MOS logic, the MOS digital category traditionally accounts for about 70 percent of the total semiconductor market in EMEA. From a low of 69 percent in 1996 this proportion is forecast to rise to 73 percent in 2002 driven by growth in the memory market as a result of a DRAM boom. In spite of the healthy CAGR expected for the memory category, Dataquest is still forecasting that MOS microcomponent will remain the largest of the three MOS digital categories until 2002.

MOS Memory

Following a decline of 13 percent in 1997, the MOS memory market is forecast to decline by a further 21 percent in 1998. Overcapacity and continued device cost reductions continue to suppress DRAM ASPs. Price pressure is also a feature of the SRAM and flash memory markets; it is caused by abundant supply and fierce competition. Longer term, the DRAM market is expected to boom again as continued bit growth combined with a slowdown in capital investment bring supply and demand back into balance during 1999. A DRAM boom is therefore forecast for 2000, 2001 and 2002 with a bust anticipated in 2003. Prospects for SRAM are not so bright. It now looks likely that the fast SRAM market in the EMEA region will disappear because of the move to modular microprocessor solutions for the PC market. The slow SRAM market is buoyed by demand from EMEA's communications sector, but price pressure means that spectacular market growth is unlikely. In the nonvolatile arena, the EPROM market demise is accelerating as flash becomes more and more competitive because of continued ASP declines.

MOS Microcomponent

The MOS microcomponent sector is dominated by the microprocessor, which, in turn, is dominated by Intel's X86 architecture. The accelerated pace of product introduction has resulted in Intel's ASPs being maintained, although fierce competition in the low-end and midrange segments of the X86 market will result in entry-level and midrange ASPs (including Intel's) declining over the forecast period. Intel will recoup these losses in the high end of the market—that is, servers and workstations—which it will continue to expand. PC production is forecast to remain healthy, thereby continuing to make microprocessors a lucrative sector.

Microcontroller unit shipments continue to grow and, while the 8-bit market will still suffer from ASP attrition, the 16-bit-and-above arena is growing in importance as volume applications in automotive and consumer segments come onstream. These devices are becoming increasingly application specific and Europe has become a focal point of design for devices aimed at these high-volume applications. The higher ASPs of these application-specific products combined with the continuing unit growth of the 8-bit devices will result in continuous revenue growth for this product category over the forecast period.

Digital signal processors (DSPs) are the glamour product within the microcomponents portfolio, with the highest growth of any product over the forecast period. Increasingly, these devices are finding new applications in high-volume consumer products. The ongoing digital revolution in consumer products would not be possible without affordable DSP products. During the forecast period, standalone DSPs will continue to grow based on their use in digital cellular infrastructure and other applications such as motor control. The bulk of the DSP market will become increasingly IP based, with DSP cores being embedded into application specific standard products targeted at specific products such as single-chip baseband devices for cellular phones or single-chip solutions for the various digital broadcast delivery systems.

MOS Logic

Downward pressure on pricing is likely to continue through 1998 and into 1999. This will not be as marked as in other areas of the semiconductor market, but will still impact growth significantly.

Cell-based ICs (CBICs), the main vehicle for system-level integration products, will continue to be the fastest-growing logic product. Gate arrays, however, are under serious pricing pressure and are entering the decline phase of the life cycle. CBICs are displacing gate arrays from high-end applications as programmable logic devices (PLDs) displace gate arrays from low-end applications. This translates into higher long-term growth in the CBIC and PLD segments, and lower growth for gate arrays, which are squeezed between the two.

PLDs are suffering from more rapid price erosion than the other ASIC categories. However, price reduction is necessary in order for PLDs to penetrate the widest possible range of market sectors. The difficulty for the vendors is one of slowing down these price falls at the right levels.

The major applications driving the logic market in EMEA over the forecast period are set-top boxes, automotive navigation systems, cellular handsets, LAN adapter boards and MPEG-based multimedia engines for digital video applications.

In spite of the increased digitization of many applications, mixed-signal devices will continue to be a significant factor in the EMEA ASIC market, driven largely by requirements in the telecommunications and automotive sectors. We forecast that this technology will increase its share of the cell-based market over the forecast period.

The use of cores or large functional blocks that are pretested is clearly on the rise. According to Dataquest's latest analysis of design starts, cores are taking up a larger portion of the die area at the expense of random logic. Trade in these cores—the so-called intellectual property (IP) market—will begin to be a major factor in the ASIC market during the forecast period.

Analog, Discrete and Optical Semiconductors

In the EMEA region the analog category is, in fact, larger than that of MOS logic. Europe's standing as a center of excellence for telecommunications and automotive electronics design assures continued equipment production and demand for analog semiconductors.

The discrete category accounts for about 10 percent of semiconductor revenue in the EMEA region, which is not an insignificant TAM. However, this category will do well if it manages to hold its share of the total semiconductor market as, in spite of healthy growth products such as IGBTs, it faces the threat of higher integration.

The optical semiconductor market is expected to experience a modest CAGR of 8 percent for the period 1997 to 2002, allowing the market to break through the $1 billion barrier by the end of the forecast period.

EMEA Outlook by Country/Region

The trends in the semiconductor market in EMEA are dependent on semiconductor consumption by the major electronics equipment manufacturers. Therefore, there tends to be a concentration of the majority of the market in regions where there is a strong electronics production base, such as in Germany and United Kingdom/Ireland, together with regions characterized by a particular expertise, such as mobile communications in Scandinavia.

The history and forecast for each of the EMEA regions is contained in Table 5 and Figure 5. In 1997, the United Kingdom/Ireland region became the largest single market for semiconductors, ahead of Germany, and this situation is expected to continue throughout the forecast period. The Benelux region is the smallest, and will continue to lose share gradually. The Italian market is expected to lose share at the fastest rate, because of the absence of any new electronics production investment to compensate for the demise of Olivetti. Growth in the Nordic region is the highest in the EMEA region as it continues to benefit from communications equipment production. Semiconductor market growth in France is on a par with the EMEA average—a reflection of the wide applications base in the country. Spectacular growth is not expected in Rest of EMEA, as many of the constituent countries have yet to develop any significant electronics manufacturing capability.

Table 6 shows the overall top 10 semiconductor market share ranking by revenue for the EMEA region in 1997. Intel retained number-one spot with double the revenue of its nearest competitor, Siemens, which was in second place. Unsurprisingly, broadliners Motorola, Philips, STMicroelectronics and Texas Instruments feature in ranked positions three to six, while Samsung, NEC and Hitachi, companies with a narrower product focus, are in positions seven through nine. Lucent Technologies makes up the top 10 ranking at number 10.

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Table 5
Total EMEA Semiconductor History and Forecast by Country/Region, 1990-2002

Revenue ($M)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Total EMEA	10,414	11,014	12,220	15,456	20,899	28,410	28,382	30,048	30,933	35,304	42,601	50,962	62,126	15.6%
Benelux	651	661	610	730	880	1,100	1,108	1,152	1,177	1,339	1,603	1,902	2,265	14.5%
France	1,494	1,395	1,453	1,731	2,250	3,469	3,773	3,979	4,208	4,886	5,834	6,972	8,387	16.1%
Italy	1,212	1,136	1,280	1,457	1,769	2,124	1,819	1,728	1,612	1,799	2,117	2,472	2,927	11.1%
Nordic	712	706	779	1,067	1,714	2,625	2,495	2,687	3,012	3,458	4,028	4,833	5,756	16.5%
United Kingdom/Ireland	2,411	2,592	3,047	4,205	5,820	7,904	7,775	8,951	8,799	9,942	12,418	15,312	19,019	16.3%
Germany	2,912	3,271	3,728	4,217	5,681	8,339	7,836	7,453	7,977	9,110	10,876	12,888	15,582	15.9%
Rest of EMEA	1,022	1,253	1,323	2,049	2,785	2,849	3,576	4,098	4,148	4,770	5,725	6,583	8,190	14.9%
Growth (%)	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	
Total EMEA	10%	6%	11%	26%	35%	36%	0%	6%	3%	14%	21%	20%	22%	
Benelux	32%	2%	-8%	20%	21%	25%	1%	4%	2%	14%	20%	19%	19%	
France	11%	-7%	4%	19%	30%	54%	9%	5%	6%	16%	19%	20%	20%	
Italy	15%	-6%	13%	14%	21%	20%	-14%	-5%	-7%	12%	18%	17%	18%	
Nordic	7%	-1%	10%	37%	61%	53%	-5%	8%	12%	15%	16%	20%	19%	
United Kingdom/Ireland	-5%	8%	18%	38%	38%	36%	-2%	15%	-2%	13%	25%	23%	24%	
Germany	11%	12%	14%	13%	35%	47%	-6%	-5%	7%	14%	19%	18%	21%	
Rest of EMEA	31%	23%	6%	55%	36%	2%	26%	15%	1%	15%	20%	15%	24%	

Source: Dataquest (August 1998 Estimates)

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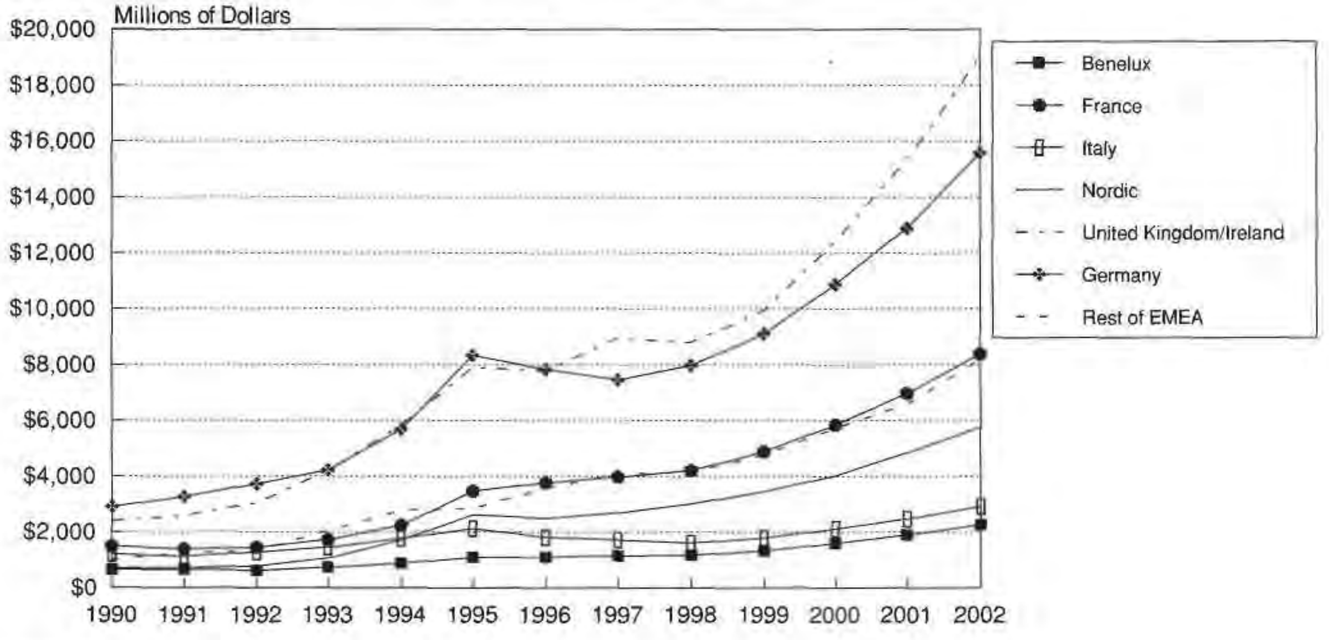
Figure 5
EMEA Semiconductor Country Market Shares by Revenue, 1990-2002



Source: Dataquest (August 1998 Estimates)

Table 6
EMEA Top 10 Semiconductor Market Share Rankings by Revenue, 1997

Rank 1997	Rank 1996	Rank Change	Companies	Revenue 1997 ($M)	Revenue 1996 ($M)	AGR (%)	Share 1997 (%)	Share 1996 (%)
1	1	0	Intel	5,811	5,044	15%	19.3%	17.8%
2	2	0	Siemens	2,182	2,068	6%	7.3%	7.3%
3	3	0	Motorola	1,885	1,887	0%	6.3%	6.6%
4	5	1	Philips	1,847	1,750	6%	6.1%	6.2%
5	4	-1	STMicroelectronics	1,777	1,814	-2%	5.9%	6.4%
6	6	0	Texas Instuments	1,748	1,502	16%	5.8%	5.3%
7	7	0	Samsung	1,240	1,156	7%	4.1%	4.1%
8	8	0	NEC	1,099	1,095	0%	3.7%	3.9%
9	9	0	Hitachi	759	872	-13%	2.5%	3.1%
10	13	3	Lucent Technologies	707	562	26%	2.4%	2.0%
			Top 10 Subtotal	19,055	17,750	7%	63.4%	62.5%
			Others	10,991	10,629	3%	36.6%	37.5%
			Total	**30,046**	**28,379**	**6%**	**100.0%**	**100.0%**

Source: Dataquest (August 1998 Estimates)

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Benelux

The Benelux semiconductor market history and forecast is shown in Tables 7 and 8. Dataquest estimates that the Benelux region, defined as Belgium, the Netherlands and Luxembourg, was worth about $1.2 billion in semiconductor revenue in 1997, a growth in dollar terms of 4.1 percent over 1996. However, growth of 20 percent in local currency is hidden by a significant devaluation of 15 percent against the dollar between 1996 and 1997. In dollar terms, the region accounted for 3.8 percent of the EMEA semiconductor TAM in 1997, 0.1 percent less than in 1996.

Historically, the Benelux region has relied upon the communications and consumer segments for its semiconductor markets. This reliance has tended to restrict the growth prospects of the semiconductor TAM, but there is increasing activity in the region from Europe's PC manufacturers that will help to slow the decline in the Benelux region semiconductor TAM. Although a market size in excess of $2 billion by 2002 is forecast, a marginal decline in share over the forecast period is expected, which will reduce the Benelux region share to 3.6 percent of the EMEA semiconductor TAM.

Table 9 shows the top 10 semiconductor vendors in the Benelux region, ranked by sales revenue in 1997. Intel's position at number one is testimony to the existence in the region of a healthy PC industry that consumes appreciable quantities of the microprocessor vendors' high-value products. The fact that Philips and STMicroelectronics are ranked second and third is no surprise and confirms the region's semiconductor market profile as heavily consumer-segment oriented, because both companies have a strong consumer electronics focus. Further down the ranking, broadliners such as Texas Instruments, Siemens and Motorola feature, as well as more specialist vendors such as Lucent Technologies and Alcatel Microelectronics, attracted by the telecommunications sector. The presence of AMD and NEC in the rankings is further evidence of an increasing PC manufacturing sector.

In 1998 the Benelux region is expected to show marginally positive dollar growth of about 2 percent, which equates to some 7 percent growth in gulden. Over the next five years, the semiconductor market in the Benelux region is forecast to grow at a CAGR of 14.5 percent, which is below the average for the EMEA region as a whole. A graphical representation of the Benelux semiconductor market history and forecast by product category is shown in Figures 6 and 7.

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Table 7
Benelux Semiconductor Market History, 1990-1996

Millions of Dollars	1990	1991	1992	1993	1994	1995	1996	CAGR 1991-1996
Total Semiconductor	651	661	610	730	880	1,100	1,108	10.9%
Total Integrated Circuit	496	507	484	613	745	922	999	14.5%
Bipolar Digital	14	12	8	6	6	6	4	-19.7%
MOS Digital	163	180	188	296	383	484	592	26.9%
MOS Memory	57	58	60	106	151	219	229	31.6%
MOS Microcomponent	60	68	76	141	171	210	217	26.1%
MOS Logic	46	54	52	49	61	55	146	22.0%
Analog	319	315	288	311	356	432	403	5.1%
Discrete	120	112	94	90	97	137	66	-10.0%
Optoelectronic	35	42	32	27	38	41	43	0.5%
Millions of ECU	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**CAGR 1991-1996**
Total Semiconductor	513	536	470	626	742	851	885	10.5%
Total Integrated Circuit	391	411	373	526	628	713	798	14.2%
Bipolar Digital	11	10	6	5	5	5	3	-21.4%
MOS Digital	128	146	145	254	323	374	473	26.5%
MOS Memory	45	47	46	91	127	169	183	31.2%
MOS Microcomponent	47	55	59	121	144	162	173	25.8%
MOS Logic	36	44	40	42	51	43	117	21.6%
Analog	251	255	222	267	300	334	322	4.8%
Discrete	95	91	72	77	82	106	53	-10.2%
Optoelectronic	28	34	25	23	32	32	34	0.0%
Millions of Gulden	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**CAGR 1991-1996**
Total Semiconductor	1,185	1,235	1,068	1,357	1,599	1,763	1,868	8.6%
Total Integrated Circuit	903	947	848	1,139	1,354	1,478	1,684	12.2%
Bipolar Digital	25	22	14	11	11	10	7	-20.5%
MOS Digital	297	336	329	550	696	776	998	24.3%
MOS Memory	104	108	105	197	274	351	386	29.0%
MOS Microcomponent	109	127	133	262	311	337	366	23.6%
MOS Logic	84	101	91	91	111	88	246	19.5%
Analog	581	588	504	578	647	692	679	2.9%
Discrete	218	209	165	167	176	220	111	-11.9%
Optoelectronic	64	78	56	50	69	66	73	-1.3%
Exchange Rate (Dollars to ECU)	**0.788**	**0.811**	**0.770**	**0.858**	**0.844**	**0.774**	**0.799**	
Exchange Rate (Dollars to Gulden)	**1.820**	**1.868**	**1.751**	**1.858**	**1.817**	**1.603**	**1.686**	

Source: Dataquest (August 1998 Estimates)

Table 8
Benelux Semiconductor Market Forecast, 1996-2002

Millions of Dollars	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Total Semiconductor	1,108	1,152	1,177	1,339	1,603	1,902	2,265	14.5%
Total Integrated Circuit	999	1,049	1,085	1,238	1,482	1,772	2,121	15.1%
Bipolar Digital	4	2	1	1	1	1	1	-12.9%
MOS Digital	592	651	648	738	906	1,123	1,411	16.7%
MOS Memory	229	186	123	132	186	276	418	17.6%
MOS Microcomponent	217	337	418	480	564	663	769	17.9%
MOS Logic	146	128	107	126	156	184	224	11.8%
Analog	403	396	436	499	575	648	709	12.4%
Discrete	66	65	55	61	78	83	95	7.9%
Optoelectronic	43	38	37	40	43	47	49	5.2%
Millions of ECU	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**CAGR 1997-2002**
Total Semiconductor	885	1,020	1,078	1,225	1,467	1,741	2,073	15.2%
Total Integrated Circuit	798	929	994	1,133	1,356	1,622	1,941	15.9%
Bipolar Digital	3	2	1	1	1	1	1	-12.9%
MOS Digital	473	576	594	675	829	1,028	1,291	17.5%
MOS Memory	183	165	113	121	170	253	383	18.3%
MOS Microcomponent	173	298	383	439	516	607	704	18.8%
MOS Logic	117	113	98	115	143	168	205	12.7%
Analog	322	351	400	457	526	593	649	13.1%
Discrete	53	58	50	56	71	76	87	8.4%
Optoelectronic	34	34	34	37	39	43	45	5.8%
Millions of Gulden	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**CAGR 1997-2002**
Total Semiconductor	1,868	2,248	2,406	2,735	3,274	3,884	4,626	15.5%
Total Integrated Circuit	1,684	2,047	2,218	2,528	3,027	3,619	4,332	16.2%
Bipolar Digital	7	4	2	2	2	2	2	-12.9%
MOS Digital	998	1,270	1,325	1,507	1,850	2,293	2,882	17.8%
MOS Memory	386	363	251	270	380	564	854	18.7%
MOS Microcomponent	366	658	854	980	1,152	1,354	1,570	19.0%
MOS Logic	246	250	219	257	319	376	457	12.8%
Analog	679	773	891	1,019	1,174	1,323	1,448	13.4%
Discrete	111	127	112	125	159	170	194	8.8%
Optoelectronic	73	74	76	82	88	96	100	6.2%
Exchange Rate (Dollars to ECU)	**0.799**	**0.885**	**0.916**	**0.915**	**0.915**	**0.915**	**0.915**	
Exchange Rate (Dollars to Gulden)	**1.686**	**1.951**	**2.044**	**2.042**	**2.042**	**2.042**	**2.042**	

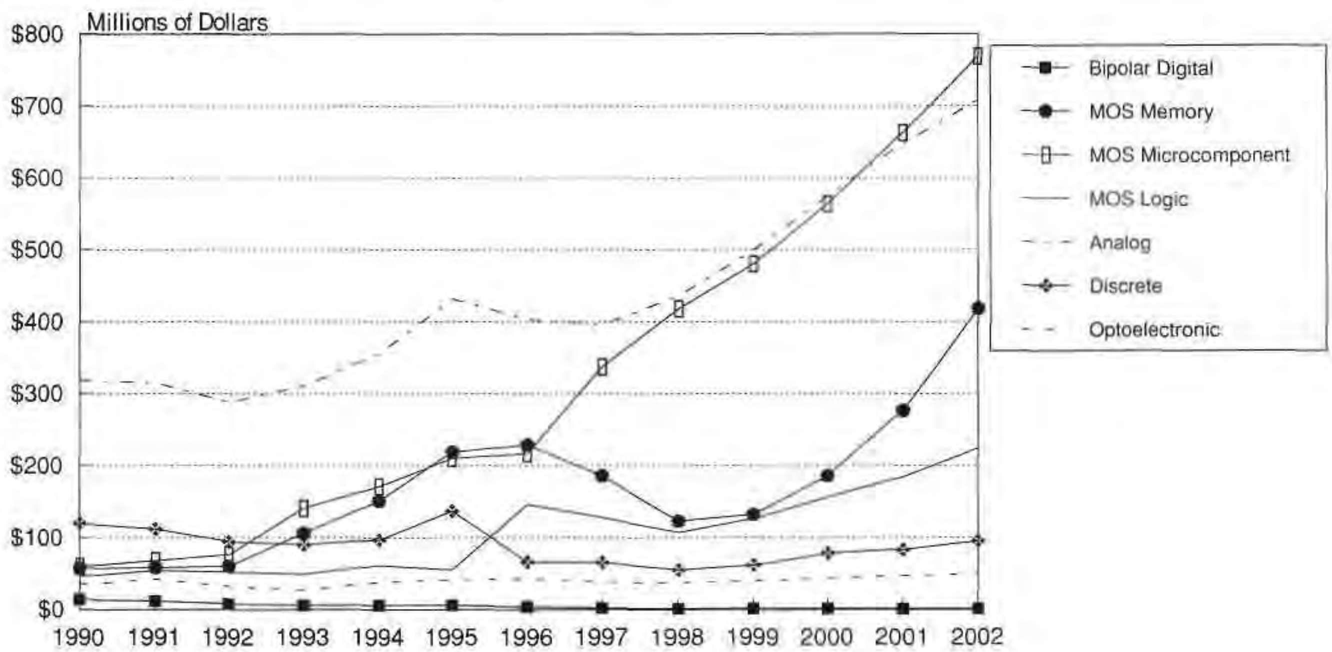
Source: Dataquest (August 1998 Estimates)

Table 9
Top 10 Semiconductor Vendors in the Benelux Region, 1997

Rank 1997	Rank 1996	Rank Change	Companies	Revenue 1997 ($M)	Revenue 1996 ($M)	AGR (%)	Share 1997 (%)	Share 1996 (%)
1	1	0	Intel	287	235	22%	25.0%	21.3%
2	2	0	Philips	179	130	38%	15.6%	11.8%
3	3	0	STMicroelectronics	103	86	20%	9.0%	7.8%
4	8	4	Texas Instruments	75	50	50%	6.5%	4.5%
5	6	1	NEC	55	55	0%	4.8%	5.0%
6	5	-1	Siemens	49	58	-16%	4.3%	5.2%
7	7	0	Lucent Technologies	46	52	-12%	4.0%	4.7%
8	4	-4	Motorola	37	67	-45%	3.2%	6.1%
9	9	0	Advanced Micro Devices	30	30	0%	2.6%	2.7%
10	31	21	Alcatel Microelectronics	25	N/A	NA	2.2%	N/A
			Top 10 Subtotal	886	763	16%	77.0%	69.0%
			Others	264	342	-23%	23.0%	31.0%
			Total	**1,150**	**1,105**	**4%**	**100.0%**	**100.0%**

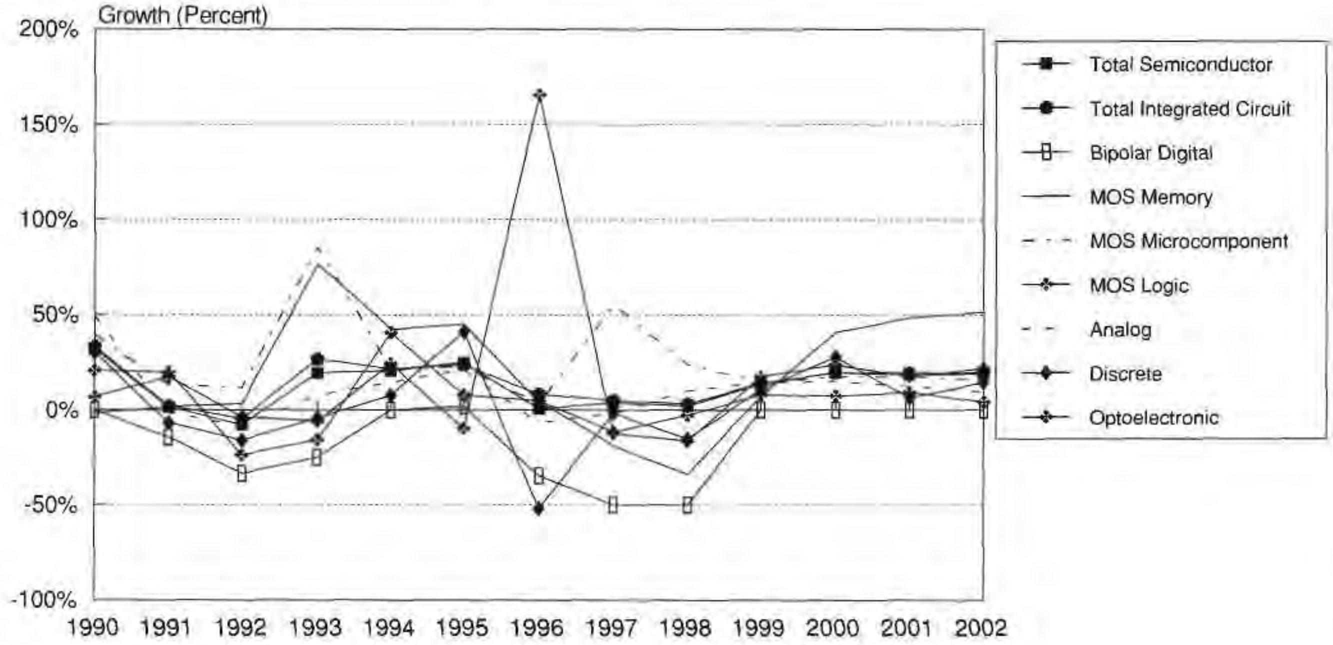
N/A = not available
NA = not applicable
Source: Dataquest (August 1998 Estimates)

Figure 6
Benelux Semiconductor Market by Revenue, 1990-2002



Source: Dataquest (August 1998 Estimates)

Figure 7
Benelux Semiconductor Market by Growth, 1990-2002



Source: Dataquest (August 1998 Estimates)

France

The French semiconductor market history and forecast is shown in Tables 10 and 11. The semiconductor market in France was estimated to be worth almost $4 billion in 1997, about 13 percent of the EMEA semiconductor TAM. Growth of 5.4 percent in dollar terms in 1997 over 1996 was on a par with the EMEA average, but again a devaluation of 14 percent by the franc against the dollar meant that 20 percent growth in local currency was masked.

The French electronics sector is well-balanced between the six traditional application segments. As well as significant EDP and telecommunications equipment manufacturing, often the mainstay of any region's semiconductor marketplace, the semiconductor TAM in France also benefits from strong consumer, automotive, industrial, and military and civil aerospace sectors.

Table 12 shows the top 10 semiconductor vendors in France ranked by sales revenue in 1997. Intel retained its number-one position, growing sales by 22 percent to more than $600 million, while STMicroelectronics held on to second spot in spite of relatively flat sales in 1997 over 1996. Philips, whose electronics arm manufactures cellular handsets in France, gained one place in the ranking at the expense of Motorola. Siemens gained three positions in the ranking as a result of a product portfolio well-suited to the applications profile of the French market. Siemens is traditionally strong in communications and automotive, and is also one of the leading vendors of silicon for the booming French chip card market. NEC and Samsung, two vendors with a heavy DRAM bias, suffered revenue loss in France in 1997, and each fell one place in the ranking, as did Texas Instruments, although revenue for the American company was up by 9 percent. National Semiconductor, another broadliner, entered the top 10 at the expense of Toshiba, while Analog Devices held on to a top 10 ranking, growing revenue as a result of the continued strength of the mobile telecommunications sector.

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In 1998 Dataquest expects the French semiconductor market to show dollar growth of nearly 6 percent, which equates to a franc growth rate of 10 percent. The outlook for the French semiconductor market remains healthy because of its wide applications base, although the region will fail to benefit significantly from the anticipated recovery in the DRAM market. Nevertheless, France is well-placed in almost all non-PC sectors, and it will benefit from a continued boom in chip card production. This broad applications spectrum means that the French semiconductor market ought to grow at a CAGR of about 16 percent over the forecast period, in line with the EMEA average, holding a share of about 13 percent and putting the TAM at more than $8 billion by 2002. A graphical representation of the product breakdown for the French semiconductor market history and forecast is shown in Figures 8 and 9.

Table 10
France Semiconductor Market History, 1990-1996

Millions of Dollars	1990	1991	1992	1993	1994	1995	1996	CAGR 1991-1996
Total Semiconductor	1,494	1,395	1,453	1,731	2,250	3,469	3,773	22.0%
Total Integrated Circuit	1,186	1,128	1,214	1,506	1,975	3,038	3,199	23.2%
Bipolar Digital	75	56	45	42	42	40	32	-10.6%
MOS Digital	828	821	921	1,180	1,603	2,547	2,621	26.1%
MOS Memory	313	289	323	463	673	1,204	780	22.0%
MOS Microcomponent	263	266	323	439	592	855	1,426	39.9%
MOS Logic	252	266	275	278	338	488	415	9.3%
Analog	283	251	248	284	330	451	546	16.8%
Discrete	260	218	197	190	225	364	492	17.7%
Optoelectronic	48	49	42	35	50	67	82	10.8%
Millions of ECU	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**CAGR 1991-1996**
Total Semiconductor	1,177	1,131	1,119	1,485	1,898	2,683	3,013	21.6%
Total Integrated Circuit	935	915	935	1,292	1,666	2,350	2,555	22.8%
Bipolar Digital	59	45	35	36	35	31	26	-10.4%
MOS Digital	652	666	709	1,012	1,352	1,970	2,093	25.7%
MOS Memory	247	234	249	397	568	931	623	21.6%
MOS Microcomponent	207	216	249	377	499	661	1,139	39.4%
MOS Logic	199	216	212	239	285	378	331	8.9%
Analog	223	204	191	244	278	349	436	16.4%
Discrete	205	177	152	163	190	282	393	17.3%
Optoelectronic	38	40	32	30	42	52	65	10.2%
Millions of Francs	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**CAGR 1991-1996**
Total Semiconductor	8,127	7,865	7,659	9,818	12,458	17,243	19,302	19.7%
Total Integrated Circuit	6,452	6,359	6,399	8,542	10,935	15,101	16,365	20.8%
Bipolar Digital	408	316	237	238	233	198	164	-12.3%
MOS Digital	4,504	4,629	4,855	6,693	8,875	12,661	13,409	23.7%
MOS Memory	1,703	1,629	1,703	2,626	3,726	5,985	3,990	19.6%
MOS Microcomponent	1,431	1,500	1,703	2,490	3,278	4,250	7,295	37.2%
MOS Logic	1,371	1,500	1,450	1,577	1,871	2,426	2,123	7.2%
Analog	1,540	1,415	1,307	1,611	1,827	2,242	2,793	14.6%
Discrete	1,414	1,229	1,038	1,078	1,246	1,809	2,517	15.4%
Optoelectronic	261	276	221	199	277	333	419	8.7%
Exchange Rate (Dollars to ECU)	**0.788**	**0.811**	**0.770**	**0.858**	**0.844**	**0.774**	**0.799**	
Exchange Rate (Dollars to Francs	**5.440**	**5.638**	**5.271**	**5.672**	**5.537**	**4.971**	**5.116**	

Source: Dataquest (August 1998 Estimates)

Table 11
France Semiconductor Market Forecast, 1996-2002

Millions of Dollars	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Total Semiconductor	3,773	3,979	4,208	4,886	5,834	6,972	8,387	16.1%
Total Integrated Circuit	3,199	3,362	3,504	4,084	4,857	5,934	7,239	16.6%
Bipolar Digital	32	22	18	17	13	10	7	-20.5%
MOS Digital	2,621	2,782	2,815	3,281	3,951	4,911	6,136	17.1%
MOS Memory	780	689	560	619	849	1,261	1,892	22.4%
MOS Microcomponent	1,426	1,577	1,730	2,025	2,334	2,739	3,150	14.8%
MOS Logic	415	516	525	637	768	911	1,094	16.2%
Analog	546	558	671	786	893	1,013	1,096	14.5%
Discrete	492	542	618	709	877	930	1,035	13.8%
Optoelectronic	82	75	86	93	100	108	113	8.5%
Millions of ECU	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**CAGR 1997-2002**
Total Semiconductor	3,013	3,523	3,856	4,472	5,339	6,381	7,676	16.9%
Total Integrated Circuit	2,555	2,976	3,211	3,738	4,445	5,431	6,625	17.4%
Bipolar Digital	26	19	16	16	12	9	6	-20.6%
MOS Digital	2,093	2,463	2,579	3,003	3,616	4,495	5,616	17.9%
MOS Memory	623	610	513	567	777	1,154	1,732	23.2%
MOS Microcomponent	1,139	1,396	1,585	1,853	2,136	2,507	2,883	15.6%
MOS Logic	331	457	481	583	703	834	1,001	17.0%
Analog	436	494	615	719	817	927	1,003	15.2%
Discrete	393	480	566	649	803	851	947	14.6%
Optoelectronic	65	66	79	85	92	99	103	9.3%
Millions of Francs	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**CAGR 1997-2002**
Total Semiconductor	19,302	23,222	25,594	29,698	35,460	42,377	50,978	17.0%
Total Integrated Circuit	16,365	19,621	21,312	24,823	29,522	36,068	44,000	17.5%
Bipolar Digital	164	128	109	103	79	61	43	-19.6%
MOS Digital	13,409	16,236	17,121	19,943	24,015	29,850	37,296	18.1%
MOS Memory	3,990	4,021	3,406	3,762	5,160	7,665	11,500	23.4%
MOS Microcomponent	7,295	9,204	10,522	12,308	14,187	16,648	19,146	15.8%
MOS Logic	2,123	3,011	3,193	3,872	4,668	5,537	6,650	17.2%
Analog	2,793	3,257	4,081	4,777	5,428	6,157	6,662	15.4%
Discrete	2,517	3,163	3,759	4,309	5,331	5,653	6,291	14.7%
Optoelectronic	419	438	523	565	608	656	687	9.4%
Exchange Rate (Dollars to ECU)	**0.799**	**0.885**	**0.916**	**0.915**	**0.915**	**0.915**	**0.915**	
Exchange Rate (Dollars to Francs	**5.116**	**5.836**	**6.082**	**6.078**	**6.078**	**6.078**	**6.078**	

Source: Dataquest (August 1998 Estimates)

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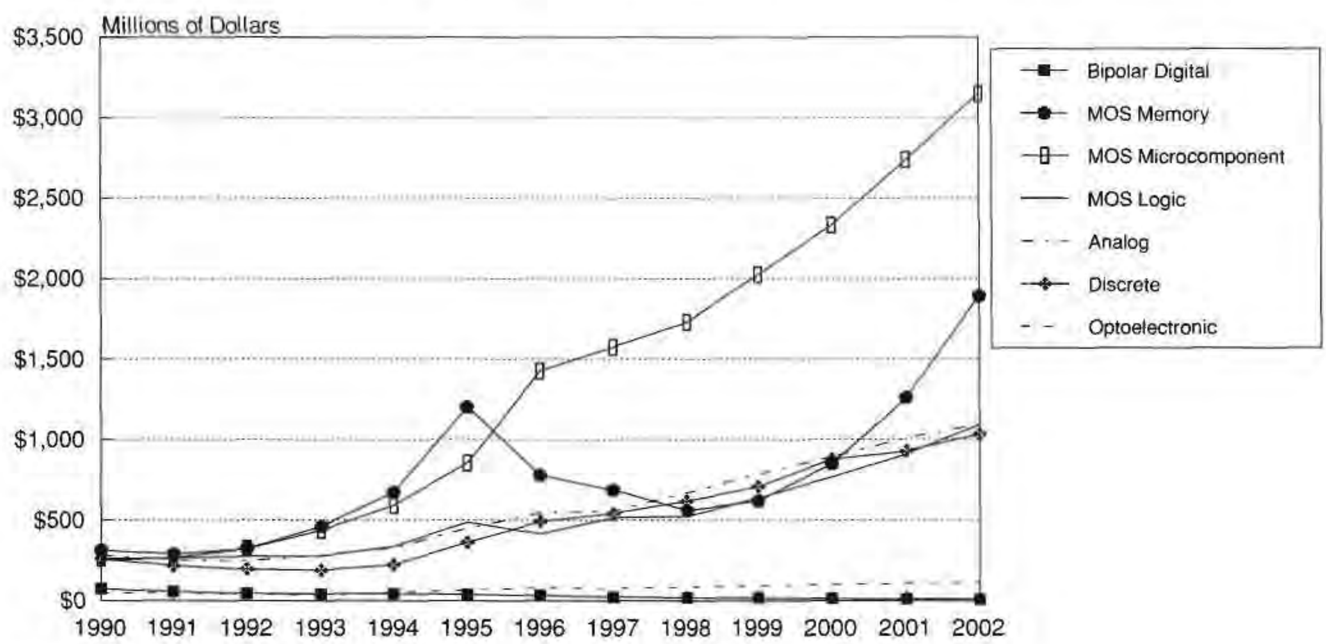
Table 12
Top 10 Semiconductor Vendors in France, 1997

Rank 1997	Rank 1996	Rank Change	Companies	Revenue 1997 ($M)	Revenue 1996 ($M)	AGR (%)	Share 1997 (%)	Share 1996 (%)
1	1	0	Intel	636	520	22%	16.0%	13.8%
2	2	0	STMicroelectronics	406	393	3%	10.2%	10.4%
3	4	1	Philips	348	230	51%	8.7%	6.1%
4	3	-1	Motorola	273	280	-3%	6.9%	7.4%
5	8	3	Siemens	219	144	52%	5.5%	3.8%
6	5	-1	NEC	213	219	-3%	5.4%	5.8%
7	6	-1	Texas Instruments	175	160	9%	4.4%	4.2%
8	7	-1	Samsung	135	150	-10%	3.4%	4.0%
9	15	6	National Semiconductor	74	60	23%	1.9%	1.6%
10	10	0	Analog Devices	71	66	8%	1.8%	1.7%
			Top 10 Subtotal	2,550	2,222	15%	64.1%	58.8%
			Others	1,431	1,554	-8%	35.9%	41.2%
			Total	**3,981**	**3,776**	**5%**	**100.0%**	**100.0%**

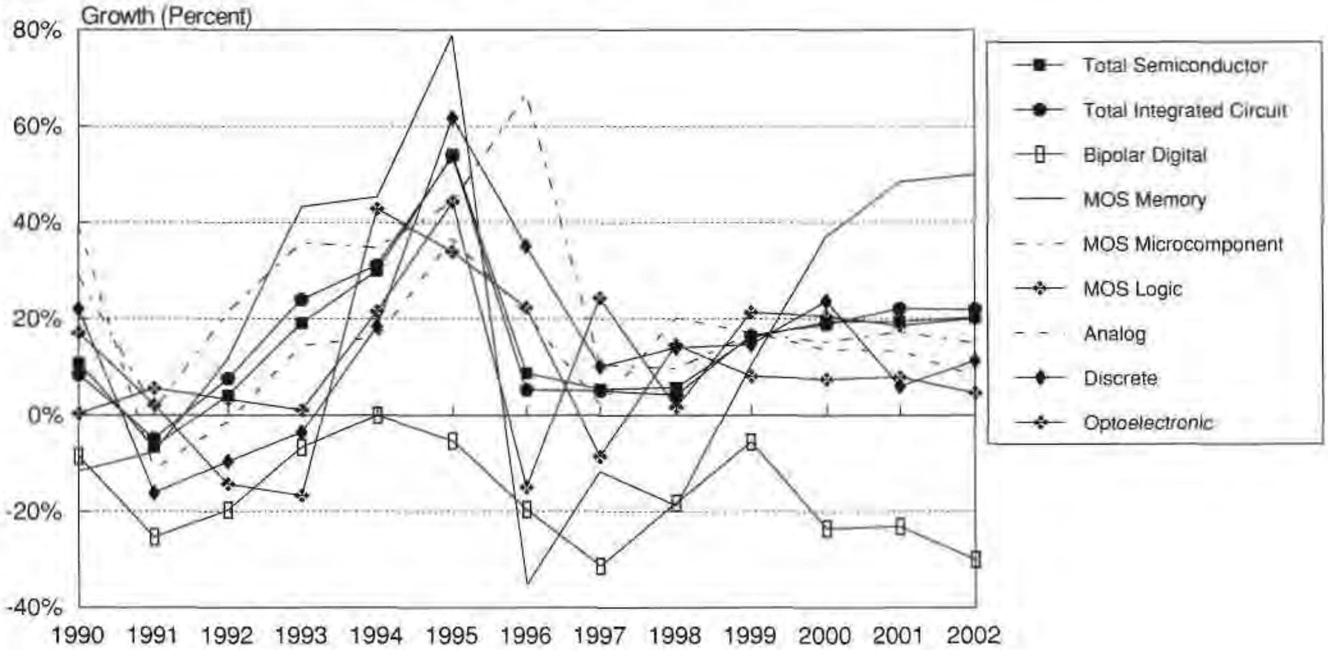
Source: Dataquest (August 1998 Estimates)

Figure 8
France Semiconductor Market by Revenue, 1990-2002



Source: Dataquest (August 1998 Estimates)

Figure 9
France Semiconductor Market by Growth, 1990-2002



Source: Dataquest (August 1998 Estimates)

Germany

The German semiconductor market history and forecast is shown in Tables 13 and 14. Dataquest estimates that the German semiconductor market declined by 5 percent in dollar terms last year to less than $7.5 billion, putting the TAM significantly lower than the United Kingdom/Ireland region for the first time since 1988. However, growth in local currency did return in 1997, signifying that a recovery in the semiconductor market in the region is being hidden by the relative strength of the dollar against the deutsche mark.

Although the EDP sector has suffered in Germany relative to the United Kingdom/Ireland region, late 1997 saw the start of a recovery as consumer PC demand was rekindled. The German telecommunications and automotive sectors remain the strongest in the EMEA region, and there are signs of an upturn in the industrial sector. The consumer segment remains weak, although it may benefit from increased white goods semiconductor content during the coming years.

Table 15 shows the top 10 semiconductor vendors in Germany ranked by sales revenue in 1997. There is a change at the top of the revenue rankings, in that Intel has now added the German market to its "collection of top spots" by displacing Siemens. The mid-ranked vendors, Motorola, STMicroelectronics, Texas Instruments and Philips, all posted a revenue decline in Germany in 1997, but the two European companies declined most in the ranking, reflecting the poor state of the consumer electronics industry in the region. NEC and Samsung represented the memory vendors in the rankings, but both companies' revenues remained in the doldrums as the DRAM market failed to recover. AMD held both ranking and revenue steady as it continued to chip away at Intel's dominant position in microprocessors, while Fujitsu entered the ranking at number 10, displacing Toshiba.

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In 1998 Dataquest forecasts that the German semiconductor market will grow by 7 percent in dollar terms, double the EMEA average. In the longer term, Germany's broad electronics manufacturing base means that its semiconductor market fortunes mirror the wider EMEA marketplace. A CAGR of about 16 percent for the period 1997 to 2002 is therefore no surprise, and will put the German semiconductor market at $15.5 billion by the end of the forecast period.

Graphs of the product split for the German semiconductor market history and forecast are shown in Figures 10 and 11.

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Table 13
Germany Semiconductor Market History, 1990-1996

Millions of Dollars	1990	1991	1992	1993	1994	1995	1996	CAGR 1991-1996
Total Semiconductor	2,912	3,271	3,728	4,217	5,681	8,339	7,836	19.1%
Total Integrated Circuit	2,169	2,482	2,951	3,489	4,780	6,922	6,379	20.8%
Bipolar Digital	228	208	182	170	150	138	110	-12.0%
MOS Digital	1,431	1,723	2,171	2,633	3,812	5,740	5,076	24.1%
MOS Memory	463	515	639	954	1,648	2,704	1,776	28.1%
MOS Microcomponent	610	750	1,006	1,148	1,501	2,134	2,397	26.2%
MOS Logic	358	458	526	531	663	902	903	14.5%
Analog	510	551	598	686	818	1,044	1,193	16.7%
Discrete	615	627	627	604	702	1,155	1,157	13.0%
Optoelectronic	128	162	150	124	199	262	300	13.1%
Millions of ECU	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**CAGR 1991-1996**
Total Semiconductor	2,295	2,653	2,871	3,618	4,792	6,451	6,259	18.7%
Total Integrated Circuit	1,709	2,013	2,272	2,994	4,032	5,355	5,095	20.4%
Bipolar Digital	180	169	140	146	127	107	88	-12.2%
MOS Digital	1,128	1,397	1,672	2,259	3,216	4,440	4,054	23.7%
MOS Memory	365	418	492	819	1,390	2,092	1,418	27.7%
MOS Microcomponent	481	608	775	985	1,266	1,651	1,914	25.8%
MOS Logic	282	371	405	456	559	698	721	14.2%
Analog	402	447	460	589	690	808	953	16.3%
Discrete	485	508	483	518	592	894	924	12.7%
Optoelectronic	101	131	116	106	168	203	240	12.9%
Millions of Deutsche Marks	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**CAGR 1991-1996**
Total Semiconductor	4,717	5,425	5,799	6,982	9,205	11,932	11,792	16.8%
Total Integrated Circuit	3,514	4,116	4,590	5,776	7,745	9,904	9,600	18.5%
Bipolar Digital	369	345	283	281	243	197	166	-13.6%
MOS Digital	2,318	2,857	3,377	4,359	6,177	8,213	7,639	21.7%
MOS Memory	750	854	994	1,579	2,670	3,869	2,673	25.6%
MOS Microcomponent	988	1,244	1,565	1,901	2,432	3,054	3,607	23.7%
MOS Logic	580	760	818	879	1,074	1,291	1,359	12.3%
Analog	826	914	930	1,136	1,325	1,494	1,795	14.5%
Discrete	996	1,040	975	1,000	1,137	1,653	1,741	10.9%
Optoelectronic	207	269	233	205	322	375	451	10.9%
Exchange Rate (Dollars to ECU)	**0.788**	**0.811**	**0.770**	**0.858**	**0.844**	**0.774**	**0.799**	
Exchange Rate (Dollars to Deutsche Marks)	**1.620**	**1.658**	**1.555**	**1.656**	**1.620**	**1.431**	**1.505**	

Source: Dataquest (August 1998 Estimates)

Table 14
Germany Semiconductor Market Forecast, 1996-2002

Millions of Dollars	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Total Semiconductor	7,836	7,453	7,977	9,110	10,876	12,888	15,582	15.9%
Total Integrated Circuit	6,379	5,981	6,271	7,199	8,571	10,459	12,899	16.6%
Bipolar Digital	110	72	63	54	43	35	24	-19.7%
MOS Digital	5,076	4,798	4,819	5,552	6,726	8,399	10,687	17.4%
MOS Memory	1,776	1,435	1,206	1,359	1,860	2,729	4,093	23.3%
MOS Microcomponent	2,397	2,376	2,611	3,001	3,436	3,993	4,581	14.0%
MOS Logic	903	987	1,002	1,192	1,430	1,677	2,013	15.3%
Analog	1,193	1,111	1,389	1,593	1,802	2,025	2,188	14.5%
Discrete	1,157	1,210	1,405	1,591	1,962	2,064	2,298	13.7%
Optoelectronic	300	262	301	320	343	365	385	8.0%
Millions of ECU	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**CAGR 1997-2002**
Total Semiconductor	6,259	6,598	7,309	8,337	9,954	11,795	14,261	16.7%
Total Integrated Circuit	5,095	5,295	5,746	6,589	7,844	9,572	11,805	17.4%
Bipolar Digital	88	64	58	49	39	32	22	-19.2%
MOS Digital	4,054	4,248	4,416	5,081	6,156	7,687	9,781	18.2%
MOS Memory	1,418	1,270	1,105	1,244	1,702	2,498	3,746	24.2%
MOS Microcomponent	1,914	2,103	2,392	2,747	3,145	3,654	4,193	14.8%
MOS Logic	721	874	918	1,091	1,309	1,535	1,842	16.1%
Analog	953	984	1,273	1,458	1,649	1,853	2,002	15.3%
Discrete	924	1,071	1,287	1,456	1,796	1,889	2,103	14.4%
Optoelectronic	240	232	276	293	314	334	352	8.7%
Millions of Deutsche Marks	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**CAGR 1997-2002**
Total Semiconductor	11,792	12,923	14,475	16,518	19,720	23,369	28,253	16.9%
Total Integrated Circuit	9,600	10,371	11,379	13,053	15,541	18,964	23,388	17.7%
Bipolar Digital	166	125	114	98	78	63	44	-18.8%
MOS Digital	7,639	8,320	8,745	10,067	12,196	15,229	19,378	18.4%
MOS Memory	2,673	2,488	2,188	2,464	3,373	4,948	7,421	24.4%
MOS Microcomponent	3,607	4,120	4,738	5,441	6,230	7,240	8,306	15.1%
MOS Logic	1,359	1,711	1,818	2,161	2,593	3,041	3,650	16.4%
Analog	1,795	1,926	2,520	2,888	3,267	3,672	3,967	15.5%
Discrete	1,741	2,098	2,550	2,885	3,557	3,742	4,167	14.7%
Optoelectronic	451	454	546	580	622	662	698	9.0%
Exchange Rate (Dollars to ECU)	**0.799**	**0.885**	**0.916**	**0.915**	**0.915**	**0.915**	**0.915**	
Exchange Rate (Dollars to Deutsche Marks)	**1.505**	**1.734**	**1.815**	**1.813**	**1.813**	**1.813**	**1.813**	

Source: Dataquest (August 1998 Estimates)

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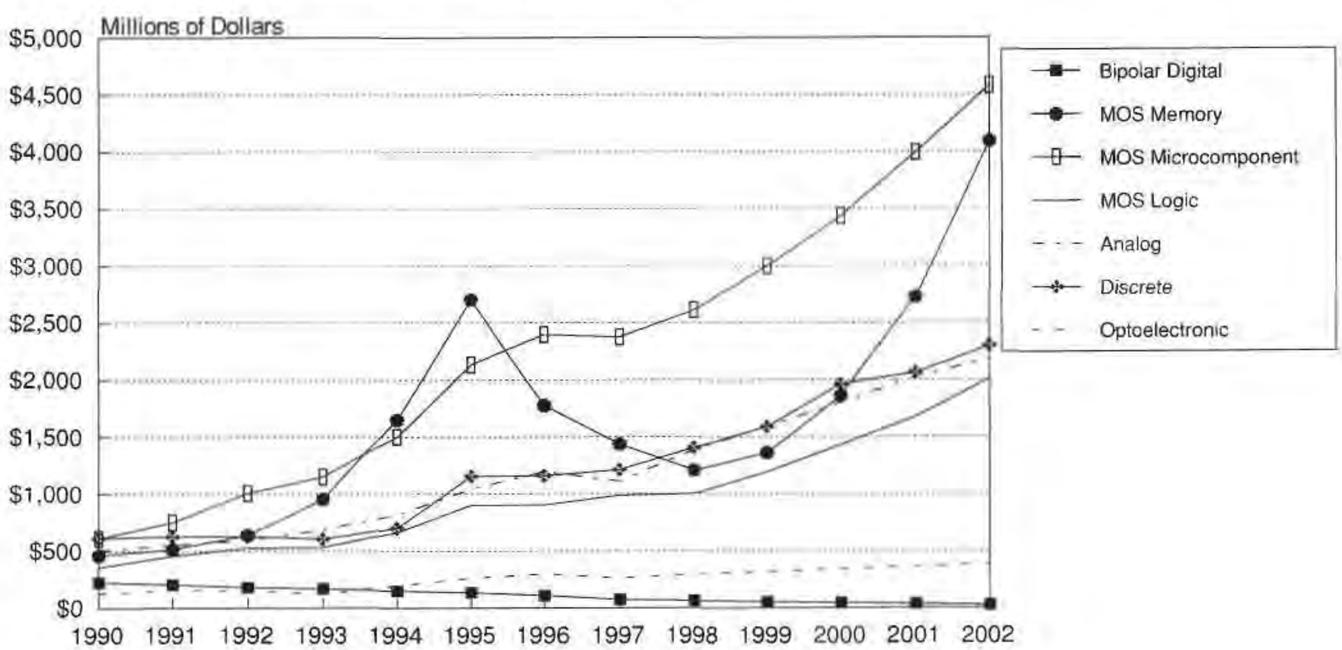
Table 15
Top 10 Semiconductor Vendors in Germany, 1997

Rank 1997	Rank 1996	Rank Change	Companies	Revenue 1997 ($M)	Revenue 1996 ($M)	AGR (%)	Share 1997 (%)	Share 1996 (%)
1	2	1	Intel	1,417	1,200	18%	19.0%	15.3%
2	1	-1	Siemens	1,339	1,210	11%	18.0%	15.4%
3	3	0	Motorola	559	583	-4%	7.5%	7.4%
4	4	0	STMicroelectronics	433	517	-16%	5.8%	6.6%
5	6	1	Texas Instruments	416	450	-8%	5.6%	5.7%
6	5	-1	Philips	389	470	-17%	5.2%	6.0%
7	7	0	NEC	308	306	1%	4.1%	3.9%
8	8	0	Samsung	232	254	-9%	3.1%	3.2%
9	9	0	Advanced Micro Devices	196	195	1%	2.6%	2.5%
10	13	3	Fujitsu	172	166	4%	2.3%	2.1%
			Top 10 Subtotal	5,461	5,351	2%	73.3%	68.3%
			Others	1,990	2,482	20%	26.7%	31.7%
			Total	**7,451**	**7,833**	**-5%**	**100.0%**	**100.0%**

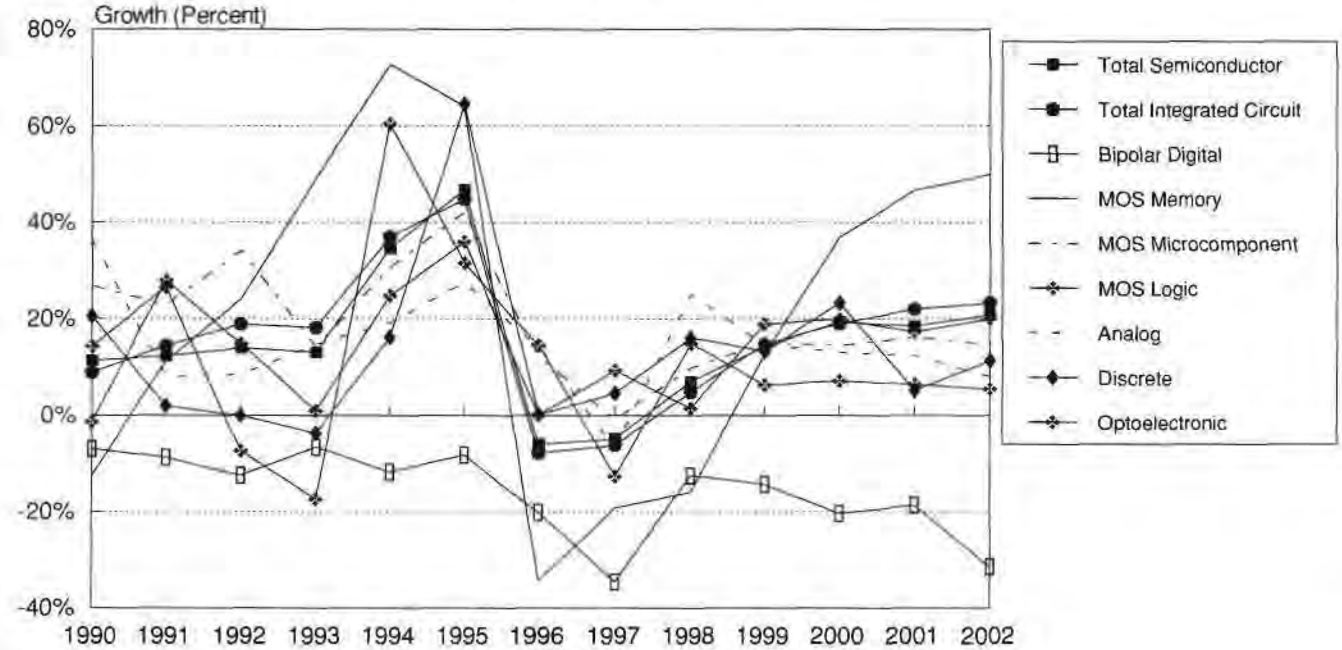
Source: Dataquest (August 1998 Estimates)

Figure 10
Germany Semiconductor Market by Revenue, 1990-2002



Source: Dataquest (August 1998 Estimates)

Figure 11
Germany Semiconductor Market by Growth, 1990-2002



Source: Dataquest (August 1998 Estimates)

Italy

The Italian semiconductor market history and forecast is shown in Tables 16 and 17. At $1.7 billion, Italy's semiconductor market declined by 5 percent in dollar terms in 1997 over 1996, and accounted for less than 6 percent of the semiconductor billings in the EMEA region. Only the Benelux region is a smaller semiconductor market. Growth in lire terms was a modest 5 percent, as semiconductor sales continue to suffer from a lack of semiconductor-rich electronics manufacturing in the country.

Apart from some ongoing telecommunications equipment manufacturing by Italtel, the production of midrange cars and low-semiconductor-content white goods epitomizes the weakness of the Italian electronics sector for semiconductor vendors. Olivetti, once a significant PC manufacturer, shows no sign of emerging revitalized from is protracted restructuring, so prospects for the Italian semiconductor market are bleak.

Table 18 shows the top 10 semiconductor vendors in Italy ranked by sales revenue in 1997. The same 10 vendors appear in the ranking table as in 1996, although there were mixed fortunes. Siemens' performance in gaining three places to reach number seven in the ranking by growing sales almost 30 percent stands out in a year when seven of the top 10 ranked vendors saw sales decline. STMicroelectronics now ranks as the number-one vendor in Italy, because Intel's sales declined significantly as a result of Olivetti's continued demise. The lack of any PC manufacturing powerhouse in the country affected the sales of Samsung, Toshiba and Hitachi, which all experienced a decline, with NEC being the only memory vendor to hold revenue level. Recent progress by Motorola and Philips in Italy was reversed in 1997, while Texas Instruments bounced back from a significant decline in 1996.

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Dataquest does not see any sign of an improvement in the Italian semiconductor market on the horizon. In 1998, the market is expected to decline by a further 6 percent in dollar terms, or 2 percent in local currency terms. Longer term, the outlook is for a continued decline in regional market share. A CAGR of 11 percent in dollar terms is expected, resulting in a 5 percent share of the EMEA semiconductor market in 2002. This CAGR is well below the European average, and will result in a market size that fails to reach $3 billion by the end of the forecast period. A graphical representation of the product split for the Italian semiconductor market history and forecast split is shown in Figures 12 and 13.

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Table 16
Italy Semiconductor Market History, 1990-1996

Millions of Dollars	1990	1991	1992	1993	1994	1995	1996	CAGR 1991-1996
Total Semiconductor	1,212	1,136	1,280	1,457	1,769	2,124	1,819	9.9%
Total Integrated Circuit	963	918	1,016	1,266	1,573	1,886	1,441	9.4%
Bipolar Digital	61	46	50	31	31	21	17	-18.1%
MOS Digital	672	668	802	995	1,305	1,629	1,151	11.5%
MOS Memory	255	234	358	379	592	777	459	14.4%
MOS Microcomponent	213	217	275	387	473	567	433	14.8%
MOS Logic	204	217	169	229	240	285	259	3.6%
Analog	230	204	164	240	237	236	273	6.0%
Discrete	210	177	229	161	159	200	332	13.4%
Optoelectronic	39	41	35	30	37	38	46	2.3%
Millions of ECU	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**CAGR 1991-1996**
Total Semiconductor	955	921	986	1,250	1,492	1,643	1,453	9.5%
Total Integrated Circuit	759	744	782	1,086	1,327	1,459	1,151	9.1%
Bipolar Digital	48	37	39	27	26	17	14	-17.7%
MOS Digital	530	542	618	854	1,101	1,260	919	11.1%
MOS Memory	201	190	276	325	499	601	367	14.1%
MOS Microcomponent	168	176	212	332	399	439	346	14.5%
MOS Logic	161	176	130	196	202	220	207	3.3%
Analog	181	165	126	206	200	183	218	5.7%
Discrete	165	144	176	138	134	155	265	13.0%
Optoelectronic	31	33	27	26	31	29	37	2.3%
Billions of Lire	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**CAGR 1991-1996**
Total Semiconductor	1,451	1,407	1,572	2,299	2,847	3,459	2,806	14.8%
Total Integrated Circuit	1,153	1,137	1,247	1,998	2,531	3,071	2,223	14.3%
Bipolar Digital	73	57	61	49	50	35	26	-14.5%
MOS Digital	805	828	985	1,570	2,100	2,652	1,776	16.5%
MOS Memory	305	290	440	598	953	1,265	708	19.5%
MOS Microcomponent	255	269	338	611	761	923	668	20.0%
MOS Logic	244	269	207	361	386	464	400	8.3%
Analog	275	253	201	379	381	384	421	10.7%
Discrete	251	219	281	254	256	326	512	18.5%
Optoelectronic	47	51	43	47	60	62	71	6.8%
Exchange Rate (Dollars to ECU)	**0.788**	**0.811**	**0.770**	**0.858**	**0.844**	**0.774**	**0.799**	
Exchange Rate (Dollars to Lire, K)	**1.197**	**1.239**	**1.228**	**1.578**	**1.609**	**1.628**	**1.543**	

Source: Dataquest (August 1998 Estimates)

Table 17
Italy Semiconductor Market Forecast, 1996-2002

Millions of Dollars	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Total Semiconductor	1,819	1,728	1,612	1,799	2,117	2,472	2,927	11.1%
Total Integrated Circuit	1,441	1,349	1,203	1,335	1,555	1,882	2,278	11.0%
Bipolar Digital	17	11	9	8	6	4	4	-18.3%
MOS Digital	1,151	1,092	929	1,018	1,207	1,496	1,869	11.3%
MOS Memory	459	363	270	243	325	474	698	14.0%
MOS Microcomponent	433	437	425	495	551	635	713	10.3%
MOS Logic	259	292	234	280	331	387	458	9.4%
Analog	273	246	265	309	342	382	405	10.5%
Discrete	332	342	372	423	519	545	603	12.0%
Optoelectronic	46	37	37	41	43	45	46	4.5%
Millions of ECU	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**CAGR 1997-2002**
Total Semiconductor	1,453	1,530	1,477	1,646	1,937	2,262	2,679	11.9%
Total Integrated Circuit	1,151	1,194	1,102	1,222	1,423	1,722	2,085	11.8%
Bipolar Digital	14	10	8	7	5	4	4	-16.7%
MOS Digital	919	967	851	932	1,105	1,369	1,711	12.1%
MOS Memory	367	321	247	222	297	434	639	14.8%
MOS Microcomponent	346	387	389	453	504	581	653	11.0%
MOS Logic	207	259	214	256	303	354	419	10.1%
Analog	218	218	243	283	313	350	371	11.2%
Discrete	265	303	341	387	475	499	552	12.7%
Optoelectronic	37	33	34	38	39	41	42	4.9%
Billions of Lire	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**CAGR 1997-2002**
Total Semiconductor	2,806	2,943	2,888	3,222	3,792	4,428	5,243	12.2%
Total Integrated Circuit	2,223	2,297	2,155	2,391	2,785	3,371	4,080	12.2%
Bipolar Digital	26	19	16	14	11	7	7	-18.1%
MOS Digital	1,776	1,860	1,664	1,823	2,162	2,680	3,348	12.5%
MOS Memory	708	618	484	435	582	849	1,250	15.1%
MOS Microcomponent	668	744	761	887	987	1,137	1,277	11.4%
MOS Logic	400	497	419	502	593	693	820	10.5%
Analog	421	419	475	553	613	684	725	11.6%
Discrete	512	582	666	758	930	976	1,080	13.2%
Optoelectronic	71	63	66	73	77	81	82	5.4%
Exchange Rate (Dollars to ECU)	**0.799**	**0.885**	**0.916**	**0.915**	**0.915**	**0.915**	**0.915**	
Exchange Rate (Dollars to Lire, K)	**1.543**	**1.703**	**1.791**	**1.791**	**1.791**	**1.791**	**1.791**	

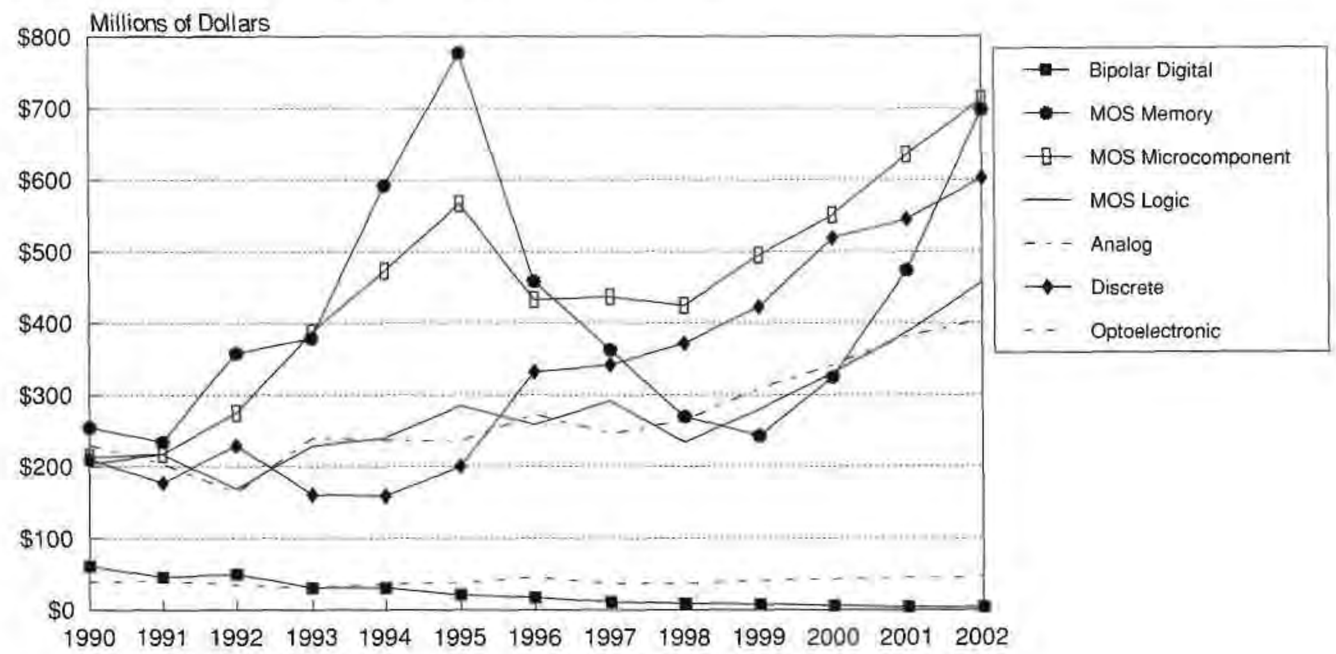
Source: Dataquest (August 1998 Estimates)

Table 18
Top 10 Semiconductor Vendors in Italy, 1997

Rank 1997	Rank 1996	Rank Change	Companies	Revenue 1997 ($M)	Revenue 1996 ($M)	AGR (%)	Share 1997 (%)	Share 1996 (%)
1	2	1	STMicroelectronics	190	205	-7%	11.0%	11.3%
2	1	-1	Intel	166	280	-41%	9.6%	15.4%
3	3	0	Motorola	148	169	-12%	8.6%	9.3%
4	4	0	Philips	102	155	-34%	5.9%	8.5%
5	7	2	Texas Instruments	100	90	11%	5.8%	5.0%
6	5	-1	Samsung	97	104	-7%	5.6%	5.7%
7	10	3	Siemens	89	69	29%	5.2%	3.8%
8	8	0	NEC	88	87	1%	5.1%	4.8%
9	9	0	Toshiba	71	81	-12%	4.1%	4.5%
10	6	-4	Hitachi	68	100	-32%	3.9%	5.5%
			Top 10 Subtotal	1,119	1,340	-16%	64.8%	73.8%
			Others	607	476	28%	35.2%	26.2%
			Total	**1,726**	**1,816**	**-5%**	**100.0%**	**100.0%**

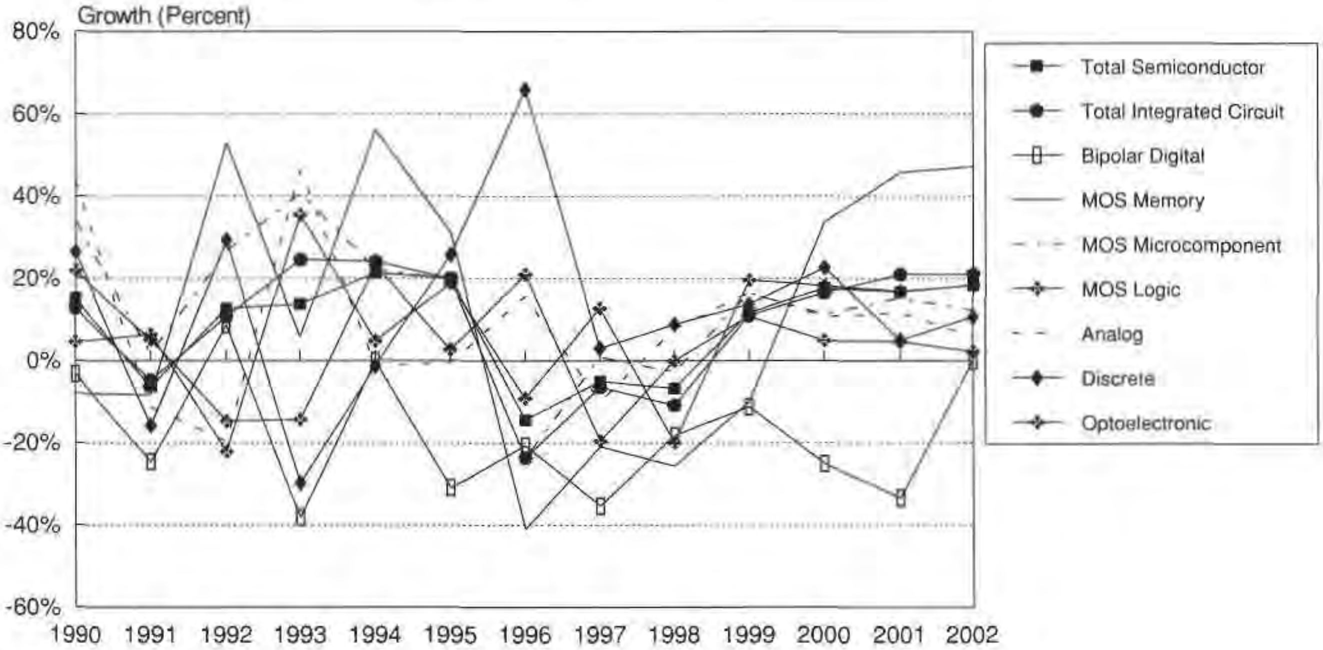
Source: Dataquest (August 1998 Estimates)

Figure 12
Italy Semiconductor Market by Revenue, 1990-2002



Source: Dataquest (August 1998 Estimates)

Figure 13
Italy Semiconductor Market by Growth, 1990-2002



Source: Dataquest (August 1998 Estimates)

Nordic

The Nordic semiconductor market history and forecast is shown in Tables 19 and 20. Dataquest estimates that the market in the Nordic region grew by almost 8 percent to reach $2.7 billion in 1997. Local currency growth was an impressive 22 percent.

The Nordic semiconductor market is dominated by Nokia and Ericsson, which continue to gain in standing in the field of global telecommunications equipment manufacturing. As an indication of how mobile telephony has now reached a mass market, in 1997 GSM handset unit production grew by more than 100 percent, and the two Scandinavian companies are the leading manufacturers. However, in the light of a global overcapacity of all types of semiconductor products, severe price pressure has tempered the semiconductor TAM despite the phenomenal unit demand. There is also a continuing trend towards contract electronics manufacturing by Nokia and Ericsson that is in danger of shifting the semiconductor TAM progressively towards the Baltic states, although the majority of semiconductors are still procured centrally by the two OEM giants. As well as telecommunications, the region also has significant automotive production and some declining EDP activity generating additional demand for semiconductors.

Table 21 shows the top 10 semiconductor vendors in the Nordic region ranked by sales revenue in 1997. As expected, the ranking is populated by vendors that serve the mobile telecommunications sector, so those that have strong ASIC, mixed signal and power product offerings feature. Of the companies strong in mixed signal and power semiconductors, STMicroelectronics consolidated its number-one position, growing revenue by 21 percent, while Philips suffered a revenue decline of 25 percent, dropping to number four in the rankings. Texas Instruments, through a series of GSM design wins, grew revenue by almost a third, but failed to improve on its second place in the ranking.

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Declining PC production, coupled with severe ASP erosion on flash products, hit Intel and it fell one place to third in the rankings even though growth was a healthy 36 percent. Lucent Technologies, on the other hand, was able to jump two places in the ranking as a result of a 27 percent increase in revenue. Another GSM design win beneficiary was VLSI Technology, which entered the rankings at number six. Another new entrant was National Semiconductor, which increased revenue by 22 percent to displace Toshiba in ninth spot. Along with Toshiba, the other memory vendor in the rankings is Hitachi. Both companies' SRAM products feature in GSM handsets, but this failed to prevent single-digit slides in revenue for the two Japanese vendors. Siemens also suffered a single-digit decline in revenue with its focus on fixed-line telephony infrastructure preventing it benefiting from the boom in mobile communications.

The outlook for 1998 is for growth of 12 percent in dollars, or 17 percent in local currency, as unit demand continues to boom. Dataquest is still forecasting growth in the Nordic region as the strongest within the EMEA semiconductor market, although abundant supply and OEM pressure will continue to mean severe price erosion. Therefore, the CAGR for the period 1997 to 2002 has been trimmed back to 16.5 percent in dollar terms, putting the Nordic semiconductor TAM at about $5.7 billion by the end of the forecast period. Graphs of the product split for the Nordic region semiconductor market history and forecast are shown in Figures 14 and 15.

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Table 19
Nordic Semiconductor Market History, 1990-1996

Millions of Dollars	1990	1991	1992	1993	1994	1995	1996	CAGR 1991-1996
Total Semiconductor	712	706	779	1,067	1,714	2,625	2,495	28.7%
Total Integrated Circuit	576	577	655	942	1,515	2,342	2,305	31.9%
Bipolar Digital	17	14	11	12	16	15	6	-15.6%
MOS Digital	264	283	341	556	923	1,526	1,507	39.7%
MOS Memory	112	112	136	222	381	728	372	27.1%
MOS Microcomponent	69	76	99	218	361	540	783	59.4%
MOS Logic	83	95	106	116	181	258	352	29.9%
Analog	295	280	303	374	576	801	792	23.1%
Discrete	112	101	99	103	155	235	154	8.8%
Optoelectronic	24	28	25	22	44	48	36	5.2%
Millions of ECU	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**CAGR 1991-1996**
Total Semiconductor	561	573	600	915	1,446	2,031	1,993	28.3%
Total Integrated Circuit	454	468	504	808	1,278	1,812	1,841	31.5%
Bipolar Digital	13	11	8	10	13	12	5	-14.6%
MOS Digital	208	230	263	477	779	1,181	1,204	39.2%
MOS Memory	88	91	105	190	321	563	297	26.7%
MOS Microcomponent	54	62	76	187	305	418	625	58.7%
MOS Logic	65	77	82	100	153	200	281	29.6%
Analog	232	227	233	321	486	620	633	22.8%
Discrete	88	82	76	88	131	182	123	8.4%
Optoelectronic	19	23	19	19	37	37	29	4.7%
Millions of Kronor	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**CAGR 1991-1996**
Total Semiconductor	4,215	4,268	4,526	8,346	13,191	18,770	16,738	31.4%
Total Integrated Circuit	3,410	3,488	3,806	7,368	11,660	16,747	15,463	34.7%
Bipolar Digital	101	85	64	94	123	109	40	-14.0%
MOS Digital	1,563	1,711	1,981	4,349	7,104	10,910	10,110	42.7%
MOS Memory	663	677	790	1,736	2,932	5,205	2,496	29.8%
MOS Microcomponent	408	459	575	1,705	2,778	3,861	5,253	62.8%
MOS Logic	491	574	616	907	1,393	1,845	2,361	32.7%
Analog	1,746	1,693	1,761	2,925	4,433	5,727	5,313	25.7%
Discrete	663	611	575	806	1,193	1,680	1,033	11.1%
Optoelectronic	142	169	145	172	339	343	242	7.4%
Exchange Rate (Dollars to ECU)	**0.788**	**0.811**	**0.770**	**0.858**	**0.844**	**0.774**	**0.799**	
Exchange Rate (Dollars to Swedish Kroner)	**5.920**	**6.045**	**5.811**	**7.822**	**7.696**	**7.150**	**6.709**	

Source: Dataquest (August 1998 Estimates)

Table 20
Nordic Semiconductor Market Forecast, 1996-2002

Millions of Dollars	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Total Semiconductor	2,495	2,687	3,012	3,458	4,028	4,833	5,756	16.5%
Total Integrated Circuit	2,305	2,519	2,810	3,239	3,772	4,553	5,443	16.7%
Bipolar Digital	6	3	3	2	2	2	2	-7.8%
MOS Digital	1,507	1,756	1,893	2,198	2,592	3,212	3,981	17.8%
MOS Memory	372	275	235	298	398	604	914	27.2%
MOS Microcomponent	783	1,042	1,164	1,319	1,501	1,782	2,065	14.7%
MOS Logic	352	439	494	581	693	826	1,002	17.9%
Analog	792	760	914	1,039	1,178	1,339	1,460	13.9%
Discrete	154	142	171	187	223	243	273	14.0%
Optoelectronic	36	26	31	32	33	37	40	9.0%
Millions of ECU	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**CAGR 1997-2002**
Total Semiconductor	1,993	2,379	2,760	3,165	3,686	4,423	5,268	17.2%
Total Integrated Circuit	1,841	2,230	2,575	2,964	3,452	4,167	4,981	17.4%
Bipolar Digital	5	3	3	2	2	2	2	-7.8%
MOS Digital	1,204	1,555	1,735	2,012	2,372	2,940	3,643	18.6%
MOS Memory	297	243	215	273	364	553	836	28.0%
MOS Microcomponent	625	922	1,067	1,207	1,374	1,631	1,890	15.4%
MOS Logic	281	389	453	532	634	756	917	18.7%
Analog	633	673	837	951	1,078	1,225	1,336	14.7%
Discrete	123	126	157	171	204	222	250	14.7%
Optoelectronic	29	23	28	29	30	34	37	10.0%
Millions of Kronor	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**CAGR 1997-2002**
Total Semiconductor	16,738	20,530	23,713	27,055	31,514	37,812	45,034	17.0%
Total Integrated Circuit	15,463	19,247	22,122	25,341	29,511	35,622	42,585	17.2%
Bipolar Digital	40	23	24	16	16	16	16	-7.0%
MOS Digital	10,110	13,417	14,903	17,197	20,279	25,130	31,147	18.3%
MOS Memory	2,496	2,101	1,850	2,331	3,114	4,726	7,151	27.8%
MOS Microcomponent	5,253	7,961	9,164	10,320	11,744	13,942	16,156	15.2%
MOS Logic	2,361	3,354	3,889	4,546	5,422	6,462	7,839	18.5%
Analog	5,313	5,807	7,196	8,129	9,216	10,476	11,423	14.5%
Discrete	1,033	1,085	1,346	1,463	1,745	1,901	2,136	14.5%
Optoelectronic	242	199	244	250	258	289	313	9.5%
Exchange Rate (Dollars to ECU)	**0.799**	**0.885**	**0.916**	**0.915**	**0.915**	**0.915**	**0.915**	
Exchange Rate (Dollars to Swedish Kroner)	**6.709**	**7.641**	**7.873**	**7.824**	**7.824**	**7.824**	**7.824**	

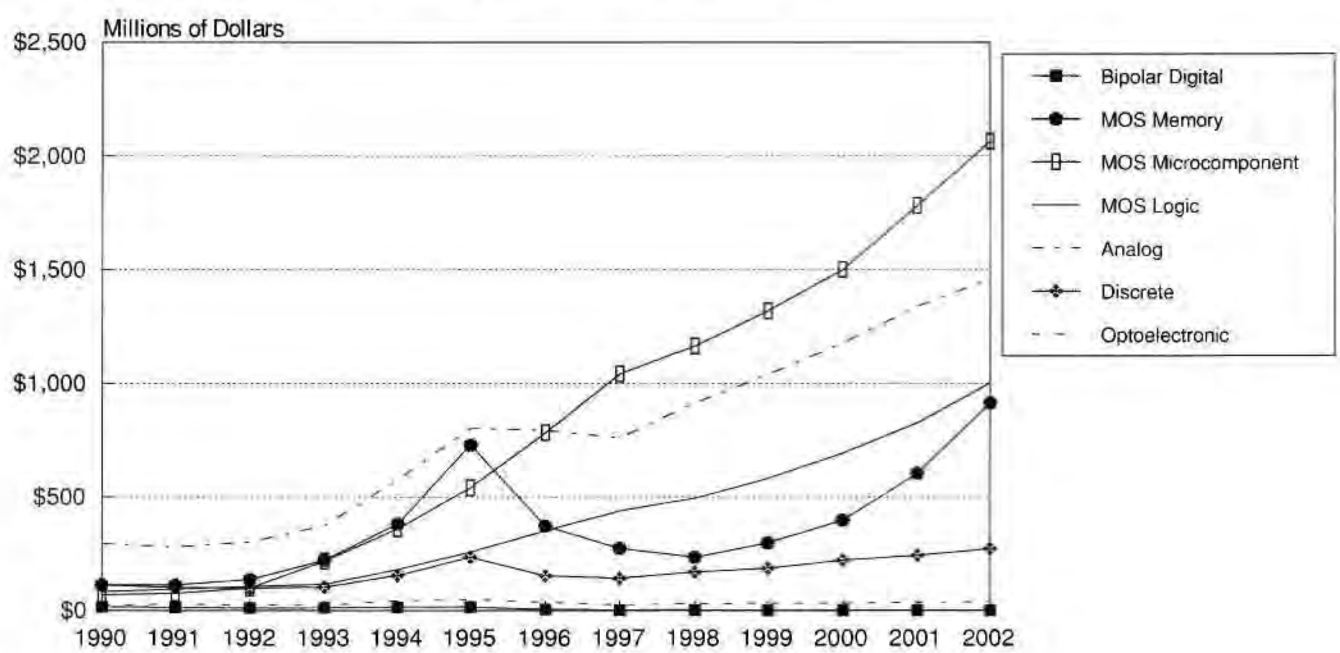
Source: Dataquest (August 1998 Estimates)

Table 21
Top 10 Semiconductor Vendors in the Nordic Region, 1997

Rank 1997	Rank 1996	Rank Change	Companies	Revenue 1997 ($M)	Revenue 1996 ($M)	AGR (%)	Share 1997 (%)	Share 1996 (%)
1	2	1	STMicroelectronics	358	295	21%	13.3%	11.8%
2	3	1	Texas Instruments	315	240	31%	11.7%	9.6%
3	4	1	Intel	286	210	36%	10.7%	8.4%
4	1	-3	Philips	220	295	-25%	8.2%	11.8%
5	7	2	Lucent Technologies	161	127	27%	6.0%	5.1%
6	NA	NA	VLSI Technology	152	NA	NA	5.7%	NA
7	6	-1	Hitachi	131	140	-6%	4.9%	5.6%
8	5	-3	Siemens	131	143	-8%	4.9%	5.7%
9	12	3	National Semiconductor	118	97	22%	4.4%	3.9%
10	9	-1	Toshiba	110	115	-4%	4.1%	4.6%
			Top 10 Subtotal	1,982	1,662	19%	73.8%	66.7%
			Others	703	830	-15%	26.2%	33.3%
			Total	**2,685**	**2,492**	**8%**	**100.0%**	**100.0%**

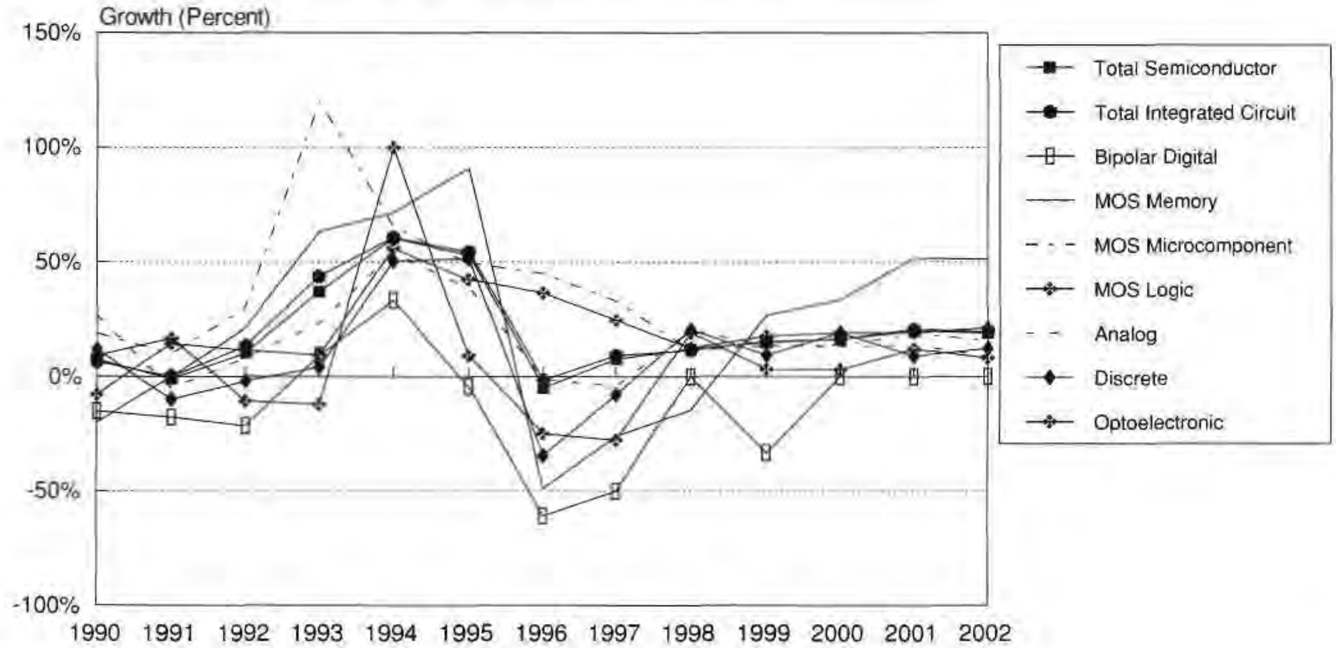
NA = not applicable
Source: Dataquest (August 1998 Estimates)

Figure 14
Nordic Semiconductor Market by Revenue, 1990-2002



Source: Dataquest (August 1998 Estimates)

Figure 15
Nordic Semiconductor Market by Growth, 1990-2002



Source: Dataquest (August 1998 Estimates)

United Kingdom/Ireland

The United Kingdom/Ireland semiconductor market size history and forecast is shown in Tables 22 and 23. In 1997, Dataquest estimates that the semiconductor TAM grew by 15 percent to almost $9 billion, ahead of Germany in second place at about $7.5 billion. In contrast with all the other regions within the greater EMEA region, the United Kingdom/Ireland local currency actually grew stronger against the dollar, which added to the dollar growth in the United Kingdom/Ireland semiconductor market. Sterling growth is estimated at about 10 percent.

The United Kingdom/Ireland region's semiconductor market is dominated by PCs. Although the DRAM market remains in decline, strong PC unit growth together with increased main memory fit meant that any adverse effect on the semiconductor market size was limited. The consolidation of PC production among the large vendors, such as Compaq and IBM, benefited the United Kingdom/Ireland region, especially in the microprocessor market, where increased units and continued healthy microprocessor ASPs fueled growth. In addition to the PC sector, the United Kingdom/Ireland region has significant mobile telephony infrastructure and handset manufacture, a sizable automotive electronics sector and a fast-growing consumer electronics segment.

Table 24 shows the top 10 semiconductor vendors in the United Kingdom/Ireland region ranked by sales revenue in 1997. While the top eight vendors maintained their ranking positions, it is interesting to note that some consolidation of market share occurred in the market. The top four vendors grew revenue sharply, while vendors ranked in positions five to eight lost market share. Of course Intel, as the dominant microprocessor vendor, remains atop the ranking with 25 percent market share and semiconductor revenue four times greater than its nearest rival Samsung, which was in second place. The South Korean company posted a revenue increase as a result of increased DRAM bit shipments and in spite of continued DRAM price erosion. Motorola and Texas Instruments were the other vendors to do particularly well, benefiting from the United Kingdom/Ireland region's non-PC electronics segments. Apart from

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Samsung, the memory vendors did not fair so well. Although Hitachi's revenues were flat, the semiconductor revenues of NEC, Siemens and Toshiba all declined by a modest amount, as did those of Philips in eighth position. Finally, National Semiconductor entered the ranking at number 10 displacing IBM Microelectronics.

Although 1997 was a good year for the United Kingdom/Ireland region, the outlook for 1998 is more gloomy, with more or less flat revenue growth expected. However, longer term, the region will ride the anticipated DRAM boom cycle. A CAGR of more than 16 percent is forecast for the period 1997 to 2002, which will grow the United Kingdom/Ireland semiconductor TAM to $19.0 billion by the end of the forecast period. Graphs of the product split for the United Kingdom/Ireland region semiconductor market history and forecast are shown in Figures 16 and 17.

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Table 22
United Kingdom/Ireland Semiconductor Market History, 1990-1996

Millions of Dollars	1990	1991	1992	1993	1994	1995	1996	CAGR 1991-1996
Total Semiconductor	2,411	2,592	3,047	4,205	5,820	7,904	7,775	24.6%
Total Integrated Circuit	1,971	2,145	2,604	3,754	5,285	7,249	7,165	27.3%
Bipolar Digital	161	141	124	121	100	80	67	-13.8%
MOS Digital	1,468	1,652	2,095	3,155	4,696	6,722	6,485	31.5%
MOS Memory	726	771	966	1,525	2,612	4,107	2,535	26.9%
MOS Microcomponent	467	544	739	1,208	1,608	2,093	3,048	41.2%
MOS Logic	275	337	390	422	476	522	902	21.8%
Analog	342	352	385	478	489	447	613	11.7%
Discrete	350	339	342	360	410	523	445	5.6%
Optoelectronic	90	108	101	91	125	132	165	8.8%
Millions of ECU	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**CAGR 1991-1996**
Total Semiconductor	1,900	2,102	2,346	3,608	4,910	6,114	6,210	24.2%
Total Integrated Circuit	1,553	1,740	2,005	3,221	4,458	5,607	5,723	26.9%
Bipolar Digital	127	114	95	104	84	62	54	-13.9%
MOS Digital	1,157	1,340	1,613	2,707	3,962	5,200	5,180	31.1%
MOS Memory	572	625	744	1,308	2,203	3,177	2,025	26.5%
MOS Microcomponent	368	441	569	1,036	1,357	1,619	2,434	40.7%
MOS Logic	217	273	300	362	402	404	720	21.4%
Analog	269	285	296	410	413	346	490	11.4%
Discrete	276	275	263	309	346	405	355	5.2%
Optoelectronic	71	88	78	78	105	102	132	8.4%
Millions of Pounds	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**CAGR 1991-1996**
Total Semiconductor	1,350	1,471	1,733	2,804	3,804	5,002	4,984	27.6%
Total Integrated Circuit	1,104	1,217	1,481	2,503	3,454	4,588	4,593	30.4%
Bipolar Digital	90	80	71	81	65	50	43	-11.7%
MOS Digital	822	938	1,191	2,104	3,069	4,254	4,157	34.7%
MOS Memory	407	438	549	1,017	1,707	2,599	1,625	30.0%
MOS Microcomponent	262	309	420	805	1,051	1,325	1,954	44.6%
MOS Logic	154	191	222	281	311	330	578	24.8%
Analog	192	200	219	319	320	283	393	14.5%
Discrete	196	192	194	240	268	331	285	8.2%
Optoelectronic	50	61	57	61	82	84	106	11.7%
Exchange Rate (Dollars to ECU)	**0.788**	**0.811**	**0.770**	**0.858**	**0.844**	**0.774**	**0.799**	
Exchange Rate (Dollars to Pounds)	**0.560**	**0.568**	**0.569**	**0.667**	**0.654**	**0.633**	**0.641**	

Source: Dataquest (August 1998 Estimates)

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Table 23
United Kingdom/Ireland Semiconductor Market Forecast, 1996-2002

Millions of Dollars	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Total Semiconductor	7,775	8,951	8,799	9,942	12,418	15,312	19,019	16.3%
Total Integrated Circuit	7,165	8,220	8,012	9,066	11,315	14,126	17,716	16.6%
Bipolar Digital	67	50	41	35	28	23	16	-20.4%
MOS Digital	6,485	7,437	7,146	8,088	10,147	12,794	16,289	17.0%
MOS Memory	2,535	2,356	1,838	1,939	2,745	4,071	6,124	21.1%
MOS Microcomponent	3,048	3,832	4,050	4,655	5,536	6,506	7,496	14.4%
MOS Logic	902	1,249	1,258	1,494	1,866	2,217	2,669	16.4%
Analog	613	733	825	943	1,140	1,309	1,411	14.0%
Discrete	445	563	608	684	889	953	1,059	13.5%
Optoelectronic	165	168	179	192	214	233	244	7.7%
Millions of ECU	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**CAGR 1997-2002**
Total Semiconductor	6,210	7,924	8,063	9,099	11,365	14,014	17,406	17.0%
Total Integrated Circuit	5,723	7,277	7,341	8,297	10,355	12,928	16,214	17.4%
Bipolar Digital	54	44	38	32	26	21	15	-19.4%
MOS Digital	5,180	6,584	6,548	7,402	9,287	11,709	14,908	17.8%
MOS Memory	2,025	2,086	1,684	1,775	2,512	3,726	5,605	21.9%
MOS Microcomponent	2,434	3,392	3,711	4,260	5,067	5,954	6,860	15.1%
MOS Logic	720	1,106	1,153	1,367	1,708	2,029	2,443	17.2%
Analog	490	649	756	863	1,043	1,198	1,291	14.7%
Discrete	355	498	557	626	814	872	969	14.2%
Optoelectronic	132	149	164	176	196	213	223	8.4%
Millions of Pounds	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**CAGR 1997-2002**
Total Semiconductor	4,984	5,466	5,283	5,945	7,426	9,157	11,373	15.8%
Total Integrated Circuit	4,593	5,020	4,810	5,421	6,766	8,447	10,594	16.1%
Bipolar Digital	43	31	25	21	17	14	10	-20.3%
MOS Digital	4,157	4,542	4,290	4,837	6,068	7,651	9,741	16.5%
MOS Memory	1,625	1,439	1,104	1,160	1,642	2,434	3,662	20.5%
MOS Microcomponent	1,954	2,340	2,432	2,784	3,311	3,891	4,483	13.9%
MOS Logic	578	763	755	893	1,116	1,326	1,596	15.9%
Analog	393	448	495	564	682	783	844	13.5%
Discrete	285	344	365	409	532	570	633	13.0%
Optoelectronic	106	103	107	115	128	139	146	7.2%
Exchange Rate (Dollars to ECU)	**0.799**	**0.885**	**0.916**	**0.915**	**0.915**	**0.915**	**0.915**	
Exchange Rate (Dollars to Pounds)	**0.641**	**0.611**	**0.600**	**0.598**	**0.598**	**0.598**	**0.598**	

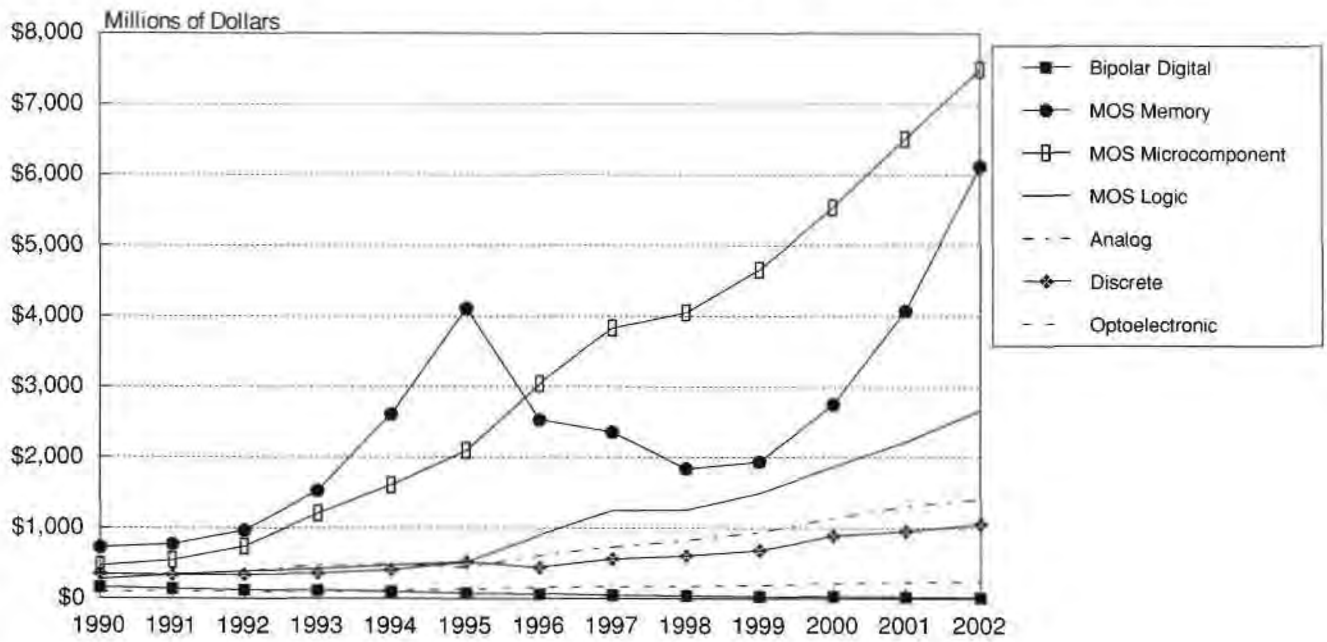
Source: Dataquest (August 1998 Estimates)

Table 24
Top 10 Semiconductor Vendors in the United Kingdom/Ireland Region, 1997

Rank 1997	Rank 1996	Rank Change	Companies	Revenue 1997 ($M)	Revenue 1996 ($M)	AGR (%)	Share 1997 (%)	Share 1996 (%)
1	1	0	Intel	2,386	1,997	19%	26.7%	25.7%
2	2	0	Samsung	592	463	28%	6.6%	6.0%
3	3	0	Motorola	560	433	29%	6.3%	5.6%
4	4	0	Texas Instruments	475	410	16%	5.3%	5.3%
5	5	0	Hitachi	324	320	1%	3.6%	4.1%
6	6	0	NEC	268	285	-6%	3.0%	3.7%
7	7	0	Siemens	245	256	-4%	2.7%	3.3%
8	8	0	Philips	244	255	-4%	2.7%	3.3%
9	10	1	Toshiba	213	228	-7%	2.4%	2.9%
10	13	3	National Semiconductor	211	170	24%	2.4%	2.2%
			Top 10 Subtotal	5,518	4,817	15%	61.6%	61.9%
			Others	3,435	2,961	16%	38.4%	38.1%
			Total	**8,953**	**7,778**	**15%**	**100.0%**	**100.0%**

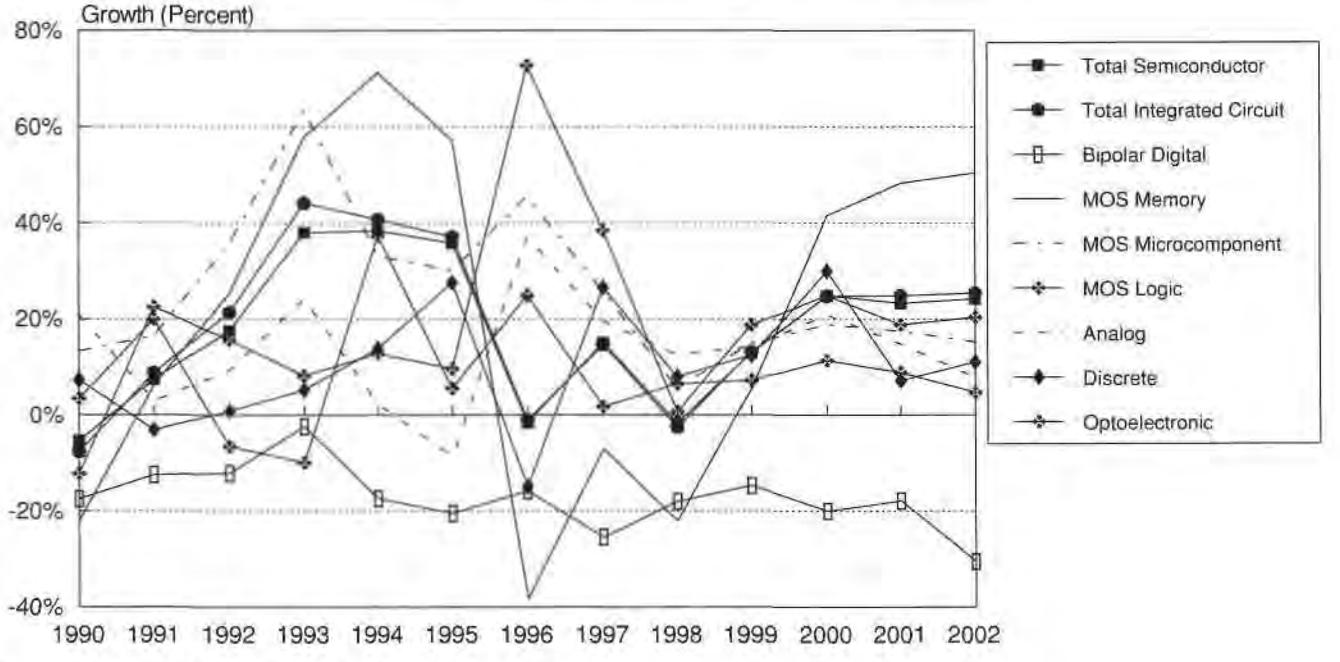
Source: Dataquest (August 1998 Estimates)

Figure 16
United Kingdom/Ireland Semiconductor Market by Revenue, 1990-2002



Source: Dataquest (August 1998 Estimates)

Figure 17
United Kingdom/Ireland Semiconductor Market by Growth, 1990-2002



Source: Dataquest (August 1998 Estimates)

Rest of EMEA

Note that the TAM estimates shown for the Central and Eastern Europe and Middle East and Africa regions are for true end-market consumption and are not the same as for the other regional markets. Dataquest estimates of market sizes are normally based on sales made by semiconductor vendors, that is, first-invoice sales. These include sales made to distributors and agents that then sell on to the true end users. In the case of markets such as the Czech Republic or South Africa, the industry chooses to consider their TAM based on surveying the true end users. So, the sales opportunity visible to semiconductor vendors in these new and emerging markets is somewhat smaller than the TAM we have shown in the tables pertaining to these regions.

Dataquest expects the regions encompassed within the Rest of EMEA to grow at a rate marginally below the industry average over the forecast period. Despite a high degree of interest, particularly in the developing economies of Eastern Europe, many of these countries are still very much immature markets, with much of the electronics equipment production utilizing subassemblies coming in from outside the region.

A CAGR of 15 percent is forecast for the region as a whole for the period 1997 to 2002. Detailed forecasts are shown in Tables 25 and 26 and Figures 18 and 19. Table 27 shows the market forecast regional breakdown detail within the Rest of EMEA region.

Table 25
Rest of EMEA Semiconductor Market History, 1990-1996

Millions of Dollars	1990	1991	1992	1993	1994	1995	1996	CAGR 1991-1996
Total Semiconductor	1,022	1,253	1,323	2,049	2,785	2,849	3,576	23.3%
Total Integrated Circuit	754	945	1,036	1,744	2,343	2,252	3,245	28.0%
Bipolar Digital	10	10	7	9	12	6	10	0.0%
MOS Digital	400	529	615	1,176	1,589	1,380	2,214	33.2%
MOS Memory	125	151	178	392	516	335	767	38.4%
MOS Microcomponent	121	162	205	496	702	601	1,037	45.0%
MOS Logic	154	216	232	288	371	444	410	13.7%
Analog	344	406	414	559	742	866	1,021	20.3%
Discrete	228	253	239	261	360	504	203	-4.3%
Optoelectronic	40	55	48	44	82	93	128	18.4%
Millions of ECU	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**CAGR 1991-1996**
Total Semiconductor	805	1,016	1,019	1,758	2,349	2,204	2,856	23.0%
Total Integrated Circuit	594	766	798	1,496	1,977	1,742	2,592	27.6%
Bipolar Digital	8	8	5	8	10	5	8	0.0%
MOS Digital	315	429	474	1,009	1,340	1,068	1,768	32.7%
MOS Memory	99	122	137	336	435	259	613	38.1%
MOS Microcomponent	95	131	158	426	592	465	828	44.6%
MOS Logic	121	175	179	247	313	343	327	13.3%
Analog	271	329	319	480	626	670	815	19.9%
Discrete	180	205	184	224	304	390	162	-4.6%
Optoelectronic	32	45	37	38	69	72	102	17.8%
Exchange Rate (Dollars to ECU)	**0.788**	**0.811**	**0.770**	**0.858**	**0.844**	**0.774**	**0.799**	

Source: Dataquest (August 1998 Estimates)

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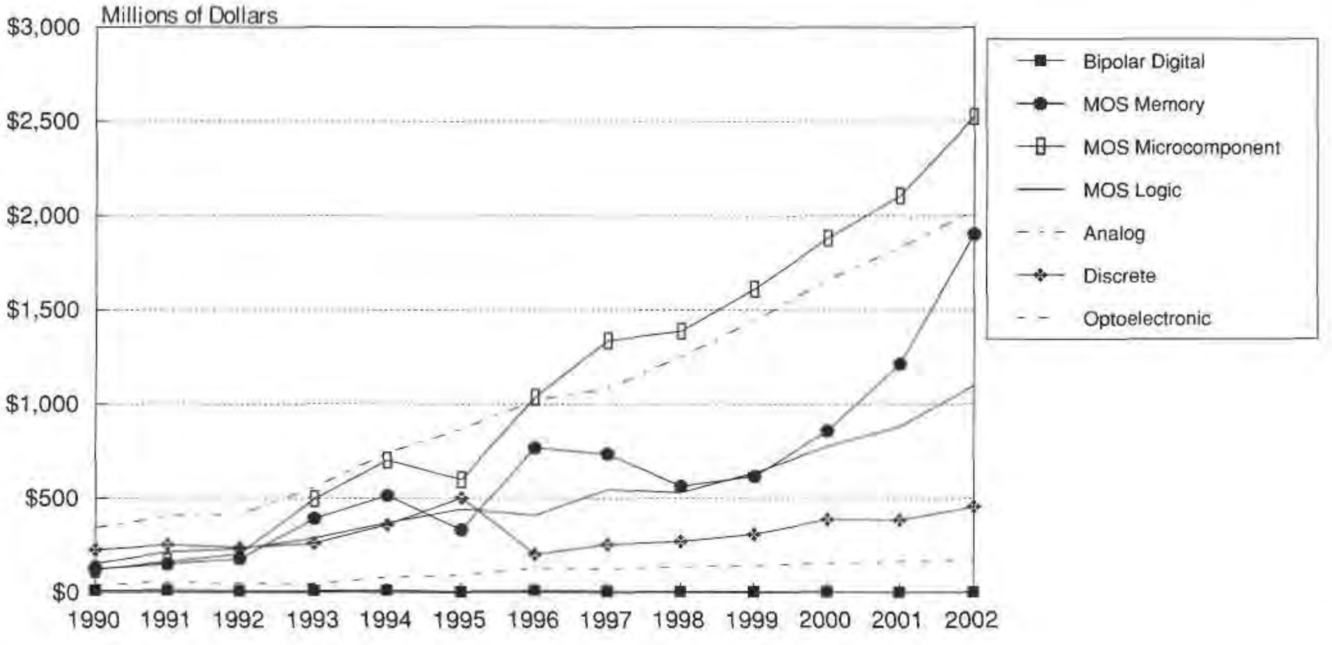
Table 26
Rest of EMEA Semiconductor Market Forecast, 1996-2002

Millions of Dollars	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Total Semiconductor	3,576	4,098	4,148	4,770	5,725	6,583	8,190	14.9%
Total Integrated Circuit	3,245	3,717	3,741	4,314	5,180	6,033	7,558	15.3%
Bipolar Digital	10	8	6	5	4	3	2	-24.2%
MOS Digital	2,214	2,623	2,483	2,864	3,515	4,198	5,526	16.1%
MOS Memory	767	737	565	617	858	1,213	1,902	20.9%
MOS Microcomponent	1,037	1,338	1,388	1,611	1,881	2,106	2,524	13.5%
MOS Logic	410	548	530	636	776	879	1,100	15.0%
Analog	1,021	1,086	1,252	1,445	1,661	1,832	2,030	13.3%
Discrete	203	256	272	311	389	386	456	12.2%
Optoelectronic	128	125	135	145	156	164	176	7.1%
Millions of ECU	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**CAGR 1997-2002**
Total Semiconductor	2,856	3,628	3,801	4,366	5,240	6,025	7,495	15.6%
Total Integrated Circuit	2,592	3,291	3,428	3,948	4,741	5,521	6,917	16.0%
Bipolar Digital	8	7	5	5	4	3	2	-22.2%
MOS Digital	1,768	2,322	2,275	2,621	3,217	3,842	5,057	16.8%
MOS Memory	613	652	518	565	785	1,110	1,741	21.7%
MOS Microcomponent	828	1,185	1,272	1,474	1,721	1,927	2,310	14.3%
MOS Logic	327	485	486	582	710	804	1,007	15.7%
Analog	815	961	1,147	1,322	1,520	1,677	1,858	14.1%
Discrete	162	227	249	285	356	353	417	12.9%
Optoelectronic	102	111	124	133	143	150	161	7.7%
Exchange Rate (Dollars to ECU)	**0.799**	**0.885**	**0.916**	**0.915**	**0.915**	**0.915**	**0.915**	

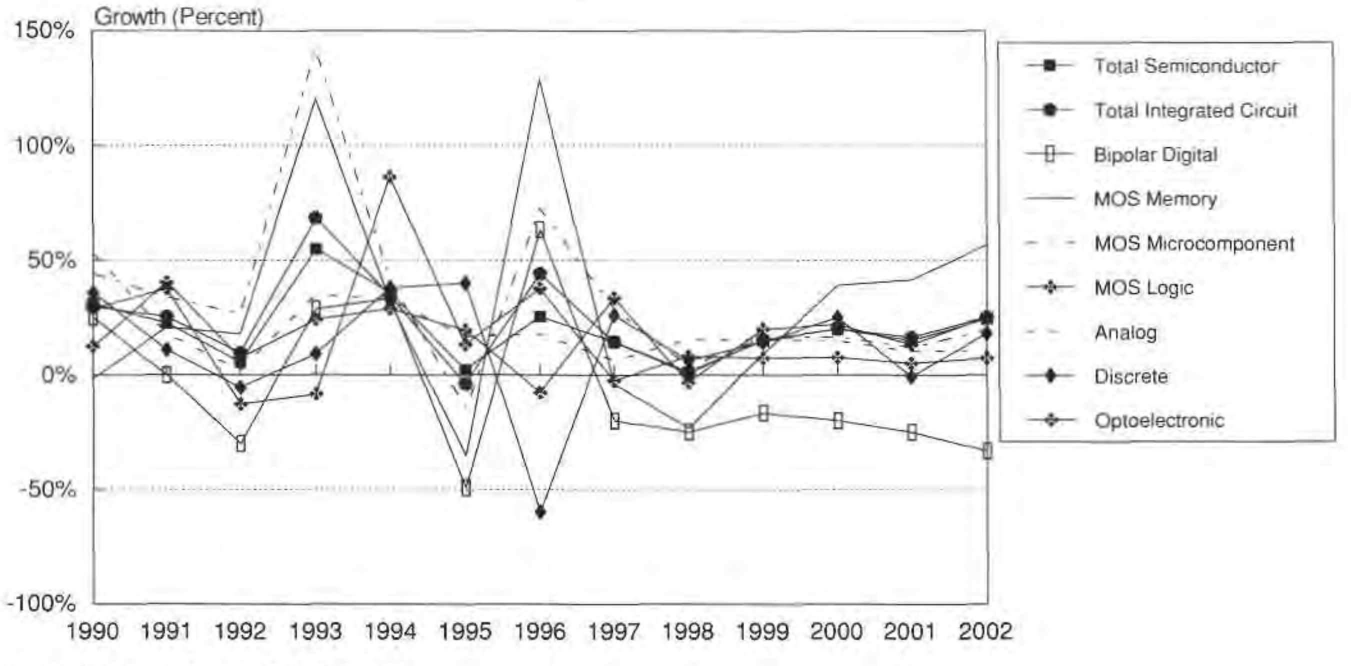
Source: Dataquest (August 1998 Estimates)

Figure 18
Rest of EMEA Semiconductor Market by Revenue, 1990-2002



Source: Dataquest (August 1998 Estimates)

Figure 19
Rest of EMEA Semiconductor Market by Growth, 1990-2002



Source: Dataquest (August 1998 Estimates)

Table 27
Rest of EMEA Semiconductor Market Forecast Detail, 1995-2002

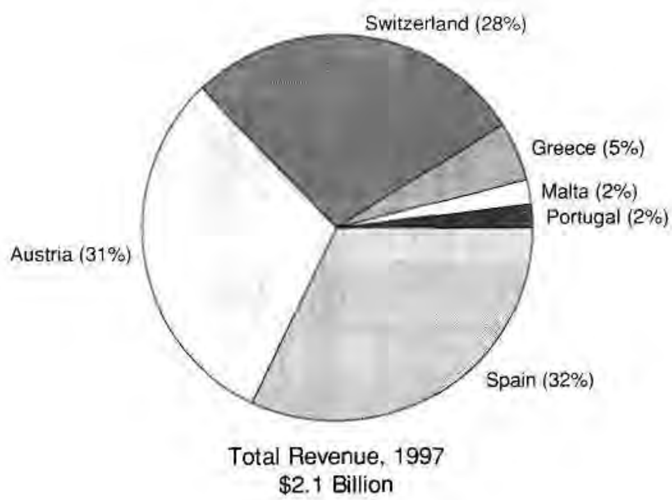
Millions of Dollars	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Rest of EMEA	2,849	3,579	4,100	4,150	5,023	6,034	7,181	8,460	15.6%
Rest of Western Europe	1,670	1,865	2,123	2,128	2,665	3,218	3,830	4,320	15.3%
Central and Eastern Europe	320	724	711	683	785	976	1,200	1,400	14.5%
Middle East and Africa	859	990	1,266	1,339	1,573	1,840	2,151	2,740	16.7%
Millions of ECU	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**CAGR 1997-2002**
Rest of EMEA	2,205	2,860	3,649	3,812	4,614	5,543	6,596	7,772	16.3%
Rest of Western Europe	1,293	1,490	1,889	1,955	2,448	2,956	3,518	3,969	16.0%
Central and Eastern Europe	248	578	633	627	721	896	1,102	1,286	15.2%
Middle East and Africa	665	791	1,127	1,230	1,445	1,690	1,976	2,517	17.4%
Exchange Rate (Dollars to ECU)	**0.77**	**0.80**	**0.89**	**0.92**	**0.92**	**0.92**	**0.92**	**0.92**	

Source: Dataquest (August 1998 Estimates)

Rest of Western Europe

Within the Rest of Western Europe region there are three major countries—Austria, Spain and Switzerland—each accounting for about 30 percent of the Rest of Western Europe TAM. The remaining 10 percent or so is split between Greece, Portugal and Malta. In a definition change, Turkey is now included in the Middle East and Africa region, and the market size numbers have been retrospectively adjusted to take account of this change. A breakdown of the Rest of Western Europe TAM in 1997 is shown in Figure 20. A semiconductor market CAGR of about 15 percent is forecast for the region as a whole in the period 1997 to 2002.

Figure 20
Rest of Western Europe Total Available Market Shares, 1997

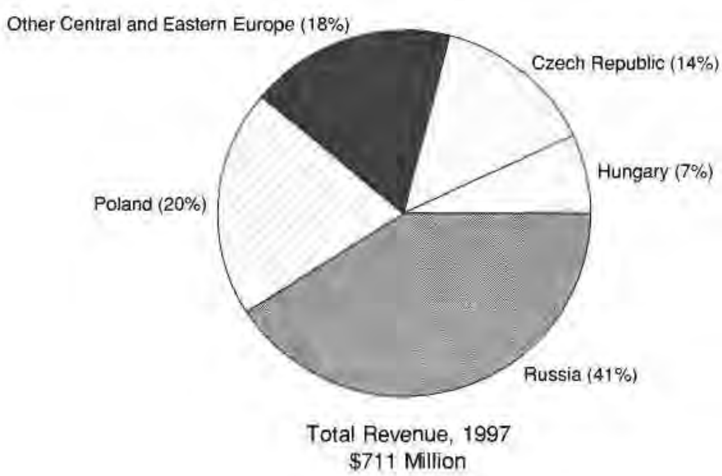


Source: Dataquest (August 1998 Estimates)

Central and Eastern Europe

A breakdown of the Central and Eastern Europe TAM in 1997 is shown in Figure 21. Of the three most developed economies in the region, namely the Czech Republic, Hungary and Poland, it is the Czech Republic that is attracting most interest from the semiconductor vendor community because of a recent increase in electronics equipment manufacturing activity. The Russian market, although full of promise for the future, has scared many semiconductor vendors away for the time being because of the unstable political situation. A semiconductor market CAGR of 14.5 percent is forecast for the region as a whole in the period 1997 to 2002.

Figure 21
Central and Eastern Europe Total Available Market Shares, 1997



Source: Dataquest (August 1998 Estimates)

Middle East and Africa

A breakdown of the Middle East and Africa region TAM in 1997 is shown in Figure 22. There are three countries within the region with measurable semiconductor markets. Israel is the largest of the three, and South Africa the smallest. In both cases, market growth has slowed because of a lack of new electronics production. The booming market in the region is Turkey, which is now included in the Middle East and Africa region rather than in the Rest of Western Europe region. Here production of consumer goods, especially televisions, has taken off in parallel with increased CEM activity in the country. An above-average semiconductor market CAGR of almost 17 percent is forecast for the region as a whole in the period 1997 to 2002.

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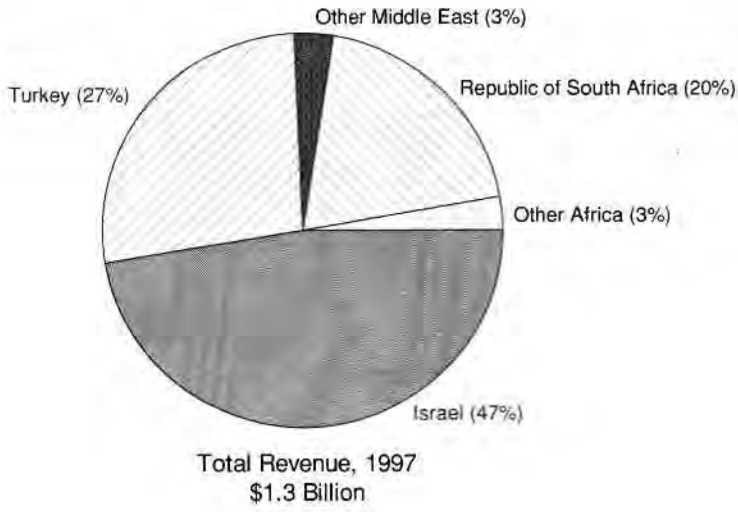
Figure 22
Middle East and Africa Total Available Market Shares, 1997



Source: Dataquest (August 1998 Estimates)

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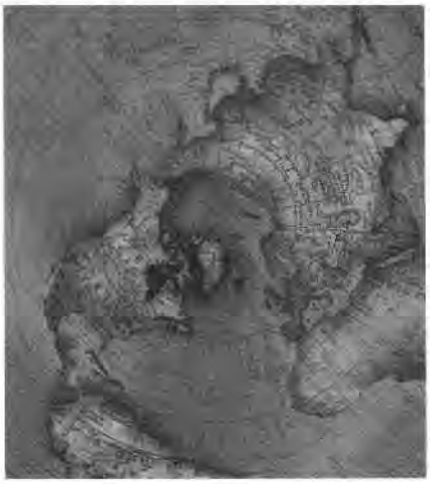

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European Semiconductor Procurement Survey, 1998-1999

User Wants and Needs

1998

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European Semiconductor Procurement Survey, 1998-1999

User Wants and Needs

1998

Program: Semiconductors Europe
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Chapter 1
Executive Summary

Overview of Results and Key Findings

One of the most valuable insights provided by market research is that of determining customer requirements and the short-term expectations of customers. Attention paid to this information benefits both vendor and customer alike. The Dataquest European semiconductor procurement survey seeks semiconductor buyer positions and requirements, then analyzes this information to allow appropriate actions to be taken. This year, the electronic data processing (EDP) segment regained its lead as the largest purchaser of semiconductors in Europe. The use of distributors rose, together with the average number of vendors used by buyers. Unusually, inventory fell over 1997; pricing again heads the list of major issues facing buyers. However, these overall findings mask the significantly different perspectives in individual segments, reflecting the varying dynamics of each segment. The key findings are summarized as follows:

- The companies surveyed provided insight into their semiconductor purchasing needs, trends and favored suppliers. The survey sample was chosen to represent the views of the market in each segment of interest. The semiconductor spend of the 93 companies that responded was 42 percent of the entire European semiconductor market estimated spend for 1998.
- The companies estimate their spend for 1998 at $13.5 billion. This will rise to $16.5 billion in 1999.
- Unsurprisingly, the EDP segment regained the lead in the purchasing league, with $5.3 billion spent by the survey respondents in 1998. EDP respondents forecast that their semiconductor spend would increase by 32 percent in the next 12 months.
- The EDP and communications segments dominate European semiconductor procurement, together taking three-quarters of the total spend. Automotive was the third-largest group, responsible for $1.3 billion in 1998, followed by industrial at $1.2 billion. The consumer segment reported a spend of $793 million, while the military and civil aerospace segment reported $107 million.
- The five most important purchasing criteria of 1998 are the same as those of 1997, with pricing remaining the most important issue. Despite the fact that semiconductor pricing has been very attractive in 1998, buyers are facing pressure as price competition in their end markets forces them to maintain margins by reducing manufacturing costs.
- On-time delivery remains the second most important issue to survey respondents, only marginally behind pricing. This is because companies are demanding that suppliers become an integrated part of the manufacturing process—a fact that is further illustrated by the significant increase in importance of just-in-time (JIT) delivery in 1998 over 1997.
- Flexibility, lead times and availability were third, fourth and fifth in importance respectively. Again, these issues are indicative of buyers' desires to secure their supply lines and integrate delivery into the manufacturing process.
- Technical support and design-in issues were rated much higher than last year, indicating a strong demand for more support from suppliers.
- Inventory levels have fallen in 1998. The average target inventory in 1998 is 20.5 days—a decrease of 23 percent over 1997.
- Distributors accounted for $821 million of respondents' semiconductor spend. This figure amounts to 7.6 percent of the total spend.

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- Surprisingly, the trend of decreasing the number of suppliers with which respondents do business has been reversed this year. The average number rose to levels similar to those in 1996. The average number of suppliers of all components that equipment manufacturers do business with was 73—an increase of 47 percent over 1997.
- The most common factors that cause a semiconductor supplier to lose business with the end-equipment producer are: pricing, followed by quality and delivery problems.
- The Dataquest vendor of the year awards for outstanding performances in serving customers in Europe were made to the following companies:
  - European overall vendor of the year: Texas Instruments
  - European vendor of the year for responsiveness and flexibility: Philips
  - European vendor of the year for technical support: Siemens Semiconductor
  - European medium-sized vendor of the year (European sales of less than $600 million): Fairchild Semiconductor
  - European niche vendor of the year (European sales of less than $50 million): Sharp
  - European distributor of the year: Arrow

Project Analysts: Jim Tully and Edmund Gemmell

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Chapter 2
Methodology, Demographic Overview and Significance of Results

This report summarizes the results of the 1998 European procurement survey conducted by Dataquest's European Semiconductor group from March to May 1998. This section of the report describes the methodology and survey demographics and discusses the significance of the results.

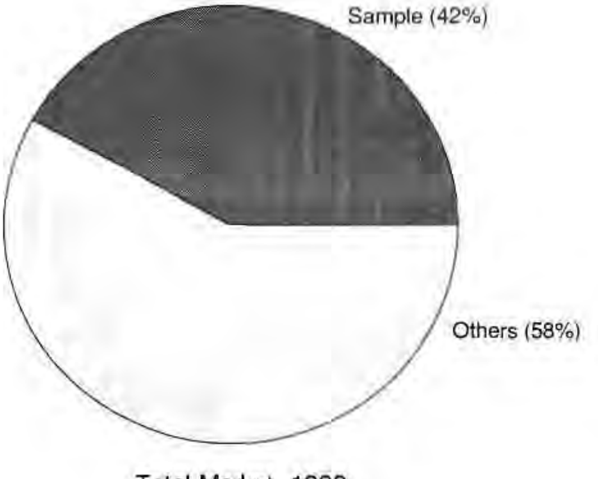
This year, 93 companies took part in the survey, providing insight into their purchasing needs, trends and favored semiconductor suppliers. The survey sample was chosen to represent the views of the market in each of the segments of interest. Of this year's surveyed buyers, the semiconductor spends totaled 42 percent of the expected market of $35.6 billion in Europe, as shown in Figure 2-1. Because of this, the actions and opinions of this sample of companies closely mirror the overall market and are a sound basis on which to make decisions.

Figure 2-2 shows the dollar values of purchases made by each segment for 1997 to 1999. Forecast growth in spending by segment is shown in Figure 2-3. Growth rates for 1998 vary considerably, with 1999 having a higher growth outlook across all segments.

This year, EDP has overtaken the communications segment to head the purchasing responses, with $5.3 billion projected to be spent in 1998—in spite of flat or falling DRAM prices. This figure is 39 percent of total respondents' semiconductor spend. EDP respondents forecast that the segment's semiconductor spend will increase by one third in 1999, bringing it to slightly more than $7 billion worth of purchases.

Along with EDP, the communications segment contributed greatly to respondents' semiconductor spend. This segment was responsible for 35 percent of semiconductor spend or $4.8 billion, although growth this year is a relatively flat 1.6 percent. EDP and communications dominated the responses, jointly accounting for three-quarters of the overall semiconductor spend.

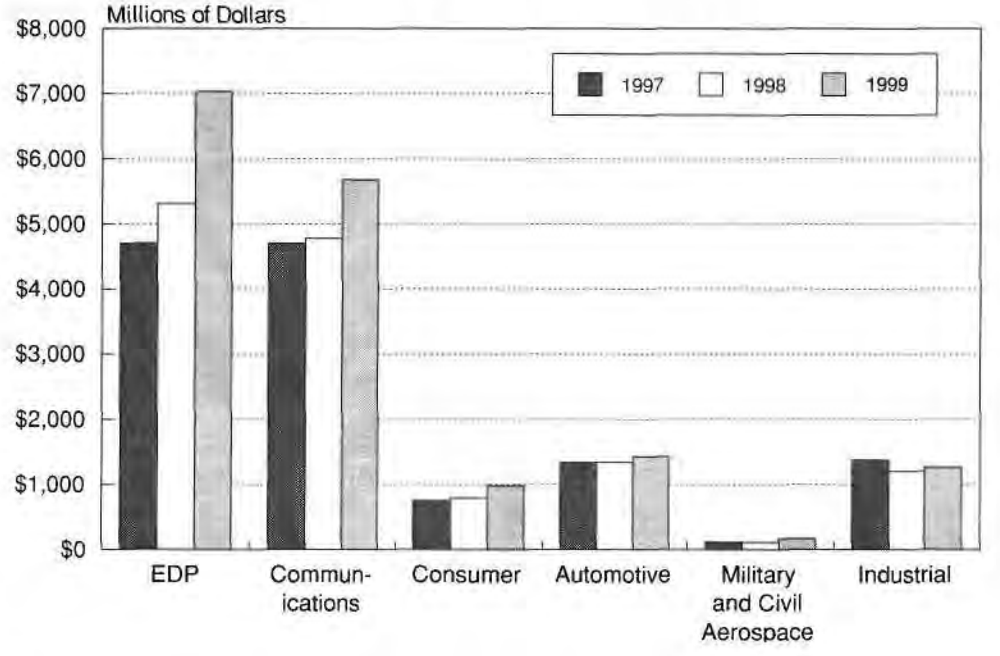
Figure 2-1
European Semiconductor Purchasing Trends
Total Procurement Sample Size, 1998



Total Market, 1998
$35.6 Billion

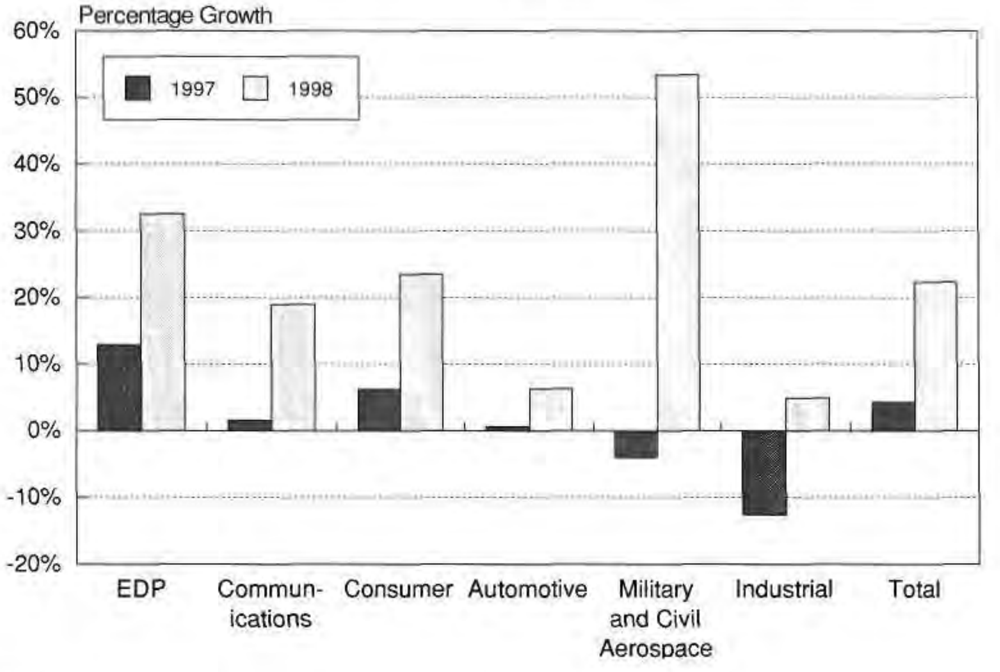
Source: Dataquest (July 1998 Estimates)

Figure 2-2
European Semiconductor Purchasing Trends
Total Semiconductor Spend by Segment, 1997-1999



n = 93
Source: Dataquest (July 1998 Estimates)

Figure 2-3
European Semiconductor Purchasing Trends
Growth in Semiconductor Spend by Segment, 1997-1999



n = 93
Source: Dataquest (July 1998 Estimates)

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The automotive segment accounted for $1.3 billion with virtually no growth projected for 1998, while the consumer segment accounted for little more than half of this figure at $790 million.

The industrial segment showed the most disappointing performance of all the segments in 1998 with a fall of 12.6 percent to $1.2 billion, accounting for 8.9 percent of respondents' semiconductor spend. Military and civil aerospace also declined in reported spending in 1998 to $107 million or just 0.8 percent of respondents' semiconductor spend.

This pattern of purchases is different from the actual market distribution. Yet, these responses of spending outlook reveal more than market forecast figures. These are the *perceptions* of the respondents, based on knowledge of their own production requirements, and on their goals and expectations in terms of device prices. This means they will be second-guessing price changes in the market. In EDP a sharp increase is expected next year, presumably in anticipation of sharp rises in DRAM prices at that time. Smart cards are another major factor in the EDP segment, generating strong growth in 1998 and 1999.

In the communications segment, mobile telephony is now a significant part of the European end-equipment market and digital cellular accounts for most of the growth. Digital enhanced cordless telephony (DECT) and computer networking applications are also significant semiconductor sectors. However, in spite of the increase in production volume, price erosion has been severe and is shaping the perceptions and responses of the survey participants.

The industrial segment is powered by some large companies in Europe, and is linked to the macroeconomic conditions in the main industrialized countries of Europe. As such, growth next year (1998 to 1999) is forecast to be higher as Germany and France emerge from their relative downturns.

As digital devices creep further into consumer electronics, there are certain to be higher semiconductor purchases in the consumer segment, although this may happen beyond the scope of this report. Nevertheless, consumer companies are forecasting growth rates of about 23 percent in 1999. Digital set-top boxes are a major factor in the consumer segment; this equipment will have some impact in 1998 but the effect will be felt most strongly in 1999.

Another notable segment is military and civil aerospace. Defense budgets continue to be attractive targets for spending cuts, but as the Eurofighter 2000 program moves into full production defense electronics will rise as a percentage of the total. This, together with increased spending on military communications, helps to explain the 53 percent anticipated growth in 1999.

In the automotive segment we draw two conclusions:

- That automotive companies have prices on their minds this year, so vendors should expect some tough negotiations.
- Much of the sharp growth next year comes from car entertainment companies rather than engine control, safety or other applications. This can mean only one thing: they expect strong growth in DAB. This is a similar pattern to last year's survey, suggesting that the rise in DAB expected by the industry is delayed by one year.

Chapter 3
Procurement and Inventory Trends and Issues

This chapter considers procurement and inventory trends and issues. Where possible, the 1998 results for purchasing issues have been compared with last year's to check for changes and trends.

Procurement Issues

Each company that returned a survey was allocated to one or more end applications, then weighted to produce the results.

Each respondent was asked to rate the importance of 24 different purchasing criteria (Table 3-1). Each criterion was marked out of 10, with 1 being the least important issue and 10 the most important.

The overall survey results can be seen in Table 3-2. In Tables 3-3 to 3-8, data is analyzed by application segment. These statistics are shown graphically in Figures 3-1 to 3-7. Last year's results are included in the tables and figures to allow comparisons to be made.

Table 3-1
European Semiconductor Purchasing Trends
Semiconductor Procurement Issues, 1998

Availability of products	On-time delivery
Design-in issues	Pricing
EDI	Quality/reliability
Environmental issues	Reducing vendor base
Flexibility of vendor	Responsiveness of vendor
Fluctuating currency exchange	Second sourcing
Forecasting internal demand	Speed of bringing new products to market
IC packaging	Supplier certification/accreditation status (for example, ISO 9000)
Inventory control (for example, JIT)	Technical support
Lead times	Total cost of ownership
Long-term agreements/partnerships	Vendor local manufacturing capabilities
Obsolescence risks	

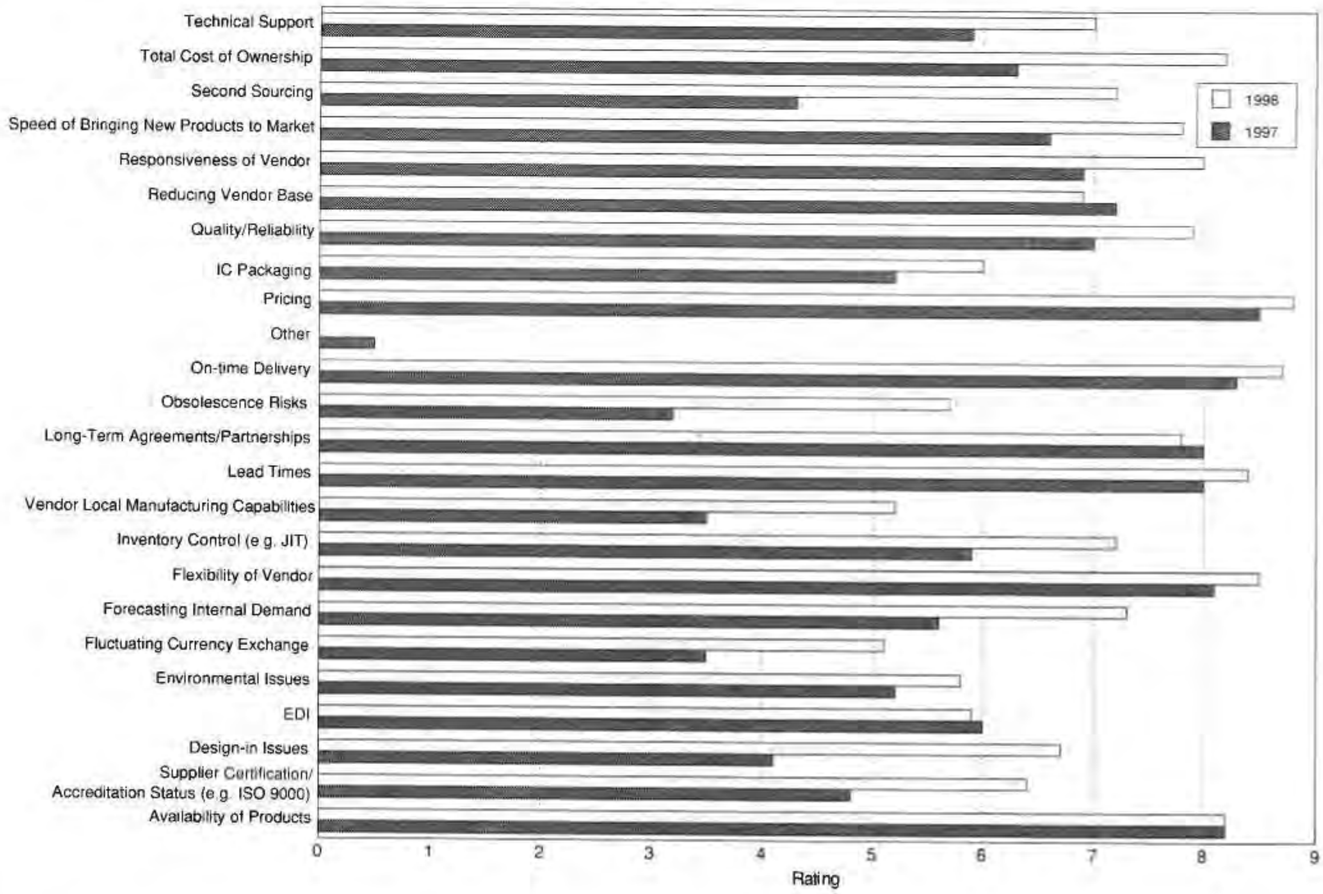
Source: Dataquest (July 1998)

Table 3-2
European Semiconductor Purchasing Trends
Semiconductor Procurement Issues
Total Survey Results, 1997 and 1998

Rank	1998	Rating	1997	Rating
1	Pricing	8.8	Pricing	8.5
2	On-time delivery	8.7	On-time delivery	8.3
3	Flexibility of vendor	8.5	Availability of products	8.2
4	Lead times	8.4	Flexibility of vendor	8.1
5	Availability of products	8.2	Lead times	8.0

n = 93
Source: Dataquest (July 1998)

Figure 3-1
European Semiconductor Purchasing Trends
Semiconductor Procurement Issues
Total Survey Results, 1997 and 1998



n = 93
Source: Dataquest (July 1998)

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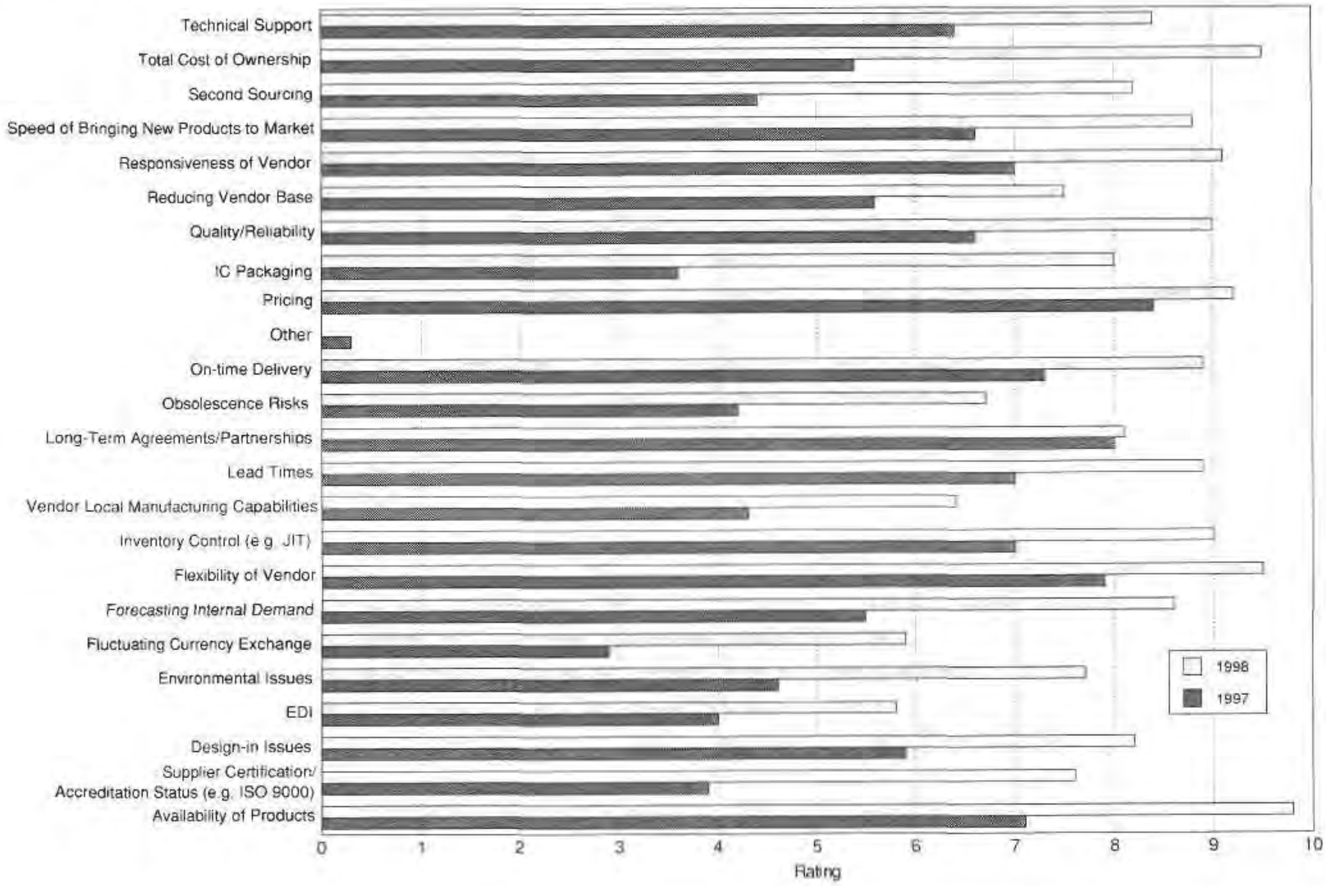
Table 3-3
European Semiconductor Purchasing Trends
Semiconductor Procurement Issues
EDP Segment Survey Results, 1997 and 1998

Rank	1998	Rating	1997	Rating
1	Availability of products	9.8	Pricing	8.4
2	Flexibility of vendor	9.5	Long-term agreements	8.0
3	Total cost of ownership	9.5	Flexibility of vendor	7.9
4	Pricing	9.2	On-time delivery	7.3
5	Responsiveness of vendor	9.1	Availability of products	7.1

Source: Dataquest (July 1998)

Figure 3-2
European Semiconductor Purchasing Trends
Semiconductor Procurement Issues
EDP Segment Survey Results, 1997 and 1998



Source: Dataquest (July 1998)

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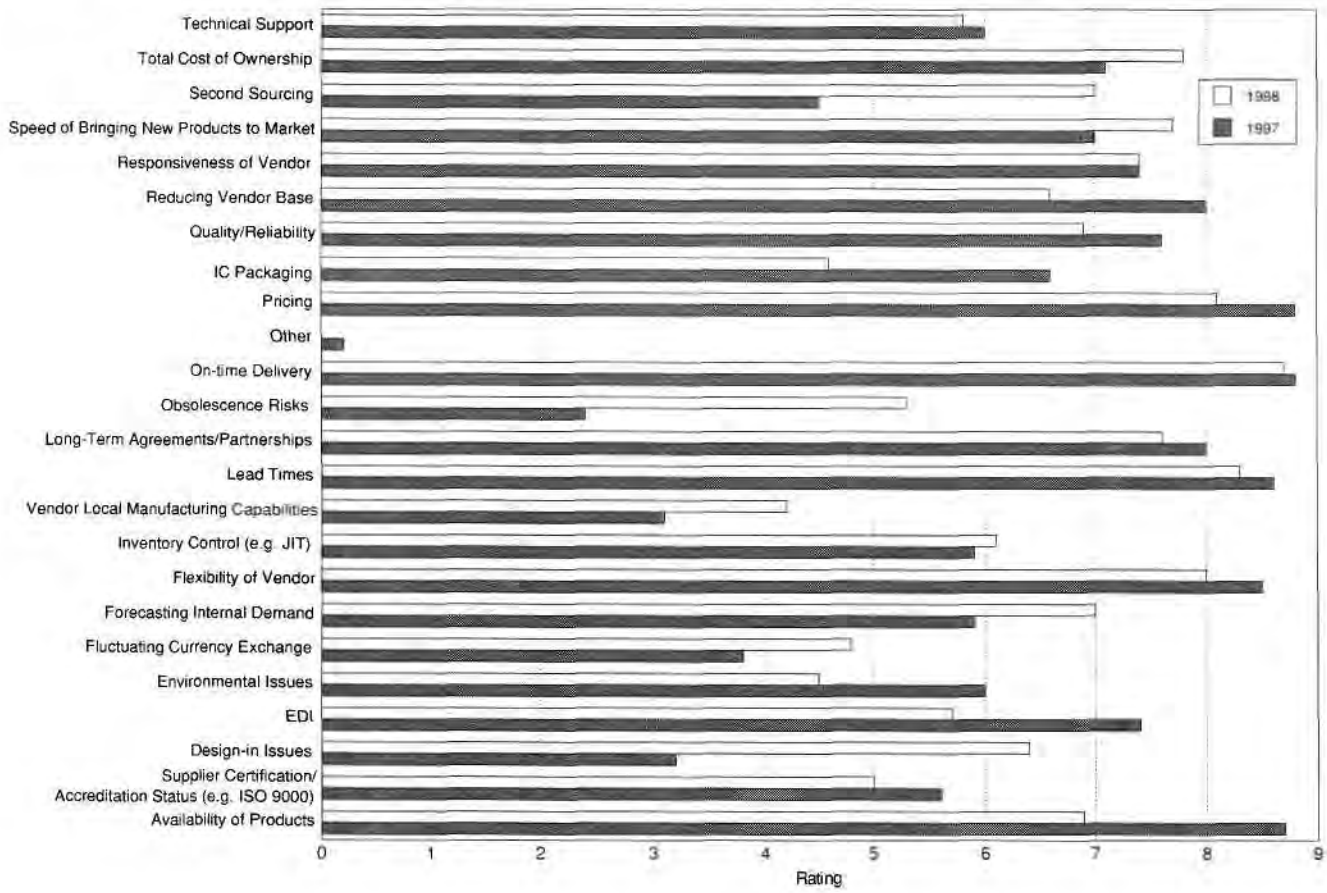
Table 3-4
European Semiconductor Purchasing Trends
Semiconductor Procurement Issues
Communications Segment Survey Results, 1997 and 1998

Rank	1998	Rating	1997	Rating
1	On-time delivery	8.7	On-time delivery	8.8
2	Lead times	8.3	Pricing	8.8
3	Pricing	8.1	Availability of products	8.7
4	Flexibility of vendor	8.0	Lead times	8.6
5	Total cost of ownership	7.8	Flexibility of vendor	8.5

Source: Dataquest (July 1998)

Figure 3-3
European Semiconductor Purchasing Trends
Semiconductor Procurement Issues
Communications Segment Survey Results, 1997 and 1998



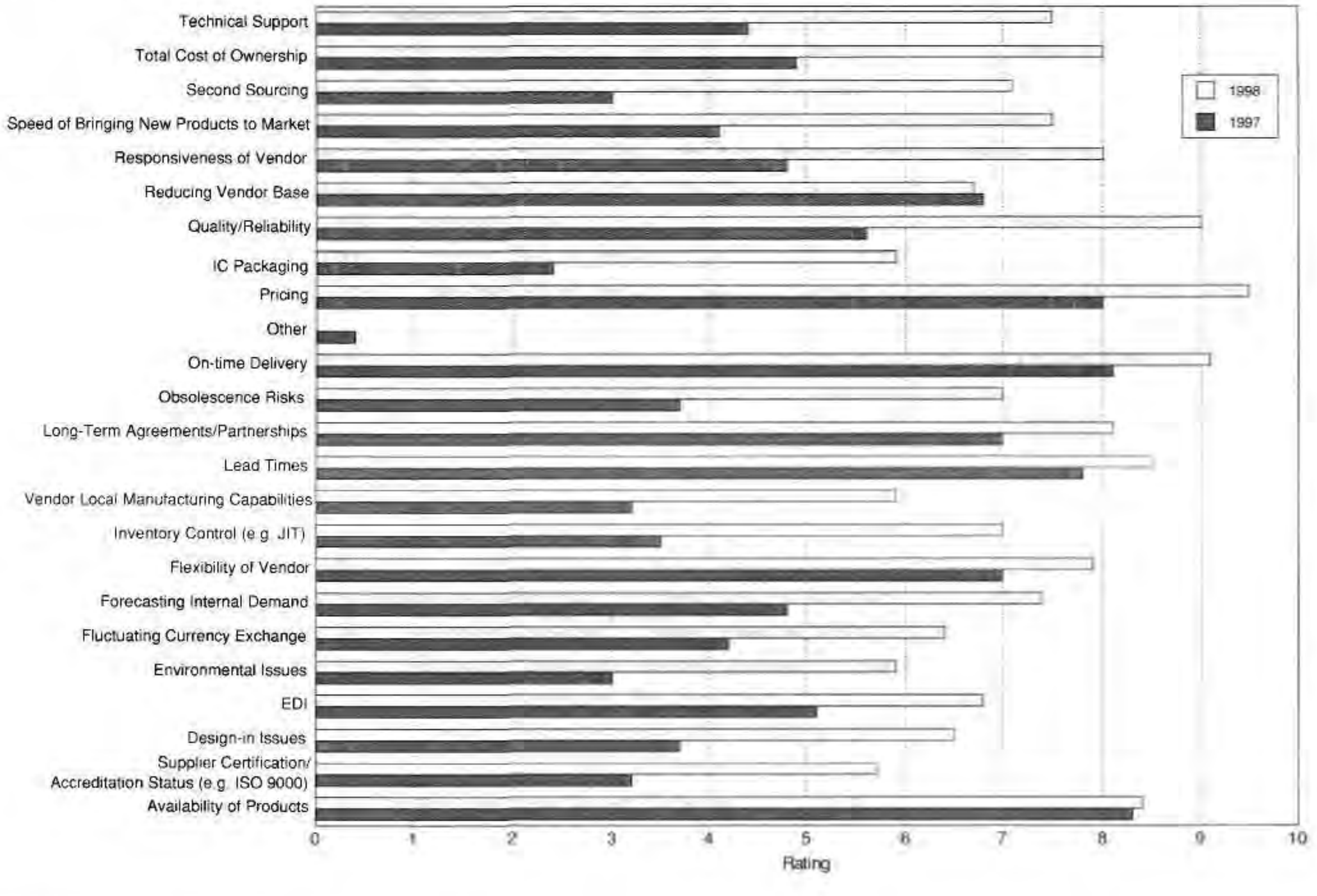
Source: Dataquest (July 1998)

Table 3-5
European Semiconductor Purchasing Trends
Semiconductor Procurement Issues
Consumer Segment Survey Results, 1997 and 1998

Rank	1998	Rating	1997	Rating
1	Pricing	9.5	Availability of products	8.3
2	On-time delivery	9.1	On-time delivery	8.1
3	Quality/reliability	9.0	Pricing	8.0
4	Lead times	8.5	Lead times	7.8
5	Availability of products	8.4	Flexibility of vendor	7.0

Source: Dataquest (July 1998)

Figure 3-4
European Semiconductor Purchasing Trends
Semiconductor Procurement Issues
Consumer Segment Survey Results, 1997 and 1998



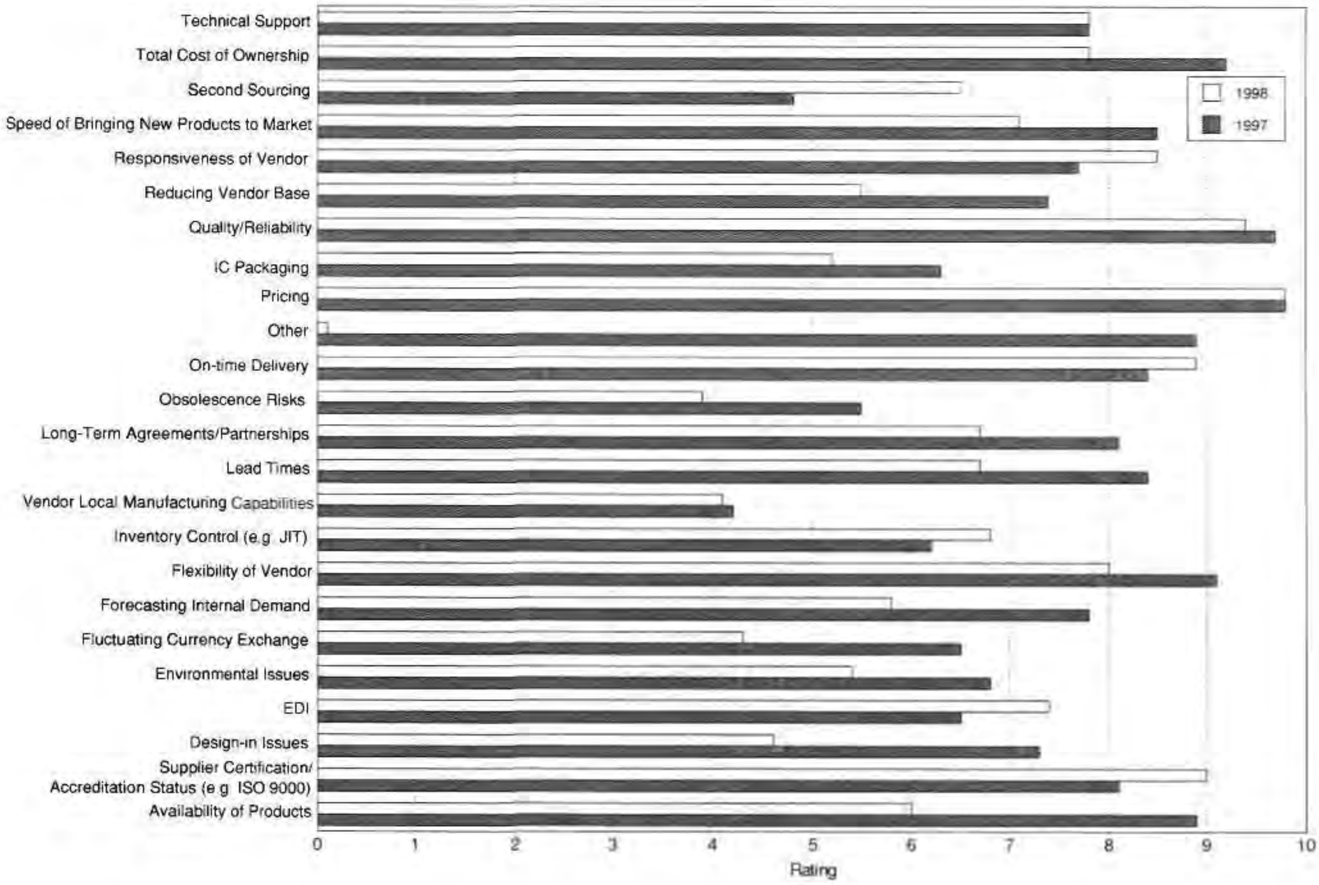
Source: Dataquest (July 1998)

Table 3-6
European Semiconductor Purchasing Trends
Semiconductor Procurement Issues
Automotive Segment Survey Results, 1997 and 1998

Rank	1998	Rating	1997	Rating
1	Pricing	9.8	Pricing	9.8
2	Quality/reliability	9.4	Quality/reliability	9.7
3	Supplier certification/accreditation status	9.0	Total cost of ownership	9.2
4	On-time delivery	8.9	Flexibility of vendor	9.1
5	Responsiveness of vendor	8.5	Availability of products	8.9

Source: Dataquest (July 1998)

Figure 3-5
European Semiconductor Purchasing Trends
Semiconductor Procurement Issues
Automotive Segment Survey Results, 1997 and 1998



Source: Dataquest (July 1998)

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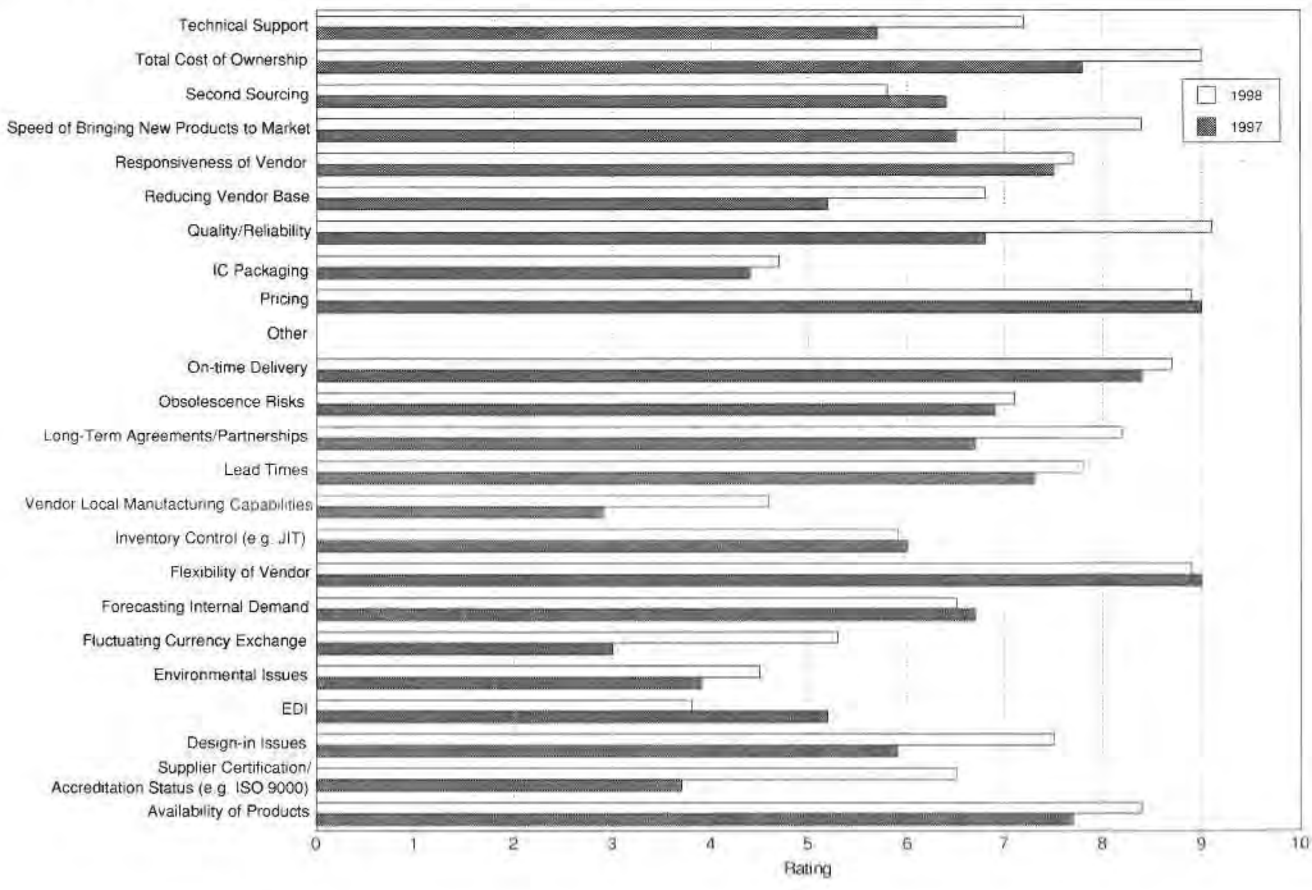
Table 3-7
European Semiconductor Purchasing Trends
Semiconductor Procurement Issues
Military and Civil Aerospace Segment Survey Results, 1997 and 1998

Rank	1998	Rating	1997	Rating
1	Quality/reliability	9.1	Pricing	9.0
2	Total cost of ownership	9.0	Flexibility of vendor	9.0
3	Flexibility of vendor	8.9	On-time delivery	8.4
4	Pricing	8.9	Total cost of ownership	7.8
5	On-time delivery	8.7	Availability of products	7.7

Source: Dataquest (July 1998)

Figure 3-6
European Semiconductor Purchasing Trends
Semiconductor Procurement Issues
Military and Civil Aerospace Segment Survey Results, 1997 and 1998



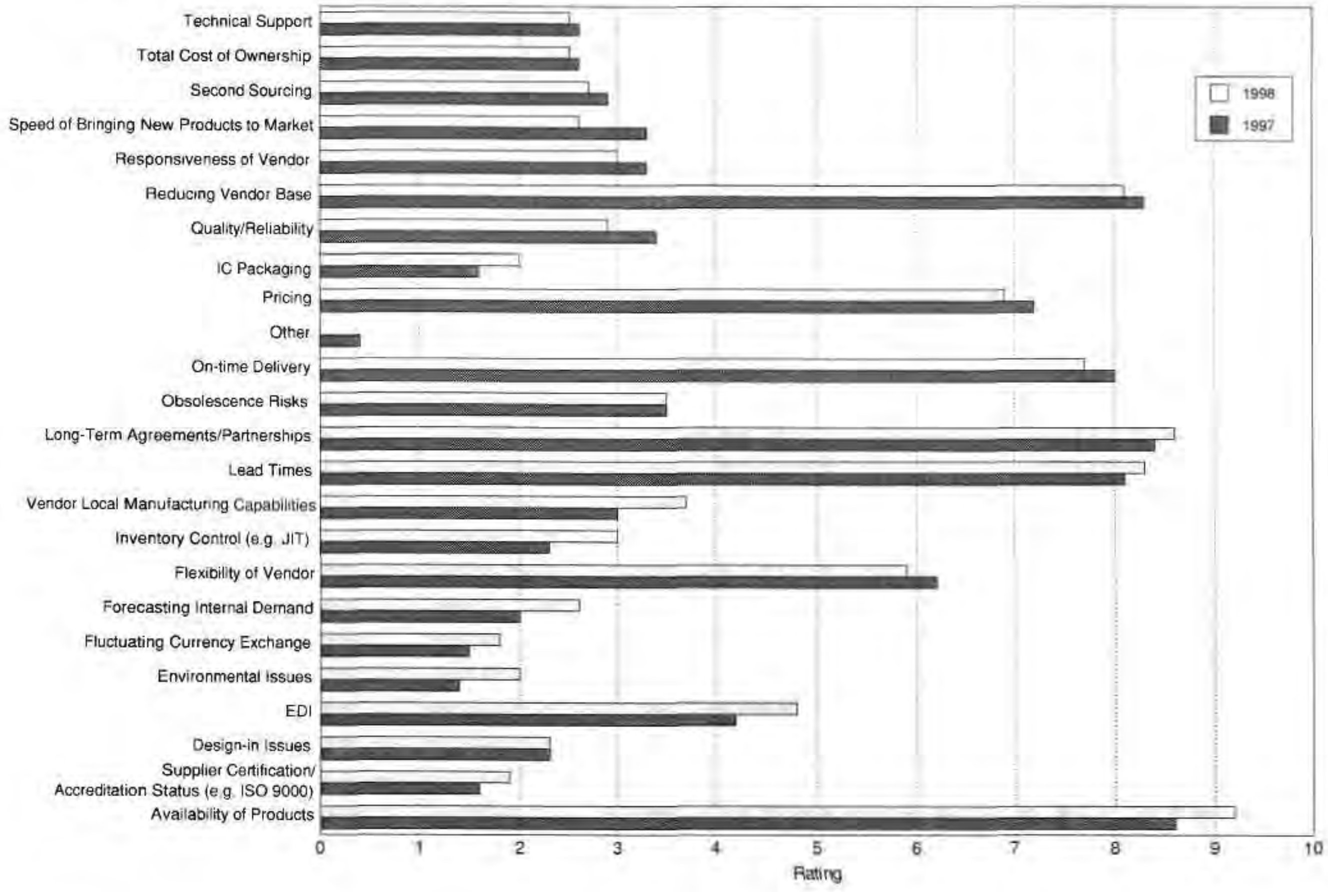
Source: Dataquest (July 1998)

Table 3-8
European Semiconductor Purchasing Trends
Semiconductor Procurement Issues
Industrial Segment Survey Results, 1997 and 1998

Rank	1998	Rating	1997	Rating
1	Availability of products	9.2	Availability of products	8.6
2	Long-term agreements	8.6	Long-term agreements	8.4
3	Lead times	8.3	Reducing vendor base	8.3
4	Reducing vendor base	8.1	Lead times	8.1
5	On-time delivery	7.7	On-time delivery	8.0

Source: Dataquest (July 1998)

Figure 3-7
European Semiconductor Purchasing Trends
Semiconductor Procurement Issues
Industrial Segment Survey Results, 1997 and 1998



Source: Dataquest (July 1998)

The ratings given by respondents do not measure the absolute importance of each criterion. Rather they indicate those issues that occupied a greater share of mind at the time of each survey. The responses can therefore provide valuable insight into current issues from a buyer's perspective. Pricing, unsurprisingly, has remained the number-one criterion for buyers. With continued price erosion over the past year, buyers are used to the concept of a deflationary marketplace and are looking for opportunities to drive prices as low as possible.

Overall, the top five purchasing criteria have remained the same as in last year's report. On-time delivery has remained the second most important criterion, with availability of products moving down to fifth from third most important and flexibility of vendors and lead times moving up one place each.

The continued importance of on-time delivery confirms last year's observation that vendors are being increasingly integrated into the manufacturing process, and that manufacturers are expanding their expectations of vendors (while expecting continually lower pricing). In this year's survey these growing expectations are borne out by several other criteria responses. Inventory control methods (such as JIT) increased its importance rating to 7.2, an increase of 22 percent over the result in 1997. Total cost of ownership also became significantly more important to buyers, increasing to 8.2 on the buyers' importance scale.

Responsiveness of vendor and design-in issues also increased their importance significantly, suggesting that buyers are becoming much more strategic in their approach to sourcing manufacturing inputs and are expecting more added value from suppliers. Contrary to this, EDI is marginally less important this year when compared to last year's response. Lead times also remained very important to buyers this year—a strange response considering that for most products lead times generally are not an issue, although as manufacturers require more specialized components the situation is starting to change.

Segment Issues

In the EDP segment, all criteria except "other" increased their importance rating significantly. This may indicate that purchasing managers within the EDP segment are coming under more pressure from their organizations to provide a better or wider service.

Availability was the most important issue for EDP buyers, up from number five in 1997. Given the current DRAM market environment, this seems to be an unusual result; however, with noncontract pricing falling below contract pricing, it could be indicative of buyers having to take a more active role in sourcing DRAM and other components to ensure that they get the best possible price consistently. In addition, it could reflect buyer discomfort at relying on a sole vendor for key microprocessor purchasing. It could also be explained by the increasing use of PC technology in dedicated systems such as point-of-sale terminals and ATM machines. There is a life cycle incompatibility issue here that concerns a lot of people. Devices are being rendered obsolete too soon for some of these non-PC EDP applications which have a longer life cycle than PCs.

Other factors within the EDP segment are consistent with the key overall trends. Namely, integrating suppliers into the manufacturing process to reduce manufacturing costs as much as possible in order both to offset the ASP squeeze being felt throughout the PC market and to further ensure the supply chain is free of uncertainty.

In the communications segment, on-time delivery and lead times are given the highest weightings in the list. Pricing and flexibility of vendor are third and fourth in importance respectively, while total cost of ownership moved up to number five at the expense of availability of products.

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The overriding importance placed on on-time delivery and lead times is likely to be a reaction to the changing customer base of the market. Before liberalization, PTTs were the dominant customers in the communications segment. Now, each country has several operators, all expanding at different rates, promoting their services at different times and requiring new products from manufacturers on a much less orderly basis than previously known.

The speed of bringing new products to market increased its importance significantly this year—a consistent trend over the past few years. Companies in this segment have tackled the issue by forming closer strategic partnerships with fewer vendors. One of the disadvantages of this approach is the problem of securing second-sourcing arrangements, particularly in ASICs—hence the 55 percent increase in importance in second sourcing this year.

The importance of most purchasing criteria within the consumer application segment grew substantially in 1998, which seems to indicate that the life of a buyer in the consumer market is becoming more difficult and which would be consistent with a market segment overcoming the issues associated with the process of digitization. Buyers in the consumer segment report an increase in importance of technical support of more than 70 percent, second sourcing more than 135 percent, quality and reliability more than 60 percent, obsolescence risks more than 85 percent and design-in issues more than 75 percent. All these issues are critical during the implementation of new technologies and new designs, the mid stages of which the consumer market is currently undergoing. In addition, the rise in importance of other issues such as responsiveness of vendor, pricing and EDI shows that buyers in the consumer segment are dealing with issues faced by the rest of the industry, such as integrating the supply chain into the manufacturing process.

Industrial segment companies are often small and are rarely viewed as strategic partners by semiconductor companies. Also, specialized components are often needed. For both of these reasons, availability of products remains the number-one concern for industrial segment companies. Unlike in all other segments, pricing is not rated highly. However, long-term agreements and reducing the vendor base have risen sharply in importance. Many industrial products are particularly affected by economic conditions in the major industrialized countries of Europe. These turbulent market conditions raise concerns about availability, lead times and on-time delivery; as such, they require special arrangements with a limited number of vendors.

As in previous years, the pricing issue was the major concern in the automotive segment, retaining its average rating of 9.8 out of 10—higher than in any other segment. Quality/reliability retained second place. Six purchasing criteria became significantly more important to buyers: second sourcing, responsiveness of vendor, on-time delivery, inventory control, EDI and supplier certification/accreditation. Most of those categories relate to the issue of guaranteeing supply. Car manufacturers are focusing heavily on reducing their cost bases in order to achieve greater margins in a more price-competitive market; they are using initiatives like creating common vehicle platforms and reducing suppliers. For those companies that have maintained their supplier status, guaranteeing delivery performance is the only way to retain their position.

Inventory

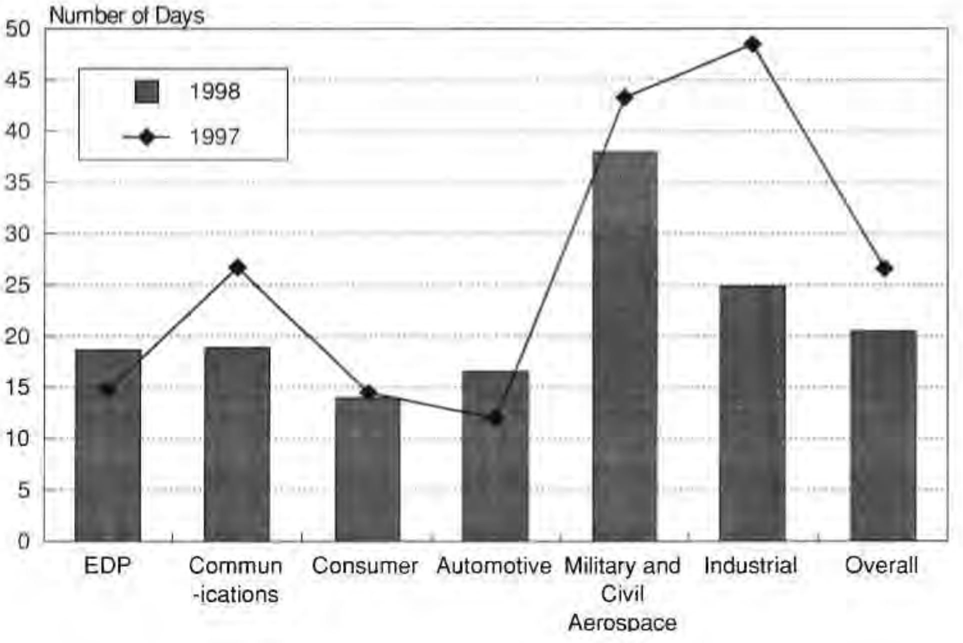
Inventory levels have consistently proved an important issue to buyer companies. In the questionnaire, respondents were asked about their present and anticipated inventory levels based on the first six months of 1998.

Overall, inventory levels have fallen since last year. The target inventory in 1998 is 20.5 days—lower than in 1997 and 1996. Curiously, Figure 3-8 shows that the average inventory level for the EDP segment has increased from 14.8 days to 18.7 days, despite the favorable pricing and availability of products in the marketplace just now. Inventory levels have fallen in all other segments except automotive.

Figure 3-9 illustrates the attitude of respondents to current inventory levels. It shows that a majority of respondents consider inventory levels to be still too high, despite the general decrease over 1997 levels. Almost 50 percent of EDP respondents feel that inventory levels are too high. Given that inventory levels in this segment have increased over 1997, this figure appears to be a little low in view of the favorable conditions for the EDP market. A clear majority of respondents in each of the other segments think that inventory levels are still too high.

Overall, looking forward to next year, companies expect to reduce inventory levels—see Figure 3-10. However, previous surveys suggest that companies often state this but rarely actually achieve it. So this should be viewed as a wish rather than a firm intention. Nevertheless, there could be major benefits for vendors that help these companies make the wish come true.

Figure 3-8
European Semiconductor Purchasing Trends
Average Inventory Level by Segment, 1997 and 1998



n = 93
Source: Dataquest (July 1998)

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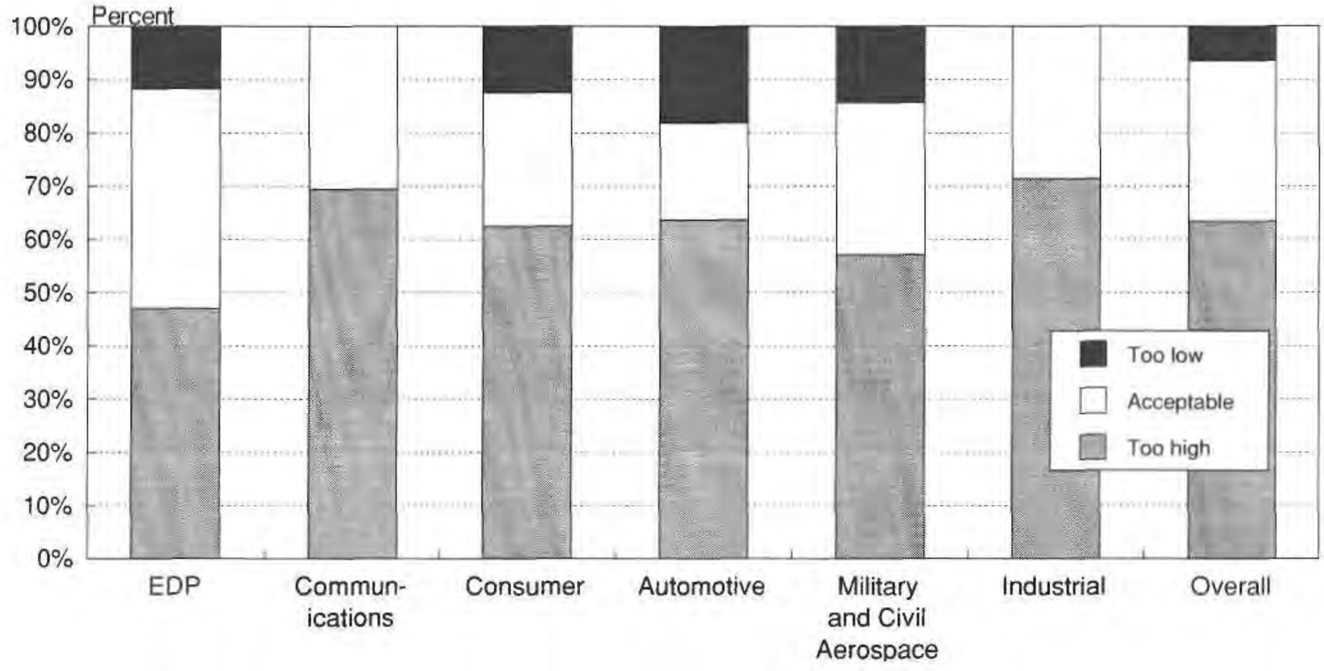
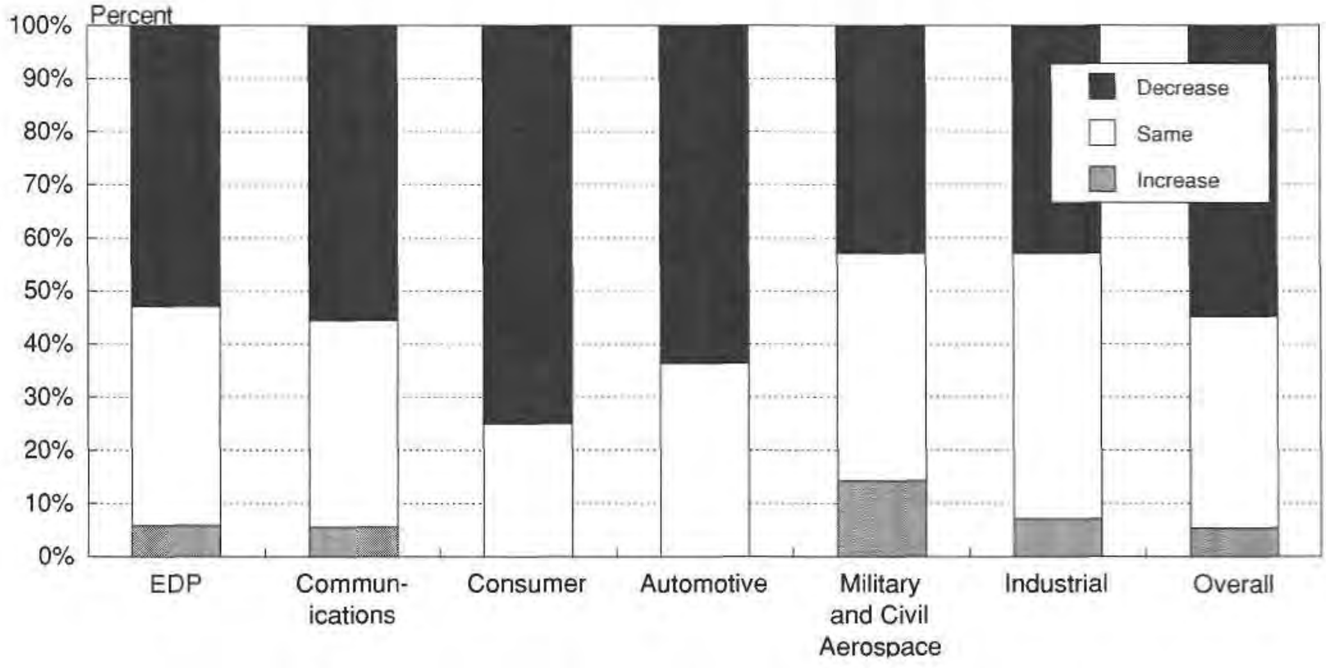
Figure 3-9
European Semiconductor Purchasing Trends
Current Inventory Level by Segment, 1998



n = 93
Source: Dataquest (July 1998)

Figure 3-10
European Semiconductor Purchasing Trends
Anticipated Inventory Level Over the Next 12 Months by Segment, 1998



n = 93
Source: Dataquest (July 1998)

Chapter 4
Distribution Factors

This chapter focuses on issues relating to sourcing via distributors. The amount purchased via distributors varied considerably by company size and by segment.

Figure 4-1 shows both the total and distributor spend of each company surveyed, ranked in order of decreasing total spend. For example, company number 1 at the left-hand side spent approximately $2.6 billion, 10 percent of which was through distributors. By contrast, company number 93 at the right-hand side was a much lower spender and 95 percent of its spend was through distributors.

There is a general trend to increase the use of distributors as overall spend falls, although this is by no means true for every company. Even quite low-spending companies buy all their semiconductors directly. But these low-spending/low-distributor companies tend to be in the following categories:

- Divisions of larger companies, able to leverage off the purchasing muscle of their parent companies
- Specialized or focused companies whose semiconductor purchases are of a small set of components, such as memory-board companies

Overall, distributors accounted for a relatively small percentage of the total spend at almost 7.6 percent—up significantly on last year's figure of 4 percent. The distributor spend of the sample amounted to $821 million of semiconductor purchases.

Figure 4-2 shows that EDP accounted for almost $400 million of distributor spending, while communications also accounted for a significant percentage with a distribution spend of more than $200 million. Figure 4-3 illustrates that, although the EDP segment is the major distributor spender in dollar terms, it is in line with most other application segments at between 5 percent and 10 percent of total spend. Military and civil aerospace is the largest distributor spender as a percentage of total spend, with more than 30 percent of sales originating through this channel. This is consistent with the relatively low-volume, infrequent purchases made by military and civil aerospace companies, as well as with a recent trend of using standard semiconductor products rather than specially qualified parts.

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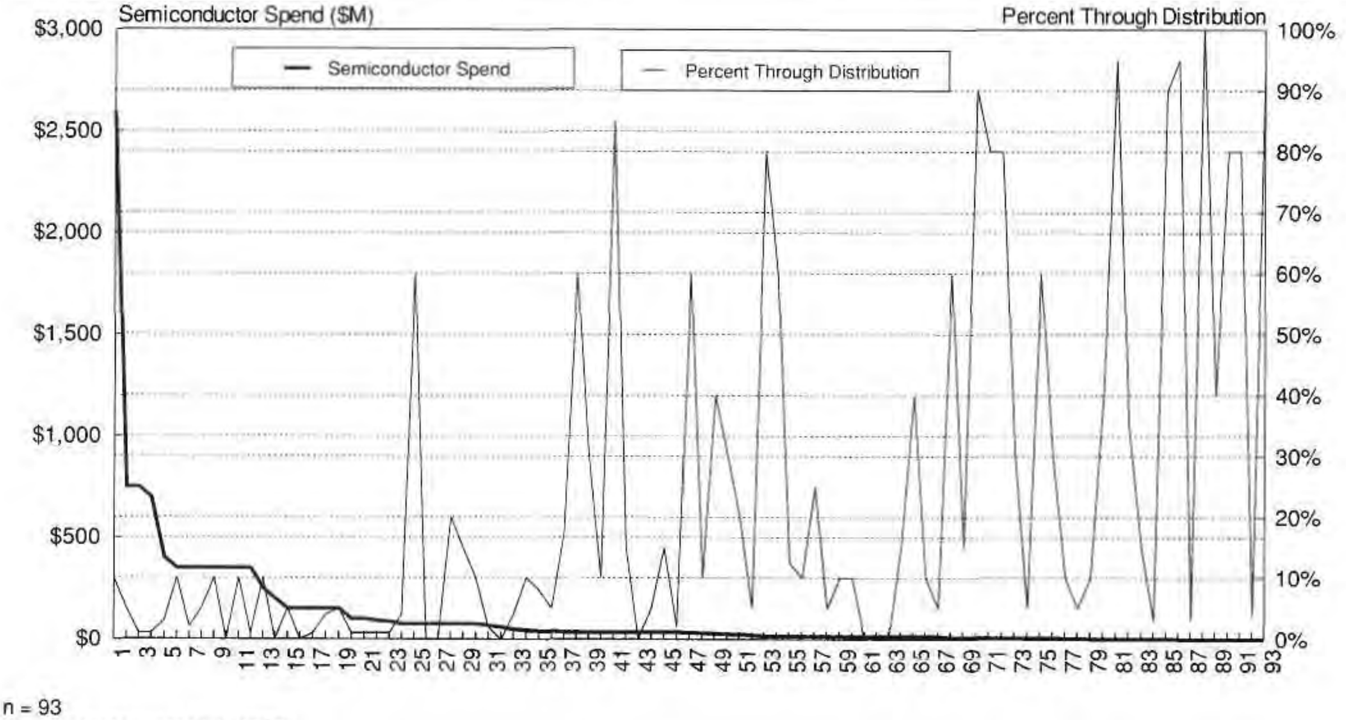
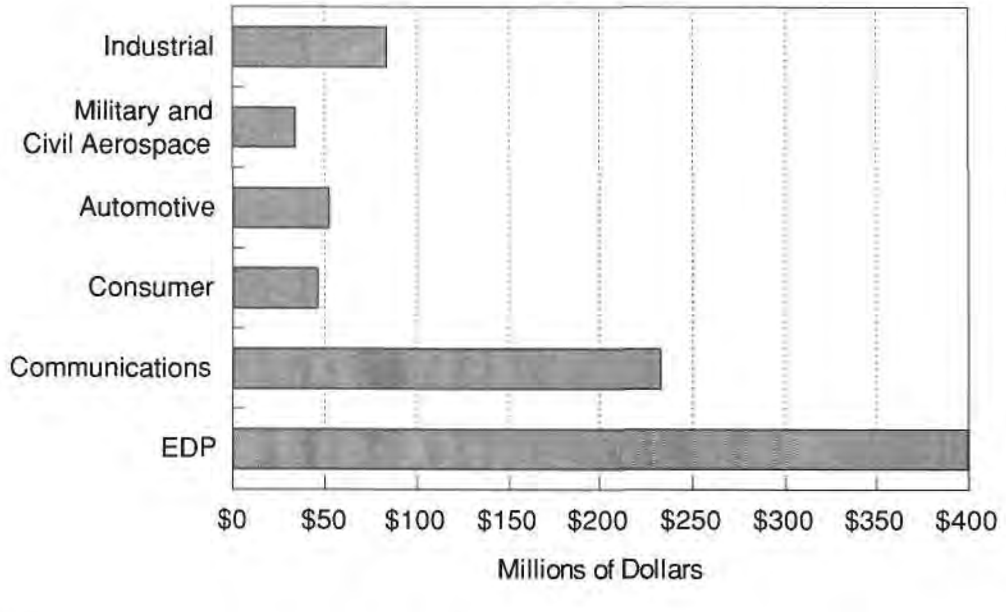
Figure 4-1
European Semiconductor Purchasing Trends
Spending by Direct Means and Through Distributors by Company, 1998



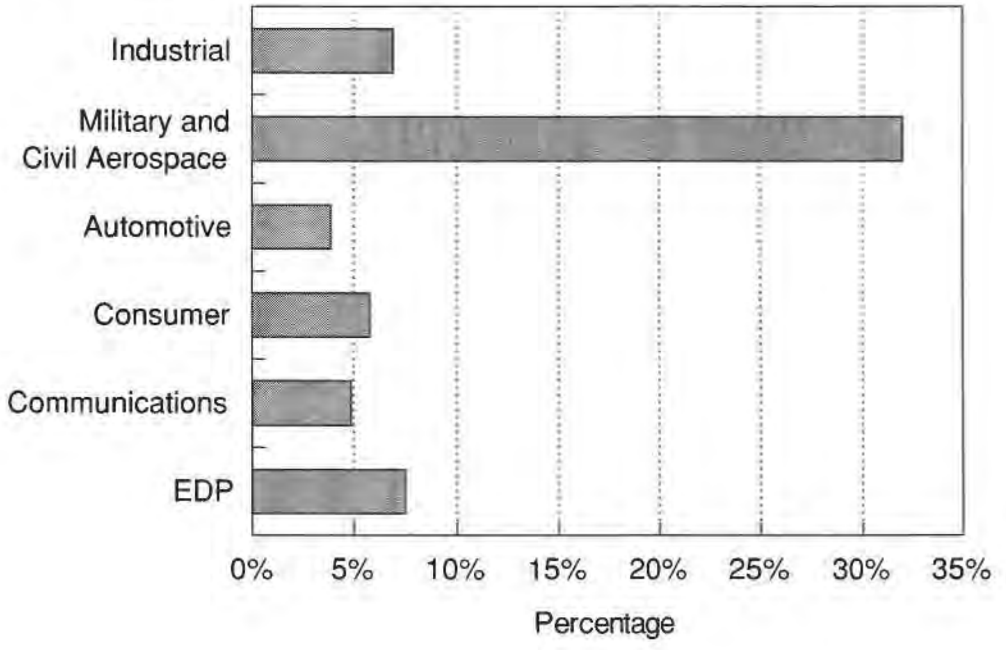
n = 93
Source: Dataquest (July 1998)

Figure 4-2
European Semiconductor Purchasing Trends
Purchasing Through Distributors by Segment, 1998



n = 93
Source: Dataquest (July 1998)

Figure 4-3
European Semiconductor Purchasing Trends
Percentage of Purchasing Through Distributors by Segment, 1998



n = 93
Source: Dataquest (July 1998)

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Chapter 5
Supplier Assessment

This chapter focuses on the issues relating to supplier assessment—how customers view and evaluate their suppliers.

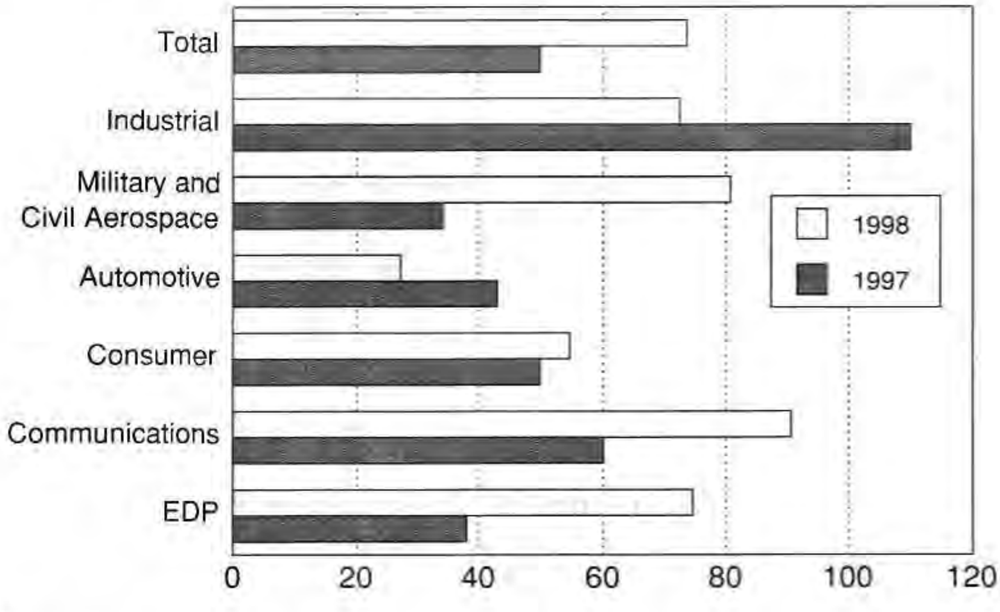
Supplier Base

Part of the survey tracks changes in the number of component vendors that respondents do business with. The key finding is that the trend has reversed and that the average number of suppliers has gone up in 1998. The only application segments that have not shown an increase in vendors are industrial and automotive. The efforts being made in the automotive industry to consolidate supply chains are mentioned earlier.

Figure 5-1 shows the number of suppliers of all semiconductor components that equipment manufacturers do business with. The average number of suppliers has grown from 50 in 1997 to 73 in 1998—an increase of 47 percent. However, this figure was skewed by a number of very high responses in the industrial and military and civil aerospace segments. Nonetheless, increases have also been registered in the number of suppliers used in the consumer and communications segments, which grew 10 percent and 50 percent respectively. In addition, there was a near doubling of suppliers in the EDP segment, which appears to have grown its supplier base by 96 percent.

Interestingly, supplier numbers in all segments except automotive have returned to levels close to those of 1996. This could mean that, having undergone supplier-reduction programs, manufacturers have found operating conditions to be unsatisfactory or supply chains too volatile, or—and perhaps more likely—that respondents are including component suppliers (rather than solely semiconductor suppliers) in their responses.

Figure 5-1
European Semiconductor Purchasing Trends
Number of Semiconductor Suppliers, 1997 and 1998



n = 93
Source: Dataquest (July 1998)

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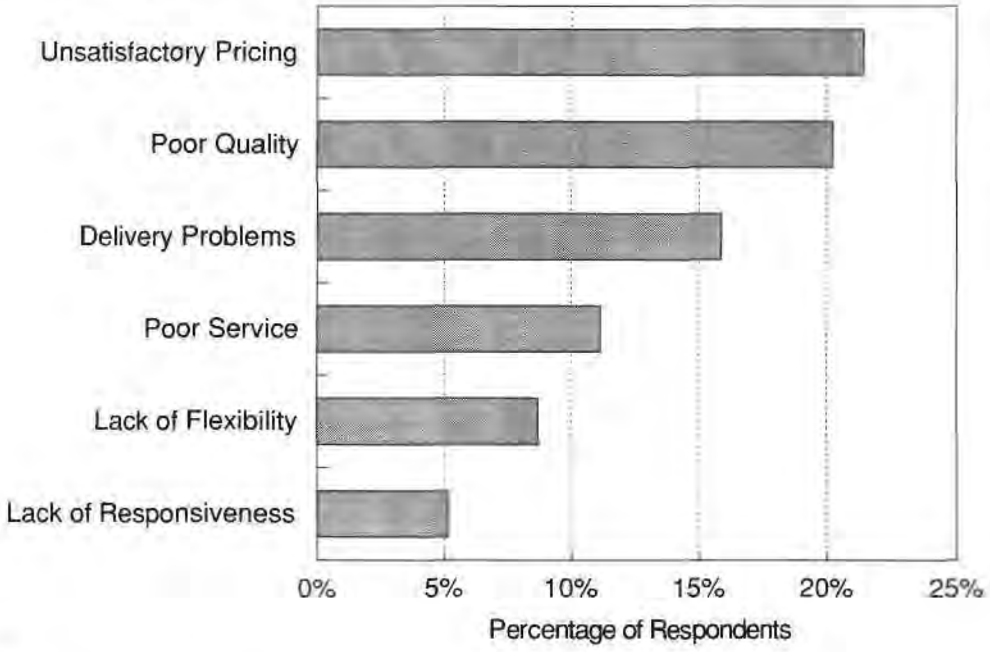
Figure 5-2 illustrates respondents' reasons for canceling business with semiconductor suppliers. In line with last year's responses, unsatisfactory pricing and poor quality remain the two most commonly cited reasons why suppliers lose business; both issues are mentioned by more than 20 percent of respondents.

Proof of manufacturers' desire to integrate suppliers more closely into their manufacturing process is underlined by the fact that the next four most mentioned reasons refer to unsatisfactory levels of value added by semiconductor suppliers. Delivery problems was the third most mentioned reason for losing business, followed by poor service, lack of flexibility and lack of responsiveness. To reinforce the validity of these reasons, all six appear in the ten most important criteria shown in Figure 3-1.

Figure 5-2
European Semiconductor Purchasing Trends
Reasons Why Semiconductor Suppliers Lose Business, 1998



n = 93
Source: Dataquest (July 1998)

Vendor of the Year

One of the sections in the procurement survey asks buyers to nominate their "best" vendors in a number of categories. The results are aggregated and result in a ranking of vendors in these categories. Dataquest presents the leading vendor in each category with an award in recognition of this achievement.

This year, Dataquest made awards to five companies for their outstanding performance in serving their customers in Europe. There were 77 companies nominated and these are shown in alphabetical order in Table 5-1. This was a significant increase on the 50 companies nominated in 1997.

Table 5-1
European Semiconductor Purchasing Trends
Companies Nominated for Vendor of the Year, 1998

Accorde	Macro
Altera	Matra
AMD	Maxim
AMI	Memec
Analog Devices	Micron
Arrow	Mitsubishi
Atmel	Motorola
Austria Micro Systeme	National Semiconductor
Avera	NEC
Avnet Access	Nortel
Catalyst	Panasonic
Cherry Semiconductor	Philips
Cirrus	Rockwell
Crystal	Rohm
Cypress	S3
Cyrix	Samsung
D2D	Sanyo
Dialog	Scaib
Elmos	Sharp
Fairchild Semiconductor	Siemens Semiconductor
Farnell/E.S.D.	Silicon Systems
Fujitsu Microelectronics	Siliconix
Future	Sipex
GEC Plessey	Sony
General Instrument	Spoerle
Harris	STMicroelectronics
Hitachi	Symbios
Honeywell	Tekelec
Hyundai	TEMIC
IBM	Texas Instruments
IDT	Thame
Intel	Toshiba
ITT	Vishay
Jermyn	Vitramon
Lattice	VLSI Technology
LG Semicon	Winbond
Linear	Xilinx
LSI Logic	Zilog
Lucent Technologies	

Source: Dataquest (July 1998)

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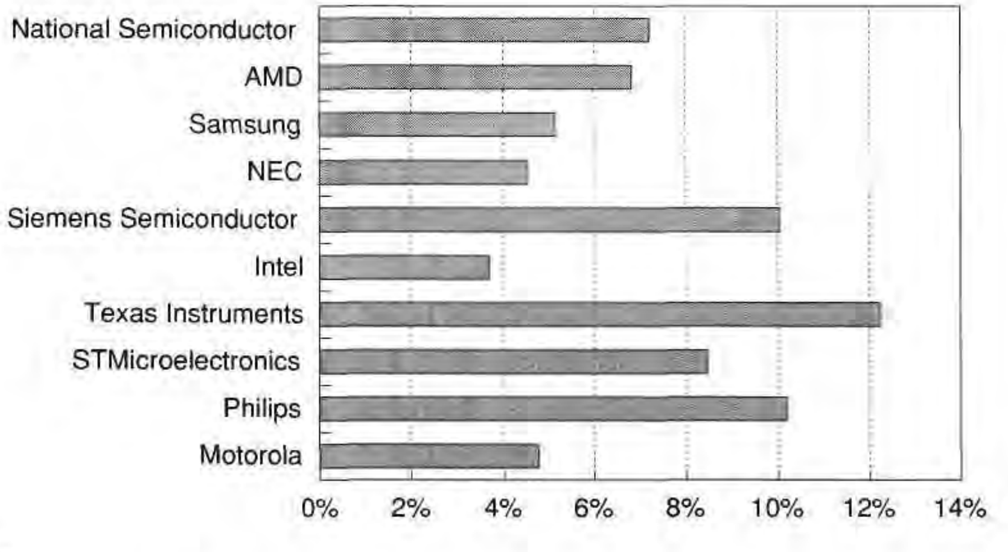
In 1998, the categories and winners are as follows:

- European overall vendor of the year: Texas Instruments
- European vendor of the year for responsiveness and flexibility: Philips
- European vendor of the year for technical support: Siemens Semiconductor
- European medium-sized vendor of the year (European sales between $50 million and $500 million): Fairchild Semiconductor
- European niche vendor of the year (European sales of less than $50 million): Sharp
- European distributor of the year: Arrow

This year's top prize was again awarded to Texas Instruments, which continued its outstanding performance of the past three years. As shown in Figure 5-3, Texas Instruments took 12.2 percent of all the votes, while Philips moved up into second place from sixth last year and Siemens Semiconductor maintained third position. National Semiconductor, which has been second over the past few years, fell to fifth, no doubt owing to its divestiture of Fairchild Semiconductor.

Figure 5-3
European Semiconductor Purchasing Trends Results of Vendor of the Year Awards, 1998



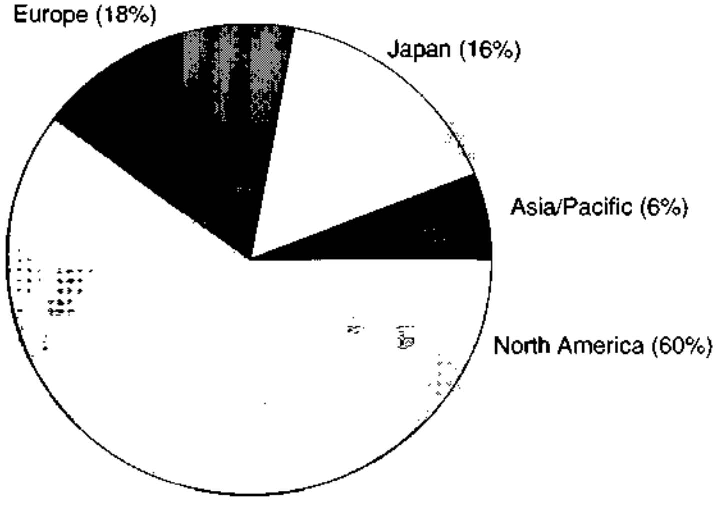
n = 93
Source: Dataquest (July 1998)

Figure 5-4 examines the votes awarded to each region's suppliers in 1998. In this analysis, distributors were not included. As in previous years, North American companies received the most nominations, gaining share from all other regions to achieve 60 percent. Japan, Europe and Asia/Pacific's percentage of nominations all decreased—Japan by 4 percent, Europe by 2 percent and Asia/Pacific by 1 percent.

However, certain European suppliers have improved their performance. Europe's three major semiconductor manufacturers are all in the top five ranking in terms of customer service. In 1997, Siemens Semiconductor was number three while STMicroelectronics ranked fourth. In 1998, Philips ranked second, Siemens Semiconductor third and STMicroelectronics fourth.

Asia/Pacific suppliers continue to lag significantly behind vendors in other regions, although the reasons for this gap are related to the comparatively small number of vendors from the region with significant presence in Europe, as well as to the commodity nature of the markets in which they participate. Japan, which lost market share, is still very close to Europe in terms of percentage of nominations received.

Figure 5-4
European Semiconductor Purchasing Trends
Companies Nominated by Base Region
Vendor of the Year Awards, 1998



Source: Dataquest (July 1998)

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Chapter 6

Conclusion

Yet again we see significant differences between the current snrvey results and those of previous years. Clearly, buyer requirements and the market conditions they reflect remain volatile and subject to rapid change. The radically different findings of different segments are also significant. This is consistent with the varying business conditions ranging from high-volume, short life cycle products (such as, consumer) to low-volume, specialized long lifetime products (such as, military and civil aerospace).

One of the most intriguing questions raised by this research is the difference between survey respondents' spending plans and their resulting spend. The reasons for this are discussed earlier and are probably best explained by the differing perceptions and negotiating positions of the respondents. One factor is clear from these surveys over successive years: the short-term perspective of most of the responses. Typically, the current year's spend is understated and the next year's spend is overstated. A full year ahead is a long time in many buying organizations and therefore is difficult to predict. These factors should be kept in mind when interpreting the results of the survey and should always be compared with Dataquest's current semiconductor forecast in the segment of interest. The determination of customer requirements should always be of great interest to vendors and the procurement survey remains a prime tool for this purpose.

Survey Questionnaire

A floppy disk containing the survey questionnaire is enclosed with hard copies of this document; if you are referring to the Web, the questionnaire can be obtained from Edmund Gemmell on +44 (0) 1784 487506 or Lea Davies on +44 (0) 1784 487512.

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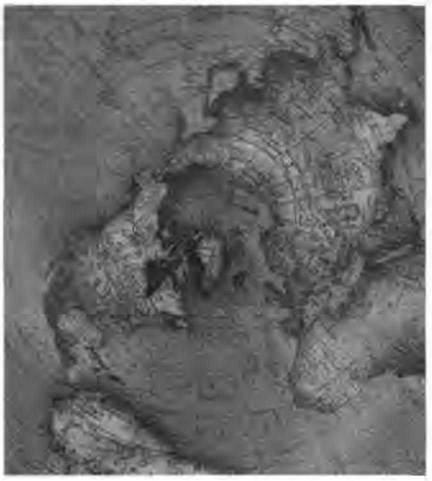

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The Semiconductor Markets and Industries of Central and Eastern Europe

Focus Report
1998

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The Semiconductor Markets and Industries of Central and Eastern Europe

Focus Report

1998

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Chapter 1
Executive Summary

Total semiconductor consumption in Central and Eastern Europe (C&EE) in 1997 was $1.8 billion. The major countries in terms of semiconductor consumption were Russia, which consumed 43 percent of all semiconductors used in the region, Poland, which accounted for 21 percent of all semiconductors, and the Czech Republic and Hungary, which consumed 9 percent and 8 percent respectively.

The dominant application market within the C&EE semiconductor market was electronic data processing (EDP), which accounted for 60 percent of all semiconductors consumed in 1997; this was a slight increase over 1996's level of 57 percent. The consumer electronics market was the next largest user of semiconductors, which accounted for 17 percent of semiconductor consumption in 1996 and 1997. The communications market accounted for 11 percent of semiconductor consumption in 1997.

Direct semiconductor shipments into the region by non-C&EE semiconductor vendors accounted for 32 percent of all consumption in 1997 and 30 percent in 1996. A major contributor to these figures was PC-related semiconductors in the form of microprocessors from Intel, AMD and Cyrix, and DRAM from various vendors. In addition to direct shipments of semiconductors by vendors, the formal semiconductor distribution channel, mostly derived from Western Europe, accounts for a further 5 percent to 10 percent of the total market.

The C&EE region's semiconductor industry is several generations of technology behind the rest of the world, and a large proportion of indigenous semiconductor companies has ceased trading, while a substantial part survives at subsistence levels. However, there are several indigenous semiconductor companies that have found niche markets, primarily in southeast Asia or at home, for their product ranges. Included in this category of company are Mikron JSC, Angstrem and JSC Voronezh Semiconductor Plant (VZPP) of Russia, as well as Kvazar Micro of Ukraine, Integral of Belarus and Tesla Sezam of the Czech Republic.

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Chapter 2
Geographic Definition

For the purposes of this report, the C&EE region is defined as Bulgaria, the Czech Republic, Hungary, Poland, Romania, Russia, Slovakia, Slovenia, Ukraine and the Rest of Central and Eastern Europe (Albania, Armenia, Azerbaijan, Belarus, Bosnia/Herzegovina, Croatia, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Macedonia, Moldova, Serbia/Montenegro, Tajikistan, Turkmenistan, Uzbekistan).

In addition to this top-level categorization, a subcategorization distinguishing between Central Europe and Eastern Europe is occasionally referred to. For the purposes of this report Central Europe refers to the former satellite states of the Soviet Union and includes the Czech Republic, Hungary, Poland, Slovakia and Slovenia. Eastern Europe refers to the countries which made up the Soviet Union including Russia, Ukraine, the Baltic states and those countries which are now part of the Commonwealth of Independent States (CIS).

Chapter 3
Methodology

This document is the first Dataquest publication on the C&EE semiconductor markets, and will be followed by an update later in 1998.

The information in this report is gathered from both primary and secondary sources. Primary sources include surveys and interviews of industry vendors and customers, combined with analyst knowledge and opinions. Secondary sources include government and trade sources on sales, production, trade and public spending as well as international organizations such as the World Bank and the European Bank for Reconstruction and Development. Semiconductor content assumptions are based on both surveys of producing OEMs and teardown evaluations by Dataquest analysts of representative electronic equipment.

Accurate data concerning the sales of semiconductors is particularly difficult to obtain, given the developing nature of the C&EE electronics industry, the formal distribution channels and, importantly, the informal distribution channels. It is especially difficult to establish the value of sales at the first point of invoice. Many of the semiconductors consumed in the region are imported from other regions, in which the first point of invoice sale may already have been registered. The semiconductor typically passes through two or more levels of distribution, all of which add their margin, before it reaches the equipment manufacturer. Therefore, Dataquest's estimates of semiconductor market size are based on electronic equipment production output, data for which has been collected from various economic sources as well as Dataquest's own knowledge of certain market activities.

Unfortunately, the automotive application market has been excluded from this first report as little reliable or accurate data was available for this market segment. As Dataquest's experience in this emerging market increases, future reports will incorporate the automotive application segment.

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Chapter 4

Central and Eastern Europe Overview

Introduction

Much has been written about the blossoming demand for PCs, telecommunications equipment and electronic consumer goods in the emerging electronic equipment markets of the C&EE region. This *Focus Report* analyzes this blossoming demand and assesses its effects on the indigenous manufacturing infrastructure of C&EE countries and on the demand for semiconductors, both imported and locally manufactured.

Macroeconomic Trends

After seven years of continuous decline, the C&EE region as a whole witnessed the resumption of economic growth in 1997, but the projected rate for 1997 is still fragile, at less than 1 percent. Compared with 1996, average growth is likely to slow down slightly in Eastern Europe but accelerate in the Baltic states, while economic contraction seems to have finally come to an end in the CIS. This turnaround is largely the result of the improving performance of Russia and Ukraine, with Russia likely to register its first year of positive growth. Of 26 economies in the region, 11 are expected to grow at rates of 4 percent or more in 1997. Table 4-1 shows GDP growth rates of the major C&EE economies.

Inflation has been brought further under control in most of the C&EE region. Median inflation fell from 32 percent in 1995 to a projected 14 percent in 1997. Year-end inflation in 1997 is expected to be 40 percent or less in 20 of the 26 countries, and there is now single-digit inflation in nine countries. Most cases of improvement have been in the CIS, although inflation performance has not been uniform; there have been slippages both in the CIS and in some Central European countries.

Table 4-1
Major Central and Eastern European GDP Growth Rates, 1993-1998

Country	1993 (%)	1994 (%)	1995 (%)	1996 (%)	1997 (%)	1998 (%)
Bulgaria	-2.4	1.8	2.1	-10.9	-7.0	2.5
Czech Republic	0.6	2.7	5.9	4.1	1.0	2.5
Hungary	-0.6	2.9	1.5	1.0	3.0	4.0
Poland	3.8	5.2	7.0	6.0	5.5	5.0
Romania	1.5	3.9	7.1	4.1	-1.5	1.5
Slovakia	-3.7	4.9	6.8	6.9	4.5	3.0
Slovenia	2.8	5.3	4.1	3.1	4.0	4.5
Russia	-8.7	-12.6	-4.0	-5.0	1.0	3.0
Ukraine	-14.2	-23.0	-11.8	-10.1	-3.0	2.0
Total Central Europe and Baltic States	0.4	3.7	5.3	4.1	3.1	
Total Commonwealth of Independent States	-9.3	-13.5	-4.9	-4.6	0.8	
Total C&EE Region	-5.4	-6.6	-0.8	-1.1	1.7	

Source: European Bank for Reconstruction and Development Transition Report 1997

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In Bulgaria, the loss of macroeconomic control during 1996 and early 1997 drove the economy back into extreme inflation. Year-end inflation of 311 percent was recorded in 1996 and is projected to have reached nearly 600 percent in 1997. However, since March 1997 there has been a rapid disinflation, which was reinforced by the introduction of a currency board system in July 1997.

In Romania, inflationary pressure has built up because of high levels of government debt in the second half of 1996. Despite significant monetary tightening in 1997, inflation accelerated to slightly more than 100 percent by the year-end, following the removal of administrative price controls. Table 4-2 shows inflation rates of the major C&EE economies.

Table 4-2
Major Central and Eastern European Inflation Rates, 1993-1998

Country	1993 (%)	1994 (%)	1995 (%)	1996 (%)	1997 (%)	1998 (%)
Bulgaria	64	122	33	311	592	1,049
Czech Republic	18	10	8	9	9	9.5
Hungary	21	21	28	20	17	18
Poland	38	29	22	19	15	16
Romania	296	62	28	57	116	145
Slovakia	25	12	7	5	7	6.5
Slovenia	23	18	9	9	9	9
Russia	837	217	132	22	14	17
Ukraine	10,155	401	182	40	15	20
Total Central Europe and Baltic States	166	35	19	38	65	
Total Commonwealth of Independent States	4,584	1,387	363	63	33	

Source: European Bank for Reconstruction and Development Transition Report 1997

Semiconductor Market

Because of the unstructured nature of a significant proportion of semiconductor distribution channels within the C&EE region, Dataquest has calculated semiconductor consumption for the region based on the value of electronic equipment output. Electronic equipment output is taken at its most liberal sense and for the purposes of this report includes all activities resulting in finished electronic goods, including simple "screwdriver" manufacturing operations.

The benefit of using this definition derives from the relatively small amount of true manufacturing in the C&EE electronics and semiconductor markets. However, as the economies of C&EE develop, demand from the region's 400 million inhabitants will begin to be satisfied by developing domestic manufacturers using domestic raw materials, as opposed to the current solution: imports from other regions and final assembly of electronic product kits. This means that although current real semiconductor demand is relatively low, in future years the C&EE electronics industry will move into value-added manufacturing, which requires the use of semiconductor components instead of board and kit-level products. Thus, the current board-level semiconductor consumption will change to semiconductor consumption as measured in the rest of the world. Analysis of the current C&EE board-level semiconductor consumption leads to an estimate of the region's future semiconductor consumption.

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An example of this type of market development can already be seen in Russia. Sistema, a holding company with companies at all levels of the production chain, has recently negotiated a deal with Ericsson to build telecommunications equipment. This equipment will not simply be the usual model of final assembly; sub-assemblies for the systems will be manufactured in Russia using Russian components where possible, thus ensuring real local content and local added value in the final product.

Using this definition of electronic equipment output, the semiconductor market of C&EE based on electronic equipment production totaled $1.8 billion in 1997. In terms of significance in Europe, this makes the entire C&EE region larger in demand than Benelux and smaller than Italy. Tables 4-3 and 4-4 show total semiconductor consumption by country and by product category respectively, based on electronic equipment production, from 1994 to 1997.

Table 4-3
Central and Eastern Europe—Total Semiconductor Consumption by Country, 1994-1997
(Based on Electronic Equipment Production)

Country	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Bulgaria	11.5	24.9	17.5	16.2
Croatia	23.0	28.7	27.5	31.1
Czech Republic	95.7	139.1	143.8	171.9
Hungary	85.7	129.1	128.3	142.3
Poland	168.5	279.6	310.4	389.0
Romania	43.7	60.3	62.3	76.3
Russia	461.3	596.1	615.8	781.0
Slovakia	30.7	43.9	45.2	55.2
Slovenia	49.0	65.3	62.1	67.8
Ukraine	52.2	57.8	53.6	69.2
Others	0.0	17.7	16.9	24.3
Total	**1,021.3**	**1,442.6**	**1,483.5**	**1,824.2**

Source: Dataquest (April 1998 Estimates)

Table 4-4
Central and Eastern Europe—Total Semiconductor Consumption by Product Category, 1994-1997
(Based on Electronic Equipment Production)

Product Category	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Total Semiconductor	1,021.3	1,442.6	1,483.5	1,824.2
Total IC	894.8	1,276.0	1,316.2	1,625.9
Bipolar Digital	13.4	19.3	19.9	24.9
MOS Digital	740.4	1,072.0	1,110.4	1,380.8
MOS Memory	290.4	428.7	446.7	561.0
MOS Microcomponent	298.4	430.4	445.2	552.7
MOS Logic	151.5	212.9	218.5	267.1
Analog (Monolithic and Hybrid)	141.1	184.7	185.9	220.2
Total Discrete	92.2	121.1	121.4	143.7
Total Optical Semiconductor	34.3	45.4	45.8	54.6

Source: Dataquest (April 1998 Estimates)

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Table 4-5, which gives semiconductor consumption by application, shows that, like elsewhere in the world, EDP is the dominant market application, accounting for 60 percent of the market in 1997. This is significantly higher than the 40 percent that EDP represents in the Western European semiconductor total available market. EDP's dominance in the C&EE region is undoubtedly the result of indigenous PC manufacturers' rapid entry into the C&EE market and their success in terms of the market share they hold over imported PCs. In 1997 indigenous PC manufacturers held a 73 percent share of the four largest PC markets (Russia, Poland, the Czech Republic and Hungary), an increase from 69 percent in 1996.

Table 4-5
Central and Eastern Europe—Total Semiconductor Consumption by Application, 1994-1997
(Based on Electronic Equipment Production)

Application	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Electronic Data Processing	514.9	802.2	848.1	1,093.0
Industrial	123.4	163.9	158.8	183.5
Military and Civil Aerospace	33.0	35.3	34.1	38.5
Communications	142.6	185.0	185.7	207.0
Consumer	207.5	256.5	257.0	302.4
Total	**1,021.5**	**1,442.8**	**1,483.7**	**1,824.4**

Source: Dataquest (April 1998 Estimates)

Table 4-6 shows the value of semiconductor sales into C&EE by nonindigenous semiconductor vendors. This shows that true sales into the region represent approximately one-third of total semiconductor consumption in C&EE. A major contributor to this amount is the microprocessor market, whose leading participants—Intel, AMD and Cyrix—sell directly into the C&EE PC market.

If PC manufacturing were removed from semiconductor consumption based on electronic equipment production output, the value of semiconductor consumption in 1996 would have been $635.4 million, and $731.2 million in 1997. True semiconductor sales would have been approximately $160 million in 1996 and $200 million in 1997.

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Table 4-6
Central and Eastern Europe—Semiconductor Sales by Nonindigenous Vendors, 1996 and 1997

	Direct Sales to C&EE by Nonindigenous Semiconductor Vendors		Semiconductor Consumption (Based on Electronic Equipment Production)	
Country	1996 ($M)	1997 ($M)	1996 ($M)	1997 ($M)
Bulgaria	4.8	5.0	17.5	16.2
Croatia	7.6	9.7	27.5	31.1
Czech Republic	39.8	53.7	143.8	171.9
Hungary	35.5	44.5	128.3	142.3
Poland	86.0	121.5	310.4	389.0
Romania	17.3	23.8	62.3	76.3
Russia	170.5	243.9	615.8	781.0
Slovakia	12.5	17.2	45.2	55.2
Slovenia	17.2	21.2	62.1	67.8
Ukraine	14.8	21.6	53.6	69.2
Other	4.7	7.6	16.9	24.3
Total	**410.8**	**569.7**	**1,483.5**	**1,824.2**

Source: Dataquest (April 1998 Estimates)

In addition to direct sales from semiconductor vendors into the C&EE region, a significant percentage of semiconductors sold into the region originate from semiconductor distribution companies. Their business structures typically mean that their representatives in C&EE purchase semiconductors from the Western part of the organization, which in turn purchases the semiconductors direct from the semiconductor vendors. This means that within the semiconductor vendor's reporting structure the sale is recorded as being into Germany, the United Kingdom or whichever country the distributor manages its C&EE operations from. Through distribution reporting structures, vendors typically get some feedback concerning the final destination of their products. Dataquest estimates that the distribution channel generated revenue of approximately $105 million originating from the C&EE region in 1997.

Indigenous Semiconductor Industry

Until 1991 the semiconductor industry of the C&EE region was an integral part of the Warsaw Pact defense industry. In addition, no part of the industry was exposed to competitive forces. These factors have had two primary effects on the C&EE semiconductor industry.

Firstly, items produced by semiconductor companies were limited in their range. Most products were designed primarily for military purposes, which is in itself no bad thing, given that the entire US semiconductor industry grew from the same need for defense technology. However, within the Warsaw Pact community, the innovation and access to technology which would have developed these military products for nonmilitary applications and spawned new industries were stifled in an atmosphere of mistrust and secrecy. Nonmilitary applications were largely ignored or developed with second-rate technology which was regarded as safe enough to release to the general public.

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Secondly, because semiconductor companies faced no competition or commercial pressures, manufacturing technologies developed only enough to ensure sufficient supply for the defense industry and paid scant regard to manufacturing costs. The lack of competition meant no single company needed to innovate manufacturing technology in order to maintain any competitive advantage, and once a level of manufacturing technology was reached that was sufficient to meet demand, innovation tended to plateau at a less-than-optimal level. This led to wafer fabrication plants with similar levels of technology and capabilities, which, although more than sufficient for military needs, were in comparison with non-C&EE technologies several generations behind. This applied to both semiconductor manufacturing and factory efficiency technologies.

Unfortunately, once exposed to free market economics and the almost overnight demise of their traditional markets and loss of governmental support in 1991 and 1992, the structural weaknesses which characterized the region's semiconductor industry left it completely unable to compete with the rest of the world's semiconductor industries. Exposed to market forces, C&EE semiconductor and electronic equipment manufacturers could only offer products with less advanced technology and lower quality assurance levels than available elsewhere, and so were denied access to new markets that could have replaced the rapidly shrinking home markets.

In 1989 there were more than 100 semiconductor wafer fabrication plants throughout the Soviet Union; approximately six years after exposure to world market dynamics, Dataquest estimates that between 30 and 40 enterprises still maintain any sort of manufacturing capabilities. These companies range from plants surviving on tens of thousands of dollars annually to several companies with tens of millions of dollars in revenue.

Among the most commercially active C&EE semiconductor vendors are Tesla Sezam in the Czech Republic; Baneasa SA in Romania; Angstrem, Mikron, VZPP of Russia; Integral from Belarus and Kvazar Micro from Ukraine, all of which have revenues measured in millions of dollars. Table 4-7 lists those semiconductor enterprises in the C&EE region that Dataquest believes to be economically active. Table 4-8 shows details of selected wafer fabrication plants.

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Table 4-7
Central and Eastern Europe—Economically Active Semiconductor Enterprises

Company	Location	Country
Integral	Minsk	Belarus
Transistor	Minsk	Belarus
Microelectronica	Botevgrad	Bulgaria
Info Semiconductor	Sofia	Bulgaria
DZU	Stara Zagora	Bulgaria
Tesla Sezam	Roznov	Czech Republic
Estel Semiconductor	Tallin	Estonia
Melcom	Budapest	Hungary
Intermos Microelectronics	Budapest	Hungary
Alfa Semiconductor	Riga	Latvia
Venta	Vilnius	Lithuania
ITE	Warsaw	Poland
Lamina Semiconductor International	Plaseczno	Poland
Baneasa SA	Bucharest	Romania
Microelectronica SA	Bucharest	Romania
Romes SA	Bucharest	Romania
Angstrem	Zelenograd	Russia
Electronica R&D Institute	Voronezh	Russia
Elex	Alexandrov	Russia
JSC Voronezh	Voronezh	Russia
Komponent Plant	Zelenograd	Russia
Kremniy Group JSC	Bryansk	Russia
Mikron JSC	Zelenograd	Russia
Pulsar	Zelenograd	Russia
R&PA Electronic Device Manufacturer	Voronezh	Russia
Eliz	Fryazino	Russia
Exiton	Pavlov Pasad	Russia
Iskra	Ylyanovsk	Russia
Soyuz	Novosibirsk	Russia
Vostok	Novosibirsk	Russia
Ei Semi	Nis	Serbia
IHTM	Belgrade	Serbia
Diotec	Radosina	Slovakia
Tesla Piestany	Piestany	Slovakia
JSC Kwazar	Kiev	Ukraine
Kvazar Micro	Kiev	Ukraine
Gamma	Zaporozhye	Ukraine
Rodon	Ivano-Frankivsk	Ukraine

Source: Dataquest (April 1998)

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Table 4-8
Central and Eastern Europe—Semiconductor Wafer Fabrication Plants

Company	City	Country	Products Manufactured	Clean Room Completed	Maximum Monthly Wafer Starts	Planned Maximum Monthly Wafer Starts	Clean Room Area	Minimum Clean Room Class	Equipment Limited Minimum Linewidth in Microns	Equipment Limited Maximum Wafer Diameter
Info Semiconductor	Sofia	Bulgaria	Mixed signal ASIC, custom	1984	1,800	4,000	700 m²	10	Stepper	Furnaces
Tesla Sezam	Roznov	Czech Republic	Discretes							4"
Melcom	Budapest	Hungary	Hybrid ICs							
Melcom	Gyöngyös	Hungary	Assembly and test of diodes				2,000 m²	400 m² 10,000 class, 1,600 m² 100,000 class		
Melcom	Budapest	Hungary	Assembly and test of diodes, transistors							
Alfa Semiconductors	Riga	Latvia	Power, discrete and analog	1990	1,000	1,500	350 m²	10	3	100 mm
Venta	Vilnius	Lithuania	Amplifiers, thyristors, bipolar digital, bipolar IC for televisions	1985	5,000	8,000	1,000 m²	10	Stepper	100 mm (4")
Venta	Warsaw	Poland		1985	10,000 per year	10,000 per year	1,000 m²			3"
Institute of Electron Technology (ITE)	Warsaw	Poland	Digital ASICs, MEMs, photodiodes	1975	500	500	1,200 m²	100	3	4"
Institute of Electronic Materials Technology (ITME)	Warsaw	Poland		1985	100,000 per year	100,000 per year	1,000 m²	1,000		4"
Institute of Electronic Materials Technology (ITME)	Bucharest	Romania	Linear ICs	1973				10,000		3"
Institute of Electronic Materials Technology (ITME)	Bucharest	Romania	Discrete, transistor and diode	1975	1,000			10,000	3	3"
Baneasa SA	Bucharest	Romania	Discrete, diode and thyristor	1972				10,000		2"
Microelectronica SA	Bucharest	Romania	SMCS, PMOS, NMOS	1983	2,500 (3")	3,000 (4")	2,425 m²	1,000	1	4"

(continued)

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Table 4-8 (Continued)
Central and Eastern Europe—Semiconductor Wafer Fabrication Plants

Company	City	Country	Products Manufactured	Clean Room Completed	Maximum Monthly Wafer Starts	Planned Maximum Monthly Wafer Starts	Clean Room Area	Minimum Clean Room Class	Equipment Limited Minimum Linewidth in Microns	Equipment Limited Maximum Wafer Diameter
Romes SA	Bucharest	Romania	Discrete, optoelectronics IC	1979	400 (3")	800 (3")	400 m²	10,000	5	3"
Mikron JSC	Zelenograd	Russia	Video consumer, analog, MCU, power ICs, transistors	1967	25,000	60,000	10,300 m²	10	0.8, 1	150 mm
Mikron JSC	Zelenograd	Russia		1996			2,500 m²	10,000 (planned class: 10)	Not equipped	Not equipped
Diotec Manufacturing spol s.r.o.	Radosina	Slovakia	Diodes	1993	10,000	12,000				4"
Tesla Piestany	Pieštany	Slovakia	A/D, D/A converters, CMOS logic, SRAMs, DRAMs, low-power transistor	1982	8,000		1,200 m²	100	3.5	4"
Gamma	Zaporozhye	Ukraine	MCU, custom, interface, bipolar digital		20,000	20,000	1,900 m²	100	3	4"
Kvazar Micro	Kiev	Ukraine	MPU, analog	1985	4,000	5,000	1,000 m²	100	Light graphic	Light graphic
JSC Kwazar	Kiev	Ukraine	Analog, amplifiers, MPU, MCU, EPROM	1985	6,000	10,000	630 m²	160	18	100 mm
Pillar	Zaporozhye	Ukraine	Diode, IGBT, MOSFET, power transistor, transistor, thyristor	1964	14,000	14,000	2,200 m²	1,000	3	3"

Source: Dataquest (April 1998 Estimates)

EDP Market

The PC market of C&EE is small when compared with that in the rest of Europe. In 1997, 3.5 million PCs were shipped into the C&EE marketplace, compared with the 19.1 million units which were shipped in Western Europe. Table 4-9 compares shipments in the two regions since 1995. Within the C&EE marketplace, indigenous PC manufacturers hold the majority of market share. In 1995, C&EE PC manufacturers held 62 percent of the region's market; by 1997, this had grown to 73 percent of all shipments. Table 4-10 shows the market split between indigenous manufacturers and importers.

The largest single market was Russia, which accounted for 41 percent of the total market and 42 percent of all indigenously manufactured PCs. In addition to Russia, the PC markets of Poland, the Czech Republic and Hungary are also significant in local terms.

Table 4-9
Central and Eastern Europe and Western Europe—PC Shipments, 1995-1997
(Thousands of Units)

Region	1995	1996	1997
Central and Eastern Europe	2,220.2	2,760.5	3,500.0
Western Europe	14,708.2	16,322.9	19,073.2
Total	**16,928.4**	**19,083.4**	**22,573.2**

Source: Dataquest (April 1998 Estimates)

Table 4-10
Central and Eastern Europe—PC Shipments by Source, 1995-1997
(Thousands of Units)

Shipment Source	1995	1996	1997
Indigenous Manufacturers	1,384.1	1,860.9	2,565.5
Import	836.1	899.6	934.5
Total	**2,220.2**	**2,760.5**	**3,500.0**

Source: Dataquest (April 1998 Estimates)

Unlike the Western European PC market, which is more or less homogenous, the PC market of C&EE is definitely heterogeneous: each country has its own set of dominant manufacturers which serve primarily their local market. Very little exporting occurs within the indigenously produced market, because within the C&EE marketplace indigenous manufacturing consists of little more than final assembly of PC units. Motherboards and all other major function boards are imported (primarily from southeast Asia); assembly is by the cheap labor pools in each C&EE local market. Little advantage can be gained by a manufacturer in one C&EE country exporting to another, because production costs are equal and additional transport costs will be incurred. Moreover, foreign manufacturers will have little knowledge of the market dynamics that apply in other countries; C&EE PC manufacturers have little capital to invest in setting up a brand name elsewhere, and experience difficulty in setting up distribution channels.

The only true consumption of semiconductors (measured from first point of invoice) within the PC production market is the purchase of microprocessors and DRAM. In the C&EE markets the same dynamics as in the rest of the world apply.

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Communications Market

Manufacturing

The telecommunications manufacturing environment in C&EE is characterized by joint ventures. The principal non-C&EE participants are Alcatel, Lucent Technologies, Ericsson and Siemens, all of which have joint ventures in at least two C&EE countries. For the most part, these joint ventures are final assembly plants which produce products for their local markets. This means that those non-C&EE semiconductor companies with products designed in with the major telecommunications infrastructure manufacturers already have a significant presence in the region by default. However, this presence is unseen, because only board-level kits are shipped into the C&EE region by manufacturers, although there are signs that this is gradually changing.

Cellular Telephony

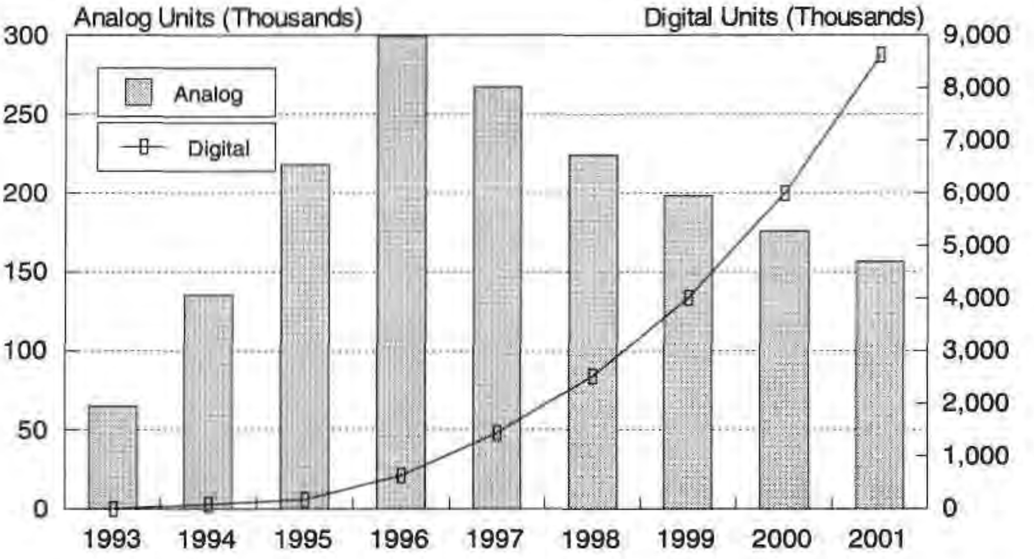
Table 4-11 and Figure 4-1 show shipments of cellular handsets to C&EE. While they do not give any indication of cellular handset manufacturing in the C&EE region (which is very low), they indicate the proliferation of mobile telephony in the region, which in time will be serviced with some element of local manufacturing.

Table 4-11
Central and Eastern Europe—Cellular Handset Shipments, Average Selling Price and Revenue, 1993-2001

	1993	1994	1995	1996	1997	1998	1999	2000	2001
Unit Shipments (K)	64.9	217.5	392.1	930.6	1,705.6	2,740.2	4,199.2	6,172.3	8,784.4
Average selling Price ($)	1,492.4	1,033.9	898.7	689.0	522.3	421.1	356.7	312.5	272.4
Total Revenue ($M)	96.9	224.9	352.4	641.2	890.8	1,153.8	1,498.0	1,929.0	2,393.2

Source: Dataquest (April 1998 Estimates)

Figure 4-1
Central and Eastern Europe—Cellular Handset Shipments by Technology, 1993-2001



Source: Dataquest (April 1998 Estimates)

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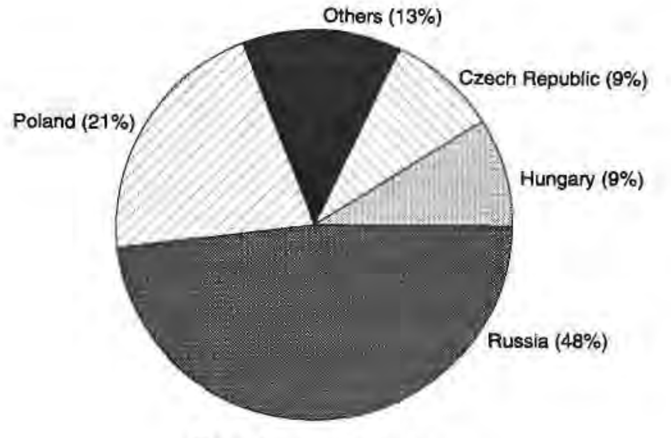
Modems

At the end of 1996, the C&EE modem market was worth $76.7 million in end-user revenue, and shipments totaled 230,140 units. Shipments are forecast to grow with a CAGR of 32.7 percent by 2001 to reach more than 1.2 million units.

In 1996, Russia continued to lead as the largest market for modem products, with its share increasing by 5 percent compared with 1995. The Polish market grew significantly and accounted for 21 percent of all shipments in 1996. Figure 4-2 shows a country breakdown of the C&EE modem market, while Table 4-12 shows the leading vendors in this market.

Figure 4-2
Central and Eastern Europe—Voiceband Modem Market by Country, 1996



Source: Dataquest (April 1998 Estimates)

Table 4-12
Central and Eastern Europe—Top 10 Vendors of Voiceband Modems, 1996

Ranking	Vendor	Shipments
1	Motorola-ISG	76,050
2	U.S. Robotics	32,000
3	Microcom	21,000
4	Action Tec	20,949
5	Archtek Telecom	17,280
6	Telindus	5,422
7	Xircom	5,179
8	Multi-Tech Systems	2,697
9	AT&T	1,890
10	Ericsson	960
	Others	46,713
	Total	**230,140**

Source: Dataquest (April 1998 Estimates)

Chapter 5
Bulgaria

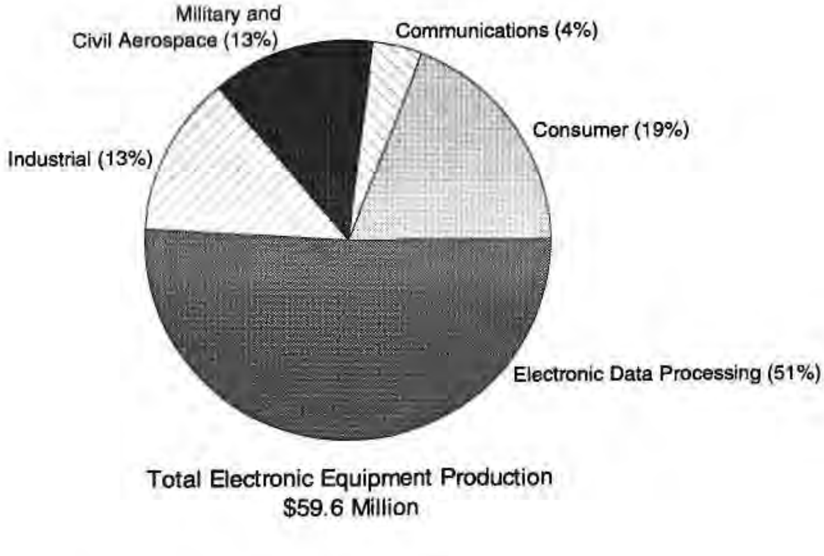
Introduction

Although Bulgaria's GDP fell by 7 percent in 1997, private sector output, which represented 46 percent of the nation's GDP in 1996, fell by only 1 percent in 1997. A series of major privatizations, which began during the first half of 1997 and is expected to continue until the end of 1998, is likely to boost the private sector share of GDP even further. The telecommunications monopoly will be included in 1998's privatizations, and an adviser has already been selected.

Semiconductor Market

Unsurprisingly, the difficulties of the Bulgarian economy have fed through to the electronics manufacturing industry. Output in the electronics industry compounded its position as the smallest in Central Europe by falling by 3 percent in 1997 to $59.6 million. In terms of semiconductor equipment, this equated to $16.2 million, which makes Bulgaria the smallest semiconductor market in Central Europe. Figure 5-1 shows Bulgaria's electronic equipment production broken down by application market, while Tables 5-1 and 5-2 show the resultant semiconductor consumption broken down by application market and product category respectively.

Figure 5-1
Bulgaria—Electronic Equipment Production by Application, 1997



Source: Dataquest (April 1998 Estimates)

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Table 5-1
Bulgaria—Semiconductor Consumption by Application, 1994-1997
(Based on Electronic Equipment Production)

Application	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Electronic Data Processing	8.3	20.9	14.0	12.2
Industrial	1.3	1.3	1.0	1.0
Military and Civil Aerospace	0.4	0.4	0.4	0.4
Communications	0.4	0.5	0.4	0.5
Consumer	1.1	1.8	1.7	2.2
Total	**11.5**	**24.9**	**17.5**	**16.2**

Source: Dataquest (April 1998 Estimates)

Table 5-2
Bulgaria—Semiconductor Consumption by Product Category, 1994-1997
(Based on Electronic Equipment Production)

Product Category	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Total Semiconductor	11.5	24.9	17.5	16.2
Total IC	10.4	23.1	16.1	14.8
Bipolar Digital	0.2	0.4	0.3	0.3
MOS Digital	9.1	20.7	14.3	12.9
MOS Memory	3.9	9.1	6.2	5.5
MOS Microcomponent	3.6	8.2	5.6	5.1
MOS Logic	1.6	3.5	2.5	2.3
Analog (Monolithic and Hybrid)	1.1	1.9	1.5	1.6
Total Discrete	0.8	1.3	1.0	1.0
Total Optical Semiconductor	0.3	0.5	0.4	0.4

Source: Dataquest (April 1998 Estimates)

Indigenous Semiconductor Industry

Bulgaria has three semiconductor manufacturing companies of note: Microelectronica in Botevgrad, Info Semiconductor based in Sofia and DZU in Stara Zagora. Revenue data is not available for any of these companies. Microelectronica produces MOS and bipolar semiconductors in addition to discretes.

EDP Market

The Bulgarian PC market has been hit hard by the country's macroeconomic trends. Total shipments have fallen from 45,000 in 1995 to an estimated 33,500 in 1997. Within this environment however, indigenous PC manufacturers have raised their market share from 64 percent in 1995 to approximately 72 percent in 1997. Tables 5-3 and 5-4 show the split between imported and indigenously manufactured PCs in Bulgaria as well as the top 10 Bulgarian PC manufacturers and their unit shipments in 1996.

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Table 5-3
Bulgaria—PC Shipments by Source, 1995-1997
(Thousands of Units)

Shipment Source	1995	1996	1997
Indigenous Manufacturers	28.8	23.0	24.1
Import	15.7	10.7	9.4
Total	**44.5**	**33.6**	**33.5**

Source: Dataquest (April 1998 Estimates)

Table 5-4
Bulgaria—Top 10 Indigenous PC Manufacturers, 1996

Ranking	Company	Shipments (K Units)	Indigenous Market Share
1	Art Systems	3.8	17%
2	Most	2.8	12%
3	Prosoft	2.2	10%
4	Argus	2.0	9%
5	Daisy	2.0	9%
6	Elcot	1.9	8%
7	Express Consult	1.7	7%
8	Leo	1.0	4%
9	Risk Electronics	0.5	2%
10	Others	5.2	22%
	Total	**23.0**	**100%**

Source: Dataquest (April 1998 Estimates)

Communications Market

Manufacturing

Since 1925, when it installed its first exchanges, Siemens has held a strong presence in Bulgaria. It has a 40 percent stake in Digicom, based in Sofia, a joint venture with Incoms Telecom Holding. Digicom produces switching and transmission equipment, and in 1993 built Bulgaria's first digital telephone exchange in Varna on the Black Sea. The Bulgarian Telephone Company, the state monopoly, participates in five joint ventures that manufacture telecommunications equipment.

Cellular Telephony

Mobikom operates an NMT-450 service in Bulgaria, for which Ericsson supplies the infrastructure. Mobitel, 49 percent of which is owned by Cable & Wireless, provides a GSM service, for which Siemens supplies the infrastructure. Table 5-5 shows total cellular handset shipments to Bulgaria between 1993 and 2001.

Table 5-5
Bulgaria—Cellular Handset Shipments, Average Selling Price and Revenue, 1993-2001

	1993	1994	1995	1996	1997	1998	1999	2000	2001
Unit Shipments (K)	0.7	5.9	14.0	21.5	28.5	48.0	68.7	95.8	136.1
Average Selling Price ($)	1,322.7	1,200.0	1,002.1	842.3	614.9	451.7	364.5	312.6	277.0
Total Revenue ($M)	0.9	7.1	14.0	18.1	17.5	21.7	25.0	29.9	37.7

Source: Dataquest (April 1998 Estimates)

Consumer Market

For political reasons, the Bulgarian cable television industry has been much slower to develop than in other C&EE countries. Although the government has been awarding operational licenses since the end of 1994, few cable television operators have started to construct networks or offer services. A total of 100,000 homes were estimated to be connected to cable at the end of 1996.

The leading Bulgarian cable television operators are Union Television and Globo Sofia Cable. Union Television has been awarded licenses for at least 16 locations and plans to link about 15 percent of the country's television-owning households by cable. Globo Sofia Cable won licenses to operate in five cities, including Sofia, with a planned total investment in network development of $39 million. Globo Sofia Cable offers up to 35 channels, including its own 24-hour service.

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Chapter 6
Czech Republic

Introduction

Long considered, along with Poland, to be the leading country in the transfer to free market economics, the Czech Republic is now at a crossroads. Economic growth has slowed, export growth has stagnated and imports have risen considerably on the back of consumer demand. In addition, domestic inflation is running at a two-year high of 10 percent, unemployment is increasing and, despite a public-sector wage freeze for 1998, wages continue to rise, meaning private consumption continues to increase faster than domestic production. Growth in 1998 is expected to remain weak. Despite these economic difficulties, the electronic equipment production industry continues to grow and add value to the economy.

Semiconductor Market

The Czech Republic has the second-highest semiconductor consumption level in Central Europe (behind Poland), and the third-highest consumption level in the region (behind Russia and Poland). Within the former COMECON framework, the Czech electronics industry was technically advanced. Since the postliberalization market upheaval of 1992 and 1993, when significant numbers of electronics enterprises ceased trading, the Czech electronics industry has made a fast recovery and grew by more than 84 percent between 1994 and 1997. The semiconductor market of the Czech Republic has continued to grow in line with the electronic equipment industry during the difficulties of past years. Electronic equipment production in the Czech Republic grew by 22 percent in 1997, which led to an increase in semiconductor consumption of 19 percent in the same year. Figure 6-1 shows electronic equipment production by application in 1997, while Tables 6-1 and 6-2 show the Czech Republic's semiconductor consumption by application market and device category respectively.

Within the Czech Republic an important part of the production capacity of the electronics industry is concentrated in the greater Prague area. Other traditional areas of electronics production are in north and central Moravia and in east Bohemia. Almost two-thirds of the country's electronic equipment production is found in these four areas.

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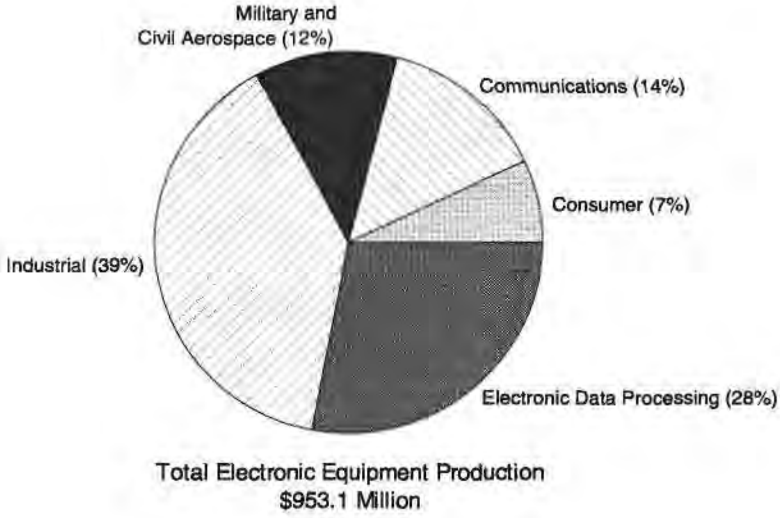
Figure 6-1
Czech Republic—Electronic Equipment Production by Application, 1997



Source: Dataquest (April 1998 Estimates)

Table 6-1
Czech Republic—Semiconductor Consumption by Application, 1994-1997
(Based on Electronic Equipment Production)

Application	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Electronic Data Processing	58.3	84.8	83.9	95.2
Industrial	14.7	25.1	29.1	39.8
Military and Civil Aerospace	4.0	4.7	4.8	5.6
Communications	11.6	16.0	17.0	20.2
Consumer	7.1	8.5	8.9	11.1
Total	**95.7**	**139.1**	**143.9**	**171.9**

Source: Dataquest (April 1998 Estimates)

Table 6-2
Czech Republic—Semiconductor Consumption by Product Category, 1994-1997
(Based on Electronic Equipment Production)

Product Category	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Total Semiconductor	95.7	139.1	143.8	171.9
Total IC	85.5	124.1	127.5	151.3
Bipolar Digital	1.5	2.1	2.2	2.6
MOS Digital	73.5	106.9	109.2	128.7
MOS Memory	30.0	43.5	44.0	51.1
MOS Microcomponent	29.2	42.5	43.6	51.7
MOS Logic	14.4	20.9	21.6	25.9
Analog (Monolithic and Hybrid)	10.5	15.1	16.1	20.1
Total Discrete	7.5	11.2	12.1	15.4
Total Optical Semiconductor	2.7	3.9	4.2	5.2

Source: Dataquest (April 1998 Estimates)

Indigenous Semiconductor Industry

Tesla Sezam in the Czech Republic is possibly the most well-known semiconductor company in the C&EE region. The Roznov-based company has been working with Motorola since 1994 on a foundry basis, producing bipolar analog ICs and transistors solely for the American corporation, which now owns 57 percent of Tesla Sezam. Revenue for 1997 was $15.1 million, which represented an increase of 60 percent over 1996's revenue.

In addition to Tesla Sezam, the Czech Republic is also home to design house ASICentrum, formerly the microelectronic division of Tesla Vust, which was established in 1978. The division's first ASICs were designed in 1986. ASICentrum became a privately owned company and restarted operations in December 1992.

Tesla Vrchlabi was a discrete power semiconductor manufacturer; now in partnership with Optrex, it makes LCDs which are sold worldwide to companies including Lucas, BMW, Philips and Blaupunkt.

EDP Market

In 1997, the EDP application market accounted for 28 percent of Czech electronic equipment production and 55 percent of semiconductor consumption. In line with the other countries in the C&EE region, PC manufacturing in the Czech Republic consists of little more than the final assembly of PC kits shipped primarily from southeast Asia. Within the Czech Republic, local PC manufacturers have the dominant share of the market, shipping 157,400 units, or 62.2 percent of the total market, in 1997.

The major Czech PC manufacturers are AutoCont, Brave and Vikomt, which hold approximately 30 percent of the indigenously produced PC market between them. In addition, Elko provides final assembly for IBM's PC 100 and PC 300 computer ranges, initially set at 1,500 units per month. H&J Computers has a similar final assembly contract with Unysis for approximately 1,000 PCs per month. Table 6-3 shows the split between indigenously manufactured and imported PC shipments, while Table 6-4 shows the top 10 indigenous manufacturers in 1997.

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Table 6-3
Czech Republic—PC Shipments by Source, 1995-1997
(Thousands of Units)

Shipment Source	1995	1996	1997
Indigenous Manufacturers	106.5	132.0	157.4
Import	122.5	120.0	95.7
Total	**229.0**	**252.1**	**253.1**

Source: Dataquest (April 1998 Estimates)

Table 6-4
Czech Republic—Top 10 Indigenous PC Manufacturers, 1997

Ranking	Company	Shipments (K Units)	Indigenous Market Share
1	AutoCont	20.9	14%
2	Brave	12.7	9%
3	Vikomt	8.2	6%
4	Master	6.4	4%
5	Tesco	5.4	4%
6	CS21	4.1	3%
7	ABM	1.7	1%
8	OASA	0.8	1%
9	Multisys	0.1	0%
10	Others	84.6	58%
	Total	**144.9**	**100%**

Source: Dataquest (April 1998 Estimates)

Communications Market

Manufacturing

During the Communist era, the Czech electronics industry suffered from state bureaucracy and a lack of investment. Measures were taken to provide greater independence for these enterprises, known as Tesla, as far back as 1989. These measures were aimed at promoting exports, and the latitude established by the measures were a precursor of later reforms, when a number of joint ventures were established, including the following:

- Tesla Trebohosticka (Research Institute) and Marconi
- Tesla Hloubetin and AT&T (later Lucent Technologies)
- Tesla Karlin and Siemens

The Tesla and Lucent Technologies joint venture distributes telecommunications equipment; Lucent Technologies also holds the majority share in Telenet, a distributor of telecommunications products.

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Siemens has been present in the Czech Republic for more than 100 years. During the past five years, Siemens has invested $150 million, with another $42 million earmarked for investment until the end of the century. Siemens, operating as Tescom with its main base in Prague, employs in excess of 7,500 people at 12 sites. Tescom became a wholly owned subsidiary of Siemens in mid 1994 when the old Tesla units were restructured into regional operating centers. The company faces a major challenge in producing high-quality digital equipment on order to supply the modernization program of SPT, the privatized Czech PTO.

Cellular Telephony

EuroTel Praha provides the Czech Republic with an NMT-450 and a GSM service for which Nokia supplies the infrastructure. EuroTel Praha is 24.5 percent owned by U S WEST and 24.5 percent owned by Bell Atlantic. RadioMobil, which is part owned by DeTeMobil, provides a GSM service with Motorola infrastructure. Table 6-5 shows cellular handset shipments to the Czech Republic.

Table 6-5
Czech Republic—Cellular Handset Shipments, Average Selling Price and Revenue, 1993-2001

	1993	1994	1995	1996	1997	1998	1999	2000	2001
Unit Shipments (K)	6.0	16.0	23.4	148.1	230.9	337.1	468.9	614.7	760.1
Average Selling Price ($)	1,524.7	985.2	935.2	618.8	473.5	381.5	318.7	276.9	248.3
Total Revenue ($M)	9.1	15.8	21.9	91.7	109.3	128.6	149.4	170.2	188.7

Source: Dataquest (April 1998 Estimates)

Consumer Market

The Czech cable television industry is well developed, with a penetration rate of 14 percent and about 580,000 households connected to cable by the end of 1996. Since 1993 a number of small, privately owned cable companies have been building their own networks. The Association of Czech Cable and Telecommunications Network Operators represents the interests of more than 30 of these operators.

The major investor in the Czech cable television industry is U S WEST, which originally purchased a 28.6 percent stake in Cable Plus in May 1995. It raised its interest to 57.5 percent in June 1996, and then increased its stake to nearly 94 percent in October 1996. Cable Plus is the largest cable television operator in C&EE, with some 424,000 customers in September 1996. By April 1997 the number of subscribers had grown to 435,000. Cable Plus has more than 1.6 million homes in its franchise areas in both the Czech Republic and Slovakia. The operator's nearest competitor, Codis, had approximately 55,000 customers at the end of 1996. The next largest competitor is Dattel, which had 15,000 subscribers in January 1997.

The Czech consumer electronics market has had several high-profile inward investments. In 1996, Panasonic created a $66 million subsidiary called Matsushita Television Central Europe s.r.o., which manufactures Panasonic televisions in Pilsen, west Bohemia. Initial production of 300,000 units per year began in 1997; full capacity will be 1 million units per year, requiring 1,500 employees. Denon Consumer Electronics has transferred a $550,000 subassembly facility from Nettetal in Germany to Liberec in north Bohemia.

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Chapter 7
Hungary

Introduction

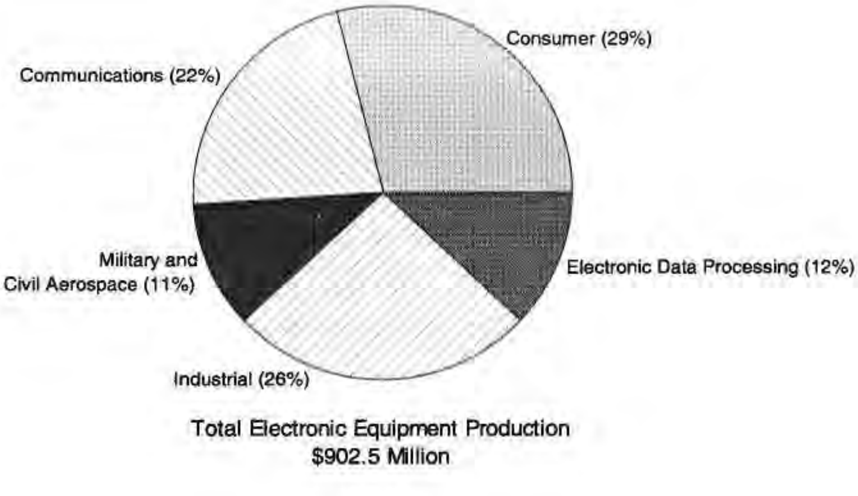
Following the low of 1992, when Hungary experienced many of the problems common to the rest of the region, the country has made a sustained recovery. In many respects Hungary has taken the slow and steady route to free market transformation. Private enterprise's contribution has risen from 58 percent in 1993 through successive increases to 78 percent in 1997, while GDP has grown year on year since 1994 to a projected 4 percent growth rate in 1998, the third-highest in the C&EE region.

Semiconductor Market

The electronic equipment production market of Hungary is only marginally smaller than that of the Czech Republic. In 1997 electronic equipment production grew by 7.5 percent to $902.5 million. During the four years since 1994, total electronic equipment production growth of 52 percent has been recorded against a background of approximately 9 percent GDP growth, indicating that electronic equipment production is a driving force behind Hungary's economic development.

Figure 7-1 shows the breakdown by application category of 1997's electronic equipment production statistics. Similar to the Czech Republic, industrial goods form a substantial part of manufacturing output, while EDP plays an unusually small role in the country's production output. Tables 7-1 and 7-2 show the resultant semiconductor consumption by application market and device category.

Figure 7-1
Hungary—Electronic Equipment Production by Application, 1997



Source: Dataquest (April 1998 Estimates)

Table 7-1
Hungary—Semiconductor Consumption by Application, 1994-1997 (Based on Electronic Equipment Production)

Application	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Electronic Data Processing	24.4	35.9	35.7	38.4
Industrial	18.4	25.1	23.7	26.1
Military and Civil Aerospace	2.5	3.6	3.9	4.6
Communications	23.3	28.8	28.0	30.3
Consumer	17.1	35.6	37.0	42.9
Total	**85.7**	**129.1**	**128.3**	**142.4**

Source: Dataquest (April 1998 Estimates)

Table 7-2
Hungary—Semiconductor Consumption by Product Category, 1994-1997
(Based on Electronic Equipment Production)

Product Category	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Total Semiconductor	85.7	129.1	128.3	142.3
Total IC	72.5	108.5	107.8	119.3
Bipolar Digital	0.9	1.3	1.3	1.5
MOS Digital	57.2	84.2	83.5	92.0
MOS Memory	20.2	29.6	29.4	32.2
MOS Microcomponent	23.3	34.8	34.5	38.1
MOS Logic	13.7	19.9	19.6	21.7
Analog (Monolithic and Hybrid)	14.4	22.9	22.9	25.8
Total Discrete	9.8	15.2	15.1	16.9
Total Optical Semiconductor	3.4	5.4	5.4	6.1

Source: Dataquest (April 1998 Estimates)

Indigenous Semiconductor Industry

Melcom and Intermos Microelectronics, both based in Budapest, represent the semiconductor industry of Hungary. Melcom started in 1970, manufacturing power transistors. Melcom's revenue of approximately $110,000 is generated primarily by sales in Hungary and Romania; the company also carried out assembly, test and packaging operations for TEMIC, with which it worked closely.

EDP Market

In 1997, the EDP segment accounts for 12 percent, or $109 million, of the Hungarian electronic equipment production market. The leading Hungarian PC companies are Albacomp and Muszertechnika, which hold almost 40 percent of the indigenous PC market between them, and almost 20 percent of the entire PC market in Hungary.

Albacomp was established in 1985 by the staff of Videoton Holding. In 1996, Albacomp employed 150 staff and had a $2.4 million revenue. Muszertechnika was established in 1981. A trading group with nearly two dozen companies, Muszertechnika's turnover in 1996 was $35 million.

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The Hungarian PC market grew by 13 percent in 1997 to $140.2 million. Indigenous manufacturers held marginally more than 50 percent of the market, 3 percent lower than their market share in 1996. With the exception of the top two indigenous vendors, Hungarian manufacturers held only small market shares; only one other company—Ready Computers—exceeded 2,000 unit shipments in 1997. Table 7-3 shows the split between indigenous and import-based shipments; Table 7-4 ranks the top 10 indigenous PC manufacturers in 1997.

Table 7-3
Hungary—PC Shipments by Source, 1995-1997
(Thousands of Units)

Shipment Source	1995	1996	1997
Indigenous Manufacturers	52.8	70.0	74.4
Import	59.4	53.9	65.8
Total	**112.2**	**123.9**	**140.2**

Source: Dataquest (April 1998 Estimates)

Table 7-4
Hungary—Top 10 Indigenous PC Manufacturers, 1997

Ranking	Company	Shipments (K Units)	Indigenous Market Share
1	Albacomp	16.5	23%
2	Muszertechnika	11.0	15%
3	Ready Computers	2.1	3%
4	Elender	2.0	3%
5	Fefo	2.0	3%
6	Fan	1.7	2%
7	Lap	1.2	2%
8	Escom	1.2	2%
9	Portocom	1.0	1%
10	Others	32.0	45%
	Total	**70.7**	**100%**

Source: Dataquest (April 1998 Estimates)

One of the most significant foreign investors in Hungary is IBM, which launched production of hard drives in its Szekesfehervar factory in 1995. The factory's turnover in 1996 was $300 million, making IBM Storage Products Ipari Vamszabadterulet Kft. the ninth-largest domestic company in Hungary.

Nokia started assembling monitors in Pecs in 1996. Initial annual production was 100,000 units; in 1997 an increase to 500,000 units was planned. Nokia's initial investment to purchase the incumbent Hantarex Monitorgyar company was $30 million.

In 1997 Philips commenced production at its new $20 million monitor assembly factory in Szombathely. Initial plans were for 1 million units per year.

SCI Systems Inc. plans to build a 9,000 m^2 factory in Tatbanya. The $5.8 million plant will produce electronic goods for the Hungarian market, Central and Western Europe.

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Communications Market

Manufacturing

Siemens has invested $41 million in a wholly owned subsidiary, Siemens Telefongyar, based in Budapest, which has been producing switching and transmission equipment since October 1992. Siemens also has a cable-manufacturing joint venture that operates under the name of Dunakabel.

Ericsson Technika is a joint venture between Ericsson and the Hungarian company Muszertechnika that manufactures telephone exchanges. Ericsson has delivered more than one million AXE lines to Hungary, gaining the vendor approximately 45 percent of the market.

AHT Communications Ltd. is a Budapest-based joint venture founded in 1990 to manufacture Alcatel business telephone exchanges. Alcatel owns 96.23 percent and Comex owns 3.77 percent of the company. Nortel also has a local operation in Hungary.

Siemens and Ericsson dominate the fixed line telecommunications market on the basis of a five-year supply contract with Matav that ended in 1996. The two vendors will continue to dominate the market as only their equipment type has the requisite approvals.

The vendors that set up local companies have positioned themselves strategically so that they would be able to meet the requirements placed on operators by their concession agreements which stipulate that in the future an increasing proportion of new telecommunications infrastructure has to be supplied by local vendors. Matav already claims to source 50 percent of its equipment requirements in Hungary.

Cellular Telephony

Westel, which is 49 percent owned by U S WEST, provides Hungary with NMT-450 and GSM services. Infrastructure for these is supplied by Nokia, Motorola and Ericsson. Pannon GSM's infrastructure is supplied by Nokia. Table 7-5 shows handset shipments to Hungary between 1993 and 2001.

Table 7-5
Hungary—Cellular Handset Shipments, Average Selling Price and Revenue, 1993-2001

	1993	1994	1995	1996	1997	1998	1999	2000	2001
Unit Shipments (K)	18.9	102.3	144.4	231.8	279.0	363.1	469.3	592.6	741.2
Average Selling Price ($)	1,280.4	852.5	689.4	512.6	404.8	337.8	291.3	260.7	239.7
Total Revenue ($M)	24.2	87.2	99.6	118.8	112.9	122.7	136.7	154.5	177.7

Source: Dataquest (April 1998 Estimates)

Consumer Market

The Hungarian cable television industry is among the most advanced in C&EE. The market is served by about 200 cable operators, some of which are also program providers. One of the more active operators is Kabelkom, a joint venture between Time Warner and United Communications International. Kabelkom rapidly entered into joint ventures with operators in nine Hungarian cities, one of which was with Monor Group Telecom to implement a pilot cable television/telephony project in the town of Monor. In October 1996 this joint venture, called Monor Telefon Tarsasag (MTT), offered services to about 38,000 households. By the end of 1996, investment into this network totaled $90 million. MTT expects to have 40,000 cable subscribers and 80,000 telephone lines by 2000.

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Chapter 8
Poland

Introduction

Poland is the largest of the transitional economies in Central Europe and is second only to Russia in the C&EE region. Since 1992, Poland has consistently shown one of the highest GDP growth rates of any of the transitional economies, growth that is set to continue at more than 5 percent per annum into 2000. However, Poland also has endured consistently above-average inflation rates. The present economic environment is characterized by expanding growth with no related reduction in unemployment, which stood at 10.6 percent in September 1997. Consumer consumption is increasing, fueled by real wage growth and a widening trade deficit, which approached 4 percent of GDP in the first half of 1997. The Polish economy is very close to overheating.

Semiconductor Market

The Polish electronic equipment production market is by far the largest in Central Europe. At almost $2 billion in 1997, it was larger than the combined electronic equipment production output of the Czech Republic and Hungary, and two-thirds of Russia's output.

The three major application markets are EDP, communications and the consumer sector. The EDP market, which is dominated by indigenous manufacturers, accounted for almost 53 percent of semiconductor consumption in 1997, while the communications market accounted for approximately 18 percent.

All aspects of the Polish electronic equipment manufacturing industry are more commercially developed than their C&EE counterparts. For example, in the Polish telecommunications market, the government has only offered type approval to those non-C&EE companies that have invested in local manufacturing companies. This may be seen as protectionist, but it has ensured the survival of the local manufacturing base. Figure 8-1 shows the Polish electronic equipment manufacturing industry broken down by industry, while Tables 8-1 and 8-2 show semiconductor consumption by application and device category respectively.

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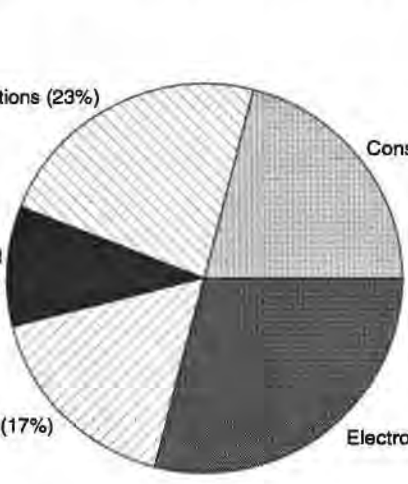
Figure 8-1
Poland—Electronic Equipment Production by Application, 1997



Source: Dataquest (April 1998 Estimates)

Table 8-1
Poland—Semiconductor Consumption by Application, 1994-1997
(Based on Electronic Equipment Production)

Application	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Electronic Data Processing	70.3	133.2	154.3	205.2
Industrial	20.9	31.1	31.2	36.6
Military and Civil Aerospace	5.0	6.8	7.6	9.2
Communications	32.9	54.4	60.4	69.9
Consumer	39.4	54.2	57.0	68.1
Total	**168.5**	**279.7**	**310.5**	**389.1**

Source: Dataquest (April 1998 Estimates)

Table 8-2
Poland—Semiconductor Consumption by Product Category, 1994-1997
(Based on Electronic Equipment Production)

Product Category	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Total Semiconductor	168.5	279.6	310.4	389.0
Total IC	145.8	245.0	273.3	344.2
Bipolar Digital	2.0	3.4	3.8	4.9
MOS Digital	118.0	202.4	227.2	288.2
MOS Memory	44.6	78.5	88.9	114.2
MOS Microcomponent	47.8	81.3	90.9	115.1
MOS Logic	25.6	42.6	47.4	58.9
Analog (Monolithic and Hybrid)	25.8	39.3	42.3	51.1
Total Discrete	16.5	25.1	26.9	32.4
Total Optical Semiconductor	6.2	9.5	10.2	12.4

Source: Dataquest (April 1998 Estimates)

Indigenous Semiconductor Industry

Poland has two semiconductor manufacturing companies—ITE and Lamina Semiconductor International. ITE has a 3-micron plant capable of CMOS ASIC manufacture. Data on Lamina Semiconductor International is not yet available. The Institute of Electron Technology in Warsaw has set up an ASIC design center which participates in the Eurochip consortium.

EDP Market

Like many other aspects of the Polish economy, the Polish PC market is the second-largest in the C&EE region, behind only Russia. Russia is also the only market which is more dominated by indigenous manufacturers; in the Polish PC market, indigenous manufacturers accounted for more than 70 percent of 1997's shipments.

The largest local player was Optimus which held 26 percent of the indigenous PC market and more than 18 percent of the total market. The nearest local competitors were JTT and NTT, which each held 8 percent of the indigenous PC market and 6 percent of the total market. Tables 8-3 and 8-4 provide details of shipment origin and indigenous market ranking.

Table 8-3
Poland—PC Shipments by Source, 1995-1997
(Thousands of Units)

Shipment Source	1995	1996	1997
Indigenous Manufacturers	215.3	307.2	409.5
Import	112.7	138.8	140.2
Total	**328.0**	**446.1**	**549.7**

Source: Dataquest (April 1998 Estimates)

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Table 8-4
Poland—Top 10 Indigenous PC Manufacturers, 1997

Ranking	Company	Shipments (K Units)	Indigenous Market Share
1	Optimus	101.2	26%
2	JTT	32.7	8%
3	NTT	32.5	8%
4	Baza	14.9	4%
5	Brave	12.7	3%
6	MSD	9.0	2%
7	Gulipin	6.4	2%
8	California Access	4.6	1%
9	Aristo	1.4	0%
10	Others	177.3	45%
	Total	**392.8**	**100%**

Source: Dataquest (April 1998 Estimates)

Communications Market

Manufacturing

In October 1992, AT&T (later Lucent Technologies) acquired Telfa, Poland's only digital exchange manufacturer, and has since brought the company's two manufacturing sites up to international manufacturing standard. Future plans envision the manufacturing of Lucent Technologies 5ESS switches. The company has been present in the Polish market since 1992 and is Poland's main switch manufacturer. Recently, it has further expanded its operation to five main subsidiaries.

In 1993, the Polish government awarded the sale of four out of five state-owned Polish telecommunications equipment manufacturers to Alcatel Alsthom and Siemens. In this way, these two companies joined Lucent Technologies as Poland's major equipment suppliers, with a virtual guarantee of all government business for the next few years.

Alcatel has been present in the Polish market for 20 years and in 1990 established its first two joint ventures. In March 1993 Alcatel SESA acquired Teletra and PZT Telekom, which were both profitable operations. Alcatel plans to retool the companies for the production of Alcatel 1000 and S-12 switches.

Siemens has been operating in the Polish market since the mid 1980s, and in 1991 entered into a joint venture. Initially $1.5 million was invested to upgrade local manufacturing capacities and a new plant began operation in 1993. CEWIS, a joint venture between Siemens and the Warsaw-based PBX manufacturer ZWUT, produces Siemens EWSD Switches. ZWUT also has supply agreements with Samsung and Italtel.

Alcatel, Lucent Technologies and Siemens are the only manufacturers to gain full type approval as switch manufacturers. According to the Polish ministry of communication's proposals, the current exclusivity accorded to these foreign suppliers to the Polish market may be extended for another three years.

Other joint ventures include: DTS-ZWUT, a joint venture between ZWUT and US-based Arnica that manufactures and sells PBXs; Nortel Elwro is a joint venture which manufactures DMS-10 central office switches; the company has a capacity of up to 50,000 lines per year. Kapsch, the Nortel Austrian licensee, also collaborated with Elwro to produce the ADS-100 product.

Cellular Telephony

Poland's GSM services are provided by Polska Telefonia (which is part-owned by U S WEST and DeTeMobil) and Polkomtel (which is part-owned by Tele Danmark and Air Touch Communications). Ericsson and Nokia supply the infrastructure for these services. In addition, Centertel offers an NMT-450 service, for which Nokia, Alcatel and Ericsson provide the infrastructure. Table 8-5 shows handset shipments to Poland.

Table 8-5
Poland—Cellular Handset Shipments, Average Selling Price and Revenue, 1993-2001

	1993	1994	1995	1996	1997	1998	1999	2000	2001
Unit Shipments (K)	10.5	28.3	42.1	164.2	356.9	577.5	887.5	1,326.5	1,899.9
Average Selling Price ($)	1,586.1	1,118.7	1,031.2	688.4	493.7	377.1	309.9	269.2	243.7
Total Revenue ($M)	16.7	31.7	43.4	113.0	176.2	217.8	275.0	357.1	462.9

Source: Dataquest (April 1998 Estimates)

Consumer Market

Poland ended 1996 with the most developed and competitive cable television market in C&EE, with some 2.35 million subscribers. Poland's largest cable operator, with approximately 350,000 subscribers nationally at the end of 1996, is PTK, which was launched in 1990. PTK is planning to enter the cable telephony market. Its position has been strengthened by an $8 million credit from overseas agencies in 1995, a $63 million investment from the equity firm Advent International and a corporate bond issue of $130 million in early 1996. PTK's biggest rivals are Porion and Aster City, both in Warsaw, Gosat in Wroclaw, and Dami in Radom, all of which had a combined subscriber base of 340,000 in November 1996.

Thomson Consumer Electronics has invested $35 million in 51 percent of Polkolor Piaseczno to manufacture television sets, while US-based Curtis has invested in a television set production plant in Mlawa.

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Chapter 9

Romania

Introduction

In Romania, 1998 is expected to be a year of recovery after a year of macroeconomic deterioration. Inflation in March 1997 stood at 31 percent per month; by October it had fallen to 6.5 percent. For 1998, an annual inflation rate of 145 percent is forecast, despite the government's attempts at economic "shock therapy." Industrial output for 1997 fell 1.5 percent, although this is expected to be regained in 1998.

A significant amount of Romanian industry is still in state hands, and 74 percent of industrial GDP was generated by the state in 1997. Although unemployment is still relatively low, this is because a large number of state-owned enterprises remain unrestructured, and increasing unemployment is expected as restructuring commences.

Semiconductor Market

The Romanian electronic equipment production market is less than half the size of the Czech market or the Hungarian market. This is primarily because of a small EDP sector and almost nonexistent communications sector. Despite the economic difficulties Romania has experienced, electronic equipment production has continued to grow. In 1997, the market was $433 million, achieving 14 percent growth over 1996. Since 1994, electronic equipment production has grown by almost 50 percent. Semiconductor consumption has grown even faster: related semiconductor consumption grew by 22 percent in 1997 and has grown by 75 percent since 1994. This is largely thanks to the indigenous EDP sector, which, although small, grew by more than 30 percent in 1997—the fastest growth rate for any semiconductor application segment in Romania. Figure 9-1 shows Romanian electronic equipment production broken down by industry application; Tables 9-1 and 9-2 show semiconductor consumption by application and device category respectively.

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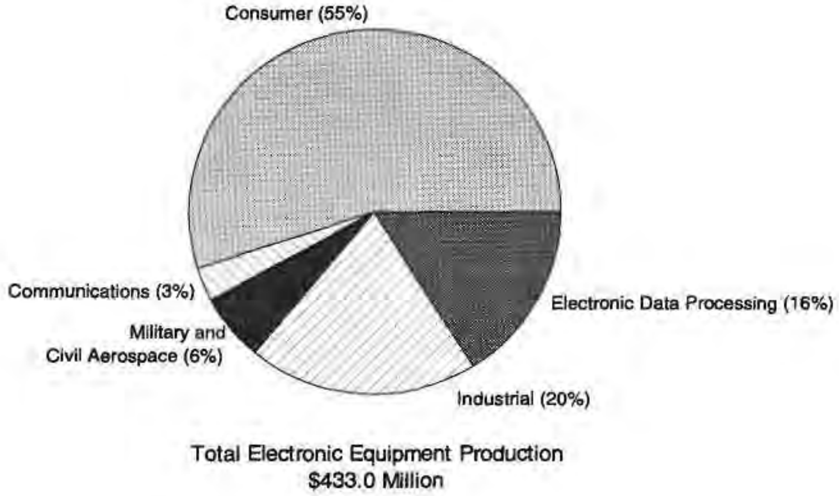
Figure 9-1
Romania—Electronic Equipment Production by Application, 1997



Source: Dataquest (April 1998 Estimates)

Table 9-1
Romania—Semiconductor Consumption by Application, 1994-1997
(Based on Electronic Equipment Production)

Application	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Electronic Data Processing	11.7	18.5	19.0	24.6
Industrial	7.2	8.9	8.5	9.6
Military and Civil Aerospace	0.9	1.1	1.2	1.3
Communications	1.1	1.6	1.6	1.8
Consumer	22.8	30.2	32.0	38.9
Total	**43.7**	**60.3**	**62.3**	**76.3**

Source: Dataquest (April 1998 Estimates)

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Table 9-2
Romania—Semiconductor Consumption by Product Category, 1994-1997 (Based on Electronic Equipment Production)

Product Category	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Total Semiconductor	43.7	60.3	62.3	76.3
Total IC	35.8	49.9	51.5	63.3
Bipolar Digital	0.4	0.6	0.6	0.8
MOS Digital	26.3	37.3	38.4	47.5
MOS Memory	9.0	13.2	13.5	16.9
MOS Microcomponent	11.5	16.1	16.6	20.5
MOS Logic	5.8	8.0	8.2	10.1
Analog (Monolithic and Hybrid)	9.0	12.0	12.5	15.1
Total Discrete	5.8	7.6	7.9	9.4
Total Optical Semiconductor	2.1	2.8	2.9	3.6

Source: Dataquest (April 1998 Estimates)

Indigenous Semiconductor Industry

Romania has three principal semiconductor manufacturing companies: Baneasa SA, Romes SA and Microelectronica SA.

Baneasa SA, the largest of the three companies, is primarily a supplier of discrete devices to the automotive and consumer market segments. The company achieved revenue totaling $6.7 million in 1997, which was 17 percent higher than in 1996. Of 1997's revenue, 43 percent originated from outside the C&EE region, compared with 39 percent from outside C&EE in 1996.

Romes SA, the second-largest semiconductor company in Romania, also produces discrete and optical semiconductors. Its revenue in 1997 was $190,000, which represented an increase of 31 percent over 1996's revenue. Approximately 80 percent of the company's revenue is generated within the Romanian marketplace, while the remainder comes from sales to companies in Germany, Holland and Belgium.

Revenue data is not available for Microelectronica SA, which has CMOS capabilities and also produces optoelectronics.

EDP Market

Although the Romanian PC market is one of the less significant PC markets in C&EE, indigenous PC manufacturers are performing well in their market. In 1997 Romanian PC manufacturers raised their market share by 5 percent to 60 percent of the total PC market, and shipped more units in the Romanian market than their indigenous counterparts in the Slovakian market, even though the total Slovakian PC market is 17 percent larger. Table 9-3 shows indigenous PC manufacturer market share in Romania, while Table 9-4 ranks the country's largest PC manufacturers.

Table 9-3
Romania—PC Shipments by Source, 1995-1997 (Thousands of Units)

Shipment Source	1995	1996	1997
Indigenous Manufacturers	22.5	29.5	31.0
Import	23.1	24.8	21.0
Total	**45.5**	**54.3**	**52.0**

Source: Dataquest (April 1998 Estimates)

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Table 9-4
Romania—Top 10 Indigenous PC Manufacturers, 1996

Ranking	Company	Shipments (K Units)	Indigenous Market Share
1	PGA	6.2	21%
2	Starsoft	5.3	18%
3	KT Technology	3.8	13%
4	Flamingo	2.8	10%
5	BB Computers	1.4	5%
6	MBL Computerland	1.4	5%
7	Escort	0.6	2%
8	Others	8.0	27%
	Total	**29.5**	**100%**

Source: Dataquest (April 1998 Estimates)

Communications Market

Manufacturing

Telecommunications equipment production is moving slowly from the state toward the private sector. At present, the largest enterprises are the joint ventures between Rom Telecom and foreign investors. Electromagnetica, the dominant manufacturer, produces the majority of Romanian telecommunications equipment. In conjunction with Siemens and Gold Star, the company's Emcom and Gold Star Electromagnetica joint ventures are changing production from electromechanical Pentaconta switches to digital systems.

Alcatel Network Systems Romania is another major joint-venture supplier. The company, which manufactures E10B exchanges, has Alcatel CIT as its main shareholder (51 percent), as well as IFC (10 percent), and the Romanian-based Data Tim (32 percent), Rom Telecom (6 percent), IIRUC (1 percent) and Promotion Group Romania (1 percent).

Emcom manufactures EWSD switches. Siemens is its main shareholder; the remaining shareholders are the EBRD, Electromagnetica and Rom Telecom.

Cellular Telephony

Romania's only GSM operator is Mobifon, which uses infrastructure provided by Ericsson. Telefónica Romania offers an NMT-450 service, for which Ericsson again provides the infrastructure. Table 9-5 shows statistics for handset shipments in Romania.

Table 9-5
Romania—Cellular Handset Shipments, Average Selling Price and Revenue, 1993-2001

	1993	1994	1995	1996	1997	1998	1999	2000	2001
Unit Shipments (K)	0.7	2.3	6.2	11.1	23.0	38.8	75.7	137.8	241.6
Average Selling Price ($)	1,820.4	1,415.9	1,258.7	1,061.3	683.2	479.0	381.7	326.7	294.3
Total Revenue ($M)	1.3	3.3	7.8	11.8	15.7	18.6	28.9	45.0	71.1

Source: Dataquest (April 1998 Estimates)

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Chapter 10
Russia

Introduction

Russia appears to be turning the economic corner. Year-on-year industrial output stopped falling for the first time since the collapse of the Soviet Union, increasing by 0.5 percent in 1997 and is set to increase by 3 percent in 1998. However, investment in the Russian economy continues to fall, which could hold serious problems for future GDP growth. In the first nine months of 1997, investment in the Russian economy fell by 7.1 percent compared with 1996's level.

Inflation was brought under control in 1997. Inflation in 1994 was 214 percent, by 1996 it had been reduced to 22 percent and in 1997 the figure was almost halved to 14 percent. Projections for 1998 show a slight rise to 17 percent because of the effects of increasing GDP on consumer demand. Foreign direct investment also has remained stubbornly low in Russia—less than 1 percent of GDP, apart from modest increases in 1996 and early 1997.

An interesting feature of the Russian transitional economy is the emergence of barter as a method of trading within industry. Although not very common in the rest of C&EE, it is now widespread in Russia. The EBRD estimates that as much as 40 percent of industrial sales are by way of barter. This is a problem for Russia in several respects: most barter transactions end up as part of the unofficial economy and therefore detract from tax revenue, which is already insufficient to cover public expenditure and is poorly administered and collected. Barter prevents the development of credit and capital markets, and, because it is a method of trade that most Western enterprises will not entertain, the prevalence of barter in the economy could be a cause of the low levels of foreign direct investment.

Semiconductor Market

Despite the continuous decline in Russia's GDP until 1997, the electronic equipment production market has been one of the factors driving economic recovery. Although the electronics industry virtually collapsed in 1992, by 1994 it had recovered to $2.3 billion. In 1997 the electronic equipment production market had grown to $3.1 billion, having achieved growth of 20 percent over 1996 and total growth of 36 percent since 1994.

Given the sheer size of Russia it is unsurprising that it has the largest electronic equipment production market in the C&EE region. Russia accounted for 38 percent of the C&EE region's electronic equipment production output in 1997. In terms of semiconductor consumption, Russia consumed 43 percent of the semiconductors used in C&EE in 1997.

The PC market is the dominant driver of the Russian electronic equipment market. In 1997, Russia accounted for 41 percent of the total C&EE PC market and 42 percent of all PCs manufactured in the C&EE region. In 1997, the Russian EDP market manufactured goods worth $1.7 billion—56 percent of total electronic equipment production in the country. This was 39 percent more than was produced in 1996 and 121 percent more than in 1994. Figure 10-1 shows electronic equipment production broken down by industry application, while Tables 10-1 and 10-2 show semiconductor consumption by application and device category respectively.

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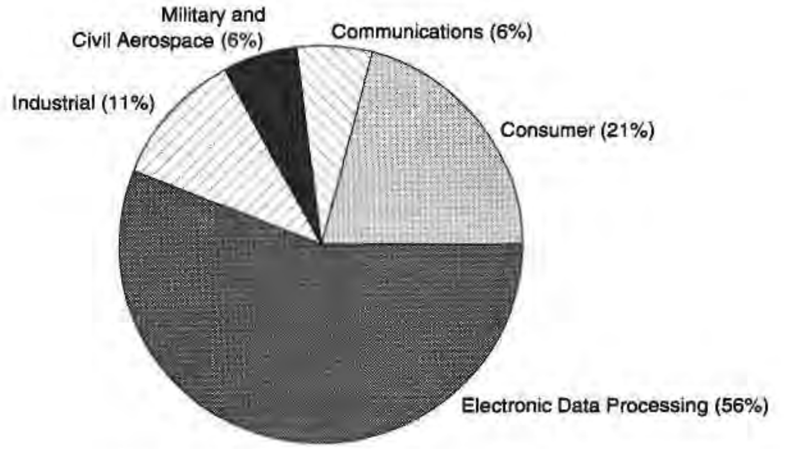
Figure 10-1
Russia—Electronic Equipment Production by Application, 1997



Total Electronic Equipment Production
$3,074.2 Million

Source: Dataquest (April 1998 Estimates)

Table 10-1
Russia—Semiconductor Consumption by Application, 1994-1997
(Based on Electronic Equipment Production)

Application	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Electronic Data Processing	289.4	414.8	449.6	599.3
Industrial	36.4	41.9	36.5	38.0
Military and Civil Aerospace	11.5	10.4	8.7	9.1
Communications	34.3	33.6	28.6	28.9
Consumer	89.8	95.5	92.5	105.7
Total	**461.3**	**596.2**	**615.8**	**781.1**

Source: Dataquest (April 1998 Estimates)

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Table 10-2
Russia—Semiconductor Consumption by Product Category, 1994-1997 (Based on Electronic Equipment Production)

Product Category	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Total Semiconductor	461.3	596.1	615.8	781.0
Total IC	412.1	539.1	560.3	715.4
Bipolar Digital	6.5	8.7	9.1	11.8
MOS Digital	350.2	466.7	489.0	630.1
MOS Memory	143.9	196.0	207.6	270.5
MOS Microcomponent	140.4	186.2	194.7	250.1
MOS Logic	65.8	84.4	86.7	109.5
Analog (Monolithic and Hybrid)	55.4	63.7	62.2	73.5
Total Discrete	35.4	41.0	39.7	46.7
Total Optical Semiconductor	13.7	16.1	15.8	18.9

Source: Dataquest (April 1998 Estimates)

Indigenous Semiconductor Industry

Mikron JSC

Mikron JSC, based in Zelenograd, is Russia's largest semiconductor company, and was founded in March 1964. Upon privatization it inherited the state's national microelectronics research center, which became its R&D facility. Mikron JSC currently manufactures primarily bipolar digital components, SRAM and ASIC devices with up to 500,000 gates, along with MOS digital logic and discrete products.

Mikron JSC recently completed a new fabrication plant with Hong Kong's Hua Ko Electronics for the production of 0.8-micron CMOS technology on 6-inch wafers. Production is being brought online with a monthly capacity of 10,000 wafers per month. The company is planning to develop an 0.5-micron, 8-inch wafer fabrication plant which would ramp up to volume production in 2000. The investment for this project is estimated at $250 million, in addition to the $60 million spent on the first plant.

In 1997, more than 90 percent of Mikron JSC's revenue was generated outside the C&EE region. China/Hong Kong is the company's primary market; the United States accounted for a significant 28.5 percent of revenue in 1997.

Within the C&EE region, Mikron JSC's two largest markets are Ukraine and Belarus. However, this may change during 1998: Sistema, Mikron JSC's parent group, has entered a joint venture with Ericsson to produce base stations, and Mikron JSC will be designing some of its components into the system.

Angstrem

Angstrem is Russia's second-largest semiconductor company. Angstrem is based in Zelenograd too, and also faced a complete loss of its marketplace in 1992, when the Russian electronics industry faced a crisis of meltdown proportions. Since then, Angstrem has made a remarkable recovery and now conducts most of its business—8-bit and 16-bit microcontroller products—in southeast Asia.

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Angstrem has two fully operational wafer fabrication plants: a 1.5-micron, 4-inch CMOS technology facility with capacity for 30,000 wafers per month, and a 1-micron, 6-inch wafer plant producing 3,000 wafers per month. The second fabrication plant is being ramped up to a capacity of 12,000 wafer starts per month with geometries reduced to 0.8 micron. In addition, Meistner & Wurst has recently completed a new plant for Angstrem, which will handle 20,000 8-inch wafer starts per month with a geometry of 0.5 microns.

Angstrem's microcontroller product lines are shipped primarily to southeast Asia, which accounted for approximately $20 million of the company's revenue in 1997.

VZPP

Unlike Mikron JSC and Angstrem, VZPP's main semiconductor market is the C&EE region. VZPP had total sales of $8.3 million in 1997, down significantly on 1996's level of $10.3 million. In 1997 only 7 percent of the company's sales originated outside the C&EE region.

Within the C&EE region, VZPP exports to seven countries, making it the most significant indigenous company in the region. Sales within Russia were $6.1 million in 1997, down from $7.5 million in 1996.

VZPP's primary product offerings are in the discrete category, mostly power related, and accounted for slightly more than half of its 1997 revenues. In addition, VZPP gained significant amounts of its revenue from bipolar digital products, as well as approximately $500,000 from MOS digital product offerings. As would be expected from a manufacturer of discrete products, VZPP's sales fall into most application categories, with EDP representing its smallest market.

Elex

Russia's fourth-largest semiconductor company is Elex, based in Alexandrov in the Vladimir region. Elex manufactures analog and discrete semiconductors, gaining $526,000 of revenue in 1997—a fall of 24 percent over 1996's level of $690,000. The major reason for the fall in revenue was a loss of market in Western Europe and the C&EE region. To compensate for the decline, Elex raised its exports to China/Hong Kong by 45 percent to $234,000 in 1997; exports to Singapore and Taiwan also grew, increasing to $143,000.

Other Companies

Of the surviving semiconductor companies in Russia, Dataquest believes the following are the most economically active:

- Komponent Plant
- Kremniy Group JSC
- R&PA Electronic Device Manufacturer

EDP Market

The PC market has been the driver of the growing level of electronic equipment production in Russia. In 1997, the EDP market accounted for 55 percent of electronic equipment production; the increase over 1996's figure of 48 percent indicates the growing importance of EDP to the electronic equipment production market.

The Russian PC market is dominated by indigenous manufacturers. In 1997 local manufacturers held 78 percent of the total market; this was a 4 percent increase over 1996's figure. The PC market has been growing at a consistent rate of about 20 percent for the past four years; in 1997 the market grew by 21 percent.

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Vist is the dominant Russian PC vendor, holding 24 percent of the indigenous market and 19 percent of the total Russian PC market. R&K and Formosa are other major local manufacturers that each hold a share of more than 10 percent of the locally produced market. Table 10-3 shows indigenous and total market shipments between 1995 and 1997, while Table 10-4 ranks Russia's largest PC manufacturers.

Table 10-3
Russia—PC Shipments by Source, 1995-1997
(Thousands of Units)

Shipment Source	1995	1996	1997
Indigenous Manufacturers	699.1	886.0	1,139.1
Import	306.9	319.5	325.1
Total	**1,006.0**	**1,205.5**	**1,464.2**

Source: Dataquest (April 1998 Estimates)

Table 10-4
Russia—Top 10 Indigenous PC Manufacturers, 1997

Ranking	Company	Shipments (K Units)	Indigenous Market Share
1	Vist	275.3	24%
2	R&K	187.2	16%
3	Formoza	115.1	10%
4	CLR	33.5	3%
5	R-Style	29.3	3%
6	IVK	20.4	2%
7	Kami	19.9	2%
8	Kraftway	17.7	2%
9	Klondike	9.4	1%
10	Others	438.4	38%
	Total	**1,146.2**	**100%**

Source: Dataquest (April 1998 Estimates)

Communications Market

Manufacturing

Siemens has two joint ventures in Russia—Izhtel and Kamatel. Izhtel commissioned production of EWSD exchange systems in Izhevsk in September 1995, and Kamatel began manufacturing transmission systems in Perm in 1994.

Ericsson launched two joint-venture manufacturing projects in 1998. Ericsson Svyaz will be producing Ericsson's DRA 1900 products for radio access to fixed telephone lines in conjunction with Nitel, a former television manufacturer, in Nizhny Novgorod. In addition, Ericsson recently struck a deal with Sistema, to build Siemens AXE 10 products in Zelenograd. It is believed that this production, rather than being merely assembly-based, will include local content in the form of Russian semiconductors on Russian PCBs.

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Alcatel established a joint venture in St. Petersburg in 1991, and has been gradually integrating the manufacturing process into the plant. In April 1998 the factory will start assembling line boards with imported semiconductors for use in the digital exchange equipment assembled there.

Lucent Technologies began manufacturing 5ESS digital switches in St. Petersburg in 1997, in a joint venture with LONIIS, the Leningrad Research and Development Institute in Telecommunications.

Cellular Telephony

In 1996, there were about 120 cellular operators in the Russian Federation. Cellular communications networks have been launched in most Russian regions, although the largest numbers of users are concentrated in Moscow and St. Petersburg. NMT-450 and GSM were chosen by the Ministry of Communications as Russia's federal standards, although there are several standards in operation including GSM, NMT-450, AMPS/D-AMPS, PCS and the old 300-MHz Altai system.

The five major cellular communications players are VimpelCom, Moscow Cellular Communications (MCC), Delta Telecom, North-West GSM and Mobile TeleSystems. Ericsson provides VimpelCom with AMPS/D-AMPS infrastructure in the Moscow region. MCC's infrastructure consists of Nokia base stations and Ericsson switches. North-West GSM uses only Nokia infrastructure.

Table 10-5 gives details of cellular handset shipments to Russia.

Table 10-5
Russia—Cellular Handset Shipments, Average Selling Price and Revenue, 1993-2001

	1993	1994	1995	1996	1997	1998	1999	2000	2001
Unit Shipments (K)	4.3	16.0	79.7	131.0	288.4	569.6	1,004.6	1,657.2	2,571.5
Average Selling Price ($)	1,523.4	1,222.1	1,001.2	805.4	549.4	421.4	345.2	298.0	266.5
Total Revenue ($M)	6.6	19.6	79.8	105.5	158.5	240.0	346.8	493.9	685.3

Source: Dataquest (April 1998 Estimates)

Consumer Market

The Russian cable access industry is highly fragmented. The majority of existing networks are set up for one-way broadcast of television signals and offer only a limited number of channels.

The largest cable operator is Kosmos TV, which was established as a joint venture between Metromedia and General Center for Radio and Television. At the beginning of 1996, the operator had 1,500 subscribers in Moscow and several Moscow suburbs.

Cable services in Moscow, which have a potential audience of more than 6 million, first appeared in 1990. By 1995 there were more than 80 small cable television networks in Moscow, which in November 1995 were united into a single network called Moscow Municipal Cable Television.

Mosteletechnic, the principal contractor of the Moscow city government, has several plans for building up the network, including the building of a two-way cable television network for 105,000 subscribers. Once completed, the network's capacity will be leased out to local operators, which then will be able to use it to provide cable telephony.

Chapter 11
Slovakia

Introduction

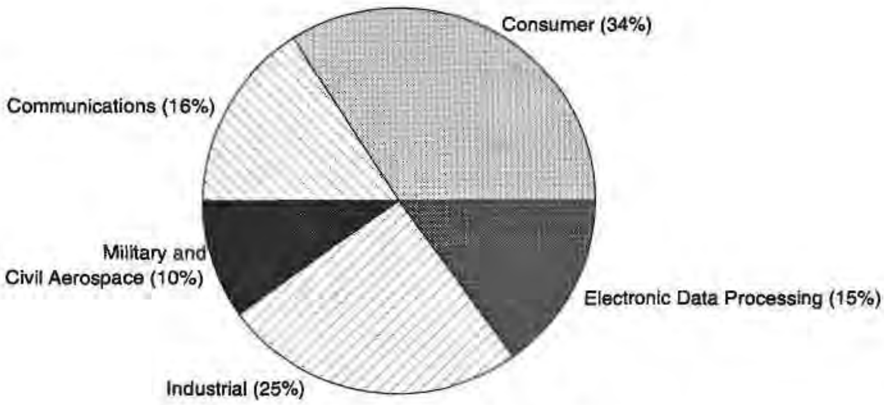
GDP growth in Slovakia continued at a robust 4.5 percent in 1997, although this is less than the 6.9 percent growth recorded in 1996. Domestic demand, underpinned by strong growth in real wages, has been the driving factor of increasing GDP. There are major doubts about the sustainability of Slovakia's growth; the principal problems are the current-account deficit of approximately 10 percent of GDP, which is funded largely by short-term capital inflows, and the fiscal deficit, which expanded significantly during 1997. Interest rates have increased sharply as the government tries to tackle these problems, raising concerns about the ability of enterprises to finance investment and restructuring.

Privatization has proceeded quickly in Slovakia. The private sector accounts for approximately 77 percent of GDP and 70 percent of industrial output, 4 percent higher than 1996's figures. The private sector also accounts for about 45 percent of industrial employees.

Semiconductor Market

Although it grew by a healthy 17 percent in 1997 and has grown by 66 percent since 1994, the Slovakian electronic equipment production market remains one of the second-tier markets of the C&EE region, albeit substantially larger than the Bulgarian electronic equipment production market. The small size of the electronic equipment production market is not aided by the less-than-important role played by the PC production market—only 15 percent of the total—and is compounded by the fact that the two major manufacturers of PCs in Slovakia are Czech and account for all of their production in the Czech Republic. Figure 11-1 shows the Slovakian electronic equipment manufacturing industry broken down by application sector; Tables 11-1 and 11-2 show semiconductor consumption by application and device category respectively.

Figure 11-1
Slovakia—Electronic Equipment Production by Application, 1997



Source: Dataquest (April 1998 Estimates)

Table 11-1
Slovakia—Semiconductor Consumption by Application, 1994-1997
(Based on Electronic Equipment Production)

Application	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Electronic Data Processing	10.5	15.6	14.6	17.8
Industrial	4.7	7.2	7.5	9.1
Military and Civil Aerospace	1.0	1.3	1.4	1.7
Communications	4.1	6.1	6.8	8.3
Consumer	10.3	13.8	14.9	18.4
Total	**30.7**	**43.9**	**45.2**	**55.2**

Source: Dataquest (April 1998 Estimates)

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Table 11-2
Slovakia—Semiconductor Consumption by Product Category, 1994-1997
(Based on Electronic Equipment Production)

Product Category	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Total Semiconductor	30.7	43.9	45.2	55.2
Total IC	25.9	37.2	38.1	46.5
Bipolar Digital	0.3	0.5	0.5	0.6
MOS Digital	20.2	29.2	29.6	36.1
MOS Memory	7.3	10.7	10.6	13.0
MOS Microcomponent	8.4	12.1	12.3	15.0
MOS Logic	4.5	6.4	6.6	8.1
Analog (Monolithic and Hybrid)	5.4	7.5	8.0	9.8
Total Discrete	3.5	4.9	5.2	6.4
Total Optical Semiconductor	1.3	1.8	1.9	2.3

Source: Dataquest (April 1998 Estimates)

Indigenous Semiconductor Industry

Dataquest is aware of two semiconductor companies in Slovakia: Diotec and Tesla Piestany. Revenue data is not available for either of these companies.

EDP Market

The EDP market of Slovakia plays a relatively small part in the country's total electronic equipment production. The EDP sector's percentage share of the total has remained almost constant, at about 14 percent or 15 percent, since 1994.

In unit terms, the Slovakian PC market is one of the smallest in C&EE: only 67,000 units were sold in 1997, and growth in the same year was also very low, at slightly more than 1 percent. It is also the only market where indigenous PC manufacturers hold less than 50 percent of the local market, making Slovakian PC vendors' market share the smallest in the C&EE region. Among the indigenous vendors, Tesco and AutoCont are the significant players. Table 11-3 shows indigenous market share, while Table 11-4 shows the market ranks of Slovakian PC manufacturers.

Table 11-3
Slovakia—PC Shipments by Source, 1995-1997
(Thousands of Units)

Shipment Source	1995	1996	1997
Indigenous Manufacturers	23.5	27.2	28.0
Import	34.2	38.8	39.0
Total	**57.7**	**66.1**	**67.0**

Source: Dataquest (April 1998 Estimates)

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Table 11-4
Slovakia—Top 10 Indigenous PC Manufacturers, 1996

Ranking	Company	Shipments (K Units)	Indigenous Market Share
1	Tesco	3.2	12%
2	AutoCont	2.9	11%
3	Libra	1.8	7%
4	Eurocomp	1.2	4%
5	Gamo	1.1	4%
6	CCW	1.0	4%
7	Vella	0.9	3%
8	Others	15.1	55%
	Total	**27.2**	**100%**

Source: Dataquest (April 1998 Estimates)

Communications Market

Cellular Telephony

Slovakia's GSM networks are operated by GlobTel (which is 35 percent owned by France Telecom Mobile International) and EuroTel Bratislava (which is part-owned by U S WEST and Bell Atlantic). EuroTel Bratislava also provides an NMT-450 network. The infrastructure for all of these services is from Ericsson, Nokia and Ascom Timeplex. Table 11-5 shows details of shipments of cellular handsets to Slovakia.

Table 11-5
Slovakia—Cellular Handset Shipments, Average Selling Price and Revenue, 1993-2001

	1993	1994	1995	1996	1997	1998	1999	2000	2001
Unit Shipments (K)	1.8	3.7	6.1	16.4	136.3	191.2	251.3	304.4	355.9
Average Selling Price ($)	1,820.4	1,379.8	1,270.2	1,084.5	551.4	455.9	371.8	318.1	285.9
Total Revenue ($M)	3.3	5.1	7.8	17.8	75.2	85.3	93.4	96.8	101.8

Source: Dataquest (April 1998 Estimates)

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Chapter 12
Ukraine

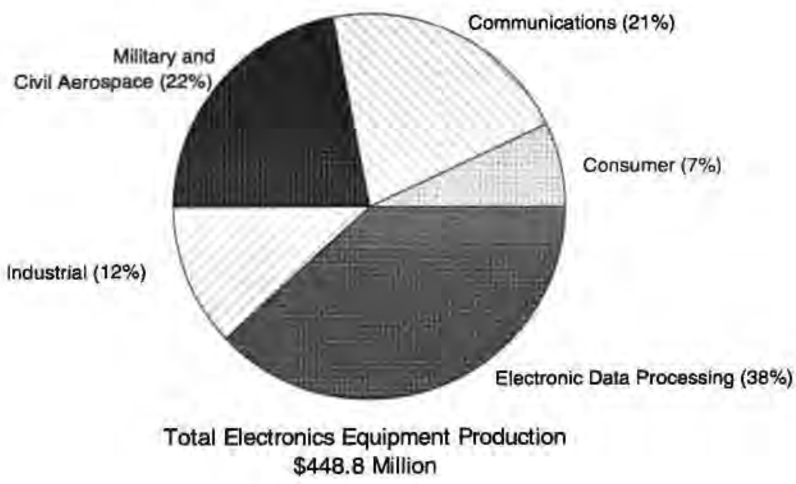
Introduction

Ukraine is economically about one year behind Russia. Although GDP continues to fall, the rate of decrease has slowed down and in 1997 GDP fell by an estimated 3 percent as opposed to the 10 percent decline experienced in 1996. Inflation is also coming under control from its hyperinflationary levels of 1994. However, it is believed that Ukraine has a substantial informal economy, which, if added to the official economy, would show a much healthier picture for the country. This informal economy also has had repercussions on tax collection, which remains highly problematic.

Semiconductor Market

After several years of decline and stagnation, the Ukrainian electronic equipment production market increased by 17 percent to $449 million in 1997, roughly equal to 1994's production level. The EDP sector plays a significant part in this market, accounting for 38 percent of output in 1997, which was up from 27 percent in the previous year. Figure 12-1 shows the Ukrainian electronic equipment production market broken down by application, while Tables 12-1 and 12-2 show semiconductor consumption by application and by device category respectively.

Figure 12-1
Ukraine—Electronic Equipment Production by Application, 1997



Source: Dataquest (April 1998 Estimates)

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Table 12-1
Ukraine—Semiconductor Consumption by Application, 1994-1997 (Based on Electronic Equipment Production)

Application	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Electronic Data Processing	11.1	20.7	24.1	38.5
Industrial	7.3	7.2	5.9	5.9
Military and Civil Aerospace	6.0	5.2	4.4	4.7
Communications	15.1	16.0	14.4	14.7
Consumer	12.8	8.7	4.9	5.5
Total	**52.3**	**57.8**	**53.6**	**69.3**

Source: Dataquest (April 1998 Estimates)

Table 12-2
Ukraine—Semiconductor Consumption by Product Category, 1994-1997
(Based on Electronic Equipment Production)

Product Category	1994 ($M)	1995 ($M)	1996 ($M)	1997 ($M)
Total Semiconductor	52.2	57.8	53.6	69.2
Total IC	43.9	50.0	47.3	62.0
Bipolar Digital	0.7	0.8	0.8	1.1
MOS Digital	33.6	40.4	39.3	52.8
MOS Memory	11.6	15.1	15.3	21.3
MOS Microcomponent	13.4	15.9	15.3	20.6
MOS Logic	8.5	9.4	8.7	10.9
Analog (Monolithic and Hybrid)	9.6	8.8	7.1	8.1
Total Discrete	6.2	5.7	4.7	5.3
Total Optical Semiconductor	2.2	2.1	1.7	2.0

Source: Dataquest (April 1998 Estimates)

Indigenous Semiconductor Industry

The Ukrainian semiconductor industry consists of the following four main companies:

- Kvazar Micro
- JSC Kwazar
- Gamma
- Rodon

Kvazar Micro, based in Kiev, produces primarily microprocessors. In 1997 the company's total revenue was $18.6 million, which was an increase of more than 80 percent over 1996's revenue. Kvazar Micro's sales are mostly to Russia, which generated three-quarters of its 1997 revenue.

JSC Kwazar, also based in Kiev, manufactures chiefly analog products, although it also derives income from MOS memory products. In 1997, the company had a total revenue of $732,000, which represented a decline of 20 percent over 1996. The Ukrainian market accounts for approximately 50 percent of its revenues; sales to Russia accounted for approximately $200,000 revenue in 1997.

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Gamma, based in Zaporozhye, manufactures discrete semiconductors including a range of low- and medium-power devices.

EDP Market

The Ukrainian PC market is the fourth-largest PC market in the C&EE region. Although Ukrainian GDP has been falling for the past four years, PC production has continued to increase in value each year. PC shipments grew by 49 percent in 1997 after growing by a similar percentage in 1996.

Similar to the Russian market, local manufacturers hold a dominant share of the PC market. In 1997 indigenous manufacturers accounted for 82 percent of total PC shipments in Ukraine. No individual manufacturer has a substantial share of the market, although Elecomp TV and Spez are the two largest indigenous manufacturers. Table 12-3 shows indigenous PC market share and Table 12-4 shows indigenous PC manufacturer market rankings.

Table 12-3
Ukraine—PC Shipments by Source, 1995-1997
(Thousands of Units)

Shipment Source	1995	1996	1997
Indigenous Manufacturers	49.7	74.3	132.9
Import	39.5	35.9	30.1
Total	**89.2**	**110.2**	**163.0**

Source: Dataquest (April 1998 Estimates)

Table 12-4
Ukraine—Top 10 Indigenous PC Manufacturers, 1996

Ranking	Company	Shipments (K Units)	Indigenous Market Share
1	Elecomp TV	6.3	8%
2	Spez	4.1	6%
3	Kvazar Micro	4.1	5%
4	Ukraine NTT	3.5	5%
5	Vladibor	2.9	4%
6	NOOS Ukraine	2.8	4%
7	MERX International	2.6	4%
8	Folgat	2.2	3%
9	DiaWest	2.0	3%
10	Others	43.82	59%
	Total	**74.3**	**100%**

Source: Dataquest (April 1998 Estimates)

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Communications Market

Manufacturing

Siemens launched its first Ukrainian joint venture with MKM Telekom in Kiev, which started manufacturing EWSD exchanges in July 1993.

Cellular Telephony

Ukraine has two cellular service providers. Ukraine Mobile Communications, whose shareholders include DeTeMobil, Tele Danmark and PTT Netherlands, operates an NMT-450 service, with infrastructure from Nokia. Bankomsvyaz operates a DCS-1800 service with Motorola infrastructure .

Table 12-5 provides details of cellular handset shipments to Ukraine.

Table 12-5
Ukraine—Cellular Handset Shipments, Average Selling Price and Revenue, 1993-2001

	1993	1994	1995	1996	1997	1998	1999	2000	2001
Unit Shipments (K)	0.3	4.7	10.1	15.8	37.5	77.0	142.2	244.4	396.9
Average Selling Price ($)	1,820.0	1,547.3	1,315.2	1,079.1	810.4	630.8	550.0	488.1	437.3
Total Revenue ($M)	0.5	7.3	13.3	17.0	30.4	48.6	78.2	119.3	173.6

Source: Dataquest (April 1998 Estimates)

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Chapter 13

Rest of Central and Eastern Europe

Introduction

This chapter provides information relating to certain aspects of the electronic equipment production industries of other countries within the C&EE region.

Indigenous Semiconductor Industry

Outside Russia, the Baltic states and Belarus provided something of a (comparative) semiconductor powerhouse for the former Soviet Union. The following five semiconductor companies are of note:

- Integral (Belarus)
- Transistor (Belarus)
- Estel Semiconductor (Estonia)
- Alfa Semiconductor (Latvia)
- Venta (Lithuania)

Integral, which is based in Minsk, Belarus, consists of five fabrication plants, with geometries from 5 microns to 1.2 microns, and four R&D centers. The company manufactures standard logic families, DRAM and SRAM, 16-bit microprocessors, 4-bit and 8-bit microcontrollers, communications ICs, ICs for televisions and discrete semiconductors. At present no revenue data is available.

Alfa Semiconductor, based in Riga, Latvia, manufactures mostly analog semiconductors as well as discretes. The company's revenue in 1997 was $736,000, which was a 15 percent fall over 1996's revenue. Alfa Semiconductor's largest market is Russia, accounting for more than $500,000 of the company's revenue in 1997.

Venta, based in Vilnius, Lithuania, manufactures bipolar digital products as well as analog and discrete semiconductors. In 1997 the company's revenue was $290,000, the same as the previous year. Sales to Russia represented 50 percent of Venta's revenue in 1997.

EDP Market

Tables 13-1 and 13-2 provide details of the indigenous PC market in the Baltic states (Estonia, Latvia and Lithuania); Tables 13-3 and 13-4 give similar statistics for Belarus. In both cases the markets are dominated by local manufacturers.

Table 13-1
Estonia, Latvia and Lithuania—PC Shipments by Source, 1995-1997 (Thousands of Units)

Shipment Source	1995	1996	1997
Indigenous Manufacturers	19.9	29.2	50.0
Import	22.0	21.0	20.0
Total	**41.9**	**50.2**	**70.0**

Source: Dataquest (April 1998 Estimates)

Table 13-2
Estonia, Latvia and Lithuania—Top 10 Indigenous PC Manufacturers, 1996

Ranking	Company	Shipments (K Units)	Indigenous Market Share
1	Microlink	7.6	26%
2	Astroline	4.0	14%
3	Pennu	3.8	13%
4	Elko-Vacriga	1.9	7%
5	VAR	1.7	6%
6	Labas	1.0	4%
7	Elva	1.0	3%
8	Capital	1.0	3%
9	Ordi	0.9	3%
10	Others	6.3	22%
	Total	**29.2**	**100%**

Source: Dataquest (April 1998 Estimates)

Table 13-3
Belarus—PC Shipments by Source, 1995-1997
(Thousands of Units)

Shipment Source	1995	1996	1997
Indigenous Manufacturers	25.7	26.0	35.8
Import	15.3	12.1	12.4
Total	**41.0**	**38.1**	**48.2**

Source: Dataquest (April 1998 Estimates)

Table 13-4
Belarus—Top 10 Indigenous PC Manufacturers, 1996

Ranking	Company	Shipments (K Units)	Indigenous Market Share
1	Tair NTT	5.0	19%
2	Dainova	3.0	12%
3	Inkomag	2.1	8%
4	BelABM	1.5	6%
5	InterComputer Systems	1.5	6%
6	MAS Electronic	1.4	5%
7	High Technologies	1.2	5%
8	BelValex	1.2	4%
9	Link Technologies	1.1	4%
10	Others	8.1	31%
	Total	**26.0**	**100%**

Source: Dataquest (April 1998 Estimates)

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Dear Client,

Please note that there has been a modification to the content of page 9 in the above-mentioned document. We enclose a revised version of the affected pages; please insert them at the appropriate place in the original *Market Analysis*. We apologise for any inconvenience.

Perspectives

Semiconductors Europe

Market Analysis

Microcontrollers and the European "Big Three"

Abstract: *This Market Analysis examines the success of European-based microcontroller vendors in the world market, focusing on the big three European semiconductor companies—Philips Semiconductors, STMicroelectronics and Siemens Semiconductor—and their microcontroller strategies and offerings.*

By Joe D'Elia

European Overview

European microcontroller manufacturers increased their share of the worldwide market for these devices by 17.4 percent from 1995 to 1997. Although some of this growth has been influenced by the changing ownership of certain players, most of it has come from increased penetration of developing market areas. Table 1 gives the market rankings for 1997, showing that the eight European companies that count in this segment are well spread throughout the ranking spectrum. The top European-based players are Europe's three largest semiconductor players, and are ranked either side of tenth place, with the remaining European-based companies much further down (from twenty-fourth place down to last). This *Market Analysis* focuses on the big three: Philips Semiconductors, STMicroelectronics (STM) and Siemens Semiconductor, concentrating on their geographic split, architectural split and target application areas. European companies grew faster than the segment as a whole in 1997, at 7.4 percent compared with the total segment's 5.6 percent.

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Table 1
Top Ten Worldwide Companies' Revenues and Other European Companies' Worldwide Revenues from Microcontrollers, 1997

1996 Rank	1997 Rank		1996 Revenue ($M)	1997 Revenue ($M)	AGR 1996-1997 (%)	1997 Market Share (%)
1	1	Motorola	1,984	1,781	-10.2%	16.3%
2	2	NEC	1,474	1,483	0.6%	13.6%
3	3	Hitachi	1,173	1,224	4.3%	11.2%
4	4	Mitsubishi	848	884	4.2%	8.1%
5	5	Toshiba	577	591	2.45	5.4%
7	6	Intel	530	548	3.4%	5.0%
9	7	Fujitsu	372	537	44.4%	4.9%
6	**8**	**Philips Semiconductors**	**558**	**502**	**-10.0%**	**4.6%**
10	**9**	**STMicroelectronics**	**366**	**445**	**21.6%**	**4.1%**
8	10	Matsushita	402	343	-14.7%	3.1%
11	**11**	**Siemens Semiconductor**	**284**	**333**	**17.3%**	**3.1%**
20	**24**	**TEMIC**	**78**	**57**	**-26.9%**	**0.5%**
26	**26**	**Micronas Intermetall (ITT Intermetall)**	**43**[1]	**50**	**NA**	**0.5%**
32	**36**	**Melexis**	**13**	**7**	**-46.2%**	**0.0%**
36	**38**	**EM Microelectronics Marin**	**4**	**4**	**0%**	**0.0%**
NA	**41**	**Mitel (GEC Plessey Semiconductors)**	**0**	**1**	**NA%**	**0.0%**
		Americas Companies	3,186	3,289	3.2%	30.2%
		Japanese Companies	5,609	5,828	3.9%	53.5%
		European Companies	**1,303**	**1,399**	**7.4%**	**12.8%**
		Asia/Pacific Companies	224	380	69.6%	3.5%
		Total Market	10,322	10,896	5.6%	100.0%

Note 1: This value is not included in the European company total because the company was US-owned at this time
NA = not applicable
Source: Dataquest (January 1999 Estimates)

Some of the data in this *Market Analysis* differs from data previously published by Dataquest for this product category. In particular, STM's revenue in 1995 and 1996 has been raised to include Dataquest's estimates of revenue from microcontroller-based smart cards, which the company had included in the EEPROM section of nonvolatile memory. This has also resulted in an increase in the total microcontroller revenue for 1995 and 1996. Table 2 gives individual company revenues for 1995 to 1997 and shows the European share of the worldwide total growing from 10.9 percent to 12.8 percent. For the purpose of this analysis, Micronas Intermetall is counted as a European company in 1997 only, because previously the company was the US-owned ITT Intermetall. Future years will see TEMIC and GEC Plessey Semiconductors disappear from the European microcontroller list as in 1998 these companies were purchased by Atmel and Mitel, respectively.

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Table 2
European Companies' Worldwide Microcontroller Revenues, 1995-1997

Company	1995 Revenue ($M)	1996 Revenue ($M)	1997 Revenue ($M)
EM Microelectronics Marin	2	4	4
GEC	-	-	1
Melexis	23	13	7
Micronas Intermetall (ITT Intermetall)	15[1]	43[1]	50
Philips	524	558	502
Siemens	208	284	333
STMicroelectronics	299	366	445
TEMIC	68	78	57
Total European-Based Revenue	**1,124**	**1,303**	**1,399**
Total Worldwide Microcontroller Revenue	**10,250**	**10,322**	**10,896**
European Share of Worldwide Revenue (%)	**10.9%**	**12.6%**	**12.8%**

Note 1: These values are not included in the 1995 and 1996 European-based totals because the company was US-owned at this time
Source: Dataquest (January 1999 Estimates)

European growth in market share has come during a period in which the average selling price (ASP) of microcontrollers has been declining. However, the region's focus on devices targeted at growth areas has paid off and resulted in the increase in market share. Microcontroller-based smart cards have been a particularly rewarding area, shipment revenue having grown worldwide from $215 million in 1995 to $461 million in 1997, with the big three European companies accounting for about 80 percent of this revenue. Individual companies have targeted different application areas—a topic that is explored in the company-specific section of this *Market Analysis*.

Another interesting point is the shift in the geographic end markets of European microcontroller vendors (see Figure 1). Although the largest market for these companies' microcontroller products is Europe, their export markets are changing, with increasing focus on the Far East, where sales as a percentage of the total have grown from 16.8 percent to 22.4 percent in the Asia/Pacific region and from 1.2 percent to 2.1 percent in Japan. The geographic area that has declined as a share of the total market is the Americas, which has fallen from 22.8 percent to 14.1 percent. This shift in geographic base is again related to the applications markets that are being targeted by European microcontroller vendors—consumer and electronic data processing (EDP) products are now manufactured primarily in the Far East.

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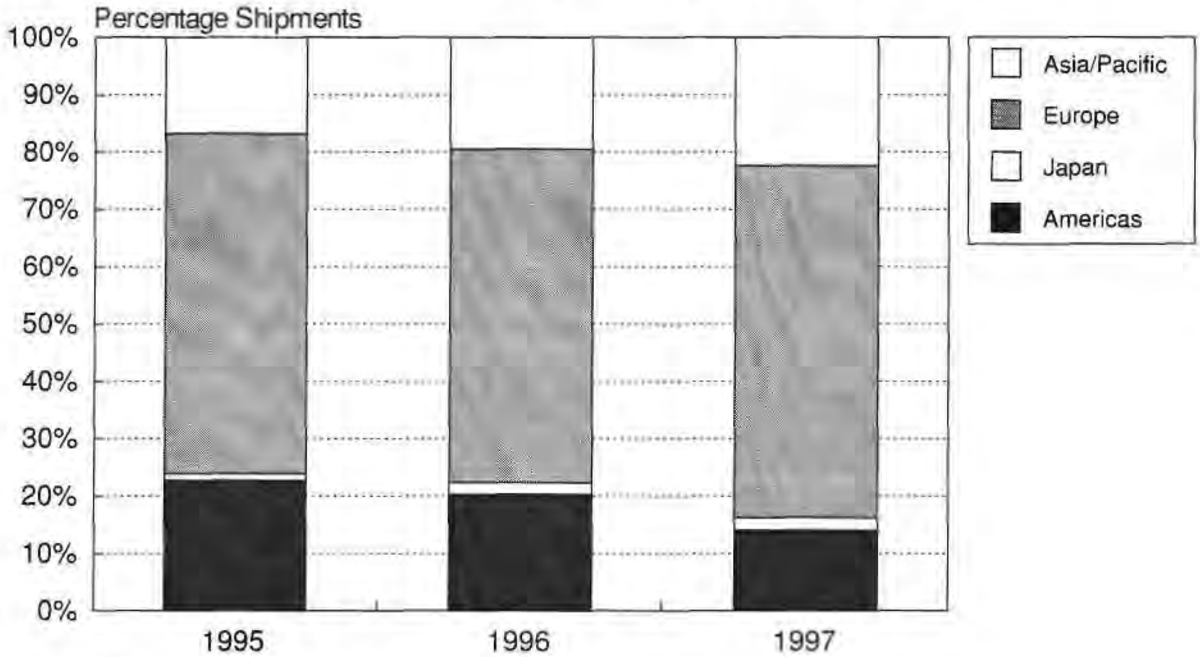
Figure 1
European Vendors' Microcontroller Shipments by Geography, 1995-1997



Source: Dataquest (January 1999 Estimates)

Company Overviews

With the impending disappearance of TEMIC and GEC Plessey Semiconductors from the European list, and excluding for the moment the big three companies, we are left with three European microcontroller companies that serve the market: Micronas, Melexis and EM Microelectronics Marin. These companies are very focused on the niche markets of consumer, automotive and low-power applications respectively. With the exception of Micronas, their markets are in Europe and amounted to no more than 4.5 percent of the total. Consequently, this *Market Analysis* will not examine these companies further, but rather focus on the European big three companies and their respective market offerings.

Philips Semiconductors

Of the big three players, Philips has the most balanced geographic microcontroller revenue split. However, it is leading the charge in increasing its market share in the Asia/Pacific region. Historically, the company has been strong in the United States as a result of its Signetics roots, but as its application balance has shifted so has its geographic base. Figure 2 shows that from 1995 to 1997 the company's Asia/Pacific revenue from microcontrollers rose from 21.4 percent to 39.2 percent of the total. In 1998, the company's Asia/Pacific microcontroller revenue is likely to have been the largest portion. Shipments to the Americas over the same period fell from 33.4 percent to 18.7 percent. Shipments to Europe declined by 3.1 percent, while shipments to Japan remained at approximately 1 percent. This reapportioning of regional revenue occurred against a backdrop of falling microcontroller revenue for Philips, as the company's overall microcontroller revenue during this period fell by 4.2 percent from $524 million to $502 million. This fall resulted solely from a 31.0 percent drop in ASP that was not compensated for by a corresponding rise in unit volumes.

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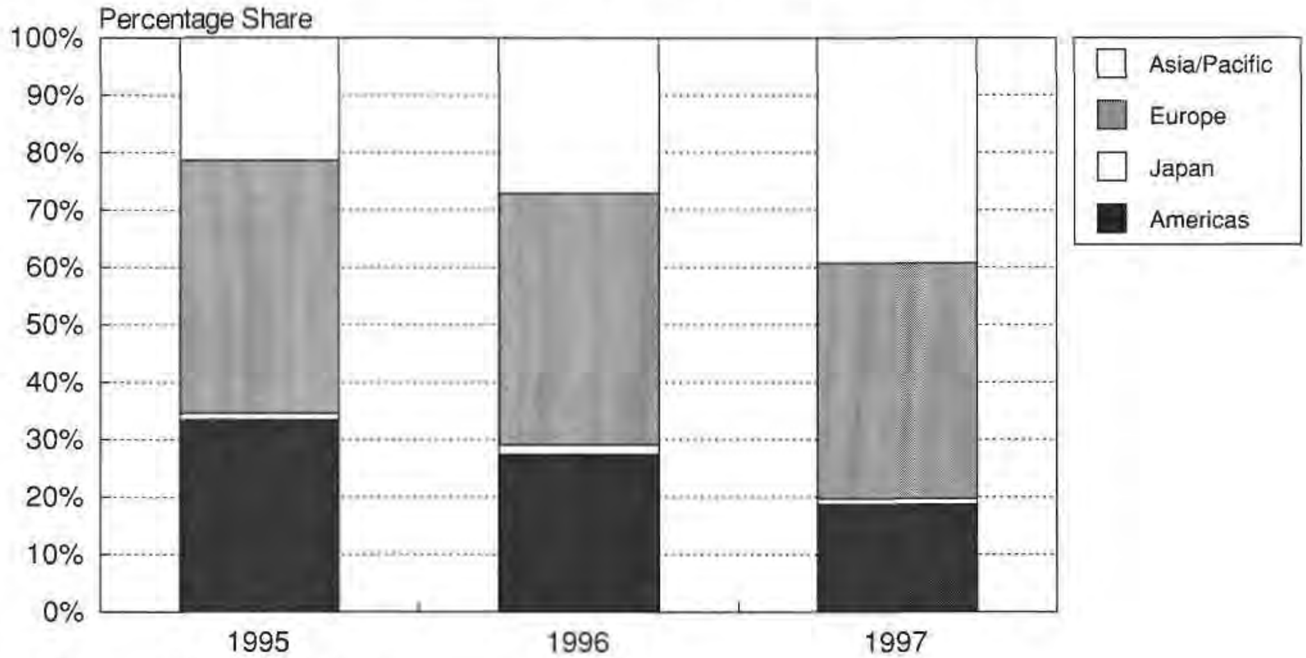
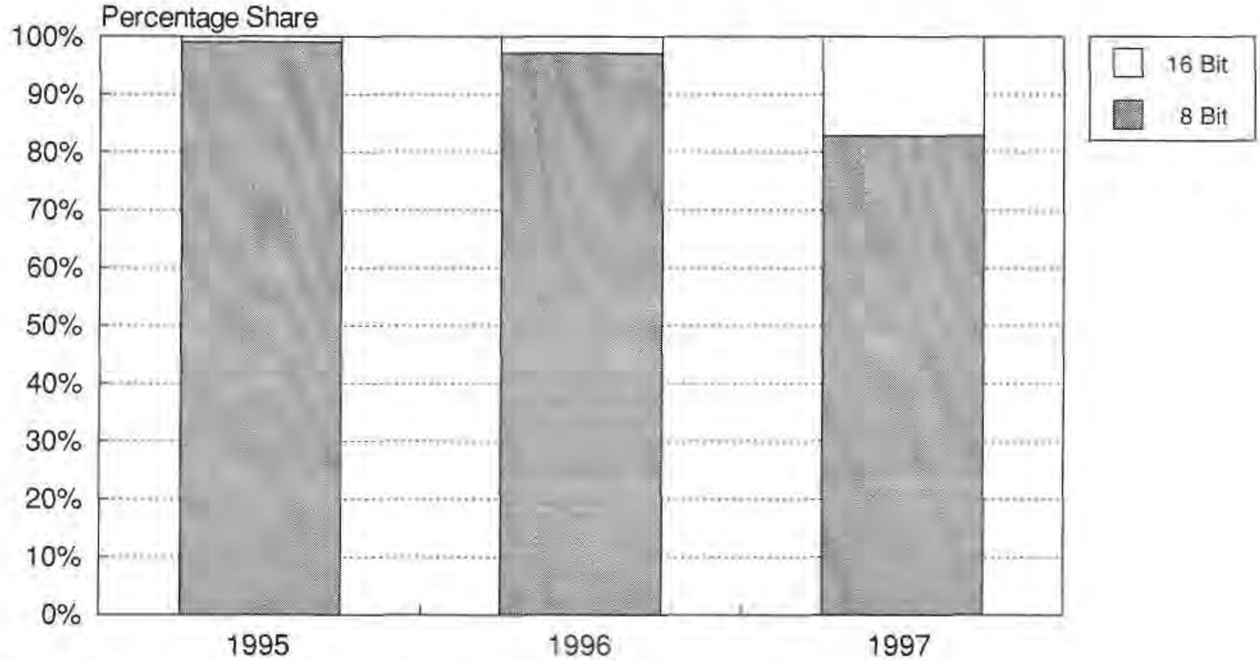
Figure 2
Philips Semiconductors' Microcontroller Revenue by Region, 1995-1997



Source: Dataquest (January 1999 Estimates)

Philips' main focus is consumer applications, and its success in developing its Asia/Pacific business is based on its dominance of the television market. Over the years the company has built up an impressive portfolio of microcontrollers based on the 8048 and 80C51 architectures aimed at television control. As the Chinese market is opening up, many of these older designs have got a "second wind" as they are well suited to the less-sophisticated requirements of this market. Philips participates in the 8-bit and 16-bit microcontroller markets with devices that are 80C51-based, and the company is the leading shipper of this architecture. Its 16-bit XA architecture is a backward-compatible extension of the 80C51 and, as can be seen from Figure 3, is gaining market acceptance, having accounted for 17 percent of Philip's microcontroller shipments in 1997.

Figure 3
Philips Semiconductors' Microcontroller Revenue by Word Length, 1995-1997



Source: Dataquest (January 1999 Estimates)

The major portion of Philip's 8-bit shipments is 80C51-based as the older 8048-based devices are declining steadily. In 1997, 8048 shipments accounted for 15 percent of Philips' total microcontroller shipment revenue. The company claims to have more than 100 variations on the 80C51, with devices targeting specific applications, such as various television functions, computer monitors, telecommunications, automotive and general-purpose applications. Products are offered primarily in ROM and OTP versions, with flash-based devices being introduced only in late 1997. Not being a company steeped in memory technology, Philips has had to look outside for this technology and has formed a partnership with Taiwanese flash manufacturer Macronix to acquire a suitable flash process module. As a by-product, Philips also gained a second source for its 16-bit XA architecture, which is no bad thing. As well as using this flash process for its XA architecture, Philips is quickly adding new flash-based 80C51 variants as it backfills some of its catalog.

The XA architecture is Philips' 16-bit offering, and the key to this product is its ability to leverage the multitude of legacy 80C51-based designs created since the introduction of this architecture in the early 1980s. There are now four variants in this family, with the latest variants using the Macronix-developed flash technology.

Looking beyond 16 bits, there are no signs that Philips is seeking to produce a standard catalog microcontroller family. The company's efforts seem to be more focused on generating ASSPs for specific applications based on MIPS cores which, historically, it has brought in from established MIPS vendors. Philips had used Toshiba cores, but in 1997 signed an agreement to use NEC's VR4300 64-bit processor core. Another factor in this arena could be Philips' "infatuation" with the multimedia processor—the company has spent considerable resources on getting its TriMedia processor to market. This effort may well have detracted from any desire to tie up resources in developing a totally new microcontroller architecture as it is improbable that the 80C51 foundations could, or should, be extended to 32 bits.

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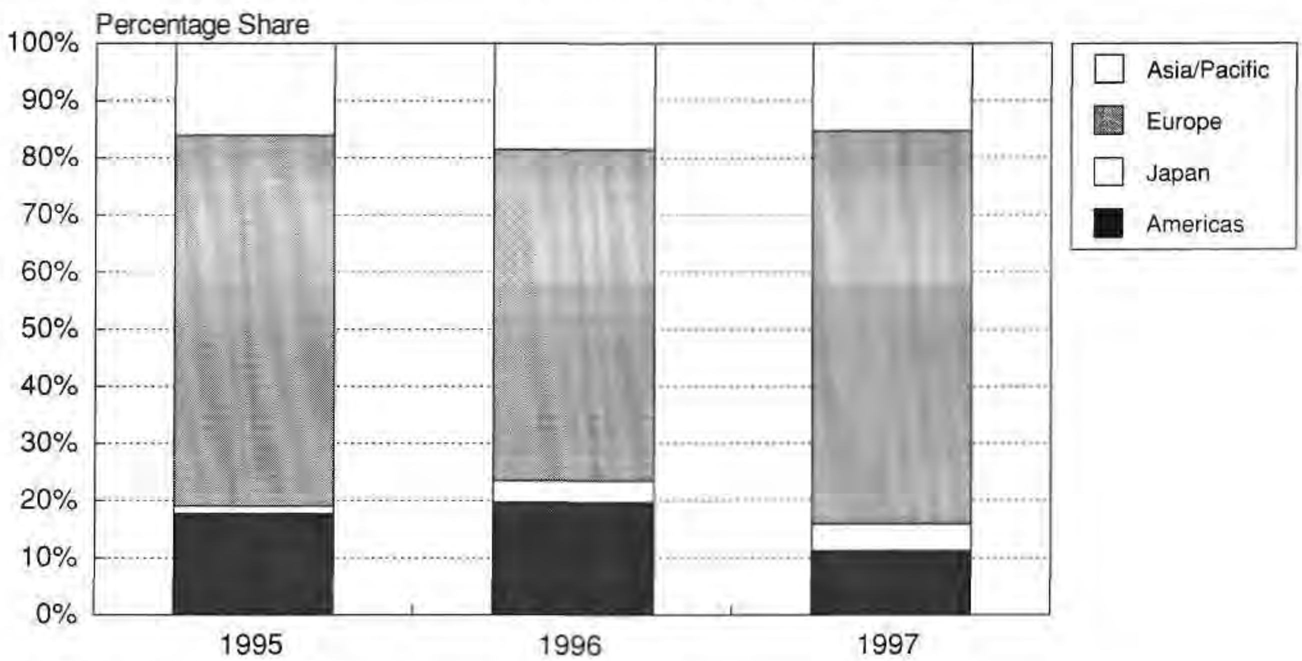
Like the other major European vendors, Philips is a player in the smart card market—albeit a minor one, with only a 5 percent market share in 1997. Philips is participating in both contact and contactless applications and has both 8-bit and 16-bit device families, both of which are based on the company's mainstream microcontroller architectures, the 80C51 and XA respectively. The new 16-bit $SMART_{XA}$ devices are aimed at the developing market for multifunction smart cards and take an innovative approach to security by incorporating an onboard hardware firewall that isolates individual applications from each other.

STMicroelectronics

The regional split of STM's markets for microcontrollers are going in the opposite direction to the other two vendors in that Europe is gaining share (see Figure 4). This is a direct result of the company's involvement in microcontroller-based smart cards, which have grown by more than a factor of two from 1995 to 1997. STM has almost doubled its share of the microcontroller-based smart card market—from 27 percent in 1995 to 45 percent in 1997, and the bulk of this market is now focused in Europe. In 1997, the company shipped $31 million worth of its 32-bit ST20 family, which is targeted at high-volume consumer applications such as digital set-top boxes and digital video broadcasting players. As a result of this targeting, the bulk of these 32-bit shipments was split between Europe and Japan. At the 8-bit level, Europe is the main focus because of the predominance of smart card shipments, while 16-bit products with their EDP and telecommunications focus were split between Europe and the Asia/Pacific region. Over the same period, STM increased its overall microcontroller revenue by 49 percent, from $299 million to $445 million.

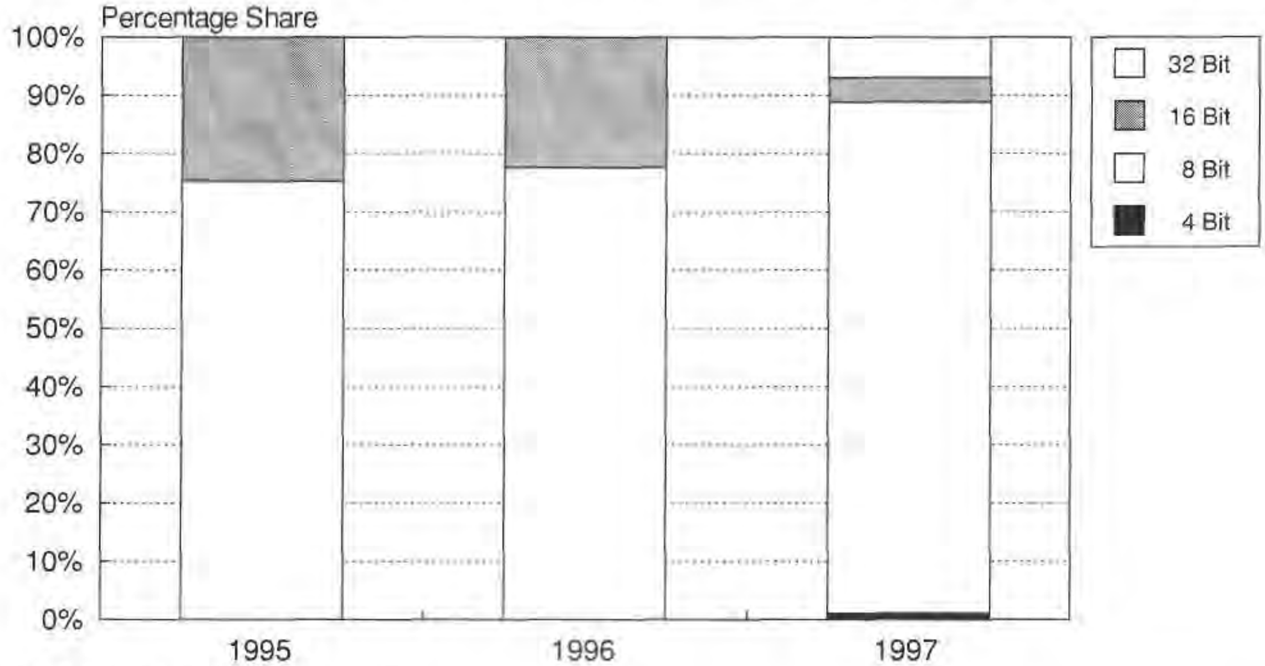
Figure 4
STMicroelectronics' Microcontroller Revenue by Region, 1995-1997



Source: Dataquest (January 1999 Estimates)

Viewed from a word-length perspective, STM has the most diverse range of products available—it has products that range in word length from 4 bits to 32 bits. Some of this diversity stems from legacy second-source products, such as the 4-bit second source of National Semiconductor's COP400 family (which is now obsolete) and the second sources of Motorola's 68HC04 and 6805. Figure 5 gives STM's microcontroller revenue by word length. It shows a leap in 8-bit share in 1997, which again resulted from the jump in smart card usage in 1997 as these devices were rolled out in many end-user programs.

Figure 5
STMicroelectronics' Microcontroller Revenue by Word Length, 1995-1997



Source: Dataquest (January 1999 Estimates)

STM has a core-based approach to building microcontrollers, which enables it to produce many variations of a basic family. Its various 8-bit architectures have about 100 different permutations of compute core, memory type and size, peripherals and so on. This is without taking into consideration what type of program memory (that is, ROM, EPROM or OTP) has been chosen. As well as devices aimed at general-purpose industrial applications, several groups of device focus on specific applications, such as televisions, satellite video receivers and computer monitors with the requisite peripheral fit to enable onscreen displays and application-specific functions. Other product groups are intended for use in automotive and portable applications.

Toward the top end of the spectrum, STM has the ST10 16-bit family—the company's first flash-based microcontroller devices. Again these are core-based and have already generated variants that are targeted specifically at the automotive and telecommunications markets. At the very top end there is the 32-bit ST20 family, which is focused on specific high-volume consumer applications. It is becoming questionable whether this class of device is a microcontroller or an ASSP. For the future, the company has joined with Hitachi to develop a 64-bit family of controllers called either the ST50 or SH5 depending on which company sells it. This agreement also gives STM the rights to Hitachi's SH4 products under the ST40 banner.

In addition to these generic microcontroller families, STM also has two families of dedicated 8-bit smart card microcontrollers that supply various permutations of core, EEPROM, RAM and ROM sizes plus specific smart card security-related peripherals such as encryption engines. These products have enabled STM to become the worldwide market leader in this product category.

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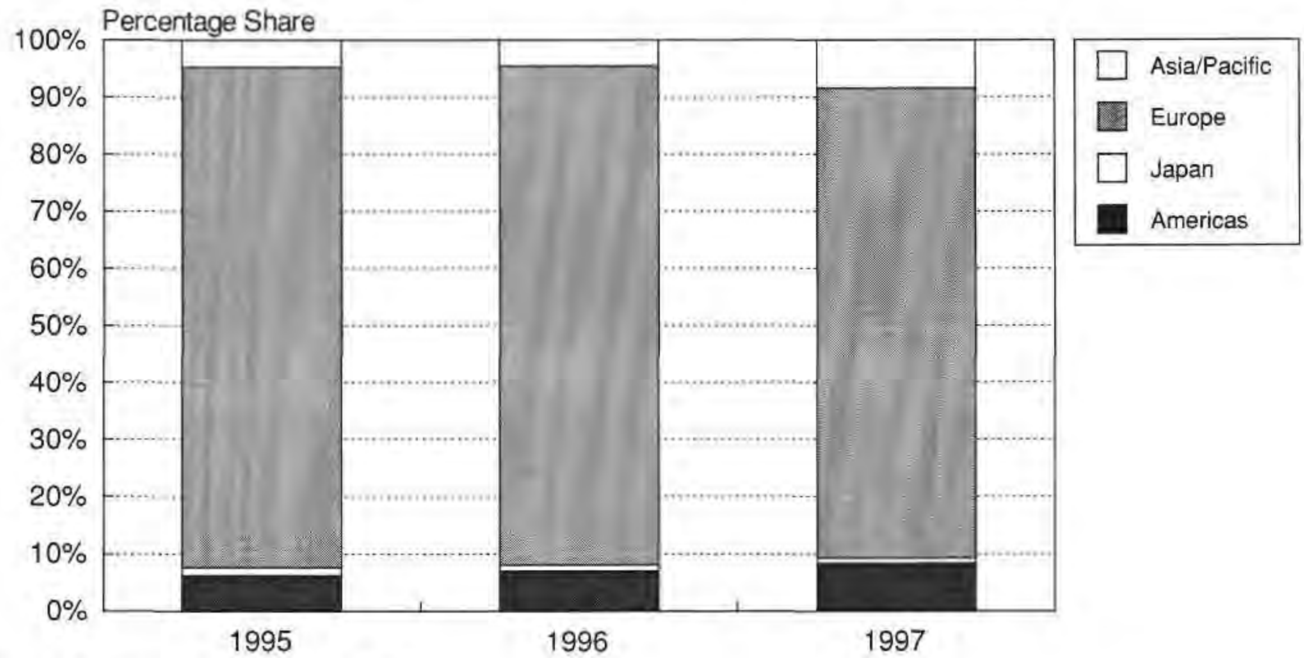
Siemens Semiconductor

Of the big three companies, Siemens not only has the lowest microcontroller revenue, but also the most Eurocentric customer base, with 82 percent of its 1997 microcontroller revenue being of European origin. Figure 6 shows that Siemens is developing its foreign sales; from 1995 to 1997 Siemens increased its Asia/Pacific revenue by 75 percent (from 4.8 percent to 8.4 percent of the total) and its Americas' revenue by 35 percent (from 6.2 percent to 8.4 percent of the total). Over the same period, Siemens' overall microcontroller sales grew by 59 percent from $208 million to $333 million.

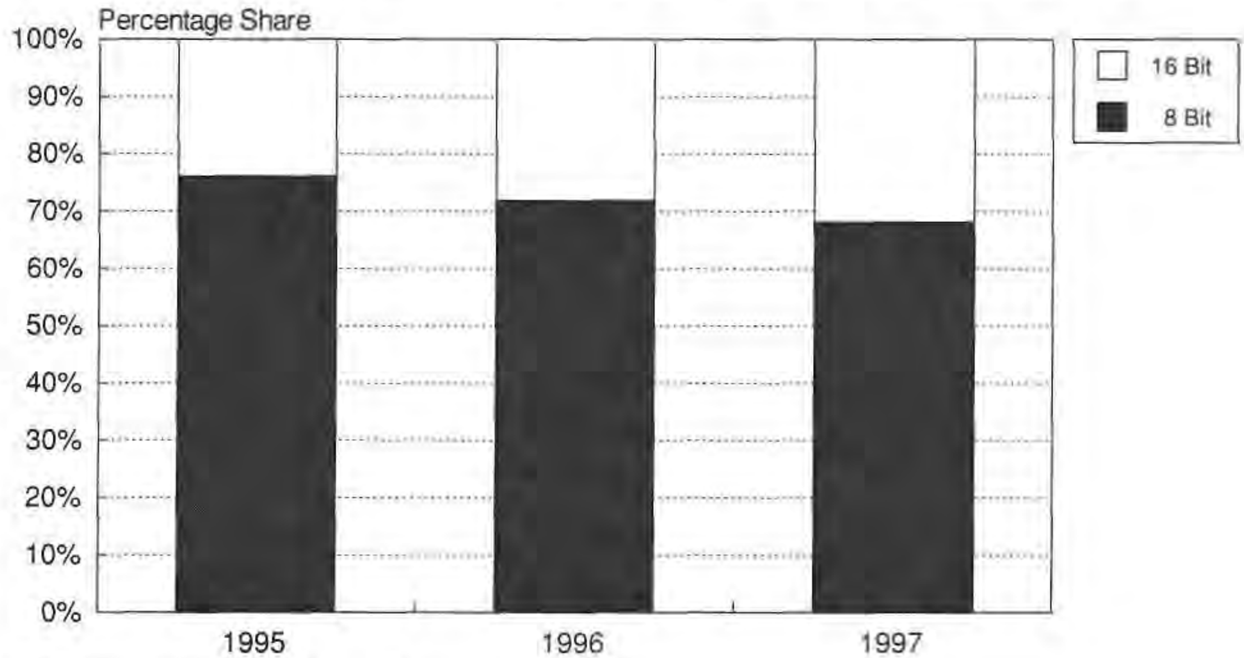
Figure 6
Siemens Semiconductor's Microcontroller Revenue by Region, 1995-1997



Source: Dataquest (January 1999 Estimates)

Like Philips, Siemens' product offerings are restricted to 8-bit and 16-bit architectures, with the 8-bit family again rooted in the 80C51 architecture. The split by word length for Siemens is less biased toward the 8 bit as the company's C166 16-bit architecture has been around for some years and had some market success. Figure 7 shows that, in 1997, the C166 took 32 percent of Siemens' microcontroller revenue, having risen from 24 percent in 1995. Siemens' C500 family of 80C51 derivatives has been around for more than ten years, over which time the company has developed a significant number of devices that focus on data storage, automotive and communications-specific applications. Much of this development has benefited from direction from Siemens' own end-equipment manufacturing divisions in these areas, which have also provided initial customers for the products. Two new family members were introduced in 1997 to attack the burgeoning market for USB peripherals. To complement these focused devices there has also been a line of more general-purpose devices targeted at less-specific industrial applications.

Figure 7
Siemens Semiconductor's Microcontroller Revenue by Word Length, 1995-1997



Source: Dataquest (January 1999 Estimates)

The C166 family also has several subsegments that are aimed at specific application areas, with the particular focus being telecommunications and automotive. The inclusion of CAN functionality on several devices makes this family popular in automotive applications. Aiding this popularity is a specialized family of CAN host controllers—the 81C90/91. Although Siemens has made its devices available in the usual memory technologies, it was short of a flash offering until late 1997 when it introduced the C163-16F, which incorporated 128KB of on-chip flash memory. Flash is being introduced in several new members of both the 8-bit and 16-bit families.

Looking to the future, Siemens has taken a novel approach to increasing the performance of its microcontrollers beyond 16 bits. In 1997, it introduced the TriCore architecture, which utilizes a microcontroller core that has a unified instruction set aimed at supporting both control and DSP tasks in a single core. Although the first derivative of this architecture, the TC10, is a highly integrated general-purpose device that is designed to tackle a wide range of multitasking embedded control applications, the future of this family must be as specifically focused ASSPs rather than as general-purpose devices. The fundamental role of the TC10 is as a proof of concept and prototyping device rather than as a high-volume microcontroller in its own right.

As with the other vendors, Siemens has two families of smart card devices. Both the SLE44 and SLE66 families are 8-bit devices. Siemens' main focus is the contact type of card, although it has some devices aimed at the contactless market. Siemens is the second-biggest player in the smart card market, with 29 percent of the worldwide revenue in this category.

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Dataquest Perspective

European-based microcontroller vendors are succeeding by focusing on specific application areas and targeting those geographic areas where high-volume end-equipment production is concentrated. Despite these strategies, they will have suffered in 1998 as the whole of the microcontroller market downshifted as a result of the overcapacity that become rampant. Unit growth is up, but ASPs continue to decline faster, ensuring that revenue will decline. Furthermore, the Asian financial crisis is continuing to have an impact, driving prices down. This is especially prevalent in multisourced products. Fortunately, the variants of microcontrollers—even when based on the same root architecture—make these devices effectively sole-sourced products and therefore less susceptible to pricing pressures.

Although the list of European-owned microcontroller vendors is declining because of changes of ownership, this will be a short-term phenomenon as several new companies are starting to supply microcontrollers targeted at niche markets and will have measurable revenues in 1998. Furthermore, several of the old Russian semiconductor industry companies, who all shipped 8048/8051-based second sources, are trying to expand their horizons by marketing their products around the world. These companies should start to generate significant revenues, which will take them out of the "others" group and allow Dataquest to track them as separate companies, thereby expanding the list of European microcontroller vendors.

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Perspectives

Semiconductors Europe

Market Analysis

European ASIC Design Starts Survey, 1998

Abstract: *This Market Analysis analyzes the number of ASIC design starts, device technology trends and industry sector issues in 1997 and 1998. Trends in core usage, feature size and interconnect are considered, together with the impact of system-level integration. The number of designs in each European country or region is also presented.*

By Jim Tully

Executive Summary

The number of European ASIC designs continued to grow in a difficult year for the industry. Average revenue per design has risen from $2.06 million in 1996 to a forecast $2.63 million in 1999. Gate count continues to rise, with the most common category being 100,001 to 200,000 gates at 0.35 micron in 1998. A 52 percent growth in system-level integration (SLI) designs is expected to occur in 1998 with SRAM, ROM, microcontrollers, DSP, A/D converters and cellular functions being the most common cores this year. Regionally, Germany continues to account for the largest number of designs, with the United Kingdom showing the strongest growth; the sharpest fall was in the Nordic region, owing to a reduction in cellular design activity. Analog and mixed-signal designs are continuing their growth to a point where they are challenging the supremacy of digital designs.

Dataquest's 1998 European ASIC design starts survey was based on responses from 21 vendors. These vendors account for 90 percent of the gate array and cell-based ASIC markets by revenue in 1997. The results of the survey are therefore highly representative of the overall market and provide a sound basis on which to make decisions. The main findings of the survey are summarized in a commentary with references to the corresponding tables and figures. Dataquest's conclusions are given at the end of the document.

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Survey Results

- Europe accounted for 1,092 ASIC design starts in 1997, a rise of 2.2 percent over 1996. In 1998 this figure is projected to rise by 9.4 percent (see Figure 1).
- The largest band of ASIC production quantity per design will increase from the 50,001 to 100,000 devices category in 1997 to the 100,001 to 500,000 devices category in 1998 (see Figure 2).
- Our calculations show that an average ASIC design has a revenue-generating lifetime of three years, with most of the contribution in the first year after design completion. Revenue in the second year is impacted by price erosion in spite of production growth. The yearly revenue contribution is given in Table 1. On this basis, the average ASIC revenue per design in Europe will rise from $2.48 million in 1997 to $2.58 million in 1998, an increase of 4.1 percent (see Table 2).
- Cell-based designs account for approximately three-quarters of all design starts, with array designs accounting for the remainder. Embedded arrays increased their share by 2 percentage points to reach 7 percent of all design starts (see Figure 3).
- Communications applications continue to dominate ASIC design and production in Europe, growing from 58 percent to 59 percent of all designs in the 1997 to 1998 period. Industrial and consumer designs are ranked second and third respectively (see Figure 4).
- The percentage of mobile communications designs is expected to fall for the first time in many years in 1998, but it remains the single largest category and is closely followed by public switching and transmission applications (see Figure 5). The production of ASIC units in the mobile sector continued its sharp growth (although at a lower rate than in previous years); however, price erosion outpaced production growth, resulting in overall revenue decline. The data networking applications category was notable for its sharp growth from 14 percent to 18 percent of designs.
- The single largest gate count category in 1997 was less than 50,000 gates. However, this figure is expected to change to 100,001 to 200,000 gates in 1998 (see Figure 6).
- For several years up to and including 1997, 0.5-micron geometry devices led the rankings. In 1998, 0.35 micron is expected to be the dominant geometry (see Figure 7). Three-level metal interconnect will remain dominant, with a significant increase in five-level metal (see Figure 8).
- Dataquest's definition of a system-level design includes all designs above 100,000 gates, that contain a compute engine (micro or DSP core), memory and user logic. In 1998, 383 design starts are designated as SLI designs, a rise of 52 percent over 1997 (see Figure 9). These designs are undertaken by a small number of vendors and are still a small minority of all European designs, but Dataquest expects that they will dominate the ASIC market within three years.
- SRAM is by far the most commonly used core in ASIC designs, occurring in almost 60 percent of cases, followed by data conversion, ROM and microcomponents. Particularly high growth is forecast in cellular, WAN and A/D converter functions (see Figure 10). Vendors' ability to use cores in an effective SLI strategy relies upon the availability of an adequate design reuse technology. Also, the percentage of designs that are reused is an important productivity metric. Figure 11 shows that the largest category of percentage reused was the 1 percent to 15 percent band in 1997, and we anticipate this to shift to the 16 percent to 25 percent band in 1998. This corresponds to a weighted average reuse factor of 22 percent in 1997 and 33 percent in 1998.

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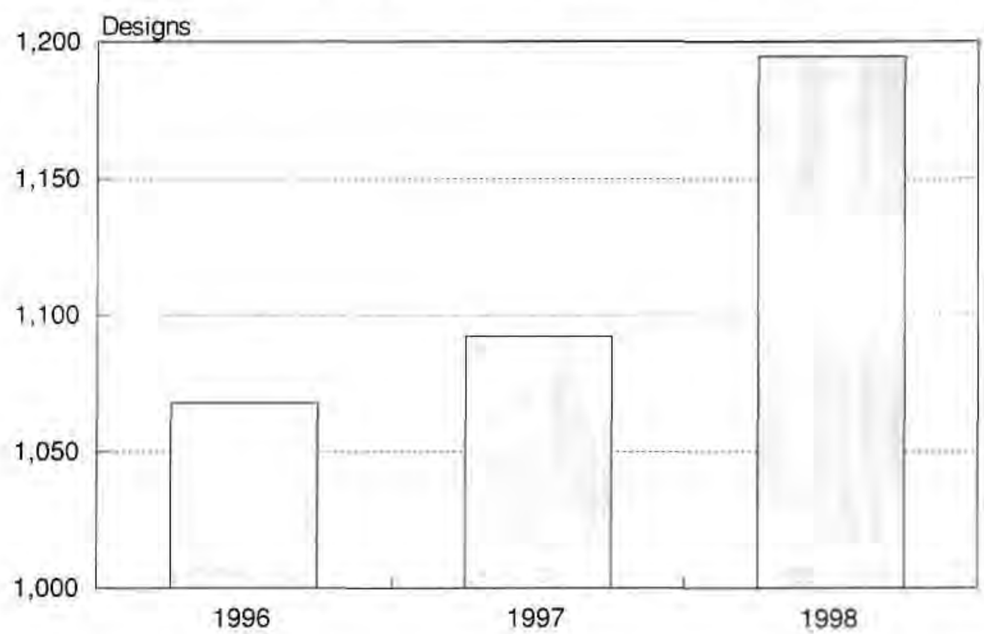
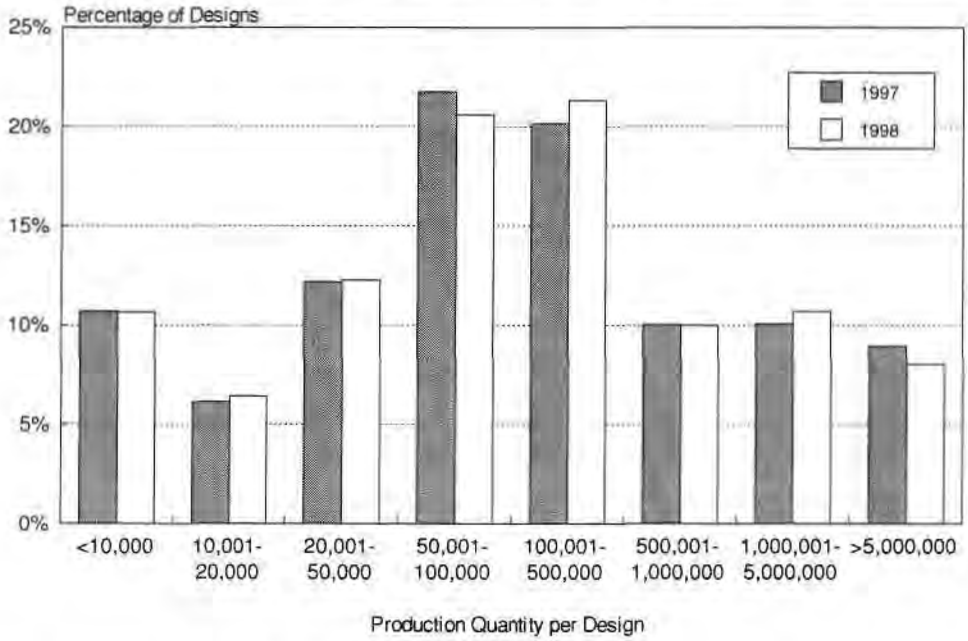
- Germany continues to account for the largest number of designs, followed by France (see Figure 12). The German market has continued its growth for the past two years led by its telecommunications sector, following two or three years of relative decline. The percentage of designs in the Nordic region fell in line with the reduction in cellular activity mentioned earlier. The Middle East reported increased activity—notably in Israel. Two designs were reported in Africa.
- Digital designs continue to account for the bulk of ASIC design starts in Europe. However, analog and mixed-signal technology has long been of growing importance in Europe, owing mainly to the requirements of the telecommunications sector. The gap is continuing to narrow, with analog and mixed-signal design starts now at 44 percent of total designs (see Figure 13). However, analog and analog-dominated mixed-signal designs (requiring special processes) are still a relatively small percentage of total designs.
- The dividing line between customer and vendor responsibility in the design process is continuing to change. The traditional model in which customers design up to netlist level and vendors undertake physical design continues to grow in popularity (see Figure 14). However, a significant number of ASIC designs do not involve ASIC vendors, being designed entirely by customers and manufactured by independent foundries. This category of design is not represented in this *Market Analysis*, but Dataquest estimates that revenue from these channels is 10 percent to 15 percent of the overall ASIC market, and growing.

Figure 1
Number of ASIC Designs per Vendor—Europe, 1996-1998



Source: Dataquest (November 1998 Estimates)

Figure 2
ASIC Production Quantity per Design—Europe, 1997 and 1998



Source: Dataquest (November 1998 Estimates)

Table 1
Revenue Contribution of ASIC Design Start

Time Period After Year X Design Start	Revenue Contribution From Design Start
Year X + 1 year	55%
Year X + 2 years	37%
Year X + 3 years	8%

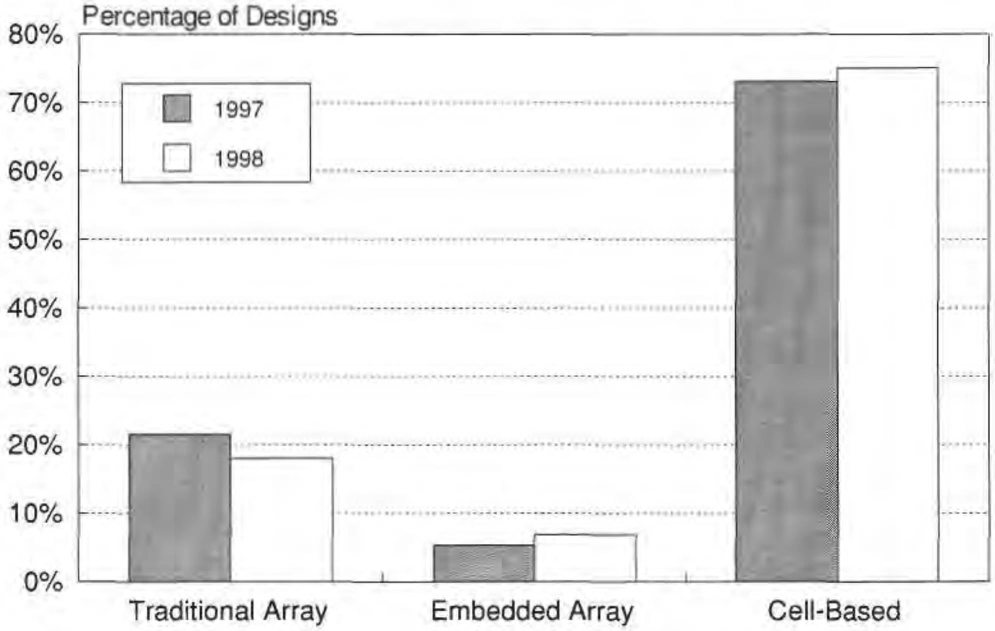
Source: Dataquest (November 1998 Estimates)

Table 2
Average Revenue per ASIC Design—Europe, 1996-1999

Year	Number of Designs	Revenue ($M)	Revenue per Design ($M)*
1993	1,205		
1994	1,210		
1995	1,169	1,982	
1996	1,068	2,450	2.06
1997	1,092	2,764	2.48
1998	1,195	2,806	2.58
1999		3,020	2.63

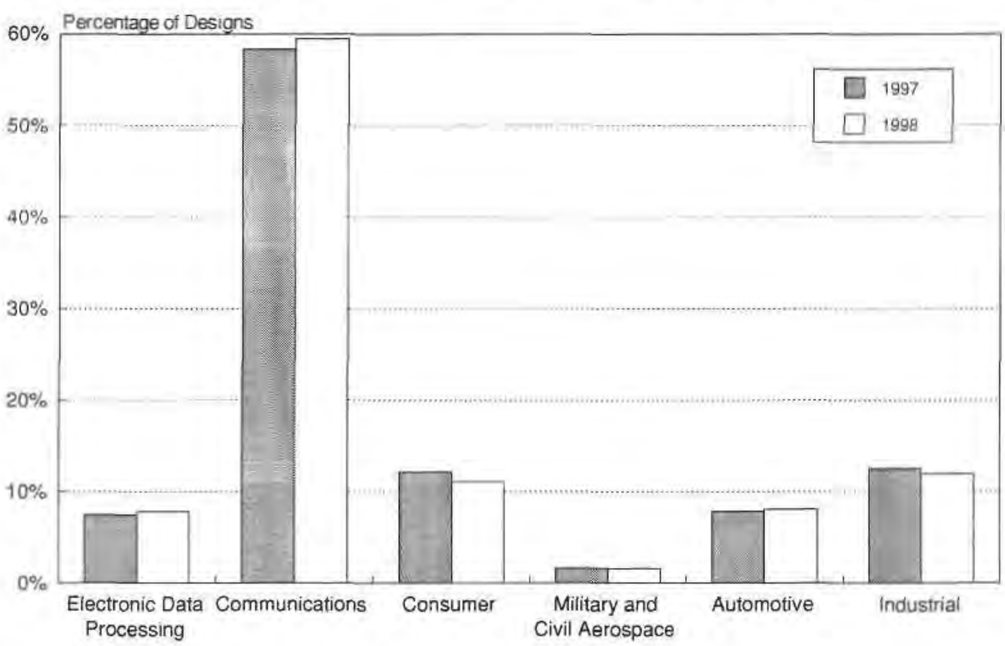
*Based on formula in Table 1
Source: Dataquest (November 1998 Estimates)

Figure 3
ASIC Design Starts by Product—Europe, 1997 and 1998



Source: Dataquest (November 1998 Estimates)

Figure 4
ASIC Designs by Application Market—Europe, 1997 and 1998



Source: Dataquest (November 1998 Estimates)

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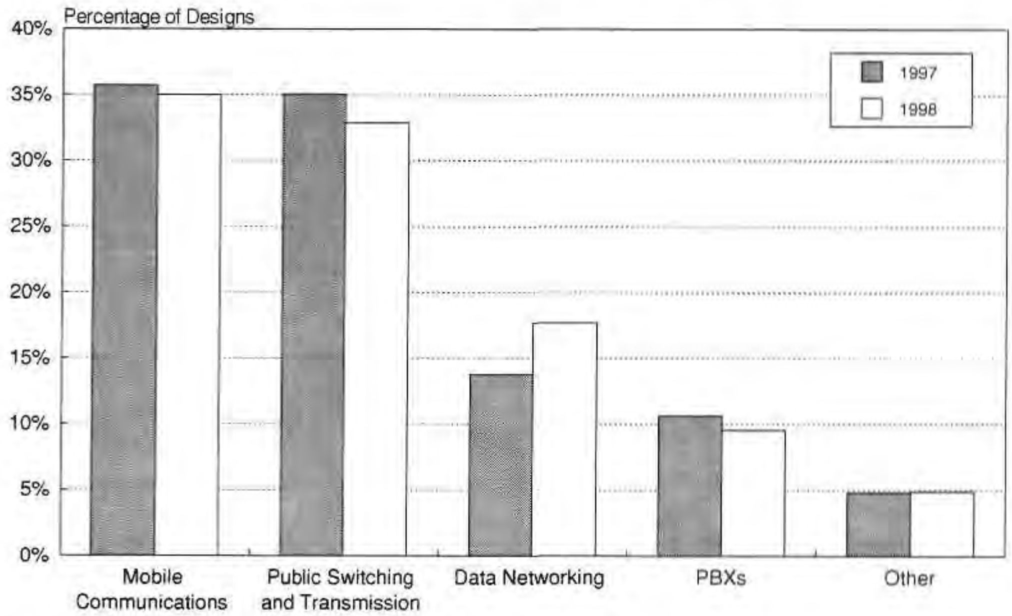
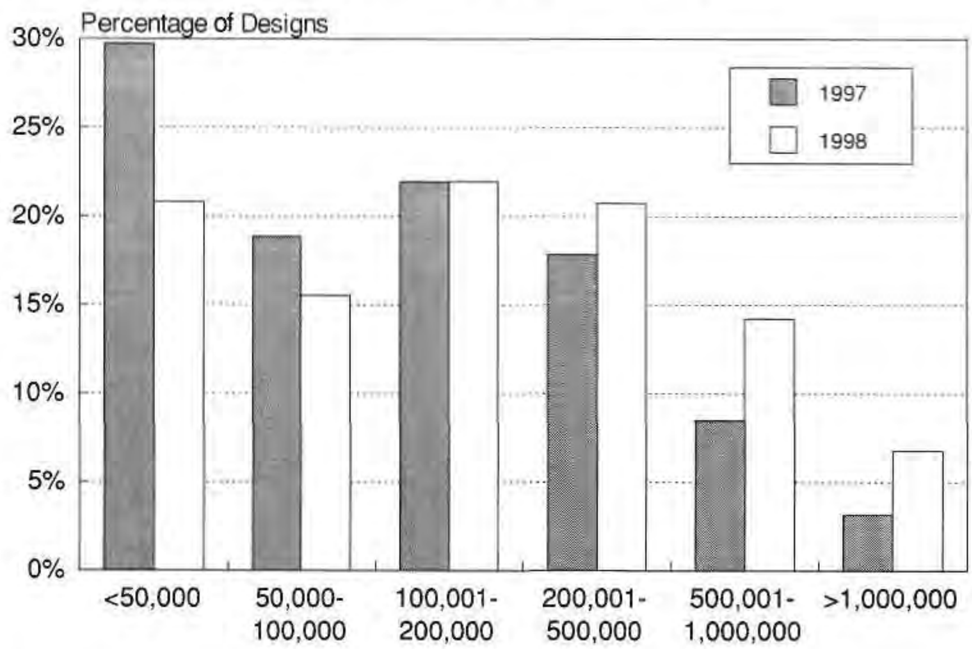
Figure 5
ASIC Communications Designs by Category—Europe, 1997 and 1998



Source: Dataquest (November 1998 Estimates)

Figure 6
ASIC Designs by Gate Count—Europe, 1997 and 1998



Source: Dataquest (November 1998 Estimates)

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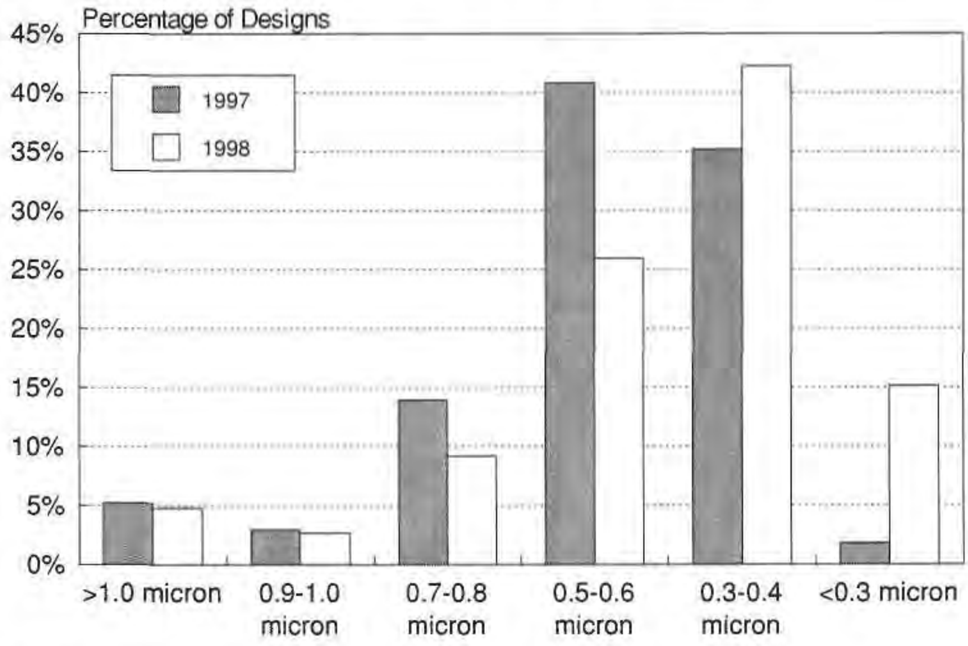
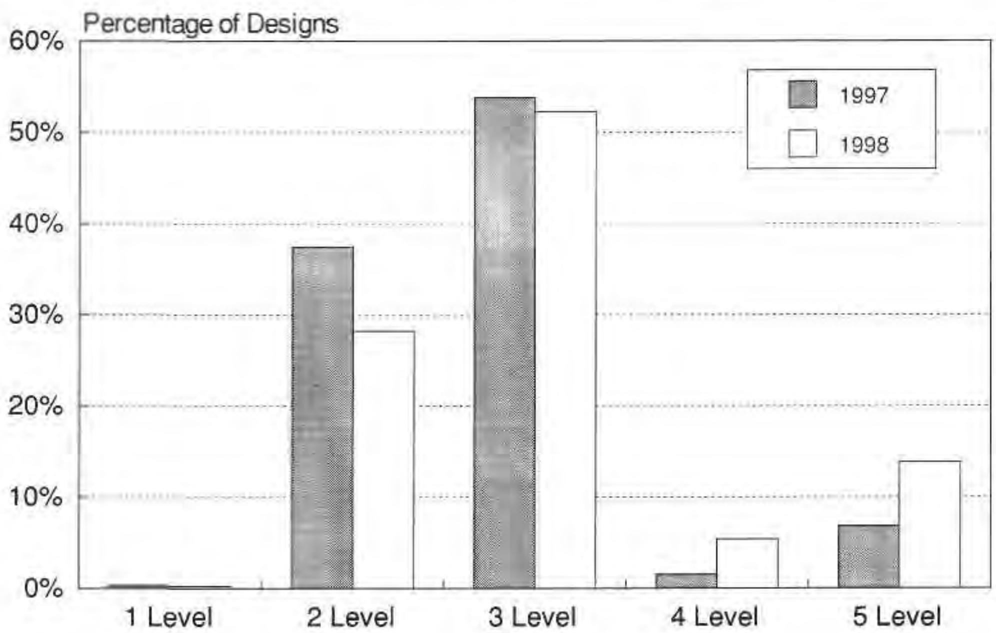
Figure 7
ASIC Designs by Feature Size—Europe, 1997 and 1998



Source: Dataquest (November 1998 Estimates)

Figure 8
ASIC Designs by Metal Interconnect—Europe, 1997 and 1998



Source: Dataquest (November 1998 Estimates)

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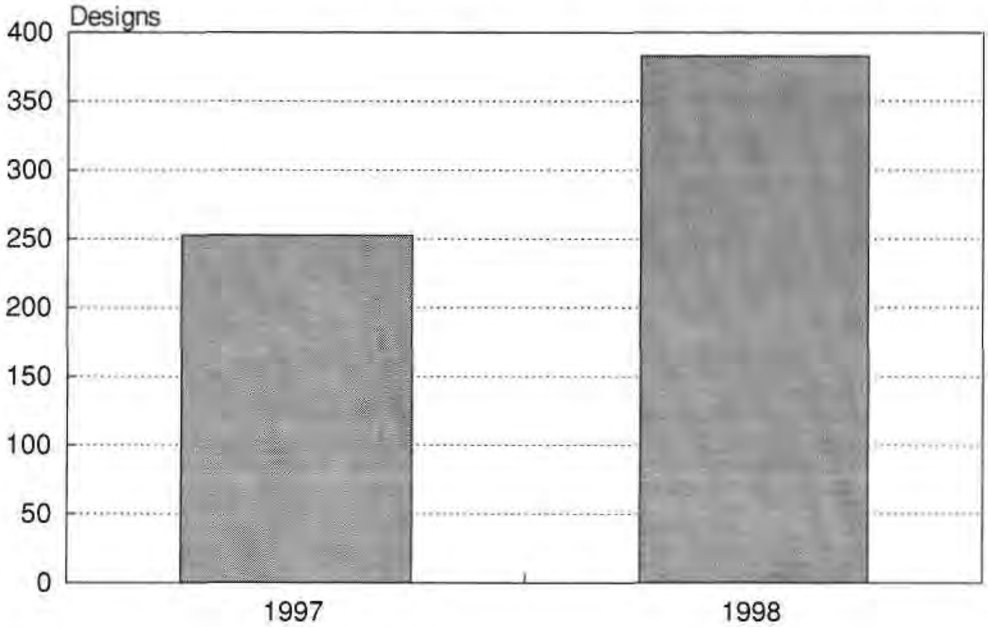
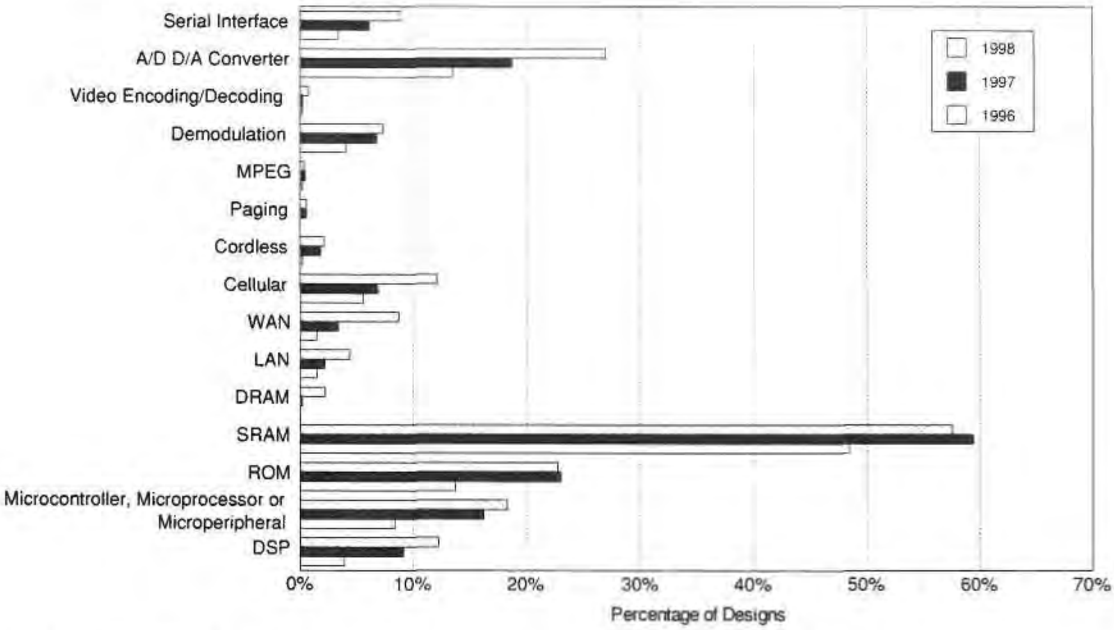
Figure 9
Number of System-Level ASIC Design Starts—Europe, 1997 and 1998



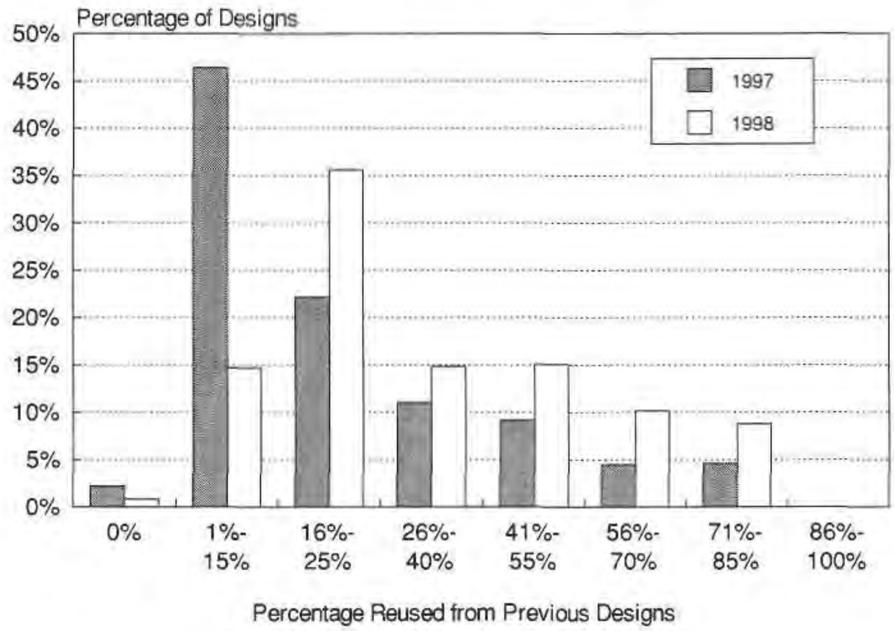
Source: Dataquest (November 1998 Estimates)

Figure 10
ASIC Designs by Core/Macro Usage—Europe, 1996-1998



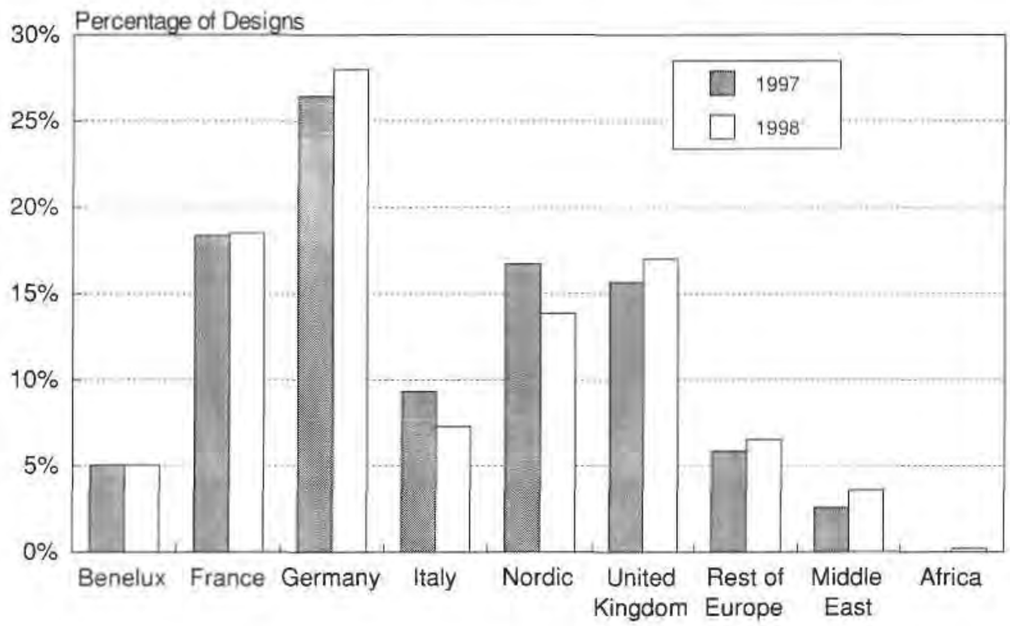
Source: Dataquest (November 1998 Estimates)

Figure 11
ASIC Designs by Reuse—Europe, 1997 and 1998



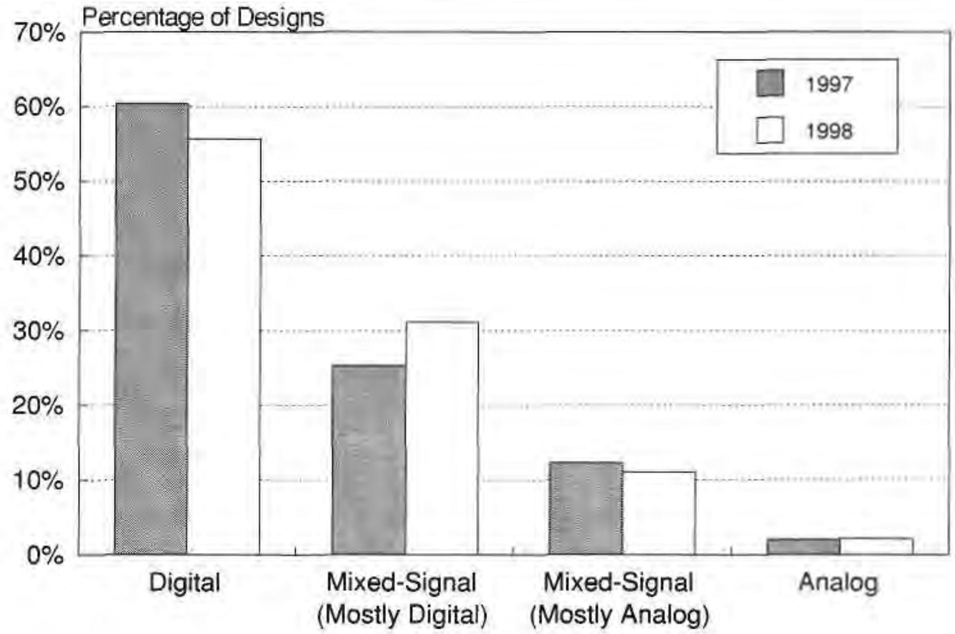
Source: Dataquest (November 1998 Estimates)

Figure 12
ASIC Designs by Country or Region—Europe, 1997 and 1998



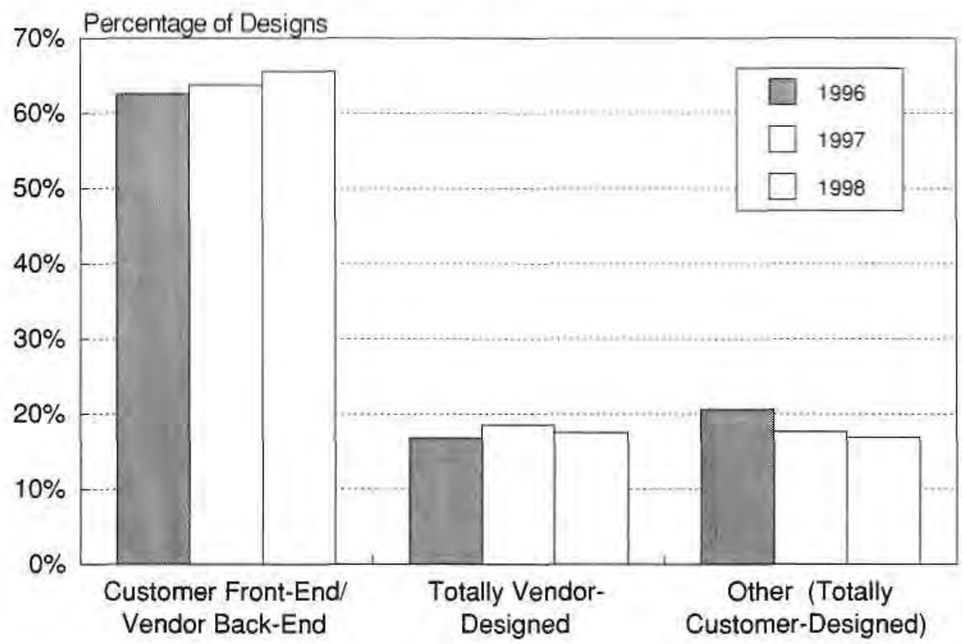
Source: Dataquest (November 1998 Estimates)

Figure 13
Digital, Mixed-Signal and Analog ASIC Designs—Europe, 1997 and 1998



Source: Dataquest (November 1998 Estimates)

Figure 14
ASIC Design Responsibility—Europe, 1996-1998



Source: Dataquest (November 1998 Estimates)

Dataquest Perspective

The past two years have been relatively poor in the recent history of the ASIC market. Growth began to slow during 1997 and the situation worsened in 1998, mainly because of unit price pressure. Market conditions such as these have a marked impact on the number of design starts in which ASIC vendors are involved. The number of design starts grew by 2.3 percent in 1997 and is expected to grow by 9.4 percent in 1998. Why, then, should the number of designs rise at a time when market growth has been moving in the opposite direction?

As the revenue resulting from ASIC designs is spread over several years, a short-term dip in the market may not have a major impact on the average revenue per design. On the contrary, revenue per design has grown over the past few years and is likely to continue growing for the next few years.

However hard ASIC vendors try to approach design projects, ultimately these projects are viewed as an overhead within the company. The goal is the revenue resulting from device shipments, not the nonrecurring engineering (NRE) charges from the design project itself. But the NRE charges that (in theory) apply to designs are often blurred as the two revenue items are frequently merged together. The design project is necessary in order to achieve the device revenue, but a larger number of design projects leads to inefficiencies as effective relationships with new customers take time to develop. In view of this, ASIC vendors naturally prefer a few high-value projects to a larger number of small-value projects. But, at a time of market downturn, the value of projects comes under pressure, forcing vendors to increase the number of projects in an attempt to drive up revenue.

Another issue affecting the profitability of design projects is the expertise of the customer's design team and the industry sector to which the design belongs. A "pecking order" exists in the ASIC industry in which specific vendors tend to pick up the high-value projects, often in mobile communications and related sectors. Other vendors are left with lower-value projects, often in the industrial sector. These lower-value projects have a double problem: their revenue contribution is lower and the customer has less knowledge of the ASIC design process. This latter problem means that unrealistic expectations are often set and the ASIC vendor's engineering effort is significantly higher. As a result, such projects tend to be far less profitable than those carried out by top-tier vendors. The challenge for these smaller ASIC vendors is to move up the value chain by focusing on a niche within a higher-value application.

The demand for more highly complex ASICs designed in a shorter time seems to be inexhaustible. This is a positive indicator for the underlying ASIC market, yet ASIC vendors and OEMs are feeling the strain. The main limiting factors are design engineers and design (EDA) tools. The rate at which new design centers have been locating in Europe has been incredible. The vendors that are strong in DRAM have been the latest entrants to establish design operations with an eye to better utilizing fab capacity for high-value ASICs, while developing embedded DRAM technology. OEM demand for ASIC designers also continues to rise sharply, yet the supply of engineers is not keeping pace. One solution is the greater use of cores and more effective overall reuse of designs and design elements; this is progressing well, as demonstrated in the survey results. However, it is a good solution for low-speed, low-technology applications but does not work well for 200-MHz designs at 0.25 micron. Here the engineering effort to integrate cores in the form of hard macros is very complex, requiring highly skilled engineers and expensive software tools. The skill shortage is a major problem that is likely to get worse before it gets better.

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The shortage of engineers is one reason why many of them have formed design houses, operating on a contract basis to fill the gap for OEMs during peak loads. Engineers can often earn higher salaries in this way than by working for a permanent employer. These design houses are thriving in Europe to a greater extent than in any other region of the world and are now an essential ingredient in the success of many companies involved in ASIC design.

Some shift in the pattern of applications was evident this year, including a sharp rise in data networking designs and (significantly) a relative reduction in mobile communications designs. These shifts highlight the absolute importance of vendors developing and maintaining a strong skill base in a few chosen applications. Design support, base libraries, cores (intellectual property) and manufacturing technology must all be focused on these application categories. This is one of the primary keys to success in the modern ASIC business.

Vendors must also find ways to leverage this application focus in the development of application-specific standard products (ASSPs). Dataquest has observed a shift from ASIC to ASSP solutions as technology matures and standards stabilize. Vendors must look for further payback on their design investment by spinning off ASSPs from ASICs whenever possible.

Finally, ASIC vendors must be constantly aware of the threat posed by third-party foundry services. A significant "invisible" ASIC revenue stream is generated through these services, aided by the large number of design houses in Europe. These houses undertake designs for clients (typically OEMs) then have them manufactured by foundries. Design houses have the skills and design tools to carry out physical design using third-party libraries, such that ASIC vendors are eliminated from the process. Dataquest estimates that revenue from these channels is valued at 10 percent to 15 percent of the overall ASIC market, and rising. The primary defenses for ASIC vendors are to continue to provide a complete high-value package (design, manufacturing, test and assembly) and to be "the best" in a chosen application.

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Perspectives

Semiconductors Europe

Competitive Analysis

Applications Focus: The Key to European Growth

Abstract: *The performance of Europe's top three semiconductor vendors in the first half of 1998 was better than the market's overall growth. This Competitive Analysis reviews these companies' performances and analyzes their strategies for future growth.*

By Edmund Gemmell

Introduction

Europe's three largest indigenous semiconductor vendors—Philips Semiconductors, STMicroelectronics (ST) and Siemens Semiconductor—accounted for 80 percent of European-based semiconductor companies' worldwide sales in 1997. They also accounted for 8 percent of the worldwide semiconductor market in 1997—up marginally on 1996. This *Competitive Analysis* reviews the performance of these companies in the first half of 1998 and their positions in the semiconductor markets. It also looks at their strategies for growth over the next few years.

STMicroelectronics

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Tables 1 and 2 summarize ST's performance in 1997. Tables 3 and 4 summarize the company's performance during the first half of 1997 and the first half of 1998 by application and region respectively. ST grew by 8 percent in the first half of 1998—a significant contrast to a worldwide market that contracted by 9 percent in the same period. This growth was achieved because ST increased the percentage of its differentiated, application-specific sales into vertical markets. These sales have typically been offerings to high-growth application markets.

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Table 1
STMicroelectronics' Revenue by Device Category and Region, 1996 and 1997

	Worldwide		Americas		Japan		Europe		Asia/Pacific	
Category	1996 ($M)	1997 ($M)	1996 ($M)	1997 ($M)	1996 ($M)	1997 ($M)	1996 ($M)	1997 ($M)	1996 ($M)	1997 ($M)
Total Semiconductor	4,112	4,019	934	952	228	215	1,814	1,777	1,136	1,075
Bipolar Digital	0	0	0	0	0	0	0	0	0	0
MOS Digital	1,651	1,556	426	357	118	114	795	835	312	250
MOS Memory	738	502	144	122	96	75	391	203	107	102
MOS Microcomponent	482	616	158	118	18	31	211	387	95	80
MOS Digital Logic	431	438	124	117	4	8	193	245	110	68
Analog-Monolithic	1,875	1,891	384	457	102	93	698	659	691	682
Discrete	586	572	124	138	8	8	321	283	133	143
Optoelectronic	0	0	0	0	0	0	0	0	0	0

Source: Dataquest (September 1998 Estimates)

Table 2
STMicroelectronics' Revenue by Application Market, 1997

Application	1997 ($M)
Automotive	442.1
Consumer	763.6
Electronic Data Processing	1,044.9
Industrial	803.8
Military and Civil Aerospace	0
Communications	964.6
Total	**4,019.0**

Source: STMicroelectronics

Table 3
STMicroelectronics' Revenue by Application Market, First Half of 1997 and First Half of 1998

Application	First Half of 1997 ($M)	First Half of 1998 ($M)	Growth (%)
Automotive	214.4	238.7	11.3%
Consumer	369.5	423.4	14.6%
Electronic Data Processing	474.8	577.0	21.5%
Industrial	388.7	348.7	-10.3%
Military and Civil Aerospace	0	0	0
Communications	467.2	487.8	4.4%
Total	**1,914.6**	**2,075.7**	**8.4%**

Source: STMicroelectronics

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Table 4
STMicroelectronics' Revenue by Region, First Half of 1997 and First Half of 1998

Region	First Half of 1997 ($M)	First Half of 1998 ($M)	Growth (%)
Europe	855.8	865.6	1.1%
Americas	413.6	442.1	6.9%
Japan	111.0	85.1	-23.4%
Asia/Pacific	490.1	631.0	28.7%
Region 5	44.0	51.9	17.8%
Total	**1,914.6**	**2,075.7**	**8.4%**

Note: Region 5 is STMicroelectronics' term for its emerging geographical markets
Source: STMicroelectronics

ST organizes its products into two categories: differentiated products (ST's term for ASSPs) and standard products. Differentiated products are those of higher integration and high functionality that are typically targeted at specific application markets. ST aims for its differentiated products to contribute 67 percent of its annual revenue. To date in 1998, ST has achieved 63 percent of its sales from differentiated products, so the company is not far from its objective. Table 5 illustrates how ST's growth has been driven by its differentiated product offerings, revenue from which increased by 19 percent in the first half of 1998 compared with the first half of 1997. Table 6 shows the growth rates of the markets in which ST has significant market presence in the first half of 1988.

Table 5
STMicroelectronics' Revenue from Differentiated and Standard Products, First Half of 1997 and First Half of 1998

	First Half of 1997 ($M)	First Half of 1998 ($M)	Growth (%)
Differentiated Products	1,095.2	1,305.6	19.2%
Standard Products	819.4	770.1	-6.0%
Total	**1,914.6**	**2,075.7**	**8.4%**

Source: STMicroelectronics

Table 6
Growth Rates of Product Markets Important to STMicroelectronics, First Half of 1998

Category	Revenue Growth (%)	ASP Growth (%)
EPROM	-24%	-23%
Flash/EEPROM	-9%	-31%
8-Bit MCU	-14%	-19%
Cell-Based IC	-13%	-3%
Telecommunications IC	29%	-4%
Audio/Video Special IC	-1%	-13%
Power Transistor	-5%	-10%

Source: WSTS

Table 5 also illustrates ST's need for two distinct strategies for its two product categories. Revenue from the company's standard products fell by 6 percent in the first half of 1998 compared with the first half of 1997—more in line with industry levels. This is driving ST to increase the market visibility of its standard products to offset the downward price pressure that is affecting all commodity markets, and especially all memory markets.

Part of this strategy includes the joint development and marketing with Mitsubishi Electric of a new 64Mb flash product range for the mobile market. ST has been working with Mitsubishi Electric since 1993. ST has a reputation for leading the market in pricing for many of its more mature commodity products as a result of the low manufacturing costs achieved from its fully depreciated wafer fabs. The prospect of an attractive source of revenue from low-cost manufacturing and increasing sales in its commodity product ranges makes ST's participation in these markets understandable.

ST is, however, focused on its strategy for differentiated products. These products account for almost 63 percent of revenue and are driving the company's growth and ensuring profitability by maintaining gross margins that are consistently greater than 38 percent. ST's strategy is to target high-growth products in each of the major applications markets and offer differentiated products and reference designs. This overriding strategy is defining ST's strategic alliance needs and giving direction to its expanding R&D efforts. Markets that ST has identified as being of strategic interest include the following:

- Digital video
- Computer peripherals
- Information appliances
- Digital networking
- Digital mobile telephones
- Smart cards
- Automotive

In 1997, the consumer electronics application market accounted for about 19 percent of ST's revenue. In the first half of 1998, this figure rose by 20 percent. The main reason for this increase was the increasing numbers of set-top boxes (STBs) being made. ST is very strong in the STB market, having design-ins with most major service providers on every continent. Along with digital STBs, ST is targeting the digital TV and DVD markets in a category that it calls digital video.

Key differentiated products that have been designed to meet the needs of the digital video market include the STi5500, ST's complete back-end STB/DVD system on a chip, which includes an MPEG-2 audio/video decoder and a 32-bit RISC microprocessor. To address the terrestrial digital video broadcast market ST offers a four-chipset design to handle front-end receiving functions (both 2K and 8K COFDM) including demodulation, channel correcting and decoding and DSP synchronization. The developing high-definition TV market is being addressed by ST with the launch of the STi7000 device which integrates MPEG-2 decoder technology as well as advanced display and format converter technology onto a single chip.

ST gained 26 percent of its revenue from the computer applications market in 1997. To date in 1998, this figure has risen to 28 percent. Much of this increase has been driven by ST's disk drive controller products. This contrasts sharply with the company's performance in 1997, when it lost a significant amount of market share.

A major strategic alliance was announced in July 1998 that will increase the importance of this market to ST—the company announced a partnership with IBM to develop system-on-a-chip products for data storage applications and PC-compatible information appliances. Initial offerings from the partnership have been based on hard drive controller products to address a market that Dataquest expects to grow from $710 million in 1997 to $3 billion in 2002. ST expects to begin launching other products toward the end of 1999. These products could be along the lines of ST's existing x86-based ST PC Consumer. Other products from the partnership are expected to target the PC motherboard, World Wide Web browser, in-car multimedia and network PC markets.

ST is one of two European semiconductor companies that dominate the chip card market. Dataquest estimates that ST held 44 percent of the microcontroller-based chip card (smart card) market and 15 percent of the memory-based chip card (memory card) market in 1997. Dataquest estimates that the chip card market will be $3.7 billion dollars by 2002. It is, therefore, very important for ST that it continues to dominate this market. ST is well positioned to do so through its participation in the MEDEA MASSC project, which aims to develop next-generation 32-bit smart cards using VLSI manufacturing processes.

ST has supported its application-focused product development strategy and its strategic partnerships by investing heavily in R&D. ST invested $610.9 million in R&D in 1997. In the first half of 1998 ST invested $342.5 million in R&D—a 17 percent increase over the first half of 1997. In the first half of 1998, capital expenditure also increased to $453.6 million—a 21 percent rise compared with the first half of 1997.

To enhance the company's system-on-a-chip capabilities, ST has released 0.25-micron and 0.18-micron CMOS manufacturing technology at its fabrication plant in Crolles, France. ST has also announced that it will build a new 12-inch wafer research fabrication plant and pilot line at Crolles, and a new nonvolatile memory research center in Agrate, Italy. Each of these new facilities will employ about 600 researchers.

Philips Semiconductors

Philips Semiconductors began 1998 in a rather mixed position. Overall revenue in 1997 rose by 5 percent on 1996 (to $4.4 billion), but there were failures as well as successes. Revenue from the company's 8-bit microcontroller lines fell by 23 percent from 1996 to 1997, as average selling prices (ASPs) in that market fell. Philips Semiconductors' revenue from 16-bit microcontroller products increased by 438 percent to $86 million; revenue from other special consumer ICs grew by 51 percent. By far the largest revenue growth, however, came from telecommunications ICs; these generated almost $300 million, probably because of Philips Consumer Communications' increasing production of GSM mobile telephones.

Philips Semiconductors' revenue in the first half of 1998 totaled approximately Fl 4.5 million (about $2.2 billion). This was a substantial 18 percent increase over 1997's first half revenue, and consolidated the company's overall 1997 improvement. This increase in revenue is, like that of ST, indicative of the company's strengths in noncommodity products and its solid focus on application markets, as well as its continued absence from any of the memory markets. Tables 7 and 8 show Philips Semiconductors' revenue by device category and region in 1996 and 1997. Table 9 shows the growth rates of the markets in which Philips Semiconductors has significant market presence in the first half of 1998.

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Table 7
Philips Semiconductors' Revenue by Device Category, 1996 and 1997

Category	1996 ($M)	1997 ($M)	Growth (%)
Total Semiconductor	4,220	4,440	5%
Bipolar Digital	90	80	-11%
MOS Digital	1,858	1,619	-13%
MOS Memory	0	73	NA
MOS Microcomponent	1,085	791	-27%
MOS Digital Logic	773	755	-2%
Analog-Monolithic	1,331	1,717	29%
Discrete	941	1,024	9%
Optoelectronic	0	0	NA

NA = not applicable
Source: Dataquest (September 1998 Estimates)

Table 8
Philips Semiconductors' Revenue by Region, 1996 and 1997

Region	1996 ($M)	1997 ($M)	Growth (%)
Europe	1,748	1,847	6%
Americas	829	831	0%
Japan	172	182	6%
Asia/Pacific	1,471	1,580	7%
Total Worldwide	**4,220**	**4,440**	**5%**

Source: Dataquest (September 1998 Estimates)

Table 9
Growth Rates of Product Markets Important to Philips Semiconductors, First Half of 1998

Category	Revenue Growth (%)	ASP Growth (%)
8-Bit MCU	-14%	-19%
Communications Controller	-25%	8%
Graphics and Imaging Controller	13%	6%
Mass Storage Controller	55%	-11%
Audio/Video Special IC	-1%	-13%
Other MOS Logic	0%	-3%
Diode	2%	-12%
Transistors	8%	NA

NA = not applicable
Source: WSTS

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The first half of 1998 appears to show a consolidation of the turnaround in Philips Semiconductors' fortunes. The markets on which it has focused its newest product offerings are beginning to develop and its system-on-a-chip strategy is producing attractive products. The company's target applications include the following:

- Digital consumer
- Telecommunications handsets
- Handheld computing
- Automotive
- Emerging multimedia

Building on its traditional strengths in the consumer applications market, Philips Semiconductors is positioning itself as a major player in the digital consumer marketplace. Like ST, Philips Semiconductors is targeting the future growth markets of digital TV and digital STBs. One of its key offerings in these markets is the TriMedia processor, which it hopes to establish as the de facto standard architecture through its design-in with Philips Consumer Electronics. Currently, however, the TriMedia's versatility is proving to be a weakness as it struggles to define itself in any one particular marketplace.

Although Philips Semiconductors' position in the consumer market is strong—in 1997 it was the third-largest semiconductor vendor in the consumer applications market, with revenue of $1.7 billion—revenue from sales into next-generation, digital consumer products totaled only $65.5 million, making the company the thirteenth-largest vendor in this emerging market. Standalone MPEG-2 sales accounted for a significant amount of Philips Semiconductors' next-generation consumer sales. However, with the high rate of device integration in the digital STB market—digital STBs being one of the major applications for MPEG-2—the company will need to progress and integrate its reference designs into smaller and smaller chip numbers. Dataquest estimates that the digital STB market will grow to almost 39 million units in 2002—a CAGR of 38 percent. The related semiconductor market is estimated to grow to almost $3.8 billion—a CAGR of 26 percent. This, then, is a market in which it is well worth investing.

In 1997, Philips Semiconductors was the second-largest semiconductor supplier to the worldwide wireless communications market with revenue of $789 million, only marginally behind Motorola. This amounted to 32 percent revenue growth compared with 1996. Given the company's overall growth in the first half of 1998, this solid performance looks to have been maintained. Philips Semiconductors' growth in the wireless market is driven by its strong product offerings in RF, IF and power amplifier markets (in which it is the number-one semiconductor vendor), and the digital cellular baseband markets (where it occupies the number-three position with a 6 percent share of the market).

Philips Consumer Communications' aggressive growth plans in 1997 will have contributed to Philips Semiconductors' growth in the wireless market. However, with Philips Consumer Communications' relatively poor performance in 1998 and competition from Lucent Technologies to replace Philips Semiconductors' design wins in Philips Consumer Communications, Philips Semiconductors may not achieve similar growth rates in the wireless market this year. The expertise of Philips Semiconductors' wireless group has been highlighted by new product offerings this year. Recent offerings include a chipset for dual-band time-division multiple access cellular and PCS/DCS telephones that halves the number of components needed to build a dual-band RF system, and a dual-band GSM and satellite handset RF front end for the Asian market.

Since late 1997, Philips Semiconductors has won contracts with many major handheld PC manufacturers. The first half of 1998 will have seen Philips increase shipments of its TwoChipHCG family of RISC-based processors to companies such as Sharp, Compaq, Samsung and Quantum Micro Systems. Dataquest estimates that the handheld market in 1997 amounted to 803,000 units, and that it will grow to 3.8 million units by 2001. Given the still fragmented nature of the handheld processor market, Philips Semiconductors has an opportunity to gain significant market share.

Siemens Semiconductor

Anyone judging Siemens Semiconductor by its recent press coverage would think that the company is in the midst of a severe crisis. The DRAM market, into which Siemens Semiconductor has invested much capital in recent years, has experienced a protracted downturn that has forced DRAM manufacturers to continue accepting losses. This has led the company to close a new 8-inch wafer, 64Mb DRAM fabrication plant in England, to announce a strategy to improve its performance and to start a high-profile offensive against its DRAM competitors.

Siemens Semiconductor's DRAM division aside, this is a semiconductor company that competes successfully in many growing marketplaces. The company's worldwide revenue in 1997 was about $3.4 billion—14 percent growth compared with 1996. For the first half of 1998, Siemens Semiconductor recorded deutsche mark growth of 7 percent, although in terms of dollars, revenue was essentially flat. Revenue for the first half of 1998 (financial quarters two and three for the company) was DM 3.3 billion ($1.82 billion) compared with DM 3.1 billion ($1.83 billion) in the first half of 1997. Importantly, Siemens Semiconductor's book-to-bill ratio increased from 1.065 in the first half of 1997 to 1.091 in the first half of 1998, indicating that revenue in the second half of 1998 should be greater than that of the second half of 1997. Tables 10 and 11 give details of the company's revenue in 1996 and 1997.

In 1997, Siemens Semiconductor's largest product market was DRAM, accounting for almost 28 percent of revenue. In the first six months of 1998 the world DRAM market declined by 34 percent in dollar terms over the first half of 1997. The company's revenue has remained stable despite this decline. There are two possible explanations for this. Either the company has increased its market share in the DRAM market enough to offset price erosion, or its performance in other product markets has been sufficient to offset lost DRAM revenue. Dataquest believes the second explanation to have been the case.

Siemens Semiconductor's other major product markets include 8-bit and 16-bit microcontrollers, telecommunications ICs and small signal and power transistors. Table 12 shows the growth rates of the markets in which Siemens Semiconductor has significant market presence in the first half of 1998.

Wired and wireless telecommunications represent strategic markets for Siemens Semiconductor, both now and in future. Other key markets that the company will focus on during the next few years include the chip card market and the wider automotive and industrial markets.

In the wired telecommunications market, Siemens Semiconductor began 1998 as the seventh-largest provider of wired telecommunications ICs. The company was head and shoulders above its competitors in the ISDN market, with revenue of $108 million. Performance in 1998 is reported to be strong, despite continued price pressure in the market and increasing competition from Lucent Technologies. Siemens Semiconductor is continually updating its ISDN products to maintain its competitive advantage in 1998. Advancements in 1998 include further integration of its products to offer single-chip solutions in network termination, as well as expansions in its high-level data link controller line. The company's other major wired offerings are in the area of line cards, where it has been losing ground in recent years to competitors such as AMD, Lucent Technologies and ST.

Table 10
Siemens Semiconductor's Worldwide Revenue by Device Category, 1996 and 1997

Category	1996 ($M)	1997 ($M)	Growth (%)
Total Semiconductor	3,029	3,441	13.6%
Bipolar Digital	32	37	15.6%
MOS Digital	1,226	1,384	12.9%
MOS Memory	911	1,028	12.8%
MOS Microcomponent	284	333	17.3%
MOS Digital Logic	31	23	-25.8%
Analog-Monolithic	980	1,082	10.4%
Discrete	452	554	22.6%
Optoelectronic	339	384	13.3%

Source: Dataquest (September 1998 Estimates)

Table 11
Siemens Semiconductor's Worldwide Revenue by Region, 1996 and 1997

Region	1996 ($M)	1997 ($M)	Growth (%)
Europe	2,068	2,182	5.5%
Americas	466	651	39.7%
Japan	41	57	39.0%
Asia/Pacific	454	551	21.4%
Total Worldwide	**3,029**	**3,441**	**13.6%**

Source: Dataquest (September 1998 Estimates)

Table 12
Growth Rates of Product Markets Important to Siemens Semiconductor, First Half of 1998

Category	Revenue Growth (%)	ASP Growth (%)
Flash/EEPROM	-9%	-31%
8-Bit MCU	-14%	-19%
16-Bit MCU	21%	-10%
Telecommunications IC	29%	-4%
Transistors	8%	NA

NA = not applicable
Source: WSTS

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In the wireless semiconductor market Siemens Semiconductor's performance has leapt forward in recent years. The company began 1998 as the third-largest provider of wireless communications semiconductors, only fractionally behind Motorola and Philips Semiconductors.

Siemens Semiconductor's strengths lie throughout the digital wireless market. In the GSM market, revenue from its RF/IF chips puts them in second place behind Philips Semiconductors', while Siemens Semiconductor's baseband solution ranks third. Siemens Semiconductor's challenge for 1998 is to improve the position of its HiGOLD product in the merchant market, building on its success in Siemens handsets. Part of the company's 1998 strategy is the introduction of the Carmel DSP architecture. Siemens Semiconductor dominates the DECT baseband semiconductor market, being almost three times larger than its closest competitor in 1997. This should be of importance as Dataquest predicts that DECT handset production will grow into a $1.6 billion market in 1998 (from $1.2 billion in 1997), and into a market worth more than $4 billion by 2002.

Siemens Semiconductor is the second of two European companies that dominate the chip card market. In 1997, Siemens Semiconductor was number one in the memory-based chip card (memory card) market, with a 67 percent share and revenue more than four times greater than that of its nearest competitor, ST. In the microcontroller-based chip card (smart card) market, Siemens Semiconductor began 1998 in second place behind ST, with a 29 percent market share. With chip card revenue expected to reach $3.7 billion by 2002, the chip card market should become a significant revenue generator for Siemens Semiconductor.

Other strategic targets that the company will address over the next few years include mounting a logic device marketing offensive in the communications, automotive and industrial applications markets. This strategy will produce new driver information and in-car communication products for the automotive market, and drive, control and power supply products for the industrial market.

Dataquest Perspective

Although everything (with the exception of DRAM) appears rosy for Europe's three largest semiconductor companies, there are potential problems ahead. All three companies have focused on similar application markets, namely next-generation digital consumer, digital telephone and smart cards. All three applications are very attractive and, although these companies are doing well in their target markets, many other semiconductor companies will begin to make inroads into these markets to take advantage of high growth rates. Inevitably this will detract from the profitability of these markets as they become more price sensitive. Many of these markets are already experiencing downward ASP pressure (see Tables 6, 9 and 12).

On a positive note, these companies have a head start on many of their competitors. This should enable them to maintain their advantage, at least in the short term. These companies possess the key analog and digital technologies and the intellectual property necessary to compete in future, highly integrated markets. Furthermore, many of the growth application markets that will emerge over the next few years will be driven by Europe. Examples will include DECT, smart cards and digital STBs. Continued collaboration at a European level through initiatives such as Eureka and Esprit should also assist all three companies in driving the shape of future markets.

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Perspectives

Semiconductor Application Markets Europe

Market Analysis

LAN and LAN Internetworking Equipment Production in EMEA

Abstract: *This Market Analysis outlines the major issues affecting LAN evolution and reports on hub, switch and router equipment production in Europe, the Middle East and Africa (EMEA), comparing this with shipment statistics.*

By Andrew Phillips

Executive Summary

This document presents Dataquest's share statistics for EMEA production of LAN and LAN internetworking equipment (comprising hubs, switches, backbone routers and access routers). Manufacturing locations and subcontractors are also detailed. Although many of the major OEMs have design and manufacturing activity in EMEA, Cisco Systems' absence means that local production contributes only a small percentage toward the total equipment shipped in the region. The fastest-growing opportunities for semiconductor usage are in access routers (for the LAN internetworking market), which are forecast to grow at 31 percent compound annual growth rate (CAGR) between 1997 and 2002, and LAN switches, which are forecast to grow at 31 percent CAGR over the same period. Higher-speed protocols, such as Gigabit Ethernet, are encouraging a trend toward ASIC solutions for these products. Developments in LAN hardware configuration, protocol usage and Layer 3 switching are also presented.

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LAN Equipment Definition and Evolution

Dataquest defines LAN hubs, switches and routers as follows:

- Shared media hubs: these are LAN devices that connect multiple PCs through a single node on the network.
- Switches: these provide dedicated bandwidth to one or more users on each switched port. Devices that have multiple shared media ports linked to individual switch ports (known as group switches) are treated as hubs. Layer 2 and Layer 3 switches are included.
- Routers: these are a class of network controller that determine the best routing for data transmission between a transmitter and a receiver. Routers operate at Layer 3 of the ISO-OSI model and can be segmented further into backbone routers and access routers. Access routers may be classified as branch office routers or personal routers.

Dataquest

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Dataquest defines EMEA networking equipment production as follows:

- Full-build: the assembly of electronic components (both active and passive) onto the main printed circuit board (PCB) in addition to the assembly of the system.
- System-build: system assembly and configuration only, using PCBs imported from outside EMEA.

Total networking production is the sum of full-build and system-build assembly, which are mutually exclusive.

In recent years, LAN communications have become critical to the success of many knowledge-based organizations. Networking products continue to evolve to meet the demands of traffic growth and new applications. As the breadth of communications dependence increases, organizations spend more time evaluating the cost/benefit and bottleneck issues relating to system hardware.

Advances in PC and workstation technology and processing power have driven this evolution. Multimedia applications, e-commerce and portable computing products have increased the demands on the LAN and the requirement for fast, reliable access to it for remote workers.

Hardware Configuration

Figure 1 illustrates the hardware configuration of a typical large business enterprise LAN and WAN. Remote workers and the branch office have access to the main office servers via the WAN. The hardware shown is representative of many installations. In this example, desktop PC subgroups, equipped with standard Ethernet network interface cards (NICs), have a twisted pair connection to a local shared media hub or switch. The hubs provide a shared bandwidth (in this case, 10 Mbit/s), while switches provide a guaranteed maximum bandwidth (10 Mbit/s) to each NIC. The backbone connection from these hubs and switches multiplexes the subgroup communications (via 100-Mbit/s Fast Ethernet in our example) to the backbone router; this router manages traffic to the servers and, via the remote access server, to the WAN. The remote workers may access the LAN using personal routers, but are more likely to use analog modems. The branch office uses dedicated equipment (that is, a branch-office router) to access the servers via a higher-bandwidth link such as ISDN or leased line.

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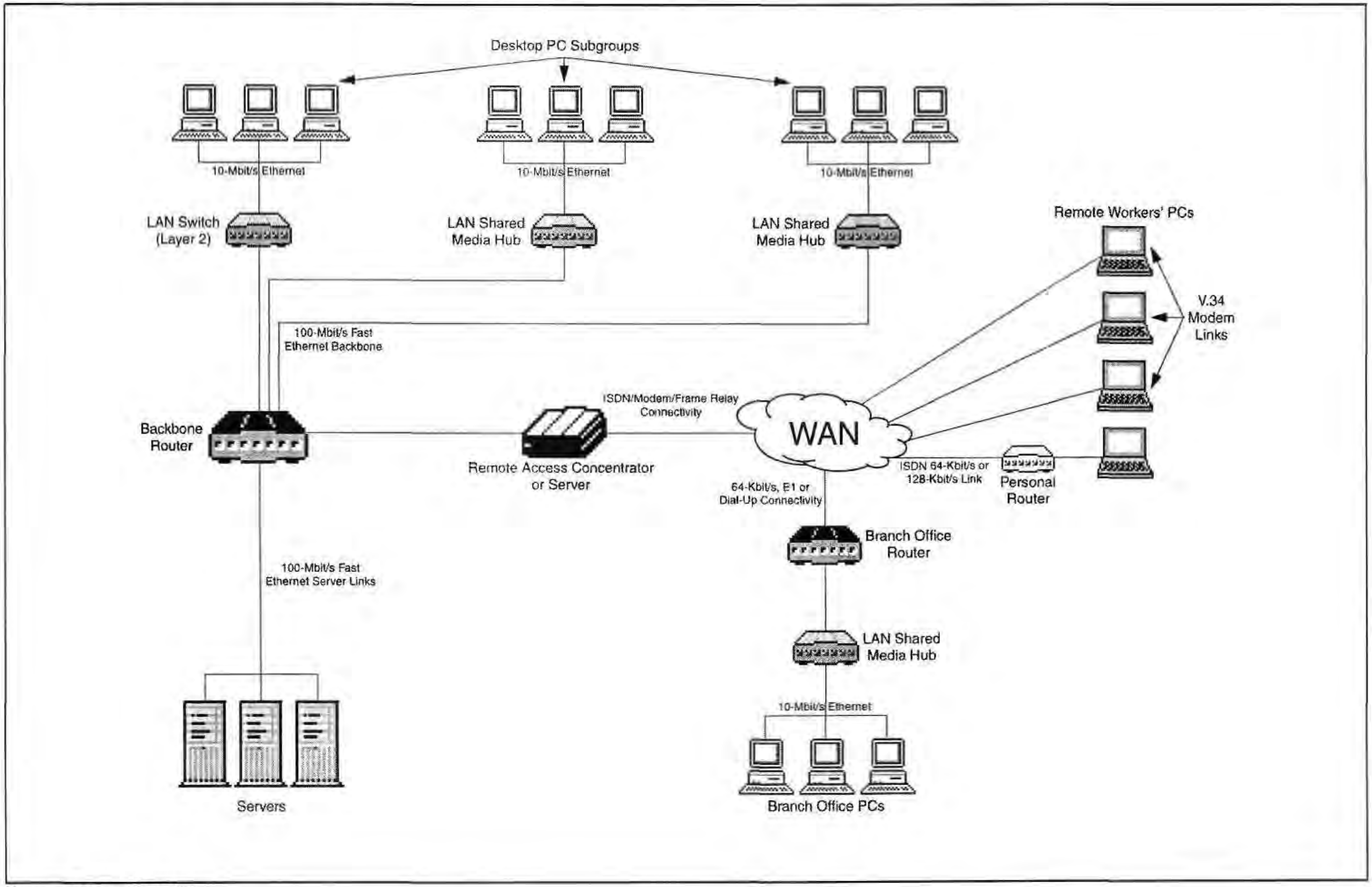
Figure 1
Typical LAN/WAN Hardware Configuration of a Large Business



Source: Dataquest (July 1998)

Ethernet Evolution

Traditional LAN communications are based on a shared media approach whereby multiple users (that is, a subgroup), linked in a star configuration to a repeater hub, compete for a fixed amount of bandwidth. When the hub receives a packet of data the incoming signal must be rebroadcast to all the attached nodes. This inefficient use of bandwidth has the additional problem of reducing the average bandwidth available in the subgroup each time a new node is added.

The original solution to increased LAN traffic was to divide subgroups into smaller segments linked by bridges or routers. Routers are expensive and add delay to data throughput. A more cost-effective solution was achieved with the development of 100-Mbit/s Fast Ethernet and by using LAN switches instead of shared media hubs to allocate dedicated bandwidth to each port. These switches operate at Layer 2 of the ISO-OSI model, supporting a single subgroup address and guaranteeing bandwidth to that node. Recent price erosion in the 10/100-Mbit/s Ethernet NIC market has accelerated this trend, with 1997 EMEA sales of 10/100-Mbit/s NICs overtaking 10-Mbit/s products for the first time. Table 1 presents the major applications for various LAN protocols.

Table 1
Major Applications for LAN Protocols

Protocol	Maximum Data Rate (Mbit/s)	Major Applications
Ethernet	10	Desktop and backbone
Fast Ethernet	100	Backbone upgrades and 10/100-Mbit/s NICs
Gigabit Ethernet	1,000	Fastest-growing backbone upgrade technology
Token-Ring	4/16	Desktop and backbone, but losing share
FDDI	100	Backbone, but losing share
ATM	25/155	Backbone upgrades

Source: Dataquest (July 1998)

Backbone Bottlenecks

The emergence of the Internet, intranets and client/server applications has caused a dramatic shift in LAN traffic distribution over the past few years. Working teams are more fluid and less likely to be situated in the same physical area sharing the same subgroup. While 80 percent of traffic used to be localized within a subgroup, today a much larger percentage of traffic traverses multiple subgroup boundaries. This has increased the bandwidth requirements on the LAN backbone and, although 10-Mbit/s Ethernet is the dominant backbone, Fast Ethernet is expected to have the majority share two years from now.

Until recently, if a network became sufficiently large to require segmenting, the best way to achieve this was to put backbone routers in the network. Routers use the information contained within Layer 3 of the ISO-OSI model to segment the network, increasing efficiency and adding security and manageability in each subgroup. The routers are typically software controlled and can be programmed to provide the cheapest, fastest or least busy of all available routes to LAN or WAN interfaces.

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The Layer 3 Switching Solution

By relying on lookup tables to route all the packets in a transmission, the router is inherently slow. The larger the network the larger the lookup tables and the greater the propagation delay. Today's high-performance routers achieve throughput rates of 1 million packets per second (pps). The slowest Layer 3 switches operate at millions of pps and, given their lower cost, present a price/performance benefit that cannot be ignored. Table 2 compares the features of Layer 3 switching with traditional routing.

The limitations of Layer 3 switches make them unsuitable for interface to the WAN; consequently, traditional backbone routers that were replaced by these Layer 3 switches are being redeployed in WAN interface applications. In addition, access routers, incorporating a WAN interface, are being developed for the remote-worker and branch office markets.

Table 2
Features of Traditional Routing versus Layer 3 Switching

Traditional Routing	Layer 3 Switching
Typical cost $80,000	Typical cost $30,000
Packet forwarding up to 1 million pps	Packet forwarding up to 11 million pps
CPU and software architecture	ASIC architecture
Multiprotocol support	Currently supports TCP/IP and IPX only
Supports extensive filtering	Supports some filtering
Supports multiple subgroups	Supports multiple subgroups

pps = packets per second
Source: Dataquest (July 1998)

Other Networking Considerations

Having the correct LAN configuration is clearly important, but many organizations have legacy issues to consider and networks that are expanding in terms of applications and users. LAN bottlenecks may occur in other areas. The installed base of Cat 3 (16 MHz), Cat 4 (20 MHz) and Cat 5 (100 MHz) cabling presents its own limitations. Cat 5's bandwidth restrictions have encouraged the Institute of Electrical and Electronics Engineers to work on a scheme for sending Gigabit Ethernet over copper; Cat 6 and Cat 7 cable specifications offer marginal bandwidth improvements, but at significant cost.

Moving to gigabit data rates in the backbone may move the bottleneck to the servers themselves. Amdahl's law states that an execution rate of 1 million instructions per second (Mips) is needed to utilize every Mbit/s of communications bandwidth available to the processor. Thus, 1,000 Mips are required for gigabit data rates, which equates to approximately four 200-MHz Pentium Pro processors. Raw processing power may be compromised further by server hard disk access times or Level 2 cache size and wait states.

Internet access and the increased mobility of workers have fueled voice over IP technology, increased sales of analog modem and ISDN remote access technology products and encouraged design activity in cable modem and xDSL digital modem techniques. Financing new hardware for the remote worker has the combined effect of reducing funds available to upgrade other areas of the LAN, while increasing the potential number of users and the amount of traffic.

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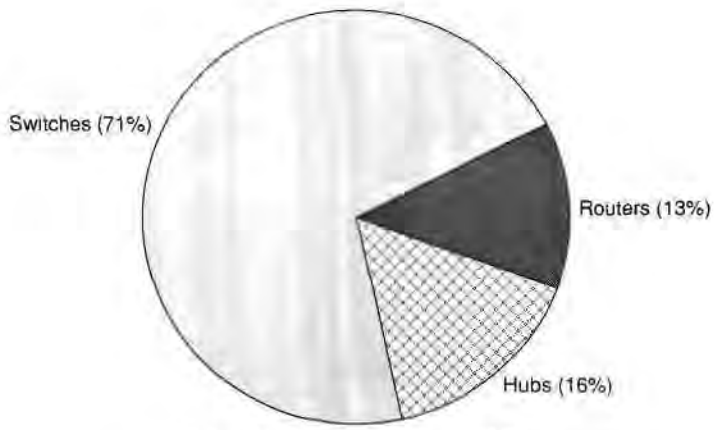
EMEA Networking Market Overview

Shipments of networking products (hubs, switches and routers) in EMEA amounted to $6,500 million in 1997. Three manufacturers—Bay Networks, 3Com and Cisco Systems—dominate this market, and sales of their products into the region accounted for 66 percent of this revenue.

Networking products manufactured in EMEA account for only a small part of this shipment revenue—the majority of products shipped are imported into the region. Dataquest estimates that the value of EMEA production of hubs, switches and routers was $748 million in 1997. Figures 2 and 3 illustrate the share of this ex-factory revenue by product (hub, switch and router) and by manufacturer, respectively.

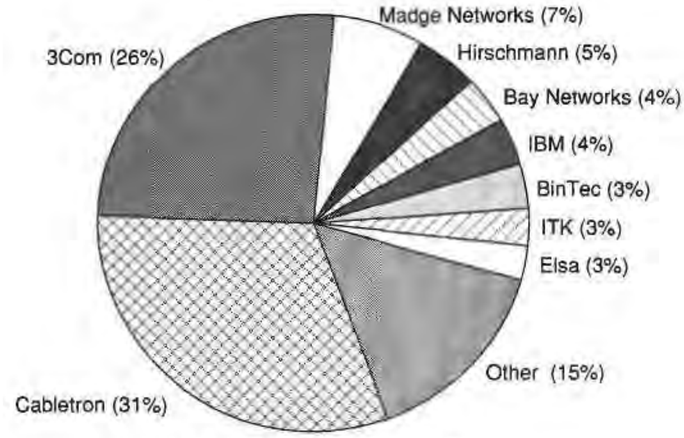
Table 3 lists the equipment manufactured in EMEA by the major manufacturers; Table 4 details their design and manufacturing locations. Notably absent from the list is Cisco Systems, which has a major share of the shipments of LAN switches and routers in EMEA. Newbridge Networks' UK headquarters performed some assembly, but this ceased in October 1997. Olicom has design activity only in its Denmark facility.

Figure 2
LAN Equipment Production Ex-Factory Revenue by Product in EMEA, 1997



Source: Dataquest (July 1998 Estimates)

Figure 3
LAN Equipment Production Ex-Factory Revenue by Manufacturer in EMEA, 1997



Total Ex-Factory Revenue, 1997
$748 Million

Source: Dataquest (July 1998 Estimates)

Table 3
Overview of Networking Manufacturers with Production in EMEA

Manufacturer	Products Manufactured
3Com	Hubs, switches and routers
Bay Networks	Hubs, switches and access routers
BinTec	Backbone routers and access routers
Cabletron	Hubs and switches
Elsa	Access routers
Hirschmann	Hubs, switches and access routers
IBM	Hubs and switches
ITK	Access routers
LanOptics	Ethernet switches
Madge Networks	Token-Ring hubs, switches and ATM switches
NBase	Hubs and switches
Sagem	Access routers
SysKonnect	FDDI hubs
Thornflex	ATM switches

Source: Dataquest (July 1998)

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Table 4
Networking Manufacturing and Design Locations in EMEA

Manufacturer	Town/City	Country	Design at this Location	Subcontract Manufacturer	Location of Subcontractor
3Com	Dublin	Ireland	[1]	Jabil, Welwyn, Solectron[2]	Various
Bay Networks	Limerick	Ireland	[3]	Solectron for selected products	Various
BinTec	Nuremberg	Germany	Yes	Siemens Nixdorf and Pantel	Germany
Cabletron	Limerick	Ireland	Yes	None	
Elsa	Aachen	Germany	Yes	None	
Hirschmann	Neckartenzingen	Germany	Yes	None	
IBM	Various	United Kingdom, Germany, France	Yes	MSL Valencia, Xyratex	Spain and United Kingdom
ITK	Dortmund	Germany	Yes	None	
LanOptics	Migdal	Israel	Yes	None	
Madge Networks	Wexham	United Kingdom	Yes	Celestica	Ireland and United Kingdom
NBase	Yokneam	Israel	Yes	None	
Newbridge Networks	Maidenhead	United Kingdom	Yes	[4]	
Olicom	Lyngby	Denmark	Yes	[5]	
Sagem	Paris	France	Yes	None	
SysKonnect	Ettlingen	Germany	Yes	Ludbe Electronic	Germany
Thornflex	Colombes	France	Yes	Thomson-CSF	France

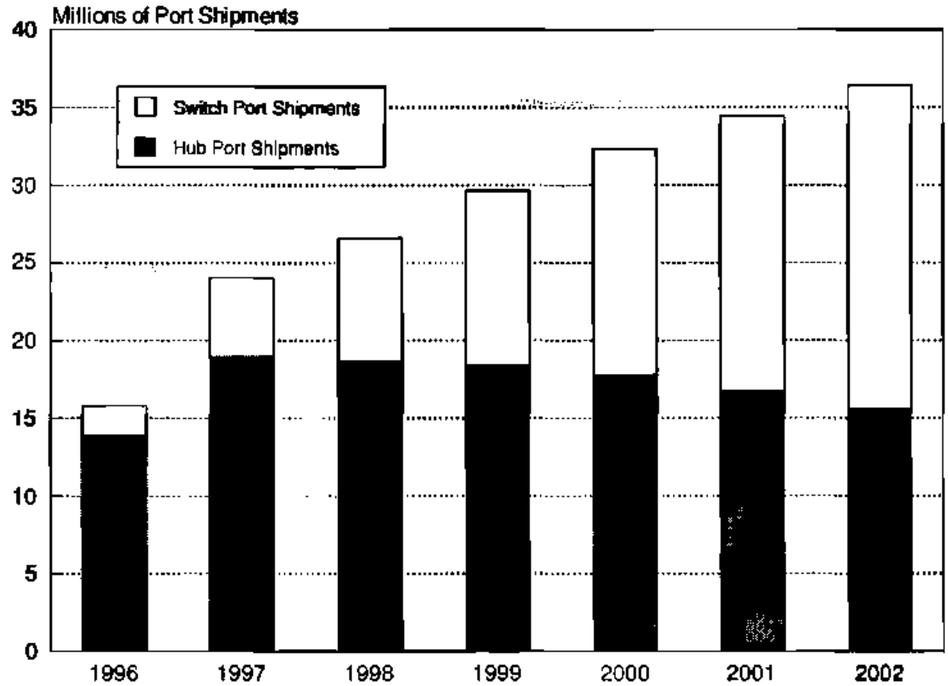
[1] 3Com has design facilities in Hemel Hempstead, United Kingdom
[2] 3Com also has in-house manufacturing facilities
[3] Bay Networks has design facilities in Watford, United Kingdom
[4] Newbridge Networks ceased European assembly in October 1997
[5] Olicom has design facilities only in Europe
Source: Dataquest (July 1998)

EMEA LAN and LAN Internetworking Equipment Production Forecast

Shared Media Hub and LAN Switch Forecast

EMEA shipments of 10-Mbit/s Ethernet shared media hubs continue to account for the majority (76 percent in 1997) of all shared and switched LAN ports sold. However, shared 10-Mbit/s Ethernet equipment sales are dropping, while all other types of Ethernet connection—including switched 10 Mbit/s—are growing. This trend has been encouraged during the past year by aggressive product pricing from commodity-oriented suppliers and Asia/Pacific vendors shipping autosensing 10/100-Mbit/s Ethernet switches. Combined with low-cost 10/100-Mbit/s NICs, these present a flexible and affordable solution. Fast Ethernet switches are forecast to show very strong shipment growth (48 percent CAGR from 1997 to 2002). ATM and Gigabit Ethernet switches also show strong growth, but their relatively recent introduction and backbone rather than desktop application has limited shipments. The shipment forecast for shared media hubs and LAN switches is shown in Figure 4.

Figure 4
Shared Media Hub and LAN Switch Shipment Forecast in EMEA, 1996-2002



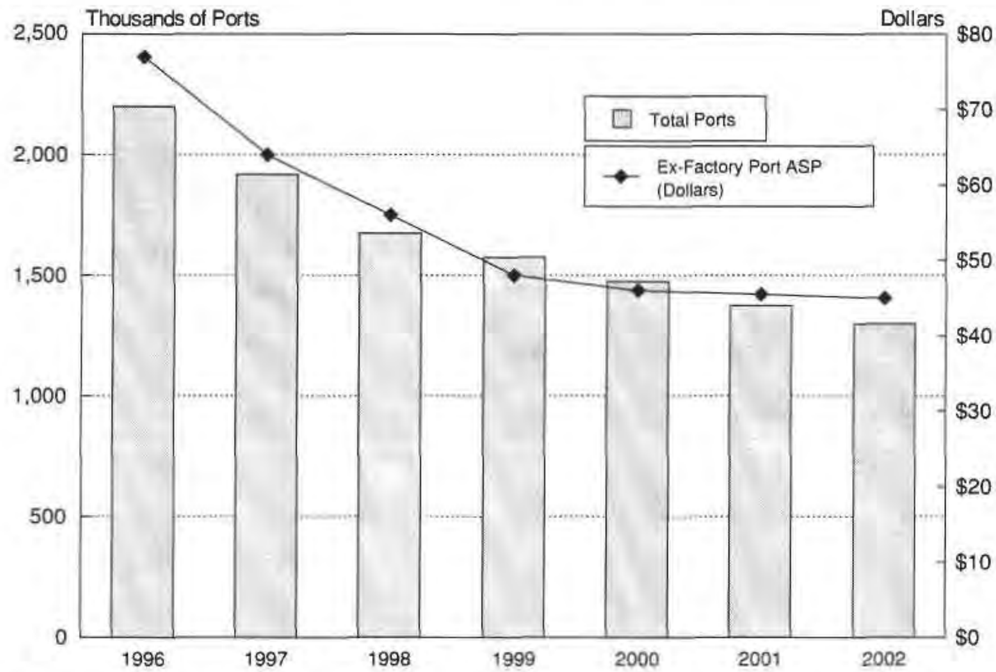
Source: Dataquest (July 1988 Estimates)

The EMEA shared media hub and LAN switch production forecasts, shown in Figures 5 and 6, show similar trends to the shipment figures. Although Fast Ethernet shared media hub production is increasing, the overall trend in the hub market is for declining port production and ASP. To compete with the popularity of the latest switched solutions, shared media hubs have become aggressively priced. The shared media hub ex-factory ASP forecast levels off toward the end of the forecast period as Fast Ethernet hubs become a significant percentage of units produced.

LAN switch production shows increasing production volumes and decreasing ASP. The vast majority of these products are Layer 2, although Dataquest also groups Layer 3 switches in this category. Layer 3 switch production is also increasing, but volumes are very limited and account for less than 10 percent of the total port production by the end of the forecast period.

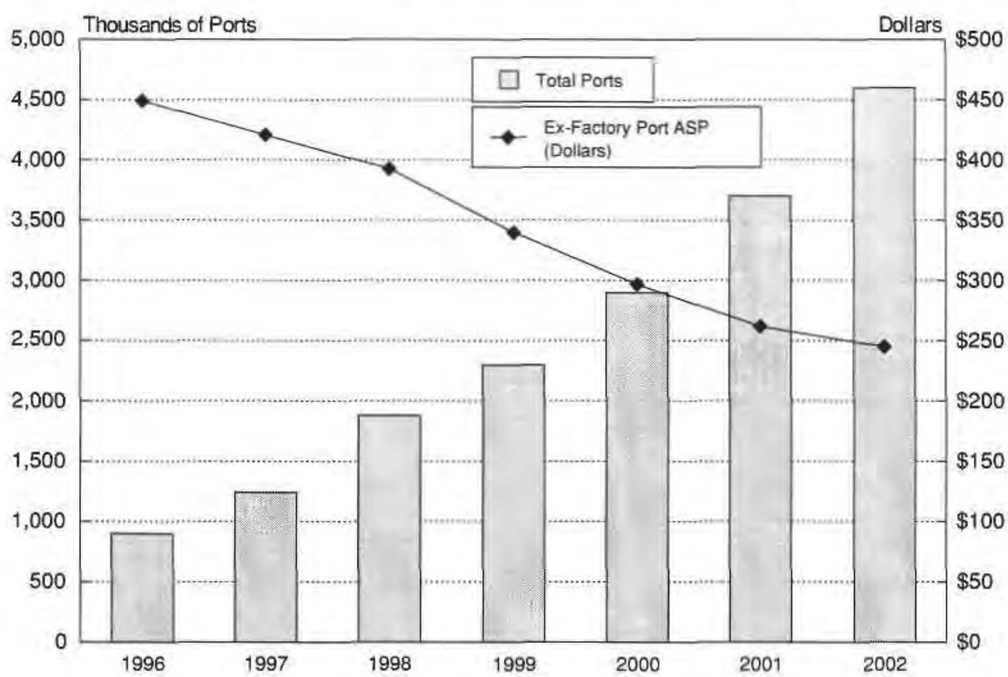
Layer 3 switches have been shipping only since 1997, and still have some technical boundaries to overcome in terms of multiprotocol interpretation. This suggests that their ASP is unlikely to fall as rapidly as that of Layer 2 switches.

Figure 5
Shared Media Hub Production and Ex-Factory ASP in EMEA, 1996-2002



Source: Dataquest (July 1988 Estimates)

Figure 6
LAN Switch Production and Ex-Factory ASP in EMEA, 1996-2002



Source: Dataquest (July 1988 Estimates)

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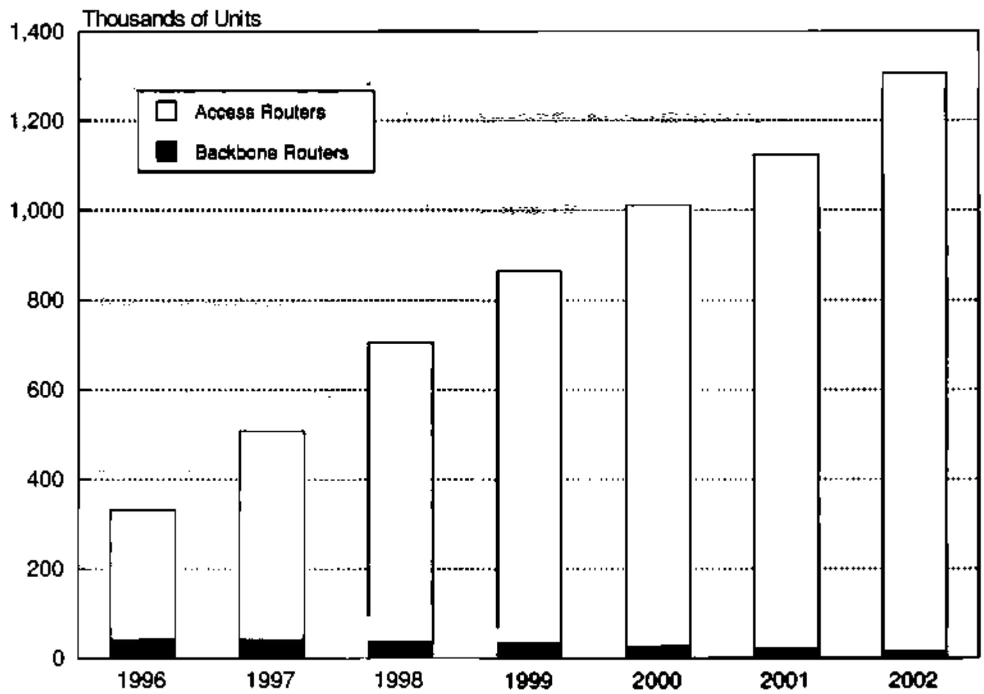
Router Forecast

The router shipments forecast, shown in Figure 7, highlights the growth of this market, led by the explosion of access router products for the LAN internetworking market. Access routers are significantly less expensive than backbone products and revenue from router shipments will decline beyond 1999, even with the strong growth of access routers.

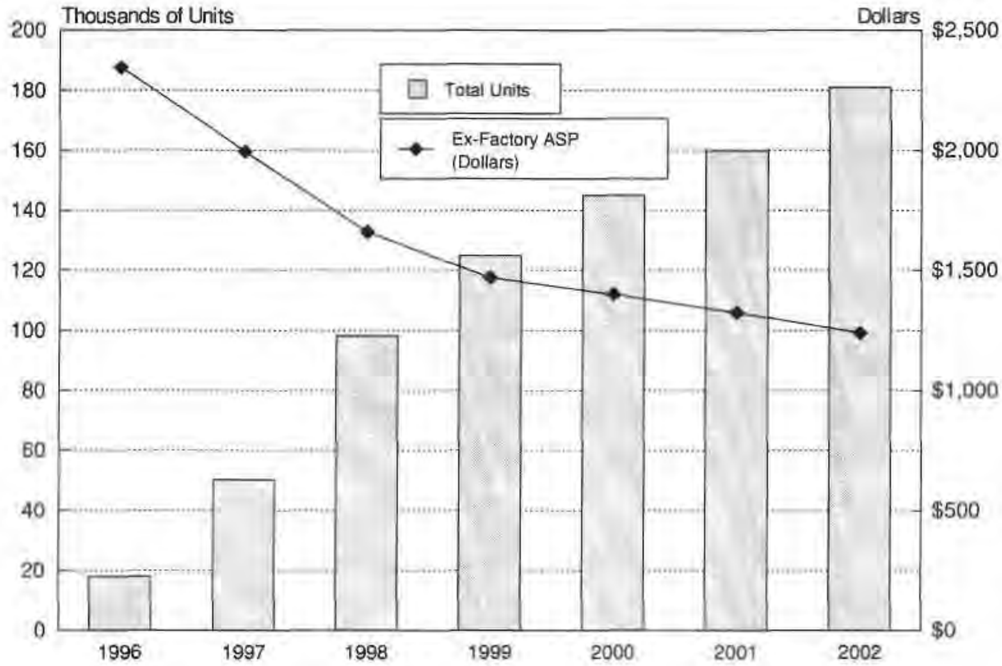
The situation for EMEA production is slightly different. Cisco Systems has the majority share of the backbone and access router market in EMEA, with more than 40 percent of total shipments, but has no production facility in the region. Figure 8 forecasts EMEA router production—which consists almost entirely of access routers. The decline in ASP reflects the fierce competition in this expanding market. With the introduction of Layer 3 switching products competing for part of the same market, it is unlikely that backbone routers will be built in significant numbers in EMEA. However, backbone routers are still necessary at the edge of the LAN to provide security and a wide-area interface, and manufacturers will focus on selling them to Internet service providers rather than the corporate network.

Figure 7
Backbone and Access Router Shipments in EMEA, 1996-2002



Source: Dataquest (July 1988 Estimates)

Figure 8
Total LAN Router Production and Ex-Factory ASP in EMEA, 1996-2002



Source: Dataquest (July 1988 Estimates)

Application Market Forecast

Table 5 presents the market forecast and accompanying semiconductor demand for shared media hubs, LAN switches and routers.

Silicon developments for hubs and switches have focused on reducing the cost per port and integrating multiple-port functionality into ASICs. Integration of the physical layer onto these transceiver devices reduces system costs further, although power consumption issues have prevented this for 10/100-Mbit/s PHY devices.

Traditional routers are microprocessor based and software intensive, but Layer 3 switches achieve the data-forwarding function in silicon. Moving more of the routing function into hardware increases speed and has cost benefits. However, while traditional routers support a wide range of data communication protocols, commercial considerations have limited Layer 3 switches to addressing only the most popular protocols. Most Layer 3 switches support TCP/IP and in some cases Novell's IPX as well. True multiprotocol Layer 3 switches are not yet a reality.

Switches and routers have a declining semiconductor content value over the forecast period. However, as Table 5 shows, this is not significant enough to impact revenue growth in the semiconductor market.

Table 5
Shared Media Hub, LAN Switch and Router Application Market in EMEA, 1996-2002

	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Shared Media Hub Ports (K)	2,200	1,919	1,674	1,575	1,475	1,375	1,300	-7.49%
Ex-Factory Port ASP ($)	77	64	56	48	46	46	45	-6.80%
Ex-Factory Revenue ($M)	169	123	94	76	68	63	59	-13.79%
Semiconductor Content ($)	7.4	6.5	6.2	6.3	6.3	6.2	6.2	-1.01%
Semiconductor Market ($M)	16	12	10	10	9	9	8	-8.43%
LAN Switch Ports (K)	900	1,244	1,881	2,300	2,900	3,700	4,600	29.89%
Ex-Factory Port ASP ($)	449	421	393	340	297	262	245	-10.26%
Ex-Factory Revenue ($M)	404	524	739	782	861	969	1,127	16.56%
Semiconductor Content ($)	33	27	26	26	26	26	26	-0.44%
Semiconductor Market ($M)	30	33	49	59	76	96	120	29.32%
Router Total Units (K)	18	50	98	125	145	160	181	30.73%
Ex-Factory ASP ($)	2,345	1,995	1,661	1,470	1,400	1,325	1,240	-7.62%
Ex-Factory Revenue ($M)	42	100	163	184	203	212	224	20.76%
Semiconductor Content ($)	351	298	272	273	290	256	248	-4.34%
Semiconductor Market ($M)	6	15	27	34	42	41	45	25.06%
Total Ex-Factory Revenue ($M)	**616**	**747**	**996**	**1,041**	**1,132**	**1,244**	**1,410**	**13.56%**
Total Semiconductor Market ($M)	**52**	**60**	**86**	**103**	**127**	**146**	**173**	**23.33%**

Source: Dataquest (July 1988 Estimates)

Dataquest Perspective

In enterprise applications, the LAN has progressed from being a novelty, to a convenience, to a necessity: in many cases, if the LAN goes down the business cannot function. This fact is affecting the development of networking products and making issues relating to quality and reliability as important as issues of functionality.

However, functionality is not standing still. Switch technology and access router products present a sales opportunity to those manufacturers that can meet the time-to-market and technology demands. This directly impacts semiconductor suppliers. They too must meet timescale and technology demands to achieve "design ins." The 1997 EMEA semiconductor market for networking products amounted to $60 million, and is forecast to exceed $170 million by 2002. Access routers and LAN switches drive this growth and application-specific standard products (ASSPs) are fundamental to these products. Silicon vendors Texas Instruments and Galileo Technology have penetrated successfully the LAN switch ASSP market, while vendors such as LSI Logic offer ASIC transceiver functions.

Production of hubs, switches and routers in EMEA accounts for only a small percentage of equipment shipped in the region. Dataquest forecasts that this percentage will increase as networking products become not only more widespread (particularly in smaller enterprises where delivery issues influence sales), but also more diverse; products such as Gigabit Ethernet hubs, Layer 3 switches and personal routers are recent examples of this diversity.

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Subcontractors play an important role in LAN equipment manufacture in EMEA (see Table 4) and will benefit from semiconductor contract pricing negotiated directly by the networking vendor. Cisco Systems uses European subcontractors for occasional short production runs, but as yet has no dedicated production facility in the region.

Entry into this market may prove difficult for new players because the major manufacturers are marketing themselves using product branding and system-solution strategies rather than advertising technical features. This will encourage sales to smaller, less technically aware customers, creating more difficult market conditions for the medium-sized and specialist manufacturers. Vendor-specific protocol enhancements limit interoperability and exacerbate this problem.

As continual mergers, acquisitions and partnerships in the industry prove (for example, Intel's acquisition of Case Technology, Cabletron's acquisition of DEC's networking business, Nokia's acquisition of Ipsilon and the acquisition of Radnet by Siemens/Newbridge), this market is worth competing for. Nortel's recent agreement to acquire Bay Networks (the largest merger so far) may encourage other companies, such as Ericsson, to make similar moves.

The dynamics of the networking industry often arise from companies buying technology in order to broaden their product portfolios. Time-to-market issues and system-solution marketing strategies limit in-house development of new products. This presents an underutilized channel for semiconductor design-in. The typical acquisition trail involves the purchase of smaller start-ups by established LAN vendors that, in turn, may be acquired major industry players (such as Nortel, Cisco Systems or Lucent Technologies). Traditionally, a semiconductor vendor's application engineers focus their activity on major players. The likelihood of design-in is limited, but the potential rewards are considerable. Smaller start-ups are serviced typically by the semiconductor distribution network, which is less experienced in establishing long-term potential. However, the semiconductor design from the start-up company moves through the acquisition trail and future design-ins are effectively locked out.

Collectively, these issues should serve as a warning to any silicon vendor expecting to succeed on technology alone. A strategy for financing promising start-ups should be considered and a broader understanding of the volatility of the networking market must be attained.

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Perspectives

Semiconductor Application Markets Europe

Technology Analysis

Flash Talks in EMEA Digital Cellular Handset Production

Abstract: *Digital cellular phones are the single largest market for flash in Europe, the Middle East and Africa (EMEA). This article covers flash usage in digital cellular handsets and the wireless market forces driving the segment's success. Cellular phone production data, including market share leaders, is summarized.*

By Bruce Bonner and Dale Ford; adapted by Richard Gordon and David Moorhouse

Digital Cellular Handset Production Overview

A dramatic change in the technology of cellular phones has occurred in recent years. Although analog handsets represented the vast majority of worldwide cellular phone production in 1993, the manufacture of digital handsets had overtaken that of analog ones by 1996. Last year worldwide digital cellular handset production represented 80 percent of all handsets manufactured, and this figure is expected to rise to almost 100 percent by 2002. In this respect, the EMEA region is well placed as it accounted for nearly 55 percent of worldwide production of digital cellular handsets in 1997. This share is expected to hold up reasonably well in the face of production migrating to lower-cost manufacturing regions of the Far East. A forecast compound annual growth rate (CAGR) of 18 percent between 1997 and 2002 would take EMEA digital cellular handset production to 124 million units by the end of the forecast period, as shown in Table 1.

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The digital GSM handset market exploded in Europe during the 1990s as European countries agreed on the unified GSM standard. This market had experienced very low cellular phone penetration rates before that time, but it took off after the introduction of the GSM standard (which allowed easier roaming between countries) and has grown quickly to become the largest digital cellular market in the world. Although many countries in other regions also have adopted the GSM standard, the Americas market has been much slower to adopt digital technology than anticipated.

As GSM has grown to become the dominant worldwide cellular standard, three variants have emerged to support different market demands: GSM900; GSM1800; and, for the US market, GSM1900. The difference between the three lies in the frequency of operation of the radio interface in each case—900, 1800

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and 1900 MHz respectively.. As each of these markets has matured, there has been a technology and market trend towards handsets that can operate in more than one of these frequencies or bands—so-called multiband handsets.

The market in Europe for multiband handsets is growing rapidly, especially for the GSM900/GSM1800 combination. As the cost of these handsets is less than 10 percent more than a standard digital handset, production of multiband handsets is expected to grow rapidly and to dominate the manufacture of digital cellular phones in EMEA by the end of Dataquest's forecast period, as shown in Table 2.

In another development, digital cellular handsets that operate in more than one mode are expected to enter the European market in 1998. The first multimode products will be a combination of GSM mode and digital enhanced cordless telephony (DECT) mode. This mixing of modes will allow the introduction of handsets that offer a single phone number associated with a single handset irrespective of user location, whether at home or in the workplace, via a cordless connection to a DECT base station or via a connection to a cellular network while traveling.

Further insight of the handheld wireless market is available in Dataquest's *Market Trends* report titled "Communications Application Markets—Cellular/Broadband PCS and Cordless Telephones" (CSAM-WW-MT-9707).

Table 1
EMEA Digital Cellular Handset Production, 1993-2002

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Units (K)	2,310	5,412	12,200	25,000	54,000	71,000	88,000	104,000	117,000	124,000	18%

Source: Dataquest (July 1998 Estimates)

Table 2
Proportion of EMEA Digital Cellular Handset Production by Type, 1995-2002

Type	1995	1996	1997	1998	1999	2000	2001	2002
Single Band	100%	100%	98%	89%	76%	53%	32%	20%
GSM900 Only	95%	94%	86%	80%	70%	50%	30%	18%
GSM1800 Only	5%	6%	12%	9%	6%	3%	2%	2%
Multiband	0%	0%	2%	10%	22%	42%	60%	70%
Multimode	0%	0%	0%	1%	2%	5%	8%	10%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Dataquest (July 1998 Estimates)

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Market and Brand Leaders

EMEA digital cellular handset production is dominated by a small number of manufacturers, as shown in the preliminary market share rankings in Table 3.

Table 3
Preliminary EMEA Digital Cellular Handset Production Market Shares by Manufacturer, 1996-1997

1996 Rank	1997 Rank	Manufacturer	1996 Units (K)	1997 Units (K)	AGR 1996-1997
1	1	Nokia	6,500	13,500	108%
2	2	Ericsson	6,000	12,500	108%
3	3	Motorola	4,800	10,300	115%
4	4	Siemens	2,350	4,300	83%
7	5	Philips	1,050	3,300	214%
5	6	Alcatel	1,100	2,800	155%
5	7	Panasonic	1,100	2,200	100%
8	8	AEG/Matra	700	1,300	86%
9	9	NEC	250	1,000	300%
9	10	Dancall (Bosch)	250	700	180%
		Top 10 Manufacturers	24,100	51,900	115%
		Others	900	2,100	133%
		Total	**25,000**	**54,000**	**116%**

Source: Dataquest (July 1998 Estimates)

How Cellular Phones Work

Cellular phones involve a relatively low-power handset corresponding with a local base station, of which there are many. The area surrounding the base station is called a "cell," and this can be visualized as a honeycomb. This simple concept yields powerful benefits. The handset can be small and light because it does not need to transmit long distances. A large number of subscribers can be connected simultaneously because their signals travel only a short distance and do not overlap with those in other cells. Traveling phones that move from one cell to another during a conversation can be accommodated by a central control's handing over responsibility for the handset from one base station to another. Multiple phones in the same area can be used at the same time by using multiple frequencies.

Digital Cellular Phones

Analog cellular phones were the initial standard deployed in the early days of cellular telephony. Voices are transmitted and received using a time-division multiplexing scheme, where periodic samples of the voice are frequency modulated (FM) on a carrier frequency. The advantages of an analog approach are a straightforward, minimal design for both handsets and base stations. A disadvantage, it turns out, is a lack of security for both the information (the voice) and the control signals the phone uses to stay synchronized with the cellular network. This minor technical issue became a major financial opportunity for some ethically challenged members of society, who would "clone" phone serial numbers to circumvent usage fees and having an identifying number associated with calls. Another segment of society was able to listen in on, and record, phone calls with simple scanning receivers. A better solution was needed.

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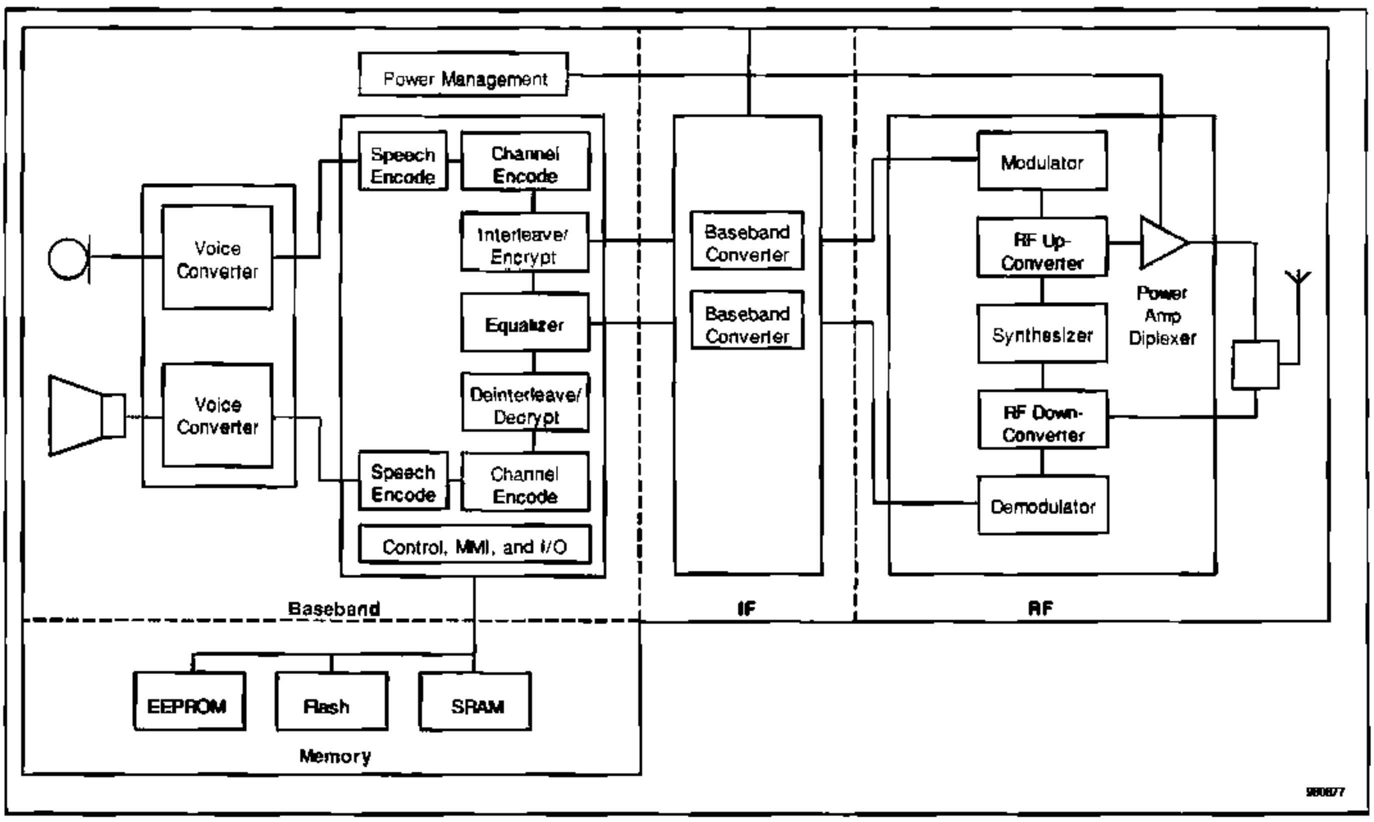
Digital cellular phones were the answer to these issues. Instead of transmitting the voice as an FM signal, it was digitized and sent as ones and zeros over a network optimized for digital traffic. A major benefit of this change is the ability to service multiple handsets with a single operation frequency instead of tying up a frequency slot per handset, yielding a dramatic increase in network call capacity. Digital handsets also have better energy efficiency, yielding longer battery lives. But at the same time a digital standard was being created, encryption was added for both serial number and voice data, making cloning extremely difficult. The initial digital standard was a European product using the GSM standard; since then, code-division multiple access (CDMA, or IS-95) and time-division multiple access (TDMA, or IS-54 and IS-136) are the other digital standards that have been propagated. A block diagram of a typical digital cellular phone is shown in Figure 1, which shows a clear separation between the radio frequency (RF) and intermediate frequency (IF) sections and the baseband section. The baseband circuitry controls both the function of the phone and its connection with the phone network, using specific protocols for the system in which it is being used. But digital cellular phones are much more complex than analog models, which gave rise to the use of flash memory in them.

Figure 1
Digital Cellular Phone Block Diagram



Source: Dataquest (July 1998)

Memory Use in Cellular Phones

As shown in Figure 1, three types of discrete memory are typically used in cellular phones: SRAM, flash memory and EEPROM. SRAM is used to store information temporarily in conjunction with the baseband microcontroller. This is for interaction with both base stations and the cellular network and for remembering the status of functions used by the user. EEPROM is employed like SRAM, but as a nonvolatile memory for small amounts of operating data. Flash memory stores the firmware, the operation software, of the microcontroller. Flash memory was originally pressed into service by European cellular phone manufacturers for the rollout of GSM, when they needed regulatory approval of models they wanted to sell but for which the firmware was likely to change. The signaling protocols were complex, and they did not want delays in getting to market because a phone had to be resubmitted for approval with hardware changes. Flash memory came to the rescue by allowing the changes to be implemented in software and to be updated as necessary, mainly in production lines, but also for field units if they were returned to a service center. Analog phones normally do not use flash because the code size is small and simple, allowing a nonupdatable memory such as mask ROM or one-time-programmable EPROM to be used.

Flash Memory Use in Digital Cellular Phones

Flash memory is used as a reprogrammable storage medium for operating software in the cellular phone. It is normally written just once, when the phone is originally assembled. After that, the ability to update the code is an "insurance policy" for either a protocol function or a feature visible to the user. One idea floating in the cellular industry is for "over the air" updates to a phone—the flash memory could have a new program written to it from information moved to it over the cellular network itself. Although this *could* be used to fix bugs, the concept is more attractive to service providers because they could use it to sell new features, such as voice mail, to subscribers for additional monthly fees. This would be a win-win situation: the flash makers would sell more expensive and larger chips to the market, and more revenue would come to the providers. Alas, it is not to be for some time, because it requires extensive changes in a cellular network infrastructure focused on delivering real-time voice, not operating code.

A recent departure from this paradigm is the consolidation of the EEPROM function into the flash chip, which is discussed in more depth later.

Key Flash Device Issues

Key areas of interest for cellular phone design engineers using flash memory are operating voltage, architecture, packaging, density, speed and standardization.

Voltage

The coin of the realm for cellular flash is low operating voltage. This is a compatibility issue, because the rest of the logic in the phone reduces power dissipation as voltage is reduced. The power consumption of the flash device is not reduced as a direct result of this—in fact, it could go up if other steps were not taken, because the flash cell uses high voltages for programming and erase. The benefit of lower voltage is longer battery life, both for standby and talk time, and lighter, smaller phones from the reduced battery size.

Because cellular phones are the largest market for flash memory, many innovative products have been developed for the application. Advanced Micro Devices Inc. introduced a 1.8V 8Mb device, the Am29SL800, and Intel Corporation has 2.7V chips compatible with 1.8V logic levels in its Smart 3 product family. The Intel smart voltage concept allows both single- and dual-voltage supply operation. The dual supply usage, when an optional V_{pp} voltage is connected, speeds up programming considerably, an issue for production line loading of the contents of an entire memory. Companies are now starting work on 0.9V devices! Although these are probably at least two years away, flash companies are being driven very hard by cellular phone manufacturers, which are themselves in a fiercely competitive environment, and there is no doubt that voltage and energy will continue to drop as a result.

An interesting aspect of the AMD 1.8V product is what the company calls "zero power." This is an automatic power down to the "sleep" mode, which takes only nanoamperes of supply current, when the device is not being accessed. This addressed another concern of digital cellular phone designers: low energy usage. Instantaneous power consumption does not matter, per se. What is important is *energy*, and energy equals power times time. To say it another way, the key is the "area under the curve." This is an issue for flash because the physics of operating a flash chip do not change just because the operating voltage goes down. It still takes so many electrons on the floating gate to program a cell, and the energy required to do that stays constant no matter what the supply voltage is. This is a prime area for innovation in different technology approaches, such as DiNOR from Mitsubishi Corporation. New thinking is probably required for substantial energy usage reductions.

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Architectural issues for this application are more complex than for many other uses. The starting point is the assumption of an x16 data path, because the flash is connected to a high-performance microcontroller, often RISC-based, in a direct execute manner. A second issue is the need for asymmetrical "boot block" organizations to allow both code and control information to be stored and used efficiently. The third challenge for flash is consolidation of the EEPROM and flash memory into a single chip for space and cost savings.

As discussed previously, cellular phones use flash for "code storage," but the handsets also need to store small amounts of data during operation. Currently, this need is being filled by EEPROMs, sometimes with multiple EEPROMs in a single unit. The obstacle to moving this auxiliary storage to the flash chip is that flash is not a direct-overwrite implementation as EEPROM is, and the erase block where the data is located must sometimes be used to reset the information. Currently, an erase function in a flash chip puts it offline, not allowing it to continue executing code in parallel, which is a need for real-time operation. Writing data has the same issue. This is a problem.

One solution to this problem is called "read while write" (RWW). The flash device can be designed with duplicate peripheral circuitry for separate sections of the flash memory array. This allows concurrent reading of program information while a write or erase operation is occurring in a different part of the chip. AMD has introduced "simultaneous read/write" flash, the Am29DL800, which allows this. This 8Mb part has the flash divided into two banks, one having large "code" blocks of 64KB and the other having two 32KB, two 16KB and four 8KB "data" sectors.

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Another solution is putting a small EEPROM section on a larger flash chip, giving an integrated solution to the same problem. This is the ultimate RWW chip, but it is not very flexible as the size of the read-write memory is fixed.

Packaging

A final trend in the wireless phone industry is the constant push to make the electronics as physically small as possible. For flash, this will take two directions: either including flash in another system chip, such as the DSP, or using advanced packaging techniques to shrink the footprint of the chip on the PCB.

Embedding flash (or any memory type, for that matter) is an important trend in the consumer electronics industry, and it will be used when the amount of memory is small enough not to raise the cost of the one-chip solution significantly over the cost of a two-chip solution. Because the code size in these products is currently 8Mb to 16Mb, this merging of functions is not yet economical, so a physical approach is more appealing.

Most flash chips used in cellular handsets have a TSOP plastic package, which is thin and small. But an increasingly popular way to shrink the flash package is to use chip scale packaging (CSP) technology. Most of these packages are variations of a ball grid array method of electrically and mechanically attaching the device to the PCB. Another method is to place a memory die directly on the PCB and attach by the chip-on-board or flip-chip methods. Although this is theoretically possible now, there are many hurdles to high-volume supply and use of these, most of which are fixed by CSP. Dataquest expects CSP to win in the digital wireless flash market soon, and flip chip to become the method of choice eventually.

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Read access time shows the most direct adverse effects of lowering the operating voltage of a flash memory. For instance, a 5V 70-ns device may slow to 120 ns at 3V. In some cases, where an older, slower microcontroller is used, this is not an issue. But many new chipsets have RISC processors and a "need for speed." To make matters worse, cellular phone integrated circuits must operate over a negative 40° to positive 85°C temperature range. Currently, 120 ns is sufficient, but speed varies greatly, from products under 100 ns to those with latencies of 200 ns.

Dataquest foresees the use of architecture techniques, such as "page mode" designs, to give increased performance at lower voltages.

Standardization

An issue that continues to dog cellular phone design engineers is a lack of standardization for flash memory in general, especially for the devices used in advanced cellular handsets. Some of the blame for this must go to Intel and AMD, which continue to have different strategies for implementing cutting-edge designs. Pinouts and protocols continue to be different between them, not to mention erase block architectures. But the largest handset providers are pushing the flash vendors for innovative products that solve their problems, and the suppliers are responding as well as they can and as quickly as they can, which leaves standardization in the dust. Designers are advised to allow for multiple sourcing of flash chips at the earliest possible times in their design cycles to maximize purchasing flexibility, because drop-in substitutes do not exist in many cases.

EMEA Flash Market Size Estimates for the Digital Cellular Handset Application

Table 4 shows flash consumption by digital cellular handset production in EMEA in megabit and revenue terms.

Table 4
Flash Consumption by EMEA Digital Cellular Handset Production, 1993-2002

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Units (K)	2,310	5,412	12,200	25,000	54,000	71,000	88,000	104,000	117,000	124,000	18%
Megabits (K)	9,240	27,060	73,200	174,999	431,999	674,500	1,144,000	1,664,000	2,340,000	2,976,000	47%
Revenue ($K)	62,116	98,120	153,091	346,577	410,175	410,037	500,571	619,474	741,573	852,214	16%

Source: Dataquest (July 1998 Estimates)

Dataquest Perspective

The tremendous surge in sales of digital cellular phones makes this market the largest opportunity by far for flash vendors. This is particularly true in the EMEA region, where production of digital cellular handsets is expected to account for some $850 million of flash revenue by 2002—about 60 percent of the total available market revenue of $1.4 billion in that year. As these units ramp up in emerging markets, worldwide sales will continue to expand. Because the cost of a wireless phone typically is subsidized by a service provider (although there is a trend towards direct purchasing), normal consumer demand elasticity is not an issue; the true cost of the handset is hidden from consumers and amortized into monthly charges.

The flash market recently has been very trying for the participants. They are shipping more and more products and bits but are collecting less money. Part of this has to do with a larger supplier base, but it also is because the largest cellular phone manufacturers, Motorola, Ericsson and Nokia, wield tremendous power with flash suppliers and are able to procure at commodity prices advanced products that should have hefty premiums instead.

Finally, Dataquest sees this market continuing to be key for the flash memory industry. The application values flash functionality and has the budget to pay for it. The level of innovation will prevent a true supply/demand free-for-all—but, as with most semiconductor sectors, this market is not for the faint of heart.

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Perspectives

Semiconductors Europe

Technology Analysis

Flash Talks in EMEA Digital Cellular Handset Production

Abstract: *Digital cellular phones are the single largest market for flash in Europe, the Middle East and Africa (EMEA). This article covers flash usage in digital cellular handsets and the wireless market forces driving the segment's success. Cellular phone production data, including market share leaders, is summarized.*

By Bruce Bonner and Dale Ford; adapted by Richard Gordon and David Moorhouse

Digital Cellular Handset Production Overview

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MARIA VALENZUELA

A dramatic change in the technology of cellular phones has occurred in recent years. Although analog handsets represented the vast majority of worldwide cellular phone production in 1993, the manufacture of digital handsets had overtaken that of analog ones by 1996. Last year worldwide digital cellular handset production represented 80 percent of all handsets manufactured, and this figure is expected to rise to almost 100 percent by 2002. In this respect, the EMEA region is well placed as it accounted for nearly 55 percent of worldwide production of digital cellular handsets in 1997. This share is expected to hold up reasonably well in the face of production migrating to lower-cost manufacturing regions of the Far East. A forecast compound annual growth rate (CAGR) of 18 percent between 1997 and 2002 would take EMEA digital cellular handset production to 124 million units by the end of the forecast period, as shown in Table 1.

The digital GSM handset market exploded in Europe during the 1990s as European countries agreed on the unified GSM standard. This market had experienced very low cellular phone penetration rates before that time, but it took off after the introduction of the GSM standard (which allowed easier roaming between countries) and has grown quickly to become the largest digital cellular market in the world. Although many countries in other regions also have adopted the GSM standard, the Americas market has been much slower to adopt digital technology than anticipated.

As GSM has grown to become the dominant worldwide cellular standard, three variants have emerged to support different market demands: GSM900; GSM1800; and, for the US market, GSM1900. The difference between the three lies in the frequency of operation of the radio interface in each case—900, 1800

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and 1900 MHz respectively.. As each of these markets has matured, there has been a technology and market trend towards handsets that can operate in more than one of these frequencies or bands—so-called multiband handsets.

The market in Europe for multiband handsets is growing rapidly, especially for the GSM900/GSM1800 combination. As the cost of these handsets is less than 10 percent more than a standard digital handset, production of multiband handsets is expected to grow rapidly and to dominate the manufacture of digital cellular phones in EMEA by the end of Dataquest's forecast period, as shown in Table 2.

In another development, digital cellular handsets that operate in more than one mode are expected to enter the European market in 1998. The first multimode products will be a combination of GSM mode and digital enhanced cordless telephony (DECT) mode. This mixing of modes will allow the introduction of handsets that offer a single phone number associated with a single handset irrespective of user location, whether at home or in the workplace, via a cordless connection to a DECT base station or via a connection to a cellular network while traveling.

Further insight of the handheld wireless market is available in Dataquest's *Market Trends* report titled "Communications Application Markets—Cellular/ Broadband PCS and Cordless Telephones" (CSAM-WW-MT-9707).

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	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Units (K)	2,310	5,412	12,200	25,000	54,000	71,000	88,000	104,000	117,000	124,000	18%

Source: Dataquest (July 1998 Estimates)

Table 2
Proportion of EMEA Digital Cellular Handset Production by Type, 1995-2002

Type	1995	1996	1997	1998	1999	2000	2001	2002
Single Band	100%	100%	98%	89%	76%	53%	32%	20%
GSM900 Only	95%	94%	86%	80%	70%	50%	30%	18%
GSM1800 Only	5%	6%	12%	9%	6%	3%	2%	2%
Multiband	0%	0%	2%	10%	22%	42%	60%	70%
Multimode	0%	0%	0%	1%	2%	5%	8%	10%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: Dataquest (July 1998 Estimates)

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Market and Brand Leaders

EMEA digital cellular handset production is dominated by a small number of manufacturers, as shown in the preliminary market share rankings in Table 3.

Table 3
Preliminary EMEA Digital Cellular Handset Production Market Shares by Manufacturer, 1996-1997

1996 Rank	1997 Rank	Manufacturer	1996 Units (K)	1997 Units (K)	AGR 1996-1997
1	1	Nokia	6,500	13,500	108%
2	2	Ericsson	6,000	12,500	108%
3	3	Motorola	4,800	10,300	115%
4	4	Siemens	2,350	4,300	83%
7	5	Philips	1,050	3,300	214%
5	6	Alcatel	1,100	2,800	155%
5	7	Panasonic	1,100	2,200	100%
8	8	AEG/Matra	700	1,300	86%
9	9	NEC	250	1,000	300%
9	10	Dancall (Bosch)	250	700	180%
		Top 10 Manufacturers	24,100	51,900	115%
		Others	900	2,100	133%
		Total	**25,000**	**54,000**	**116%**

Source: Dataquest (July 1998 Estimates)

How Cellular Phones Work

Cellular phones involve a relatively low-power handset corresponding with a local base station, of which there are many. The area surrounding the base station is called a "cell," and this can be visualized as a honeycomb. This simple concept yields powerful benefits. The handset can be small and light because it does not need to transmit long distances. A large number of subscribers can be connected simultaneously because their signals travel only a short distance and do not overlap with those in other cells. Traveling phones that move from one cell to another during a conversation can be accommodated by a central control's handing over responsibility for the handset from one base station to another. Multiple phones in the same area can be used at the same time by using multiple frequencies.

Digital Cellular Phones

Analog cellular phones were the initial standard deployed in the early days of cellular telephony. Voices are transmitted and received using a time-division multiplexing scheme, where periodic samples of the voice are frequency modulated (FM) on a carrier frequency. The advantages of an analog approach are a straightforward, minimal design for both handsets and base stations. A disadvantage, it turns out, is a lack of security for both the information (the voice) and the control signals the phone uses to stay synchronized with the cellular network. This minor technical issue became a major financial opportunity for some ethically challenged members of society, who would "clone" phone serial numbers to circumvent usage fees and having an identifying number associated with calls. Another segment of society was able to listen in on, and record, phone calls with simple scanning receivers. A better solution was needed.

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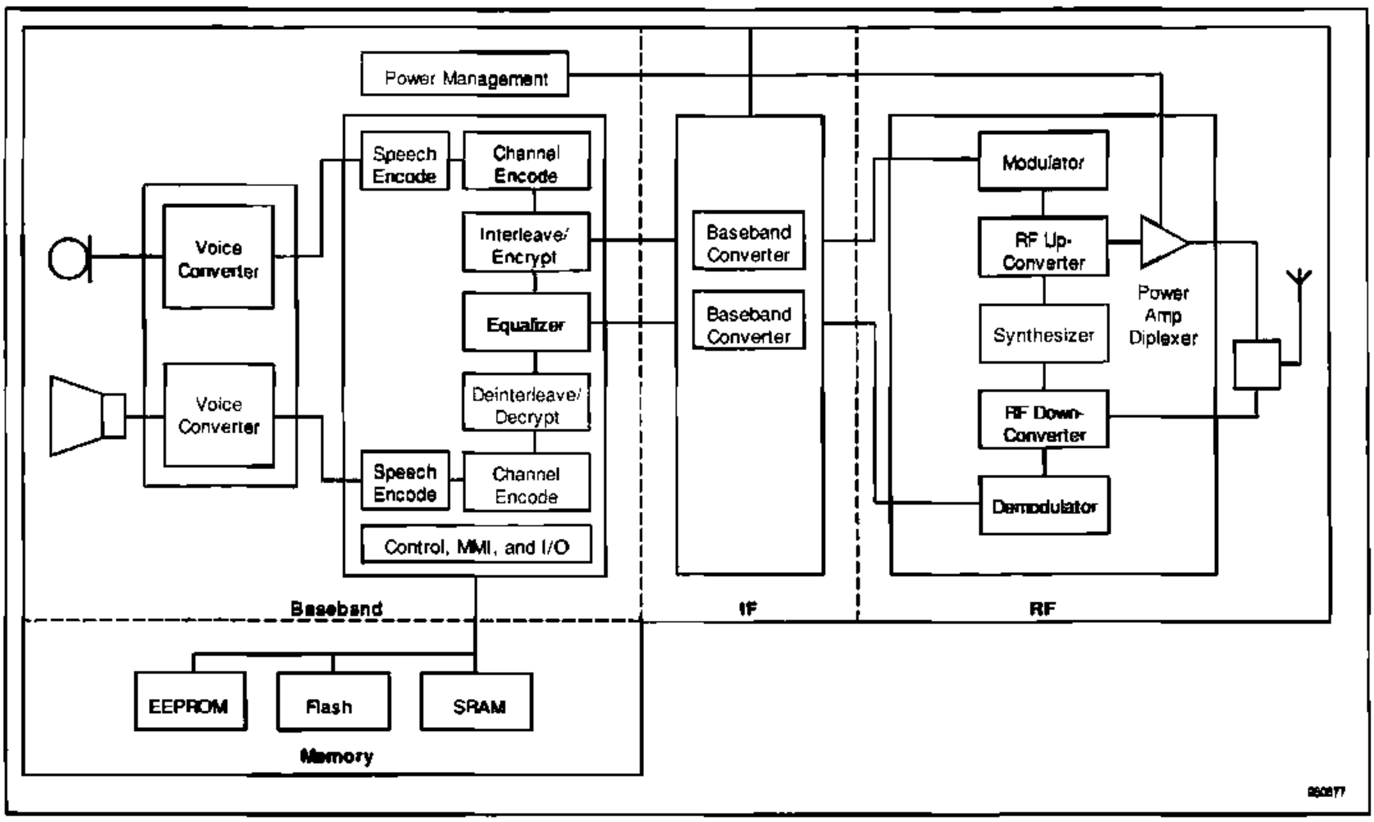
Digital cellular phones were the answer to these issues. Instead of transmitting the voice as an FM signal, it was digitized and sent as ones and zeros over a network optimized for digital traffic. A major benefit of this change is the ability to service multiple handsets with a single operation frequency instead of tying up a frequency slot per handset, yielding a dramatic increase in network call capacity. Digital handsets also have better energy efficiency, yielding longer battery lives. But at the same time a digital standard was being created, encryption was added for both serial number and voice data, making cloning extremely difficult. The initial digital standard was a European product using the GSM standard; since then, code-division multiple access (CDMA, or IS-95) and time-division multiple access (TDMA, or IS-54 and IS-136) are the other digital standards that have been propagated. A block diagram of a typical digital cellular phone is shown in Figure 1, which shows a clear separation between the radio frequency (RF) and intermediate frequency (IF) sections and the baseband section. The baseband circuitry controls both the function of the phone and its connection with the phone network, using specific protocols for the system in which it is being used. But digital cellular phones are much more complex than analog models, which gave rise to the use of flash memory in them.

Figure 1
Digital Cellular Phone Block Diagram



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Flash Consumption by EMEA Digital Cellular Handset Production, 1993-2002

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR 1997-2002
Units (K)	2,310	5,412	12,200	25,000	54,000	71,000	88,000	104,000	117,000	124,000	18%
Megabits (K)	9,240	27,060	73,200	174,999	431,999	674,500	1,144,000	1,664,000	2,340,000	2,976,000	47%
Revenue ($K)	62,116	98,120	153,091	346,577	410,175	410,037	500,571	619,474	741,573	852,214	16%

Source: Dataquest (July 1998 Estimates)

Dataquest Perspective

The tremendous surge in sales of digital cellular phones makes this market the largest opportunity by far for flash vendors. This is particularly true in the EMEA region, where production of digital cellular handsets is expected to account for some $850 million of flash revenue by 2002—about 60 percent of the total available market revenue of $1.4 billion in that year. As these units ramp up in emerging markets, worldwide sales will continue to expand. Because the cost of a wireless phone typically is subsidized by a service provider (although there is a trend towards direct purchasing), normal consumer demand elasticity is not an issue; the true cost of the handset is hidden from consumers and amortized into monthly charges.

The flash market recently has been very trying for the participants. They are shipping more and more products and bits but are collecting less money. Part of this has to do with a larger supplier base, but it also is because the largest cellular phone manufacturers, Motorola, Ericsson and Nokia, wield tremendous power with flash suppliers and are able to procure at commodity prices advanced products that should have hefty premiums instead.

Finally, Dataquest sees this market continuing to be key for the flash memory industry. The application values flash functionality and has the budget to pay for it. The level of innovation will prevent a true supply/demand free-for-all—but, as with most semiconductor sectors, this market is not for the faint of heart.

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Perspectives

Semiconductors Europe

Market Analysis

European Inward Investment Opportunities

Abstract: *In this Market Analysis Dataquest examines what the key factors are in attracting inward investment from the semiconductor industry, and analyzes eight major locations. Funding is no longer the critical factor it once was, while educational infrastructure is playing an increasingly significant role.*

By Edmund Gemmell

Executive Summary

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Most countries in Europe are interested in, and are actively seeking, inward investment from semiconductor manufacturers. With most countries offering broadly similar incentives by way of capital grants and taxation benefits, the battleground to win high-quality inward investment is shifting to skills management. The future winners in this battle will be those that offer a combination of the correct skills in the right numbers, as well as attractive financial packages. This calls for an integrated response by each country to the demands of the semiconductor industry.

Some countries have recognized this and are rising to the challenge of developing methods to meet these demands. These will be the countries that attract the added-value inward investment projects. Some countries or regions will continue to offer large grants, but as this becomes more expensive, and as their competitors become more differentiated, the quality of inward investment that these regions or countries attract will suffer. While the focus of this *Market Analysis* is the semiconductor industry, many of the financial and fiscal incentives described are equally applicable to other industries.

Introduction

The location of a wafer fabrication plant or assembly and test plant is a key decision taken by semiconductor vendors when considering capital expenditure programs. Identifying where sufficient staffing, reliable infrastructure and suitable land can be found is becoming increasingly important. At the same time, many countries within the European Union (EU) have realized the potential benefits of having semiconductor plants located within their borders, in terms of direct employment, indirect employment, enterprise creation and regional regeneration. It is no surprise, therefore, that many countries, and

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specific regions within countries, are positioning themselves as high-technology centers and competing vigorously for new inward investment proposals. This *Market Analysis* analyzes some of the regions that a semiconductor manufacturer might consider when deciding upon a location within the EU. This *Market Analysis* also provides details of appropriate staffing availability, as well as training infrastructure and an overview of the financial incentives and support available in each location.

The locations covered in this *Market Analysis* are as follows:

- Flanders, Belgium
- Southeast France
- Western France
- Eastern Germany (Saxony)
- Ireland
- Northern England
- Central Scotland
- Central and eastern Spain

Table 1 shows the regions which have been most successful in promoting themselves to the semiconductor vendor community.

Table 1
Semiconductor Inward Investment Projects in Europe Since 1990

Year	Investment Location	Company
1990	Scotland	Motorola
	Scotland	Motorola
	Italy	Texas Instruments
1991	Northern England	Fujitsu
	Sweden	Mitel
	Northern Germany	Philips
	Northern Italy	SGS-Thomson
1993	Southern Germany	Hitachi
	Southern France	SGS-Thomson
1994	Ireland	Intel
1995	Western France	Philips
	Ireland	Analog Devices
1996	Scotland	NEC
	Northern England	Philips
	Netherlands	Philips
	Southern Italy	SGS-Thomson
	Southern France	SGS-Thomson
	Eastern Germany	Siemens
	Italy	Texas Instruments
1997	Southern France	Atmel
	Corbielle-Essomes, France	IBM
	Ireland	Intel
	Northern Italy	International Rectifier
	Germany	Mitsubishi
	Southern Italy	SGS-Thomson
	Northern England	Siemens
1998	Israel	Intel
1999	Eastern Germany	AMD
	Northern England	Fujitsu
	Scotland	Hyundai
	Wales	LG Semicon

Source: Dataquest (May 1998)

Flanders

Recently, Flanders has been one of the more proactive regions in Europe trying to attract inward investment. The main focus of activity has been in attempting to attract a semiconductor wafer fabrication facility into the region, which, it is hoped, will act as a catalyst for the further development of the semiconductor industry within the region.

One of the most interesting ideas being investigated by the Flanders Foreign Investment Office (FFIO) is the concept of building its own wafer fabrication plant and leasing this out to semiconductor vendors on a long-term basis. The model would have the Flanders government consortium managing the plant and issues such as chemical, gas and waste handling, while the tenant vendor would be responsible for manufacturing development and core competencies. This business model is still being developed by the FFIO and Meissner and Wurst, a wafer fab design company.

Flanders is home to two semiconductor fabrication facilities. Alcatel Microelectronics, which is based in Oudenaarde, near Gent and IMEC, which has a smaller-scale facility in the region. IMEC is the largest independent microelectronics R&D center in Europe. IMEC's R&D activities are concentrated on the development of novel design methodologies, the development of processing technologies for the next generation of ULSI chips and the support of the training of VLSI design engineers on behalf of both educational institutes and industry. IMEC also provides training facilities for industrial partners upon request.

However, there are approximately ten other fabrication modules located within 150 km of Brussels. In addition to the semiconductor wafer fabrication plants and IMEC, Flanders has two other universities with specialist electronics faculties. The Flanders region also has 15 industrial engineering colleges which provide four-year electronics courses to degree standard.

The principal financial incentive offered by the Flanders government to inward investors is a series of cumulative direct subsidies. The first is a basic subsidy of 4 percent of total investment, which is available to qualifying investments that are the first operational unit by the company in Flanders. The second is a direct subsidy of up to 8 percent of the total investment, depending on the economic importance of the investment into the region. Given Flanders' eagerness to attract a semiconductor fabrication plant, it would be fair to assume that such an investment would be considered as being of great economic importance and, thus, would attract a significant part of this 8 percent. The third subsidy is based on employment growth, and can be up to 9 percent of the total investment. The combination of these three subsidies means a total direct subsidy of 21 percent of total investments is available to any qualifying inward investment project.

In addition to the direct subsidies that are available as incentives, Flanders also offer several fiscal measures to increase the value of inward investment support packages. These measures include an exemption of real estate tax for the investment site for five years and accelerated depreciation schemes. The FFIO will also participate in site acquisition and preparation.

The Flanders employment agency also participates in the sourcing of staff for any inward investment project. The Flanders employment agency, as part of an incentive package, will meet the expenses of new staff's first six to eight weeks of employment, when they usually will be in training.

France

Within France, the regions of western France and Marseilles-Provence in the southeast are two of France's primary high-technology and IT conurbations. Consequentially, both regions are being given a lot of support from the Invest in France Agency. Philips, Temic Matra (now part of Atmel) and SGS-Thomson have all located wafer fabrication plants within western France. Marseilles-Provence hosts wafer fabrication plants belonging to SGS-Thomson and Atmel. In addition, Motorola is nearby in Toulouse, and SGS-Thomson has more plants close by in Grenoble.

The importance of this high level of wafer fabrication plants is that both regions have been acclimatized to the high levels of service that wafer fabrication investments need in terms of ground preparation requirements, planning permission, waste material management, traffic and customs infrastructure, and supply infrastructure. In addition, the regions also have an existing skill base and orientation towards high-technology industries.

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Western France

As well as the wafer fabrication plants located in western France, the region also has a high concentration of R&D facilities, including CNET (applied telecommunications research organization), CCETT (applied audiovisual research) and the microelectronics center for the west of France (CCMO), which is a collaboration between three electronics educational establishments in Rennes together with SGS-Thomson, Matra and SOREP. CCMO provides R&D facilities as well as further training facilities and courses for workers in the electronics industry.

Western France is also home to more than 50 university- or engineering-school-based laboratories or departments with a high-technology orientation. These laboratories and departments are in 13 universities or engineering schools specializing in electronics, data processing and telecommunications.

The primary financial incentive available to companies investing in western France is the regional development grant (PAT). Most areas within western France qualify for a subsidy of up to FF 50,000 (approximately $8,250) per job created, although some areas within the region qualify for up to FF 70,000 (approximately $11,500) per job created. PAT is available to all companies investing at least FF 20 million (approximately $3.3 million) and creating 20 permanent jobs over three years. Neither of these restrictions would pose much of a problem for a semiconductor vendor considering investing in a new operation. The PAT incentive is limited to 17 percent of total investment. Some exceptional levels of financial assistance are available from PAT in western France, however, because of the restructuring of the French defense industry.

In addition to PAT, other assistance schemes are available for training programs and ensuring that manufacturing facilities are environmentally friendly. Full or partial exemption from business tax (a local tax) is also negotiable for up to five years for inward investment projects. In PAT-qualifying areas, local authorities are also prepared to become involved in land acquisition and preparation, and may provide a discount of up to 25 percent on purchase or lease costs.

Marseilles-Provence

The Marseilles-Provence region in the southeast of France has, as stated earlier, many wafer fabrication plants either in the region or close by. Additionally, the region has several technology parks serving the electronics industry, including Rousset, Aixles-Milles industrial development park, the Chateau-Gombert science park and the Arbois Europole project.

Within these parks and the region's universities there are 30 laboratories carrying out research in various fields of microelectronics. These laboratories are based around the four universities in the Bouches du Rhone region. In addition, Marseilles-Provence is home to the Microelectronics Regional Study Center on Silicon (CREMSI), which has some 40 members, including SGS-Thomson, Atmel, Gemplus and DuPont Photomasks, and 10 R&D laboratories. CREMSI is focused on furthering microelectronics in the Marseilles-Provence region and undertakes joint research for those companies involved. The Marseilles-Provence region also provides training programs and facilities for the technicians and senior technicians required to populate semiconductor fabrication plants.

Financial incentives in the Marseilles-Provence region are structured as those for western France. Marseilles-Provence is one of the few regions in the southeast of France which qualifies for PAT. The PAT rate for Marseilles-Provence is FF 70,000 per job created, subject to a maximum of 25 percent of total investment.

Ireland

Analog Devices' investment in Limerick in 1976 was the catalyst for Ireland's interest in attracting electronics-related investment. Since then, in addition to attracting a prestigious investment from Intel, Ireland has attracted several other semiconductor-related inward investments in the form of design houses.

Ireland has focused its efforts to attract future inward investment by building an infrastructure to supply the key staff for future technology. In addition to the National Microelectronics Research Centre base at University College Cork, which has a 3-inch foundry, IC design group, and interconnect and packaging laboratory, Ireland has eight universities with electronic engineering faculties, which produce between 600 and 700 electronics engineering graduates per year. Also, the Irish government has put in place an Ir£50 million ($68 million) program aimed at developing additional engineering courses.

As well as its higher education establishments, Ireland also has 12 regional technical colleges offering electronics-related courses. Included in these courses is one codesigned by Hewlett-Packard and Intel to develop a suitably educated pool of technician-level staff.

One of the major financial attractions for investing in Ireland is the level of corporation tax levied against companies. The standard corporate tax rate is set at 10 percent until 2010. From 2010 until 2025 the rate will be 12.5 percent, which is significantly lower than that of most other countries. Surprisingly, other financial incentives aimed at attracting investment are significantly lower than those that some other regions are offering. The Irish Development Agency (IDA) offered Intel approximately IR£30,000 ($40,000) per job, which was significantly below some other offers, for a total commitment of 2,800 jobs, yet it still won the bid. This speaks volumes for the quality of staff on offer.

The IDA tends to work on an investment incentive per job created basis. However, once an amount per job has been fixed, it is broken down into three constituent parts: a capital grant based on the value of fixed assets; an employment grant, which, typically, would not exceed Ir£10,000 ($14,000) per job; and a training grant, which would cover up to 100 percent of agreed training costs.

Saxony, Germany

The former East German state, now one of the new German *Länder*, is positioning itself as the microelectronics center of eastern Germany. Since the reunification of Germany, Siemens has built a new DRAM wafer facility, in which it is planning its new 300-mm pilot line, and AMD is close to completing a new wafer fabrication plant for the manufacture of microprocessors. These developments are on top of the semiconductor infrastructure which existed when Saxony was part of East Germany. Zentrum Mikroelektronik Dresden (ZMD), which produces primarily memory products, has been located in Dresden since 1987. Prereunification, ZMD employed more than 3,000 staff in the microelectronics industry. Today it employs approximately 500, but the supply base for skilled employees, many of which worked in high-technology industries prior to reunification, remains.

Saxony, and Dresden in particular, offers a significant R&D and university infrastructure; Dresden has more than 30 educational and research institutes. Included in this number are the Institute for Semiconductor and Microsystems Technology, the Institute for Communications Systems, the Institute for Information Systems and the Institute for Technical Informatics, all at the Technical University (TU) Dresden, which has 21,000 students. In addition to TU Dresden, TU Chemnitz, FHS Mittweida, FHS Zwickau and FHS Zittau-Goerlitz all have IC design courses. Dresden is also home to the Fraunhofer Institutes for Microelectronic Circuits and Systems, the Fraunhofer Institute for Material Physics and Layer Technology and the Fraunhofer Institute for Integrated Circuits.

The financial incentives offered to inward investors in Saxony, and the new *Länder* of eastern Germany in general, are quite significant. Both Siemens and AMD received funding of approximately DM 800 million (approximately $450 million) to assist in their fabrication plant location decision.

Start up grants can reach 28 percent for large inward investment firms in the surrounding areas of Dresden and Leipzig. In other regions of the new federal states, grants can reach 35 percent of total inward investment. These grants are from the Improvement of Regional Economic Structures Program, which is funded by the Saxony Government, the federal government of Germany and the EU.

In addition to grants, several tax incentives are available to inward investors. Included in these are an investment allowance and a special accelerated depreciation allowance. The investment allowance returns 5 percent of any investment in movable depreciable equipment. Given that the cost of facilitizing a state-of-the-art wafer fabrication plant is now in the region of $1 billion, this allowance on its own is worth approximately $50 million. The special accelerated depreciation allowance allows companies to depreciate their capital equipment by between 20 percent and 40 percent above the normal depreciation rates.

United Kingdom

The United Kingdom has three regions that are focusing their attention on attracting semiconductor inward investment. These regions are the central belt of Scotland, stretching from the east coast around Edinburgh to the west coast around Glasgow, northern England and South Wales.

In 1996, semiconductor companies with manufacturing locations in the United Kingdom, along with the UK government, founded the National Microelectronics Institute (NMI). The NMI's role is to coordinate and enhance the activities of all parts of the UK semiconductor industry's support infrastructure. Included in this is the development of supporting industries and the coordination of further- and higher-education activities related to the microelectronics industry, as well as facilitating cooperation between companies in noncompetitive areas.

The NMI treats the three geographic areas as a single cluster, given their relative geographical proximity, coordinating all its activities to assist each area equally. The NMI has, with semiconductor vendors, developed two further-education courses designed to supply the semiconductor industry with appropriately qualified operators and technicians. To date, four further-education colleges in Scotland, and ten in the United Kingdom, offer these courses. In addition, the NMI has also created and had accredited a microelectronics MSc qualification for the development of engineer-level staff.

The main financial incentives provided to those considering investing in any of the three regions are, in principle, the same, although in the last round of inward investment, which involved Hyundai, the peculiar situation of two regions within the cluster trying to outbid each other occurred. Regional Selective Assistance (RSA) is the main financial incentive and applies to all three regions. Locate in Scotland, the inward investment agency, and the Northern Development Agency say only that RSA is negotiable on an individual basis, but is based on levels of capital expenditure and jobs created. In addition to RSA, all three regions have enterprise zones, which attract additional benefits of exemption from property taxes for 10 years and 100 percent depreciation allowance for buildings in the first year of operation.

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Investors into the three regions will also be eligible for training and employment grants. Typically, these grants cover up to 50 percent of training costs, with a maximum of £4,000 ($6,500) per eligible employee.

An example which shows other potential benefits for investors is available in Scotland, where other substantial benefits including site acquisition and preparation, as well as considerable assistance with site management costs have been made available. An example of these is Hyundai's ongoing (and delayed) investment in Dunfermline, where it was reported that in an assistance package which totaled £151 million ($250 million) for a total maximum investment of £2.3 billion ($3.8 billion), amounts of £9.6 million ($16 million) for site acquisition, £23.4 million ($39 million) for site preparation (including new road infrastructure) and £9 million ($15 million) for waste treatment facilities were included.

Central Scotland

Since the mid 1970s, when National Semiconductor opened its first fabrication plant in Greenock, Scotland has recognized the increasing importance of high-technology manufacturing as a driver of national growth and large-scale provider of jobs. Since the 1970s, central Scotland has tried to reposition itself as the high-technology center of Europe, going so far as to coin the term "Silicon Glen."

The central belt of Scotland is home to six semiconductor companies, which have a total of ten wafer fabrication plants between them, and a further two plants are in planning or under construction. Central Scotland is therefore very adept at dealing with the requirements of semiconductor wafer fabrication plants.

In addition to the NMI infrastructure, central Scotland also houses 11 institutes and research centers related to the microelectronic industry. These are based at eight universities throughout the central belt region. Four of these universities are participating in a project with Cadence Design Systems to establish the world's first system-level integration institute. There are also 46 further education colleges, in and around the central belt, offering two-year electronic or electronic engineering courses.

Northern England

In addition to the regions' participation in the NMI, northern England also has a significant electronics-oriented training infrastructure, which produces more than 800 electronics-related graduates per year. In early 1998 the North of England Microelectronics Institute, a joint venture between the region's universities, Siemens and Fujitsu, opened in North Tyneside. The £16.5 million ($26 million) site includes laboratories for testing post-wafer processing reliability and design fault analysis, together with a new interconnection research project.

The region also has two universities: the University of Newcastle upon Tyne and Durham University, which both have a number of research groups related to the microelectronics industry. The University of Newcastle upon Tyne includes the Semiconductor Technology Group, the Microelectronic Systems Design Group and the DSP Group. Durham University includes the Centre for Molecular Electronics and the Centre for Electronic Systems. Durham University also manages a course developed by Fujitsu and continued by Siemens to fulfil the educational needs of both companies.

Spain

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Spain appears to be something of an enigma in the field of attracting inward investment from the semiconductor industry. Since attracting Lucent Technologies to Madrid in the late 1980s it has not attracted any other major semiconductor fabrication investment.

Spain has set up two scientific parks focusing on the semiconductor industry. The first is Valles Technology Park located just outside Barcelona, and the second is Tres Cantos Technology park in Madrid, where Lucent Technologies has its wafer fabrication plant. In and around Valles Technology Park are the Spanish National Microelectronics Center, the Regional General Testing and Research Laboratory, and the New Materials Center, which is part of the Higher Center for Scientific Research. The National Microelectronics Center also has a site in the Tres Cantos Technology Park.

The principal financial incentive offered in Spain is for investment in certain regions. This is offered by the state, and varies from 20 percent to 60 percent of a project's capital expenditure. However, neither of the scientific parks mentioned above fall into one of the qualifying regions and, thus, they receive no regional incentive from the Spanish central government. In addition to the central government regional aid, each autonomous region also offers its own smaller-scale investment packages.

Spain has also created a $420 million high-technology fund called the ATYCA initiative, which will run until the end of 1999. The program is financed by the Ministry of Industry and Energy, and can provide funding for the improvement of the technology infrastructure and training.

Dataquest Perspective

Potentially useful manufacturing locations are essentially products for which there is a very small, but valuable, customer base. When Europe started attracting semiconductor inward investment, each country's offerings were essentially commodities, where, typically for commodities, price played the pivotal role in deciding which country won the inward investment. Price in this marketplace was represented by the amount of cash a region or country would pay to convince the prospecting company to move to their location.

However, the market has moved on; in the marketplace of inward investment the emerging key differentiator is the supply chain for appropriate human resources. Those regions or countries that develop a coherent and integrated road map to supply sufficient numbers of appropriate graduates and other technical staff will be the winners in attracting the quality inward investment projects in most cases.

For some, though, location will remain a commodity product and price (in the form of capital grants) will still have a key role to play. It could be argued that AMD's investment in Dresden, Germany was an example where "price" was the determinant factor whereas Intel's investment in Ireland was an occurrence where the differentiator won out over the highest bidder—the differentiating factor being the availability of staff at all levels of engineering expertise.

Some regions are further along the differentiation curve than others. For those lagging behind, price, in the form of subsidies, will continue to be their major attraction. For some companies this may be enough, although the dynamic is changing. Companies are beginning to want more than just a massive cash handout at the beginning of a project. They now want to ensure the long-term future of their plants and maximize the value they add to the company.

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Equally, countries want more than a cash for jobs equation, especially as the amount of cash required to win becomes unaffordable. They want investment in their communities and participation in their educational infrastructure. We may not have seen the last of the bidding wars that occurred in the fight to attract inward investment in the 1980s and early 1990s, but they will be fewer, as will be the participants involved in the fight. The next step for the inward investment market may well be its segmentation, on both the part of the semiconductor vendor and the regions.

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Perspectives

Semiconductors—Top Views

Competitive Analysis

A Comprehensive Analysis of Compaq's Acquisition of Digital Equipment

Abstract: *On January 26, Compaq Computer Corporation announced an agreement to acquire Digital Equipment Corporation for $9.6 billion, the largest acquisition in the history of the computer industry. The ramifications of this merger impact every corner of the IT industry. This Perspectives provides a Dataquest-wide analysis of the effects of this acquisition on the IT market, the competition, and on the future of Compaq and Digital Equipment.*

By Dataquest Analysts

Introduction

This Perspective represents a Dataquest-wide effort to explore the significance and meaning behind Compaq Computer Corporation's acquisition of Digital Equipment Corporation. This acquisition is touted as the largest deal ever to take place in the history of the computer industry, thus catapulting Compaq to new heights as one of the world's top computer companies. The following pages explore the impact this merger will have on the industry, the competitive landscape, and the future of Compaq and Digital Equipment.

The Largest Acquisition in the History of the Computer Industry

On January 26, Compaq Computer Corporation and Digital Equipment Corporation announced, to a somewhat surprised public, that Compaq will acquire Digital Equipment. The deal, worth $9.6 billion, is the largest acquisition in the history of the computer industry. This announcement came amidst ongoing speculation that Compaq was talking with Digital Equipment, but many industry pundits would have bet that the resulting deal was for Digital Equipment's profitable services business, as opposed to the entire company. Under the terms of the agreement, Compaq will complete the purchase with a combination of stock and cash. Digital Equipment shareholders will receive $30 in cash and about 0.945 shares of Compaq common stock for each share of Digital Equipment stock. Compaq will issue about 150 million shares of Compaq common stock and $4.8 billion in cash. Estimates indicate that the acquisition cost works out to between $60 and $65 per share. Pending approval by Digital Equipment's shareholders and clearance under antitrust laws, Digital Equipment will become a wholly owned subsidiary of Compaq.

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The true cost of Digital Equipment to Compaq, however, is much less. Digital Equipment, at the end of December 1997, had just over $2 billion in cash—making the net cash outlay only $2.8 billion and the 150 million shares representing 19 percent of Compaq's shares outstanding. This means that if Digital Equipment produces no earnings, Compaq's earnings per share would be diluted by 19 percent. However, if Compaq is successful in making whatever parts of Digital Equipment it keeps, as profitable as the rest of Compaq, there will be no dilution. As a result, Dataquest expects Compaq to act swiftly in realigning the parts of Digital Equipment it will keep and spinning off whatever remains.

Who Is the Biggest of Them All?

As part of its announcement, Compaq made the claim that once combined with Digital Equipment, the resulting company will be the second largest computer company in the world after IBM; Table 1, in some ways, supports Compaq's boast. In total revenue, Compaq combined with Digital Equipment comes in fifth place. Backing out noncomputer revenue is difficult at best. However, Dataquest's best estimate shows the combined revenue of computer-related products from Compaq and Digital Equipment to be second only to IBM. Table 1 and Table 2 present a breakout of this data.

Table 1
Total Worldwide Company Revenue, 1996 and 1997
(Millions of Dollars)

Company	1996	1997
IBM	75,947	78,508
Hitachi	65,207	68,735
Hewlett-Packard	38,420	42,895
NEC	34,904	39,907
Compaq and Digital Equipment	34,572	37,646
Fujitsu	29,160	36,318

Note: All numbers are Dataquest estimates.
Source: Dataquest (January 1998)

Table 2
Total Worldwide Computer Revenue, 1996 and 1997
(Millions of Dollars)

Company	1996	1997
IBM	72,222	74,777
Compaq and Digital Equipment	32,593	35,800
Hewlett-Packard	31,559	35,449
Hitachi	34,174	35,325
Fujitsu	23,286	30,887
NEC	27,340	30,540

Note: All numbers are Dataquest estimates.
Source: Dataquest (January 1998)

For Compaq to maintain its role as the second largest computer company, it must effectively integrate Digital Equipment's operations into its own with minimal cannibalization, while continuing to grow at its stated growth rate of 25 percent per year or better. Clearly, Compaq will not be able to keep all of Digital Equipment's market share in PCs and low-end servers, making the combined companies' revenue not completely additive. However, even with an assumed loss of 75 percent of Digital Equipment's PC revenue, Compaq is still ahead of Hewlett-Packard Company after backing out HP's test and medical equipment revenue (but not by much). In essence, the race for the No. 2 position in the computer industry is a dead heat between the combined Compaq and Digital Equipment, HP, and Hitachi. Fujitsu and NEC are not far behind.

A key benefit for Compaq is Digital Equipment's core enterprise business, which occupies a market position that Compaq has been unsuccessful at penetrating because of its Intel-based architecture. However, Digital Equipment's Alpha business is the clear technical leader in large computing system hardware, but it has been unsuccessful in a marketing sense. Compaq can take the Alpha systems business and dramatically accelerate it through Compaq's powerful sales and marketing skills. If it succeeds, the prize will be large—Table 2 indicates that there is plenty of money in this particular pot.

How Does the Acquisition Impact the Competition?

Prior to the acquisition, Compaq competed against IBM's and HP's products. Today and in the future, the battle will be waged over solutions that Dataquest defines as the strategic bundling of products and services. IBM is still by far the world's largest computer company. However, its hardware revenue is dominated by aging legacy systems such as S/390 mainframes, AS/400 midrange systems, and its UNIX-based RS/6000 products. The inevitable maturation of Windows NT should have a profound effect on IBM's ability to keep its business from shrinking. Compaq's acquisition of Digital Equipment puts increasing pressure on IBM to decide whether to aggressively pursue a Windows NT-based product and services strategy as have HP and Compaq. If IBM continues to shy away from a similar strategy, its customers may become fodder for HP and Compaq's growth. The ultimate key challenge for Compaq is to create its own solutions methodology, thus moving away from a products-only strategy.

As for PC companies, Compaq has moved significantly ahead of its traditional competition. Dell Computer Corporation must decide whether to become a computer company or stay a very efficient channel for PC products. A major risk for PC and other systems vendors is that Compaq, IBM, and HP will become the primary product and service suppliers for end users. Customers may not see the need to include more than three vendors on their short lists. This may have force other competitors to become niche solution providers.

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How Will the Acquisition Impact Products and Technologies?

A Dataquest analyst made the analogy that "the merger of these two enterprises and cultures will be like two galaxies colliding: slow to happen, and some worlds may collide and be destroyed." This comment reflects the multitude of perceived product overlaps within Compaq, Tandem, and Digital Equipment. Understandably, these redundancies will be remedied—the perceived outcome is the eradication of certain products and technologies. Perhaps the more interesting question is which products and technologies have enough brand and market value to succeed under the new Compaq regime. Dataquest briefly explores these questions by product and technology type.

Workstations

With the workstation market in a period of major transition, Compaq's acquisition of Digital Equipment has the potential to significantly change the balance of power. Although it is relatively new to the workstation business, Compaq has shown itself to be one of the movers and shakers in the rapidly growing Windows NT workstation market. By comparison, Digital Equipment has not been doing as well—not only losing market share in the stagnant UNIX market, but more importantly losing ground in the Windows NT segment where it was one of the early leaders. Digital Equipment workstation customers stand to gain from Compaq's leadership and momentum. Almost immediately, Compaq can challenge HP more effectively for the No. 1 position in the Windows NT market segment by pooling the market share of both companies (Compaq and Digital Equipment).

Compaq also gains significantly on the technology front with a technically credible UNIX offering. The most significant impact of this could be in the graphics area. Until now, Compaq has had no graphics strategy of its own, relying upon third-party cards while HP and Intergraph have been able to differentiate their Windows NT product lines with proprietary high-end graphics capabilities. Along with Digital Equipment's workstation business, Compaq has gained the high-end graphics technology from Megatek, which Digital Equipment acquired in 1996. Compaq has the opportunity to add the fruits of this venture to its workstation business potentially filling one area of weakness.

Servers

The issues dealing with the operating system of choice take place most predominantly in the server space. Compaq supports Windows NT, SCO UnixWare, and Novell's NetWare; Digital Equipment provides Windows NT and its proprietary UNIX, as well as systems based on VMS. The third element of the new company, Tandem (acquired by Compaq in June 1997), has its proprietary NonStop Kernel (NSK), a small investment in UNIX, and Windows NT. Also there is a mix of processors (that is Intel, Alpha, and MIPS) within the new company and the operating system decision goes jointly with the chip selection.

Dataquest foresees that Compaq will opt to keep Tandem's high-end systems and operating system while at the same time maintaining Digital Equipment's UNIX variety. There may be an opportunity to migrate the NSK operating system to an Intel design in the future, but it is well after the turn of the century. The Alpha solutions gain credibility with Compaq's endorsement and can provide a path from IA 32-bit to the Merced technology. The real test of strengths will be the price/performance ratings of the processors and operating systems after Merced is stabilized and Microsoft's next generation matures.

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Personal Computers

Through the first three quarters of 1997, Compaq sold roughly as many PCs every month as Digital Equipment did the entire period. This underscores the fragility of the Digital Equipment PC business as part of a much larger Compaq. Although Dataquest believes that Digital Equipment brings valuable technology and engineering to the table, these attributes will be more effectively leveraged in Compaq branded PCs. Therefore, Dataquest ultimately foresees the death of Digital Equipment branded PCs.

As customers' short list of vendors becomes dominated by IBM, HP, and Compaq, this may force other computer vendors (PC and otherwise) to target niche markets. Ultimately, this standardizes and simplifies the desktop, leading to a real commodity market where vendors must search long and hard to add significant value and differentiation. Whether customers will accept single vendor solutions is an open question.

As for the mobile portion of the PC business, there are no immediate magic bullets—it is truly a draw between the mobile technology of Compaq or Digital Equipment. Dataquest believes, however, that the acquisition may allow Compaq to finally get a shot at obtaining the kind of flagship product that instantly defines the entire line and its potential. Additionally, Digital Equipment design engineers and marketers have a chance to join a mobile team that has been one of the top three in the world for the past few years. Compaq has been vying for the top spot on the mobile PC vendor heap for almost as long as there have been mobile PCs. The addition of Digital Equipment's products and skills will help Compaq compete more effectively.

Microprocessors

Digital Equipment's Alpha chip will afford Compaq the chance to penetrate and grow its business in the data center environment. It raises Compaq to the elite ranks of HP and IBM as a provider of a full suite of systems and services and allows Compaq to let the PC business evolve into a box-delivery component of its overall system strategy. Compaq's server growth will no longer be limited by any perception that Compaq is just a PC company, and the opportunity to mate the advanced Alpha servers with Compaq's marketing and sales skills could lead Compaq to significantly higher overall margins by the end of the decade. Therefore, after the dust settles, there is a third major contender for the enterprise systems market as Compaq joins HP and IBM.

What's the Impact on IT Services?

The addition of Digital Equipment's services business to Compaq fills an immense void that has kept Compaq from becoming a significant player in the enterprise computing market. Compaq's distinct lack of a service business (especially in terms of field personnel), even with its acquisition of Tandem last June, had a "pigeonhole" effect on it as a product company. It could offer great technology that was admissible for workgroup computing, but would never fly in the enterprise because of the company's lack of mission-critical services infrastructure and IT integration and management skills. Compaq attempted to minimize its lack of robust enterprise services by crafting partnerships with Digital Equipment and Unisys. However, IBM and HP continually attacked this leveraged support model in competitive bid situations, even though they, too, used partners.

The addition of a direct service business is a major boost for Compaq. It now has a chance at the enterprise and may be able to give IBM and HP a run for their money, provided the integration runs smoothly and there is an increased focus on providing solutions. This move also places more distance between Compaq and its PC competitors, particularly Dell and Apple. Compaq can now go to market competing on product and service while most others will not be able to compete at this level in the services arena.

In terms of skills and resources, Digital Services Division consists of 22,000 service professionals split between its three service business units. These business units and the specific skills sets contained therein are as follows:

- Multivendor Customer Services (MCS): This group accounts for 66 percent of fiscal 1997 service revenue ($3.8 billion). MCS delivers hardware service, support, and maintenance services, as well as multivendor availability and management services that focus on providing technical expertise in UNIX and Windows NT for mission-critical environments. Compaq leverages the MCS organization as a global service partner. Overall, the MCS group will be challenged to maintain its vendor neutrality as a vendor-to-vendor service partner.
- Network and System Integration Services (NSIS): This group accounted for 24 percent of fiscal 1997 service revenue ($1.4 billion). It has competencies in application solutions for mail and messaging, Internet/intranet services, electronic commerce, and manufacturing and telecomm industry solutions. Strong technology solutions have also been built around NT. Compaq made an initial foray into the network business with its acquisition of Thomas Conrad and Networth several years ago. To date, Compaq has not figured the nuances in delivering service for networks versus delivering services for desktops. This NSIS group will help better define Compaq's role as a network integrator.
- Operations Management Services (OMS): This group accounted for 10 percent of fiscal 1997 service revenue ($0.6 billion). Service offerings include operations support for distributed client/server environments, including desktop systems infrastructure management, application operations management, and Internet/intranet management. The services and skills in OMS will enable Compaq to offer life cycle management services to its customer base.

The integration of Digital Services into Compaq is, in theory, like finishing a puzzle—almost. Dataquest perceives certain weaknesses in Digital Equipment's services business that may directly translate into lost opportunity for Compaq. Specifically, Dataquest cites its lack of a mature applications integration practice as a major hole in Digital Equipment's capabilities. These skills are essential for a major play in the enterprise. As both companies are aware of this distinct lack, there is a chance that there may be additional acquisitions down the road.

Once the integration process gets under way between the two companies, Dataquest foresees a potential culture clash between product-oriented Compaq and the Digital Equipment's services business. Although Compaq's executives understand the need for services, there is a distinct lack of understanding about how to shift from a product to a solutions model. Compaq needs to make a concerted effort to leverage the knowledge and expertise housed within Digital Equipment in order to effectively make this transition. Compaq may very well end up integrating into Digital Equipment's service culture rather than the other way around. Dataquest believes Compaq's best bet is to let current Digital Services management remain in full control of services.

The existence of a Compaq/Digital Equipment service partnership prior to the acquisition may help move the integration process along. In fact, Compaq stated that talks between the companies first began because of the services partnership. However, there's a concern that Compaq will continue to be quite focused on the capabilities offered by Digital Equipment's Multivendor Customer Services (MCS) business unit, which are quite product support oriented. Compaq needs to expand its services vision and leverage the outsourcing and network services skills housed in Digital Equipment's other services units.

Lastly, there are several looming questions—the answers will directly impact the success of Compaq's merger with Digital Equipment and their future success as a unified company. Some of these key questions are as follows:

- How will Compaq manage its channel relationships given that it now has a direct service capability?
- Will Digital Equipment be able to sustain its reputation and viability as a multivendor service provider given that it is now a Compaq-owned company?
- Does Digital Equipment bring the right mix of service expertise that Compaq needs to deliver enterprise solutions to the Fortune 1000?
- How will Compaq integrate the Tandem and Digital Equipment professional services capabilities?

Dataquest believes that most of the elements are in place for Compaq to compete squarely in the demanding enterprise services arena. However, it needs to take a hint from IBM and HP: lead with solutions, not just products.

What's the Impact on the Channel?

The potential for product channel conflict is technology dependent. Clearly in an open technology market such as PCs, channel conflict is a key issue because a reseller can make the decision to switch brands if it is concerned that it is competing for business with the vendor. With Digital Equipment's PC business expected to be merged into Compaq's business, this should not be an issue—particularly since Digital Equipment's existing business is almost exclusively indirect.

Further up the technology curve, segmenting between direct and indirect channels is more difficult; it is a question that companies such as HP and Digital Equipment have struggled with, especially as WinTel technology has encroached into the workstation and midrange computer spaces. If technology is proprietary and demanded by users, then a vendor can operate through both direct and indirect channels. More difficult for vendors is how to stop and separate sales organizations from competing against each other. HP's solution is to put both sales organizations under the same umbrella. Compaq will need to move in this direction.

Channel relations regarding service could be a touchy subject, as Compaq now has direct service capabilities. However, considering Compaq's recent redesign of its Authorized Service Provider (ASP) program around customer requirements and satisfaction, and Digital Equipment's multivendor services accomplishment of integrating services at point of product purchase, there will be plenty of service opportunity for the channel. Current business partners focused on the services side of the equation have compelling reasons to stay the course or even upgrade their relationships with both companies.

Compaq needs the channel's support. Even with the Digital Services Division under its belt, the company still needs the channel's core competencies such as broad customer reach and custom software expertise. HP and IBM have recognized this and it is reflected in their channel strategies. The Digital Equipment acquisition puts Compaq in a more powerful position when dealing with the channel, but there are alternatives that resellers can choose. Resellers will be watching Compaq very closely in the coming months.

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What's the Impact on Sales and Marketing?

Neither Compaq nor Digital Equipment has as yet determined the overlap between accounts. Digital Equipment's MCS organization is already supporting many Compaq environments—all signs indicate that Compaq intends to preserve this vendor neutral asset. Digital Equipment's product and service top accounts map closely in Fortune 1000 market segments. Its services business has helped Digital Equipment penetrate Fortune 2000 and middle market segments with little overlap on the product side. Digital Equipment's strengths are in middle market and global enterprise organizations. Compaq views its markets slightly differently. Compaq clearly plays in the small office/home office segment and in what it labels the small/medium business, middle market, and global/mission-critical enterprises.

In terms of sales resources, Digital Equipment has about 1,000 dedicated service sales specialists worldwide who prospect for and close the company's service business. A number of these dedicated service sellers line up to strategic accounts and sell to end users as members of Digital Equipment's Enterprise Sales Force (ESF) account teams. They also include channel sales representatives who sell to, through, and with partners. ESF staffs about 2,000 people worldwide and sells the company's technology products; it segments into three types of selling orientations. One group is assigned to about 500 strategic corporate accounts, another group has a territory responsibility covering from two to 25 accounts, and the rest are devoted to prospecting for new business and generating leads for Digital Equipment's partners.

A potential concern however, before the acquisition and now, is the lack of sufficient consultative selling talent in both companies. Compaq's model is indirect through partners, with limited experience in the business solution sell at the top of the enterprise. Digital Equipment's only real engagement managers are in the OMS business and are already stretched. Pockets of excellence exist within Digital Equipment's service sales organization, with considerable talent in networks, business-critical support, migration, mail, and messaging. However, the new entity will require a prudent sales retention, conversion, and recruitment effort designed to bring the enterprise selling talent to a level commensurate with the new and considerable enterprise capabilities.

The new value proposition is one of client choice of highly engineered products and technology platforms, superb service capability, true global distribution and service infrastructure, and a wealth of experience in managing complex distributed computing environments. This proposition gives the combined salesforce some powerful new selling opportunities that cannot afford to wait six months or even one year.

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Dataquest Perspective: What's the Bottom Line?

Overall, Dataquest regards Compaq's acquisition of Digital Equipment as a positive move. Critical synergies exist that will greatly improve both companies' future positions and bring added value to existing and future customers. In the short term, Compaq will continue as it has been: driving NT over UNIX and proprietary systems, and leading the world selling PCs. Further down the road, Dataquest foresees significant product, technology, and service implications as a result of the acquisition.

One of the primary overlaps between companies is in the personal computer market. It is likely that Digital Equipment's PC business will be subsumed totally under the Compaq brand because of overlap and limited brand equity. Digital Equipment's mobile PC business will also be absorbed, but the company's pioneering work in low-profile large-screen products could combine with Compaq's solid mainstream devices to allow the combined company to challenge Toshiba from the No. 1 slot. Dataquest believes that Compaq will retain Alpha and Digital UNIX because they have the strategic implication of expanding Compaq's reach into the enterprise—that is until Intel's IA-64 architecture delivers a compelling alternative to the market (not until 2001 at the earliest) and NT matures. The combination of Tandem's NonStop Kernel, Alpha and Digital UNIX, and Compaq's PC contribution creates a powerful technology engine that will allow the combined company to compete against a wide variety of competitors.

On the services side, Compaq has historically been penalized for its lack of a substantial services business. With the acquisition, it gains a service giant, 22,000-people strong with global capabilities. Dataquest anticipates some form of a culture clash between the two companies as Compaq struggles to make room for services in its product world. Despite the addition of a formidable services business, Dataquest questions whether Digital Services has the precise array of services required to provide full solutions to enterprise customers. One of Digital Equipment's key weaknesses is its lack of application integration skills that are quickly becoming a requirement given the burgeoning enterprise resource planning market. Because both companies seem to be aware of this deficiency, Dataquest can't help but wonder if there are other acquisitions waiting in the wings.

Taken as a whole, the ultimate challenge will be the integration of products and technology with services. Compaq's goals of becoming one of the top three computer companies in the world and reaching $50 billion in revenue by the millennium are largely dependent on its success at solutions selling. Dataquest perceives that most of the working materials are in place to make the new Compaq a full solutions provider, with the exception of data center and application integration skills. Aside from these holes, Dataquest anticipates a success-filled future for Compaq as an enterprise player.

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Perspectives

Semiconductors Europe

Market Analysis

The Great White Hope Turned into a Great White Shark

Abstract: *Far from recovering, the DRAM market has taken another nosedive in 1998 and the next 18 months will be critical for all concerned. This Market Analysis updates the EMEA market statistics, specifically detailing DRAM unit shipments, ASPs and revenues for 1998 by month, and for 1999 by quarter.*

By Richard Gordon

Just When You Thought It Was Safe ...

FILE COPY:
MARIA VALENZUELA

If only Steven Spielberg's 30-foot rubber shark was all the DRAM vendors had to worry about in their struggle for survival! Unfortunately, in the churning waters of the DRAM industry things are not so straightforward—death by a thousand cuts is more likely than by a single killer bite from "Jaws." There have already been bloody casualties and so it is, with a heightened sense of panic, that the remaining DRAM players swim for their lives, the relative safety of the shoreline tantalizingly close.

The companies that survive and drag themselves out of the water will have to deal with the following market conditions:

- EMEA DRAM revenues are expected to decline by 32 percent to almost $2.8 billion in 1998
- Average selling prices (ASPs) are expected to fall to about $1.15 per megabyte during the second half of 1998
- Bit growth of 82 percent will result in more than 900 million 16Mb equivalents shipped in 1998
- In 1999, more than 75 percent of all DRAM bits are expected to ship as 64Mb devices
- The ASP decline is expected to slow to settle at an average of slightly less than $1.00 per megabyte in 1999
- More than 1.5 billion 16Mb equivalents are expected to ship in 1999, following modest bit growth of 67 percent over 1998
- Modest growth of 8 percent will help DRAM revenues recover to reach almost $3.0 billion in 1999

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When Will the Madness End?

An unprecedented third successive year of declining DRAM revenues is now inevitable. The prevailing view within the DRAM industry is that all the leading vendors were selling DRAM products at prices below variable production cost during much of the first half of 1998. Once the decision to sell at this level has been taken, forecasting price trends becomes almost impossible because rational business behavior has, by that time, been abandoned. The effect of this kind of pricing policy is to reduce any revenue forecast to the status of idle speculation, but, as the fourth quarter approaches, there are signs that some semblance of sanity will return. It is doubtful whether this forthcoming period of calm will mark a dramatic turnaround in the DRAM market—that may be several quarters away—but it ought at least to mark the low point. The remainder of 1998 and all of 1999 is therefore a critical period that will shape the strength of the expected DRAM boom that will follow it. It is with this thought in mind that this DRAM forecast update has been complied, presenting, as it does, a detailed short-term view with increased granularity.

Table 1 shows the annual history and forecast detail for the EMEA DRAM market, for the period 1992-1999.

Table 1
EMEA DRAM Consumption History and Forecast, 1992-1999

	1992	1993	1994	1995	1996	1997	1998	1999
Units (Millions)								
256Kb	22.0	12.0	8.0	4.0	1.2	0.6	0.2	-
1Mb	148.9	117.0	92.4	49.0	35.0	25.8	21.4	5.9
4Mb	70.0	151.0	235.0	294.0	222.0	171.7	59.7	51.0
16Mb	0.2	3.6	21.2	67.9	179.0	377.4	383.1	195.1
64Mb	-	-	-	-	1.0	18.9	126.1	297.8
128Mb	-	-	-	-	-	-	-	5.5
256Mb	-	-	-	-	-	-	-	3.9
Total	241.1	283.6	356.6	414.9	438.2	594.4	590.5	559.2
Terabits	459	820	1,440	2,425	4,038	8,348	15,163	25,263
16Mb Equivalents	27.4	48.9	85.9	144.5	240.7	497.6	903.8	1,505.8
Bit Growth (%)	-	79%	76%	68%	67%	107%	82%	67%
ASPs ($)								
256Kb	1.70	1.99	2.37	2.50	1.50	1.50	1.60	-
1Mb	3.36	3.62	4.40	4.70	2.00	1.40	1.57	2.00
4Mb	14.24	12.70	13.54	13.51	5.10	2.41	1.45	1.22
16Mb	112.34	85.18	62.25	54.11	18.42	7.20	3.19	2.06
64Mb	-	-	-	-	121.00	45.73	11.15	7.70
128Mb	-	-	-	-	-	-	-	15.42
256Mb	-	-	-	-	-	-	-	30.85
Average	6.46	9.42	13.82	19.01	10.55	6.78	4.66	5.32
Price per Megabit	3.24	3.11	3.26	3.10	1.09	0.46	0.17	0.11
Revenue ($M)								
256Kb	37	24	19	10	2	1	0	-
1Mb	500	424	407	230	70	36	34	12
4Mb	997	1,918	3,182	3,972	1,132	414	87	62
16Mb	22	307	1,320	3,674	3,297	2,717	1,224	403
64Mb	-	-	-	-	121	864	1,406	2,294
128Mb	-	-	-	-	-	-	-	84
256Mb	-	-	-	-	-	-	-	120
Total Revenue	**1,557**	**2,672**	**4,927**	**7,886**	**4,622**	**4,032**	**2,750**	**2,975**
Annual Growth Rate (%)	-	72%	84%	60%	-41%	-13%	-32%	8%

Source: Dataquest (August 1998 Estimates)

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1998

Despite healthy bit growth of 82 percent over 1997, EMEA DRAM revenues are expected to decline by 32 percent to almost $2.8 billion in 1998. Prices have continued to fall throughout the first half of 1998—by about 50 percent in the case of high-volume 16Mb and 64Mb devices—which means that, even if prices were to stabilize for the remainder of the year and even when a continued increase in unit shipments is taken into account, revenues in the second half of 1998 will still be lower than those in the first half.

Covering the 4Mb, 16Mb and 64Mb densities, a detailed monthly breakdown history and forecast for EMEA DRAM units, ASPs and revenues in 1998 is shown in Table 2.

In 1998 first half revenues of about $1.5 billion are expected to exceed those in the second half, which are estimated at about $1.2 billion. Clearly the trend is towards higher shipments of the 64Mb density so that, by the end of 1998, it will account for about 75 percent of all bits shipped into the EMEA DRAM market. ASPs are expected to stabilize during the second half of 1998 as the PC industry increases its demand for 64Mb PC100 devices, because there are signs that there could be localized shortages of this high-end DRAM device as vendors struggle with yields during the shift of allocation of production capacity from the 16Mb EDO generation to the 64Mb PC100 device generation.

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Table 2
EMEA DRAM Consumption History and Forecast by Month, 1998

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total 1998
Units (Millions)													
4Mb	6.3	6.4	6.1	3.7	4.3	4.6	4.8	5.1	5.9	3.9	4.2	4.4	59.7
16Mb	41.3	39.2	43.7	30.7	33.4	32.7	30.2	27.8	29.9	25.5	25.1	23.6	383.1
64Mb	4.1	4.9	6.1	6.2	7.8	9.3	10.4	11.9	15.2	15.1	16.7	18.4	126.1
ASPs ($)													
4Mb	1.32	1.27	1.16	1.06	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.45
16Mb	4.56	4.45	4.13	3.71	2.97	2.65	2.35	2.35	2.35	2.35	2.35	2.35	3.19
64Mb	21.73	21.20	19.61	14.05	12.46	10.60	9.24	9.24	9.24	9.24	9.24	9.24	11.15
Revenue ($M)													
256Kb													0.3
1Mb													33.6
4Mb	8.3	8.1	7.1	3.9	6.8	7.3	7.6	8.1	9.4	6.2	6.7	7.0	86.6
16Mb	188.3	174.4	180.5	113.9	99.2	86.7	71.0	65.3	70.3	59.9	59.0	55.5	1,223.9
64Mb	89.1	103.9	119.6	87.1	97.2	98.6	96.1	110.0	140.4	139.5	154.3	170.0	1,405.8
Total (4Mb, 16Mb, 64Mb)	285.7	286.4	307.2	204.9	203.2	192.5	174.7	183.4	220.1	205.7	220.0	232.5	
Total Revenue													2,750.2

Source: Dataquest (August 1998 Estimates)

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1999

Dataquest is forecasting the beginning of recovery in EMEA DRAM market revenues in 1999 based on more modest bit growth of 67 percent and a gentle decline in ASPs. A detailed quarterly breakdown history and forecast for EMEA DRAM units, ASPs and revenues covering the 4Mb, 16Mb and 64Mb densities in 1999 is shown in Table 3.

The expected slowdown in ASP erosion will result in EMEA DRAM revenue of almost $3.0 billion in 1999, an increase of 8 percent over 1998. A critical factor in this revenue forecast for 1999 is the global production capacity outlook. If, as expected, overcapacity remains in place for much of the year, then there will be continued downward pressure on ASPs, and this assumption forms the basis of the forecast for 1999. However, this outlook probably represents a downside scenario in revenue terms for two reasons. First, if market conditions do not improve significantly it is conceivable that further capacity could be forced out of the industry (in addition to Siemens' closure of a leading-edge DRAM fab in the United Kingdom), thus restricting supply. Secondly, with a rapid move to 64Mb PC100 devices, it is likely that there will be a tightening of supply, because fewer vendors will have the capability to produce these devices in high volume. Both these factors could result in price stability which, in turn, could lead to higher revenue growth than forecast next year.

Table 3
EMEA DRAM Consumption Forecast by Quarter, 1999

	First Quarter	Second Quarter	Third Quarter	Fourth Quarter	Total 1999
Units (Millions)					
4Mb	12.5	12.7	16.5	9.3	51.0
16Mb	62.2	49.3	46.4	37.2	195.1
64Mb	60.8	63.6	81.2	92.2	297.8
128Mb					5.5
256Mb					3.9
ASPs ($)					
4Mb	1.37	1.26	1.17	1.08	1.22
16Mb	2.28	2.10	1.94	1.80	2.06
64Mb	8.77	8.10	7.49	6.92	7.70
128Mb					15.42
256Mb					30.85
Revenue ($M)					
1Mb					11.8
4Mb	17.1	16.0	19.2	10.0	62.4
16Mb	141.7	103.7	90.2	66.8	402.5
64Mb	533.1	515.3	607.9	637.8	2,294.0
128Mb					84.0
256Mb					120.3
Total (4Mb, 16Mb, 64Mb)	691.8	635.1	717.3	714.6	
Total Revenue					**2,975.0**

Source: Dataquest (August 1998 Estimates)

Dataquest Perspective

The EMEA DRAM market for 1998 can already be written off as a financial disaster for the vendors. Although it may have been possible to remain profitable in 1996 and 1997, this is certainly not the case in 1998, and when the companies' accounts are finalized, it will have to be acknowledged that the global DRAM industry has operated at a loss.

More positively, there are signs that 1998 will mark the low point in this most recent DRAM recession. Sooner or later, market forces will prevail and the DRAM industry will return to profit. The slowdown in capital spending that has resulted because of the reduction in DRAM profits in the past two years will ripple through to cause undercapacity in 2000 and beyond. This will mean undersupply and, therefore, stable price and increasing revenues, assuming that the insatiable demand for increased DRAM bits remains in place—and there are no signs that the demand for DRAM is likely to slacken off.

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Perspectives

Semiconductor Application Markets Europe

Market Analysis

Semiconductors Second Quarter 1998: A Buyer's Boon and a Supplier's Gloom

Abstract: *Since the release of Dataquest's spring worldwide semiconductor forecast, severe DRAM price erosion and economic downturns have begun to affect the revenue not only of MOS memory but also of all other major semiconductor product categories. The consumer and data processing electronic equipment markets are showing further signs of weakening. Capital spending forecasts have declined 15 percent. Weakened by economic turmoil in Asia/Pacific and financial weakness in Japan, prices on electronic imported goods arriving at Europe's and America's doorsteps have declined for seven consecutive months. The DRAM downturn that began in December 1995 is taking the rest of the market down. This very long downturn is reminiscent of the DRAM nosedive that began in January 1985. Many companies barely survived, and those that did were lucky to walk away bruised and battered. How do these events affect Dataquest's clients and current forecast?*

By Mary Ann Olsson

A Worldwide Forecast Update

For two and one-half years, there has been both decline and growth in semiconductor products. MOS memory devices have led the decline. In terms of historical volume and driving overall profit, DRAMs, the powerhouse products, have been pivotal to this decline (down 38 percent in 1996, down 20 percent in 1997). Judging from the decline in prices during the first half of 1998, there will be a third year of decline in DRAMs. This decline could go beyond 23 percent, taking DRAM revenue below $16 billion in 1998.

Although multiple forecasts and scenarios different from Dataquest's original forecast have been publicized, Dataquest has tried to avoid following the herd. This Perspective offers the most likely scenario for the market and, possibly, moments of sanity that rise above soothsaying.

The spring publication of Dataquest's worldwide semiconductor forecast for semiconductors and ICs showed the optimistic forecast; the most likely downside scenario for 1998 is shown in Table 1. Barring major economic downturns that even Dataquest cannot predict, we believe that the market will fall within this range.

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Table 1
1998 Worldwide Semiconductor Forecast Downside Scenario
(Millions of Dollars)

	Actual 1993	Actual 1994	Actual 1995	Actual 1996	Actual 1997	Optimistic 1998	Most Likely 1998
Total Semiconductors	85,514	110,513	151,310	142,150	147,165	159,249	149,198
Total ICs	73,429	95,861	132,184	123,761	127,571	138,617	129,121
Total MOS DRAM	14,581	23,266	42,249	26,012	20,744	20,960	16,000
Semiconductor Growth (%)	31.0	29.2	36.9	-6.1	3.5	8.2	1.4

Source: Dataquest (June 1998 Estimates)

Analysis and Assumptions

Since the first quarter of 1998, significant events have occurred that have affected not only industry dynamics but also Dataquest's initial forecast. The Asian financial crisis has worsened, weakening the financially struggling Korean semiconductor companies. Overcapacity is still prevalent. A price collapse continues to erode the DRAM market. Continued oversupply and unbalanced currencies in Asia/Pacific and Japan and competitive posturing by the 64Mb DRAM suppliers are the main cause of this erosion. Are those cries of dumping in the distance?

It is Dataquest's view that vendors will continue to lower prices, even to the point of selling at or below cost, to gain share or just to fill the fabs. The aggressive capital spending and overexpansion that continued through 1997 exacerbated the problems of a market already in the throes of overcapacity and accelerated DRAM technology die shrinks. In 1996, overcapacity in DRAM was about 20 percent, and it was rumored to be at 40 percent in 1997. With the shrink factor and the addition of net capacity over the last year and a half, the signs do not bode well for an 8 percent growth in 1998. Add to that a recent downward trend in microprocessor (MPU) and logic prices, and Dataquest's most likely scenario becomes more reasonable.

Buyers of semiconductor products are happy about these prices. But the risks are great. Building too much inventory in a shaky market with weak trading partners coupled with low import pricing could send the entire semiconductor industry spiraling into a recession. Many suppliers (merchant and foundry) are scurrying to fill fabs with non-DRAM products, offering lucrative contract pricing for products in the non-DRAM sectors. Many buyers are building low-priced inventories to keep up with pricing pressures while meeting demand for lower-end systems in the data processing, consumer, and communications sectors. Is the market spiraling out of control, and is this a market transition of electronic equipment demand growth from less sophisticated business sectors? Or is this simply a downshift in revenue growth as the equipment market becomes a commodity market?

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Product Analysis

MOS Memory

DRAM has always been the key driver of growth and the key culprit in decline in the semiconductor industry. In the major DRAM and overall semiconductor market downturns, excess (capacity or strategic inventory) is the real culprit. There are many similarities between this market downturn and the market downturn that began in 1985. Some of these are listed in Table 2.

A stroll down memory lane might jangle some nerves but would help many to understand what is happening in the semiconductor industry. The DRAM market declined 52 percent, from $3.5 billion in 1984 to $1.7 billion in 1985. In 1984, suppliers hoarded products and buyers double-ordered on contracts to guarantee shipments. In 1985, as suppliers began dumping products and lowering prices, buyers canceled long-range contracts to reap the benefits of lower prices. Pricing wars raged until trading wars and dumping issues resulted in government intervention, and foreign market value (FMV) duties were imposed. The suppliers in this market suffered the worst losses and faced the worst price erosion. Several companies made well-publicized withdrawals from the DRAM market during that year. The manufacturers that fared best were those well positioned in the 256K DRAM market, which enabled them to shift their revenue base as the 64K market declined.

The historical path of DRAM revenue versus non-DRAM revenue through the historical eyes of World Semiconductor Trade Statistics (WSTS) data reveals that a slowdown in market growth actually occurred in the last three months of 1984 (see Figure 1), before the DRAM market took a nosedive in January 1985. It took the market and its suppliers 27 months, from January 1985 through March 1987, to return to growth.

Table 2
Market Comparisons: 1985 through 1987 versus 1995 through 1998

1985-through-1987 Market	1995-through-1998 Market
Product hoarding/double-ordering led to supply excess, which precipitated price erosion.	Excessive capital spending added to overcapacity that precipitated price erosion.
Capital spending was depressed in the United States because of uncertainty about proposed tax reforms.	Capital spending was depressed in the United States, Japan, Europe, and Korea because of a capital spending binge.
International trade issues over product prices below fair market values led to antidumping duties on DRAMs and EPROMs.	Uncertainty about antidumping duties on DRAMs rises as rumors abound about dumping products at below cost to gain market share.
Damaged by price erosion, a depressed market, and aggressive competitors, Mostek, Intel, and Inmos disappeared from key market sectors.	Damaged by excessive spending, price erosion, and aggressive competitors, some DRAM suppliers are evaluating departure from the market.
A crossover point in price was reached between the 64K DRAM and 256K DRAM. The 1Mb DRAMs reached price-per-bit parity with 256K at the end of 1987.	In a dance of death, 64Mb DRAM chases the 16Mb DRAM. Price-per-bit parity could be reached by the end of 1998. A 4Mb-to-16Mb crossover could occur during this time.
There was a dramatic change in the yen exchange rate, from ¥254/dollar in 1985 to ¥128.4 at the end of 1987.	The yen/dollar exchange rate changed dramatically from ¥129.73 for the spring forecast period to ¥143 for 1999. The Korean won lost 50 percent of its value against the dollar, like the yen in 1985 through 1987.
Price erosion affected all memory products.	Price erosion affects the majority of ICs.

Source: Dataquest (June 1998)

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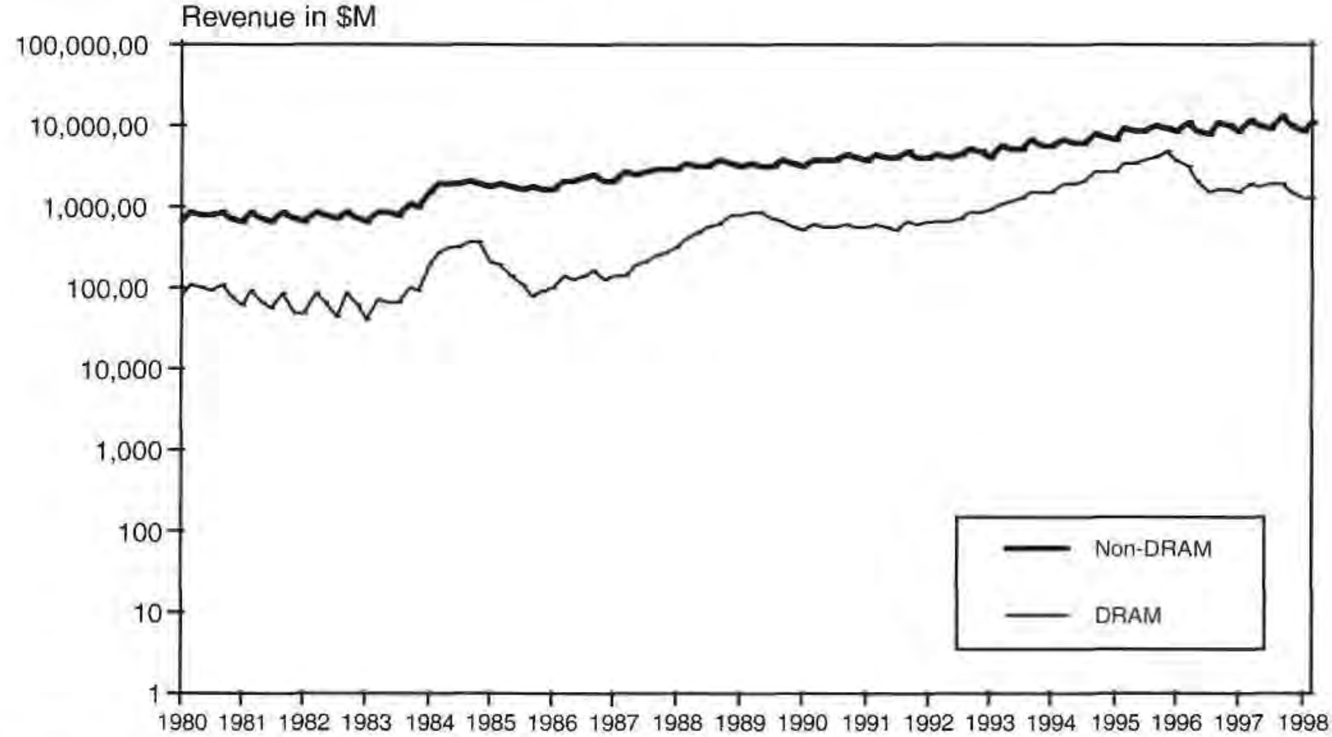
Figure 1
DRAM versus Non-DRAM Revenue over Time



Source: WSTS

Today's market is very reminiscent of that downturn. DRAM growth slowed during the fourth quarter of 1995, and the decline began December 1995. From that time, it has been 29 months of more or less declining revenue. There was a brief respite in September 1996. There were gasps of minor growth in February and March 1997, growth mostly propelled by the Korean suppliers. There was a lull in April before revenue strengthened from May through September, and then the second downturn hit during the fourth quarter of 1997.

Figure 2 shows that DRAM shipments over time were very smooth in the shortage years (1992 through 1995) but quite bumpy in times of oversupply (all other years). Do smooth shipments represent extremely tight allocation, with factories operating at maximum efficiency? If this is true, then the bumpy times reflect opportunistic buying binges followed by times of feasting off the excess purchases. This figure has been extended to include the first four months of shipments in 1998. Given the fact that overcapacity remains, this period of decline could extend beyond 29 months into a 31-to-34-month decline in revenue.

There are two major differences between history (1986) and the present day. First, the 1997 market had about a six-month resurgence in spending in DRAM, which did not happen in 1986. On the bright side, the market for front-end equipment grew over 50 percent in 1988, which would correspond to 2000 in Dataquest's current forecast. Second, changes occurring now in the PC sector, the major area of consumption for all semiconductor products, not just DRAM, are exacerbating the situation even further.

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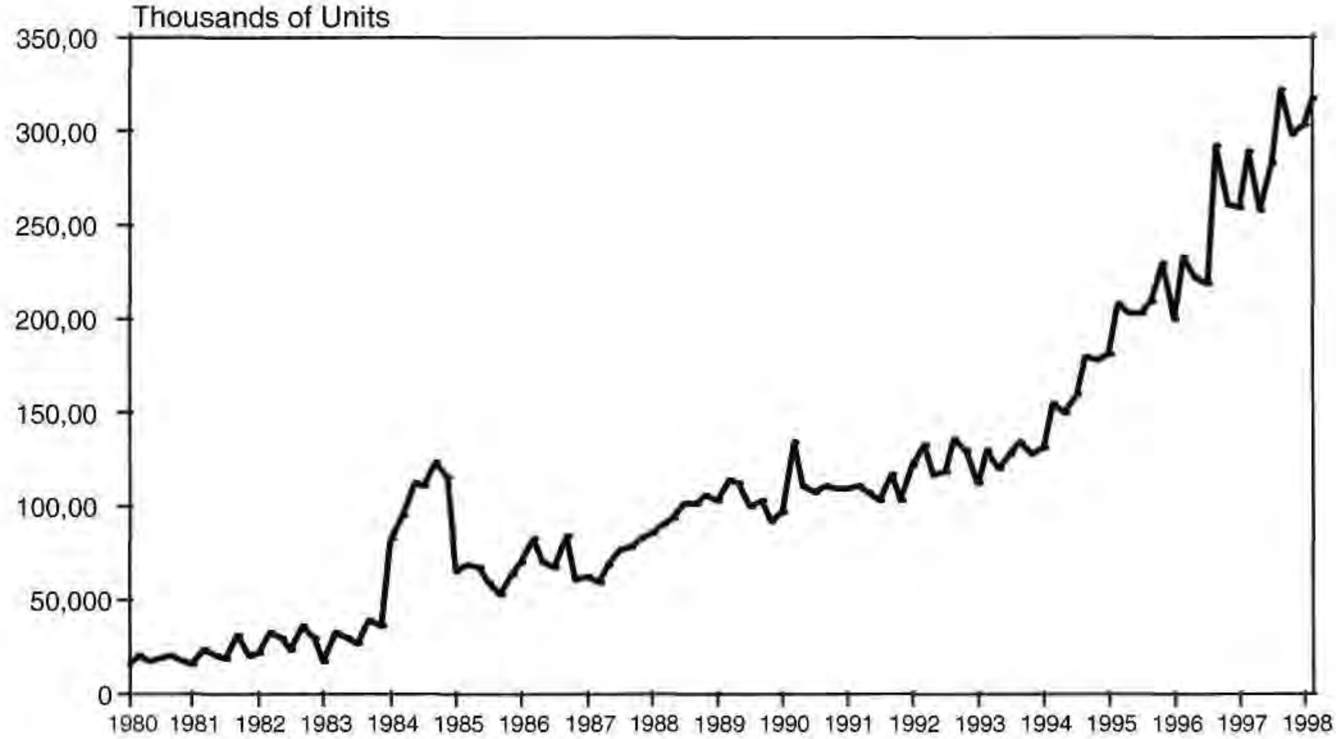
Figure 2
Historical DRAM Shipments



Source: WSTS

Microcomponents

What are the lingering effects of this lengthy price pressure on the market? As with memory, microprocessor pricing is also in the throes of downturn. Some attribute this to increased competition from Advanced Micro Devices Inc. and Cyrix Corporation, while others blame the increasing visibility of sub-$1,000 personal computers. Dataquest argues that the real culprit behind microprocessor price erosion is the declining number of $2,000 and $3,000 personal computers in the sales mix. With the performance of today's low-end and midrange machines, few users feel the need to pay top dollar for the fastest machines they can buy. Some of this desktop MPU price pressure may be offset later in the year as Intel introduces processors priced at $1,000, $2,000, and $4,000, specifically targeted at servers and workstations. Although sold in far smaller volumes than desktop MPUs, the new high-end devices could still contribute mightily to microprocessor average selling prices (ASPs). The combination of one $4,000 microprocessor and 38 $100 processors still results in a $200 average for the lot overall. If Intel's plan works as expected, the second half of the year will produce far stronger MPU revenue than the first.

Logic

Logic is also under pricing pressure and feeling the effects of the turmoil in Asia, but to a much lesser degree than DRAM and microprocessors. Programmable logic devices (PLDs) are a good leading indicator among logic products, and this market has slowed noticeably in the first half of 1998. Pricing pressure can be blamed to some degree, but this market has seen rapid price reductions for some time as suppliers bid for market share. The gate array market is most vulnerable because a large portion of these devices are consumed in Japan, so at least a 10 percent decline can be expected in this market in 1998. Cell-based ICs are still the shining star, but they too have slowed in the first six months of the year.

Price/Cost Analysis

Although megabytes of DRAM grew 77 percent in 1996 and 95 percent in 1997, price-per-bit and price-per-byte declines have eroded DRAM revenue growth potential. Non-DRAM products are expected to continue on a growth path through the end of the year, but pricing pressures in microprocessors, logic, analog, and discrete products have reduced the market's non-DRAM revenue potential from Dataquest's original estimate of $138.3 billion to a more likely scenario of $133.2 billion.

The price forecasts for the most popular 1Mbx16 DRAM part had a contract price value of $3.50 in first quarter 1998. The second quarter 1998 price dropped to $2.55 and could drop to $1.80 by the year's end. The 4Mbx16 DRAM part was $24.00 in first quarter 1998. By second quarter 1998, it had dropped to $11.40 (below Dataquest's $15.00 estimate) and is expected to decline to $8.00 by the end of the year.

Dataquest's original forecast was based on a price per megabyte averaging $2.37 in 1998. A quick review of WSTS worldwide DRAM data (note that revenue for February and April 1998 was restated) is an eye-opening documentation of the disastrous downturn the market has taken since our forecast (see Table 3).

Specific densities show even more cause for concern. Units of 16Mb DRAMs have declined significantly, while 64Mb units increased less, causing an overall decline in bit shipments of 11 percent from March 1998 to April 1998.

Table 3
Price per Megabyte Stays below the Cost Line

Month	Price/Megabyte ($)	Growth (%)	Cost Trend ($)	Price/Cost Change (%)
October 1997	3.10	-9	2.99	104
November 1997	2.59	-16	2.89	90
December 1997	2.19	-15	2.80	78
January 1998	1.96	-11	2.71	72
February 1998	1.97	0	2.63	75
March 1998	1.67	-15	2.54	66
April 1998	1.63	-2	2.46	66

Source: WSTS, Dataquest (June 1998)

Application Market Analysis

Economic growth in Asia/Pacific and now Japan is grinding to a standstill, and that will almost certainly lower electronics demand even further. Japan's deteriorating economic circumstances are particularly distressing. Most forecasters now expect Japan to experience a sharp contraction in economic activity this year. If recent estimates of this contraction (a drop of 0.2 to 0.9 percent) are realized, then Japanese electronics demand will decline precipitously. This downward tumble in Japan would not only affect Japan's already hobbled electronics industry, but it would also seriously affect Asia/Pacific's export production.

The falling yen compounds this problem. The yen recently fell below ¥140 to the dollar and appears well on its way to falling even further, U. S. Treasury Department intervention notwithstanding. To be sure, the continuing depreciation of the yen could provide some stimulus to Japan's sagging economy. However, it is likely to reduce dollar-valued Japanese electronics activity. Moreover, by making Japanese exports less expensive, it almost certainly increases the economic stress of Japan's afflicted Asia/Pacific competitors. In the worst case, a deflating yen could raise the specter of competitive currency devaluation between Japan and its Asia/Pacific neighbors (notably China) that could depress both electronics and semiconductor activity well beyond 1998.

Given all these potential developments, it is not too unreasonable to believe that Dataquest's electronic equipment forecast, shown in Table 4, could also have a most likely scenario that may go well below 4.4 percent. When analyzing semiconductor activity from an end-use perspective, it is important to remember that semiconductor growth is ultimately driven by growth in electronics production and the semiconductor content of electronics. In short, the formula is as follows:

Semiconductor Growth = Electronic Equipment Growth + Semiconductor Content Growth

For 1998, a no-growth scenario is possible if (dollar-valued) electronics production slows significantly and average semiconductor content is reduced. Slower electronics growth now seems very likely, given economic circumstances in Japan and Asia/Pacific. A decline in the average semiconductor content of electronic equipment also appears highly likely, given the apparent inelasticity of DRAM demand in the face of falling DRAM prices. Added to that, Dataquest believes that the growing price competition in several key electronics markets (PCs!) is likely to curtail average semiconductor content as manufacturers struggle to preserve margins by holding the line on semiconductor consumption.

Inventory was a real issue for some PC suppliers during the fourth quarter of 1997 and the first quarter of 1998, and they have slowed their chip orders significantly in the second quarter of 1998. Added to this, server systems are sluggish as spending on these is being cut in favor of funding year 2000 software consultants. The cost concerns of year 2000 issues could be enormous if the additional cost hits from insurance protection and litigation potential are included.

More worrisome is the state of the rigid disk drive business. This sector remains in a prolonged overcapacity as prices and production plans continue to be cut. This pain has also been passed along to the semiconductor suppliers.

In the communications sectors, LAN and Internet access systems saw even worse price pressure than expected. This also affected the semiconductor suppliers because they were also pressured into lowering prices.

The segment that should come under close scrutiny in all regions is consumer electronics. Reports now indicate that the consumer sector is faring worse than expected as the financial turmoil in Japan and Asia/Pacific cuts spending in that area.

Table 4
1998 Electronic Equipment Production Forecast Downside Scenario (Billions of Dollars)

	Actual 1997	Actual 1998	Most Likely 1998 Scenario
Electronic Equipment Production	906.6	968.9	946.5
Growth (%)	6.8	6.9	Greater than or equal to 4.4

Source: Dataquest (June 1998 Estimates)

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Regional Analysis

Asia/Pacific

The overall business climate in the Asia/Pacific region is weak and unstable. It is Dataquest's opinion that the Korean semiconductor market is dead. Korean semiconductor capital spending as a percentage of Asia/Pacific capital spending has traditionally been very aggressive. Korean DRAM suppliers originally gained access to the DRAM market during the government negotiations between Japan and U.S. DRAM suppliers during the trade wars of 1986 and 1987. Korean companies accounted for just over 14 percent of all capital spending worldwide in 1997, but it now appears that all new Korean semiconductor investment projects have stopped. Dataquest's capital spending forecast assumes that Korean companies will cut spending 40 percent in U.S. dollars. This is a total of about $3.3 billion for the big three companies (Hyundai Electronics Company Ltd., LG Semicon Co. Ltd., and Samsung Electronics Company Ltd.). DRAM price drops caused by the Asian turmoil are changing the outlook for 1998 DRAM growth in the region. DRAM, which originally was expected to contract 0.7 percent, is now expected to drop 31.0 percent. This could translate to a 0.6 percent contraction in Asia/Pacific semiconductor revenue for 1998. Asia/Pacific is a trade-intensive region that is basically in a trade recession. Its largest trading partner, Japan, has now become its largest trading competitor. China and Taiwan appear to be the more stable areas of the region. However, capital spending in Taiwan has begun to slow this quarter compared with the previous quarter.

Japan

The analysis from Japan does not bode well for a quick return to market growth. The biggest change has been felt in price declines in various MOS digital products—not just DRAM but also flash memory, microprocessors, microcontrollers, and application-specific ICs (ASICs). In the logic product markets, there have been mild price changes in cell-based ICs, while prices for application-specific standard products (ASSPs, the "other MOS logic" category) are falling rapidly. DRAM prices have come down below cost. In the microprocessor and logic product markets, vendors are offering aggressive prices that could bring revenue growth down substantially from the levels forecast at the beginning of 1998. It now appears that the yen/dollar exchange rate, assumed for Dataquest's spring forecast to be ¥129.73, will be closer to ¥138 for 1998 and ¥143 for 1999. This translates to a 6.3 percent yen depreciation against the spring forecast assumption. During recent interviews with Japanese semiconductor vendors, they gave estimates for growth in Japan ranging from a 5 percent contraction to flat for 1998. Contacts in the consumer applications believe that there may be a yen-based total semiconductor contraction this year.

Europe

The continued decline in DRAM pricing is affecting all device categories for European vendors, although analog, discrete, and optoelectronic product growth appears to be more robust than that of the more complex products. Microcomponent growth is down, even though unit demand continues to grow. Regional PC demand in the first quarter was unexpectedly strong, with first quarter 1998 shipments up 26 percent over the first quarter of 1997. Demand has been weaker in the second quarter. The third quarter is historically weakest; however, strong fourth quarter demand should hold the year to the 14.3 percent PC unit growth forecast.

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Production of other high-volume products, such as digital cellular handsets, remains robust, with the equipment manufacturers reveling in low prices, short lead times, and minimal inventories. A de facto just-in-time ordering system seems to be the norm on commodity products, with equipment manufacturers happy to have the semiconductor vendors acting as their warehouses and transferring products to their own ownership at the last possible moment. This has enabled them to decrease their inventories, but this is a dangerous game because, when the upturn comes, lead times will rise overnight, leaving less astute purchasers without adequate backlog coverage.

The current forecast for Europe is for 8.6 percent growth, but that the change in circumstances makes this an unlikely occurrence. On the basis of the reasonably strong end-equipment growth still forecast for Europe, Dataquest expects the region to outperform the worldwide market with growth, at best, at about 3 percent for the year.

Americas

The Americas region, originally forecast to grow around 10.9 percent, could instead decline to growth of about 4 to 5 percent. Americas investment in DRAM is minor compared with that of Asia/Pacific and Japan. The major price declines in other memory products (SRAM, flash, and EEPROM), microprocessors, and logic/ASIC devices are an indirect result of other market downturns and DRAM system price pressures. All the major North American semiconductor and front-end equipment suppliers are posting declines in quarterly earnings. Some have chosen more drastic measures, layoffs, to stem the revenue decline. National Semiconductor Corporation, Motorola Incorporated, and Applied Materials Inc. have all announced major layoffs. Lam Research Corporation has chosen a two-week plant shutdown. Even with the U.S. Federal Trade Commission breathing down its back, Intel Corporation has buckled under the system pricing pressures and announced price reductions of up to 20 percent on various MPU products. The automotive and consumer application markets are stable, but the communications sector, especially the cellular telephone market, has weakened.

What about Capital Spending Now?

A "technology" spending cycle during 1997, normal in the middle stages of an oversupply-driven downturn, was much stronger than expected, driven by the sheer momentum of an increased number of new and inexperienced players in the market. The correction in spending is now under way, following very closely, and perhaps exceeding, the downside scenario presented by Dataquest in January ("Wafer Fab Equipment Market Forecast Update: Question Marks for 1998," SEMM-WW-DP-9801, and "Conference Call on Capital Spending and Wafer Fab Equipment Year-End Forecast Update," SEMM-WW-DP-9803). A revised capital spending forecast will be released in mid-July; however, the current view is that 1998 spending is likely to be 14 to 16 percent lower in 1998 than 1997. The weakness is the underlying chip market in 1998 should delay a recovery in spending until 2000, meaning that 1999 should be a single-digit growth year, at best.

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Dataquest Perspective

The tried and true survivors of the semiconductor industry understand the angst of these memory boom-to-bust death cycles. The length of this DRAM downturn will weaken the growth potential of 1999. At this time, Dataquest does not expect memory IC revenue to return to 1995 growth levels until after 2000, when balance returns to the market. Despite the ups and downs of the semiconductor industry, semiconductors are fundamental to information technology. The market has seen revenue set back for the last two and one-half years. This may turn into a full three-year downturn or it may be temporary, unless the markets in Asia/Pacific and Japan weaken further.

Is there a bright side somewhere? A return to growth could come from many of the top 10 emerging consumer, communications, and data processing equipment markets. These are expected to account for about 70 percent of semiconductor consumption through 2002. The PC market is undergoing an intense transition from the high-end desktop products to the low-end, low-priced systems. There is concern about demand for the system above 300 to 400 MHz, which will drive DRAM megabyte growth. Is real demand developing for high-end thin servers and workstations? Intel could make that demand real, based on its recent price decrease efforts. Prices for various 300-to-400-MHz devices have recently been cut from 12 to 20 percent. The wireless and new digital consumer application markets continue to drive digital signal processor, embedded, and digital ASIC growth.

Dataquest will continue to closely monitor regional, product, and application events as they occur. Comments on updates are always welcome.

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Perspectives

Semiconductors Europe

Market Analysis

Semiconductors Second Quarter 1998: A Buyer's Boon and a Supplier's Gloom

Abstract: *Since the release of Dataquest's spring worldwide semiconductor forecast, severe DRAM price erosion and economic downturns have begun to affect the revenue not only of MOS memory but also of all other major semiconductor product categories. The consumer and data processing electronic equipment markets are showing further signs of weakening. Capital spending forecasts have declined 15 percent. Weakened by economic turmoil in Asia/Pacific and financial weakness in Japan, prices on electronic imported goods arriving at Europe's and America's doorsteps have declined for seven consecutive months. The DRAM downturn that began in December 1995 is taking the rest of the market down. This very long downturn is reminiscent of the DRAM nosedive that began in January 1985. Many companies barely survived, and those that did were lucky to walk away bruised and battered. How do these events affect Dataquest's clients and current forecast?*

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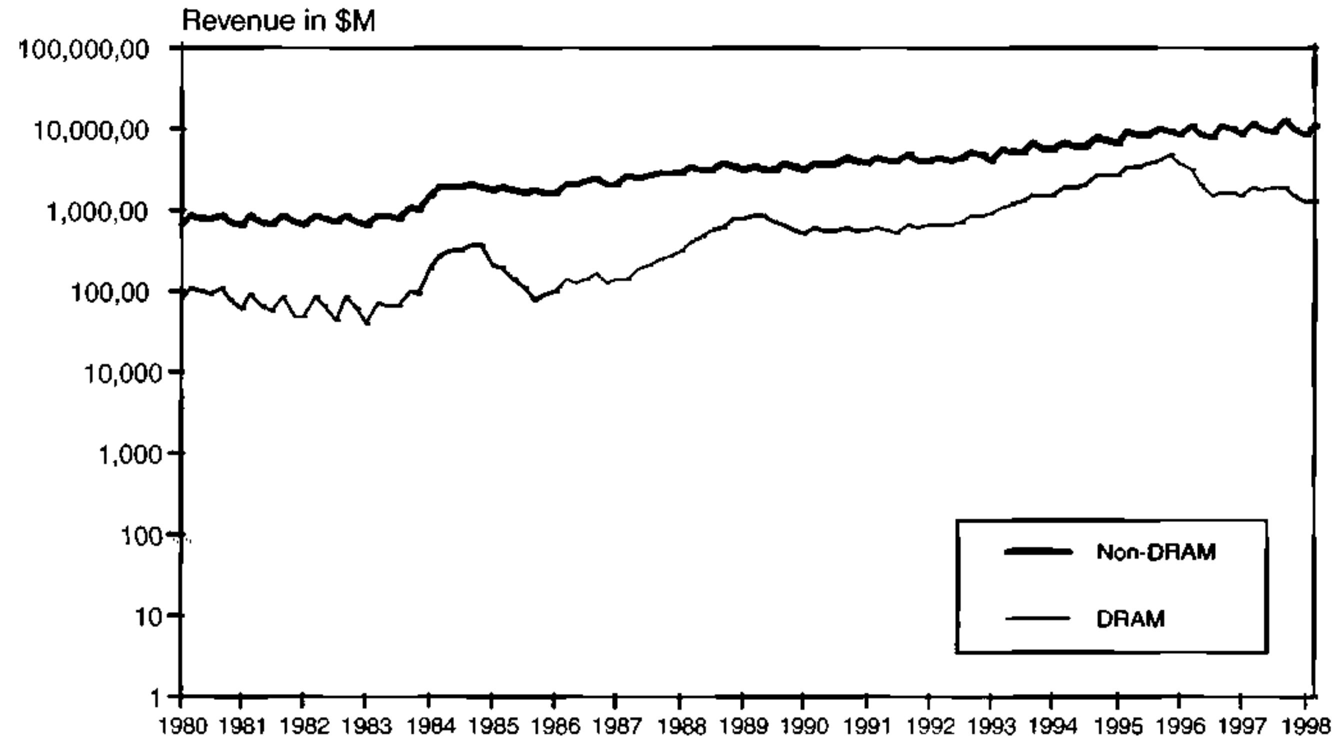

Source: WSTS

Today's market is very reminiscent of that downturn. DRAM growth slowed during the fourth quarter of 1995, and the decline began December 1995. From that time, it has been 29 months of more or less declining revenue. There was a brief respite in September 1996. There were gasps of minor growth in February and March 1997, growth mostly propelled by the Korean suppliers. There was a lull in April before revenue strengthened from May through September, and then the second downturn hit during the fourth quarter of 1997.

Figure 2 shows that DRAM shipments over time were very smooth in the shortage years (1992 through 1995) but quite bumpy in times of oversupply (all other years). Do smooth shipments represent extremely tight allocation, with factories operating at maximum efficiency? If this is true, then the bumpy times reflect opportunistic buying binges followed by times of feasting off the excess purchases. This figure has been extended to include the first four months of shipments in 1998. Given the fact that overcapacity remains, this period of decline could extend beyond 29 months into a 31-to-34-month decline in revenue.

There are two major differences between history (1986) and the present day. First, the 1997 market had about a six-month resurgence in spending in DRAM, which did not happen in 1986. On the bright side, the market for front-end equipment grew over 50 percent in 1988, which would correspond to 2000 in Dataquest's current forecast. Second, changes occurring now in the PC sector, the major area of consumption for all semiconductor products, not just DRAM, are exacerbating the situation even further.

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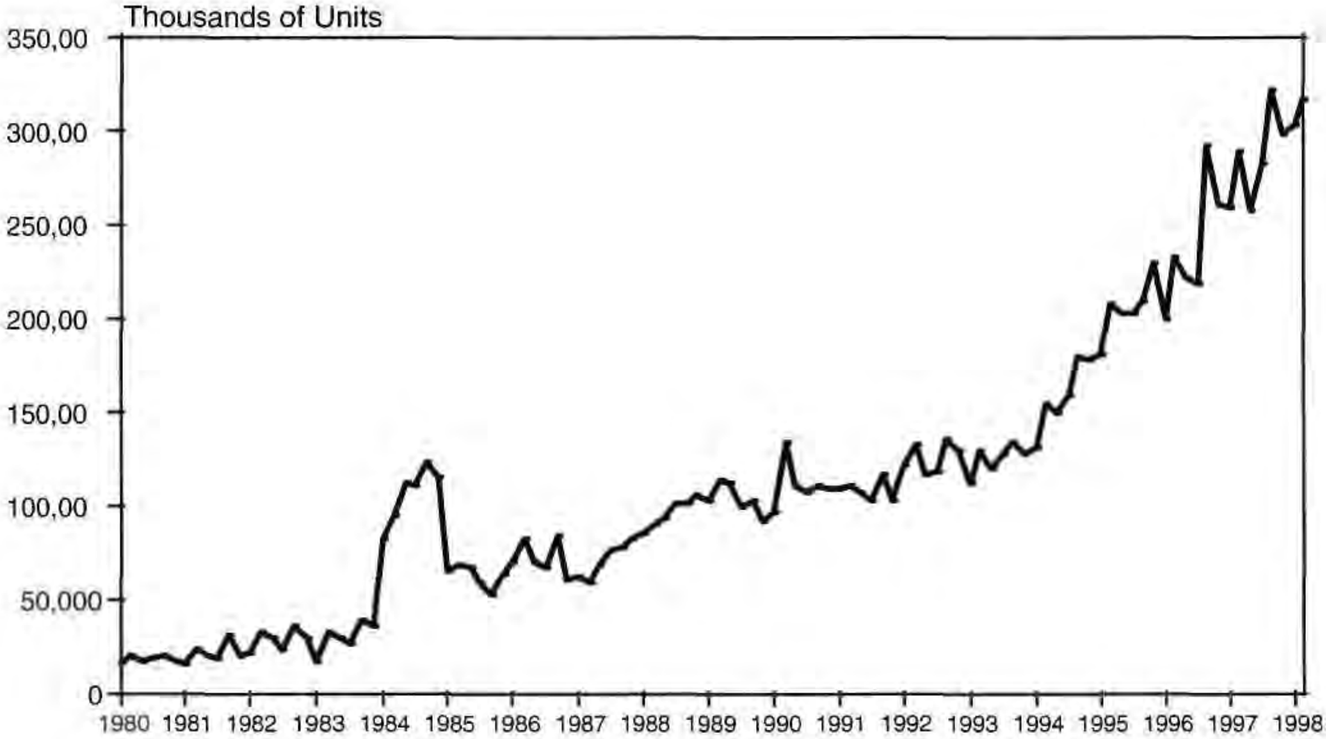
Figure 2
Historical DRAM Shipments



Source: WSTS

Microcomponents

What are the lingering effects of this lengthy price pressure on the market? As with memory, microprocessor pricing is also in the throes of downturn. Some attribute this to increased competition from Advanced Micro Devices Inc. and Cyrix Corporation, while others blame the increasing visibility of sub-$1,000 personal computers. Dataquest argues that the real culprit behind microprocessor price erosion is the declining number of $2,000 and $3,000 personal computers in the sales mix. With the performance of today's low-end and midrange machines, few users feel the need to pay top dollar for the fastest machines they can buy. Some of this desktop MPU price pressure may be offset later in the year as Intel introduces processors priced at $1,000, $2,000, and $4,000, specifically targeted at servers and workstations. Although sold in far smaller volumes than desktop MPUs, the new high-end devices could still contribute mightily to microprocessor average selling prices (ASPs). The combination of one $4,000 microprocessor and 38 $100 processors still results in a $200 average for the lot overall. If Intel's plan works as expected, the second half of the year will produce far stronger MPU revenue than the first.

Logic

Logic is also under pricing pressure and feeling the effects of the turmoil in Asia, but to a much lesser degree than DRAM and microprocessors. Programmable logic devices (PLDs) are a good leading indicator among logic products, and this market has slowed noticeably in the first half of 1998. Pricing pressure can be blamed to some degree, but this market has seen rapid price reductions for some time as suppliers bid for market share. The gate array market is most vulnerable because a large portion of these devices are consumed in Japan, so at least a 10 percent decline can be expected in this market in 1998. Cell-based ICs are still the shining star, but they too have slowed in the first six months of the year.

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Price/Cost Analysis

Although megabytes of DRAM grew 77 percent in 1996 and 95 percent in 1997, price-per-bit and price-per-byte declines have eroded DRAM revenue growth potential. Non-DRAM products are expected to continue on a growth path through the end of the year, but pricing pressures in microprocessors, logic, analog, and discrete products have reduced the market's non-DRAM revenue potential from Dataquest's original estimate of $138.3 billion to a more likely scenario of $133.2 billion.

The price forecasts for the most popular 1Mbx16 DRAM part had a contract price value of $3.50 in first quarter 1998. The second quarter 1998 price dropped to $2.55 and could drop to $1.80 by the year's end. The 4Mbx16 DRAM part was $24.00 in first quarter 1998. By second quarter 1998, it had dropped to $11.40 (below Dataquest's $15.00 estimate) and is expected to decline to $8.00 by the end of the year.

Dataquest's original forecast was based on a price per megabyte averaging $2.37 in 1998. A quick review of WSTS worldwide DRAM data (note that revenue for February and April 1998 was restated) is an eye-opening documentation of the disastrous downturn the market has taken since our forecast (see Table 3).

Specific densities show even more cause for concern. Units of 16Mb DRAMs have declined significantly, while 64Mb units increased less, causing an overall decline in bit shipments of 11 percent from March 1998 to April 1998.

Table 3
Price per Megabyte Stays below the Cost Line

Month	Price/Megabyte ($)	Growth (%)	Cost Trend ($)	Price/Cost Change (%)
October 1997	3.10	-9	2.99	104
November 1997	2.59	-16	2.89	90
December 1997	2.19	-15	2.80	78
January 1998	1.96	-11	2.71	72
February 1998	1.97	0	2.63	75
March 1998	1.67	-15	2.54	66
April 1998	1.63	-2	2.46	66

Source: WSTS, Dataquest (June 1998)

Application Market Analysis

Economic growth in Asia/Pacific and now Japan is grinding to a standstill, and that will almost certainly lower electronics demand even further. Japan's deteriorating economic circumstances are particularly distressing. Most forecasters now expect Japan to experience a sharp contraction in economic activity this year. If recent estimates of this contraction (a drop of 0.2 to 0.9 percent) are realized, then Japanese electronics demand will decline precipitously. This downward tumble in Japan would not only affect Japan's already hobbled electronics industry, but it would also seriously affect Asia/Pacific's export production.

The falling yen compounds this problem. The yen recently fell below ¥140 to the dollar and appears well on its way to falling even further, U. S. Treasury Department intervention notwithstanding. To be sure, the continuing depreciation of the yen could provide some stimulus to Japan's sagging economy. However, it is likely to reduce dollar-valued Japanese electronics activity. Moreover, by making Japanese exports less expensive, it almost certainly increases the

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economic stress of Japan's afflicted Asia/Pacific competitors. In the worst case, a deflating yen could raise the specter of competitive currency devaluation between Japan and its Asia/Pacific neighbors (notably China) that could depress both electronics and semiconductor activity well beyond 1998.

Given all these potential developments, it is not too unreasonable to believe that Dataquest's electronic equipment forecast, shown in Table 4, could also have a most likely scenario that may go well below 4.4 percent. When analyzing semiconductor activity from an end-use perspective, it is important to remember that semiconductor growth is ultimately driven by growth in electronics production and the semiconductor content of electronics. In short, the formula is as follows:

Semiconductor Growth = Electronic Equipment Growth + Semiconductor Content Growth

For 1998, a no-growth scenario is possible if (dollar-valued) electronics production slows significantly and average semiconductor content is reduced. Slower electronics growth now seems very likely, given economic circumstances in Japan and Asia/Pacific. A decline in the average semiconductor content of electronic equipment also appears highly likely, given the apparent inelasticity of DRAM demand in the face of falling DRAM prices. Added to that, Dataquest believes that the growing price competition in several key electronics markets (PCs!) is likely to curtail average semiconductor content as manufacturers struggle to preserve margins by holding the line on semiconductor consumption.

Inventory was a real issue for some PC suppliers during the fourth quarter of 1997 and the first quarter of 1998, and they have slowed their chip orders significantly in the second quarter of 1998. Added to this, server systems are sluggish as spending on these is being cut in favor of funding year 2000 software consultants. The cost concerns of year 2000 issues could be enormous if the additional cost hits from insurance protection and litigation potential are included.

More worrisome is the state of the rigid disk drive business. This sector remains in a prolonged overcapacity as prices and production plans continue to be cut. This pain has also been passed along to the semiconductor suppliers.

In the communications sectors, LAN and Internet access systems saw even worse price pressure than expected. This also affected the semiconductor suppliers because they were also pressured into lowering prices.

The segment that should come under close scrutiny in all regions is consumer electronics. Reports now indicate that the consumer sector is faring worse than expected as the financial turmoil in Japan and Asia/Pacific cuts spending in that area.

Table 4
1998 Electronic Equipment Production Forecast Downside Scenario (Billions of Dollars)

	Actual 1997	Actual 1998	Most Likely 1998 Scenario
Electronic Equipment Production	906.6	968.9	946.5
Growth (%)	6.8	6.9	Greater than or equal to 4.4

Source: Dataquest (June 1998 Estimates)

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Regional Analysis

Asia/Pacific

The overall business climate in the Asia/Pacific region is weak and unstable. It is Dataquest's opinion that the Korean semiconductor market is dead. Korean semiconductor capital spending as a percentage of Asia/Pacific capital spending has traditionally been very aggressive. Korean DRAM suppliers originally gained access to the DRAM market during the government negotiations between Japan and U.S. DRAM suppliers during the trade wars of 1986 and 1987. Korean companies accounted for just over 14 percent of all capital spending worldwide in 1997, but it now appears that all new Korean semiconductor investment projects have stopped. Dataquest's capital spending forecast assumes that Korean companies will cut spending 40 percent in U.S. dollars. This is a total of about $3.3 billion for the big three companies (Hyundai Electronics Company Ltd., LG Semicon Co. Ltd., and Samsung Electronics Company Ltd.). DRAM price drops caused by the Asian turmoil are changing the outlook for 1998 DRAM growth in the region. DRAM, which originally was expected to contract 0.7 percent, is now expected to drop 31.0 percent. This could translate to a 0.6 percent contraction in Asia/Pacific semiconductor revenue for 1998. Asia/Pacific is a trade-intensive region that is basically in a trade recession. Its largest trading partner, Japan, has now become its largest trading competitor. China and Taiwan appear to be the more stable areas of the region. However, capital spending in Taiwan has begun to slow this quarter compared with the previous quarter.

Japan

The analysis from Japan does not bode well for a quick return to market growth. The biggest change has been felt in price declines in various MOS digital products—not just DRAM but also flash memory, microprocessors, microcontrollers, and application-specific ICs (ASICs). In the logic product markets, there have been mild price changes in cell-based ICs, while prices for application-specific standard products (ASSPs, the "other MOS logic" category) are falling rapidly. DRAM prices have come down below cost. In the microprocessor and logic product markets, vendors are offering aggressive prices that could bring revenue growth down substantially from the levels forecast at the beginning of 1998. It now appears that the yen/dollar exchange rate, assumed for Dataquest's spring forecast to be ¥129.73, will be closer to ¥138 for 1998 and ¥143 for 1999. This translates to a 6.3 percent yen depreciation against the spring forecast assumption. During recent interviews with Japanese semiconductor vendors, they gave estimates for growth in Japan ranging from a 5 percent contraction to flat for 1998. Contacts in the consumer applications believe that there may be a yen-based total semiconductor contraction this year.

Europe

The continued decline in DRAM pricing is affecting all device categories for European vendors, although analog, discrete, and optoelectronic product growth appears to be more robust than that of the more complex products. Microcomponent growth is down, even though unit demand continues to grow. Regional PC demand in the first quarter was unexpectedly strong, with first quarter 1998 shipments up 26 percent over the first quarter of 1997. Demand has been weaker in the second quarter. The third quarter is historically weakest; however, strong fourth quarter demand should hold the year to the 14.3 percent PC unit growth forecast.

Production of other high-volume products, such as digital cellular handsets, remains robust, with the equipment manufacturers reveling in low prices, short lead times, and minimal inventories. A de facto just-in-time ordering system seems to be the norm on commodity products, with equipment manufacturers happy to have the semiconductor vendors acting as their warehouses and transferring products to their own ownership at the last possible moment. This has enabled them to decrease their inventories, but this is a dangerous game because, when the upturn comes, lead times will rise overnight, leaving less astute purchasers without adequate backlog coverage.

The current forecast for Europe is for 8.6 percent growth, but that the change in circumstances makes this an unlikely occurrence. On the basis of the reasonably strong end-equipment growth still forecast for Europe, Dataquest expects the region to outperform the worldwide market with growth, at best, at about 3 percent for the year.

Americas

The Americas region, originally forecast to grow around 10.9 percent, could instead decline to growth of about 4 to 5 percent. Americas investment in DRAM is minor compared with that of Asia/Pacific and Japan. The major price declines in other memory products (SRAM, flash, and EEPROM), microprocessors, and logic/ASIC devices are an indirect result of other market downturns and DRAM system price pressures. All the major North American semiconductor and front-end equipment suppliers are posting declines in quarterly earnings. Some have chosen more drastic measures, layoffs, to stem the revenue decline. National Semiconductor Corporation, Motorola Incorporated, and Applied Materials Inc. have all announced major layoffs. Lam Research Corporation has chosen a two-week plant shutdown. Even with the U.S. Federal Trade Commission breathing down its back, Intel Corporation has buckled under the system pricing pressures and announced price reductions of up to 20 percent on various MPU products. The automotive and consumer application markets are stable, but the communications sector, especially the cellular telephone market, has weakened.

What about Capital Spending Now?

A "technology" spending cycle during 1997, normal in the middle stages of an oversupply-driven downturn, was much stronger than expected, driven by the sheer momentum of an increased number of new and inexperienced players in the market. The correction in spending is now under way, following very closely, and perhaps exceeding, the downside scenario presented by Dataquest in January ("Wafer Fab Equipment Market Forecast Update: Question Marks for 1998," SEMM-WW-DP-9801, and "Conference Call on Capital Spending and Wafer Fab Equipment Year-End Forecast Update," SEMM-WW-DP-9803). A revised capital spending forecast will be released in mid-July; however, the current view is that 1998 spending is likely to be 14 to 16 percent lower in 1998 than 1997. The weakness is the underlying chip market in 1998 should delay a recovery in spending until 2000, meaning that 1999 should be a single-digit growth year, at best.

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Dataquest Perspective

The tried and true survivors of the semiconductor industry understand the angst of these memory boom-to-bust death cycles. The length of this DRAM downturn will weaken the growth potential of 1999. At this time, Dataquest does not expect memory IC revenue to return to 1995 growth levels until after 2000, when balance returns to the market. Despite the ups and downs of the semiconductor industry, semiconductors are fundamental to information technology. The market has seen revenue set back for the last two and one-half years. This may turn into a full three-year downturn or it may be temporary, unless the markets in Asia/Pacific and Japan weaken further.

Is there a bright side somewhere? A return to growth could come from many of the top 10 emerging consumer, communications, and data processing equipment markets. These are expected to account for about 70 percent of semiconductor consumption through 2002. The PC market is undergoing an intense transition from the high-end desktop products to the low-end, low-priced systems. There is concern about demand for the system above 300 to 400 MHz, which will drive DRAM megabyte growth. Is real demand developing for high-end thin servers and workstations? Intel could make that demand real, based on its recent price decrease efforts. Prices for various 300-to-400-MHz devices have recently been cut from 12 to 20 percent. The wireless and new digital consumer application markets continue to drive digital signal processor, embedded, and digital ASIC growth.

Dataquest will continue to closely monitor regional, product, and application events as they occur. Comments on updates are always welcome.

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Perspectives

Semiconductors Europe

Market Analysis

EMEA DRAM Market: 1997 in Review and the Outlook for 1998

Abstract: *This Market Analysis reviews the Europe, Middle East and Africa (EMEA) DRAM market in 1997 and provides an early outlook for 1998. Taking into account current market conditions and upcoming product and technology trends, it also provides scenario-based bit, ASP and revenue forecasts for 1998.*

By Richard Gordon

Casey Jones, A-Steamin' and A-Rollin' ...

The light at the end of the tunnel might just be an oncoming locomotive. No doubt some DRAM manufacturers will feel that they have already been run over by Casey Jones during the latest DRAM market downturn; however, it looks as though the Cannonball Express might just be coming down the line again ...

1997 Review

Bit Demand

A surge in DRAM bit demand late in the third quarter and into the fourth quarter last year helped to lift the moving average annual growth rate for worldwide DRAM revenue in 1997 from a low of almost minus 60 percent in April to about minus 15 percent by year end. In fact, Dataquest estimates that bit growth last year reached an unprecedented 107 percent, driven by demand for increased PC main memory. It appears that PC manufacturers were finally able and willing to pass on savings in DRAM prices to end users, and this trend manifested itself in a rapid move from 16MB-configured machines to a 32MB base fit as standard during the fourth quarter of 1997. As 1998 gets under way, the trend towards higher main-memory fit is continuing as high-end Windows NT 4.0-targeted machines hit the streets fitted with 64MB as standard. However, there seems to be no justifiable rationale for a trend towards higher PC DRAM content in the short term other than an opportunistic move by PC vendors to differentiate product offerings at a time when adding more memory is a low-cost option.

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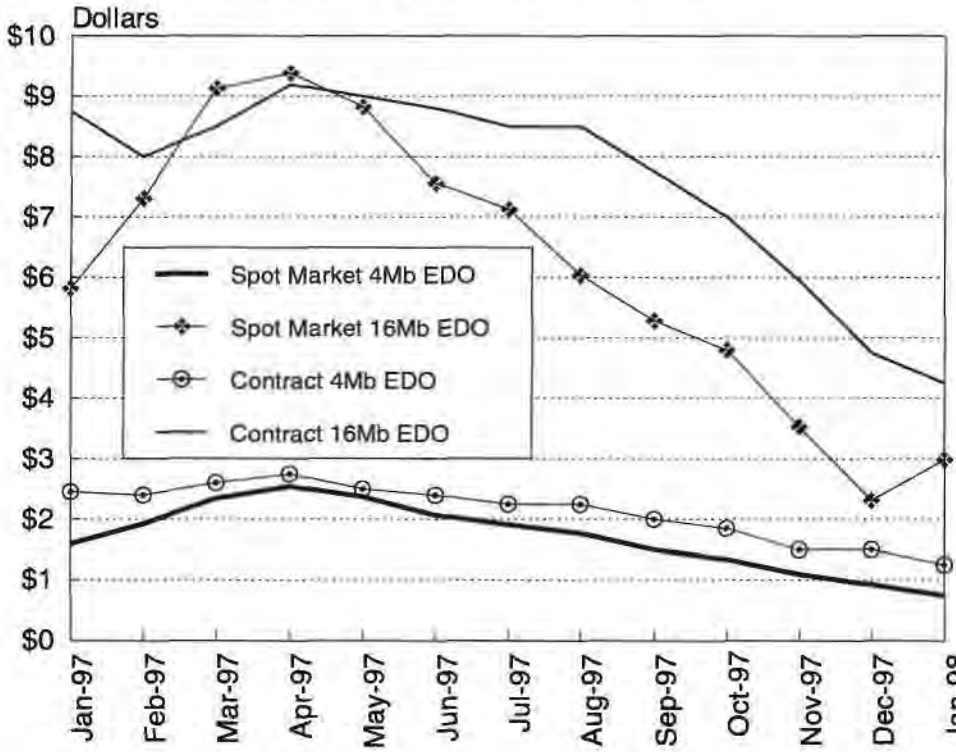
ASPs

Despite the surge in bit demand, global overcapacity remained a feature of the DRAM industry throughout 1997 and ASPs continued to decline steadily, as shown in Figure 1. There were "false dawns" during the year when spot market ASPs briefly twitched upwards, but these upticks were short-lived and confined to specific device configurations. Although there was talk of production cutbacks to ease the oversupply situation and stabilize prices, concrete action failed to materialize; as a result, there are still no signs that the fundamental problem of overcapacity in the short term has been addressed.

Figure 1
Worldwide DRAM ASPs—Spot Market versus Contract, 1997-1998



Source: Dataquest (March 1998 Estimates)

Vendors

In this competitive marketplace, initial soundings suggest that tier-one DRAM vendors have consolidated their market leadership positions. This makes sense for a number of reasons: for example, thanks to abundant supply, customers could deal exclusively with preferred suppliers at little price premium; and, as demand increased for DRAM incorporating technology developments such as the 64Mb density and the synchronous interface, supply was largely the preserve of the leading vendors. However, we will have to wait until the spring, when Dataquest publishes its final vendor market share numbers, for this view to be confirmed.

Regulatory Issues

Regulatory issues, although in the headlines for much of 1997, thankfully were not allowed to interfere with the DRAM marketplace in the EMEA region. Within the European Union (EU), the free market was allowed to determine DRAM market conditions as the European Commission (EC) finally dispensed with DRAM antidumping legislation. Although this legislation was nominally in place for a time, it was not enforced in practice, suggesting that the EC had lost patience with trying to police the price of DRAM imports.

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As DRAM prices fell day by day, the imposition of reference pricing for DRAM imported from the Far East would have been difficult to implement and would have had serious implications for European electronic equipment production. In a global economy, purchasing and production decisions would have been reviewed, and the European electronics and semiconductor markets would have suffered as a result. The interests of Europe-based DRAM suppliers are being served now via "gentlemen's agreements" between the European Electronic Component Manufacturers Association, the Korean Semiconductor Industry Association and the Electronics Industry Association of Japan. Common sense appears to have prevailed on this issue, although it remains to be seen how effective this self-regulation will be.

There was also good news last year on the subject of tariffs. As momentum continues to build towards a global zero semiconductor import tariff (under the direction of the International Technology Agreement and the World Semiconductor Council), the EC announced last year an accelerated reduction to zero of DRAM tariffs. This has resulted in zero tariffs being in force from January 1, 1998 for DRAM imports into the EU.

Investment and Capacity

Despite many high-profile announcements of cutbacks in DRAM fab investment, the wafer fab equipment market grew by about 3 percent in 1997 over 1996. An increase in DRAM capital spending was driven by a surge in technology purchases in the second half of last year, particularly on the part of Taiwanese DRAM vendors. However, because overcapacity in the DRAM market has been ever present since late 1995 and is an enduring feature, any increase in capital spending will serve only to make matters worse—especially in the light of recent and continuing efficiency improvements in DRAM manufacturing.

When Dataquest published its latest DRAM market forecasts in October 1997, DRAM supply and demand were expected to come into balance towards the end of 1998. That assumption had a bearing on our outlook for future DRAM pricing trends, hence affecting our revenue forecasts. Dataquest is no longer convinced that DRAM supply and demand will be balanced by the end of this year—unless some capacity is actively removed from the market it looks increasingly likely that such equilibrium will be deferred until 1999, thus keeping prices lower for longer and reducing the likelihood of price stability this year. Whether that happens depends largely on the actions of the South Korean DRAM vendors in response to the Asian financial crisis, but the suspicion is that significant reductions in supply will not be forthcoming, so supply will have to wait for demand to catch up.

Asian Financial Crisis

Much has been written about the implications of the Asian financial crisis on the electronics and semiconductor industries in general. In the case of DRAM the impact of the crisis on the South Korean semiconductor industry is the most critical factor, because South Korean companies account for more than 30 percent of global DRAM revenue.

The fall of the Korean won against other world currencies and the restructuring of investment financing required by the IMF will result in two key effects, one short term, the other long term.

Short-Term Effects

Throughout 1997 DRAM was priced at a level near the cost of manufacture, as oversupply forced prices down to levels effectively defined by the need to avoid antidumping allegations. Dataquest expects continuing overcapacity in 1998, forcing manufacturers to continue their efforts to keep prices low to maintain market share.

This situation has been exacerbated by a recent devaluation of the won in South Korea, which has effectively lowered the costs of manufacturing DRAM in that country (as measured in any other currency). Dataquest estimates that at least 55 percent of the cost to manufacture a South Korean DRAM is borne in won-based transactions rather than foreign-currency-based transactions. Therefore, as a result of local currency devaluation, South Korean manufacturers have a significantly cheaper DRAM manufacturing cost in dollar terms than either their Japanese or their US competitors do.

There are two possible consequences of this state of play, both of which are winning situations for the South Korean DRAM manufacturers. Firstly, South Korean suppliers could reduce the selling price of a DRAM to a point where their Japanese and US counterparts could not compete without being accused of dumping. If the South Koreans are interested simply in increasing market share, then they can drop DRAM prices, outprice their competitors and sell a larger DRAM volume. Using this approach, the South Korean companies could run their facilities at full capacity while forcing their competitors to close their fabs. This is an extreme scenario; nevertheless, Dataquest believes that South Korean manufacturers' share of the worldwide DRAM market will increase in 1998. Alternatively, South Korean vendors could maintain current DRAM market prices and reap the windfall of much greater profits per device sold.

Buyers outside the Asia/Pacific region, always eager to get the best deal, will be pushing hard for price reductions, playing the trump card of continued market oversupply to force the South Koreans' hand.

Long-Term Effects

One condition of the IMF bailout of Southeast Asian economies is that loans must be granted based upon standard good business practices, rather than on less tangible reasons. Consequently, South Korean DRAM manufacturers are less able to obtain loans for new equipment—previously, a company's mission to become a market leader was sufficient reason for the granting of a loan, but now the prospect of repayment is more important. Under this restriction, South Korean DRAM manufacturers have cut their spending plans to the bare minimum.

Reduced DRAM capital spending in 1998 will take about two years to ripple through to the marketplace. By the end of the decade, Dataquest expects to see a deficiency of competitive manufacturing capacity in South Korea; as a result, the South Korean market share gains anticipated by Dataquest in 1998 will begin to be lost to other countries as 2000 approaches. The winners will be those companies that have invested continuously while South Korean companies have cut back.

The turn-of-the-century time frame coincides with the period in which Dataquest expects to see a worldwide DRAM capacity shortage. Owing to more drastic cutbacks in DRAM capital investment by the South Koreans, this shortage is likely to be more marked than first envisaged.

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Outlook for 1998

Following the global DRAM market turmoil of 1996, last year closed in recovery mode, prompting optimistic forecasts for 1998. As the DRAM market made a significant upswing during the second half of last year, growth in 1997 over 1996 recovered to approximately minus 15 percent, and healthy positive growth was widely predicted for 1998. However, several factors have combined to temper optimism for a continued strong DRAM recovery during 1998; if it comes, it will be weighted heavily towards the back end of the year and may not be strong enough to pull annual growth above zero.

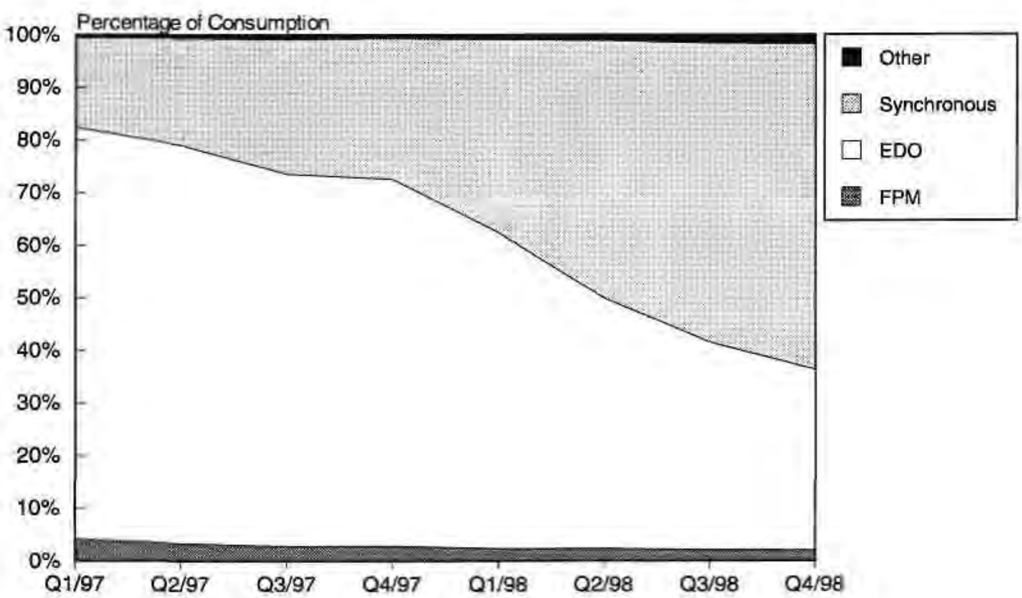
DRAM Technology Issues

EDO to Synchronous Transition

Although the transition from EDO to synchronous DRAM is well under way (as shown in Figure 2), the introduction of the eagerly awaited PC100-specification PC memory bus is required for the synchronous market to really take off. The expected rapid uptake of this initiative by PC manufacturers will lead to a recovery in the worldwide DRAM market as a predicted shortage of 100-MHz synchronous DRAM leads to a strengthening of DRAM prices.

However, there are a couple of good reasons why DRAM vendors should not be looking to 1998 as the year of this recovery. Firstly, for PC100 to establish itself, chipsets have to be available in volume. A limited number of chipsets are available already, particularly for use with non-Intel "socket 7" microprocessor solutions, but the Intel 440BX chipset, which will support a 100-MHz memory bus, is not due to be launched until later in the first quarter of 1998—and typically it takes two quarters from the launch of a new chipset to volume utilization. Secondly, new microprocessors that make use of the 100-MHz bus specification are not due for release until the second quarter of this year, and it is usual for at least four quarters to elapse between the launch of a new microprocessor and its incorporation into mainstream PC manufacture. Consequently, although synchronous DRAM will become increasingly common through 1998, it is the 66-MHz variant that will predominate; moreover, the price premium over EDO can be expected to be modest and hardly likely to give the DRAM market a major boost.

Figure 2
DRAM Interface Technology Transitions, 1997-1998

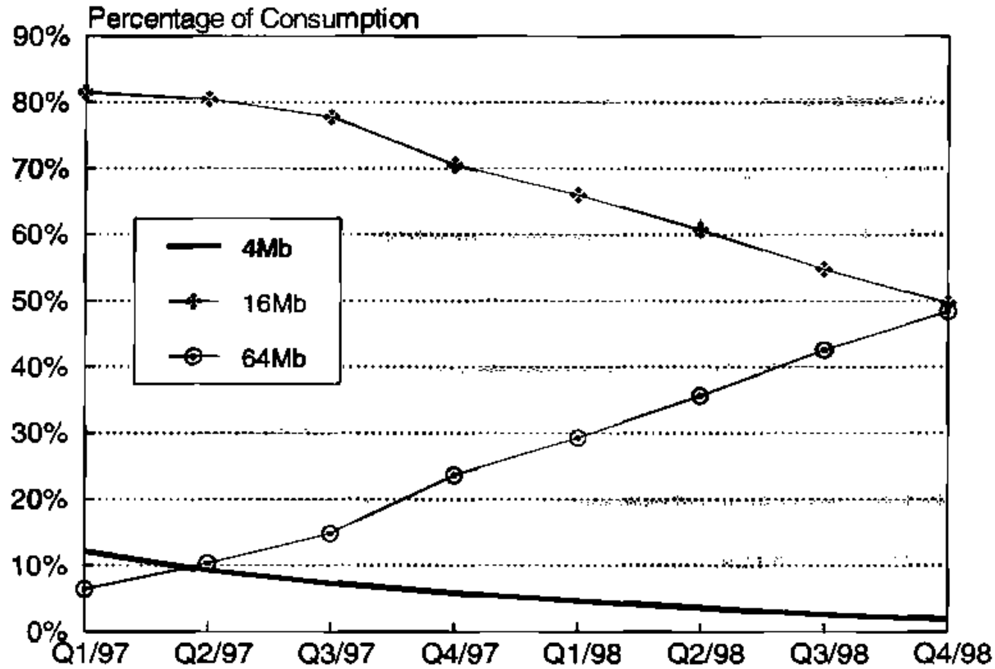


Source: Dataquest (March 1998 Estimates)

16Mb to 64Mb Transition

Although won devaluation as a result of the Asian financial crisis may fan the dying embers of the 16Mb device density by allowing further ASP reductions, price crossover between the 16Mb and 64Mb device densities is approaching fast. Time is running out for the 16Mb; certainly by the fourth quarter of 1998 demand will have switched to the 64Mb, as shown in Figure 3.

Figure 3
Worldwide DRAM Bit Consumption by Chip Density, 1997-1998



Source: Dataquest (March 1998 Estimates)

Bit-Growth Outlook

PC Production Outlook

Dataquest estimates that PC production in the EMEA region grew by a healthy 18 percent in 1997 over 1996, to reach approximately 21 million units. A compound annual growth rate of about 15 percent is expected to raise this figure to 40 million units by 2002. In parallel with this growth in PC production, PC main-memory requirements will increase as new applications are introduced.

Software Application Drivers

The introduction of the Windows 98 operating system in mid 1998 is not expected to lead to a step-function increase in PC main memory largely because the vast majority of new PCs are shipping with 32MB as standard, which is sufficient to run the new Windows offering. However, as Windows NT continues to penetrate the corporate PC environment, and version 4.0 becomes established, more and more PCs will leave the factory with 64MB of DRAM fitted as standard; therefore, a general shift upwards in average PC main-memory content will continue. Although fueled by more feature-rich and graphics-intensive application software, the absence of a veritable "killer" software application will lead to steady rather than spectacular annual bit growth in excess of 60 percent over the next five years. In other words, an average PC main-memory fit of about 30MB in 1997 is anticipated to rise to about 170MB by 2002.

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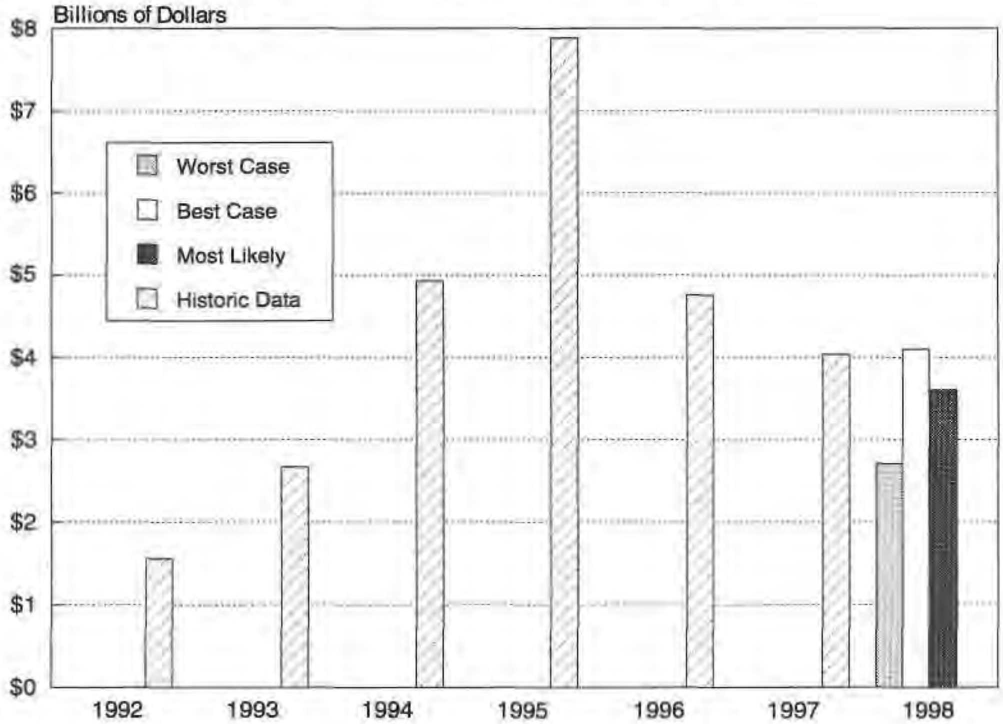
EMEA DRAM Forecast for 1998

Forecast Assumptions

Rather than simply presenting a table of data for this EMEA DRAM forecast outlook, Dataquest has decided to provide additional analysis and present forecast assumptions for a number of scenarios. In practical terms, this approach offers a forecast range based on best case, worst case and most likely scenarios for 1998, as shown in Figure 4.

Figure 4
EMEA DRAM Revenue History and Forecast, 1992-1998



Source: Dataquest (March 1998 Estimates)

Best Case Scenario for 1998: Bit-price crossover between the 16Mb and 64Mb occurs in the second quarter of this year, and a rapid move to PC100 occurs during the third quarter. This leads to product-mix-related undersupply and DRAM prices firm up. PC main-memory fit continues to increase so that more than 50 percent of PCs ship with 64MB in the fourth quarter of 1998. DRAM content averages 46MB per system. These conditions would result in the following:

- The price per megabyte stabilizing for 1998 at January levels.
- Bit growth remaining healthy, albeit lower than during the "bit boom" of 1997.

Worst Case Scenario for 1998: The Asian financial crisis allows South Korean manufacturers to continue to cut costs. The 16Mb device ASP declines steadily throughout 1998, pulling the price of the 64Mb device lower and delaying bit parity until 1999. The need for increased PC main memory fails to materialize, and the vast majority of PCs ship with 32MB throughout 1998. DRAM content averages 36MB per system. These conditions would result in the following:

- ASPs declining by 30 percent in line with the historic cost-reduction curve.
- Bit growth stalling as the need for higher PC main memory is not recognized.

Most Likely Scenario for 1998: Although DRAM ASPs are likely to fall further during the coming months, there is an overwhelming desire by the leading DRAM vendors to move the market to the 64Mb device density. An ongoing shift in production mix will allow DRAM vendors to benefit from economies of scale in the manufacture of 64Mb devices while reducing the oversupply of 16Mb. A move from EDO DRAM to synchronous DRAM also will occur, but this might be restricted to the 66-MHz variety until the final quarter of this year when PC100 chipsets begin to penetrate the market. These transitions are likely to cause a strengthening of ASPs in the second half of 1998.

Although the levels of bit growth seen in 1997 are unlikely to be repeated this year, there is an expectation among PC end users that PC vendors will continue to increase main-memory fit, especially in high-end machines fitted with the latest 300-MHz-plus microprocessors. This momentum to take advantage of what are perceived to be low DRAM prices may take some time to slow down, so DRAM content should easily reach an average of 42MB per system during 1998.

These conditions would result in the following:

- ASPs declining during the first half of 1998 until restricted supply of 64Mb and synchronous devices leads to firmer ASPs in the second half.
- Bit growth remaining healthy as last year's bit boom spills over into this year.

Dataquest Perspective

The DRAM outlook for 1998 remains very difficult to call. By this point in the industry cycle, a recovery in DRAM ASPs normally would have been expected along with a resultant recovery in revenue. In a new departure, whether this happens depends on events outside the semiconductor industry. The semiconductor industry cycle is usually out of step with global economic cycles, but the semiconductor industry perhaps cannot remain isolated from external economic factors this time, such has been the scale of the Asian financial crisis. The unique situation in South Korea—where the semiconductor arms of large conglomerates are almost entirely dependent on DRAM revenue, and account for more than 30 percent of global DRAM revenue—could send the DRAM industry into a siding for the next few quarters, effectively stalling the long-awaited recovery until 1999.

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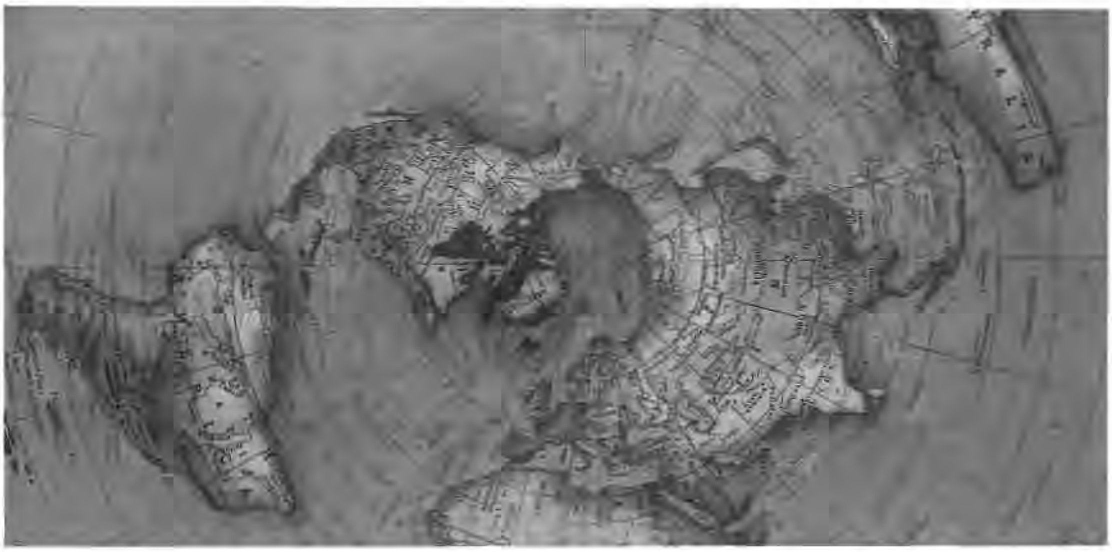

Perspectives

Semiconductors Europe

Market Analysis

The Impact of the Asian Financial Crisis on Worldwide Electronics Production and the Semiconductor Market

Abstract: *The Asian financial crisis will dampen the growth in 1998 of worldwide electronic equipment production and the semiconductor market to lower than previously forecast by Dataquest. This document examines the negative impact the Asian crisis will have on these forecasts.*

By Semiconductor Industry Analysts

Section I: Introduction

The financial crisis in Asia is a daily topic of discussion and in publications as the world tries to assess the impact of the crisis on worldwide financial markets, stock markets, banking systems, and national economies. At Dataquest, clients are continually asking us to assess the impact of the Asian crisis on the electronics, PC, and semiconductor industries, and much has been written by Dataquest about this.

In particular, our semiconductor clients are asking us how Asia's financial woes will affect Dataquest's 1998 semiconductor industry and electronic equipment production forecasts. These forecasts were released in October 1997, and much has happened since then. To date, we have refrained from issuing new formal forecasts mainly because the situation is still very, very fluid, and we felt we were unable to publish accurate 1998 forecasts until more information was at hand. Nevertheless, our clients want to know what our thinking is.

FILE COPY:
MARIA VALENZUELA

This document is a summary of Dataquest's current thinking about the impact of the Asian financial crisis on electronics production, the semiconductor market, including DRAMs, and semiconductor capital spending. The analysis presented in this document represents a qualitative point of view of the potential impact. Dataquest will issue new formal 1998 forecasts at the end of April. In the interim, we will keep our clients up to date as the Asian crisis evolves and more information becomes available.

Dataquest

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This analysis represents the collective thinking of Dataquest's semiconductor analysts in all regions of the world. Further information on any of the topics is available from the analysts listed at the end of each section or by referring to the other documents, noted in the text, that Dataquest has already published on Asia's financial crisis.

The Bottom Line

The following are the major conclusions of this analysis:

- In 1998, worldwide electronic equipment production will likely decline from Dataquest's previously forecast $1,009 billion to $953 billion. This means that 1998 electronic equipment production will grow only about 3 percent instead of the 9 percent previously forecast.
- Solely because of the decrease in electronic equipment production, the worldwide semiconductor market is likely to decline from our previously forecast $175 billion to $165 billion.
- Also, because of the potentially lower cost of DRAM manufacturing, the 1998 DRAM market could decline by $3 billion to $5 billion from our previous forecast.
- Combining the effects of decreased electronic equipment production and the lower DRAM market, the overall 1998 worldwide semiconductor market could be as low as $160 billion. Our previous 1998 forecast (released in October 1997) was $175 billion, for a growth of 17 percent over 1997. The new forecast of $160 billion represents a growth of about 7 percent over 1997.
- Capital spending is forecast to be down 4 percent in 1998 to $43 billion and does reflect the conditions in Asia through December. Dataquest has also published a detailed downside capital spending scenario with a set of changed assumptions that places the downside risk at $39 billion, about a 12 percent decline from 1997 levels.

It is important to note that the numbers presented in this document are not "official forecasts" but are meant to provide guidance to clients until we do publish firmer forecasts. This forecast represents our current thinking about the impact of the Asian financial crisis and is subject to change as the situation continues to unfold.

Section II: Background on the Asian Financial Crisis

The beginning of summer 1997 saw the devaluation of the Thai baht amid escalating difficulties in the Thai banking and finance community, which forced the Thai government to finally surrender to the currency speculators. At that time, few people, if any, would have predicted this to be the start of a financial storm sweeping throughout Asia, with far-reaching global implications.

Shortly after the Thai baht devaluation, the governments of Malaysia, Indonesia, and the Philippines succumbed one by one to the speculative currency attacks. The rapid currency devaluation sent shock waves through the regional stock markets of Thailand, Malaysia, Indonesia, and the Philippines. Singapore and Hong Kong, which remained largely unaffected initially, saw their stock markets tumble in October amid growing investor anxiety.

The financial crisis deepened in November as it spread to Korea and Japan, the world's 11th-largest and second-largest economies, respectively. The value of the Korean won dropped sharply, along with Korea's stock market, after the Korean government gave up its battle to prop up its currency in November. A $57 billion rescue package led by the International Monetary Fund (IMF) was negotiated for Korea, after $40 billion and $17 billion were negotiated for Indonesia and Thailand, respectively. In the meantime, Japan saw the closure of its

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fourth-largest securities company, Yamaichi Securities Company, on November 24, following the closure of Hokkaido Takushoku Bank, its 10th-largest commercial bank, a week earlier.

Behind these events lies a tale of massive regional expansion based largely on politically manipulated debt directed over the past 40 years to conglomerates that are now unable to pay the money back.

Simply stated, the current Asian financial crisis stems from the inability of South Korean and other regional companies to repay their short-term debts. The expansion that has given South Korea an average annual gross domestic product (GDP) growth rate of 8.6 percent during the past 30 years has been achieved largely on the back of massive, politically backed short-term borrowing, which was rolled over regularly and renewed by the country's top companies—family-run conglomerates, commonly known as chaebols. Problems have occurred with this short-term borrowing strategy because many of the investments made were long term and not suited to short-term returns. More important, the primarily South Korean banks, which in turn borrowed mainly US dollars from Japanese banks, are now unable to continue rolling over the debts and granting extensions. Inevitably, huge debts are now due for repayment. There are several factors that have caused this.

Until mid-1997, the Southeast Asian currencies and the Korean won were pegged to the US dollar. With the growth in the strength of the dollar since mid-1995, caused by the improving performance of the US economy, the won and the Southeast Asian currencies also strengthened, in conjunction with the US dollar. The strong local currencies resulted in the slowdown of Southeast Asian and Korean exports because they became more expensive and less competitive in a worldwide market that was already showing signs of slowing and overcapacity. The slowdown in exports contributed to the large current account deficit in Southeast Asian countries and Korea, which ultimately left the currencies in those countries susceptible to devaluation.

The dramatic currency devaluation that occurred in Southeast Asian countries and Korea will now make exports more cost-competitive. However, these devaluations increased the local value of debts borrowed in foreign currencies, massively increasing the amount of home currencies required by banks and conglomerates to repay their debts.

The second catalyst for the crisis concerns the primarily Japanese banks that, by lending to the region's banks, including South Korean banks, financed the growth of South Korea and other countries. Japanese banks were unable to renegotiate their South Korean debts because of their own liquidity problems. Much of the security on which Japanese banks based their value was property and stock market-based investments; however, in the early 1990s, the Japanese property and stock markets collapsed, taking with them much of the equity on which Japanese banks relied. The loss of equity and the effectively defaulted loans of Japanese companies caught in the collapse impaired their ability to borrow money on the international money markets; thus, less new money was available to renegotiate South Korean debts. South Korean loans therefore came due for repayment.

The problem is so severe that the South Korean ministry of finance and economy estimates that about $21.5 billion of external debt will be due for repayment in the first three months of 1998. In the first six months of 1998, about $70 billion of external liabilities will be payable—this represents about 70 percent of the nation's total external debt.

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These debt levels, devaluing currencies, and slowing revenue mean that mass restructuring will be needed in the South Korean and other Southeast Asian economies to restore the market confidence necessary to allow the region to recover. This restructuring will involve mass layoffs as loss-making companies and insolvent banks are closed down and the giant chaebols are restructured to focus on core competencies.

Contributing Analysts: Edmund Gemmell (United Kingdom), Jim Liang (United States), and J.H. Son (Korea)

Section III: The Macroeconomic Effects of Asia's Financial Crisis and the Impact on Electronics Production and Semiconductor Consumption

Asia's Macroeconomic Outlook for 1998 Has Changed Dramatically

Asia's currency and financial crisis has dramatically changed the macroeconomic outlook for most Asian economies. Changes in outlook have been the greatest for the economies most affected by the crisis: Indonesia, South Korea, and Thailand. Economic forecasters have uniformly downgraded their estimates of GDP for Asia's troubled Pacific Basin region in 1998. Based on a survey of prominent forecasters, Dataquest estimates that 1998 GDP for the region will be reduced about $690 billion from the levels expected at the time of Dataquest's fall forecasts. GDP estimates for Indonesia, South Korea, and Thailand have been reduced especially sharply. These significant changes in the outlook for GDP have been accompanied by equally significant changes in the outlook for inflation. Inflation is expected to increase markedly throughout the region, especially for Indonesia, South Korea, and Thailand, as lower currency values push up the prices of imports.

Macroeconomic Outlook Elsewhere Remains Mixed but Could Sour If Asia's Troubles Worsen

The macroeconomic outlook for the rest of the world remains mixed in the face of Asia's troubles. Forecasters have generally downgraded their outlook for Japan in 1998. They have done this not so much because of Asia's crisis but because of continuing economic difficulties in Japan. Japan remains deeply mired in an ongoing economic recession. Continued troubles in Asia pose a significant threat to Japan's recovery. Because most Asian currencies have depreciated far more against the dollar than the yen has since summer, Japan has lost much of the competitive advantage it had regained from its Asian rivals during the past few years. More important, Japan holds significant amounts of the dollar-denominated debt floated by Asian economies before the onset of the crisis. Outright default on this debt would likely paralyze Japan's already crippled financial system. As things currently stand, Dataquest estimates that Japanese 1998 GDP will prove $650 billion lower than expected.

Forecasters' outlooks for the United States remain surprisingly bright. The prospects for economic growth in the United States remain strong in spite of Asia's troubles. Asia's difficulties are expected to exert some drag on the US economy, but America's domestic economy is currently so strong it appears capable of overcoming adverse effects from Asia. The outlook for Western Europe is somewhat more enigmatic. For the moment, most forecasters appear to believe that economic growth will not be adversely impacted by Asia's troubles. But this outlook is qualified with the recognition that Western Europe could suffer serious impacts if Asia's difficulties were to worsen significantly. Western Europe has extensive economic and financial ties with many of Asia's crisis-afflicted economies. What is more, ongoing economic growth in Western Europe is still heavily dependent on exports. A tidal wave of Asian debt default combined with a collapse of Asian imports would hobble Western European economic performance. All in all, Dataquest estimates that 1998 GDP for the United States and Western Europe combined will be about $80 billion lower than previously expected because of the US dollar's continuing strength against Western European currencies.

Macroeconomic Impacts on 1998 Electronics Production and Semiconductor Consumption

We can use this information about changing macroeconomics in combination with Dataquest's fall forecasts of electronics production and semiconductor consumption to infer the potential impact of changing macroeconomics on worldwide electronics production and semiconductor consumption. We want to warn readers up front that the following discussion is an inexact first-order analysis based on some very simplifying assumptions about the links between macroeconomics and the markets for electronics and semiconductors. It is important to note that a comprehensive and conclusive analysis would require extensive study of interrelated demand and supply impacts in both the electronics and semiconductor markets.

Worldwide Electronics Production to Decline about $56 Billion

The analysis begins by linking macroeconomic changes to electronics demand. For this simplified analysis, we believe it is reasonable to assume that electronics demand is related to GDP and will vary with changes in GDP. Research by the Technology Foresight Programme, a British government-sponsored organization, estimates that Asia's Pacific Basin economies expend about 5 percent of their GDP on electronics consumption. For Japan, it estimates that about 3 percent of GDP is expended on electronics consumption. For the United States and Western Europe, the estimate is 3.5 percent. These numbers compare favorably with Dataquest's own estimates of worldwide expenditure on electronics relative to GDP. Based on figures from our fall forecasts and IMF estimates of world GDP, we estimate worldwide electronics spending amounted to about 3 percent of world GDP in 1997.

Unfortunately, these various figures reflect average rates of expenditure on electronics from GDP. They do not tell us how electronics spending will change as a result of changes in GDP. For that, we would need to know the marginal rates of expenditure on electronics from GDP. There is good reason to believe the marginal rates of expenditure on electronics from GDP in all these regions are actually higher than the average rates cited earlier. Because of this, impacts based on these average rates could be understated.

Nonetheless, the result of applying these average rates to the changes in 1998 GDP noted earlier is that electronics demand is likely to be reduced $34.5 billion in Asia's Pacific Basin, $19.5 billion in Japan, and $2.8 billion in the United States and Western Europe combined. For the sake of simplified analysis, the decline in worldwide demand reflected in the sum of these figures is assumed to generate an equal decline in worldwide electronics production. Please note that Dataquest is not assuming that the declines in demand for each region generate equal declines in production for each region. As discussed later, this certainly will not be the case. Given this assumption, Dataquest expects 1998 electronics production to decline $56 billion relative to the fall forecast, which was $1,009 billion. This represents a decrease of 5.6 percent from the fall forecast.

Semiconductor Consumption to Decline about $10 Billion

Naturally, the forecast decline in electronics production has implications for semiconductor consumption. Here again, Dataquest makes a simplifying assumption. In the fall semiconductor consumption forecast, we estimated that worldwide semiconductor consumption would average 17.3 percent of worldwide electronics production value in 1998. Assuming that semiconductor content remains unaffected by the changing macroeconomics stemming from Asia's financial crisis, Dataquest estimates that worldwide semiconductor consumption will fall about $9.8 billion from the previous forecast for 1998. This would (again) represent a 5.6 percent decline from the fall semiconductor forecast, which was $175 billion, resulting in an estimated $165 billion semiconductor forecast for 1998.

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More Detailed Demand and Supply Analysis Needed

Once again, it is important to emphasize that these results are based on several simplifying assumptions in lieu of more detailed demand and supply analysis. These assumptions are open to serious question. The potential bias to these results that stems from using average rates of expenditure on electronics from GDP in the analysis instead of marginal rates of expenditure has already been discussed. Also, these results may be biased by the assumption that a forecast decline in worldwide electronics demand will generate an equal decline in worldwide electronics production.

In the final analysis, the dollar-valued volume of electronics produced worldwide is determined by the interaction of demand and supply in the market for electronics. Dataquest's assumption that declining electronics demand will generate an equal decline in electronics production is tantamount to assuming that electronics supply is perfectly price elastic and will remain unaffected by the changing macroeconomics of Asia's crisis. The former seems highly unlikely, and the latter is almost certainly not true. Although we cannot be absolutely certain, we suspect that electronics production may ultimately decline less than electronics demand. As demand subsides, it is likely that electronics prices will fall, especially for Asian goods whose producers are both willing and able to press the production cost advantage that currency devaluations have given them. Backed by aggressive marketing, declining electronics prices could stimulate sufficient new demand to counter much of the decline being forecast.

Dataquest's results are also likely to be biased by the assumption that the semiconductor content of electronics will remain unaffected by changing macroeconomics. Like the dollar-valued volume of electronics produced and semiconductors consumed from which it is derived, semiconductor content emerges from the outcome of market interactions among electronics and semiconductor producers. Precisely because semiconductor content is ultimately determined by the mechanics of the electronics and semiconductor markets, it is unreasonable to assume values for it. Changes in semiconductor content must be deduced from detailed analysis of forecast changes in market demand and supply for both the electronics and semiconductor markets. On the whole, we are inclined to believe that semiconductor content will decline in 1998. Dataquest believes that the interaction of declining semiconductor demand induced by lower electronics production and of increased semiconductor supply induced by lower production costs in Asia will cause dollar-valued semiconductor consumption to decline more than electronics production. This would de facto lower semiconductor content.

Currency and Financial Impacts on Electronics and Semiconductor Supply—Asian Producers Face Potential Double Bind

The dramatic declines in Asian currency values, the most visible aspect of the crisis, have at least temporarily altered the relative economics of both electronics and semiconductor production across regions. Despite the very real pain these devaluations have caused, they have imparted a potentially large production cost advantage to Asia, especially to countries such as South Korea that have experienced the sharpest devaluations. Of course, this cost advantage is somewhat tempered by devaluation-induced increases in the cost of components and subsystems that must be imported from Japan and outside Asia. Still, there is an advantage to exploit if Asian electronics producers can maintain the working capital needed to finance their day-to-day operations.

In this regard, South Korean producers could paradoxically emerge as the crisis' biggest winner, at least over the short term. Assuming that Korean electronics producers can retain sufficient working capital, they appear well-positioned to increase significantly their share of electronics and semiconductors sold outside Asia. Unfortunately, they could have trouble defending their increased

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share over the long term if they are unable to generate the investment capital necessary to expand capacity. By the same token, producers outside Asia now have increased incentive to locate production in the region. Although this is unlikely to happen so long as economic and political uncertainty remained heightened, it is likely to occur once stability is re-established and the crisis appears to be moving toward resolution, especially if Asian currency values remain at or near their current levels.

Non-Asian Producers Also Face Risks

The currency upheavals and financial upset of Asia's crisis threaten consequences not only to the fortunes of Asian companies but also to the operations of non-Asian companies. In 1996, Asia/Pacific-based electronics equipment manufacturers accounted for $29.7 billion, or about 21 percent, of worldwide semiconductor sales. About 18 percent of American semiconductor sales, 18 percent of Japanese sales, and nearly 25 percent of European sales were derived from sales to Asia/Pacific. This, in turn, fed electronics manufacturing worth $153.7 billion, about 18 percent of the worldwide total. Clearly, a significant decline in semiconductor demand among Asian electronics producers could harm non-Asian semiconductor companies dependent on the region.

The perils to continuing business in Asia for both Asian and non-Asian companies is probably best illustrated with circumstances in South Korea. Most manufacturing locations within South Korean are locally owned. This means liquidity problems arising from Korea's financial difficulties are a real issue for these manufacturers. With IMF restrictions in place, South Korean companies will now find it very difficult to obtain letters of guarantee, which are essential if they are to make purchases on credit. Without these letters, their only option is to pay cash for purchases of semiconductors. Currency devaluation has made this cash now twice as expensive to obtain, and obtaining it may prove very difficult.

The availability of credit is potentially one of the major issues of the crisis. Should credit in the form of letters of guarantee and the like become available again through IMF intervention, the liquidity issues that indigenous manufacturers face will be significantly reduced, and they will be able to continue purchasing the raw materials needed for manufacturing. Only then will they be able to press home the cost advantage that currency devaluations have given them. If, however, these letters do not become available, manufacturing in South Korea, as well as in other crisis-impacted countries, could be seriously curtailed as manufacturers run out of raw materials, with only a diminished ability to purchase operational stocks. Indeed, the issue of credit availability has already been raised in a recent announcement from Atmel Corporation.

Just recently, this American supplier of nonvolatile memory and application-specific ICs (ASICs) announced a fourth quarter charge of $160 million, citing "credit problems with specific Asian customers." Although this statement may be open to further scrutiny, it does raise the important point that non-Asian companies may be exposed to the risk of potential bad debts and future loss of market because of the inability of Asian OEMs and contract equipment manufacturers (CEMs) to obtain letters of guarantee. Should similar problems be encountered by other semiconductor manufacturers with their "Asian customers," then potentially significant semiconductor market share could be put at risk.

Summing Up

Dataquest believes that both worldwide electronics production and semiconductor consumption will be affected in 1998 as a result of Asia's financial crisis. Our simplified analysis suggests that electronics production will be reduced about $56 billion and semiconductor consumption about $10 billion. These

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changes represent about a 5.6 percent decline from Dataquest's fall forecast for 1998. We remain uncertain about the prospects for individual regions and consumers. Although it is clear that Asian-based electronics and semiconductor producers have gained some production cost advantages owing to currency devaluations, it is not clear that they will be able to press home those advantages because of potential problems with liquidity and credit arising from the financial upsets of the crisis. Moreover, many non-Asian companies are clearly at risk owing to their strong dependence on Asia and their close financial relationships with Asian producers. Although we do not believe that Asia's financial crisis will break worldwide electronics and semiconductor markets, we do believe it will test them as never before.

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Section IV: Impact of the Crisis on DRAM Costs and the Forecast

The effect of the Asian financial crisis on Dataquest's DRAM forecast will be caused mainly by the fall of the Korean won against other world currencies and by some of the restructuring of financing the IMF has required of the Korean chaebols. These two causes will result in two key effects, one short term and the other long term. Taiwanese DRAM manufacturers are disregarded in this analysis because, in 1996, Korean companies provided 33.6 percent of the world DRAM market, while Taiwanese companies shipped only 2.4 percent (*Worldwide Memory Market Share 1994 to 1996*, MMRY-WW-MS-9701, May 1997).

Short-Term Effects

Throughout 1997, DRAMs have been priced at a level near their manufacturing cost, a minimum that must be followed if antidumping measures are to be avoided. Going into 1998, Dataquest sees a continuing overcapacity, forcing manufacturers to continue their efforts to keep prices low to win the fight for their share of their customers' business, a fight they encounter at buyers' desks.

In a competitive market, semiconductor manufacturers use manufacturing cost reductions to reduce the selling price of their products. A knowledge of semiconductor manufacturing cost trends is useful for projecting long-term costs/selling price relationships, which vary from product to product and company to company, as well as by market and business conditions.

What happens with a devaluation of the Korean won against other currencies? It only stands to reason that a devaluation of the won would lower manufacturing costs (as measured in any other currency). How much impact will the devaluation have? Dataquest has analyzed the situation, and it appears that at least 55 percent of the cost to manufacture a DRAM is in won-based transactions rather than foreign currency-based transactions ("Dataquest's Tactical Memories Newsletter, Volume II, No. 26," MMRY-WW-DP-9733, December 1997).

The Dataquest semiconductor cost model uses 16 variables of semiconductor manufacturing. These variables cover the main areas where costs accrue and processes can improve. The variables that have the most influence over cost are wafer processing, wafer size, die size, sort yield, package type, and final test yield. The financial crisis in Asia has caused major changes in Asian cost structures based on devalued local currencies, compared with the US dollar. The costs affected are those whose basis is predominantly local Asian currencies. This category includes all the major costs associated with wafer processing and test ("Dataquest's Tactical Memories Newsletter, Volume II, No. 26," MMRY-WW-DP-9733, December 1997). For the purposes of this conservative model, we have assumed that 50 percent of all wafer processing and test costs are won-based.

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Table 1 shows the DRAM cost model and compares the DRAM costs before won devaluation and after devaluation. Differences in this cost model are based mainly on exchange rate variations, but Dataquest has also included a comparison of costs for different die sizes (Micron Technology Inc. alone has a 42-mm^2 16Mb DRAM, whereas die sizes for Korean and Japanese manufacturers range from 58 mm^2 to more than 90 mm^2.)

For the past year, DRAM price levels have hovered at or near cost levels to the extent that few suppliers were or are profitable in this business. The cost model highlights how changes in local currency costs dramatically alter the cost structure as reported in dollars. Using Micron as an efficient 16Mb DRAM cost benchmark, this model shows that, even with die shrinks and lower wafer processing costs, Micron still cannot produce at a lower cost than the Korean companies, because the revalued won has substantially reduced wafer processing and test costs, even with a larger Korean die.

The upshot of this analysis is that Asian companies now have a significantly less expensive DRAM cost of manufacture in dollar terms than either their Japanese or American competitors. This also means that the Korean companies could sell DRAM at a lower price than the other regional manufacturers without running the risk of dumping charges. In other words, the Korean suppliers could reduce the selling price of a DRAM to a point at which the Japanese or American companies will not be able to compete without being accused of dumping. How will the Korean companies behave?

If they are interested in simply increasing market share, then they can drop DRAM prices, outprice their competitors, and sell a larger DRAM volume. Using this approach, these companies could run their facilities at full capacity while forcing their competitors to close their fabs. Although it is unlikely that such a severe change will occur, Dataquest believes that in 1998 Korean manufacturers' share of the DRAM market will increase.

Alternatively, they could maintain current DRAM market prices and reap the windfall of much greater profits per device sold. Both scenarios are win/win situations for the Korean DRAM manufacturers. In both, their foreign currency cash flow increases significantly, as do their profit margins.

Buyers outside Asia/Pacific, always eager to get the best deal, will be pushing hard for price reductions, playing the trump card of continued market oversupply to force the Korean companies' hand. In the current oversupplied market, it remains to be seen which way Asia/Pacific suppliers will go in pricing their newly profitable product lines.

This discussion has examined Asia/Pacific only as a DRAM supplier. What about the demand side? Most of the DRAM consumed in Asia/Pacific is used to produce computing equipment sold in the Americas, Europe, and Japan. The cost of DRAM to the end users in these three regions is unaffected by the exchange rate in the Asia/Pacific country where the system is assembled. Dataquest believes that the devaluation will not affect the price or quantity of DRAM purchased in Asia/Pacific as much as it affects Asia/Pacific wages compared with the wages in other regions. More competitive wages should shift more manufacturing away from other regions and into Asia/Pacific.

Dataquest expects to lower the DRAM forecast by $3 billion to $5 billion to compensate for the combined effects of the Asian financial crisis and the additional DRAM capacity that was put into place in 1997. The net effect will be a decrease of the 1998 DRAM market to between $22 billion and $25 billion, representing a growth range of 0 percent to 7 percent over 1997's estimated $22 billion.

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Table 1
1998 16Mb DRAM Cost Model

	Micron Q3/97	Micron Q1/98	Korea Q3/97	Korea Q1/98	Korea Q1/98
Die Size (mm^2)	42 mm	30 mm	60 mm	60 mm	42 mm
Exchange Rate (Won/US$)	-	-	912	1,748	1,748
Wafer Sort					
Wafer Size (Inches Diameter)	8	8	8	8	8
Capacity Utilization (%)	100.00	100.00	100.00	100.00	100.00
Geometry (Micron)	0.35	0.35	0.35	0.35	0.35
Processed Wafer Cost ($)	*1,450*	*1,305*	*1,450*	*725*	*725*
Die Area (Square Mils)	65,487	46,887	93,091	93,091	65,487
Active Area Factor	1.00	1.00	1.00	1.00	1.00
Number of Masks	18	18	18	18	18
Defect Density per Square Inch	0.056	0.056	0.056	0.056	0.056
Gross Die per Wafer	614	858	432	432	614
Processed Wafer Cost per Gross Die ($)	2.36	1.52	3.36	1.68	1.18
Test Cost per Hour ($)	*110.00*	*110.00*	*110.00*	*55.00*	*55.00*
Wafers Tested per Hour	0.10	0.07	0.14	0.14	0.10
Wafer Sort Cost per Gross Die ($)	1.83	1.83	1.83	0.92	0.92
Cost per Gross Die at Wafer Sort ($)	4.19	3.35	5.19	2.60	2.10
Wafer Sort Yield (%)	94	95	91	91	94
Cost per Sorted Die ($)	4.48	3.52	5.70	2.85	2.24
Assembly					
Material Cost/Sorted Die, SOJ Package($)	*0.34*	*0.34*	*0.34*	*0.20*	*0.20*
Number of Pins	28	28	28	28	28
Assembly Yield (%)	99	99	99	99	99
Cost per Assembled Die ($)	4.87	3.89	6.10	3.08	2.46
Final Test					
Test Time per Die (Sec.)	10.00	10.00	10.00	10.00	10.00
Cost per Hour of Testing ($)	*90.00*	*90.00*	*90.00*	*45.00*	*45.00*
Test Cost per Die ($)	0.25	0.25	0.25	0.13	0.13
Final Test Yield (%)	98	98	98	98	98
Cost per Final Tested Unit ($)	5.22	4.23	6.48	3.27	2.64
Mark, Pack, and Ship					
Cost at 99% Yield (%)	0.05	0.04	0.06	0.03	0.03
Total Fabricated Cost per Net Unit ($)	**5.27**	**4.27**	**6.54**	**3.30**	**2.67**

*Costs directly affected by local currency devaluation:-50 percent wafer/test costs
Source: Dataquest (January 1998)

Long-Term Effects

One condition of the IMF bailout is that loans must be granted based on standard good business practice, rather than on less tangible reasons. For this reason, Korean DRAM manufacturers find it harder to get loans for new equipment. Previously, a company's mission to become a market leader was a sufficient reason for a loan to be granted, but now the prospects for repayment are more important. Under this restriction, Korean DRAM manufacturers have cut their spending plans to the bare essentials.

The full ramifications of reduced capital spending in 1998 will take about two years to appear. In 2000, Dataquest expects to see a relatively severe deficiency of competitive manufacturing capacity in Korea as Korean fabs start to lag the technology available in other countries. As a result of this, the Korean market share gains that Dataquest expects to see in 1998 will be lost to other countries in 2000. The winners will be those that have invested continuously during the time that Korean companies have cut back.

This coincides with the period in which Dataquest expects to see a mild worldwide DRAM capacity shortage, and prices will firm for about half a year to a full year.

There will be a Dataquest Telebriefing on February 13, 1998, at 8:30 PST, discussing the impact of the Asian financial crisis on the spring memory forecast. To confirm attendance, please call Carole Phillips at (408) 468-8376 or Jenny Williams at (408) 468-8263 or fax them at (408) 468-8044.

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Section V: How Will the Asian Financial Crisis Impact Capital Spending?

Even without the Asian financial crisis, the fundamentals have not changed much and indeed may have gotten worse as a result of the aggressive spending patterns in 1997. Overcapacity never went away, and acceleration of shrinks has actually exacerbated the situation.

In DRAM, with the shrink factor and the addition of net capacity of the last 18 months, the situation has not improved. Given these facts, Dataquest is no longer convinced that the market will be balanced by the end of 1998 unless capacity is actively removed from the market.

Dataquest's analysis of supply and demand in the foundry industry at 0.35-micron technology continues to show that, although demand is strong, supply base plans are about three months ahead of demand for the leading-edge 0.35-micron technology through 1999. Evidence supporting this can be found in the continued pricing pressure, with greater than normal declines. Given the evidence that more suppliers are entering the foundry business, this situation is likely to deteriorate somewhat during the next year.

Dataquest is therefore continuing to call 1998 an essentially flat spending year overall. The stronger-than-expected 1997 actually pushes the sustained recovery in spending, driven by a balance in capacity, into mid-1999. Companies will continue to concentrate on technology, with emphasis on 0.25-micron and 300-mm technology, along with investments in new interconnect materials and processes.

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What Are the Assumptions and Downside Risks for 1998 Capital Spending?

Dataquest's forecast and assumptions are more explicitly detailed in a Perspective ("Wafer Fab Equipment Market Forecast Update: Question Marks for 1998 as the Second Half of the 'W' Unfolds," SEMM-WW-DP-9801, January 1998) and a Market Trends Report to be published shortly (*Year-End 1997 Forecast: Capital Spending, Wafer Fab Equipment, and Silicon Markets*, SEMM-WW-MT-9801). The base forecast calls for an essentially flat year, with capital spending down 3 percent and wafer fab equipment experiencing 2 percent growth.

Dataquest has developed a detailed second scenario for the 1998 wafer fab equipment market to give clients a "window" of outcomes possible if several of the key assumptions are changed based on the Asian financial crisis. For the most part, these changes simply reflect the timing differences of spending plans. For the "downside risk" scenario, the following assumptions are made:

- Korean companies will cut back spending almost 60 percent in US dollar terms, with at least one project in Europe falling out of 1998 (quite likely Hyundai's, because LG Semicon. has significantly lower debt-to-equity ratios). Dataquest's forecast assumes a 40 percent cut.
- Taiwanese companies' DRAM spending will be cut by 45 percent overall in US dollar terms as funding from Japan is lost and profitability concerns govern loan approvals. The forecast assumes a 15 percent cut.
- Taiwanese foundry spending growth is assumed to remain at 40 percent, because the primary source of funds is the profitable players.
- Taiwanese company spending overall would therefore be down only 2 percent, to $6 billion. The forecast assumes growth of 13 percent to $6.9 billion.
- Japanese companies will cut spending overall by 8 to 10 percent in yen terms, or 14 percent in US dollar terms, compared to 1997. Dataquest's forecast assumes an overall spending cut of only 5 percent in US dollar terms.
- Spending on 300-mm equipment will be reduced to $700 million, based on the timing of shipments into Japan and the United States. Siemens' project appears safe in 1998 because the German government is funding a portion. Dataquest's forecast assumes that $1.1 billion will be spent on 300-mm equipment.
- The US and European major companies that are increasing spending in 1998 will cut these levels back 5 to 10 percent. This places the group at a 4 percent growth instead of the forecast scenario of 10 percent and makes Intel Corporation's spending flat (excluding the Digital Equipment Corporation plant acquisition), compared to 1997. Philips Electronics NV, SGS-Thomson Microelectronics B.V., and Advanced Micro Devices Inc. will continue to increase spending in this scenario for 1998.

Putting this all together, capital spending levels would be cut by about $3.7 billion compared to the 1998 forecast scenario, with these cuts reflected primarily in discretionary equipment spending and with all regions being affected. The wafer fab equipment market would be reduced by about $2.4 billion, with about 70 percent of the difference being related to lower DRAM spending. These reductions have about a 9 to 10 percentage point negative impact on growth of spending in 1998.

The US market would be the least affected, because the reduction in Korean company spending is already accounted for in the forecast scenario; the European and Asia/Pacific markets are likely to see the largest negative impacts. The equipment technologies focused on enabling logic and 0.25-micron processing, such as chemical mechanical polishing (CMP) and deep-UV steppers, would not be affected much by these changed assumptions.

However, the equipment segments dependent on capacity or DRAM-sensitive investment, such as diffusion tubes and implant, would be more heavily affected.

Should the downside scenario come to pass, there should be a silver lining—the DRAM market will likely come into balance sooner, leading to stronger profitability in the chip sector and renewed higher growth in spending on equipment.

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Section VI: Worldwide PC Market Overview

Despite the volatility experienced in some Asia/Pacific countries during the second half of 1997, preliminary Dataquest estimates indicate that the worldwide PC industry's unit growth rate was just under 16 percent, off slightly from Dataquest's original forecast of 17 percent. Dataquest estimates that more than 82 million PCs were shipped by manufacturers in 1997.

Although both Japanese and Asia/Pacific demand for PCs did not meet our expectations in 1997, flourishing markets in the United States and Western Europe aided greatly in keeping the global PC industry healthy. At the beginning of last year, Dataquest had predicted that the Japanese market would grow by 9.6 million PCs and that Asia/Pacific would experience growth resulting in 11.4 million additional units.

Dataquest now estimates that actual PC shipments into Japan were 7.9 million units and that Asia/Pacific absorbed 9.7 million units. We expect that Japan's unit growth rate will be less than 10 percent in 1998 and that the Asia/Pacific region will grow at a respectable 15 percent.

Dataquest believes now that the strong growth in the United States and Western Europe will continue to offset in part the setbacks in Japan and Asia/Pacific. We still expect worldwide PC unit growth to be in the mid-teens. Total PC production will exceed 94 million units.

For many years, total worldwide demand for personal computers has sustained sensational growth, and Dataquest expects this trend to continue through the foreseeable future. Regardless of fluctuating economies, the demand fundamentals are compelling for both the commercial PC market and the consumer market. The most significant of these demand fundamentals is the concept of "critical mass." In effect, this Dataquest theory asserts that when the majority of participants in a specific PC market segment require a personal computer, then all participants in that segment must acquire and use a PC.

"Critical mass" has already been reached in the United States and other regional commercial PC market segments, and the requirement for personal computers in US homes is growing each year. Dataquest estimates that more than 42 percent of all US households have at least one PC. We are near "critical mass" in the US home market, and this phenomenon will spread throughout the world well into the next century.

Solid unit growth will continue for years to come. However, solid revenue growth may elude many PC manufacturers and component suppliers in the coming years. Dataquest believes that the pricing trends followed in the US consumer market last year will spill over into the commercial PC market as early as the second quarter of 1998. The sub-$1,000 PC is a harsh reality, and this price point is as appealing to the business segment as to the home segment; its allure will reach all regions by year's end.

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The sub-$1,000 PC is possible for two major reasons. First, component suppliers have been drained of their customary "rightful share of profits." There simply is not enough money in a $700 PC for everyone. Second, successful PC manufacturers have adjusted to a business model of return on investment rather than gross margin. "Velocity manufacturing" is a requisite in this industry, and it manifests itself as build to order, channel assembly, and contract manufacturing.

Finally, Dataquest expects that the "elite few" PC manufacturers that captured nearly 70 percent of growth in the worldwide PC market in 1997 will continue to dominate the industry, forcing continued consolidation and straining the deep pockets of some megaparents.

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Section VII: What about China?

Dataquest has recently published a detailed analysis of China/Hong Kong's electronics production in a Focus Report (*China/Hong Kong's Computers, Communications, and Consumer Electronics Industry in 2001*, SEMI-CH-FR-9701, November 1997). The highlights are presented in this section.

Dataquest believes that the Asian financial crisis has a lot to do with speculative investment "bubbles" in property, construction, semiconductors, and other industries. It is clear what happens when rapid economic growth occurs in the absence of a transparent financial system and clean government regulations: overcapacity and irrational loans. The effects of these bubbles can become so serious as to bring down entire financial systems and impair international confidence and, hence, economic growth.

China and Hong Kong are not immune to these problems, although they seemed to be dealing with these bubbles more effectively by popping them before they get too big. China's economic czar, Zhu Rongji, burst the stock market bubble, property bubble, and construction bubble in 1996 and 1997. After 1997's October party congress, he is now more empowered than ever to pop the next speculative runs, whatever they may be. In 1998, he will be promoted to prime minister. Zhu's charter is to fix the state-owned enterprises to avoid overwhelming the financial system with bad loans. If China slacks off, its financial system will face serious problems, potentially worse than those of Korea. China is learning to avoid Korea's expensive lesson—although having $200 billion in combined reserves with Hong Kong will help, too. Strong economic growth in North America and Europe will be critical to China and the region because Japanese consumption is weakening with its own economic malaise.

That China's currency is not convertible may help in the short run, although this does not necessarily insulate China from the possibility of a major depreciation. In 1994, the Chinese government significantly devalued its renminbi. It may have to do so again in the near future because of mounting pressure in the region and because of competition from Asian neighbors on the export front. However, because the government's stated long-term goal is to merge the renminbi with the Hong Kong dollar, it is not likely that the Hong Kong dollar will lose its US dollar peg.

Currency depreciation has lowered production costs in various Southeast Asian countries and Korea. So, will China become less competitive for its vital export markets? Currency depreciation will lower export costs in numerous Asia/Pacific countries, but only to the extent that they do not need imported components (most do, though).

This means that short-term competition with China for exports and possible long-term competition for foreign investment will come from Southeast Asian countries and Korea. However, there are even broader issues facing China, including the currencies and economies in neighboring countries, which are highlighted as follows:

- Raising the competitiveness of its faltering domestic companies, especially state-owned enterprises, before entering the World Trade Organization
- Countering the serious slowdown in foreign investments resulting from rising costs of doing business in China
- Maintaining 7 percent to 10 percent GDP growth and raising the rate of domestic consumption to absorb excess capacity and overdependence on exports
- Dealing with a slowdown in Japanese imports of consumer electronics and PCs from Asia/Pacific. China may be hurt most because its currency has not depreciated, and therefore its costs are increasing relative to other countries.
- Responding to the heavy reliance on exports by Korea and other affected countries as they try to pull themselves out of their economic turmoil

The following factors will help China counter these major challenges and maintain relatively strong electronic growth:

A large proportion of Chinese electronics companies are successfully competing against major multinational corporations, particularly in the computer and consumer equipment markets. The priority for the government is to improve efficiencies and quality; therefore, information technology will continue to be rapidly deployed as an infrastructure necessity.

- Although total investment was down in 1997, production capacity of the large multinational corporations and local electronics manufacturers has increased by more than 50 percent. Furthermore, the two main reasons for investing in China remain intact: to develop the long-term potential of the domestic market and to take advantage of an abundant, inexpensive labor force.
- Inflation was the major concern in 1996; now deflation is the top priority of the government. Interest rates are likely to fall to stimulate growth.
- Japanese manufacturers are shipping goods worldwide from China. Exports of electronics to Japan from China represent 10 to 15 percent of China's total electronics exports. Therefore, Japan's slowdown in consumption has a minor effect on Chinese production.
- Korean and other affected Asia/Pacific electronics and semiconductor companies may have an increasing currency advantage for exports relative to China in the short term. However, these companies are being seriously hurt by increasing debt-service costs.

In summary, China/Hong Kong has not been affected significantly by this financial crisis in the short term because of the stable renminbi and Hong Kong dollar, which are backed by about US$200 billion in combined foreign reserves. However, Dataquest has outlined the deflation and investment challenges within China. Most notably, Southeast Asia and Korea are likely to receive increased investment in the future that would otherwise have gone to China (after four years of very high foreign investment levels in China). However, the power of the Chinese market and its production prowess for international markets will continue to attract investment, enabling it to extend its lead as the largest and fastest-growing semiconductor market in Asia/Pacific.

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Dataquest
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Perspectives

Semiconductors Europe

Market Analysis

The Implications of the Asian Financial Crisis on the European Semiconductor Industry

Abstract: *The current financial crisis in Asia/Pacific will have consequences throughout the world. This Market Analysis examines and quantifies the European semiconductor industry's exposure to the events on the other side of the world.*

By Edmund Gemmell

Introduction

Much has been heard about the current financial crisis in South Korea and Southeast Asia in general; however, the implications of the crisis for all sectors of industry are much less clear. Dataquest has been following the events of the past few months and analyzing their implications for the European semiconductor industry, and this *Market Analysis* discusses the possible ramifications for European semiconductor manufacturers.

Where Does the Crisis Stem From?

Simply stated, the crisis stems from the inability of South Korean companies to repay their short-term debts. The expansion that has given South Korea an average annual gross domestic product (GDP) growth rate of 8.6 percent over the past 30 years has been achieved largely on the back of massive, politically-backed short-term borrowings, which were rolled over regularly and renewed by the country's top companies—family-run conglomerates, commonly known as chaebols. Problems have occurred with this short-term borrowing strategy because many of the investments made were long term and not suited to short-term returns. More importantly, the primarily South Korean banks, which in turn borrowed mainly US dollars from Japanese banks, are now unable to continue rolling over the debts and granting extensions. Inevitably, the huge amounts of debt are now due for repayment. There are several factors that have caused this.

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Until mid-1997, several Southeast Asian currencies, including the South Korean won, were pegged to the US dollar. With the growth in the strength of the dollar since mid-1995, caused by the improving performance of the American economy, the won and the other currencies also grew in strength. This growth made Southeast Asian exports more expensive and uncompetitive in a worldwide market that was already showing signs of slowing down and overcapacity because of overinvestment. In an attempt to revive South Korea's failing export-led economy, the dollar pegging was abandoned and the won devalued in order to make South Korean goods cheaper in the world marketplace. This devaluation, however, increased the won value of debts borrowed in foreign currencies, massively increasing the amount of won required by banks and chaebols to repay their debts. In May 1997 the won/dollar rate was approximately \$1:W900. As of January 8, 1998 the rate was \$1:W1,800, meaning that South Korean companies now have to pay twice as much won for their dollar-based debt as they did in May 1997.

The second factor concerns the primarily Japanese banks that, by lending to South Korean banks, financed South Korea's growth. Japanese banks were unable to renegotiate their South Korean debts because of their own liquidity problems. Much of the security upon which Japanese banks based their value was property-based investments; however, in the early 1990s the Japanese property market collapsed, taking with it much of the equity that Japanese banks relied upon. The loss of equity impaired their ability to borrow money on the international money markets, thus, less new money was available to renegotiate South Korean debts. South Korean loans therefore became due for repayment.

The problem is so severe that the South Korean ministry of finance and economy estimates that approximately \$21.5 billion of external debt will be due for repayment in the first three months of 1998. In the first six months of 1998 approximately \$70 billion of external liabilities will be payable—this represents about 70 percent of the nation's total external debt.

Behind these statistics lies a myriad of companies with liabilities unheard of in Western economies. Halla Group, South Korea's twelfth-largest conglomerate declared bankruptcy on December 6, 1997 with a debt-to-equity ratio of almost 20:1 (its debts were 20 times greater than its net worth). Halla Group is not alone, 1996 financial statements by South Korean chaebols reported that of the top 25 chaebols, 22 have debt-to-equity ratios greater than 3:1 and 10 have ratios greater than 5:1. In 1996 the top 25 companies had combined total assets of \$192.0 billion and debts totaling \$149.5 billion.

What Is the Significance of the Crisis for the European Semiconductor Industry?

To consider the answer to this question, South Korea should be reviewed both as a competitor and as a consumer.

South Korea as a Competitor

As explained in *Dataquest Tactical Memories Newsletter* (vol. II, no. 26), much of South Korea's DRAM manufacturing costs are based in won. As the value of the won slides against international currencies, so too do the costs of the South Korean DRAM manufacturers. Given that the won has devalued by 50 percent against the dollar in the past eight months, this "cost holiday" gives South Korean DRAM manufacturers significant opportunity to cut dollar-based prices while maintaining won-based margins. In the short term, this means that in an already deflated DRAM market further price pressure can be brought to bear by South Korean and other Southeast Asian DRAM manufacturers. This will enable them to achieve greater market share and generate much-needed revenue and profit-making dollars while putting pressure on non-Southeast Asian competitors to such an extent that antidumping inquiries, so recently resolved, may be put back on the political agenda.

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Similarly, however, many non-Southeast Asian semiconductor companies have packaging and test plants throughout the Southeast Asia region. Where these companies have fixed and variable costs based in local currencies, marginal savings will be realized because of the depreciation of those local currencies. These savings will provide those non-Southeast Asian semiconductor companies with some extra leeway to respond to competitive pricing from Southeast Asian semiconductor companies.

South Korea as a Consumer

Perhaps of greater significance may be Europe's exposure to the loss of purchasing power in Southeast Asia. In America, Atmel, the nonvolatile memory and ASIC supplier, has announced a fourth-fiscal-quarter charge of $160 million, citing "credit problems with specific Asian customers." While this statement may be open to further scrutiny, it does raise the point that companies may be exposed to risks regarding the occurrence of potential bad debts and future loss of custom as a result of the inability of Southeast Asian OEMs and contract equipment manufacturers (CEMs) to obtain letters of guarantee from their banks, which are essential when they wish to trade on credit.

In 1996 European semiconductor companies achieved sales of $3.4 billion (25 percent of their total revenue) through sales into the Southeast Asian region; the percentage is likely to be similar for 1997. South Korea represents 17 percent of Asia/Pacific's semiconductor consumption. Using this percentage on Europe's revenue total means that South Korea represents approximately $500 million of European semiconductor companies' revenue. Most manufacturing locations within South Korea are owned locally, and this represents a problem for European semiconductor manufacturers. With IMF restrictions in place, South Korean companies will find it very difficult to obtain letters of guarantee. Without these letters their only option is to pay cash for purchases of semiconductors—cash which is twice as expensive to buy as it was eight months ago, and which may prove very difficult to obtain. This potentially puts at risk a substantial proportion of the $500 million revenue realized by European semiconductor companies, both in the current and future financial years, because of a loss of South Korean purchasing power.

Other Southeast Asian Countries

Within the rest of the Southeast Asian region the situation is varied. The Philippines, Thailand, Indonesia and Malaysia all have problems similar to South Korea, and all have experienced IMF intervention in their economies to some degree. In total, the four countries have received more than $30 billion in IMF-led relief. The constrictions associated with IMF intervention and the currency crises being experienced in these countries will affect indigenous producers in these countries as they have affected South Korean manufacturers. A significant proportion of OEMs and CEMs in these countries are, however, non-Southeast Asia-based. These companies will therefore experience a cost holiday, which may encourage them to ramp up production while costs are low. Therefore, the position of semiconductor demand in these countries is unclear. Any potential loss of demand from indigenous manufacturers because of loss in purchasing power may well be countered by increasing demand from nonindigenous manufacturers benefiting from cost holidays.

Taiwan, Singapore and China/Hong Kong are in a significantly different position to the four countries discussed above, as their economies are financially more advanced. External debts within these countries are minimal in comparison to those of the above countries and government reserves are more than adequate to cover these debts and protect the currency when necessary, although Hong Kong is coming under increasing pressure. With the exception of a general loss of confidence because of their geographical proximity, these countries have been much less severely affected, although all have experienced weakening of their currencies and stock markets.

The Potential Effects of Lost GDP

In December 1997 the OECD projected that the Asian financial crisis would reduce the GDPs of Asia/Pacific countries, including Japan, by 1.4 percent in 1998, and that the knock-on effect would reduce the GDPs of Europe and the United States by 0.4 percent. Dataquest estimates that approximately 4.5 percent of GDP is spent each year on consumption of electronic equipment in Southeast Asia. We estimate that in Japan the percentage is approximately 3.0 percent. Given a 1.4 percent reduction in GDP across the Asia/Pacific region this would lead to a fall in electronics equipment consumption of $2.5 billion. This would equate to semiconductor revenue of approximately $500 million. In terms of European revenue, given Europe's current market share of the worldwide total available market, this would mean lost revenue of approximately $50 million. However, since the OECD made its December forecast, much has come to light which would indicate a worsening situation. For each additional 1 percent fall in Asia/Pacific GDP, worldwide semiconductor revenue would fall by approximately $360 million, equating to European revenue of roughly $36 million.

A major assumption in this calculation is that with decreasing GDP, the marginal propensity to consume would also decrease at a uniform rate. In reality, however, the loss of confidence in the market and consumers' worry over job security and desire to save would almost certainly make the marginal propensity to consume decrease at a faster rate than the reducing GDP. Thus, electronics equipment consumption would fall more sharply leading to a larger fall in semiconductor revenues. In addition, for each 0.5 percent fall in the rest of the world's GDP, $600 million would be lost from worldwide semiconductor revenue, equating to approximately $60 million of European semiconductor revenue.

A secondary issue that arises from the current crisis is the effect on European inward investment. Already, all three major South Korean DRAM manufacturers have announced reduced capital investment levels for 1998. Most notably, Hyundai has announced a delay in the facilitation of its new fabrication plant in Dunfermline, Scotland. However, reduced inward investment may be apparent from other sources.

Asia represents 44 percent of Japan's export market. Already faced with a troubled economy at home, reduced consumer demand from Southeast Asia will represent a further major headache for Japanese conglomerates. It will also make a Japanese recession that much more likely in 1998. Consequently, any new major investment from Japan into Europe carries increased risk of delay or cancellation.

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Dataquest Perspective

While it can be seen from some of the figures shown in this *Market Analysis* that the current financial turmoil in Southeast Asia has the capacity to impact the revenues of European semiconductor companies, it cannot be overstated that the current situation is far from clear and has some time to go before the full facts are known.

For several years, semiconductor manufacturing capacity, and indeed manufacturing capacity in general, throughout the world has been growing faster than demand. The crisis in the Asia/Pacific region can be interpreted as a shaking-out of the market to bring supply and demand back into equilibrium. Those firms with sound financial footing and successful product lines will flourish as competition becomes less intensive in the medium term. Those with a less sound financial footing may be the losers of this shakeout; it is very unlikely that any European firms would fall into this category. A danger does exist though that Asia/Pacific-owned manufacturing locations in Europe may suffer.

Of more immediate interest to the European semiconductor industry is quantifying the potential for losses of revenue. As we have shown, although exposure does exist in actual dollar terms, it is relatively small when compared to overall revenue. The OECD's forecast for falling GDPs would lead to a loss of revenue for European semiconductor firms of slightly more than 0.5 percent of 1996's total revenue, which is significantly less than disastrous.

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Perspectives

Semiconductors Europe

Market Analysis

x86 Processor Review 1997—All Change, But No Change

Abstract: *The year 1997 saw great technological development in the x86 processor market. Competitive x86 devices were introduced and Intel's position came under serious challenge. This Market Analysis examines the companies, products and market involved and previews the possibilities for 1998.*

By Joe D'Elia

The Year

The past twelve months have seen many developments in the x86 processor arena, exciting new products launched, some players retired from the ring, a new player made its entrance, another was taken over, but at the end of the day, the net effect was minimal. The industry still consists of one giant with a handful of dwarfs nibbling at its ankles, hoping that by so doing they will topple the giant. In this they have not succeeded, although they have forced the giant to recognize that they exist and can be a nuisance. In this report we will examine the companies, their products and the status of the x86 compute microprocessor market as it enters 1998.

The Companies

There were two exits from the x86 compute processor arena in 1997: Texas Instruments and SGS-Thomson Microelectronics (STM) both called it a day. The reality was that both were or had been dependent on Cyrix for their technology and, owing to contract reasons or an inability to successfully transfer technology respectively, both had been excluded from the first-generation Pentium clone market and therefore their exit from the standard x86 market was inevitable. However, we should not count STM totally out of the fray, as in May 1997 it purchased a majority stake in Metaflow Technologies Inc., based in San Diego, California, a design group working on next-generation x86 devices. A further indication of STM's future direction can be gained from the company's launch in June 1997 of a high-integration multimedia PC on a single chip, known as the ST PC Consumer. While the company has not announced any major design wins for this product, its existence, plus the general STM strategy of focusing on high-volume differentiated products and other developments by the company in the key area of multimedia, would indicate that we should expect further announcements in early 1998 in the consumer PC/compute appliance arena.

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In November National Semiconductor Corporation (NSC) completed its purchase of Cyrix and together they also appear to be heading down the high-integration consumer PC/compute appliance path. All announcements subsequent to the takeover focused on the sub-$1,000 and sub-$500 highly integrated PC segments and the company's desire not to compete directly with Intel. The fusion of NSC's proven Super I/O, networking, communications and analog skills with Cyrix's CPU cores, plus the multimedia expertise that NSC has been quietly accumulating over the past 15 months though acquisition of small focused start-ups, makes for a very powerful combination.

NSC's purchase of Cyrix does not bode well for IBM, Cyrix's sole remaining production fab and partner prior to the takeover. Current contracts run until late 1998 and early 1999, but there is no obligation to continue beyond these dates, and with NSC ramping up its 0.25-micron fab in Portland, Maine and therefore able to provide Cyrix with sufficient capacity, there is no expectation that the IBM contract will be renewed. This leaves IBM with the problem of deciding what to do in 1999 if it wants to remain in the x86 market. Dataquest expects that IBM will exit the market as the x86 has always seemed an opportunistic play by the vendor, with the minimum of engineering resource invested in turning Cyrix devices into products worthy of the IBM brand. The salesforce of IBM has been somewhat more enthusiastic about the product and has consistently been more aggressive in its pursuit of orders than Cyrix's own salesforce, another reason for Cyrix/NSC not to renew the contract. With its captive design center having been ensnared by NSC, it would require considerable investment by IBM to continue in the x86 market past the current generation of devices. This we do not believe will be forthcoming, unless IBM can find another partner to take the Cyrix role, as IBM is focusing away from commodity products, even high-technology commodities like DRAMs and x86 processors, into ASICs, ASSPs and embedded PowerPC, which are more profitable.

The surprise of 1997 was the entry of Integrated Device Technology (IDT), though its Centaur Technology subsidiary, into the x86 market. While this has had no perceptible impact on the market yet, owing to the product needing to be quickly upgraded and therefore not shipping, the company should show results in 1998. Its low-key strategy of leveraging the channel infrastructure put in place by existing players to service tier-2 and tier-3 accounts will no doubt result in meaningful sales in 1998.

AMD has cause simultaneously to celebrate and to regret the events of 1997. On the celebration front, the new infrastructure that the company had put together in 1996, spinning off the x86 organization into a separate, focused division with different channels to the normal semiconductor products, began to pay off. The company finally launched a product—the K6—that was on a performance par with Intel's latest mass market offerings and was in demand by many companies, including several significant international players. Life seemed good. However, the regret is that AMD failed to execute and could not deliver the volume of products that the market demanded in the mix that it wanted, and so the company exited 1997 leaving a bad taste in the mouths of a lot of smaller PC vendors. AMD did not get the speed distribution that it expected from its 0.35-micron process and the switch to 0.25 micron proved more difficult than expected. The company focused on servicing key accounts in major regions and "cut loose" the small nonstrategic local assemblers that play the x86 market on an opportunistic basis. Therefore, AMD should not suffer in the long term from its inability to execute in 1997.

Having discussed the dwarfs, we come to the giant: Intel, the largest semiconductor vendor in the world, with the bulk of its sales geared to x86 processors. Intel exited 1997 having lost some market share in the x86 market, which was expected, as 1996 was an exceptional year in which it had total domination of the market.

It is useful at this point to restate the 1996 figures and compare them with Dataquest's latest forecast for 1997. In 1996 the worldwide compute x86 revenue was $15.4 billion, of which Intel accounted for $14.7 billion or a 95 percent market share; in 1997 Dataquest expects the worldwide figure to be $20.6 billion, with Intel accounting for $18.4 billion or 89 percent. Therefore Intel lost six percentage points to AMD, Cyrix and IBM combined, dropping the company's share below the 1995 figure of 91 percent.

From a unit perspective, the competition has always had a larger share of the market; 16 percent in 1996 and a forecast 18 percent in 1997. This small increase in unit market share is good news for Intel's competitors as it shows that they have managed to raise their average selling prices (ASPs) and therefore gained more revenue for each unit shipped.

One of the consequences of the improved market share of the "alternative" x86 manufacturers ("clone" no longer being an appropriate term to describe their products) is the boom in the sub-$1,000 PC market, especially in the United States. With its strategy of constantly pushing the performance envelope upwards, this unexpected development has left Intel without a product specifically targeted at this segment, an omission that the other vendors have been quick to exploit. This development, together with others that result in further fragmentation of the PC market, has caused Intel to rethink its product strategy for 1998.

The Products

The first half of 1997 saw all players introduce new sixth-generation products which will be at the core of most PCs built in 1998 and 1999. We will review each manufacturer's introductions and the update to product strategy that each provided at the 1997 Microprocessor Forum in October.

AMD Benefits from Nexgen Purchase

In March AMD launched the first fruits of its Nexgen purchase, the K6, officially known as the AMD-K6. Introductory speeds on a 0.35-micron process were 166 MHz, 200 MHz and 233 MHz; benchmarks quickly showed that the product was speedier than Intel's Pentium and Pentium MMX products at the same clock speeds. AMD also entered into an agreement with Via Technology to codevelop chipsets that would provide optimum support for the K6 and, as the year developed, these efforts resulted in support of the K6 by all leading BIOS companies and saw most third-party motherboard vendors offering K6-compatible products. Late 1997 saw AMD quietly announcing a 266-MHz product with the promise of 300 MHz in the new year, this being the first result of the K6's migration to 0.25 micron.

At the Microprocessor Forum, AMD launched its plans for 1998, revealing that in early 1998 the company would ship the K6 3D, an improved device fabricated on its 0.25-micron process. As well as a 300-MHz introductory clock speed, the device would benefit from two major refinements. Firstly, the system bus would be increased to 100 MHz, thereby giving improved L2 cache and main memory performance. Secondly, and more radically, the device would have its MMX performance improved by the addition of a second MMX execution unit and the introduction of MMX-like floating point instructions called AMD-3D which will be incompatible with any other manufacturer's MMX instructions. The new instructions will facilitate improved 3D graphics performance as a result of faster execution of 3D geometry and lighting algorithms.

Late in 1998 AMD will improve K6 performance yet again with the introduction of the K6+ 3D, which will add onboard L2 cache running at processor core speed to the package announced in the first quarter. All these improvements are geared to prolonging the life of Socket 7 and are given the generic title of

Super 7 by AMD. With these improvements onboard, the K6 should have a useful life into 1999, when AMD will launch the K7, which should finally give it a product to go head-to-head with the slot-based Pentium II products.

Hot from Cyrix—Cayenne

Early in the first quarter of 1997, Cyrix revealed MediaGX, a highly integrated device that combined its 5x86 core with a graphics accelerator, a memory controller and a PCI interface onboard. This product, together with the Cx5510 companion device—which provides an ISA interface and a sound codec—and some external DRAM is all that is needed to implement a low-cost PC. At the MediaGX launch Cyrix was also able to announce that Compaq was utilizing the device in the Presario 2100, the first of the big-name vendor sub-$1,000 machines that were to prove so popular in 1997.

It was not until late second quarter that Cyrix finally launched the M2 as the 6x86 MX. Like the previous 6x86, Cyrix did not stick to the same clock speed and bus speed as Intel products; therefore there is again the confusion of having to compare actual clock speeds with PR (Pentium-equivalent clock speed) ratings. As in the previous generation, this also meant that Cyrix products were not directly supported by Intel chipsets, which are only guaranteed to 66-MHz bus speed, while Cyrix parts run with an external bus of 75 MHz. However, this time there were third-party chipsets available designed to run at the higher speeds, and therefore the initial adoption rate of the M2 has been higher than that of the M1.

The M2 was introduced at PR166-, PR200- and PR233-equivalent performance ratings, and Cyrix's path is to migrate the device from the current 0.35-micron process to a 0.30-micron process, which will result in an increase in bus speed to 83 MHz, enabling a PR266-equivalent performance device in the first quarter of 1998. This will be followed by a further migration to a 0.25-micron process in the middle of 1998 that will give a PR300-equivalent performance rating.

Late July 1997 saw the announcement of Cyrix's intended merger with National Semiconductor, and releases since have focused on high integration. At the Microprocessor Forum, Cyrix announced the Cayenne core that was to be at the heart of its future products. Products utilizing Cayenne are expected in the third quarter of 1998, however very little has been released regarding specific implementations, so the core itself must be examined to see what kind of devices are possible. The core will be based on a 0.25-micron process and will be very similar to the M2, but will feature a 100-MHz bus and a new floating point unit to address the M2's weakness in this area. MMX performance will also be addressed with a higher-performance MMX unit which will also feature MMXFP, Cyrix's proprietary enhancements to the MMX instruction set.

The first product that Cyrix has previewed using the Cayenne core is the MXi, the next device in the product path started by the MediaGX. The MXi incorporates the Cayenne core, an AGP-compliant memory controller, enhanced 2D/3D/DVD-capable graphics engine and PCI interface. Used in conjunction with external DRAM and a "south bridge" chip that handles ISA interface, graphics RAMDAC and audio codec, this device should give performance equivalent to 300-MHz and 400-MHz Pentium II devices.

Beyond Cayenne, there are whispers of Jalapeno, which is the code name for what was previously the M3. Little is known of this and what National Semiconductor intends to do at this level of performance or how it would fit into a high-integration product strategy.

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IDT/Centaur Technology, a Surprise Contender

May 1997 saw the introduction of the C6 from Centaur Technology, a subsidiary of IDT specifically set up to address the Intel-compatible x86 compute processor market. The C6 device was developed in great secrecy by a team led by Glenn Henry, an industry veteran, who had set out to prove that by going back to basic RISC concepts it was possible to design an x86-compatible device that was much simpler, and therefore smaller and cheaper than those currently on offer. This was achieved with the C6, which offered Pentium MMX-like performance at the initially offered speeds of 180 MHz and 200 MHz.

While IDT has considerable microprocessor experience in the MIPS-embedded market, it has never been a player in the mainstream PC arena and therefore the company has had to evolve a strategy that enables it to leverage the existing channel infrastructure in place to serve tier-2 and tier-3 customers. This results in IDT having to make a minimal investment in developing its own channels specifically aimed at the PC market and gives its channel partners another product line they can offer to the assembler community.

At the Microprocessor Forum, IDT announced a renaming of the product to the Winchip C6, as well as the introduction of 225-MHz and 240-MHz offerings. More importantly, the company outlined its plans to develop the Winchip C6+. Like all manufacturers to date, this involves ultimately migrating to a 0.25-micron process, a faster system bus, an improving of MMX performance by proprietary extensions to the instruction set, and an improved floating point unit. Like AMD's K6+ the new fully developed device will also have the option of 256KB of onboard L2 cache running at core speed, which will be 300 MHz at introduction. Versions of the C6+ without onboard cache and fabricated on a 0.28-micron process will be offered at incremental clock speeds throughout the year, with the first 266-MHz devices due late first half 1998.

IDT has modest plans for its products, hoping to gain 1 percent to 2 percent market share, a goal that would add $250 million to $500 million revenue in 1998. For a company that is currently in the $600 million range, this is a considerable gain.

Intel, Active on all Fronts

Finally we come to Intel, whose 1997 was extremely busy with several major product family introductions and a market that again had choice, forcing an accelerated ride down the price curve. February saw the launch of the 166-MHz and 200-MHz Pentium MMX (originally P55C), incorporating the first major additions to the x86 instruction set since it became 32 bit in 1986. MMX instructions are geared to dealing with data types used in media-rich applications and will result in increased performance and therefore higher-quality graphics and audio.

Unlike previous introductions, the mobile version of Pentium MMX was launched at the same performance level as the desktop devices, and a few weeks later a new mobile module was unveiled that enabled portable PC manufacturers to upgrade their product lines easily. This module incorporates an MMX processor, a "north bridge" chip, L2 cache and power management circuitry on a small daughtercard that plugs into a motherboard. Keeping all speed-related products on the one daughterboard will enable mobile PC vendors to have common units that can be upgraded merely by plugging in the latest version of the module, allowing the latest processors to be brought to market very quickly.

The highlight of Intel's product launches was in May, when the company introduced the Pentium II (originally Klamath). The second generation of the Pentium Pro family, this added MMX to that family, as well as reduced production costs by using a daughterboard concept, enabling Intel to utilize off-the-shelf L2 cache rather than custom devices, as had previously been used in the Pentium Pro. The Pentium Pro had introduced the concept of a separate bus for the L2 cache that was available only to the processor. In the Pentium Pro, this was achieved by using a multichip package with the special L2 die placed in the same cavity as the processor, running at processor speed. This was an expensive solution, owing to the cost of the package and the custom L2 SRAM die.

With Pentium II, Intel kept the separate L2 bus, but ran it at half processor speed, enabling the use of merchant-market SRAM devices and conventional packaging for the processor itself. As introduced, the Pentium II consists of a printed circuit board on which the processor, four SRAM devices and a cache tag device are mounted. The board is then packaged in a plastic shell which has thermal management features and is connected to the motherboard via an edge connector. It is with this connector, called Slot 1, and the associated Pentium Pro bus, that Intel has split from all other x86 vendors and placed the industry in a major quandary. Intel claims that to achieve scalable speed improvements the old packaging concepts were running out of bandwidth and it would be difficult to achieve the tight interconnect necessary on a commercial motherboard. Intel has therefore decided that putting all the relevant elements on a daughterboard in a controlled environment was the only guaranteed way that it could give all customers the performance increases expected over the next few years.

Intel's competition respond that this solution is just a method of locking customers into Intel, as the Pentium Pro bus and the Single Edge Cartridge (SEC), as the daughterboard is known, are protected by patents and copyright. The competition also argues that scalable performance can be achieved through higher integration, such as that seen on the K6+ and C6+, and faster buses. Whatever the rights and wrongs of either argument, the split between slot-based devices and the established Socket 7- and Socket 8-based products has divided the industry.

A shortcoming of the Pentium II that was not addressed by its 233-MHz, 266-MHz and 300-MHz introductory speeds and its 512KB onboard L2 cache was an inability to have more than two devices in a multiprocessor system. This meant that in August Intel had to launch a version of the 200-MHz Pentium Pro with a 1MB onboard L2 cache to keep its SMP server customers happy until the launch of Deschutes in 1998.

In September Intel launched the latest of the Pentium MMX chips when it announced the 200-MHz and 233-MHz mobile Pentium MMXs based on the Tillamook die. The significance of this is that these are the first production 0.25-micron products from Intel and (as well as their mobile role) will allow desktop Pentiums to go to 266 MHz and above if deemed necessary.

Microprocessor Forum saw the true highlight of Intel's year when it and Hewlett-Packard, its long-standing partner in the project, finally started the Merced "striptease." Merced is the first product in what Intel and Hewlett-Packard are now calling EPIC (Explicitly Parallel Instruction Computing) technology, the basis for the new 64-bit instruction set architecture (IA-64) which will provide the platform for mainstream computing in the next decade.

As Merced is not due until 1999 and IA-64 will not impact mainstream PCs until the new decade, we will not go into any detail, but look at what we can expect from Intel in 1998. Starting in the first quarter, Intel is expected to launch Deschutes, a 0.25-micron Pentium II family that will address both the high-end workstation and server markets and will allow Pentium II performance to be utilized in portables for the first time. During the year we will see four main iterations of Deschutes, a Slot 1-based product to address the mainstream desktop, a Slot 2-based device to address multiway SMP servers and workstations and two differently packaged versions for the portable market to address the competencies of different vendors. By the end of 1998, products at the top end will be running at 450 MHz with a 100-MHz bus, at least bringing Intel in line with the competition on this one point.

Beyond Deschutes are Katmai and Willamette, which will expand the Pentium II envelope further and keep the flame of IA-32-based computing going well into the next decade. These are targeted for 1999 release, so we will not speculate on what little is known about them at this time.

Intel wants to exit 1998 with slot- or mobile module-based Pentium II products dominating every market sector. To do this, the vendor will have to launch products to address the burgeoning sub-$1,000 PC sector. Although Intel has not discussed these products openly, Dataquest believes that such devices exist in the line-up for 1998, and that, even further from public sight, Intel is working on high-integration, not slot-compatible, devices that will address the sub-$500 compute appliance markets. If they are not developing these devices, some of the initiatives that the company launched in 1997 into automotive, WebTV, lean clients and other areas do not make any sense.

As well as the above major processor launches, Intel launched several new chipsets and many platform initiatives geared to maintaining its dominance of the PC market. Despite all this activity the single event that most people will remember about Intel in 1997 was that it was sued by Digital Equipment Corporation. Interestingly, unlike many past litigation sagas in which Intel was involved, this one was resolved (assuming that US government approval is forthcoming) in a matter of months and outside the courts. Unlike previous litigation, both companies came out of this surprisingly well, with both having gained something they wanted. Readers are referred to other Dataquest documents that cover the settlement in depth.

The Marketplace

Figure 1 shows that Dataquest expects the worldwide x86 market to grow from $15.4 billion in 1996 to $44.2 billion in 2002, a CAGR of 16 percent over the forecast period from 1997 to 2002. Intel's percentage share of that revenue will fall from 95 percent in 1996 to 82 percent in 2002; this reflects an actual revenue of $14.7 billion in 1996 growing to $36.4 billion in 2002 and a CAGR of 15 percent over the period 1997 to 2002.

Non-Intel revenue will rise from $0.7 billion in 1996 to $7.8 billion in 2002, with a CAGR of 28 percent from 1997 to 2002. The highest growth for competing products occurred in the jump from 1996 to 1997, when they grew 210 percent, increasing their share from 5 percent to 11 percent. In subsequent years the growth will be less spectacular but will result in a steady attrition of Intel's market share.

Figure 2 shows the forecast relating to worldwide unit shipments and, as previously mentioned, the competition has a higher market share when viewed from a shipment perspective. Over the period 1996 to 2002, shipments are expected to grow from 77.6 million units to 188.1 million units, a CAGR of 16 percent from 1997 to 2002.

Intel shipments are expected to grow at a CAGR of 11 percent, resulting in 126.0 million units shipments in 2002, while the competition will grow substantially faster with a CAGR of 30 percent over the same period, resulting in unit shipments of 62.1 million in 2002.

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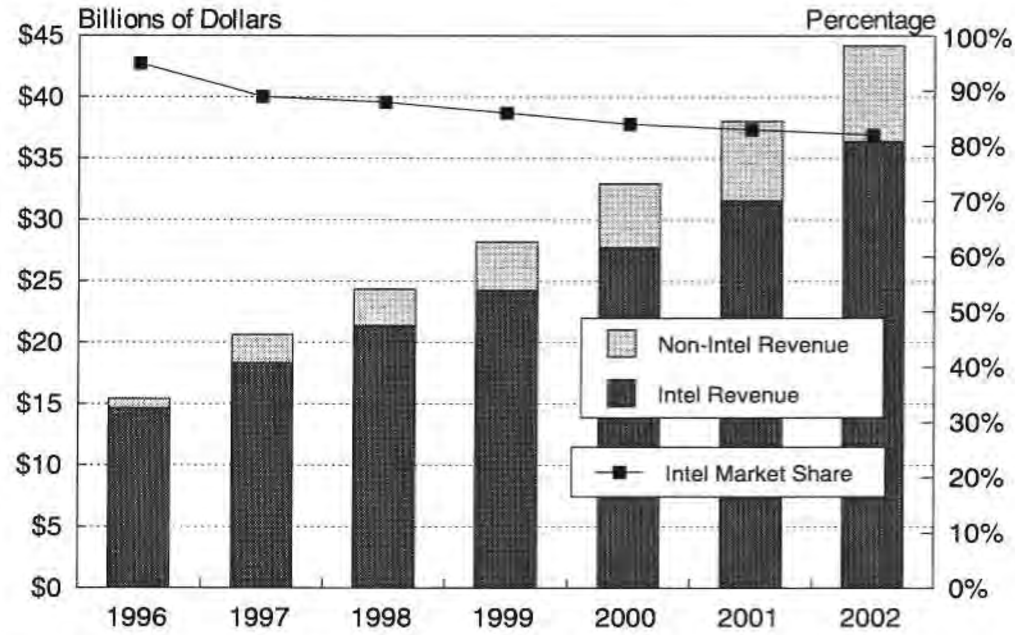
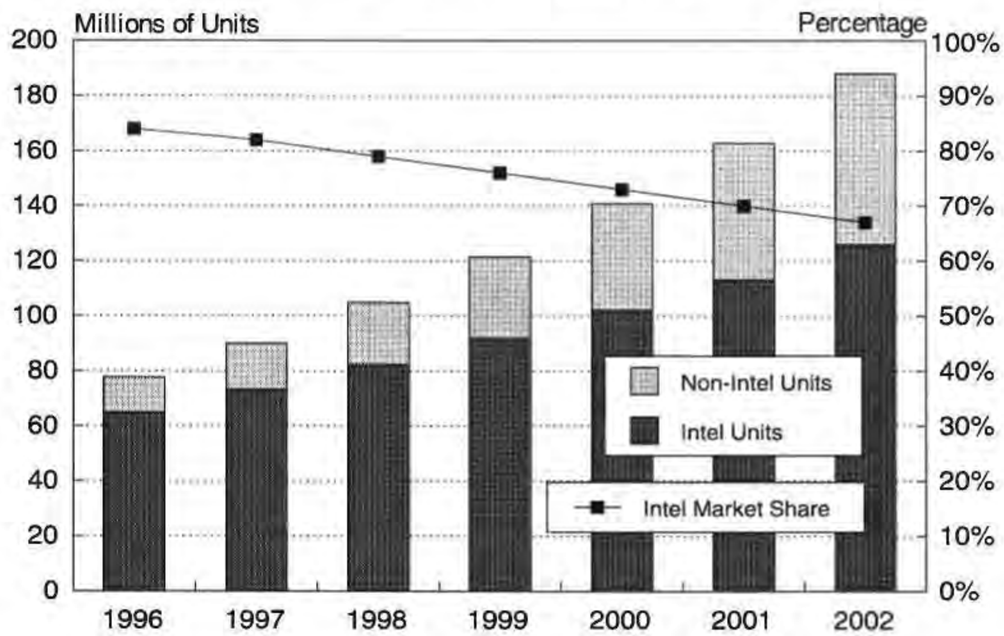
Figure 1
Worldwide x86 Processor Revenue, 1996-2002



Source: Dataquest (January 1998 Estimates)

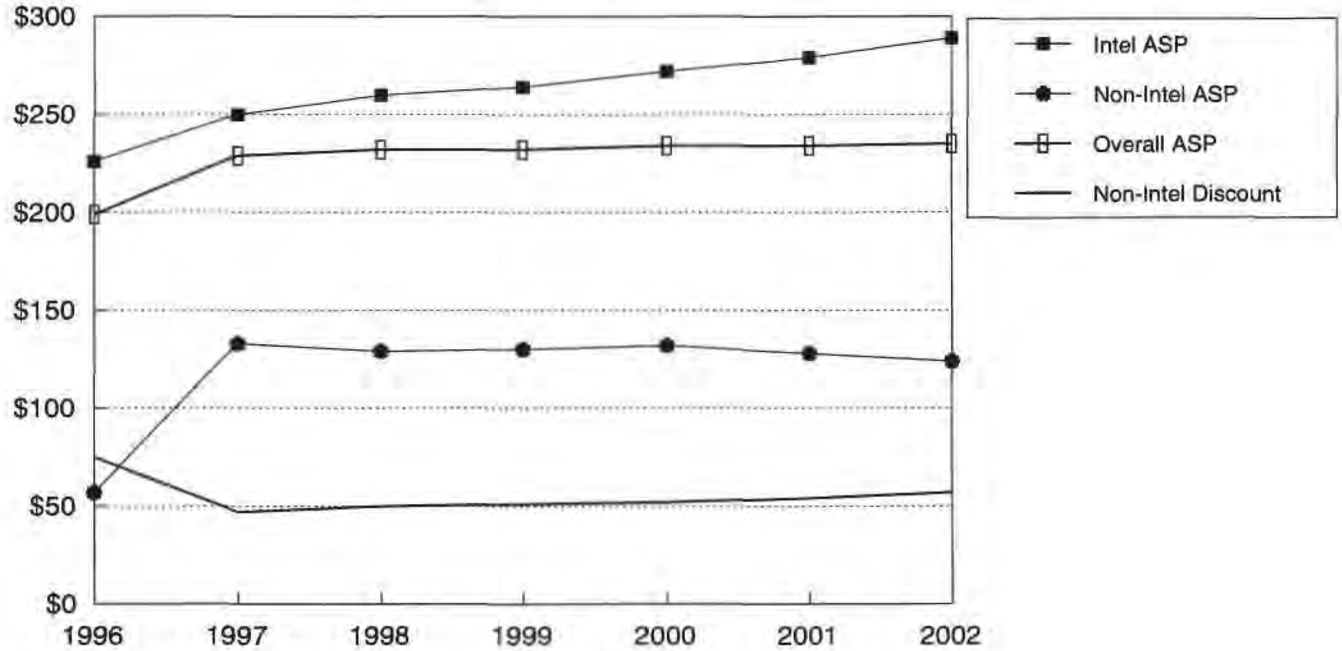
Figure 2
Worldwide x86 Processor Shipments, 1996-2002



Source: Dataquest (January 1998 Estimates)

Faster unit shipment growth for Intel's competition will result in the competition's ASP eroding over the forecast period and the non-Intel discount—or Intel premium—increasing after a temporary drop in 1997. This is shown in Figure 3, which also shows the ASP for Intel rising over the period, resulting in an essentially flat overall ASP from 1997 to 2002.

Figure 3
Worldwide x86 Processor Average Selling Prices, 1996-2002



Source: Dataquest (January 1998 Estimates)

Over the next five years we will see some generational changes as Intel and the other players introduce new products to keep the performance envelope expanding. The year 1997 saw the last vestiges of fourth-generation products, as residual traces of 486 devices were flushed from the market. More importantly, it saw the start of the transition from fifth-generation (that is, Pentium, Pentium MMX, Cyrix M1 and AMD K5) to sixth-generation products such as Pentium II, Cyrix M2 and AMD K6. The year 1998 will be dominated by these sixth-generation products and by the end of 1998 there should be no fifth-generation products in volume production.

In 1998, Dataquest expects to see a much wider spectrum of sixth-generation products, as both Intel and the competition introduce improved members of their current families. How well the competition does will be determined by how well it succeeds in prolonging the life of Socket 7 and the growth of the sub-$1,000 PC segment.

Dataquest Perspective

From an analyst's perspective, this was an exciting market to cover in 1997, with the prospect of 1998 being even more so. Apart from the new products, the real issue is whether the PC industry is so enamored of processor choice that it will support the infrastructure needed to keep two package architectures viable. Will slot-based technology drive all vestiges of Socket 7 from the market or will the Super 7 initiative from AMD and the programs from other vendors keep Socket 7 viable?

The key to this question will be whether Intel's competitors can subdue their egos and work collectively toward a single alternative solution. Fragmentation is already evident in the various announcements made for 1998, as all three camps announce proprietary MMX extensions and claiming extensive support for their particular "flavor." Unfortunately history is not on the side of the competitors; when Intel announces its MMX extensions (MMX2) the industry will swing to those, and all other contenders will vanish unless they have been able to establish a strong single alternative with a reasonable share of the market.

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The three are supposed to be secretly talking about this kind of rationalization, however it is going to take some strong ego-suppression to get them all to agree on a common position. For their own good and for the good of the industry, we hope that some humility and common sense can come into play at these discussions.

Looking further ahead, and accepting the inevitability of Intel establishing slot-based products as the dominant products on the market, the next area that Intel's competitors need to address is a common slot-based alternative that launches with the Jalapeno and K7 generation. AMD has stated that it will have an SEC product based on a bus similar to that employed by Digital's 21264 device. Cyrix and IDT are keeping quiet but must be reviewing their options. A common solution is a must: the various chipset manufacturers, BIOS writers and motherboard manufacturers can support two different infrastructures—Intel and one other, if the other is of a viable size. With three alternatives to Intel, two will not survive. Assuming that common sense prevails, in 1998 the dwarfs should grow in stature such that they can start attacking the giant at knee height, and so having a better chance of toppling him over in the future!

Intel will have to address the sub-$1,000 PC issue and has two alternatives: extend the life of Socket 7 Pentium MMX devices as a low-cost entry vehicle or introduce cost-reduced slot-based Pentium II devices. Dataquest believes the latter is more likely, as extending the life of Socket 7 devices will legitimize its competitors' efforts to sustain that market, and Intel is not renowned for knowingly helping the competition.

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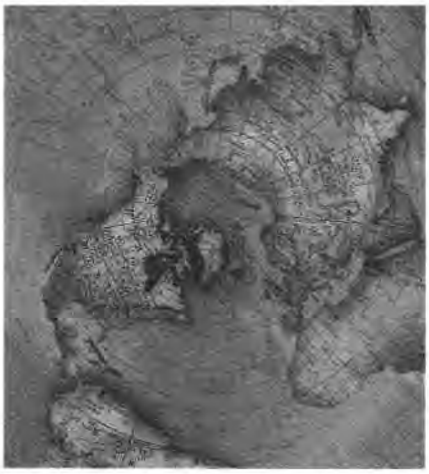
Market Trends



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An Introduction to Dataquest's European Semiconductor Group, 1998

Guides

1998

Program: Semiconductors—Top Views
Product Code: SCND-EU-GU-9801
Publication Date: March 4, 1998
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An Introduction to Dataquest's European Semiconductor Group, 1998

Introduction

The aim of this *Guide* is to help you, our client, to get the most from your Dataquest research program by explaining the best way to work with our analysts. This document covers the following:

- The role of our analysts, and what you should expect from them
- Who the analysts are, their specialist subject areas and how to contact them
- The scope of research undertaken by Dataquest's European Semiconductor group

Analyst Charter

Analysts in the European Semiconductor group have two roles. Firstly, they are responsible for conducting research into every aspect of the European semiconductor market, the European semiconductor industry and European-headquartered semiconductor manufacturers. Secondly, they are responsible for providing a local (same time zone) contact point for subscribers to any of Dataquest's 25 or more worldwide semiconductor-related research programs. These roles are equally important.

When providing support to clients based in Europe who subscribe to non-European research programs, our analysts will do their best to answer your inquiry, but it is likely that they will have to refer the question to our experts at other research locations—either Dataquest's worldwide research headquarters in San Jose, California, United States or our regional headquarters in Tokyo, Japan or Seoul, South Korea (our Asia/Pacific headquarters). In no way does this process preclude you from making direct contact with analysts in any of Dataquest's research sites around the world; our European staff are simply there to provide support if you prefer to deal with a local contact.

The Analysts

We recruit our analysts because they possess certain skills. Generally we recruit staff from either an engineering or a marketing background in the semiconductor industry. A review of our biographies on pages 8 to 13 of this *Guide* reflects this preference.

The role of the analyst in the account relationship is to ensure that your company receives the information it requires in a timely manner. After you have subscribed to a research program, our team of analysts becomes the primary link between your company and Dataquest. The analyst team is responsible for the following:

- Communicating the scope and subject areas covered by Dataquest's semiconductor service
- Responding to your inquiries in a timely manner
- Proactively seeking the participation of your firm in research studies that might be of particular interest to your organization
- Alerting you, either personally or through *Dataquest Alerts,* to industry developments that might impact your strategy or your markets
- Soliciting your company's suggestions on new areas for research
- Responding to questions your company might have about using Dataquest's semiconductor service

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You will elicit the quickest response to your inquiry by directing it to the analyst who specializes in the area that concerns you. However, occasionally it may not be clear who the right analyst is, or indeed the specialist may not be available. In this case please feel free to contact any member of the group.

Client Contact

On the other side of the equation, we need to know how you want to work with us, and who in your organization will be the users of our service. It is important for us to know who you have authorized to use the inquiry hours you have purchased from Dataquest.

From an administrative point of view, the working arrangement is fairly straightforward. One individual in your company—usually the person responsible for, and decided at the time of, signing the agreement for your Dataquest subscription—is designated the "binderholder," and is our point of contact for issues regarding billing, shipping, renewal and so on.

However, from an operational viewpoint, clients prefer a variety of working arrangements, particularly with regard to the use of the inquiry service. Some companies prefer to funnel all inquiries through an individual they hold responsible for managing the overall usage level; other companies nominate several individuals to use the service at will. It is very helpful for us to understand how you want the relationship to work—once we do, we will be in a much better position to both deliver the service effectively and support your objectives.

Inquiry Service

The value of the information and analysis we publish in our documents becomes evident to you only when it finds a practical application in your company's market intelligence and business planning activities. In many instances you will have specific questions about markets, competitors' offerings or the business environment that can be addressed directly through the use of the material we have published. However, you may require further insight into our data, analysis and conclusions, and this is when our inquiry service can maximize the value of your investment. You will receive a specified number of hours of consultative inquiry support as part of your contract with Dataquest, giving you ongoing access to Dataquest's European Semiconductor group over the 12 months of your program subscription.

What Is an Inquiry?

For many clients, our inquiry service is the most valuable element of their Dataquest subscription. Most use this service frequently, and with a high level of satisfaction. By understanding the inquiry process, we believe that you will be better able to use this service effectively.

We define an inquiry as a question or questions that fall(s) within the scope of the published research you receive as part of your research program subscription, and that can be answered by our analysts in less than two hours of dedicated research time.

We want the process to appear simple and transparent to you whenever you call us. We have carefully constructed our inquiry support process to ensure a swift and thorough response, and have structured our senior staff to be readily available to address those inquiries that require a higher-level response. The bottom line is that we work very hard at providing the best possible inquiry support to you, and we continually look for ways to be more efficient and helpful.

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Before Calling with an Inquiry

Our ability to meet your information needs is only as good as your ability to formulate your requests to our industry analysts. Therefore, please keep the following guidelines in mind:

Formulate your inquiry questions carefully—It is especially important to think through carefully each inquiry request and to give us as much background information as possible so that we fully understand your needs. What should you do if you are not quite sure what questions to ask or what information you need? Call an analyst. Our extensive experience of working with clients will help you to formulate your market research requirements properly.

Please limit "rush" inquiries—Try to anticipate your information needs so that you can give us enough time to respond to your inquiries. No-one can prevent the last-minute question that comes up just as you are entering a meeting, but the likelihood of us being able to give you the information you need in a crunch is far less than when we are given more time to access all of our sources.

Try to avoid multiple inquiries—Clients generally are allowed one active inquiry per program subscription at any time. If you must make more than one inquiry at a time, our analysts will work with you to prioritize your active inquiries.

Sensitive information gathering—When structuring an inquiry, please keep in mind that we are able to provide responses based only on information that is in the public domain. If you are asking for a type of more sensitive information which your company would not be willing to disclose, it is unlikely that we would be able to obtain similar information from your competitors.

Industry analysts are more than "data diggers"—Our analysts should be seen as consultants on call. They can give you valuable feedback as you refine your service marketing strategies, programs and policies.

How to Place an Inquiry

There are three means of communicating your inquiries to your assigned analyst/account manager, namely telephone, fax and e-mail. In most cases the appointed analyst will acknowledge receipt of your inquiry, in one form or another, to inform you that your request has been received. However, it is advisable that you follow up with a telephone call to the analyst after logging your inquiry to check that it has been received.

When Will You Receive an Answer to Your Inquiry?

Most inquiries are answered within five working days, but please remember that this is an average. An analyst will discuss with you a reasonable expectation for answers and will call to let you know if an inquiry will require more time to complete.

How Will Answers Be Communicated to You?

Dataquest will respond to your inquiries in the most effective means possible, which may include the telephone, fax, e-mail, or a regular or express mail service.

Inquiry Management Systems and Databases

All Dataquest inquiries are logged in a database so that we can track all active and historical inquiries, and conduct searches on past inquiries. This system allows us to respond to your questions quickly by reducing the number of times we have to "reinvent the wheel," and to give you an up-to-the-minute status report on your inquiries.

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Furthermore, if you are curious about your inquiry usage for the year, we can produce a report that tells you the number of hours you have consumed and the number of hours you have remaining. If you use up your assigned inquiry hours before your contractual term ends, additional inquiry hours may be purchased to fulfill your requirements for the remainder of your contract's duration. Any unused inquiry hours are forfeited once your subscription has expired.

Custom/Fee-Based Projects

Questions that require more than two hours of effort are better handled on a special-fee basis. There are two alternatives: speaking and short engagements and custom consulting. Speaking and short engagements are fee-based projects that can be completed within two to three days of dedicated research and/or analysis. If the project you are requesting goes beyond that timescale, custom consulting is the next option. Our inquiry analysts will work with you to determine the best method to get your questions answered.

We encourage you to use the interactive inquiry process to gain maximum value from your investment, and look forward to a long-term productive relationship based on an ongoing dialog.

Group Structure

Figure 1 shows how Dataquest's European Semiconductor group is organized, and Tables 1 and 2 provide directories of research expertise by analyst and by subject respectively. This information is ensued by a biography of each group member.

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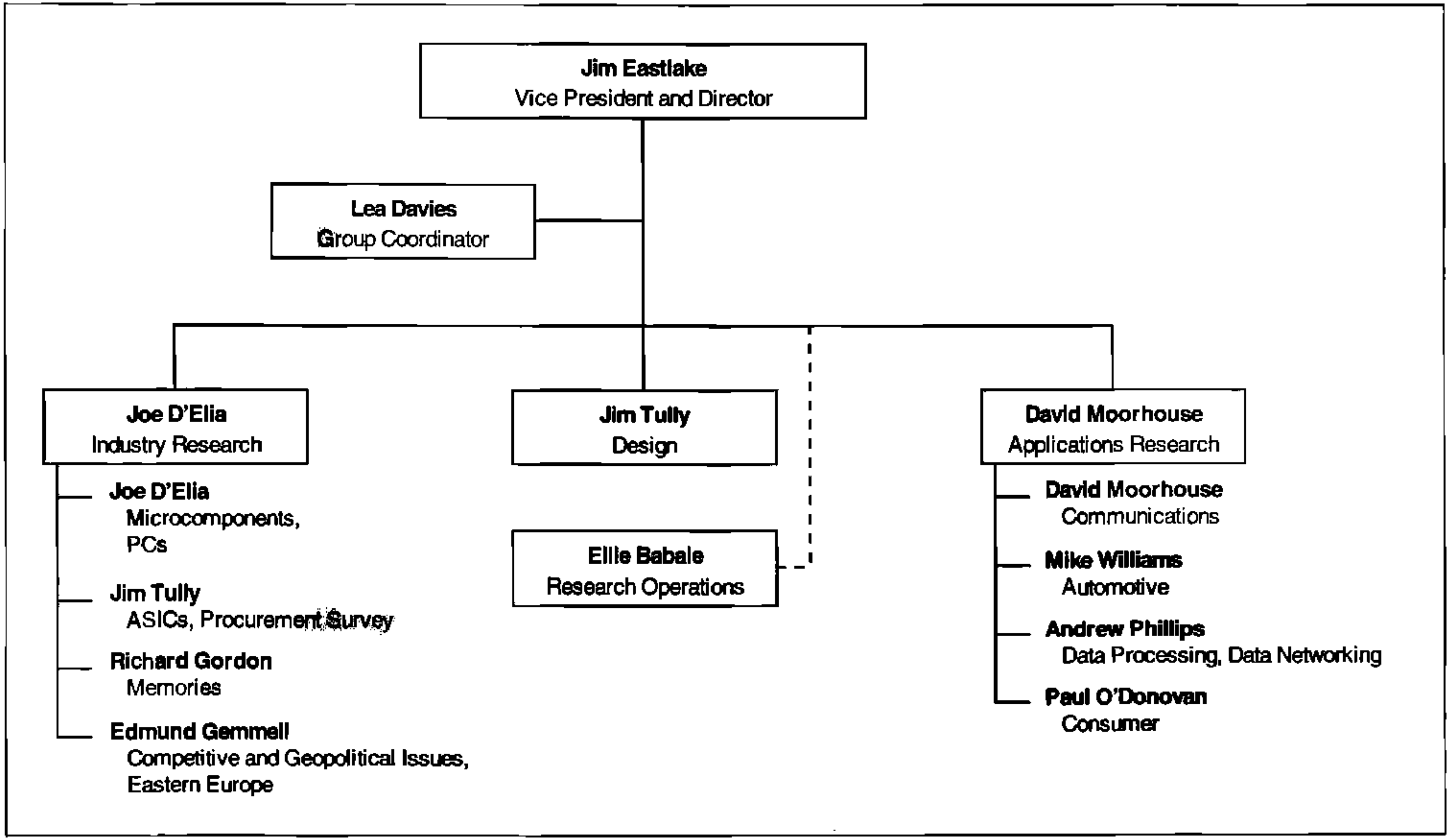
Figure 1
European Semiconductor Group Organization



Source: Dataquest (March 1998)

Table 1
Directory of Research Expertise—By Analyst

Babaie, Ellie Associate Analyst +44-1784-488799 ellie.babaie@gartner.com	**Research expertise:** Market shares, statistics
Davies, Lea Group Coordinator +44-1784-487512 lea.davies@gartner.com	If you need to contact an analyst urgently and are having difficulty, please contact Lea
D'Elia, Joe Associate Director +44-1784-487505 joe.delia@gartner.com	**Program Manager:** Semiconductors Europe **Research expertise:** PC production, PC semiconductors, microcomponents (microprocessors, microcontrollers, digital signal processors, microperipherals), vendor market shares, *DQ Monday* European device pricing, fab database
Eastlake, Jim Vice President and Director +44-1784-487511 jim.eastlake@gartner.com	**Head of Group** **Research expertise:** Semiconductor market forecast for Europe, the Middle East and Africa, vendor analysis, geopolitical issues affecting semiconductors, European country trends, discretes and power semiconductors
Gemmell, Edmund Associate Analyst +44-1784-487506 edmund.gemmell@gartner.com	**Research expertise:** Eastern European markets, European competitive issues, *I.C. Europe*, European capital investments and R&D, tariffs
Gordon, Richard Industry Analyst +44-1784-487508 richard.gordon@gartner.com	**Research expertise:** Memories (DRAM, SRAM, flash, EPROM, EEPROM), European country markets, *DQ Monday* European device pricing
Moorhouse, David Associate Director +44-1784-487509 david.moorhouse@gartner.com	**Program Manager:** Semiconductor Application Markets Europe; Electronic Equipment Production Monitor Europe **Research expertise:** Communications semiconductors and applications, military and civil aerospace and industrial applications, European applications total available market analysis
O'Donovan, Paul Industry Analyst +44-1784-487504 paul.o'donovan@gartner.com	**Research expertise:** Consumer semiconductors and applications, audio, video and domestic appliances
Phillips, Andrew Industry Analyst +44-1784-487507 andrew.phillips@gartner.com	**Research expertise:** Electronic data processing and data networking semiconductor applications
Tully, Jim Principal Analyst +44-1784-487503 jim.tully@gartner.com	**Research expertise:** ASICs, cell-based ICs, gate arrays, programmable logic, custom ICs, design/electronic design automation, semiconductor procurement survey
Williams, Mike Senior Industry Analyst +44-1784-487510 mike.williams@gartner.com	**Research expertise:** Automotive semiconductors and applications, consumer applications, European applications total available market analysis

Source: Dataquest (March 1998)

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Table 2
Directory of Research Expertise—By Subject

ASICs	**Jim Tully** +44-1784-487503 Backups: Joe D'Elia, Jim Eastlake
Automotive (engine control units, antilock braking, airbag and navigation systems and so on)	**Mike Williams** +44-1784-487510 Backup: David Moorhouse
Communications (data networking)	**Andrew Phillips** +44-1784-487507 Backup: David Moorhouse
Communications (mobile and public)	**David Moorhouse** +44-1784-487509 Backup: Andrew Phillips
Consumer (audio, video and domestic appliances)	**Paul O'Donovan** +44-1784-487504 Backup: Mike Williams
Discretes and power semiconductors	**Jim Eastlake** +44-1784-487511 Backup: none in Europe
Electronic data processing (storage, mainframes, network computers, printers, EFTPOS)	**Andrew Phillips** +44-1784-487507 Backup: David Moorhouse
Electronic design automation	**Jim Tully** +44-1784-487503 Backup: none in Europe
Inward investment	**Richard Gordon** +44-1784-487508 Backup: Edmund Gemmell
Memories (DRAM, SRAM, nonvolatile and so on)	**Richard Gordon** +44-1784-487508 Backup: Joe D'Elia
Microcomponents (microprocessors, microcontrollers, microperipherals, digital signal processors)	**Joe D'Elia** +44-1784-487505 Backup: none in Europe
PCs (production, semiconductor trends)	**Joe D'Elia** +44-1784-487505 Backup: Andrew Phillips
Procurement trends	**Jim Tully** +44-1784-487503 Backup: Jim Eastlake
Semiconductor fabrication issues	**Richard Gordon** +44-1784-487508 Backup: Joe D'Elia
Semiconductor market forecast	**Joe D'Elia** +44-1784-487505 Backups: Jim Tully, Richard Gordon
Semiconductor vendor market shares	**Joe D'Elia** +44-1784-487505 Backups: Jim Eastlake, Richard Gordon
Tariffs (memories)	**Richard Gordon** +44-1784-487508 Backup: Joe D'Elia
Tariffs (general)	**Edmund Gemmell** +44-1784-487506 Backup: Joe D'Elia
Test	**Jim Tully** +44-1784-487503 Backup: Richard Gordon

Source: Dataquest (March 1998)

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Jim Eastlake
Vice President and Director, European Semiconductor Group

Mr. Eastlake is the director of Dataquest's European Semiconductor group, based in Egham, England, and he has more than 18 years' experience in the electronics industry. Prior to joining Dataquest, Mr. Eastlake worked in Texas Instruments' Northern European semiconductor division, and in his most recent post at Texas Instruments he ran the European distribution program for the linear functions business group. Earlier he managed Texas Instruments' advanced bipolar logic families and was responsible for launching the company's programmable logic families and bit-slice functions in Northern Europe. He also held a product marketing position for 8- and 16-bit microprocessors and peripherals.

Mr. Eastlake graduated from the University of Newcastle-on-Tyne, England, with an honors degree in Physics.

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Ellie Babaie
Associate Analyst, Research Operations (Semiconductors)

Ms. Babaie works very closely with the European Semiconductor group. Her main responsibilities include conducting market research, analysing data and gathering market share information. Ms. Babaie joined Dataquest after completing an MBA degree, prior to which she worked for an international company, where she was involved in strategic planning, analysis of entry barriers for new product markets and conducting negotiations with suppliers and buyers. She has also carried out various research projects within the public sector.

Ms. Babaie graduated from the University of Manchester Institute of Science and Technology in England with a B.Sc. (Hons) in Computation, and gained her MBA at Aston Business School, England.

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Lea Davies

Group Coordinator, European Semiconductor Group and Research Operations

Mrs. Davies joined Dataquest in the spring of 1996 as group coordinator for the European Semiconductor and Research Operations groups. Her main responsibilities include coordinating the itinerary of research analysts for European conferences and sales trips. She is also in charge of all procurement for the groups as well as general administrative duties. Prior to joining Dataquest, Mrs. Davies worked as an account manager for a large blue-chip company, where she dealt with the management of client accounts and was responsible for their aftersales care. As a result, Mrs. Davies has gained vast knowledge and experience regarding client relations.

Mrs. Davies holds a Diploma in Business and Finance.

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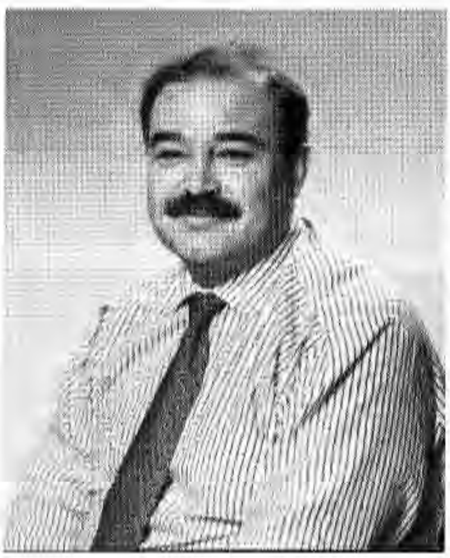
Joe D'Elia

Associate Director, European Semiconductor Group



Mr. D'Elia is an associate director and manages the Semiconductors Europe program. He is based at Dataquest's European headquarters in Egham, and has worked in the semiconductor industry for 28 years. Before joining Dataquest, Mr. D'Elia held the position of European customer marketing director for LSI Logic in Munich, managing a team responsible for providing tactical marketing support for all of the company's products, and prior to this he was based at LSI Logic's Californian headquarters as an international marketing manager. Earlier Mr. D'Elia spent 4 years at Intel Corporation in major accounts management and in EPLD marketing, 8 years at National Semiconductor in field applications, sales and market development, and 10 years at Texas Instruments in manufacturing and consumer applications. Mr. D'Elia's research responsibilities as an analyst encompass microcomponents, vendor market shares in Europe, the Middle East and Africa (EMEA), and the EMEA PC manufacturing industry and associated technology.

Mr. D'Elia is a member of the IEEIE.

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Edmund Gemmell
Associate Analyst, European Semiconductor Group

Mr. Gemmell is an associate analyst in Dataquest's Semiconductor group in Egham, and has 3 years' research experience within the semiconductor industry. Mr. Gemmell is responsible for researching European geopolitical and competitive issues, including the emerging semiconductor markets of Eastern Europe. He also compiles the monthly semiconductor industry newsletter, *I.C. Europe*. Before joining Dataquest, Mr. Gemmell worked at National Semiconductor's European headquarters outside Munich, where his main role was to develop and implement a European marketing research function in support of the European product marketing groups. Furthermore, he carried out substantial research into the developing markets of Eastern Europe.

Mr. Gemmell holds a degree in Business and Marketing from Stirling University, Scotland.

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Richard Gordon
Industry Analyst, European Semiconductor Group

Mr. Gordon is an industry analyst responsible for Dataquest's European memories research, based at Egham, and he has 11 years' experience in the electronics and semiconductor industries. Before joining Dataquest, Mr. Gordon worked at Advanced Micro Devices as senior product engineer, supporting nonvolatile memory product customers across Europe. Prior to this he was a transputer device engineer at the INMOS wafer fab in South Wales, and earlier he spent 2 years with A.B. Electronics in the subcontract electronics assembly industry.

Mr. Gordon holds a B.Sc. (Hons) degree in Electronics from the University of Glasgow, Scotland, and has a Postgraduate Diploma in Marketing from the Chartered Institute of Marketing.

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David Moorhouse
Associate Director, European Semiconductor Group

Mr. Moorhouse is an associate director based at Egham, and he manages Dataquest's Semiconductor Application Markets Europe and Electronic Equipment Production Monitor Europe programs. His research domain is communications applications, and he has worked in the European electronics industry for the past 16 years. Prior to joining Dataquest, he was a senior consultant with design house ID Devices, responsible for product developments in fiber-optic communications and speech synthesis systems. His previous marketing experience was gained at Standard Telephones and Cables (STC) hybrids division as product marketing manager and applications manager. Before STC Mr. Moorhouse worked for GEC Avionics as a designer in high-speed serial data bus systems used in military and civil aircraft.

Mr. Moorhouse is a graduate of Salford University, England, with a degree in Electronics.

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Paul O'Donovan
Industry Analyst, European Semiconductor Group

Mr. O'Donovan is an industry analyst covering consumer applications within the European Semiconductor group, his main area of responsibility being video and audio application segments. Mr. O'Donovan is based at Dataquest's European headquarters in Egham and has more than 12 years' experience in the semiconductor industry. Before joining Dataquest he worked at National Semiconductor's European headquarters outside Munich, where he had pan-European responsibility for managing the company's logic families through its distribution network. His primary tasks were the gathering and analysis of trends for his product responsibilities and the setting of tactics and strategies. Prior to this role he was a marketing assistant at National Semiconductor's headquarters in the United Kingdom within the digital logic group, and earlier he worked in production planning.

Mr. O'Donovan studied Sales and Marketing with the Chartered Institute of Marketing.

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Andrew Phillips
Industry Analyst, European Semiconductor Group

Mr. Phillips is an analyst who works on Dataquest's Semiconductor Application Markets Europe program and is based at the European headquarters in Egham. His research covers electronic data processing and data networking applications, and he has 9 years' experience in the semiconductor industry. Before joining Dataquest, Mr. Phillips worked for semiconductor distributor SEI Macro, which involved commercial and technical promotion of many semiconductor manufacturers' products (including Hitachi, Motorola, National Semiconductor, Philips, Siemens, Sony, TEMIC and Texas Instruments) and specific focus on developing imaging- and multimedia-based markets.

Mr. Phillips holds a B.Sc. (Hons) degree in Electronics and Communications Engineering from the Polytechnic of North London, England.

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Jim Tully
Principal Analyst, European Semiconductor Group

Dr. Tully is the principal analyst in Dataquest's European Semiconductor group, based at Egham. He is responsible for Dataquest's electronic design automation (EDA), ASIC and semiconductor user and buyer research in Europe. Before joining Dataquest in 1990, Dr. Tully spent 7 years with EDA company Racal Redac Limited in the United Kingdom, where he had design engineering, engineering management and, later, worldwide marketing management responsibilities. Before this, he held design, design management and production management roles within the Armstrong Organization (now Mitsubishi), Ferranti Limited, the UK Atomic Energy Authority and Rediffusion Cable TV. In these roles, he designed, specified and purchased a wide range of electronic components and systems.

Dr. Tully is a chartered electronic engineer. He holds M.Sc. and Ph.D. degrees in electrical and electronic engineering from the University of Bradford, England, and an MBA from the University of Warwick, England.

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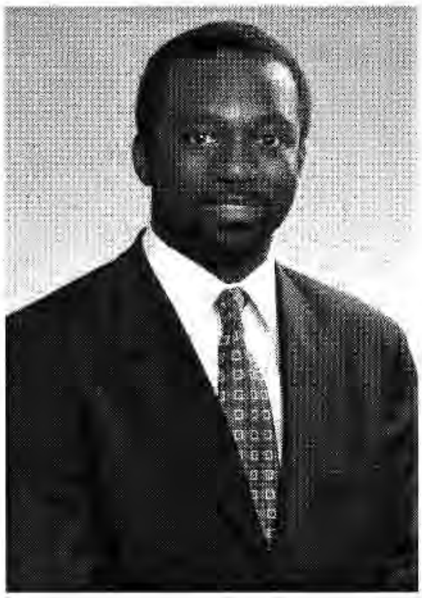
Mike Williams
Senior Industry Analyst, European Semiconductor Group



Mr. Williams is a senior industry analyst for Dataquest's Semiconductor Application Markets Europe program and is based at Egham. He has 11 years' experience in research and analysis into the semiconductor industry. Although his main area of expertise is automotive application markets, Mr. Williams also conducts specific research into the computer and consumer application segments. Prior to joining Dataquest, he worked for Aidcom International, a consumer marketing research company based in London.

Mr. Williams studied Computer Management at the Institute of Data Processing Management in London.

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Overview of Research Programs

The European Semiconductor group divides its research focus into two main areas, namely industry and applications.

The industry side of the group focuses on the following:

- Semiconductor product market research (memories, microcomponents, ASICs and so on)
- Vendor analysis
- European geopolitical issues (trade, tariffs, investment and so on)
- Semiconductor technology trends
- Purchasing issues and trends (what the customer thinks and does)
- The EDA market
- Eastern European devices and applications markets

The applications side of the group deals with electronic applications that use semiconductors and other electronic components and subassemblies.

The group provides four research programs in total. There are two "industry" programs and two "applications" programs, as follows:

- Industry
  - Semiconductors Europe (SEMI-EU)
  - Electronic Design Automation Worldwide (CEDA-WW)
- Applications
  - Semiconductor Application Markets Europe (SAMM-EU)
  - Electronic Equipment Production Monitor Europe (SAPM-EU)

Following you will find a description of the research contents and scope of each of these programs.

Semiconductors Europe

Dataquest's Semiconductors Europe program provides clients with quantitative and qualitative analysis of product, regional and technology trends in EMEA. Dataquest maintains databases containing information about company market shares, capital and R&D investment and manufacturing capability, to which clients have access through this service. Vendor strategies are monitored closely. The program also follows and analyzes the many geopolitical issues affecting both vendors and users of semiconductors in EMEA, and the impact of these factors is reflected in Dataquest's product and regional market forecasts.

Topical Coverage

Topics covered by this program include the following:

- Competitive dynamics
- Investment
- Industry trends
- Purchasing trends

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Regional Coverage

Market estimates and forecasts are provided for the following countries or regions:

- Africa
- Benelux
- Eastern Europe
- France
- Germany
- Italy
- Middle East
- Nordic
- Rest of Western Europe
- United Kingdom and Ireland

Product Coverage

Market share estimates and forecasts are provided for the following product categories:

- ASICs—Gate arrays, programmable logic devices, cell-based ICs, custom ICs
- Memories—DRAM, SRAM, EPROM, EEPROM, flash, ROM
- Microcomponents—Microprocessors, microcontrollers, microperipherals, digital signal processors
- Analog and mixed-signal ICs
- Discretes
- Optocomponents

Key Databases

This program maintains the following databases to monitor and analyze Europe:

- EMEA semiconductor fabrication database
- Capital and R&D investment by European vendor
- Major OEMs' annual semiconductor spend
- EMEA semiconductor market shares by vendor
- EMEA semiconductor forecasts by product and region

The Analysts

The program manager for Semiconductors Europe is Joe D'Elia. Analysts researching this program along with Joe are Richard Gordon, Edmund Gemmell and Jim Tully.

Semiconductor Application Markets Europe

Dataquest's Semiconductor Application Markets Europe program is the leading information source for market statistics and strategic analysis of the European semiconductor market. The program provides demand-side information and decision support on electronic equipment production and design trends. It has been developed to aid the marketing and strategic planning of semiconductor and other electronic component manufacturers, and it provides market estimates and forecasts of European electronic equipment production and semiconductor consumption.

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Primary Application Coverage

Detailed forecast and trend analysis is provided for the following:

- Electronic data processing—Including PCs, computer peripherals, storage devices and IC cards
- Communications—Central office switches, telephone handsets, data communications equipment and mobile/cellular communications
- Consumer—Including analog and digital audio and video systems, set-top boxes, personal electronics and domestic appliances
- Automotive—Including in-car entertainment systems, body control and vehicle control electronics, driver information (including navigation), power train, and safety and convenience systems

Market Overview

Market estimates and forecasts are provided for the following six basic application markets:

- Electronic data processing
- Communications
- Consumer
- Industrial
- Military and civil aerospace
- Automotive

Key Market Statistics

The following statistics are included:

- Electronic equipment production forecasts in units and revenue
- Semiconductor market forecasts by application
- European country market forecasts by application
- Vendor market shares by application
- High-volume electronic equipment unit production forecasts

Regional Coverage

Market estimates and forecasts are provided for the following countries or regions:

- Benelux
- France
- Germany
- Italy
- Nordic
- United Kingdom and Ireland

The Analysts

The program manager for Semiconductor Application Markets Europe is David Moorhouse. Analysts researching this program along with David are Mike Williams, Andrew Phillips and Paul O'Donovan.

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Electronic Equipment Production Monitor Europe

Dataquest's Electronic Equipment Production Monitor Europe program is the leading source of information on component content trends of new and/or high-volume electronics systems manufactured in Europe. It is intended to be of interest to all vendors of electronic components, from semiconductors to subassemblies. The core research activity involves the disassembly, or "tear-down," of key electronics products. Once dismantled, a bill-of-materials listing is made and component prices estimated for each product. A report analyzing the content of the product is then produced, and it includes: a complete listing of all the electronic components found, their sources, quantities per system and estimated prices; commentary on future trends in component usage within the product being analyzed; and, on behalf of the OEM/designer, the identification of scope for cost savings through redesign, using knowledge of emerging component solutions and methods.

Primary Application Coverage

The program will provide analysis of the following 34 key items of electronic equipment:

Electronic Data Processing	Communications
Optical disk drives	Analog cellular telephones
Page (laser) printers	Analog cordless telephones
PC motherboards	Answering machines
PCs	Central office line cards
Rigid disk drives	Corded telephones
Serial printers	Digital cellular telephones
Smart cards	Digital cordless telephones
Workstations	Fax machines
	LAN cards
Consumer	Modems
Analog camcorders	Pagers
Analog set-top boxes	PBX line cards
Color TVs	
Digital camcorders	**Automotive**
Digital set-top boxes	Airbag systems
Digital still cameras	Antilock braking systems
DVD players	Engine control units
Personal stereos	Navigation systems
VCRs/VTRs	Stereo systems

Market Statistics

The program maintains the following market statistics databases:

- High-volume European electronic equipment production—Provides history and a five-year forecast of European electronic systems unit production for the 34 products listed, with their factory production ASP and total production value.
- Major European electronic equipment manufacturing locations—Identifies by product, region and company the locations of major European manufacturers of the 34 items of electronic equipment listed. This database, updated annually, is an indispensable marketing tool providing the client with vital information about key potential customers.

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The Analysts

The program manager for Electronic Equipment Production Monitor Europe is David Moorhouse. Analysts researching this program along with David are Andrew Phillips, Mike Williams and Paul O'Donovan.

Electronic Design Automation Worldwide

Dataquest's Electronic Design Automation Worldwide program provides detailed analysis of the industry trends, players, products and end-user issues that drive the market for EDA applications and tools. The program covers the three major EDA application areas—IC layout, electronic CAE and PCB/MCM/hybrid layout tools—and provides the most reliable worldwide market size, market share and market forecast estimates available. The program also provides data, advice and analysis to help clients make informed planning decisions. Publications include a mix of analytical articles, weekly news bulletins and event-driven faxes. Periodic briefings and conferences bring clients together with analysts to share insights and opinions.

Key Topics

Topics covered by this program include the following:

- ES level (ESDA)—Virtual prototypes, hardware and software codesign
- RTL design—VHDL and verilog, synthesis, design for test
- Gate-level design—Schematic capture, analog design, analysis tools
- IC CAD—Physical verification, floor planning, FPGA fitters, IC layout
- PCB design—PCB, MCM and hybrid place and route
- Miscellaneous—Accelerators and emulators, libraries, interoperability tools

Regional Coverage

The program covers the following countries or regions:

- Asia/Pacific (by country)
- Europe (by country)
- Japan
- North America
- Rest of World
- Worldwide

Standard Data Metrics

The following data metrics are covered:

- Total factory, hardware and software revenue
- Service revenue
- Revenue by operating system
- Software shipments
- Revenue by industry sector
- 37 different subapplications by end use and by platform

The Analysts

The program manager in Europe for Electronic Design Automation Worldwide is Jim Tully.

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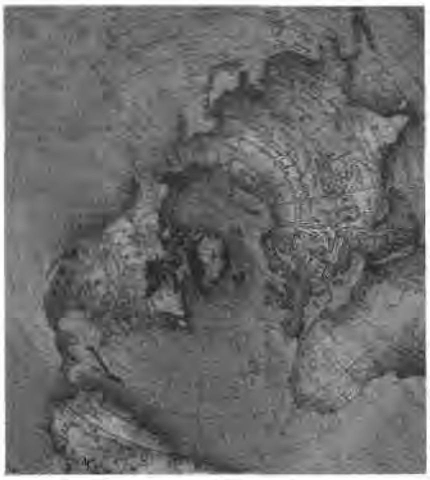

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Guides

1998

Program: Semiconductors—Top Views
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Publication Date: March 4, 1998
Filing: Guides

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Publication Date: March 4, 1998
Filing: Guides

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Introduction

The aim of this *Guide* is to help you, our client, to get the most from your Dataquest research program by explaining the best way to work with our analysts. This document covers the following:

- The role of our analysts, and what you should expect from them
- Who the analysts are, their specialist subject areas and how to contact them
- The scope of research undertaken by Dataquest's European Semiconductor group

Analyst Charter

Analysts in the European Semiconductor group have two roles. Firstly, they are responsible for conducting research into every aspect of the European semiconductor market, the European semiconductor industry and European-headquartered semiconductor manufacturers. Secondly, they are responsible for providing a local (same time zone) contact point for subscribers to any of Dataquest's 25 or more worldwide semiconductor-related research programs. These roles are equally important.

When providing support to clients based in Europe who subscribe to non-European research programs, our analysts will do their best to answer your inquiry, but it is likely that they will have to refer the question to our experts at other research locations—either Dataquest's worldwide research headquarters in San Jose, California, United States or our regional headquarters in Tokyo, Japan or Seoul, South Korea (our Asia/Pacific headquarters). In no way does this process preclude you from making direct contact with analysts in any of Dataquest's research sites around the world; our European staff are simply there to provide support if you prefer to deal with a local contact.

The Analysts

We recruit our analysts because they possess certain skills. Generally we recruit staff from either an engineering or a marketing background in the semiconductor industry. A review of our biographies on pages 8 to 13 of this *Guide* reflects this preference.

The role of the analyst in the account relationship is to ensure that your company receives the information it requires in a timely manner. After you have subscribed to a research program, our team of analysts becomes the primary link between your company and Dataquest. The analyst team is responsible for the following:

- Communicating the scope and subject areas covered by Dataquest's semiconductor service
- Responding to your inquiries in a timely manner
- Proactively seeking the participation of your firm in research studies that might be of particular interest to your organization
- Alerting you, either personally or through *Dataquest Alerts*, to industry developments that might impact your strategy or your markets
- Soliciting your company's suggestions on new areas for research
- Responding to questions your company might have about using Dataquest's semiconductor service

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You will elicit the quickest response to your inquiry by directing it to the analyst who specializes in the area that concerns you. However, occasionally it may not be clear who the right analyst is, or indeed the specialist may not be available. In this case please feel free to contact any member of the group.

Client Contact

On the other side of the equation, we need to know how you want to work with us, and who in your organization will be the users of our service. It is important for us to know who you have authorized to use the inquiry hours you have purchased from Dataquest.

From an administrative point of view, the working arrangement is fairly straightforward. One individual in your company—usually the person responsible for, and decided at the time of, signing the agreement for your Dataquest subscription—is designated the "binderholder," and is our point of contact for issues regarding billing, shipping, renewal and so on.

However, from an operational viewpoint, clients prefer a variety of working arrangements, particularly with regard to the use of the inquiry service. Some companies prefer to funnel all inquiries through an individual they hold responsible for managing the overall usage level; other companies nominate several individuals to use the service at will. It is very helpful for us to understand how you want the relationship to work—once we do, we will be in a much better position to both deliver the service effectively and support your objectives.

Inquiry Service

The value of the information and analysis we publish in our documents becomes evident to you only when it finds a practical application in your company's market intelligence and business planning activities. In many instances you will have specific questions about markets, competitors' offerings or the business environment that can be addressed directly through the use of the material we have published. However, you may require further insight into our data, analysis and conclusions, and this is when our inquiry service can maximize the value of your investment. You will receive a specified number of hours of consultative inquiry support as part of your contract with Dataquest, giving you ongoing access to Dataquest's European Semiconductor group over the 12 months of your program subscription.

What Is an Inquiry?

For many clients, our inquiry service is the most valuable element of their Dataquest subscription. Most use this service frequently, and with a high level of satisfaction. By understanding the inquiry process, we believe that you will be better able to use this service effectively.

We define an inquiry as a question or questions that fall(s) within the scope of the published research you receive as part of your research program subscription, and that can be answered by our analysts in less than two hours of dedicated research time.

We want the process to appear simple and transparent to you whenever you call us. We have carefully constructed our inquiry support process to ensure a swift and thorough response, and have structured our senior staff to be readily available to address those inquiries that require a higher-level response. The bottom line is that we work very hard at providing the best possible inquiry support to you, and we continually look for ways to be more efficient and helpful.

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Before Calling with an Inquiry

Our ability to meet your information needs is only as good as your ability to formulate your requests to our industry analysts. Therefore, please keep the following guidelines in mind:

Formulate your inquiry questions carefully—It is especially important to think through carefully each inquiry request and to give us as much background information as possible so that we fully understand your needs. What should you do if you are not quite sure what questions to ask or what information you need? Call an analyst. Our extensive experience of working with clients will help you to formulate your market research requirements properly.

Please limit "rush" inquiries—Try to anticipate your information needs so that you can give us enough time to respond to your inquiries. No-one can prevent the last-minute question that comes up just as you are entering a meeting, but the likelihood of us being able to give you the information you need in a crunch is far less than when we are given more time to access all of our sources.

Try to avoid multiple inquiries—Clients generally are allowed one active inquiry per program subscription at any time. If you must make more than one inquiry at a time, our analysts will work with you to prioritize your active inquiries.

Sensitive information gathering—When structuring an inquiry, please keep in mind that we are able to provide responses based only on information that is in the public domain. If you are asking for a type of more sensitive information which your company would not be willing to disclose, it is unlikely that we would be able to obtain similar information from your competitors.

Industry analysts are more than "data diggers"—Our analysts should be seen as consultants on call. They can give you valuable feedback as you refine your service marketing strategies, programs and policies.

How to Place an Inquiry

There are three means of communicating your inquiries to your assigned analyst/account manager, namely telephone, fax and e-mail. In most cases the appointed analyst will acknowledge receipt of your inquiry, in one form or another, to inform you that your request has been received. However, it is advisable that you follow up with a telephone call to the analyst after logging your inquiry to check that it has been received.

When Will You Receive an Answer to Your Inquiry?

Most inquiries are answered within five working days, but please remember that this is an average. An analyst will discuss with you a reasonable expectation for answers and will call to let you know if an inquiry will require more time to complete.

How Will Answers Be Communicated to You?

Dataquest will respond to your inquiries in the most effective means possible, which may include the telephone, fax, e-mail, or a regular or express mail service.

Inquiry Management Systems and Databases

All Dataquest inquiries are logged in a database so that we can track all active and historical inquiries, and conduct searches on past inquiries. This system allows us to respond to your questions quickly by reducing the number of times we have to "reinvent the wheel," and to give you an up-to-the-minute status report on your inquiries.

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Furthermore, if you are curious about your inquiry usage for the year, we can produce a report that tells you the number of hours you have consumed and the number of hours you have remaining. If you use up your assigned inquiry hours before your contractual term ends, additional inquiry hours may be purchased to fulfill your requirements for the remainder of your contract's duration. Any unused inquiry hours are forfeited once your subscription has expired.

Custom/Fee-Based Projects

Questions that require more than two hours of effort are better handled on a special-fee basis. There are two alternatives: speaking and short engagements and custom consulting. Speaking and short engagements are fee-based projects that can be completed within two to three days of dedicated research and/or analysis. If the project you are requesting goes beyond that timescale, custom consulting is the next option. Our inquiry analysts will work with you to determine the best method to get your questions answered.

We encourage you to use the interactive inquiry process to gain maximum value from your investment, and look forward to a long-term productive relationship based on an ongoing dialog.

Group Structure

Figure 1 shows how Dataquest's European Semiconductor group is organized, and Tables 1 and 2 provide directories of research expertise by analyst and by subject respectively. This information is ensued by a biography of each group member.

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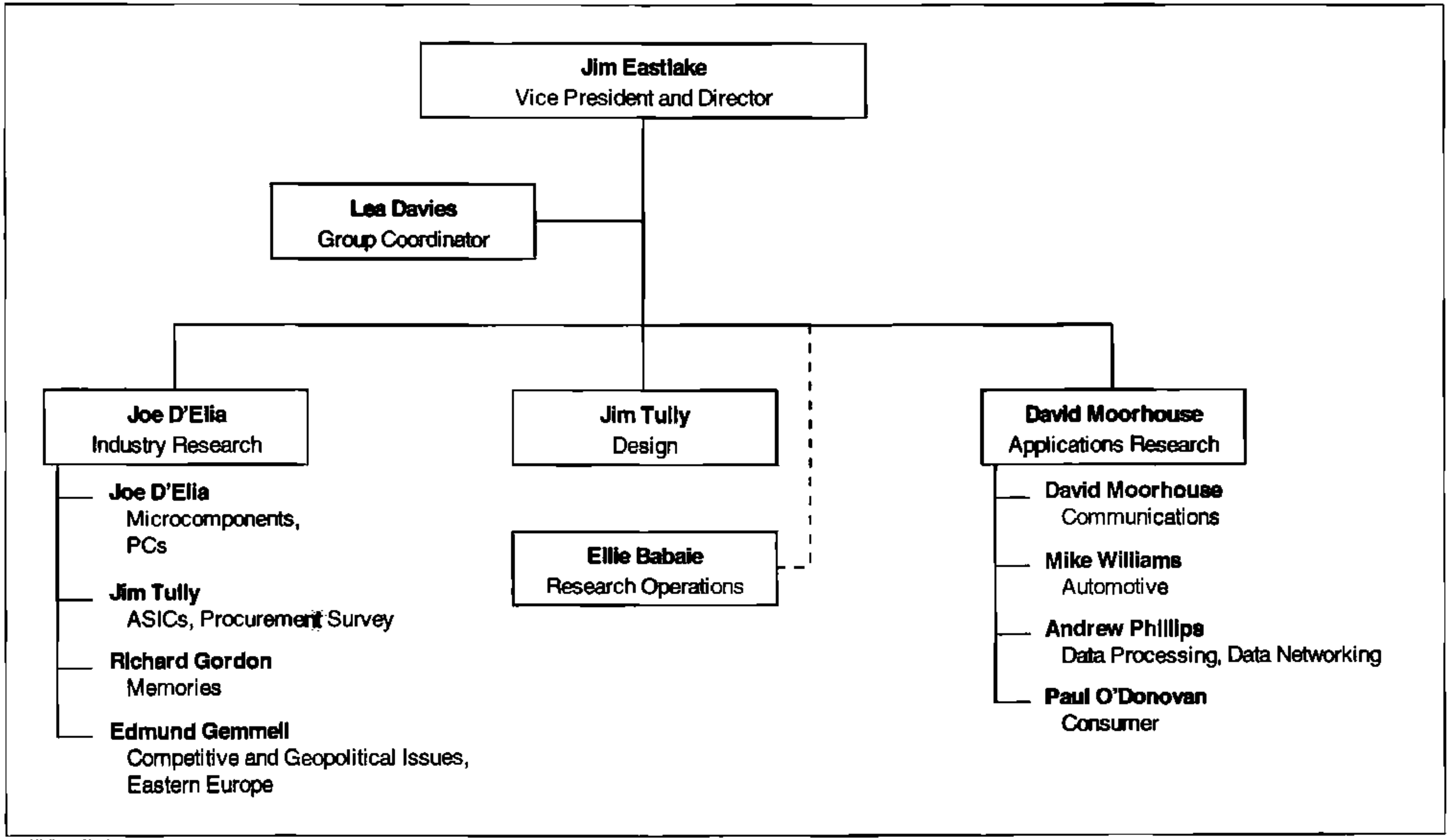
Figure 1
European Semiconductor Group Organization



Source: Dataquest (March 1998)

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Table 1
Directory of Research Expertise—By Analyst

Babaie, Ellie Associate Analyst +44-1784-488799 ellie.babaie@gartner.com	**Research expertise:** Market shares, statistics
Davies, Lea Group Coordinator +44-1784-487512 lea.davies@gartner.com	If you need to contact an analyst urgently and are having difficulty, please contact Lea
D'Elia, Joe Associate Director +44-1784-487505 joe.delia@gartner.com	**Program Manager**: Semiconductors Europe **Research expertise:** PC production, PC semiconductors, microcomponents (microprocessors, microcontrollers, digital signal processors, microperipherals), vendor market shares, *DQ Monday* European device pricing, fab database
Eastlake, Jim Vice President and Director +44-1784-487511 jim.eastlake@gartner.com	**Head of Group** **Research expertise:** Semiconductor market forecast for Europe, the Middle East and Africa, vendor analysis, geopolitical issues affecting semiconductors, European country trends, discretes and power semiconductors
Gemmell, Edmund Associate Analyst +44-1784-487506 edmund.gemmell@gartner.com	**Research expertise:** Eastern European markets, European competitive issues, *I.C. Europe*, European capital investments and R&D, tariffs
Gordon, Richard Industry Analyst +44-1784-487508 richard.gordon@gartner.com	**Research expertise:** Memories (DRAM, SRAM, flash, EPROM, EEPROM), European country markets, *DQ Monday* European device pricing
Moorhouse, David Associate Director +44-1784-487509 david.moorhouse@gartner.com	**Program Manager:** Semiconductor Application Markets Europe; Electronic Equipment Production Monitor Europe **Research expertise:** Communications semiconductors and applications, military and civil aerospace and industrial applications, European applications total available market analysis
O'Donovan, Paul Industry Analyst +44-1784-487504 paul.o'donovan@gartner.com	**Research expertise:** Consumer semiconductors and applications, audio, video and domestic appliances
Phillips, Andrew Industry Analyst +44-1784-487507 andrew.phillips@gartner.com	**Research expertise:** Electronic data processing and data networking semiconductor applications
Tully, Jim Principal Analyst +44-1784-487503 jim.tully@gartner.com	**Research expertise:** ASICs, cell-based ICs, gate arrays, programmable logic, custom ICs, design/electronic design automation, semiconductor procurement survey
Williams, Mike Senior Industry Analyst +44-1784-487510 mike.williams@gartner.com	**Research expertise:** Automotive semiconductors and applications, consumer applications, European applications total available market analysis

Source: Dataquest (March 1998)

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Table 2
Directory of Research Expertise—By Subject

ASICs	**Jim Tully** +44-1784-487503 Backups: Joe D'Elia, Jim Eastlake
Automotive (engine control units, antilock braking, airbag and navigation systems and so on)	**Mike Williams** +44-1784-487510 Backup: David Moorhouse
Communications (data networking)	**Andrew Phillips** +44-1784-487507 Backup: David Moorhouse
Communications (mobile and public)	**David Moorhouse** +44-1784-487509 Backup: Andrew Phillips
Consumer (audio, video and domestic appliances)	**Paul O'Donovan** +44-1784-487504 Backup: Mike Williams
Discretes and power semiconductors	**Jim Eastlake** +44-1784-487511 Backup: none in Europe
Electronic data processing (storage, mainframes, network computers, printers, EFTPOS)	**Andrew Phillips** +44-1784-487507 Backup: David Moorhouse
Electronic design automation	**Jim Tully** +44-1784-487503 Backup: none in Europe
Inward investment	**Richard Gordon** +44-1784-487508 Backup: Edmund Gemmell
Memories (DRAM, SRAM, nonvolatile and so on)	**Richard Gordon** +44-1784-487508 Backup: Joe D'Elia
Microcomponents (microprocessors, microcontrollers, microperipherals, digital signal processors)	**Joe D'Elia** +44-1784-487505 Backup: none in Europe
PCs (production, semiconductor trends)	**Joe D'Elia** +44-1784-487505 Backup: Andrew Phillips
Procurement trends	**Jim Tully** +44-1784-487503 Backup: Jim Eastlake
Semiconductor fabrication issues	**Richard Gordon** +44-1784-487508 Backup: Joe D'Elia
Semiconductor market forecast	**Joe D'Elia** +44-1784-487505 Backups: Jim Tully, Richard Gordon
Semiconductor vendor market shares	**Joe D'Elia** +44-1784-487505 Backups: Jim Eastlake, Richard Gordon
Tariffs (memories)	**Richard Gordon** +44-1784-487508 Backup: Joe D'Elia
Tariffs (general)	**Edmund Gemmell** +44-1784-487506 Backup: Joe D'Elia
Test	**Jim Tully** +44-1784-487503 Backup: Richard Gordon

Source: Dataquest (March 1998)

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Jim Eastlake
Vice President and Director, European Semiconductor Group

Mr. Eastlake is the director of Dataquest's European Semiconductor group, based in Egham, England, and he has more than 18 years' experience in the electronics industry. Prior to joining Dataquest, Mr. Eastlake worked in Texas Instruments' Northern European semiconductor division, and in his most recent post at Texas Instruments he ran the European distribution program for the linear functions business group. Earlier he managed Texas Instruments' advanced bipolar logic families and was responsible for launching the company's programmable logic families and bit-slice functions in Northern Europe. He also held a product marketing position for 8- and 16-bit microprocessors and peripherals.

Mr. Eastlake graduated from the University of Newcastle-on-Tyne, England, with an honors degree in Physics.

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Ellie Babaie
Associate Analyst, Research Operations (Semiconductors)

Ms. Babaie works very closely with the European Semiconductor group. Her main responsibilities include conducting market research, analysing data and gathering market share information. Ms. Babaie joined Dataquest after completing an MBA degree, prior to which she worked for an international company, where she was involved in strategic planning, analysis of entry barriers for new product markets and conducting negotiations with suppliers and buyers. She has also carried out various research projects within the public sector.

Ms. Babaie graduated from the University of Manchester Institute of Science and Technology in England with a B.Sc. (Hons) in Computation, and gained her MBA at Aston Business School, England.

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Lea Davies

Group Coordinator, European Semiconductor Group and Research Operations

Mrs. Davies joined Dataquest in the spring of 1996 as group coordinator for the European Semiconductor and Research Operations groups. Her main responsibilities include coordinating the itinerary of research analysts for European conferences and sales trips. She is also in charge of all procurement for the groups as well as general administrative duties. Prior to joining Dataquest, Mrs. Davies worked as an account manager for a large blue-chip company, where she dealt with the management of client accounts and was responsible for their aftersales care. As a result, Mrs. Davies has gained vast knowledge and experience regarding client relations.

Mrs. Davies holds a Diploma in Business and Finance.

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Joe D'Elia

Associate Director, European Semiconductor Group

Mr. D'Elia is an associate director and manages the Semiconductors Europe program. He is based at Dataquest's European headquarters in Egham, and has worked in the semiconductor industry for 28 years. Before joining Dataquest, Mr. D'Elia held the position of European customer marketing director for LSI Logic in Munich, managing a team responsible for providing tactical marketing support for all of the company's products, and prior to this he was based at LSI Logic's Californian headquarters as an international marketing manager. Earlier Mr. D'Elia spent 4 years at Intel Corporation in major accounts management and in EPLD marketing, 8 years at National Semiconductor in field applications, sales and market development, and 10 years at Texas Instruments in manufacturing and consumer applications. Mr. D'Elia's research responsibilities as an analyst encompass microcomponents, vendor market shares in Europe, the Middle East and Africa (EMEA), and the EMEA PC manufacturing industry and associated technology.

Mr. D'Elia is a member of the IEEIE.

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Edmund Gemmell
Associate Analyst, European Semiconductor Group

Mr. Gemmell is an associate analyst in Dataquest's Semiconductor group in Egham, and has 3 years' research experience within the semiconductor industry. Mr. Gemmell is responsible for researching European geopolitical and competitive issues, including the emerging semiconductor markets of Eastern Europe. He also compiles the monthly semiconductor industry newsletter, *I.C. Europe*. Before joining Dataquest, Mr. Gemmell worked at National Semiconductor's European headquarters outside Munich, where his main role was to develop and implement a European marketing research function in support of the European product marketing groups. Furthermore, he carried out substantial research into the developing markets of Eastern Europe.

Mr. Gemmell holds a degree in Business and Marketing from Stirling University, Scotland.

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Richard Gordon
Industry Analyst, European Semiconductor Group

Mr. Gordon is an industry analyst responsible for Dataquest's European memories research, based at Egham, and he has 11 years' experience in the electronics and semiconductor industries. Before joining Dataquest, Mr. Gordon worked at Advanced Micro Devices as senior product engineer, supporting nonvolatile memory product customers across Europe. Prior to this he was a transputer device engineer at the INMOS wafer fab in South Wales, and earlier he spent 2 years with A.B. Electronics in the subcontract electronics assembly industry.

Mr. Gordon holds a B.Sc. (Hons) degree in Electronics from the University of Glasgow, Scotland, and has a Postgraduate Diploma in Marketing from the Chartered Institute of Marketing.

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David Moorhouse
Associate Director, European Semiconductor Group

Mr. Moorhouse is an associate director based at Egham, and he manages Dataquest's Semiconductor Application Markets Europe and Electronic Equipment Production Monitor Europe programs. His research domain is communications applications, and he has worked in the European electronics industry for the past 16 years. Prior to joining Dataquest, he was a senior consultant with design house ID Devices, responsible for product developments in fiber-optic communications and speech synthesis systems. His previous marketing experience was gained at Standard Telephones and Cables (STC) hybrids division as product marketing manager and applications manager. Before STC Mr. Moorhouse worked for GEC Avionics as a designer in high-speed serial data bus systems used in military and civil aircraft.

Mr. Moorhouse is a graduate of Salford University, England, with a degree in Electronics.

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Paul O'Donovan
Industry Analyst, European Semiconductor Group

Mr. O'Donovan is an industry analyst covering consumer applications within the European Semiconductor group, his main area of responsibility being video and audio application segments. Mr. O'Donovan is based at Dataquest's European headquarters in Egham and has more than 12 years' experience in the semiconductor industry. Before joining Dataquest he worked at National Semiconductor's European headquarters outside Munich, where he had pan-European responsibility for managing the company's logic families through its distribution network. His primary tasks were the gathering and analysis of trends for his product responsibilities and the setting of tactics and strategies. Prior to this role he was a marketing assistant at National Semiconductor's headquarters in the United Kingdom within the digital logic group, and earlier he worked in production planning.

Mr. O'Donovan studied Sales and Marketing with the Chartered Institute of Marketing.

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Andrew Phillips
Industry Analyst, European Semiconductor Group

Mr. Phillips is an analyst who works on Dataquest's Semiconductor Application Markets Europe program and is based at the European headquarters in Egham. His research covers electronic data processing and data networking applications, and he has 9 years' experience in the semiconductor industry. Before joining Dataquest, Mr. Phillips worked for semiconductor distributor SEI Macro, which involved commercial and technical promotion of many semiconductor manufacturers' products (including Hitachi, Motorola, National Semiconductor, Philips, Siemens, Sony, TEMIC and Texas Instruments) and specific focus on developing imaging- and multimedia-based markets.

Mr. Phillips holds a B.Sc. (Hons) degree in Electronics and Communications Engineering from the Polytechnic of North London, England.

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Jim Tully
Principal Analyst, European Semiconductor Group

Dr. Tully is the principal analyst in Dataquest's European Semiconductor group, based at Egham. He is responsible for Dataquest's electronic design automation (EDA), ASIC and semiconductor user and buyer research in Europe. Before joining Dataquest in 1990, Dr. Tully spent 7 years with EDA company Racal Redac Limited in the United Kingdom, where he had design engineering, engineering management and, later, worldwide marketing management responsibilities. Before this, he held design, design management and production management roles within the Armstrong Organization (now Mitsubishi), Ferranti Limited, the UK Atomic Energy Authority and Rediffusion Cable TV. In these roles, he designed, specified and purchased a wide range of electronic components and systems.

Dr. Tully is a chartered electronic engineer. He holds M.Sc. and Ph.D. degrees in electrical and electronic engineering from the University of Bradford, England, and an MBA from the University of Warwick, England.

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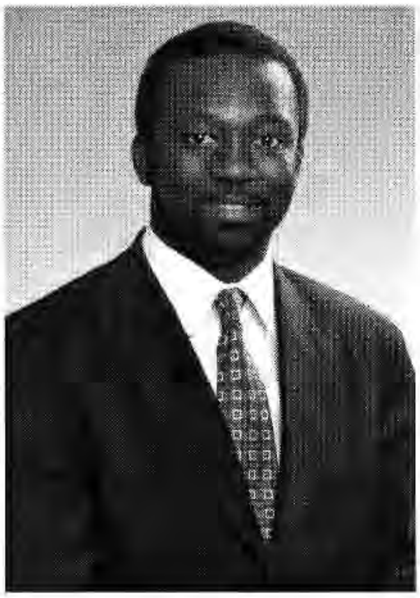
Mike Williams
Senior Industry Analyst, European Semiconductor Group



Mr. Williams is a senior industry analyst for Dataquest's Semiconductor Application Markets Europe program and is based at Egham. He has 11 years' experience in research and analysis into the semiconductor industry. Although his main area of expertise is automotive application markets, Mr. Williams also conducts specific research into the computer and consumer application segments. Prior to joining Dataquest, he worked for Aidcom International, a consumer marketing research company based in London.

Mr. Williams studied Computer Management at the Institute of Data Processing Management in London.

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Overview of Research Programs

The European Semiconductor group divides its research focus into two main areas, namely industry and applications.

The industry side of the group focuses on the following:

- Semiconductor product market research (memories, microcomponents, ASICs and so on)
- Vendor analysis
- European geopolitical issues (trade, tariffs, investment and so on)
- Semiconductor technology trends
- Purchasing issues and trends (what the customer thinks and does)
- The EDA market
- Eastern European devices and applications markets

The applications side of the group deals with electronic applications that use semiconductors and other electronic components and subassemblies.

The group provides four research programs in total. There are two "industry" programs and two "applications" programs, as follows:

- Industry
  - Semiconductors Europe (SEMI-EU)
  - Electronic Design Automation Worldwide (CEDA-WW)
- Applications
  - Semiconductor Application Markets Europe (SAMM-EU)
  - Electronic Equipment Production Monitor Europe (SAPM-EU)

Following you will find a description of the research contents and scope of each of these programs.

Semiconductors Europe

Dataquest's Semiconductors Europe program provides clients with quantitative and qualitative analysis of product, regional and technology trends in EMEA. Dataquest maintains databases containing information about company market shares, capital and R&D investment and manufacturing capability, to which clients have access through this service. Vendor strategies are monitored closely. The program also follows and analyzes the many geopolitical issues affecting both vendors and users of semiconductors in EMEA, and the impact of these factors is reflected in Dataquest's product and regional market forecasts.

Topical Coverage

Topics covered by this program include the following:

- Competitive dynamics
- Investment
- Industry trends
- Purchasing trends

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Regional Coverage

Market estimates and forecasts are provided for the following countries or regions:

- Africa
- Benelux
- Eastern Europe
- France
- Germany
- Italy
- Middle East
- Nordic
- Rest of Western Europe
- United Kingdom and Ireland

Product Coverage

Market share estimates and forecasts are provided for the following product categories:

- ASICs—Gate arrays, programmable logic devices, cell-based ICs, custom ICs
- Memories—DRAM, SRAM, EPROM, EEPROM, flash, ROM
- Microcomponents—Microprocessors, microcontrollers, microperipherals, digital signal processors
- Analog and mixed-signal ICs
- Discretes
- Optocomponents

Key Databases

This program maintains the following databases to monitor and analyze Europe:

- EMEA semiconductor fabrication database
- Capital and R&D investment by European vendor
- Major OEMs' annual semiconductor spend
- EMEA semiconductor market shares by vendor
- EMEA semiconductor forecasts by product and region

The Analysts

The program manager for Semiconductors Europe is Joe D'Elia. Analysts researching this program along with Joe are Richard Gordon, Edmund Gemmell and Jim Tully.

Semiconductor Application Markets Europe

Dataquest's Semiconductor Application Markets Europe program is the leading information source for market statistics and strategic analysis of the European semiconductor market. The program provides demand-side information and decision support on electronic equipment production and design trends. It has been developed to aid the marketing and strategic planning of semiconductor and other electronic component manufacturers, and it provides market estimates and forecasts of European electronic equipment production and semiconductor consumption.

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Primary Application Coverage

Detailed forecast and trend analysis is provided for the following:

- Electronic data processing—Including PCs, computer peripherals, storage devices and IC cards
- Communications—Central office switches, telephone handsets, data communications equipment and mobile/cellular communications
- Consumer—Including analog and digital audio and video systems, set-top boxes, personal electronics and domestic appliances
- Automotive—Including in-car entertainment systems, body control and vehicle control electronics, driver information (including navigation), power train, and safety and convenience systems

Market Overview

Market estimates and forecasts are provided for the following six basic application markets:

- Electronic data processing
- Communications
- Consumer
- Industrial
- Military and civil aerospace
- Automotive

Key Market Statistics

The following statistics are included:

- Electronic equipment production forecasts in units and revenue
- Semiconductor market forecasts by application
- European country market forecasts by application
- Vendor market shares by application
- High-volume electronic equipment unit production forecasts

Regional Coverage

Market estimates and forecasts are provided for the following countries or regions:

- Benelux
- France
- Germany
- Italy
- Nordic
- United Kingdom and Ireland

The Analysts

The program manager for Semiconductor Application Markets Europe is David Moorhouse. Analysts researching this program along with David are Mike Williams, Andrew Phillips and Paul O'Donovan.

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Electronic Equipment Production Monitor Europe

Dataquest's Electronic Equipment Production Monitor Europe program is the leading source of information on component content trends of new and/or high-volume electronics systems manufactured in Europe. It is intended to be of interest to all vendors of electronic components, from semiconductors to subassemblies. The core research activity involves the disassembly, or "teardown," of key electronics products. Once dismantled, a bill-of-materials listing is made and component prices estimated for each product. A report analyzing the content of the product is then produced, and it includes: a complete listing of all the electronic components found, their sources, quantities per system and estimated prices; commentary on future trends in component usage within the product being analyzed; and, on behalf of the OEM/designer, the identification of scope for cost savings through redesign, using knowledge of emerging component solutions and methods.

Primary Application Coverage

The program will provide analysis of the following 34 key items of electronic equipment:

Electronic Data Processing	**Communications**
Optical disk drives	Analog cellular telephones
Page (laser) printers	Analog cordless telephones
PC motherboards	Answering machines
PCs	Central office line cards
Rigid disk drives	Corded telephones
Serial printers	Digital cellular telephones
Smart cards	Digital cordless telephones
Workstations	Fax machines
	LAN cards
Consumer	Modems
Analog camcorders	Pagers
Analog set-top boxes	PBX line cards
Color TVs	
Digital camcorders	**Automotive**
Digital set-top boxes	Airbag systems
Digital still cameras	Antilock braking systems
DVD players	Engine control units
Personal stereos	Navigation systems
VCRs/VTRs	Stereo systems

Market Statistics

The program maintains the following market statistics databases:

- High-volume European electronic equipment production—Provides history and a five-year forecast of European electronic systems unit production for the 34 products listed, with their factory production ASP and total production value.
- Major European electronic equipment manufacturing locations—Identifies by product, region and company the locations of major European manufacturers of the 34 items of electronic equipment listed. This database, updated annually, is an indispensable marketing tool providing the client with vital information about key potential customers.

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The Analysts

The program manager for Electronic Equipment Production Monitor Europe is David Moorhouse. Analysts researching this program along with David are Andrew Phillips, Mike Williams and Paul O'Donovan.

Electronic Design Automation Worldwide

Dataquest's Electronic Design Automation Worldwide program provides detailed analysis of the industry trends, players, products and end-user issues that drive the market for EDA applications and tools. The program covers the three major EDA application areas—IC layout, electronic CAE and PCB/MCM/hybrid layout tools—and provides the most reliable worldwide market size, market share and market forecast estimates available. The program also provides data, advice and analysis to help clients make informed planning decisions. Publications include a mix of analytical articles, weekly news bulletins and event-driven faxes. Periodic briefings and conferences bring clients together with analysts to share insights and opinions.

Key Topics

Topics covered by this program include the following:

- ES level (ESDA)—Virtual prototypes, hardware and software codesign
- RTL design—VHDL and verilog, synthesis, design for test
- Gate-level design—Schematic capture, analog design, analysis tools
- IC CAD—Physical verification, floor planning, FPGA fitters, IC layout
- PCB design—PCB, MCM and hybrid place and route
- Miscellaneous—Accelerators and emulators, libraries, interoperability tools

Regional Coverage

The program covers the following countries or regions:

- Asia/Pacific (by country)
- Europe (by country)
- Japan
- North America
- Rest of World
- Worldwide

Standard Data Metrics

The following data metrics are covered:

- Total factory, hardware and software revenue
- Service revenue
- Revenue by operating system
- Software shipments
- Revenue by industry sector
- 37 different subapplications by end use and by platform

The Analysts

The program manager in Europe for Electronic Design Automation Worldwide is Jim Tully.

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Japanese Semiconductor Consumption by Application Market: Five-year revenue forecasts of the semiconductor-value composition of various categories of electronic equipment, derived by applying I/O ratios to the equipment production forecast estimates. ***Q2 and Q4 1998***

Japanese Electronic Equipment Production Forecast: Five-year forecasts for six categories and 21 subcategories of electronic equipment, providing a demand-side view of the Japanese semiconductor market. ***Q2 and Q4 1998***

Japanese Wafer Fabrication Facilities: Pilot and production fab lines by company, location, fab name, products produced, process technology, minimum linewidth, wafer diameter, and estimated wafer capacity. ***Q4 1998***

Reports

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Focus Report: A special report focusing on a hot topic in the Japanese semiconductor market will provide you with essential information to support your tactical and strategic planning needs. ***Q3 1998***

Competitive Trends: Details of the organizational structure, financial status, product portfolio strengths/weaknesses, and strategic directions of major Japanese semiconductor vendors will be provided in a comprehensive report on competitive semiconductor trends in Japan. ***Q4 1998***

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January 1998

Dear Dataquest Client,

Best wishes for the festive season and welcome to 1998! This is destined to be a year of exciting changes in the IT industry, and we are looking forward to working closely with you to make it your best year ever.

Like the industries we track, Dataquest is always evolving to keep pace with the times. I am writing to inform you of some of the important changes we have made to better serve you — our valued client — in 1998.

First, you will notice a change to our binder distribution procedures this year —

It has been our policy in past years to provide clients with new research program binders every January. However, because more and more of our clients are moving to electronic delivery via our web site and CD-ROM, binders are becoming less important for filing and retrieving our research publications than in the past. In recognition of this trend, beginning this year we are moving to an "evergreen" binder which is reused year upon year. This means that you will use your current binder to house your 1998 DQ document collection. A binder spine, tab dividers, and instructions for updating your binder are provided in this mailing.

Second, please look for your "DQ Archive CD-ROM" in January * —

Toward the end of January, you will receive your *DQ Archive CD-ROM.* This customized tool — created just for you — will house electronic copies of documents published through December 1997 for all of the research programs to which you subscribed during that year. We believe that this CD-ROM will serve as a handy electronic archive whenever you need to look back at a document from 1997, and will enhance your productivity in using past issues of Dataquest's market research publications. (* Current clients of our CD-ROM will receive this archive CD as part of the normal, monthly CD-ROM mailing.)

Third, we are improving our publishing system in 1998 —

I am pleased to announce that we will be moving to continuous publishing during 1998 — a tremendous step forward for Dataquest. As our research documents are released from editing, this automated publishing system converts them to web, CD-ROM, and paper formats with only minor intervention required by our Interactive Services staff. The benefit to you is that documents are published more quickly and efficiently in hard copy format, and reach the web site more rapidly.

Lastly, we will be introducing our new brand identity —"Gartner Market Dynamics"—
All companies in the GartnerGroup family will reflect a new corporate brand identity, which will roll out over the course of 1998. We will continue to be called ***Dataquest,*** but you will also see us referred to as a part of Gartner Market Dynamics, the market research arm of Gartner's Advisory Services. **You will see this branding reflected as** we update our letterhead and marketing collaterals during the year.

So, you can see that 1998 is going to be a year of changes for Dataquest. By streamlining operations and introducing you to electronic delivery via the *DQ Archive CD-ROM*, we are positioning Dataquest to better serve you — now and in the future.

As always, I welcome your comments and feedback on Dataquest directions.

Sincerely,

R. And Holtvedt

R. Andrew Holtvedt
President of Dataquest and Senior Vice President, GartnerGroup

X

Perspective

Semiconductors Japan
Market Analysis

Restructuring Goes On at Japanese Semiconductor Fabs

Abstract: *In 1998, industry reorganization has emerged as a trend against the backdrop of an unprecedented downturn in the worldwide semiconductor industry. A variety of factors, including the protracted semiconductor slowdown, weakening profits, changing dynamics for product-specific markets, and system-level integration (SLI) efforts, are forcing chip makers to reconsider their businesses. In this Perspective, Dataquest reviews fab construction trends among the Japanese manufacturers based on the results of Dataquest's fall 1998 semiconductor fab survey. Please note that we are still in the process of finalizing the results of this survey on a global basis, and therefore, our final release of data may vary slightly from what is presented in this Perspective.*
By Yoshihiro Shimada

Overview of 1998 Fab Survey

Three main observations were made from the results of the 1998 fab survey of Japanese semiconductor manufacturers. They are as follows:

- There are no announced plans for building new fabs.
- DRAM fabs are being substantially reorganized.
- Overseas fabs are being substantially reorganized.

Some of these moves have already been announced by chip makers. Moreover, these results are reasonably predictable considering the current state of supply and demand and the earnings environment. However, a comparison with past low points in the market cycle indicates that more significant steps are being taken this time around.

The survey results for Japanese manufacturers are shown in Figures 1 and 2. Note that the numbers provide a comparison with the situation at the end of 1997.

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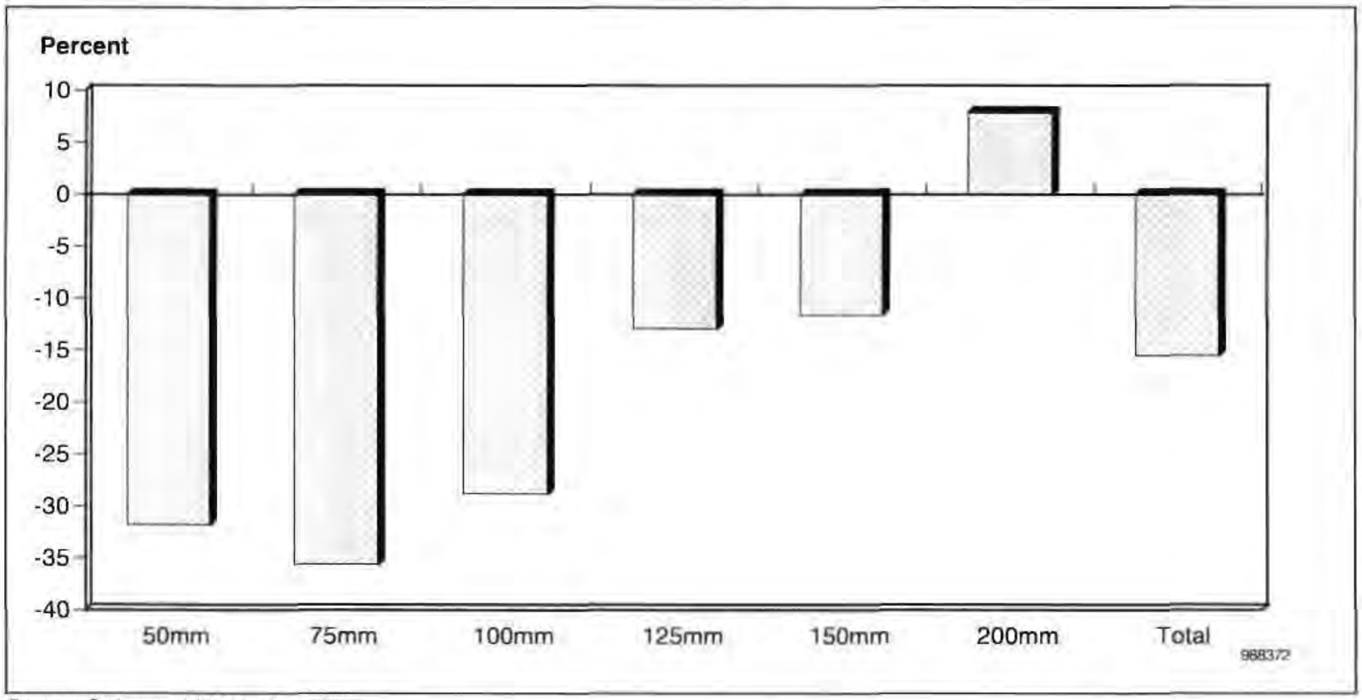
The key points are listed below:

- Among the wafer processing capacity categories, the 50mm to 100mm segments contracted substantially, the 125mm and 150mm segments contracted slightly, and the 200mm segment rose.
- The 0.35-micron process is becoming the mainstay design rule for MOS digital.
- There are 0.25-micron fabs being launched.
- Some chip makers have 300mm fab pilot line plans, but volume production line plans are undetermined.

Figure 1
1998 Japanese Manufacturers' Wafer Processing Capacity by Wafer Size (Change over the Previous Year)



Source: Dataquest (December 1998)

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Figure 2
Japanese Manufacturers' Production Capacity by Operating Minimum Geometry (Change over the Previous Year)

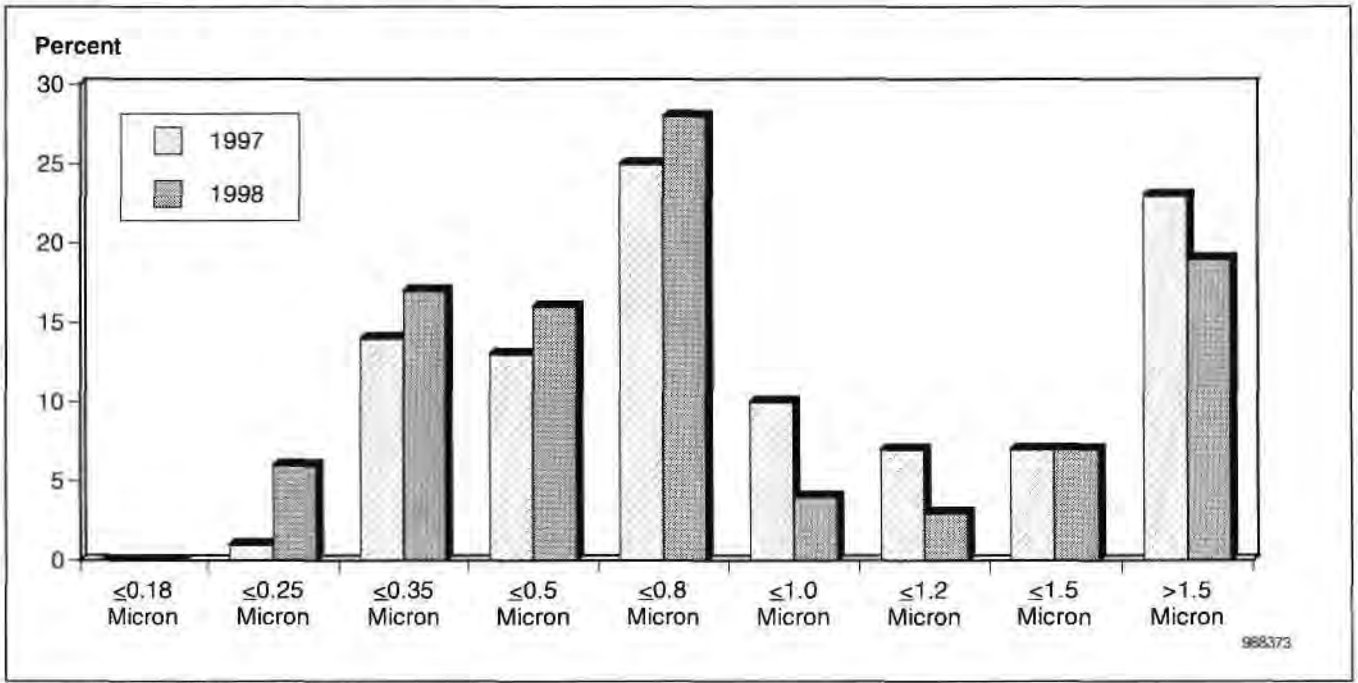

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Figure 3 shows the state of DRAM production capacity by memory size for Japanese chip makers. The 200mm fabs designed primarily for DRAMs began operation in 1994 and continued to be built to keep up with the sharp increases in semiconductor demand from the PC boom. Facility launches were equally harried, with only six months between the start of volume production and escalation to maximum equipment output levels. Unable to apply the brakes to this rapid expansion of wafer processing capacity, new facility launches continued even after the DRAM market conditions reversed their course from the end of 1995. However, by 1997, new fab construction had ended, and no new line launches were reported for 1998.

Chip shrink techniques, which have gained rapid acceptance by chip makers as a way of improving profitability, dramatically increase the number of devices obtained from a fixed amount of wafer processing capacity and have worked against the dissolution of excess production capacity. Even though this makes it possible to achieve production capacity expansion while delaying the construction of new 200mm fabs, Dataquest expects continued investment in 200mm fabs by the semiconductor industry as a whole; this is because investment in 64Mb-and-later-generation, high-speed DRAM facilities is being given priority, and the useful life of 200mm fabs is being extended by a move to push back the timing of a switch to 300mm fabs. The question is whether Japanese chip makers will make these investments on their own or whether they will utilize resources outside of their own operations.

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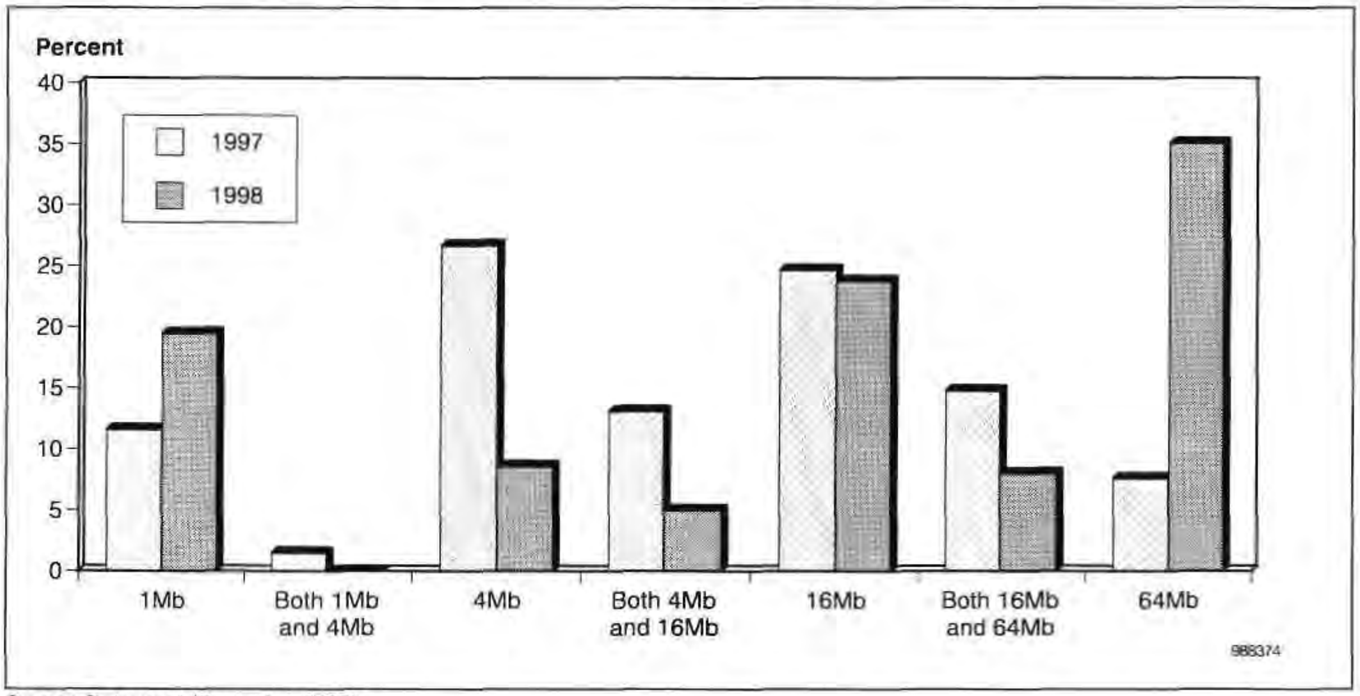
Figure 3
Japanese Manufacturers' DRAM Production Capacity by Memory Size



Source: Dataquest (December 1998)

Despite the shift for MOS digital devices to 200mm fabs, 150mm fab facilities are relatively stable with support from the shift by analog 100mm and 125mm fabs. Dataquest's wafer consumption forecast expects just a slight decline in worldwide 150mm wafer consumption, and we believe that 1998 fab trends are in line with this forecast. 100mm and 125mm fabs were operating through the mid-1990s to fill analog and discrete device demand, but the transition to larger-diameter wafers began with the wafer shortages experienced during the 1994-to-1995 time period. Meanwhile, even though investments to expand fab capacity for MOS digital devices are on hold, investments in fabs to satisfy analog device requirements have continued. Specifically, these investments are aimed at responding to high-growth products such as mixed-signal ICs, power devices, and high-frequency devices, as well as to growing demand for linear ICs, which contain standard analog devices.

Trends by Product Type

Reviewing the situation by product type, it is evident that the number of DRAM-dedicated fabs has dropped sharply. Even when adding fabs that combine DRAMs with other devices, it is clear that the DRAM presence is declining. We believe this is happening for the following reasons:

- Even though volume demand is strong, chip shrink techniques enable production volume increases without expanding wafer processing capacity.

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- Chip maker fab investments are being reduced by utilizing external resources such as foundries and OEMs.
- Acceleration of the chip shrink trend is making older-generation fabs outdated and unable to compete.
- There is already adequate capacity for other device types that might be used as a conversion alternative or for facility sharing.

As things currently stand, the primary focus in DRAM capacity strategies is on increasing production volumes through chip shrink techniques, and new investments are dominated by facility upgrades to accomplish this. Therefore, DRAM fab investments in 1998 are dedicated mainly to 0.18-micron design rule capabilities, moving forward with greater precision. Leading chip makers expect to have prototypes using the 0.18-micron process at the end of this year and intend to embark on volume production in 1999.

Logic fabs are also increasing design rule precision to 0.25 micron, and investments in 0.18-micron facilities are beginning to be made for system-level integration (SLI) devices. Looking at process technology line widths, logic fabs have caught up with DRAM fabs at the 0.25-micron mark. Furthermore, the facility investment burden for logic fabs is rising in order to introduce planar technology required for multilayer logic devices and process integration to deal with embedded memory and analog function elements.

This survey has confirmed the development of two distinct types of logic fabs. One is an application-specific standard products (ASSP)-oriented fab, and the other is a microcontroller (MCU)- and ASIC-oriented fab. For the former type, the main focus is on reducing costs by enhancing productivity, and for the latter type, productivity improvements are being accomplished by stabilizing yields with process integration. Considering the product technology and production technique, the expression "microcomponent core ASIC" can be applied.

These product-specific trends are creating clear distinctions among the fab construction investments of Japanese chip makers. Naturally, the restrictions on capital spending resources vary by company, and differences in earnings structures also produce differences in capital investment approaches. However, capital spending investments ultimately are guided by product strategies. Dataquest expects to see differences in the capital-to-application capital spending investment stances having a significant impact on the positioning of Japan's chip makers.

Capital Investments

Dataquest is currently in the process of conducting a survey on capital investments by chip makers, and it appears that changes in capital investment levels are linked to the fab survey results. We will report on the details in a separate document, but the gist of it is that leading chip makers are significantly reducing their investment levels.

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The reductions in capital investments during 1998 are most prominent in the area of production-expansion investments primarily for DRAMs. Taking a slightly different angle, the downward trend is steepest for overseas plants (see Table 1). During the DRAM boom, chip makers moved aggressively to establish new overseas plants. However, under the current DRAM recession conditions, the impetus to secure overseas production capacity has subsided considerably as chip makers focused on improving the operating rates at domestic plants and on reducing the foreign exchange risk from yen depreciation. Also, because the chip makers are giving priority to the introduction of chip shrink techniques at domestic plants, in cases where the overseas plants are joint ventures or where production items are jointly developed, Dataquest believes that overseas plants will have considerable trouble staying competitive.

Table 1
Japanese Manufacturers' Overseas Plant Trends

Company Name	Fab Name	Date of Change	Prior to the Change	After the Change
Oki Electric	Oregon	September 1998	Back-end fab in operation	Back-end fab closed
Hitachi (joint venture with TI)	TwinStar	March 1998	16Mb DRAM	Hitachi's share sold to TI (afterward, TI sold the whole share to Micron Technology)
Hitachi	Irving	June 1998	4Mb DRAM, MCU	Fab closed
Fujitsu	Dahrum	December 1998	16Mb DRAM	Fab closed
Matsushita Electronic Industries	Matsushita Semiconductors America (MASCA)	December 1998	New 64Mb fab, suspension of 4Mb fab, continuation of 4/8-bit MCU fab	Operations halted
Mitsubishi Electric	Aachen	Early 1999	16Mb DRAM	Product types changed (embedded DRAM, SRAM, flash memory)
Mitsubishi Electric	Raleigh	March 1998	4Mb DRAM	Wafer fab stopped, packaging continued
Mitsubishi Electric	Raleigh	November 1998	Discrete assembly and test, memory module assembly	Packaging stopped (capabilities moved to Nagano packaging facility)

Source: Dataquest (December 1998)

At overseas plants where older-generation DRAM fabs are being converted to logic and analog device operations, it is becoming increasingly difficult to offer the functionality that customers demand as logic products rely more and more on advanced technologies. The value of these facilities has largely vanished as the benefits of supplying products that use existing technologies at a low cost and free of foreign exchange risk have diminished. Further, countries and regional governments that showed an active interest in attracting semiconductor plants with preferential measures during the strong

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years are not wooing additional investments; this is because a larger number of plants require infrastructure upgrades, and tax revenue is down from the poor earnings performance.

Under these circumstances, there has been a string of overseas plant closures and freezes on additional investments. These appear to be appropriate business decisions for the current situation. However, a longer-term view shows a pattern of extremes in Japanese chip makers' overseas investments, with extremely aggressive investment during the good years and retreat and withdrawal strategies during the bad years. In fact, the passive posture of the Japanese chip makers in the early 1990s, following the rise in overseas plant openings in the latter half of the 1980s, can be cited as a factor in their slow start in the semiconductor boom, which materialized initially in the overseas markets. If the overseas plant strategies of Japanese chip makers are on the retreat merely as a by-product of a cutback in total capital investment levels, these companies run the same risk once again of missing future opportunities.

Dataquest's spring survey forecast a 20 percent reduction in capital investments by Japanese chip makers in 1998 compared to the previous year, but it appears that the actual rate of decline will exceed this level. This larger-than-expected decline in capital investments is a combination of large-scale cutbacks through the postponement of new fab investments and microadjustments to existing fab upgrade and production-expansion investments. The relative share of investment funds going to the packaging process is rising as new test equipment is introduced to handle the growing diversity in package types and higher device speeds. However, chip makers are working to reduce gross unit levels, the basis for determining investment amounts, by enhancing yields and thereby avoiding an excessive rise in investment costs, as has happened with the fab process.

The motivation to limit capital investment is twofold: restrictions on investment resources and a move to stem excess supply capacity. However, the real question is whether chip makers have lost a sense of direction in the industry's so-called focus on "system LSIs." Not only are chip makers unable to determine what facilities are necessary, how to best link products and technology development, and other key strategic points, but they also appear to be having trouble defining an appropriate road map for their own fab operations. This suggests that once economic conditions recover, the chip makers will simply re-start the supply capacity expansion approach to competition.

A less simplistic readying of supply capacity requires a well-reasoned capital investment strategy, which includes the following:

- A strategic narrowing of business areas based on systematic marketing
- A narrowing of production items for company fabs and the selective use of external resources
- Development of a company structure that utilizes external resources

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At the same time, these strategies also involve the following risks:

- Trouble commercializing products if appropriate customers cannot be secured, even if the application-specific narrowing of products is performed in advance at the development stage through systematic marketing
- The need to develop a structure for assessing and minimizing the costs of utilizing external resources

Japanese chip makers are currently in the process of cautiously, but steadily, expanding production consignment to outside companies. However, in cases where the consignments are not for integrated production from the fab to final testing, it is necessary to develop know-how to avoid overlapping tests and understand how to utilize foundry services.

It is difficult to define clear income levels for custom logic production, which cannot assume the high yield levels of classic memory device production. Also, real operating rates are falling because of multiple-lot and mixed-lot production. Thus, facility plans must be worked out using lower yield and operating rate assumptions. This is reminiscent of the generational shift in DRAM production when facilities were allocated on the basis of low yield rates, but yields surprised everyone by rising sharply and then combined with chip shrink techniques to cause excess supply.

Although increasingly complex business management is required for SLI opportunities, given our outlook that restrictions on investment resources will continue, chip makers will be forced to make decisions from the perspective of their total semiconductor business rather than planning capital investments at the individual product or business unit level.

Dataquest Perspective

Far from the initial expectation for a recovery in the world semiconductor market in 1998, conditions worsened, and the overall market contracted, making this a year of serious challenges for chip makers. Meanwhile, the 1999 outlook foresees a return to a path of recovery, and high growth at 20 percent annual levels is expected again in 2000 and 2001. However, this growth pace is just an average for the total semiconductor market. Dataquest expects to see the market split into two segments: chip makers who achieve high growth rates and those who only receive a minor boost. There are two reasons for this departure of fortunes. From the demand side, there are signs that the market is moving from system diversity to integrated systems, and the success of chip makers enjoying the benefits of the SLI era, which hinges on system support, depends largely on whether they can secure suitable customers. On the supply side, investment strategies currently crippled with a variety of restrictions will define the course of chip makers' potential capacities.

Price stabilization is revisiting the DRAM market, beginning with PC100 specification, high-speed devices, and talk of long-term agreements (LTAs) has returned after a long interlude. Meanwhile, in 1999, leading chip makers will prepare 0.15-micron facilities and gear themselves up for the next phase of market growth. Dataquest believes that under these circumstances, semiconductor companies' capital investments require both bold and refined judgment, which ensures that an overall balance in the business and appropriate investment timing are maintained.

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Perspective

Semiconductors Japan

Market Analysis

Silicon Wafer Market in Transition: Moderate Growth Is Expected for the Japanese Market

Abstract: *The silicon wafer market seemed to be in a stage of recovery during the first quarter of 1997. However, the market is staggering again, partly because of the sluggishness of the device market late in 1997 and partly because of reduced wafer consumption caused by the accelerated pace of chip shrinkage in DRAM production. Now, two more forces, the expected changes in regional wafer consumption patterns in the future and a delay in migration to the 300mm wafer process, are working against a market that faces significant changes and turning points. This Perspective analyzes the current state of the Japanese wafer market as well as Japanese suppliers and offers a future outlook for the market.*

By Takashi Ogawa and Clark Fuhs

World Trends in Silicon Wafer Consumption

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MARIA VALENZUELA

According to Dataquest's survey, worldwide consumption of silicon wafers in 1997 increased 7 percent from the previous year to 4,014 million square inches (MSI). This is the result of some recovery seen between late 1996 and early 1997, which was partially offset by a decline that began late in the second half of 1997. At present, the market is losing the momentum that was gained from the temporary recovery. Among the major factors causing the downturn, chip shrinkage is particularly noteworthy. It was accelerated by DRAM suppliers that desperately needed to improve profitability under pressure from the market slump, resulting in a significant drop in wafer consumption.

During the 1Mb and 4Mb DRAM era, the rate of chip shrinkage between the first and final versions was estimated to be in the range of 50 to 60 percent. Since last year, however, DRAM suppliers have accelerated the pace, and 60 to 70 percent reduction has already been achieved in shrink versions of 16Mb

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DRAM. For 64Mb DRAM, for which volume shipments began only last year, shrink versions have been developed over a shorter period of time by using the deep ultraviolet (DUV) technology. As a result, even under the optimistic scenario where bit growth is assumed to reach 60 to 70 percent between mid-1997 through the end of 1998, wafer consumption for DRAM production will remain almost unchanged on a quarterly basis.

Given the effect of the rapid pace of chip shrinkage and the slack device market as a whole, wafer consumption in 1998 is expected to expand at a meager 3 percent to 4,113 MSI, according to Dataquest's July forecast. Furthermore, if device demand continues to wither beyond the current forecast, the wafer market will likely experience negative growth. It is expected to make a rebound in 1999 when the device market will show a modest recovery, but full-fledged recovery will have to wait until 2000 as the crossover of DRAM generations (on a unit basis) is completed. The market will then record two-digit growth in 2000 and 2001. Dataquest predicts that silicon wafer consumption will expand at a compound annual growth rate (CAGR) of 9 percent between 1997 and 2003, reaching 6,825 MSI in 2003.

Japanese Trends in Silicon Wafer Consumption

In 1997, silicon wafer consumption in the Japanese market grew 2 percent to 1,527 MSI, reflecting its sensitivity to DRAM market conditions. Again, the sluggish DRAM market and the accelerated pace of chip shrinkage will continue to suppress wafer consumption in 1998. Although Dataquest expects, as of June 1998, that 1998 consumption will remain unchanged from 1997's growth rate of 2 percent, silicon wafer consumption may experience negative growth, depending on an actual recovery of DRAM demand in the second half of 1998. Recovery will occur in 2000 or afterward, accompanied by the revival of the DRAM market. In 2000, wafer consumption in Japan will reach 1,887 MSI, a 12 percent increase over consumption in 1999.

One of the notable characteristics of the Japanese wafer market is a high percentage of smaller-diameter wafers (150mm or less). This is evidenced by the 1997 distribution of water consumption by diameter: 75mm wafers accounting for 0.6 percent of total consumption in the market (on a wafer-area basis), 100mm accounting for 7.7 percent, 125mm accounting for 21.8 percent, 150mm accounting for 43.9 percent, and 200mm accounting for 25.6 percent (see Figure 1). Because Japanese semiconductor manufacturers have curtailed their capital spending in reaction to the murky market conditions in the past few years, the resulting modification or delay in the planned installation of 200mm fab lines will further delay the shift from 150mm to 200mm fabs in terms of percentage share of wafer consumption. In fact, if this trend of cautious investment continues to prevail in the industry, 200mm wafers will not become the mainstay of the Japanese market until 2001—a sharp contrast to the world market, where they will take over 150mm wafers in 1998.

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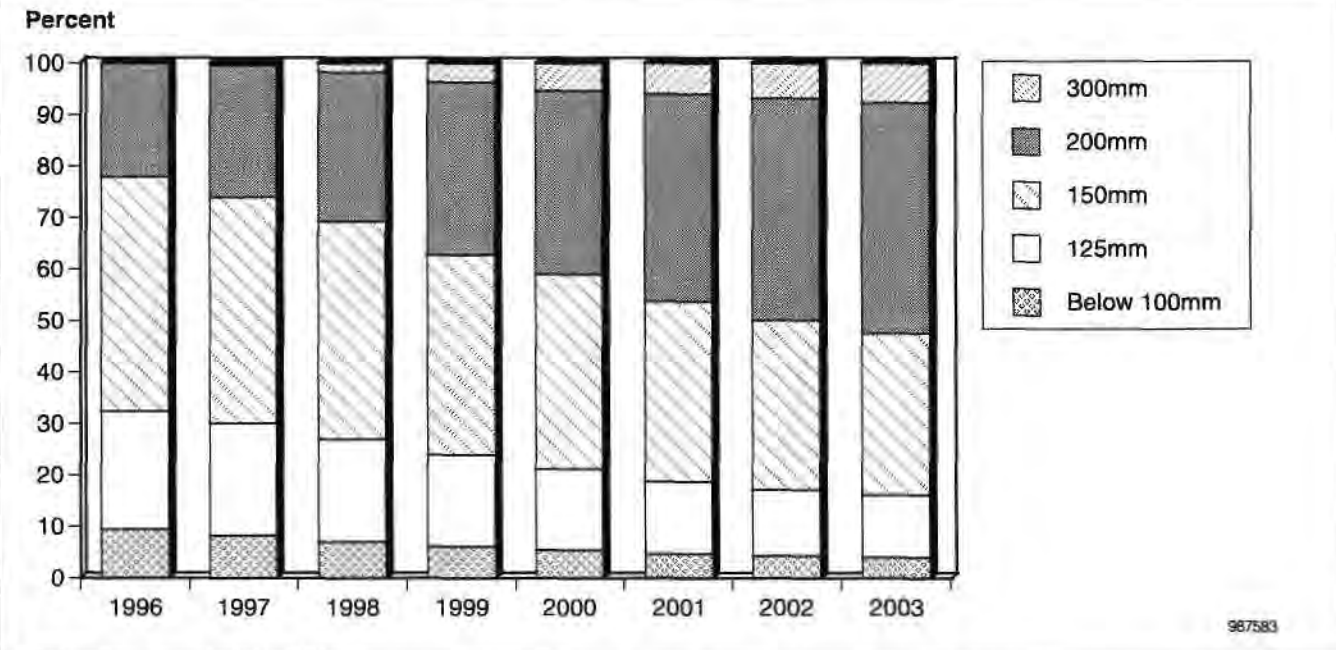
Figure 1
Silicon Wafer Consumption by Wafer Size in Japan, 1996 to 2003



Source: Dataquest (November 1998)

Another important trend is the rapid growth of epitaxial wafer demand for 64Mb DRAM production, which is breaking away from the historical trend, where the Japanese market typically has been a relatively small consumer of epitaxial wafers, primarily using them for discrete and bipolar devices. According to Dataquest's survey, epitaxial wafer consumption for DRAM production (including R&D) jumped from 7.2 MSI to 56 MSI in 1997. Then, after a slowdown anticipated in 1998 because of the DRAM recession, it will grow at a CAGR of 13 percent between 1997 and 2003, amounting to 475 MSI in 2003. Thus, Japan will become the second-fastest-growing market for epitaxial wafers, following the Asia/Pacific market.

In the long run, growth in total wafer consumption in the Japanese market will turn into moderate growth for two reasons: continued investment cutbacks by Japanese semiconductor companies whose business is still highly DRAM-dependent and a decreased reliance on domestic production by Japanese companies as a result of increased procurement from foreign manufacturers through alliances. Dataquest predicts that the Japanese market will record a CAGR of 7 percent between 1997 and 2003, the lowest among four regions (Europe, Asia/Pacific, the Americas, and Japan), and it will lose share in the world wafer market in terms of consumption (see Figure 2).

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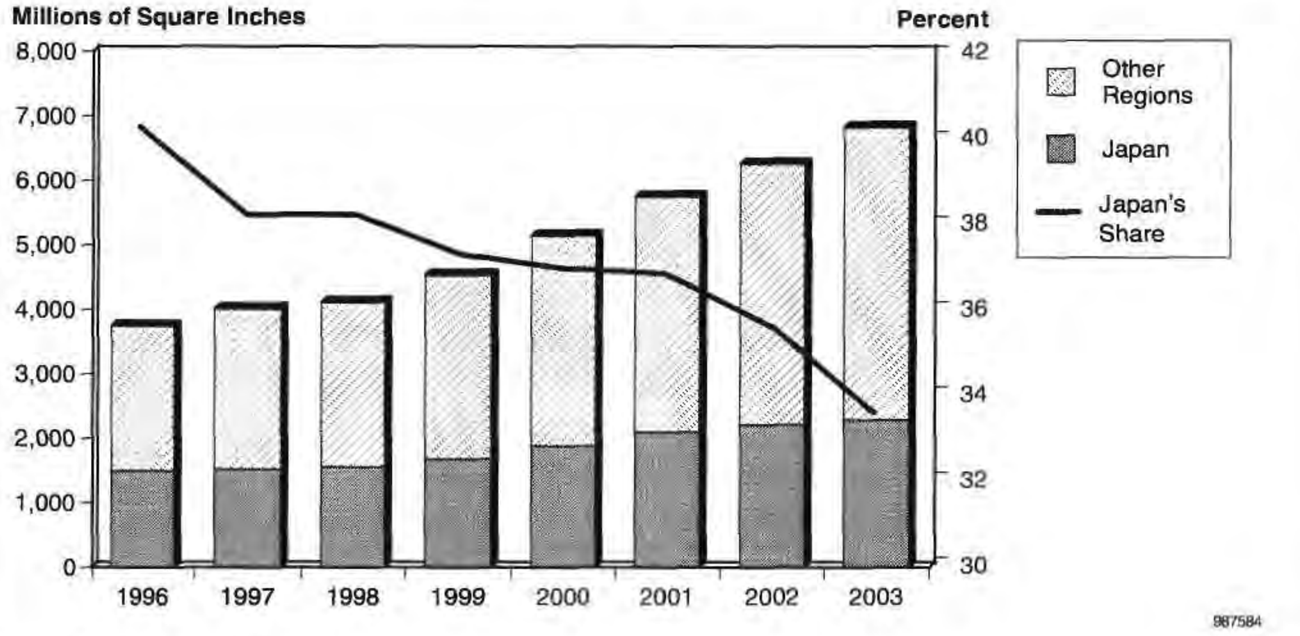
Figure 2
Silicon Wafer Consumption Forecast, 1996 to 2003



Source: Dataquest (November 1998)

Japanese Silicon Wafer Manufacturers: 1997 Market Review

Table 1 summarizes the world market share of Japanese silicon wafer suppliers in 1997 (on a revenue basis), and Table 2 lists their product focus. Share distribution in the world market has remained virtually unchanged during the past decade. In the world market, Shin-Etsu Handotai Co. Ltd. has maintained the leading position with a market share of 24 to 26 percent, and the next five companies, including non-Japanese, have generally stayed within the share range between 10 percent and 12 percent. Japanese companies control a dominant share in the world market. In 1997, they held a combined share of 63.8 percent, while U.S. companies held 15.5 percent, European companies held 13.3 percent, and Asia/Pacific companies held 7.4 percent. In particular, Japanese companies nearly monopolize the Japanese market with an outstanding 90.8 percent share.

Table 1
Japanese Silicon Wafer Makers' Market Share and Revenue in 1997

Maker	Revenue ($B)	Market Share (%)	Market Share Gain or Loss (%)
Shin-Etsu	1.65	23.4	-0.3
Sumitomo Sitix	0.96	13.5	0.7
Mitsubishi Materials	0.75	10.6	1.3
Komatsu Electronic Metals	0.61	8.7	-0.2
Toshiba Ceramics	0.35	4.9	-0.8
NSC Electron	0.16	2.3	0.2

Source: Dataquest (November 1998)

Table 2
Japanese Silicon Wafer Makers' Product Focus in 1997

Maker	DRAM	CMOS Logic Epitaxial	Power/Discrete Epitaxial
Shin-Etsu	X	Emerging	-
Sumitomo Sitix	-	X	X
Mitsubishi Materials	-	X	X
Komatsu Electronic Metals	Small	-	X
Toshiba Ceramics	X	-	X
NSC Electron	X	-	-

Note: The "X" indicates the products that each company makes.
Source: Dataquest (November 1998)

Shin-Etsu, controlling the dominant share, is a key supplier of silicon wafers to DRAM manufacturers, together with MEMC Electronic Materials Inc. (MEMC). Because Shin-Etsu gains most of its revenue from 200mm wafers in the DRAM market, it was directly hit by the slow market in 1997, which was accompanied by wafer price erosion, and its market share fell slightly (0.3 percentage points) from the previous year. Sumitomo Sitix Corporation, which recently merged with Sumitomo Metal Industries Ltd., is a major player in the epitaxial wafer market for CMOS logic applications. It is also a major supplier to Intel Corporation and maintains first place in the U.S. epitaxial market with a 22.7 percent share. The company is now boosting share in the power and discrete IC market.

Mitsubishi Material Silicon Corporation (MSIL) is another important supplier in the epitaxial wafer market for power and discrete devices. Although the market is still small, together with sales in epitaxial wafers for DRAM, MSIL registered strong growth in the Americas market in 1997, a 19.1 percent increase over the previous year, and increased its share by 1.3 percentage points. In the future, the company expects business expansion in the epitaxial wafer market for CMOS logic applications, to follow in the footsteps of Shin-Etsu. Komatsu Electronic Metals Co. Ltd. is a secondary supplier to the DRAM market and the major supplier in the power/discrete device segment. In 1997, it demonstrated healthy annual growth of 19 percent in the epitaxial

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market but lost revenue in the polished wafer market by 13.6 percent, resulting in a 0.2 percentage point decline in its overall market share.

Toshiba Ceramics Co. Ltd. supplies epitaxial wafers for power and discrete devices and DRAM wafers, but the latter is limited to several customers, as is also the case with NSC Electron Corporation. Toshiba Ceramics now is focusing on hydrogen annealed, low-defect wafers and steadily is improving product quality in an attempt to expand its share. Finally, Showa Denko KK announced that it would withdraw from the silicon market entirely in fiscal year 1998.

Global Trends in 200mm Wafer Consumption

In 1997, world consumption of 200mm wafers grew 26 percent to 1,485 MSI. In 1998, however, consumption inevitably will be affected by increased cases of phased-down or postponed construction of 200mm fab lines and a slowdown in consumption by the DRAM industry because of the chip shrinkage boom. In June 1998, Dataquest predicted that the 200mm wafer market would expand at a CAGR of 17 percent between 1997 and 2003, reaching 3,824 MSI in 2003 (see Figure 3). However, because the average monthly shipments during the first half of 1998 remained at around 2.6 million wafers, the short-term results may fall below the forecast. Given the many uncertainties about new fab construction plans—which are heavily dependent on the general economy, the timing of the much-awaited DRAM market recovery, and the development of shrink versions—consistent analysis and vigilant watching are essential. Dataquest expects that essentially all of the reduced levels of wafer consumption for 1998 will take place in the 200mm wafer segment.

It is also important to note that test wafer consumption is experiencing a significant decline, reflecting the maturing of production technology and the increased demand for cost reduction. In particular, consumption of 200mm test wafers in the Asia/Pacific region in 1997 decreased by around 30 MSI compared to the previous year. It is expected to decline further during the forecast period, and as a result, the test/process wafer ratio will change from 1:3 in 1998 (worldwide average) to 1:5 in 2003.

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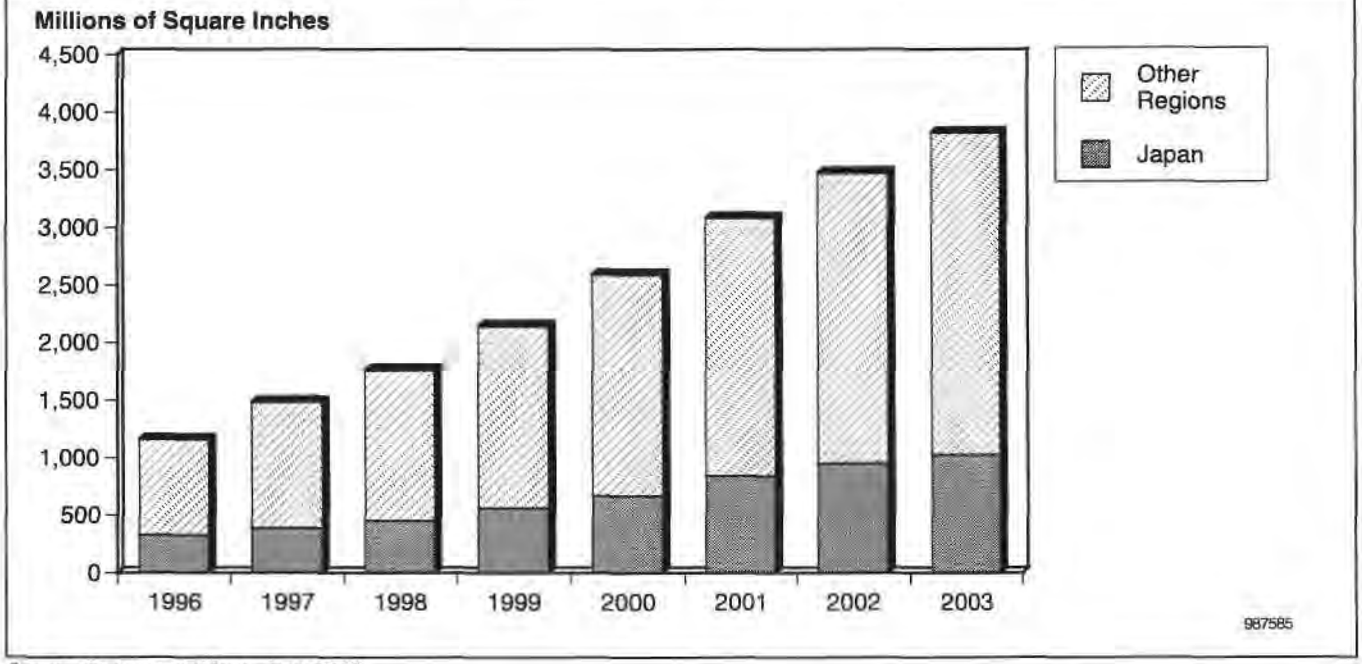
Figure 3
200mm Silicon Wafer Consumption Forecast, 1996 to 2003



Source: Dataquest (November 1998)

Japanese Trends in 200mm Wafer Consumption

In 1997, around 391 MSI of 200mm wafers were consumed in Japan, accounting for 26 percent of the world total; epitaxial wafers represented 26 percent of those (23 percent in the world market). Because demand for 200mm wafers in the Japanese market primarily comes from the DRAM industry, it will be adversely affected in the short run by the sluggish DRAM market and the increased efficiency in wafer use because of chip shrinkage. Dataquest's June forecast expected recovery in the second half of 1998 and double-digit annual growth, but the apparent delay in recovery will likely cause 200mm wafer consumption in Japan to remain flat or record negative growth compared to consumption in 1997. One exception is the demand for epitaxial wafers, which grows steadily because it is driven by demand for 64Mb DRAM production. As a result, epitaxial wafers will account for 30 percent of 200mm wafer consumption in the first half of 1998. In the long run, 200mm wafer consumption in the Japanese market will expand at a CAGR of 17.5 percent between 1997 and 2003.

300mm Wafer Trends and Fab Activity

Technological development efforts to commercialize the 300mm wafer are undertaken through two consortiums—Semiconductor Leading Edge of Technologies (SELETE) and International 300mm Initiative (I300I)—which have produced a number of achievements and deliverables. Nevertheless, semiconductor companies are forced to cut back investments in 300mm wafer

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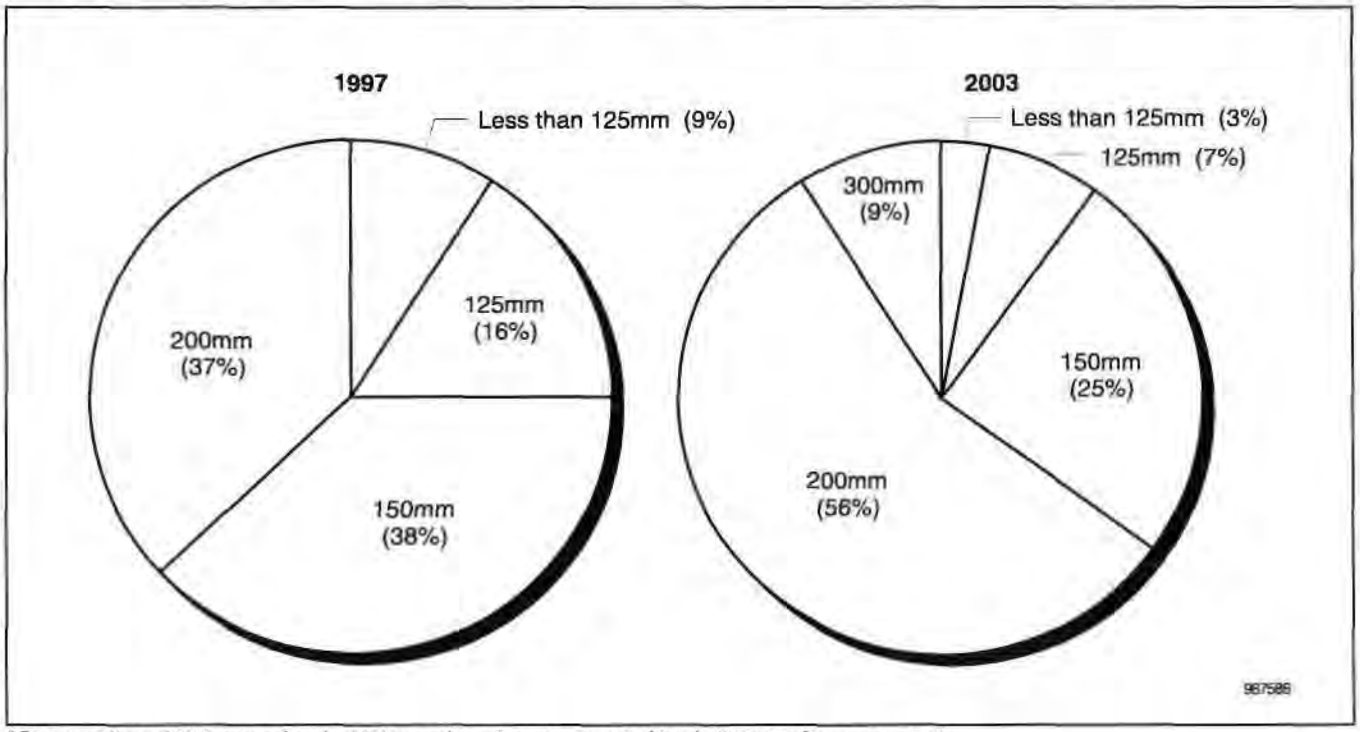
production in order to weather the unfavorable business environment—a grave, but logical consequence of the persistent slump in the device market. Dataquest believes that most of the movement toward 300mm fab construction will be postponed further by another year.

According to Dataquest's fab equipment market forecast, the share of semiconductor equipment for 300mm processes will grow to 2.4 percent in 1998 as the market for R&D and pilot production purposes emerges; it then will grow to 7.0 percent in 1999 and 9.0 percent in 2000, reaching a small peak. Then, after a temporary setback, the market for volume production will ramp up, and 300mm process equipment will boost its share to over 20 percent by 2003. It is assumed that eight to 11 pilot fab lines will be operating by the end of 2001, followed by volume production in 2002, with a substantial wafer volume ramp-up during 2004 and 2005.

In addition to the unfavorable investment climate, 300mm fab plans seem to have lost their impetus because most semiconductor manufacturers are still struggling to find the business case (viability) for the 300mm process in the changing semiconductor market environment. In particular, many Japanese semiconductor companies are striving to cultivate new market opportunities, such as system-level integration (SLI), in an attempt to become less dependent on the DRAM business; it is difficult for them to find proper positioning for the 300mm process technology in future business strategies. On the other hand, the 300mm process seems to be one possible choice for companies that have product offerings in the established monopolistic markets and that can find technical advantages from the new process. Dataquest believes that Intel, IBM, and Siemens AG will likely become early adopters of the 300mm process.

Historically, silicon wafer consumption has experienced the crossover of generations at an interval of six to seven years (on a wafer-area basis). The life cycle of 200mm wafers is expected to be much longer: probably ten to 11 years. The previous crossover occurred in 1998 when 200mm wafers took over 150mm products in terms of volume consumed. At that time, 300mm wafers accounted for less than 1 percent of total silicon wafers consumed and were mainly used for testing purposes related to the development of transportation systems (see Figure 4). The share will grow slowly to reach 9 percent in 2003, which would be almost the sixth year of the historical life cycle. This will be equivalent to 5.6 million wafers.

Figure 4
Worldwide Silicon Wafer Consumption Forecast by Wafer Size, 1997 versus 2003

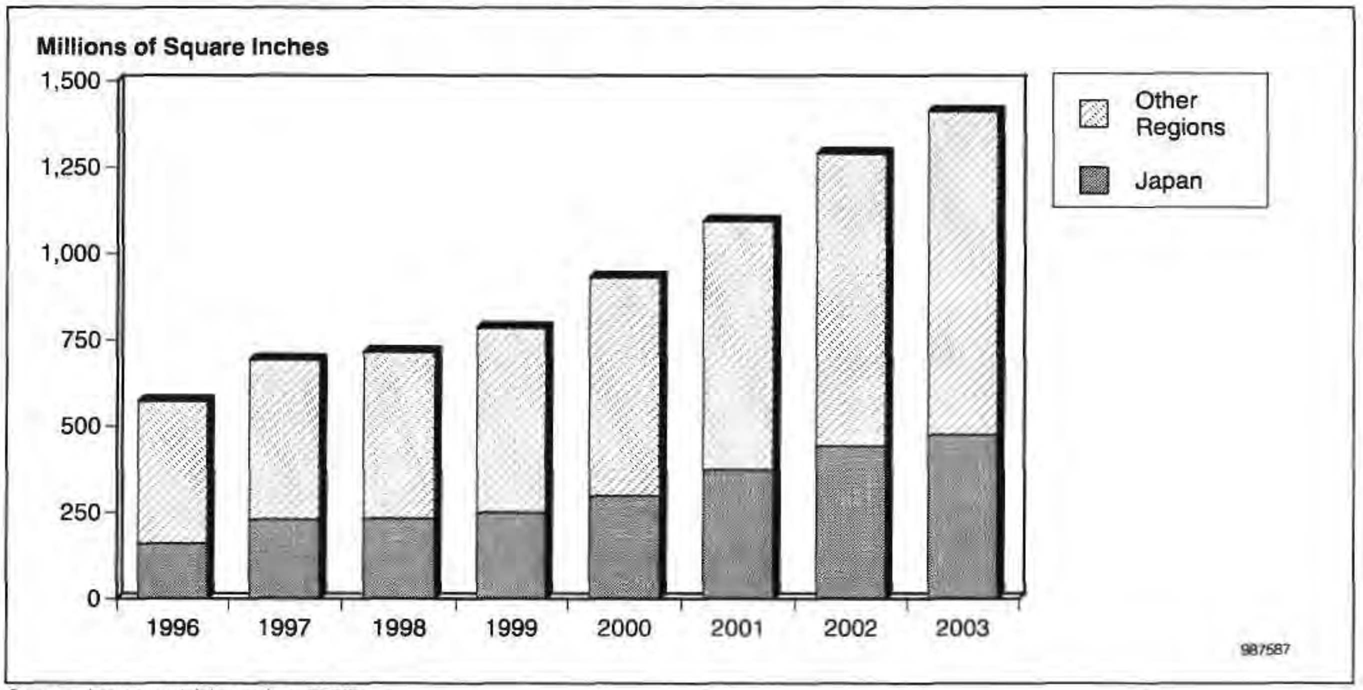


*Consumption of 300mm wafers in 1997 was less than 1 percent of total silicon wafers consumed.
Source: Dataquest (November 1998)

Epitaxial Wafer Consumption Trends

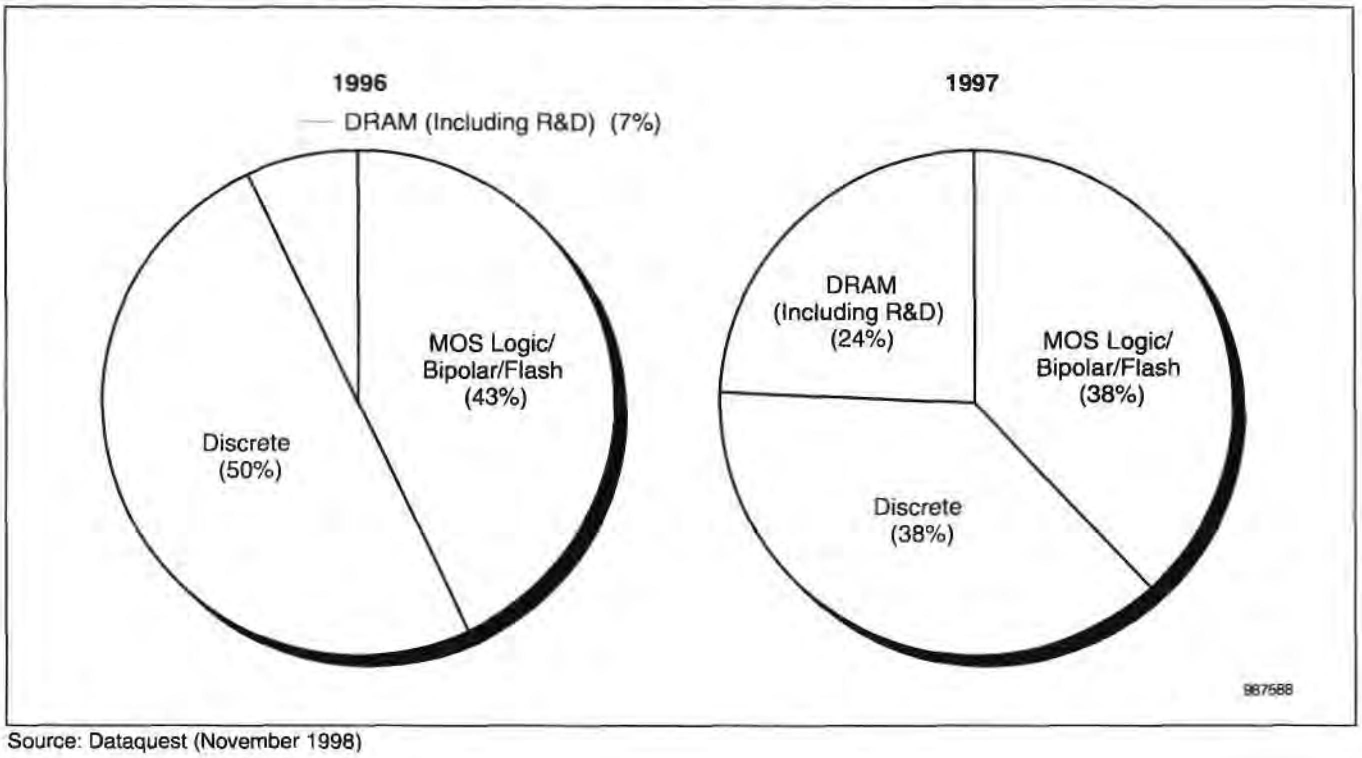
Worldwide epitaxial wafer consumption (merchandise sales only) in 1997 surged 21 percent to 693 MSI, far exceeding polished wafer consumption, which remained at a 5 percent growth rate. In particular, the Japanese market registered an impressive 42 percent growth rate to 230 MSI in 1997 (see Figure 5). In 1997, the breakdown of the world market by application was logic/bipolar/flash memory with 61.6 percent, discrete with 25.4 percent, and DRAM with 13.0 percent. (DRAM applications jumped from 3.0 percent in 1996.) The breakdown was far more conspicuous in 1997 in the Japanese market where the DRAM market still plays a major role: Logic/bipolar/flash memory represented 38.1 percent, discrete represented 37.6 percent, and DRAM represented 24.3 percent (see Figure 6).

Figure 5
Epitaxial Wafer Consumption Forecast, 1996 to 2003



Source: Dataquest (November 1998)

Figure 6
Epitaxial Wafer Consumption by Application in Japan, 1996 versus 1997



Source: Dataquest (November 1998)

Epitaxial demand for DRAM production has risen sharply since the end of 1996 because epitaxial wafers are an effective means of preventing grown-in defects, such as crystal-originated particles (COPs), on silicon wafers. These defects are known to cause a variety of device defects in 0.3-micron-or-finer processes, such as abnormal electric fields below the gate, the poor separation of features, and increased current leakage, depending on the actual position of the COPs.

Meanwhile, other factors that influence epitaxial demand have loomed over the past year. First of all, the persistent DRAM recession forces manufacturers to accelerate the development of shrink versions in a desperate attempt to reduce production costs by improving per-wafer yields. This suppresses wafer consumption while DRAM shipments increase in volume. Second, epitaxial technology was the first to receive industry attention due to its high levels of perfection and reliability. Also, the development of competing technologies—hydrogen annealed wafers and low-COP-type CZ wafers—has progressed steadily with improved performance, so that DRAM suppliers need to be cautious in their choice of wafer technology in consideration of price trends as well as technological advancement.

Nevertheless, Dataquest predicts that epitaxial wafer demand for DRAM production will grow firmly in the medium term at a CAGR of 30 percent between 1997 and 2003. Volume demand will reach 428 MSI in 2003, of which 46 percent will be consumed in Japan. This will fuel epitaxial demand, to achieve a CAGR of 13 percent during the same period, totaling 1,411 MSI in 2003. Similarly, consumption in the Japanese market will grow at an annual rate of 13 percent, bolstered by DRAM demand, and will amount to 475 MSI in 2003, of which the DRAM industry will consume a lofty 42 percent.

Dataquest Perspective

The silicon wafer market is about to experience some significant changes and turning points. The accelerated pace of process miniaturization since 1997, driven by the proliferation of DUV technology, has brought a wave of changes to the silicon wafer market. In particular, this has created a dilemma for the wafer industry because consumption does not grow side by side with increased DRAM shipments. The move is expected to prevail in the medium term, making it necessary for the industry to interpret the market trends on the basis of new criteria to reflect the future evolution of submicron processes (that is, its impact on wafer consumption). A regional consumption pattern will also change. In the past, most of the wafers produced in Japan were consumed locally to meet the gigantic appetite of the fast-growing DRAM industry. In the future, however, domestic consumption will slow down because of increased offshore production and the use of overseas foundries in the form of joint ventures, not to mention the sluggish DRAM market. As a result, domestic consumption market share will drop appreciably.

At the same time, the introduction of a larger-wafer generation will follow a new pattern. The delay in the commercialization of 300mm processes will break the historical pattern, and 200mm wafers will maintain the longest life

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cycle among past generations since the start of product standardization by the Semiconductor Equipment and Materials Industry (SEMI). This means that the wafer industry will face difficulty in relying on its traditional strategy for market expansion, under which it has used larger wafers as a source of value add. In addition to the structural changes in factors affecting profitability, the industry is required to continue capital investment in 300mm wafers. Various moves have recently surfaced as clear signs of response to the situation—for example, the announcement that Showa Denko KK planned to pull out from the market and the merger between Sumitomo Sitix and Sumitomo Metal Industries, which was partly motivated by the need for strengthening the financial base to meet increasing R&D investment. Because wafer manufacturers are facing the same situation as that of chip makers and semiconductor equipment manufacturers, such moves are expected to intensify in order to spread investment risks and boost market share.

Regional wafer consumption trends largely reflect regional device market and production trends. In the Japanese markets that remain in a stage of moderate growth, wafer consumption seems to signify the stagnate semiconductor industry, which is still groping in the dark to find new market opportunities as alternatives to the sluggish DRAM market. Although the need to make a livelihood will likely force Japanese companies to rely on the DRAM business for the time being, there is no doubt that any new direction that they find will have important bearing on the future of the Japanese wafer market. In fact, Dataquest believes that the move for change by the semiconductor industry will not be felt directly by the wafer industry until 2003.

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Perspective

Semiconductors Japan

Market Analysis

Fall 1998 Forecast: Japanese Electronic Equipment Production and Semiconductor Market

Abstract: *Dataquest has brought down its forecast of the semiconductor market in Japan. Economic difficulties both in Japan and other parts of the world, including Asia/Pacific and the Americas, are hurting Japanese electronic equipment production, causing semiconductor consumption to remain below the 1997 level. Persistent oversupply is also a culprit, bringing revenue down even where unit demand is sound. From 1997 to 2002, the Japanese semiconductor market will experience only modest growth, with a 6.7 percent compound annual growth rate (CAGR). However, there will be changes and challenges in each product market, including product transitions in DRAM and an accelerated move toward system-level integration (SLI) ASIC. There are also a number of possible drivers to this semiconductor market forecast, as well as restraints, and the key for resuming growth lies in the overall recovery of Japanese electronics production in various categories, specifically leveraging on infrastructure development.*

By Yoshihiro Shimada, Motoya Ohgami, Masahiro Suzuki, and Yoshihisa Toyosaki

Overview of Electronic Equipment Production in Japan

Japan's economic slump is becoming increasingly severe, with practically no sign of a recovery. This is most starkly seen in the outlook for negative gross domestic product (GDP) growth. Although yen depreciation has improved the profitability of exports, Japan's export markets are drying up. Asian economies, a major destination for Japanese exports, are embroiled in the Asian financial crisis (AFC), and even the United States, Japan's other key trading partner, has begun to show signs of weakening since mid-1998. This economic environment has spelled trouble for Japan's electronic equipment production.

Electronic equipment production in Japan in 1997 rose by 9.7 percent against the previous year on a yen basis, but the real slowdown has taken hold since

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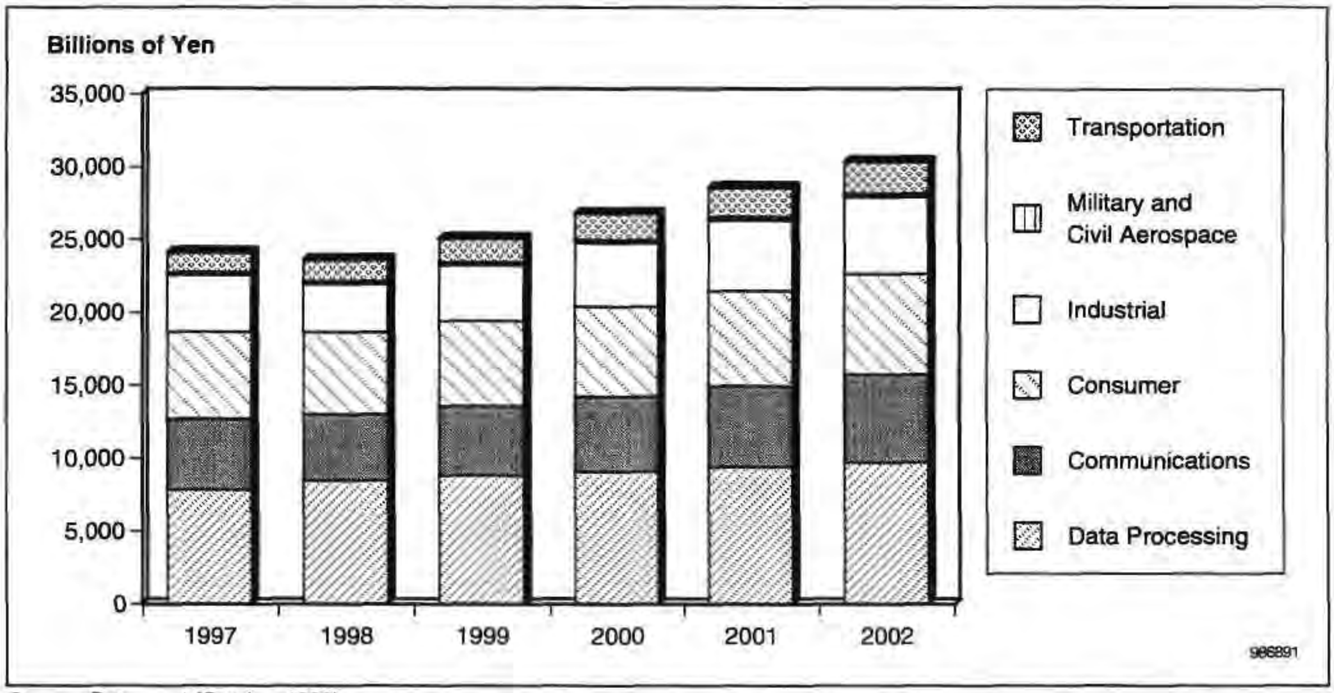
spring 1998. In our spring forecast, Dataquest estimated 3.1 percent growth in Japan's electronic equipment production for 1998. Based on the production results for the first half of 1998, which show a substantial decline in PC and other key electronic equipment production, Dataquest determined that it is necessary to adjust our outlook for 1998 downward. Dataquest expects electronic equipment production in Japan to achieve ¥23,579 billion in revenue in 1998, a 2.1 percent decline since 1997, and to maintain a compound annual growth rate (CAGR) of 4.7 percent during the 1997 to 2002 period (see Figure 1).

Figure 1
Japanese Electronic Equipment Production Forecast



Source: Dataquest (October 1998)

Slumping PC Market and EDP Equipment Production

With the release of Windows 98 delayed until July, PC shipments from January through June suffered a sharp turn for the worst, off 11.9 percent from 1997's shipments to 1.67 million units. Following the release of Windows 98, however, the market is rebounding, fueled primarily by individual demand. Hope is limited for an expansion of demand for PCs used by businesses, which account for nearly 70 percent of the domestic PC market, because of cutbacks in corporate capital spending in response to financial difficulties, including loans. At the same time, client/server systems are picking up as companies move to purchase computer systems to support the introduction of business applications such as enterprise resource planning (ERP) and supply chain management.

In the area of universal serial bus (USB)-compatible peripheral devices, designed to capitalize on the new Windows 98 USB feature, a steady stream of keyboards, mouse units, and other medium- and low-speed equipment is being marketed. Therefore, Dataquest is expecting increased demand not only for new PCs but also for peripheral devices. With the popularity of sub-$1,000 PCs, storage devices such as CD-ROMs, DVD-ROMs, and rigid disk drives (RDDs) are faced with rather difficult price metrics. As a result, CD-ROM drives continue to be primarily available in a 40x speed mode, while 2.5-inch-and-smaller RDDs are becoming the mainstream for thin, high-capacity notebook computers. From the perspective of added value, desktop computers are offering high-speed rotation at 7,200 rpm and faster. Dataquest expects scanners and printers to continue enjoying healthy demand in the input/output (I/O) device segment in Japan.

Dataquest estimates that data processing equipment production in Japan will increase by 7.7 percent, compared to 1997 production, to ¥8,462 billion in 1998. The CAGR for the 1997 to 2002 period is set at 4.4 percent.

A Breather for Communications Electronic Equipment Production

The total number of wireless phone subscribers including those subscribing to personal handyphone systems (PHSs) has surpassed 40 million, but new subscriber growth for personal digital cellular (PDC), the primary domestic digital cellular phone service, is slowing. In contrast to the steady pace of new subscriber growth for PDC service at 700,000 to 800,000 new subscribers per month, PHS, pager, and other service contracts continue their downward slide. Replacement demand for home phone terminals has been reinvigorated by the start of number display service. Nonetheless, the number of new contracts for fixed telephone service is declining as an increasing number of users are opting for mobile phones to satisfy their telephone requirements. In November 1998, regulatory changes are planned that will allow phone service rates to be set or changed through a reporting system rather than requiring permission in advance. Dataquest expects that this will increase the variety of low-cost services offered.

Investment in communications infrastructure in 1998 is tailing off following the completion of the digitization of all telephone office switching systems by the end of 1997. While demand for LAN and WAN systems is strong, the benefits are being discounted by sharply lower hub and router prices. In fact, the Japanese market is now considered to be more price-attractive than other Asian markets—even Taiwan, where Japanese companies used to go for a deal. Dataquest believes that demand for LAN-related equipment will expand at an annual rate of around 20 percent for the next few years.

Communications electronic equipment production in Japan is expected to decrease to ¥4,559 billion in 1998, which is 6.5 percent lower than production in 1997. The CAGR for 1997 to 2002 is forecast to be 4.3 percent.

Digital Systems—A Bright Spot for Domestic Consumer Equipment Production

Japan's consumer equipment market for audiovisual equipment is rapidly being digitized. In the audio equipment area, mini-disc (MD) shipments are posting solid gains. MD functionality is no longer only a portable phenomenon and can be found as a standard capability in minicomponent systems. As a result, its growth is expanding into all sectors, including replacement demand. Meanwhile, in the video equipment market, DV-C

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shipments are sharply increasing. On a domestic shipment basis, DV-Cs account for 70 percent of all video camera volume, surpassing analog video cameras.

The digital still camera (DSC) market is discovering two distinct segments: a high-pixel-density version with over 1 million pixels and an economy version. With more than 30 companies participating in this market, excessive competition is a concern. Demand is also expanding in overseas markets for application as a simple image input device for Internet home page creation. However, this opportunity is being challenged by the expense of DSC compared to the recent emergence of flatbed-style scanners, which are selling in the ¥20,000 range. DVD player revenue growth is expected to exceed 100 percent in 1998, compared to 1997, but shipment volumes are still small. The conditions for further expansion of this market are in place as consumer prices for a stationary system are down to around ¥30,000, and DVD software offerings are being enhanced.

Domestic production in existing TV and VCR markets improved in 1998, spurred by the Nagano Olympics and World Cup Soccer, major sporting events that had a positive effect on the sales of wide-screen TVs. Upcoming opportunities in this market include receiver equipment for earth-based wave digital broadcasts and broadcasting satellite (BS) digital broadcasts scheduled to begin in 2000. Given these developments, Dataquest expects continued growth in demand for wide-screen TVs with high-image quality and multiple functions. In contrast, Dataquest expects negative growth for air conditioners, refrigerators, other consumer appliances, and VCRs.

Dataquest estimates that the value of consumer equipment production in Japan will be ¥5,624 billion in 1998, a 5.3 percent decrease from 1997 production. The CAGR is forecast to be 3.1 percent from 1997 to 2002.

Trends for Other Electronic Equipment Production in Japan

With the worsening economic situation, capital investments in manufacturing have substantially dropped off. Facility operating rates are also lower, and temporary operation halts have been introduced in some cases. The production of production-related and machining equipment is down across the board for the first half of 1998, with negative annual growth of 20 percent or more. Meanwhile, the necessity of monitoring equipment and other security applications in the safety and security alarm markets is expected to grow. For all industrial electronic equipment, Dataquest expects a 1998 production value of ¥3,316 billion, a 15.0 percent decline from 1997 production. A CAGR of 6.3 percent is forecast for the 1997 to 2002 period.

Although the number of new vehicles registered in Japan's domestic car market recorded a double-digit decline from 1997 in the first half of 1998, sales of car navigation sets continued posting steady growth. This market received a boost from the start of the Vehicle Information and Communication System (VICS) transportation information service, and currently more than 600,000 car navigation systems with VICS functionality have been shipped. There are also plans for evolving this system into an all-around information service with more sophisticated capabilities than

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Intelligent Transport Systems (ITS). The value of transportation electronic equipment production in Japan is expected to be ¥1,428 billion in 1998, a 7.9 percent increase from 1997 production. The CAGR from 1997 to 2002 is forecast to be 10.4 percent.

The 1998 Semiconductor Market Disappoints

In a forecast update issued in July, Dataquest put forth a scenario of 1.4 percent growth in the 1998 worldwide market, compared to the same market in 1997. However, the market has continued to lose ground, and there is little doubt that even this scenario is no longer attainable. The following points can be cited as causes of this market's decline:

- Continuing downward slide in DRAM prices—Chip shrinking and other efforts to secure supplier-side profits are backfiring on the elimination of oversupply.
- Growing AFC impact—The AFC has spread on a worldwide scale and is causing an economic slowdown in the United States and other regions.
- Oversupply is spreading to the entire semiconductor market—Market conditions began weakening for microcomponents and logic devices late last year, and this trend has extended to analog and discrete devices. Foundry demand is also rapidly declining.
- Oversupply of electronic equipment—Production adjustments are starting for electronic equipment, and either demand for semiconductor volume is temporarily falling, or the pace of growth is slowing.

Eliminating Excess Supply Capacity

When setting forecasts for the semiconductor market, Dataquest formulates a supply/demand scenario and uses this as the basis for analyzing semiconductor consumption trends. The scenario adopted for this market forecast is outlined as follows:

- Shortages of PC100-specification DRAMs are already occurring, and facility investment cutbacks, factory closings, and other efforts to adjust supply capacity for the entire DRAM segment have started. In light of these circumstances, Dataquest believes that the DRAM supply/demand will balance in mid- to late-2000.
- A restoration of the supply/demand balance for the overall semiconductor market is expected to occur approximately one to two quarters after the DRAM supply/demand balance recovers.
- As a result, there will be a slight shortage in the semiconductor market in 2000, and market conditions will recover. The positive market conditions will continue through 2001, and this will prompt a reinstatement of capital investment.
- Supply capacity will expand because of the increasing capital investments, and another excess supply situation will occur in 2002. Affected by a mild worsening of market conditions, the peak in market

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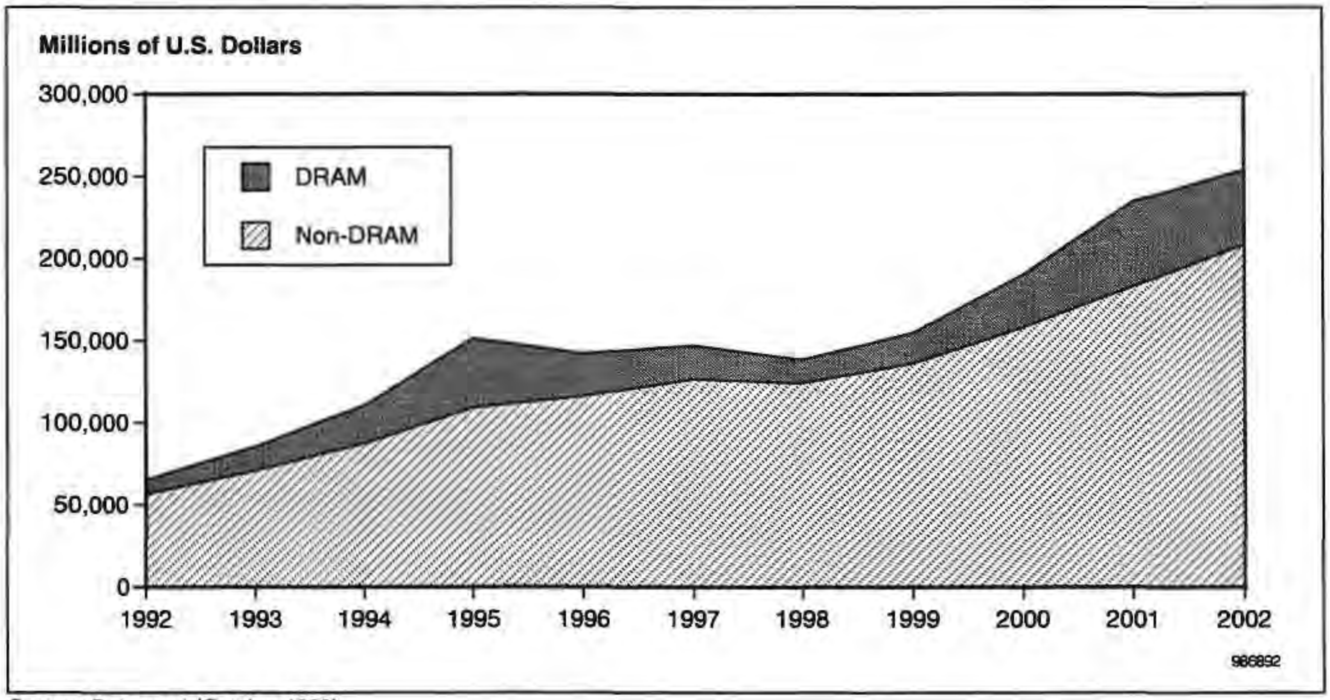
growth rates is expected to occur in 2001. Furthermore, negative growth is only expected for the DRAM segment. The rest of the semiconductor market will continue growing.

The main culprit behind the semiconductor market slump since the end of 1995 has been excess supply capacity. Since 1997, however, the market sentiment has shifted, and slowing demand has emerged as the key factor dragging the market. The phase during which adjustments of supply capacity had a significant impact on semiconductor market trends is approaching an end, and the primary question is whether demand can continue expanding. This is the scenario on which the current Dataquest forecast is based. Accordingly, in 1998, Dataquest expects a 5.9 percent decline for worldwide market growth and a 15.8 percent decline for Japan's market growth, compared to 1997. The main points of this forecast are as follows:

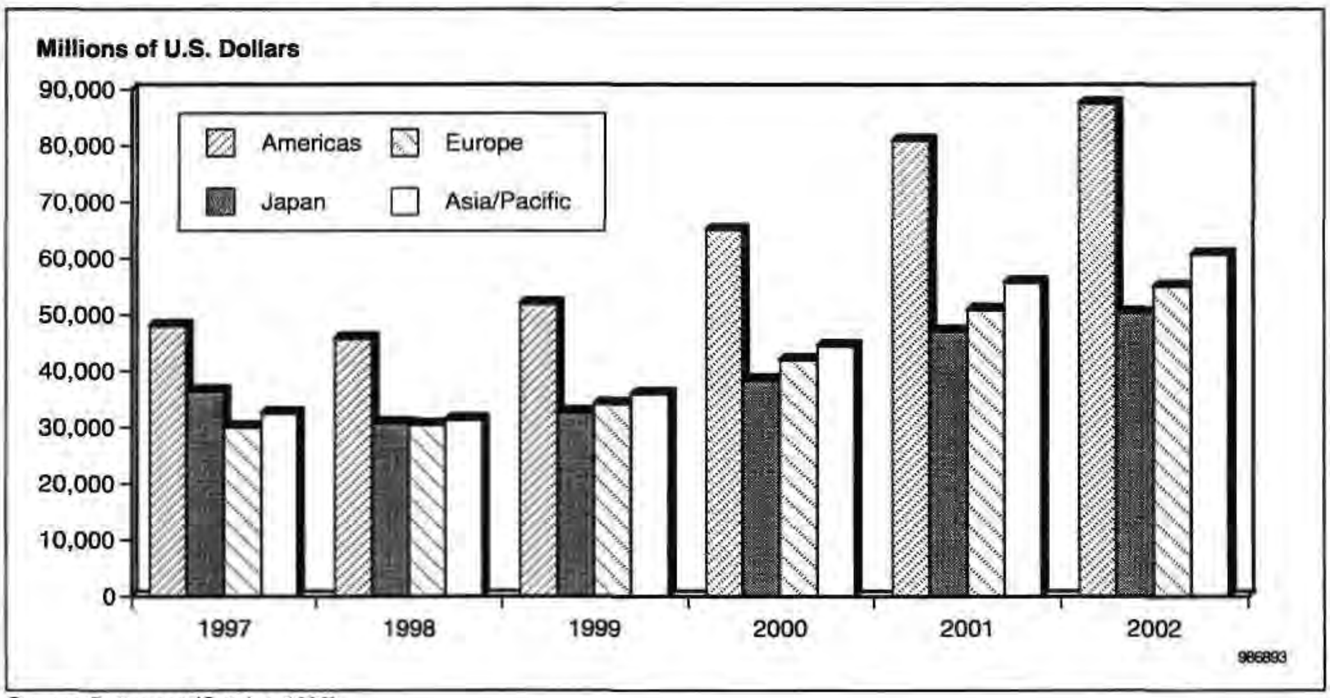
- 1998
  - The worldwide semiconductor market will again post negative growth (see Figure 2).
  - The DRAM market, following three consecutive years of negative growth, will contract to one-third of the historical peak reached in 1995.
  - The "non-DRAM" category, which previously managed to experience positive growth despite negative growth in the overall market, will also record negative growth this year.
  - The Japanese market, affected by yen depreciation, is turning in the weakest results and will be surpassed by the Asia/Pacific market (see Figure 3).
  - The only region likely to record positive growth in 1998, compared to 1997, is the European market.
- 1999 and later
  - The worldwide market in 1999 will begin to recover with double-digit growth.
  - Growth rates will be highest in the Americas and lowest in Japan. As a result, the Japanese market will be surpassed by Europe and will become the smallest of the four regional markets.
  - The supply/demand balance is expected to improve in 1999, and positive market conditions will be enjoyed in 2000 and 2001.
  - A mild adjustment period will occur in 2002 with DRAM revenue falling to negative growth and overall semiconductor market growth slowing to the single-digit level.

Figure 2
Worldwide Semiconductor Market Forecast



Source: Dataquest (October 1998)

Figure 3
Regional Semiconductor Market Forecast



Source: Dataquest (October 1998)

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Drivers and Restraints

Dataquest's market forecasts are based on the "most likely scenario," as described previously. However, actual market trends will change depending on the manner in which various factors move, either upward or downward. The main elements that could affect market trends for the current forecast are the following:

- Drivers
  - Short-term (1998 to 1999)
    - Improvement in domestic economic trends (personal consumption trends and capital investment)
    - Early recovery of the Asian economies
    - Future Olympic demand and progress in audiovisual-related infrastructure projects
    - Stabilization of DRAM prices
  - Long-term (2000 to 2002)
    - Recovery in the domestic economy
    - Progress in infrastructure projects that link the digital consumer, communications, and data processing segments, and related increases in domestic electronic equipment production
- Restraints
  - Short-term (1998 to 1999)
    - Continuing economic weakness in the Asian and Japanese economies
    - Sluggish replacement demand as the level of mobile communications equipment dissemination rises
    - DRAM price stabilization limiting the pace of megabyte demand expansion
  - Long-term (2000 to 2002)
    - Delays in information communications infrastructure development
    - Falling prices because of intensified competition in system-level integration (SLI)

The forecast for growth of electronic equipment production in Japan is the lowest of the four regions. Likewise, the 6.7 percent dollar-based CAGR for Japan's semiconductor market for the 1997 to 2002 period is also the weakest (see Figure 4). Although from past experience Dataquest knows that growth in Japan's semiconductor market is accelerated during periods of yen strength, Dataquest's market forecast is based on a constant exchange rate in future years (see Figure 5).

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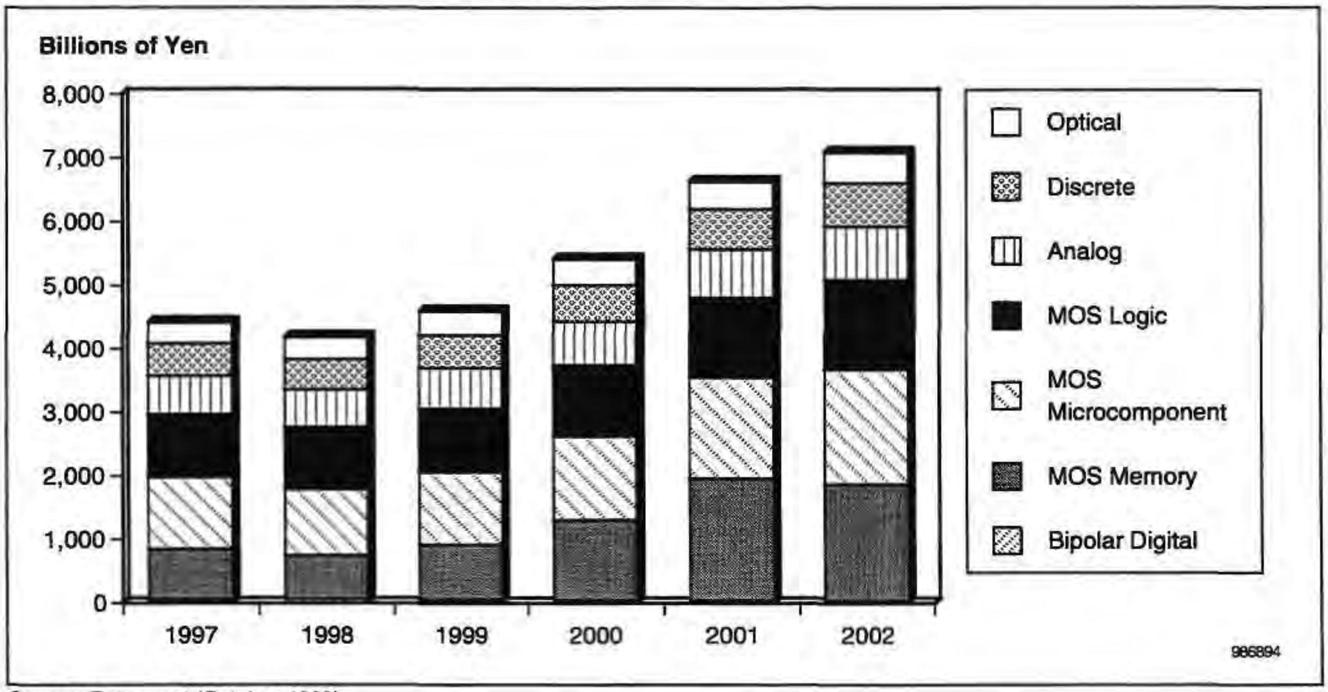
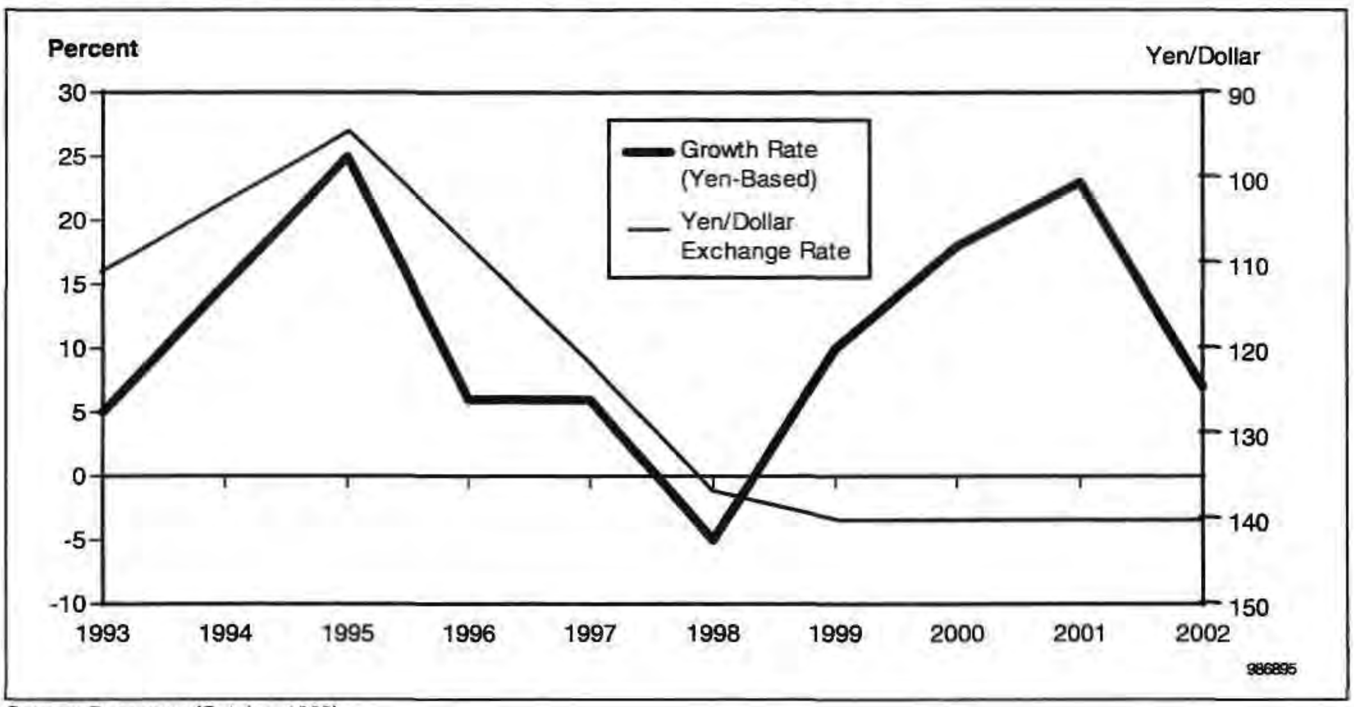
Figure 4
Japanese Semiconductor Market Forecast



Source: Dataquest (October 1998)

Figure 5
Japanese Semiconductor Market Growth and Exchange Rate



Source: Dataquest (October 1998)

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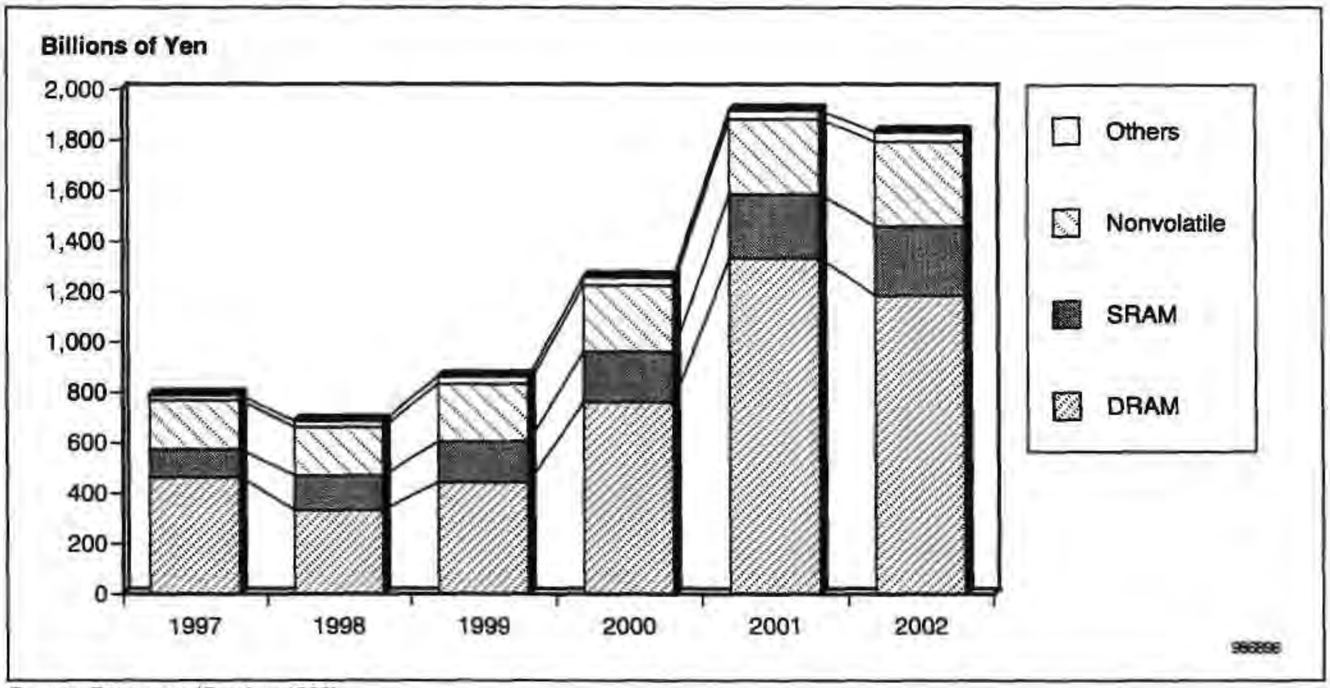
MOS Memory Market in Japan

Dataquest expects the MOS memory market in Japan to decline 13 percent (22.8 percent on a U.S. dollar basis) in 1998, compared to 1997 (see Figure 6). This represents a hefty downward adjustment of 20.0 points from the spring forecast. The primary factor behind this forecast revision is the rapid pace of DRAM price deterioration, which has been much faster than originally thought because of excess supply capacity, a similar pattern to what is happening in the worldwide MOS memory market. In the spring forecast, Dataquest stated that the activities of Korean manufacturers in 1998 would significantly affect DRAM prices and that plummeting 16Mb DRAM prices would also affect 64Mb DRAM prices. In fact, these worries have become a reality over the course of this year. Shipments of 16Mb DRAMs by Korean manufacturers in the first half of 1998 at levels far exceeding demand triggered a downward price slide for not only 16Mb DRAMs but also 64Mb DRAMs. In the 1998 MOS market, static RAM (SRAM) and other MOS memory devices will compensate for the negative DRAM factor.

Figure 6
Japanese MOS Memory Market Forecast



Source: Dataquest (October 1998)

From 1999 onward, Dataquest again expects the MOS memory market in Japan to follow the worldwide market trend, in which the DRAM and nonvolatile memory segments return to positive growth while solid SRAM performance continues. A full-scale expansion of the market will not happen until 2000, and this phase will peak in 2001 with a drop back to negative growth in 2002. The outlook also follows the worldwide market cycle. Dataquest believes that the dip in 2002 will occur when the colossal DRAM market takes a downturn from the negative effect of a generational transition from 64Mb to 256Mb memory devices. Japan's MOS memory market CAGR

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for the 1997 to 2002 period is forecast to be 18.3 percent, a 2.9-point upward revision from the spring forecast's projected CAGR.

DRAM Market in Japan

On a product basis, Dataquest is forecasting a 28.2 percent decline in Japan's DRAM market in 1998 (36.3 percent on a U.S. dollar basis) compared to 1997. This is a sizable downward adjustment of our spring forecast. Just as in worldwide market forecasts, the dramatic reductions in DRAM prices at a pace way beyond original expectations are forcing lower forecasts. Even though DRAM-makers have taken steps to reduce capital investment plans, they also have adopted a strategy of maintaining shipment volumes at a certain level through the introduction of reduced-size chip technology and OEM procurement from Taiwanese manufacturers, while keeping capital investment budgets to a minimum. Moreover, DRAM-makers already have sufficient production capacity with existing 16Mb DRAM facilities, and it is this product area (16Mb DRAMs) that can be blamed for the DRAM price slide.

However, Dataquest sees the shift in PC DRAM demand from the 66-MHz type to the 100-MHz type picking up speed in the latter half of 1998 and believes that this will require more advanced production facilities. In 1999 and thereafter, DRAM-makers will need 0.2-micron-level production facilities to keep up with high-speed DRAM demand. Capital investments in 1998 and 1999 will be vital for maintaining production capacities based on such advanced facilities at a certain level. The implementation of finer process technology is moving forward at a faster pace than it did previously. Dataquest expects this trend to continue, and therefore, Dataquest foresees DRAM-makers having to shoulder an even heavier capital investment burden.

Dataquest's positive growth forecast for 1999 is based on an assumption that production capacity using advanced facilities will be introduced in balance with demand. Dataquest expects the DRAM market in Japan to enter a phase of full recovery in 2000, with a peak reached in 2001. Thereafter, in 2002, the market will be revisited by negative growth. Dataquest forecasts a CAGR of 20.6 percent for the 1997 to 2002 period.

Nonvolatile Memory Market in Japan

Dataquest's forecast for the nonvolatile memory market in Japan is a 1.5 percent decline (12.5 percent on a U.S. dollar basis) in 1998 compared to 1997. This represents a 1.8-point downward adjustment from the spring forecast. Dataquest's decision to lower the forecast was prompted by a change in the flash memory outlook from positive growth to slight negative growth. Over the next few years leading up to 2002, Dataquest expects that flash memory and EEPROM will turn in positive-growth performances, but it is worth emphasizing that the real driver in the nonvolatile memory market is flash memory. Dataquest is sticking to its view that the EEPROM market will shrink and the mask ROM market will be flat.

Portable equipment such as mobile phones is the primary application fueling growth in the flash memory market. Japan's semiconductor makers, in

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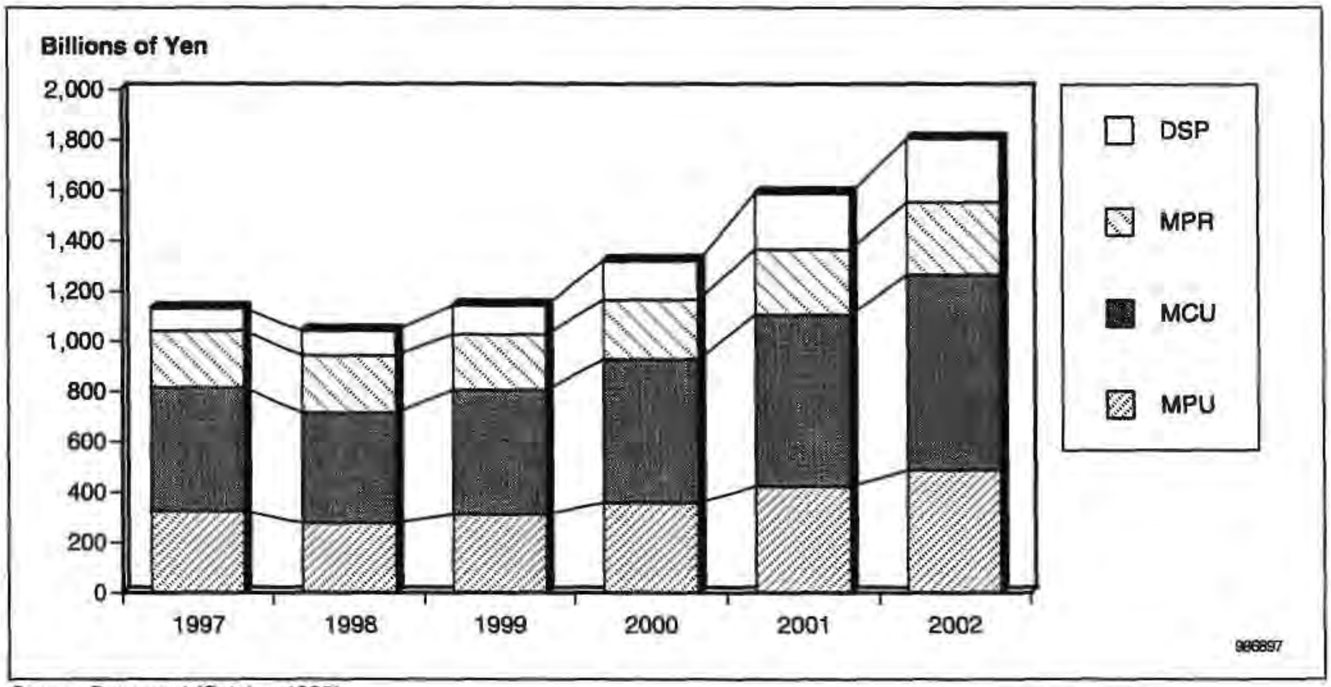
particular, rely heavily on mobile phones. In contrast, U.S. semiconductor makers depend on the communications equipment application. While the flash memory market currently is led by NOR-type devices, Japan's top semiconductor makers are making a move into the large-capacity flash memory arena in 1998. The main application for large-capacity flash memory is DSCs; however, this market is still rather small. The success of developing new market opportunities will be the primary determining factor for flash memory market expansion.

MOS Microcomponent Market in Japan

Dataquest has revised its 1998 forecast for the MOS microcomponent market substantially downward, compared to the previous forecast, to a 7.9 percent decline (18.2 percent on a U.S. dollar basis) since 1997. During the 1997 to 2002 period, a CAGR of 9.8 percent is expected (see Figure 7). Dataquest expects Japan's MPU market to record negative growth in 1998 because of weak demand in the domestic PC market and sliding MPU prices. Meanwhile, the microcontroller (MCU) segment, which accounts for the largest share of Japan's microcomponent market, is still posting higher shipment volumes, but revenue growth is being diluted by the decline in product prices. Feeling the effect of the disorder in the Asian economies caused by the AFC, Japanese makers' shipments of low-bit MCUs to the Asian market are experiencing even tougher circumstances than those of Asian competitors. Another factor hampering market growth is the stringent cost reduction demands of Asian system manufacturers.

Figure 7
Japanese MOS Microcomponent Market Forecast



Source: Dataquest (October 1998)

Looking at MCU market trends by product type, although the range of applications for 4-bit products has greatly broadened, this market entered a mature phase in 1997 from a growth perspective, and prices are falling. Revenue performance for 4-bit products is taking the brunt of slowing demand for portable game machines, a major market driver until last year. Meanwhile, Dataquest expects stable growth opportunities for 8-bit products, with the upper-layer compatibility shift from 4-bit products and growing demand for more complicated system control.

Although there is a possibility of 16-bit products experiencing a slight decline from the correlation between existing application shipments and unit prices, the first half of 1998 recorded high annual growth, benefiting primarily from strong demand for air conditioners caused by the strange weather. In other areas, as well, including VCRs, RDDs, telephones, digital mobile phones, CD-ROMs, printers, DSCs, automotive equipment, analog camcorders, and pachinko game machines, shipments are posting steady gains. On the technology front, a shift from mask ROM to flash technology is taking place, and the added value that this technology can deliver is expected to win 8-bit application business.

The main applications for 32-bit-and-higher MCUs, including 64-bit MCUs, are DSCs, DV-Cs, DVD players (including ROM), car navigation systems, next-generation home game machines, printers, digital mobile phones, and smart cards. Dataquest expects that demand for lower-power consumption features and cost reduction in the digital mobile phone category will drive a transition from 16-bit MCUs to higher-bit MCUs. Sharply higher growth is expected in the higher-bit MCU market, primarily in applications such as digital consumer equipment and mobile communications equipment, shored up by requirements for systems with sophisticated digital signal processing and advances in SLI technology. From 1999 onward, DVD player demand is expected to rise dramatically, mainly in the U.S. market, and Dataquest expects that this will also contribute to growth for higher-bit MCU products.

Demand for flash MCUs is showing steady growth in 1998. Applications driving the 8-bit, 16-bit, and 32-bit flash MCU market are memory cards, CD-ROMs, DVD-ROMs, RDDs, and automotive equipment. Also, Dataquest expects that custom LSIs, which combine an embedded ARM core with a flash core, will open up entirely new opportunities in the portable game machine market. Digital signal processors (DSPs) are finding demand in inverter-control and servo-control application areas, in addition to the existing market for mobile communications equipment.

MOS Digital Logic Market in Japan

Dataquest's forecast for the MOS digital logic market in Japan is a 1.2 percent (12.2 percent on a U.S. dollar basis) decline in 1998 compared to 1997. A CAGR of 7.4 percent is forecast for the 1997 to 2002 period (see Figure 8).

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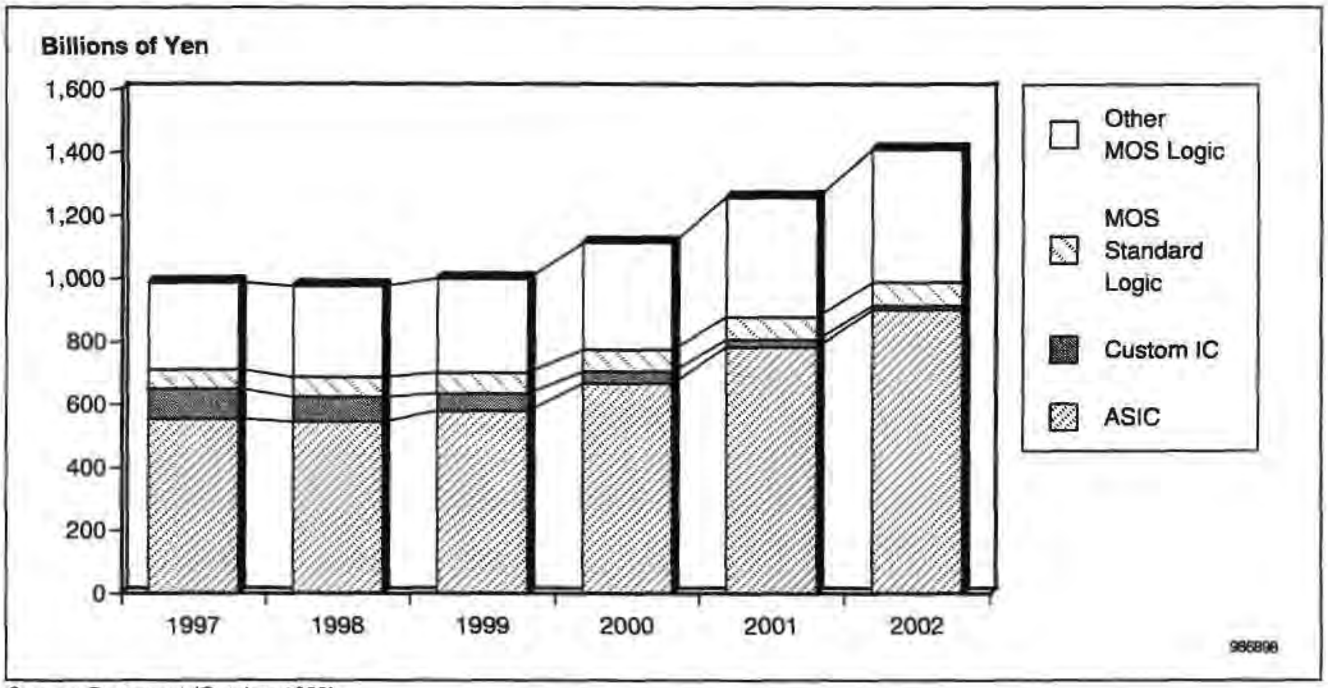
Figure 8
Japanese MOS Logic Market Forecast



Source: Dataquest (October 1998)

Japanese chipmakers excel in the gate array segment of the ASIC market and have shown impressive growth while Americas chipmakers have vanished from the top of the rankings for this segment. Essentially, while the Americas chipmakers are strategically focused on the SLI business and are staging a withdrawal from the gate array market, the Japanese chipmakers are stepping up to the plate in this segment and are winning orders from markets around the world that have been left open. Dataquest believes that this trend will continue.

The programmable logic device (PLD) market in Japan still has not demonstrated the expansion taking place in the Americas market. This is primarily because of internal system customer requirements that a stable supply of gate arrays and extensive support be provided. Chipmakers in Japan and the Americas are clearly operating in different business environments. In Japan, chipmakers are part of a vertically integrated organization that is dedicated to generating profits as a whole. This contrasts starkly with the situation in the Americas, where companies are divided into independent entities or independent business groups and have a mandate to return profitable results. The approach of Japanese chipmakers to the ASIC business is escalating the weakness of the market in Japan. A similar trend is observed across the full spectrum of logic products.

Although today ASIC and application-specific standard product (ASSP) devices incorporate nearly all of the functions offered by standard logic devices, Dataquest still anticipates demand for logic devices that satisfy special applications such as one-gate CMOS, ultrahigh-speed CMOS, and low-amplitude signal logic. Dataquest also believes that strong future

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demand exists for LCD drivers, grouped in the "other logic" category, from the proliferation of portable systems with built-in LCD panels and flat panel display (FPD)-related products.

Dataquest Perspective

When the semiconductor market fell short of previous-year results in 1996, there was a pervasive recognition that this was the first negative growth in a decade. At the same time, while acknowledging that the market was in an adjustment phase, expectations were that once the adjustment was completed, the market would recover to a growth trajectory again. What has happened instead is that market conditions have not improved and are heading for a second dip in results. The DRAM market has contracted back to the level it was at before its last burst of growth, and joining this is negative growth for all other non-DRAM semiconductor products. The CAGR for the 1997 to 2002 period for the worldwide market is forecast to be 11.5 percent, indicating a long-term trend during which the semiconductor market will enjoy double-digit, stable growth, but not at the feverish pace of past years.

The semiconductor industry in Japan is in the process of transitioning supply capacity from DRAMs to other products as a response to the sharp cycles in market conditions characteristic of the DRAM segment. In fact, logic product offerings have been bolstered with each DRAM downturn. However, recent trends clearly underline the ineffectiveness of this approach for dealing with future market circumstances.

It is apparent from the domestic market's slip into the position of being the smallest of the four regional markets worldwide that Japanese chipmakers must make every effort to strengthen their approach to overseas markets. In doing so, the Japanese market cannot be the model for conceiving business strategies. This effort must be firmly rooted in applications and customer trends enjoying success in these overseas markets. From this perspective, Dataquest believes that the limits have been reached in the conventional approach, which treats the Asia/Pacific market as merely a site for the offshore operations of Japanese electronic equipment makers and puts this region in the same category as semiconductor business in Japan.

From a perspective of product evolution, the importance of SLI and other system-oriented products is growing. Success in this field requires further integration of product functions and manufacturing processes. The prolonged weakening of market conditions is increasing the losses incurred by Japan's semiconductor industry as a whole and thereby is limiting the resources available for expanding the scale of operations. However, Japan's chipmakers should consider the process of building an infrastructure to support system products as an opportunity to implement much-needed efficiencies. Dataquest sees growth in alliances and intellectual property business in the product design and development field. Meanwhile, foundry business is gaining force in the manufacturing area. Finally, for sales and customer support, alliances are being formed to ensure the proper response to application trends in regions throughout the world, and distributors with a global presence are accelerating their activities.

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In a situation where mild semiconductor market growth is expected for the next few years, the focus has returned to the demand side. Given this current market outlook, Dataquest believes that the future evolution of the semiconductor industry hinges on the extent to which efficient resource use can be accomplished in all aspects of the semiconductor business.

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Perspective

Semiconductors Japan
Technology Analysis

CSP: Next-Generation High-Density Packaging Technology

Abstract: *Low-cost chip scale package (CSP) technology has entered a full-growth stage as the package for system-level integration (SLI) ASICs and memory, including flash memories and static RAMs (SRAMs) in the 0.25- to 0.35-micron arena. A major driver is the increased demand for more compact and lighter systems by mobile communications equipment and digital consumer equipment, which form fast-growing markets. This Perspective analyzes CSP technology, which holds the key to the successful implementation of device miniaturization.*
By Yoshihisa Toyosaki

Evolution of High-Density Mounting Packaging Technology

With the rapid growth of the information and communications equipment markets, such as personal digital assistants (PDAs), digital cellular phones, mobile computing devices, and subnotebook PCs, and with the swift expansion of digital consumer equipment markets, including digital video camcorders (DV-Cs), digital still cameras (DSCs), and portable digital video disk (DVD) players, packaging technology for high-density mounting is becoming a technological and commercial focal point. For IC packaging, leading-edge technologies such as chip scale package (CSP) and ball grid array (BGA) have been accepted by a number of applications at a faster pace than previously forecast. In the near future, flip chip (FC), direct chip attach (DCA), and known good die (KGD) are expected to follow suit as emerging technologies.

These leading-edge IC packaging technologies—as well as printed circuit boards (PCBs) accommodating multiple chips that represent buildup substrates, such as surface laminate circuits (SLCs)—are being widely used in a range of volume applications that demand system miniaturization, and new materials appear to be expanding into sizable markets. There are various issues to be addressed, however. First, buildup substrate suppliers continue

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to be limited in number, keeping board costs at lofty levels. Also, the reliability of the materials for IC packaging still needs to be improved. Finally, there are differences in CSP package standards between the United States and Japan.

What Is CSP?

CSP is highly compact IC packaging, which almost equates to a die area. Many CSPs use terminals of a dense area array type on their rear side. CSP is considered to be the same as BGA, but it is not. CSP occupies a smaller area on the PCB (to reduce cost) and helps implement a variety of mobile applications. Also, its ability to reduce the IC package size leads to the improvement of electrical performance. Its market potential is being carefully examined by system manufacturers.

At present, volume markets using CSP are divided into digital consumer equipment, including DV-Cs and portable DVD players, and communications equipment, including digital cellular phones and pagers. Other promising markets are hard disk drives (HDDs), PC cards including modem cards, PDAs, DSCs, and portable audio equipment. These application markets are demanding system size and cost reduction, which can also be satisfied by CSP. These systems have relatively small pin counts (176 or fewer, as of 1998), and many of them are restricted in package height in addition to width and depth. At present, the CSP with the smallest form factor is primarily used to accommodate memories such as flash, static RAM (SRAM), and Rambus DRAM (RDRAM). These devices are relatively large in chip size with 50 or fewer pins, making them highly suitable for the package that is slightly larger than the die.

There are various obstacles to a wider market acceptance of CSP. One of them is establishing a small package with a narrow terminal pitch width. This increases the initial packaging cost, which is an important element of digital consumer equipment, and limits wiring patterns on the PCB. More precisely, to avoid "pin-out" in the area array type package with a narrow terminal pitch, a highly dense PCB needs to be used to secure a certain degree of freedom in the wiring pattern. Partly because the PCB industry must invest in costly equipment to meet the density requirements at a low cost for major applications, the cost issue related to CSP equipment is primarily governed by the PCB cost. As a result, Dataquest believes that an industrywide use of "true" CSP will take some more time.

Nevertheless, the industry must address package miniaturization requirements demanded by system manufacturers, which entails the development of an optimum solution to meet a specific cost target. The solution should include low-profile/thin quad flat package (L/TQFP) and BGA. In due course, the industry is expected to improve the ability to provide a matured technological infrastructure and will offer CSP with higher pin counts, which increasingly will be consumed by volume applications. In fact, system-level integration (SLI) ASICs in CSP are adopted in many DV-Cs, where buildup substrates consisting of an average of six to eight layers are used in PCBs.

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Devices most suitable for CSP are those having a very large area of logic circuits compared to pin counts, namely "core-limited design," where an inner core is limited. This type of circuit design requires a relatively large die area to accommodate balls in the interconnection area, so that the ball terminal pitch can approach a standard grid arrangement. As for applications, CSP is optimum for those that must mount low-pin-count devices on a very small and highly dense PCB. These applications usually use 176 or fewer pin packages. For digital cellular phone and DV-C manufacturers, size and weight reduction of system products are of supreme importance; it is justifiable for them to use very costly SLC boards. In fact, SLC boards permit CSP to be used in the area array layout. In contrast, CSP is not suitable for computing or transmission/telecommunications applications that require high-pin-count packages.

The full-featured CSP, which increasingly is used for memory devices, is ready for volume production in 1998. This serves as the buildup of the technological infrastructure and will spur demand. At this point, chip makers and their subcontractors will provide "true" CSP technology. CSP technologies implemented by Sharp and Texas Instruments Japan are not technological breakthroughs, but they will build on top of proven technologies; their main goal is to minimize cost and risk. Technological advancement will occur in the reduction of ball pitch to less than 1.27mm, namely 1.0mm and 0.8mm. IC package size will continue to shrink until the chip itself becomes a limiting factor, because the improved infrastructure for PCB production and assembly will enable a smaller terminal pitch (the 0.5mm pitch used in DV-C, for example).

Current Status of CSP

Currently available chip packages are mostly shrink versions of existing packages—the results of gradual efforts. A typical example is seen in modified plastic BGA (PBGA) and L/TQFP versions with a 1.27mm or smaller ball pitch. CSP, having the same or a similar pin count, is smaller and lighter than these modified versions. In this sense, CSP can be defined as a low-cost, low-pin-count solution. The industry defines CSP as a package that does not exceed 120 percent of the chip area. The development of CSP was started around 1990, and a large number of semiconductor suppliers are currently working with diverse structures in their R&D efforts. From the density point of view, CSP is positioned midway between existing standard packages and FC, with technical issues to be cleared accordingly (see Figure 1). Given the industrywide trend toward increasingly high-density mounting, CSP is expected to provide a feasible solution for a wide range of applications; however, it is difficult to forecast when exactly it will win which share of which market.

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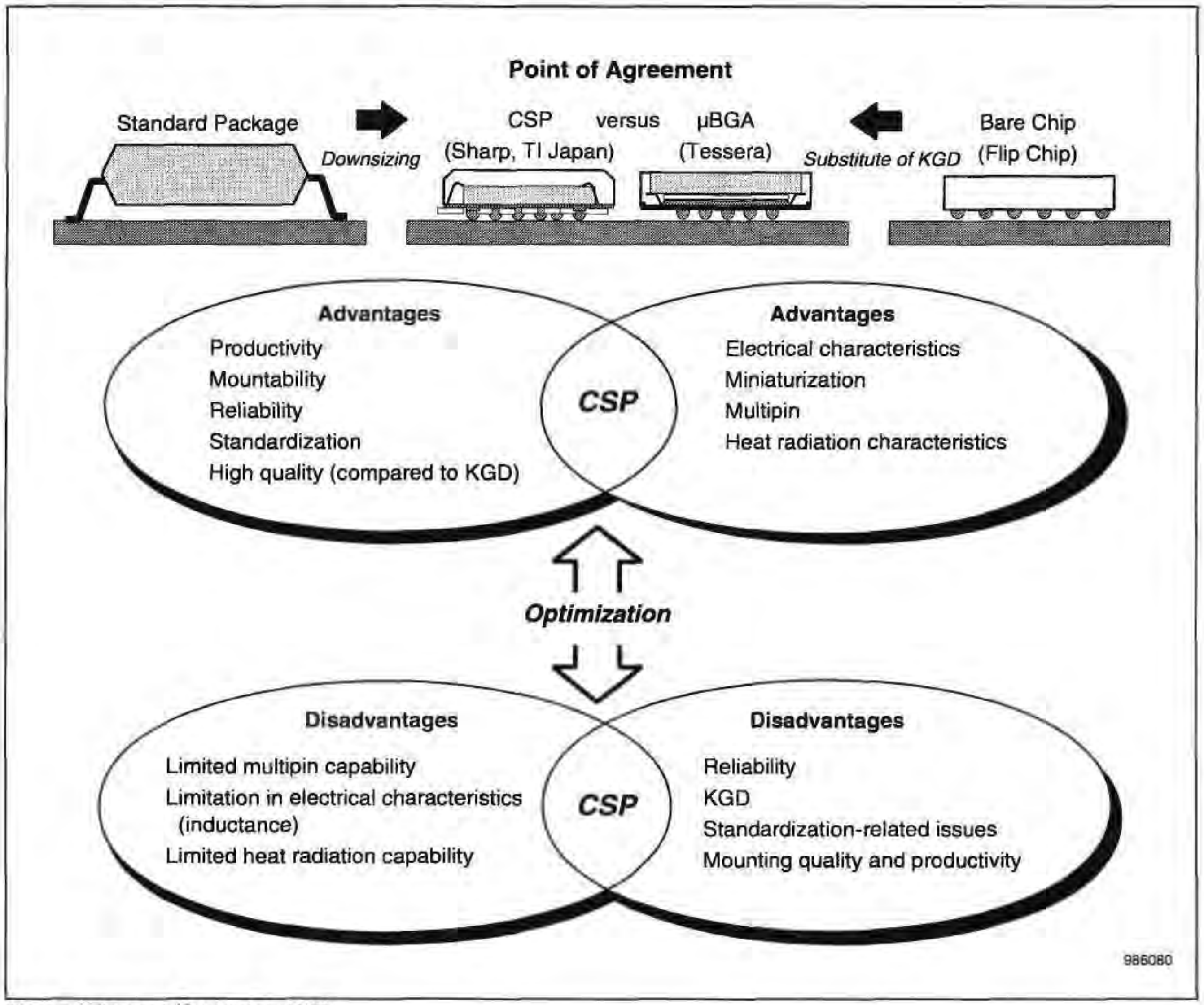
Figure 1
Advantages and Disadvantages of CSP



Source: Dataquest (September 1998)

CSP is undoubtedly a focal point of the PCB industry. Overall, the volume market for true CSP will be a bit slower than expected because of the immature technological infrastructure. Meanwhile, CSP technology capable of satisfying diverse applications will enable package miniaturization at the lowest cost. The CSP-enabled package size will be free from chip size limitation and can be reduced to address a wide range of terminal counts, required by system manufacturers according to a ball pitch allowed by wiring patterns on a PC. Regardless of the package type and name, the industry's goal is to supply small packages in volume and at low cost, as required by system companies.

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Major Features and Advantages of CSP

The proliferation of CSP is driven by size and cost. In particular, applications subject to strict limitations in terms of size and weight will find the solution highly attractive. As the continued miniaturization of devices ends up in bare chips—the minimum practicable package size is no package—CSP will be compared to bare chips and KGD in addition to existing packages. CSP implementation methods commercially adopted in the industry are basically divided into chip-on-board (COB)—derived from wire bonding technology—and FC-on-board (FCOB)—derived from FC technology.

In terms of size, CSP is much smaller than standard packages and is larger than bare chips. A major advantage of package miniaturization, in addition to its space-saving, is its reduction of the accumulation of electricity and heat. CSP is a surface-mounting package and is mainly of area array type. As a result, its terminal pitch is more narrow than that of current BGA packages and wider than that of FC.

Figure 2 shows CSP structures developed by leading vendors. A few of them have already implemented CSP for ASICs and other devices. As for CSP used in the SLI ASIC business, Dataquest believes that the Sharp/Texas Instruments Japan type (a tape type that can be implemented at low cost by using existing equipment) and the Matsushita/Kyocera type (alumina ceramic) will become the mainstay for mobile communications equipment and digital consumer equipment with low system operation frequency. At present, other technologies still have yet to reach a volume production stage. Commercialization depends on several factors, including cost, technical feasibility, and infrastructure development.

In fact, applications suitable for CSP vary with each technology. For instance, the area array type is suitable for applications with a relatively high pin count (50 pins or more) designed by ASIC vendors because of a large terminal pitch. Table 1 compares specifications of the packaging technologies. Compared to bare chips (including KGD), CSP has the advantages that are usually available in packages. In terms of external appearance and terminal shape, CSP is a standard contact device, and it can help simplify the subsequent mounting of parts in the following respects:

- Ability to standardize sockets for cost reduction and simplified testing
- Ability to simplify PCB design regardless of chip design change or generation shift (silicon respin) by offering the same package solution (for bare chip, PCB design modification is often required)
- Ability to allow any semiconductor suppliers to reduce the mounting cost, as demanded by system companies, by standardizing packages' external appearance and terminal shape

It should be noted that system companies that adopted CSP at an earlier time intend to use it as a differentiating factor and to provide their own solutions before standards are established.

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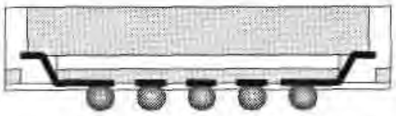
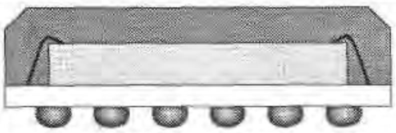
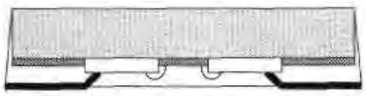
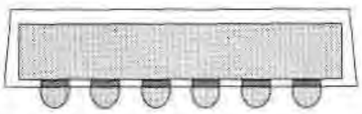
Figure 2
CSP Structures of Leading Manufacturers

Package Type	Sectional View	Manufacturer
Tape Type (TCP Base)		Intel, AMD, Hitachi, Samsung, Sony, LG Semicon, Hyundai (Tessera, Shinko, Amkor-Anam, Mitsui High-Tech)
		NEC, Samsung
		Sharp, TI Japan, NEC, Mitsubishi Electric, Fujitsu, Rohm, Toshiba, Oki, LSI Logic
PCB Type		Sony
Ceramic Type (Substrate)		Matsushita Electric/Electronics, Toshiba, Kyocera
		Fujitsu, Toshiba
Leadframe Type		Fujitsu
Interposerless Type		Mitsubishi Electric

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Note: All companies listed here have developed CSP for ASIC production.
Source: Dataquest (September 1998)

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Table 1
Comparison of Specifications by Packaging Technology

Item	Current	CSP	Flip Chip (Including KGD)
Package Total Width	PQFP: 28mm PBGA: 23mm LQFP: 20mm	8mm to 12mm (x1.2 chip size)	5mm to 10mm (chip size)
Height	PQFP: 3.3 to 3.5mm PBGA: 2.2mm LQFP: 1.0 to 1.4mm	0.5mm to 2.0mm	0.6mm
Terminal Width	PQFP: 0.5 to 0.8mm PBGA: 1.27mm LQFP: 0.4mm to 0.5mm	0.5mm to 1.27mm	0.25mm to 1.0mm
Testing Method	Standard socket	Development of socket axis	Establishment of bare chip testing technique
Footprint	Standard	Standard footprint	Establishment of bare chip testing technique
Cost	PQFP: Low PBGA: Medium LQFP: Medium	Originally high (lower with volume production)	High cost to meet diverse pin count
Electrical Characteristics	PQFP: Low PBGA: Medium LQFP: Low	Medium	High performance

Note: Data on low-cost packages covers those with 144 to 176 pins.
Source: Dataquest (September 1998)

CSP Technology and Competitive Analysis

Diverse CSP technologies that are under development are all categorized by chip scale and include area array and peripheral packages. These technologies use substrates, flex inserters, wafer-level reallocation, and overmolding for interconnections to the PCB. Table 2 lists selected CSP technologies currently owned by vendors. Table 3 ranks currently offered CSP packages according to their estimated volume production costs. Note that the list ranks the packages that are similar to low-cost LQFP, which is already commercialized with a sufficient technological infrastructure. Sandia National Laboratories' technology is not included because it is closer to reallocated FC than to CSP.

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Table 2
CSP Technologies under Development

Manufacturer	Terminal Structure	Interconnection/Substrate
Tessera	A	Tape inserter, TAB bonding, solder balls
TI MicroStar	A	Tape inserter, wire bonding, solder balls
Matsushita Electric/Electronics	A	Mounting of flip chip to ceramic LGA, underfill
Motorola SLICC	A	Mounting of flip chip to laminated substrate, underfill
NEC	A	Tape inserter, thermo-compression bonding, solder balls
Mitsubishi Electric	A	Reallocation to solder pads, transfer molding, ball bonding to pads
Sandia National Laboratories	A	Reallocation of polyimide to gold or solder balls
GE	A	Flex bonding to Si and bump formation using bear holes, development of HDI
Hitachi Densen	A	Derivative of leadframe technology arranging metal posts in perimeter, overmolding
IBM	A	Flip chip bonding to ceramic mini-BGA with cap, eutectic crystal solder balls
Nitto Denko	A	Tape inserter, thermo-compression bonding, solder balls
Toshiba	A	Flip chip bonding to ceramic LGA, underfill
Sharp	A	Wire bonding to flex substrate, molding
Hitachi Densen	P	Leadframe by small J lead, overmolding
ChipScale	P	Wafer reallocation to silicon post, expoxi-resin encapsulation to active face
Rohm	P	Flip TCP, resin sealing of die front side
Fujitsu	P	Die-size leadframe LOC, formation of LGA by one side overmolding
LG Semicon	P	Small leadframe, formation of LGA by overmolding
ShellCase	P	Sealing of Si between two glass plates, metallization of end contact

A = Array terminal layout
P = Peripheral terminal layout
Source: Dataquest (September 1998)

Table 3
Current State of CSP Packaging Development and Volume Production

Manufacturer	Volume Production Cost	Maturity Level	Advantage/Disadvantage
Matsushita Electric/Electronics	Low	Commercialized	Flip chip (SBB), ceramic substrate (mainly for captive users)
NEC	Low	Using two systems of sample level	Advantages/disadvantages vary with methods. The NEC system is similar to the one in Figure 1.
Fujitsu	Low	Prototype	TSOP's derivative technology
Kyocera	Low	Commercialized	Land-type ceramic substrate/PCB (supplied to semiconductor suppliers, SBB technology applied for partial connection)
Hitachi Densen (P)	Low	Commercialized	QFP's derivative technology
Nitto Denko	Medium to low (future)	Commercialized	Additional cost because of bold bonding on tape
Motorola SLICC	Medium	Sample level	Flip chip, for PowerPC
Mitsubishi Electric	Medium	Development level	Cost increase because of multistage process
Hitachi Densen (A)	Medium	Development level	Cost increase because of multistage "post" leadframe, no standard substrate assembly
Tessera	High to medium (future)	Partially commercialized	Equity participation by Amkor-Anam and a few licensing agreements have accelerated CSP development and capital investment; this is expected to result in cost reduction in the near future.
GE	High	Development level	Scrap cost increase because of the initial die mounting process
IBM	High	Development level	Flip chip, ceramic substrate
Toshiba	High	Development level	Flip chip, ceramic substrate

SBB = Stud bump bonding technology
P = Peripheral structure
A = Array structure
Source: Dataquest (September 1998)

Major factors affecting the CSP cost are the substrate cost, assembly techniques (FC and wire bonding technology, for example), the number of process steps, and yield. On the other hand, the price is ultimately governed by the level of market penetration. No technology can achieve the lowest possible cost unless it follows learning curves determined by very large volume production. Dataquest sees that any CSP technology involves a certain risk until official standards are established to depict a "technological winner."

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An Analysis of Alternative Technologies

The introduction of CSP technology is hindered by interindustrial barriers that increase the initial cost. To meet short-term design requirements for cost and size, LSI Logic and other vendors propose the small form factor package (SFP)—mini-BGA—technology as a temporary substitute for CSP. This solution includes LQFP and BGA with a small terminal pitch. Table 4 compares existing products using these alternative technologies. It should be noted that the size difference between each IC package and the chip varies greatly among them. For instance, the large core-limited design allows a more efficient use of the package, so that the name "chip scale package" is not appropriate.

Table 4
Comparison of Existing Packages and Mini-BGA

Package Item	LQFP	PBGA	1mm BGA/SFP
Package Total Width	7mm to 28mm	23mm to 35mm	15mm
Package's Relative Size (Compared to Chip Size)	2.5 to 28 times	3.7 to 25 times	3 to 10 times
Height	1.0mm to 1.4mm	2.3mm	1.6mm
Package's Relative Cost in 1997 (Compared to PQFP)	1.2 times	1.5 times	1.5 times
Terminal Width	0.4mm to 0.5mm	1.27mm to 1.8mm	1mm to 0.8mm
Pin Count	44 to 208	169 to 456	100 to 176

Source: Dataquest (September 1998)

Because the package size is primarily governed by size requirements for the system and PCB, it is more appropriate to standardize the package size relative to an available area on the PCB rather than the chip area. In the future, as the CSP cost declines and capabilities related to PCB production and assembly improve, the high-density, area array package will be promoted. The possible evolution of these technologies is analyzed by taking the example of LSI Logic: how the company will implement SFP technology for the 100-to-200-pin markets (see Figure 3).

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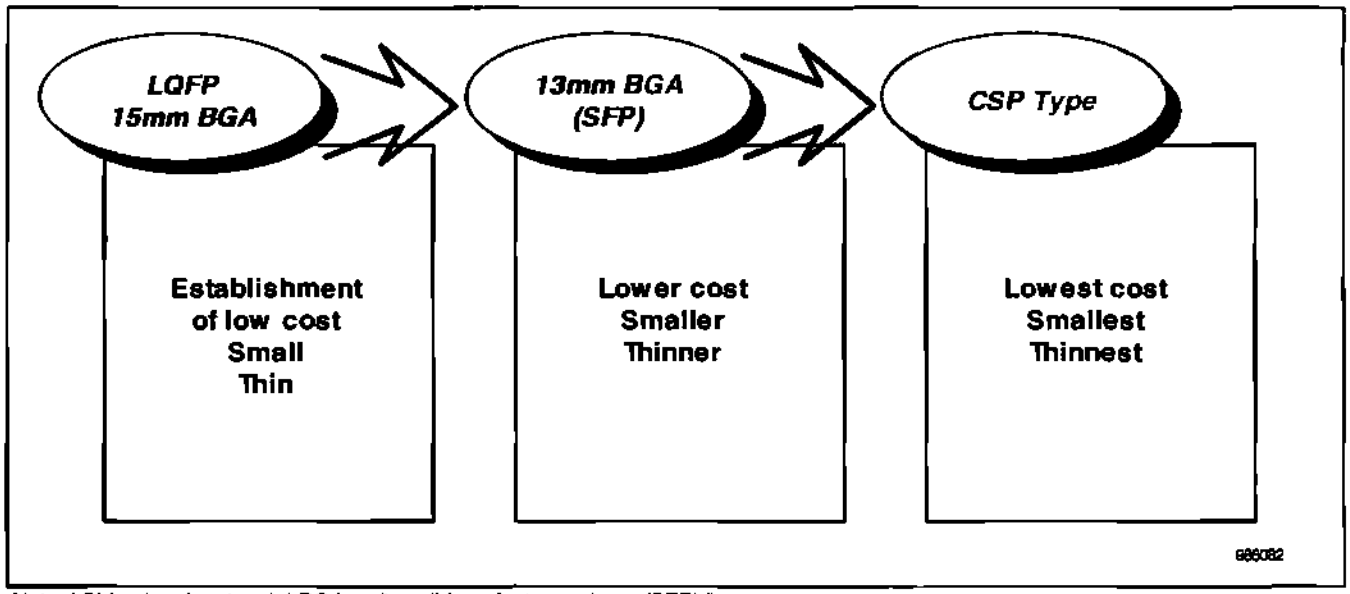
Figure 3
SFP to CSP Road Map at LSI Logic



Note: LSI Logic refers to mini-BGA as "small form factor package (SFP)."
Source: Dataquest (September 1998)

Not all of the currently available CSP-alternative technologies, such as COB, FCOB, chip-on-flex (COF), and LQFP, are suitable for the ASIC market. They basically consist of many bare chip technologies and several types of packages. Many ASIC suppliers have not weighed bare chip sales, because there are pros and cons on the use of the bare chip. The bare chip can be less costly than packaged devices if all the tests are eliminated; however, it must sacrifice many of the advantages offered by the package solution, while suffering the following drawbacks:

- Testing—Testing techniques on the bare chip still have to be matured.
- Standardization—Chip design changes or the commercialization of a new-generation chip often lead to various changes in external appearance and pad shape. Unless a standard package to absorb such changes is used, the PCB needs to be reconfigured and then tested.
- Risk and reliability related to handling—Without physical protection provided by the package, the bare chip can be damaged by various causes, including corrosion and a mechanical or physical shock. Also, the production process to mount bare chips to systems, similar to a semiconductor assembly line, is required.
- Exchange of chips (rework)—The exchange of chips is more difficult for the bare chip than for CSP.

Barriers to Commercial Implementation of CSP

Major obstacles to the commercial implementation of CSP are an immature technological infrastructure and high equipment costs. The major technical issue facing CSP is how to maintain the terminal pitch and array required to implement cost-effective interconnection patterns at a PCB level. The infrastructure refers to the technological capabilities of the PCB industry in supporting assembly and testing operations. In particular, infrastructure development should address the following areas:

- Standard lead and package shapes to support compatibility
- Test socket connection
- Testing process
- Standard tapes and reels
- Assemblies handling equipment
- Visual aid systems for assembly
- Assembly process and thermal distribution, including adequate soldering materials and their geometries

These areas require extensive development efforts, and the use of a standard BGA is considered to be the first step toward the development of CSP.

Also, the total system cost poses a major challenge. Following the learning curve for volume production, the CSP package cost will fall to a very low level because small amounts of materials are used and existing assembly techniques can be used with some modifications. On the other hand, the PCB cost as the basis of the above technologies, particularly Tessera's BGA, is much higher than the cost of standard PCBs.

Figure 4 lists routing issues related to small-pitch, area array packages. As shown in this figure, the escape route is established in one layer, representing the worst case. In a small 7 x 7 array, the maximum number of traces escaping between two balls in the array is three. Generally, the required routing density is proportional to the number of ball rows; the routing issue becomes more serious as the array becomes larger. In practice, the required routing density is secured by using a multilayer PCB. Basic rules related to the PCB are governed by the terminal pitch of the package array, the number of balls, and the size of the capture pads. The PCB's cost impacts vary with markets and are generally determined by PCB size and the number of CSP devices mounted on it.

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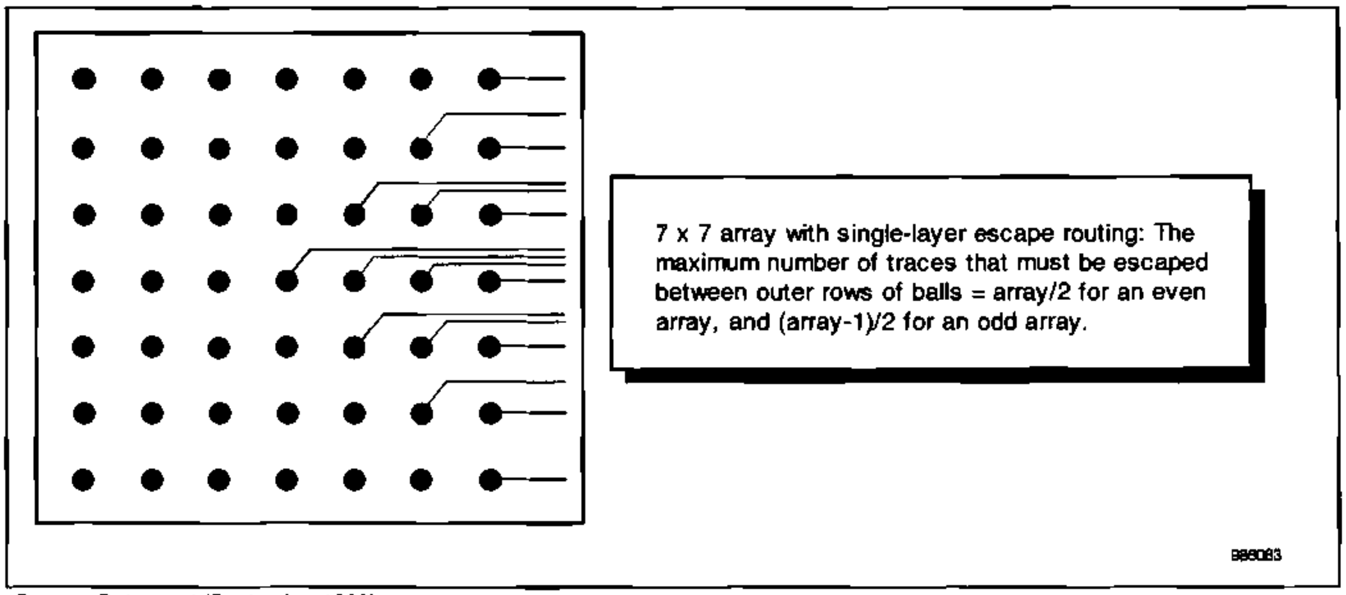
Figure 4
Routing Rule in Area Array Layout



Source: Dataquest (September 1998)

Dataquest Perspective

In the conventional ASIC process development, each manufacturer has established its basic process and packaging technology that are then incorporated into products. Also, in many cases, the memory process, such as DRAM, has been adapted to the ASIC process as a technology driver. Historically, Japanese semiconductor companies have developed products on the basis of "the supply-side logic" and have palmed them off to system companies. This reflects that the product development process lacks the marketing concept—efforts to grasp and serve market needs. In recent years, Americas ASIC suppliers seem to have established a clear competitive edge over Japanese competitors. The difference comes from not only a technology gap in the basic process and packaging but also the lack of market analysis and marketing strategy to address users' needs on the Japanese side.

Because the ASIC industry has already entered the SLI ASIC age, where large-scale LSI development efforts are required, it has become imperative for ASIC suppliers to respond effectively to the needs of application users. Future challenges for establishing the product concept of SLI ASIC include optimizing application requirements by semiconductor technologies, including packaging, process, libraries, and IP core. Dataquest believes that CSP will be one of the critical factors for success.

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Perspective

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Market Analysis

A Comparative Analysis of Wafer Fab Equipment Markets in 1997: The Japanese Market Was Down 23 Percent

Abstract: *In 1997, the worldwide wafer fab equipment market declined 7 percent from the year before to $20.2 billion. The regional breakdown showed mixed results, however. While the Americas and Taiwan maintained double-digit growth, Europe, Japan, and Asia/Pacific (excluding Taiwan) recorded negative growth. From the first quarter through the third quarter, leading-edge equipment, led by excimer laser and equipment used for MPU and logic production, expanded and bolstered growth of the entire market. In the fourth quarter, however, a lingering slump in the DRAM market put a drag on market growth because of capacity expansion, resulting in negative growth on an annual basis.*
By Takashi Ogawa

1997 World Market Trends

In 1997, the wafer fab equipment market recorded negative growth for the first time since 1992 with a 7 percent decrease from 1996. Of $20.2 billion, the Americas accounted for $6.7 billion and maintained a double-digit growth of 15 percent. In contrast, the Japanese market decreased by 23 percent (to $5 billion), Asia/Pacific decreased by 7 percent (to $6 billion), and Europe decreased by 15 percent (to $2.4 billion). Within the Asia/Pacific market, Korea plunged 37 percent (to $1.9 billion), whereas Taiwan expanded 30 percent (to $3.3 billion). The polarized results between regions as well as individual markets (see Figure 1) seem to reflect their semiconductor product mix. Japan and Korea, which are heavily dependent on DRAM, showed sharp declines, while the Americas maintained firm growth, fueled by the expansion of the MPU, ASIC, and logic markets. Taiwan benefited from the booming foundry business, which was increasing capacity.

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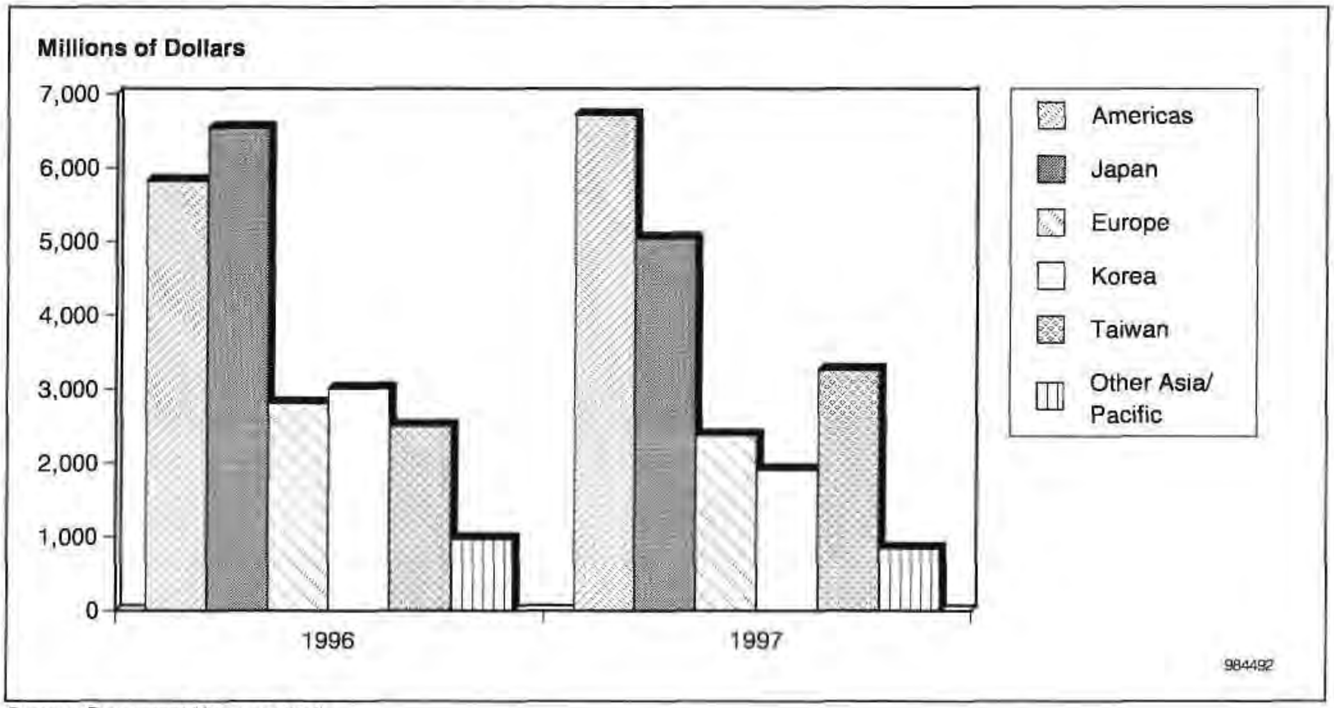
Figure 1
Wafer Fab Equipment Market Trends by Region



Source: Dataquest (August 1998)

The market breakdown by segment also showed mixed results. Major winners were leading-edge equipment markets, including excimer steppers, chemical mechanical polishing (CMP), rapid thermal processing (RTP), and high-density plasma chemical vapor deposition (CVD). On the other hand, the segments relying on capacity expansion, such as auto wet stations and diffusion equipment, suffered a defeat. By ownership, North American companies increased their share to 50 percent, widening a lead over Japanese competitors, whose share declined to 40 percent. This shift was mainly because U.S. companies had a stronger lead in the logic-oriented technologies, which grew relative to the DRAM-oriented equipment segments. Also, the Japanese companies were weaker than average in 1997. European companies maintained their share of 7 percent with their strength in the lithography segment (see Figure 2).

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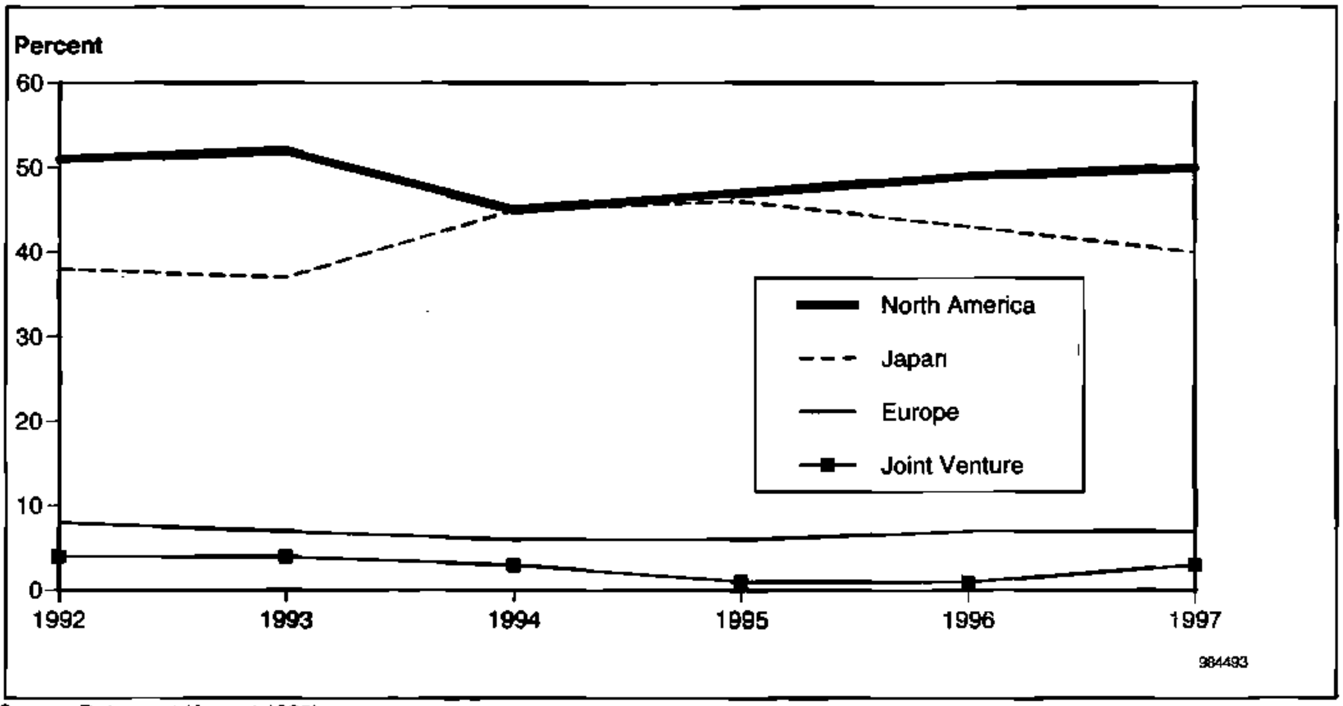
Figure 2
Recent Trends in Wafer Fab Equipment Market Share by Ownership



Source: Dataquest (August 1998)

1997 Japanese Market Trends

After Korea, in terms of losses, the Japanese fab equipment market suffered a major decline of 23 percent. Notably, as shown in Table 1, all of the categories recorded double-digit negative growth. Resist processing equipment plummeted 44 percent to $256 million, ion implantation equipment was down 41 percent to $202 million, and RTP and diffusion equipment declined 29 percent to $208 million. The major downturns reflect the direct impact of curtailed capital spending by Japanese semiconductor companies because of the sluggish DRAM market. As a result, the Japanese market's world share dropped from 30 percent in 1996 to 25 percent, a sharp contrast to the Americas market, which increased its share from 27 percent to 33 percent.

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Table 1
Breakdown of Wafer Fab Equipment Market in 1997

Equipment	Japan's Revenue ($M)	Worldwide Revenue ($M)	Japan's Market Share (%)	Japan's Growth Rate (%)
Lithography	1,058.5	3,904.2	27	-14
Resist Processing	255.5	1,205.9	21	-44
Etching, Cleaning, and Planarization	1,285.4	5,194.8	25	-23
Deposition	1,186.1	4,551.5	26	-21
RTP and Diffusion	207.7	805.9	26	-29
Ion Implantation	202.3	912.2	22	-41
Process Control	570.7	2,212.9	26	-14
Manufacturing and Control	196.1	1,056.1	19	-28
Others	84.2	327.6	26	-21
Total	**5,046.5**	**20,171.0**	**25**	**-23**

Source: Dataquest (August 1998)

The breakdown by ownership reveals a similar pattern. Japanese companies lost revenue by 13 percent to $7.9 billion, compared to moderate performances of North American companies (down 1 percent) and European companies (up 1 percent). Of Japanese companies' total revenue, lithography equipment accounted for 31 percent, and resist processing accounted for 11 percent, indicating a continued dominance of exposure technology in terms of revenue. In contrast, North American companies, which are strong in the MPU and logic (including ASIC) markets, earned 59 percent of the revenue from equipment related to interconnection technology, such as etching, cleaning, and planarization and deposition.

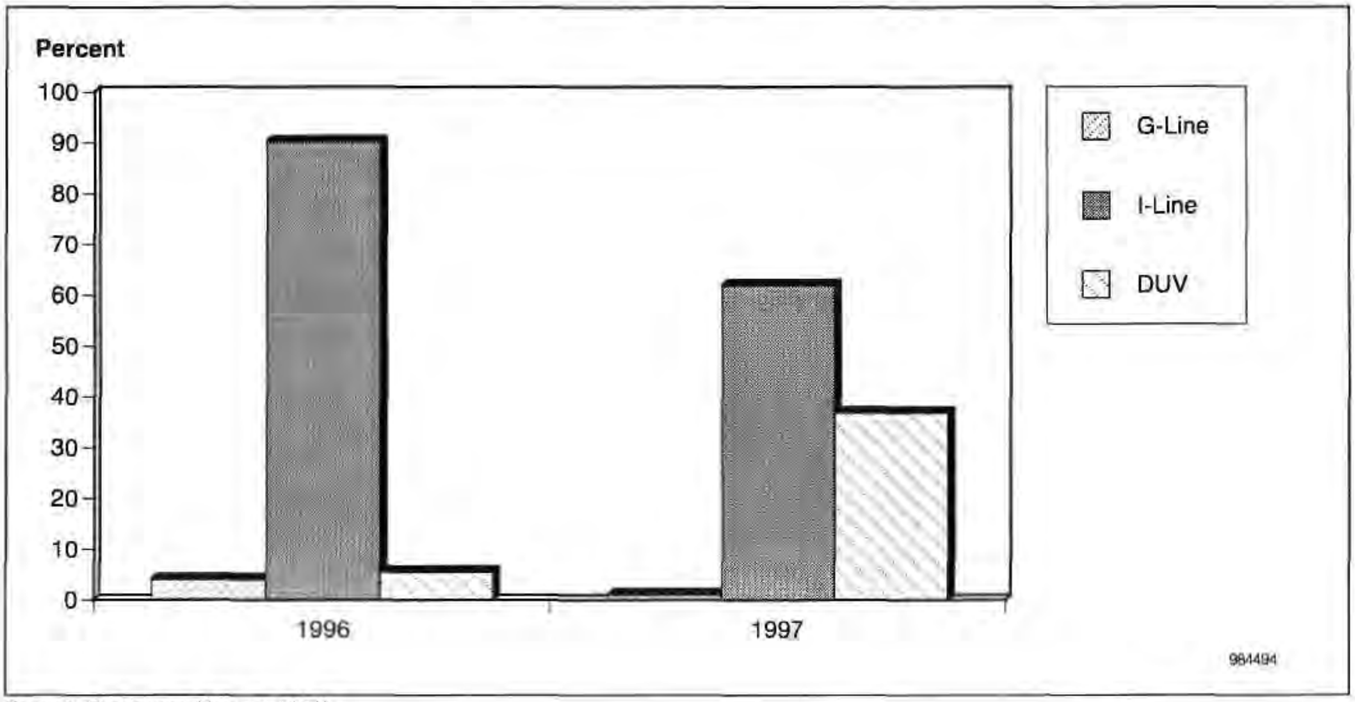
The following sections analyze major trends, reflecting the Japanese fab equipment market and manufacturers by the type of equipment.

Steppers

Steppers form a major element of wafer fab equipment investment. In 1997, the world stepper market remained almost flat from the previous year, totaling $3.6 billion. The Japanese market dropped 16 percent to $938 million. Notably, while shipment revenue (on a dollar basis) maintained more or less the previous year's level, unit shipments declined from 1,321 to 1,043. This reflects the fact that the shipment of conventional i-line steppers declined significantly because of cutbacks in capital spending for capacity expansion, whereas sales of higher-priced krypton-fluoride (KrF) excimer laser steppers grew considerably because of the commercial rollout of 0.25-micron technology. Dataquest's survey indicates that unit shipments of excimer steppers surged from about 8 percent in 1996 to 30 percent in 1997.

The breakdown by region and technology indicates that the Americas and European markets previously held high shares of deep ultraviolet (DUV) stepper shipments, but in 1997, unit shipments to the Japanese and Korean markets grew rapidly as 0.25-micron technology was introduced to 64Mb DRAM production (Figure 3). The increased use of excimer steppers for volume production has affected each vendor's share as well; while no significant change was seen in unit shipment ranking, companies that dominated the excimer stepper segment on a revenue basis increased their shares. Following Nikon Corporation, which maintained first place with a 43 percent share in 1997 (47 percent in 1996), ASM Lithography Holding N.V. advanced to second place by expanding its share from 20 percent to 25 percent and replaced Canon Inc., whose share dropped from 25 percent to 23 percent. In the second-tier group, Silicon Valley Group Inc. raised its share from 4 percent to 7 percent.

Figure 3
Recent Trends in Stepper Shipments to the Japanese Market by Technology (Units)



Source: Dataquest (August 1998)

Auto Wet Stations

The world auto wet station market totaled $954 million in 1997, an 18 percent decrease from the previous year. The highest rates of decline were seen in Europe (down 43 percent) and Korea (down 25 percent). The Japanese market also experienced a 17 percent decrease, totaling $247 million. All of these regions were adversely affected by a major setback in capacity expansion investment, particularly in the DRAM area.

The market shares by company underwent some reshuffling. While Dainippon Screen Corporation continued to hold the leading position with a 20 percent share, Sugai Corporation advanced from fourth to second place (13.3 percent), and Tokyo Electron Ltd. fell from second to third place (12.6 percent), followed by Kaijo Corp. (from fifth to fourth) and STEAG

MicroTech Inc. Japanese companies command a combined share of around 70 percent of the market. Interestingly, different companies have established dominant positions in different regions. Dainippon takes a lead in the Americas, Japan, and Korea; Kaijo takes a lead in Taiwan; Tokyo Electron takes a lead in other countries in Asia/Pacific; and STEAG MicroTech takes a lead in Europe. While there is no global winner, Sugai and Sankyo Engineering Company Ltd. are moving toward a merger, and the new company is expected to emulate Dainippon's 1997 market share. Much more consolidation is expected in the market.

Resist Processing

The resist processing market was by no means immune to the sluggish capital spending triggered by the DRAM recession. As a result, the worldwide resist processing market declined 28 percent in 1997 to $1.2 billion. The momentum of the equipment for DUV lithography, market-driven by the proliferation of excimer steppers, was dwarfed by a major decline in the conventional equipment segment. The Korean market was hit hardest, and value shipments decreased 45 percent to $105 million, followed by the Japanese market, which dropped 44 percent to $256 million. Again, high dependency on the DRAM business was a determinant factor.

As for vendor ranking, Tokyo Electron dominated the market (59 percent share), followed by SVG (15 percent) and Dainippon (13 percent). Fairchild Technologies GmbH was the only company reporting high growth (50 percent increase over the previous year) and advanced to fifth place by winning a 4 percent share. Its significantly increased presence in the Korean market served as a major impetus for this.

The DUV equipment market is expected to grow consistently with expansion of the excimer stepper market. Vendors are vying for higher performance by focusing on several areas: the controllability of atmosphere inside equipment by means of chemical filters and increased durability of the filters, accurate temperature control in the oven, and the reduction of footprint for the 300mm wafer process.

Dry Etching

In 1997, the worldwide dry etching market declined 13 percent from the previous year to $3.0 billion. Segment-wise, the low-density plasma etching equipment market was down 26 percent to $1.6 billion, while the high-density segment reported an impressive 9 percent increase to $1.4 billion. High-density plasma etching equipment has gained popularity with the pervasiveness of the 0.25-micron process, on account of profile characteristics accompanying the pattern's high-aspect ratio, selectivity, and adaptability to pattern shape. It has now reached a market size similar to that of low-density plasma etching equipment.

Regionally, the high-density plasma etching markets in the Americas and Taiwan recorded high growth, 62 percent and 61 percent over the previous

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year, respectively, whereas the Japanese market plunged 17 percent to $333 million. As for each company's share in the high-density plasma etching markets, Applied Materials Inc. boosted revenue by 208 percent to hold a 27 percent share and get closer to the leader, Lam Research Corporation (43 percent). Hitachi Ltd. came in third. Applied Materials increased sales in the Americas, European, and Japanese markets.

Chemical Mechanical Polishing

Compared to the dreary condition of the wafer fab equipment market, which recorded a 7 percent decline, the worldwide CMP market grew 75 percent in 1997 to $518 million. In addition to the traditional strongholds in the Americas and Europe, the CMP market underwent rapid expansion in Asia/Pacific, particularly in Taiwan (up 352 percent) and Korea (up 303 percent). In all of the regions, CMP technology expanded its applications from the production of leading-edge logic devices to DRAMs. The Japanese market grew 56 percent to $134 million. As a result, regional shares changed to 41 percent for the Americas, 26 percent for Japan, 10 percent for Europe, and 23 percent for Asia/Pacific, with the Japanese and Asia/Pacific markets ahead of the European market.

In terms of system configuration, integrated CMP equipment that incorporates post-cleaning equipment has expanded its market, a 227 percent increase over 1996, to total $179 million and a 35 percent share. In particular, the Japanese market accounted for 53 percent of the entire segment.

Each company's share showed notable changes as well. IPEC/Planar managed to hold the No. 1 position, although its share dropped to 26 percent, and Ebara Corporation came in second by boosting its share to 22 percent. Applied Materials also gained a 15 percent share and followed SpeedFam Corporation, which was in third place (21.5 percent). Japanese companies together registered a considerable gain from 36 percent to 49 percent. With more Japanese companies (for example, Mitsubishi Materials Corporation, Tokyo Seimitsu Co. Ltd., and Sony Corporation) looking for market share, coupled with expanded applications (such as shallow trench isolation and the dual damascene process), the market should become more competitive.

Chemical Vapor Deposition

In 1997, the worldwide vertical- and horizontal-tube CVD system market totaled $603 million, down 24 percent from a year ago. Two markets recorded healthy growth: the Americas with 22 percent and Taiwan with 18 percent. On the other hand, the Korean and European markets declined sharply, with 64 percent and 47 percent, respectively. Similarly, the Japanese market recorded a negative growth of 25 percent, totaling $190 million. The regional disparity clearly reflects the different conditions of individual device markets.

The distinctive patterns in different segments are more pronounced in the nontube CVD system market. Low-pressure CVD (LPCVD) and

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atmospheric/subatmospheric CVD (APCVD/SACVD) maintained the same revenue levels as the previous year, as bolstered by the first growth of the markets in Taiwan, the Americas, and Europe. In these markets, primary film demand comes from logic-oriented products such as blanket tungsten and gap-fill dielectric depositions. The worldwide nontube CVD market grew 6 percent to $610 million, and the worldwide APCVD/SACVD market was up 1 percent to reach $657 million. In contrast, the Japanese market recorded double-digit negative growth in the both segments—the nontube CVD market totaling $180 million, and the APCVD/SACVD market totaling $138 million—as these markets depended on the DRAM-sensitive films of tungsten silicide and higher-temperature deposited dielectric materials.

In the plasma CVD market, the low-density segment reported a 13 percent decline to $609 million, while the high-density segment recorded an outstanding gain of 88 percent, totaling $202 million. Strong market expansion was seen across the regions: The Americas grew 77 percent, Europe grew 144 percent, and Asia/Pacific grew 144 percent. The Japanese market also grew 10 percent to $12 million.

In the future, further market expansion is expected in the 0.25-micron-and-finer processes where high-density plasma CVD systems expand applications such as dielectric layers below metal films and trench isolation, in addition to the formation of dielectric layers between metal films. Leading the high-density plasma CVD market is Novellus Systems Inc., which managed to maintain first place with a 49 percent share, closely followed by Applied Materials, which increased revenue by 246 percent to gain a 48 percent share. Thus, the market is almost equally divided between the two vendors.

Silicon Epitaxial Reactors

The worldwide silicon epitaxial reactor market recorded a 25 percent growth in 1996 that was driven by DRAM demand; this turned into a negative growth of 13 percent in 1997, totaling $226 million. While it grew somewhat in the first half of 1997, it seemed to cool down in the second half. A major cause was the delay or cutback in the expansion of 200mm wafer production capacities by silicon wafer manufacturers because of the sluggish DRAM market and the lackluster outlook for wafer demand as a result of accelerated chip shrinkage. The falloff from investment in power/discrete capacity was another major cause. Regionally, the Japanese market recorded a 20 percent growth ($99 million), while other regions suffered declines: the Americas by 26 percent ($79 million), Europe by 26 percent ($39 million), and Asia/Pacific by 50 percent ($9 million). This reflects the continuous efforts of Japanese companies to explore the DRAM market as design rules fall below 0.3 micron.

In the world of 0.3-micron-or-finer linewidth, it is well known that crystal defects such as crystal-originated particles (COPs) impede yield in DRAM production. DRAM suppliers take varied approaches, which primarily reflect the maturity and economics of their processes. At present, most Japanese companies address the issue by using epitaxial wafers. At the same time, some continue to use CZ wafers (wafers created using the Czochralski

Method), adopt hydrogen-annealed wafers (Hi wafers), or consider low-COP CZ wafers.

In terms of share by company, Applied Materials continued to lead the market by holding a 57 percent share, followed by ASM International N.V. (24 percent), whose position also did not change. In third place, however, Concept Systems Design was replaced by Moore Epitaxial Inc. with a 12 percent share.

Rapid Thermal Processing

In 1997, the worldwide RTP equipment market grew strongly at 49 percent and reached $273 million. Double-digit growth was recorded in all of the regions except Europe. The Americas market was up 60 percent (totaling $106 million), Japan was up 69 percent ($69 million), and Asia/Pacific was up 69 percent ($71 million), while Europe was down 19 percent ($28 million). Entering the 0.25-micron age that requires ever finer and thinner devices, precise temperature control in the thermal treatment process becomes increasingly critical, and RTP finds new applications in ion implantation and annealing of source drains, silicide formation, and the formation of gate oxide films.

In terms of vendor ranking, Applied Materials, in first place, recorded a 139 percent increase in revenue to $162 million and gained a 59 percent share. While the company boosted sales in all of the regions, major contributions came from the Japanese market, where its sales skyrocketed by 1,640 percent over the previous year and its share grew to 58 percent. As a result, Dainippon slid from the top position in 1996, and its share plummeted to 17 percent in Japan. In the worldwide market, STEAG AST Elektronik maintained second place with a share of 18 percent. AG Associates came in fourth with a 15 percent share. Future technological challenges in the market include uniform temperature control, the improvement in temperature reproducibility because of variation in wafers' emissivity, and the improvement in the maintainability and reduction of running costs associated with the use of 300mm wafers. Various vendors are establishing volume production capabilities.

Ion Implantation

The ion implanter market is one of the markets primarily governed by individual device market trends and new fab construction. In 1997, the worldwide ion implanter market declined 18 percent to $912 million. Regionally, the Americas and Taiwan reported double-digit growth, whereas other regions suffered negative growth in double digits. Looking at individual segments, high-current ion implanters used in the source drain process and medium-current ion implanters used in the field threshold voltage control process recorded negative growth of 27 percent and 23 percent, respectively, to reflect new fab investment cutbacks by most companies, except for those in the Americas and Taiwan. On the other hand, the high-energy ion implanter market (used for the formation of barrier

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layers and retrograde wells) recorded a 12 percent growth. A regional breakdown, however, unveils mixed results. While the DRAM-dependent Japanese and Korean markets declined 8 percent and 47 percent, respectively, the Americas and European markets reported appreciable growth of 59 percent and 31 percent, respectively, because they rely on logic processes where high-energy ion implantation expands applications. Overall, the Japanese market declined in all of the segments, resulting in a 41 percent decrease and $202 million.

Share by company has remained unchanged for the top three vendors: Eaton Corporation (45 percent), Varian Associates Inc. (30 percent), and Applied Materials (13 percent). However, because Varian acquired the ion implanter division of Genus Incorporated and vendors are introducing products with wider applications, market reshuffling is expected among the segments.

CD-SEM

In 1997, the worldwide critical dimension scanning electron microscope (CD-SEM) market decreased 1 percent to $327 million. Again, a regional breakdown shows polarized results. Two markets recorded strong growth: the Americas (up 21 percent) and Taiwan (up 46 percent). Two markets suffered declines: Korea (down 50 percent) and Japan (down 16 percent and totaling $79 million). The wafer testing and inspection systems industry went through major consolidations between 1996 and 1997, including the merger of KLA Instrument with Tencor Instrument and the market entry of Applied Materials. These moves have already affected market share. Hitachi continued to dominate the 1997 market with a 60 percent share, followed by KLA-Tencor Corporation (18 percent) and Applied Materials (13 percent). In the future, performance improvement efforts will focus on measurement accuracy and reproducibility at low acceleration voltage and on higher throughput. Recently, the need has arisen to implement defect analysis capabilities and evaluation capabilities in the form of data processing utilities through a graphical execution manager (GEM) interface.

Manufacturing Automation and Control

This year, Dataquest newly defined a segment in the factory automation equipment market, called semiconductor manufacturing automation and control (SMAC), for a full-scale market study. The SMAC market is further divided into automation software systems covering system integration and similar functions, transport and storage automation covering wafer handling and transportation, lithography management systems, transition environmental control systems such as standard mechanical interface (SMIF), and process environmental control systems such as cluster tool platforms.

Generally, the SMAC market is expected to be directly affected by fab investment, which was clearly seen in 1997. The entire market showed a slight increase of 2 percent to $1,209 million. Regionally, three markets showed firm growth: The Americas grew 10 percent, Europe grew 36 percent, and Taiwan grew 19 percent. The Korean and Japanese markets, on the other

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hand, declined 22 percent and 23 percent, respectively. Again, the market contrasts are evidence of the impacts of major cutbacks in DRAM-related capital spending on some markets. However, in the Japanese market, to which total shipments in 1997 amounted to $237 million, the transition and process environmental control segments registered positive growth, albeit a small size, and systems adaptive to the next-generation production environment, including SMIF and cluster tool platforms, showed some signs of market expansion.

In terms of share by company, Japanese and North American manufacturers dominate the market, controlling 30 percent and 64 percent, respectively. North American companies hold high shares in Taiwan, other Asia/Pacific countries, and Europe, in addition to their home ground. On the other hand, Japanese companies take the lead in the Japanese and Korean markets. In the 1997 market share ranking, PRI Automation came first with a 15 percent share, followed by Daifuku Company Ltd. (14 percent), Asyst Technologies Inc., and Digital Equipment Corporation. Among the Japanese companies, Shinko Electric Company Ltd. ranked sixth (6 percent).

Equipment Vendor Ranking

Table 2 lists the top ten semiconductor equipment manufacturers in 1997. Clearly, Japanese companies decreased their revenue, whereas U.S. companies recorded firm growth. While no change is seen in the top three, KLA-Tencor ranked fourth because of the merger, and Canon fell from fifth to seventh place because of slow sales in the stepper market. In contrast, ASML maintained sixth position by gaining share in the excimer stepper market and boosting revenue by 21 percent. SVG was also driven by increased revenue from excimer steppers and achieved ninth place. On the other hand, Dainippon stepped down from seventh to tenth place because of the slump in the resist processing and auto wet station markets.

Table 2
Semiconductor Equipment Vendor Ranking

1996 Rank	1997 Rank	Vendor	1996 Revenue ($M)	1997 Revenue ($M)	1997 Growth (%)	1996 Market Share	1997 Market Share
1	1	Applied Materials	3,350.5	3,669.3	9.5	15.9	18.7
2	2	Tokyo Electron	2,591.2	2,145.1	-17.2	12.3	10.9
3	3	Nikon	1,721.2	1,565.2	-9.1	8.2	8.0
-	4	KLA-Tencor	-	1,027.2	-	-	5.2
4	5	Lam Research	1,091.9	915.6	-16.1	5.2	4.7
6	6	ASML	726.0	875.9	20.6	3.5	4.5
5	7	Canon	956.0	862	-9.8	4.5	4.4
8	8	Hitachi	631.9	609.2	-3.6	3.0	3.1
10	9	SVG	551.2	560.6	1.7	2.6	2.9
7	10	Dainippon	648.1	500.8	-22.7	3.1	2.6

Source: Dataquest (August 1998)

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The wave of consolidation in 1997—including the mergers, acquisition of divisions, and alliances—seems to have subsided in 1998. Nevertheless, Sugai and Sankyo Engineering plan to merge for the sake of survival in the auto wet station market to form a new company, SES, and Varian has announced the acquisition of the ion implanter division of Genus. Thus, market reorganization is expected to continue through mergers or acquisitions, and market share in various segments will change accordingly.

Dataquest Perspective

The 1997 fab equipment market trends can be summarized in several ways. Generally, the Japanese and Korean markets contracted dramatically as they relied heavily on DRAM investment, and, therefore, equipment companies selling their products primarily in these two markets suffered significant revenue loss. In contrast, the Americas market, whose lifeblood lies in logic (including ASICs) and MPUs, and Taiwan, where foundry investment is rampant, enjoyed expansion, and equipment manufacturers holding share in these markets recorded healthy growth. Thus, the fab equipment market in 1997 was directly linked to the local characteristics of device production, which resulted in a notable regional gap.

Parallel to the widening regional disparity, technology-driven market expansion continues, as seen in 1996. Figure 4 lists segments that recorded high growth in 1997. While the fab equipment market recorded a negative growth of 7 percent, several segments related to 0.25-micron and later process technologies, led by excimer steppers, grew strongly. While the entire market is expected to remain sluggish for another year or two, these high-end segments that hold the key to the commercialization of leading-edge process technology—particularly, sputtering equipment that forms copper interconnections (seed layers) and the formation of electroplated films—will follow a path of solid growth.

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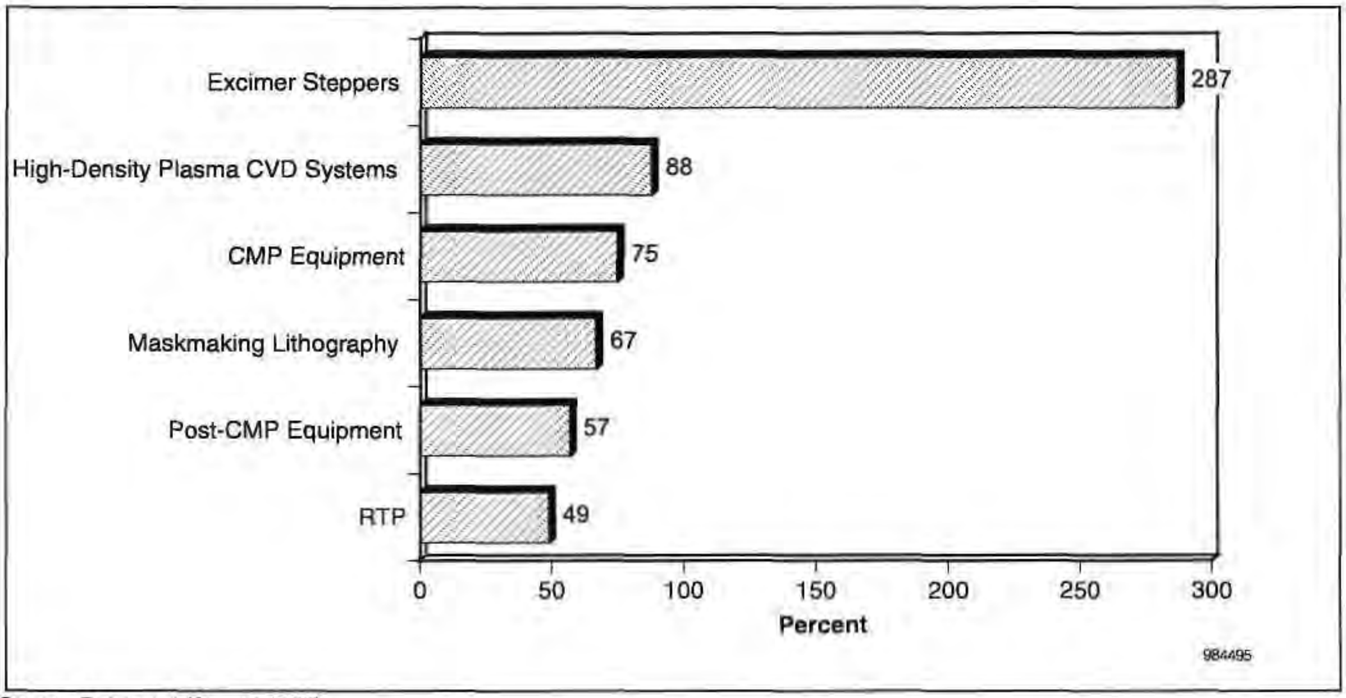
Figure 4
Fast-Growing Segments in 1997 (Worldwide)



Source: Dataquest (August 1998)

In the future, regional equipment market trends will further be differentiated according to the development of leading-edge technology and according to their local device markets and growth patterns. At present, Japanese semiconductor companies are struggling to pursue and nurture high-value-added businesses, such as system-level integration (SLI). In the short run, however, they still have to depend upon DRAM. Dataquest predicts that the DRAM market will make a sufficient recovery after the end of 1999, allowing suppliers to resume full-scale capacity expansion. In the meantime, the Japanese wafer fab equipment market will have to rely on leading-edge equipment such as excimer steppers, CMP, RTP, and high-density plasma CVD as market drivers.

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Perspective

Semiconductors Japan
Market Analysis

Time to Think about the Marketability of 128Mb DRAM

Abstract: *Traditionally, DRAM has quadrupled its integration level. In 1998, however, the grand tradition has been broken with the introduction of 128Mb DRAM. The industry considered the development of 32Mb DRAM in 1996 to be a bridge between 16Mb and 64Mb DRAM, although the 32Mb DRAM failed to materialize as marketable, generic DRAM. Likewise, many view the newly rolled-out 128Mb as a short-lived stopgap between 64Mb and 256Mb DRAM. Whether the quadrupling pattern will continue to dominate or the industry will undergo a paradigm shift in DRAM evolution where the doubling becomes the norm is a critical issue for both DRAM users and suppliers in their product development. This Perspective analyzes 128Mb DRAM from the marketability point of view and examines differentiating factors for 64Mb, 128Mb, and 256Mb DRAM with opportunities for market segmentation.*

By Masahiro Suzuki

Market Forecast for 128Mb DRAM

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In 1998, the DRAM market is in transition from 16Mb to 64Mb, the demand for which has yet to ramp up. However, some leading Japanese and Korean DRAM vendors have unveiled the start of volume production of 128Mb products, which is to take place at the end of this year, and other companies seem to be following suit. To add complexity or choice, some Japanese and Korean suppliers have announced commercial shipments of 256Mb DRAM, starting in early 1999. If these plans proceed according to schedule, 64Mb will become the mainstay in the 1998 DRAM market, and three generations of leading-edge DRAM—64Mb, 128Mb, and 256Mb—will coexist in 1999.

In making forecasts for various device markets, Dataquest refers to past trends and demand forecasts for electronics. In our extensive database, however, there is no comparable case like this one—three generations of leading-edge devices competing in the same market. It is therefore important

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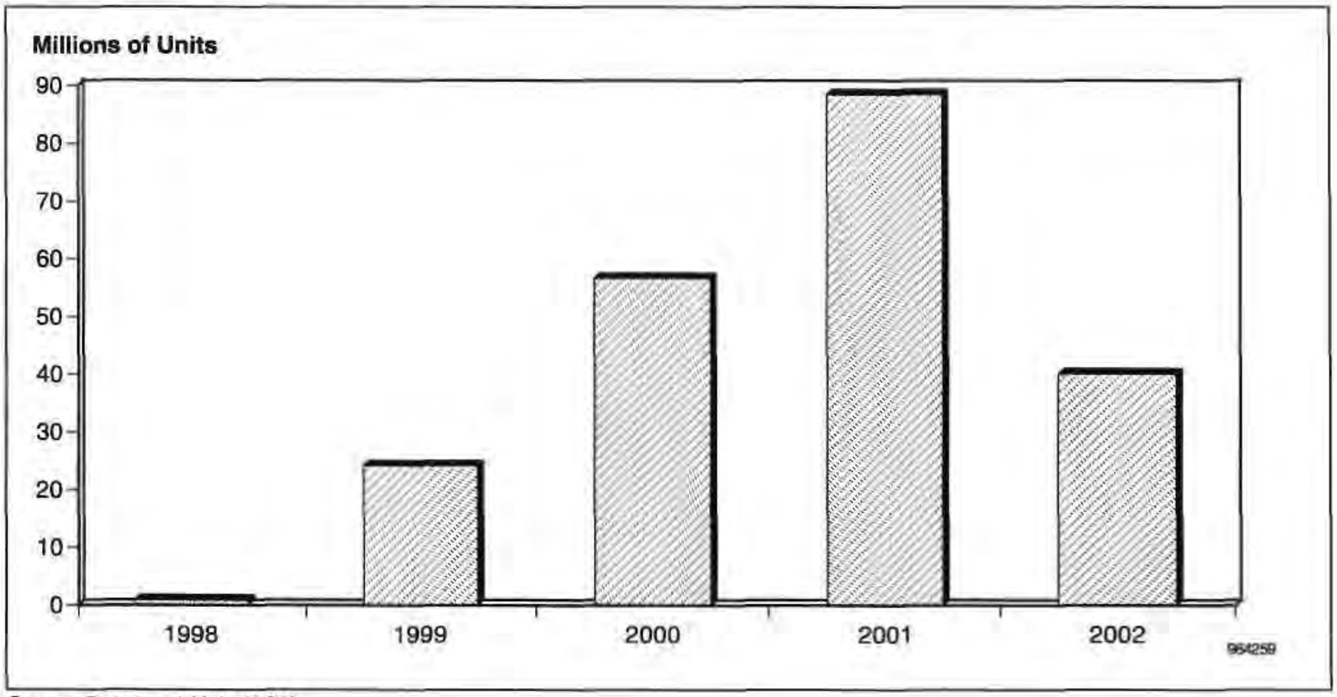
to analyze the 128Mb DRAM market in our May 1998 forecast by focusing on the demand-side, system vendors and their products.

Figure 1 shows unit shipment forecasts for 128Mb DRAM between 1998 and 2002. Note that the 1998 shipments are rather limited, around 900,000, as the forerunners are expected to start up volume production in the third quarter of 1998. To encapsulate the 128Mb chip in the 400-mill package required by DRAM users, semiconductor companies must use the leading-edge production process of 0.23-micron or finer, the capacity of which will inevitably be limited in 1998.

In 1999, other leading vendors will enter the market, and unit shipments will grow steadily. The market is expected to peak in 2001 and then plummet in 2002 to one-half the level of 2001, under the assumption that volume production of the 256Mb version will start to trigger the bit price crossover with 64Mb in that year. Some believe that 128Mb will be further short-lived as volume production of 256Mb ramps up earlier than expected. However, if this happens and 256Mb starts to replace 128Mb at an earlier time, suppliers will face price erosion of the leading-edge device, which will make it difficult for them to reap major investment and secure sufficient profitability for the DRAM business.

Figure 1
Total 128Mb Unit Demand



Source: Dataquest (July 1998)

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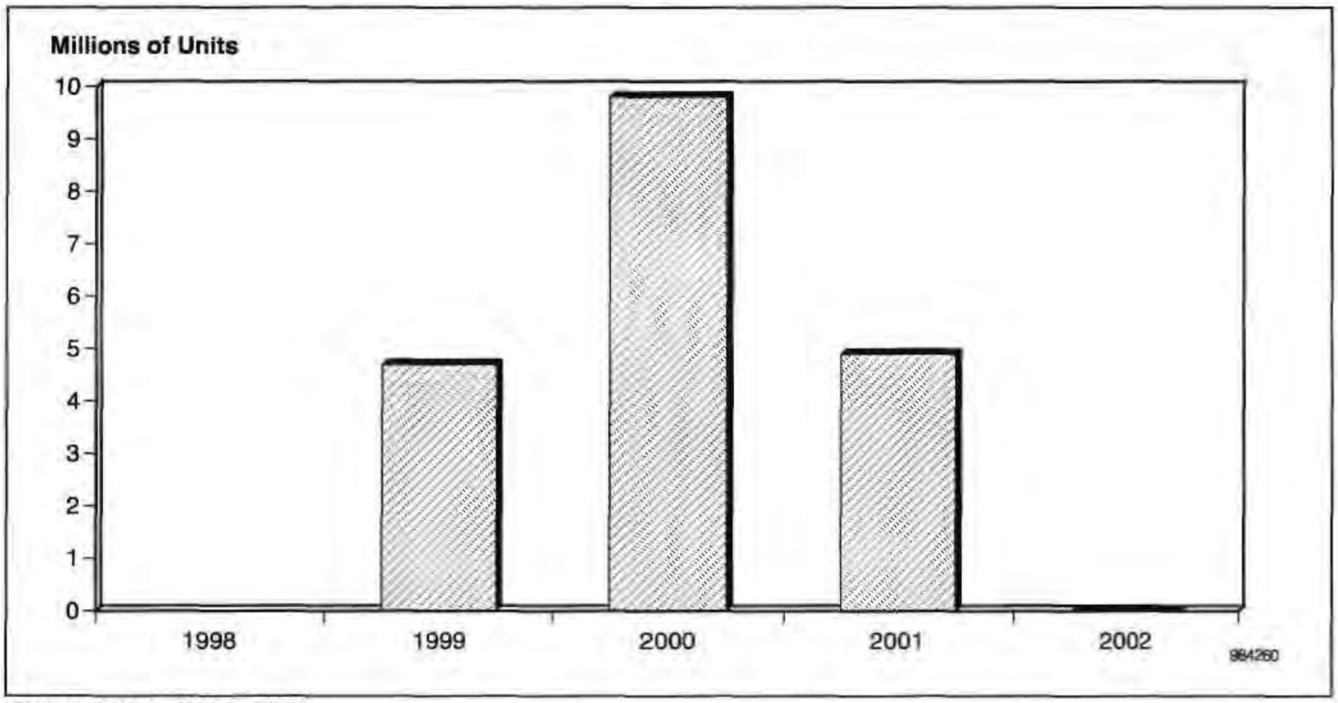
Demand Forecast for 128Mb DRAM

Major target applications for 128Mb DRAM include midrange computers, workstations, PC servers, and high-end notebook PCs. Generally, high-end computers require a larger main memory, which consumes DRAMs of larger capacity, resulting in a higher price premium. On the other hand, semiconductor companies are focusing their efforts on the development of 128Mb synchronous DRAMs (SDRAMs). Generally, when SDRAMs are packaged in a buffer-type dual inline memory module (DIMM), the number of slots available on the motherboard is limited to eight. Thus, supercomputers and mainframes, which require a very large main memory, tend to use extended data out (EDO)-type DRAMs rather than SDRAMs by maximizing performance through the interleave approach.

Midrange Computers

Midrange computers are classified as one class above workstations and thus have relatively large main memory requirements. 128Mb DRAMs will be an attractive choice for low-end machines with a smaller memory size, but they will soon be replaced with 256Mb DRAMs according to the price decline. As a result, 128Mb DRAM demand in the midrange market will reach its peak level in 2000 (see Figure 2).

Figure 2
Midrange Computers: 128Mb Unit Demand



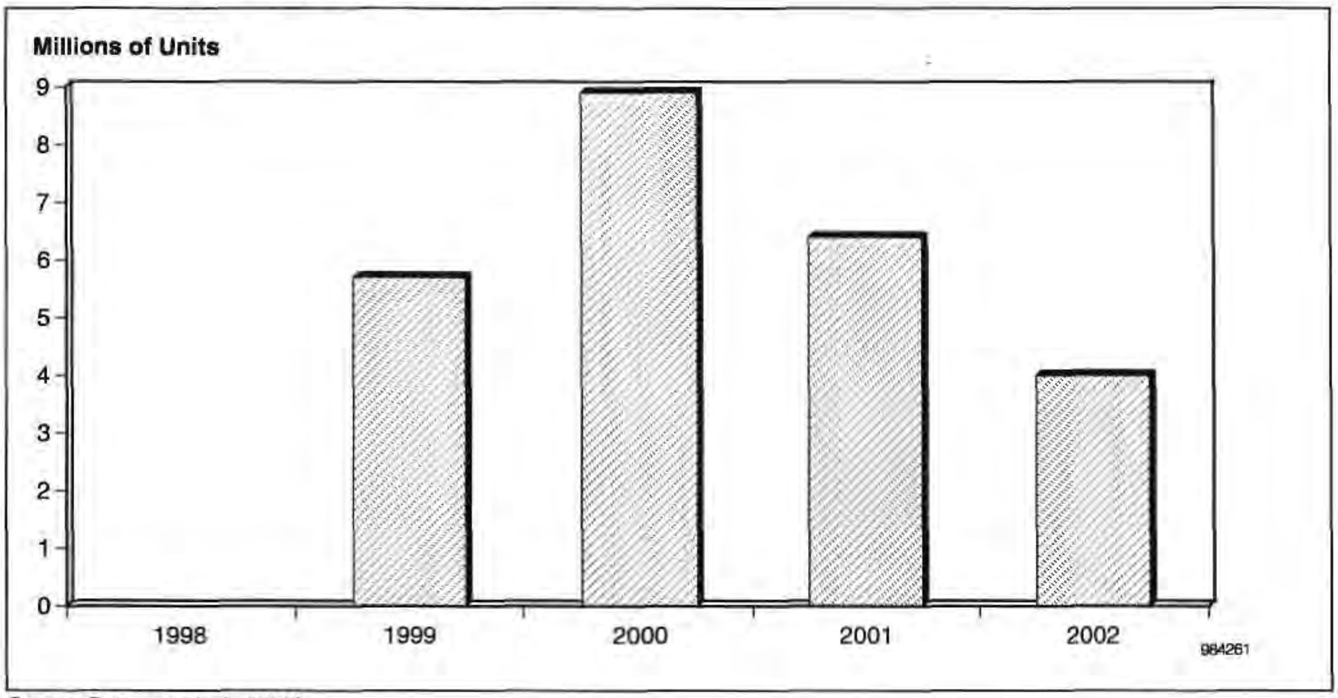
Source: Dataquest (July 1998)

Workstations

This is the segment where replacement of 128Mb by 256Mb is not certain. When the market is divided into three parts—high-end, midlevel, and low-end—the replacement process will be sure to occur in the high-end segment. On the other hand, in midlevel and low-end machines, it will be conditional to the 256Mb price, which must decline to a level triggering the crossover. Furthermore, the low-end segment should be preceded by the proliferation of 128Mb products as their bit price becomes closer to that of 64Mb products.

Interestingly, high-end workstations account for less than 1 percent of the total annual unit shipments, whereas low-end machines represent more than 70 percent. This means that unless the 256Mb price falls significantly, the rate of replacement is not likely to accelerate. In the low-end segment, the 256Mb nonbuffered DIMM will be mainly used for cost saving. In contrast, high-end machines with large memory will demand the buffer DIMM version. The main memory size of 1GB seems to be a threshold. Dataquest predicts that demand for 128Mb DRAM in the workstation market will peak in 2000 and then will gradually be replaced by 256Mb DRAM with a declining price (see Figure 3).

Figure 3
Workstations: 128Mb Unit Demand



Source: Dataquest (July 1998)

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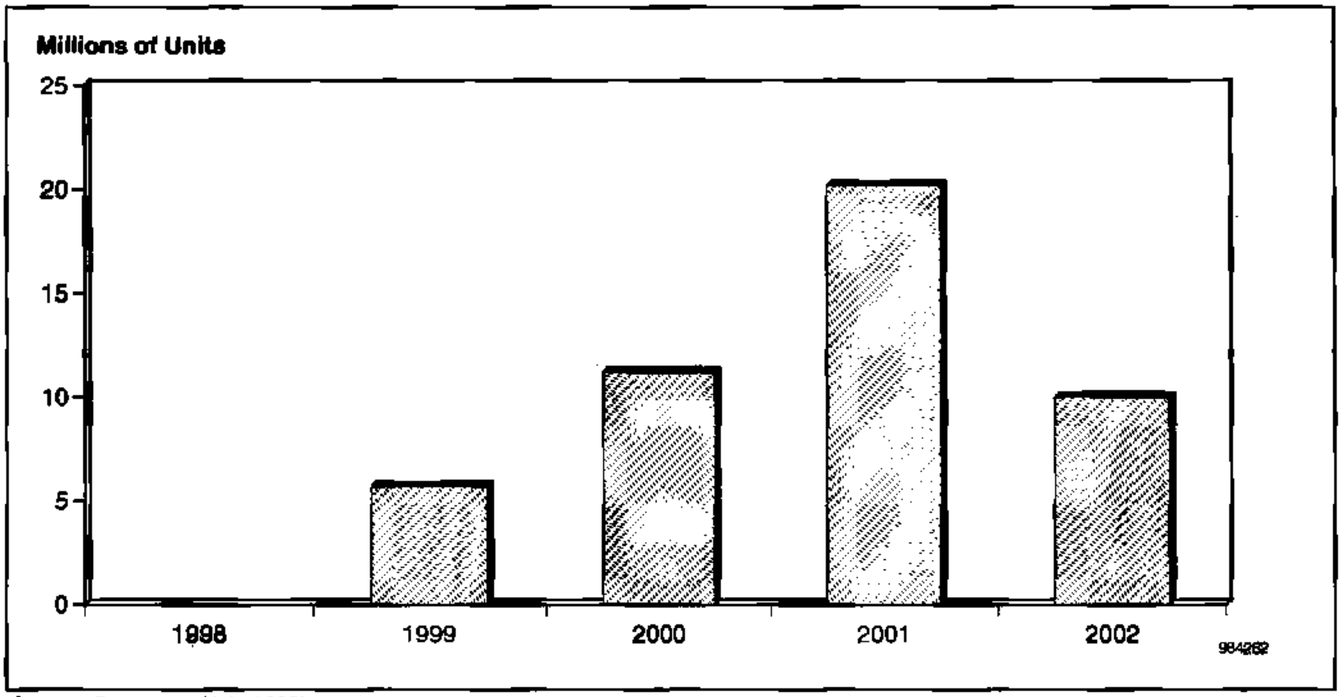
PC Servers

As also seen in the low-end workstation segment, PC servers will become a major application market for 128Mb DRAM that can replace 64Mb DRAM if a parity is reached for the bit price. Between 1998 and 1999, unit demand for 128Mb will expand so much that it will prompt DRAM suppliers to launch strategic pricing for market share. Again, PC servers will opt for the nonbuffered DIMM type. Market demand for 128Mb will reach the highest level in 2001 (see Figure 4), during which time 128Mb will still keep price competitiveness against 256Mb on a bit-price basis.

Figure 4
PC Servers: 128Mb Unit Demand



Source: Dataquest (July 1998)

Notebook PCs

The seemingly relentless drive for a thin form factor makes the packing of parts into less space an increasingly critical issue. The use of 64Mb DRAMs in high-end notebook PCs in early 1997 is evidence that vendors can afford to select costly, large-capacity DRAMs if main memory is to be expanded. The 64MB main memory will increasingly become a standard feature of 1998 models with the release of Windows 98. 128Mb DRAMs will be able to easily configure a thin 64Mb module by allowing four units to be mounted on the single side of the small-outline DIMM (SODIMM). Dataquest believes that high-end models will start to incorporate 128Mb DRAMs in the second half of 1998. The 128Mb price is expected to enter a downward path in 1999, pushing the pervasiveness of notebook PCs. Demand in the notebook PC market will reach its peak in 2001 (see Figure 5).

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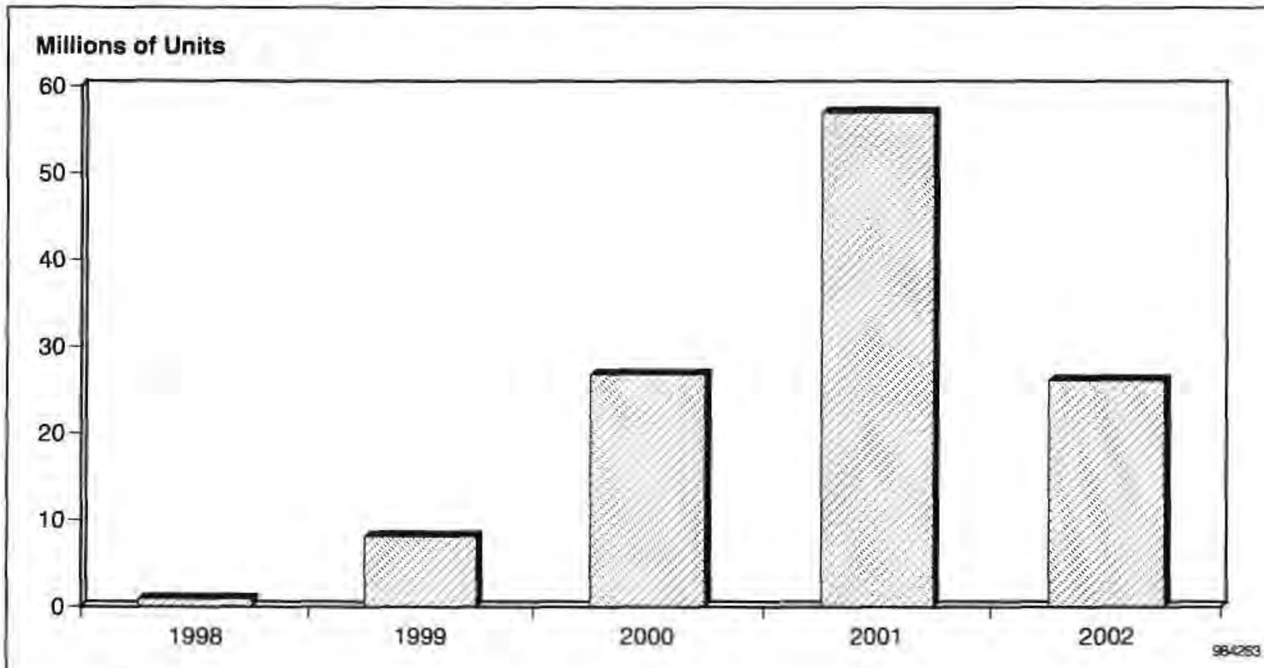
Figure 5
Notebook PCs: 128Mb Unit Demand



Source: Dataquest (July 1998)

As demand forecast for 128Mb DRAM in four major target applications indicates, actual market acceptance is governed by price levels and the timing of model changes in each segment. Another factor is the generation shift from 64Mb to 256Mb, which is expected to occur in 2002. Once the bit price crossover takes place between 64Mb and 256Mb products, it will entail accelerated replacement of 128Mb DRAM by 256Mb DRAM. Table 1 lists 128Mb DRAM shipment schedules of eight leading DRAM suppliers in Japan and Korea.

Table 1
128Mb DRAM Shipment Schedules of Leading Suppliers in Japan and Korea

	Hitachi	NEC	Samsung	Toshiba	Hyundai	LG Semicon	Mitsubishi	Fujitsu
Samples	Q1/98	Apr 98	Q2/98	Q3/98	Q3/98	Q3/98	Q4/98	H1/99
Volume Production	Q2/98	Aug 98	Q3/98	Q4/98	Q4/98	Q4/98	Q1/99	H1/99

Source: Dataquest (July 1998)

Dataquest Perspective

In 1998, the previous hype about 128Mb DRAM is beginning to subside among leading Japanese and Korean DRAM suppliers, as they can afford less and less R&D expenditure. At present, the highest priority is given to the development of a 64Mb shrink chip, for which leading-edge fabrication processes are starting up at an accelerated pace. The next priorities will be

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the 64Mb version that is adaptive to column address strobe (CAS) Latency 2 for PC100, which will take up much time toward the end of 1998, and the next-generation high-speed DRAM in 1999. Future development points to cost reduction, high speed, and large capacity. In particular, the first two areas are already subject to intensive competition. Under these situations, 128Mb DRAM, which is doomed to serve as a stopgap between 64Mb and 256Mb, inevitably lags behind in the R&D priority list.

128Mb DRAMs come in two types: the stack type to integrate two 64Mb chips into one package and the single-chip type. The stack type, already marketed by a Japanese manufacturer, is more costly than the single-chip version. Also, the use of two chips doubles input capacitance, which results in larger dynamic power loss because of charge/discharge with the switching operation, making it unsuitable for notebook PCs. Korean suppliers, originally working on the stack type, are now focusing on the single-chip version. Dataquest believes that the single chip will become the mainstay in the 128Mb segment.

Because there is a limited number of Japanese and Korean DRAM suppliers who can start volume production in 1998, the forerunners will be able to maintain leadership in the 128Mb pricing. The use in PC servers is spurred when the bit price of 128Mb becomes 1.5 to two times that of 64Mb. Dataquest expects that the total shipments of 128Mb DRAMs will reach 24.2 million units in 1999, which translates to a moderate number of 2 million per month. Thus, the initial target is set for midrange computers, workstations, PC servers, and notebook PCs; the market can be sufficiently served by the three forerunners. However, as shown in Table 1, more entrants are expected, and oversupply is highly likely in 1999.

In conclusion, the general impact of 128Mb products on the entire DRAM market can be described by two possible scenarios:

- Scenario 1: When the bit price of 128Mb DRAM constantly exceeds that of 64Mb DRAM, target markets for 64Mb, 128Mb, and 256Mb become highly distinctive: 128Mb for midrange computers, workstations, PC servers, and notebook PCs; and 64Mb for supercomputers, mainframes, and PCs. Then, once 256Mb DRAM is introduced, migration will start from the high-end segments. In this case, DRAM suppliers, particularly the three forerunners, will be able to reap profits from the business.
- Scenario 2: Generally, the semiconductor business relies on volume production for profitability. However, unless semiconductor companies listed in Table 1 discipline themselves in curtailing their output, a supply glut is hard to avoid, and price erosion will follow. The question is how far the price will decline. As the bit price of 128Mb becomes closer to that of 64Mb, desktop PC manufacturers will be enticed to use it, which will push the 64Mb price downward to trigger the price decline cycle between the two products. In this case, manufacturers having volume production capabilities of both 64Mb and 128Mb on the 0.23-micron-or-finer process will be able to have a cost advantage in 128Mb fabrication, if the production yield is more or less the same for the two products. In other words, 128Mb DRAM will be a lucrative product for companies that have

a competitive edge in leading-edge process technology. On the other hand, those without it will have to suffer a blow.

Dataquest believes that the significance of 128Mb DRAM is found not only in the fact that it breaks from the traditional quadrupling but that this device will determine the profitability of DRAM suppliers entangled in persistent excess capacity.

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Perspective

Semiconductors Japan

Market Analysis

A Changing Landscape for the Japanese Foundry Business

Abstract: *This Perspective analyzes foundry business trends for Japanese semiconductor companies on the basis of Dataquest's latest foundry shipments survey results. The prolonged recession of the Japanese semiconductor market increases the capital investment burden, and alliances are needed to build the ability to produce system LSIs—the wave of the future. In the changing environment, foundry business plays a much different, increasingly active role in the industry. Foundry business is gaining new meaning for Japanese semiconductor manufacturers, which are becoming foundry users themselves rather than foundry providers as in the past.*
By Yoshihiro Shimada

Start of Dataquest's Official Foundry Survey

Dataquest has been tracking semiconductor companies' brand shipment revenue trends in the annual market share survey. In 1997, we added a new item, foundry shipments and purchase, covering gross revenue from foundry business, as well as users and technology trends. Since foundry demand is continuously on the rise, the new survey focus is designed to shed light on this demand from the foundry company's perspectives and analyze the overall impact of foundry business on the semiconductor industry.

Most Japanese semiconductor companies have their own fabs and are generally referred to as integrated device manufacturers (IDMs). Japanese IDMs characteristically ramped new fabs producing the most advanced DRAMs, and as new fabs with more advanced technology are built, the old fabs are converted to produce other devices, including MOS logic, MOS microcomponents, and later, even analog. This has been regarded as the most efficient method of fab utilization and has actually been the most typical method. This traditional conversion cycle, however, has been changing recently. Instead of converting DRAM fabs to production of other

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devices, companies are required to build new fabs with logic capabilities. The change is partially driven by the notable success of dedicated foundry providers led by Taiwan Semiconductor Manufacturing Company (TSMC), together with the high profitability they have demonstrated.

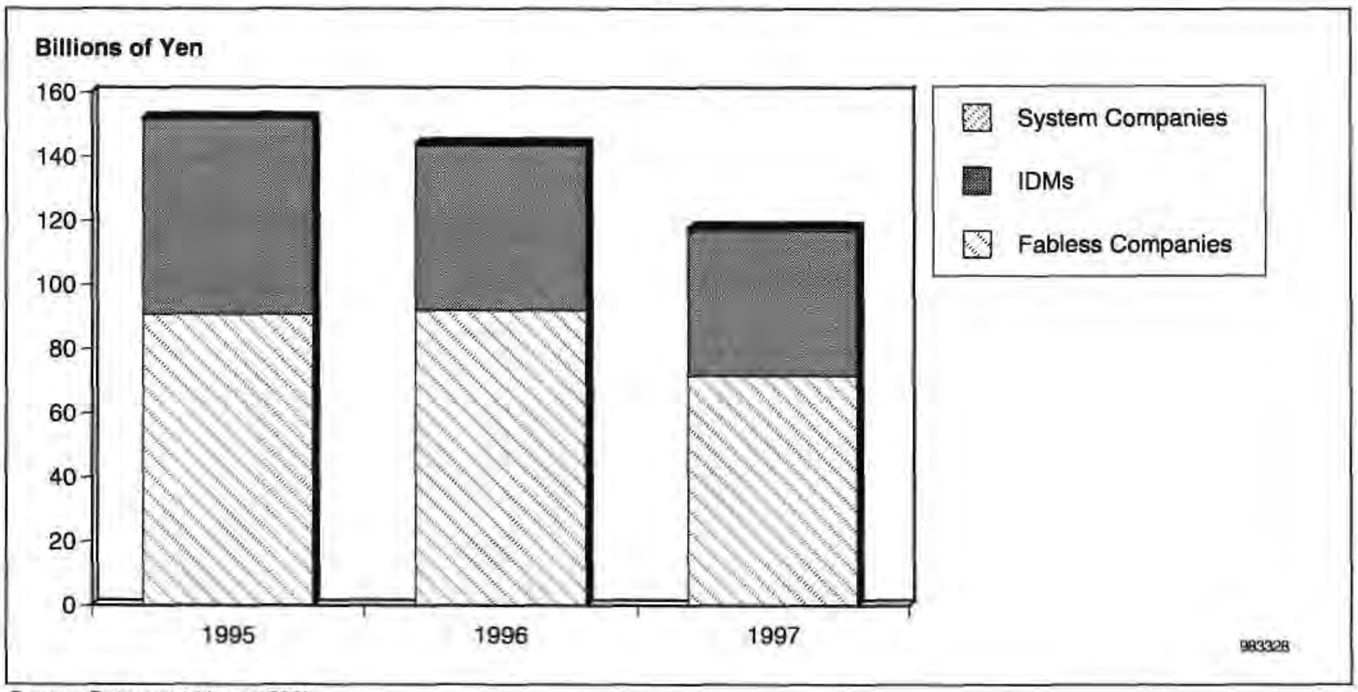
Foundry production as referred to throughout this Perspective includes the OEM production observed among Japanese and Korean companies.

Declining Foundry Shipments from Japan

In the 1997 semiconductor brand shipments ranking, Japanese companies again lost share in the worldwide market. At the same time, their total foundry shipments declined while the worldwide foundry market was expanding (see Figure 1). This makes a sharp contrast to the increasing commitment by Japanese semiconductor companies to foundry business. To put it simply, their decision came long after that of their competitors, especially dedicated foundry providers in Taiwan, who established technical leadership and developed close relationships with U.S. fabless companies.

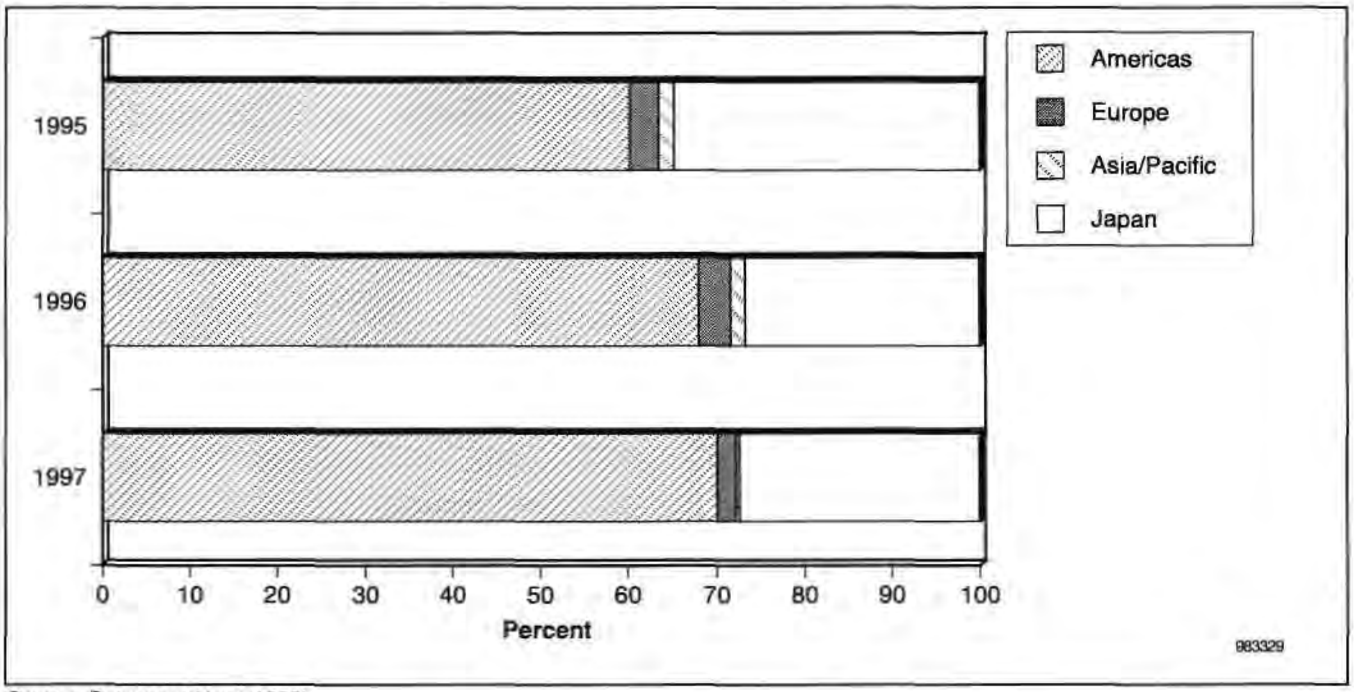
A major destination of foundry shipments by Japanese companies is the Americas market, which accounts for 70 percent of the total (see Figure 2). While the share of the Americas region has been on the rise since 1995, the absolute figure shows slight declines. This reduction in shipments comes mainly from reduced foundry business with U.S. fabless companies. At the same time, the value of shipments to the Japanese market has been declining, which reflects not only sluggish foundry contracts among Japanese companies, but also a decline in domestic delivery to foreign foundry users.

Figure 1
Japanese Companies' Foundry Shipments by User Type



Source: Dataquest (June 1998)

Figure 2
Japanese Companies' Foundry Shipments by Destination



Source: Dataquest (June 1998)

The downward trends are clearly evident in an analysis of revenue by product. The market share of logic and microcomponents, which accounts for a major portion of foundry shipments to Americas fabless companies, has dropped significantly compared to two years ago (see Figure 3). Instead, flash memory foundry has increased, with shipments from Japanese companies such as Sharp Electronics Corporation and SANYO Electric Company Ltd. to U.S. partners.

Technology trends are visible in the change in share by wafer size, down for 150mm and up for 200mm (see Figure 4). The major reasons for these changes include the following, given that 200mm fabs:

- Account for a large chunk of excess capacity because they were built during the previous boom
- Need to be operated to their capacity to vie effectively for the increasingly competitive foundry business
- Are more advanced than their 150mm counterparts in terms of design rule

The third point is substantiated by the fact that 0.5-to-0.8-micron processes using 150mm wafers lost share, while 0.5-micron or finer processes, which can be translated to 200mm fab technology, have gained sharply (see Figure 5). Finally, products with one to two metal layers lost share, while three-layer designs grew to 17 percent of the total in 1997. No contract has been won for four or more layers (see Figure 6).

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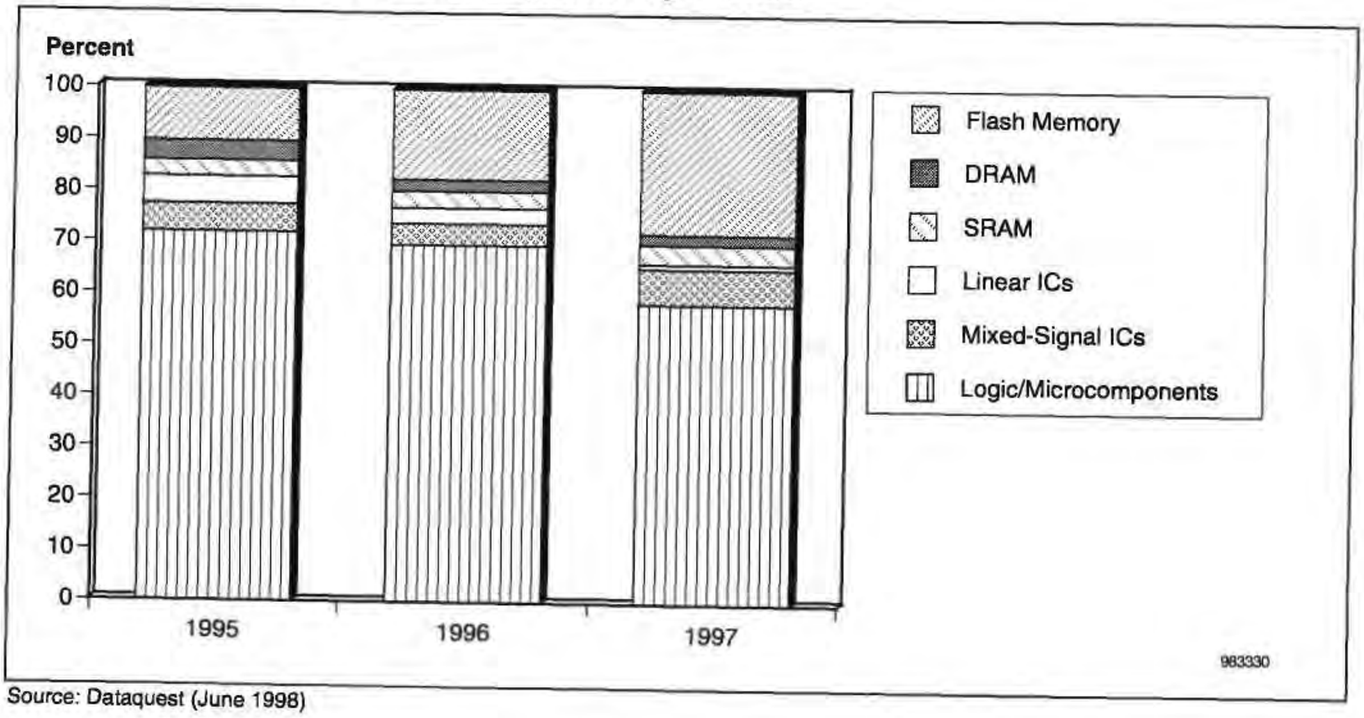
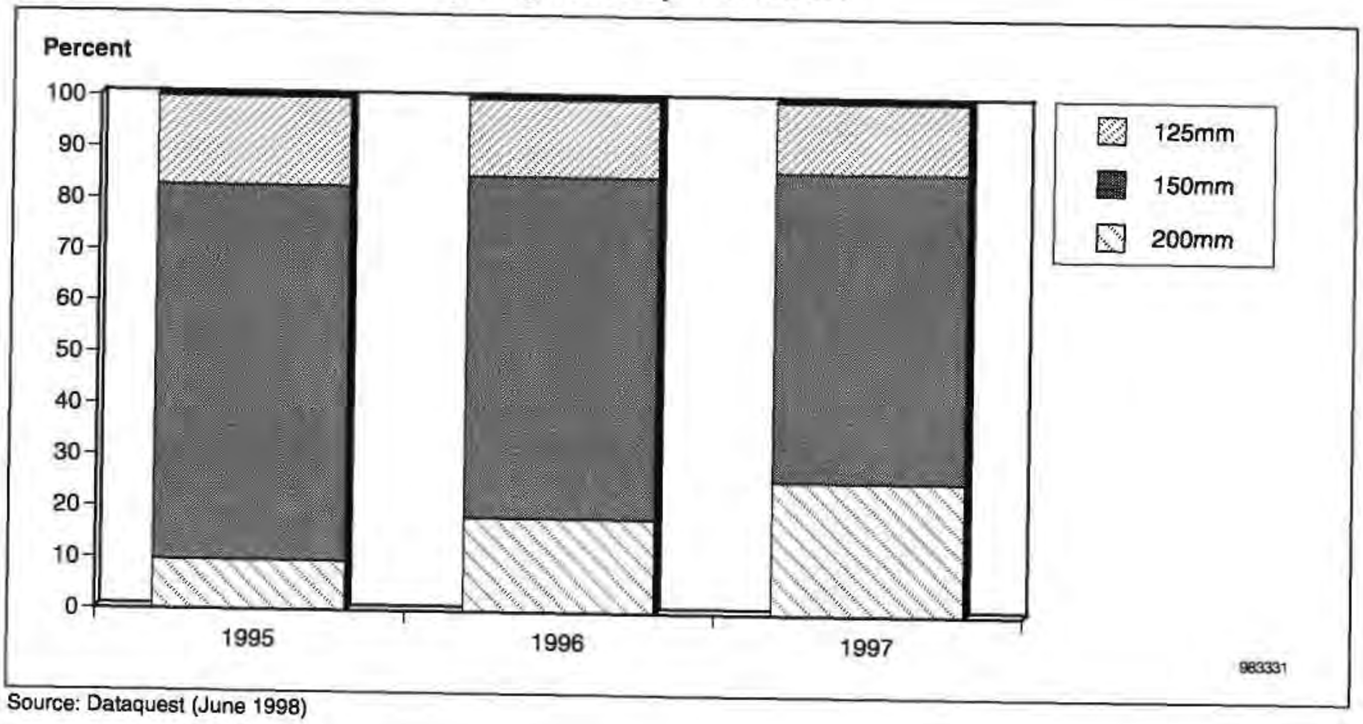
These technology trends suggest that Japanese foundries are focusing on higher capacity utilization for 200mm fabs, while they still have to establish capabilities to support U.S. fabless companies.

Figure 3
Japanese Companies' Foundry Shipments by Product



Source: Dataquest (June 1998)

Figure 4
Japanese Companies' Foundry Shipments by Wafer Size



Source: Dataquest (June 1998)

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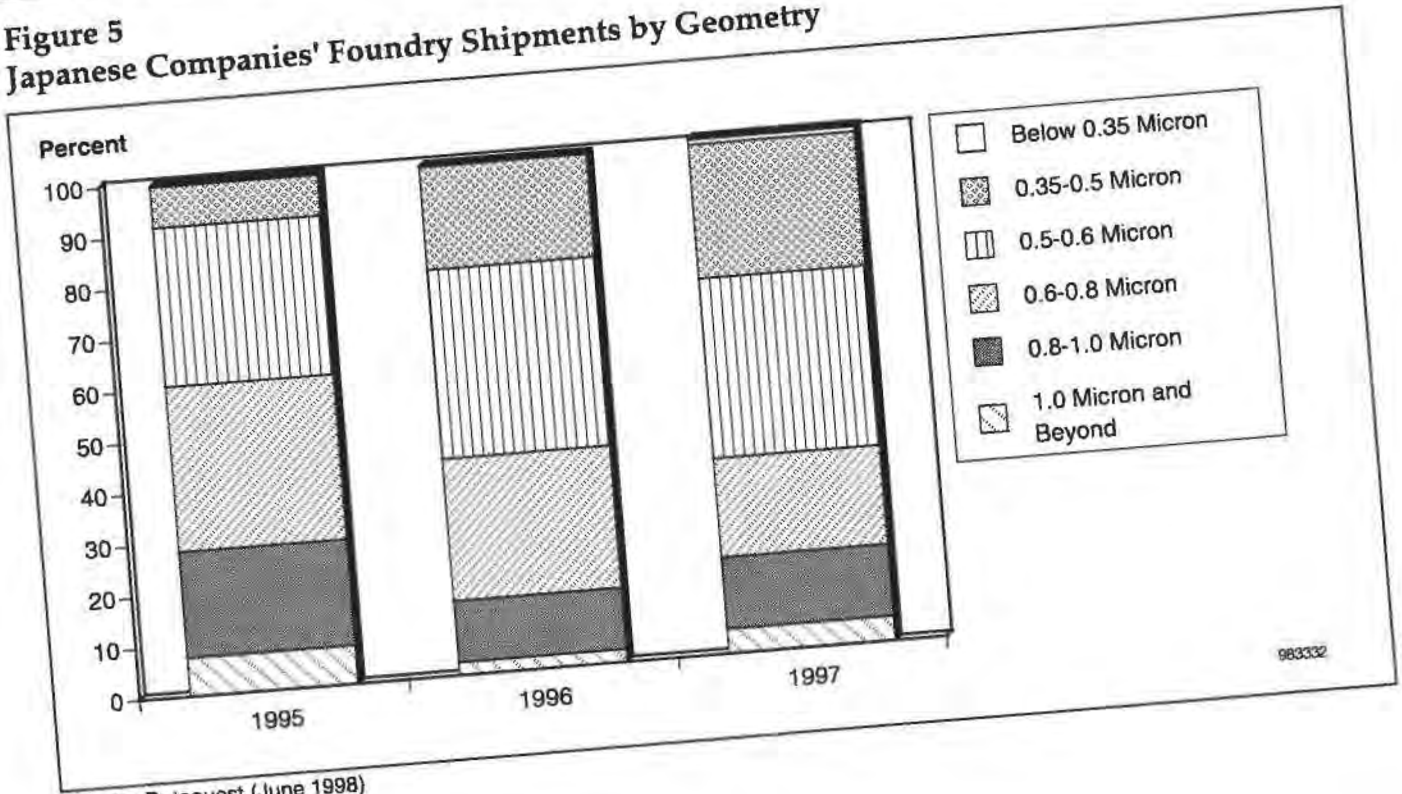
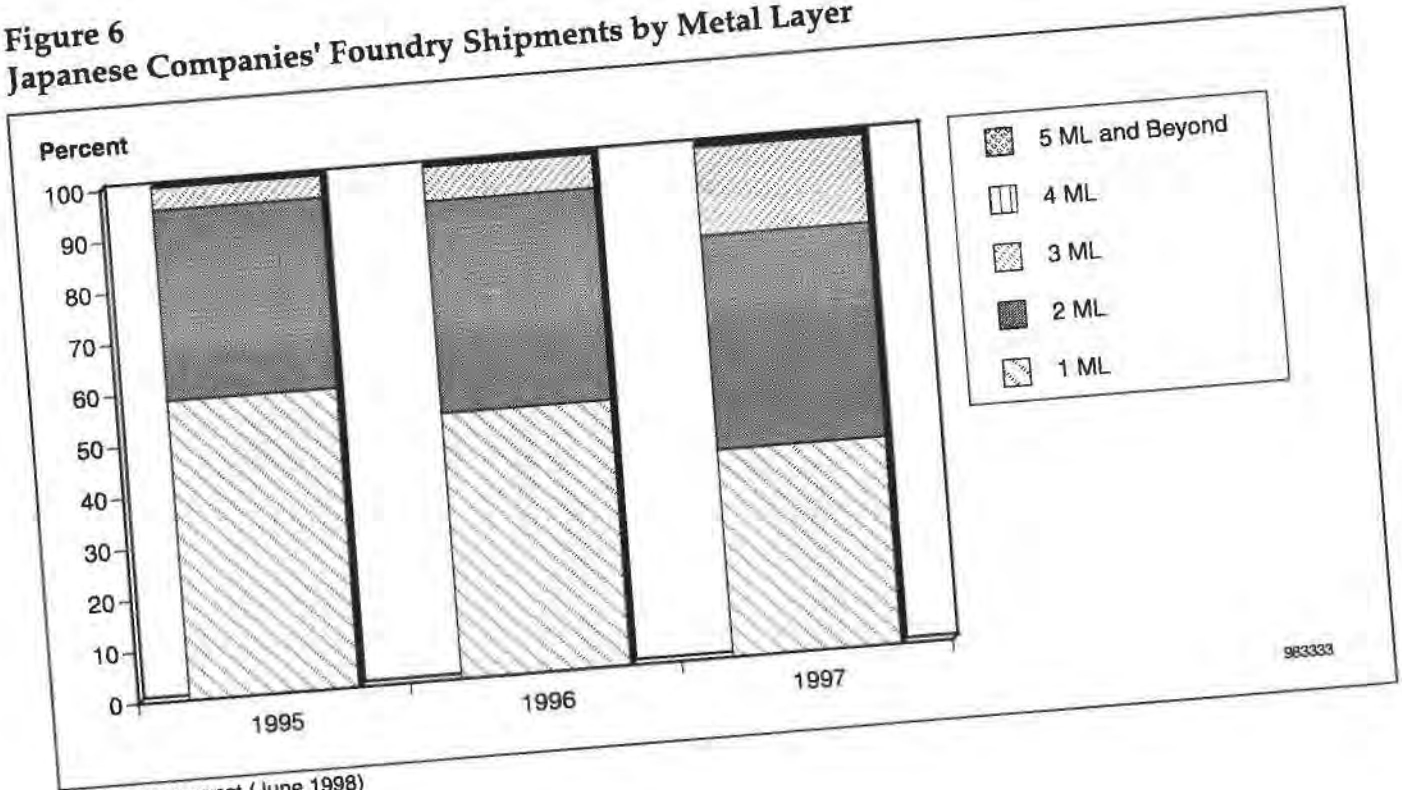
Figure 5
Japanese Companies' Foundry Shipments by Geometry



Source: Dataquest (June 1998)

Figure 6
Japanese Companies' Foundry Shipments by Metal Layer



Source: Dataquest (June 1998)

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Foundry Orders on the Rise

Showing a clear contrast to declining foundry shipments, foundry orders by Japanese companies have been increasing steadily, although their worldwide share is still fairly small. While Japanese IDMs have not yet utilized their DRAM capacity fully, their logic fabs are not meeting customer demand, either in volume capacity or in technological capability. Rather than converting memory fabs to logic, which requires additional capital spending, Japanese IDMs are trying to leverage the low production cost of dedicated foundry providers. Alliances and foundry deals involving Japanese companies can be classified into the following models.

Evolution from Joint Development to Foundry Production

Primary examples are Sharp, producing flash memory for Intel Corporation, and Hitachi Ltd. and Mitsubishi Corporation, which share development and production efforts for their own brands of flash products. The intent is to reduce the R&D burdens on circuit design, process technology development, and product planning, while optimizing a production system where partners are responsible for production resources that they can provide with a comparative advantage.

Generally, the manufacture of a product developed by a partner leaves a foundry (an OEM) with relatively little value added. Still, the foundry provider can benefit by gaining experience with a product that it would be difficult to develop or market on its own, not to mention the infusion of new technology, which may enable it to develop proprietary products. This type of partnership can be mutually beneficial as long as each partner has a key technology to license. By sharing the development process from the outset, the production process can be made more reliable. At the same time, it allows the partners to maximize flexibility and efficiency in marketing their own products.

Capacity Supplementation

Traditionally, Japanese companies have seen foundry contracts as a means of using their excess capacities and keeping fabs highly utilized. In particular, when companies are hit by recession just as fabs invested in during a booming market come on line, foundry use is considered to be the "last resort" to avoid idling capacities. Companies often accept orders that are far below the ordinary break-even point for brand shipments.

Foundry deals in the form of such capacity supplementation are typically limited to a specific period, especially in the case of an IDM, that is, until the IDM's own fab is ready for start-up. In the case of an OEM deal, foundry production may be a temporary relief for the customer until it has the ability to develop and manufacture its own products. On the other hand, the OEM may rely on the foundry deal as a strategic instrument that effectively prevents the manufacturer from making inroads into the market.

At present, Japanese companies that order foundry production to supplement their capacities are primarily doing so in the DRAM field, such as Hitachi/LG Semicon, Fujitsu/TSMC, and Toshiba/Winbond Electronics.

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The Hitachi/LG Semicon deal is unique in that the two companies—major players in the DRAM market with their own established brands—have entered an alliance in the form of a joint production arrangement. Hitachi also maintains a long-term relationship with Texas Instruments Inc. and operates diverse DRAM processes. This framework allows Hitachi to disperse burdens and risks related to product development and manufacture, but at the same time, Hitachi has presumably been loaded with the management of those diversified masks and processes. For LG Semicon Co. Ltd., the alliance is intended to ensure a jump-start of its new business thrust by leveraging technology and production capacities.

The other two deals differ from that of Hitachi and LG Semicon. TSMC and Winbond Electronics Corporation do not intend the first step of entering the DRAM market for foundries. The decision by TSMC to start a DRAM foundry with Fujitsu seems to represent a point of confluence for TSMC's strategy to establish "0.35-micron and beyond DRAM cell" technology, which was included in its technology road map. On the other hand, Fujitsu intends to disperse risks related to capital spending. These two companies' strategies match, which has led to their foundry deal. The Toshiba/Winbond alliance, which follows a similar pattern to the TSMC case, is characterized as part of their broader partnership, including LCDs.

Strategic Alliance

The Toshiba/Motorola alliance has served as a model for a constructive relationship between Japanese and U.S. semiconductor industries facing much-publicized trade friction. This broad-based, long-term (seven-year) relationship embraced a number of models and paved the way for a myriad of subsequent alliances. Among these were joint product development initiatives uniting the strengths of the partners, committed assistance in increased access to the Japanese market, wafer fab production at a joint venture (for instance, Tohoku Semiconductor), and factory-based collaboration in production efforts.

Nevertheless, the relationship seems to have matured to a stage requiring redefinition as the Japanese semiconductor market is losing its attractiveness in the global context and semiconductor production in the country is waning in terms of comparative advantage. The Hitachi/TI alliance faces a similar situation. Under the long-term relationship, the two companies chose a U.S. joint venture rather than a foundry contract. However, the joint venture was discontinued this March. In this sense, foundry is becoming a less desirable option for IDMs, which have traditionally used it as part of a strategic alliance. Foundry business itself increasingly makes sense on the basis of its flexible, low-cost production.

Evolution from Joint Production

Mitsubishi Electric Corporation has established Powerchip Semiconductor Corporation with UMAX Group of Taiwan to reduce financial burdens from capital spending, use the Taiwan semiconductor industry and its increasingly credible resources, and explore a new DRAM user (since UMAX is a PC motherboard manufacturer). The deal includes a new attempt to reduce the workload for marketing efforts through the joint venture, as

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opposed to the traditional approach that foundries are solely responsible for production. Powerchip is authorized to ship its own products in excess of a certain production level under its own brand. If this happens, shipments to Mitsubishi Electric will be on a partial foundry basis that goes beyond the traditional, narrow definition.

The Powerchip case relied on UMAX's high expectations for profits from the booming DRAM business as well as Mitsubishi's expectation of securing users for its products. In this sense, this type of alliance cannot be positioned as a general model. Nevertheless, it certainly suggests one of the feasible directions for the industry, which is seeking a way to reduce capital investment requirements by leveraging the technological prowess of each company.

This categorization seems to depict, among other things, the versatile roles of Taiwan companies. Backed by rich financial resources, they have successfully developed semiconductor production into the broad relationships shown here. Japanese PC manufacturers have accelerated procurement from Taiwan companies on an OEM basis since the mid-1990s. The viability of these complementary roles is based on the fact that semiconductor companies in the two countries are both primarily vertically integrated electronics manufacturers. This long-term relationship seems to lay the foundation for diverse alliances in semiconductor production and can serve as the core of a strategy.

Dataquest Perspective

Japanese semiconductor companies largely assume foundry business to be less than profitable, which clearly reflects the "opportunistic" nature of the Japanese foundry business model. Foundry business is forced to assume this less-than-exalted position for several reasons. First, obsolete fabs, rather than leading-edge ones, are used for foundry. Second, the primary purpose of foundry production lies in maximizing utilization. Finally, foundry production is considered a part of complementary or diverse alliances between IDMs. However, with the emergence of TSMC, which has proven the high profitability of the dedicated foundry business, Japanese companies are looking for opportunities to improve the profitability of their own foundry contracts. Many are expecting foundry deals to fill a growing gap between demand and supply capacity stemming from the prolonged recession of the semiconductor market. However, this expectation is no longer feasible, as evidenced by declining foundry revenue. Clearly, the tide has turned. The foundry market continues to establish itself by offering lucrative opportunities for specialized manufacturers. It cannot be viewed as the last resort for IDMs to replenish idling capacities.

Dr. Morris Chang of TSMC, in his recent speech at Dataquest's Semiconductor Conference 98, stated, "It is not correct to think of foundry as a manufacturing issue. Rather, foundry is a service business, and without that notion, you cannot be successful in the business." Foundry service as a reliable and viable business becomes feasible only when there is no need for

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the manufacturer to adjust a process conflict with its own products, which strongly suggests the need for the specialized company.

For dedicated foundry providers, Japanese semiconductor companies can be primary customers because of their broad product lines and business structure, which require ever-growing capital spending. The benefits they offer, that is, elimination of the need for capital investment, including broad process development and optimization toward volume production, are highly attractive for Japanese companies. Not many Japanese companies, however, have a clear, corporatewide foundry strategy; only a handful of them are prepared to deploy foundry business by keeping the optimum balance with brand businesses. What Japanese companies need is to establish core competence in the semiconductor business, which entails a redefinition of "strategic domains" in many cases. Dataquest believes that it is increasingly becoming a critical management issue for Japanese companies to utilize foundry providers (especially Taiwanese companies) effectively as an integral part of the redefinition process.

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Perspective

Semiconductors Japan
Dataquest Predicts

Spring 1998 Forecast: Japanese Electronic Equipment Production and Semiconductor Market

Abstract: *Dataquest's spring forecast shows downward adjustments for electronic equipment production and the semiconductor market in Japan and worldwide, reflecting a clear slowdown in the electronics industry following the end of the PC boom. In the long run, however, growth of the industry will continue, along with expansion of the semiconductor market. When will we see the market bottom out from the present recession, and in what form will this occur? In particular, will the DRAM market reach its bottom this year? Will system LSI become the key to market recovery? With a focus on Japan, this Perspective analyzes electronics production and semiconductor consumption trends up to 2002, on the basis of Dataquest's latest forecast. Unless otherwise specified, world market data is indicated in U.S. dollars, and Japan market data is in yen (exchange rates: ¥121.10/$1.00 in 1997 and ¥129.73/$1.00 from 1998 through 2002).*
By Yoshihiro Shimada, Motoya Ohgami, Masahiro Suzuki, and Yoshihisa Toyosaki

Electronic Equipment Production in Japan

The Japanese economy in 1997, after a temporary surge in domestic demand prior to the consumption tax hike in April, was beleaguered by turmoil in the financial system, a decline in consumer expenditure, and a slowdown in capital spending, which was amplified by the Asian financial crisis toward the year-end. Against the backlash, electronic equipment production showed stronger growth than expected, 7.8 percent over 1996, reaching ¥23,715 billion. Cellular phones contributed greatly as fueled by a series of price cuts and the shift in demand from personal handy phone (PHS) models. Electronic data processing (EDP) equipment also outgrew the forecast, despite a slowdown in domestic PC shipments, and consumer equipment added some momentum that came from video game systems and digital equipment.

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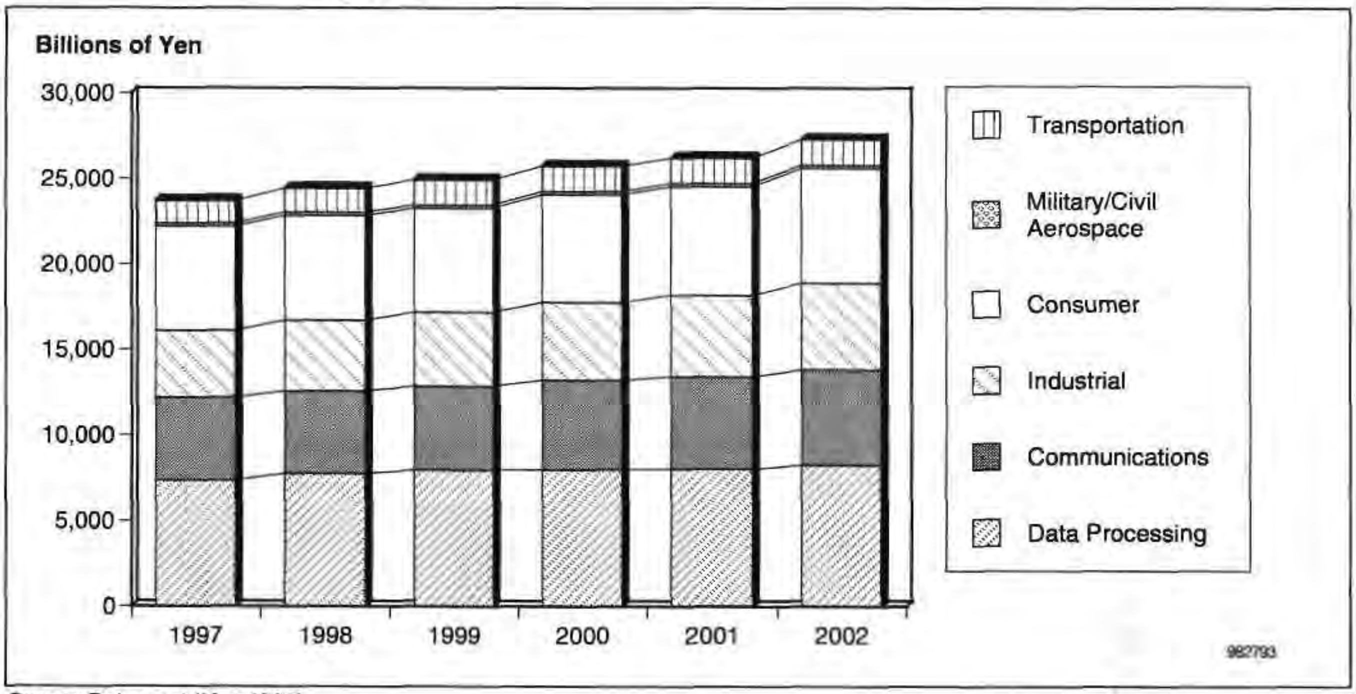
In 1998, communications equipment will no longer serve as a major impetus, as the cellular phone market reaches a high level of penetration and digitization of backbone networks completes its first round. Thus, Dataquest predicts that electronic equipment production in Japan will grow at a moderate 3.1 percent to ¥24,459 billion, down 1.5 percentage points from the fall forecast. Similarly, the compound annual growth rate (CAGR) between 1997 and 2002 will settle at 2.8 percent (see Figure 1).

Future growth opportunities must come from a surge in PC demand stimulated by introduction of low-cost models, and increased implementations of plug-and-play interfaces such as Universal Serial Bus (USB) and Institute of Electrical and Electronics Engineers (IEEE) 1394. While Windows 98 will not have much impact on the PC market, evolution of PCs to a new platform for WebTV and other media-mix services will hold the key to growth of demand for personal equipment.

The following section provides a detailed analysis of electronic equipment production in Japan, by major segment.

Figure 1
Japanese Electronic Equipment Production Forecast



Source: Dataquest (May 1998)

EDP Equipment

In 1997, EDP equipment production in Japan soared 8.3 percent to ¥7,380 billion (see Figure 2). While PC shipments to the domestic market slowed down to less than 5 percent on a unit basis, the price decline spurred the purchase of peripherals such as printers and display units. Also, storage devices led by high-speed optical disk drives, for example, 32x CD-ROM drives and DVD-ROM drives, enjoyed strong growth. The segment is expected to drive the market in the forecast range.

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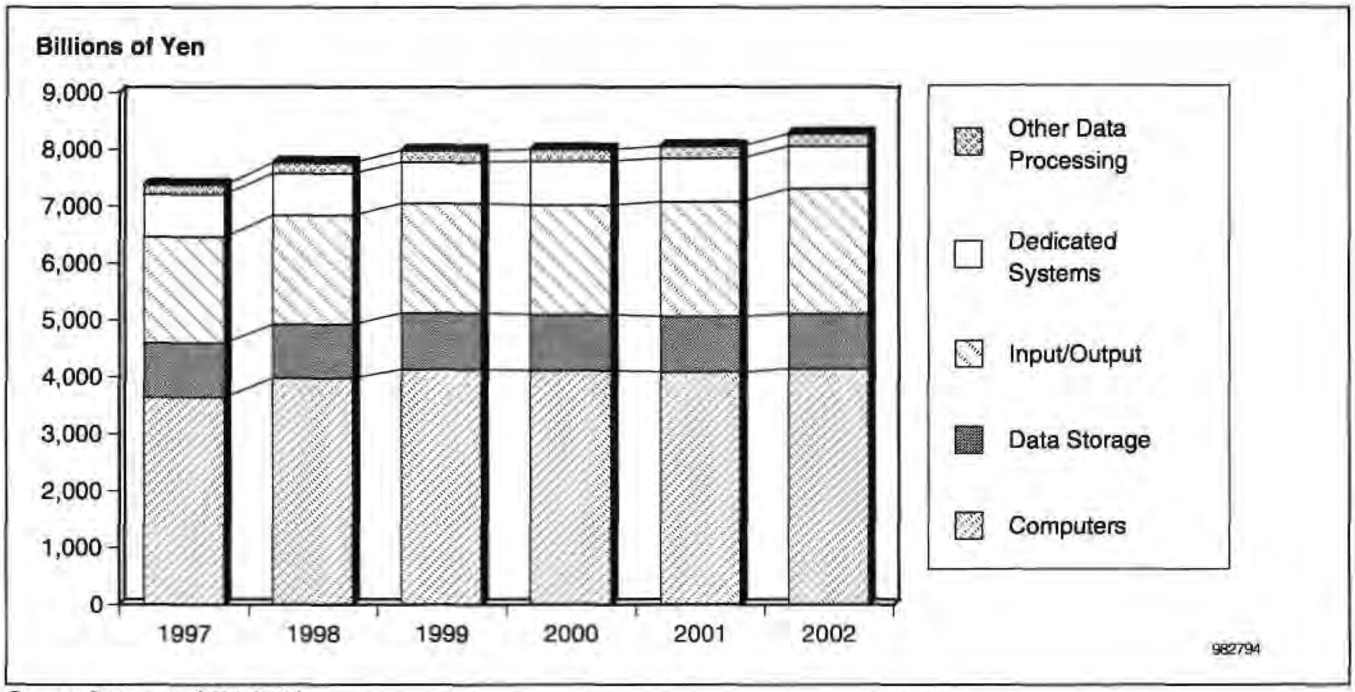
Figure 2
Japanese Data Processing Production Forecast



Source: Dataquest (May 1998)

IT investment will continue to be a major driver in 1998 while Japanese financial institutions are exposed to global competition as a result of the "Big Bang," which urges them to strengthen information systems. Therefore, more than compensating for the general economic slump, computers will drive EDP equipment production, growing 5.3 percent in 1998 with a CAGR of 2.3 percent during the next five years. Gradual recovery of the Japanese economy will continue to fuel EDP equipment production after 1998, which should exceed ¥8 trillion in 2001.

Communications Equipment

Communications equipment production in 1997 jumped 19.8 percent to ¥4,844 billion (see Figure 3). A prime driver was mobile communications equipment; subscribers grew much faster than expected, recording a net increase of 10 million in 1997. While PHS production decelerated at 7 million units, the market is expected to expand as its focus shifts from personal to office use.

Nevertheless, the penetration of mobile phones combining PHS and cellular phones has surpassed 50 percent, and continuation of previous high growth will become inevitably difficult. Meanwhile, digitization of infrastructure facilities by Nippon Telegraph and Telephone (NTT) was completed by the end of 1997. These factors will consequently put a brake on communications equipment production, which will turn into negative growth of 0.2 percent. On the other hand, network equipment, including LANs, will experience healthy growth at a CAGR of 15 percent or above. All in all, communications equipment production will grow at a CAGR of 2.9 percent between 1997 and 2002.

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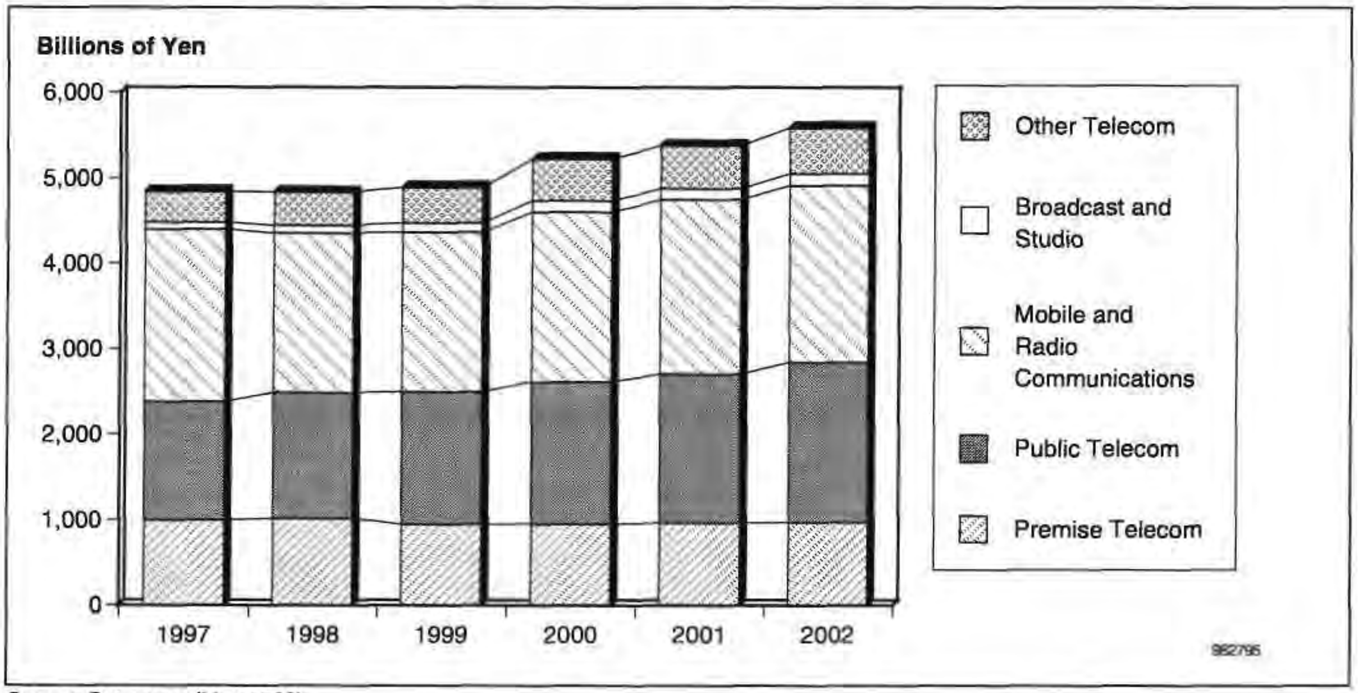
Figure 3
Japanese Communications Equipment Production Forecast



Source: Dataquest (May 1998)

Industrial Equipment

Industrial equipment production in 1997 was up 7.2 percent, totaling ¥3,908 billion (see Figure 4). Of the total, manufacturing systems and instruments recorded the highest growth rate of 14.9 percent. As the wave of relocation of production sites to Asia/Pacific countries subsides, the focal point of the market will shift to computerization and sophistication for value addition and further automation. In particular, medical equipment will show strong growth, with increasing demand for advanced systems to meet the needs of the aging society, resulting in the CAGR of 5.2 percent between 1997 and 2002. Overall, Dataquest predicts a CAGR of 5.3 percent, the highest among the six segments.

Consumer Equipment

Consumer equipment production recorded a 1.3 percent increase in 1997, reaching ¥6,098 billion (see Figure 5). In the video equipment segment, where TVs and VCRs sold in the domestic market are mostly made overseas, it was the replacement demand for wide-screen TVs produced at domestic sites that contributed greatly. In the digital consumer equipment market, digital video cameras (DV-Cs) recorded notable growth, and unit shipments up to the end of 1997 were estimated at slightly below 1 million. The DV-C will become pervasive quickly, driven by price declines and improved availability of key components. Similarly, digital still cameras (DSCs) will ramp up rapidly as they can be easily connected to PCs or TVs via a flash memory card or IEEE 1394 interface. On the other hand, commercialization of digital TVs will have to wait until after 2000 as infrastructure construction has been delayed.

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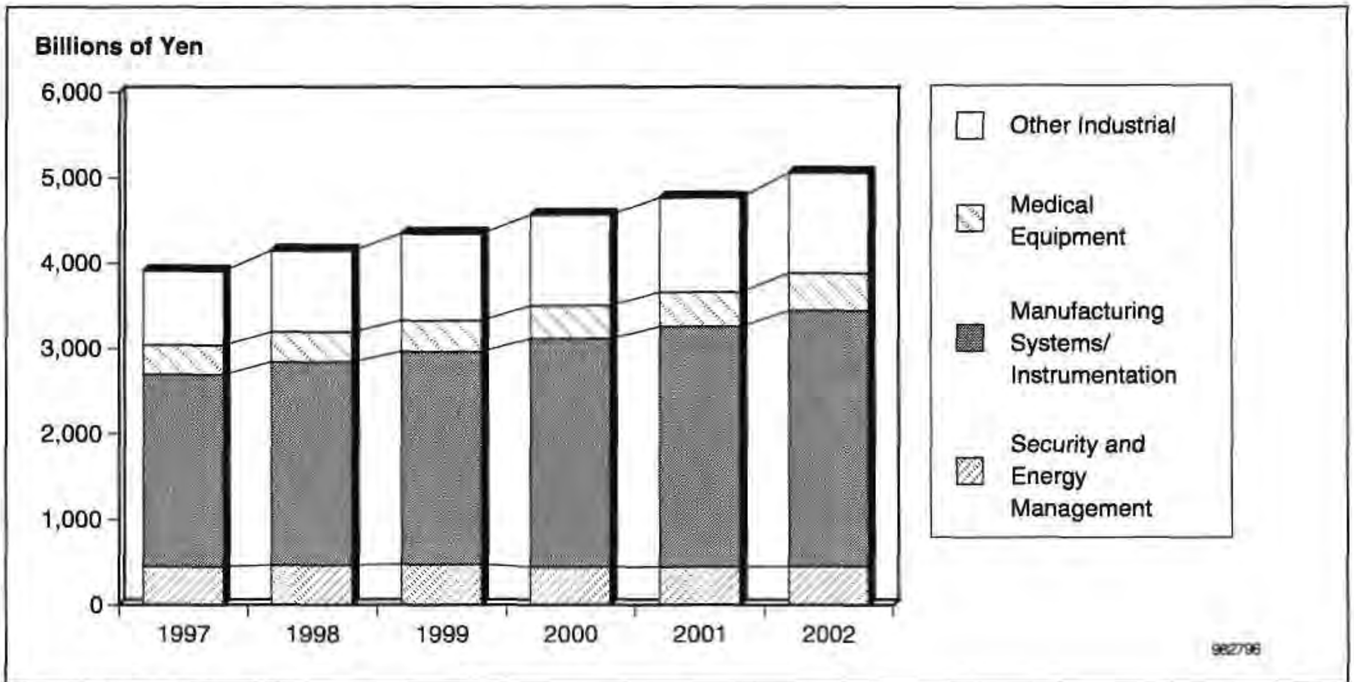
Figure 4
Japanese Industrial Equipment Production Forecast



Source: Dataquest (May 1998)

The current recession will hit household appliance production directly, leading to negative growth in 1998. Video game systems will continue to be a fierce battlefield for a 32-bit hegemony, but production will remain mostly unchanged in 1998, until the next-generation products are introduced in 1999. Dataquest predicts that consumer equipment production as a whole will grow at a CAGR of 1.9 percent between 1997 and 2002.

Japanese Semiconductor Market

In 1997, the Japanese semiconductor market recorded negative growth on a dollar basis, becoming the only market to shrink among the four world regions. Although the yen depreciation diluted the dollar-based figure, the fact remains that the Japanese market is the weakest of the four regions. While electronic equipment production grew faster than previously forecast, semiconductor consumption was sluggish. This indicates that a major source of growth in electronics production came from the segments with little semiconductor content. Also, PC shipment lost momentum in Japan, exerting negative impact on consumption of a variety of semiconductor products, including memory, microprocessors (MPUs), and logic.

The Japanese semiconductor market in 1998 will grow at 9.8 percent (2.5 percent on a dollar basis), down from the fall forecast (see Figure 6). While this reflects the anticipated slowdown in electronic equipment production and the hovering market conditions for DRAMs, a recovery is expected in the second half, leading to double-digit growth. Nevertheless, the CAGR between 1997 and 2002 will be the lowest among the four regions, at 12.4 percent (10.9 percent on a dollar basis).

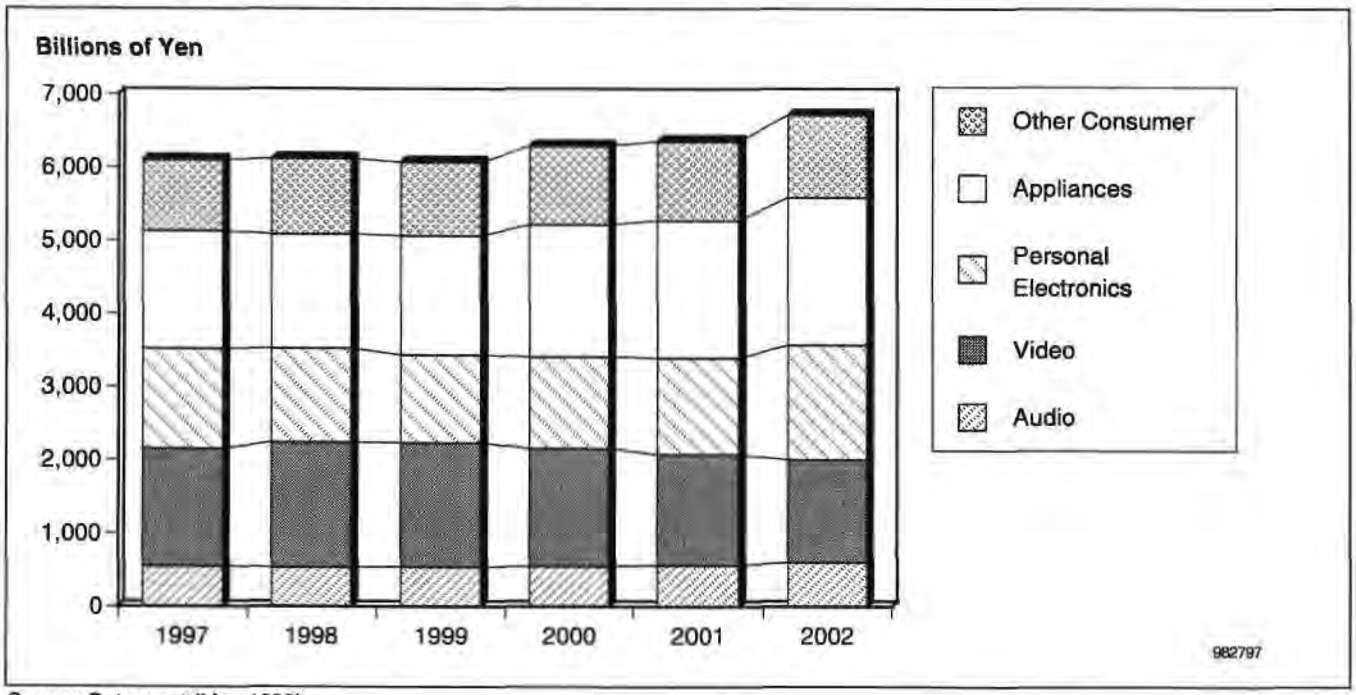
The following section analyzes the future outlook for the Japanese semiconductor market by device.

MOS Memory

In 1997, the Japanese MOS memory market suffered a 14.5 percent decline (23.1 percent on a dollar basis) (see Figure 7). Dataquest predicts that the 1998 market will grow 7.0 percent (a 0.1 percent decrease on a dollar basis), which represents a downward adjustment of 6 percentage points compared to the fall forecast. Again, DRAM price decline because of supply glut is the major culprit. While increased 16Mb production by U.S. companies triggered the price fall in 1997, the aggressive moves of Korean suppliers will dictate DRAM prices. At present, 16Mb prices continue to fall below $3 on the spot market, which pulls 64Mb prices downward.

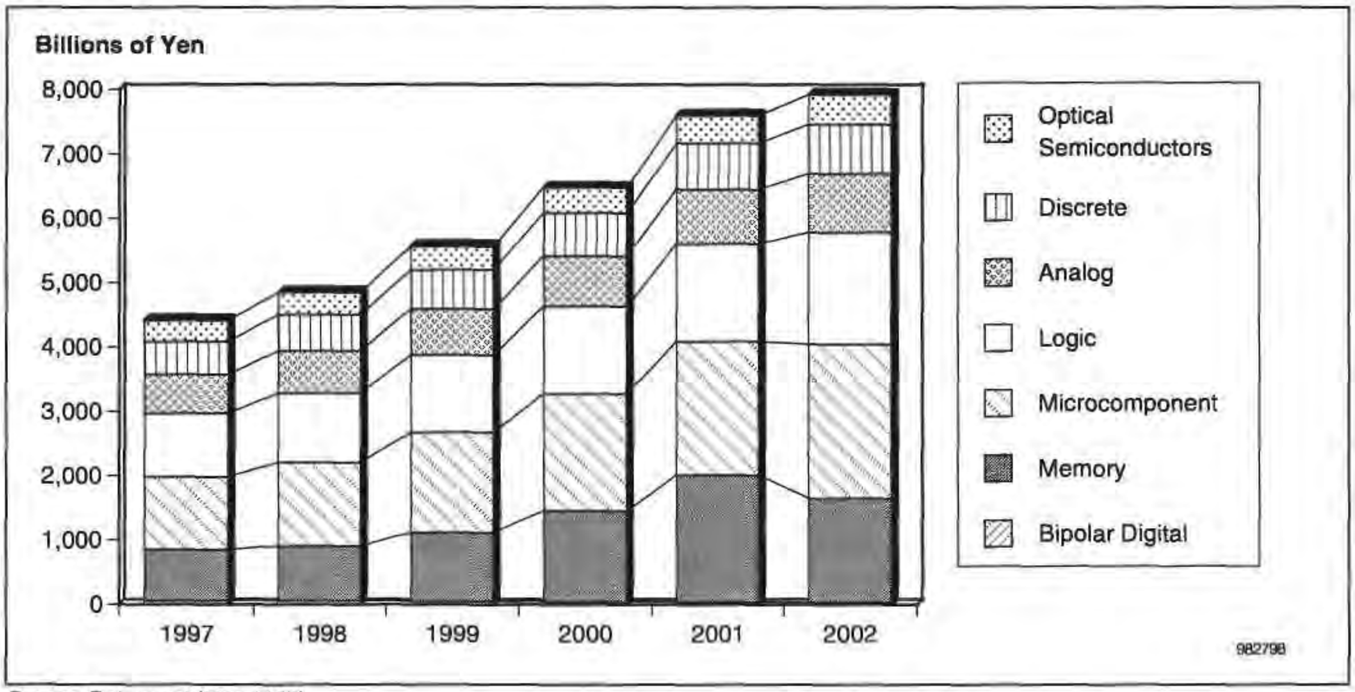
The Japanese MOS memory market in 1998 will be driven by SRAM, EEPROM, and flash memory. In particular, after 1999, the DRAM market will expand at an accelerated pace, while SRAM and nonvolatile memory markets will maintain healthy growth. In 2002, however, the DRAM market will experience negative growth as the generation crossover from 64Mb to 256Mb occurs. Dataquest predicts that the market's CAGR between 1997 and 2002 will be 15.4 percent (13.8 percent on a dollar basis).

Figure 5
Japanese Consumer Equipment Production Forecast



Source: Dataquest (May 1998)

Figure 6
Japanese Semiconductor Consumption Forecast



Source: Dataquest (May 1998)

While the fall forecast assumed that DRAM companies would curtail capital spending in 1998, they are currently moving to minimize the rate of investment cutbacks where possible. In particular, Korean companies are considering maintaining capital spending as close as possible to the 1997 level (on a won basis), despite the DRAM recession and the pain from the AFC. Dataquest pointed out in the fall forecast that a major reduction of 64Mb-production capacity would be required to regain revenue growth in 1998. However, DRAM companies are not reducing capital spending as much as expected, which necessitated the downward adjustment of the DRAM market growth forecast.

In 1998, a major event in the DRAM market will be a full-blown shift from extended data out (EDO) to synchronous DRAM (SDRAM). During the first half of 1998, 100-MHz SDRAMs for PC100 will keep a price premium against 66-MHz versions, which will significantly narrow in the second half as DRAM companies roll out 0.25-micron fab lines. After 1999, the Japanese DRAM market will be driven by better-managed capacity expansion by DRAM suppliers, recording a CAGR of 16.1 percent (14.6 percent on a dollar basis) between 1997 and 2002.

The Japanese nonvolatile memory market will be up slightly 0.3 percent (6.3 percent down on a dollar basis) in 1998 because of double-digit declines in EPROM and mask ROM, which will more than offset the 20 percent growth of EEPROM and flash segments. The CAGR between 1997 and 2002 will be 9.6 percent, as the market will be driven by EEPROM and flash memory.

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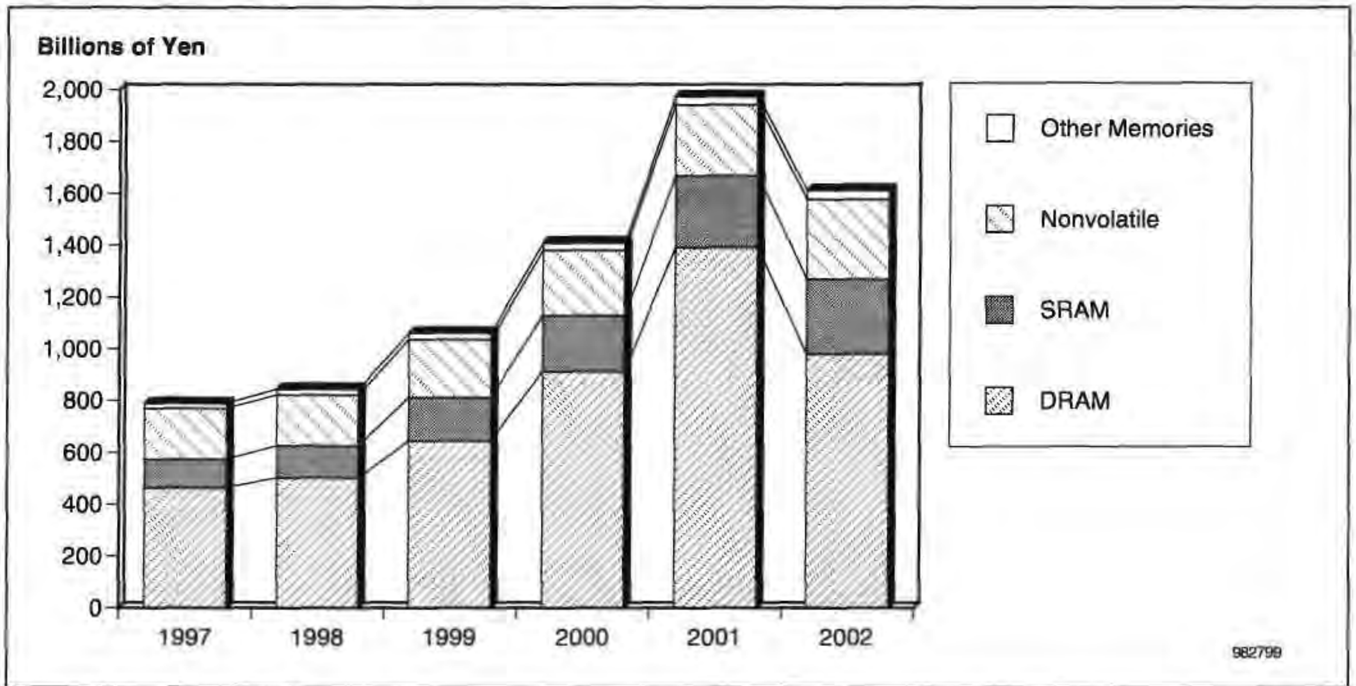
Figure 7
Japanese Memory Consumption Forecast



Source: Dataquest (May 1998)

The Japanese flash memory market recorded negative growth of 9.8 percent in 1997, but it is expected to resume growth in 1998. Major applications include mobile communications equipment, led by cellular phones as well as IC cards. In particular, smart phones are expected to ramp up early in Europe, becoming an important consumer of flash memory. This is expected to a have a positive impact on the Japanese mobile communications and flash memory market.

In the MOS memory market, Japanese semiconductor companies still strive to become less dependent on DRAM business. Large suppliers will increasingly shift their strategic focus to flash memory. The 1997 flash market saw price declines in 8Mb-or-less products. Dataquest expects that the move will spread to 16Mb-or-larger segments in 1998 and after.

MOS Microcomponents

The Japanese MOS microcomponent market will expand 15.2 percent (7.5 percent on a dollar basis) in 1998 (see Figure 8). The CAGR between 1997 and 2002 will be 16.2 percent (14.6 percent on a dollar basis) with firm growth expected for each year.

The Japanese MPU market in 1998 will fail to meet the previously forecast level because of the slowdown in the PC market. The market should grow at 12.6 percent (5.1 percent on a dollar basis). The market will see a wider variety of products besides Intel's X86 families (Pentium with MMX technology, PentiumPro, and MMX Pentium II). Products will include non-Intel, high-speed MPUs, MPUs for low-cost PCs, and MPUs designed for

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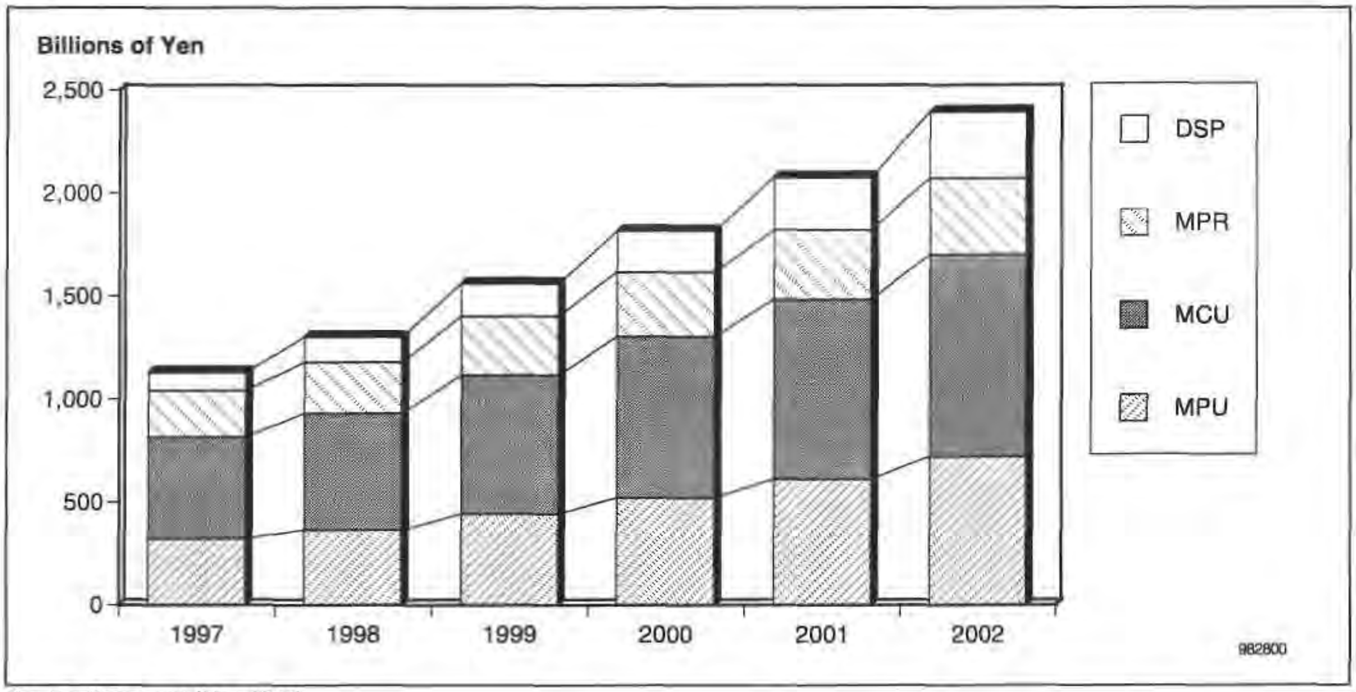
portable applications, including mobile computing (embedded MIPS, SH, Strong ARM), for example, Tillamook, Mobile Pentium II, and Windows CE2.0.

Microcontrollers (MCUs), the largest of the Japanese microcomponent segments, are expected to surge 15.1 percent (7.4 percent on a dollar basis) in 1998. They are incorporated into a variety of electronic equipment. Low-bit versions are embedded into household appliances for system control purposes, many of which are implemented on a 4-bit or 8-bit basis. Japanese companies still hold a dominant share in the 4-bit segment.

Four-bit MCUs are used in diverse products ranging from toys to analog cordless telephones, and companies are still exploring new applications. Nevertheless, the market size will grow only moderately, partly because of the weakening demand from portable game systems, which have been a major driver, and partly because of increased migration to 8-bit products. In particular, revenue growth will be minimal because of low prices, although unit growth may continue.

On the other hand, the 8-bit MCU market will enjoy strong growth as a result of upgrading from 4-bit applications and the need to address the increasing complexity of system control. Development of MCUs embedding flash-memory technology is under way, and the competition has heated up among U.S., European, and Japanese companies for market share.

Figure 8
Japanese Microcomponent Consumption Forecast



Source: Dataquest (May 1998)

In 1997, 8-bit MCUs were used in most electronic equipment, including the following range of products:

- Video and audio equipment
- Computer-related equipment, including keyboards and display units
- Communications equipment, including analog cordless telephones and digital portable telephones
- Antilock braking systems (ABSs)
- *Pachinko* game systems
- Household appliances

Applications expected to emerge in 1998 and afterward include smart cards, minidisc (MD) players, USB controllers (8-bit basis), and MCUs incorporating Infrared Data Association (IrDA) communications features. Encouraged by potential demand for contact/noncontact IC cards, semiconductor companies will opt for alliances to consolidate technological resources and vie for industrial standards. Finally, MCUs integrating ferroelectric memory technology will be introduced to the noncontact IC card market to invigorate the 8-bit MCU market.

Sixteen-bit MCUs, on the other hand, will be increasingly used for digital processing applications, particularly digital cellular phones, PHS phones, hard disk drives (HDDs), and CD-ROM drives. Applications expected in 1998 and afterward include DVD, fixed and on-board audio MD players, and DV-C. Again, flash memory technology will be increasingly incorporated to address system requirements in terms of flexibility, and semiconductor companies will focus on enhancement of their offerings.

As for 32-bit and 64-bit MCUs, system-level integration (SLI) based on ASIC technology will become the mainstay. Promising applications that will be developed after 1998 by using a leading-edge process and an embedded MPU include vehicle information and communication system (VICS)-based car navigation systems incorporating DVD-ROM drives, next-generation home/portable video game systems, and set-top boxes (STBs). Sixteen-, 32-, and 64-bit MCUs will enjoy strong growth next to 8-bit products, driven by price declines resulting from SLI, the emergence of digital consumer equipment, and digitization of systems. Dataquest expects solid profitability.

In 1997, rapid growth was seen in the flash MCU market. Major applications include memory cards for video game systems, CD-ROM drives, and HDDs, spurring consumption of 8- and 16-bit MCUs. As for multibit, embedded MPU (MCU) architectures, ARM will be rapidly accepted in 1998 and afterward. Diverse architectures offered by vendors (MIPS, M Core, SH, SPARC, PowerPC, and X86) will be optimized for different applications according to their SLI strategy.

In 1998, the Japanese microperipherals (MPR) market is expected to grow 9.6 percent over the previous year (2.3 percent on a dollar basis). A variety of PC peripherals based on PC98 standards will become pervasive, and different

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application-specific standard product (ASSP) segments (chipset, USB, IEEE 1394, and MPACT1/2) will grow in relation to different applications.

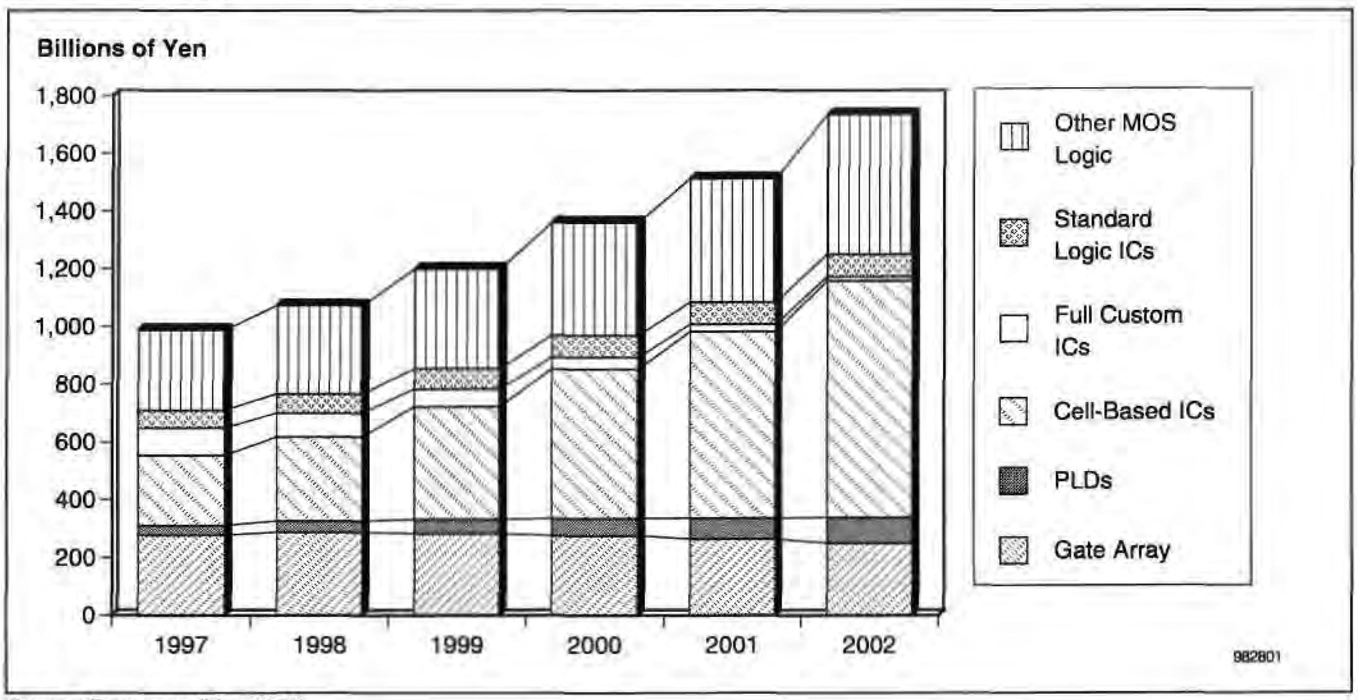
The Japanese digital signal processor (DSP) market will continue strong growth of 39.8 percent (30.5 percent on a dollar basis) in 1998. With the increasingly shortened development cycle for system products, DSPs and media processors will undoubtedly become core technologies as they offer flexibility in development of digital consumer equipment with the ability to reconfigure themselves by replacing middleware/microcode. By 2002, 0.18-to-0.12 micron processes will be commercialized. As a result, the DSP market will grow strongly at a CAGR of 29.7 percent (27.9 percent on a dollar basis) between 1997 and 2002.

Finally, embedded DSPs are increasingly incorporated into servo controllers for CD and MD players as well as codec processing for cellular phones. Generic DSPs including media processors are primarily used in high-speed analog modems (56Kbps) for PCs and sound source processing. New applications emerging in 1998 and afterward include digital cellular phones, which use a single chip integrating a 16/32 bit MCU and DSP, HDD controllers containing DSP/MCU and DRAM for buffer memory, and high-speed disk drives such as DVD-ROM/RAM, incorporating partial response maximum likelihood (PRML) technology and DSP.

Logic/ASICs

In 1998, the Japanese total logic market will grow 8.7 percent (1.5 percent on a dollar basis). The total ASIC market will expand 11.8 percent (4.3 percent on a dollar basis) (see Figure 9).

Figure 9
Japanese Logic Consumption Forecast



Source: Dataquest (May 1998)

In 1997, high-performance systems, as seen in digital consumer equipment, were implemented to incorporate multiple, large-scale circuits by using intellectual property (IP) core and leading electronic design automation (EDA) tools. We also saw a rapid increase in volume production of ASSPs and SLI ASIC products in single-chip implementation by using a highly integrated ASIC process and SLI technologies. A future challenge lies in reducing the cycle time for system development to minimize turnaround time (TAT) and R&D investment, reduce development-related risks, and support early LSI implementation.

Traditionally, the "core-limited design" issue, derived from large-scale internal cores, was a major obstacle in designing ASICs. Recently, however, as the ASIC process reached submicron levels, the shrink ratio of the internal core has been improved. This, in turn, has resulted in an increase in the "I/O pad-limited design," where I/O pads set the limit rather than cores. Also, flexibility in ASIC design to result in small-lot production adversely affects the profitability of business.

Many leading ASIC vendors in the Americas region started to de-emphasize gate array business by 1997. This move is favorable for the programmable logic device (PLD) market and accelerates the collapse of the U.S. gate array market. Technically, PLDs have already integrated 250,000 to 500,000 gates on a commercial basis by using process technology based on 0.25-micron, five-layer interconnect, and shallow trench structure. Dataquest believes that 1 million gates will be integrated by using a 0.18-micron process technology by 2000.

In 1998, the Japanese PLD market will show a strong growth of 15.6 percent (7.9 percent on a dollar basis). In Japan, the gate array business still dominates because of high captive demand. Nevertheless, as SLI will lead ASIC business in the future, the Japanese PLD market will grow to an appreciable size compared to the Americas market. Dataquest expects that the market will register the second-highest growth rate, following cell-based ICs (CBICs), with a CAGR of 21.3 percent between 1997 and 2002.

The Japanese CBIC market (including mixed signal) will grow 20.7 percent (12.7 percent on a dollar basis) in 1998. The ramp-up of 0.35- to 0.25-micron process manufacturing and the increasing need for design optimization in various applications have been driving the market for CBICs, which are regarded as the key infrastructure factor in SLI technologies such as embedded MPUs/DSPs, IP core, embedded memories, and mixed-signal designs. At the same time, the establishment of CBIC technology has caused the custom IC market to shrink rapidly, resulting in the negative CAGR of 15.2 percent (20.8 percent on a dollar basis) between 1997 and 2002.

At present, standard logic features such as small-scale integration (SSI), middle-scale integration (MSI), and large-scale integration (LSI) are mostly incorporated into ASICs, but demand for standard logic still exists in the area of super high-speed CMOS- or BiCMOS-based standard logic, such as CMOS-based one-gate logic products and wide bus products. Thus, the Japanese standard logic market will continue to grow steadily at a CAGR of 5.1 percent (3.7 percent on a dollar basis).

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Finally, LCD drivers classified as other MOS logic will be driven by increased market acceptance of LCD-equipped systems as well as exploration of new application markets. As a result, the Japanese market's CAGR will be 11.8 percent (10.3 percent on a dollar basis) during the five-year period.

In 1998, ASIC suppliers announced a number of next-generation 0.18-micron processes, and some of them in Japan and the United States started volume production. Also development efforts are under way to commercialize a "unified process" that represents a "dream process integration." Dataquest believes that portable applications in the Japanese market will contribute to technological progress in the areas of ultralow operating voltage below 1.0V, embedded flash memory, mixed-signal designs, and high-density packages such as chip-scale packaging (CSP) and direct chip attach (DCA), thereby driving the SLI ASIC market.

Other Devices

The outlook for analog, discrete, and opto markets has been adjusted downward from the previous forecast. It should be noted that the analog market was partially affected by reclassification of linear array and mixed signal ASICs (although small in size) into total ASICs.

Dataquest sees that strong demand growth for analog ICs in the past few years has caused the industry to hold unduly high expectations. With the rapid progress of system diversification, accompanied by LSI implementations over several generations, demand for analog ICs and discrete devices experiences a momentum surge. Nevertheless, expansion of mixed-signal analog IC markets will ultimately lead to CBICs absorbing analog functions, so that suppliers tend to overestimate long-term demand by extrapolating the recent high-growth trends. Also, sluggish electronics production causes demand for generic analog devices to slow down.

In the first quarter of 1998, suppliers do not seem to be accelerating analog capacity, partly because of heavy constraints on investment resources. If supply capacity expands abruptly, prices will plummet to result in unit growth without revenue growth. Given this cap for capacity expansion, Dataquest believes that it is difficult for the Japanese analog market to continue double-digit growth.

Dataquest Perspective

After the rapid progress of production site relocation to the Asia/Pacific countries, electronic equipment production in Japan has increasingly depended on the domestic market by building high-value-added production capacities. Given the economic slump and curtailed personal spending in response to the gloomy outlook, digital consumer equipment incorporating advanced technologies fails to create a market opportunity, despite its great potential. Thus, strong growth of electronics production hinges highly on whether the ongoing attempt to reinvigorate domestic consumption can spur demand for new digital consumer equipment and personal information equipment.

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The slack state of electronic equipment production is directly reflected in softened semiconductor demand. At present, Japanese semiconductor companies sell about 50 percent of their products to the domestic market, even though Japan is expected to show the weakest growth trends in the forecast range years. If slow growth persists, overseas strategies cannot help being affected seriously. If the foreign exchange rate does not change significantly, and manufacturers opt to site production capacities near their markets, the increasing weight of overseas markets will cause Japanese companies to boost overseas production. Manufacturers lacking distribution channels other than Japan and the Asia/Pacific region will not be able to survive under the traditional strategy. This may create a dramatic change in the industrial landscape, including semiconductor equipment and materials.

The industry seems to expect a paradigm based on a new market driver: the development of digital consumer equipment by offering SLI-based solutions. Before that, it must answer a question raised in relation to the development of 300mm wafer fabs: "Will there be a market large enough to absorb the explosive growth of supply capacity?" Unless the industry finds an answer, it cannot rely on the domestic market as it has in the past. While Japanese companies have to streamline their business from nontechnological perspectives, such as the introduction of supply chain management, they may have to redefine their global operations and business structure. Dataquest believes that the industry's future lies in its ability to determine whether the redefined business structure serves the overall interest of maintaining business efficiency and whether it can adapt to the change derived from the redefinition process.

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Perspective

Semiconductors Japan

Market Analysis

The Present and Future of the Japanese Semiconductor Equipment Industry

Abstract: *The Japanese semiconductor device industry thrived on its DRAM business, but it is now being threatened by the Korean and Taiwanese competitors. The prosperity of the device industry led to the eminence of the wafer fab equipment industry. Today, Japanese equipment suppliers share the world market equally with U.S. competitors, with different industry structures that reflect the characteristics of the device industries of the two countries. This Perspective discusses the position of the Japanese wafer fab equipment industry on the basis of the two clearly distinguishable semiconductor markets and discusses opportunities and issues facing the industry.*

By Takashi Ogawa

The Japanese Semiconductor Equipment Industry Is Prosperous

According to Dataquest's survey, the world wafer fab equipment market in 1996 reached $21.68 billion, of which Japanese companies earned $8.75 billion and held a 40 percent share. Figure 1 shows the total semiconductor revenue of Japanese companies between 1982 and 1996, together with revenue from DRAM and wafer fab equipment. During that period, Japanese companies' semiconductor revenue recorded a compound annual growth rate (CAGR) of 17.4 percent. As is already widely known, Japanese companies earn a higher percentage of their semiconductor revenue from DRAM sales (the DRAM ratio) than U.S. companies. In 1996, the average DRAM ratio among U.S. chipmakers was 7 percent, while that of Japanese companies was a lofty 23 percent. This is closely associated with the development history of the Japanese device industry, which is equated with the DRAM business that has recorded such phenomenal success.

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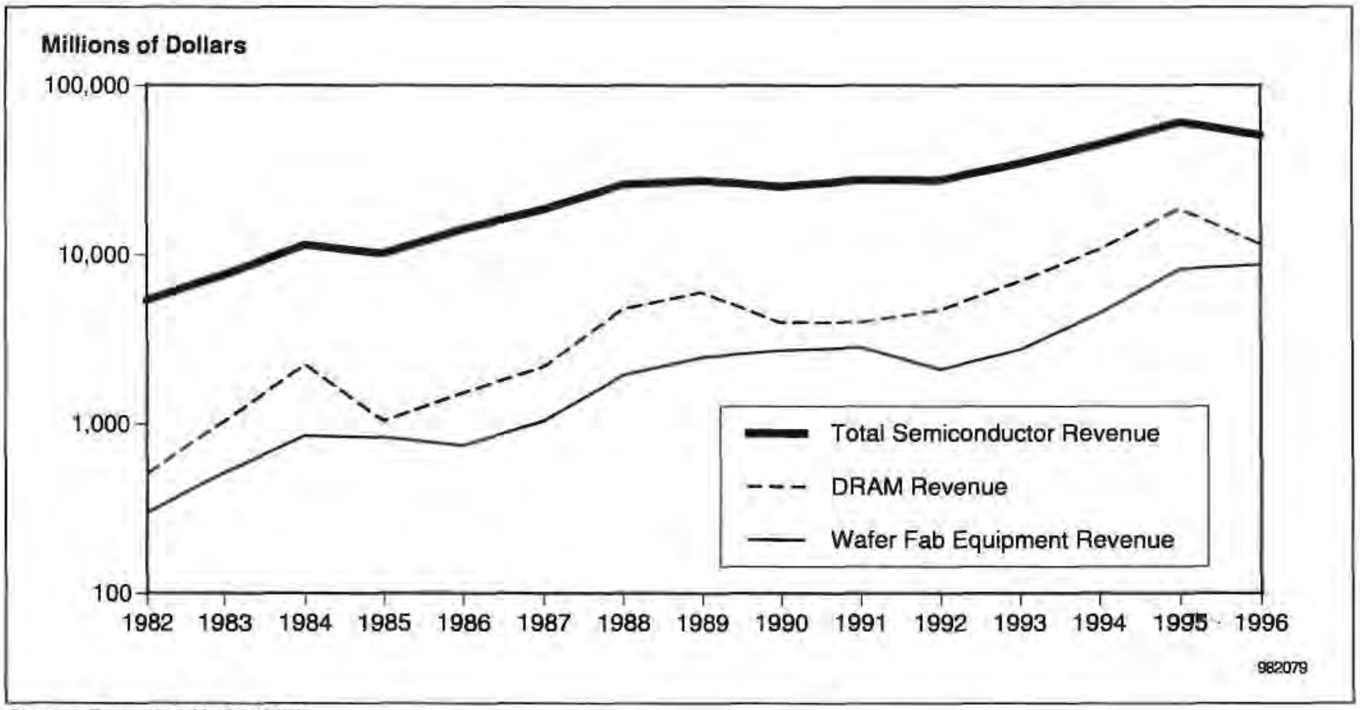
Between 1982 and 1996, the Japanese DRAM industry maintained strong growth at a CAGR of 25 percent. The growth path virtually synchronized with growth in sales of wafer fab equipment supplied by Japanese companies, which grew 30 times from $298 million to $8.75 billion during the period, at a CAGR of 27 percent. Semiconductor manufacturing technologies share common ground with device process technologies, so the emergence of a new process technology or the enhancement of existing technology spurs the birth of new production technology and equipment. Adoption of the new technology then leads to the emergence of a market.

Analyzing the history of semiconductor device development reveals a complementary relationship between wafer fab equipment technologies and device process technologies; both served to support the remarkable growth of the semiconductor industry. In other words, the device market and the equipment market have been evolving in closely related patterns that reflect their specific characteristics.

Figure 1
Changes in Japanese Companies' Semiconductor and Wafer Fab Equipment Revenue, 1982 to 1996

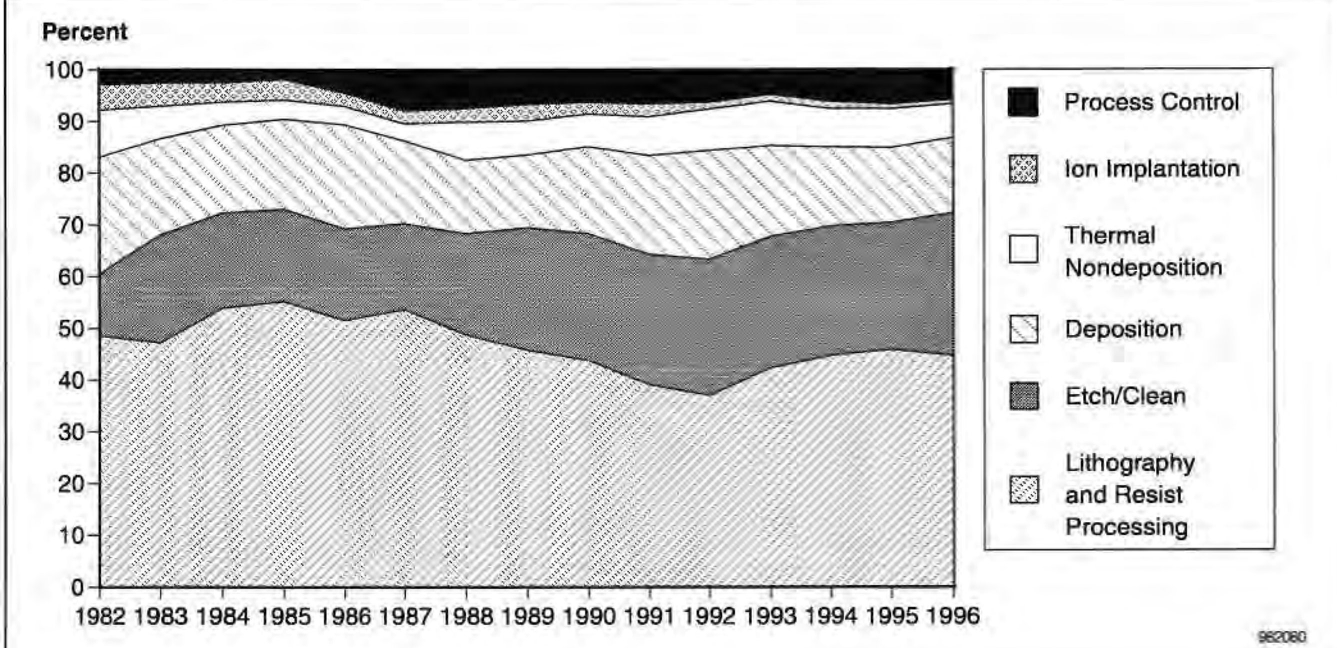


Source: Dataquest (April 1998)

Why Is the Japanese Wafer Fab Equipment Market the Way It Is?

In Japan, semiconductor production technology has evolved in close association with development of DRAM process technology. In the 1970s, Japan, under a near-national consensus to develop the semiconductor industry as a strategic sector, established several consortia, such as the VLSI Technology Research Association, which aimed to develop key process technologies. The industry used these projects to build a technological infrastructure in key areas such as exposure, deposition, and wafer fabrication. In the development process, a number of semiconductor equipment makers worked together with device makers. As they entered the nascent market, industrial leaders such as Nikon Corporation, Canon Inc., Kokusai Electric Co. Ltd., and Ulvac Japan Ltd. prepared themselves for success. More important, certain characteristics emerged and cemented the market. Figure 2 shows a breakdown of wafer fab equipment revenue by Japanese companies between 1982 and 1996 by segment.

Figure 2
Changes in Japanese Companies' Wafer Fab Equipment Revenue, by Segment, 1982 to 1996



Source: Dataquest (April 1998)

Lithography and resist processing equipment has consistently held a very high share, around 45 percent, except for some turmoil during downward phases of the silicon cycles. Of the DRAM process technologies, lithography equipment, led by steppers and developers, constitutes a critical element. To survive in the highly competitive and volatile DRAM market, manufacturers must keep up with a relentless cost-cutting race, boosting integration levels through chip shrinkage, adoption of increasingly fine design rules, and increasing the number of die from each wafer. Japanese semiconductor manufacturers, armed with superb production technologies, centered on lithography. Through joint development initiatives and quality control practices, they gained share in the worldwide DRAM market until the 1980s. Explosive device market growth has, in turn, spurred the equipment market. Japanese makers virtually monopolized the lithography and resist processing equipment market. This was during the time when the market was highly skewed toward lithography, and the resist processing segment was born.

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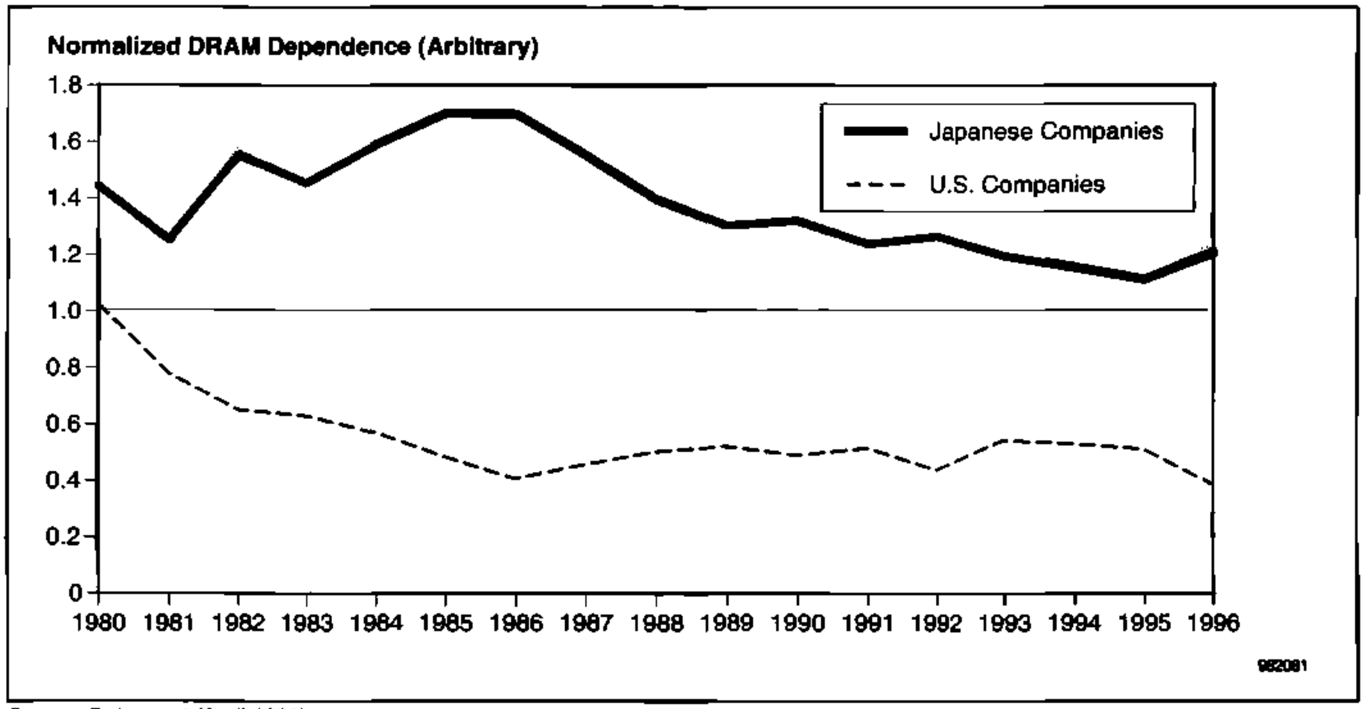
Figure 3 shows normalized DRAM dependence in semiconductor revenue. "Normalized" means that the worldwide average of DRAM dependence is standardized as 1.0. After 1986, Japanese companies gradually decreased their dependence on DRAM; however, their ratio remains at 1.2, higher than the worldwide standard of 1.0. Meanwhile, Japanese equipment makers, which have grown under the umbrella of the device makers, are pursuing global business deployment strategies, including targeting Korean chipmakers, but the market structure originally shaped by the DRAM industry during the dawn of the market has shown little change.

Figure 3
Changes in Normalized DRAM Dependence in Semiconductor Revenue, 1980 to 1996

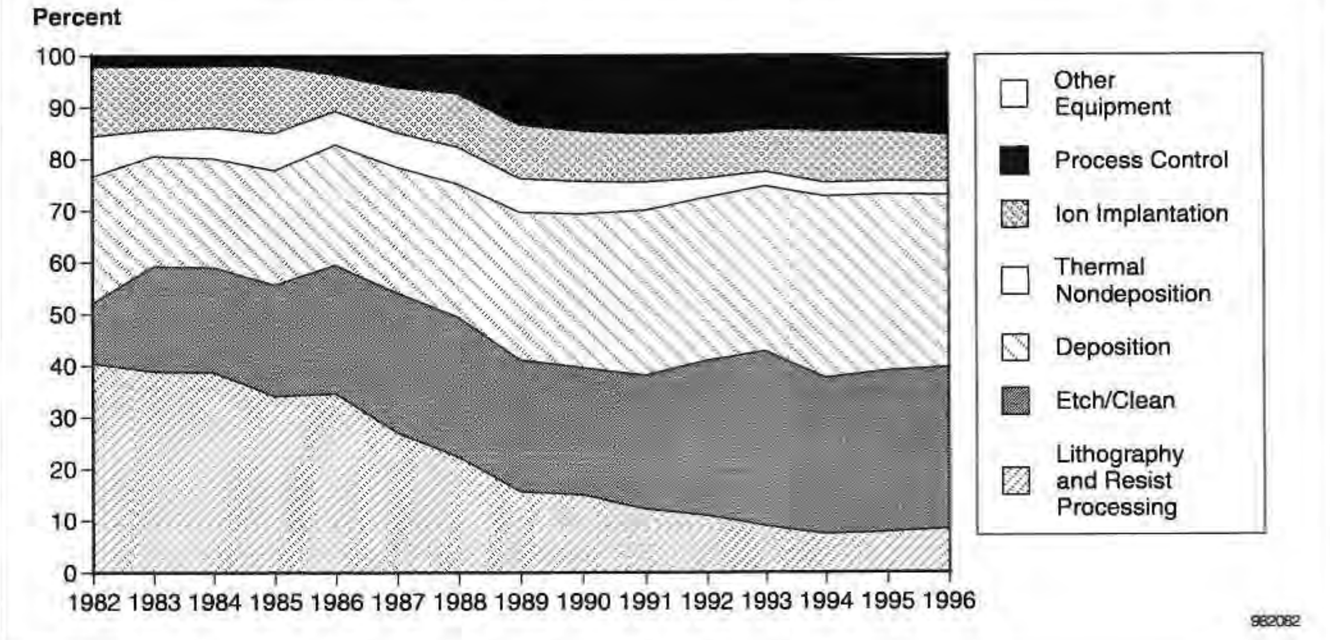


Source: Dataquest (April 1998)

The U.S. Wafer Fab Equipment Industry

The wafer fab equipment market in the United States has also shown distinctive characteristics. In 1996, the wafer fab equipment revenue of U.S. companies totaled $9.73 billion. The world market was more or less divided between U.S. companies and Japanese companies. The U.S. market's CAGR from 1982 through 1996 was 21 percent, about in parity with the Japanese market. Figure 4 shows a breakdown of revenue for U.S. equipment manufacturers between 1982 and 1996 by segment, which reveals a noticeable change. In 1982, lithography and resist processing equipment accounted for about 40 percent of the U.S. equipment market. The share dropped sharply, to 8.5 percent, in 1996. In contrast, the share of the deposition and etch/clean segments grew steadily, from 24.4 percent to 33.3 percent and from 11.7 percent to 31.2 percent, respectively, during the period. In 1996, the combined share of the two segments amounted to 65 percent. Clearly, the U.S. equipment market transformed itself from a structure centered on lithography and resist processing to one centered on deposition and etch/clean during this period. Again, this structural change reflects the evolution of the U.S. device industry.

Figure 4
Changes in U.S. Companies' Wafer Fab Equipment Revenue by Segment, 1982 to 1996



Source: Dataquest (April 1998)

In the U.S. semiconductor industry, DRAM served as a starting point and springboard for prosperity. Before 1980, U.S. semiconductor companies wielded the power in the DRAM market. According to a Dataquest survey, they controlled more than 40 percent of the market before 1980. At that time, they relied on domestic suppliers for wafer fab equipment, including lithography and other key technologies. In fact, the stepper market was dominated by U.S. companies until the mid-1980s, including such companies as GCA, Perkin-Elmer Corporation, and American Semiconductor Equipment Technology, with a combined share exceeding 50 percent. Thus, the U.S. fab process equipment market was originally dominated by lithography and resist processing segments. However, U.S. companies faced aggressive competition and lost share to Japanese DRAM manufacturers. At the same time that the market landscape changed, Nikon and Canon made inroads into the stepper market, and U.S. companies were driven out or lost substantial share.

Intel Corporation, which withdrew from the DRAM market, established new turf, the microprocessor market. Following this bellwether, the U.S. semiconductor industry successfully converted its structure to microcontroller (MCU) and application-specific IC (ASIC) production. In the process, it adopted the consortium approach seen in Japan in the 1970s; the SEMATECH consortium was born in 1987. This initiative focused originally on developing device processes, but this was later replaced by efforts to strengthen semiconductor manufacturing technology.

It is important to understand what the strategic shift in the U.S. semiconductor device industry has meant for the equipment industry. Although DRAMs demand state-of-the-art lithography technologies and have acted as a technology driver for device miniaturization, production of ASICs and MPUs calls for technology to form multiple layers for interconnection, including metallization and formation of contact holes. This entails refinement of deposition, etching, and planarization technologies. The United States maintained an advanced technological base in this field, particularly within the military and aerospace industries, and semiconductor equipment companies capitalized on this and expanded their share of these segments through vigorous R&D efforts.

Comparing of Figure 4 with Figure 3 shows that, as DRAM dependence dropped, starting in the early 1980s, U.S. market share from the lithography and resist processing segment declined as well, in contrast to the rise in share of the deposition and etch/clean segments. In 1996, these two segments held a combined share of more than 60 percent. Clearly, the U.S. semiconductor equipment market has completed a structural transformation, moving from the original market focus in response to the changing device market.

Another Strategic Shift?

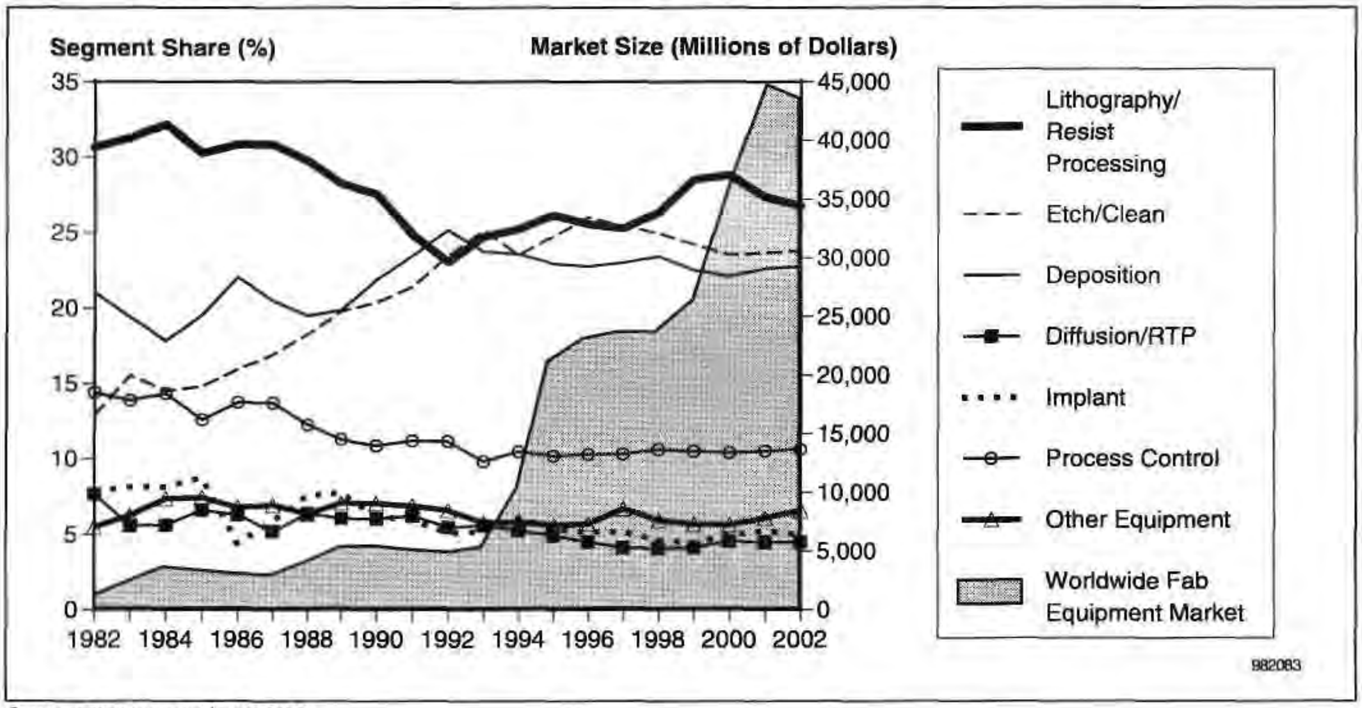
It is reasonable to ask how the semiconductor device market will evolve to understand how the equipment market will evolve. Dataquest predicts that the world semiconductor market will grow at a CAGR of 16 percent between 1996 and 2001, reaching $300 billion in 2001. The DRAM market's CAGR will be 19 percent for the same period, and in 1999, it will achieve major growth, reaching $620 billion in 2001. The DRAM market's share of the total semiconductor market will grow slowly in the next few years and will ramp up in 1999. As a result, DRAM market share is expected to go from 14 percent in 1997 to 16 percent in 1998, to 19 percent in 1999, and to 25 percent in 2000. How will this trend be reflected in the fab process equipment market? Figure 5 summarizes the changes in the world equipment market size and in the percentage breakdown by segment between 1982 and 2002. In short, the semiconductor equipment market is expected to expand at a CAGR of 12 percent up to 2002, when the total market will reach $43 billion. The change in segment composition reveals the following two trends:

- Lithography/resist processing segment will take an increasing share because of the shift to deep-UV laser-based technologies.
- Three markets, lithography/resist processing, deposition, and etch/clean, will polarize.

Year 1 for excimer technology at volume production levels was clearly 1997. According to the results of Dataquest's preliminary surveys, the excimer equipment market in 1997 grew at 240 percent over the previous year. As 0.25-micron or finer processes are adopted for ASICs as well as for DRAMs, deep-UV equipment will become a driver for expansion of the lithography and resist processing equipment market. Because the unit price of the krypton-fluoride (KrF) excimer equipment is higher than that of traditional i-line products (about 70 percent higher at present), the deep-UV segment will gain share, with deep-UV applications expanding after 1998. Therefore, in the lithography and resist processing equipment market, in which Japanese companies have been showing dominance, the ability to gain share in the excimer market will hold the key to success. In fact, the landscape is already changing with the emergence of ASM Lithography.

The lithography and resist processing segment's share eroded gradually from the late 1980s through the early 1990s, while the deposition and etch/clean segments expanded share. In the future, the three segments will divide the market nearly equally. In other words, the deposition and etch/clean market size will increase to approach that of the lithography/resist processing market. Also, new technologies , including the use of such new materials as copper in interconnection and the addition of metal layers, will make deposition and etching technologies more prominent in the ASIC market. Moreover, in DRAM technology, which has traditionally been driven by lithography, mainstream technologies for ASIC/MCU production such as chemical mechanical polishing (CMP) are increasingly being adopted for stack-structured 64Mb and higher devices using 0.25-micron design rules. Again, the deposition and etch/clean segments will be critical in the equipment market.

Figure 5
Trends in the Wafer Fab Equipment Market and in Segment Share, 1982 to 2002

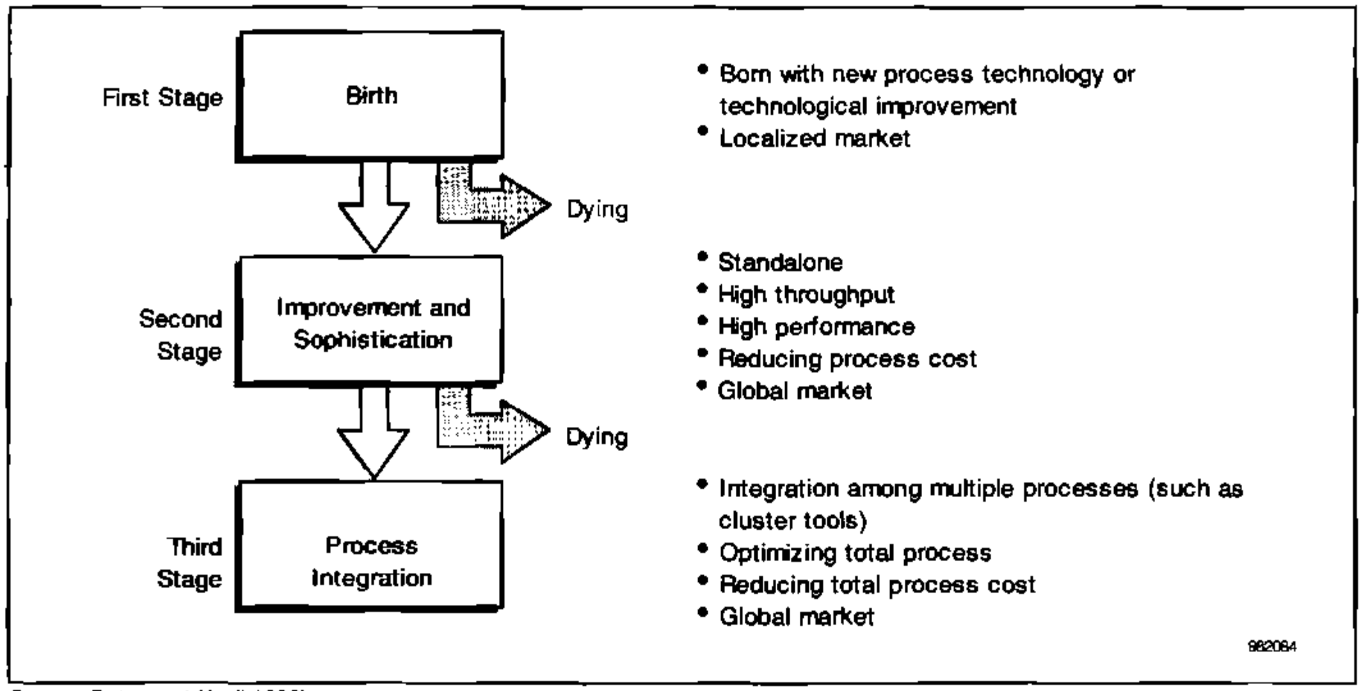


Source: Dataquest (April 1998)

Moving to Process Integration

In addition to market changes, wafer fab equipment is about to enter a new era. Figure 6 shows a conceptual view of the evolution of wafer fab equipment. As discussed earlier, most equipment has been developed for a particular semiconductor process technology. As a new process technology comes on stream, it is incorporated into equipment that will be marketed widely later. At this first stage, the market is still localized; that is, the technology is used by a handful of manufacturers, or the market is limited to a specific country or industrial area.

Figure 6
Development of Semiconductor Manufacturing Equipment



Source: Dataquest (April 1998)

Eventually, the process technology and its advantages become widely recognized, and the equipment is widely accepted, expanding the market. At this level, the market becomes global and attracts new customers. Competition increases, and equipment manufacturers are busy developing variants that extract maximum performance by improving throughput and yield and by reducing process costs, as well as enhancing the original process technology. Now the market is at the second level. Most equipment that incorporates field-proven process technology and has entered the world market is considered to be in this stage.

What's next, then? In the next stage, multiple processes are integrated and a new development concept pursues maximum performance. More precisely, cluster tools and other equipment will be adopted to integrate various process steps, and equipment manufacturers will be required to help optimize performance, including costs. This concept has already been proposed by a U.S. manufacturer. At this stage, equipment vendors must

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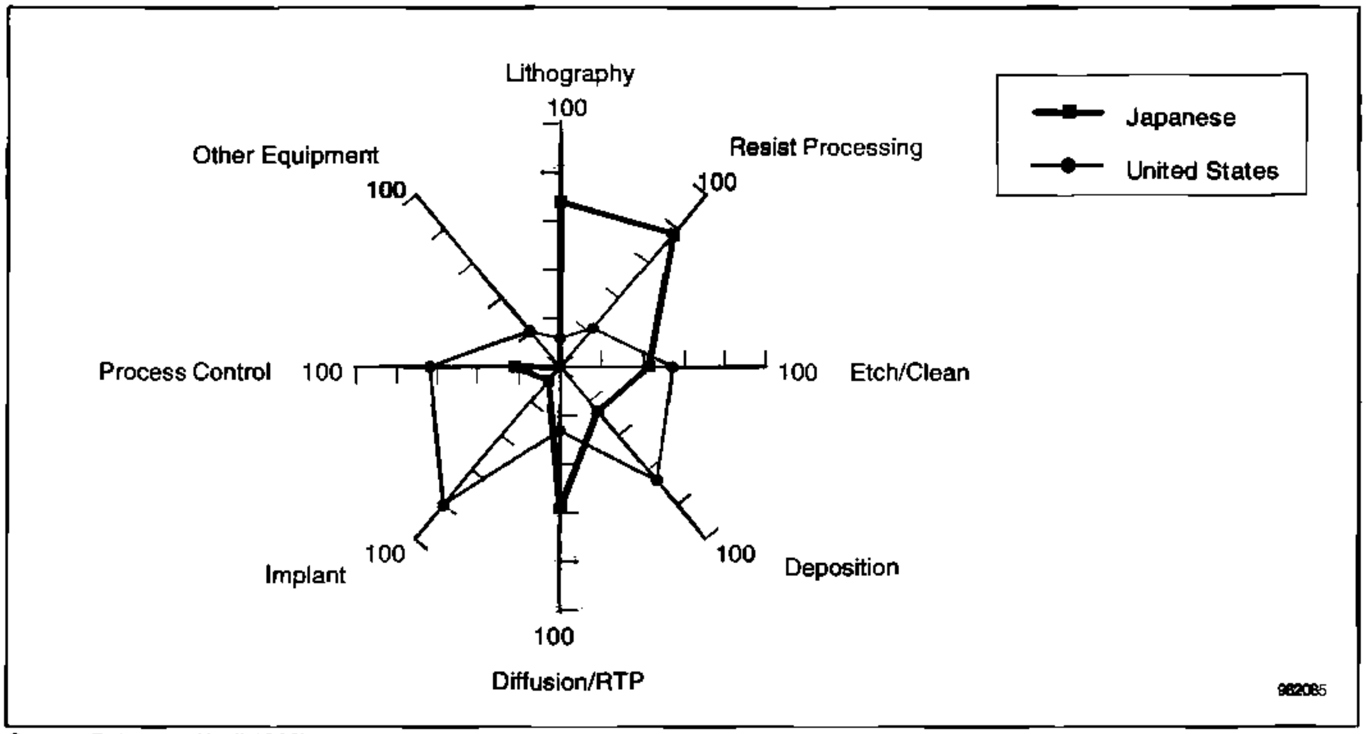
provide know-how related to process conditions, in addition to upgrading hardware technology, such as improving the reliability of existing equipment. In fact, the ability to provide such expertise will increasingly become a key factor in the success of semiconductor equipment makers, which will be required to address "software aspects" of market needs—they will need to cover the entire semiconductor production process.

Dataquest Perspective

Figure 7 shows the share of Japanese and U.S. companies in the semiconductor equipment market by segment. As noted earlier, Japanese companies dominate the lithography and resist processing segment, which has been nurtured in the DRAM market, but they are weak in other segments of the market, except for diffusion and rapid thermal processing (RTP). If market share reflects strength, including technological and management capabilities, then the lopsided share structure of the Japanese wafer fab equipment industry suggests unbalanced allocation of abilities and resources.

Figure 7
Comparison of Wafer Fab Equipment Market Share of Japanese and U.S. Companies by Segment, 1996



Source: Dataquest (April 1998)

A similar pattern is found in the diffusion/RTP segment, in which Japanese companies hold a high share of traditional diffusion equipment. They are being overwhelmed by U.S. companies in the RTP area, which is considered to be essential in advanced control of the thermal process. Given the technological significance and market potential of the deposition and

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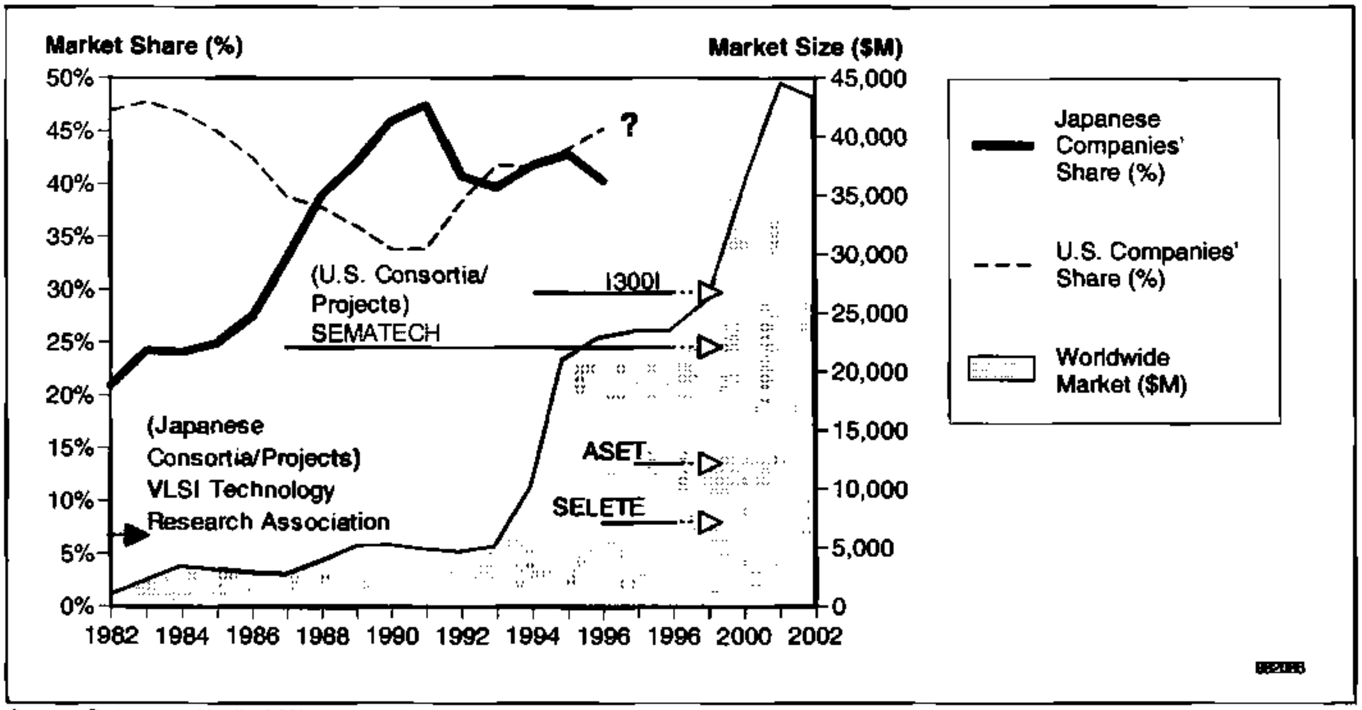
etch/clean segments, the Japanese wafer fab equipment industry needs to refocus on these areas. At the same time, the irreversible move toward process integration will require a broad range of technical capabilities and know-how in a variety of segments. The prosperity of the Japanese wafer fab equipment industry will hinge on its ability to foster companies or consortia that can offer such capabilities, including cost reduction.

It is very important for semiconductor equipment vendors and device makers to work together in developing new process technologies, which lead to new equipment and market opportunities. In retrospect, national projects and consortia have been the most effective means of producing results for the wafer fab equipment industries in both Japan and the United States.

Figure 8 shows the changes in market share of Japanese and U.S. wafer fab equipment companies and the progress of joint development projects in the two countries. Market share positions reversed five to six years after the start of a joint development project in either country. These projects have developed tangible technologies that have helped strengthen the equipment industries and have produced measurable results. In fact, the enhancement of key technologies has proven to play a critical role in periods when a major technology change occurs.

Figure 8
Semiconductor Technology Development, Wafer Fab Equipment Market Size and Share, 1982 to 2002



Source: Dataquest (April 1998)

Today, the industry is in the midst of technology change as various novel technologies, including deep UV and 300mm wafer processing, are about to enter a commercial stage. It is a technology change that will significantly alter the market's structure, and the winners of the race will become the next-generation market leaders. The Japanese wafer fab equipment industry is aware of the imminent change and seems to be determined to meet the challenge by initiating joint development projects—Semiconductor Leading-Edge Technology (SELETE) and Association of Super-Advanced Electronics Technologies (ASET). Dataquest believes that the time has come for Japanese equipment companies to make concerted efforts to refine and enhance key technologies by setting aside their own interests, just as they did in the 1970s—which remains the best course of action to ensure the industry's growth.

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Perspective

Semiconductors Japan

Market Analysis

Analyzing the 1998 DRAM Market

Abstract: *The DRAM market has been plagued by oversupply since 1996, and there are no clear signs of its moving toward a balance. The persistent glut has been squeezing profits for DRAM suppliers, who must relentlessly restructure their DRAM business. Predicting the timing of the market recovery has become urgent. This Perspective analyzes the 1998 DRAM market, focusing on synchronous DRAMs, which are expected to become central in the market. The DRAM shipment and demand data used in this Perspective is based on Dataquest's DRAM supply/ demand quarterly statistics survey in December 1997.*

By Masahiro Suzuki

The General Outlook for the DRAM Market in 1998

The 1998 Japanese DRAM market will be characterized by three distinct trends: increased 64Mb production, 16Mb production cutbacks led by Japanese companies, and rapidly growing share of synchronous DRAMs (SDRAMs).

First, 1998 will be a year of a generation shift from 16Mb to 64Mb. Volume production of 64Mb, led by Samsung Electronics Company Ltd. and NEC Corporation, is steadily on the rise, with other leading suppliers having started commercial production from the second half of 1997. As of February 1998, both 16Mb and 64Mb products were in oversupply, except for 100-MHz, 64Mb SDRAMs, of which a slight shortage is being felt. Dataquest estimates that DRAM demand measured by total bits will reach about 7.5 billion megabytes in 1998, while total supply will amount to 7.7 billion megabytes, resulting in a sufficiency ratio (supply/demand ratio) of around 102. Dataquest believes that, even if DRAM suppliers curtail capital spending significantly, the glut will prevail in 1998.

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Meanwhile, 1998 will see another major shift, an accelerated technology shift from EDO DRAMs to SDRAMs. SDRAM emerged in the third quarter of 1997, when it was rapidly adopted in 16Mb products. Nevertheless, development of 64Mb SDRAMs, particularly PC-100 versions, is somewhat behind schedule. PC-100-enabled and 100-MHz versions will therefore be in slightly tight supply during the first and second quarters. A stable supply of PC-100 versions can be expected in the third quarter of 1998.

DRAM Demand in 1998

The total DRAM demand forecast for 1998, about 7.5 billion megabytes, translates to 3,760 million 16Mb DRAMs, representing a 56 percent increase over 1997. The major driver continues to be PCs, with shipments expected to surge 16.7 percent in 1998, reaching 98.4 million units. At the same time, the average system memory size of PCs will grow to 56.3MB (including the aftermarket). Two factors are important here: The market environment will still work against DRAM prices, which are unlikely to rise rapidly in 1998, and the release of Windows 98 and NT 5.0 will prompt a further increase in system memory size.

Meanwhile, the use of SDRAMs on PCs has accelerated since the third quarter of 1997, and SDRAMs are increasingly outpacing EDO DRAMs in share of design wins. This trend is expected to continue throughout this year. It should be noted that the adoption of SDRAMs for notebook PCs is a bit slower than for desktops, mainly because current SDRAMs consume more power than EDO products. In fact, SDRAMs consume much less power than LCD backlighting and mechanical components, but notebook suppliers continue to use power-saving versions of SDRAMs. DRAM companies are apparently being slow to develop low-power 64Mb SDRAMs.

DRAM Demand Outlook by Integration Level

Figures 1, 2, and 3 show Dataquest's worldwide supply and demand forecast for 4Mb, 16Mb, and 64Mb DRAMs, respectively. Note that a sufficiency ratio of over 100 represents a market glut.

4Mb DRAM

Major systems consuming 4Mb DRAMs include PCs, rigid disk drives (RDDs), printers, facsimile machines, network routers, set-top boxes, and video game systems. Note that total consumption has entered a declining trend. One exception is 4Mb, which is now replacing 1Mb in RDDs. Similarly, the supply of 4Mb DRAMs is on the decline, as shown in Figure 1; unit shipments in 1998 are expected to plunge 45 percent to 472 million from 859 million in 1997. The shipment forecast data for leading manufacturers indicates that most of them will proceed with production cutbacks throughout 1998. In particular, leading suppliers have already switched to order production. The sufficiency ratio will be at about 100 throughout 1998, meaning that the market will be near balance this year. One variant scenario would be further acceleration of production cutbacks by major suppliers, which would spur second-tier companies to boost their production.

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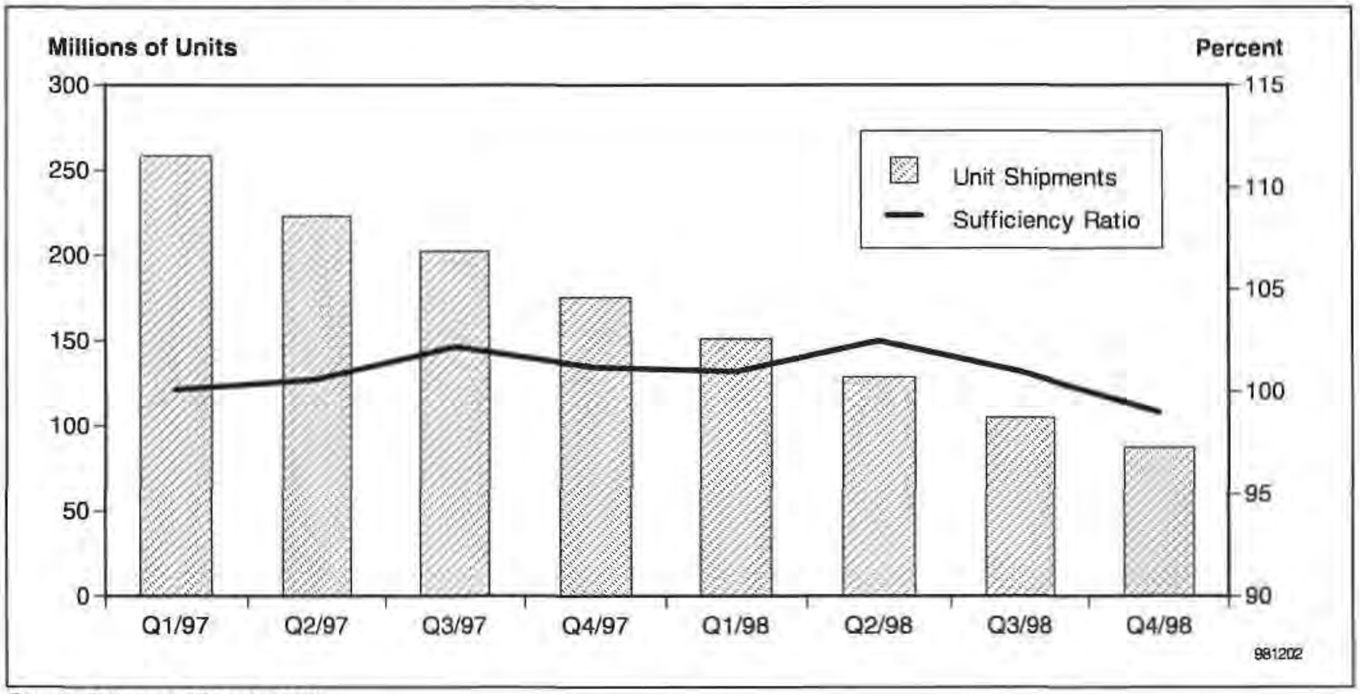
Figure 1
Supply/Demand Forecast for 4Mb DRAMs



Source: Dataquest (March 1998)

16Mb DRAM

Major application markets for 16Mb DRAMs, in addition to PCs, include printers, network routers, DVD players, set-top boxes, and video game systems. Of these, laser printers are the largest consumer. Supply was on the rise in 1997 but flattening in 1998 (see Figure 2). Total shipments of 16Mb DRAMs in 1998 will reach 2,128 million, a 10 percent increase from 1,982 million in 1997.

Analysis of shipment trends by individual manufacturers indicates that leading Japanese and Korean suppliers have already launched production cutbacks. Leading DRAM companies have changed the plans made in mid-1997 and now plan to make the actual cutbacks one or two quarters earlier, to the third or fourth quarter of 1997. However, second-tier companies will generally increase their production throughout 1998, which reflects their delay in developing 64Mb products. Depending on price trends, they may boost 4Mb production while curtailing 16Mb output.

Conspicuous 16Mb DRAM players in the 1998 market are Micron Technology Inc., Texas Instruments Inc., Siemens AG, and Nan Ya Technology Corporation. All of them plan to continue to expand production in 1998. Micron has announced plans to boost 16Mb production while it has the ability to expand 64Mb production. Micron's annual 16Mb shipments reached 224 million units in 1997, ranked second in the world next to the 244 million units shipped by Samsung Electronics. Micron plans a further increase to 416 million units in 1998. Nevertheless, Dataquest believes that Micron will cut back 16Mb capacity and ramp up 64Mb production once

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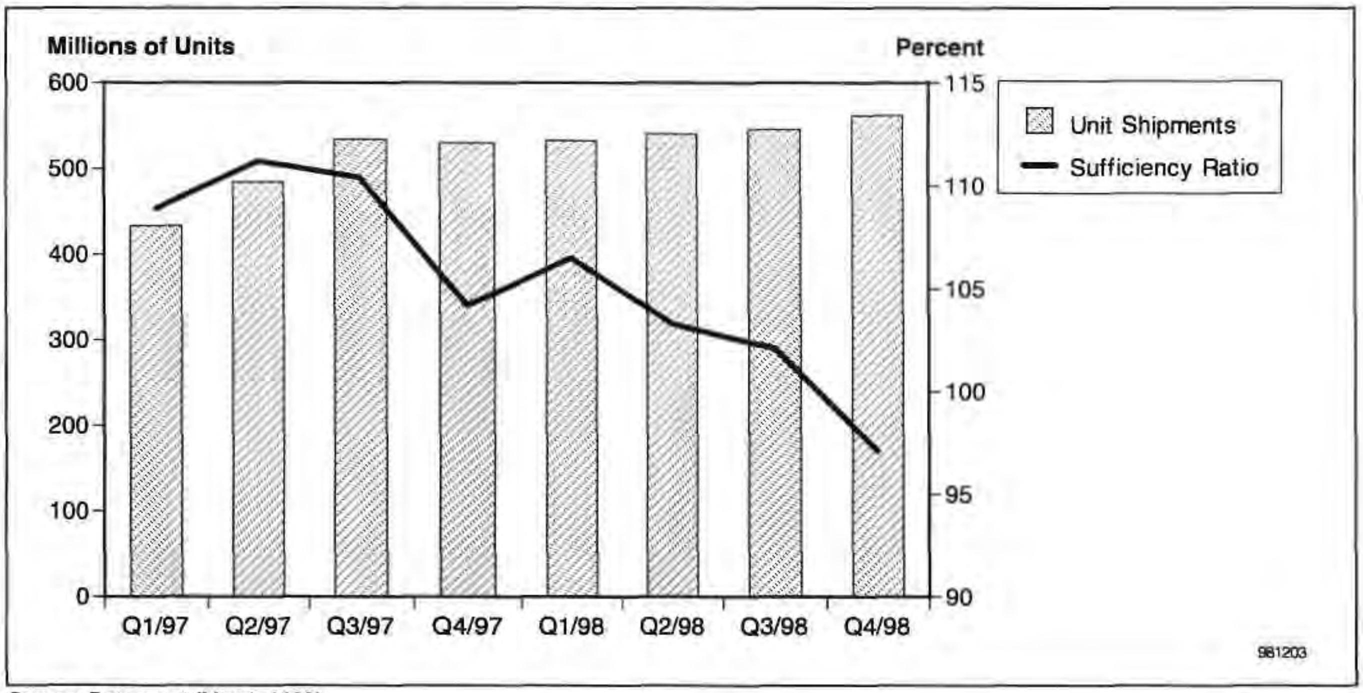
64Mb DRAMs begin proliferating in desktop PCs. In that case, the total supply in 1998 might be reduced from 2,128 million.

TI follows Micron in a major production expansion plan. The company's 16Mb shipments in 1997 totaled 205 million units, ranked No. 3, next to Micron, and it is expected to churn out 278 million units in 1998. However, Siemens and Nan Ya, although they plan to increase production, will ship a combined total of 243 million units in 1998, far below TI's shipments. Thus, Micron and TI will have major clout in the 16Mb market in 1998.

As shown in Figure 2, the oversupply will remain pervasive in the 1998 market if these companies act on their plans to increase production, which will compensate for the production cutbacks planned by other companies. One note of caution—a temporary shortage is possible if so many suppliers cut back production so quickly. More important, Micron's move needs to be watched because it plays a key role in the group intending to boost production. The company may adjust the production ratio between 16Mb and 64Mb according to 64Mb demand. By doing so, it would be a decisive factor in supply and demand trends in 1998.

Figure 2
Supply/Demand Forecast for 16Mb DRAMs



Source: Dataquest (March 1998)

64Mb DRAM

Again, PCs and other higher-end computers are a major consumer of 64Mb DRAMs. In fact, computer main memory seems to be the only application requiring 8MB capacity in the memory device. In addition to PCs, workstations, with a relatively short product cycle, are fast adopting high-integration DRAMs. In 1997, major demand came from workstations in the first half and from some notebook PCs in the second half.

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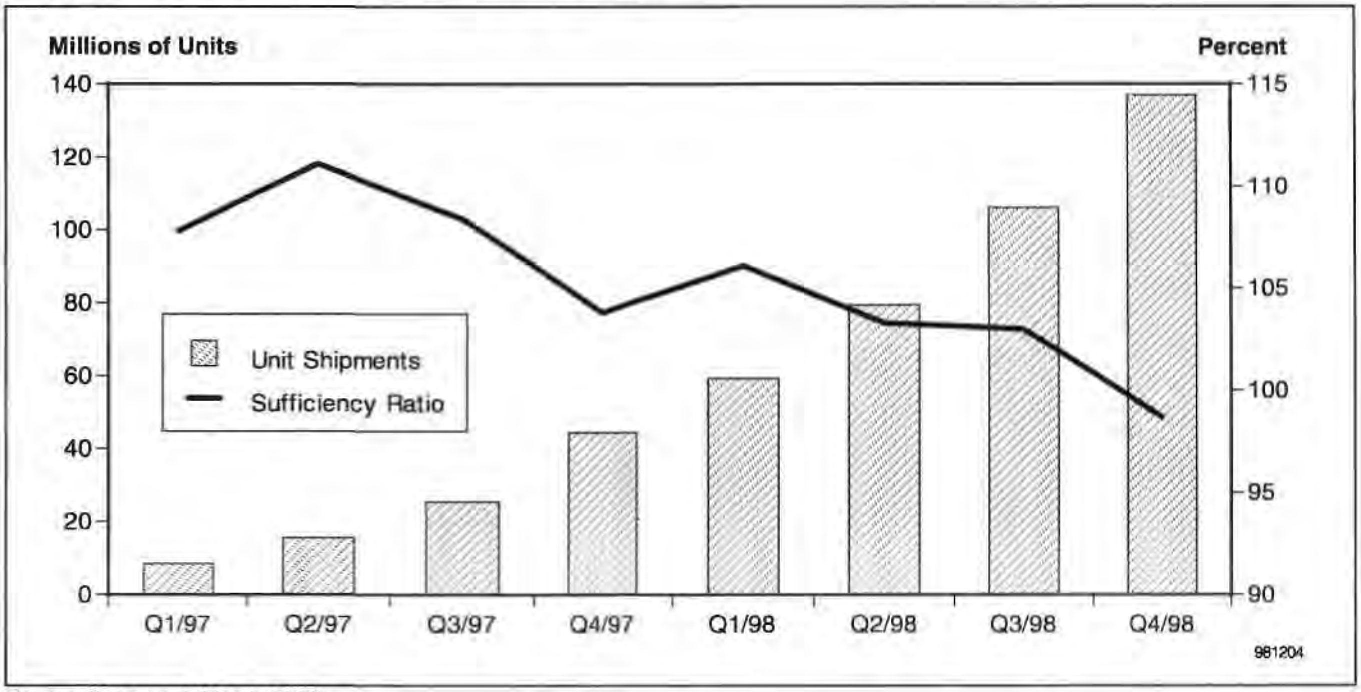
In 1998, 64Mb DRAMs will make inroads into desktop PCs to replace 16Mb products. As shown in Figure 3, 64Mb production will ramp up steadily, and oversupply will be seen in 1998. Korean and Japanese DRAM suppliers have been forced since 1996 to curtail capacity expansions in the wake of the recession. However, Dataquest believes that their cutbacks alone will not lead to the long-awaited balance unless other DRAM companies follow suit by substantially reducing capital spending.

Samsung Electronics shipped an estimated 32 million units in 1997 and will ship 79 million units in 1998. NEC followed Samsung with 21 million units in 1997 and 63 million units in 1998. Micron, however, in 1997 produced 2.8 million units and plans production of 10 million units this year, although the company will likely adjust its plans when 64Mb demand ramps up.

Figure 3
Supply/Demand Forecast for 64Mb DRAMs



Source: Dataquest (March 1998)

Shipment Trends and Forecast by DRAM Type

Figures 4 and 5 show shipment trends and the forecast for 16Mb and 64Mb DRAMs, respectively. (The category "next-generation DRAM" refers to Rambus DRAMs, or RDRAMs).

For 16Mb, the shift to SDRAMs has accelerated since the third quarter of 1997. In 1997, Intel released the 430TX and the 440LX for supporting SDRAMs. The increase in SDRAM shipments coincided with Intel's release of the 440LX in the third quarter. Nevertheless, it is well known that replacement of EDO with 66-MHz SDRAM does not improve the performance of the memory system. Thus, the increasing use of SDRAMs

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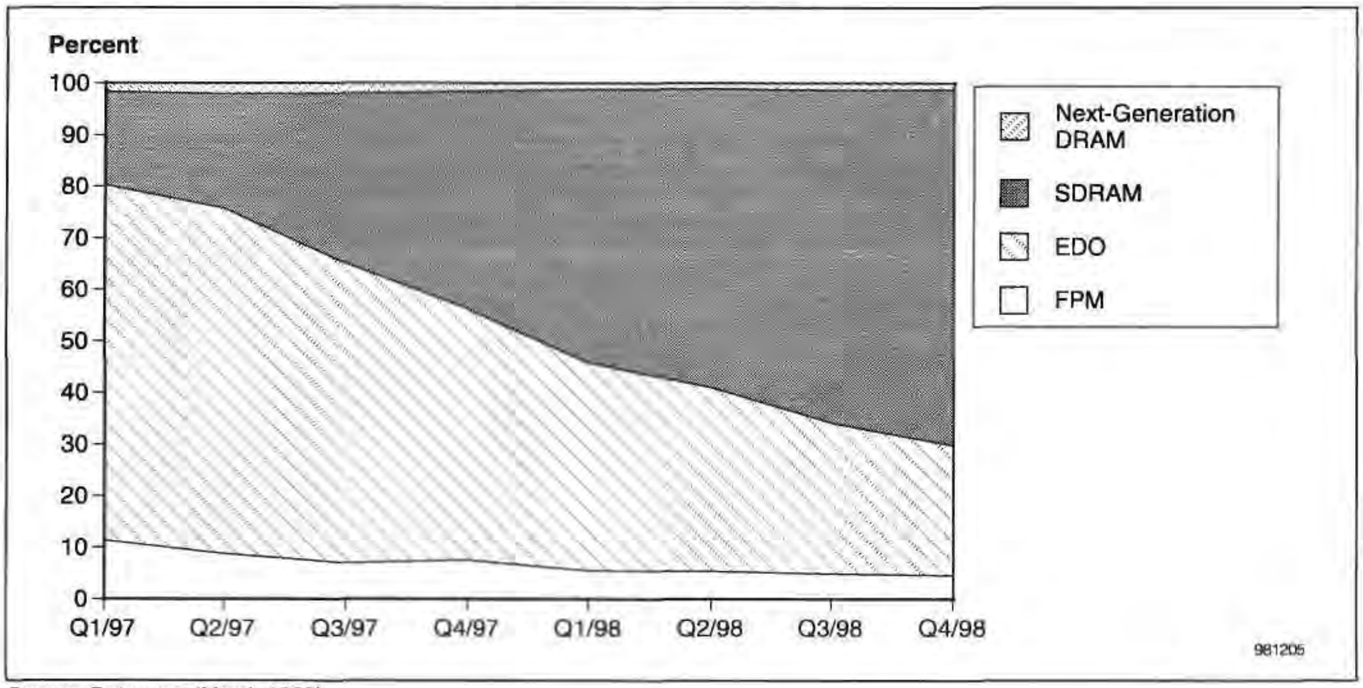
seems to reflect the intention of systems companies to gain know-how about use of the future mainstream device by adopting early. SDRAM shows little difference in price over EDO DRAMs, and using it as a replacement early reduces the kinds of products that require inventory control as early as possible.

Figure 4
Breakdown of 16Mb DRAM Shipments by Device Type



Source: Dataquest (March 1998)

Figure 5 shows that the shift to 64Mb SDRAMs will speed up during the first quarter of 1998. A major driving force is Intel's 440BX, a chipset supporting 100-MHz SDRAMs slated for release in the first quarter. At present, 64Mb SDRAMs are primarily 66 MHz, and 100-MHz versions are available from only a few vendors. For SDRAMs to operate at a system clock speed of 100 MHz on PC motherboards, they must operate at 100 MHz as they are mounted on the dual in-line memory module (DIMM), which is equivalent to a speed of 125 MHz for an SDRAM device alone. (Note that 100-MHz SDRAMs are usually used at the system clock frequency of 66 MHz.) Volume production of 125-MHz SDRAMs requires a 0.25-micron type of process technology.

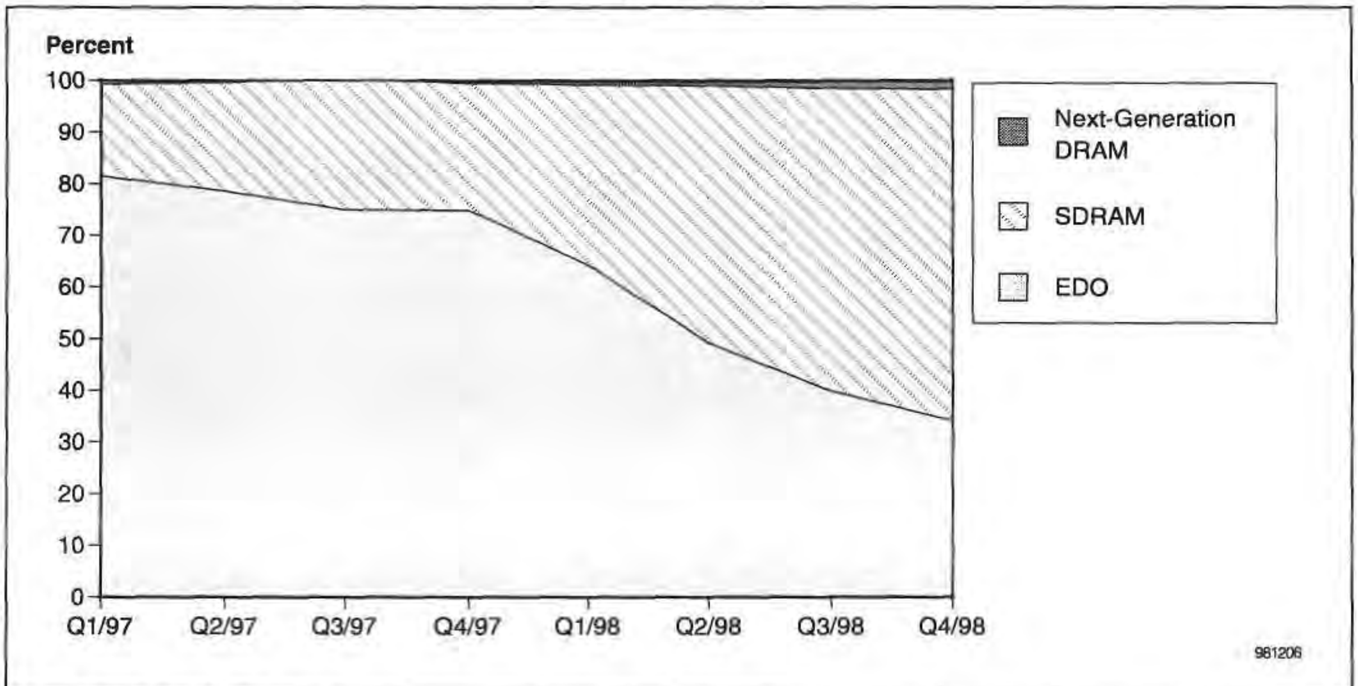
Dataquest Perspective

The Japanese DRAM market in 1998 will be still characterized by oversupply, judging by analysis of total bid-based supply and demand as well as of supply capacities of DRAM suppliers and their likely changes. One exception is 125-MHz 64Mb products, which may face some shortages, accompanied by price premiums. The 125-MHz versions will be required for the 440BX, which operates at a clock frequency of 100 MHz, as well as for 350-MHz

Pentium II or later MPUs. If volume production of these MPUs is substantially delayed, DRAM suppliers will focus on building up 0.25-micron process capacities, and a shortage of the 125-MHz products will become less likely.

Many development challenges are waiting for DRAM companies. In addition to the traditional race for higher integration, they are expected to commercialize high-speed SDRAMs, low-power SDRAMs, and next-generation DRAMs, including RDRAMs, double-data-rate (DDR) DRAMs, and SLDRAMs. In particular, next-generation products, for which specifications have still not been finalized (except for RDRAMs), have a long way to go. Dataquest believes that the most important challenge for DRAM makers is to identify which device type will become mainstream and to allocate their resources effectively to allow timely introduction of suitable products to the market.

Figure 5
Breakdown of 64Mb DRAM Shipments by Type



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Perspective

Semiconductors Japan
Market Analysis

The Impact of the Asian Financial Crisis on Japanese Semiconductor Companies

Abstract: *The impact of the Asian financial crisis is beginning to be felt on a wider basis. The loss in GDP in the areas hit by the crisis has started to affect local demand for goods, including electronics, affecting both exports to those countries and local production. This Perspective analyses the impact of the crisis on Japanese electronic equipment production and Japanese semiconductor suppliers and offers possible scenarios.*
By Yoshihiro Shimada

The Asian Financial Crisis

The arrival of the Asian financial crisis in 1997 shook Asia/Pacific countries, including Thailand, Korea, Indonesia, Malaysia, Philippines, Singapore, and Hong Kong. The crisis is a financial phenomenon, but its widespread impact is beginning to be felt in the overall economies of those countries.

In Korea, as in Japan in the early 1990s, production of low-end model shifted to Association of Southeast Asian Nations (ASEAN) countries because of their lower costs, and the domestic production remaining in Korea showed a profile similar to domestic production in Japan. The yen depreciation that preceded the Asian financial crisis, however, strengthened Japanese exports of consumer equipment, and production of that equipment in Korea was adversely affected. Semiconductors had already become a major contributor to nationwide exports in Korea, but weak pricing over the past two years or so has hurt Korean exports and the country's foreign exchange reserves. At the same time, rapid expansion of DRAM production capacity required vast capital spending, but most manufacturing equipment and manufacturing materials had to be imported. This is one of the most serious impacts of the Asian financial crisis for Korean semiconductor companies.

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In countries such as Singapore, Malaysia, Thailand, and Indonesia, the production shift from Japan, the United States, and Europe has contributed to a rapid growth in electronic equipment production. Because products have been exported back to those advanced countries, as well as to other regional markets, the economies of those countries have benefited, on the whole. This scheme, however, made those countries heavily dependent on imports as more manufacturing equipment and materials were required, making them vulnerable to the effects of the financial crisis.

Hong Kong, too, has been exposed to the Asian financial crisis, and a financial blow has been unavoidable. In Hong Kong, a large portion of imported semiconductors are re-exported to other parts of the mainland China, and the impact of the crisis must be measured in relation to equipment production sites supported by imported semiconductors. The Chinese government has been making every effort to maintain the value of renminbi, but if the currency should be hit directly by the Asian financial crisis, the impact could be felt throughout the whole Asia/Pacific region.

Taiwan has seen only a minimum impact and has proven its excellence in managing industries and finance. Major industries such as PCs, peripherals, and semiconductors are still growing fast in Taiwan, and Dataquest expects Taiwan to remain comparatively unaffected by the Asian financial crisis.

As the Asian financial crisis's adverse impact widens, Japanese export of industrial equipment is starting to show a decrease. Asia/Pacific countries have been forced to scale down utilization of production sites for equipment to be marketed within Asia/Pacific, and Japanese companies have been no exception.

Impact of the Crisis on Japanese Electronics Production in Asia/Pacific

Dataquest is conducting in the first quarter of 1998 a detailed survey of 1997 semiconductor revenue. The final results are scheduled to be released in the second quarter of 1998, but a preliminary look at Japanese companies has already shown that 1997 revenue has been influenced by the crisis. It should be noted, however, that a discrepancy between company plans and actual revenue in Asia/Pacific does not necessarily come from the Asian financial crisis alone —some equipment had been plunged into a painful correction when oversupply followed a period of robust production.

In the first half of 1997, consumer equipment production in Asia/Pacific on the whole saw recovery from an extended slump that started in mid-1995. There were doubts about PC peripherals' continued production growth, but an adjustment phase had not started yet.

By mid-1997, the winds of change had started to blow. Video CD players, which had enjoyed a sudden increase in production because of a rapid rise in demand from mainland China, began to show sluggishness, and production plummeted. CD players, portable audio equipment, rigid disk drives, and CD-ROMs also saw a decrease in production.

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So far in 1998, there has been no clear sign that production levels of this equipment are recovering, and semiconductor orders for those applications continue to be slow.

The Impact on Japanese Semiconductor Companies

The impact of the Asian financial crisis on semiconductor companies is not necessarily negative. The following factors need to be considered:

- Demand side
  - Negative—Reduction in orders from Asia/Pacific users
  - Negative—Price pressure from users
  - Positive—Increase in orders because of improved competitiveness of electronic equipment manufactured in Asia/Pacific
- Supply side
  - Negative—Asia/Pacific semiconductor companies' drive to export
  - Positive—Improvement in short-term semiconductor supply and demand because of production constraints stemming from difficulties in importing materials
  - Positive—Improvement in long-term supply and demand because of limited capital spending by Asia/Pacific semiconductor companies

In this analysis, Dataquest attempts to estimate the impact of the Asian financial crisis on Japanese companies' revenue, using metrics such as revenue by country and semiconductor revenue share of local users in Asia/Pacific.

Naturally, actual problems that semiconductor vendors face will be affected also by the application involved and, eventually, each user. This analysis, however, attempts to show trends in the impact of the crisis on semiconductor orders. Dataquest classifies Asia/Pacific into the following five countries or areas: Korea, Taiwan, China/Hong Kong, Singapore, and Rest of Asia/Pacific (ROA). In this analysis, it is assumed that the higher the revenue in Korea, Singapore, and ROA and the higher the ratio of local users, the higher the risks in semiconductor orders.

Although there has been industry input into these estimates, this analysis is not based on a rigorous survey, and therefore Dataquest chooses to avoid using specific company names. Metrics have, however, been estimated based on each company's characteristics as perceived by Dataquest. The companies analyzed are the top 11 Japanese companies included in the ranking of the top 30 worldwide Asia/Pacific companies: NEC Corporation, Toshiba Corporation, Hitachi Ltd., Fujitsu Ltd., Mitsubishi Corporation, Matsushita Electric Industrial Co. Ltd., SANYO Electric Company Ltd., Sharp Electronics Corporation, Sony Corporation, Sanken Electric Company Ltd., and Rohm Company Ltd.

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These 11 Japanese companies combined hold a 33 percent share of the revenue of the top 30 companies in Asia/Pacific (see Table 1), and their sales into Korea, Singapore, and ROA together account for 60 percent of their total revenue in Asia/Pacific (see Figure 1). In Korea, most of the sales come from business with local users, while in Singapore and ROA, the major portion of their revenue comes from Japanese users or Americas and European users. Among those 11 companies, consumer applications-oriented companies tend to show higher dependence on local users, but they also benefit from their internal user divisions' Asia/Pacific production sites. For those 11 Japanese companies combined, 55 percent of the revenue comes from local users in Asia/Pacific (see Figure 2).

Figure 3 shows the results of estimating the risks that Japanese companies face in semiconductor orders because of the crisis. The first risk scenario is for Korea, Singapore, and ROA combined, and the second risk scenario is for Korea and ROA only. There are some companies whose sales to local users are significantly high but whose risks from the Asian financial crisis are small. Those companies' users are associated with either Japanese, Americas, or European electronics vendors. DRAM companies show similar trends. On the other hand, there are companies whose risks may be high not only because of the Asian financial crisis but also because of sluggishness in certain application markets worldwide. Japanese companies' semiconductor sales in Asia/Pacific are generally characterized by high dependence on Japanese users.

Table 1
Revenue of Selected Japanese Semiconductor Companies in Asia/Pacific, 1996 (Millions of Dollars)

1996 Rank	Company	1996 Revenue	Percentage of Top 30 Companies' Revenue
3	Toshiba	1,804	7.3
7	NEC	1,283	5.2
9	Hitachi	1,169	4.7
11	SANYO	913	3.7
13	Mitsubishi	729	3.0
15	Matsushita	500	2.0
16	Fujitsu	476	1.9
17	Rohm	471	1.9
20	Sharp	406	1.6
23	Sony	286	1.2
29	Sanken	215	0.9
	Top 11 Japanese Companies	**8,252**	**33.4**
	Top 30 Worldwide Companies in Asia/Pacific	**24,699**	**100.0**

Source: Dataquest (February 1998)

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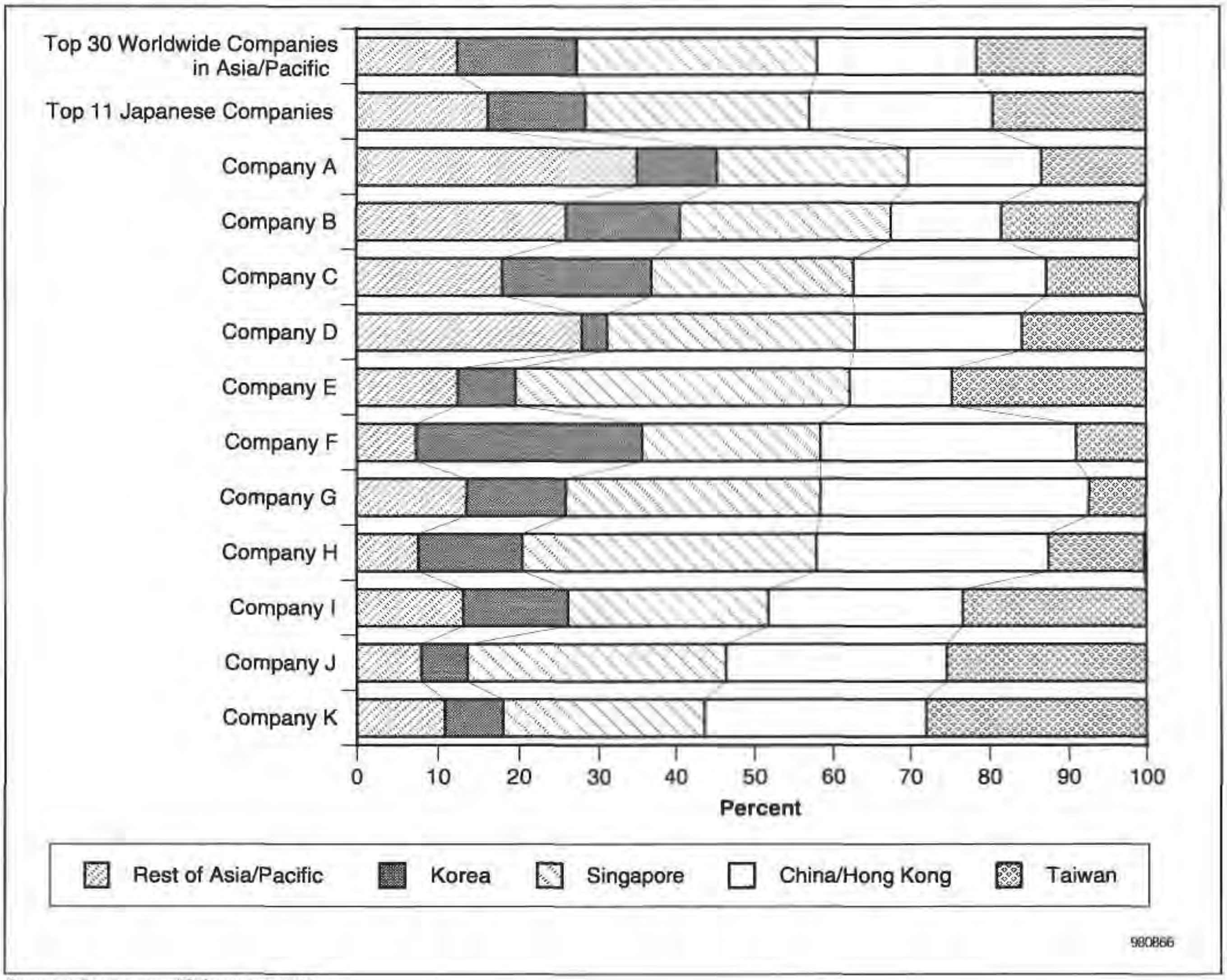
Figure 1
Japanese Companies' Sales into Major Countries in Asia/Pacific

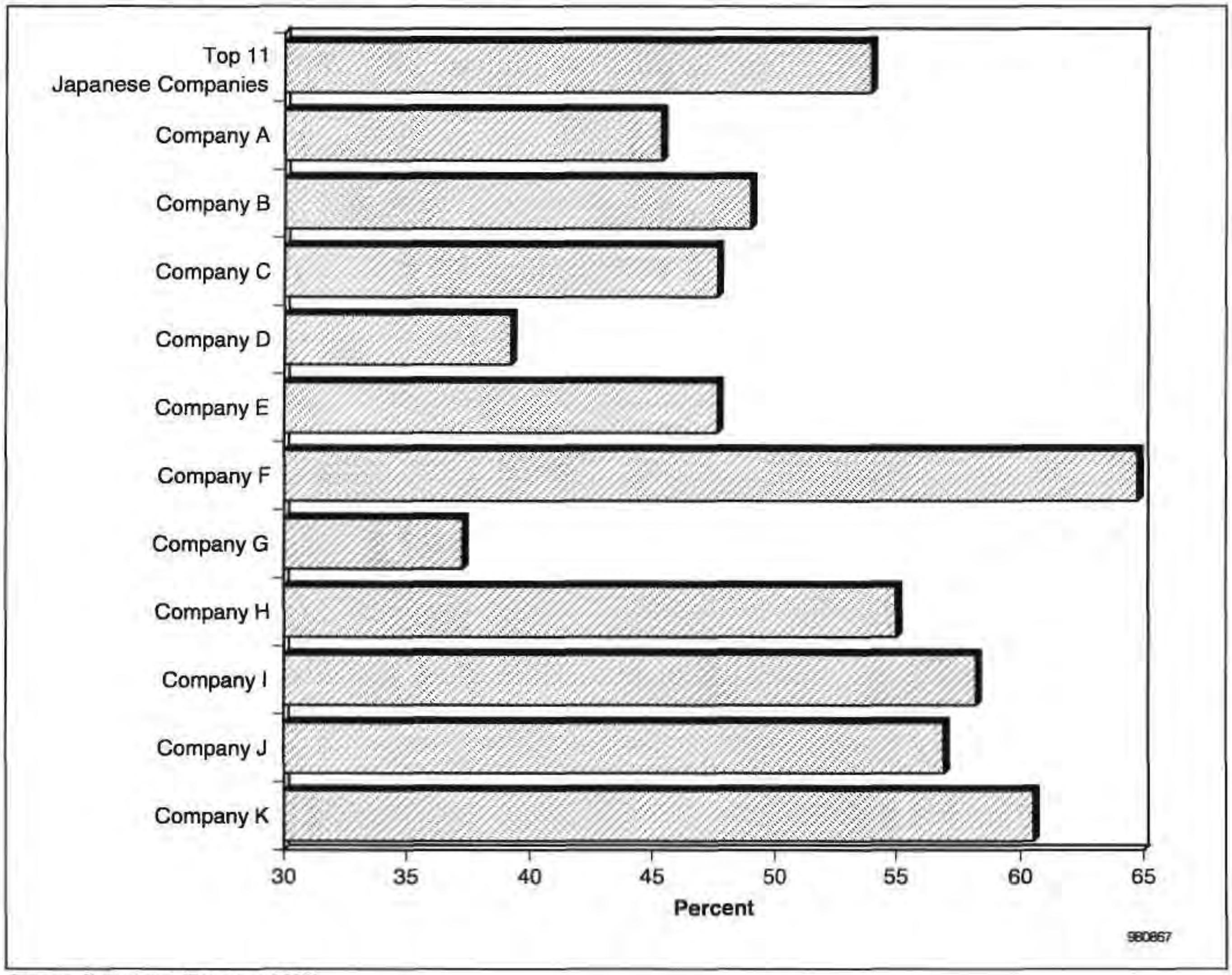


Source: Dataquest (February 1998)

One trend shown in this estimate of risk is that the element of risk added by the Asian financial crisis increases as the total revenue in the crisis-hit areas increases, but at a certain point, the crisis-based risk saturates. This again reflects low dependency on purely local users.

True, semiconductor orders from Asia/Pacific had started to decline even in 1997, and companies with a stronger emphasis on the Korean market were exposed to direct and immediate losses in orders. Dataquest has not heard of any Japanese companies officially attributing lower sales forecasts in Asia/Pacific solely to the Asian financial crisis.

Figure 2
Japanese Companies' Sales to Local Users



Source: Dataquest (February 1998)

This analysis has focused on semiconductor orders and revenue, and manufacturing issues have intentionally been put aside. There has been no immediate change to Japanese companies' wafer fab plans in Asia/Pacific. Test and assembly, or back-end, operations also remain unaffected, because most of the materials are still imported from Japan and the only visible change would come from labor costs.

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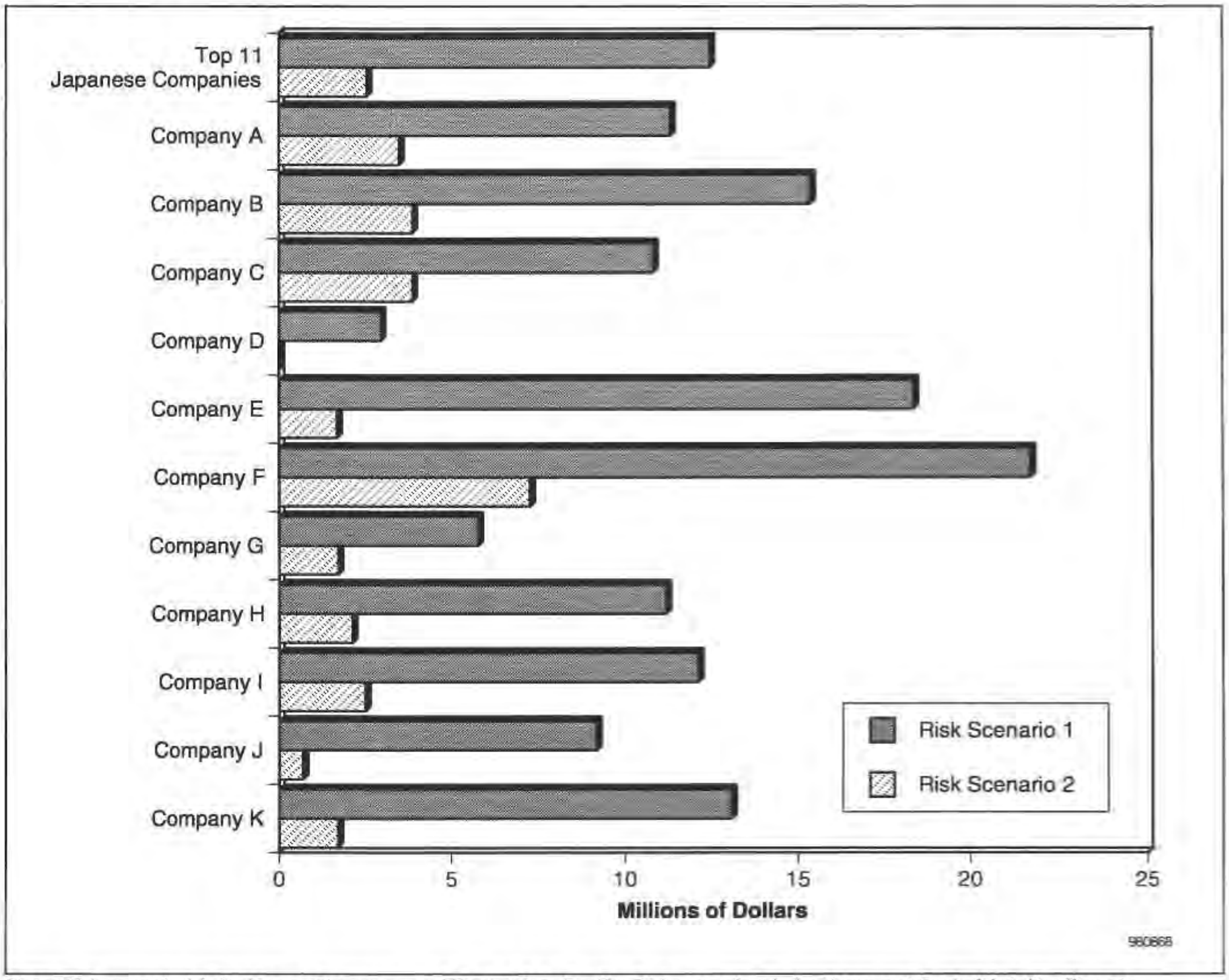
Figure 3
Impact of the Asian Financial Crisis Japanese Companies' Sales into Major Countries in Asia/Pacific



Note: Risk scenario 1 is for Korea, Singapore, and Rest of Asia/Pacific; Risk scenario 2 is for Korea and Rest of Asia/Pacific only.
Source: Dataquest (February 1998)

Possible Scenarios

The future impact of the Asian financial crisis should be measured and analyzed from several aspects, including time frame, origin of demand (whether domestic or export) for application equipment, production of equipment in Asia/Pacific or in other parts of the world, high-end models versus low-end models, availability of semiconductor materials and manufacturing equipment, and semiconductor capital spending.

In the short term, confusion in orders is unavoidable as suppliers and users try to reach new terms of trade incorporating lower exchange rates for local currencies. Local users are putting pressure on local semiconductor sales

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offices to decrease prices, while prices of imported devices now translate into higher value in local currencies.

In the mid- to long term, after new terms of trade have been settled on, Asia/Pacific countries will see changes in their basic economic structures in terms of electronic product categories as Japanese electronics companies rearrange production sites to take advantage of lower costs. Lower exchange rates will also encourage foreign companies to acquire local companies, and the increase in direct investment will contribute to re-establishing and renewing manufacturing facilities in the region.

In terms of demand for electronics manufactured in Asia/Pacific, domestic demand-oriented production will suffer an immediate and direct loss while export demand remains strong. Because overall demand for electronics in Americas and Europe seems to remain firm, the key factor here would be demand in Japan and China.

Lower exchange rates for local currencies will improve the export competitiveness of electronics produced in Asia/Pacific countries, but this could happen at the expense of production in other parts of the world. There is a possibility that some electronics equipment could see lower prices in export markets, and that may increase demand for those products. Whether electronics production in Asia/Pacific increases or decreases affects industrial equipment companies in Japan, because they have benefited from the Japanese electronics companies' production shift, which brought manufacturing equipment to those new sites. One other factor to be considered in electronics manufacturing is the possible shift in product class—in the past few years, ASEAN countries have shifted to middle-range products from low-end models, while China, with its low labor costs, took up production of low-end products. Depreciation of currencies in the ASEAN countries could enable them to resume production of low-end models, especially when they are motivated to increase exports to acquire foreign currency reserves.

Industrial equipment and manufacturing equipment are the areas hit hard by the Asian financial crisis because local companies find imported equipment too expensive. Along with the impact on the purchase of imported materials, this may motivate Asia/Pacific countries to secure industry autonomy.

Dataquest Perspective

The Asian financial crisis in its early stages was a set of financial phenomena. It should be noted that in countries whose gross domestic product (GDP) was not already damaged, economic fundamentals were not necessarily ailing, but the impact of the crisis is already being felt in various industries both inside and outside Asia/Pacific.

It should also be noted that, in Japan, the bursting of the bubble economy several years ago and the yen appreciation that followed continue to drag the Japanese economy down. If the effects of the crisis are managed poorly, there

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could be similar aftereffects in Asia/Pacific countries; if better managed, those countries' economies and industries could become more efficient.

One important factor that this Perspective has not covered is the impact of the Asian financial crisis on semiconductor production by Asia/Pacific companies and Japanese semiconductor companies' reactions to it. Although there is a general expectation in semiconductor industry circles that the crisis will bring the supply and demand into equilibrium sooner than predicted, the actual effects are yet to be seen. If the Asian financial crisis proves to provide an effective adjustment period, electronics industries may find it an opportunity instead.

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Perspective

Semiconductors Japan

Market Analysis

A First Look at 1997 Semiconductor Market Share from the Japanese Perspective

Abstract: *Dataquest has conducted phase one of the annual market share survey for the worldwide top 20 and regional top 10 semiconductor company rankings. This Perspective analyzes the Japanese ranking trends observed in the 1997 survey, trends related to Japanese companies in foreign markets, and the top 10 topics of conversation in the semiconductor industry, from the Japanese perspective.*
By Yoshihiro Shimada

Scope of Survey

Dataquest's annual 1997 market share survey was conducted in November and early December 1997, and the results were published in an earlier Perspective ("Intel, NEC, and Motorola Remain atop the Worldwide Semiconductor Market," SCND-WW-DP-9706, January 1998). We limited our information request to total worldwide semiconductor revenue plus revenue in four regions. We structured the survey to capture the top 20 worldwide plus the top 10 in each region. We did not survey every company worldwide, which explains why the published tables do not have a market total or "other companies" category. Also, we did not survey at detailed product levels.

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The Top 10 in the Japanese Market

In the 1997 spring forecast, the Japanese market was expected to show clear signs of recovery by growing at an annual rate of more than 10 percent. By the time Dataquest started work on the fall forecast, this initial expectation had started to look too optimistic. The fall forecasts states that the Japanese

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market will grow annually only 9.5 percent on a yen basis, and 1.0 percent on a dollar basis. As mentioned, total market trends will be analyzed in the detailed survey to come, but the qualitative information obtained in this semiconductor revenue survey suggests deteriorating revenue trends, basically because of weak pricing of products such as DRAM and application-specific ICs (ASICs). Production of application equipment showed a slowdown in some areas, such as PCs, peripherals, and consumer equipment. Putting aside the shift of demand from PHS to cellular phones, mobile communications, on the whole, was the only area in which the industry outpaced initial forecasts that predicted weak or negative growth.

In such a market, the top 10 rankings of semiconductor shipments into Japan changed little during 1997 (see Table 1). Hitachi Ltd. suffered a major loss in revenue because of its high ratio of DRAM to total semiconductor revenue, but managed to maintain its No. 2 position. The only change in ranking was between Intel Corporation and Mitsubishi Corporation. Mitsubishi, with the second-highest DRAM ratio of major Japanese companies, recorded a contraction, while Intel's revenue continued to grow, even though Japanese PC markets turned sluggish in the second half of the year.

Japanese Companies in Foreign Markets

Table 2 shows Japanese companies in the worldwide top 20 ranking. NEC Corporation leads Japanese companies at No. 2 in the worldwide rankings. Hitachi's revenue exceeded Toshiba Corporation's in 1996, but its lead did not last long. Other than that, because revenue changes were comparatively small for most companies, the rankings among Japanese companies did not change much.

Table 1
Revenue of Top 10 Companies Worldwide from Shipments of Semiconductors to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Growth (%) 1996-1997
1	1	NEC	5,756	5,830	1.3
2	2	Hitachi	4,252	3,749	-11.8
3	3	Toshiba	3,838	3,562	-7.2
4	4	Fujitsu	2,645	2,912	10.1
5	5	Matsushita	2,268	2,340	3.2
7	6	Intel	2,028	2,211	9.0
6	7	Mitsubishi	2,147	2,101	-2.1
8	8	Texas Instruments	1,634	1,640	0.4
9	9	Sharp	1,561	1,511	-3.2
10	10	Sony	1,386	1,392	0.4

Source: Dataquest (January 1998)

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Table 2
Revenue of Japanese Semiconductor Companies in the Worldwide Top 20 Ranking (Millions of U.S. Dollars)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Growth (%) 1996-1997
2	2	NEC	10,428	10,656	2.2
5	5	Toshiba	8,065	7,507	-6.9
4	6	Hitachi	8,071	6,523	-19.2
8	8	Fujitsu	4,427	4,872	10.1
11	10	Mitsubishi	4,100	4,097	-0.1
14	14	Matsushita	3,003	3,055	1.7
15	16	SANYO	2,491	2,577	3.5
19	20	Sharp	2,124	2,059	-3.1

Source: Dataquest (January 1998)

In the Americas region, three Japanese companies were listed among the top 10. NEC, with flat growth, gave way to Texas Instruments Inc. to become No. 4, while Toshiba and Hitachi switched places. In a market in which weak DRAM pricing eroded revenue, Japanese companies as well as Korean companies suffered two-digit reductions in total semiconductor revenue.

In the European market, only two Japanese companies made their way into top 10, NEC and Fujitsu. NEC maintained its No. 8 position, while Fujitsu jumped into No. 9.

In the Asia/Pacific region, three Japanese companies, again, appeared in the top 10 ranking. In this region, Toshiba has traditionally been strong, but it gave way to Texas Instruments and became No. 4. NEC, with comparatively strong growth of 7.9 percent over 1996, maintained its No. 7 position. The third Japanese company was SANYO, which has also had advantages in the Asia/Pacific region. SANYO's historical strength has been in consumer applications, and it was a beneficiary of the recovery in consumer equipment production in this region. None of these three Japanese companies' revenue showed any significant or immediate impact of Asia's financial crisis for 1997.

Starting in January 1998, Dataquest will conduct a detailed survey of all semiconductor companies' 1997 product revenue plus memory unit shipments and microprocessor (MPU), microcontroller (MCU), and digital signal processor (DSP) unit shipments. We will release that detailed information during the second quarter of 1998. Those detailed results will provide information on companies that enjoyed product successes in 1997 that are not listed in this document's tables.

The 10 Most Popular Topics in 1997 from the Japanese Perspective

Dataquest has put together a list of the top 10 news in the 1997 semiconductor industry from the perspective of the Japanese semiconductor industry, based on interviews with Dataquest's contacts in the industry, as well as from various Dataquest analysts' input.

Table 3 lists 10 ubiquitous topics of industry conversation. The top three topics, characteristically, centered around DRAMs. DRAM consumption was expected to resume a recovery path, but the actual trends betrayed this expectation. Although the shift from 16Mb to 64Mb started to make substantial progress and overall bit demand was more than steady, the delay in the shift from extended data out (EDO) to synchronous DRAM (SDRAM), weak pricing trends, and the PC slowdown in Japan and Asia/Pacific brought revenue growth down.

Micron Technology Inc. became the third most frequent topic. Micron Technology increased production and shipments of 16Mb DRAM while Japanese and Korean companies were seeking ways to stabilize the supply/demand balance. Its production trends and pricing and the profit Micron secured in 1997 revealed a totally new strategy in the DRAM business. True, Micron has been known for its unique strategy, but the fact that the company has finally become the top producer of 16Mb DRAM was a shock to many in industry circles—especially Japanese industry circles.

PC shipment trends were the fourth most frequent topic of discussion. In 1997, the Japanese PC market started to show sluggishness, and peripherals such as CD-ROMs finally started to show signs of production constraint. There is some indication that 1997 PC market trends can be characterized by language—in two-byte language regions such as Japan and Asia/Pacific, PC shipment growth weakened. This stems from the fact that, with PC penetration becoming high, additional demand for PCs lies in the growth of networking. In two-byte language areas, where English is not necessarily spoken as a native language, access to cyberspace is limited while Web sites in the native language may appear to be less attractive than those in English, especially those with American origins. Needless to say, the turbulence in Asian economies is playing a role, too.

Table 3
The 10 Ubiquitous Topics, from a Japanese Perspective

Rank	Topic
1	Contraction in the DRAM market for the second consecutive year
2	Continued fall of DRAM prices
3	Micron Technology's production increase and marketing strategy
4	Winds of change in the regional PC markets
5	Sluggishness in equipment production and semiconductor consumption in Asia/Pacific
6	Construction of quarter-micron fabs
7	Increase in flash memory market players
8	Visibility of Taiwanese manufacturers in the DRAM business
9	Disappointment in worldwide semiconductor consumption growth
10	Continued sound growth in mobile communications applications

Source: Dataquest (January 1998)

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The Asian financial crisis ranked fifth as a topic. In 1997, the real impact was yet to come and influenced Japan very little. Japanese equipment companies with production sites in Asia/Pacific maintained their levels of production, especially in cases where products were destined to be shipped out of the region. Currently, the strongest interest lies in assessing the magnitude of the impact of the crisis on Korean semiconductor companies' capital spending. A major impact is anticipated, however, on various aspects of electronics industry in 1998.

The construction of quarter-micron fabs and their production starts is one of the few positive topics. Contrary to the initial expectation of improvements in profits, quarter-micron fab output was immediately exposed to harsh pricing competition, both in memories and in logic areas.

Flash memories drew interest as a substitute for DRAM in filling fabs as the fast-growing digital still camera market diversified the applications. MCUs with flash memory have also started to show strong growth. With prices lower than originally planned, flash MCUs are finding their markets quickly.

Ranked eighth is Taiwanese companies' penetration into the DRAM market. Over several generations, the winners in the DRAM business have shifted first from American companies to Japanese companies, then to Korean companies. Now the focus of interest is the question of whether Taiwanese companies will become the next leaders in the DRAM market. Taiwanese companies have already started to produce 64Mb DRAMs to seriously penetrate into the DRAM market, which they initially planned to with 16Mb. Whether their product and technology transfers with foreign partners can contribute to the success of Taiwanese companies is yet to be determined.

Ninth on the list is the disappointment in worldwide semiconductor market growth. The industry expected 1997 to be the year of recovery, but the signs of recovery ended up being very modest. In fact, it became the year when applications that had driven the semiconductor market for the past several years failed to bring about strong demand. Although Dataquest's fall forecast was lower than the spring forecast, actual market trends toward the end of the year suggest even further reductions in growth rates.

Last comes a topic in the communications. While the emphasis of the worldwide semiconductor market is shifting from standalone PCs to communications-related applications such as networks and mobile phones, the Japanese electronics industry is still dwelling on PCs and peripherals. Network-related equipment is yet to come into focus, but mobile phones have come to be recognized as one driver of semiconductor demand. In fact, at the beginning of the year, a slowdown in the production of mobile phones was expected, especially for PHS. It is true that PHS subscriptions suffered contraction in the last few months of 1997, but cellular phones remained steady.

Outside the top 10 are other topics, including:

- Applications: Windows 97/98, CD-ROM production, Windows CE machines, and cyberpets

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- Semiconductors: SDRAM, embedded memories, Pentium MMX and Pentium II, clone chips, media processors, and analog ICs
- Manufacturing: fab construction trends, Korean companies' capital spending, and 300mm fab technology and construction

A pleasant surprise was seen among analog companies. As electronic equipment production rose on a worldwide basis, it was only natural for demand for analog ICs to grow steadily. But this is an area in which capital spending and engineering staffing have been underestimated, and the actual growth in demand for analog took companies by surprise. Lack of capital spending brought tight supply, even allocation in some cases, as well as constraint in product development because of the lack of analog engineers. This is expected to continue for some years, but the industry is trying to evaluate the actual demand that remains for independent analog devices, as opposed to analog functions incorporated into system-level integration (SLI) ASICs.

Topics of 300mm fab technology kept conversation going throughout the year and will continue to in the coming several years. The collaboration agreement between the International 300mm Wafer Initiative (I300I) and SELETE groups is expected to bring efficiency into the scheme through global standardization, but actual technology development and fab construction are dependent on each company. Semiconductor companies must face issues such as the cost comparison between 300mm and 200mm technologies, technology and equipment development, the long-term semiconductor supply/demand outlook, and semiconductor companies' product development.

Dataquest Perspective

The results of Dataquest's 1997 market share survey show a sharp contrast between strengthening American and European vendors and weakening Japanese and Korean companies.

This, however, does not result solely from a difference in their emphasis on DRAM but also from a difference in their successful systems-oriented marketing and product development. Even among major Japanese and Korean companies, there are companies that have managed to minimize the negative impact of the DRAM price drops by expanding nonmemory MOS digital products, such as microcomponents and logic. Even in DRAM, which has long been considered a typical commodity product category, a systems orientation can be seen, including development of SDRAM and certain companies' marketing efforts focused on PC companies and memory module companies.

The 1997 Japanese market share results, as well as the top 10 topics of interest to the semiconductor industry from a Japanese perspective, seem to pose one question: Has the Japanese semiconductor industry really become global, selective, and diversified? In 1998, systems-oriented product

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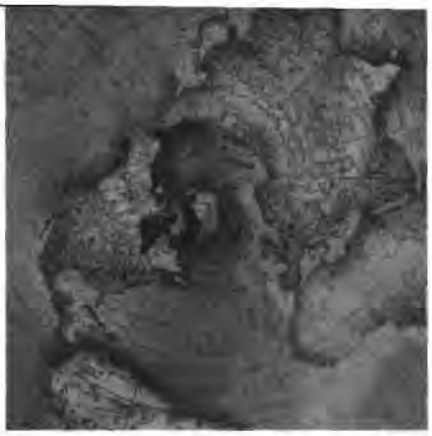
Market Trends



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Japanese Semiconductor Market Trends

Market Trends

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Chapter 1
Executive Summary

Scope of This Report

This Market Trends report analyzes the following trends in Japan from 1997 through 2002:

- Electronic equipment production market trends
- Semiconductor market trends
- Semiconductor companies' capital spending trends

Chapter 1 sets the stage for the analysis in this booklet. Chapter 2 discusses electronic equipment production trends, focusing on four major categories: electronic data processing (EDP), communications, industrial, and consumer. Chapter 3 covers the overall semiconductor market trends in Japan, analyzing 1997 market share results and forecasting the market for five years to come. Chapters 4 through 7 discuss detailed product market trends for MOS memories; MOS microcomponents; MOS logic; and analog, discrete, and optical semiconductors, respectively. Those chapters also cover 1997 market share results and forecast market trends for 1998 through 2002. Chapter 8 sheds light on the Japanese semiconductor industry, focusing on the capital spending trends of the Japan-based semiconductor companies during 1997 and 1998.

Research Methodology and Definitions

This Market Trends report follows standard Dataquest market share and forecasting methodologies, but several points may need to be noted.

Numbers are expressed in Japanese yen to make the analysis of time series trends free from fluctuations in the yen/dollar exchange rate. Where necessary, numbers on a dollar basis are mentioned, using the exchange rates shown in Table 1-1.

Table 1-1
Yen-per-Dollar Exchange Rate, 1992 to 1998

Year	Yen (¥)
1992	126.45
1993	111.20
1994	101.81
1995	93.90
1996	108.81
1997	121.10
Preliminary 1998	129.73

Source: Dataquest (August 1998)

The preliminary 1998 exchange rate estimate incorporated in this report uses actual exchange rates through December 1997 and assumes that the December rate applies to all future months. For the years 1999 through 2002, the preliminary 1998 exchange rate is assumed to apply.

Dataquest has made some minor changes to the product definitions in the 1997 market share survey and analysis and is considering a major shift to a new set of definitions in the future; these future changes will be in conjunction with those made in 1997, aiming at the best analysis of system-oriented market trends.

The following are the changes that have been made:

- The hybrid ICs category has been erased from 1997 revenue. Revenue from the shipment of hybrid ICs is counted on the basis of component chips produced by the same vendor in the product categories that those chips belong to, such as analog and discrete. 1996 revenue remains as it was.
- Linear array revenue has been moved from analog to ASIC in 1997 revenue, while 1996 revenue remains the same. Mixed-signal ASIC revenue has also been moved from analog to ASIC, both in 1996 and 1997 revenue. As a result of those changes, analog and ASIC revenue in 1996 is different from previously published numbers for vendors of those products. Also, as a result, the ASIC category is now called "Total ASIC," and what was formerly called "MOS Digital Logic" is now called "Total Logic."

These changes do not appear explicitly in this book, because it describes top-line trends for each product category, but for any comparison of 1997 trends—as well as future trends—with the past trends, including 1996 and before, these changes may need to be noted in some cases.

Major points discussed in this document include the following:

- Japanese electronics production is forecast to grow 3.0 percent in 1998, and the compound annual growth rate (CAGR) for the coming five years will be 2.8 percent. These growth rates have been brought down from the level previously forecast, and Japan still needs to identify strong drivers of electronics production.
- The Japanese semiconductor market is forecast to grow 9.8 percent in 1998, and the CAGR for the coming five years will be 12.4 percent. In a downside scenario, however, 1998 growth could go down to 1.5 percent. The lack of a strong electronics driver is affecting semiconductor consumption in Japan, and the prolonged oversupply in various semiconductor products is affecting pricing trends negatively.
- Japanese semiconductor companies' capital spending in 1998 will see a major drop from the previous year. Reduction in spending is mostly seen in memories, and Japanese companies are placing more emphasis on preparing supply capacity for advanced logic products to serve SLI markets.

- The Japanese semiconductor market is forecast to grow at the slowest pace among the four regional markets worldwide. Along with prolonged weakness in the DRAM market and the acceleration of the SLI move, the changes in regional market size and application trends will force domestic vendors to restructure their operation toward improved support of global customers. Whether digital consumer applications can revive the Japanese market, and whether it is the Japanese vendors or overseas vendors that benefit from emerging applications, depend on each company's efforts to restructure semiconductor operation and transform from commodity vendor to system-level integrator.

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Chapter 2
Japanese Electronic Equipment Production Trends

The Japanese economy in 1997, after a temporary surge in domestic demand prior to the consumption tax hike in April, was beleaguered by turmoil in the financial system, a decline in consumer expenditure, and a slowdown in capital spending. The economic hardship was amplified by the Asian financial crisis (AFC) toward the year-end.

In 1997, against all the backlash in the Japanese economy and in Asia/Pacific, electronic equipment production showed stronger growth than expected: 7.8 percent over 1996, reaching ¥23,715 billion (see Tables 2-1 and 2-2). Cellular phones contributed greatly, fueled by a series of price cuts and the shift in demand from personal handy phone (PHS) models. EDP equipment also outgrew the forecast, despite a slowdown in domestic PC shipments, and consumer equipment added some momentum that came from video game systems and digital equipment.

In 1998, communications equipment will no longer serve as a major impetus, as the cellular phone market reaches a high level of penetration and the digitization of backbone networks completes its first round. Thus, Dataquest predicts that electronic equipment production in Japan will grow a moderate 3.0 percent to ¥24,425 billion, down 1.6 percentage points from the fall forecast. Similarly, the CAGR between 1997 and 2002 will settle at 2.8 percent.

Future growth opportunities must come from a surge in PC demand stimulated by the introduction of low-cost models and increased implementations of plug-and-play interfaces, such as universal serial bus (USB) and Institute of Electrical and Electronics Engineers (IEEE) 1394. While Windows 98 will not have much of an impact on the PC market, the evolution of PCs to a new platform for WebTV and other media-mix services will hold the key to growth in demand for personal equipment.

The following section provides a detailed analysis of electronic equipment production in Japan for the four major categories, namely, EDP, communications, industrial, and consumer.

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Table 2-1
Japanese Electronic Equipment Production History and Forecast, 1992 to 2002 (Billions of Yen)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	1997-2002 CAGR (%)
Electronic Equipment	**21,154.7**	**19,363.3**	**19,382.3**	**19,814.8**	**22,000.7**	**23,715.2**	**24,425.0**	**24,900.9**	**25,725.4**	**26,201.2**	**27,280.4**	2.8
Data Processing	6,206.5	5,645.2	5,752.6	5,913.4	6,811.7	7,379.9	7,759.1	7,969.8	7,989.4	8,046.1	8,264.7	2.3
Communications	2,829.3	2,803.9	2,889.2	2,985.0	4,042.2	4,844.2	4,829.8	4,887.3	5,221.2	5,373.7	5,581.4	2.9
Industrial	3,190.2	2,948.7	2,948.3	3,342.6	3,647.5	3,908.4	4,140.0	4,339.0	4,560.0	4,763.0	5,057.0	5.3
Consumer	7,387.2	6,477.2	6,365.8	6,134.3	6,018.5	6,097.6	6,109.8	6,059.8	6,281.5	6,345.7	6,701.9	1.9
Military/Civil Aerospace	211.8	207.4	202.8	199.6	197.4	195.0	192.4	189.8	187.2	185.0	182.6	-1.3
Transportation	1,329.7	1,280.9	1,223.6	1,239.9	1,283.4	1,290.1	1,393.9	1,455.2	1,486.2	1,487.7	1,492.7	3.0
Exchange Rate (Yen/U.S.$1)	126.45	111.20	101.81	93.90	108.81	121.10	129.73	129.73	129.73	129.73	129.73	-

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (August 1998)

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Table 2-2
Japanese Electronic Equipment Production History and Forecast, 1992 to 2002 (Yen-Based Percentage Change over Preceding Year)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Electronic Equipment	**-12.5**	**-8.5**	**0.1**	**2.2**	**11.0**	**7.8**	**3.0**	**1.9**	**3.3**	**1.8**	**4.1**
Data Processing	-9.6	-9.0	1.9	2.8	15.2	8.3	5.1	2.7	0.2	0.7	2.7
Communications	-9.0	-0.9	3.0	3.3	35.4	19.8	-0.3	1.2	6.8	2.9	3.9
Industrial	-18.7	-7.6	0	13.4	9.1	7.2	5.9	4.8	5.1	4.5	6.2
Consumer	-15.1	-12.3	-1.7	-3.6	-1.9	1.3	0.2	-0.8	3.7	1.0	5.6
Military/Civil Aerospace	-2.1	-2.1	-2.2	-1.6	-1.1	-1.2	-1.3	-1.4	-1.4	-1.2	-1.3
Transportation	-2.7	-3.7	-4.5	1.3	3.5	0.5	8.0	4.4	2.1	0.1	0.3

Source: Dataquest (August 1998)

EDP Equipment

In 1997, EDP equipment production in Japan soared 8.3 percent to ¥7,380 billion. While PC shipments to the domestic market slowed down to less than 5 percent growth on a unit basis, the price decline spurred the purchase of peripherals such as printers and display units. Also, storage devices led by high-speed optical disk drives—32x CD-ROM drives and DVD-ROM drives, for example—enjoyed strong growth. This segment is expected to drive the market during the forecast period.

IT investment will continue to be a major driver in 1998 while Japanese financial institutions are exposed to global competition as a result of the "Big Bang," which urges them to strengthen information systems. Therefore, more than compensating for the general economic slump, computers will drive EDP equipment production, growing 5.1 percent in 1998 with a CAGR of 2.3 percent during the next five years. The gradual recovery of the Japanese economy will continue to fuel EDP equipment production after 1998, which should exceed ¥8 trillion in 2001.

Communications Equipment

Communications equipment production in 1997 jumped 19.8 percent to ¥4,844 billion. A prime driver was mobile communications equipment; subscribers grew much faster than expected, recording a net increase of 10 million in 1997. While PHS production decelerated at 7 million units, the market is expected to expand as its focus shifts from personal to office use.

Nevertheless, the penetration of mobile phones combining PHS and cellular phones has surpassed 50 percent, and the continuation of the previous high growth will become inevitably difficult. Meanwhile, the digitization of infrastructure facilities by Nippon Telegraph and Telephone Corporation (NTT) was completed by the end of 1997. These factors will consequently put a brake on communications equipment production, turning into a negative growth of 0.3 percent. On the other hand, network equipment, including LANs, will experience healthy growth at a CAGR of 15 percent or above. All in all, communications equipment production will grow at a CAGR of 2.9 percent between 1997 and 2002.

Industrial Equipment

Industrial equipment production in 1997 was up 7.2 percent, totaling ¥3,908 billion. Of the total, manufacturing systems and instruments recorded the highest growth rate, with 14.9 percent. As the wave of production site relocation to Asia/Pacific countries subsides, the focal point of the market will shift to computerization and sophistication for adding value and further automation. In particular, medical equipment will exhibit strong growth, with the increasing demand for advanced systems to meet the needs of an aging society, resulting in a CAGR of 5.2 percent between 1997 and 2002. Overall, Dataquest predicts a CAGR of 5.3 percent, the highest among the six segments: data processing, communications, industrial, consumer, military/civil aerospace, and transportation.

Consumer Equipment

Consumer equipment production recorded a 1.3 percent increase in 1997, reaching ¥6,098 billion. In the video equipment segment, where TVs and VCRs sold in the domestic market are mostly made overseas, the replacement demand for wide-screen TVs produced at domestic sites contributed greatly. In the digital consumer equipment market, digital video cameras (DV-Cs) recorded notable growth, and unit shipments up to the end of 1997 were estimated at slightly below 1 million. The DV-C quickly will become pervasive, driven by price declines and the improved availability of key components. Similarly, digital still cameras (DSCs) will ramp up rapidly because they can be easily connected to PCs or TVs via a flash memory card or IEEE 1394 interface. On the other hand, the commercialization of digital TVs will have to wait until after 2000 because infrastructure construction has been delayed.

The current recession will hit household appliance production directly, leading to negative growth in 1998. Video game systems will continue to be a fierce battlefield for a 32-bit hegemony, but production will remain mostly unchanged in 1998, until the next-generation products are introduced in 1999. Dataquest predicts that consumer equipment production as a whole will grow at a CAGR of 1.9 percent between 1997 and 2002.

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Chapter 3
Overall Japanese Semiconductor Market Trends

1997 Market Share

Market Trends

In 1997, the Japanese semiconductor market recorded a growth rate of 5.7 percent over the previous year on a yen basis, which was the only negative growth rate on a dollar basis among the four regional markets in the world. As discussed in the previous chapter, the production of electronics equipment in 1997 grew faster than what was forecast, but this growth was not directly translated into faster growth in semiconductor consumption. The difference in trends was caused by two factors: An increase in electronics production took place in categories with lower semiconductor contents, such as industrial equipment, and the price erosion of semiconductor devices betrayed the increase on a unit basis. Also, PC shipments lost momentum in Japan, exerting a negative impact on the consumption of a variety of semiconductor products, including memories, microprocessors (MPUs), and logic.

As a result, the Japanese semiconductor market has become less than one-fourth of the worldwide market for the first time since 1980. It is still the second-largest regional market following the Americas, but both European and Asia/Pacific markets are close behind. In fact, there were months within 1997 when the Japanese semiconductor market fell behind those two markets.

Affecting this is the sluggishness in the domestic market as well as the fast growth in other regions, especially in the Americas and Europe. Semiconductor procurement to support Japanese electronics companies' Asian production sites has moved to each site or to international purchasing offices (IPOs) outside of Japan, and the yen depreciation observed in 1997 did not reverse the trend.

Ranking Trends

The Japanese semiconductor market is characteristically led by domestic vendors, but their market share has been on a constant decline. In 1997, non-Japanese companies together had 26.4 percent of the Japanese market, and Americas companies alone had a more than 20 percent share, while Asia/Pacific companies lost share because of the weak DRAM market. European companies hold a meager 1.5 percent share but are increasing visibility by focusing on selected product areas for the target applications of digital consumer and automotive. Needless to say, the decline of the Japanese companies' combined market share was largely caused by the DRAM price fall, but it should be noted that non-Japanese companies no longer need strong side support in penetrating the Japanese market. Successful non-Japanese companies have come to enjoy close ties with Japanese system companies with their expertise in system-oriented devices in the areas of microcomponents, logic, and analog.

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NEC Corporation continued to lead the Japanese market in 1997 (see Table 3-1). While many other major domestic vendors suffered from sluggishness in various product areas, NEC managed to secure positive growth in all of the major product areas except for memories—ranging from microcomponent, logic, analog, discrete, and optical—on a yen basis. Dataquest estimates that utilization at NEC's fabs remained higher than at those of most other Japanese vendors, helping it to maintain a comparatively healthy income profile. Toshiba Corporation and Hitachi Ltd. switched places in 1997. While Toshiba became the beneficiary of design wins in the digital consumer, mobile communications, and mass storage applications, Hitachi could not fully enjoy the fruit from the increased number of design wins for its proprietary architecture microcomponent product lines. Fujitsu Ltd. and Matsushita Electronics Corporation remained at the same positions of No. 4 and No. 5, respectively. Fujitsu increased market share, with contributions from digital consumer and mass storage applications. Matsushita Electronics also benefited from those two application areas, having system manufacturing companies inside the corporate group. Although PC shipments slowed, Intel Corporation still enjoyed a sound growth of over 20 percent and became No. 6, replacing Mitsubishi Electric Corporation.

Among the non-Japanese companies that gained market share in 1997, LSI Logic Corporation, Analog Devices Inc., Macronix International Company Ltd., and Lucent Technologies stand out with their high growth rates. The growth of LSI Logic was a result of the design wins of its SLI ASIC product line in digital consumer applications, while Lucent took advantage of its communications expertise. Analog Devices was a beneficiary of healthy analog market trends, and Macronix benefited from the mask ROM business, from which Japanese companies are exiting.

Forecast through 2002

The Japanese semiconductor market in 1998 will grow at 9.8 percent (2.5 percent on a dollar basis), down from the fall forecast (see Tables 3-2 and 3-3). This reflects the anticipated slowdown in electronic equipment production and the hovering market conditions for DRAMs, and it also exemplifies the expectation for a recovery in the second half. Underlying assumptions include a mild DRAM price decline, the small direct impact of AFC, and the firming up of the PC market with the introduction of Windows 98. With this growth, however, the Japanese market will lose its share in the worldwide market, while the other three regional markets will gain share.

The CAGR between 1997 and 2002 is forecast to be 12.4 percent, or 10.9 percent on a dollar basis, which is the lowest among the four regions, making the Japanese market the smallest, with a 20 percent share in the worldwide market. With the electronics production CAGR at 2.8 percent, this slow increase in semiconductor consumption is unavoidable, but the long-term trends will pose a major challenge to Japanese vendors.

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Table 3-1
1997 Japanese Market Share Ranking: Total Semiconductor (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	NEC	626.3	686.2	9.6	15.5
3	2	Toshiba	417.6	421.9	1.0	9.5
2	3	Hitachi	462.7	406.3	-12.2	9.2
4	4	Fujitsu	287.8	335.2	16.5	7.6
5	5	Matsushita Electronics	246.8	271.7	10.1	6.1
7	6	Intel	220.7	270.9	22.8	6.1
6	7	Mitsubishi Electric	233.6	245.8	5.2	5.6
8	8	TI	177.8	187.6	5.5	4.2
9	9	Sharp	169.9	180.6	6.3	4.1
10	10	Sony	150.8	165.8	9.9	3.8
11	11	SANYO	135.9	156.5	15.1	3.5
12	12	Rohm	114.1	117.2	2.7	2.7
14	13	Motorola	72.7	75.2	3.5	1.7
13	14	Samsung	89.1	71.3	-20.0	1.6
15	15	Oki	63.0	68.2	8.2	1.5
19	16	LSI	29.9	44.4	48.5	1.0
16	17	Rockwell	48.5	42.1	-13.2	1.0
17	18	Sanken	38.3	36.6	-4.5	0.8
18	19	Fuji Electric	34.8	31.4	-9.9	0.7
20	20	National	27.6	27.5	-0.5	0.6
23	21	SGS-Thomson*	24.8	26.0	4.9	0.6
21	22	HEC	26.5	25.7	-3.3	0.6
29	23	Analog Devices	17.5	23.5	34.1	0.5
31	24	Macronix	16.0	23.0	43.9	0.5
33	25	Lucent	14.8	22.5	52.2	0.5
28	26	Philips Semiconductors	18.7	22.0	17.8	0.5
22	27	LG Semicon	26.4	21.2	-19.8	0.5
26	28	AMD	19.3	19.4	0.6	0.4
27	29	Shindengen Electric	18.8	19.0	1.0	0.4
25	30	Yamaha	20.6	18.5	-9.9	0.4
34	31	Ricoh	14.8	17.1	15.4	0.4
32	32	IBM	15.5	16.0	3.5	0.4
127	33	Stanley Electric	0	15.5	NA	0.4
36	34	New JRC	13.1	15.4	17.8	0.3
35	35	Cirrus Logic	14.5	14.2	-2.1	0.3
37	36	Altera	10.3	13.8	33.6	0.3
30	37	Seiko	17.2	13.7	-20.4	0.3
24	38	Atmel	22.7	13.1	-42.5	0.3

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Table 3-1 (Continued)
1997 Japanese Market Share Ranking: Total Semiconductor (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
46	39	Chips & Technologies	6.0	10.9	82.1	0.2
69	40	Sun	2.2	9.1	317.4	0.2
		All Others	212.1	218.1	2.8	4.9
		Americas Companies	845.1	949.9	12.4	21.5
		Japanese Companies	3,109.2	3,252.1	4.6	73.6
		European Companies	55.2	66.6	20.7	1.5
		Asia/Pacific Companies	170.2	151.4	-11.0	3.4
		Total Market	**4,179.7**	**4,420.0**	**5.7**	**100.0**

NA = Not available
* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

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Table 3-2
Japanese Semiconductor Market History and Forecast, 1992 to 2002 (Billions of Yen)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Total Semiconductor*	**2,602.2**	**2,740.5**	**3,156.9**	**3,959.4**	**4,179.7**	**4,420.0**	**4,851.5**	**5,571.0**	**6,485.0**	**7,603.5**	**7,925.5**	12.4
Total Integrated Circuit (Excluding Hybrid)	1,921.5	2,076.5	2,454.2	3,162.6	3,313.5	3,576.1	3,943.3	4,595.3	5,421.5	6,458.4	6,697.9	13.4
Total Bipolar Digital	145.9	125.4	123.8	100.6	83.8	64.2	64.6	55.1	50.5	43.5	38.9	-9.5
MOS Memory	510.5	619.4	737.7	1,150.9	923.5	789.9	845.6	1,062.8	1,410.1	1,975.0	1,613.8	15.4
MOS Microcomponent	413.4	443.4	570.4	735.2	957.2	1,130.6	1,302.4	1,561.9	1,817.5	2,077.0	2,396.1	16.2
MOS Digital Logic	484.7	523.9	610.1	730.5	851.0	988.7	1,074.5	1,200.8	1,361.1	1,513.1	1,736.7	11.9
Analog-Monolithic	367.1	364.5	412.1	445.4	498.0	602.7	656.2	714.7	782.3	849.9	912.4	8.6
Total Discrete	389.1	380.6	398.7	439.6	479.6	513.9	565.8	609.9	667.9	716.4	765.8	8.3
Total Optical Semiconductor	196.8	192.2	213.5	259.9	287.0	330.0	342.5	365.8	395.7	428.8	461.8	7.0
Exchange Rate (Yen/U.S.$1)	126.5	111.2	101.8	93.9	108.8	121.1	129.7	129.7	129.7	129.7	129.7	-

*"Total Semiconductor" includes hybrid ICs up to the year 1996, while the "Hybrid IC" category has been eliminated for years 1997 and beyond. Only semiconductor contents of hybrid ICs are counted for years 1997 and beyond.
Notes: Columne may not add to totals shown because of rounding.
Source: Dataquest (August 1998)

Table 3-3
Japanese Semiconductor Market History and Forecast, 1992 to 2002 (Yen-Based Percentage Growth over Preceding Year)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Total Semiconductor (Excluding Hybrid)	**-14.9**	**5.3**	**15.2**	**25.4**	**5.6**	**5.7**	**9.8**	**14.8**	**16.4**	**17.2**	**4.2**
Total Integrated Circuit (Excluding Hybrid)	-13.9	8.1	18.2	28.9	4.8	7.9	10.3	16.5	18.0	19.1	3.7
Total Bipolar Digital	-25.6	-14.1	-1.3	-18.7	-16.7	-23.4	0.7	-14.7	-8.5	-13.9	-10.4
MOS Memory	-11.2	21.3	19.1	56.0	-19.8	-14.5	7.0	25.7	32.7	40.1	-18.3
MOS Microcomponent	-14.4	6.5	28.6	28.9	30.2	18.1	15.2	19.9	16.4	14.3	15.4
MOS Digitel Logic	-12.5	8.1	16.5	19.7	16.5	16.2	8.7	11.8	13.4	11.2	14.8
Analog-Monolithic	-12.8	-0.7	13.1	8.1	11.8	21.0	8.9	8.9	9.5	8.6	7.4
Total Discrete	-16.6	-2.2	4.8	10.3	9.1	7.2	10.1	7.8	9.5	7.3	6.9
Total Optical Semiconductor	-19.0	-2.3	11.1	21.7	10.4	15.0	3.8	6.8	8.2	8.4	7.7

Source: Dataquest (August 1998)

After Dataquest put together the spring forecast and announced the results in April, several major changes in the electronics industry and semiconductor market have been observed. In view of those factors, Dataquest has added another scenario to the forecast, a downside of the trends described earlier.

In this scenario, worldwide electronics production, which was forecast to show 6.9 percent annual growth in 1997, is assumed at 4.4 percent, or slightly above. Affecting this scenario is the slowdown in unit production in several electronics categories, which have suffered oversupply and reduced unit demand caused by the AFC as well as downturn in the factory average selling price for various electronic equipment.

On the other hand, price erosion in the semiconductor market accelerated, not only in DRAMs but also in various product categories, including flash memory, MPUs, and ASIC; this gloomy wave has come to affect analog and discrete devices that have enjoyed healthy markets even after MOS digital products fell victim to the oversupply-ridden market.

Incorporating these factors, the new scenario sees the worldwide semiconductor market growth this year decreasing to 1.4 percent, a sharp drop from the 8.2 percent scenario in the spring forecast. In Japan, this scenario can be translated into a growth of 1.5 percent, as opposed to the 9.8 percent growth discussed above. A detailed scenario will be illustrated in Dataquest's fall forecast.

Challenge to the Vendors

Once, the Japanese semiconductor vendors grew to enjoy the largest market share in the worldwide market by focusing on two factors: DRAM and consumer applications in the domestic market. The sales into the domestic market represented over 80 percent of Japanese vendors' worldwide revenue in the 1980s, but in 1997, this decreased to 56 percent. As discussed in the long-term forecast, however, the Japanese application markets are not likely to offer major drivers for semiconductor consumption growth.

With this demand-side outlook, vendors that have focused on the Japanese market are facing two major challenges:

- Emphasize and strengthen application-oriented marketing to identify growth segments
- Increase support capability for overseas customers

In fact, not only the consumption of semiconductors, but also the system design, has begun to show signs of overseas shift. This shift is inevitable when the localization of the system is required to best serve local markets, but another factor that is prompting this shift in design capability is the realization of limitations in engineering resources, not only within Japan but on a worldwide basis as well.

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At the same time, with the DRAM market forecast to remain at around 15 percent of total semiconductors, Japanese companies need to accelerate the shift of business focus on other product areas. Already, the realization of SLI trends has prompted Japanese companies to initiate the restructuring of their businesses in all aspects of semiconductor operations, ranging from customer support and product design to process development and manufacturing capital spending. This "SLI Shift" also requires marketing power reinforcement.

With reduced profits because of weak pricing trends, major players in the Japanese market face the challenge of making all those changes with minimal resources. It is not sufficient to assume that Japanese semiconductor vendors can automatically benefit from the digital consumer just because the development and production of digital consumer equipment are taking place in the backyard. The efforts to best capture the SLI trends and reform the semiconductor operation will enable them to enjoy a reasonable share and profits in the semiconductor business.

Chapter 4
Japanese MOS Memory Market Trends

1997 Market Share

Market Trends

In 1997, the Japanese MOS memory market recorded negative growth of 14.5 percent over the previous year. On a dollar basis, the decline reached 23.1 percent, worse than that of the world market, which registered an 18.6 percent decrease. The major factor for the MOS memory decline was the relentless erosion of DRAM prices, which hit the Japanese market hard, and Japanese companies relying on the domestic market were severely damaged. As a result, the world share of the Japanese market declined slightly, from 22.3 percent in 1996 to 21.1 percent in 1997.

A breakdown of the 1997 Japanese market by device indicates major slumps in the DRAM and static RAM (SRAM) segments, which shrunk by 15.6 percent and 17.8 percent, respectively. While the two devices grew in unit shipments, price declines caused the overall market decline on a value basis. In particular, the DRAM market has been suffering a supply glut and is still experiencing a seemingly unstoppable price erosion. The sluggish DRAM market affected SRAM prices that continued to plummet. The nonvolatile memory market was not immune to the dreary market conditions, recording a 12.2 percent decrease in 1997. Clearly, the entire memory market is satiated with excess supply capacities. Even flash memory, one of the few big hopes in the market, reported a negative growth of 9.8 percent on a value basis, although unit shipments grew strongly, as bolstered by cellular phone demand. In the 1997 flash memory market, prices of 8Mb-or-smaller products dropped sharply, to bring the entire market down. In 1998, as Japanese companies are expected to shift part of their production capacity to flash-with-view to reduce dependency on DRAMs, 16Mb flash will likely be a target for another round of price decline.

Ranking Trends

In the 1997 Japanese MOS memory market, NEC ranked first with a 16.4 percent share (see Tables 4-1 through 4-4). The company managed to keep revenue downturns at a single-digit level (7.7 percent) among leading semiconductor companies that heavily rely on the DRAM business. Hitachi held second place, just as it did in 1996, even though it reported a 14.8 percent decline. Fujitsu was the only company in the top five that recorded an increase (8.6 percent); it advanced from fifth to third place. The major contributing factor was the strong growth of 16Mb flash sales, up 53.7 percent from 1996. In contrast, Toshiba fell from third to fifth place as its revenue from flash memory declined 75.7 percent.

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Table 4-1
1997 Japanese Market Share Ranking: MOS Memory (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	NEC	139.9	129.2	-7.7	16.4
2	2	Hitachi	134.8	114.9	-14.8	14.5
5	3	Fujitsu	71.7	77.9	8.6	9.9
4	4	Samsung	85.7	68.2	-20.5	8.6
3	5	Toshiba	92.4	64.7	-30.0	8.2
7	6	Mitsubishi Electric	51.2	50.3	-1.9	6.4
6	7	Sharp	57.8	46.9	-18.9	5.9
8	8	TI	42.2	27.9	-34.0	3.5
14	9	Matsushita Electronics	16.2	26.3	62.1	3.3
9	10	HEC	26.5	25.7	-3.3	3.3
10	11	LG Semicon	25.8	20.5	-20.6	2.6
12	12	Oki	20.1	20.1	-0.1	2.5
15	13	Macronix	15.3	19.0	23.9	2.4
16	14	Intel	13.3	13.1	-1.5	1.7
11	15	Atmel	22.5	12.4	-45.2	1.6
13	16	SANYO	19.6	12.0	-38.8	1.5
19	17	IBM	10.3	10.7	3.1	1.3
18	18	SGS-Thomson*	10.4	9.1	-13.1	1.1
22	19	IDT	5.7	4.6	-18.7	0.6
17	20	Sony	13.2	4.2	-67.8	0.5
20	21	Motorola	7.1	3.5	-50.3	0.4
21	22	AMD	6.1	3.4	-44.4	0.4
29	23	Cypress	2.4	3.3	36.6	0.4
31	24	Xicor	2.4	3.3	36.6	0.4
27	25	Rohm	2.6	2.7	2.0	0.3
23	26	Mosel Vitelic	4.5	2.4	-45.7	0.3
32	27	Silicon Storage Technology	2.0	2.1	5.1	0.3
24	28	Nippon Steel	3.9	1.8	-53.6	0.2
25	29	Micron	3.5	1.8	-47.8	0.2
61	30	Fairchild	0	1.8	NA	0.2
35	31	Catalyst	0.8	1.3	74.9	0.2
40	32	Ricoh	0.3	1.0	196.8	0.1
33	33	Seiko	1.1	0.8	-22.1	0.1
41	34	Alliance	0.2	0.7	233.9	0.1
37	35	Siemens	0.5	0.5	-11.0	0.1
38	36	Winbond	0.5	0.5	-11.0	0.1
36	37	Vanguard	0.8	0.4	-52.3	0

Table 4-1 (Continued)
1997 Japanese Market Share Ranking: MOS Memory (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
121	38	Philips Semiconductors	0	0.2	NA	0
28	39	UMC	2.6	0.1	-95.4	0
34	40	WaferScale	1.0	0.1	-87.6	0
		All Others	6.4	0.8	-86.8	0.1
		Americas Companies	125.1	89.9	-28.2	11.4
		Japanese Companies	625.4	553.3	-11.5	70.0
		European Companies	11.0	9.9	-9.6	1.3
		Asia/Pacific Companies	161.9	136.8	-15.5	17.3
		Total Market	**923.5**	**789.9**	**-14.5**	**100.0**

NA = Not Available
* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

Table 4-2
1997 Japanese Market Share Ranking: DRAM (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
2	1	NEC	83.3	83.6	0.3	18.0
1	2	Hitachi	96.6	81.5	-15.7	17.5
3	3	Samsung	70.8	53.6	-24.3	11.5
4	4	Toshiba	65.1	44.9	-31.0	9.7
5	5	Fujitsu	43.1	39.8	-7.5	8.6
6	6	Mitsubishi Electric	38.3	36.9	-3.6	7.9
10	7	Matsushita Electronics	15.2	25.9	70.1	5.6
9	8	HEC	24.9	24.6	-1.3	5.3
7	9	TI	36.0	20.6	-42.8	4.4
8	10	LG Semicon	25.0	19.9	-20.6	4.3
13	11	Oki	9.7	9.9	2.5	2.1
12	12	IBM	9.9	7.3	-26.6	1.6
11	13	SANYO	13.4	5.9	-55.7	1.3
14	14	Mosel Vitelic	4.4	2.4	-44.4	0.5
17	15	Sharp	3.2	1.9	-38.6	0.4
15	16	Nippon Steel	3.9	1.8	-53.6	0.4
16	17	Micron	3.3	1.8	-44.4	0.4
18	18	Motorola	2.5	0.7	-71.0	0.2
20	19	Siemens	0.5	0.5	-11.0	0.1
19	20	Vanguard	0.8	0.4	-52.3	0.1
27	21	Alliance	0	0.4	NA	0.1
21	22	Sony	0.3	0.2	-25.8	0.1
		All Others	-	-	-	-
		Americas Companies	51.7	30.8	-40.5	6.6
		Japanese Companies	372.1	332.5	-10.6	71.6
		European Companies	0.5	0.5	-11.0	0.1
		Asia/Pacific Companies	125.9	100.9	-19.9	21.7
		Total Market	**550.3**	**464.7**	**-15.6**	**100.0**

NA = Not available
Source: Dataquest (August 1998)

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Table 4-3
1997 Japanese Market Share Ranking: SRAM (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Hitachi	29.6	27.4	-7.5	24.8
2	2	NEC	26.0	15.1	-41.8	13.7
3	3	Toshiba	15.0	15.0	0	13.6
5	4	Mitsubishi Electric	10.7	10.1	-5.7	9.1
7	5	Samsung	7.2	8.1	13.0	7.4
6	6	Sharp	9.0	7.3	-19.5	6.6
8	7	Fujitsu	5.8	6.7	15.5	6.0
4	8	Sony	12.8	4.0	-68.9	3.6
18	9	IBM	0.4	3.4	679.1	3.1
9	10	Motorola	4.5	2.8	-37.6	2.5
10	11	SANYO	2.8	2.2	-22.9	2.0
12	12	Cypress	1.5	1.9	27.2	1.8
13	13	Rohm	1.3	1.3	2.0	1.2
15	14	IDT	1.0	1.2	23.7	1.1
11	15	HEC	1.6	1.1	-33.2	1.0
14	16	Seiko	1.1	0.8	-22.1	0.8
16	17	LG Semicon	0.8	0.6	-20.5	0.5
21	18	Winbond	0.4	0.4	-16.5	0.3
23	19	Alliance	0.2	0.4	66.9	0.3
17	20	TI	0.5	0.2	-55.5	0.2
20	21	Oki	0.4	0.1	-72.2	0.1
106	22	Ricoh	0	0.1	NA	0.1
118	23	TEMIC	0	0.1	NA	0.1
19	24	Matsushita Electronics	0.4	0	-100.0	0
22	25	SGS-Thomson*	0.3	0	-100.0	0
24	26	ISSI	0.2	0	-100.0	0
25	27	Micron	0.2	0	-100.0	0
26	28	AMD	0.1	0	-100.0	0
27	29	Mosel Vitelic	0.1	0	-100.0	0
		All Others	-	-	-	-
		Americas Companies	8.7	9.9	14.1	9.0
		Japanese Companies	115.0	90.1	-21.7	81.7
		European Companies	0.3	0.1	-62.9	0.1
		Asia/Pacific Companies	10.1	10.2	0.5	9.2
		Total Market	**134.2**	**110.3**	**-17.8**	**100.0**

NA = Not available
* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

Table 4-4
1997 Japanese Market Share Ranking: Flash Memory (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Fujitsu	19.2	29.4	53.7	38.1
4	2	Intel	13.3	13.1	-1.5	17.0
3	3	Sharp	15.8	8.5	-46.3	11.0
2	4	Atmel	16.2	7.4	-54.4	9.6
7	5	SANYO	2.6	3.4	29.8	4.4
14	6	Mitsubishi Electric	0.5	2.8	412.0	3.6
6	7	AMD	3.0	2.3	-24.5	3.0
10	8	Samsung	1.6	2.3	41.0	3.0
9	9	Silicon Storage Technology	2.0	2.1	5.1	2.7
5	10	Toshiba	6.0	1.5	-75.7	1.9
16	11	Hitachi	0.2	1.3	512.1	1.7
8	12	NEC	2.3	1.0	-57.6	1.3
12	13	TI	0.7	1.0	48.4	1.3
13	14	Matsushita Electronics	0.5	0.4	-33.2	0.5
11	15	SGS-Thomson*	0.9	0.2	-72.2	0.3
15	16	Macronix	0.5	0.2	-55.5	0.3
17	17	Catalyst	0.1	0.1	11.3	0.2
38	18	Fairchild	0	0.1	NA	0.2
99	19	Oki	0	0.1	NA	0.2
18	20	ISSI	0.1	0	-100.0	0
		All Others	-	-	-	-
		Americas Companies	35.4	26.0	-26.4	33.8
		Japanese Companies	47.1	48.3	2.6	62.6
		European Companies	0.9	0.2	-72.2	0.3
		Asia/Pacific Companies	2.2	2.5	16.9	3.3
		Total Market	**85.5**	**77.1**	**-9.8**	**100.0**

NA = Not available
* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

MOS Memory Forecast through 2002

Dataquest predicts that the 1998 market will grow 7.0 percent (an 0.1 percent decrease on a dollar basis), which represents a downward adjustment of 6 percentage points compared to the fall forecast (see Tables 4-5 and 4-6). Again, DRAM price decline because of supply glut is the major culprit. While increased 16Mb production by U.S. companies triggered the price fall in 1997, the aggressive moves of Korean suppliers will dictate DRAM prices. At present, 16Mb prices continue to fall below $3 on the spot market, which pulls 64Mb prices downward.

The Japanese MOS memory market in 1998 will be driven by SRAM, EEPROM, and flash memory. In particular, after 1999, the DRAM market will expand at an accelerated pace, while the SRAM and nonvolatile memory markets will maintain healthy growth. In 2002, however, the DRAM market will experience negative growth as the generation crossover from 64Mb to 256Mb occurs. Dataquest predicts that the market's CAGR between 1997 and 2002 will be 15.4 percent (13.8 percent on a dollar basis).

While the fall forecast assumed that DRAM companies would curtail capital spending in 1998, these companies are currently moving to minimize the rate of investment cutbacks where possible. In particular, Korean companies are considering maintaining capital spending as close as possible to the 1997 level (on a won basis), despite the DRAM recession and pain from the AFC. Dataquest pointed out in the fall forecast that a major reduction of 64Mb production capacity would be required to regain revenue growth in 1998. However, DRAM companies are not reducing capital spending as much as expected, which necessitated the downward adjustment of the DRAM market growth forecast.

In 1998, a major event in the DRAM market will be a full-blown shift from extended data out (EDO) to synchronous DRAM (SDRAM). During the first half of 1998, 100-MHz SDRAMs for PC100 will keep a price premium against the 66-MHz versions, which will significantly narrow in the second half of 1998 as DRAM companies roll out 0.25-micron fab lines. After 1999, the Japanese DRAM market will be driven by better-managed capacity expansion by DRAM suppliers, recording a CAGR of 16.1 percent (14.6 percent on a dollar basis) between 1997 and 2002.

The Japanese nonvolatile memory market will be up slightly 0.3 percent (6.3 percent down on a dollar basis) in 1998 because of double-digit declines in EPROM and mask ROM, which will more than offset the 20 percent growth of the EEPROM and flash segments. The CAGR between 1997 and 2002 will be 9.6 percent, as the market will be driven by EEPROM and flash memory.

The Japanese flash memory market recorded negative growth of 9.8 percent in 1997, but it is expected to resume growth in 1998. Major applications include mobile communications equipment, led by cellular phones, as well as IC cards. In particular, smart phones are expected to ramp up early in Europe, becoming an important consumer of flash memory. This is expected to have a positive impact on the Japanese mobile communications and flash memory markets.

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Table 4-5
1997 Japanese MOS Memory Market History and Forecast, 1992 to 2002 (Billions of Yen)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
MOS Memory	510.5	619.4	737.7	1,150.9	923.5	789.9	845.6	1,062.8	1,410.1	1,975.0	1,613.8	15.4
DRAM	227.6	298.8	408.5	805.9	550.3	464.7	503.0	645.4	912.9	1,391.6	981.9	16.1
SRAM	130.1	145.1	142.2	135.4	134.2	110.3	123.3	167.9	217.6	277.2	287.8	21.1
Nonvolatile Memory	151.5	171.0	181.7	198.7	222.4	195.2	195.9	223.3	251.0	274.3	308.9	9.6
Other MOS Memory	1.3	4.4	5.3	10.9	16.6	19.7	23.4	26.1	28.7	31.8	35.2	12.2
Exchange Rate (Yen/U.S.$1)	126.5	111.2	101.8	93.9	108.8	121.1	129.7	129.7	129.7	129.7	129.7	-

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (August 1998)

Table 4-6
Japanese MOS Memory Market History and Forecast, 1992 to 2002 (Yen-Based Percentage Growth over Preceding Year)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
MOS Memory	-11.2	21.3	19.1	56.0	-19.8	-14.5	7.0	25.7	32.7	40.1	-18.3
DRAM	-14.1	31.3	36.7	97.3	-31.7	-15.6	8.2	28.3	41.4	52.4	-29.4
SRAM	-11.5	11.5	-2.0	-4.8	-0.9	-17.8	11.8	36.2	29.6	27.4	3.8
Nonvolatile Memory	-5.7	12.9	6.3	9.4	11.9	-12.2	0.3	14.0	12.4	9.3	12.6
Other MOS Memory	-45.8	238.5	20.5	105.7	52.3	18.9	18.8	11.4	9.9	10.7	10.7

Source: Dataquest (August 1998)

In the MOS memory market, Japanese semiconductor companies still strive to become less dependent on DRAM business. Large suppliers will increasingly shift their strategic focus to flash memory. The 1997 flash market saw price declines in 8Mb-or-less products. Dataquest expects that the move will spread to the 16Mb-or-larger segments in 1998 and after.

Challenge to the Vendors

To analyze the current state of memory vendors, they should be divided according to their DRAM dependency. This analysis focuses on DRAM-dependent companies. At present, DRAM vendors continue to be beleaguered by serious oversupply conditions with a deteriorating profitability that shows no signs of improvement. Cutthroat competition among vendors accelerates the race for next-generation process technology and higher integration, requiring them to engage in an endurance contest to keep high capital spending. As a result, three generations of leading-edge devices—64Mb, 128Mb, and 256Mb—will coexist in 1999.

Up until 1995, the rapid advance of process technology drove the commercial development of smaller DRAM chips by applying a linear shrink approach. At present, however, cost reduction becomes a primary reason for shrinking the chip size, while the same processing technology is applied. This means that the present supply glut is a combination of excess capacities—as the aftermath of the previous capital spending spree—and an increased number of chips taken from each wafer because of the advance of shrink technology.

Needless to say, the DRAM supply capacity must be cut down drastically to bring the market back to parity. However, a reduction of production capacity would be a hard blow to Korean companies and some U.S. manufacturers that heavily depend upon the DRAM business. Compared to them, Japanese DRAM vendors are less dependent and have alternative products to offer. It is thus a reasonable option for them to convert DRAM capacities to other devices on a continuous basis. Although the large-scale production shift will adversely affect prices of other products, such as flash, it makes better sense than desperately insisting on DRAM production under the present no-win situation. While reducing DRAM capacities, even on a temporary basis, it is desirable for them to continue R&D efforts on finer process technology. Because the DRAM market is increasingly driven by higher integration and faster speeds, vendors that lead in design rules are beginning to enjoy early profits. Dataquest predicts that the current oversupply condition will continue until the end of 1999. Vendors should cut down their own DRAM capacities in consideration of capital spending by the end of the century, allowing them to establish leading-edge process technology.

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Chapter 5
Japanese MOS Microcomponent Market Trends

1997 Market Share

Market Trends

In 1997, the Japanese microcomponent market saw a sound 18.1 percent growth over the previous year (6.1 percent on a dollar basis). The major source of the increase was in the MPU and microcontroller (MCU) markets, both of which recorded two-digit growth rates.

PCs drove the MPU market, and the introduction of clone MPUs compatible with Pentium MMX helped the formation of the low-end PC and subnote PC markets. MCUs were boosted by the expansion of digital consumer equipment production, mobile communications equipment, and mass storage devices. In the emerging markets, such as the digital consumer and next-generation markets, ECU/euro areas consumed value-added 32-bit MCUs, which contributed to MCU vendors' profits. The Japanese digital signal processing (DSP) market shows a trend different from other regional markets because of Japanese application markets and the Japanese vendors' strategic technology. Notably, in mobile communications and in mass storage, Japanese system manufacturers tend to use semiconductor products developed by internal semiconductor divisions. This tendency has limited the penetration of foreign-made DSPs into the equipment and has created Japanese proprietary trends.

Ranking Trends

Intel increased its share to 22.8 percent, securing the No. 1 position in the Japanese MOS microcomponent market, as well as in other regional markets in 1997 (see Tables 5-1 through 5-5).

Following Intel was NEC, which led the worldwide MCU market as the No. 2 vendor, with a wide MCU product offering ranging from 4-bit to 64-bit. Its growth came mainly from 8-bit, proprietary 32-bit with proprietary architecture, and 64-bit million of instructions per second (MIPS) MCUs.

Ranked No. 3 was Hitachi, which lost market share in 1997 in spite of two-digit growth. Its growth in the previous year was boosted by 32-bit MCUs and MPUs used in video game applications. As its share in that application lowered in 1997, it penetrated into other applications, such as mass storage devices, but it could not make up the loss in other applications fast enough.

Toshiba, ranked No. 4, also grew in two digits, helped by mass storage and mobile communications applications. Fujitsu, with the contribution of 16-bit MCUs in mobile communications and 32-bit MCUs in storage and digital VCR applications, grew at an astonishing 49 percent, to be ranked at No. 5, surpassing Mitsubishi Electric. Mitsubishi Electric has traditionally been strong in VCR applications, and its revenue grew at a sound 13 percent, helped by 16-bit MCUs in storage applications and 32-bit proprietary MCUs with embedded DRAM for digital VCRs.

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Table 5-1
1997 Japanese Market Share Ranking: MOS Microcomponent (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Intel	207.4	257.8	24.3	22.8
2	2	NEC	149.4	182.9	22.4	16.2
3	3	Hitachi	100.0	111.0	11.1	9.8
4	4	Toshiba	77.9	87.4	12.2	7.7
6	5	Fujitsu	51.7	76.9	48.8	6.8
5	6	Mitsubishi Electric	66.9	75.7	13.1	6.7
7	7	Matsushita Electronics	51.4	49.5	-3.6	4.4
8	8	Rockwell	43.5	37.7	-13.5	3.3
9	9	Motorola	26.3	27.1	3.0	2.4
10	10	TI	21.0	24.6	17.1	2.2
11	11	Sony	16.8	17.2	2.6	1.5
12	12	Sharp	13.9	16.8	20.9	1.5
16	13	SANYO	7.1	15.1	114.0	1.3
14	14	Oki	9.6	11.7	22.7	1.0
26	15	Lucent	3.8	11.7	208.4	1.0
13	16	Cirrus Logic	13.6	11.4	-16.3	1.0
19	17	Chips & Technologies	6.0	10.9	82.1	1.0
32	18	Sun	2.2	9.1	317.4	0.8
15	19	Oak	9.2	8.4	-9.7	0.7
17	20	Ricoh	6.9	8.4	21.9	0.7
22	21	AMD	4.7	7.5	60.5	0.7
18	22	Adaptec	6.0	6.9	15.3	0.6
20	23	Yamaha	6.0	6.7	11.3	0.6
25	24	National	4.1	6.2	49.4	0.5
28	25	Analog Devices	3.4	5.0	47.2	0.4
29	26	Digital	3.3	5.0	52.1	0.4
33	27	SGS-Thomson*	2.0	3.8	91.7	0.3
21	28	Trident	4.9	3.6	-25.8	0.3
30	29	QLogic	2.6	3.0	15.9	0.3
45	30	Symbios	0.7	2.5	289.5	0.2
41	31	ATI	1.1	2.4	122.6	0.2
36	32	Seiko	1.6	2.1	26.1	0.2
24	33	Philips Semiconductors	4.6	1.9	-57.6	0.2
34	34	C-Cube	1.7	1.9	11.3	0.2
38	35	DSP Group	1.4	1.6	11.3	0.1
23	36	Rohm	4.6	1.5	-68.2	0.1
27	37	LSI	3.8	1.5	-61.8	0.1
50	38	Microchip	0.4	1.5	233.9	0.1

Table 5-1 (Continued)
1997 Japanese Market Share Ranking: MOS Microcomponent (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
35	39	VLSI	1.6	1.3	-18.4	0.1
37	40	IDT	1.4	1.3	-5.8	0.1
		All Others	12.8	12.1	-5.7	1.1
		Americas Companies	383.8	458.2	19.4	40.5
		Japanese Companies	565.1	664.7	17.6	58.8
		European Companies	7.0	6.3	-9.6	0.6
		Asia/Pacific Companies	1.4	1.3	-5.8	0.1
		Total Market	**957.2**	**1,130.6**	**18.1**	**100.0**

* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

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Table 5-2
1997 Japanese Market Share Ranking: MOS Microprocessor (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Intel	187.7	239.4	27.6	73.9
2	2	NEC	16.9	29.3	73.8	9.0
3	3	Hitachi	14.4	14.4	0.3	4.4
9	4	Sun	2.2	9.1	317.4	2.8
4	5	Motorola	7.7	8.2	6.6	2.5
5	6	Toshiba	5.0	6.5	30.7	2.0
7	7	Digital	2.9	4.6	56.6	1.4
10	8	Fujitsu	1.6	4.1	152.3	1.3
6	9	AMD	4.7	2.7	-43.1	0.8
11	10	Sharp	1.5	2.4	59.0	0.7
12	11	IDT	1.4	1.3	-5.8	0.4
18	12	National	0.2	0.8	289.5	0.3
17	13	Mitsubishi Electric	0.3	0.5	48.4	0.1
19	14	Oki	0.2	0.2	11.3	0.1
15	15	TI	0.9	0.1	-86.1	0
16	16	Zilog	0.9	0.1	-86.1	0
22	17	VLSI	0.1	0.1	11.3	0
8	18	LSI	2.7	0	-100.0	0
13	19	Cyrix	1.2	0	-100.0	0
14	20	Matsushita Electronics	1.1	0	-100.0	0
20	21	SGS-Thomson*	0.2	0	-100.0	0
21	22	Chips & Technologies	0.1	0	-100.0	0
		All Others	-	-	-	-
		Americas Companies	212.7	266.5	25.3	82.2
		Japanese Companies	41.0	57.5	40.2	17.8
		European Companies	0.2	0	-100.0	0
		Asia/Pacific Companies	0	0	-	0
		Total Market	**254.0**	**324.1**	**27.6**	**100.0**

* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

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Table 5-3
1997 Japanese Market Share Ranking: MOS Microcontroller (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	NEC	106.9	119.4	11.7	24.3
2	2	Hitachi	72.8	83.8	15.1	17.0
3	3	Mitsubishi Electric	64.6	72.5	12.2	14.8
6	4	Fujitsu	30.6	45.5	48.9	9.3
5	5	Toshiba	33.5	38.6	15.3	7.9
4	6	Matsushita Electronics	39.5	38.0	-3.7	7.7
7	7	Sony	16.8	17.2	2.6	3.5
8	8	Motorola	15.5	15.6	1.1	3.2
12	9	SANYO	6.1	13.9	128.6	2.8
9	10	Sharp	10.9	12.8	18.0	2.6
10	11	Oki	7.8	7.6	-2.6	1.6
11	12	Intel	6.1	5.9	-2.6	1.2
13	13	Ricoh	5.9	5.9	1.0	1.2
15	14	TI	2.1	2.9	40.6	0.6
17	15	SGS-Thomson*	1.5	2.5	66.9	0.5
26	16	AMD	0	2.5	-	0.5
16	17	Seiko	1.6	2.1	26.1	0.4
19	18	Microchip	0.4	1.5	233.9	0.3
14	19	Rohm	3.4	1.0	-71.3	0.2
18	20	Philips Semiconductors	1.0	0.6	-38.2	0.1
20	21	Dallas	0.3	0.4	11.3	0.1
21	22	Siemens	0.3	0.4	11.3	0.1
22	23	Zilog	0.1	0.2	122.6	0
113	24	TEMIC	0	0.1	-	0
115	25	Acer	0	0.1	-	0
116	26	LG Semicon	0	0.1	-	0
123	27	Samsung	0	0.1	-	0
		All Others	-	-	-	-
		Americas Companies	24.5	29.1	18.7	5.9
		Japanese Companies	400.3	458.5	14.5	93.3
		European Companies	2.8	3.6	28.4	0.7
		Asia/Pacific Companies	0	0.4	-	0.1
		Total Market	**427.6**	**491.5**	**14.9**	**100.0**

* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

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Table 5-4
1997 Japanese Market Share Ranking: MOS Microperipheral (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Rockwell	43.5	37.7	-13.5	16.6
4	2	Fujitsu	16.8	23.5	40.2	10.4
3	3	NEC	20.0	22.8	13.7	10.0
2	4	Toshiba	31.2	19.3	-38.3	8.5
6	5	Intel	13.6	12.5	-8.3	5.5
7	6	Hitachi	12.1	11.9	-1.7	5.2
5	7	Cirrus Logic	13.6	11.4	-16.3	5.0
11	8	Chips & Technologies	5.9	10.9	85.5	4.8
8	9	Oak	9.2	8.4	-9.7	3.7
9	10	Adaptec	6.0	6.9	15.3	3.0
10	11	Yamaha	6.0	6.7	11.3	2.9
13	12	National	3.9	5.3	36.0	2.3
12	13	Trident	4.9	3.6	-25.8	1.6
23	14	TI	1.2	3.4	183.3	1.5
24	15	Oki	1.2	3.4	183.3	1.5
16	16	QLogic	2.6	3.0	15.9	1.3
34	17	Symbios	0.7	2.5	289.5	1.1
27	18	ATI	1.1	2.4	122.6	1.1
29	19	Ricoh	1.0	2.4	147.3	1.1
52	20	AMD	0	2.3	-	1.0
14	21	Matsushita Electronics	3.8	2.2	-42.8	1.0
17	22	Motorola	2.5	1.9	-22.6	0.9
19	23	C-Cube	1.7	1.9	11.3	0.9
21	24	Sharp	1.5	1.6	3.3	0.7
22	25	DSP Group	1.4	1.6	11.3	0.7
18	26	Mitsubishi Electric	2.0	1.5	-25.8	0.6
26	27	LSI	1.1	1.5	33.6	0.6
15	28	Philips Semiconductors	3.6	1.2	-66.3	0.5
20	29	VLSI	1.5	1.2	-20.5	0.5
45	30	SGS-Thomson*	0.2	1.2	456.5	0.5
30	31	Dallas	0.9	1.0	11.3	0.4
33	32	IBM	0.7	1.0	48.4	0.4
35	33	OPTi	0.7	1.0	48.4	0.4
36	34	SMSC	0.5	0.6	11.3	0.3
44	35	WaferScale	0.2	0.6	178.2	0.3
25	36	Rohm	1.2	0.5	-59.5	0.2
37	37	Acer	0.5	0.5	-11.0	0.2
38	38	Zoran	0.4	0.5	11.3	0.2

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Table 5-4 (Continued)
1997 Japanese Market Share Ranking: MOS Microperipheral (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
39	39	Digital	0.3	0.4	11.3	0.2
40	40	Fuji Electric	0.3	0.4	11.3	0.2
		All Others	4.9	4.6	-6.0	2.0
		Americas Companies	121.1	126.1	4.1	55.6
		Japanese Companies	98.1	97.4	-0.8	42.9
		European Companies	3.8	2.4	-36.4	1.1
		Asia/Pacific Companies	1.4	1.0	-31.5	0.4
		Total Market	**224.5**	**226.8**	**1.0**	**100.0**

* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

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Table 5-5
1997 Japanese Market Share Ranking: Programmable DSP (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
2	1	Toshiba	8.2	23.0	181.9	26.1
1	2	TI	16.9	18.2	7.7	20.6
5	3	Lucent	3.8	11.7	208.4	13.3
4	4	NEC	5.7	11.4	101.2	12.9
3	5	Matsushita Electronics	7.0	9.3	33.9	10.6
6	6	Analog Devices	3.4	5.0	47.2	5.6
7	7	Fujitsu	2.7	3.8	38.0	4.3
10	8	Motorola	0.7	1.3	104.0	1.5
8	9	SANYO	1.0	1.2	23.7	1.4
94	10	Mitsubishi Electric	0	1.2	-	1.4
9	11	Hitachi	0.8	1.0	27.2	1.1
12	12	Oki	0.3	0.5	48.4	0.5
11	13	Zilog	0.7	0.2	-62.9	0.3
13	14	Zoran	0.1	0.1	11.3	0.1
14	15	GEC Plessey	0.1	0.1	11.3	0.1
110	16	Philips Semiconductors	0	0.1	-	0.1
		All Others	0	0	-	0
		Americas Companies	25.5	36.6	43.6	41.5
		Japanese Companies	25.6	51.3	100.8	58.2
		European Companies	0.1	0.2	122.6	0.3
		Asia/Pacific Companies	0	0	-	0
		Total Market	**51.1**	**88.2**	**72.4**	**100.0**

Source: Dataquest (August 1998)

MOS Microcomponent Forecast through 2002

The Japanese MOS microcomponent market will expand 15.2 percent (7.5 percent on a dollar basis) in 1998. The CAGR between 1997 and 2002 will be 16.2 percent (14.6 percent on a dollar basis), with firm growth expected for each year (see Tables 5-6 and 5-7).

The Japanese MPU market in 1998 will fail to meet the previous forecast level because of the slowdown in the PC market. The market should grow at 12.6 percent (5.1 percent on a dollar basis). The market will see a wider variety of products besides Intel's X86 families (Pentium with MMX technology, Pentium Pro, and MMX Pentium II). Products will include non-Intel, high-speed MPUs; MPUs for low-cost PCs; and MPUs designed for portable applications, including mobile computing (embedded MIPS, SH, and StrongARM)—for example, Tillamook, Mobile Pentium II, and Windows CE2.0.

Table 5-6
Japanese MOS Microcomponent Market History and Forecast, 1992 to 2002 (Billions of Yen)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
MOS Microcomponent	413.4	443.4	570.4	735.2	957.2	1,130.6	1,302.4	1,561.9	1,817.5	2,077.0	2,396.1	16.2
Microprocessor	76.4	92.9	127.0	158.7	254.0	324.1	364.9	443.7	521.5	611.0	720.0	17.3
Microcontroller	241.9	248.8	301.8	388.7	427.6	491.5	565.6	674.6	783.6	871.8	983.4	14.9
Microperipheral	82.2	88.5	124.8	162.1	224.5	226.8	248.7	285.4	312.6	339.9	369.7	10.3
DSP	12.9	13.2	16.9	25.7	51.1	88.2	123.2	158.3	199.8	254.3	323.0	29.7
Exchange Rate (Yen/U.S.$1)	126.5	111.2	101.8	93.9	108.8	121.1	129.7	129.7	129.7	129.7	129.7	-

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (August 1998)

Table 5-7
Japanese MOS Microcomponent Market History and Forecast, 1992 to 2002 (Yen-Based Percentage Growth over Preceding Year)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
MOS Microcomponent	-15.1	7.3	28.6	28.9	30.2	18.1	15.2	19.9	16.4	14.3	15.4
Microprocessor	-8.8	21.6	36.7	25.0	60.0	27.6	12.6	21.6	17.5	17.2	17.8
Microcontroller	-18.4	2.9	21.3	28.8	10.0	14.9	15.1	19.3	16.2	11.3	12.8
Microperipheral	-12.0	7.7	41.0	29.9	38.5	1.0	9.6	14.8	9.5	8.7	8.8
DSP	-2.3	2.3	28.0	52.1	99.0	72.4	39.8	28.4	26.2	27.3	27.0

Source: Dataquest (August 1998)

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MCUs, the largest of the Japanese microcomponent segments, are expected to surge 15.1 percent (7.4 percent on a dollar basis) in 1998. They are incorporated into a variety of electronic equipment. Low-bit versions are embedded into household appliances for system control purposes, many of which are implemented on a 4-bit or 8-bit basis. Japanese companies still hold a dominant share in the 4-bit segment.

Four-bit MCUs are used in diverse products, ranging from toys to analog cordless telephones, and companies are still exploring new applications. Nevertheless, the market size will grow only moderately, partly because of the weakening demand from portable game systems, which have been a major driver, and partly because of the increased migration to 8-bit products. In particular, revenue growth will be minimal because of low prices, although unit growth may continue.

On the other hand, the 8-bit MCU market will enjoy strong growth as a result of upgrading from 4-bit applications and the need to address the increasing complexity of system control. The development of MCUs embedding flash memory technology is under way, and the competition has heated up among U.S., European, and Japanese companies for market share.

In 1997, 8-bit MCUs were used in most electronic equipment, including the following range of products:

- Video and audio equipment
- Computer-related equipment, including keyboards and display units
- Communications equipment, including analog cordless telephones and digital portable telephones
- Antilock braking systems (ABSs)
- Pachinko game systems
- Household appliances

Applications expected to emerge in 1998 and afterward include: smart cards, minidisc (MD) players, USB controllers (8-bit basis), and MCUs incorporating Infrared Data Association (IrDA) communications features. Encouraged by potential demand for contact/noncontact IC cards, semiconductor companies will opt for alliances to consolidate technological resources and vie for industrial standards. Finally, MCUs integrating ferroelectric memory technology will be introduced to the noncontact IC card market to invigorate the 8-bit MCU market.

Sixteen-bit MCUs, on the other hand, will be increasingly used for digital processing applications, particularly digital cellular phones, PHSs, hard disk drives (HDDs), and CD-ROM drives. Applications expected in 1998 and afterward include DVD, fixed and on-board audio MD players, and DV-C. Again, flash memory technology will be increasingly incorporated to address system requirements in terms of flexibility, and semiconductor companies will focus on enhancing their offerings.

As for 32-bit and 64-bit MCUs, SLI based on ASIC technology will become the mainstay. Promising applications that will be developed after 1998 by using a leading-edge process and an embedded MPU include: vehicle information and communication system (VICS)-based car navigation systems incorporating DVD-ROM drives, next-generation home/portable video game systems, and set-top boxes (STBs). Sixteen-, 32-, and 64-bit MCUs will enjoy strong growth next to 8-bit products, driven by price declines resulting from SLI, the emergence of digital consumer equipment, and the digitization of systems. Dataquest expects solid profitability.

In 1997, rapid growth was seen in the flash MCU market. Major applications include memory cards for video game systems, CD-ROM drives, and HDDs, spurring consumption of 8- and 16-bit MCUs. As for multibit, embedded MPU (MCU) architectures, ARM will be rapidly accepted in 1998 and afterward. Diverse architectures offered by vendors (MIPS, M Core, SH, SPARC, PowerPC, and X86) will be optimized for different applications according to their SLI strategy.

In 1998, the Japanese microperipheral (MPR) market is expected to grow 9.6 percent over the previous year (2.3 percent on a dollar basis). A variety of PC peripherals based on PC98 standards will become pervasive, and different application-specific standard product (ASSP) segments (chipset, USB, IEEE 1394, and MPACT1/2) will grow in relation to different applications.

The Japanese DSP market will continue a strong growth of 39.8 percent (30.5 percent on a dollar basis) in 1998. With the increasingly shortened development cycle for system products, DSPs and media processors will undoubtedly become core technologies because they offer flexibility in the development of digital consumer equipment with the ability to reconfigure themselves by replacing middleware/microcode. By 2002, 0.18- to 0.12-micron processes will be commercialized. As a result, the DSP market will grow strongly at a CAGR of 29.7 percent (27.9 percent on a dollar basis) between 1997 and 2002.

Finally, embedded DSPs are increasingly incorporated into servo controllers for CD and MD players as well as codec processing for cellular phones. Generic DSPs, including media processors, are primarily used in high-speed analog modems (56-Kbps) for PCs and sound source processing. New applications emerging in 1998 and afterward include digital cellular phones, which use a single chip integrating a 16/32-bit MCU and DSP; HDD controllers containing DSP/MCU and DRAM for buffer memory; and high-speed disk drives such as DVD-ROM/RAM, incorporating partial response maximum likelihood (PRML) technology and DSP.

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Challenge to the Vendors

In order to meet technology requirements from a wide range of applications, 32-bit MPUs with embedded RISC have been rapidly expanding their market since 1996. Major applications include mobile equipment, such as cellular phones and personal digital assistants (PDAs); digital video systems, such as digital camcorders (DVC) and digital still cameras; and systems that require real-time graphical processing, such as in-car navigation and video game machines.

It is difficult to accomplish the real-time processing of large volumes of data such as graphic and/or sound in multimedia systems without high-performance MPUs. DSPs are one solution, but they could increase the number of large-scale integrators (LSIs), which poses a threat to overall system cost and/or size. This can be solved with an embedded RISC MPU solution with multimedia processing by middleware, which enables system makers to save cost and circuit board space.

User needs for graphical user interface (GUI) increases in MPU-driven systems and for high-performance embedded MPUs will be growing, expanding demand for embedded MPUs with advanced SLI ASIC technology, such as MIPS, ARM, SH, SPARC, V853(E), M32R/D, and Shark.

Complex-instruction-set computing (CISC) MPUs that can be represented by x86 architecture have expanded their market mainly in PC applications. Currently, this segment of the market is served with products that are developed and manufactured with 0.25-micron process technology, aiming at production efficiency, cost competitiveness, and high performance, such as high frequency and low-power dissipation. System makers can take advantage of existing resources such as development technology and environment.

Thus, progress in SLI ASIC technology, electronic design automation (EDA) technology, and the development of high-performance 32-bit and 64-bit RISC embedded MPUs and 32-bit CISC MPUs are enabling system companies to develop new systems and subsystems, enjoying benefits in specification optimization, shortening turnaround time, and lowering system cost.

In the microcomponent market, SLI has arrived. No longer are system designers using standalone microcomponents such as MPU, MCU, and DSP; rather, they are increasing their dependency on SLI LSIs. This trend has made the choice, alliance, and development of architecture ever more important in meeting requirements in applications.

These trends are also making the border obscure between ASIC and microcomponent, forcing microcomponent vendors to incorporate various factors, such as supply support, technology support, development environment, and future marketability, when planning microcomponent business for processor architecture. This planning should include the understanding of system technologies so that the architecture can best support system memory, cost management, system size optimization, power, and noise management.

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Achieving those technology targets alone cannot bring success in the MPU/MCU or DSP business. Microcomponent vendors will be required to focus more on factors such as technology support, risk evaluation, marketability and launch timing, business opportunity evaluation, and cost of ownership (COO) evaluation. Also included is marketing power, which previously may not have been a strength, especially for Japanese microcomponent vendors. Dataquest believes that those factors are the key to choosing processors in optimizing systems.

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Chapter 6
Japanese Total Logic Market Trends

1997 Market Share

Market Trends

In 1997, the Japanese total logic market grew at 16.2 percent over the previous year (4.4 percent on a dollar basis), while the total ASIC market showed a solid growth of 15.7 percent, driven by cell-based ICs (CBICs), including mixed-signal ASICs. This sound growth in total ASICs is supported by the SLI market expansion, where CBIC technology is the key for developing ASIC and ASSP products that can meet competitive cost targets.

The Japanese ASIC market has followed its own trends, and 1997 was no exception. The worldwide ASIC market saw the following three changes:

- LSI Logic slipped from No. 2 to No. 4 in the total ASIC market.
- IBM and Lucent moved up to No. 2 and No. 3, respectively.
- Programmable logic device (PLD) makers made it to the top 10, but Xilinx Incorporated gave way to Altera Corporation, which has become the top PLD vendor.

These worldwide trends are clearly seen in the Americas market; however, in 1997, Japanese ASIC vendors were not affected. In Japan, where ASIC market growth depends on limited applications in digital consumer equipment and mobile communications, these trends can hardly be observed.

Japanese vendors in the ASIC market are very unique in that they continue to grow in the gate array market, where Americas companies are disappearing from top rankings. Americas companies are choosing to de-emphasize gate arrays so that they can focus on SLI business, while Japanese vendors are filling the void in the market, resulting in their positive growth in gate array revenue in 1997.

In the longer run, however, this trend will turn out to be a burden rather than a market opportunity, because Japanese companies will have to allocate their resources in process technology development, library development, designing power, and profitability to this low-growth segment of the ASIC market.

The PLD market in Japan has not grown to be a major segment as it is in the Americas market. A major cause of this is the persistent demand among system makers for gate array products in supply and in technology support. Japanese ASIC companies are at the same time vertically integrated companies, where overall corporate-level profit comes before profits in product segments such as semiconductors, while at Americas companies, profit maximization as well as the independence of each business unit is clearly defined.

As a result, in an effort to meet domestic customer requirements, small to medium-size designs, which could be optimized with PLDs, are still developed with gate arrays, limiting the growth of the PLD market. Gradually, however, this inefficient design practice is being improved in areas such as communications infrastructure systems, which helped the PLD market in Japan in 1998 to show a sound growth of 15.6 percent over the previous year.

Ranking Trends

As the determinant factor in the total logic market, ASICs played a key role in ranking trends (see Tables 6-1 through 6-5). In the 1997 Japanese ASIC market, NEC ranked No. 1, capturing one-quarter of the market. NEC is actually the worldwide leader in ASICs, having strength in a wide range of applications, including industrial, communications, consumer, and data processing. In the Japanese market, it was the consumer area that contributed to NEC's two-digit growth.

Following NEC was Fujitsu, also with a more than 20 percent market share, which it increased by revenue growth in digital consumer and communications applications. The third company in Japan was Hitachi, which grew in the number of designs, leveraging on its SLI strategy based on SH architecture, but was not free from the competitive pricing trends. LSI Logic ranked at No. 4, growing an overwhelming 64.6 percent over the previous year. LSI Logic leads the SLI trends, and in Japan, its growth comes from successes in ASSP and ASIC business in digital consumer applications, as well as custom LSI for video game machines based on a MIPS architecture embedded MPU core. Ranked as No. 5, Toshiba dropped one notch, recording a negative two-digit growth—the only negative growth among the top 10 Japanese companies.

Total Logic Forecast through 2002

In 1998, the Japanese total logic market will grow 8.7 percent (1.5 percent on a dollar basis). The total ASIC market will expand 11.8 percent, or 4.3 percent on a dollar basis (see Tables 6-6 and 6-7).

In 1997, high-performance systems, as seen in digital consumer equipment, were implemented to incorporate multiple, large-scale circuits by using intellectual property (IP) core and leading EDA tools. We also saw a rapid increase in the volume production of ASSPs and SLI ASIC products in single-chip implementation by using a highly integrated ASIC process and SLI technologies. A future challenge lies in reducing the cycle time for system development to minimize turnaround time and R&D investment, reduce development-related risks, and support early LSI implementation.

Traditionally, the "core-limited design" issue, derived from large-scale internal cores, was a major obstacle in designing ASICs. Recently, however, as the ASIC process reached submicron levels, the shrink ratio of the internal core has been improved. This, in turn, has resulted in an increase in the "input/output (I/O) pad-limited design," where I/O pads set the limit rather than cores. Also, flexibility in the ASIC design, resulting in small-lot production, adversely affects the profitability of business.

Table 6-1
1997 Japanese Market Share Ranking: MOS Digital Logic (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	NEC	185.8	223.7	20.4	22.6
2	2	Fujitsu	101.4	119.3	17.6	12.1
3	3	Toshiba	81.2	89.3	10.0	9.0
4	4	Hitachi	67.1	65.4	-2.6	6.6
7	5	Sony	42.0	57.9	37.8	5.9
5	6	Matsushita Electronics	52.3	53.2	1.6	5.4
6	7	TI	51.1	52.7	3.0	5.3
8	8	Sharp	40.3	45.7	13.4	4.6
9	9	LSI	26.1	43.0	64.6	4.3
12	10	SANYO	21.3	35.4	65.8	3.6
11	11	Mitsubishi Electric	24.3	29.9	23.3	3.0
10	12	Oki	25.5	28.8	13.2	2.9
14	13	Rohm	13.8	14.2	2.5	1.4
17	14	Altera	10.3	13.8	33.6	1.4
16	15	Motorola	11.9	12.7	7.2	1.3
13	16	Yamaha	14.1	11.6	-17.8	1.2
18	17	Lucent	10.3	10.5	1.9	1.1
15	18	Seiko	13.5	9.7	-28.2	1.0
21	19	Xilinx	6.0	7.4	23.4	0.7
19	20	AMD	6.5	4.8	-25.8	0.5
23	21	Lattice	4.4	4.8	11.3	0.5
22	22	IBM	4.5	4.4	-2.3	0.4
20	23	VLSI	6.0	4.2	-29.2	0.4
42	24	Macronix	0.4	4.0	818.2	0.4
68	25	Fairchild	0	3.5	NA	0.4
25	26	Philips Semiconductors	3.5	3.1	-9.6	0.3
27	27	Fuji Electric	2.7	2.7	-2.1	0.3
28	28	Samsung	1.8	2.7	44.0	0.3
36	29	Cypress	0.8	2.7	249.8	0.3
24	30	Ricoh	3.9	2.4	-38.2	0.2
29	31	Actel	1.6	1.7	3.9	0.2
31	32	New JRC	1.0	1.5	48.4	0.1
53	33	Micronas	0.1	1.5	1,235.5	0.1
26	34	National	3.2	1.2	-61.6	0.1
30	35	Dallas	1.0	1.2	23.7	0.1
87	36	QuickLogic	0	1.2	NA	0.1
32	37	HP	0.9	1.1	25.2	0.1
33	38	Integrated Circuit Systems	0.9	1.1	25.2	0.1

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Table 6-1 (Continued)
1997 Japanese Market Share Ranking: MOS Digital Logic (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
34	39	IDT	0.9	1.1	25.2	0.1
41	40	SGS-Thomson*	0.4	1.0	122.6	0.1
		All Others	8.2	12.8	57.3	1.3
		Americas Companies	150.0	178.9	19.2	18.1
		Japanese Companies	693.7	795.4	14.7	80.5
		European Companies	4.6	7.0	53.7	0.7
		Asia/Pacific Companies	2.7	7.4	171.6	0.7
		Total Market	**851.0**	**988.7**	**16.2**	**100.0**

NA = Not available
* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

Table 6-2
1997 Japanese Market Share Ranking: Total ASIC (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	NEC	116.3	136.6	17.4	24.6
2	2	Fujitsu	100.2	117.7	17.5	21.2
3	3	Hitachi	42.8	46.1	7.9	8.3
5	4	LSI	26.1	43.0	64.6	7.8
4	5	Toshiba	41.1	34.4	-16.4	6.2
6	6	TI	25.8	26.6	3.3	4.8
7	7	Matsushita Electronics	23.0	23.1	0.7	4.2
8	8	Mitsubishi Electric	12.4	16.0	28.9	2.9
9	9	Altera	10.3	13.8	33.6	2.5
11	10	Sharp	9.9	12.0	21.1	2.2
10	11	Lucent	10.3	10.5	1.9	1.9
15	12	Seiko	6.0	8.0	33.6	1.4
14	13	Xilinx	6.0	7.4	23.4	1.3
22	14	SANYO	2.5	6.9	175.8	1.2
12	15	Oki	6.6	4.8	-27.0	0.9
17	16	Lattice	4.4	4.8	11.3	0.9
16	17	IBM	4.5	4.4	-2.3	0.8
13	18	VLSI	6.0	4.2	-29.2	0.8
20	19	Motorola	3.4	4.1	22.1	0.7
18	20	Rohm	3.8	4.0	4.9	0.7
38	21	Macronix	0.2	4.0	1,736.4	0.7
19	22	AMD	3.6	3.5	-2.2	0.6
24	23	Sony	1.3	2.5	94.8	0.5
23	24	Actel	1.6	1.7	3.9	0.3
80	25	QuickLogic	0	1.2	NA	0.2
25	26	National	1.2	1.1	-8.9	0.2
26	27	HP	0.9	1.1	25.2	0.2
27	28	Integrated Circuit Systems	0.8	1.0	27.2	0.2
32	29	Samsung	0.5	1.0	78.1	0.2
28	30	Yamaha	0.8	0.8	11.3	0.2
31	31	GEC Plessey	0.5	0.8	55.8	0.2
33	32	SGS-Thomson*	0.3	0.8	159.7	0.2
21	33	Ricoh	3.3	0.6	-81.5	0.1
30	34	Symbios	0.5	0.6	11.3	0.1
115	35	TEMIC	0	0.6	NA	0.1
29	36	Cypress	0.7	0.4	-44.4	0.1
36	37	Exar	0.2	0.4	66.9	0.1
37	38	Gould/AMI	0.2	0.4	66.9	0.1

Table 6-2 (Continued)
1997 Japanese Market Share Ranking: Total ASIC (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
42	39	Raytheon	0.1	0.4	233.9	0.1
34	40	Analog Devices	0.2	0.2	11.3	0
		All Others	0.7	2.5	289.5	0.5
		Americas Companies	107.3	133.2	24.2	24.0
		Japanese Companies	370.0	413.7	11.8	74.6
		European Companies	1.0	2.4	147.3	0.4
		Asia/Pacific Companies	0.8	5.0	551.9	0.9
		Total Market	**479.0**	**554.3**	**15.7**	**100.0**

NA = Not available
* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

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Table 6-3
1997 Japanese Market Share Ranking: Total Gate Array (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Fujitsu	69.1	78.0	12.9	28.0
2	2	NEC	65.8	74.6	13.3	26.8
3	3	Hitachi	33.3	35.5	6.6	12.7
4	4	Toshiba	22.3	20.3	-8.8	7.3
5	5	Mitsubishi Electric	10.2	13.1	27.9	4.7
6	6	Matsushita Electronics	8.8	9.2	4.4	3.3
7	7	TI	8.7	7.1	-17.9	2.6
10	8	Seiko	5.1	6.9	35.0	2.5
9	9	Sharp	5.8	6.5	13.4	2.3
14	10	SANYO	2.0	4.6	135.0	1.7
12	11	Oki	3.2	3.8	19.0	1.3
21	12	Macronix	0.2	3.8	1,625.1	1.3
8	13	LSI	6.0	3.3	-45.4	1.2
11	14	Motorola	3.4	2.8	-17.4	1.0
17	15	Sony	1.3	2.5	94.8	0.9
13	16	Rohm	2.1	2.2	5.4	0.8
15	17	IBM	1.4	0.8	-40.1	0.3
18	18	Samsung	0.4	0.7	66.9	0.3
16	19	Ricoh	1.3	0.5	-62.9	0.2
19	20	Gould/AMI	0.2	0.4	66.9	0.1
20	21	Yamaha	0.2	0.2	11.3	0.1
24	22	GEC Plessey	0.1	0.2	122.6	0.1
77	23	Raytheon	0	0.2	NA	0.1
22	24	Chip Express	0.1	0.1	11.3	0
23	25	National	0.1	0.1	11.3	0
45	26	Exar	0	0.1	NA	0
48	27	GENNUM	0	0.1	NA	0
		All Others	0	0.6	NA	0.2
		Americas Companies	19.9	15.7	-20.9	5.7
		Japanese Companies	230.5	257.9	11.9	92.6
		European Companies	0.1	0.2	122.6	0.1
		Asia/Pacific Companies	0.7	4.5	586.3	1.6
		Total Market	**251.1**	**278.4**	**10.9**	**100.0**

NA = Not available
Source: Dataquest (August 1998)

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Table 6-4
1997 Japanese Market Share Ranking: PLD (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Altera	10.3	13.8	33.6	40.7
2	2	Xilinx	6.0	7.4	23.4	21.8
3	3	Lattice	4.4	4.8	11.3	14.3
4	4	AMD	3.6	3.5	-2.2	10.4
5	5	Actel	1.6	1.7	3.9	5.0
61	6	QuickLogic	0	1.2	NA	3.6
7	7	Lucent	0.5	0.6	11.3	1.8
6	8	Cypress	0.7	0.4	-44.4	1.1
8	9	Toshiba	0.2	0.1	-44.4	0.4
9	10	Atmel	0.1	0.1	11.3	0.4
11	11	TI	0.1	0.1	11.3	0.4
12	12	Ricoh	0.1	0.1	11.3	0.4
10	13	International CMOS Technology	0.1	0	-100.0	0
		All Others	-	-	-	-
		Americas Companies	27.4	33.7	22.8	99.3
		Japanese Companies	0.3	0.2	-25.8	0.7
		European Companies	0	0	-	0
		Asia/Pacific Companies	0	0	-	0
		Total Market	**27.7**	**33.9**	**22.2**	**100.0**

NA = Not available
Source: Dataquest (August 1998)

Table 6-5
1997 Japanese Market Share Ranking: Cell-Based IC (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	NEC	50.5	62.0	22.8	25.6
2	2	Fujitsu	31.1	39.7	27.6	16.4
3	3	LSI	20.1	39.7	97.3	16.4
5	4	TI	17.0	19.4	14.1	8.0
4	5	Toshiba	18.6	13.9	-25.2	5.8
6	6	Matsushita Electronics	14.1	13.9	-1.5	5.8
8	7	Hitachi	9.5	10.7	12.6	4.4
7	8	Lucent	9.8	9.9	1.4	4.1
10	9	Sharp	4.1	5.4	31.8	2.3
9	10	VLSI	6.0	4.2	-29.2	1.8
12	11	IBM	3.0	3.5	15.3	1.5
13	12	Mitsubishi Electric	2.2	2.9	33.6	1.2
21	13	SANYO	0.5	2.3	322.9	1.0
15	14	Rohm	1.7	1.8	4.3	0.8
72	15	Motorola	0	1.3	NA	0.6
11	16	Oki	3.5	1.1	-68.7	0.5
17	17	HP	0.9	1.1	25.2	0.5
18	18	Seiko	0.9	1.1	25.2	0.5
16	19	National	1.1	1.0	-11.0	0.4
19	20	Integrated Circuit Systems	0.8	1.0	27.2	0.4
24	21	SGS-Thomson*	0.3	0.8	159.7	0.4
20	22	Symbios	0.5	0.6	11.3	0.3
22	23	Yamaha	0.5	0.6	11.3	0.3
23	24	GEC Plessey	0.4	0.6	39.1	0.3
114	25	TEMIC	0	0.6	NA	0.3
25	26	Analog Devices	0.2	0.2	11.3	0.1
26	27	Exar	0.2	0.2	11.3	0.1
28	28	Harris	0.1	0.2	122.6	0.1
31	29	Samsung	0.1	0.2	122.6	0.1
122	30	Macronix	0	0.2	NA	0.1
27	31	Atmel	0.1	0.1	11.3	0.1
29	32	Raytheon	0.1	0.1	11.3	0.1
30	33	Micronas	0.1	0.1	11.3	0.1
14	34	Ricoh	1.8	0	-100.0	0
		All Others	0	1.1	NA	0.5
		Americas Companies	60.0	83.8	39.8	34.6
		Japanese Companies	139.2	155.5	11.7	64.3
		European Companies	0.9	2.2	150.4	0.9
		Asia/Pacific Companies	0.1	0.5	345.2	0.2
		Total Market	**200.1**	**242.0**	**20.9**	**100.0**

NA = Not available
* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

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Table 6-6
1997 Japanese MOS Logic Market History and Forecast, 1992 to 2002 (Billions of Yen)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
MOS Digital Logic	**484.7**	**523.9**	**610.1**	**730.5**	**851.0**	**988.7**	**1,074.5**	**1,200.8**	**1,361.1**	**1,513.1**	**1,736.7**	**11.9**
Total ASIC	383.1	418.7	426.7	491.7	479.0	554.3	619.5	723.9	852.9	983.4	1,159.1	15.9
MOS Gate Array	152.9	166.2	187.2	235.9	251.1	278.4	288.2	284.1	276.3	264.9	250.3	-2.1
MOS CBIC	59.9	77.1	93.5	143.9	200.1	242.0	292.1	391.5	517.1	646.3	819.7	27.6
MOS PLD	7.8	11.1	12.8	19.9	27.7	33.9	39.2	48.2	59.5	72.3	89.1	21.3
Custom IC	162.5	164.2	133.2	92.0	91.3	96.3	81.7	60.4	40.8	25.5	15.1	-31.0
MOS Standard Logic	39.8	42.9	45.1	48.7	48.9	60.5	66.5	71.3	76.0	76.2	77.8	5.1
Total Other MOS Logic	61.7	62.3	138.4	190.1	231.9	277.6	306.9	345.2	391.5	427.9	484.8	11.8

Notes: Columns may not add to totals shown because of rounding.
From 1992 through 1995, the definition of Total ASIC includes MOS Gate Array, MOS CBIC, MOS PLD, and Custom IC. From 1996 on, the definition no longer includes Custom IC.
Source: Dataquest (August 1998)

Table 6-7
Japanese MOS Logic Market History and Forecast, 1992 to 2002 (Yen-Based Percentage Growth over Preceding Year)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
MOS Digital Logic	**-12.5**	**8.1**	**16.5**	**19.7**	**16.5**	**16.2**	**8.7**	**11.8**	**13.4**	**11.2**	**14.8**
Total ASIC	-12.8	9.2	1.9	15.2	-2.6	15.7	11.8	16.9	17.8	15.3	17.9
MOS Gate Array	-15.1	11.0	12.6	26.0	6.5	10.9	3.5	-1.4	-2.8	-4.1	-5.5
MOS CBIC	-11.4	21.2	21.3	53.9	39.1	20.9	20.7	34.1	32.1	25.0	26.8
MOS PLD	-21.4	42.3	15.3	55.5	39.4	22.2	15.6	22.9	23.6	21.4	23.2
Custom IC	-10.6	1.0	-18.9	-30.9	-0.8	5.5	-15.2	-26.0	-32.5	-37.4	-41.0
MOS Standard Logic	-13.6	7.8	5.1	8.1	0.2	23.9	9.8	7.2	6.6	0.4	2.0
Total Other MOS Logic	-10.2	0.9	122.2	37.4	21.9	19.7	10.6	12.5	13.4	9.3	13.3

Source: Dataquest (August 1998)

By 1997, many leading ASIC vendors in the Americas region had started to de-emphasize the gate array business. This move is favorable for the PLD market and is accelerating the collapse of the U.S. gate array market. Technically, PLDs have already integrated 250,000 to 500,000 gates on a commercial basis by using process technology based on 0.25-micron, five-layer interconnect and shallow trench structure. Dataquest believes that 1 million gates will be integrated by using an 0.18-micron process technology by 2000.

In 1998, the Japanese PLD market will show a strong growth of 15.6 percent (7.9 percent on a dollar basis). In Japan, the gate array business still dominates because of high captive demand. Nevertheless, because SLI will lead ASIC business in the future, the Japanese PLD market will grow to an appreciable size compared to the Americas market. Dataquest expects that the market will register the second-highest growth rate, following CBICs, with a CAGR of 21.3 percent between 1997 and 2002.

The Japanese CBIC market (including mixed-signal) will grow 20.7 percent (12.7 percent on a dollar basis) in 1998. The ramp-up of 0.35-to-0.25-micron process manufacturing and the increasing need for design optimization in various applications have been driving the market for CBICs, which are regarded as the key infrastructure factors in SLI technologies such as embedded MPUs/DSPs, IP core, embedded memories, and mixed-signal designs. At the same time, the establishment of CBIC technology has caused the custom IC market to shrink rapidly, resulting in a negative CAGR of 31.0 percent (31.9 percent on a dollar basis) between 1997 and 2002.

Among other logic products, standard logic features such as small-scale integration (SSI), middle-scale integration (MSI), and LSI are mostly incorporated into ASICs, but demand for standard logic still exists in the area of super-high-speed CMOS- or BiCMOS-based standard logic, such as CMOS-based one-gate logic products and wide bus products. Thus, the Japanese standard logic market will continue to grow steadily at a CAGR of 5.1 percent (3.7 percent on a dollar basis).

Finally, LCD drivers will be driven by increased market acceptance of LCD-equipped systems as well as by the exploration of new application markets. As a result, the Japanese market's CAGR for the "Total other MOS Logic" category is expected to be 11.8 percent (10.3 percent on a dollar basis) during the five-year period.

In 1998, ASIC suppliers announced a number of next-generation 0.18-micron processes, and some of them in Japan and the United States started volume production. Also, development efforts are under way to commercialize a "unified process" that represents a "dream process integration." Dataquest believes that portable applications in the Japanese market will contribute to technological progress in the areas of ultra-low operating voltage below 1.0V, embedded flash memory, mixed-signal designs, and high-density packages, such as chip-scale packaging (CSP) and direct chip attach (DCA), thereby driving the SLI ASIC market.

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Challenge to the Vendors

Traditional ASICs were mainly single-function products that integrated glue logic. With the introduction of a new business model in 1990 based on intellectual property cores, the whole ASIC industry has been moving toward SLI, and ASIC vendors have been in the process of restructuring their businesses. Japanese companies are no exception.

In this new ASIC business model, vendors first prepare a large number of IP cores, based on each vendor's own research, either developed internally or acquired from the outside. Then, in the development environment of IP cores, description languages such as Verilog Hardware Description Language (Verilog-HDL) and VHSIC HDL Roger's Interface Language (VHDL-RIL), for standardization, enable vendors to provide the appropriate set of IP cores at the request of ASIC users, which enables the design of a large, complex system with a short turnaround time. This SLI business model is advantageous to users because they can develop and market their new systems with minimum investment and risk, and within a short range of time. For ASIC vendors, users' recognition of IP cores as value-added will help differentiate them from competitors. In the ASIC business, where differentiation has been difficult, this SLI move is expected to help improve profitability.

In putting system-level functions on a single chip, traditional ASIC process technology is not sufficient. Also required are an understanding of requirements from each target application and the most advanced EDA, IP core development environment, and analog/mixed-signal technologies for designing embedded MPUs. Those are the key factors for ASIC vendors to be successful in the SLI business.

In this sense, the Virtual Socket Interface (VSI) Alliance, in which worldwide semiconductor vendors as well as system makers and EDA vendors participate, will standardize IP cores, establish their distribution system, and dramatically change the ASIC industry.

In the current market, continuing DRAM oversupply and pricing weakness have prompted semiconductor companies to shift emphasis from memories to logic, resulting in a crowded market in the latter half of 1997. This supply/demand situation has caused the price fall of logic products, and expectations about the profitability of the SLI business are being questioned. The needs for embedded DRAM and flash are increasing from the application side, and, leveraging on profitable applications such as graphics and mobile equipment, embedded memories will contribute to the market growth of SLI ASIC.

Another factor that poses challenges to vendors is the development of process technology. The main technology has shifted from 0.5 micron to 0.35 micron, and now it is shifting toward 0.25 micron and 0.18 micron concurrently. This trend may cause Japanese ASIC vendors currently investing in 0.25-micron process technology and manufacturing capacity to lose competitiveness.

The semiconductor industry has observed silicon cycles many times, but in this round, ASIC technology progress, in centering on graphics, data processing, and communications, may change the market positioning for various ASIC vendors. Americas companies have enjoyed high market share, leveraging on embedded MPU and DSP core technology. Korean companies are aiming to catch up with the forerunners by focusing on DRAM as a technology driver. Taiwanese companies have established a business model of dedicated foundry, supporting fabless companies. Japanese companies have an advantage in overall SLI technology, with their embedded technology and IP cores, based on MCU business experience. The SLI ASIC market will be more competitive with all of these vendors, and all SLI companies will be required to equip themselves with the necessary ASIC technologies, an understanding of various technical requirements for each target application, and a strategic analysis of competitors.

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Chapter 7

Japanese Analog IC, Discrete Device, and Optical Semiconductor Market Trends

1997 Market Share

Market Trends

In 1997, the Japanese market saw healthy growth for analog, discrete, and optical semiconductor products. Among those, the analog market recorded a more than 20 percent increase over the previous year for the first time in the 1990s. Contributing to this strong growth were factors such as strong unit demand because of improved electronics production, stable pricing trends, and an increase in mixed-signal products with higher average selling prices than conventional linear products.

At a time when new systems are emerging, system designers resort to discrete function chips, such as general-purpose analog ICs and discrete semiconductor devices, until system designs become stable and circuits become integrated into larger devices, including ASSP and ASIC. The year 1997, which can be marked when the shift to digital consumer systems becomes a solid move, was another example of this trend. The increase in demand for analog and discrete semiconductor products has been observed since 1995, but the acceleration in 1997 was more than the industry expected, and the tightened supply/demand balance helped to keep the prices stable, contributing to profits for vendors.

Major contributions came from segments such as telecom analog, disk-drive analog, special-function analog, and power-management analog products. Among discrete semiconductor products, it was power transistors—not only the emerging isolated gate bipolar transistors (IGBTs) but also MOS field-effect transistors (FETs) and even bipolar transistors—that marked two-digit growth over the previous year. The increase in those products was supported by PC and peripheral equipment as well as mobile communications applications. The driver for the growth in optical semiconductors in Japan was the laser diode, whose consumption was pumped by optical storage devices and audio players such as CD-ROM drive and MD players.

Ranking Trends

In the 1997 Japanese analog market, Texas Instruments Inc. continued to lead while all the rest of the top 10 companies were domestic vendors (see Table 7-1). However, other Americas and European vendors, too, increased their sales rapidly, and as a result, the combined share of non-Japanese vendors has become one-third of the market. TI's revenue growth came both from general-purpose products and ASSPs such as disk drive and automotive. Toshiba, ranked No. 2, also enjoyed growth in general-purpose product revenue as well as an increase in applications in consumer and automotive. Matsushita Electronics switched places with NEC, helped by increases in telecom and disk drives. SANYO Electric Company Ltd. and Sony remained in their respective positions of the previous year, although they recorded growth rates that were higher than the market average.

Table 7-1
1997 Japanese Market Share Ranking: Analog-Monolithic (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	TI	48.0	66.4	38.3	11.0
2	2	Toshiba	47.4	55.7	17.4	9.2
4	3	Matsushita Electronics	42.0	49.7	18.2	8.2
3	4	NEC	45.6	48.1	5.5	8.0
5	5	SANYO	37.5	44.0	17.1	7.3
6	6	Sony	33.2	41.1	23.7	6.8
9	7	Mitsubishi Electric	25.2	33.9	34.3	5.6
8	8	Fujitsu	25.5	30.6	20.3	5.1
10	9	Rohm	24.5	30.6	25.1	5.1
7	10	Hitachi	27.7	23.7	-14.5	3.9
11	11	National	14.3	18.6	30.8	3.1
13	12	Analog Devices	13.3	18.3	37.8	3.0
12	13	Motorola	14.0	16.8	19.9	2.8
16	14	Philips Semiconductors	8.9	14.5	62.9	2.4
15	15	New JRC	10.9	13.2	21.3	2.2
14	16	SGS-Thomson*	11.1	11.3	1.5	1.9
17	17	Sharp	7.1	8.0	13.0	1.3
18	18	Maxim	6.4	7.9	22.6	1.3
19	19	Burr-Brown	5.3	6.1	13.6	1.0
23	20	Ricoh	3.7	5.3	44.0	0.9
21	21	Linear Technology	4.4	5.1	16.9	0.8
113	22	Sanken	0	4.6	NA	0.8
20	23	Rockwell	5.0	4.5	-10.5	0.7
22	24	Allegro MicroSystems	3.9	3.8	-4.2	0.6
27	25	Siemens	2.0	3.1	60.8	0.5
34	26	AMD	1.1	3.1	189.4	0.5
37	27	Cirrus Logic	0.9	2.8	220.0	0.5
26	28	Harris	2.0	2.2	11.3	0.4
28	29	Oki	1.8	1.9	4.7	0.3
35	30	IR	1.1	1.6	44.7	0.3
39	31	Elantec	0.8	1.6	106.7	0.3
31	32	Fuji Electric	1.3	1.5	11.3	0.2
32	33	GEC Plessey	1.3	1.5	11.3	0.2
38	34	TEMIC	0.9	1.5	66.9	0.2
41	35	KEC	0.8	1.3	74.9	0.2
24	36	VTC	2.7	1.2	-55.5	0.2
30	37	Raytheon	1.3	1.2	-7.3	0.2
33	38	Exar	1.2	1.2	1.2	0.2

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Table 7-1 (Continued)
1997 Japanese Market Share Ranking: Analog-Monolithic (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
56	39	Semtech	0.1	1.2	1,012.9	0.2
36	40	Seiko	1.0	1.1	11.3	0.2
		All Others	12.9	13.1	1.0	2.2
		Americas Companies	130.7	169.7	29.8	28.1
		Japanese Companies	340.5	398.9	17.2	66.2
		European Companies	24.3	32.1	32.3	5.3
		Asia/Pacific Companies	2.6	2.1	-21.2	0.3
		Total Market	**498.0**	**602.7**	**21.0**	**100.0**

NA = Not available
* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

The Japanese discrete and optical semiconductor markets have traditionally been dominated by domestic vendors, and 1997 was no exception.

In the 1997 Japanese discrete semiconductor market, Toshiba maintained the lead by growing faster than the market, leveraging on its coverage in all three power transistor areas (see Table 7-2). NEC replaced Hitachi as the No. 2 vendor in Japan, showing two-digit growth rates in most of the product areas except for thyristors. Companies such as Rohm Company Ltd., Mitsubishi Electric, and SANYO kept their respective positionings, but they have a marked difference in product coverage—Rohm benefits from bipolar, SANYO from MOSFET, and Matsushita Electronics from both bipolar and MOS.

In the optical semiconductor market in Japan, Sharp Electronics Corporation widened the lead by growing at 24 percent (see Table 7-3). Contributions came from a wide range of segments, including couplers, charge-coupled devices (CCDs), and laser diodes. Companies following Sharp maintained their respective positions, with Rohm and SANYO each showing over 20 percent growth and both benefiting from the demand increase for laser diodes. Included in the survey from 1997 is Stanley Electric, which jumped in at No. 8 with its focused product coverage of LED lamps and displays.

Table 7-2
1997 Japanese Market Share Ranking: Discrete (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Toshiba	80.1	89.6	11.9	17.4
3	2	NEC	62.7	73.1	16.7	14.2
2	3	Hitachi	75.2	59.2	-21.2	11.5
4	4	Matsushita Electronics	41.7	47.5	13.9	9.2
5	5	Rohm	40.5	41.8	3.2	8.1
6	6	Mitsubishi Electric	37.0	38.6	4.4	7.5
7	7	SANYO	29.4	34.3	16.7	6.7
9	8	Sanken	19.7	28.3	43.9	5.5
8	9	Fuji Electric	28.5	26.9	-5.7	5.2
10	10	Shindengen Electric	17.1	19.0	11.3	3.7
11	11	Fujitsu	8.1	9.3	15.8	1.8
12	12	Motorola	7.9	7.8	-2.4	1.5
13	13	IR	5.5	5.2	-6.2	1.0
15	14	General Semiconductor	3.3	3.5	7.6	0.7
14	15	Sony	3.4	3.3	-3.1	0.6
17	16	TEMIC	2.9	3.1	7.2	0.6
25	17	KEC	0.8	2.5	233.9	0.5
18	18	Powerex	2.0	1.9	-1.1	0.4
20	19	Philips Semiconductors	1.2	1.9	61.9	0.4
19	20	Oki	1.2	1.5	21.4	0.3
22	21	National	0.9	1.5	66.9	0.3
56	22	Fairchild	0	1.3	NA	0.3
24	23	Siemens	0.9	1.2	39.1	0.2
21	24	HP	0.9	1.0	11.3	0.2
23	25	SGS-Thomson*	0.9	1.0	11.3	0.2
29	26	Teccor Electronics	0.2	0.5	122.6	0.1
26	27	New JRC	0.3	0.4	11.3	0.1
28	28	Supertex	0.2	0.2	11.3	0
32	29	Zetex	0.1	0.2	122.6	0
31	30	Microsemi	0.1	0.1	11.3	0
33	31	Samsung	0.1	0.1	11.3	0
59	32	Harris	0	0.1	NA	0
114	33	Ericsson	0	0.1	NA	0
115	34	GEC Plessey	0	0.1	NA	0
116	35	Micronas	0	0.1	NA	0
16	36	Toko	3.0	0	-100.0	0

Table 7-2 (Continued)
1997 Japanese Market Share Ranking: Discrete (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
27	37	ITT	0.2	0	-100.0	0
30	38	eupec	0.2	0	-100.0	0
		All Others	3.6	7.5	109.1	1.5
		Americas Companies	21.2	23.1	9.0	4.5
		Japanese Companies	451.1	480.0	6.4	93.4
		European Companies	6.4	8.1	26.4	1.6
		Asia/Pacific Companies	0.9	2.7	206.1	0.5
		Total Market	**479.6**	**513.9**	**7.2**	**100.0**

NA = Not available
* STMicroelectronics, as of 1998
Source: Dataquest (August 1998)

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Table 7-3
1997 Japanese Market Share Ranking: Optical Semiconductor (Billions of Yen)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Change (%)	1997 Market Share (%)
1	1	Sharp	50.8	63.2	24.4	19.2
2	2	Matsushita Electronics	41.7	44.7	7.2	13.5
3	3	Sony	36.8	42.1	14.6	12.8
4	4	Toshiba	29.5	32.1	8.8	9.7
5	5	Rohm	22.1	26.5	20.1	8.0
6	6	NEC	22.0	22.0	0.3	6.7
7	7	SANYO	12.6	15.7	24.7	4.8
108	8	Stanley Electric	0	15.5	NA	4.7
8	9	Fujitsu	12.3	15.1	23.1	4.6
9	10	Mitsubishi Electric	9.6	15.1	58.1	4.6
10	11	Hitachi	7.9	7.0	-11.6	2.1
11	12	HP	5.4	5.8	6.8	1.8
12	13	TI	4.4	5.2	19.6	1.6
14	14	Oki	2.9	3.8	27.8	1.1
13	15	Sanken	3.9	3.6	-7.3	1.1
16	16	Siemens	0.8	1.7	122.6	0.5
20	17	TEMIC	0.4	1.2	178.2	0.4
19	18	KEC	0.5	0.6	11.3	0.2
15	19	Mitel	0.8	0.2	-68.2	0.1
17	20	Lucent	0.7	0.2	-62.9	0.1
21	21	Motorola	0.1	0.1	11.3	0
18	22	New JRC	0.5	0	-100.0	0
		All Others	21.3	8.2	-61.4	2.5
		Americas Companies	11.3	11.6	2.7	3.5
		Japanese Companies	274.0	314.9	14.9	95.4
		European Companies	1.2	2.9	142.8	0.9
		Asia/Pacific Companies	0.5	0.6	11.3	0.2
		Total Market	**287.0**	**330.0**	**15.0**	**100.0**

NA = Not available
Source: Dataquest (August 1998)

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Analog IC, Discrete Device, and Optical Semiconductor Forecast through 2002

The outlook for the analog, discrete, and optical semiconductor markets has been adjusted downward from the previous forecast. It should be noted that the analog market was partially affected by the reclassification of linear array and mixed-signal ASICs (although small in size) into total ASICs.

The strong demand growth for analog ICs in the past few years has caused the industry to hold unduly high expectations. With the rapid progress of system diversification, accompanied by LSI implementations over several generations, demand for analog ICs and discrete devices has been experiencing a surge in momentum (see Tables 7-4 and 7-5). Nevertheless, the expansion of mixed-signal analog IC markets will ultimately lead to CBICs absorbing analog functions, so that suppliers will tend to overestimate long-term demand by extrapolating the recent high-growth trends. Also, sluggish electronics production causes demand for generic analog devices to slow down.

In the first quarter of 1998, suppliers do not seem to be accelerating analog capacity, partly because of heavy constraints on investment resources. If supply capacity expands abruptly, prices will plummet, resulting in unit growth without revenue growth. Given this cap for capacity expansion, Dataquest believes that it will be difficult for the Japanese analog market to continue double-digit growth. (In the downside scenario mentioned in Chapter 2, analog price erosion has been incorporated into the Japanese market growth.)

Challenge to the Vendors

Japanese analog vendors have enjoyed two advantages in the domestic market: IC demand and system technology from Japan-based consumer electronics makers. Now that even Japan-based consumer companies have shifted a large portion of their equipment production overseas and non-Japanese markets are growing much faster, Japanese analog vendors can no longer expect the same pattern. Also, the system technology required in digital consumer applications derives from basic technologies developed by non-Japanese system makers in the Americas and European markets. As system-oriented semiconductor suppliers, Japanese analog companies need to strengthen their design support capability in markets outside of Japan, focusing on target applications in each region.

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Table 7-4
1997 Japanese Analog, Discrete, and Optical Markets—History and Forecast, 1992 to 2002 (Billions of Yen)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Analog-Monolithic	367.1	364.5	412.1	445.4	498.0	602.7	656.2	714.7	782.3	849.9	912.4	8.6
Discrete	389.1	380.6	398.7	439.6	479.6	513.9	565.8	609.9	667.9	716.4	765.8	8.3
Optical	196.8	192.2	213.5	259.9	287.0	330.0	342.5	365.8	395.7	428.8	461.8	7.0
Exchange Rate (Yen/U.S.$1)	126.5	111.2	101.8	93.9	108.8	121.1	129.7	129.7	129.7	129.7	129.7	-

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (August 1998)

Table 7-5
Japanese Analog, Discrete, and Optical Markets—History and Forecast, 1992 to 2002 (Yen-Based Percentage Growth over Preceding Year)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Analog-Monolithic	-12.8	-0.7	13.1	8.1	11.8	21.0	8.9	8.9	9.5	8.6	7.4
Discrete	-16.6	-2.2	4.8	10.3	9.1	7.2	10.1	7.8	9.5	7.3	6.9
Optical	-19.0	-2.3	11.1	21.7	10.4	15.0	3.8	6.8	8.2	8.4	7.7

Source: Dataquest (August 1998)

Chapter 8
Japanese Companies' Capital Spending Trends

Overall Spending Trends

In 1997, capital spending in Japan saw a decline over the previous year, for the first time since 1992 (see Table 8-1). This was caused mainly by the Japanese companies, whose worldwide spending shrank by 1.7 percent. The outlook for 1998 is even gloomier because the capital expenditure in Japan is expected to be cut by 30 percent on a dollar basis—the largest reduction among all four regions. In the section below, the spending trends of Japanese companies are analyzed, as Japanese companies represent the majority of spending in Japan.

The regional distribution of Japanese companies' spending this year shows a clear preference: Domestic investment declines by one-third, while spending in the Americas and Europe is being reduced by one-half. The only region to show an increase is Asia/Pacific. This does not actually mean that Japanese companies on the whole are focusing on that region. Rather, the increase comes from a large commitment by NEC to the Shanghai joint venture.

During the boom years, Japanese companies took an aggressive approach to high-growth markets overseas by increasing the supply capacity near the markets, just like they did in the past boom years, and, just like they did after the past boom years, they are reducing overseas spending again. This trend can be attributed first to a big reduction in funds caused by lessened profits or increased loss from the semiconductor business in recent years. Realizing the need to focus on next-generation investments, Japanese companies have given up on the idea of enforcing local supply capacity. The second reason can be found in exchange rate trends, where the Japanese yen has depreciated to the level it saw about seven years ago when Japanese companies were less motivated to produce outside of Japan.

Spending trends by product also show a sharp contrast. Investment into memories is to be cut by one-third, while the microcomponent and logic segments combined show a much milder reduction of 7.6 percent. As a result, memories' share of Japanese companies' capital spending is to be surpassed by those two other categories for the first time since DRAM has become a major segment of business for Japanese semiconductor companies. The focus on microcomponent and logic clearly shows their determination to pursue SLI trends. Analog and discrete, two major product categories that represent a large portion of the profits, are given ample share in the investment this year. This, however, poses a threat to the near-future supply/demand of those categories, because the progress of SLI may imply a reduced rate of growth in demand—not reduced demand—for analog and discrete products.

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Table 8-1
Semiconductor Capital Spending of Top 20 Japanese Companies (Billions of Yen)

	1991	1992	1993	1994	1995	1996	1997	1998
Fuji Electric	15.1	15.0	6.8	5.2	7.7	11.5	11.8	10.1
Fujitsu	95.6	71.3	77.9	109.2	149.5	137.5	174.8	107.4
Hitachi	88.4	65.0	86.3	98.8	140.6	139.8	122.9	86.8
Matsushita Electronics	62.9	25.3	18.8	52.3	79.5	103.8	90.0	65.1
Mitsubishi Electric	90.4	60.0	50.0	68.8	105.0	100.0	91.3	57.9
NEC	102.3	77.5	77.5	113.8	188.7	195.0	177.7	173.6
New JRC	4.8	4.2	1.7	1.6	3.8	3.5	2.9	3.4
Nippon Steel	19.5	12.0	9.5	8.6	9.6	7.8	6.8	4.8
Oki	43.2	25.8	13.9	32.0	46.2	47.4	35.6	18.4
Ricoh	5.0	3.5	2.8	3.7	4.0	4.0	5.0	3.9
Rohm	24.2	14.0	25.9	35.2	52.7	42.2	40.8	49.1
Sanken	6.2	4.4	4.2	4.1	6.1	7.7	7.5	12.4
SANYO	40.4	35.5	38.6	36.3	60.8	60.5	52.6	50.2
Seiko	13.9	9.0	7.0	9.3	10.0	42.3	45.8	25.3
Sharp	33.3	30.0	30.0	34.5	38.0	71.2	63.8	47.0
Shindengen Electric	4.5	5.0	5.0	5.0	4.6	5.6	5.4	5.3
Sony	70.7	47.5	40.0	40.0	42.2	48.3	63.3	60.3
Stanley Electric	NA	NA	NA	NA	NA	NA	0.3	0.5
Toshiba	107.3	85.0	80.0	95.0	152.5	155.0	165.5	142.3
Yamaha	3.5	2.3	2.8	4.5	6.9	7.1	6.4	10.9
Total	**831.2**	**592.3**	**578.7**	**757.9**	**1,108.4**	**1,190.2**	**1,169.9**	**934.6**

NA = Not available
Source: Dataquest (August 1998)

Looking at facilities, the expenditure in property and land is being cut in half, while wafer fab equipment spending is to be reduced by 20 percent, and back-end facilities show only a 6 percent reduction. In view of the continuing overcapacity in the market, Japanese companies are discouraged about increasing overall supply capacity; once again they are carefully filling the shells that they build during the boom years. Most of the wafer fab equipment is aimed at upgrades to 0.25-micron technology, while in a limited number of cases, investments in deep submicron fab equipment are included. The efforts in 300mm wafer technology have been slowed for several reasons, including reduced overall spending, technology/equipment problems, and a market condition of prolonged overcapacity. The ultimate question for semiconductor manufacturers in pursuit of large wafer technology is whether they will really need production capacity of that magnitude. Not many companies can fully enjoy the increased efficiency in production of commodity products including DRAMs, but not many companies are ready to offer SLI products that can utilize 300mm wafer fab capacity. Shifting product preference is seen in back-end investment trends, where the focus on microcomponent and logic requires additional equipment for the interconnect/metal layer.

In the past down-cycle years, Japanese companies sought to increase foundry shipment to improve fab utilization. Ever since the emergence of dedicated foundry providers equipped with advanced logic technology, however, that "opportunistic foundry shipment" practice has become a less easy choice. Dedicated foundries are well prepared to cope with fabless companies' requirements. Foundry providers in Taiwan have a strong tie with the U.S. semiconductor industry, and the tie—especially with fabless companies—has brought them ample orders, taking away business opportunities from other companies. Thus, the decrease in foundry shipments has been another reason for Japanese companies' reduction in additional supply capacity.

The current weak revenue and pricing trends, and consequential dwindling profits, hardly justify strong spending in manufacturing equipment. The question then lies in deciding how much spending is the appropriate amount. There has been a general, empirical belief in the industry that capital spending of over 20 percent of revenue is not necessarily a safe practice unless a company has good reasons to do so and understands the financial risks involved. Looking at Japanese companies' spending, this criterion seems to apply to larger suppliers, while medium-size companies have spent over 20 percent of their revenue, and companies with specific product orientation in discrete and optical areas have spent characteristically less than 15 percent of their revenue. Noteworthy is the ratio for NEC, the largest semiconductor supplier and capital spender among Japanese companies, which is less than 15 percent. Taking into consideration that NEC tends to construct its own proprietary fabs with the exception of recent two cases in China, NEC's investment efficiency is strikingly high among Japanese companies. With the exception of NEC, however, major Japanese companies have started to seek alliances in outsourcing manufacturing at a pace never seen before. This is causing a restructuring of the Japanese semiconductor industry, and Dataquest believes that this is an unavoidable step for Japanese companies to regain strength in the semiconductor business.

Taking into consideration the current trends toward SLI, as well as prolonged DRAM oversupply, it is not likely that Japanese companies will resume a high pace of spending in manufacturing capacity. Even 300mm wafer production has dropped from the list of top priorities, while some companies have not given up technology development and pilot production. Some Japanese companies are facing the ultimate question of whether to make or buy in some product areas where investment efficiency cannot easily be achieved, given their own product portfolio and large amount of expenditure. Dataquest believes that semiconductor vendors that make the bold but required decision to refocus their business, with ample consideration of and emphasis on SLI, will come out shining beyond the current turmoil in the semiconductor industry.

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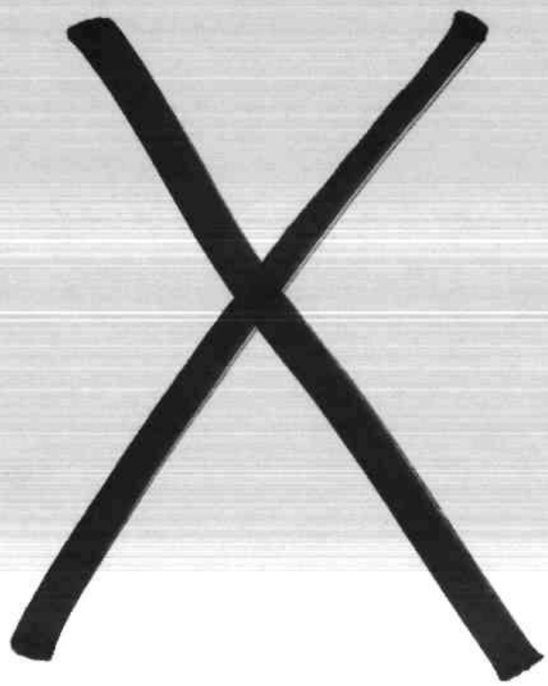

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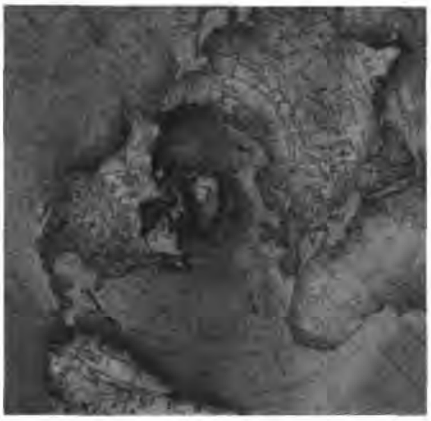
Market Statistics



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Japanese Fab Database

Market Statistics

Program: Semiconductors Japan
Product Code: SEMI-JA-MS-9806
Publication Date: February 8, 1999
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Japanese Fab Database

Market Statistics

Program: Semiconductors Japan
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Chapter 1
Japanese Fab Database

Background and Methodology

This report contains the Japanese portion of Dataquest's wafer fab database. The records in these tables are fabs located in the Japan region. The Semiconductor Equipment, Materials, and Manufacturing Worldwide (SEMM) program conducts extensive annual surveys, complemented with quarterly secondary research to maintain this database. Published once a year, this document represents Dataquest's best insights and estimates into the end-market of semiconductor equipment.

The tables in this report cover planned and existing merchant, captive, and foundry fab lines. A fab line is a series of equipment to do front-end (from initial oxide through wafer probe) semiconductor manufacturing. Occasionally, two or more separate product-specific fab lines or wafer sizes operate in a single clean room or physical plant. In this situation, Dataquest divides the clean room as separate fab lines if the company dedicates equipment to each wafer size or product line. If a company installs substantially different equipment during an expansion (for example, equipment to increase its maximum wafer diameter), again Dataquest divides the clean room and creates two entries into the database. Therefore, a company may operate many fab lines at one location.

Worldwide Geographic Region Definitions and Regional Roll-Ups

Americas

Includes Central America (all nations), Canada, Mexico, United States, Puerto Rico, and South America (all nations).

Japan

Japan is the only single-country region.

Europe, Africa, and Middle East

Includes Africa (all nations), Albania, Andorra, Armenia, Azerbaijan, Belarus, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Gibraltar, Hungary, Iceland, Israel, Italy, Kazakhstan, Kyrgyzstan, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Middle East (all nations), Moldova, Monaco, Netherlands, Norway, Poland, Romania, Russia, San Marino, Scandinavia, Slovakia, Spain, Sweden, Sweden, Switzerland, Tajikistan, Turkey, Turkmenistan, Ukraine, United Kingdom, Uzbekistan, Vatican City, and all nations within the former Yugoslavia.

Asia/Pacific

Includes Australia, Bangladesh, Cambodia, China, Hong Kong, India, Indonesia, Laos, Malaysia, Maldives, Myanmar, Nepal, New Zealand, Pakistan, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, and Vietnam.

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Field Definitions

The Company field indicates the operator of the fab line. For contract manufacturers that trade capacity for capital investment in the fab, Dataquest lists the contract manufacturer. For incorporated joint ventures, Dataquest lists either the incorporated entity or the major investors, separated with slashes.

The City field displays the most detailed location information. This reference is usually a city or town, but could be an often-used district name (for example, Science Park in the city of Hsinchu, Taiwan). If this field lists a district, Dataquest will list the city in the State or Province field. In some cases, a reference to a state or province will be included in the City or District field to create a unique identifier for this location.

The Prefecture field denotes the second most detailed location. This reference is usually a state (for the United States), province (for Canada and many European and Asian countries), or a prefecture (for Japan). For countries within the United Kingdom, Dataquest lists the country name (for example, "Scotland") in this field so Dataquest can list the descriptor "U.K." in the Country field.

The Country field indicates the broadest location identifier in this report. This reference is usually a country, except in the case of the United Kingdom (see "State or Province" above). Because Japan is a single-country region, there is no regional qualifier for fabs in Japan.

The Fab Name field provides a reference to a particular fab or fab line to distinguish it from other fabs or lines owned by that company. Although Dataquest makes every attempt to match the nomenclature used by the company, occasionally some additional qualifiers (for example, "Phase 1") will appear to provide insight to the facility's history or organization.

The Products field lists the products manufactured at this site. The listings generally fall into five product groups, with the following nomenclature and definitions (when warranted):

- MOS memory
  - DRAM: Dynamic RAM
  - EEPROM: Electrically erasable PROM
  - EPROM: Ultraviolet erasable PROM
  - FERRAM: Ferroelectric RAM
  - FIFO: First-in/first-out memory
  - Flash: Flash memory
  - Mem: Memory
  - NV Mem: Nonvolatile memory (ROM, PROM, EPROM, EEPROM, and FERRAM)
  - PROM: Programmable ROM
  - RAM: Random-access memory

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- ROM: Read-only memory
- SGRAM: Synchronous graphics RAM
- Sp Mem: Other specialty memory (such as dual-port, shift-register, or color lookup)
- SRAM: Static RAM
- VRAM: Video RAM

- MOS microcomponent/digital logic
  - Array: Gate array
  - ASIC: Application-specific IC
  - ASSP: Application-specific standard product
  - Bit: Bit slice (subset of MPU functions)
  - CBIC: Cell-based IC
  - Custom: Full-custom IC (single user)
  - DSP: Digital signal processor
  - FPGA: Field-programmable gate array
  - LISP: 32-bit list instruction set processor for AI
  - Logic: Standard logic
  - LSI: Large-scale integration
  - MCU: Microcontroller unit
  - MixSig ASIC: Mixed-signal ASIC
  - MPR: Microperipheral
  - MPRCom: MPR digital communication (ISDN, LAN, UART, or modem)
  - MPU: Microprocessor unit
  - PLD: Programmable logic device
  - RISC: Reduced-instruction-set computation 32-bit MPU
  - Telecom: Telecommunications chip
- Power/discrete/analog (including bipolar power)
  - A/D D/A: Analog-to-digital, digital-to-analog converter
  - Automotive: Dedicated to automobile applications
  - CODEC: Coder/decoder
  - Diode
  - Discrete
  - FET: Field-effect transistor
  - GTO: Gate turn-off thyristor
  - HEMT: High-electron-mobility transistor
  - IGBT: Insulated-gate bipolar transistor

- Interface: Interface IC
- Linear: Linear/analog device
- MDiode: Microwave diode
- MESFET: Metal semiconductor field-effect transistor
- MFET: Microwave field-effect transistor
- Modem: Modulator/demodulator
- MMIC: Monolithic Microwave IC
- MOSFET: MOS-based field-effect transistor
- Op Amp: Operational amplifier
- Pwr IC: Power IC
- Pwr Tran: Power transistor
- Rectifier
- Reg: Voltage regulator
- RF: Radio frequency
- SCR: Schottky rectifier
- Sensor
- Smart Pwr: Smart power
- SST: Small-signal transistor
- Switches: Switching device
- Thyristor
- Tran: Transistor
- Zener Diode

- Optoelectronic
  - CCD: Charge-coupled device (imaging)
  - Coupler: Photocoupler
  - IED: Infrared-emitting diode
  - Image Sensor
  - Laser: Semiconductor laser or laser IC
  - LED: Light-emitting diode
  - Opto: Optoelectronic
  - PDiode: Photo diode
  - PTran: Photo transistor
  - SAW: Surface acoustic wave device
  - SIT Image Sensor: Static induction transistor image sensor

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- Bipolar Digital and Other Devices (includes all digital ICs using a bipolar process)
  - Darlington
  - Micromachining sensors
  - MilStd: Military Standard Logic
  - RadHard: Radiation hardened

The Process Technology field indicates each fab's use of five major types of processes. The process grouping is as follows:

- P/CMOS: P-channel metal-oxide semiconductor (PMOS) or complementary metal-oxide semiconductor (CMOS)
- NMOS: N-channel metal-oxide semiconductor (NMOS)
- BiCMOS: Bipolar and CMOS combined on a chip
- Bipolar
- III-V: Gallium arsenide and other compound semiconductor processes

The Estimated Minimum Geometry is the smallest linewidth feature size, measured in microns, attainable in production volume.

The Wafer Diameter represents the maximum wafer size that the fab or fab line can process. Wafer diameters, although expressed colloquially in inches, conform to metric specifications. For wafers greater than 3 inches in diameter, expression in inches becomes inaccurate. When calculating square inches, Dataquest uses the following approximations:

- Stated diameter of 4 inches (100mm) = Approximate diameter of 3.938 inches
- Stated diameter of 5 inches (125mm) = Approximate diameter of 4.922 inches
- Stated diameter of 6 inches (150mm) = Approximate diameter of 5.906 inches
- Stated diameter of 8 inches (200mm) = Approximate diameter of 7.87 inches
- Stated diameter of 12 inches (300 mm) = Approximate diameter of 11.84 inches.

The Year and Quarter of Initial Production displays the year (and quarter, if available) in which this line, having completed all qualifications, began manufacturing in production volumes. The format for this reference is "year.quarter" (for example, 1994.3 translates to the third calendar quarter of 1994).

The Initial Monthly Wafer Starts field indicates the initial monthly volume of production wafer throughput.

The Estimated Maximum Monthly Wafer Starts field contains the equipment-limited wafer start capacity per four-week period. Only the throughput of the installed equipment and the process complexity limits the maximum starts. Dataquest does not consider current staffing or the number of shifts operating in determining this metric.

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The Fab Type field shows the types of semiconductor manufacturing performed at this location. The fab types include the following:

- "F" indicates that this is a production-based fab.
- "R" indicates a semiconductor R&D and/or trial production facility.
- "P" means that this location produces a pilot line.
- "T" means that this location performs assembly or testing.
- "N" indicates that this location performs foundry production, or contract manufacturing.
- "VD" means that this location performs VHDL design.
- "PD" means that this location performs IC place and route design.

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Chapter 2
Market Statistics Tables

Tables 2-1 and 2-2 provide information on fabs located in the Japan region.

Table 2-1
Japan's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Aishin Seiki	Hekinan-Shi	Aichi	Japan	Shinkawa	Automotive	-	2.20	75	1990.0	4,700	15,700	F
Aishin Seiki	Handa-Shi	Aichi	Japan	Handa	Automotive	-	1.00	150	1991.0	5,700	19,100	F
Asahi Kasei Micro Systems	Atsugi-Shi	Kanagawa	Japan	-	Tran Custom	NMOS	1.60	125	1987.0	1,400	4,000	FRN
Asahi Kasei Micro Systems	Nobeoka-Shi	Miyazaki	Japan	-	SRAM Full Custom Other MOS Logic	PCMOS	0.80	150	1993.3	1,500	6,000	FT
Canon	Hiratsuka-Shi	Kanagawa	Japan	-	Amorphous Image Sensors	III-V	1.70	75	1986.0	3,800	11,000	F
Canon	Hiratsuka-Shi	Kanagawa	Japan	-	ASIC	PCMOS	0.35	150	1988.0	700	3,000	F
Canon Denshi	Chichibu-Shi	Saitama	Japan	-	CCD	-	3.00	125	1984.0	1,700	5,000	F
Casio	Hachioji-Shi	Tokyo	Japan	-	ASIC	-	1.20	100	1985.0	2,700	11,000	FT
Fuji Electric	Matsumoto-Shi	Nagano	Japan	-	Custom ASSP	-	2.00	100	1981.0	4,500	15,000	F
Fuji Electric	Matsumoto-Shi	Nagano	Japan	-	Diode Pwr Tran MOSFET	-	6.00	100	1985.0	17,500	50,000	F
Fuji Electric	Matsumoto-Shi	Nagano	Japan	-	Custom ASSP	-	0.80	150	1990.0	700	3,000	F
Fuji Electric	Matsumoto-Shi	Nagano	Japan	-	MOSFET IGBT High-Voltage Diode	-	3.00	125	1995.0	10,500	30,000	F
Fuji Electric	Matsumoto-Shi	Nagano	Japan	-	IGBT Power MOSFET	-	1.60	200	1998.3	6,600	19,100	F
Fuji Film Microdevice	Kurokawa-Gun	Miyagi	Japan	-	CCD Converter Full Custom	PCMOS	1.00	150	1992.0	1,000	3,000	F
Fuji Xerox	Suzuka-Shi	Mie	Japan	-	Pwr ICs Image Sensor Log	PCMOS	3.00	125	1986.0	1,000	3,000	F
Fujitsu	Isawa-Gun	Iwate	Japan	No. 2	8-bit/16-bit MCU	PCMOS	0.80	125	1982.0	11,200	20,000	F
Fujitsu	Isawa-Gun	Iwate	Japan	No. 3	8-bit/17-bit MCU	PCMOS	0.50	150	1984.0	12,500	50,000	F
Fujitsu	Kuwana-Gun	Mie	Japan	No. 1	Arrays	PCMOS	0.25	150	1984.0	2,500	15,000	F
Fujitsu	Aizu Wakamatsu-Shi	Fukushima	Japan	Bldg. No. 1-1	Bipolar	-	0.60	125	1985.0	2,500	12,000	F
Fujitsu	Aizu Wakamatsu-Shi	Fukushima	Japan	Bldg. No. 1-2	Arrays CBIC 32-bit MCU	PCMOS	0.70	150	1985.0	5,000	20,000	FN
Fujitsu	Kawasaki-Shi	Kanagawa	Japan	-	R&D	PCMOS	0.13	150	1988.0	1,700	5,000	FRVD
Fujitsu	Aizu Wakamatsu-Shi	Fukushima	Japan	Bldg. No. 2-1	Arrays Logic CBIC MPU	PCMOS	0.35	150	1990.2	8,700	15,000	FN
Fujitsu	Isawa-Gun	Iwate	Japan	No. 4-1	16Mb DRAM SGRAM	PCMOS	0.42	150	1990.3	10,000	20,000	F
Fujitsu	Kuwana-Gun	Mie	Japan	No. 3 Phase 1	MPU	PCMOS	0.25	150	1991.0	3,700	5,000	F
Fujitsu	Kuwana-Gun	Mie	Japan	No. 3 Phase 2	R&D	PCMOS	0.18	200	1994.0	200	10,000	F
Fujitsu	Isawa-Gun	Iwate	Japan	No. 4-2	64Mb DRAM	PCMOS	0.32	200	1995.0	10,000	25,000	F
Fujitsu	Aizu Wakamatsu-Shi	Fukushima	Japan	Bldg. No. 2-2	Arrays Logic CBIC MPU	-	0.35	200	1996.0		20,000	F
Fujitsu	Kuwana-Gun	Mie	Japan	No. 2	R&D	PCMOS	0.18	150	1998.0	2,500	10,000	F
Fujitsu-Advanced Micro Devices (FASL)	Aizu Wakamatsu-Shi	Fukushima	Japan	Fab 1	4Mb 8Mb 16Mb Flash	PCMOS	0.25	200	1994.0	10,000	25,000	F
Fujitsu-Advanced Micro Devices (FASL)	Aizu Wakamatsu-Shi	Fukushima	Japan	Fab 2 Phase 2	16Mb Flash	PCMOS	0.35	200	1999.0	5,000	25,000	F
Fujitsu-Advanced Micro Devices (FASL)	Aizu Wakamatsu-Shi	Fukushima	Japan	Fab 2	16Mb 64Mb Flash	PCMOS	0.23	200	1998.2	5,000	25,000	F
Fujitsu-Quantum Device	Nakakoma-Gun	Yamanashi	Japan	No.1	FET Opto HEMT	III-V	1.50	100	1985.0	4,500	4,000	F
Fujitsu-Quantum Device	Nakakoma-Gun	Yamanashi	Japan	No.2	HEMT ASIC MMIC	III-V	0.25	100	1991.0	4,500	4,000	F

Table 2-1 (Continued)
Japan's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Genesys Technology	Nishiwaki-Shi		Japan	-	-	-	1.20	150	1992.0	8,500	19,000	F
Hamamatsu Photonics	Hamamatsu-Shi	Shizuoka	Japan	-	Opto	-	1.70	75	1967.0	5,200	15,000	FR
Hitachi	Nakano-Shi	Nagano	Japan	Nakano	Laser Hybrid	III-V	1.50	75	1980.0	5,200	15,000	FT
Hitachi	Hitachi-Shi	Ibaraki	Japan		Pwr GTO Thyristors TU	Bipolar	3.00	125	1983.0	5,200	15,000	F
Hitachi	Nakakoma-Gun	Yamanashi	Japan	K4-1F	MPU Logic	PCMOS	1.30	125	1983.0	7,500	30,000	F
Hitachi	Hitachinaka-Shi	Ibaraki	Japan	N1-1F	MCU	PCMOS	0.60	150	1983.0	7,500	18,000	F
Hitachi	Takasaki-Shi	Gunma	Japan	Honkan	Discrete Analog	-	1.30	125	1986.0	5,200	60,000	F
Hitachi	Ome-Shi	Tokyo	Japan	D5-1	MPU Memory CBIC	PCMOS	0.18	200	1987.0	1,200	5,000	FR
Hitachi	Takasaki-Shi	Gunma	Japan	TM3	Discrete Analog	-	0.80	125	1988.0	4,500	7,500	F
Hitachi	Chitose-Shi	Hokkaido	Japan	Chitose 2-1F	MCU	PCMOS	0.60	150	1988.0	3,700	15,000	F
Hitachi	Nakakoma-Gun	Yamanashi	Japan	K4-2F	MPU Logic	PCMOS	0.60	125	1988.0	5,000	20,000	F
Hitachi	Goshogawara-Shi	Aomori	Japan	5M-2F	MCU	PCMOS	0.35	150	1988.0	4,000	16,000	F
Hitachi	Nakakoma-Gun	Yamanashi	Japan	K4-3F	MCU SRAM	PCMOS	0.60	150	1989.0	3,500	16,000	F
Hitachi	Takasaki-Shi	Gunma	Japan	T	Discrete Analog	BiCMOS	0.60	150	1992.0	7,000	15,000	F
Hitachi	Hitachinaka-Shi	Ibaraki	Japan	N2-1F	64Mb DRAM MPU	PCMOS	0.18	200	1994.4	10,000	15,000	F
Hitachi	Goshogawara-Shi	Aomori	Japan	5M-1F	MCU	PCMOS	0.80	150	1995.0	4,200	17,000	F
Hitachi	Nakakoma-Gun	Yamanashi	Japan	K2-2F	Flash SRAM	PCMOS	0.35	200	1995.0	5,000	10,000	F
Hitachi	Hitachinaka-Shi	Ibaraki	Japan	N2-2F	64Mb DRAM	PCMOS	0.25	200	1996.0	10,000	15,000	F
Hitachi	Hitachinaka-Shi	Ibaraki	Japan	N2-3F	64Mb DRAM	PCMOS	0.25	200	1996.0	10,000	15,000	F
Hitachi	Hitachinaka-Shi	Ibaraki	Japan	N1-2F	MCU Logic	PCMOS	0.80	150	1996.0	10,000	18,000	F
Hitachi	Hitachinaka-Shi	Ibaraki	Japan	N1-2F	MCU Logic	PCMOS	0.80	150	1996.0	10,000	18,000	F
Honda	Haga-Gun	Tochigi	Japan	Tochigi Lab	Engine Control Sensors MMIC	PCMOS	2.00	75	1990.0	3,800	11,000	F
IBM Microelectronics	Yasu-Gun	Shiga	Japan	-	Array MPU ROM	PCMOS	1.00	125	1986.0	7,500	30,000	F
IBM Microelectronics	Yasu-Gun	Shiga	Japan	-	64Mb DRAM pDSP	PCMOS	0.35	200	1990.0	6,000	15,000	F
Iwatsu	Hachioji-Shi	Tokyo	Japan	-		PCMOS	1.50	125	1986.0	2,100	6,000	F
JVC	Yokosuka-Shi	Kanagawa	Japan	-	1Kb Arrays DSP Custom	PCMOS	3.00	75	1983.0	2,700	9,000	F
Kawasaki Steel	Utsunomiya-Shi	Tochigi	Japan	-	256Kb SRAM CBIC Arrays	PCMOS	0.25	150	1991.0	2,200	9,000	FN
Kobe Steel (KTI)	Nishiwaki-Shi	Hyogo	Japan	KTI Fab 1	16Mb DRAM ASIC	PCMOS	0.50	150	1992.2	12,500	25,000	FT
Kobe Steel (KTI)	Nishiwaki-Shi	Hyogo	Japan	KTI Fab 2	16Mb 64Mb DRAM ASIC	PCMOS	0.35	200	1995.4	8,500	25,000	F
Kodenshi	Uji-Shi		Japan	Plant 3	Opto Discrete	-	0.80	125	1995.2	2,400	7,000	FT
Konica	Nishi-Shinjuku	Tokyo	Japan	Lab	Opto	-	2.20	75	1984.0	2,400	7,000	FR
Kyocera	Kansai-Shi	Kyoto	Japan	-	-	-	0.65	150	1992.2	8,500	19,000	FR
Kyoto Semiconductor	Kyoto-Shi	Niigata	Japan	-	LED Tran Image Sensor	III-V	1.40	100	1985.0	4,400	12,700	F
LSI Logic	Tsukuba-Shi	Ibaraki	Japan	Tsukuba Fab 2	ASIC CBIC MPU MPR SRAM	-	0.60	150	1993.0	2,000	8,000	FN
Matsushita	Arai-Shi	Niigata	Japan	Fab A	Analog Discrete	Bipolar	6.00	100	1967.0	15,800	30,000	F
Matsushita	Hioki-Gun	Kagoshima	Japan	-	Opto LED Laser	-	3.00	51	1974.0	300	1,000	F
Matsushita	Nagaokakyo-Shi	Kyoto	Japan	C	Discrete (Power)	Bipolar	10.00	100	1980.0	6,300	15,000	F

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Table 2-1 (Continued)
Japan's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Matsushita	Hioki-Gun	Kagoshima	Japan	Fab A	Analog	-	2.00	100	1980.0	8,400	28,000	F
Matsushita	Nagaokakyo-Shi	Kyoto	Japan	V	Discrete	-	2.00	100	1982.0	6,600	10,000	F
Matsushita	Arai-Shi	Niigata	Japan	Fab B	MCU Logic ASSP Analog	-	1.50	125	1982.0	4,200	14,000	F
Matsushita	Utsunomiya-Shi	Tochigi	Japan	-	Discrete (Ss Tr Varicap)	NMOS	5.00	100	1983.0	3,500	10,000	FT
Matsushita	Arai-Shi	Niigata	Japan	Fab C-1	Analog	-	2.00	125	1984.0	2,100	5,000	FT
Matsushita	Arai-Shi	Niigata	Japan	Fab C-2	CCD MixSig ICs	-	0.60	125	1984.0	2,400	7,000	FT
Matsushita	Arai-Shi	Niigata	Japan	Fab D-1	Analog	Bipolar	1.80	100	1985.0	6,600	11,000	F
Matsushita	Uozu-Shi	Toyama	Japan	Fab A	Discrete	-	1.50	125	1985.0	8,500	25,000	F
Matsushita	Arai-Shi	Niigata	Japan	Fab D-2	Analog	-	1.50	125	1985.0	5,400	13,000	F
Matsushita	Uozu-Shi	Toyama	Japan	Fab C-1	MPU MCU Logic ASSP	PCMOS	0.80	150	1987.0	6,700	27,000	F
Matsushita	Uozu-Shi	Toyama	Japan	Fab C-2	MCU	PCMOS	0.50	150	1990.0	6,000	20,000	F
Matsushita	Kyoto-Shi	Kyoto	Japan	Kyoto R&D	DRAM MCU Logic	PCMOS	0.25	200	1991.0	200	500	FTR
Matsushita	Uozu-Shi	Toyama	Japan	Fab B	MCU DSP Logic ASSP	PCMOS	0.60	150	1991.0	5,000	20,000	F
Matsushita	Kadoma-Shi	Osaka	Japan	S/C R6	16Mb DRAM 64-bit MPU 64Mb DRAM	PCMOS	0.35	150	1991.1	200	500	FTR
Matsushita	Tonami-Shi	Toyama	Japan	Fab A/B	MCU ASIC Other Memory	PCMOS	0.35	150	1994.0	5,000	15,000	F
Matsushita	Tonami-Shi	Toyama	Japan	Fab C	MCU	PCMOS	0.35	200	1996.4	5,000	20,000	F
Meidensha	Numazu-Shi	Shizuoka	Japan	-	GTO Thyristor	-	4.00	125	1985.0	2,400	7,000	F
Mitsubishi	Kikuchi-Gun	Kumamoto	Japan	B-2F	ASIC MOSFET	PCMOS	1.00	100	1975.0	7,500	30,000	F
Mitsubishi	Fukuoka-Shi	Fukuoka	Japan	No. 1	Pwr Tran Diode Bip	-	3.00	100	1976.0	11,900	34,000	FT
Mitsubishi	Kikuchi-Gun	Kumamoto	Japan	B-1F	OTP MCU	PCMOS	1.00	125	1977.0	9,000	30,000	F
Mitsubishi	Kikuchi-Gun	Kumamoto	Japan	C-2F	MCU SRAM	PCMOS	1.30	125	1981.0	7,000	28,000	F
Mitsubishi	Kikuchi-Gun	Kumamoto	Japan	C-1F	Fast SRAM MCU	-	0.80	125	1982.0	12,500	25,000	F
Mitsubishi	Fukuoka-Shi	Fukuoka	Japan	No. 2	Bipolar Linear A/D D/A Discrete	-	1.50	125	1984.0	14,700	42,000	F
Mitsubishi	Saijo-Shi	Ehime	Japan	SB	MCU	PCMOS	0.90	125	1984.3	19,500	39,000	F
Mitsubishi	Saijo-Shi	Ehime	Japan	SC	MCU	PCMOS	0.80	125	1985.7	10,000	50,000	F
Mitsubishi	Kami-Gun	Kochi	Japan	TA2	8-bit 16-bit 32-bit MCU ASIC	PCMOS	0.50	150	1987.0	15,000	30,000	FT
Mitsubishi	Kami-Gun	Kochi	Japan	TA1	1Mb SRAM ASSP MCU	PCMOS	0.50	150	1989.0	15,000	30,000	F
Mitsubishi	Saijo-Shi	Ehime	Japan	SA-2A	Flash MCU 4Mb SRAM	PCMOS	0.40	150	1991.8	7,000	20,000	F
Mitsubishi	Itami-Shi	Hyogo	Japan	ULSI	64Mb 256Mb DRAM ASIC Flash	PCMOS	0.18	200	1993.0	5,000	10,000	FR
Mitsubishi	Saijo-Shi	Ehime	Japan	SA-2B	eRAM ASIC	PCMOS	0.35	200	1993.1	8,000	16,000	F
Mitsubishi	Kikuchi-Gun	Kumamoto	Japan	D-1F	64Mb DRAM	PCMOS	0.25	150	1996.0	5,000	18,000	F
Mitsubishi	Saijo-Shi	Ehime	Japan	SA-1F	eRAM	PCMOS	0.25	200	1997.0	10,000	15,000	FT
Mitsubishi	Itami-Shi	Hyogo	Japan	E2	Analog Discrete Opto	-	0.8	75				F
Mitsubishi	Itami-Shi	Hyogo	Japan	E3	Analog Discrete Opto	-	0.8	100				F
Mitsubishi	Itami-Shi	Hyogo	Japan	E2	Analog Discrete Opto	-	0.8	75				F
Mitsubishi	Itami-Shi	Hyogo	Japan	E3	Analog Discrete Opto	-	0.8	100				F
Mitsumi	Atsugi-Shi	Kanagawa	Japan	-	Log Discrete	Bipolar	2.00	100	1984.0	10,500	30,000	FT

Table 2-1 (Continued)
Japan's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Mitsumi	Atsugi-Shi	Kanagawa	Japan	-	Logic Power	-	0.80	200	1997.3	7,800	19,700	FT
Moririca Electronics	Yokohama-Shi	Kanagawa	Japan	-	Opto	III-V	1.40	100	1983.0	4,400	12,700	F
Motorola	Aizu Wakamatsu-Shi	Fukushima	Japan	MOS 7	Discrete Logic Analog	-	1.80	100	1972.0	17,500	50,000	FT
Motorola	Fukuyama		Japan	Phenitec	Discrete Power Logic	-	1.00	125	1986.0	4,000	50,000	FJ.V.
Motorola	Yama-Gun	Fukushima	Japan	MOS 7A	Logic Analog	-	0.80	150	1994.0	5,000	25,000	FTR
Murata Manufacturing	Yasu-Gun	Shiga	Japan	Yasu	FET MMIC	III-V	0.80	150	1993.0	5,000	14,400	FR
NEC	Tsuruoka-Shi	Yamagata	Japan	Tsuruoka Works 1	Bipolar Logic Linear Discrete	Bipolar	1.00	100	1976.0	6,000	20,000	FT
NEC	Kumamoto-Shi	Kumamoto	Japan	Dif-5	Logic MCU Other MOS	-	0.80	150	1978.0	10,000	15,000	F
NEC	Otsu-Shi	Shiga	Japan	Dif-1	Pwr Tran Linear	Bipolar	2.00	100	1978.0	8,700	25,000	FT
NEC	Otsu-Shi	Shiga	Japan	Dif-2	MCU LCD Driver	-	0.80	150	1981.0	8,000	30,000	F
NEC	Kumamoto-Shi	Kumamoto	Japan	Dif-4	MCU ASIC	PCMOS	0.80	150	1983.0	7,500	20,000	F
NEC	Otsu-Shi	Shiga	Japan	Dif-3	SRAM 4Mb DRAM Micro ASIC	-	0.50	150	1983.0	4,200	20,000	F
NEC	Kumamoto-Shi	Kumamoto	Japan	Dif-6	MPU	-	0.80	150	1987.0	7,500	30,000	F
NEC	Sagamihara-Shi	Kanagawa	Japan	G-1	16Mb DRAM ASIC MPU 4Mb ROM	-	0.80	150	1988.0	2,500	10,000	FTR
NEC	Kumamoto-Shi	Kumamoto	Japan	Dif-7	MCU ASSP Logic	-	0.50	150	1988.0	7,500	30,000	F
NEC	Otsu-Shi	Shiga	Japan	GaAs	Diode Opto FET	III-V	3.00	75	1988.0	700	5,000	F
NEC	Asa-Gun	Yamaguchi	Japan	Dif-1	SRAM MPU FLASH	-	0.50	150	1988.0	11,200	35,000	FT
NEC	Otsu-Shi	Shiga	Japan	Dif-4	16-bit MCU LCD Driver ASIC	PCMOS	0.25	150	1989.0	10,000	22,000	FT
NEC	Higashi Hiroshima-Shi	Hiroshima	Japan	Dif-1	ASIC MCU Other Memory	PCMOS	0.35	150	1990.4	7,500	60,000	FT
NEC	Tsuruoka-Shi	Yamagata	Japan	Tsuruoka Works 2	Logic Linear MPU ASIC	Bipolar	0.70	125	1993.0	10,000	20,000	F
NEC	Asa-Gun	Yamaguchi	Japan	Dif-2 (Bldg.C)	ASIC	PCMOS	0.35	150	1993.0	22,500	35,000	FT
NEC	Kumamoto-Shi	Kumamoto	Japan	Dif-8	16Mb DRAM 4Mb SRAM RISC ASIC	PCMOS	0.27	200	1994.0	15,000	60,000	F
NEC	Kamigori	Hyogo	Japan	-	-	-	0.50	200	1997.1	7,800	19,700	F
NEC	Higashi Hiroshima-Shi	Hiroshima	Japan	Dif-2	64Mb DRAM ASIC	-	0.25	200	1997.2	11,500	23,000	F
New Japan Radio	Kamifukuoka-Shi	Saitama	Japan	Fab 1	Analog Op Amp Opto	Bipolar	4.00	100	1977.0	7,300	17,000	FTR
New Japan Radio	Kamifukuoka-Shi	Saitama	Japan	Fab 2	Analog A/D D/A	Bipolar	2.50	100	1981.0	10,500	35,000	FTRN
New Japan Radio	Kamifukuoka-Shi	Saitama	Japan	Gaas	Analog Discrete Opto	-	0.50	100	1984.0	200	700	FTRN
New Japan Radio	Kamifukuoka-Shi	Saitama	Japan	Fab 3	Logic Analog MCU	-	0.80	125	1986.0	5,700	21,000	FTRN
Nippon Precision Circuits	Nasu-Gun	Tochigi	Japan	Bldg S	Logic Linear A/D D/A Modem	PCMOS	1.60	100	1984.0	4,500	15,000	F
Nippon Precision Circuits	Nasu-Gun	Tochigi	Japan	Bldg H	A/D D/A DSP Logic ASSP	PCMOS	2.00	150	1990.0	6,000	10,000	F
Nippon Silicon	-	-	Japan	-	16Mb DRAM	-	0.60	150	1990.0	9,800	19,700	FR
Nippon Steel Semiconductor	Tateyama-Shi	Chiba	Japan	M3	16Mb DRAM (will close)	PCMOS	0.40	150	1990.0	10,000	20,000	FT
Nippon Steel Semiconductor	Sagamihara-Shi	Kanagawa	Japan	Electronics Lab	ASIC 16Mb 64Mb DRAM	-	0.35	150	1991.4	200	500	FVDPD
Nippon Steel Semiconductor	Tateyama-Shi	Chiba	Japan	N1	16Mb (64Mb) DRAM (will close)	PCMOS	0.35	200	1996.3	7,000	10,000	FT
Nippondenso	Kariya-Shi	Aichi	Japan	Bldg. 1	Logic Custom MCU Opto	-	1.50	125	1987.0	700	2,000	F
Nippondenso	Nukata-Gun	Aichi	Japan	705	MCU Custom	-	1.50	125	1993.4	2,500	10,000	FT

Table 2-1 (Continued)
Japan's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Nissan	Yokosuka-Shi	Kanagawa	Japan	R&D Center	MCU Custom	PCMOS	2.00	125	1987.0	100	500	FT
NKK	Ayase-Shi	Kanagawa	Japan	Phase 1	256Kb 1Mb 4Mb SRAM Flash MROM RISC MPU ASIC	PCMOS	0.50	200	1992.0	1,500	6,000	F
Oki	Miyazaki-Gun	Miyazaki	Japan	M1	Micro Logic	-	2.00	100	1981.0	15,000	55,000	FTN
Oki	Miyazaki-Gun	Miyazaki	Japan	M2	1Mb DRAM 4MB MROM LOGIC	-	0.80	125	1984.0	21,000	65,000	FTN
Oki	Hachioji-Shi	Tokyo	Japan	V3	Micro Gate Array ROM Flash Bipolar	-	0.35	150	1985.0	500	2,000	FTRVDPD
Oki	Kurokawa-Gun	Miyagi	Japan	S1	4Mb DRAM VRAM 1Mb SRAM 16M MROM Logic	PCMOS	0.45	150	1988.0	15,000	32,500	FTN
Oki	Miyazaki-Gun	Miyazaki	Japan	M3	4Mb 16Mb DRAM Logic	PCMOS	0.40	150	1991.0	15,000	35,000	FT
Oki	Hachioji-Shi	Tokyo	Japan	U1	16Mb 64Mb 256Mb DRAM Micro Logic Flash	PCMOS	0.18	150	1992.0	500	2,500	FRVDPD
Oki	Kurokawa-Gun	Miyagi	Japan	S2	16Mb 64Mb DRAM System LSI ASIC	PCMOS	0.22	200	1996.1	5,000	16,500	FTN
Olympus	Kamiina-Gun	Nagano	Japan	S/C Technology Cente	SIT Image Sensor	PCMOS	3.00	125	1986.0	1,700	5,000	F
Olympus	Hachioji-Shi	Tokyo	Japan	-	IC	-	1.40	100	1987.0	4,400	12,700	F
Omron	Kouka-Gun	Shiga	Japan	-	Opto Image Sensor	-	2.20	100	1975.0	7,000	20,000	F
Omron	Kouka-Gun	Shiga	Japan	-	Opto Image Sensor	-	3.00	100	1987.0	300	1,000	FT
Origin Electric	Oyama-Shi	Tochigi	Japan	-	Tran Diode Discrete	Bipolar	2.20	100	1983.0	5,900	17,000	FT
Pioneer Video	Kofu-Shi	Yamanashi	Japan	-	MPR ASIC Analog	PCMOS	0.80	125	1985.0	2,400	8,000	FT
Ricoh	Ikeda-Shi	Osaka	Japan	Fab 1	GaAs CBIC Voltage Regulator	-	1.50	150	1982.0	1,200	5,000	FVDPDN
Ricoh	Ikeda-Shi	Osaka	Japan	Fab 2	8-bit MCU GaAs CBIC	PCMOS	0.80	100	1986.0	1,200	5,000	FVDPDN
Ricoh	Kato-Gun	Hyogo	Japan	Fab 3	16-bit MCU GaAs CBIC	PCMOS	1.50	150	1990.0	3,000	12,000	FVDPDN
Rohm	Kyoto		Japan	Fab line 1	MCU Bipolar	-	0.35	200	1990.0			FRVD
Sanken	Niiza-Shi	Saitama	Japan	Niiza	Diode	Bipolar	2.20	100	1970.0	15,000	22,000	F
Sanken	Higashine-Shi	Yamagata	Japan	Yamagata Sanken	Pwr Tran Diode IC	-	1.50	125	1981.4	10,000	97,000	F
Sanken	Nihonmatsu-Shi	Fukushima	Japan	Fukushima Sanken	LED	III-V	0.80	75	1991.0	700	2,000	F
SANYO	Oura-Gun	Gunma	Japan	Bip 1	Analog	Bipolar	3.00	51	1967.0	20,000	50,000	FN
SANYO	Oura-Gun	Gunma	Japan	Tr 1	Tran (SST Pw.T)	Bipolar	1.00	100	1972.0	10,500	30,000	FN
SANYO	Oura-Gun	Gunma	Japan	Tr 2	Tran SST Power	Bipolar	2.00	100	1980.0	21,000	80,000	FN
SANYO	Oura-Gun	Gunma	Japan	Bip 2	Analog	Bipolar	3.00	75	1981.0	13,500	50,000	FN
SANYO	Tottori-Shi	Tottori	Japan	Tottori	LED Laser Diode	-	2.00	75	1983.0	14,000	35,000	FN
SANYO	Oura-Gun	Gunma	Japan	MOS 2	Logic ASSP MCU	PCMOS	1.20	125	1984.0	11,000	22,000	FRN
SANYO	Ojiya-Shi	Niigata	Japan	A 1	4-bit 8-bit MCU DSP Logic (ASSP)	PCMOS	0.80	125	1985.0	17,500	35,000	FTN
SANYO	Anpachi-Gun	Gifu	Japan	VL3	SRAM EEPROM Disk Drive ICs Custom CCD nROM	PCMOS	0.35	125	1986.0	10,500	32,000	FRN
SANYO	Ojiya-Shi	Niigata	Japan	B 2	Analog	-	1.20	125	1987.0	30,000	44,000	FTN
SANYO	Ojiya-Shi	Niigata	Japan	B 1	EEPROM Flash Logic ASSP 8-bit MCU 1Mb DRAM	PCMOS	0.50	150	1989.0	14,000	28,000	FTN

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Table 2-1 (Continued)
Japan's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
SANYO	Oura-Gun	Gunma	Japan	Bip 3	Analog	Bipolar	1.20	100	1991.0	12,000	40,000	FN
SANYO	Anpachi-Gun	Gifu	Japan	Tr-G1	MOSFET	PCMOS	0.80	100	1991.0	6,000	5,000	FN
SANYO	Ojiya-Shi	Niigata	Japan	C 2	DRAM Logic SRAM Flash	PCMOS	0.50	150	1994.0	12,500	20,000	FTN
SANYO	Ojiya-Shi	Niigata	Japan	C1	Flash MCU	-	0.35	200	1998.0	10,000	15,000	FTN
SANYO	Anpachi-Gun	Gifu	Japan	Tr-G2	MOSFET	PCMOS	0.80	125			15,000	F
SANYO	Oura-Gun	Gunma	Japan	Tr 3	RF Tran Compound	Bipolar	2.00	75			500	F
Seiko Epson	Suwa-Gun	Nagano	Japan	Bldg. B	Arrays CBIC SRAM EEPROM	-	2.50	100	1981.0	12,500	50,000	FN
Seiko Epson	Suwa-Gun	Nagano	Japan	Bldg. A	Arrays 256Kb SRAM EPROM	PCMOS	1.50	125	1985.0	8,700	35,000	FN
Seiko Epson	Suwa-Gun	Nagano	Japan	Bldg. D	1Mb SRAM ASIC	-	0.80	150	1989.0	5,000	25,000	F
Seiko Epson	Sakata-Shi	Yamagata	Japan	Bldg 3	FPGA PLD CBIC	-	0.65	150	1991.0	5,000	20,000	FN
Seiko Epson	Sakata-Shi	Yamagata	Japan	-	ICs SRAM Telecom ICs PLDs FPGAs ASICsDRAMembDRAM	-	0.25	200	1997.4	5,000	20,000	F
Seiko Instruments	Matsudo-Shi	Chiba	Japan	-	SRAM Arrays CBIC EEPROM	PCMOS	0.80	150	1987.0	700	3,000	FN
Sharp	Tenri-Shi	Nara	Japan	Tenri	Analog LCD Driver	-	1.20	125	1977.0	7,500	25,000	F
Sharp	Tenri-Shi	Nara	Japan	Factory 3	SRAM MROM MCU ASIC LCD Driver	-	0.80	125	1980.0	6,600	22,000	FTN
Sharp	Kita Katsuragi-Gun	Nara	Japan	-	Optocoupler	III-V	1.60	75	1981.0	8,700	25,000	FTN
Sharp	Fukuyama-Shi	Hiroshima	Japan	Factory 1	MCU Arrays CBIC LCD Driver	PCMOS	0.80	150	1985.0	7,500	35,000	F
Sharp	Fukuyama-Shi	Hiroshima	Japan	Factory 1B	MCU Arrays CBIC LCD Driver	PCMOS	0.80	150	1985.0	7,500	30,000	F
Sharp	Yamato Koriyama-Shi	Nara	Japan	-	Laser LED Opto	III-V	1.70	75	1987.0	7,700	22,000	PT
Sharp	Fukuyama-Shi	Hiroshima	Japan	Factory 2	16Mb MROM 256kSRAM Opto	PCMOS	0.60	150	1989.0	20,000	40,000	FTN
Sharp	Fukuyama-Shi	Hiroshima	Japan	Factory 3	Flash 32Mb MROM SRAM Opto DRAM Logic	PCMOS	0.35	200	1993.0	15,000	25,000	FN
Shimadzu	Atsugi-Shi	Kanagawa	Japan	Atsugi	Laser Diode	III-V	1.60	100	1985.0	4,400	12,700	FT
Shindengen	Honjo-Shi	Akita	Japan	Ohura -1	Diode Thyristor	Bipolar	10.00	51	1972.0	35,000	100,000	F
Shindengen	Honjo-Shi	Akita	Japan	Ohura -2	Diode Thyristor	Bipolar	10.00	51	1983.0	21,000	60,000	FT
Shindengen	Higashine-Shi	Yamagata	Japan	Bldg. 1	Tran	-	10.00	75	1965.0	10,000	15,000	F
Shindengen	Higashine-Shi	Yamagata	Japan	Bldg. 2	MOSFET	-	10.00	75	1987.0	8,700	25,000	F
Shindengen	Hanno-Shi	Saitama	Japan	R&D Center	Pwr MOSFET Hybrid	NMOS, Bipolar	5.00	100	1989.0	300	1,000	FTVDPD
Shindengen	Hanno-Shi	Saitama	Japan	Trial	Pwr MOSFET Hybrid	NMOS, Bipolar	5.00	100	1991.0	300	1,000	FT
Shindengen	Higashine-Shi	Yamagata	Japan	Bldg. 3	Power Tran	-	10.00	100	1993.0	5,000	7,000	F
Sony	Kokubu-Shi	Kagoshima	Japan	-	CCD	NMOS	0.60	125	1973.0	7,000	20,000	F
Sony	Kokubu-Shi	Kagoshima	Japan	No. 2 Phase1	Discrete	Bipolar	3.00	100	1975.0	30,000	20,000	F
Sony	Kokubu-Shi	Kagoshima	Japan	No. 2 Phase2	Linear A/D D/A	Bipolar	2.00	125	1976.0	25,000	20,000	F
Sony	Kokubu-Shi	Kagoshima	Japan	No. 4	SRAM MCU	-	1.30	125	1978.0	14,000	28,000	FT
Sony	Atsugi-Shi	Kanagawa	Japan	-	Linear	Bipolar	2.00	100	1983.0	100	400	FT
Sony	Atsugi-Shi	Kanagawa	Japan	-	FET Laser CCD HEMT	III-V	2.00	75	1988.0	100	500	FT
Sony	Isahaya-Shi	Nagasaki	Japan	2G	CCD 256Kb SRAM 1Mb SRAM	PCMOS	0.80	150	1989.4	5,900	17,000	F

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Table 2-1 (Continued)
Japan's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Sony	Isahaya-Shi	Nagasaki	Japan	3G	1Mb SRAM 4Mb VRAM CCD Logic	PCMOS	0.50	150	1991.1	8,700	25,000	F
Sony	Kokubu-Shi	Kagoshima	Japan	No. 6	Logic Memory MCU Linear	-	0.80	150	1992.0	7,500	15,000	FT
Sony	Isahaya-Shi	Nagasaki	Japan	4G	Logic	-	0.35	150	1997.0	2,500	10,000	F
Sony	Kokubu-Shi	Kagoshima	Japan	-	Logic	-	0.35	200	1997.0	2,500	10,000	F
Stanley	Hadano-Shi	Kanagawa	Japan	-	Laser LED	III-V	1.60	100	1986.0	3,500	10,000	F
Stanley	Yamagata		Japan	-	LED	III-V	1.20	150	1993.0	5,000	14,400	F
Sumitomo Metal Industries	Amagasaki-Shi	Hyogo	Japan	-	4Mb DRAM Arrays	-	0.80	150	1991.0	300	300	F
Texas Instruments	Hayami-Gun	Oita	Japan	Hiji 1	Logic Linear GaAs	Bipolar	1.00	125	1974.0	2,000	8,000	F
Texas Instruments	Inashiki-Gun	Ibaragi	Japan	Miho 5	ASSP ASIC MPU DSP CBIC	NMOS	1.00	125	1982.0	7,200	29,000	FT
Texas Instruments	Hatogaya-Shi	Saitama	Japan	Hato	Analog LCD Driver ASSP	-	1.00	125	1982.0	5,300	17,700	FT
Texas Instruments	Inashiki-Gun	Ibaragi	Japan	Miho 6	1Mb 4Mb DRAM ASSP MPU	-	0.80	150	1988.0	3,700	15,000	FT
Texas Instruments	Hayami-Gun	Oita	Japan	Hiji 8	Logic	-	0.80	150	1990.0	5,000	10,000	F
Tokin	Sendai-Shi	Miyagi	Japan	-	Power SIT	Bipolar	1.70	75	1984.0	3,500	10,000	F
Toko	Iruma-Gun	Saitama	Japan	-	-	NMOS	3.00	125	1990.0	5,200	15,000	F
Toko	Iruma-Gun	Saitama	Japan	-	A/D D/A Telecom Diode	Bipolar	3.50	125	1990.0	7,000	20,000	FT
Toshiba	Kawasaki-Shi	Kanagawa	Japan	Bldg.108 D-1	Pwr Tran Lin	-	2.00	125	1970.0	5,200	15,000	F
Toshiba	Kimitsu-Shi	Chiba	Japan	Phase 1 & 2	Diode Rectifier Thyristor	Bipolar	4.00	100	1970.0	15,400	44,000	FT
Toshiba	Himeji-Shi	Hyogo	Japan	No.2	Tran Diode FET	-	0.35	150	1982.0	10,500	30,000	FT
Toshiba	Kitakami-Shi	Iwate	Japan	Bldg.101, D-1	CCD ASIC MPU MCU MROM	PCMOS	0.60	125	1984.0	10,000	40,000	FT
Toshiba	Kita Kyushu-Shi	Fukuoka	Japan	Kubik 1	Bipolar Analog Opto	-	1.50	100	1986.0	12,600	45,000	F
Toshiba	Kitakami-Shi	Iwate	Japan	Bldg.101, D-2	CCD ASIC MPU MCU MROM	PCMOS	0.60	125	1986.0	14,000	40,000	F
Toshiba	Oita-Shi	Oita	Japan	C-Cubed 1	MCU Logic	-	0.60	125	1986.0	8,200	33,000	F
Toshiba	Oita-Shi	Oita	Japan	C-Cubed 2	MCU Logic	PCMOS	0.60	125	1987.0	8,000	32,000	F
Toshiba	Kita Kyushu-Shi	Fukuoka	Japan	Kubik 2	Bipolar Analog	-	1.20	125	1988.0	9,000	20,000	FN
Toshiba	Kitakami-Shi	Iwate	Japan	Bldg.102, D-3	ASIC	PCMOS	0.60	150	1989.0	3,700	15,000	F
Toshiba	Oita-Shi	Oita	Japan	C-Cubed 3	MCU Logic SRAM Flash	PCMOS	0.40	150	1989.0	8,000	32,000	F
Toshiba	Himeji-Shi	Hyogo	Japan	No.1	Pwr FET Tran Diode	-	2.00	125	1990.0	15,700	45,000	FT
Toshiba	Kawasaki-Shi	Kanagawa	Japan	Bldg.108 D-2	16Mb 64Mb DRAM Flash MPU Logic	PCMOS	0.35	200	1990.0	600	1,300	F
Toshiba	Kitakami-Shi	Iwate	Japan	Bldg.102, D-4	EPROM MROM MPU ASIC	PCMOS	0.40	150	1991.0	3,700	15,000	F
Toshiba	Oita-Shi	Oita	Japan	C-Cubed 4	Embedded DRAM Flash	PCMOS	0.25	200	1991.0	20,000	40,000	F
Toshiba	Nomi-Gun	Ishikawa	Japan	-	Pwr Tran	Bipolar	2.00	125	1992.0	10,500	30,000	FT
Toshiba	Kita Kyushu-Shi	Fukuoka	Japan	Kubik 3	Analog	-	0.60	150	1993.0	9,000	30,000	F
Toshiba	Kitakami-Shi	Iwate	Japan	Bldg.106, D-5	EPROM MROM MPU ASIC	-	0.40	150	1993.0	6,000	24,000	F
Toshiba	Yokkaichi-Shi	Mie	Japan	Y-Cubed, No. 1-Mod 1	SRAM Flash	PCMOS	0.45	200	1993.0	5,000	10,000	F
Toshiba	Yokkaichi-Shi	Mie	Japan	Y-Cubed, No. 1-Mod 2	SRAM Flash	PCMOS	0.20	200	1994.0	10,000	25,000	F

Table 2-1 (Continued)
Japan's Existing Pilot and Production Fab Lines (Including Fabs Beginning Operation in 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Toshiba	Yokkaichi-Shi	Mie	Japan	Y-Cubed, No. 2	64Mb 128Mb 256Mb DRAM	PCMOS	0.18	200	1996.3	14,000	28,000	F
Toshiba	Oita-Shi	Oita	Japan	C-Cubed 5	Embedded DRAM MCU MPR Logic	-	0.25	200	1997.4	12,500	25,000	F
Toshiba-Motorola (Tohoku)	Sendai-Shi	Miyagi	Japan	Tohoku Step 1	ASIC MPU MCU	PCMOS	0.80	150	1988.0	1,800	7,500	FT
Toshiba-Motorola (Tohoku)	Sendai-Shi	Miyagi	Japan	Tohoku Step 1	ASIC MPU MCU	PCMOS	0.80	150	1988.0	1,800	7,500	FT
Toshiba-Motorola (Tohoku)	Sendai-Shi	Miyagi	Japan	Tohoku Step 2	ASIC MPU MCU	-	0.60	150	1991.0	2,500	10,000	F
Toshiba-Motorola (Tohoku)	Sendai-Shi	Miyagi	Japan	Tohoku Step 2	ASIC MPU MCU	-	0.60	150	1991.0	2,500	10,000	F
Toshiba-Motorola (Tohoku)	Sendai-Shi	Miyagi	Japan	Tohoku Step 3	ASIC MPU MCU	PCMOS	0.35	200	1995.2	7,500	15,000	F
Toshiba-Motorola (Tohoku)	Sendai-Shi	Miyagi	Japan	Tohoku Step 3	ASIC MPU MCU	PCMOS	0.35	200	1995.2	7,500	15,000	F
Toyoda Group	Kariya-Shi	Aichi	Japan	Higashi Kariya	ASIC	PCMOS	0.80	125	1990.0	4,400	17,800	F
Toyoda Group	Obu-Shi	Aichi	Japan	Kyowa	Power Tran	Bipolar	2.20	100	1990.2	6,100	17,600	FT
Toyoda Group	Inazawa-Shi	Aichi	Japan	Technology Center	LED	III-V	25.00	51	1993.0	11,600	33,200	F
Toyota Motor	Toyota-Shi	Aichi	Japan	Me	MCU Pwr ICs Custom	-	2.00	125	1990.0	100	500	FT
UMC Group	Tateyama-Shi	Chiba	Japan	M3	16Mb DRAM	PCMOS	0.40	150	1990.0	10,000	20,000	FT
Unizon	Itami-Shi	Hyogo	Japan	-	Zener Diode Reg Arrays	Bipolar	1.20	125	1984.0	3,500	10,000	F
Yamaha	Toyooka-Mura	Shizuoka	Japan	Building 11	ASIC MPR	PCMOS	0.35	150	1990.10	5,000	6,000	FRVDPD
Yamaha	Aira-Gun	Kagoshima	Japan	Fab 2	ROM CBIC ASSP	PCMOS	0.50	150	1996.10	2,500	5,000	FTN
Yamaha	Hamamatsu-Shi	Shizuoka	Japan	Tenryu	ASIC ASSP	PCMOS	0.25	200	1998.6	1,700	7,000	F
Yokogawa Int	Kamiina-Gun	Nagano	Japan	-	Tran Diode Opto Analog	-	3.00	100	1988.0	2,400	7,000	FT

Source: Dataquest (December 1998)

Table 2-2
Japan's Future Pilot and Production Fab Lines (Including Fabs Beginning Operation during 1998)

Company	City or District	Prefecture	Country	Fab Name	Products	Process Technology	Estimated Minimum Geometry	Wafer Diameter	Year of Initial Production	Initial Monthly Wafer Starts per Month	Estimated Maximum Monthly Wafer Starts	Fab Type
Fuji Electric	Matsumoto-Shi	Nagano	Japan	IGBT Power MOSFET	-	-	1.60	200	1998.3	6,600	19,100	F
Fujitsu	Kuwana-Gun	Mie	Japan	R&D	No. 2	PCMOS	0.18	150	1998.0	2,500	10,000	F
Fujitsu	Aizu Wakamatsu-Shi	Fukushima	Japan	Logic Memory	Bldg. No. 3-1 300mm		0.18	300	2001.0	7,500	15,000	F
Fujitsu-Advanced Micro Devices (FASL)	Aizu Wakamatsu-Shi	Fukushima	Japan	16Mb 64Mb Flash	Fab 2	PCMOS	0.23	200	1998.2	5,000	25,000	F
Fujitsu-Advanced Micro Devices (FASL)	Aizu Wakamatsu-Shi	Fukushima	Japan	16Mb Flash	Fab 2 Phase 2	PCMOS	0.25	200	1999.0	4,300	12,500	F
Hitachi	Hitachinaka-Shi	Ibaraki	Japan	64Mb 256Mb DRAM	N3-2F	-	0.18	200	2000.0	5,000	30,000	F
Kawasaki Steel	Utsunomiya-Shi	Tochigi	Japan	SOC ASICs for Telecom and Consumer Electronics	Phase 2	PCMOS	0.18	150	2001.0	1,000	4,000	F
Kawasaki Steel	Utsunomiya-Shi	Tochigi	Japan	SOC ASICs for Telecom and Consumer Electronics	-	PCMOS	0.18	150	2001.0	1,000	4,000	F
Matsushita	Arai-Shi	Niigata	Japan	Memory Logic	-	-	0.18	200	2001.0	3,000	5,000	F
NEC	Sagamihara-Shi	Kanagawa	Japan	-	UC	-	0.18	200	2000.0	1,700	5,000	F
Rohm	-	-	Japan	16Mb ROM ASIC MCU Telecom ICs	Fab Line 2	-	0.25	200	1999.3	-	-	FTR
SANYO	Ojiya-Shi	Niigata	Japan	Flash MCU	C1	-	0.35	200	1998.0	10,000	15,000	FTN
Yamaha	Hamamatsu-Shi	Shizuoka	Japan	ASIC ASSP	Tenryu	PCMOS	0.25	200	1998.6	1,700	7,000	F

Source: Dataquest (December 1998)

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Japanese Semiconductor Consumption Forecast by Electronics Application, Fall 1998

Market Statistics

Program: Semiconductors Japan
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Preface

Dataquest's *Japanese Semiconductor Consumption Forecast by Electronics Application, Fall 1998* is a revised and reformatted version of our long-standing semiannual semiconductor consumption by electronics application market forecast. We have made several changes to this publication in an effort to make it more relevant and meaningful; we have also included a new category of information that shows unit production trends for selected systems. Major changes include:

- Categorization changes to secure consistency with electronic equipment production forecasts
- Addition of high-volume electronic equipment unit production forecast data for 40 major systems

Dataquest has directed its semiconductor applications research toward better understanding the dynamics of production and semiconductor use across individual electronic systems. We have developed forecast models capable of tracking production and estimating total semiconductor consumption for some 40 different individual electronic systems, shown in full scale for the first time in this report.

Project Analyst: Motoya Ohgami

Chapter 1
Introduction and Discussion

Introduction

This document contains Dataquest's forecast of Japanese semiconductor consumption by electronics application, 1997 to 2002, based both on U.S. dollars and Japanese yen. It also contains our forecast of worldwide semiconductor consumption by broad categories over the same period. This is the second of two semiannual forecasts. This forecast reflects changes since this spring in Dataquest's view of semiconductor consumption by electronic equipment worldwide and in Japan. It incorporates changes suggested by Dataquest's recently updated forecasts of electronic equipment production and semiconductor shipments.

The tables in this document present data intended to answer the following questions:

- What is the estimated semiconductor consumption of various categories of electronic equipment?
- What is the estimated semiconductor consumption of the key individual electronic systems that make up these broad categories?

The estimates offered in this document are intended to provide very general answers to these questions. They are meant as a broad guide to semiconductor consumption by electronic equipment production in Japan. The most detailed information about estimated semiconductor consumption by individual electronic systems is available in the last chapter of this document.

The semiconductor consumption forecasts presented here complement Dataquest's recently updated forecasts of electronic equipment production and semiconductor shipments. Updated Japanese electronic equipment forecasts can be found in the Market Statistics report *Japanese Electronic Equipment Production Forecast, Fall 1998* (November 1998). Our updated semiconductor forecast is found in the Market Trends report *Worldwide Semiconductor Forecast and Trends, Fall 1998* (November 1998). Additional regional and semiconductor device details for this forecast can also be requested through Dataquest's inquiry service.

The tables in this document are organized as follows:

- Tables 2-1 and 2-2 summarize the worldwide semiconductor consumption forecast and compare it to the worldwide semiconductor shipments forecast.
- Tables 2-3 and 2-4 summarize the Japanese semiconductor consumption forecast on a dollar basis and compare it to the Japanese semiconductor shipments forecast.
- Tables 2-5 to 2-12 detail Japanese semiconductor consumption by individual electronic system, grouped by equipment type, on a dollar basis.

- Tables 2-13 and 2-14 summarize the Japanese semiconductor consumption forecast on a yen basis and compare it to the Japanese semiconductor shipments forecast.
- Tables 2-15 to 2-22 detail Japanese semiconductor consumption by individual electronic system, grouped by equipment type, on a yen basis.
- Tables 3-1 to 3-40 present unit production and semiconductor consumption forecasts in Japan for 40 major electronic systems.
- Figures 3-1 to 3-40 show Japan's share of the worldwide unit production for 40 major electronic systems for 1997 and 2002.

Segmentation of Semiconductor Applications

Dataquest forecasts semiconductor consumption by end-use electronic application. We divide electronic applications into six broad groups in accordance with our segmentation of electronic equipment production. These groups are, in turn, disaggregated into more narrow electronic systems categories, as follows:

- Data processing
    - Computers
    - Data storage
    - Input/output devices
    - Dedicated systems
    - Other data processing
- Communications
    - Premise telecommunications
    - Public telecommunications
    - Mobile communications
    - Broadcast and studio equipment
    - Other communications
- Industrial
    - Security and energy management systems
    - Manufacturing systems and instruments
    - Medical equipment
    - Other industrial equipment
- Consumer
    - Audio
    - Video
    - Personal electronics
    - Appliances
    - Other consumer equipment

- Military/civil aerospace
- Transportation

As part of the forecast process, Dataquest develops forecasts for about 40 individual electronic systems within these various categories and subcategories. These include the following:

- Data processing
  - Mainframes/supercomputers (computers)
  - Midrange computers (computers)
  - Workstations (computers)
  - PCs (computers)
  - Motherboards (computers)
  - Rigid disk drives (data storage)
  - Optical disk drives (data storage)
  - Removable magnetic storage (data storage)
  - Page printers (input/output)
  - Serial printers (input/output)
  - Monitors (input/output)
- Communications
  - LAN cards (premise telecommunications)
  - Premise line cards (premise telecommunications)
  - Answering machines (premise telecommunications)
  - Fax machines (premise telecommunications)
  - Modems (premise telecommunications)
  - Corded telephones (premise telecommunications)
  - Analog cordless phones (premise telecommunications)
  - Digital cordless phones (premise telecommunications)
  - Central office line cards (public telecommunications)
  - Analog cellular phones (mobile telecommunications)
  - Digital cellular phones (mobile telecommunications)
  - Pagers (mobile telecommunications)
  - Mobile telecommunications infrastructure (mobile telecommunications)
  - Other mobile telecommunications products (mobile telecommunications)

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- Consumer
  - Personal/portable stereos (audio)
  - Color TVs (video)
  - VCRs (video)
  - Analog camcorders (video)
  - Digital camcorders (video)
  - DVDs (video)
  - Analog set-top boxes (video)
  - Digital set-top boxes (video)
  - Digital still cameras (personal electronics)
  - Video game controllers (personal electronics)
- Transportation
  - Automotive stereos
  - Automotive engine control units (ECUs)
  - Antilock braking systems
  - Air bags
  - Automotive navigation systems

Geographic Segmentation

Dataquest's worldwide electronic equipment production forecast is aggregated from individual forecasts for four principal geographic regions:

- Americas
- Japan
- Europe, Middle East, and Africa
- Asia/Pacific

Exchange Rates

Dataquest's worldwide electronic equipment forecast aggregates data from many countries, each of which uses a currency that has a different and fluctuating exchange rate relative to the U.S. dollar. Because we compile our worldwide forecast from individual regional forecasts, we use the U.S. dollar as a common currency for comparisons and aggregation. As a rule, Dataquest calculates forecasts in local currencies and then converts them to U.S. dollars using projected average annual exchange rates. Dataquest does not forecast exchange rates per se. Instead, we calculate projected average annual exchange rates from current exchange rates. Our projections are based on estimates of the latest available monthly exchange rate at the time the forecast is developed. These rates are based on monthly exchange rates observed through July 1998. Additional information about historical exchange rates and Dataquest's method of calculating future average exchange rates may be requested through Dataquest's client inquiry service.

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Forecast Methodology

When discussing semiconductor consumption, it is critical to remember that semiconductors are not end products consumed for their own sake. They are intermediate products used as inputs for electronic end products that are eventually consumed by individuals and businesses for the utility they provide. Implicit in the concept of semiconductor consumption is the notion that the electronic end products in which semiconductors will be incorporated or consumed can be specified. A semiconductor forecast that does not or cannot specify this is not a forecast of semiconductor consumption. At best, it is merely a forecast of semiconductor shipments.

Dataquest's semiconductor consumption by electronic application forecast grew out of the recognition that a truly complete semiconductor forecast must specify the electronic end uses of semiconductors. However, specifying semiconductor end uses has proved far more difficult than recognizing that it must be done. Although it appears possible to specify semiconductor consumption by the variety of electronics produced, there are simply too many different types of semiconductor devices consumed in too large a variety of electronic products. As a result, semiconductor consumption must invariably be estimated. This can be done in any number of ways. Before this forecast, Dataquest used a mathematical model to estimate semiconductor consumption by various electronic end uses. Taking Dataquest's electronic equipment production and semiconductor shipments forecasts as inputs, this model allocated estimated semiconductor shipments across forecast electronics production subject to various assumptions about the semiconductor content of electronic products. The model also imposed several balancing conditions intended to guarantee that estimated semiconductor shipments were completely allocated across all forecast electronics production.

The model applied a top-down approach to estimating semiconductor consumption. In effect, it calculated estimates of semiconductor consumption by compelling agreement between the details of the electronics production forecast and the semiconductor shipments forecast. As a result, the estimates of semiconductor consumption were more an artifact of a mathematical process than truly independent estimates of semiconductor consumption. Although the model offered considerable flexibility, it was nonetheless limited by the validity of its semiconductor content assumptions and the balancing requirement that semiconductor consumption equal semiconductor shipments. Despite its potential drawbacks, the model provided the best estimates we could offer, given a paucity of knowledge about semiconductor applications in specific electronic systems.

Over the last several years, Dataquest's semiconductor applications research has been concentrated on the study of semiconductor use in specific individual electronic systems. We have successfully developed models to track and forecast the production and semiconductor consumption of some 40 different individual electronic systems. These include PCs and PC motherboards, rigid disk drives, LAN cards and modems, digital cellular phones, digital set-top boxes, and automotive navigation systems, among others. The electronic systems encompassed by our models account for about one-half of all electronics production and nearly two-thirds of estimated semiconductor consumption.

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These models have allowed us not only to codify our knowledge about individual electronic systems but also to approach the task of estimating semiconductor consumption using a bottom-up forecast method. This method was used for the forecast and will be used for future forecasts. The method essentially involves building a forecast of semiconductor consumption for all electronics production by leveraging estimates of semiconductor consumption for individual electronic systems. Dataquest uses individual systems estimates as a forecast base and augments this with estimates of semiconductor consumption for other electronic equipment categories not tracked individually. Precisely because the method uses well-researched knowledge about individual electronics systems that dominate semiconductor consumption, Dataquest believes it is capable of providing far better forecasts of semiconductor consumption than our former top-down method, especially for electronic equipment categories such as computers, where individual systems forecasts account for virtually the entire category. The results of this analysis are shown in Chapter 3.

Forecast Highlights

Dataquest estimates that worldwide semiconductor consumption will decrease by 0.2 percent in 1998 to about $148.0 billion. Dataquest expects approximately two-thirds of this growth will come about because of growth in worldwide electronics production, which is now forecast to grow 2.2 percent in 1998 to about $935.8 billion. The remainder will be the result of expected growth in the average semiconductor content of electronics, which we forecast will increase to about 15.8 percent of electronics factory value. Longer-term, we estimate worldwide semiconductor consumption will average 10.3 percent annual growth through 2002. This should raise worldwide semiconductor consumption to about $241.6 billion by 2002. Dataquest expects slightly over half of the longer-term growth in worldwide semiconductor consumption to come about because of growth in worldwide electronics production, which we are now forecasting to average 6.1 percent annual growth through 2002. Once again, remaining growth in semiconductor consumption will be the result of increases in the average semiconductor content of electronics. We now expect average semiconductor content will rise to about 19.7 percent of electronics factory value by 2002.

We are now forecasting Japanese semiconductor consumption will decrease by 10.4 percent in 1998. This compares to anticipated growth rates of 3.8 percent for Asia/Pacific and 5.0 percent for Europe, the Middle East, and Africa. In the long term, Japanese consumption is expected to average just 4.6 percent annual growth between 1997 and 2002, as opposed to 13.9 percent for Asia/Pacific and 10.2 percent for Europe, the Middle East, and Africa. (Note: All of our forecasts are valued in U.S. dollars and thus reflect projected exchange rate movements in addition to expected changes in semiconductor consumption expressed in local currencies.) Underlying these marked differences in long-term growth are equally marked differences in expected sources of growth.

There is a strong desire among suppliers to believe that semiconductor shipments, and with them semiconductor revenue, can continue to post high rates of long-term growth. However, this desire needs to be tempered with the recognition that long-term shipments growth is only possible so long as electronics makers are able to profitably increase semiconductor consumption, either by expanding electronics production or increasing semiconductor content. A number of fundamental changes are taking place in several key electronics markets that will limit the future ability of electronics makers to profitably increase semiconductor consumption. Semiconductor suppliers would be well advised to acknowledge these emerging limits because failure to do so will only intensify competition and further imperil both future shipment and revenue growth in Japan.

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Chapter 2

Worldwide and Japanese Semiconductor Consumption Forecasts

Tables 2-1 through 2-22 present Dataquest's forecast of worldwide and Japanese semiconductor consumption by electronics application.

Table 2-1
Value of Semiconductors Consumed Worldwide by Electronic Product Group, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
All Electronic Products	**148,293**	**147,951**	**165,368**	**196,390**	**229,875**	**241,605**
Data Processing Products	**71,174**	**69,312**	**80,338**	**103,376**	**127,647**	**130,236**
Computers	50,005	47,211	54,744	73,208	92,455	91,212
Data Storage	8,631	9,418	11,159	12,888	14,405	16,379
Input/Output	6,898	7,061	7,655	8,656	10,043	10,906
Dedicated Systems	2,720	2,728	3,445	4,558	5,751	6,364
Other Data Processing	2,921	2,895	3,334	4,066	4,993	5,375
Communications Products	**30,035**	**31,407**	**33,992**	**36,811**	**39,960**	**43,071**
Premise Telecommunications	11,401	12,181	13,346	13,927	15,016	15,844
Public Telecommunications	4,561	4,402	4,912	5,279	5,707	6,075
Mobile Communications	11,458	12,149	12,694	14,050	15,091	16,658
Broadcast and Studio	900	952	1,092	1,297	1,574	1,763
Other Communications	1,716	1,722	1,947	2,259	2,572	2,732
Industrial Products	**13,095**	**12,721**	**14,150**	**15,960**	**17,882**	**19,771**
Security/Energy Management	1,332	1,383	1,550	1,783	2,075	2,320
Manufacturing Systems/Instruments	8,226	7,778	8,629	9,765	10,955	12,125
Medical Equipment	1,413	1,473	1,613	1,744	1,900	2,085
Other Industrial	2,124	2,088	2,359	2,667	2,952	3,240
Consumer Products	**23,737**	**23,622**	**24,948**	**26,962**	**29,533**	**31,905**
Audio	3,933	3,692	3,976	4,455	4,923	5,075
Video	9,913	10,425	11,110	11,537	11,965	12,365
Personal Electronics	6,079	5,959	6,129	6,699	7,522	8,977
Appliances	2,825	2,678	2,818	3,234	3,876	4,159
Other Consumer	987	867	915	1,037	1,247	1,329
Military/Civil Aerospace Products	**2,597**	**2,624**	**2,756**	**2,934**	**3,130**	**3,376**
Transportation Products	**7,654**	**8,264**	**9,185**	**10,346**	**11,723**	**13,246**
Semiconductor Shipments	**147,165**	**138,437**	**154,820**	**190,153**	**234,823**	**253,842**
Exchange Rate (Yen/U.S.$)	**121.10**	**136.35**	**140.79**	**140.79**	**140.79**	**140.79**

Source: Dataquest (November 1998)

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Table 2-2
Growth in the Value of Semiconductors Consumed Worldwide by Electronic Product Group, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
All Electronic Products	**3.6**	**-0.2**	**11.8**	**18.8**	**17.1**	**5.1**	**10.3**
Data Processing Products	**-2.0**	**-2.6**	**15.9**	**28.7**	**23.5**	**2.0**	**12.8**
Computers	-6.5	-5.6	16.0	33.7	26.3	-1.3	12.8
Data Storage	21.8	9.1	18.5	15.5	11.8	13.7	13.7
Input/Output	6.5	2.4	8.4	13.1	16.0	8.6	9.6
Dedicated Systems	-8.0	0.3	26.3	32.3	26.2	10.7	18.5
Other Data Processing	10.4	-0.9	15.1	22.0	22.8	7.6	13.0
Communications Products	**16.5**	**4.6**	**8.2**	**8.3**	**8.6**	**7.8**	**7.5**
Premise Telecommunications	8.3	6.8	9.6	4.3	7.8	5.5	6.8
Public Telecommunications	10.7	-3.5	11.6	7.5	8.1	6.4	5.9
Mobile Communications	34.1	6.0	4.5	10.7	7.4	10.4	7.8
Broadcast and Studio	3.3	5.8	14.7	18.7	21.4	12.0	14.4
Other Communications	-0.4	0.4	13.1	16.0	13.8	6.2	9.7
Industrial Products	**4.6**	**-2.9**	**11.2**	**12.8**	**12.0**	**10.6**	**8.6**
Security/Energy Management	0.9	3.9	12.1	15.1	16.3	11.9	11.7
Manufacturing Systems/Instruments	5.1	-5.4	10.9	13.2	12.2	10.7	8.1
Medical Equipment	2.3	4.2	9.5	8.2	8.9	9.7	8.1
Other Industrial	7.2	-1.7	13.0	13.1	10.7	9.7	8.8
Consumer Products	**6.1**	**-0.5**	**5.6**	**8.1**	**9.5**	**8.0**	**6.1**
Audio	-0.5	-6.1	7.7	12	10.5	3.1	5.2
Video	4.0	5.2	6.6	3.8	3.7	3.3	4.5
Personal Electronics	25.7	-2.0	2.8	9.3	12.3	19.3	8.1
Appliances	-5.6	-5.2	5.2	14.8	19.9	7.3	8.0
Other Consumer	-7.2	-12.2	5.5	13.4	20.2	6.5	6.1
Military/Civil Aerospace Products	**0.5**	**1.0**	**5.0**	**6.5**	**6.7**	**7.9**	**5.4**
Transportation Products	**5.1**	**8.0**	**11.1**	**12.6**	**13.3**	**13.0**	**11.6**
Semiconductor Shipments	**3.5**	**-5.9**	**11.8**	**22.8**	**23.5**	**8.1**	**11.5**

Source: Dataquest (November 1998)

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Table 2-3
Value of Semiconductors Consumed in Japan by Electronic Product Group, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
All Electronic Products	**35,321**	**31,639**	**32,767**	**36,717**	**41,123**	**44,194**
Data Processing Products	**12,758**	**12,207**	**12,549**	**14,537**	**17,014**	**17,637**
Computers	7,778	7,441	7,196	8,204	9,663	9,450
Data Storage	1,865	2,012	2,189	2,490	2,683	2,857
Input/Output	1,849	1,664	1,701	1,797	2,021	2,113
Dedicated Systems	799	695	911	1,256	1,683	2,013
Other Data Processing	467	395	552	790	964	1,204
Communications Products	**6,846**	**5,622**	**5,779**	**6,271**	**6,817**	**7,371**
Premise Telecommunications	2,095	1,868	1,899	1,973	2,073	2,171
Public Telecommunications	1,749	1,441	1,725	2,027	2,372	2,652
Mobile Communications	2,574	1,959	1,728	1,753	1,748	1,833
Broadcast and Studio	120	110	134	162	202	237
Other Communications	308	243	293	355	423	478
Industrial Products	**3,941**	**2,990**	**3,440**	**4,029**	**4,626**	**5,233**
Security/Energy Management	285	238	257	291	340	387
Manufacturing Systems/Instruments	2,849	2,112	2,470	2,909	3,319	3,721
Medical Equipment	265	225	240	276	325	389
Other Industrial	542	414	472	553	641	736
Consumer Products	**9,284**	8,393	8,337	**8,853**	**9,323**	**10,220**
Audio	1,392	1,218	1,299	1,433	1,556	1,588
Video	2,591	2,547	2,469	2,342	2,161	2,016
Personal Electronics	4,062	3,679	3,562	3,956	4,348	5,382
Appliances	783	615	655	734	811	785
Other Consumer	456	334	353	388	448	450
Military/Civil Aerospace Products	**311**	**278**	**310**	**351**	**346**	**362**
Transportation Products	**2,180**	**2,149**	**2,351**	**2,676**	**2,996**	**3,370**
Semiconductor Shipments	**36,499**	**30,721**	**32,652**	**38,450**	**47,108**	**50,388**
Exchange Rate (Yen/U.S.$)	**121.10**	**136.35**	**140.79**	**140.79**	**140.79**	**140.79**

Source: Dataquest (Novembar 1998)

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Table 2-4
Growth in the Value of Semiconductors Consumed in Japan by Electronic Product Group, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
All Electronic Products	**3.0**	**-10.4**	**3.6**	**12.1**	**12.0**	**7.5**	**8.8**
Data Processing Products	**-3.5**	**-4.3**	**2.8**	**15.8**	**17.0**	**3.7**	**6.7**
Computers	-7.6	-4.3	-3.3	14.0	17.8	-2.2	4.0
Data Storage	37.6	7.9	8.8	13.7	7.8	6.5	8.9
Input/Output	4.3	-10.0	2.2	5.7	12.4	4.5	2.7
Dedicated Systems	-8.3	-13.0	31.0	37.9	34.0	19.6	20.3
Other Data Processing	-41.7	-15.4	39.7	43.1	22.1	24.9	20.9
Communications Products	**8.2**	**-17.9**	**2.8**	**8.5**	**8.7**	**8.1**	**1.5**
Premise Telecommunications	1.3	-10.8	1.6	3.9	5.0	4.8	0.7
Public Telecommunications	17.5	-17.6	19.7	17.6	17.0	11.8	8.7
Mobile Communications	9.6	-23.9	-11.8	1.4	-0.3	4.9	-6.6
Broadcast and Studio	-12.0	-8.0	21.8	20.7	24.8	17.2	14.6
Other Communications	7.2	-21.0	20.4	21.2	18.9	13.0	9.1
Industrial Products	**3.7**	**-24.1**	**15.1**	**17.1**	**14.8**	**13.1**	**5.8**
Security and Energy Management	-18.0	-16.3	8.0	13.1	16.9	13.7	6.3
Manufacturing Systems/Instruments	6.7	-25.9	17.0	17.8	14.1	12.1	5.5
Medical Equipment	-1.6	-15.2	6.7	14.8	17.9	19.6	7.9
Other Industrial	5.4	-23.6	14.0	17.1	15.9	14.7	6.3
Consumer Products	**11.3**	**-9.6**	**-0.7**	**6.2**	**5.3**	**9.6**	**1.9**
Audio	3.1	-12.5	6.6	10.4	8.6	2.1	2.7
Video	-2.0	-1.7	-3.1	-5.1	-7.7	-6.7	-4.9
Personal Electronics	43.1	-9.4	-3.2	11.0	9.9	23.8	5.8
Appliances	-19.2	-21.4	6.4	12.2	10.4	-3.2	0
Other Consumer	-15.6	-26.8	5.6	10.0	15.6	0.5	-0.2
Military/Civil Aerospace Products	**-8.7**	**-10.8**	**11.4**	**13.3**	**-1.3**	**4.6**	**3.1**
Transportation Products	**-3.7**	**-1.4**	**9.4**	**13.8**	**12.0**	**12.5**	**9.1**
Semiconductor Shipments	**-5.0**	**-15.8**	**6.3**	**17.8**	**22.5**	**7.0**	**6.7**

Source: Dataquest (November 1998)

Table 2-5
Value of Semiconductors Consumed in Japan by Individual Data Processing Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Mainframe/Supercomputers (Computers)	594	718	711	697	625	505
Midrange Computers (Computers)	496	555	519	608	685	748
Workstations (Computers)	358	330	331	368	410	427
PCs (Computers)	5,784	5,352	5,166	6,014	7,330	7,196
Motherboards (Computers)	545	486	470	516	613	575
Rigid Disk Drives (Data Storage)	724	650	610	626	640	678
Optical Disk Drives (Data Storage)	787	873	928	1,023	1,048	1,112
Removable Magnetic Storage (Data Storage)	354	489	652	841	995	1,067
Page Printers (Input/Output)	516	487	507	522	558	579
Serial Printers (Input/Output)	564	556	515	488	486	460
Monitors (Input/Output)	122	125	116	129	145	150
Other Data Processing Products	1,913	1,585	2,025	2,704	3,480	4,142
All Data Processing Products	**12,758**	**12,207**	**12,549**	**14,537**	**17,014**	**17,637**
Exchange Rate (Yen/U.S.$)	**121.10**	**136.35**	**140.79**	**140.79**	**140.79**	**140.79**

Source: Dataquest (November 1998)

Table 2-6
Growth in the Value of Semiconductors Consumed in Japan by Individual Data Processing Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Mainframe/Supercomputers (Computers)	6.4	20.8	-1.0	-1.9	-10.3	-19.3	-3.2
Midrange Computers (Computers)	-12.8	11.8	-6.5	17.3	12.6	9.2	8.5
Workstations (Computers)	-19.6	-7.8	0.2	11.5	11.2	4.3	3.6
PCs (Computers)	-9.4	-7.5	-3.5	16.4	21.9	-1.8	4.5
Motherboards (Computers)	17.7	-10.8	-3.3	9.6	18.9	-6.3	1.0
Rigid Disk Drives (Data Storage)	7.4	-10.3	-6.1	2.7	2.3	5.9	-1.3
Optical Disk Drives (Data Storage)	75.8	10.9	6.2	10.3	2.4	6.1	7.1
Removable Magnetic Storage (Data Storage)	51.6	38.4	33.3	28.9	18.4	7.2	24.7
Page Printers (Input/Output)	-9.4	-5.6	4.1	2.9	6.8	3.7	2.3
Serial Printers (Input/Output)	28.0	-1.4	-7.4	-5.2	-0.5	-5.4	-4.0
Monitors (Input/Output)	21.9	2.9	-7.2	10.7	12.4	3.8	4.3
Other Data Processing Products	-18.1	-17.2	27.8	33.5	28.7	19.0	16.7
All Data Processing Products	**-4.7**	**-4.3**	**2.8**	**15.8**	**17.0**	**3.7**	**6.7**

Source: Dataquest (November 1998)

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Table 2-7
Value of Semiconductors Consumed in Japan by Individual Communications Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
LAN Cards (Premise Telecommunications)	43	67	74	83	76	73
Premise Line Cards (Premise Telecommunications)	42	42	41	44	40	42
Answering Machines (Premise Telecommunications)	6	5	5	5	6	6
Fax Machines (Premise Telecommunications)	528	498	510	512	510	505
Modems (Premise Telecommunications)	7	6	6	6	6	5
Corded Telephones (Premise Telecommunications)	29	26	23	22	20	19
Analog Cordless Phones (Premise Telecommunications)	219	226	193	184	172	156
Digital Cordless Phones (Premise Telecommunications)	232	181	175	176	173	174
Central Office Line Cards (Public Telecommunications)	86	79	85	91	91	95
Analog Cellular Phones (Mobile Telecommunications)	25	-	-	-	-	-
Digital Cellular Phones (Mobile Telecommunications)	1,728	1,127	876	815	708	691
Pagers (Mobile Telecommunications)	88	68	54	47	40	37
Mobile Telecommunications Infrastructure (Mobile Telecommunications)	512	545	588	682	795	902
Other Mobile Telecommunications (Mobile Telecommunications)	221	220	210	208	204	204
Other Communications Products	3,080	2,532	2,940	3,396	3,976	4,462
All Communications Products	**6,846**	**5,622**	**5,779**	**6,271**	**6,817**	**7,371**
Exchange Rate (Yen/U.S.$)	**121.10**	**136.35**	**140.79**	**140.79**	**140.79**	**140.79**

Source: Dataquest (November 1998)

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Table 2-8
Growth in the Value of Semiconductors Consumed in Japan by Individual Communications Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
LAN Cards (Premise Telecommunications)	96.1	55.5	10.9	12.8	-9.1	-3.2	11.3
Premise Line Cards (Premise Telecommunications)	4.2	0.4	-3.2	6.3	-8.2	4.0	-0.3
Answering Machines (Premise Telecommunications)	1.1	-18.9	-10.6	17.1	14.9	4.6	0.4
Fax Machines (Premise Telecommunications)	17.4	-5.6	2.4	0.3	-0.4	-0.8	-0.9
Modems (Premise Telecommunications)	-18.8	-1.3	-2.3	-2.7	-9.1	-4.5	-4.0
Corded Telephones (Premise Telecommunications)	-23.2	-7.8	-11.4	-6.8	-6.0	-5.0	-7.4
Analog Cordless Phones (Premise Telecommunications)	-4.6	2.9	-14.7	-4.5	-6.6	-9.1	-6.6
Digital Cordless Phones (Premise Telecommunications)	-35.8	-22.3	-3.4	0.8	-1.7	0.3	-5.7
Central Office Line Cards (Public Telecommunications)	5.6	-8.2	7.5	7.0	-0.3	5.0	2.0
Analog Cellular Phones (Mobile Telecommunications)	-79.9	-100.0	-	-	-	-	-100.0
Digital Cellular Phones (Mobile Telecommunications)	14.8	-34.8	-22.3	-6.9	-13.2	-2.5	-16.8
Pagers (Mobile Telecommunications)	-25.6	-22.7	-20.0	-13.2	-14.7	-7.2	-15.7
Mobile Telecommunications Infrastructure (Mobile Telecommunications)	37.3	6.4	8.0	16.0	16.5	13.4	12.0
Other Mobile Telecommunications (Mobile Telecommunications)	-2.3	-0.7	-4.3	-0.9	-1.7	-0.4	-1.6
Other Communications Products	12.3	-17.8	16.1	15.5	17.1	12.2	7.7
All Communications Products	**8.2**	**-17.9**	**2.8**	**8.5**	**8.7**	**8.1**	**1.5**

Source: Dataquest (November 1998)

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Table 2-9
Value of Semiconductors Consumed in Japan by Individual Consumer Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Personal/Portable Stereos (Audio)	195	206	187	177	164	155
Color TVs (Video)	616	598	625	625	570	537
VCRs (Video)	510	474	448	429	407	383
Analog Camcorders (Video)	876	690	560	409	248	143
Digital Camcorders (Video)	458	659	700	710	743	750
DVDs (Video)	20	26	35	60	73	77
Analog Set-Top Boxes (Video)	12	9	6	5	4	4
Digital Set-Top Boxes (Video)	100	90	95	104	115	121
Digital Still Cameras (Personal Electronics)	289	309	345	351	340	362
Video Game Controllers (Personal Electronics)	1,794	1,275	711	592	542	810
Other Consumer Products	4,415	4,057	4,626	5,390	6,116	6,879
All Consumer Products	**9,284**	**8,393**	**8,337**	**8,853**	**9,323**	**10,220**
Exchange Rate (Yen/U.S.$)	**121.10**	**136.35**	**140.79**	**140.79**	**140.79**	**140.79**

Source: Dataquest (November 1998)

Table 2-10
Growth in the Value of Semiconductors Consumed in Japan by Individual Consumer Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Personal/Portable Stereos (Audio)	12.5	5.8	-9.3	-5.0	-7.6	-5.7	-4.5
Color TVs (Video)	0.7	-2.8	4.4	0	-8.8	-5.8	-2.7
VCRs (Video)	-20.6	-7.0	-5.5	-4.3	-5.0	-5.8	-5.5
Analog Camcorders (Video)	-5.6	-21.2	-18.9	-26.9	-39.3	-42.4	-30.4
Digital Camcorders (Video)	35.4	44.0	6.2	1.4	4.7	1.0	10.4
DVDs (Video)	111.7	30.5	33.5	71.0	21.5	5.5	30.7
Analog Set-Top Boxes (Video)	-22.9	-25.1	-27.0	-18.8	-15.0	-2.4	-18.1
Digital Set-Top Boxes (Video)	-0.6	-10.4	5.5	10.0	10.7	4.8	3.8
Digital Still Cameras (Personal Electronics)	83.3	7.0	11.6	1.9	-3.0	6.2	4.6
Video Game Controllers (Personal Electronics)	14.4	-29.0	-44.2	-16.7	-8.6	49.4	-14.7
Other Consumer Products	16.2	-8.1	14.0	16.5	13.5	12.5	9.3
All Consumer Products	**15.9**	**0.8**	**10.1**	**18.3**	**7.7**	**24.7**	**1.9**

Source: Dataquest (November 1998)

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Table 2-11
Value of Semiconductors Consumed in Japan by Individual Transportation Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Automotive Stereos	203	207	199	220	219	222
Automotive ECUs	526	565	571	588	598	605
Antilock Braking Systems	129	140	151	161	176	188
Air Bags	107	125	136	144	151	160
Automotive Navigation Systems	259	304	445	611	802	1,006
Other Transportation Products	956	807	850	953	1,050	1,189
All Transportation Products	**2,180**	**2,149**	**2,351**	**2,676**	**2,996**	**3,370**
Exchange Rate (Yen/U.S.$)	**121.10**	**136.35**	**140.79**	**140.79**	**140.79**	**140.79**

Source: Dataquest (November 1998)

Table 2-12
Growth in the Value of Semiconductors Consumed in Japan by Individual Transportation Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Automotive Stereos	-4.5	2.1	-4.1	10.8	-0.5	1.5	1.8
Automotive ECUs	6.0	7.5	1.0	2.9	1.8	1.1	2.8
Antilock Braking Systems	19.2	8.2	7.8	6.8	9.6	6.8	7.8
Air Bags	22.7	17.0	8.3	5.8	5.2	5.9	8.4
Automotive Navigation Systems	20.5	17.4	46.2	37.3	31.3	25.5	31.2
Other Transportation Products	-16.4	-15.6	5.4	12.1	10.2	13.2	4.5
All Transportation Products	**-3.7**	**-1.4**	**9.4**	**13.8**	**12.0**	**12.5**	**9.1**

Source: Dataquest (November 1998)

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Table 2-13
Value of Semiconductors Consumed in Japan by Electronic Product Group, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
All Electronic Products	**4,277**	**4,314**	**4,613**	**5,169**	**5,790**	**6,222**
Data Processing Products	**1,545**	**1,664**	**1,767**	**2,047**	**2,395**	**2,483**
Computers	942	1,015	1,013	1,155	1,360	1,330
Data Storage	226	274	308	351	378	402
Input/Output	224	227	239	253	285	297
Dedicated Systems	97	95	128	177	237	283
Other Data Processing	57	54	78	111	136	170
Communications Products	**829**	**767**	**814**	**883**	**960**	**1,038**
Premise Telecommunications	254	255	267	278	292	306
Public Telecommunications	212	196	243	285	334	373
Mobile Communications	312	267	243	247	246	258
Broadcast and Studio	15	15	19	23	29	33
Other Communications	37	33	41	50	59	67
Industrial Products	**477**	**408**	**484**	**567**	**651**	**737**
Security/Energy Management	34	32	36	41	48	54
Manufacturing Systems/Instruments	345	288	348	410	467	524
Medical Equipment	32	31	34	39	46	55
Other Industrial	66	57	67	78	90	104
Consumer Products	**1,124**	**1,144**	**1,174**	**1,246**	**1,313**	**1,439**
Audio	169	166	183	202	219	224
Video	314	347	348	330	304	284
Personal Electronics	492	502	502	557	612	758
Appliances	95	84	92	103	114	110
Other Consumer	55	45	50	55	63	63
Military/Civil Aerospace Products	**38**	**38**	**44**	**49**	**49**	**51**
Transportation Products	**264**	**293**	**331**	**377**	**422**	**474**
Semiconductor Shipments	**4,420**	**4,189**	**4,597**	**5,413**	**6,632**	**7,094**

Source: Dataquest (November 1998)

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Table 2-14
Growth in the Value of Semiconductors Consumed in Japan by Electronic Product Group, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
All Electronic Products	**14.6**	**0.9**	**6.9**	**12.1**	**12**	**7.5**	**7.8**
Data Processing Products	**7.4**	**7.7**	**6.1**	**15.8**	**17.0**	**3.7**	**10.0**
Computers	2.8	7.7	-0.1	14.0	17.8	-2.2	7.2
Data Storage	53.2	21.5	12.4	13.7	7.8	6.5	12.2
Input/Output	16.1	1.3	5.6	5.7	12.4	4.5	5.8
Dedicated Systems	2.1	-2.0	35.2	37.9	34.0	19.6	24.0
Other Data Processing	-35.1	-4.8	44.2	43.1	22.1	24.9	24.6
Communications Products	**20.4**	**-7.5**	**6.1**	**8.5**	**8.7**	**8.1**	**4.6**
Premise Telecommunications	12.8	0.4	5.0	3.9	5.0	4.8	3.8
Public Telecommunications	30.7	-7.3	23.6	17.6	17.0	11.8	12.0
Mobile Communications	22.0	-14.3	-8.9	1.4	-0.3	4.9	-3.7
Broadcast and Studio	-2.0	3.6	25.8	20.7	24.8	17.2	18.1
Other Communications	19.3	-11.1	24.3	21.2	18.9	13.0	12.5
Industrial Products	**15.4**	**-14.6**	**18.8**	**17.1**	**14.8**	**13.1**	**9.1**
Security and Energy Management	-8.8	-5.7	11.5	13.1	16.9	13.7	9.6
Manufacturing Systems/Instruments	18.8	-16.5	20.8	17.8	14.1	12.1	8.7
Medical Equipment	9.6	-4.5	10.2	14.8	17.9	19.6	11.2
Other Industrial	17.3	-14.0	17.7	17.1	15.9	14.7	9.5
Consumer Products	**23.9**	**1.8**	**2.6**	**6.2**	**5.3**	**9.6**	**5.1**
Audio	14.7	-1.5	10.1	10.4	8.6	2.1	5.8
Video	9.0	10.7	0.1	-5.1	-7.7	-6.7	-2.0
Personal Electronics	59.2	2.0	0	11.0	9.9	23.8	9.0
Appliances	-10.0	-11.6	9.8	12.2	10.4	-3.2	3.1
Other Consumer	-6.0	-17.5	9.1	10.0	15.6	0.5	2.8
Military/Civil Aerospace Products	**1.6**	**0.5**	**15.1**	**13.3**	**-1.3**	**4.6**	**6.2**
Transportation Products	**7.2**	**11.0**	**13.0**	**13.8**	**12.0**	**12.5**	**12.4**
Semiconductor Shipments	**-5.0**	**-5.2**	**9.7**	**17.8**	**22.5**	**7.0**	**9.9**

Source: Dataquest (November 1998)

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Table 2-15
Value of Semiconductors Consumed in Japan by Individual Data Processing Product, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
Mainframe/Supercomputers (Computers)	72	98	100	98	88	71
Midrange Computers (Computers)	60	76	73	86	96	105
Workstations (Computers)	43	45	47	52	58	60
PCs (Computers)	700	730	727	847	1,032	1,013
Motherboards (Computers)	66	66	66	73	86	81
Rigid Disk Drives (Data Storage)	88	89	86	88	90	95
Optical Disk Drives (Data Storage)	95	119	131	144	148	157
Removable Magnetic Storage (Data Storage)	43	67	92	118	140	150
Page Printers (Input/Output)	63	66	71	74	79	81
Serial Printers (Input/Output)	68	76	73	69	68	65
Monitors (Input/Output)	15	17	16	18	20	21
Other Data Processing Products	232	216	285	381	490	583
All Data Processing Products	**1,545**	**1,664**	**1,767**	**2,047**	**2,395**	**2,483**

Source: Dataquest (November 1998)

Table 2-16
Growth in the Value of Semiconductors Consumed in Japan by Individual Data Processing Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Mainframe/Supercomputers (Computers)	18.4	36.0	2.2	-1.9	-10.3	-19.3	-0.3
Midrange Computers (Computers)	-3.0	25.9	-3.5	17.3	12.6	9.2	11.9
Workstations (Computers)	-10.5	3.8	3.5	11.5	11.2	4.3	6.8
PCs (Computers)	0.8	4.2	-0.3	16.4	21.9	-1.8	7.7
Motherboards (Computers)	31.0	0.4	-0.1	9.6	18.9	-6.3	4.1
Rigid Disk Drives (Data Storage)	19.6	1.0	-3.1	2.7	2.3	5.9	1.7
Optical Disk Drives (Data Storage)	95.6	24.9	9.7	10.3	2.4	6.1	10.4
Removable Magnetic Storage (Data Storage)	68.7	55.8	37.6	28.9	18.4	7.2	28.5
Page Printers (Input/Output)	0.8	6.3	7.5	2.9	6.8	3.7	5.4
Serial Printers (Input/Output)	42.5	11.0	-4.4	-5.2	-0.5	-5.4	-1.1
Monitors (Input/Output)	35.7	15.9	-4.2	10.7	12.4	3.8	7.5
Other Data Processing Products	-8.8	-6.7	31.9	33.5	28.7	19.0	20.3
All Data Processing Products	**6.0**	**12.1**	**9.9**	**9.5**	**3.8**	**4.4**	**10.0**

Source: Dataquest (November 1998)

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Table 2-17
Value of Semiconductors Consumed in Japan by Individual Communications Product, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
LAN Cards (Premise Telecommunications)	5	9	10	12	11	10
Premise Line Cards (Premise Telecommunications)	5	6	6	6	6	6
Answering Machines (Premise Telecommunications)	1	1	1	1	1	1
Fax Machines (Premise Telecommunications)	64	68	72	72	72	71
Modems (Premise Telecommunications)	1	1	1	1	1	1
Corded Telephones (Premise Telecommunications)	3	4	3	3	3	3
Analog Cordless Phones (Premise Telecommunications)	27	31	27	26	24	22
Digital Cordless Phones (Premise Telecommunications)	28	25	25	25	24	24
Central Office Line Cards (Public Telecommunications)	10	11	12	13	13	13
Analog Cellular Phones (Mobile Telecommunications)	3	-	-	-	-	-
Digital Cellular Phones (Mobile Telecommunications)	209	154	123	115	100	97
Pagers (Mobile Telecommunications)	11	9	8	7	6	5
Mobile Telecommunications Infrastructure (Mobile Telecommunications)	62	74	83	96	112	127
Other Mobile Telecommunications (Mobile Telecommunications)	27	30	30	29	29	29
Other Communications Products	373	345	414	478	560	628
All Communications Products	**829**	**767**	**814**	**883**	**960**	**1,038**

Source: Dataquest (November 1998)

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Table 2-18
Growth in the Value of Semiconductors Consumed in Japan by Individual Communications Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
LAN Cards (Premise Telecommunications)	118.3	75.0	14.5	12.8	-9.1	-3.2	14.7
Premise Line Cards (Premise Telecommunications)	16.0	13.1	0	6.3	-8.2	4.0	2.8
Answering Machines (Premise Telecommunications)	12.5	-8.7	-7.7	17.1	14.9	4.6	3.5
Fax Machines (Premise Telecommunications)	30.7	6.3	5.8	0.3	-0.4	-0.8	2.2
Modems (Premise Telecommunications)	-9.7	11.1	0.9	-2.7	-9.1	-4.5	-1.1
Corded Telephones (Premise Telecommunications)	-14.5	3.8	-8.5	-6.8	-6.0	-5.0	-4.6
Analog Cordless Phones (Premise Telecommunications)	6.2	15.9	-12.0	-4.5	-6.6	-9.1	-3.7
Digital Cordless Phones (Premise Telecommunications)	-28.5	-12.5	-0.2	0.8	-1.7	0.3	-2.8
Central Office Line Cards (Public Telecommunications)	17.5	3.4	11.0	7.0	-0.3	5.0	5.1
Analog Cellular Phones (Mobile Telecommunications)	-77.6	-100.0	-	-	-	-	-100.0
Digital Cellular Phones (Mobile Telecommunications)	27.8	-26.6	-19.8	-6.9	-13.2	-2.5	-14.2
Pagers (Mobile Telecommunications)	-17.2	-13.0	-17.4	-13.2	-14.7	-7.2	-13.2
Mobile Telecommunications Infrastructure (Mobile Telecommunications)	52.8	19.8	11.5	16.0	16.5	13.4	15.4
Other Mobile Telecommunications (Mobile Telecommunications)	8.7	11.8	-1.2	-0.9	-1.7	-0.4	1.4
Other Communications Products	25.0	-7.4	19.9	15.5	17.1	12.2	11.0
All Communications Products	**20.4**	**-7.5**	**6.1**	**8.5**	**8.7**	**8.1**	**4.6**

Source: Dataquest (November 1998)

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Table 2-19
Value of Semiconductors Consumed in Japan by Individual Consumer Product, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
Personal/Portable Stereos (Audio)	24	28	26	25	23	22
Color TVs (Video)	75	82	88	88	80	76
VCRs (Video)	62	65	63	60	57	54
Analog Camcorders (Video)	106	94	79	58	35	20
Digital Camcorders (Video)	55	90	99	100	105	106
DVDs (Video)	2	4	5	8	10	11
Analog Set-Top Boxes (Video)	1	1	1	1	1	1
Digital Set-Top Boxes (Video)	12	12	13	15	16	17
Digital Still Cameras (Personal Electronics)	35	42	49	49	48	51
Video Game Controllers (Personal Electronics)	217	174	100	83	76	114
Other Consumer Products	535	553	651	759	861	968
All Consumer Products	**1,124**	**1,144**	**1,174**	**1,246**	**1,313**	**1,439**

Source: Dataquest (November 1998)

Table 2-20
Growth in the Value of Semiconductors Consumed in Japan by Individual Consumer Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Personal/Portable Stereos (Audio)	25.3	19.1	-6.4	-5.0	-7.6	-5.7	-1.6
Color TVs (Video)	12.1	9.4	7.8	0	-8.8	-5.8	0.3
VCRs (Video)	-11.7	4.7	-2.4	-4.3	-5.0	-5.8	-2.7
Analog Camcorders (Video)	5.1	-11.3	-16.2	-26.9	-39.3	-42.4	-28.3
Digital Camcorders (Video)	50.6	62.2	9.6	1.4	4.7	1.0	13.8
DVDs (Video)	135.6	46.9	37.8	71.0	21.5	5.5	34.7
Analog Set-Top Boxes (Video)	-14.1	-15.6	-24.7	-18.8	-15.0	-2.4	-15.6
Digital Set-Top Boxes (Video)	10.6	0.9	8.9	10.0	10.7	4.8	7.0
Digital Still Cameras (Personal Electronics)	104.1	20.5	15.2	1.9	-3.0	6.2	7.8
Video Game Controllers (Personal Electronics)	27.3	-20.0	-42.4	-16.7	-8.6	49.4	-12.1
Other Consumer Products	29.3	3.5	17.7	16.5	13.5	12.5	12.6
All Consumer Products	**23.9**	**1.8**	**2.6**	**6.2**	**5.3**	**9.6**	**5.1**

Source: Dataquest (November 1998)

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Table 2-21
Value of Semiconductors Consumed in Japan by Individual Transportation Product, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
Automotive Stereos	25	28	28	31	31	31
Automotive Engine Control Units (ECUs)	64	77	80	83	84	85
Antilock Braking Systems	16	19	21	23	25	26
Air Bags	13	17	19	20	21	23
Automotive Navigation Systems	31	41	63	86	113	142
Other Transportation Products	116	110	120	134	148	167
All Transportation Products	**264**	**293**	**331**	**377**	**422**	**474**

Source: Dataquest (November 1998)

Table 2-22
Growth in the Value of Semiconductors Consumed in Japan by Individual Transportation Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Automotive Stereos	6.3	14.9	-1.0	10.8	-0.5	1.5	4.9
Automotive Engine Control Units (ECUs)	18.0	21.1	4.3	2.9	1.8	1.1	6.0
Antilock Braking Systems	32.6	21.8	11.3	6.8	9.6	6.8	11.1
Air Bags	36.6	31.8	11.9	5.8	5.2	5.9	11.7
Automotive Navigation Systems	34.2	32.2	50.9	37.3	31.3	25.5	35.2
Other Transportation Products	-7.0	-4.9	8.8	12.1	10.2	13.2	7.6
All Transportation Products	**7.2**	**11.0**	**13.0**	**13.8**	**12.0**	**12.5**	**12.4**

Source: Dataquest (November 1998)

Chapter 3

High-Volume Electronic Equipment Unit Production and Semiconductor Consumption Forecast in Japan

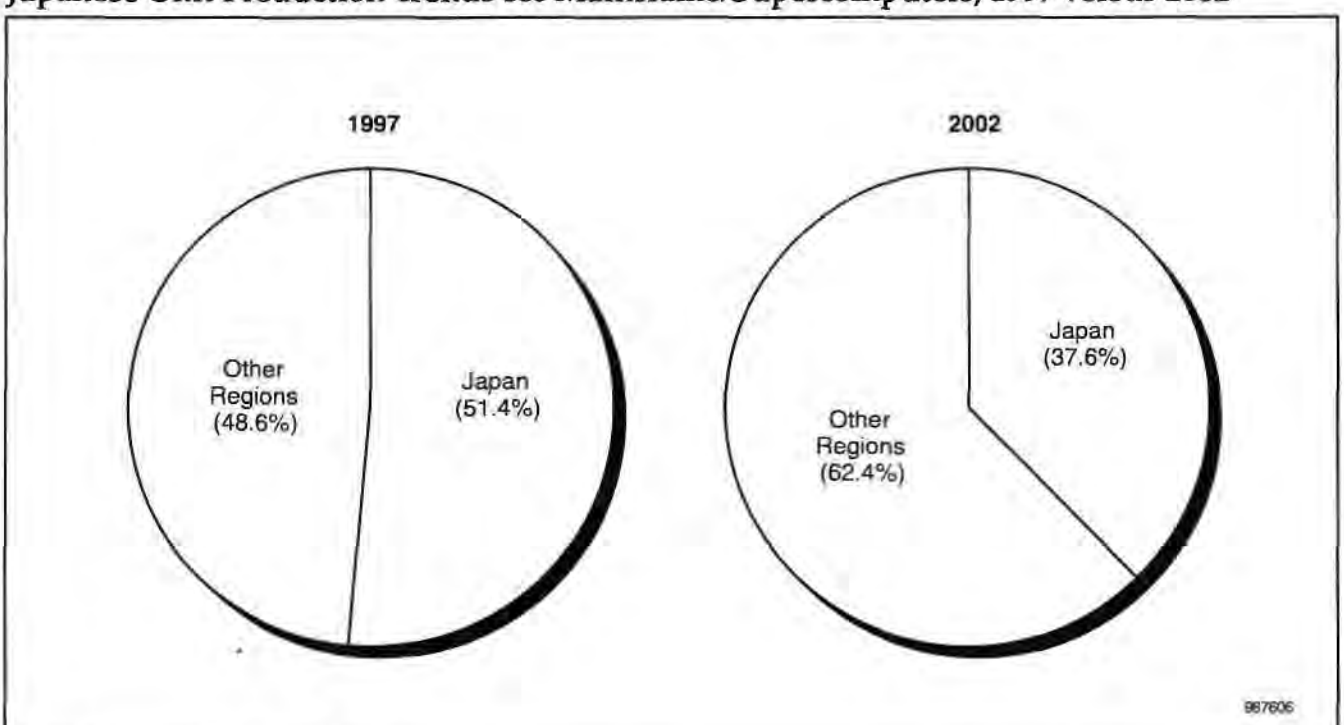
Tables 3-1 through 3-40 present Dataquest's forecast of electronic equipment unit production and semiconductor consumption for 40 major electronic systems. Figures 3-1 through 3-40 show the trends of Japan's share in production volume for 40 major electronic systems, 1997 versus 2002, in comparison with other regions.

Table 3-1
Production and Semiconductor Consumption Forecast for Mainframe/Supercomputers in Japan, 1997-2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	6	6	7	7	7	7	0.4
Factory ASP (U.S.$)	1,094,482.8	1,092,693.4	1,109,650.0	1,023,923.2	860,876.3	718,060.4	-8.1
Factory Revenue (U.S.$M)	6,986	6,964	7,426	6,686	5,652	4,685	-7.7
Semiconductor Content (U.S.$)	93,132.6	112,659.3	106,211.1	106,784.0	95,217.5	77,332.4	-3.6
Semiconductor TAM (U.S.$M)	594	718	711	697	625	505	-3.2

Source: Dataquest (November 1998)

Figure 3-1
Japanese Unit Production Trends for Mainframe/Supercomputers, 1997 versus 2002



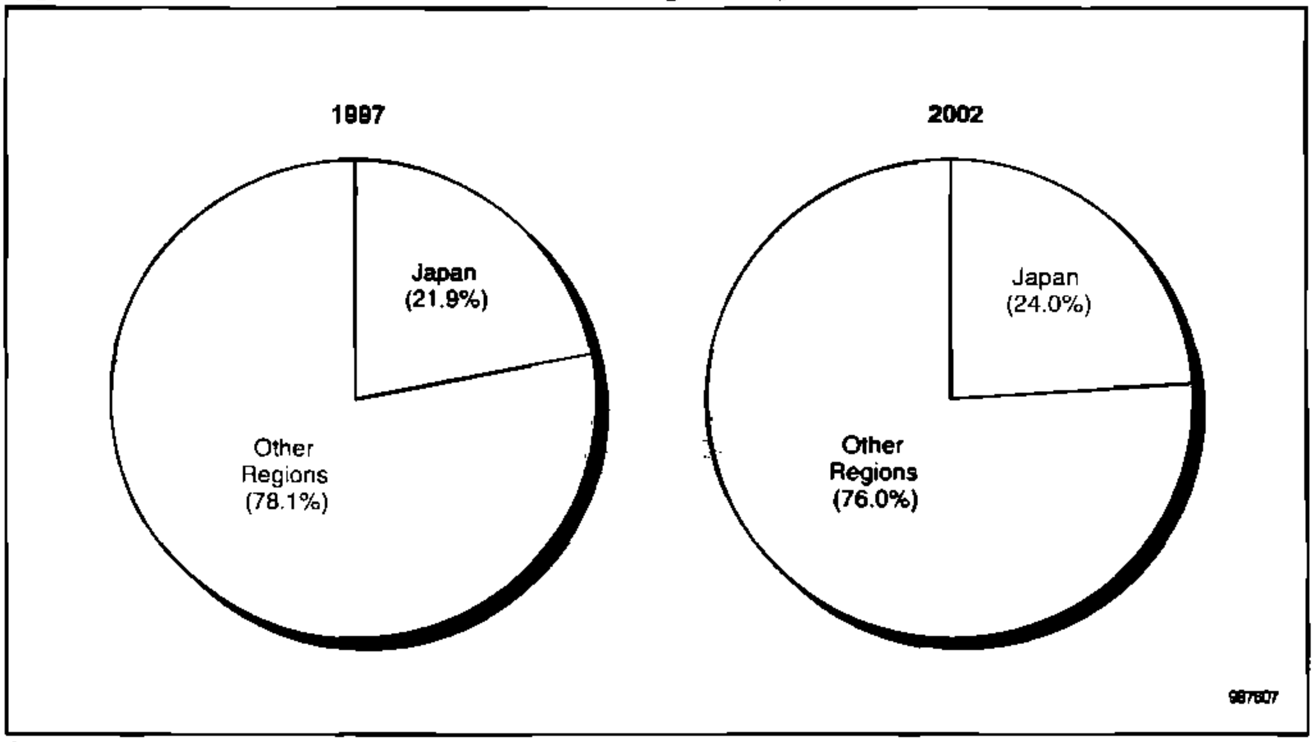
Source: Dataquest (November 1998)

Table 3-2
Production and Semiconductor Consumption Forecast for Midrange Computers in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	148	160	179	197	213	230	9.2
Factory ASP (U.S.$)	15,855.8	15,380.2	14,765.0	14,322.0	13,892.4	13,250.0	-3.5
Factory Revenue (U.S.$M)	2,345	2,457	2,642	2,819	2,953	3,041	5.3
Semiconductor Content (U.S.$)	3,355.6	3,473.0	2,898.8	3,090.0	3,222.5	3,256.9	-0.6
Semiconductor TAM (U.S.$M)	496	555	519	608	685	748	8.5

Source: Dataquest (November 1998)

Figure 3-2
Japanese Unit Production Trends for Midrange Computers, 1997 versus 2002



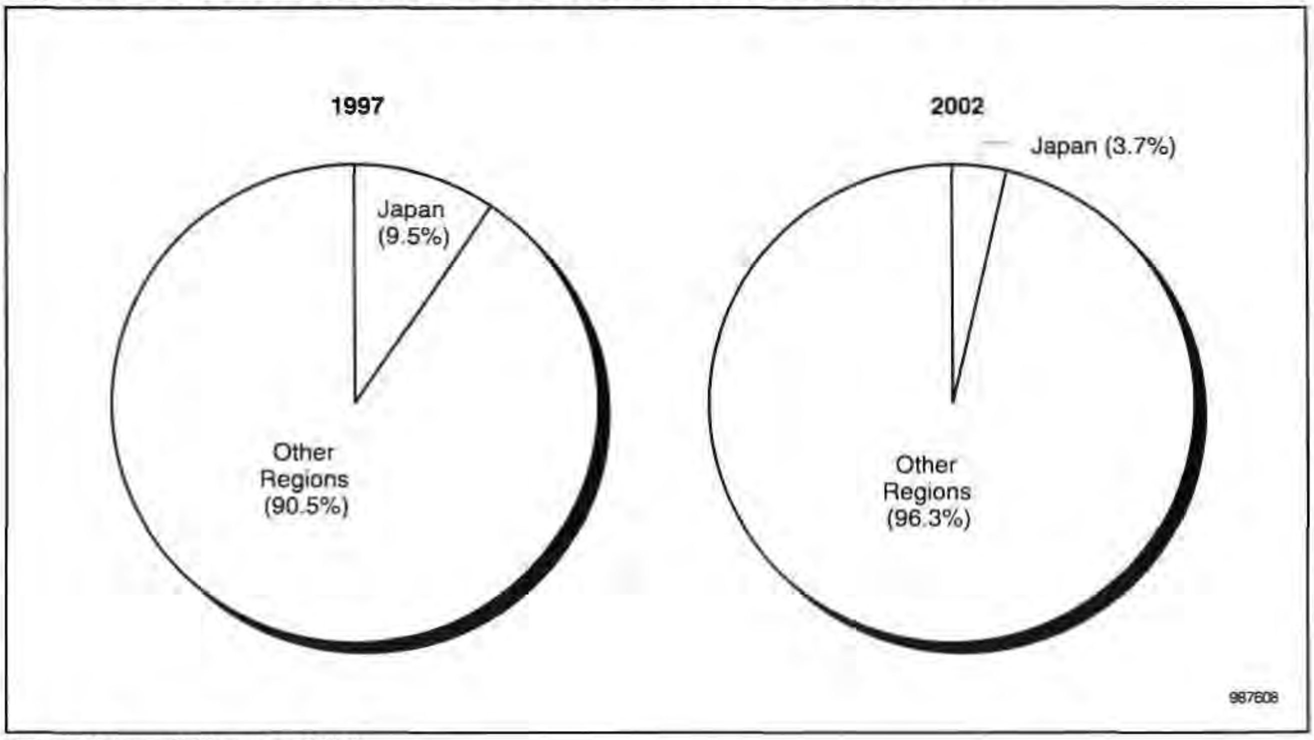
Source: Dataquest (November 1998)

Table 3-3
Production and Semiconductor Consumption Forecast for Workstations in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	97	104	112	119	126	133	6.6
Factory ASP (U.S.$)	16,323.0	14,000.0	12,600.0	11,718.0	10,780.6	9,702.5	-9.9
Factory Revenue (U.S.$M)	1,582	1,452	1,411	1,391	1,363	1,294	-3.9
Semiconductor Content (U.S.$)	3,690.8	3,179.6	2,950.7	3,103.4	3,240.4	3,202.8	-2.8
Semiconductor TAM (U.S.$M)	358	330	331	368	410	427	3.6

Source: Dataquest (November 1998)

Figure 3-3
Japanese Unit Production Trends for Workstations, 1997 versus 2002



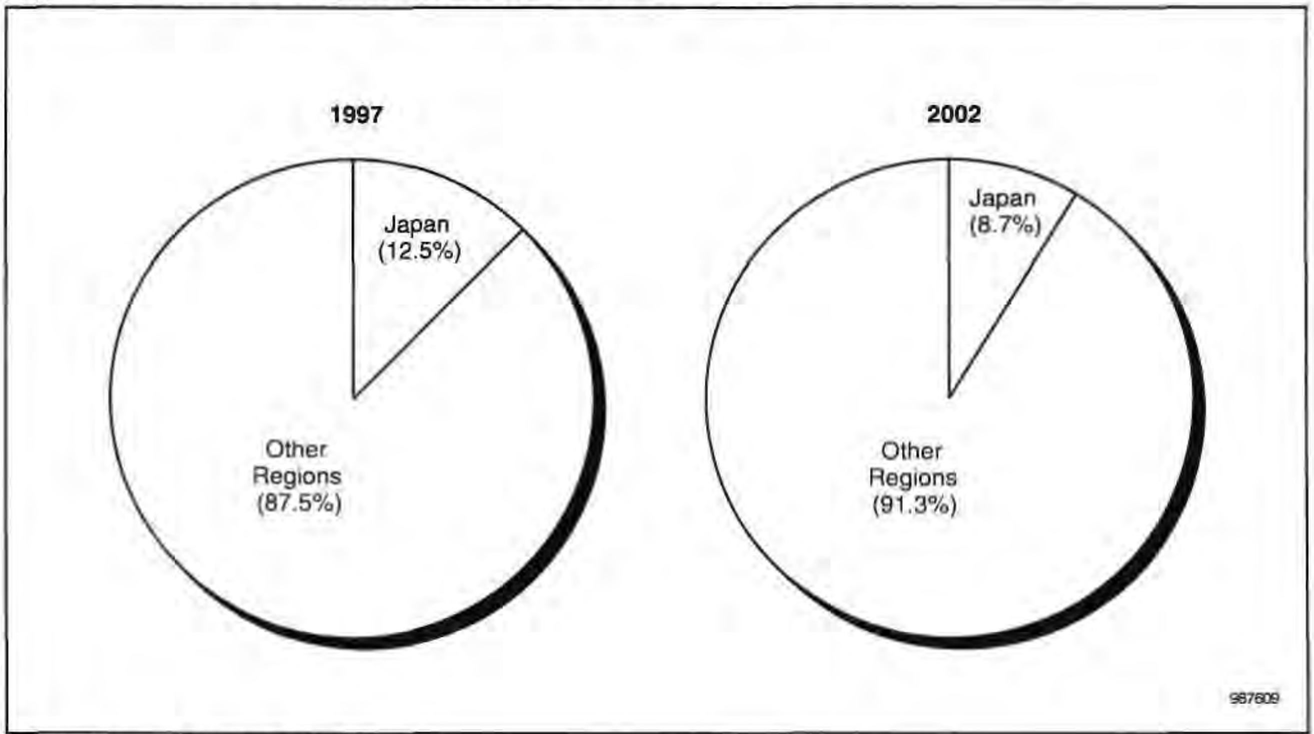
Source: Dataquest (November 1998)

Table 3-4
Production and Semiconductor Consumption Forecast for PCs in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	10,084	10,640	11,710	12,750	13,560	14,520	7.6
Factory ASP (U.S.$)	1,902.0	1,854.0	1,786.0	1,689.0	1,623.0	1,599.0	-3.4
Factory Revenue (U.S.$M)	19,179	19,727	20,914	21,535	22,008	23,217	3.9
Semiconductor Content (U.S.$)	573.6	503.0	441.1	471.7	540.6	495.6	-2.9
Semiconductor TAM (U.S.$M)	5,784	5,352	5,166	6,014	7,330	7,196	4.5

Source: Dataquest (November 1998)

Figure 3-4
Japanese Unit Production Trends for PCs, 1997 versus 2002



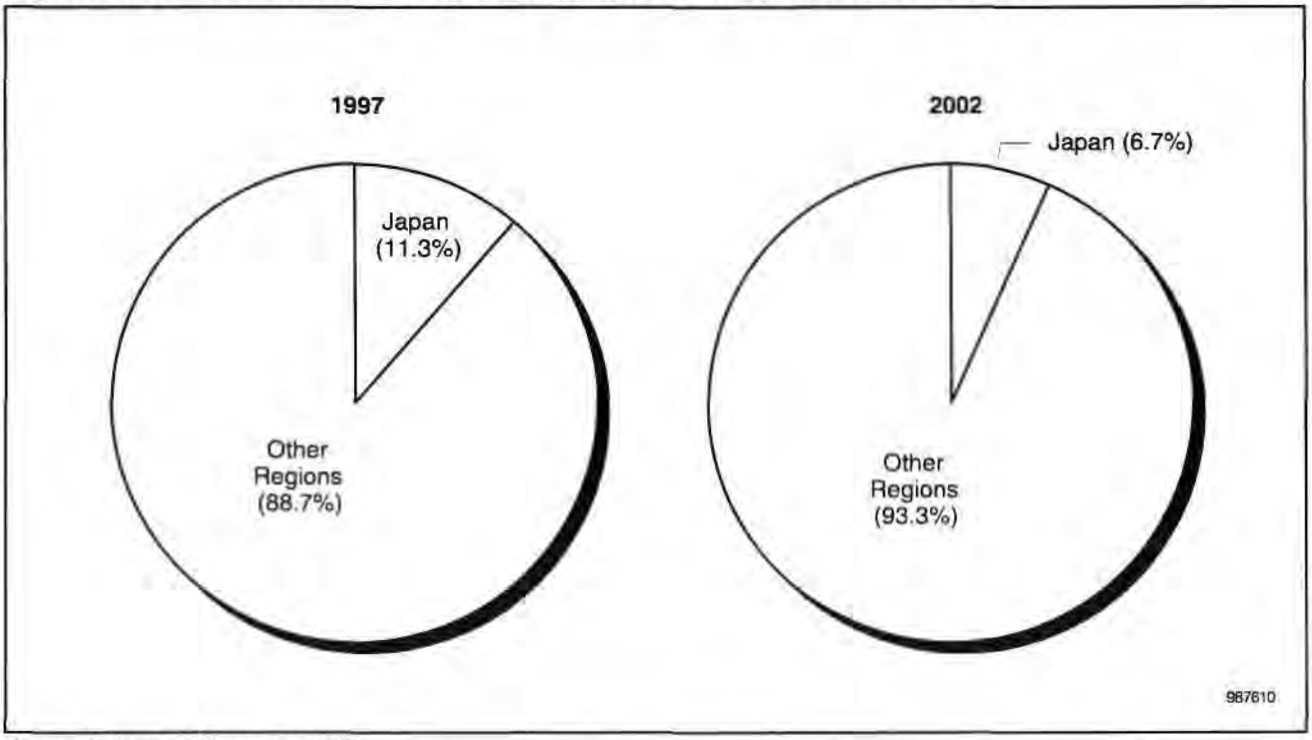
Source: Dataquest (November 1998)

Table 3-5
Production and Semiconductor Consumption Forecast for Motherboards in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	10,818	10,493	11,258	12,248	12,569	13,105	3.9
Factory ASP (U.S.$)	104.70	102.68	101.25	99.69	98.68	98.11	-1.3
Factory Revenue (U.S.$M)	1,133	1,077	1,140	1,221	1,240	1,286	2.6
Semiconductor Content (U.S.$)	50.4	46.3	41.8	42.1	48.8	43.8	-2.8
Semiconductor TAM (U.S.$M)	545	486	470	516	613	575	1.0

Source: Dataquest (November 1998)

Figure 3-5
Japanese Unit Production Trends for Motherboards, 1997 versus 2002



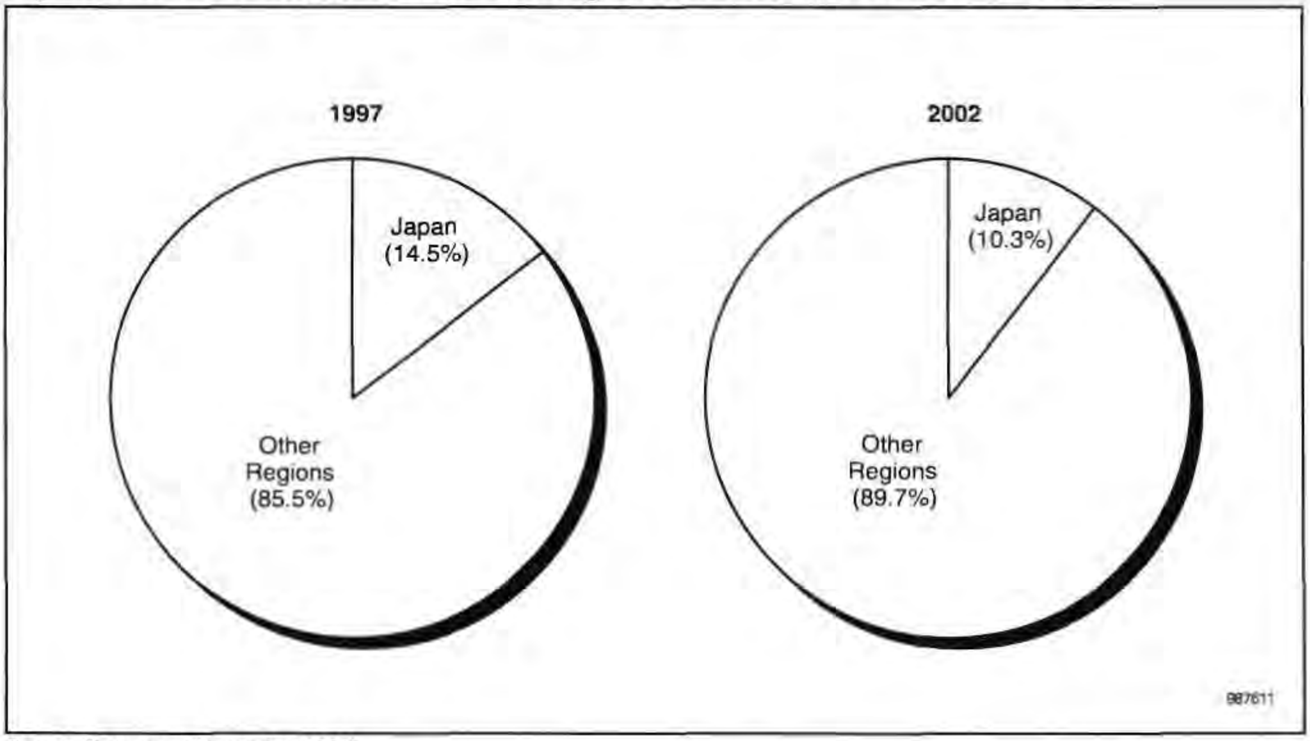
Source: Dataquest (November 1998)

Table 3-6
Production and Semiconductor Consumption Forecast for Rigid Disk Drives in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	18,635	17,889	18,783	20,661	21,838	24,506	5.6
Factory ASP (U.S.$)	312.6	275.0	254.6	230.0	220.0	180.0	-10.5
Factory Revenue (U.S.$M)	5,825	4,919	4,782	4,752	4,804	4,411	-5.4
Semiconductor Content (U.S.$)	38.9	36.3	32.5	30.3	29.3	27.7	-6.6
Semiconductor TAM (U.S.$M)	724	650	610	626	640	678	-1.3

Source: Dataquest (November 1998)

Figure 3-6
Japanese Unit Production Trends for Rigid Disk Drives, 1997 versus 2002



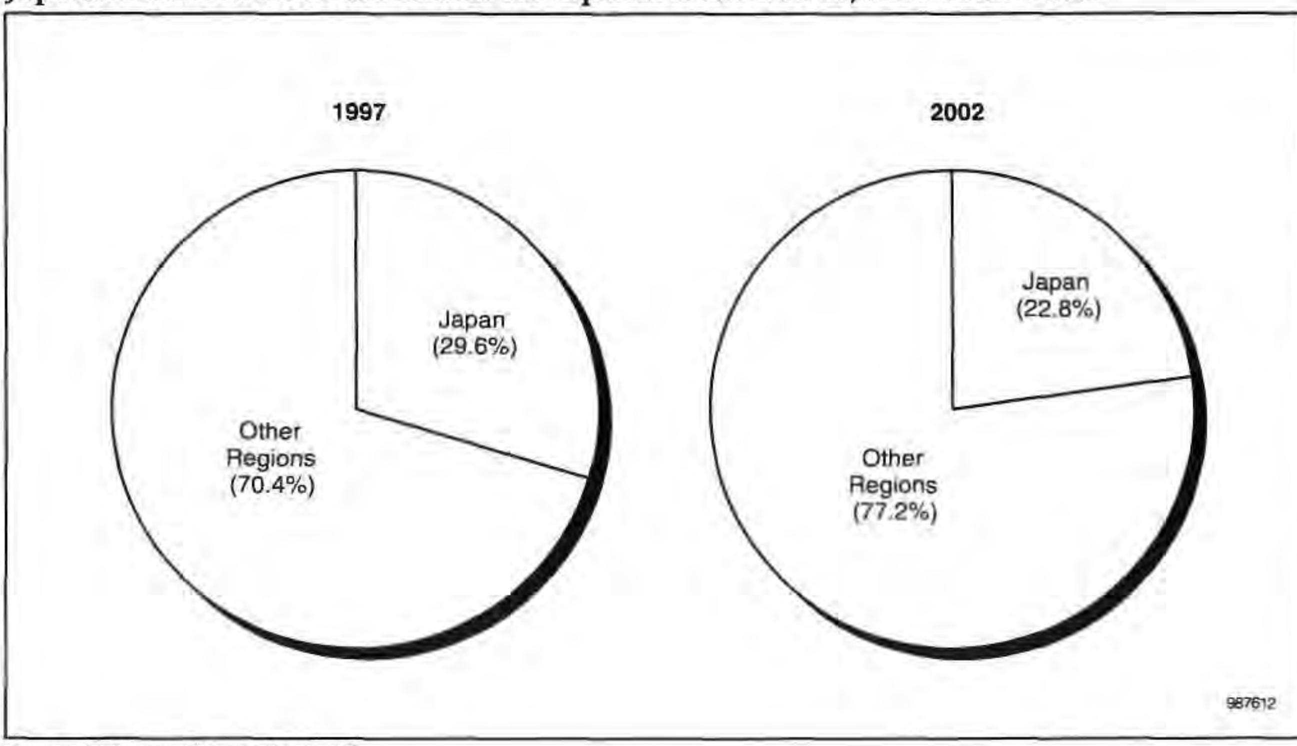
Source: Dataquest (November 1998)

Table 3-7
Production and Semiconductor Consumption Forecast for Optical Disk Drives in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	25,599	31,069	36,198	40,973	45,175	50,464	14.5
Factory ASP (U.S.$)	86.5	61.5	46.4	41.6	38.9	35.5	-16.3
Factory Revenue (U.S.$M)	2,214	1,910	1,680	1,706	1,757	1,791	-4.2
Semiconductor Content (U.S.$)	30.8	28.1	25.6	25.0	23.2	22.0	-6.5
Semiconductor TAM (U.S.$M)	787	873	928	1,023	1,048	1,112	7.1

Source: Dataquest (November 1998)

Figure 3-7
Japanese Unit Production Trends for Optical Disk Drives, 1997 versus 2002



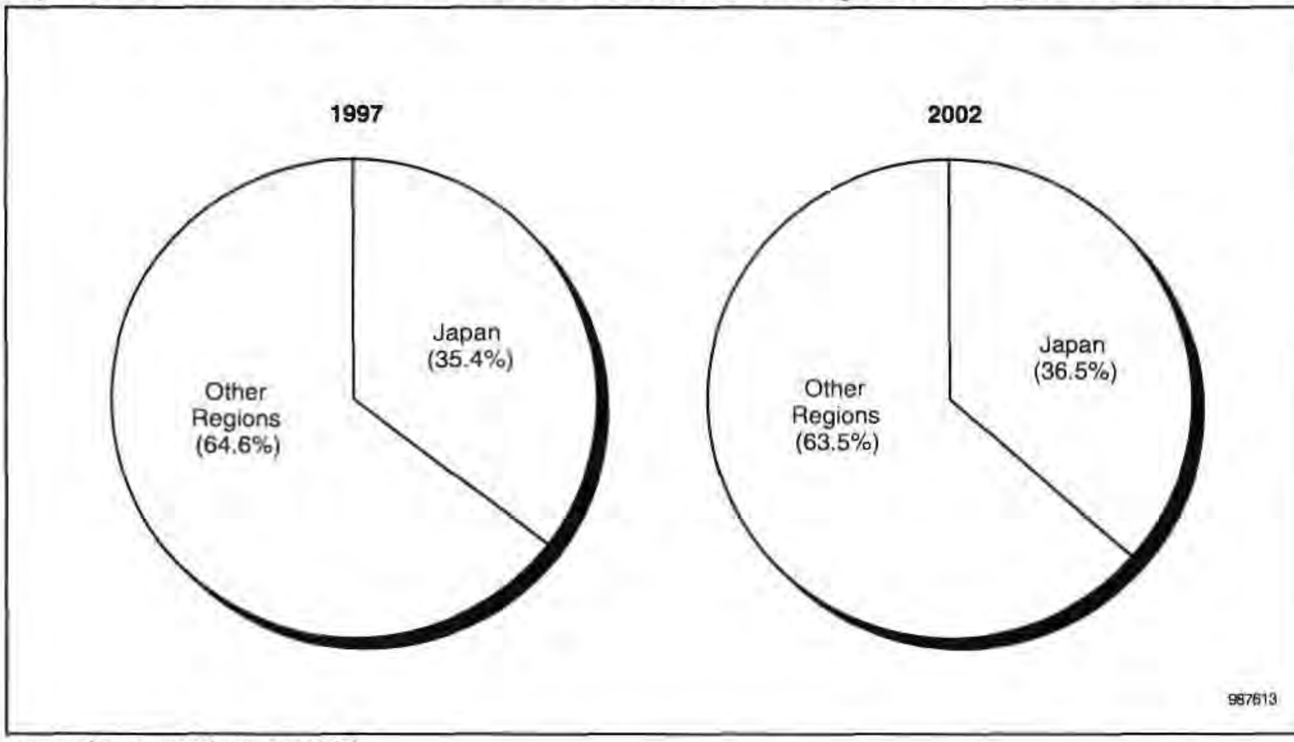
Source: Dataquest (November 1998)

Table 3-8
Production and Semiconductor Consumption Forecast for Removable Magnetic Storage in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	NA	NA	NA	NA	NA	NA	NA
Factory ASP (U.S.$)	NA	NA	NA	NA	NA	NA	NA
Factory Revenue (U.S.$M)	1,611	2,024	2,484	3,092	3,584	3,687	18.0
Semiconductor Content (U.S.$)	NA	NA	NA	NA	NA	NA	NA
Semiconductor TAM (U.S.$M)	131	142	168	188	215	227	11.6

NA = Not available or not applicable
Note: Semiconductor TAM figures are derived from regional estimation.
Source: Dataquest (November 1998)

Figure 3-8
Japanese Revenue Production Trends for Removable Magnetic Storage, 1997 versus 2002



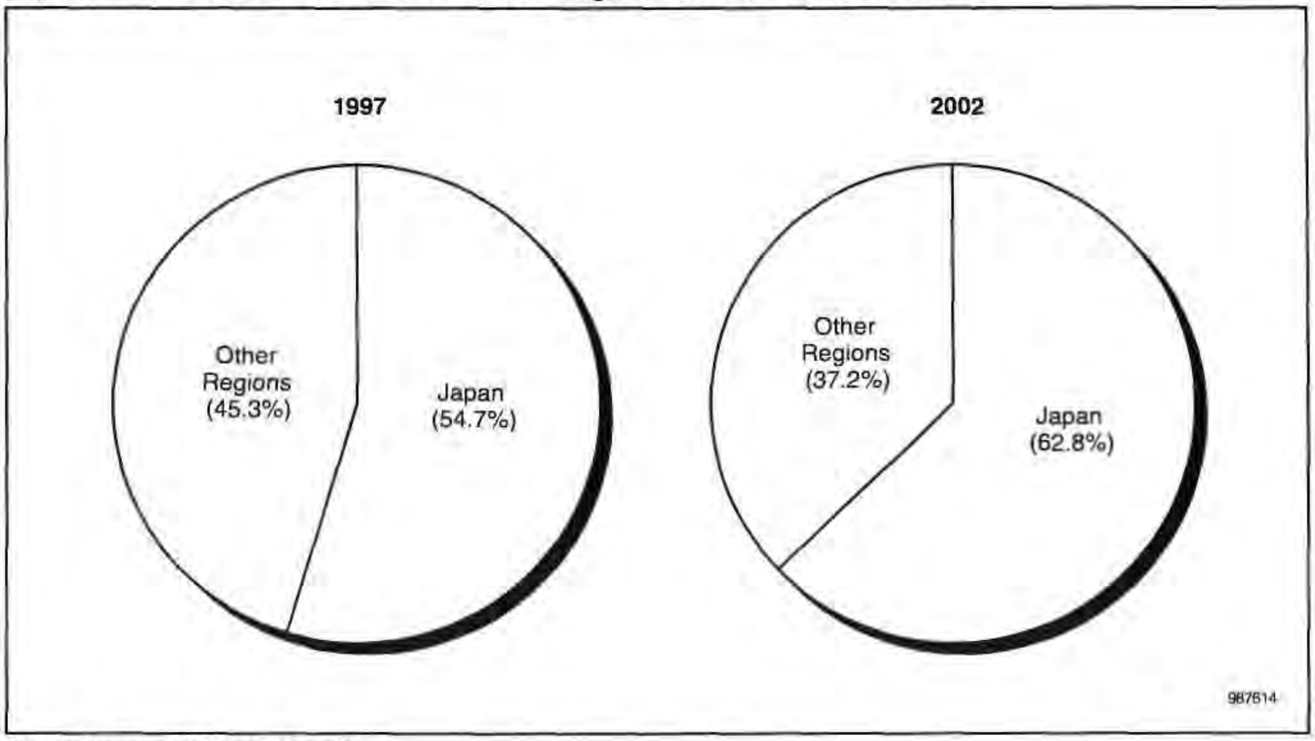
Source: Dataquest (November 1998)

Table 3-9
Production and Semiconductor Consumption Forecast for Page Printers in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	5,204	5,412	6,061	6,667	7,534	8,137	9.4
Factory ASP (U.S.$)	450.0	410.0	390.0	360.0	340.0	330.0	-6.0
Factory Revenue (U.S.$M)	2,342	2,219	2,364	2,400	2,562	2,685	2.8
Semiconductor Content (U.S.$)	99.2	90.1	83.7	78.3	74.0	71.1	-6.4
Semiconductor TAM (U.S.$M)	516	487	507	522	558	579	2.3

Source: Dataquest (November 1998)

Figure 3-9
Japanese Unit Production Trends for Page Printers, 1997 versus 2002



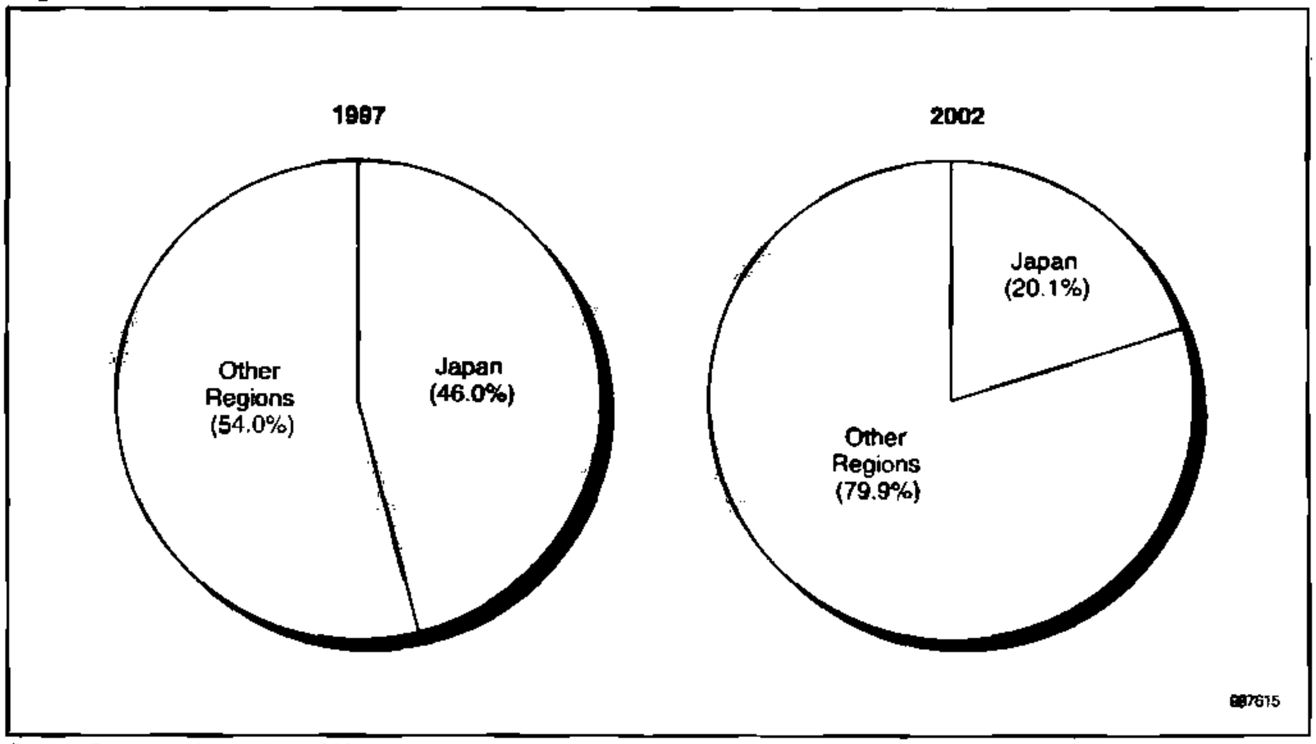
Source: Dataquest (November 1998)

Table 3-10
Production and Semiconductor Consumption Forecast for Serial Printers in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	18,403	17,483	16,084	14,798	13,762	13,074	-6.6
Factory ASP (U.S.$)	231.0	223.0	214.0	204.0	196.0	190.0	-3.8
Factory Revenue (U.S.$M)	4,251	3,899	3,442	3,019	2,697	2,484	-10.2
Semiconductor Content (U.S.$)	30.7	31.8	32.0	33.0	35.3	35.2	2.8
Semiconductor TAM (U.S.$M)	564	556	515	488	486	460	-4.0

Source: Dataquest (November 1998)

Figure 3-10
Japanese Unit Production Trends for Serial Printers, 1997 versus 2002



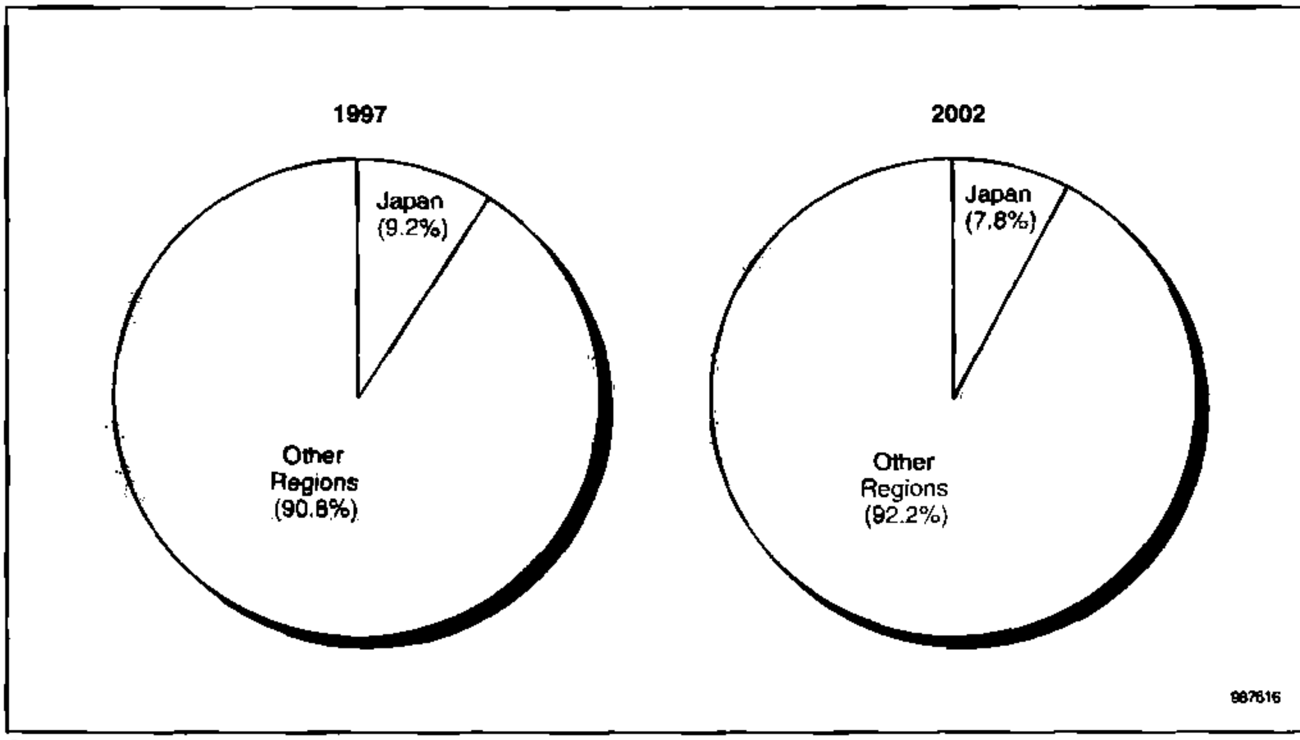
Source: Dataquest (November 1998)

Table 3-11
Production and Semiconductor Consumption Forecast for Monitors in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	7,159	7,228	7,359	8,146	9,157	10,134	7.2
Factory ASP (U.S.$)	562.0	479.0	431.0	388.0	342.0	308.0	-11.3
Factory Revenue (U.S.$M)	4,023	3,462	3,172	3,161	3,132	3,121	-5.0
Semiconductor Content (U.S.$)	17.0	17.0	16.0	16.0	16.0	15.0	-2.5
Semiconductor TAM (U.S.$M)	122	123	118	130	147	152	4.5

Source: Dataquest (November 1998)

Figure 3-11
Japanese Unit Production Trends for Monitors, 1997 versus 2002



Source: Dataquest (November 1998)

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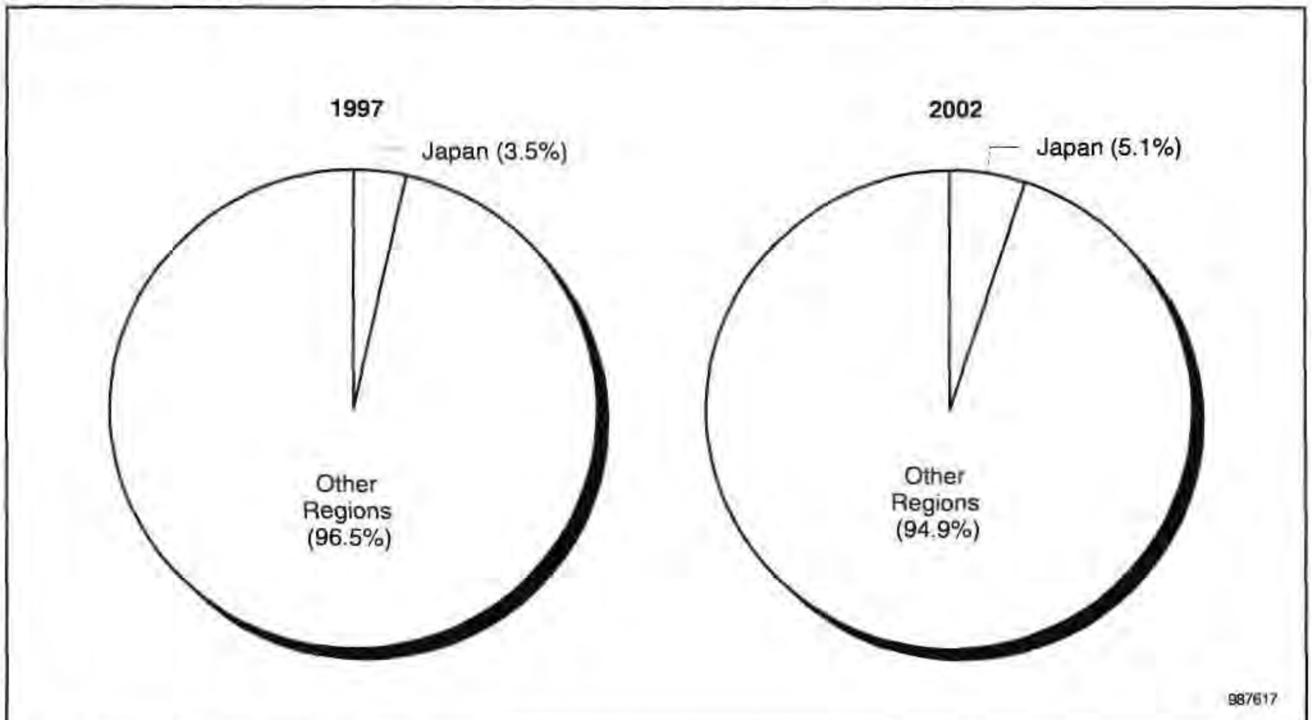
Table 3-12
Production and Semiconductor Consumption Forecast for LAN Cards in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	1,932	3,083	3,731	4,301	4,144	4,620	19.0
Factory ASP (U.S.$)	145.9	142.4	139.3	137.9	127.6	123.4	-3.3
Factory Revenue (U.S.$M)	282	439	520	593	529	570	15.1
Semiconductor Content (U.S.$)	22.2	21.2	20.0	19.6	18.5	16.1	-6.2
Semiconductor TAM (U.S.$M)	43	65	75	84	77	74	11.6

Source: Dataquest (November 1998)

Figure 3-12
Japanese Unit Production Trends for LAN Cards, 1997 versus 2002



Source: Dataquest (November 1998)

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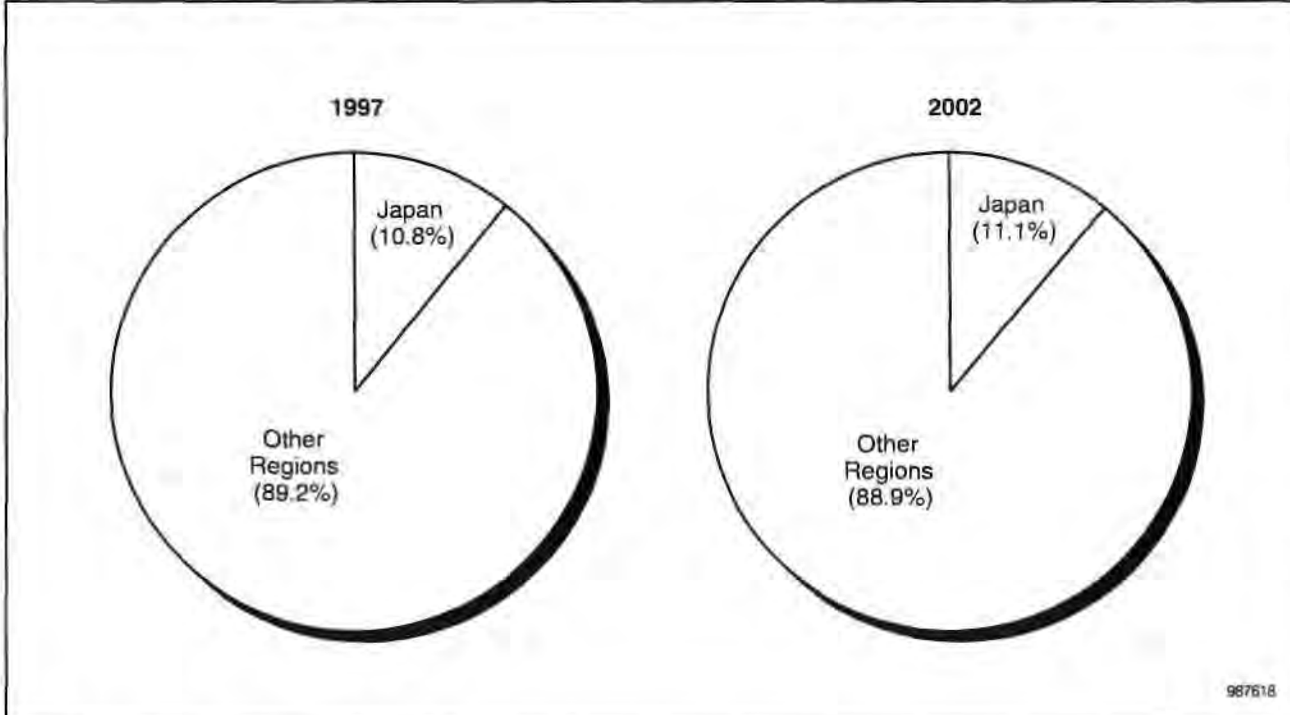
Table 3-13
Production and Semiconductor Consumption Forecast for Premise Line Cards in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	3,561	3,691	3,775	4,012	4,053	4,214	3.4
Factory ASP (U.S.$)	80.8	82.4	82.0	81.0	80.0	79.0	-0.4
Factory Revenue (U.S.$M)	288	304	310	325	324	333	3.0
Semiconductor Content (U.S.$)	11.8	11.3	11.0	11.0	10.0	10.0	-3.3
Semiconductor TAM (U.S.$M)	42	42	42	44	41	42	0

Source: Dataquest (November 1998)

Figure 3-13
Japanese Unit Production Trends for Premise Line Cards, 1997 versus 2002



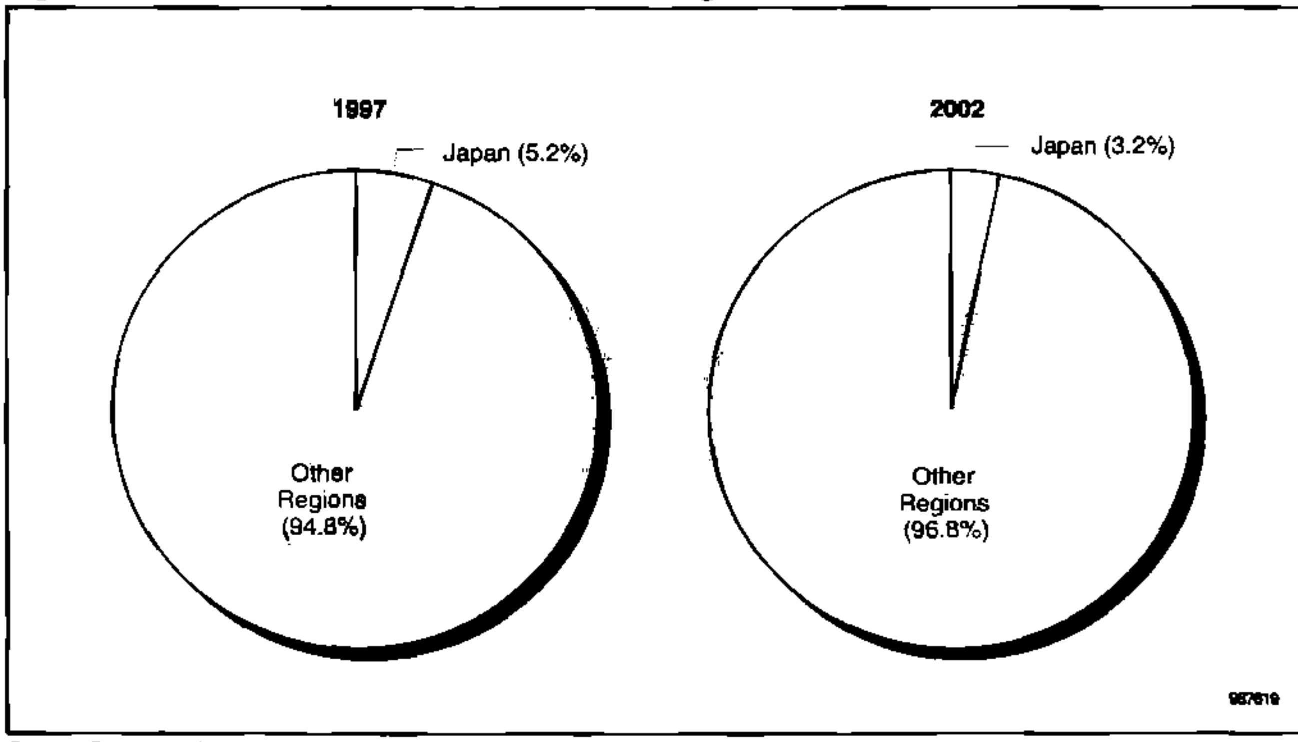
Source: Dataquest (November 1998)

Table 3-14
Production and Semiconductor Consumption Forecast for Answering Machines in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	1,357	1,311	1,217	1,140	1,092	1,087	-4.3
Factory ASP (U.S.$)	36.1	34.7	34.8	36.7	40.0	42.0	3.0
Factory Revenue (U.S.$M)	49	45	42	42	44	46	-1.4
Semiconductor Content (U.S.$)	4.6	3.8	3.8	4.7	5.6	5.9	5.2
Semiconductor TAM (U.S.$M)	6	5	5	5	6	6	0.6

Source: Dataquest (November 1998)

Figure 3-14
Japanese Unit Production Trends for Answering Machines, 1997 versus 2002



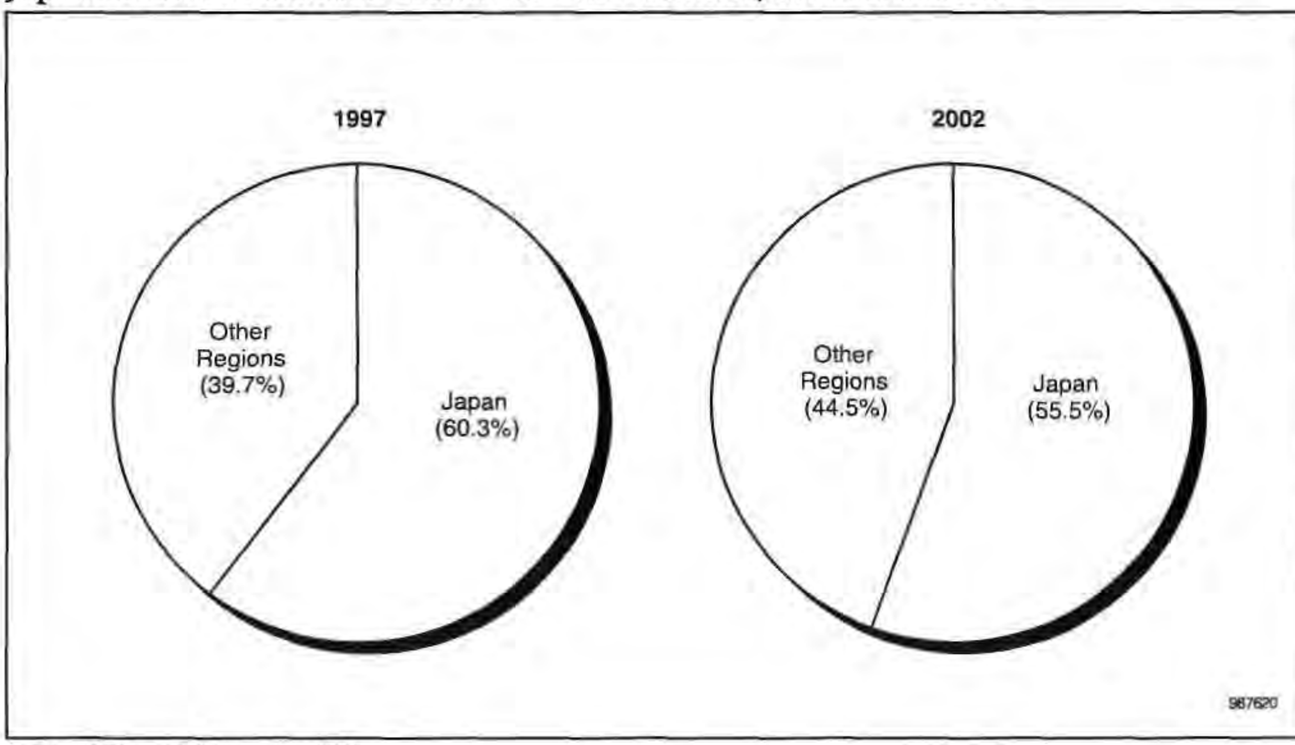
Source: Dataquest (November 1998)

Table 3-15
Production and Semiconductor Consumption Forecast for Fax Machines in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	6,595	6,266	6,892	7,099	7,170	7,313	2.1
Factory ASP (U.S.$)	388.0	375.0	370.0	365.0	362.0	360.0	-1.5
Factory Revenue (U.S.$M)	2,559	2,350	2,550	2,591	2,596	2,633	0.6
Semiconductor Content (U.S.$)	80.0	78.0	75.0	73.0	72.0	70.0	-2.6
Semiconductor TAM (U.S.$M)	528	489	517	518	516	512	-0.6

Source: Dataquest (November 1998)

Figure 3-15
Japanese Unit Production Trends for Fax Machines, 1997 versus 2002



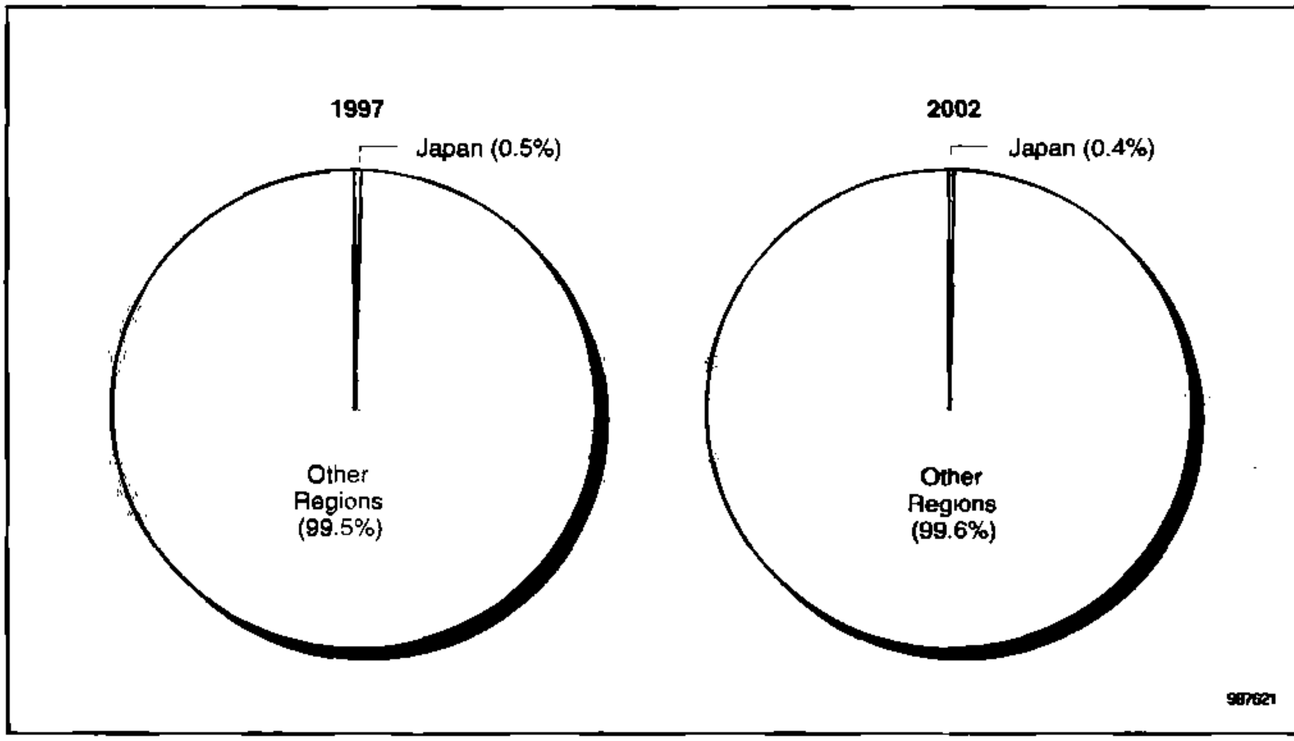
Source: Dataquest (November 1998)

Table 3-16
Production and Semiconductor Consumption Forecast for Modems in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	217	225	235	247	255	268	4.3
Factory ASP (U.S.$)	180.0	150.0	130.0	120.0	110.0	100.0	-11.1
Factory Revenue (U.S.$M)	39	34	31	30	28	27	-7.2
Semiconductor Content (U.S.$)	30.0	28.0	27.0	25.0	22.0	20.0	-7.8
Semiconductor TAM (U.S.$M)	7	6	6	6	6	5	-3.8

Source: Dataquest (November 1998)

Figure 3-16
Japanese Unit Production Trends for Modems, 1997 versus 2002



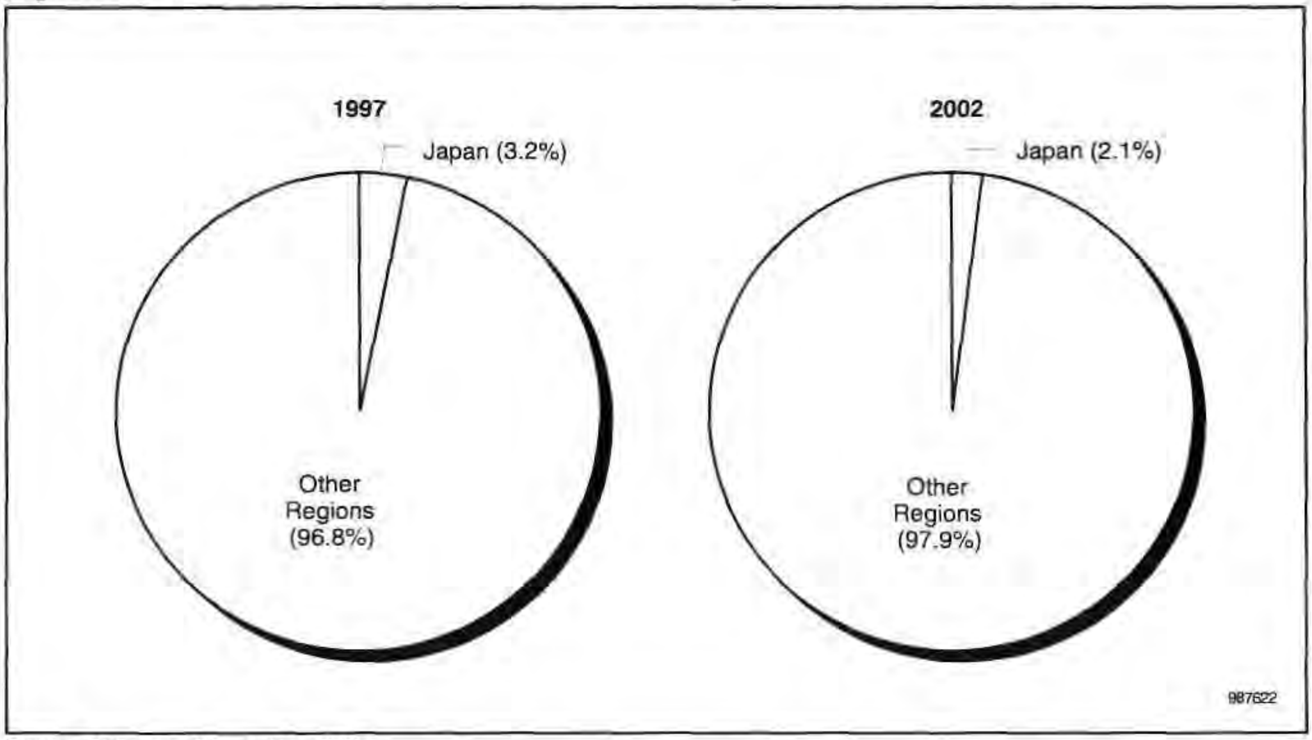
Source: Dataquest (November 1998)

Table 3-17
Production and Semiconductor Consumption Forecast for Corded Telephones in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	5,096	4,790	4,551	4,323	4,064	3,861	-5.4
Factory ASP (U.S.$)	50.0	47.0	45.0	43.0	41.0	39.1	-4.8
Factory Revenue (U.S.$M)	255	225	205	186	167	151	-9.9
Semiconductor Content (U.S.$)	5.6	5.4	5.2	5.1	5.1	5.1	-1.9
Semiconductor TAM (U.S.$M)	29	26	24	22	21	20	-7.2

Source: Dataquest (November 1998)

Figure 3-17
Japanese Unit Production Trends for Corded Telephones, 1997 versus 2002



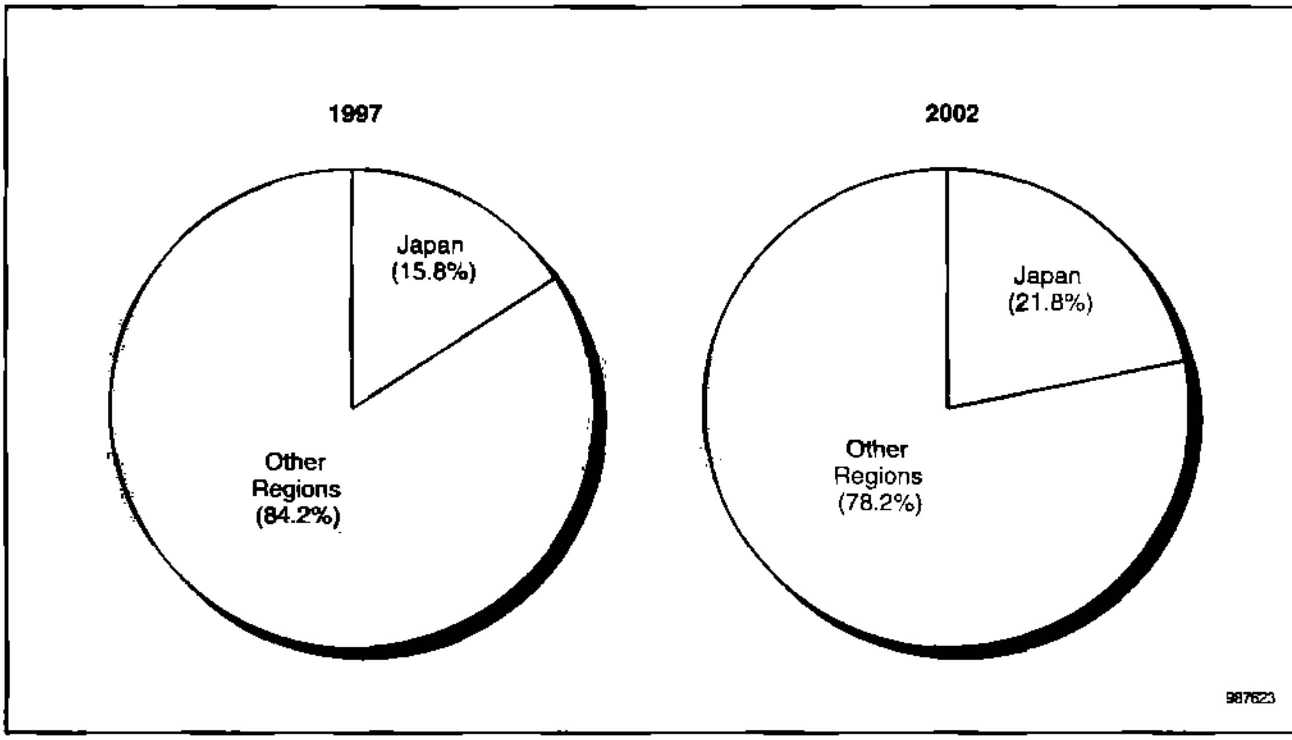
Source: Dataquest (November 1998)

Table 3-18
Production and Semiconductor Consumption Forecast for Analog Cordless Phones in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	6,857	6,924	6,502	6,208	5,996	5,448	-4.5
Factory ASP (U.S.$)	70.0	70.0	68.0	65.0	62.0	61.0	-2.7
Factory Revenue (U.S.$M)	480	485	442	404	372	332	-7.1
Semiconductor Content (U.S.$)	32.0	32.0	30.0	30.0	29.0	29.0	-1.9
Semiconductor TAM (U.S.$M)	219	222	195	186	174	158	-6.4

Source: Dataquest (November 1998)

Figure 3-18
Japanese Unit Production Trends for Analog Cordless Phones, 1997 versus 2002



Source: Dataquest (November 1998)

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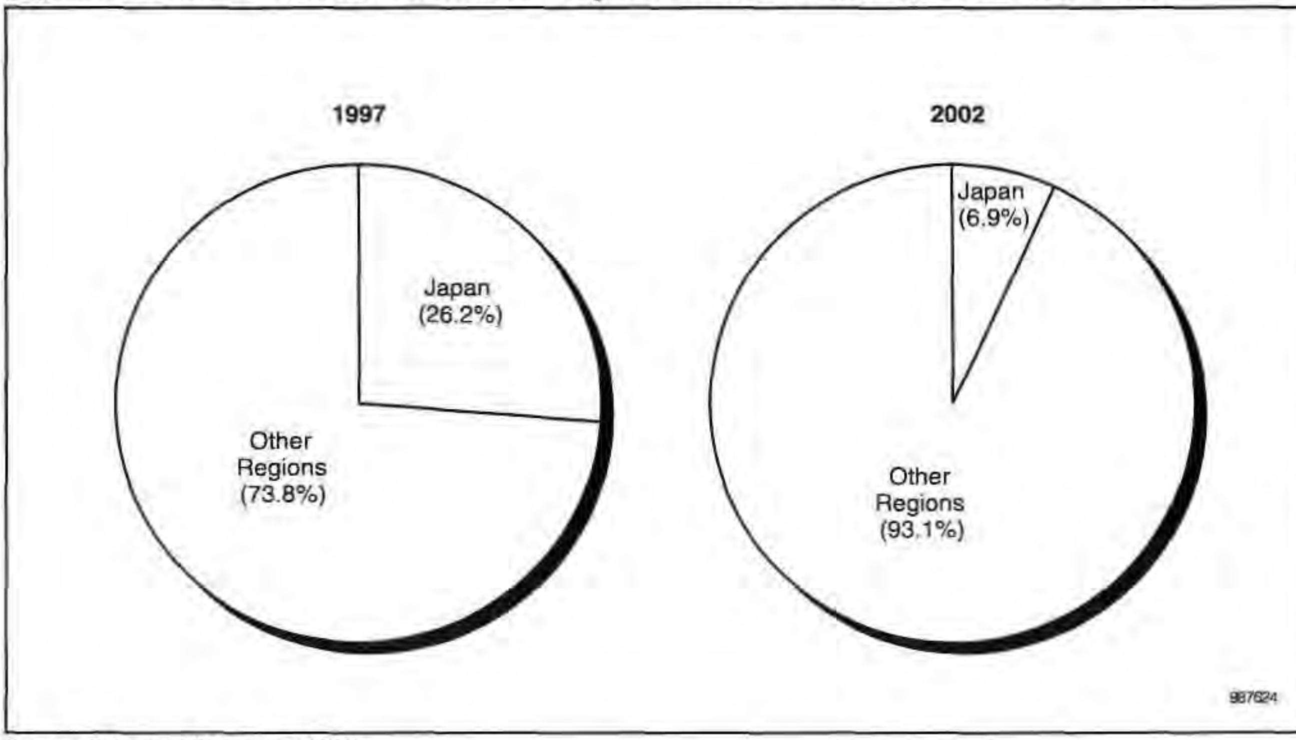
Table 3-19
Production and Semiconductor Consumption Forecast for Digital Cordless Phones in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	3,686	3,137	3,424	3,808	4,091	4,605	4.6
Factory ASP (U.S.$)	109.1	96.7	88.2	79.5	71.5	64.2	-10.1
Factory Revenue (U.S.$M)	402	303	302	303	293	296	-6.0
Semiconductor Content (U.S.$)	63.1	56.5	51.6	46.8	42.8	38.2	-9.6
Semiconductor TAM (U.S.$M)	232	177	177	178	175	176	-5.4

Source: Dataquest (November 1998)

Figure 3-19
Japanese Unit Production Trends for Digital Cordless Phones, 1997 versus 2002



Source: Dataquest (November 1998)

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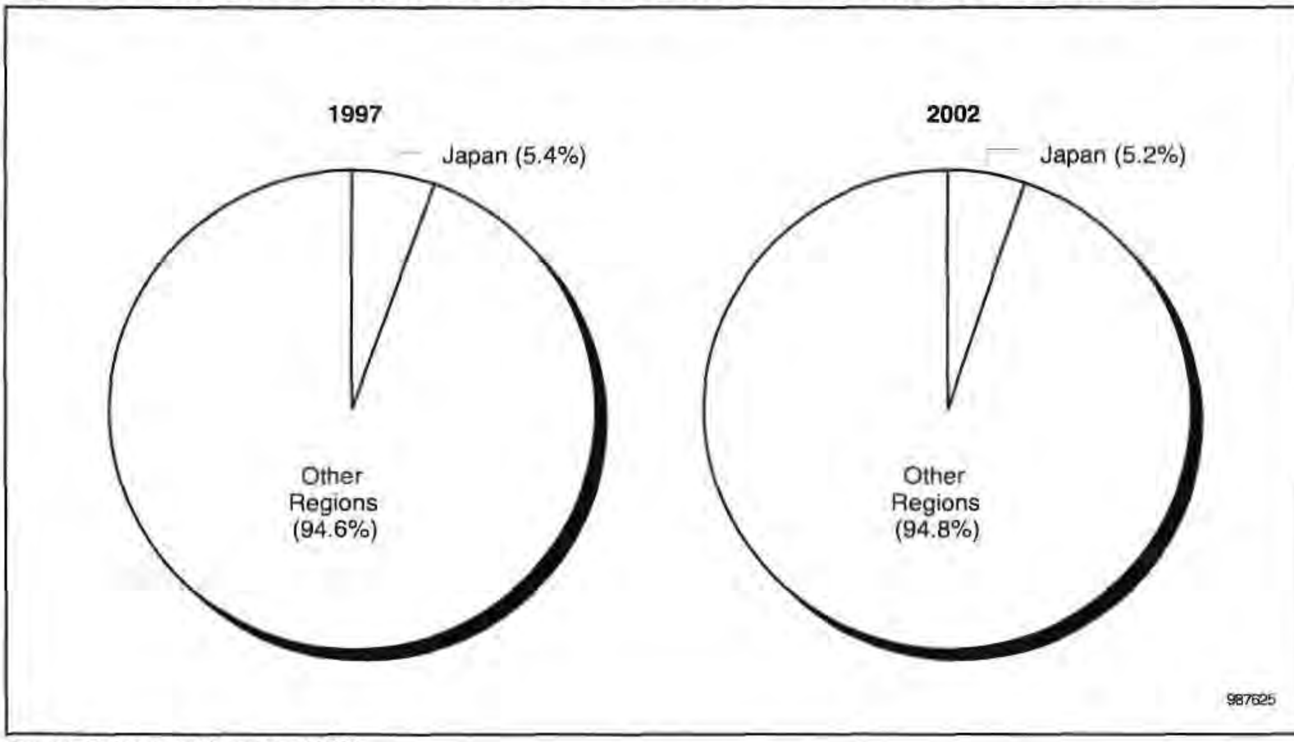
Table 3-20
Production and Semiconductor Consumption Forecast for Central Office Line Cards in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	6,162	5,977	6,634	7,099	7,667	8,050	5.5
Factory ASP (U.S.$)	80.8	82.4	80.0	78.0	77.0	75.0	-1.5
Factory Revenue (U.S.$M)	498	492	531	554	590	604	3.9
Semiconductor Content (U.S.$)	14.0	13.0	13.0	13.0	12.0	12.0	-3.0
Semiconductor TAM (U.S.$M)	86	78	86	92	92	97	2.3

Source: Dataquest (November 1998)

Figure 3-20
Japanese Unit Production Trends for Central Office Line Cards, 1997 versus 2002



Source: Dataquest (November 1998)

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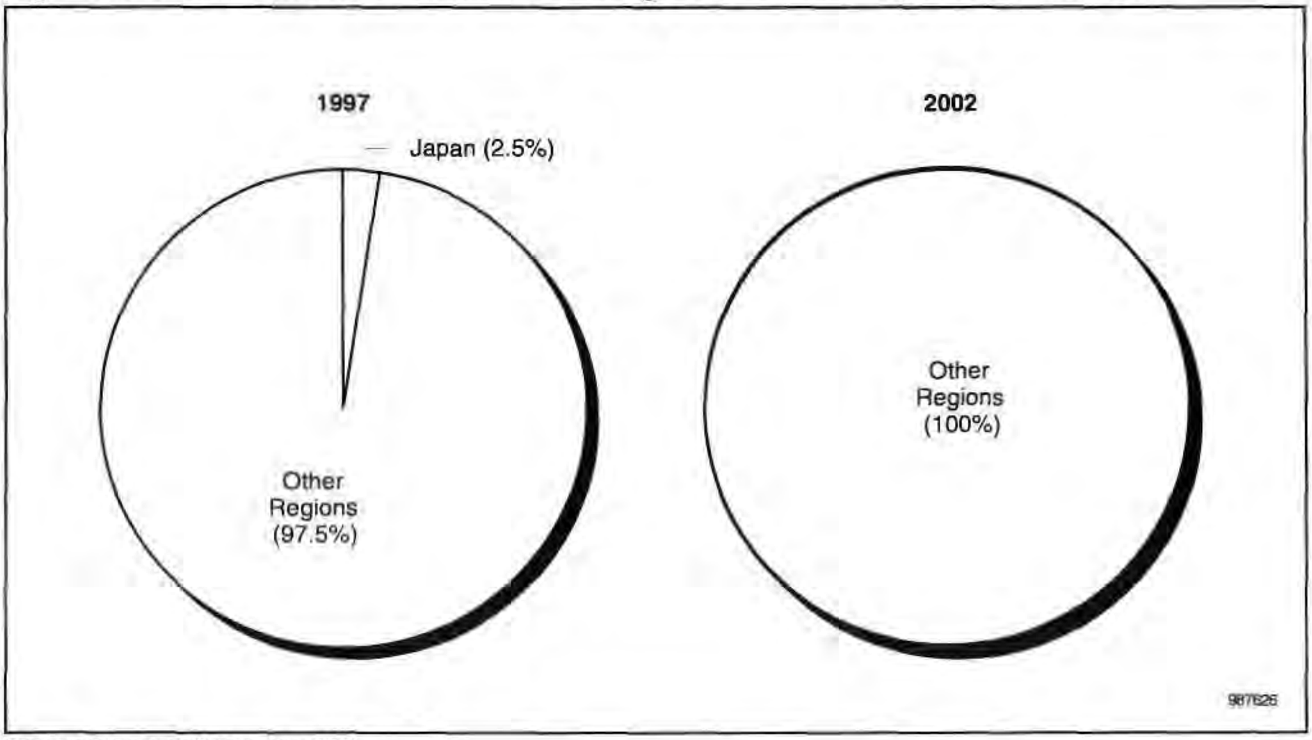
Table 3-21
Production and Semiconductor Consumption Forecast for Analog Cellular Phones in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	620	-	-	-	-	-	-100.0
Factory ASP (U.S.$)	430	-	-	-	-	-	-100.0
Factory Revenue (U.S.$M)	267	-	-	-	-	-	-100.0
Semiconductor Content (U.S.$)	41	-	-	-	-	-	-100.0
Semiconductor TAM (U.S.$M)	25	-	-	-	-	-	-100.0

Source: Dataquest (November 1998)

Figure 3-21
Japanese Unit Production Trends for Analog Cellular Phones, 1997 versus 2002



Source: Dataquest (November 1998)

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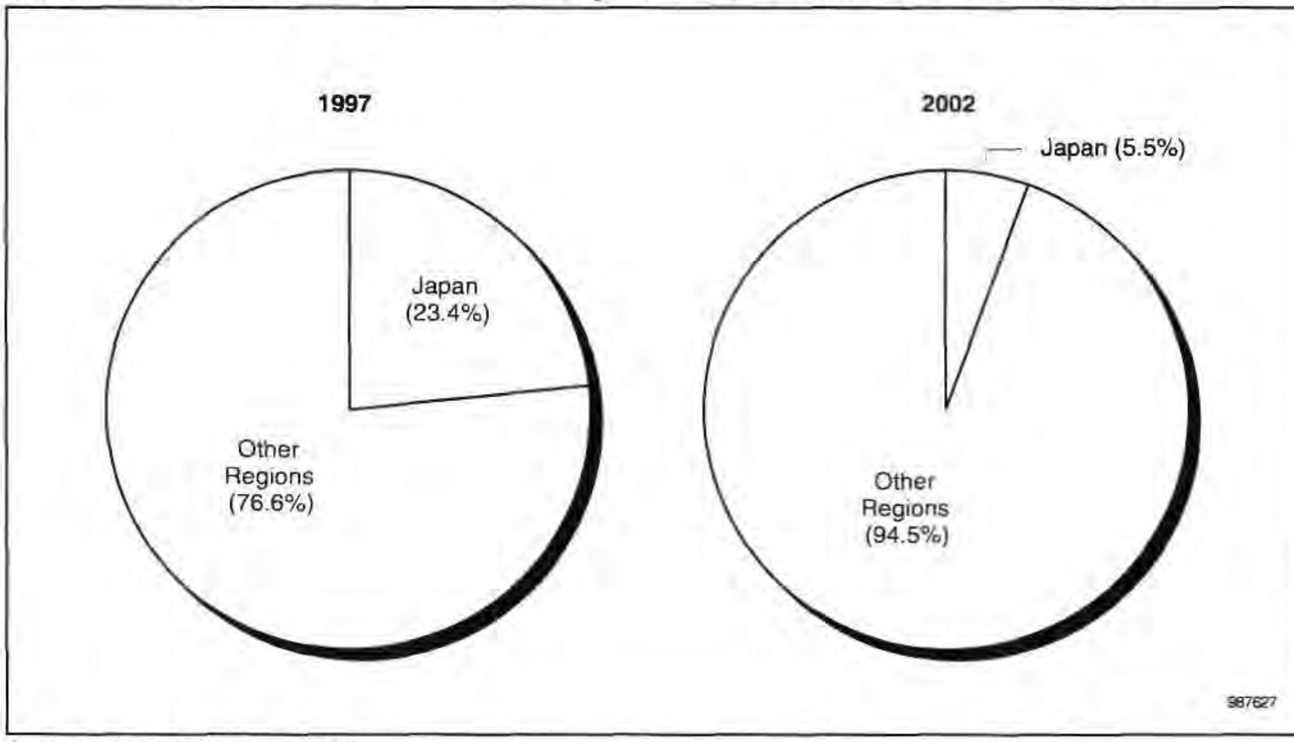
Table 3-22
Production and Semiconductor Consumption Forecast for Digital Cellular Phones in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	23,045	18,525	17,150	17,700	17,075	17,325	-5.5
Factory ASP (U.S.$)	310.0	237.5	200.0	175.1	153.2	142.5	-14.4
Factory Revenue (U.S.$M)	7,144	4,400	3,429	3,099	2,615	2,469	-19.1
Semiconductor Content (U.S.$)	75.0	59.7	51.7	46.7	42.0	40.4	-11.6
Semiconductor TAM (U.S.$M)	1,728	1,106	887	826	717	700	-16.5

Source: Dataquest (November 1998)

Figure 3-22
Japanese Unit Production Trends for Digital Cellular Phones, 1997 versus 2002



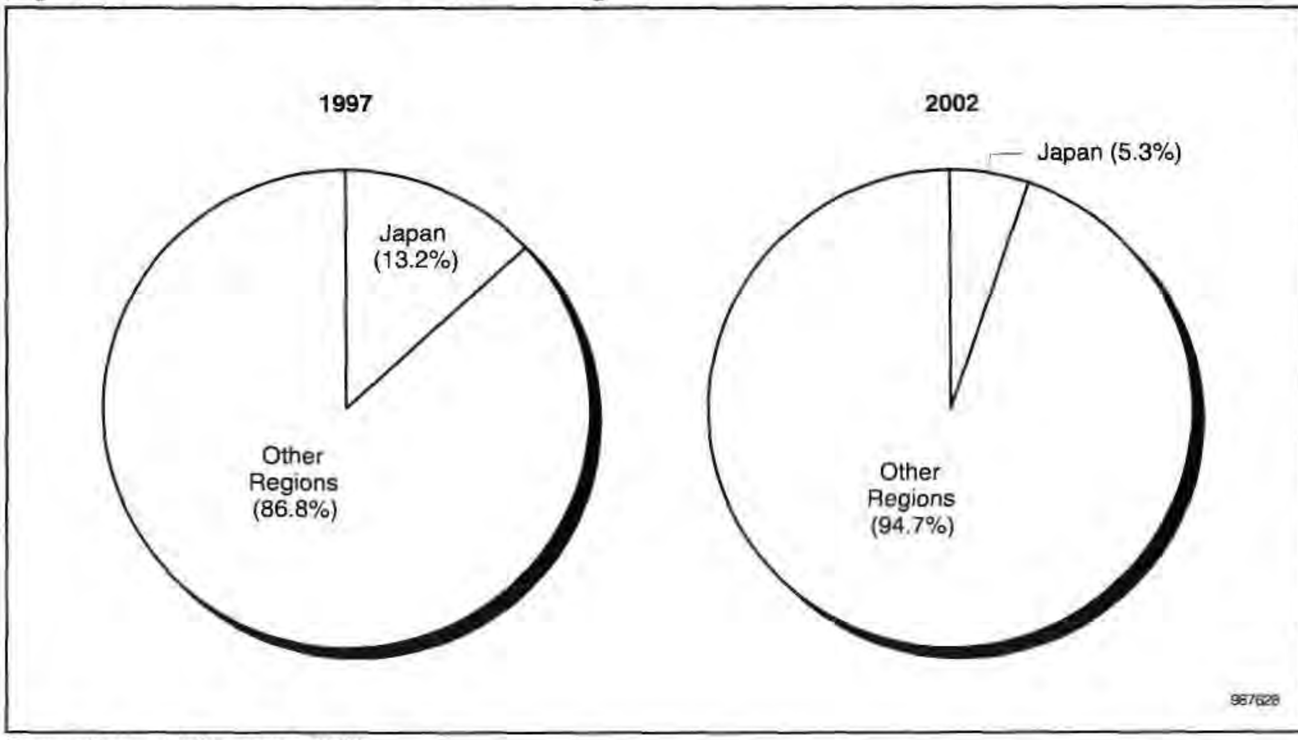
Source: Dataquest (November 1998)

Table 3-23
Production and Semiconductor Consumption Forecast for Pagers in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	5,761	4,608	3,917	3,525	3,173	3,014	-12.1
Factory ASP (U.S.$)	82	78	76	73	68	66	-4.2
Factory Revenue (U.S.$M)	472	359	298	257	216	199	-15.9
Semiconductor Content (U.S.$)	15.2	14.4	14.0	13.5	12.8	12.5	-3.8
Semiconductor TAM (U.S.$M)	88	66	55	48	41	38	-15.5

Source: Dataquest (November 1998)

Figure 3-23
Japanese Unit Production Trends for Pagers, 1997 versus 2002



Source: Dataquest (November 1998)

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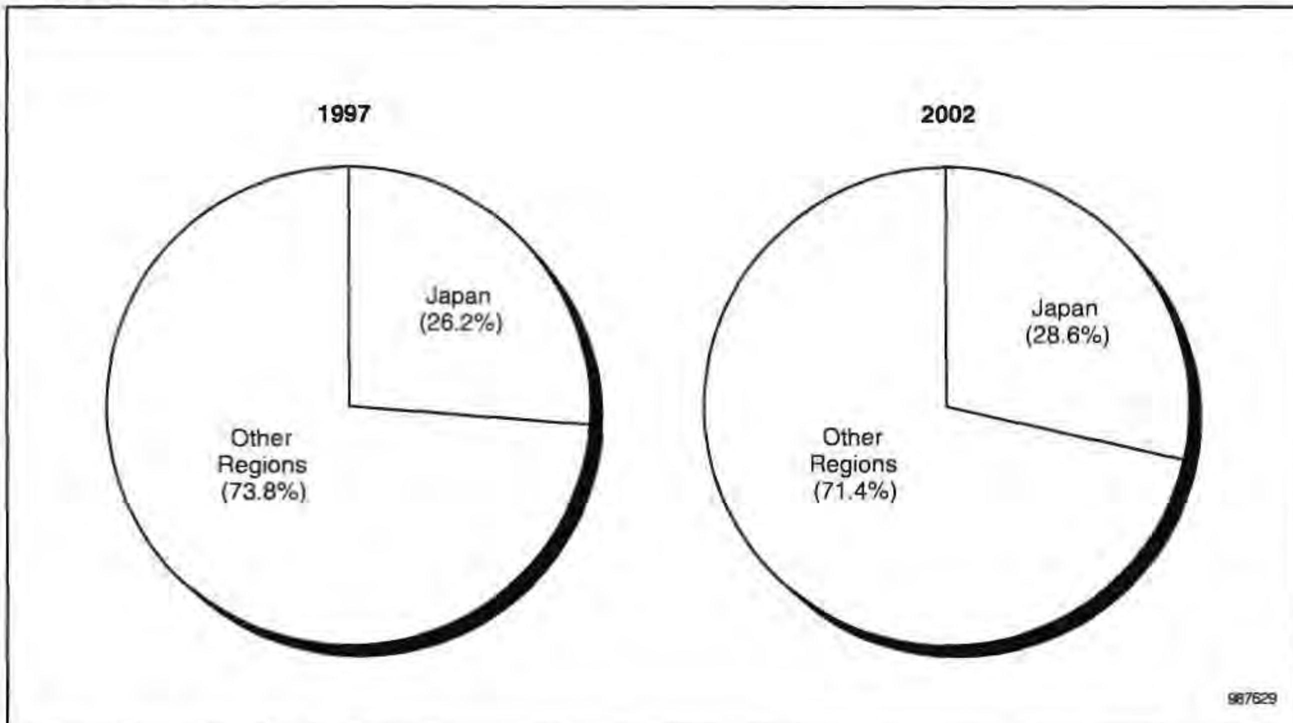
Table 3-24
Production and Semiconductor Consumption Forecast for Mobile Telecommunications Infrastructure in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	NA	NA	NA	NA	NA	NA	NA
Factory ASP (U.S.$)	NA	NA	NA	NA	NA	NA	NA
Factory Revenue (U.S.$M)	7,012	7,222	7,945	8,977	10,324	11,563	10.5
Semiconductor Content (U.S.$)	NA	NA	NA	NA	NA	NA	NA
Semiconductor TAM (U.S.$M)	512	534	596	691	805	913	12.3

NA = Not available or not applicable
Source: Dataquest (November 1998)

Figure 3-24
Japanese Revenue Production Trends for Mobile Telecommunications Infrastructure, 1997 versus 2002



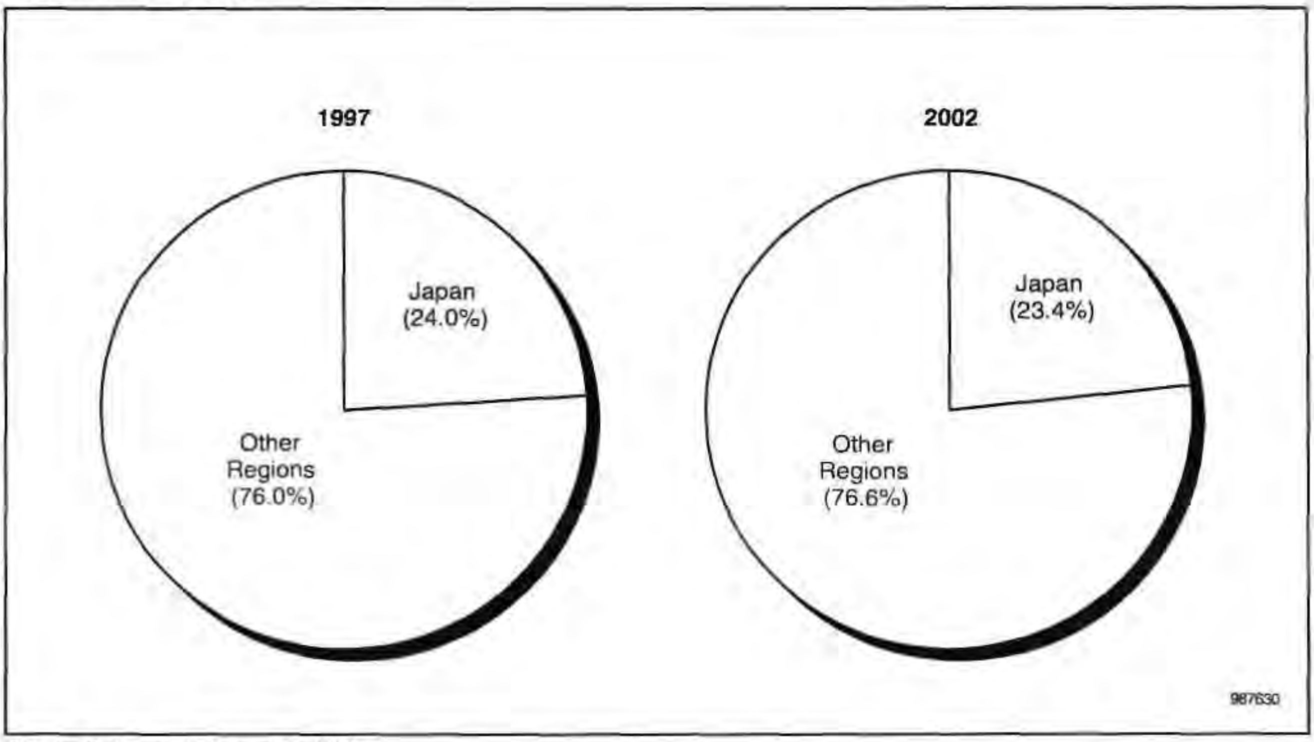
Source: Dataquest (November 1998)

Table 3-25
Production and Semiconductor Consumption Forecast for Other Mobile Telecommunications in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	NA	NA	NA	NA	NA	NA	NA
Factory ASP (U.S.$)	NA	NA	NA	NA	NA	NA	NA
Factory Revenue (U.S.$M)	1,939	1,857	1,803	1,756	1,697	1,663	-3.0
Semiconductor Content (U.S.$)	NA	NA	NA	NA	NA	NA	NA
Semiconductor TAM (U.S.$M)	221	215	213	211	207	206	-1.4

NA = Not available or not applicable
Source: Dataquest (November 1998)

Figure 3-25
Japanese Revenue Production Trends for Other Mobile Telecommunications, 1997 versus 2002



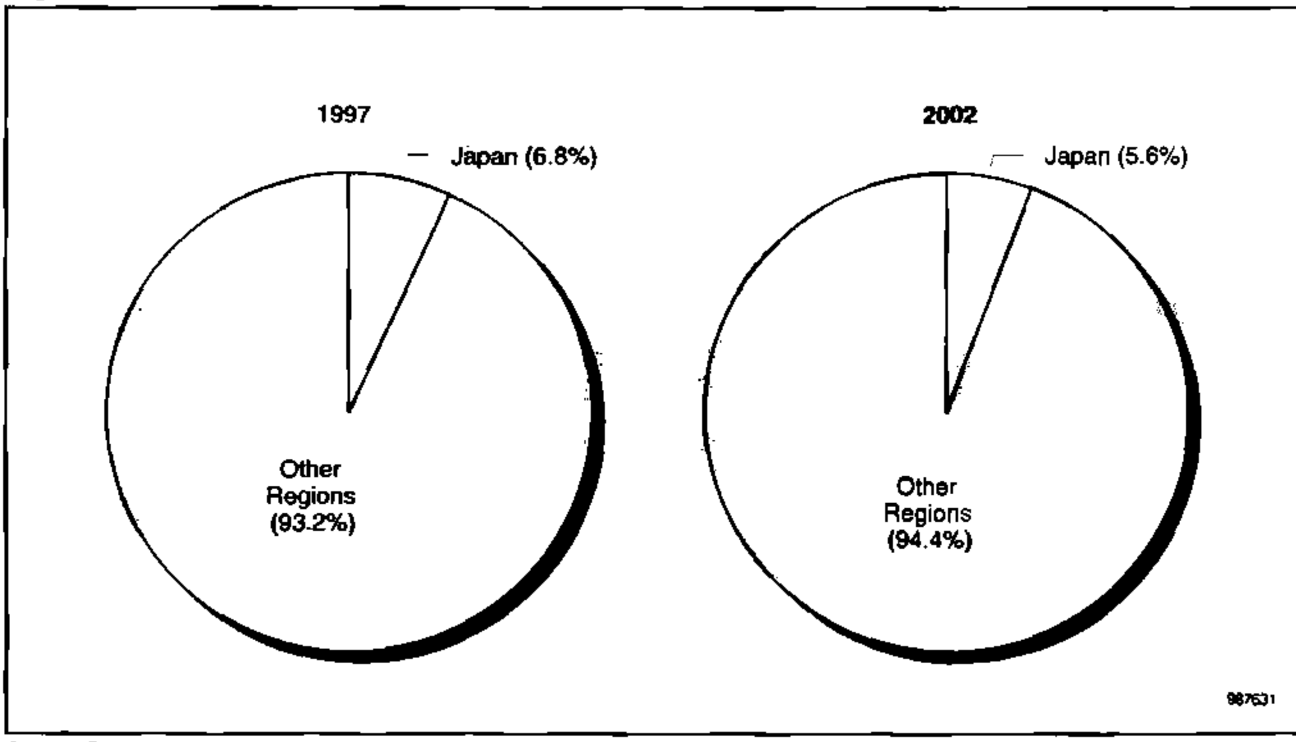
Source: Dataquest (November 1998)

Table 3-26
Production and Semiconductor Consumption Forecast for Personal/Portable Stereos in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	9,565	10,521	10,134	9,931	9,435	9,199	-0.8
Factory ASP (U.S.$)	124.2	105.7	103.6	101.4	100.1	99.6	-4.3
Factory Revenue (U.S.$M)	1,188	1,112	1,050	1,007	945	917	-5.1
Semiconductor Content (U.S.$)	20.4	19.2	18.7	18.1	17.6	17.0	-3.5
Semiconductor TAM (U.S.$M)	195	202	189	180	166	157	-4.3

Source: Dataquest (November 1998)

Figure 3-26
Japanese Unit Production Trends for Personal/Portable Stereos, 1997 versus 2002



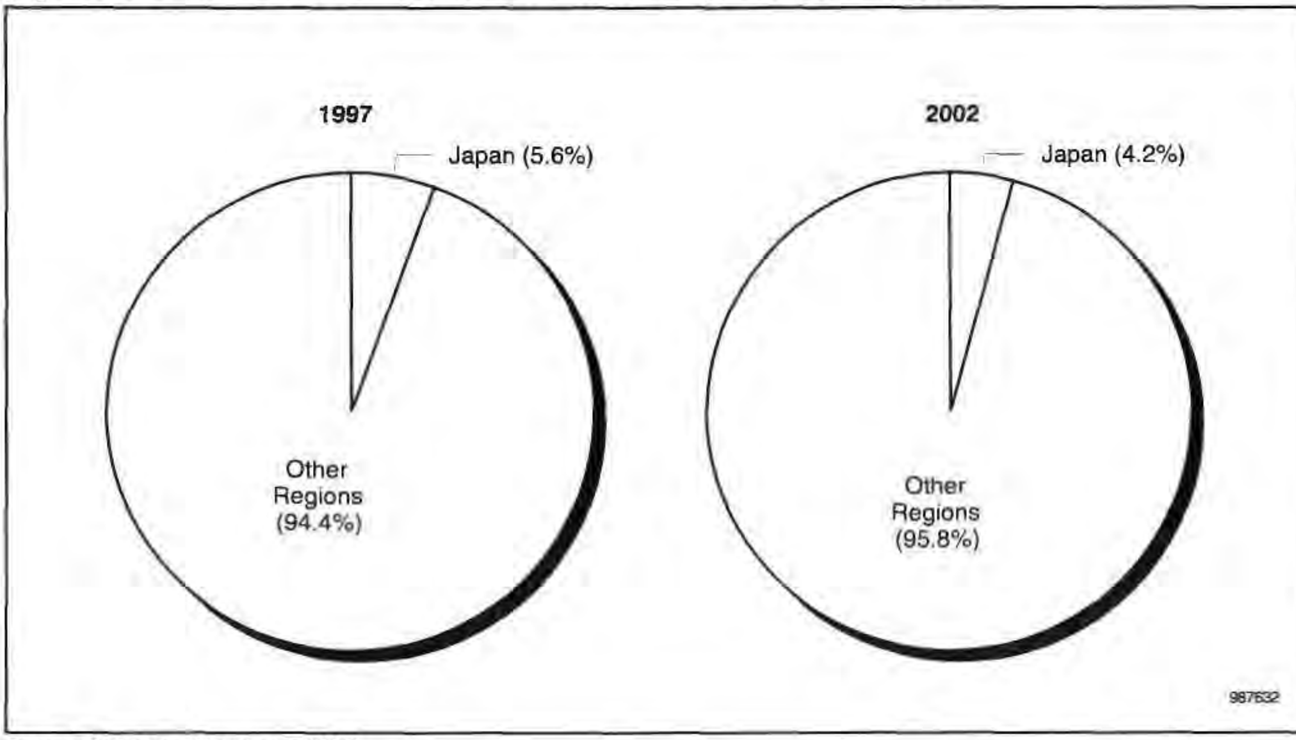
Source: Dataquest (November 1998)

Table 3-27
Production and Semiconductor Consumption Forecast for Color TVs in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	6,683	6,482	6,806	6,666	6,399	6,207	-1.5
Factory ASP (U.S.$)	579.0	550.1	533.4	517.0	497.4	478.1	-3.8
Factory Revenue (U.S.$M)	3,870	3,566	3,630	3,446	3,183	2,968	-5.2
Semiconductor Content (U.S.$)	92.1	90.6	93.0	95.0	90.3	87.6	-1.0
Semiconductor TAM (U.S.$M)	616	587	633	633	578	544	-2.4

Source: Dataquest (November 1998)

Figure 3-27
Japanese Unit Production Trends for Color TVs, 1997 versus 2002



Source: Dataquest (November 1998)

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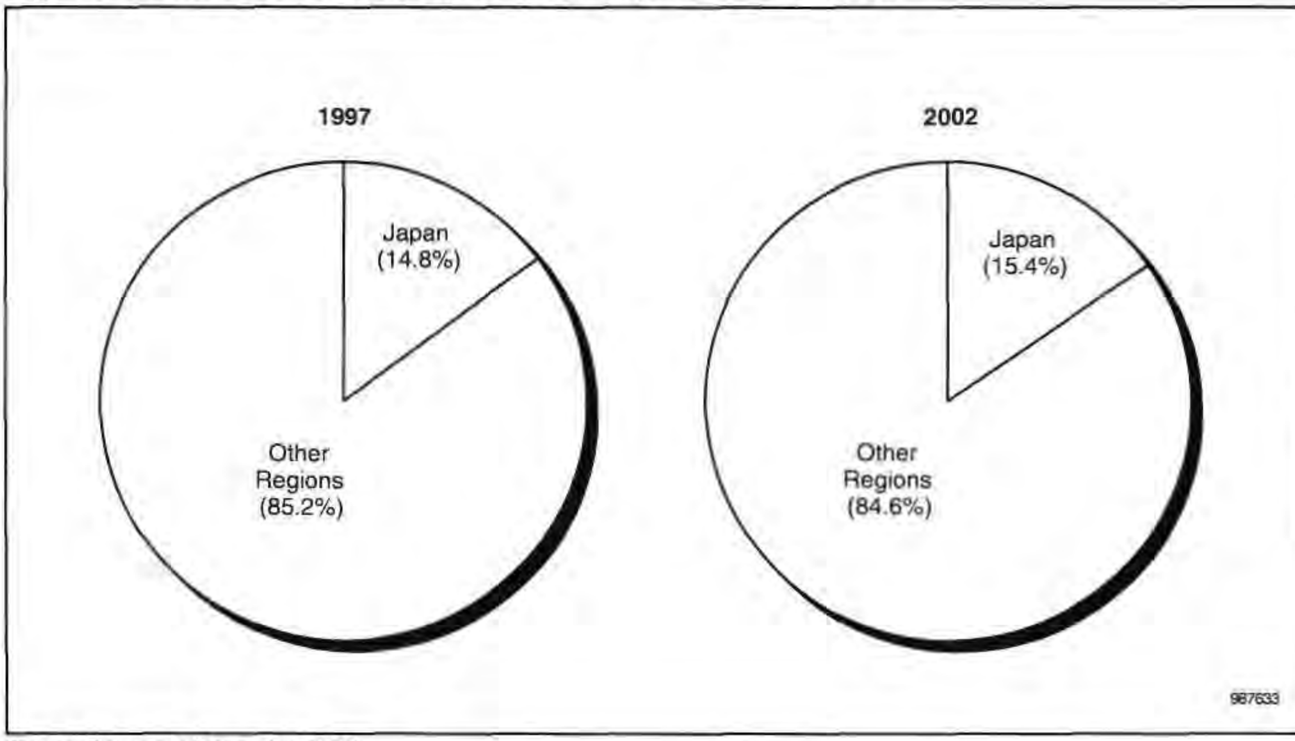
Table 3-28
Production and Semiconductor Consumption Forecast for VCRs in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	9,202	9,017	8,952	8,737	8,388	8,136	-2.4
Factory ASP (U.S.$)	228.1	211.4	198.6	197.2	193.1	187.4	-3.9
Factory Revenue (U.S.$M)	2,098	1,906	1,778	1,723	1,620	1,524	-6.2
Semiconductor Content (U.S.$)	55.4	51.6	50.7	49.7	49.1	47.7	-2.9
Semiconductor TAM (U.S.$M)	510	465	454	434	412	388	-5.3

Source: Dataquest (November 1998)

Figure 3-28
Japanese Unit Production Trends for VCRs, 1997 versus 2002



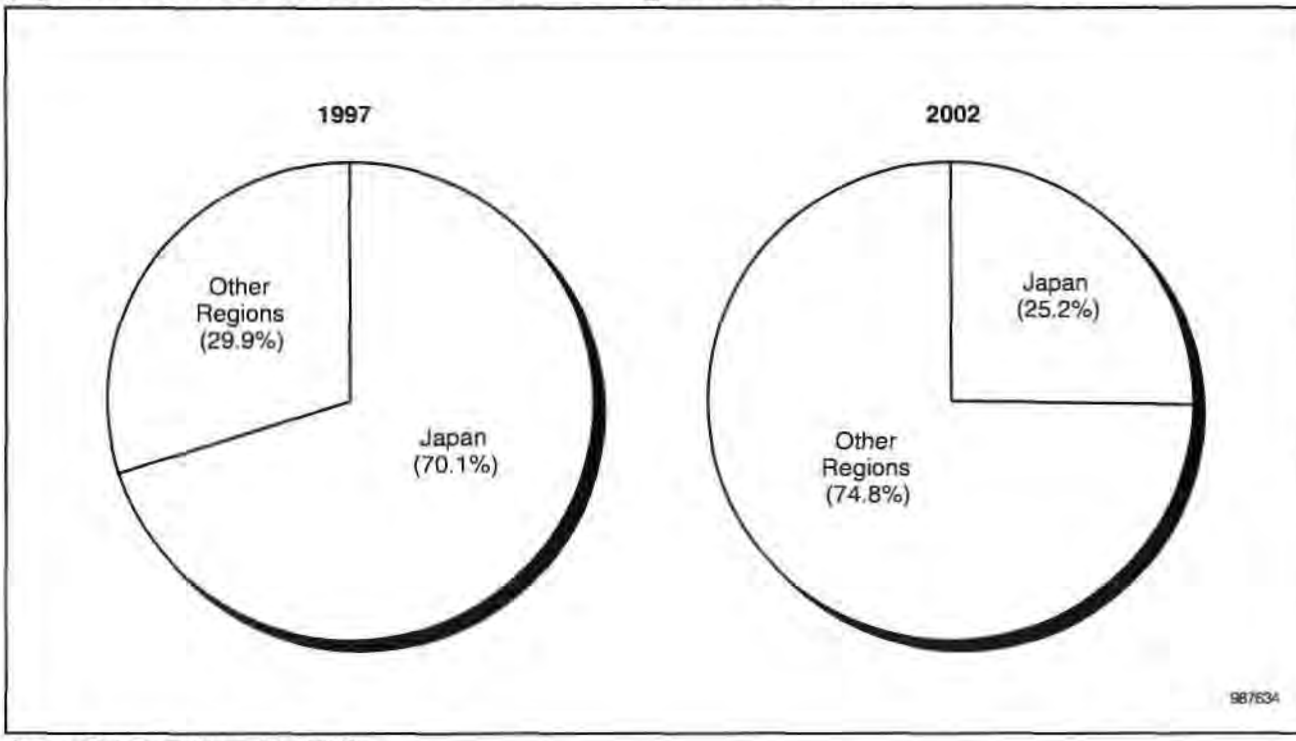
Source: Dataquest (November 1998)

Table 3-29
Production and Semiconductor Consumption Forecast for Analog Camcorders in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	7,426	6,045	5,156	3,948	2,467	1,450	-27.9
Factory ASP (U.S.$)	483	460	430	423	415	408	-3.3
Factory Revenue (U.S.$M)	3,587	2,781	2,217	1,670	1,024	592	-30.3
Semiconductor Content (U.S.$)	118	112	110	105	102	100	-3.3
Semiconductor TAM (U.S.$M)	876	677	567	415	252	145	-30.2

Source: Dataquest (November 1998)

Figure 3-29
Japanese Unit Production Trends for Analog Camcorders, 1997 versus 2002



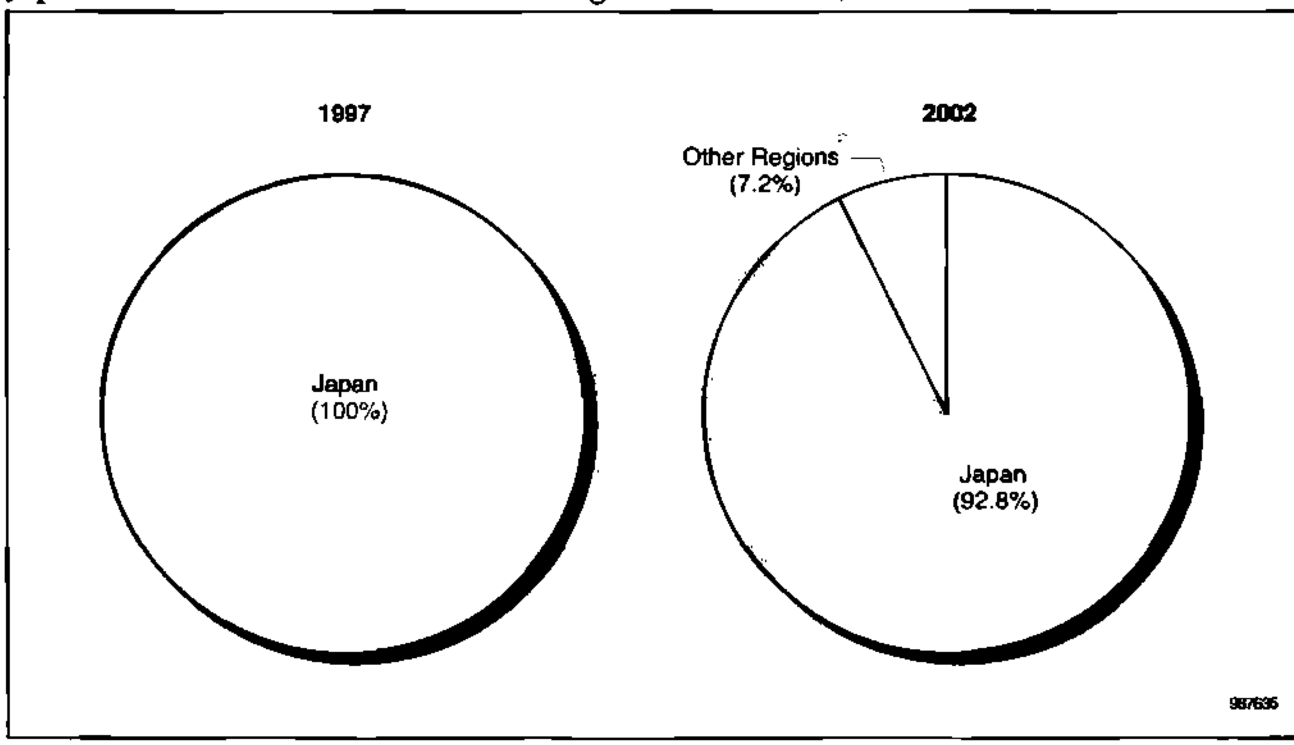
Source: Dataquest (November 1998)

Table 3-30
Production and Semiconductor Consumption Forecast for Digital Camcorders in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	1,578	2,840	3,977	5,170	6,203	7,134	35.2
Factory ASP (U.S.$)	1,221.0	989.6	774.7	604.5	529.0	463.6	-17.6
Factory Revenue (U.S.$M)	1,927	2,811	3,080	3,125	3,281	3,307	11.4
Semiconductor Content (U.S.$)	290.0	227.6	178.3	139.0	121.3	106.5	-18.1
Semiconductor TAM (U.S.$M)	458	647	709	719	753	760	10.7

Source: Dataquest (November 1998)

Figure 3-30
Japanese Unit Production Trends for Digital Camcorders, 1997 versus 2002



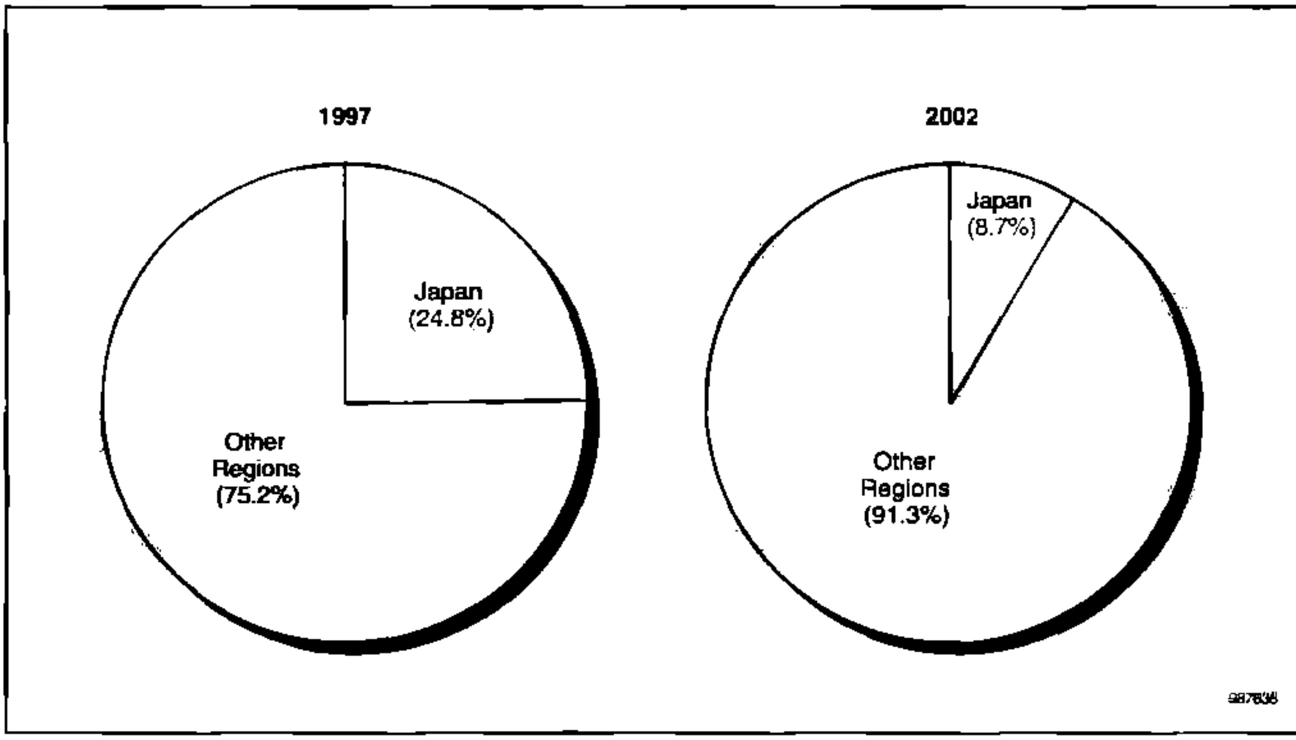
Source: Dataquest (November 1998)

Table 3-31
Production and Semiconductor Consumption Forecast for DVDs in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	175	403	725	1,525	1,915	2,350	68.1
Factory ASP (U.S.$)	394	300	236	195	177	160	-16.5
Factory Revenue (U.S.$M)	69	121	171	297	339	376	40.4
Semiconductor Content (U.S.$)	115.0	64.0	49.0	39.8	38.5	33.1	-22.0
Semiconductor TAM (U.S.$M)	20	26	36	61	74	78	31.0

Source: Dataquest (November 1998)

Figure 3-31
Japanese Unit Production Trends for DVDs, 1997 versus 2002



Source: Dataquest (November 1998)

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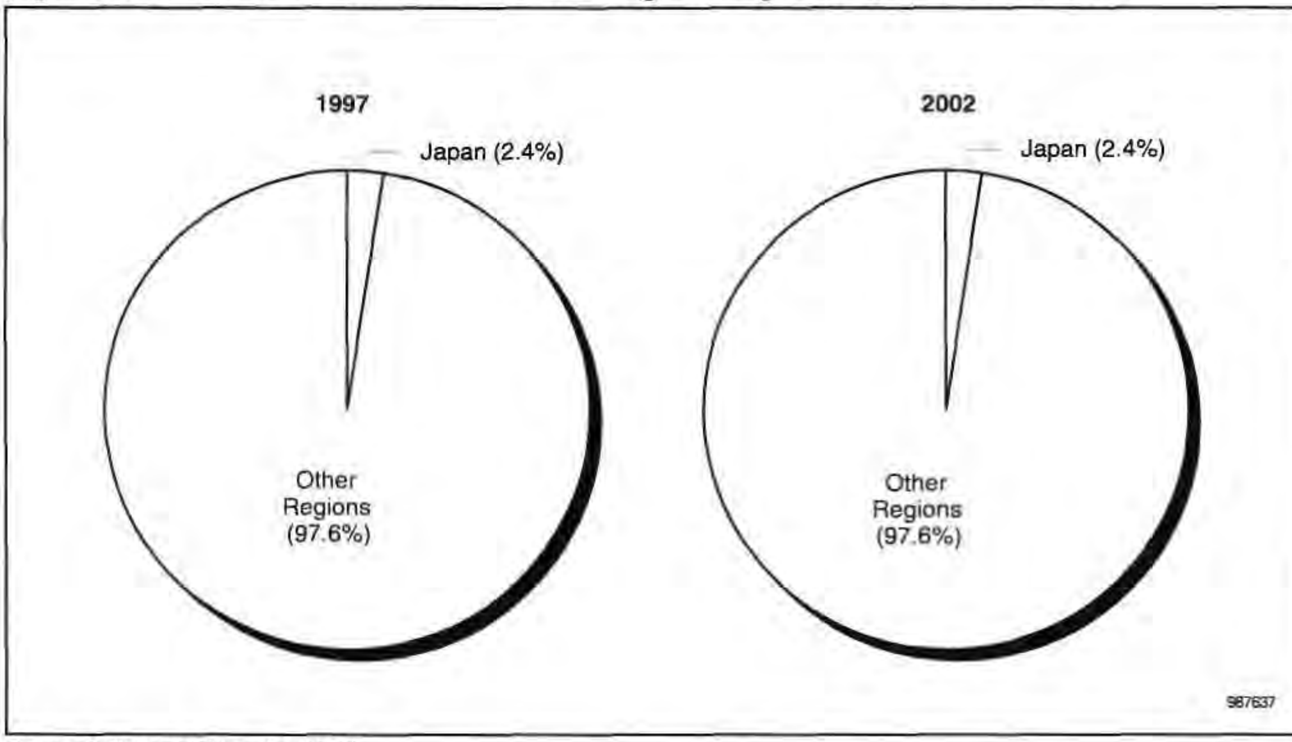
Table 3-32
Production and Semiconductor Consumption Forecast for Analog Set-Top Boxes in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	269	218	183	153	134	127	-13.9
Factory ASP (U.S.$)	98	96	96	95	94	95	-0.6
Factory Revenue (U.S.$M)	26	21	18	15	13	12	-14.5
Semiconductor Content (U.S.$)	43	39	35	34	33	34	-4.6
Semiconductor TAM (U.S.$M)	12	9	6	5	4	4	-17.9

Source: Dataquest (November 1998)

Figure 3-32
Japanese Unit Production Trends for Analog Set-Top Boxes, 1997 versus 2002



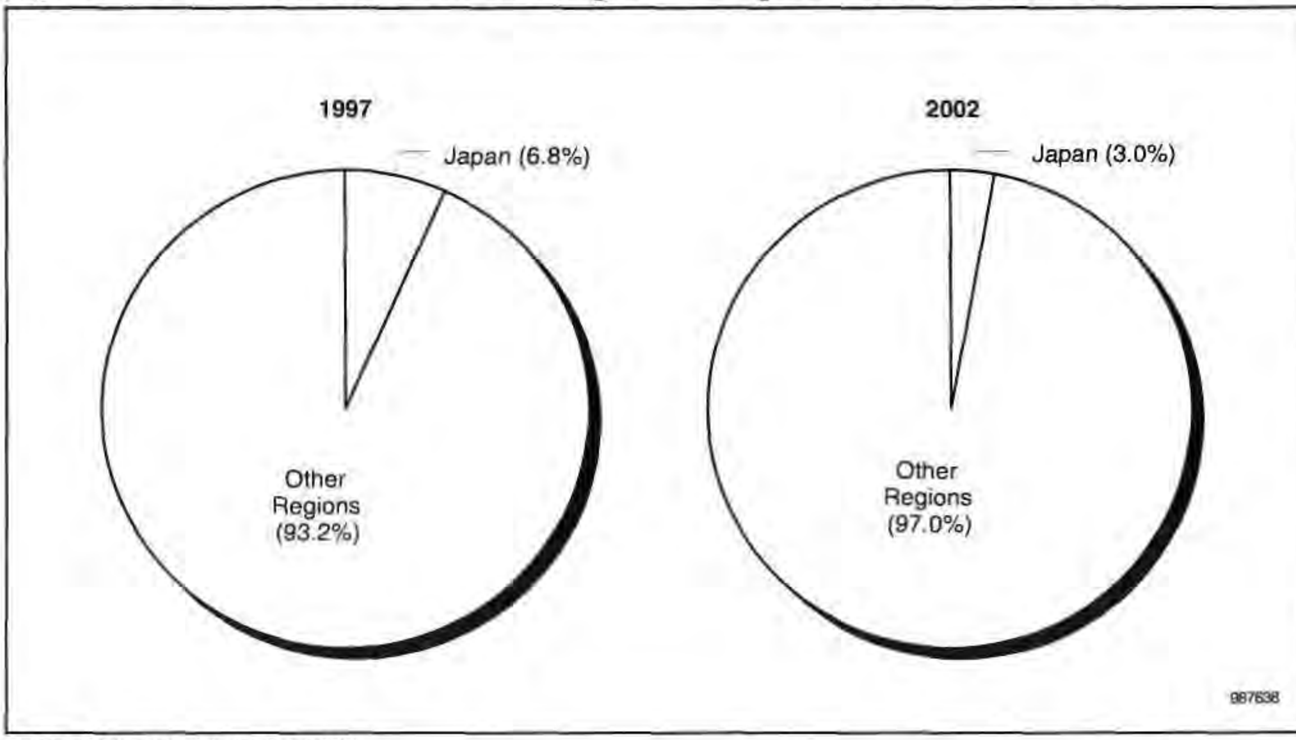
Source: Dataquest (November 1998)

Table 3-33
Production and Semiconductor Consumption Forecast for Digital Set-Top Boxes in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	557	629	768	960	1,113	1,225	17.1
Factory ASP (U.S.$)	470	300	280	275	268	260	-11.2
Factory Revenue (U.S.$M)	262	189	215	264	298	318	4.0
Semiconductor Content (U.S.$)	180	140	125	110	105	100	-11.1
Semiconductor TAM (U.S.$M)	100	88	96	106	117	122	4.1

Source: Dataquest (November 1998)

Figure 3-33
Japanese Unit Production Trends for Digital Set-Top Boxes, 1997 versus 2002



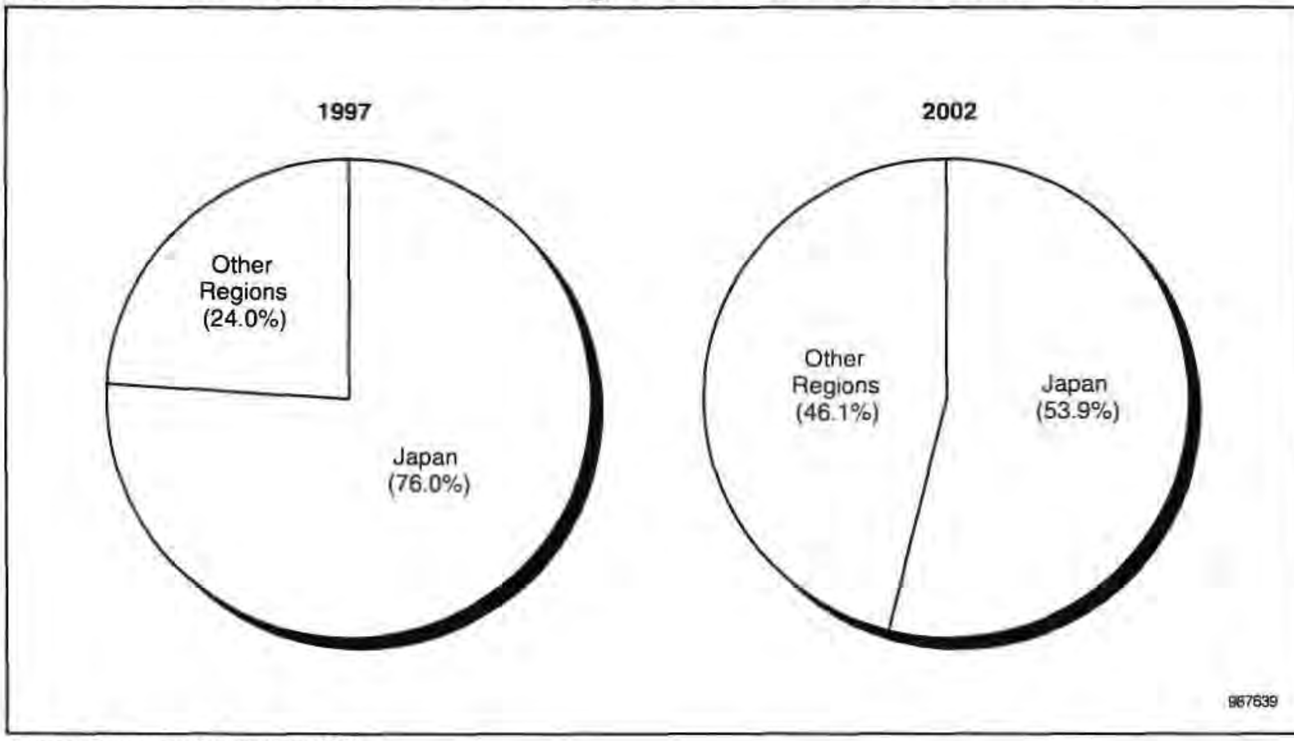
Source: Dataquest (November 1998)

Table 3-34
Production and Semiconductor Consumption Forecast for Digital Still Cameras in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	1,756	2,985	3,987	4,385	4,583	5,041	23.5
Factory ASP (U.S.$)	259.0	232.7	206.4	190.0	179.4	168.8	-8.2
Factory Revenue (U.S.$M)	455	695	823	833	822	851	13.4
Semiconductor Content (U.S.$)	164.4	101.5	87.6	81.1	75.3	72.7	-15.1
Semiconductor TAM (U.S.$M)	289	303	349	356	345	366	4.9

Source: Dataquest (November 1998)

Figure 3-34
Japanese Unit Production Trends for Digital Still Cameras, 1997 versus 2002



Source: Dataquest (November 1998)

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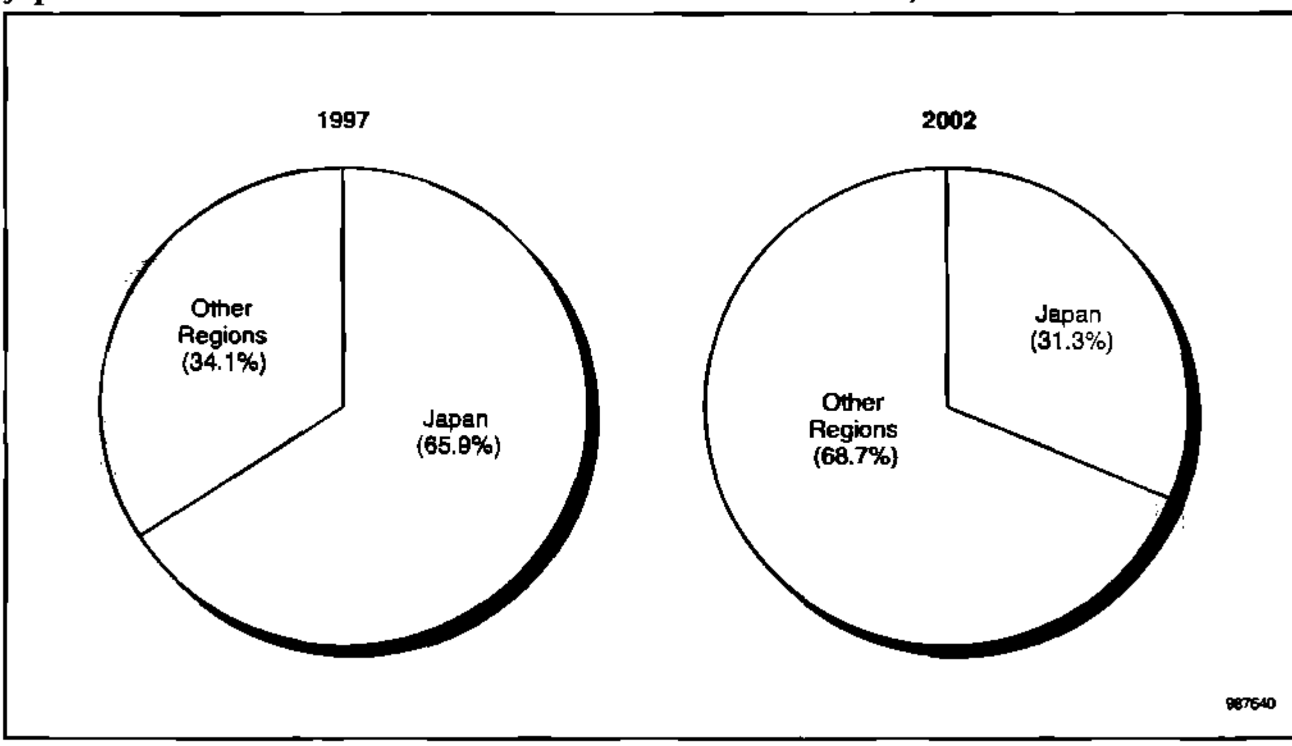
Table 3-35
Production and Semiconductor Consumption Forecast for Video Game Controllers in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	19,190	15,065	8,000	6,000	5,900	10,000	-12.2
Factory ASP (U.S.$)	151	133	142	160	152	134	-2.4
Factory Revenue (U.S.$M)	2,898	2,004	1,136	960	897	1,338	-14.3
Semiconductor Content (U.S.$)	94	83	90	100	93	82	-2.6
Semiconductor TAM (U.S.$M)	1,794	1,250	720	600	549	820	-14.5

Source: Dataquest (November 1998)

Figure 3-35
Japanese Unit Production Trends for Video Game Controllers, 1997 versus 2002



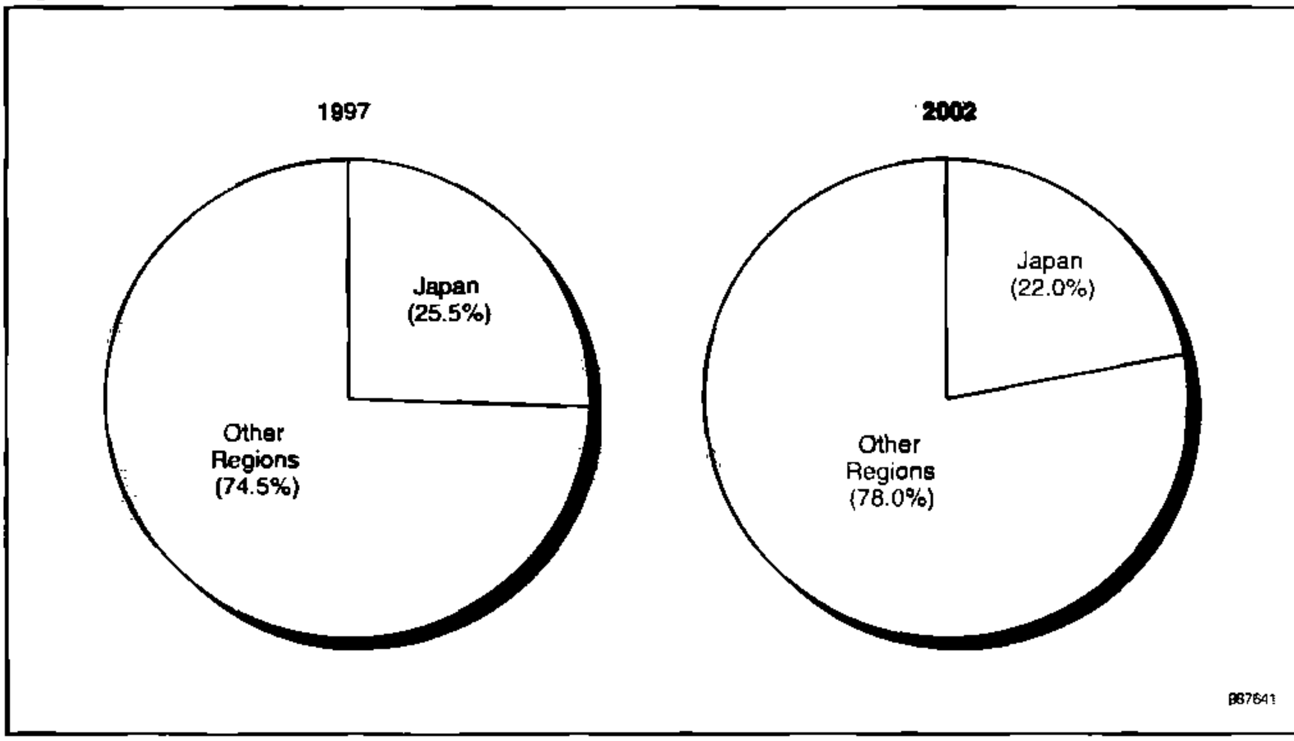
Source: Dataquest (November 1998)

Table 3-36
Production and Semiconductor Consumption Forecast for Automotive Stereos in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	13,336	12,696	12,567	13,109	13,038	12,500	-1.3
Factory ASP (U.S.$)	133	130	127	125	123	122	-1.7
Factory Revenue (U.S.$M)	1,774	1,650	1,596	1,639	1,604	1,525	-3.0
Semiconductor Content (U.S.$)	15.2	16.0	16.0	17.0	17.0	18.0	3.4
Semiconductor TAM (U.S.$M)	203	203	201	223	222	225	2.1

Source: Dataquest (November 1998)

Figure 3-36
Japanese Unit Production Trends for Automotive Stereos, 1997 versus 2002



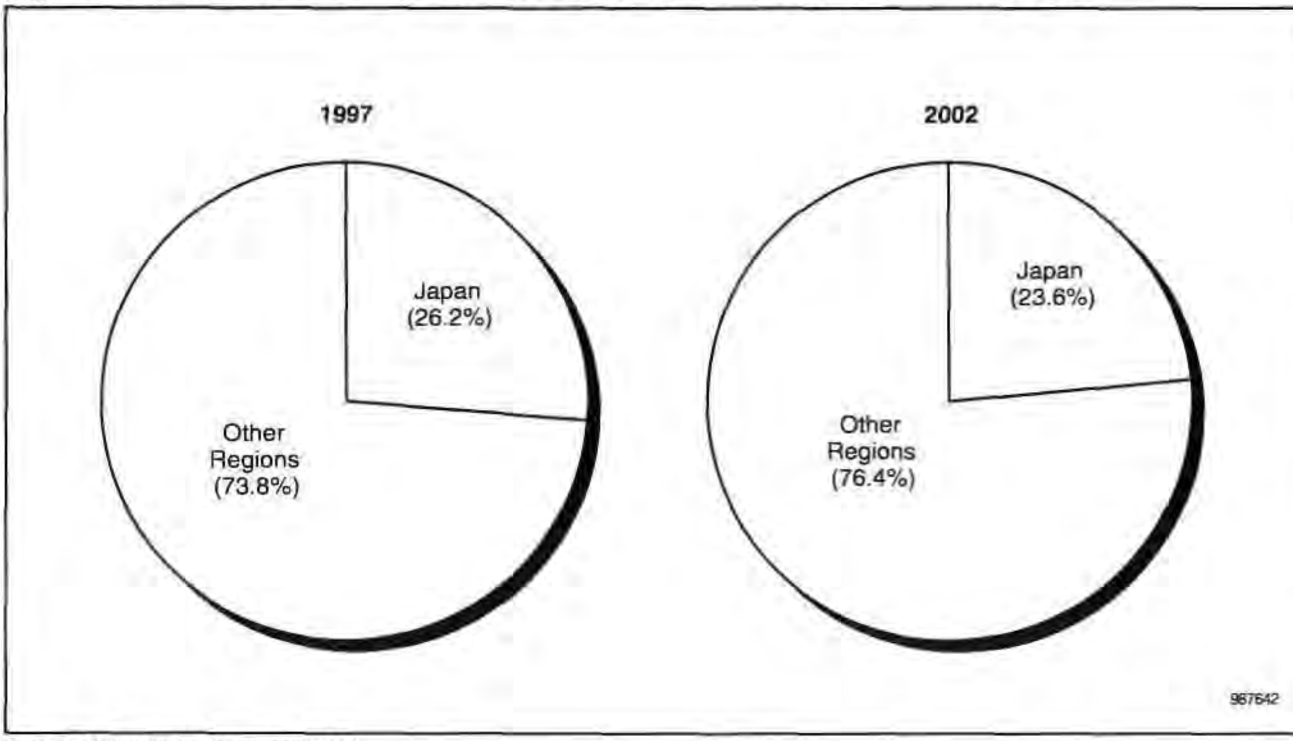
Source: Dataquest (November 1998)

Table 3-37
Production and Semiconductor Consumption Forecast for Automotive ECUs in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	11,184	11,553	11,805	12,045	12,367	12,500	2.2
Factory ASP (U.S.$)	163.0	167.0	176.0	179.8	179.8	179.0	1.9
Factory Revenue (U.S.$M)	1,823	1,929	2,078	2,166	2,224	2,238	4.2
Semiconductor Content (U.S.$)	47.0	48.0	49.0	49.4	49.0	49.0	0.8
Semiconductor TAM (U.S.$M)	526	555	578	595	606	613	3.1

Source: Dataquest (November 1998)

Figure 3-37
Japanese Unit Production Trends for Automotive ECUs, 1997 versus 2002



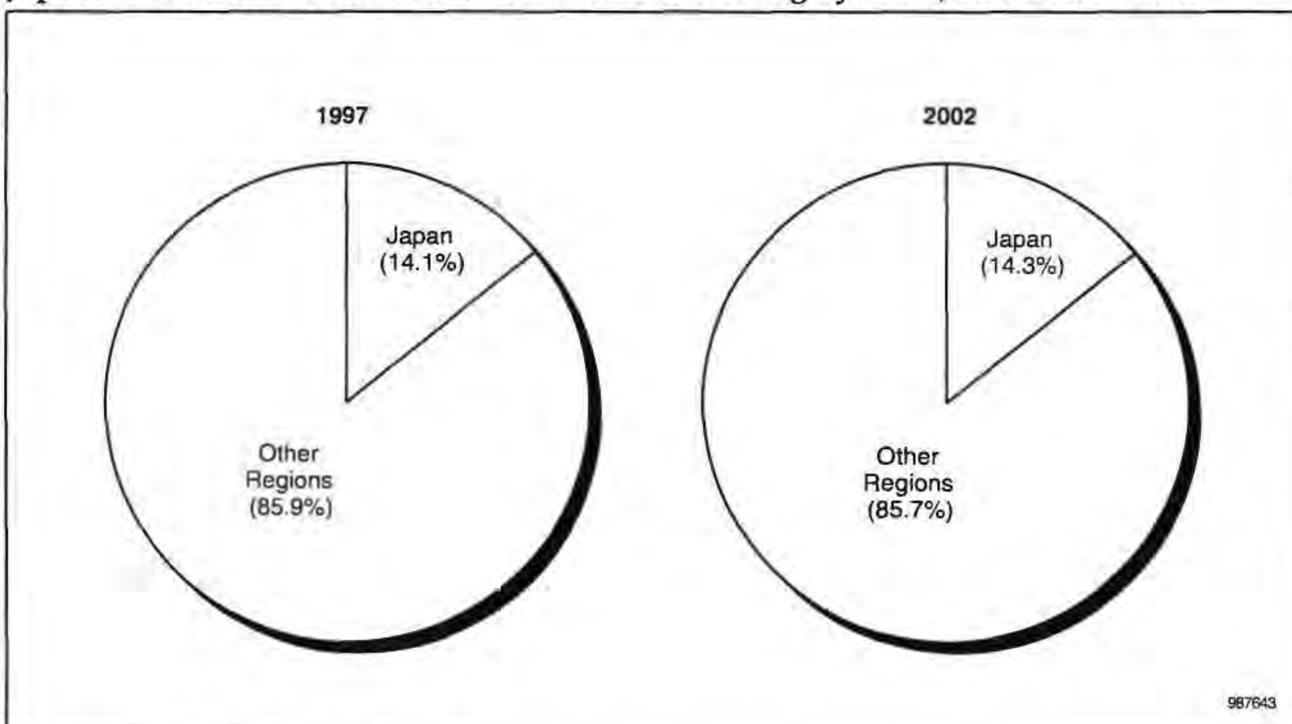
Source: Dataquest (November 1998)

Table 3-38
Production and Semiconductor Consumption Forecast for Antilock Braking Systems in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	3,148	3,425	3,911	4,286	4,697	5,150	10.3
Factory ASP (U.S.$)	195	184	172	166	155	150	-5.1
Factory Revenue (U.S.$M)	614	630	673	711	728	773	4.7
Semiconductor Content (U.S.$)	41	40	39	38	38	37	-2.0
Semiconductor TAM (U.S.$M)	129	137	153	163	178	191	8.1

Source: Dataquest (November 1998)

Figure 3-38
Japanese Unit Production Trends for Antilock Braking Systems, 1997 versus 2002



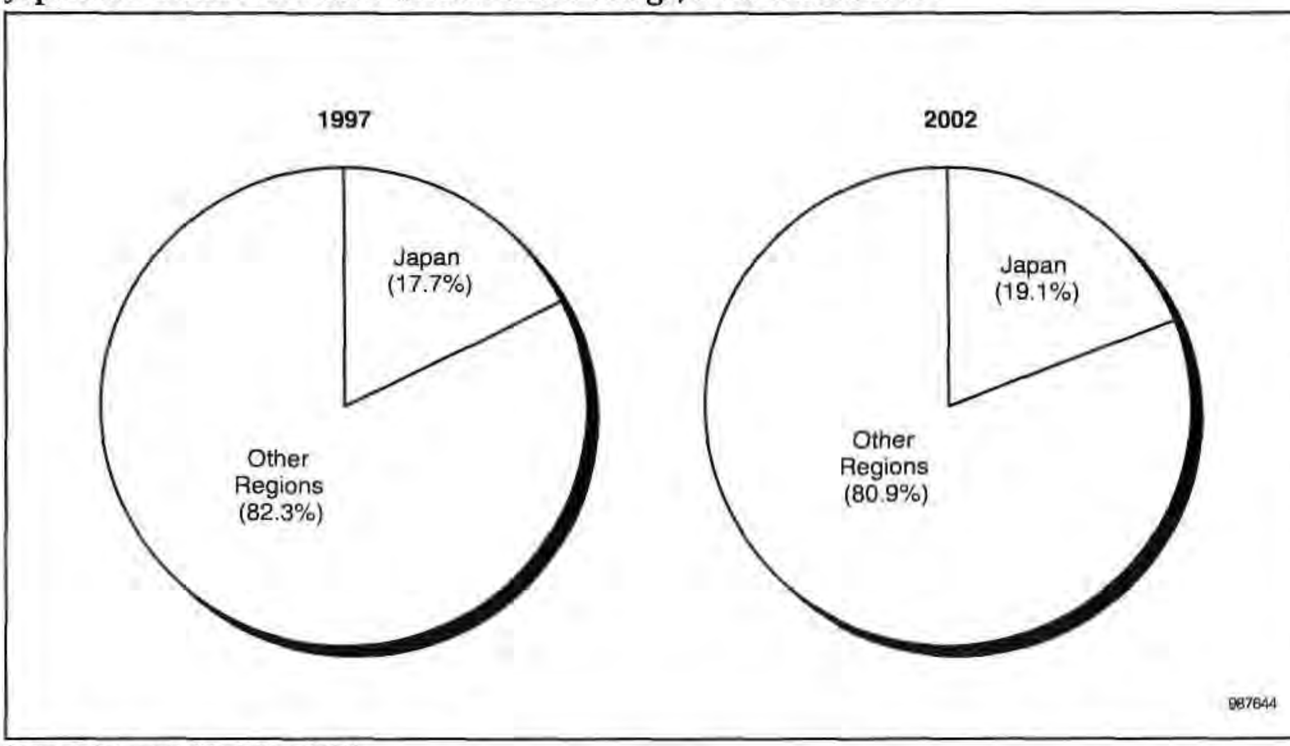
Source: Dataquest (November 1998)

Table 3-39
Production and Semiconductor Consumption Forecast for Air Bags in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	5,355	6,472	7,240	8,083	8,500	9,000	10.9
Factory ASP (U.S.$)	77	70	65	60	58	56	-6.2
Factory Revenue (U.S.$M)	412	453	471	485	493	504	4.1
Semiconductor Content (U.S.$)	20	19	19	18	18	18	-2.1
Semiconductor TAM (U.S.$M)	107	123	138	145	153	162	8.6

Source: Dataquest (November 1998)

Figure 3-39
Japanese Unit Production Trends for Air Bags, 1997 versus 2002



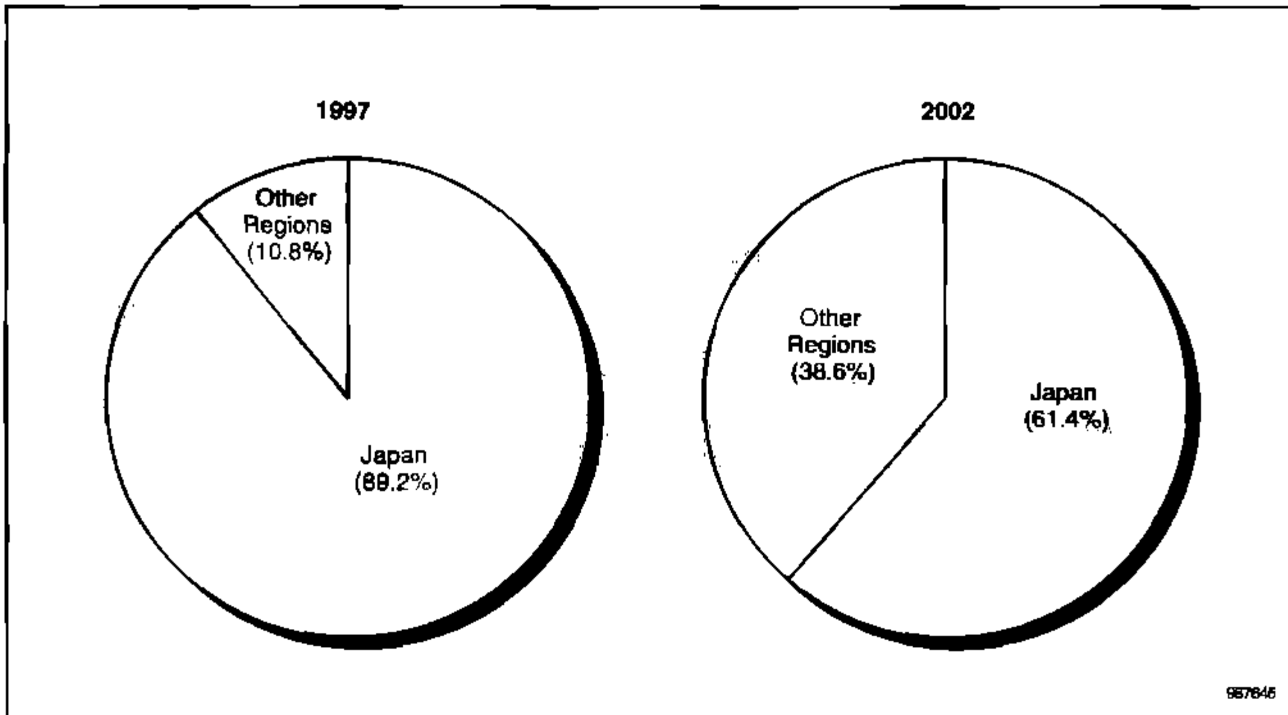
Source: Dataquest (November 1998)

Table 3-40
Production and Semiconductor Consumption Forecast for Automotive Navigation Systems in Japan, 1997 to 2002

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Units (K)	1,352	1,787	2,985	4,239	5,807	7,549	41.1
Factory ASP (U.S.$)	954	825	810	751	710	640	-7.7
Factory Revenue (U.S.$M)	1,290	1,474	2,418	3,183	4,123	4,831	30.2
Semiconductor Content (U.S.$)	191.7	167.0	150.9	145.9	139.8	135.0	-6.8
Semiconductor TAM (U.S.$M)	259	298	450	619	812	1,019	31.5

Source: Dataquest (November 1998)

Figure 3-40
Japanese Unit Production Trends for Automotive Navigation Systems, 1997 versus 2002



Source: Dataquest (November 1998)

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Japanese Electronic Equipment Production Forecast, Fall 1998

Market Statistics

Program: Semiconductors Japan
Product Code: SEMI-JA-MS-9804
Publication Date: November 30, 1998
Filing: Market Statistics

Japanese Electronic Equipment Production Forecast, Fall 1998

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Chapter 1
Japanese Electronic Equipment Production Forecast

Introduction

Electronic equipment production is an important determinant of semiconductor market activity. This is true because semiconductor demand is derived, in part, from the underlying demand for the systems that use semiconductors. That is, the demand for semiconductors is a positive (or increasing) function of the demand for electronic systems. Therefore, forecasting electronic systems production is an essential component of assessing expected semiconductor market activity.

This document contains tables detailing the fall 1998 electronic equipment production forecast. Japanese production is estimated for the years 1992 to 2002. Production tables contain both historical data and forecasts. In most tables, historical data begins with 1992 and ends with 1997, while forecast data provides estimates for 1998 through 2002. The tables detail the type of production data by application market.

Definitions and Conventions

The objective of analyzing electronic systems production activity is to estimate the important implications for semiconductor consumption. In this document, the value of production is estimated as factory revenue. Dataquest defines factory revenue as the exchange value of the commodity transaction between the original equipment manufacturer and the point of entry into distribution. In the case of a direct sale that involves no distribution, as is the case with military systems, factory revenue is equal to the final user cost, net of sales taxes.

Production is the value-adding process by which the factors of production (labor and capital) and material input are transformed into the goods and services that are desired for consumption and investment. As such, production can span both time and geography. For example, a Japanese color television company may minimize its cost of production by manufacturing its products (that is, consuming chips) in Asian countries. Dataquest would estimate this as Asia/Pacific production, because we are interested in that portion of the production process that relates specifically to semiconductor consumption.

Electronic equipment is divided into the following six semiconductor application markets and is further divided into the designated segments:

- Data processing
  - Computers
  - Data storage
  - Input/output
  - Dedicated systems
  - Other data processing

- Communications
  - Premise telecom
  - Public telecom
  - Mobile and radio equipment
  - Broadcast and studio
  - Other communications
- Industrial
  - Security/energy management
  - Manufacturing systems/instrumentation
  - Medical equipment
  - Other industrial
- Consumer
  - Audio
  - Video
  - Personal electronics
  - Appliances
  - Other consumer
- Military/civil aerospace
- Transportation

Data Sources

The historical information presented in the production data has been consolidated from a variety of sources, each of which focuses on a specific part of the market. These sources include the following:

- Japanese production statistics compiled and published by the Ministry of International Trade and Industry (MITI)
- Estimates presented by knowledgeable and reliable industry spokespersons
- Published information on products and prices

Valuation of Production

Japanese production is expressed in Japanese yen and translated into U.S. dollars. To make the tables in this document useful in comparing different regions, it is necessary to express all values in a common currency, and Dataquest chose the U.S. dollar for convenience. However, the choice of the U.S. dollar or any other currency brings with it some problems that require the readers' careful consideration in interpreting the data.

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Exchange rates are an example of this. When forecasting electronic equipment production, it is important to ensure consistency and continuity. The preliminary 1998 exchange rate estimate is based on actual monthly exchange rates through July 1998, and we assume that the July rate applies for all the future months in 1998. For the years 1999 through 2002, we maintain exchange rates at constant 1999 calendar-year values. This prevents any inconsistencies in the conversion of growth projections and currency fluctuations. The estimates in this Market Statistics report are generated primarily on a yen basis and then are converted to U.S. dollars.

Japanese Electronic Equipment Production Definitions

Data Processing Equipment

Defined as computers, data storage, input/output devices, dedicated systems, and other data processing, as follows:

- Computers include supercomputers, mainframe computers, midrange computers, entry-level servers, workstations, PCs, motherboards, and handheld computers.
- Data storage includes rigid disk drives, removable disk drives, optical disk drives, tape drives, and other data storage.
- Input/output includes all equipment that transfers data between the CPU and a peripheral device, such as printers, monitors, and other input/output devices.
- Dedicated systems include dedicated data processing systems such as copiers, personal organizers, chip cards, and other systems.
- Other data processing includes sound/audio, digital, and graphics accelerator boards. This category also includes the value of aftermarket sales of single in-line memory modules (SIMMs) and dual in-line memory modules (DIMMs).

Communications Equipment

Defined as premise telecom, public telecom, mobile and radio communications, broadcast and studio, and other communications, as follows:

- Premise telecom includes telecommunications equipment on private premises such as image and test communications equipment, data communications equipment (WAN/LAN and remote access), premise voice systems, and desktop terminals (telephones excluding mobile handsets).
- Public telecom includes key equipment involved in the public switching and transmission markets.
- Mobile and radio communications includes cellular/broadband personal communications services (PCS)/enhanced special mobile radio (ESMR) handsets, pagers, and mobile communications infrastructure, among others.
- Broadcast and studio includes audio, video, and other broadcast and studio equipment.
- Other communications includes other communications equipment not counted elsewhere, such as intercommunications systems.

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Industrial Equipment

Defined as security/energy management, manufacturing systems/instruments, medical equipment, and other industrial systems, as follows:

- Security and energy management includes alarm systems and energy management.
- Manufacturing systems/instrumentation includes semiconductor production equipment, control and process control equipment, control and processing display equipment, and robots. This category also includes automatic test equipment (ATE) semiconductor equipment, nuclear electronics, and other test and measurement equipment.
- Medical equipment includes diagnostic, therapeutic, patient monitoring and measuring systems, surgical support equipment, and irradiation equipment.
- Other industrial includes vending machines, automatic service equipment, commercial clothes-washing equipment, teaching machines and aids, particle accelerator electronic equipment, electron microscopes, and scientific equipment not counted elsewhere.

Consumer Equipment

Defined as audio, video, personal electronics, appliances, and other consumer equipment, as follows:

- Audio includes consumer audio equipment.
- Video includes consumer video equipment.
- Personal electronics includes video games, cameras, electronic watches, clocks, and toys.
- Appliances include consumer appliances.
- Other consumer includes automatic garage door openers, electronic tape measures, electronic tire gauges, and other consumer equipment not counted elsewhere.

Military/Civil Aerospace Equipment

Defined as radar/sonar/reconnaissance, missile/space, navigation, electronic warfare, aircraft flight systems, and command/control systems.

Transportation Equipment

Defined as entertainment, vehicle/body control, driver information, power train, and safety and convenience electronics.

Project Analyst: Motoya Ohgami

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Chapter 2
Market Statistics Tables

Tables 2-1 through 2-24 contain statistics for Japanese electronic equipment production. Tables 2-1 through 2-6 contain historical data and forecasts for six semiconductor application markets divided into major segments. Tables 2-7 through 2-24 show more detailed forecasts for each application market.

Table 2-1
Japanese Electronic Equipment Production History (Factory Revenue in Billions of Yen)

Segment	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Data Processing							
Computers	2,248	2,026	2,100	2,523	3,450	3,781	11.0
Data Storage	1,302	1,181	1,177	873	859	1169	-2.1
Input/Output	1,577	1,409	1,491	1,520	1,549	1,989	4.7
Dedicated Systems	999	925	839	819	750	753	-5.5
Other Data Processing	82	104	146	179	250	163	14.7
Total	**6,207**	**5,645**	**5,753**	**5,913**	**6,858**	**7,855**	**4.8**
Communications							
Premise Telecommunications	952	899	844	806	869	1,008	1.2
Public Telecommunications	732	816	832	892	1,142	1,384	13.6
Mobile and Radio Equipment	908	880	976	991	1,612	2,039	17.6
Broadcast and Studio	100	78	90	70	92	84	-3.4
Other Communications	137	132	148	226	332	360	21.3
Total	**2,829**	**2,804**	**2,889**	**2,985**	**4,048**	**4,875**	**11.5**
Industrial							
Security/Energy Management	586	522	530	559	542	448	-5.2
Manufacturing Systems/Instrumentation	1,657	1,483	1,434	1,736	1,958	2,245	6.3
Medical Equipment	318	315	287	307	340	342	1.5
Other Industrial	629	629	698	741	808	868	6.7
Total	**3,190**	**2,949**	**2,948**	**3,343**	**3,648**	**3,903**	**4.1**
Consumer							
Audio	932	774	722	602	512	597	-8.5
Video	2,371	2,008	1,840	1,528	1,354	1,434	-9.6
Personal Electronics	1,445	1,280	1,263	1,281	1,315	1,332	-1.6
Appliances	1,699	1,495	1,615	1,753	1,758	1,605	-1.1
Other Consumer	940	920	927	970	978	969	0.6
Total	**7,387**	**6,477**	**6,366**	**6,134**	**5,916**	**5,936**	**-4.3**
Military/Civil Aerospace	**212**	**207**	**203**	**200**	**197**	**195**	**-1.7**
Transportation	**1,330**	**1,281**	**1,224**	**1,240**	**1,283**	**1,323**	**-0.1**
Total Electronics Industry	**21,155**	**19,363**	**19,382**	**19,815**	**21,950**	**24,088**	**2.6**

Source: Dataquest (November 1998)

Table 2-2
Japanese Electronic Equipment Production Forecast (Factory Revenue in Billions of Yen)

Segment	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Data Processing							
Computers	3,781	4,403	4,661	4,678	4,617	4,660	4.3
Data Storage	1,169	1,231	1,244	1,327	1,410	1,375	3.3
Input/Output	1,989	1,985	1,968	2,010	2,123	2,238	2.4
Dedicated Systems	753	699	786	886	1,024	1,174	9.3
Other Data Processing	163	145	165	189	233	289	12.1
Total	**7,855**	**8,462**	**8,824**	**9,090**	**9,408**	**9,736**	**4.4**
Communications							
Premise Telecommunications	1,008	1,033	1,107	1,183	1,242	1,323	5.6
Public Telecommunications	1,384	1,223	1,363	1,528	1,716	1,883	6.3
Mobile and Radio Equipment	2,039	1,924	1,873	1,958	2,064	2,209	1.6
Broadcast and Studio	84	82	93	107	126	144	11.4
Other Communications	360	298	331	378	421	458	4.9
Total	**4,875**	**4,559**	**4,766**	**5,154**	**5,569**	**6,017**	**4.3**
Industrial							
Security/Energy Management	448	420	468	524	597	654	7.9
Manufacturing Systems/Instrumentation	2,245	1,840	2,143	2,407	2,658	2,875	5.1
Medical Equipment	342	321	347	389	436	496	7.7
Other Industrial	868	735	863	1,021	1,155	1,271	7.9
Total	**3,903**	**3,316**	**3,821**	**4,341**	**4,846**	**5,296**	**6.3**
Consumer							
Audio	597	564	602	638	676	723	3.9
Video	1,434	1,584	1,544	1,465	1,356	1,265	-2.5
Personal Electronics	1,332	1,262	1,231	1,304	1,404	1,603	3.8
Appliances	1,605	1,408	1,554	1,758	1,913	2,008	4.6
Other Consumer	969	807	903	1,012	1,168	1,304	6.1
Total	**5,936**	**5,624**	**5,834**	**6,177**	**6,518**	**6,903**	**3.1**
Military/Civil Aerospace	**195**	**190**	**214**	**235**	**230**	**230**	**3.4**
Transportation	**1,323**	**1,428**	**1,608**	**1,792**	**1,999**	**2,173**	**10.4**
Total Electronics Industry	**24,088**	**23,580**	**25,067**	**26,789**	**28,569**	**30,355**	**4.7**

Source: Dataquest (November 1998)

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Table 2-3
Japanese Electronic Equipment Production History
(Factory Revenue in Millions of Dollars)

Segment	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Data Processing							
Computers	17,775	18,223	20,625	26,868	31,710	31,225	11.9
Data Storage	10,295	10,623	11,562	9,293	7,893	9,650	-1.3
Input/Output	12,467	12,667	14,646	16,187	14,234	16,421	5.7
Dedicated Systems	7,900	8,317	8,241	8,722	6,895	6,217	-4.7
Other Data Processing	645	935	1,430	1,906	2,298	1,346	15.9
Total	**49,083**	**50,766**	**56,503**	**62,976**	**63,030**	**64,860**	**5.7**
Communications							
Premise Telecommunications	7,531	8,085	8,286	8,585	7,986	8,326	2.0
Public Telecommunications	5,786	7,335	8,168	9,499	10,497	11,431	14.6
Mobile and Radio Equipment	7,183	7,914	9,583	10,558	14,819	16,834	18.6
Broadcast and Studio	788	699	888	743	847	694	-2.5
Other Communications	1,087	1,183	1,454	2,403	3,052	2,973	22.3
Total	**22,375**	**25,215**	**28,378**	**31,789**	**37,202**	**40,257**	**12.5**
Industrial							
Security/Energy Management	4,636	4,697	5,205	5,952	4,982	3,699	-4.4
Manufacturing Systems/ Instrumentation	13,106	13,337	14,080	18,491	17,993	18,539	7.2
Medical Equipment	2,515	2,831	2,814	3,265	3,122	2,827	2.4
Other Industrial	4,972	5,652	6,860	7,889	7,426	7,168	7.6
Total	**25,229**	**26,517**	**28,959**	**35,597**	**33,523**	**32,233**	**5.0**
Consumer							
Audio	7,373	6,959	7,087	6,409	4,702	4,929	-7.7
Video	18,754	18,060	18,072	16,270	12,440	11,839	-8.8
Personal Electronics	11,426	11,514	12,403	13,647	12,088	10,999	-0.8
Appliances	13,437	13,444	15,863	18,670	16,156	13,254	-0.3
Other Consumer	7,431	8,271	9,101	10,332	8,984	8,002	1.5
Total	**58,420**	**58,248**	**62,526**	**65,328**	**54,369**	**49,022**	**-3.4**
Military/Civil Aerospace	**1,675**	**1,865**	**1,992**	**2,126**	**1,814**	**1,610**	**-0.8**
Transportation	**10,516**	**11,519**	**12,018**	**13,204**	**11,795**	**10,925**	**0.8**
Total Electronics Industry	**167,297**	**174,130**	**190,377**	**211,020**	**201,735**	**198,907**	**3.5**
Exchange Rate (Yen/U.S.$)	126.45	111.20	101.81	93.90	108.81	121.10	-

Source: Dataquest (November 1998)

Table 2-4
Japanese Electronic Equipment Production Forecast
(Factory Revenue in Millions of Dollars)

Segment	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Data Processing							
Computers	31,225	32,293	33,107	33,223	32,793	33,097	1.2
Data Storage	9,650	9,026	8,833	9,429	10,016	9,764	0.2
Input/Output	16,421	14,555	13,978	14,274	15,081	15,899	-0.6
Dedicated Systems	6,217	5,127	5,583	6,293	7,273	8,339	6.0
Other Data Processing	1,346	1,063	1,172	1,342	1,655	2,053	8.8
Total	**64,860**	**62,064**	**62,672**	**64,561**	**66,819**	**69,151**	**1.3**
Communications							
Premise Telecommunications	8,326	7,574	7,861	8,400	8,821	9,396	2.4
Public Telecommunications	11,431	8,973	9,679	10,853	12,189	13,374	3.2
Mobile and Radio Equipment	16,834	14,107	13,303	13,910	14,663	15,691	-1.4
Broadcast and Studio	694	601	661	760	895	1,023	8.1
Other Communications	2,973	2,184	2,351	2,685	2,990	3,253	1.8
Total	**40,257**	**33,440**	**33,855**	**36,608**	**39,558**	**42,737**	**1.2**
Industrial							
Security/Energy Management	3,699	3,080	3,324	3,722	4,240	4,645	4.7
Manufacturing Systems/ Instrumentation	18,539	13,495	15,221	17,096	18,879	20,420	2.0
Medical Equipment	2,827	2,354	2,465	2,763	3,097	3,523	4.5
Other Industrial	7,168	5,391	6,130	7,252	8,204	9,028	4.7
Total	**32,233**	**24,320**	**27,140**	**30,833**	**34,420**	**37,616**	**3.1**
Consumer							
Audio	4,929	4,133	4,275	4,531	4,804	5,138	0.8
Video	11,839	11,615	10,968	10,407	9,633	8,982	-5.4
Personal Electronics	10,999	9,256	8,745	9,264	9,972	11,388	0.7
Appliances	13,254	10,326	11,038	12,487	13,588	14,262	1.5
Other Consumer	8,002	5,919	6,414	7,188	8,296	9,262	3.0
Total	**49,022**	**41,249**	**41,440**	**43,876**	**46,292**	**49,032**	**0**
Military/Civil Aerospace	**1,610**	**1,393**	**1,520**	**1,669**	**1,634**	**1,634**	**0.3**
Transportation	**10,925**	**10,474**	**11,419**	**12,726**	**14,198**	**15,434**	**7.2**
Total Electronics Industry	**198,907**	**172,940**	**178,045**	**190,273**	**202,921**	**215,605**	**1.6**
Exchange Rate (Yen/U.S.$)	121.10	136.35	140.79	140.79	140.79	140.79	-

Source: Dataquest (November 1998)

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Table 2-5
Japanese Electronic Equipment Production History
(Yen-Based Annual Growth; Percent)

Segment	1992	1993	1994	1995	1996	1997
Data Processing						
Computers	-11.6	-9.8	3.6	20.1	36.8	9.6
Data Storage	-4.7	-9.3	-0.4	-25.9	-1.6	36.1
Input/Output	-13.0	-10.7	5.9	1.9	1.9	28.4
Dedicated Systems	-7.0	-7.4	-9.3	-2.4	-8.4	0.4
Other Data Processing	22.2	27.5	40.0	22.9	39.7	-34.8
Total	**-9.6**	**-9.0**	**1.9**	**2.8**	**16.0**	**14.5**
Communications						
Premise Telecommunications	-9.5	-5.6	-6.2	-4.4	7.8	16.0
Public Telecommunications	-11.4	11.5	2.0	7.3	28.0	21.2
Mobile and Radio Equipment	-3.3	-3.1	10.9	1.6	62.7	26.4
Broadcast and Studio	0.6	-22.0	16.3	-22.8	31.4	-8.7
Other Communications	-28.3	-4.3	12.5	52.4	46.9	8.4
Total	**-9.0**	**-0.9**	**3.0**	**3.3**	**35.6**	**20.4**
Industrial						
Security/Energy Management	-10.9	-10.9	1.5	5.5	-3.0	-17.3
Manufacturing Systems/Instrumentation	-25.1	-10.5	-3.3	21.1	12.8	14.7
Medical Equipment	-2.5	-1.0	-9.0	7.0	10.7	0.6
Other Industrial	-13.7	0	11.1	6.1	9.0	7.4
Total	**-18.7**	**-7.6**	**0**	**13.4**	**9.1**	**7.0**
Consumer						
Audio	-17.1	-17.0	-6.8	-16.6	-15.0	16.6
Video	-22.1	-15.3	-8.4	-17.0	-11.4	5.9
Personal Electronics	-4.0	-11.4	-1.4	1.5	2.7	1.3
Appliances	-14.0	-12.0	8.0	8.6	0.3	-8.7
Other Consumer	-10.3	-2.1	0.8	4.7	0.8	-0.9
Total	**-15.1**	**-12.3**	**-1.7**	**-3.6**	**-3.6**	**0.4**
Military/Civil Aerospace	**-2.1**	**-2.1**	**-2.2**	**-1.6**	**-1.5**	**-1.0**
Transportation	**-2.7**	**-3.7**	**-4.5**	**1.3**	**3.5**	**3.1**
Total Electronics Industry	**-12.5**	**-8.5**	**0.1**	**2.2**	**10.8**	**9.7**

Source: Dataquest (November 1998)

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Table 2-6
Japanese Electronic Equipment Production Forecast
(Yen-Based Annual Growth; Percent)

Segment	1997	1998	1999	2000	2001	2002
Data Processing						
Computers	9.6	16.4	5.9	0.4	-1.3	0.9
Data Storage	36.1	5.3	1.0	6.7	6.2	-2.5
Input/Output	28.4	-0.2	-0.8	2.1	5.7	5.4
Dedicated Systems	0.4	-7.2	12.4	12.7	15.6	14.6
Other Data Processing	-34.8	-11.0	13.8	14.5	23.3	24.0
Total	**14.5**	**7.7**	**4.3**	**3.0**	**3.5**	**3.5**
Communications						
Premise Telecommunications	16.0	2.4	7.2	6.9	5.0	6.5
Public Telecommunications	21.2	-11.6	11.4	12.1	12.3	9.7
Mobile and Radio Equipment	26.4	-5.6	-2.6	4.6	5.4	7.0
Broadcast and Studio	-8.7	-2.4	13.4	15.1	17.8	14.3
Other Communications	8.4	-17.3	11.1	14.2	11.4	8.8
Total	**20.4**	**-6.5**	**4.5**	**8.1**	**8.1**	**8.0**
Industrial						
Security/Energy Management	-17.3	-6.3	11.4	12.0	13.9	9.5
Manufacturing Systems/Instrumentation	14.7	-18.0	16.5	12.3	10.4	8.2
Medical Equipment	0.6	-6.2	8.1	12.1	12.1	13.8
Other Industrial	7.4	-15.3	17.4	18.3	13.1	10.0
Total	**7.0**	**-15.0**	**15.2**	**13.6**	**11.6**	**9.3**
Consumer						
Audio	16.6	-5.6	6.8	6.0	6.0	7.0
Video	5.9	10.5	-2.5	-5.1	-7.4	-6.8
Personal Electronics	1.3	-5.2	-2.4	5.9	7.6	14.2
Appliances	-8.7	-12.3	10.4	13.1	8.8	5.0
Other Consumer	-0.9	-16.7	11.9	12.1	15.4	11.6
Total	**0.4**	**-5.3**	**3.7**	**5.9**	**5.5**	**5.9**
Military/Civil Aerospace	**-1.0**	**-2.6**	**12.6**	**9.8**	**-2.1**	**0**
Transportation	**3.1**	**7.9**	**12.6**	**11.4**	**11.6**	**8.7**
Total Electronics Industry	**9.7**	**-2.1**	**6.3**	**6.9**	**6.6**	**6.3**

Source: Dataquest (November 1998)

Table 2-7
Japanese Electronic Equipment Production Forecast—Data Processing (Factory Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Computers							
Mainframe/Supercomputers	846	968	1,032	929	786	651	-5.1
Midrange Computers	284	341	367	392	410	423	8.3
Workstations	192	202	196	193	189	180	-1.3
PCs	2,323	2,742	2,907	2,993	3,059	3,227	6.8
Motherboards	137	150	158	170	172	179	5.4
Total	**3,781**	**4,403**	**4,661**	**4,678**	**4,617**	**4,660**	**4.3**
Data Storage							
Rigid Disk Drives	705	684	665	661	668	613	-2.8
Optical Disk Drives	268	265	234	237	244	249	-1.5
Removable Magnetic Storage	195	281	345	430	498	513	21.3
Total	**1,169**	**1,231**	**1,244**	**1,327**	**1,410**	**1,375**	**3.3**
Input/Output							
Page Printers	284	308	329	334	356	373	5.6
Serial Printers	515	542	478	420	375	345	-7.7
Monitors	487	481	441	439	435	434	-2.3
Other Input/Output	703	653	720	817	957	1,086	9.1
Total	**1,989**	**1,985**	**1,968**	**2,010**	**2,123**	**2,238**	**2.4**
Dedicated Systems	**753**	**699**	**786**	**886**	**1,024**	**1,174**	**9.3**
Other Data Processing	**163**	**145**	**165**	**189**	**233**	**289**	**12.1**
Data Processing Total	7,855	8,462	8,824	9,090	9,408	9,736	4.4

Source: Dataquest (November 1998)

Table 2-8
Japanese Electronic Equipment Production Forecast—Data Processing (Factory Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Computers							
Mainframe/Supercomputers	6,986	7,100	7,332	6,601	5,580	4,625	-7.9
Midrange Computers	2,345	2,505	2,608	2,783	2,915	3,003	5.1
Workstations	1,582	1,480	1,393	1,374	1,346	1,278	-4.2
PCs	19,179	20,110	20,648	21,261	21,728	22,922	3.6
Motherboards	1,133	1,098	1,125	1,205	1,225	1,269	2.3
Total	**31,225**	**32,293**	**33,107**	**33,223**	**32,793**	**33,097**	**1.2**
Data Storage							
Rigid Disk Drives	5,825	5,015	4,721	4,692	4,743	4,355	-5.7
Optical Disk Drives	2,214	1,947	1,659	1,685	1,735	1,768	-4.4
Removable Magnetic Storage	1,611	2,064	2,453	3,052	3,538	3,641	17.7
Total	**9,650**	**9,026**	**8,833**	**9,429**	**10,016**	**9,764**	**0.2**
Input/Output							
Page Printers	2,342	2,262	2,334	2,370	2,529	2,651	2.5
Serial Printers	4,251	3,974	3,398	2,980	2,663	2,452	-10.4
Monitors	4,023	3,530	3,131	3,120	3,092	3,082	-5.2
Other Input/Output	5,805	4,789	5,114	5,803	6,797	7,714	5.8
Total	**16,421**	**14,555**	**13,978**	**14,274**	**15,081**	**15,899**	**-0.6**
Dedicated Systems	**6,217**	**5,127**	**5,583**	**6,293**	**7,273**	**8,339**	**6.0**
Other Data Processing	**1,346**	**1,063**	**1,172**	**1,342**	**1,655**	**2,053**	**8.8**
Data Processing Total	**64,860**	**62,064**	**62,672**	**64,561**	**66,819**	**69,151**	**1.3**
Exchange Rate (Yen/U.S.$)	121.10	136.35	140.79	140.79	140.79	140.79	-

Source: Dataquest (November 1998)

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Table 2-9
Japanese Electronic Equipment Production Forecast—Data Processing (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Computers						
Mainframe/Supercomputers	12.3	14.4	6.6	-10.0	-15.5	-17.1
Midrange Computers	0.9	20.2	7.5	6.7	4.8	3.0
Workstations	-3.5	5.3	-2.8	-1.4	-2.0	-5.1
PCs	11.3	18.1	6.0	3.0	2.2	5.5
Motherboards	6.1	9.2	5.8	7.1	1.6	3.7
Total	**14.5**	**7.7**	**4.3**	**3.0**	**3.5**	**3.5**
Data Storage						
Rigid Disk Drives	16.8	-3.1	-2.8	-0.6	1.1	-8.2
Optical Disk Drives	81.7	-1.0	-12.0	1.6	3.0	1.9
Removable Magnetic Storage	81.7	44.2	22.7	24.5	15.9	2.9
Total	**36.1**	**5.3**	**1.0**	**6.7**	**6.2**	**-2.5**
Input/Output						
Page Printers	2.1	8.8	6.5	1.5	6.7	4.8
Serial Printers	84.4	5.3	-11.7	-12.3	-10.6	-7.9
Monitors	22.2	-1.2	-8.4	-0.3	-0.9	-0.3
Other Input/Output	18.5	-7.1	10.3	13.5	17.1	13.5
Total	**28.4**	**-0.2**	**-0.8**	**2.1**	**5.7**	**5.4**
Dedicated Systems	**0.4**	**-7.2**	**12.4**	**12.7**	**15.6**	**14.6**
Other Data Processing	**-34.8**	**-11.0**	**13.8**	**14.5**	**23.3**	**24.0**
Data Processing Total	14.5	7.7	4.3	3.0	3.5	3.5

Source: Dataquest (November 1998)

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Table 2-10
Japanese Electronic Equipment Production Forecast—Communications (Factory Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Premise Telecommunications							
LAN Cards	34	61	72	82	74	79	18.3
Premise Line Cards	35	42	43	45	45	46	5.8
Answering Machines	6	6	6	6	6	6	1.3
Fax	310	327	354	360	361	366	3.4
Modems	5	5	4	4	4	4	-4.6
Corded Telephones	31	31	28	26	23	21	-7.4
Analog Cordless	58	67	61	56	52	46	-4.5
Digital Cordless	49	42	42	42	41	41	-3.3
Other Premise Telecom	481	451	495	561	637	713	8.2
Total	**1,008**	**1,033**	**1,107**	**1,183**	**1,242**	**1,323**	**5.6**
Public Telecommunications							
Central Office Line Cards	60	68	74	77	82	84	6.8
Other Public Telecom	1,324	1,155	1,289	1,451	1,634	1,799	6.3
Total	**1,384**	**1,223**	**1,363**	**1,528**	**1,716**	**1,883**	**6.3**
Mobile and Radio Equipment							
Analog Cellular	32	-	-	-	-	-	-100.0
Digital Cellular	865	612	477	431	364	343	-16.9
Pagers	57	50	41	36	30	28	-13.5
Mobile Communications Infrastructure	849	1,004	1,104	1,248	1,435	1,607	13.6
Other Mobile Communications	235	258	251	244	236	231	-0.3
Total	**2,039**	**1,924**	**1,873**	**1,958**	**2,064**	**2,209**	**1.6**
Broadcast and Studio	**84**	**82**	**93**	**107**	**126**	**144**	**11.4**
Other Communications Equipment	**360**	**297.8**	**331**	**378**	**421**	**458**	**4.9**
Communications Total	**4,875**	**4,559**	**4,766**	**5,154**	**5,569**	**6,017**	**4.3**

Source: Dataquest (November 1998)

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Table 2-11
Japanese Electronic Equipment Production Forecast—Communications (Factory Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Premise Telecommunications							
LAN Cards	282	447	513	585	522	563	14.8
Premise Line Cards	288	310	306	321	320	329	2.7
Answering Machines	49	46	42	41	43	45	-1.7
Fax	2,559	2,395	2,518	2,558	2,563	2,599	0.3
Modems	39	34	30	29	28	26	-7.5
Corded Telephones	255	230	202	184	165	149	-10.2
Analog Cordless	480	494	437	398	367	328	-7.3
Digital Cordless	402	309	298	299	289	292	-6.2
Other Premise Telecom	3,972	3,308	3,516	3,985	4,524	5,064	5.0
Total	**8,326**	**7,574**	**7,861**	**8,400**	**8,821**	**9,396**	**2.4**
Public Telecommunications							
Central Office Line Cards	498	502	524	547	583	596	3.7
Other Public Telecom	10,933	8,471	9,155	10,306	11,606	12,778	3.2
Total	**11,431**	**8,973**	**9,679**	**10,853**	**12,189**	**13,374**	**3.2**
Mobile and Radio Equipment							
Analog Cellular	267	-	-	-	-	-	-100.0
Digital Cellular	7,144	4,485	3,386	3,059	2,582	2,437	-19.4
Pagers	472	366	294	254	213	196	-16.1
Mobile Communications Infrastructure	7,012	7,363	7,844	8,863	10,193	11,416	10.2
Other Mobile Communications	1,939	1,893	1,780	1,733	1,675	1,642	-3.3
Total	**16,834**	**14,107**	**13,303**	**13,910**	**14,663**	**15,691**	**-1.4**
Broadcast and Studio	**694**	**601**	**661**	**760**	**895**	**1,023**	**8.1**
Other Communications Equipment	**2,973**	**2,184**	**2,351**	**2,685**	**2,990**	**3,253**	**1.8**
Communications Total	**40,257**	**33,440**	**33,855**	**36,608**	**39,558**	**42,737**	**1.2**
Exchange Rate (Yen/U.S.$)	121.10	136.35	140.79	140.79	140.79	140.79	-

Source: Dataquest (November 1998)

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Table 2-12
Japanese Electronic Equipment Production Forecast—Communications (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Premise Telecommunications						
LAN Cards	115.1	78.6	18.5	14.0	-10.8	7.8
Premise Line Cards	16.7	21.3	1.8	5.0	-0.2	2.7
Answering Machines	6.9	6.5	-6.8	-1.3	4.4	4.6
Fax	9.1	5.4	8.5	1.6	0.2	1.4
Modems	-6.1	-0.8	-9.3	-3.0	-5.3	-4.5
Corded Telephones	-16.8	1.4	-9.0	-9.2	-10.4	-9.4
Analog Cordless	21.2	15.9	-8.8	-8.7	-7.9	-10.6
Digital Cordless	-32.9	-13.4	-0.4	0.2	-3.3	1.1
Other Premise Telecom	29.6	-6.2	9.8	13.3	13.5	11.9
Total	**16.0**	**2.4**	**7.2**	**6.9**	**5.0**	**6.5**
Public Telecommunications						
Central Office Line Cards	19.9	13.5	7.8	4.3	6.6	2.3
Other Public Telecom	21.3	-12.8	11.6	12.6	12.6	10.1
Total	**21.2**	**-11.6**	**11.4**	**12.1**	**12.3**	**9.7**
Mobile and Radio Equipment						
Analog Cellular	-77.5	-100.0	-	-	-	-
Digital Cellular	41.0	-29.3	-22.1	-9.6	-15.6	-5.6
Pagers	-10.7	-12.7	-17.2	-13.6	-16.2	-7.8
Mobile Communications Infrastructure	48.7	18.2	10.0	13.0	15.0	12.0
Other Mobile Communications	6.8	9.9	-2.9	-2.6	-3.3	-2.0
Total	**26.4**	**-5.6**	**-2.6**	**4.6**	**5.4**	**7.0**
Broadcast and Studio	**-8.9**	**-2.4**	**13.4**	**15.1**	**17.8**	**14.3**
Other Communications Equipment	**8.4**	**-17.3**	**11.1**	**14.2**	**11.4**	**8.8**
Communications Total	**20.4**	**-6.5**	**4.5**	**8.1**	**8.1**	**8.0**

Source: Dataquest (November 1998)

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Table 2-13
Japanese Electronic Equipment Production Forecast—Industrial (Factory Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Security/Energy Management	448	420	468	524	597	654	7.9
Manufacturing Systems/Instrumentation	2,245	1,840	2,143	2,407	2,658	2,875	5.1
Medical Equipment	342	321	347	389	436	496	7.7
Other Industrial Equipment	868	735	863	1,021	1,155	1,271	7.9
Industrial Total	**3,903**	**3,316**	**3,821**	**4,341**	**4,846**	**5,296**	**6.3**

Source: Dataquest (November 1998)

Table 2-14
Japanese Electronic Equipment Production Forecast—Industrial (Factory Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Security/Energy Management	3,699	3,080	3,324	3,722	4,240	4,645	4.7
Manufacturing Systems/Instrumentation	18,539	13,495	15,221	17,096	18,879	20,420	2.0
Medical Equipment	2,827	2,354	2,465	2,763	3,097	3,523	4.5
Other Industrial Equipment	7,168	5,391	6,130	7,252	8,204	9,028	4.7
Industrial Total	**32,233**	**24,320**	**27,140**	**30,833**	**34,420**	**37,616**	**3.1**
Exchange Rate (Yen/U.S.$)	121.10	136.35	140.79	140.79	140.79	140.79	-

Source: Dataquest (November 1998)

Table 2-15
Japanese Electronic Equipment Production Forecast—Industrial (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Security/Energy Management	-17.4	-6.3	11.4	12.0	13.9	9.5
Manufacturing Systems/Instrumentation	14.7	-18.0	16.5	12.3	10.4	8.2
Medical Equipment	0.8	-6.2	8.1	12.1	12.1	13.8
Other Industrial Equipment	7.4	-15.3	17.4	18.3	13.1	10.0
Industrial Total	**7.0**	**-15.0**	**15.2**	**13.6**	**11.6**	**9.3**

Source: Dataquest (November 1998)

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Table 2-16
Japanese Electronic Equipment Production Forecast—Consumer (Factory Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Audio							
Personal/Portable Stereos	144	155	146	140	131	127	-2.4
Other Audio	453	409	456	498	545	596	5.6
Total	**597**	**564**	**602**	**638**	**676**	**723**	**3.9**
Video							
Color TVs	469	496	505	479	442	412	-2.5
VCRs	254	265	247	240	225	212	-3.6
Analog Camcorders	434	387	308	232	142	82	-28.3
Digital Camcorders	233	391	428	434	456	460	14.5
DVDs	8	17	24	41	47	52	44.3
Analog Set-Top Boxes	3	3	2	2	2	2	-12.1
Digital Set-Top Boxes	32	26	30	37	41	44	6.9
Total	**1,434**	**1,584**	**1,544**	**1,465**	**1,356**	**1,265**	**-2.5**
Personal Electronics							
Digital Still Cameras	55	97	114	116	114	118	16.5
Video Game Controllers	351	279	158	133	125	186	-11.9
Other Personal Electronics	926	887	959	1,055	1,165	1,299	7.0
Total	**1,332**	**1,262**	**1,231**	**1,304**	**1,404**	**1,603**	**3.8**
Appliances	**1,605**	**1,408**	**1,554**	**1,758**	**1,913**	**2,008**	**4.6**
Other Consumer Equipment	**969**	**807**	**903**	**1,012**	**1,168**	**1,304**	**6.1**
Consumer Total	**5,936**	**5,624**	**5,834**	**6,177**	**6,518**	**6,903**	**3.1**

Source: Dataquest (November 1998)

Table 2-17
Japanese Electronic Equipment Production Forecast—Consumer
(Factory Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Audio							
Personal/Portable Stereos	1,188	1,133	1,036	994	933	905	-5.3
Other Audio	3,741	3,000	3,239	3,537	3,871	4,233	2.5
Total	**4,929**	**4,133**	**4,275**	**4,531**	**4,804**	**5,138**	**0.8**
Video							
Color TVs	3,870	3,635	3,584	3,402	3,142	2,930	-5.4
VCRs	2,098	1,943	1,755	1,701	1,599	1,505	-6.4
Analog Camcorders	3,587	2,835	2,189	1,649	1,011	584	-30.4
Digital Camcorders	1,927	2,866	3,041	3,085	3,240	3,265	11.1
DVDs	69	123	169	294	335	371	40.0
Analog Set-Top Boxes	26	21	17	14	12	12	-14.7
Digital Set-Top Boxes	262	192	212	261	295	314	3.7
Total	**11,839**	**11,615**	**10,968**	**10,407**	**9,633**	**8,982**	**-5.4**
Personal Electronics							
Digital Still Cameras	455	708	812	823	811	840	13.1
Video Game Controllers	2,898	2,043	1,122	948	885	1,321	-14.5
Other Personal Electronics	7,647	6,505	6,812	7,493	8,275	9,227	3.8
Total	**10,999**	**9,256**	**8,745**	**9,264**	**9,972**	**11,388**	**0.7**
Appliances	**13,254**	**10,326**	**11,038**	**12,487**	**13,588**	**14,262**	**1.5**
Other Consumer Equipment	**8,002**	**5,919**	**6,414**	**7,188**	**8,296**	**9,262**	**3.0**
Consumer Total	**49,022**	**41,249**	**41,440**	**43,876**	**46,292**	**49,032**	**0**
Exchange Rate (Yen/U.S.$)	121.10	136.35	140.79	140.79	140.79	140.79	-

Source: Dataquest (November 1998)

Table 2-18
Japanese Electronic Equipment Production Forecast—Consumer (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Audio						
Personal/Portable Stereos	24.5	7.4	-5.6	-4.1	-6.1	-3.0
Other Audio	14.4	-9.7	11.5	9.2	9.4	9.4
Total	**16.7**	**-5.6**	**6.8**	**6.0**	**6.0**	**7.0**
Video						
Color TVs	-2.6	5.8	1.8	-5.1	-7.6	-6.8
VCRs	-2.3	4.2	-6.7	-3.1	-6.0	-5.9
Analog Camcorders	4.4	-11.0	-20.3	-24.7	-38.7	-42.2
Digital Camcorders	45.8	67.5	9.6	1.4	5.0	0.8
DVDs	130.3	101.0	41.6	73.9	14.0	10.9
Analog Set-Top Boxes	-11.2	-8.9	-16.1	-17.3	-13.3	-4.2
Digital Set-Top Boxes	9.3	-17.2	13.9	22.8	13.0	6.7
Total	**5.9**	**10.5**	**-2.5**	**-5.1**	**-7.4**	**-6.8**
Personal Electronics						
Digital Still Cameras	111.2	75.3	18.5	1.3	-1.4	3.5
Video Game Controllers	20.4	-20.6	-43.3	-15.5	-6.6	49.2
Other Personal Electronics	-7.2	-4.2	8.1	10.0	10.4	11.5
Total	**1.3**	**-5.2**	**-2.4**	**5.9**	**7.6**	**14.2**
Appliances	**-8.7**	**-12.3**	**10.4**	**13.1**	**8.8**	**5.0**
Other Consumer Equipment	**-0.9**	**-16.7**	**11.9**	**12.1**	**15.4**	**11.6**
Consumer Total	**0.4**	**-5.3**	**3.7**	**5.9**	**5.5**	**5.9**

Source: Dataquest (November 1998)

Table 2-19
Japanese Electronic Equipment Production Forecast—Military/Civil Aerospace (Factory Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Military/Civil Aerospace	195	190	214	235	230	230	3.4

Source: Dataquest (November 1998)

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Table 2-20
Japanese Electronic Equipment Production Forecast—Military/Civil Aerospace (Factory Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Military/Civil Aerospace	1,610	1,393	1,520	1,669	1,634	1,634	0.3
Exchange Rate (Yen/U.S.$)	121.10	136.35	140.79	140.79	140.79	140.79	-

Source: Dataquest (November 1998)

Table 2-21
Japanese Electronic Equipment Production Forecast—Military/Civil Aerospace (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Military/Civil Aerospace	-1.2	-2.6	12.6	9.8	-2.1	0

Source: Dataquest (November 1998)

Table 2-22
Japanese Electronic Equipment Production Forecast—Transportation (Factory Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Auto Stereo	215	229	222	228	223	212	-0.3
Auto ECU	221	268	289	301	309	311	7.1
Antilock Braking System	74	88	94	99	101	107	7.6
Airbags	50	63	65	67	69	70	7.0
Automotive Navigation Systems	156	205	336	442	573	672	33.9
Other Automotive	607	575	602	654	724	801	5.7
Transportation Total	**1,323**	**1,428**	**1,608**	**1,792**	**1,999**	**2,173**	**10.4**

Source: Dataquest (November 1998)

Table 2-23
Japanese Electronic Equipment Production Forecast—Transportation (Factory Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Auto Stereo	1,774	1,683	1,576	1,618	1,583	1,506	-3.2
Auto ECU	1,823	1,967	2,051	2,139	2,196	2,209	3.9
Antilock Braking System	614	642	664	702	719	763	4.4
Airbags	412	462	465	479	487	498	3.8
Automotive Navigation Systems	1,290	1,503	2,387	3,143	4,071	4,770	29.9
Other Automotive	5,012	4,217	4,276	4,645	5,142	5,689	2.6
Transportation Total	**10,925**	**10,474**	**11,419**	**12,726**	**14,198**	**15,434**	**7.2**
Exchange Rate (Yen/U.S.$)	121.10	136.35	140.79	140.79	140.79	140.79	-

Source: Dataquest (November 1998)

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Table 2-24
Japanese Electronic Equipment Production Forecast—Transportation (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Auto Stereo	2.7	6.8	-3.3	2.7	-2.1	-4.9
Auto ECU	18.4	21.5	7.7	4.3	2.7	0.6
Antilock Braking System	34.9	17.8	6.7	5.8	2.3	6.1
Airbags	29.8	26.1	3.9	3.1	1.7	2.2
Automotive Navigation Systems	6.9	31.2	64	31.7	29.5	17.2
Other Automotive	-6.3	-5.3	4.7	8.6	10.7	10.6
Transportation Total	**3.1**	**7.9**	**12.6**	**11.4**	**11.6**	**8.7**

Source: Dataquest (November 1998)

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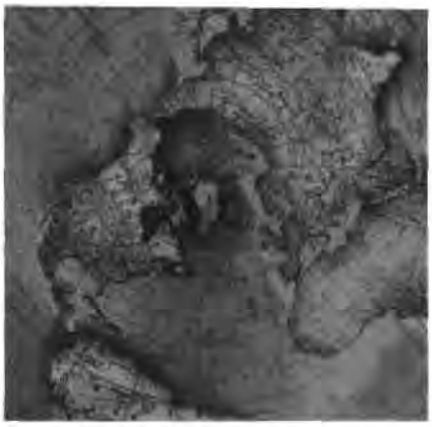

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Japanese Semiconductor Consumption Forecast by Electronics Application, Spring 1998

Market Statistics

FILE COPY:
MARIA VALENZUELA

Program: Semiconductors Japan
Product Code: SEMI-JA-MS-9803
Publication Date: July 6, 1998
Filing: Market Statistics

Japanese Semiconductor Consumption Forecast by Electronics Application, Spring 1998

Market Statistics

Program: Semiconductors Japan
Product Code: SEMI-JA-MS-9803
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Preface

Dataquest's *Japanese Semiconductor Consumption Forecast by Electronics Application, Spring 1998* is a revised and reformatted version of our long-standing semiannual semiconductor consumption by electronics application market forecast. We have made several changes to this publication in an effort to make it more relevant and meaningful, as well as more consistent with Dataquest's other research of semiconductor applications in electronic systems. Three major changes include:

- We are publishing only forecast data.
- We have increased the electronic systems detail reported in our forecast of total semiconductor consumption while eliminating the forecasts of specific semiconductor device consumption offered in previous reports.
- Dataquest's estimate of semiconductor consumption no longer equals the value of forecast semiconductor shipments.

The decision to publish only forecast data is significant. This decision stemmed from several considerations. On one hand, we have found that clients are generally far more interested in a forecast of semiconductor consumption than in estimates of past consumption. Given this and given that our estimates of historical consumption are always available to those who desire them through Dataquest's client inquiry services, Dataquest believes readers lose little from our decision to publish only forecast data. More important, we are in the midst of instituting an important and fundamental change in our forecast methodology. Data limitations severely restrict our ability to extend this method back into history. Rather than undertake the effort required to publish historical data consistent with the dictates and conventions of our new forecast method, we have decided to publish only forecast data.

The third change is admittedly quite significant and is related to the methodology change mentioned. Put succinctly, this forecast marks Dataquest's move away from a decidedly top-down method of estimating semiconductor consumption toward a bottom-up forecast approach, motivated by several factors. First, our forecast should more explicitly reflect the knowledge that Dataquest has rapidly been acquiring about semiconductor applications among individual electronic systems. For several years, Dataquest has directed its semiconductor applications research toward better understanding the dynamics of production and semiconductor use across individual electronic systems. We have developed forecast models capable of tracking production and estimating total semiconductor consumption for some 40 different individual electronic systems.

Dataquest believes these models are now sufficiently developed to use them as the backbone of our forecast of semiconductor consumption. Indeed, Dataquest believes that by leveraging the bottom-level knowledge provided by these models, we can provide far more accurate forecasts than ever before. Using these models as the basis for our forecast also allows us to report total semiconductor consumption for individual electronic systems, something that many clients have been requesting.

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Unfortunately, we are still in the process of developing semiconductor device detail for many of our individual systems models. Rather than perpetuate old ways, we have opted to forgo publishing consumption forecasts of specific semiconductor devices, at least until our individual systems models are complete enough to let us generate forecasts consistent with our new methodology.

Second, Dataquest is seeking to eliminate our dependence on an assumption-sensitive mathematical model for our estimates of semiconductor consumption. Past forecasts of semiconductor consumption were created using a top-down mathematical model. Using Dataquest's forecasts of electronic equipment production and semiconductor shipments as inputs, this model generated estimates of semiconductor consumption by mathematically matching estimated semiconductor shipments to our forecast of electronics production based on a variety of assumptions about the semiconductor content of the various electronics product categories. Thus, our semiconductor consumption estimates were more by-products of a mathematical process than true estimates of consumption. In its defense, the model was extraordinarily flexible and allowed us to create very reasonable estimates of semiconductor consumption for broad categories of electronic products. Nonetheless, its results were highly sensitive to the semiconductor content assumptions needed to drive the model. Moreover, it offered little opportunity to incorporate our growing insights into the semiconductor consumption of individual electronics systems.

Above all, we are hoping to establish a truly separate and independent forecast of semiconductor consumption that can be compared and contrasted to Dataquest's long-standing semiconductor shipments forecast. One important feature of our now-discarded mathematical forecast model was its insistence that estimated semiconductor consumption always equal forecast semiconductor shipments. Putting aside its validity, this insistence essentially robbed our semiconductor consumption forecast of any independent insight into the dynamics of the semiconductor market in the future. By forsaking this insistence, Dataquest is not only able to provide an independent view of future semiconductor developments but also a view that can and should be compared to Dataquest's well-established semiconductor shipments forecast. Our hope is that readers will find contrasting views of the semiconductor market helpful in their efforts to divine its future.

As always, Dataquest welcomes readers' comments and would greatly appreciate any suggestions about improving our research.

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Chapter 1
Introduction and Discussion

Introduction

This document contains Dataquest's forecast of Japanese semiconductor consumption by electronics application, 1997 to 2002, based both on U.S. dollars and Japanese yen. It also contains our forecast of worldwide semiconductor consumption by broad categories over the same period. This is the first of two semiannual forecasts; the second will be published this coming fall. This first forecast reflects changes since last fall in Dataquest's view of semiconductor consumption by electronic equipment worldwide and in Japan. It incorporates changes suggested by Dataquest's recently updated forecasts of electronic equipment production and semiconductor shipments.

Long-time readers will note significant changes in the focus and format of this forecast, compared to previous forecasts. This document reports only a forecast for 1997 to 2002. More significantly, we have greatly expanded the electronic systems detail supporting our forecast of total semiconductor consumption, and we have eliminated our forecasts of semiconductor device consumption by electronic application. These changes are related to a fundamental change in our forecast methodology. Dataquest's previous semiconductor consumption forecasts were a top-down mathematical reconciliation of updated electronic equipment production and semiconductor shipment forecasts. The forecast in this document represents an effort to independently estimate from the bottom up the semiconductor consumption generated by Dataquest's forecast of electronics production. Dataquest no longer attempts to specify how forecast semiconductor shipments will distribute themselves across electronics applications. Instead, the forecast separately estimates semiconductor consumption by electronic systems, unconstrained by the requirement that semiconductor consumption equal semiconductor shipments. It leaves open the possibility that estimated semiconductor consumption may differ from estimated semiconductor shipments. Unfortunately, this document is not the appropriate forum for discussing the consequences of the semiconductor demand/supply imbalance implied by persistent differences between estimated semiconductor consumption and estimated semiconductor shipments. That task will be left for other Dataquest publications.

The tables in this document present data intended to answer the following questions:

- What is the estimated semiconductor consumption of various broad categories of electronic equipment?
- What is the estimated semiconductor consumption of the key individual electronic systems that make up these broad categories?

The estimates offered in this document are intended to provide very general answers to these questions. They are meant as a broad guide to semiconductor consumption by electronic equipment production in Japan. More detailed information about estimated semiconductor consumption by individual electronic systems is available in other Dataquest documents.

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The semiconductor consumption forecasts presented here complement Dataquest's recently updated forecasts of electronic equipment production and semiconductor shipments. Updated Japanese electronic equipment forecasts can be found in *Japanese Electronic Equipment Production Forecast, Spring 1998* (SEMI-JA-MS-9802, June 1998). Our updated semiconductor shipments forecast is found in *Worldwide Semiconductor Five-Year Forecast Trends: Spring 1998* (SCND-WW-MT-9801, June 1998). Additional regional and semiconductor device detail for this forecast can also be requested through Dataquest's inquiry service.

The tables in this document are organized as follows:

- Tables 2-1 and 2-2 summarize the worldwide semiconductor consumption forecast and compare it to the worldwide semiconductor shipments forecast.
- Tables 2-3 and 2-4 summarize the Japanese semiconductor consumption forecast on a dollar basis and compare it to the Japanese semiconductor shipments forecast.
- Tables 2-5 to 2-12 detail Japanese semiconductor consumption by individual electronic system, grouped by equipment type, on a dollar basis.
- Tables 2-13 and 2-14 summarize the Japanese semiconductor consumption forecast on a yen basis and compare it to the Japanese semiconductor shipments forecast.
- Tables 2-15 to 2-22 detail Japanese semiconductor consumption by individual electronic system, grouped by equipment type, on a yen basis.

Segmentation of Semiconductor Applications

Dataquest forecasts semiconductor consumption by end-use electronic application. We divide electronic applications into six broad groups in accordance with our segmentation of electronic equipment production. These groups are, in turn, disaggregated into narrower electronic systems categories, as follows:

- Data processing
  - Computers
  - Data storage
  - Input/output devices
  - Other data processing
- Communications
  - Premise telecommunications
  - Public telecommunications
  - Mobile communications
  - Broadcast and studio equipment
  - Other communications

- Industrial
  - Security and energy management systems
  - Manufacturing systems and instruments
  - Medical equipment
  - Other industrial equipment
- Consumer
  - Audio
  - Video
  - Personal electronics
  - Appliances
  - Other consumer equipment
- Military/civil aerospace
- Transportation

As part of the forecast process, Dataquest develops forecasts for about 40 individual electronic systems within these various categories and subcategories. These include:

- Data processing
  - Mainframes/supercomputers (computers)
  - Midrange computers (computers)
  - Workstations (computers)
  - PCs (computers)
  - PC motherboards (computers)
  - Rigid disk drives (data storage)
  - Optical disk drives (data storage)
  - Removable magnetic storage (data storage)
  - Page printers (input/output)
  - Serial printers (input/output)
  - Monitors (input/output)
- Communications
  - LAN cards (premise telecommunications)
  - Premise line cards (premise telecommunications)
  - Answering machines (premise telecommunications)
  - Fax machines (premise telecommunications)
  - Modems (premise telecommunications)
  - Corded telephones (premise telecommunications)
  - Analog cordless phones (premise telecommunications)
  - Digital cordless phones (premise telecommunications)

  - Central office line cards (public telecommunications)
  - Analog cellular phones (mobile telecommunications)
  - Digital cellular phones (mobile telecommunications)
  - Pagers (mobile telecommunications)
  - Mobile telecommunications infrastructure (mobile telecommunications)
  - Other mobile telecommunications products (mobile telecommunications)
- Consumer
  - Personal/portable stereos (audio)
  - Color TVs (video)
  - VCRs (video)
  - Analog camcorders (video)
  - Digital camcorders (video)
  - DVD (video)
  - Analog set-top boxes (video)
  - Digital set-top boxes (video)
  - Digital still cameras (personal electronics)
  - Video game controllers (personal electronics)
  - Video game cartridges (personal electronics)
- Transportation
  - Automotive stereos
  - Automotive engine control units (ECUs)
  - Antilock braking systems
  - Air bags
  - Automotive navigation systems

Geographic Segmentation

Dataquest's worldwide electronic equipment production forecast is aggregated from individual forecasts for four principal geographic regions:

- Americas
- Japan
- Europe, Middle East, and Africa
- Asia/Pacific

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Exchange Rates

Dataquest's worldwide electronic equipment forecast aggregates data from many countries, each of which uses a currency that has a different and fluctuating exchange rate relative to the U.S. dollar. Because we compile our worldwide forecast from individual regional forecasts, we use the U.S. dollar as a common currency for comparisons and aggregation. As a rule, Dataquest calculates forecasts in local currencies and then converts them to U.S. dollars using projected average annual exchange rates. Dataquest does not forecast exchange rates per se. Instead, we calculate projected average annual exchange rates from current exchange rates. Our projections are based on estimates of the latest available monthly exchange rate at the time the forecast is developed. These rates are based on monthly exchange rates observed through February 1998. Additional information about historical exchange rates and Dataquest's method of calculating future average exchange rates may be requested through Dataquest's client inquiry service.

Forecast Methodology

When discussing semiconductor consumption, it is critical to remember that semiconductors are not end products consumed for their own sake. They are intermediate products used as inputs for electronic end products that are eventually consumed by individuals and businesses for the utility they provide. Implicit in the concept of semiconductor consumption is the notion that the electronic end products in which semiconductors will be incorporated or consumed can be specified. A semiconductor forecast that does not or cannot specify this is not a forecast of semiconductor consumption. At best, it is merely a forecast of semiconductor shipments.

Dataquest's semiconductor consumption by electronic application forecast grew out of the recognition that a truly complete semiconductor forecast must specify the electronic end uses of semiconductors. However, specifying semiconductor end uses has proved far more difficult than recognizing that it must be done. Although it appears possible to specify semiconductor consumption by the variety of electronics produced, there are simply too many different types of semiconductor devices consumed in too large a variety of electronic products. As a result, semiconductor consumption must invariably be estimated. This can be done in any number of ways. Before this forecast, Dataquest used a mathematical model to estimate semiconductor consumption by various electronic end uses. Taking Dataquest's electronic equipment production and semiconductor shipments forecasts as inputs, this model allocated estimated semiconductor shipments across forecast electronics production subject to various assumptions about the semiconductor content of electronic products. The model also imposed several balancing conditions intended to guarantee that estimated semiconductor shipments were completely allocated across all forecast electronics production.

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The model applied a top-down approach to estimating semiconductor consumption. In effect, it calculated estimates of semiconductor consumption by compelling agreement between the details of the electronics production forecast and the semiconductor shipments forecast. As a result, the estimates of semiconductor consumption were more an artifact of a mathematical process than truly independent estimates of semiconductor consumption. Although the model offered considerable flexibility, it was nonetheless limited by the validity of its semiconductor content assumptions and the balancing requirement that semiconductor consumption equal semiconductor shipments. Despite its potential drawbacks, the model provided the best estimates we could offer, given a paucity of knowledge about semiconductor applications in specific electronic systems.

Over last several years, Dataquest's semiconductor applications research has been concentrated on the study of semiconductor use in specific individual electronic systems. We have successfully developed models to track and forecast the production and semiconductor consumption of some 40 different individual electronic systems. These include PCs and PC motherboards, rigid disk drives, LAN cards and modems, digital cellular phones, digital set-top boxes, and automotive navigation systems, among others. The electronic systems encompassed by our models account for about one-half of all electronics production and nearly two-thirds of estimated semiconductor consumption.

These models have not only allowed us to codify our knowledge about individual electronic systems but also to approach the task of estimating semiconductor consumption using a bottom-up forecast method. This method was used for the forecast and will be used for future forecasts. The method essentially involves building a forecast of semiconductor consumption for all electronics production by leveraging estimates of semiconductor consumption for individual electronic systems. Dataquest uses individual systems estimates as a forecast base and augments this with estimates of semiconductor consumption for other electronic equipment categories not tracked individually. Precisely because the method uses well-researched knowledge about individual electronics systems that dominate semiconductor consumption, Dataquest believes it is capable of providing far better forecasts of semiconductor consumption than our former top-down method, especially for electronic equipment categories such as computers, where individual systems forecasts account for virtually the entire category.

This change to a new method has a number of consequences. Dataquest has, at least temporarily, eliminated forecasts of specific semiconductor device consumption by electronic application. Although informative, these forecasts were largely an artifact of our old top-down method. Recent research indicates that these forecasts were especially sensitive to the assumptions and balancing conditions of our top-down method. We are still in the process of developing semiconductor device detail for many of the individual systems forecasts that now serve as the basis for our new bottom-up method.

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Consequently, our systems forecasts have yet to reach the point at which they can be leveraged to provide reasonable consumption forecasts for specific semiconductor devices. We hope to reinstate device consumption forecasts as soon as possible according to this bottom-up method. In the meantime, we trust that readers will find the added electronics system detail we can now offer in our forecast adequate compensation.

More important, Dataquest no longer insists that estimated semiconductor consumption equal the forecast of semiconductor shipments. In truth, our long-standing insistence that consumption estimates equal shipment estimates was more a matter of mathematical necessity than a reflection of market realities. There are several reasons why semiconductor consumption as we estimate it may differ from a forecast of semiconductor shipments. First, there can be significant slippage between semiconductor shipments and semiconductor consumption by electronics producers over short periods because of changes in the semiconductor inventories held by electronic producers. Electronics producers naturally adjust their semiconductor inventories in response to expected changes in their level of production. Although just-in-time practices are reducing producers' inventories, the continued existence of inventories means semiconductor shipments and consumption may differ.

Second, not all semiconductor shipments are consumed by electronics producers manufacturing new electronics. Some find their way into so-called "aftermarkets" where they are eventually "consumed" by existing electronics. Dataquest excludes aftermarket activity from the estimates of semiconductor consumption. Aftermarket consumption is virtually impossible to track and, in any event, appears to be small relative to the consumption generated by electronics producers. Finally, Dataquest's estimates of both electronics production and semiconductor consumption no doubt suffer from errors of omission. We know our estimates probably exclude at least some current semiconductor applications and certainly exclude more than a few applications that cannot be anticipated now. We have good reason to believe these omissions are minor. Still, they represent yet another reason why estimated semiconductor consumption may differ from forecast semiconductor shipments.

It nonetheless seems reasonable to expect that estimated semiconductor consumption and forecast semiconductor shipments will closely parallel one another, especially over the long term. As already noted, semiconductors are first and foremost intermediate inputs to the production of electronics. Growth in semiconductor shipments is ultimately fueled by growth in the semiconductor consumption generated by electronics production. Growth in the semiconductor consumption of electronics producers is, in turn, fueled by growth in both the volume and semiconductor content of electronics production. In the end, all growth in semiconductor shipments can be attributed to growth in one or the other of these key consumption drivers. Estimation errors aside, persistent differences between estimated semiconductor consumption growth and forecast semiconductor shipment growth prefigure a demand/supply imbalance in the semiconductor market.

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In the past, Dataquest's top-down method obscured potential semiconductor market imbalances by assuming that estimated semiconductor consumption must equal forecast semiconductor shipments. The beauty of the bottom-up method is that we can offer important insights into the future of the semiconductor market. We realize that separate forecasts of semiconductor consumption and semiconductor shipments have the potential to create confusion. However, Dataquest believes that separate forecasts may actually help clarify semiconductor market movements by revealing potential market imbalances.

Forecast Highlights

Dataquest estimates that worldwide semiconductor consumption will increase by 10.7 percent in 1998 to about $160.6 billion. Dataquest expects approximately two-thirds of this growth will come about because of growth in worldwide electronics production, which is now forecast to grow 6.9 percent in 1998 to about $968.9 billion. The remainder will be the result of expected growth in the average semiconductor content of electronics, which we forecast will increase to about 16.6 percent of electronics factory value. Longer-term, we estimate worldwide semiconductor consumption will average 12.2 percent annual growth through 2002. This should raise worldwide semiconductor consumption to about $257.6 billion by 2002. Dataquest expects slightly over half of the longer-term growth in worldwide semiconductor consumption to come about because of growth in worldwide electronics production, which we are now forecasting to average 6.6 percent annual growth through 2002. Once again, remaining growth in semiconductor consumption will be the result of increases in the average semiconductor content of electronics. We now expect average semiconductor content will rise to about 20.6 percent of electronics factory value by 2002.

Japan currently ranks as the world's second-leading regional consumer of semiconductors. Asia/Pacific, in turn, ranks third just ahead of our Europe, Middle East, and Africa region. Dataquest expects at least one if not two significant changes in this ranking as time progresses. It now looks very probable that Asia/Pacific will overtake Japan as the world's No. 2 regional consumer of semiconductors by 2002. An additional possibility is that Europe, Middle East, and Africa will also overtake Japan before the end of the forecast period, placing Japan last among the regions as a semiconductor consumer. These changes appear inherent in the markedly different consumption growth rates anticipated for each region. We are now forecasting Japanese semiconductor consumption will grow just 1.9 percent in 1998. This compares to anticipated growth rates of 17.6 percent for Asia/Pacific and 10.6 percent for Europe, Middle East, and Africa. Longer-term, Japanese consumption is expected to average just 8.8 percent annual growth between 1997 and 2002 as opposed to 16.3 percent for Asia/Pacific and 12.8 percent for Europe, Middle East, and Africa. (Note: All our forecasts are valued in U.S. dollars and thus reflect projected exchange rate movements in addition to expected changes in semiconductor consumption expressed in local currencies.) Underlying these marked differences in long-term growth are equally marked differences in expected sources of growth.

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About 80 percent of Japan's longer-term consumption growth is forecast to come from increases in semiconductor content. In contrast, just over 70 percent of Asia/Pacific's longer-term consumption growth is expected to come from growing electronics production. For Europe, Middle East, and Africa, consumption growth will come from a more equally balanced combination of production growth and increased semiconductor content.

We need to note that our regional forecasts, especially for Japan and Asia/Pacific, are considerably more tentative than usual. Ongoing economic and political events in Japan and Asia/Pacific, some quite dramatic, have introduced significant uncertainty into our forecasts. In particular, Dataquest believes there is much greater potential for downward deviations from our forecasts than in the past. Readers should keep this in mind when using and interpreting our results.

As discussed earlier, this forecast represents an effort to independently forecast semiconductor consumption, free of the assumption that semiconductor consumption must always and everywhere equal semiconductor shipments. At least for the near-term, our semiconductor consumption forecasts generally agrees with our recently published forecast of semiconductor shipments. According to the latter, semiconductor supplier shipments are expected to increase 8.2 percent in 1998 to about $159.2 billion. This compares quite well to our forecast of a 10.7 percent increase in semiconductor consumption to about $160.6 billion for 1998. Given that the downside risks of ongoing turmoil in Japan and Asia/Pacific threaten our forecast, we would not be surprised to see semiconductor consumption growth move into even closer agreement with the growth currently expected for semiconductor shipments as 1998 progresses. In fact, there is a significant chance that both semiconductor consumption and semiconductor shipments growth will fall well below 8 percent before the year is out because of continuing troubles in Japan and Asia/Pacific.

Longer-term, there is significant disagreement between our two forecasts. According to Dataquest's semiconductor shipments forecast, semiconductor shipments are expected to average 14.4 percent annual growth through 2002. If realized, that would raise the value of semiconductor shipments to $287.9 billion by 2002. Recall that semiconductor consumption is forecast to average 12.2 percent annual growth through the forecast period so that it reaches $257.6 billion by 2002. As noted earlier, semiconductor consumption may reasonably differ from semiconductor shipments on several accounts. But even after due consideration of these factors, the $30.3 billion difference between our forecasts for semiconductor consumption and semiconductor shipments appears excessive. The difference suggests there is likely to be a sizable oversupply of semiconductors around 2002. We would especially urge semiconductor suppliers to consider this a distinct possibility and to ponder its consequences.

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There is a strong desire among suppliers to believe that semiconductor shipments, and with them semiconductor revenue, can continue to post high rates of long-term growth. But this desire needs to be tempered with the recognition that long-term shipments growth is only possible so long as electronics makers are able to profitably increase semiconductor consumption, either by expanding electronics production or increasing semiconductor content. A number of fundamental changes are taking place in several key electronics markets that will limit the future ability of electronics makers to profitably increase semiconductor consumption. Semiconductor suppliers would be well advised to acknowledge these emerging limits since failure to do so will only intensify competition and further imperil both future shipment and revenue growth in Japan.

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Chapter 2
Worldwide and Japanese Semiconductor Consumption Forecasts

Tables 2-1 through 2-22 present Dataquest's forecast of worldwide and Japanese semiconductor consumption by electronics application.

Table 2-1
Value of Semiconductors Consumed Worldwide by Electronic Product Group, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
All Electronic Products	**145,027**	**160,571**	**182,372**	**213,290**	**236,035**	**257,634**
Data Processing Products	66,869	74,844	85,918	101,272	112,573	121,558
Computers	49,321	54,994	62,787	73,087	81,574	88,060
Data Storage	6,810	7,935	8,890	10,404	11,588	12,969
Input/Output	6,446	6,987	8,001	9,476	10,140	10,761
Other Data Processing	4,292	4,928	6,240	8,305	9,271	9,769
Communications Products	31,353	34,439	37,917	43,111	46,932	51,178
Premise Telecommunications	11,692	13,008	13,845	15,530	16,976	17,934
Public Telecommunications	4,581	4,994	5,906	7,063	7,871	9,181
Mobile Communications	12,586	13,560	14,668	16,070	17,120	18,528
Broadcast and Studio	894	1,057	1,340	1,758	2,006	2,285
Other Communications	1,600	1,820	2,158	2,690	2,960	3,249
Industrial Products	13,122	15,199	18,370	22,710	25,771	27,661
Security/Energy Management	1,320	1,542	1,857	2,241	2,620	2,835
Manufacturing System/Instruments	8,258	9,522	11,505	14,419	16,265	17,483
Medical Equipment	1,434	1,667	1,992	2,383	2,698	2,879
Other Industrial	2,110	2,468	3,016	3,667	4,188	4,464
Consumer Products	23,843	25,613	28,668	33,226	36,398	41,728
Audio	3,857	4,107	4,825	6,034	6,381	6,867
Video	9,923	10,774	11,917	12,770	13,887	14,877
Personal Electronics	5,997	6,421	7,045	8,497	9,583	12,771
Appliances	2,619	2,746	3,116	3,687	4,068	4,509
Other Consumer	1,447	1,564	1,765	2,239	2,479	2,704
Military/Civil Aerospace Products	2,676	2,721	2,927	3,175	3,394	3,582
Transportation Products	7,165	7,755	8,572	9,796	10,967	11,928
Semiconductor Shipments	**147,165**	**159,249**	**188,256**	**227,054**	**275,028**	**287,895**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73

Source: Dataquest (June 1998)

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Table 2-2
Growth in the Value of Semiconductors Consumed Worldwide by Electronic Product Group, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
All Electronic Products	**-0.5**	**8.1**	**12.8**	**26.8**	**10.7**	**9.1**	**12.2**
Data Processing Products	-3.5	11.9	14.8	17.9	11.2	8.0	12.7
Computers	-5.5	11.5	14.2	16.4	11.6	8.0	12.3
Data Storage	9.2	16.5	12.0	17.0	11.4	11.9	13.7
Input/Output	3.1	8.4	14.5	18.4	7.0	6.1	10.8
Other Data Processing	-7.3	14.8	26.6	33.1	11.6	5.4	17.9
Communications Products	15.0	9.8	10.1	13.7	8.9	9.0	10.3
Premise Telecommunications	5.1	11.3	6.4	12.2	9.3	5.6	8.9
Public Telecommunications	8.9	9.0	18.3	19.6	11.4	16.7	14.9
Mobile Communications	32.8	7.7	8.2	9.6	6.5	8.2	8.0
Broadcast and Studio	7.8	18.2	26.8	31.2	14.1	13.9	20.6
Other Communications	-1.8	13.7	18.6	24.6	10.1	9.8	15.2
Industrial Products	4.7	15.8	20.9	23.6	13.5	7.3	16.1
Security/Energy Management	-0.3	16.9	20.4	20.7	16.9	8.2	16.5
Manufacturing System/Instruments	5.4	15.3	20.8	25.3	12.8	7.5	16.2
Medical Equipment	2.5	16.3	19.4	19.6	13.2	6.7	15.0
Other Industrial	7.1	17.0	22.2	21.6	14.2	6.6	16.2
Consumer Products	8.4	7.4	11.9	15.9	9.5	14.6	11.8
Audio	0.4	6.5	17.5	25.1	5.7	7.6	12.2
Video	3.8	8.6	10.6	7.2	8.7	7.1	8.4
Personal Electronics	32.9	7.1	9.7	20.6	12.8	33.3	16.3
Appliances	-0.2	4.9	13.5	18.3	10.3	10.8	11.5
Other Consumer	-0.5	8.1	12.8	26.8	10.7	9.1	13.3
Military/Civil Aerospace Products	0.5	1.7	7.6	8.5	6.9	5.5	6.0
Transportation Products	2.6	8.2	10.5	14.3	11.9	8.8	10.7
Semiconductor Shipments	**3.9**	**8.2**	**18.2**	**20.6**	**21.1**	**4.7**	**14.4**

Source: Dataquest (June 1998)

Table 2-3
Value of Semiconductors Consumed in Japan by Electronic Product Group, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
All Electronic Products	**36,742**	**37,438**	**41,390**	**47,414**	**50,132**	**55,932**
Data Processing Products	13,357	14,002	15,393	16,860	17,498	18,260
Computers	8,520	9,133	9,721	10,458	10,947	11,493
Data Storage	1,737	1,730	2,040	2,097	2,115	2,141
Input/Output	1,746	1,658	1,788	1,915	2,010	2,100
Other Data Processing	1,354	1,481	1,843	2,390	2,425	2,526
Communications Products	7,132	6,798	7,245	8,307	8,752	9,372
Premise Telecommunications	2,041	1,976	1,911	2,016	2,083	2,136
Public Telecommunications	1,748	1,895	2,328	2,944	3,247	3,699
Mobile Communications	2,915	2,447	2,381	2,458	2,465	2,429
Broadcast and Studio	120	132	189	275	272	319
Other Communications	308	348	436	615	685	788
Industrial Products	3,948	4,228	5,139	6,460	7,077	7,934
Security/Energy Management	285	296	340	365	384	410
Manufacturing System/Instruments	2,855	3,054	3,744	4,826	5,311	5,948
Medical Equipment	265	277	330	410	454	531
Other Industrial	542	601	724	858	928	1,046
Consumer Products	9,886	9,970	10,972	12,979	13,983	17,433
Audio	1,507	1,535	1,802	2,204	2,411	2,822
Video	2,828	2,820	2,843	2,705	2,497	2,287
Personal Electronics	4,168	4,223	4,735	6,062	6,880	9,845
Appliances	874	856	1,013	1,301	1,444	1,659
Other Consumer	508	535	578	708	752	820
Military/Civil Aerospace Products	311	294	301	313	311	316
Transportation Products	2,108	2,147	2,340	2,495	2,511	2,617
Semiconductor Shipments	**36,499**	**37,397**	**42,943**	**49,988**	**58,610**	**61,093**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73

Source: Dataquest (June 1998)

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Table 2-4
Growth in the Value of Semiconductors Consumed in Japan by Electronic Product Group, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
All Electronic Products	**3.3**	**1.9**	**10.6**	**14.6**	**5.7**	**11.6**	**8.8**
Data Processing Products	-4.7	4.8	9.9	9.5	3.8	4.4	6.5
Computers	-2.4	7.2	6.4	7.6	4.7	5.0	6.2
Data Storage	-7.7	-0.4	17.9	2.8	0.9	1.2	4.3
Input/Output	0.4	-5.1	7.9	7.1	5.0	4.5	3.8
Other Data Processing	-19.1	9.4	24.4	29.7	1.5	4.1	13.3
Communications Products	7.8	-4.7	6.6	14.7	5.3	7.1	5.6
Premise Telecommunications	-2.1	-3.2	-3.3	5.5	3.3	2.5	0.9
Public Telecommunications	17.4	8.4	22.9	26.5	10.3	13.9	16.2
Mobile Communications	11.2	-16.1	-2.7	3.2	0.3	-1.4	-3.6
Broadcast and Studio	-12.0	10.6	42.4	45.6	-0.8	17.2	21.7
Other Communications	7.1	13.0	25.4	40.8	11.4	15.0	20.7
Industrial Products	3.9	7.1	21.6	25.7	9.6	12.1	15.0
Security and Energy Management	-18.0	3.9	15.0	7.3	5.1	6.8	7.6
Manufacturing System/Instruments	6.9	7.0	22.6	28.9	10.0	12.0	15.8
Medical Equipment	-1.6	4.3	19.2	24.2	10.7	16.9	14.8
Other Industrial	5.4	10.7	20.6	18.5	8.2	12.7	14.0
Consumer Products	15.9	0.8	10.1	18.3	7.7	24.7	12.0
Audio	8.7	1.9	17.4	22.3	9.4	17.0	13.4
Video	0.1	-0.3	0.8	-4.9	-7.7	-8.4	-4.2
Personal Electronics	48.3	1.3	12.1	28.0	13.5	43.1	18.8
Appliances	-9.8	-2.1	18.4	28.4	10.9	15.0	13.7
Other Consumer	-5.8	5.3	7.9	22.6	6.1	9.1	10.0
Military/Civil Aerospace Products	-8.7	-5.6	2.5	3.9	-0.6	1.6	0.3
Transportation Products	-6.9	1.9	9.0	6.6	0.7	4.2	4.4
Semiconductor Shipments	**-5.4**	**2.5**	**14.8**	**16.4**	**17.2**	**4.2**	**10.9**

Source: Dataquest (June 1998)

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Table 2-5
Value of Semiconductors Consumed in Japan by Individual Data Processing Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Mainframe/Supercomputers (Computers)	560	599	535	452	353	311
Midrange Computers (Computers)	667	705	618	674	723	721
Workstations (Computers)	383	304	282	304	305	271
PCs (Computers)	6,120	6,650	7,319	7,969	8,475	9,075
Motherboards (Computers)	790	875	968	1,059	1,091	1,115
Rigid Disk Drives (Data Storage)	952	781	697	719	673	658
Optical Disk Drives (Data Storage)	569	704	1,011	984	1,008	979
Removable Magnetic Storage (Data Storage)	216	245	332	394	435	504
Page Printers (Input/Output)	540	484	519	540	551	559
Serial Printers (Input/Output)	394	355	359	356	353	339
Monitors (Input/Output)	122	120	118	119	126	140
Other Data Processing Products	2,045	2,180	2,635	3,291	3,406	3,589
All Data Processing Products	**13,357**	**14,002**	**15,393**	**16,860**	**17,498**	**18,260**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73

Source: Dataquest (June 1998)

Table 2-6
Growth in the Value of Semiconductors Consumed in Japan by Individual Data Processing Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Mainframe/Supercomputers (Computers)	-4.6	7.0	-10.7	-15.5	-21.9	-11.9	-11.1
Midrange Computers (Computers)	-1.8	5.6	-12.3	9.0	7.4	-0.4	1.5
Workstations (Computers)	-14.1	-20.5	-7.5	7.9	0.2	-11.0	-6.7
PCs (Computers)	-4.1	8.7	10.1	8.9	6.4	7.1	8.2
Motherboards (Computers)	25.0	10.8	10.6	9.5	3.0	2.2	7.1
Rigid Disk Drives (Data Storage)	-19.3	-18.0	-10.7	3.1	-6.4	-2.1	-7.1
Optical Disk Drives (Data Storage)	21.3	23.9	43.5	-2.6	2.4	-2.9	11.5
Removable Magnetic Storage (Data Storage)	-7.5	13.4	35.5	18.6	10.5	15.9	18.5
Page Printers (Input/Output)	-10.0	-10.3	7.3	4.0	2.0	1.4	0.7
Serial Printers (Input/Output)	4.3	-9.9	1.3	-0.9	-0.9	-4.0	-3.0
Monitors (Input/Output)	21.9	-1.7	-1.6	0.8	6.2	11.0	2.8
Other Data Processing Products	-12.4	6.6	20.9	24.9	3.5	5.4	11.9
All Data Processing Products	**-4.7**	**4.8**	**9.9**	**9.5**	**3.8**	**4.4**	**6.5**

Source: Dataquest (June 1998)

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Table 2-7
Value of Semiconductors Consumed in Japan by Individual Communications Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
LAN Cards (Premise Telecommunications)	37	54	64	74	82	83
Premise Line Cards (Premise Telecommunications)	39	37	38	44	42	42
Answering Machines (Premise Telecommunications)	6	4	4	5	6	7
Fax Machines (Premise Telecommunications)	438	449	488	545	577	622
Modems (Premise Telecommunications)	7	7	7	8	9	9
Corded Telephones (Premise Telecommunications)	40	31	33	36	38	38
Analog Cordless (Premise Telecommunications)	254	235	215	199	186	163
Digital Cordless (Premise Telecommunications)	232	177	177	178	175	176
Central Office Line Cards (Public Telecommunications)	86	82	83	83	77	77
Analog Cellular (Mobile Telecommunications)	25	0	0	0	0	0
Digital Cellular (Mobile Telecommunications)	1,728	1,259	1,084	1,001	918	792
Pagers (Mobile Telecommunications)	101	89	86	80	74	69
Mobile Telecommunications Infrastructure (Mobile Telecommunications)	841	902	1,021	1,191	1,294	1,395
Other Mobile Telecommunications (Mobile Telecommunications)	219	196	190	185	179	174
Other Communications Products	3,078	3,275	3,756	4,677	5,096	5,726
All Communications Products	**7,132**	**6,798**	**7,245**	**8,307**	**8,752**	**9,372**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73

Source: Dataquest (June 1998)

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Table 2-8
Growth in the Value of Semiconductors Consumed in Japan by Individual Communications Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
LAN Cards (Premise Telecommunications)	67.8	47.3	17.3	17.1	9.7	1.0	17.5
Premise Line Cards (Premise Telecommunications)	-3.8	-6.0	4.9	15.1	-5.5	-0.2	1.4
Answering Machines (Premise Telecommunications)	-4.2	-29.0	-4.1	26.7	21.1	6.6	2.2
Fax Machines (Premise Telecommunications)	-5.2	2.5	8.5	11.6	5.9	7.9	7.3
Modems (Premise Telecommunications)	-12.6	-1.0	3.4	13.8	6.3	2.1	4.8
Corded Telephones (Premise Telecommunications)	-1.9	-22.7	5.8	10.9	4.8	1.8	-0.7
Analog Cordless (Premise Telecommunications)	10.3	-7.2	-8.9	-7.4	-6.4	-12.1	-8.4
Digital Cordless (Premise Telecommunications)	-35.8	-23.8	-0.2	0.8	-1.7	0.3	-5.4
Central Office Line Cards (Public Telecommunications)	5.6	-5.2	1.1	0.5	-7.1	-0.5	-2.3
Analog Cellular (Mobile Telecommunications)	-79.9	NM	NM	NM	NM	NM	NM
Digital Cellular (Mobile Telecommunications)	14.8	-27.1	-13.9	-7.6	-8.3	-13.7	-14.4
Pagers (Mobile Telecommunications)	-14.3	-11.5	-3.9	-6.8	-8.0	-6.8	-7.4
Mobile Telecommunications Infrastructure (Mobile Telecommunications)	33.6	7.2	13.2	16.6	8.6	7.8	10.6
Other Mobile Telecommunications (Mobile Telecommunications)	-9.7	-10.5	-2.9	-2.6	-3.3	-3.0	-4.5
Other Communications Products	12.2	6.4	14.7	24.5	9.0	12.4	13.2
All Communications Products	**7.8**	**-4.7**	**6.6**	**14.7**	**5.3**	**7.1**	**5.6**

NM = Not meaningful
Source: Dataquest (June 1998)

Table 2-9
Value of Semiconductors Consumed in Japan by Individual Consumer Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Personal/Portable Stereos (Audio)	171	154	161	165	160	158
Color TVs (Video)	794	775	770	777	769	784
VCRs (Video)	566	475	453	435	279	231
Analog Camcorders (Video)	876	701	588	438	271	155
Digital Camcorders (Video)	458	685	814	769	849	798
DVD (Video)	22	40	64	119	154	171
Analog Set-Top Boxes (Video)	12	9	6	5	4	4
Digital Set-Top Boxes (Video)	100	136	148	162	170	143
Digital Still Cameras (Personal Electronics)	234	349	336	289	316	424
Video Game Controllers (Personal Electronics)	1,727	1,169	680	540	472	609
Video Game Cartridges (Personal Electronics)	54	27	14	8	6	4
Other Consumer Products	4,872	5,450	6,937	9,273	10,532	13,951
All Consumer Products	**9,886**	**9,970**	**10,972**	**12,979**	**13,983**	**17,433**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73

Source: Dataquest (June 1998)

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Table 2-10
Growth in the Value of Semiconductors Consumed in Japan by Individual Consumer Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Personal/Portable Stereos (Audio)	-18.4	-9.8	4.7	2.4	-3.1	-1.4	-1.6
Color TVs (Video)	0.5	-2.5	-0.6	0.9	-1.0	2.0	-0.3
VCRs (Video)	-11.8	-16.2	-4.5	-4.0	-35.9	-17.0	-16.4
Analog Camcorders (Video)	-5.6	-20.0	-16.2	-25.4	-38.1	-42.8	-29.3
Digital Camcorders (Video)	35.4	49.7	18.8	-5.6	10.5	-6.1	11.8
DVD (Video)	126.8	86.8	58.9	85.7	29.9	11.0	51.4
Analog Set-Top Boxes (Video)	-22.9	-26.5	-24.7	-18.8	-15.0	-2.4	-17.9
Digital Set-Top Boxes (Video)	-0.6	35.3	8.8	9.7	5.1	-15.9	7.4
Digital Still Cameras (Personal Electronics)	48.7	49.3	-3.9	-14.0	9.6	34.0	12.6
Video Game Controllers (Personal Electronics)	12.1	-32.3	-41.8	-20.6	-12.6	29.1	-18.8
Video Game Cartridges (Personal Electronics)	-67.2	-49.9	-46.3	-44.7	-28.6	-26.9	-40.0
Other Consumer Products	34.0	11.9	27.3	33.7	13.6	32.5	23.4
All Consumer Products	**15.9**	**0.8**	**10.1**	**18.3**	**7.7**	**24.7**	**12.0**

Source: Dataquest (June 1998)

Table 2-11
Value of Semiconductors Consumed in Japan by Individual Transportation Product, 1997 to 2002 (Millions of U.S. Dollars)

	1997	1998	1999	2000	2001	2002
Automotive Stereos	188	157	163	184	175	179
Automotive ECUs	486	490	536	597	613	627
Antilock Braking Systems	119	121	141	163	184	197
Air Bags	99	109	127	146	164	174
Automotive Navigation Systems	260	377	489	561	623	750
Other Transportation Products	956	894	884	843	752	690
All Transportation Products	**2,108**	**2,147**	**2,340**	**2,495**	**2,511**	**2,617**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73

Source: Dataquest (June 1998)

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Table 2-12
Growth in the Value of Semiconductors Consumed in Japan by Individual Transportation Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Automotive Stereos	-11.9	-16.3	3.8	13.0	-5.0	2.3	-0.9
Automotive ECUs	-2.2	0.7	9.4	11.4	2.6	2.3	5.2
Antilock Braking Systems	10.0	1.3	16.8	15.6	12.8	6.7	10.5
Air Bags	13.2	9.6	17.3	14.5	12.3	5.9	11.9
Automotive Navigation Systems	20.7	45.4	29.5	14.8	11.1	20.4	23.7
Other Transportation Products	-16.4	-6.5	-1.1	-4.6	-10.8	-8.1	-6.3
All Transportation Products	**-6.9**	**1.9**	**9.0**	**6.6**	**0.7**	**4.2**	**4.4**

Source: Dataquest (June 1998)

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Table 2-13
Value of Semiconductors Consumed in Japan by Electronic Product Group, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
All Electronic Products	**4,449**	**4,850**	**5,362**	**6,143**	**6,495**	**7,246**
Data Processing Products	1,617	1,814	1,994	2,184	2,267	2,366
Computers	1,032	1,183	1,259	1,355	1,418	1,489
Data Storage	210	224	264	272	274	277
Input/Output	211	215	232	248	260	272
Other Data Processing	164	192	239	310	315	328
Communications Products	864	881	939	1,076	1,134	1,214
Premise Telecommunications	247	256	248	261	270	277
Public Telecommunications	212	245	302	381	421	479
Mobile Communications	353	317	309	318	319	315
Broadcast and Studio	15	17	24	36	35	41
Other Communications	37	45	57	80	89	102
Industrial Products	478	548	666	837	917	1,028
Security/Energy Management	34	38	44	47	50	53
Manufacturing System/Instruments	346	396	485	625	688	771
Medical Equipment	32	36	43	53	59	69
Other Industrial	66	78	94	111	120	136
Consumer Products	1,197	1,292	1,421	1,681	1,811	2,258
Audio	183	199	233	285	312	366
Video	342	365	368	350	324	296
Personal Electronics	505	547	613	785	891	1,275
Appliances	106	111	131	169	187	215
Other Consumer	62	69	75	92	97	106
Military/Civil Aerospace Products	38	38	39	41	40	41
Transportation Products	255	278	303	323	325	339
Semiconductor Shipments	**4,420**	**4,852**	**5,571**	**6,485**	**7,604**	**7,926**

Source: Dataquest (June 1998)

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Table 2-14
Growth in the Value of Semiconductors Consumed in Japan by Electronic Product Group, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
All Electronic Products	**14.9**	**9.0**	**10.6**	**14.6**	**5.7**	**11.6**	**10.2**
Data Processing Products	6.0	12.1	9.9	9.5	3.8	4.4	7.9
Computers	8.6	14.8	6.4	7.6	4.7	5.0	7.6
Data Storage	2.7	6.7	17.9	2.8	0.9	1.2	5.7
Input/Output	11.8	1.7	7.9	7.1	5.0	4.5	5.2
Other Data Processing	-10.0	17.2	24.4	29.7	1.5	4.1	14.9
Communications Products	19.9	2.0	6.6	14.7	5.3	7.1	7.0
Premise Telecommunications	9.0	3.6	-3.3	5.5	3.3	2.5	2.3
Public Telecommunications	30.6	16.0	22.9	26.5	10.3	13.9	17.8
Mobile Communications	23.8	-10.2	-2.7	3.2	0.3	-1.4	-2.3
Broadcast and Studio	-2.1	18.3	42.4	45.6	-0.8	17.2	23.3
Other Communications	19.2	20.9	25.4	40.8	11.4	15.0	22.3
Industrial Products	15.6	14.6	21.6	25.7	9.6	12.1	16.5
Security and Energy Management	-8.8	11.2	15.0	7.3	5.1	6.8	9.0
Manufacturing System/Instruments	19.0	14.4	22.6	28.9	10.0	12.0	17.4
Medical Equipment	9.6	11.6	19.2	24.2	10.7	16.9	16.4
Other Industrial	17.3	18.5	20.6	18.5	8.2	12.7	15.6
Consumer Products	29.0	7.9	10.1	18.3	7.7	24.7	13.5
Audio	20.9	9.0	17.4	22.3	9.4	17.0	14.9
Video	11.5	6.7	0.8	-4.9	-7.7	-8.4	-2.9
Personal Electronics	65.1	8.4	12.1	28.0	13.5	43.1	20.4
Appliances	0.4	4.7	18.4	28.4	10.9	15.0	15.2
Other Consumer	4.9	12.7	7.9	22.6	6.1	9.1	11.5
Military/Civil Aerospace Products	1.6	1.0	2.5	3.9	-0.6	1.6	1.7
Transportation Products	3.6	9.0	9.0	6.6	0.7	4.2	5.8
Semiconductor Shipments	**5.7**	**9.8**	**14.8**	**16.4**	**17.2**	**4.2**	**12.4**

Source: Dataquest (June 1998)

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Table 2-15
Value of Semiconductors Consumed in Japan by Individual Data Processing Product, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
Mainframe/Supercomputers (Computers)	68	78	69	59	46	40
Midrange Computers (Computers)	81	91	80	87	94	93
Workstations (Computers)	46	39	37	39	39	35
PCs (Computers)	741	862	948	1,032	1,098	1,176
Motherboards (Computers)	96	113	125	137	141	144
Rigid Disk Drives (Data Storage)	115	101	90	93	87	85
Optical Disk Drives (Data Storage)	69	91	131	128	131	127
Removable Magnetic Storage (Data Storage)	26	32	43	51	56	65
Page Printers (Input/Output)	65	63	67	70	71	72
Serial Printers (Input/Output)	48	46	47	46	46	44
Monitors (Input/Output)	15	16	15	15	16	18
Other Data Processing Products	248	282	341	426	441	465
All Data Processing Products	**1,617**	**1,814**	**1,994**	**2,184**	**2,267**	**2,366**

Source: Dataquest (June 1998)

Table 2-16
Growth in the Value of Semiconductors Consumed in Japan by Individual Data Processing Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Mainframe/Supercomputers (Computers)	6.1	14.5	-10.7	-15.5	-21.9	-11.9	-9.9
Midrange Computers (Computers)	9.3	13.0	-12.3	9.0	7.4	-0.4	2.9
Workstations (Computers)	-4.4	-15.0	-7.5	7.9	0.2	-11.0	-5.4
PCs (Computers)	6.7	16.2	10.1	8.9	6.4	7.1	9.7
Motherboards (Computers)	39.1	18.5	10.6	9.5	3.0	2.2	8.6
Rigid Disk Drives (Data Storage)	-10.2	-12.3	-10.7	3.1	-6.4	-2.1	-5.9
Optical Disk Drives (Data Storage)	35.1	32.5	43.5	-2.6	2.4	-2.9	13.0
Removable Magnetic Storage (Data Storage)	3.0	21.4	35.5	18.6	10.5	15.9	20.1
Page Printers (Input/Output)	0.2	-4.0	7.3	4.0	2.0	1.4	2.1
Serial Printers (Input/Output)	16.1	-3.6	1.3	-0.9	-0.9	-4.0	-1.6
Monitors (Input/Output)	35.7	5.2	-1.6	0.8	6.2	11.0	4.2
Other Data Processing Products	-2.5	14.1	20.9	24.9	3.5	5.4	13.4
All Data Processing Products	**6.0**	**12.1**	**9.9**	**9.5**	**3.8**	**4.4**	**7.9**

Source: Dataquest (June 1998)

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Table 2-17
Value of Semiconductors Consumed in Japan by Individual Communications Product, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
LAN Cards (Premise Telecommunications)	4	7	8	10	11	11
Premise Line Cards (Premise Telecommunications)	5	5	5	6	5	5
Answering Machines (Premise Telecommunications)	1	1	1	1	1	1
Fax Machines (Premise Telecommunications)	53	58	63	71	75	81
Modems (Premise Telecommunications)	1	1	1	1	1	1
Corded Telephones (Premise Telecommunications)	5	4	4	5	5	5
Analog Cordless Phones (Premise Telecommunications)	31	30	28	26	24	21
Digital Cordless Phones (Premise Telecommunications)	28	23	23	23	23	23
Central Office Line Cards (Public Telecommunications)	10	11	11	11	10	10
Analog Cellular Phones (Mobile Telecommunications)	3	0	0	0	0	0
Digital Cellular Phones (Mobile Telecommunications)	209	163	140	130	119	103
Pagers (Mobile Telecommunications)	12	12	11	10	10	9
Mobile Telecommunications Infrastructure (Mobile Telecommunications)	102	117	132	154	168	181
Other Mobile Telecommunications (Mobile Telecommunications)	27	25	25	24	23	23
Other Communications Products	373	424	487	606	660	742
All Communications Products	**864**	**881**	**939**	**1,076**	**1,134**	**1,214**

Source: Dataquest (June 1998)

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Table 2-18
Growth in the Value of Semiconductors Consumed in Japan by Individual Communications Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
LAN Cards (Premise Telecommunications)	86.7	57.6	17.3	17.1	9.7	1.0	19.1
Premise Line Cards (Premise Telecommunications)	7.0	0.6	4.9	15.1	-5.5	-0.2	2.8
Answering Machines (Premise Telecommunications)	6.6	-24.0	-4.1	26.7	21.1	6.6	3.6
Fax Machines (Premise Telecommunications)	5.5	9.7	8.5	11.6	5.9	7.9	8.7
Modems (Premise Telecommunications)	-2.8	5.9	3.4	13.8	6.3	2.1	6.2
Corded Telephones (Premise Telecommunications)	9.2	-17.3	5.8	10.9	4.8	1.8	0.7
Analog Cordless Phones (Premise Telecommunications)	22.8	-0.7	-8.9	-7.4	-6.4	-12.1	-7.2
Digital Cordless Phones (Premise Telecommunications)	-28.5	-18.5	-0.2	0.8	-1.7	0.3	-4.2
Central Office Line Cards (Public Telecommunications)	17.5	1.4	1.1	0.5	-7.1	-0.5	-1.0
Analog Cellular Phones (Mobile Telecommunications)	-77.6	NM	NM	NM	NM	NM	NM
Digital Cellular Phones (Mobile Telecommunications)	27.8	-22.1	-13.9	-7.6	-8.3	-13.7	-13.3
Pagers (Mobile Telecommunications)	-4.6	-5.3	-3.9	-6.8	-8.0	-6.8	-6.2
Mobile Telecommunications Infrastructure (Mobile Telecommunications)	48.7	14.7	13.2	16.6	8.6	7.8	12.1
Other Mobile Telecommunications (Mobile Telecommunications)	0.5	-4.2	-2.9	-2.6	-3.3	-3.0	-3.2
Other Communications Products	24.9	13.8	14.7	24.5	9.0	12.4	14.8
All Communications Products	**19.9**	**2.0**	**6.6**	**14.7**	**5.3**	**7.1**	**7.0**

NM = Not meaningful
Source: Dataquest (June 1998)

Table 2-19
Value of Semiconductors Consumed in Japan by Individual Consumer Product, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
Personal/Portable Stereos (Audio)	21	20	21	21	21	20
Color TVs (Video)	96	100	100	101	100	102
VCRs (Video)	69	61	59	56	36	30
Analog Camcorders (Video)	106	91	76	57	35	20
Digital Camcorders (Video)	55	89	105	100	110	103
DVD (Video)	3	5	8	15	20	22
Analog Set-Top Boxes (Video)	1	1	1	1	1	1
Digital Set-Top Boxes (Video)	12	18	19	21	22	19
Digital Still Cameras (Personal Electronics)	28	45	43	37	41	55
Video Game Controllers (Personal Electronics)	209	151	88	70	61	79
Video Game Cartridges (Personal Electronics)	7	3	2	1	1	1
Other Consumer Products	590	706	899	1,201	1,364	1,807
All Consumer Products	**1,197**	**1,292**	**1,421**	**1,681**	**1,811**	**2,258**

Source: Dataquest (June 1998)

Table 2-20
Growth in the Value of Semiconductors Consumed in Japan by Individual Consumer Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Personal/Portable Stereos (Audio)	-9.2	-3.6	4.7	2.4	-3.1	-1.4	-0.2
Color TVs (Video)	11.8	4.3	-0.6	0.9	-1.0	2.0	1.1
VCRs (Video)	-1.8	-10.3	-4.5	-4.0	-35.9	-17.0	-15.3
Analog Camcorders (Video)	5.1	-14.4	-16.2	-25.4	-38.1	-42.8	-28.3
Digital Camcorders (Video)	50.6	60.2	18.8	-5.6	10.5	-6.1	13.3
DVD (Video)	152.4	99.9	58.9	85.7	29.9	11.0	53.4
Analog Set-Top Boxes (Video)	-14.1	-21.4	-24.7	-18.8	-15.0	-2.4	-16.8
Digital Set-Top Boxes (Video)	10.6	44.8	8.8	9.7	5.1	-15.9	8.8
Digital Still Cameras (Personal Electronics)	65.5	59.7	-3.9	-14.0	9.6	34.0	14.1
Video Game Controllers (Personal Electronics)	24.8	-27.6	-41.8	-20.6	-12.6	29.1	-17.7
Video Game Cartridges (Personal Electronics)	-63.5	-46.4	-46.3	-44.7	-28.6	-26.9	-39.2
Other Consumer Products	49.2	19.7	27.3	33.7	13.6	32.5	25.1
All Consumer Products	**29.0**	**7.9**	**10.1**	**18.3**	**7.7**	**24.7**	**13.5**

Source: Dataquest (June 1998)

Table 2-21
Value of Semiconductors Consumed in Japan by Individual Transportation Product, 1997 to 2002 (Billions of Yen)

	1997	1998	1999	2000	2001	2002
Automotive Stereos	23	20	21	24	23	23
Automotive Engine Control Units	59	63	69	77	79	81
Antilock Braking Systems	14	16	18	21	24	25
Air Bags	12	14	17	19	21	22
Automotive Navigation Systems	31	49	63	73	81	97
Other Transportation Products	116	116	114	109	97	89
All Transportation Products	**255**	**278**	**303**	**323**	**325**	**339**

Source: Dataquest (June 1998)

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Table 2-22
Growth in the Value of Semiconductors Consumed in Japan by Individual Transportation Product, 1997 to 2002 (Percent)

	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Automotive Stereos	-1.9	-10.5	3.8	13.0	-5.0	2.3	0.4
Automotive Engine Control Units	8.9	7.8	9.4	11.4	2.6	2.3	6.6
Antilock Braking Systems	22.4	8.4	16.8	15.6	12.8	6.7	12.0
Air Bags	26.0	17.3	17.3	14.5	12.3	5.9	13.4
Automotive Navigation Systems	34.3	55.5	29.5	14.8	11.1	20.4	25.3
Other Transportation Products	-7.0	0	-1.1	-4.6	-10.8	-8.1	-5.0
All Transportation Products	**3.6**	**9.0**	**9.0**	**6.6**	**0.7**	**4.2**	**5.8**

Source: Dataquest (June 1998)

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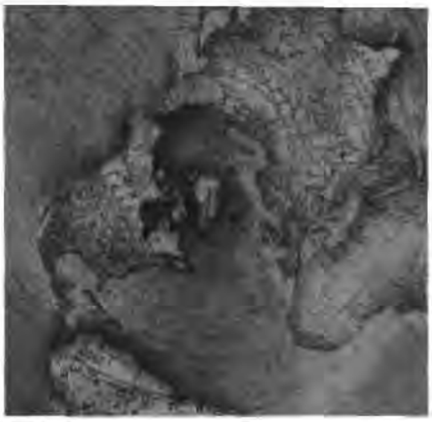

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Japanese Electronic Equipment Production Forecast, Spring 1998

Market Statistics

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MARIA VALENZUELA

Program: Semiconductors Japan
Product Code: SEMI-JA-MS-9802
Publication Date: June 29, 1998
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Japanese Electronic Equipment Production Forecast, Spring 1998

Market Statistics

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Chapter 1
Japanese Electronic Equipment Production Forecast

Introduction

Electronic equipment production is an important determinant of semiconductor market activity. This is true because semiconductor demand is derived, in part, from the underlying demand for the systems that use semiconductors. That is, the demand for semiconductors is a positive (or increasing) function of the demand for electronic systems. Therefore, forecasting electronic systems production is an essential component of assessing expected semiconductor market activity.

This document contains tables detailing the spring 1998 electronic equipment production forecast. Japanese production is estimated for the years 1992 to 2002. Production tables contain both historical data and forecasts. In most tables, historical data begins with 1992 and ends with 1997, while forecast data provides estimates for 1998 through 2002. The tables detail the type of production data by application market.

Definitions and Conventions

The objective of analyzing electronic systems production activity is to estimate the important implications for semiconductor consumption. Therefore, generalized economic concepts such as production and consumption are tailored to isolate these implications.

The value of production is estimated as factory revenue. Dataquest defines factory revenue as the exchange value of the commodity transaction between the original equipment manufacturer and the point of entry into distribution. In the case of a direct sale that involves no distribution, as is the case with military systems, factory revenue is equal to the final user cost, net of sales taxes.

Production is the value-adding process by which the factors of production (labor and capital) and material input are transformed into the goods and services that are desired for consumption and investment. As such, production can span both time and geography. For example, a Japanese color television company may minimize its cost of production by manufacturing its products (that is, consuming chips) in Asian countries. Dataquest would estimate this as Asia/Pacific production, because we are interested in that portion of the production process that relates specifically to semiconductor consumption. Production would be valued as the exchange value of the transaction between the Japanese company's Asian operations (which is factory revenue) and the European distributor or final user.

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Electronic equipment is divided into the following six semiconductor application markets and is further divided into the designated segments. Japanese production is further divided into specific types of equipment systems.

- Data processing
  - Computers
  - Data storage
  - Input/output
  - Dedicated systems
  - Other data processing
- Communications
  - Premise telecom
  - Public telecom
  - Mobile and radio communications
  - Broadcast and studio
  - Other telecom
- Industrial
  - Security and energy management
  - Manufacturing systems/instrumentation
  - Medical equipment
  - Other industrial
- Consumer
  - Audio
  - Video
  - Personal electronics
  - Appliances
  - Other consumer
- Military and civil aerospace
- Transportation
  - Entertainment
  - Control unit
  - Safety and convenience

Data Sources

The historical information presented in the production data has been consolidated from a variety of sources, each of which focuses on a specific part of the market. These sources include the following:

- Japanese production statistics compiled and published by the Ministry of International Trade and Industry (MITI)

- Estimates presented by knowledgeable and reliable industry spokespersons
- Published product literature and prices

Dataquest believes that the estimates presented here are the most accurate and meaningful generally available today.

Valuation of Production

Japanese production is expressed in Japanese yen and translated into U.S. dollars. To make the worldwide tables in this document useful in comparing different regions, it is necessary to express all values in a common currency, and Dataquest chose the U.S. dollar for convenience. However, the choice of the U.S. dollar or any other currency brings with it some problems that require the readers' careful consideration in interpreting the data, as follows:

- Inflation and deflation—No adjustment has been made in the historical or forecast data to account for the effects of past inflation or deflation or for possible future inflation or deflation. Production is expressed in current dollars (that is, dollars that include the effects of inflation and changes in exchange rates).
- Exchange rates—When forecasting electronic equipment production, it is important to ensure consistency and continuity so that we maintain exchange rates at constant 1998 calendar year values. This prevents any inconsistencies in the conversion of growth projections and currency fluctuations. The estimates in this Market Statistics report are generated primarily on a yen basis and then converted to U.S. dollars. The preliminary 1998 exchange rate estimate is based on actual exchange rates through December 1997, and we assume that the December rate applies for all the future months.

Japanese Electronic Equipment Production Definitions

Data Processing Equipment

Defined as computers, data storage, terminals, input/output, dedicated systems, and other data processing, as follows:

- Computers include general-use computers, office-use computers, personal-use computers, and control-use computers.
- Data storage includes rigid disk drives, flexible disk drives, other drives, and other data storage.
- Input/output includes printers, display units, other input/output units, general-use terminals, terminals for special use, and terminals for supporting systems.
- Dedicated systems include calculators, cash registers, copying machines, typewriters, word processors, and other dedicated equipment.
- Other data processing includes PC cards, single in-line memory modules (SIMMs), and other data processing equipment.

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Communications Equipment

Defined as premise telecom, public telecom, mobile and radio communications, broadcast and studio, and other communications, as follows:

- Premise telecom includes telephones (standard, multifunction, cordless, PHS, and others), applied telephone, facsimile, PBX telephone systems, key telephone systems, and modems.
- Public telecom includes carrier transmission equipment and central office switching.
- Mobile and radio communications includes radio communications (radio base station equipment, mobile radio equipment, and mobile communications equipment) and applied radio equipment.
- Broadcast and studio includes all electronic equipment used to make information public by means of radio and television.
- Other communications includes communications control units and other communications equipment.

Industrial Equipment

Defined as security and energy management, instrumentation, manufacturing systems, medical equipment, and other industrial equipment, as follows:

- Security and energy management includes alarm systems (intrusion detection and fire detection) and energy management (air conditioners for industrial use).
- Manufacturing systems/instrumentation includes NC machines, robotics, ultrasonic applied equipment, metering units, measuring instruments, industrial meters, and other instrumentation equipment such as analyzers.
- Medical equipment includes X-ray systems, measuring systems, and other medical equipment such as radioisotope equipment.
- Other industrial includes vending machines, automatic service equipment, commercial-type washers, electron microscopes, ultrasonic equipment, and all other industrial equipment not accounted for in the preceding segments.

Consumer Equipment

Defined as audio equipment, video equipment, personal electronics, appliances, and other consumer equipment, as follows:

- Audio includes audio amplifiers, digital audio disc (DAD) players, radios, stereo sets, tape recorders, headphone stereos, musical instruments, and other audio equipment (tuners and turntables).
- Video includes video cassette recorders (VCRs), video cameras, DVD players, color televisions, and LCD televisions.
- Personal electronics includes cameras, clocks, electronic toys, watches, and game systems and software.
- Appliances include air conditioners for home use, microwave ovens, refrigerators, and washers and dryers.

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- Other consumer includes gas heaters, gas fan heaters, oil fan heaters, electric heaters, fans, electric water heaters, gas water heaters, oil water heaters, electric pots, rice cooker and rice jar combinations, gas rice cookers, sewing machines, electric irons, vacuum cleaners, and other consumer equipment.

Military/Civil Aerospace Equipment

Defined as electronic systems for defense agencies, such as communications equipment and instrumentation.

Transportation Equipment

Defined as in-car entertainment systems, control units and safety and convenience electronics.

- In-car entertainment includes FM/AM radios, radio-cassette combination systems, and car stereo cassette units.
- Control units include electronics control equipment for engine, body, and powertrain.
- Safety and convenience includes in-car equipment for safety and convenience, such as car air conditioners.

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Chapter 2
Market Statistics Tables

Tables 2-1 through 2-42 contain statistics for Japanese electronic equipment production.

Table 2-1
Japanese Electronic Equipment Production History (Vendor Revenue in Billions of Yen)

Segment	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Data Processing							
Computers	2,248	2,026	2,100	2,523	3,352	3,643	10.1
Data Storage	1,302	1,181	1,177	873	867	959	-5.9
Input/Output	1,577	1,409	1,491	1,520	1,593	1,862	3.4
Dedicated Systems	999	925	839	819	750	753	-5.5
Other Data Processing	82	104	146	179	250	163	14.8
Total	**6,207**	**5,645**	**5,753**	**5,913**	**6,812**	**7,380**	**3.5**
Communications							
Premise Telecommunications	952	899	844	806	875	998	0.9
Public Telecommunications	732	816	832	892	1,142	1,384	13.6
Mobile and Radio Equipment	908	880	976	991	1,601	2,018	17.3
Broadcast and Studio	100	78	90	70	92	84	-3.3
Other Communications	137	132	148	226	332	360	21.2
Total	**2,829**	**2,804**	**2,889**	**2,985**	**4,042**	**4,844**	**11.4**
Industrial							
Security/Energy Management	586	522	530	559	542	448	-5.2
Manufacturing Systems/Instrumentation	1,657	1,483	1,434	1,736	1,958	2,250	6.3
Medical Equipment	318	315	287	307	340	342	1.5
Other Industrial	629	629	698	741	808	868	6.7
Total	**3,190**	**2,949**	**2,948**	**3,343**	**3,648**	**3,908**	**4.1**
Consumer							
Audio	932	774	722	602	512	551	-10.0
Video	2,371	2,008	1,840	1,528	1,455	1,605	-7.5
Personal Electronics	1,445	1,280	1,263	1,281	1,316	1,368	-1.1
Appliances	1,699	1,495	1,615	1,753	1,758	1,605	-1.1
Other Consumer	940	920	927	970	978	969	0.6
Total	**7,387**	**6,477**	**6,366**	**6,134**	**6,019**	**6,098**	**-3.8**
Military/Civil Aerospace	**212**	**207**	**203**	**200**	**197**	**195**	**-1.6**
Transportation	**1,330**	**1,281**	**1,224**	**1,240**	**1,283**	**1,290**	**-0.6**
Total Electronics Industry	**21,155**	**19,363**	**19,382**	**19,815**	**22,001**	**23,715**	**2.3**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

Table 2-2
Japanese Electronic Equipment Production Forecast (Vendor Revenue in Billions of Yen)

Segment	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Data Processing							
Computers	3,643	3,979	4,128	4,104	4,081	4,139	2.6
Data Storage	959	945	993	986	974	969	0.2
Input/Output	1,862	1,910	1,924	1,925	2,016	2,196	3.4
Dedicated Systems	753	740	725	770	765	745	-0.2
Other Data Processing	163	185	199	204	210	215	5.7
Total	**7,380**	**7,759**	**7,970**	**7,989**	**8,046**	**8,265**	**2.3**
Communications							
Premise Telecommunications	998	1,014	947	950	966	971	-0.5
Public Telecommunications	1,384	1,472	1,552	1,662	1,738	1,867	6.2
Mobile and Radio Equipment	2,018	1,864	1,863	1,987	2,042	2,072	0.5
Broadcast and Studio	84	90	110	135	125	137	10.3
Other Communications	360	389	415	487	503	534	8.2
Total	**4,844**	**4,830**	**4,887**	**5,221**	**5,374**	**5,581**	**2.9**
Industrial							
Security/Energy Management	448	465	474	440	445	451	0.1
Manufacturing Systems/Instrumentation	2,250	2,373	2,487	2,673	2,811	2,990	5.9
Medical Equipment	342	352	365	387	402	440	5.1
Other Industrial	868	950	1,013	1,060	1,105	1,176	6.3
Total	**3,908**	**4,140**	**4,339**	**4,560**	**4,763**	**5,057**	**5.3**
Consumer							
Audio	551	537	542	550	564	601	1.8
Video	1,605	1,701	1,689	1,607	1,508	1,402	-2.7
Personal Electronics	1,368	1,283	1,201	1,251	1,320	1,561	2.7
Appliances	1,605	1,558	1,627	1,803	1,875	2,013	4.6
Other Consumer	969	1,031	1,001	1,070	1,078	1,125	3.0
Total	**6,098**	**6,110**	**6,060**	**6,281**	**6,346**	**6,702**	**1.9**
Military/Civil Aerospace	**195**	**192**	**190**	**187**	**185**	**183**	**-1.3**
Transportation	**1,290**	**1,394**	**1,455**	**1,486**	**1,488**	**1,493**	**3.0**
Total Electronics Industry	**23,715**	**24,425**	**24,901**	**25,725**	**26,201**	**27,280**	**2.8**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-3
Japanese Electronic Equipment Production History (Vendor Revenue in Millions of Dollars)

Segment	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Data Processing							
Computers	17,775	18,223	20,625	26,868	30,805	30,083	11.1
Data Storage	10,295	10,623	11,562	9,293	7,965	7,915	-5.1
Input/Output	12,467	12,667	14,646	16,187	14,642	15,379	4.3
Dedicated Systems	7,900	8,317	8,241	8,722	6,895	6,217	-4.7
Other Data Processing	645	935	1,430	1,906	2,298	1,346	15.8
Total	**49,083**	**50,766**	**56,503**	**62,976**	**62,605**	**60,940**	**4.4**
Communications							
Premise Telecommunications	7,531	8,085	8,286	8,585	8,039	8,244	1.8
Public Telecommunications	5,786	7,335	8,168	9,499	10,497	11,431	14.6
Mobile and Radio Equipment	7,183	7,914	9,583	10,558	14,716	16,661	18.3
Broadcast and Studio	788	699	888	743	847	694	-2.5
Other Communications	1,087	1,183	1,454	2,403	3,052	2,973	22.3
Total	**22,375**	**25,215**	**28,378**	**31,789**	**37,151**	**40,002**	**12.3**
Industrial							
Security/Energy Management	4,636	4,697	5,205	5,952	4,982	3,699	-4.4
Manufacturing Systems/ Instrumentation	13,106	13,337	14,080	18,491	17,993	18,580	7.2
Medical Equipment	2,515	2,831	2,814	3,265	3,122	2,827	2.4
Other Industrial	4,972	5,652	6,860	7,889	7,426	7,168	7.6
Total	**25,229**	**26,517**	**28,959**	**35,597**	**33,523**	**32,274**	**5.0**
Consumer							
Audio	7,373	6,959	7,087	6,409	4,702	4,549	-9.2
Video	18,754	18,060	18,072	16,270	13,377	13,255	-6.7
Personal Electronics	11,426	11,514	12,403	13,647	12,097	11,293	-0.2
Appliances	13,437	13,444	15,863	18,670	16,156	13,254	-0.3
Other Consumer	7,431	8,271	9,101	10,332	8,984	8,002	1.5
Total	**58,420**	**58,248**	**62,526**	**65,328**	**55,315**	**50,352**	**-2.9**
Military/Civil Aerospace	**1,675**	**1,865**	**1,992**	**2,126**	**1,814**	**1,610**	**-0.8**
Transportation	**10,516**	**11,519**	**12,018**	**13,204**	**11,795**	**10,653**	**0.3**
Total Electronics Industry	**167,297**	**174,130**	**190,377**	**211,020**	**202,203**	**195,832**	**3.2**
Exchange Rate (Yen/U.S.$)	126.45	111.20	101.81	93.90	108.81	121.10	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

Table 2-4
Japanese Electronic Equipment Production Forecast (Vendor Revenue in Millions of Dollars)

Segment	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Data Processing							
Computers	30,083	30,675	31,822	31,635	31,459	31,906	1.2
Data Storage	7,915	7,285	7,658	7,602	7,509	7,473	-1.1
Input/Output	15,379	14,719	14,831	14,839	15,538	16,928	1.9
Dedicated Systems	6,217	5,704	5,589	5,935	5,897	5,743	-1.6
Other Data Processing	1,346	1,426	1,534	1,572	1,619	1,657	4.2
Total	**60,940**	**59,810**	**61,434**	**61,584**	**62,022**	**63,707**	**0.9**
Communications							
Premise Telecommunications	8,244	7,818	7,299	7,325	7,446	7,487	-1.9
Public Telecommunications	11,431	11,348	11,963	12,808	13,399	14,395	4.7
Mobile and Radio Equipment	16,661	14,372	14,364	15,319	15,737	15,969	-0.8
Broadcast and Studio	694	694	848	1,041	964	1,056	8.8
Other Communications	2,973	2,999	3,199	3,754	3,877	4,116	6.7
Total	**40,002**	**37,230**	**37,673**	**40,247**	**41,423**	**43,023**	**1.5**
Industrial							
Security/Energy Management	3,699	3,584	3,654	3,392	3,430	3,476	-1.2
Manufacturing Systems/ Instrumentation	18,580	18,292	19,171	20,604	21,668	23,048	4.4
Medical Equipment	2,827	2,713	2,814	2,983	3,099	3,392	3.7
Other Industrial	7,168	7,323	7,809	8,171	8,518	9,065	4.8
Total	**32,274**	**31,912**	**33,446**	**35,150**	**36,715**	**38,981**	**3.8**
Consumer							
Audio	4,549	4,142	4,174	4,243	4,351	4,634	0.4
Video	13,255	13,110	13,022	12,387	11,626	10,804	-4.0
Personal Electronics	11,293	9,892	9,258	9,642	10,176	12,035	1.3
Appliances	13,254	12,010	12,541	13,898	14,453	15,517	3.2
Other Consumer	8,002	7,943	7,716	8,249	8,310	8,672	1.6
Total	**50,352**	**47,096**	**46,711**	**48,420**	**48,915**	**51,661**	**0.5**
Military/Civil Aerospace	**1,610**	**1,483**	**1,463**	**1,443**	**1,426**	**1,408**	**-2.7**
Transportation	**10,653**	**10,745**	**11,217**	**11,456**	**11,468**	**11,507**	**1.6**
Total Electronics Industry	**195,832**	**188,276**	**191,944**	**198,300**	**201,967**	**210,286**	**1.4**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-5
Japanese Electronic Equipment Production History (Yen-Based Annual Growth; Percent)

Segment	1992	1993	1994	1995	1996	1997
Data Processing						
Computers	-11.6	-9.8	3.6	20.1	32.9	8.7
Data Storage	-4.7	-9.3	-0.4	-25.9	-0.7	10.6
Input/Output	-13.0	-10.7	5.9	1.9	4.8	16.9
Dedicated Systems	-7.0	-7.4	-9.3	-2.4	-8.4	0.4
Other Data Processing	22.2	27.5	40.0	22.9	39.7	-34.8
Total	**-9.6**	**-9.0**	**1.9**	**2.8**	**15.2**	**8.3**
Communications						
Premise Telecommunications	-9.5	-5.6	-6.2	-4.4	8.5	14.1
Public Telecommunications	-11.4	11.5	2.0	7.3	28.0	21.2
Mobile and Radio Equipment	-3.3	-3.1	10.9	1.6	61.5	26.0
Broadcast and Studio	0.6	-22.0	16.3	-22.8	32.1	-8.9
Other Communications	-28.3	-4.3	12.5	52.4	47.2	8.4
Total	**-9.0**	**-0.9**	**3.0**	**3.3**	**35.4**	**19.8**
Industrial						
Security/Energy Management	-10.9	-10.9	1.5	5.5	-3.0	-17.4
Manufacturing Systems/Instrumentation	-25.1	-10.5	-3.3	21.1	12.8	14.9
Medical Equipment	-2.5	-1.0	-9.0	7.0	10.8	0.8
Other Industrial	-13.7	0.0	11.1	6.1	9.1	7.4
Total	**-18.7**	**-7.6**	**0**	**13.4**	**9.1**	**7.2**
Consumer						
Audio	-17.1	-17.0	-6.8	-16.6	-15.0	7.7
Video	-22.1	-15.3	-8.4	-17.0	-4.7	10.3
Personal Electronics	-4.0	-11.4	-1.4	1.5	2.7	3.9
Appliances	-14.0	-12.0	8.0	8.6	0.3	-8.7
Other Consumer	-10.3	-2.1	0.8	4.7	0.8	-0.9
Total	**-15.1**	**-12.3**	**-1.7**	**-3.6**	**-1.9**	**1.3**
Military/Civil Aerospace	**-2.1**	**-2.1**	**-2.2**	**-1.6**	**-1.1**	**-1.2**
Transportation	**-2.7**	**-3.7**	**-4.5**	**1.3**	**3.5**	**0.5**
Total Electronics Industry	**-12.5**	**-8.5**	**0.1**	**2.2**	**11.0**	**7.8**

Source: MITI, Dataquest (May 1998)

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Table 2-6
Japanese Electronic Equipment Production Forecast (Yen-Based Annual Growth; Percent)

Segment	1997	1998	1999	2000	2001	2002
Data Processing						
Computers	8.7	9.2	3.7	-0.6	-0.6	1.4
Data Storage	10.6	-1.4	5.1	-0.7	-1.2	-0.5
Input/Output	16.9	2.5	0.8	0.1	4.7	8.9
Dedicated Systems	0.4	-1.7	-2.0	6.2	-0.6	-2.6
Other Data Processing	-34.8	13.5	7.6	2.5	2.9	2.4
Total	**8.3**	**5.1**	**2.7**	**0.2**	**0.7**	**2.7**
Communications						
Premise Telecommunications	14.1	1.6	-6.6	0.3	1.7	0.5
Public Telecommunications	21.2	6.3	5.4	7.1	4.6	7.4
Mobile and Radio Equipment	26.0	-7.6	-0.1	6.6	2.7	1.5
Broadcast and Studio	-8.9	7.1	22.2	22.7	-7.4	9.6
Other Communications	8.4	8.1	6.7	17.3	3.3	6.2
Total	**19.8**	**-0.3**	**1.2**	**6.8**	**2.9**	**3.9**
Industrial						
Security/Energy Management	-17.4	3.8	1.9	-7.2	1.1	1.3
Manufacturing Systems/Instrumentation	14.9	5.5	4.8	7.5	5.2	6.4
Medical Equipment	0.8	2.8	3.7	6.0	3.9	9.5
Other Industrial	7.4	9.4	6.6	4.6	4.2	6.4
Total	**7.2**	**5.9**	**4.8**	**5.1**	**4.5**	**6.2**
Consumer						
Audio	7.7	-2.5	0.8	1.6	2.5	6.5
Video	10.3	6.0	-0.7	-4.9	-6.1	-7.1
Personal Electronics	3.9	-6.2	-6.4	4.2	5.5	18.3
Appliances	-8.7	-2.9	4.4	10.8	4.0	7.4
Other Consumer	-0.9	6.3	-2.9	6.9	0.7	4.4
Total	**1.3**	**0.2**	**-0.8**	**3.7**	**1.0**	**5.6**
Military/Civil Aerospace	**-1.2**	**-1.3**	**-1.4**	**-1.4**	**-1.2**	**-1.3**
Transportation	**0.5**	**8.0**	**4.4**	**2.1**	**0.1**	**0.3**
Total Electronics Industry	**7.8**	**3.0**	**1.9**	**3.3**	**1.8**	**4.1**

Source: MITI, Dataquest (May 1998)

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Table 2-7
Japanese Electronic Equipment Production History—Data Processing (Vendor Revenue in Billions of Yen)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Computers							
General Use	932	758	730	664	731	763	-3.9
Office Use	287	222	219	209	198	250	-2.7
Personal Use	897	890	978	1,313	2,088	2,270	20.4
Control Use	132	157	173	338	335	360	22.3
Total	**2,248**	**2,026**	**2,100**	**2,523**	**3,352**	**3,643**	**10.1**
Data Storage							
Rigid Disk Drives	880	793	793	543	534	540	-9.3
Flexible Disk Drives	135	95	58	33	27	29	-26.4
Other Drives	249	246	261	213	205	240	-0.7
Other Data Storage	38	46	66	84	101	150	31.5
Total	**1,302**	**1,181**	**1,177**	**873**	**867**	**959**	**-5.9**
Input/Output							
Printers	657	584	584	641	676	780	3.5
Display Units	236	239	316	443	503	580	19.7
Other Units	48	37	36	8	12	12	-24.1
Terminals General Use	282	252	236	107	70	90	-20.4
Terminals Special Use	329	284	307	310	328	393	3.6
Terminal Supporting Systems	25	13	12	12	4	7	-22.3
Total	**1,577**	**1,409**	**1,491**	**1,520**	**1,593**	**1,862**	**3.4**
Dedicated Systems							
Calculators	92	78	49	30	29	29	-20.7
Cash Registers	96	79	65	65	69	72	-5.6
Copying Machines	553	523	533	550	546	547	-0.2
Typewriters	19	13	7	3	2	2	-39.7
Word Processors	239	231	185	169	104	103	-15.5
Other Dedicated Systems	0	0	1	1	1	0	20.4
Total	**999**	**925**	**839**	**819**	**750**	**753**	**-5.5**
Other Data Processing	**82**	**104**	**146**	**179**	**250**	**163**	**14.8**
Data Processing Total	**6,207**	**5,645**	**5,753**	**5,913**	**6,812**	**7,380**	**3.5**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-8
Japanese Electronic Equipment Production Forecast—Data Processing (Vendor Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Computers							
General Use	763	816	827	860	870	869	2.6
Office Use	250	328	332	335	331	341	6.4
Personal Use	2,270	2,405	2,484	2,460	2,433	2,480	1.8
Control Use	360	430	485	449	447	449	4.5
Total	**3,643**	**3,979**	**4,128**	**4,104**	**4,081**	**4,139**	**2.6**
Data Storage							
Rigid Disk Drives	540	560	534	534	492	478	-2.4
Flexible Disk Drives	29	25	8	5	3	2	-41.4
Other Drives	240	235	273	240	251	239	-0.1
Other Data Storage	150	125	178	207	228	250	10.8
Total	**959**	**945**	**993**	**986**	**974**	**969**	**0.2**
Input/Output							
Printers	780	790	795	785	632	680	-2.7
Display Units	580	618	622	629	730	776	6.0
Other Units	12	10	11	10	8	7	-10.2
Terminals General Use	90	92	90	84	72	70	-4.9
Terminals Special Use	393	395	401	413	571	660	10.9
Terminal Supporting Systems	7	5	5	4	3	3	-18.0
Total	**1,862**	**1,910**	**1,924**	**1,925**	**2,016**	**2,196**	**3.4**
Dedicated Systems							
Calculators	29	24	23	22	21	18	-9.1
Cash Registers	72	86	90	115	118	115	9.8
Copying Machines	547	549	552	580	578	570	0.8
Typewriters	2	2	2	2	2	3	10.8
Word Processors	103	79	58	51	45	39	-17.7
Other Dedicated Systems	0	0	0	0	0	0	-0.3
Total	**753**	**740**	**725**	**770**	**765**	**745**	**-0.2**
Other Data Processing	**163**	**185**	**199**	**204**	**210**	**215**	**5.7**
Data Processing Total	**7,380**	**7,759**	**7,970**	**7,989**	**8,046**	**8,265**	**2.3**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-9
Japanese Electronic Equipment Production History—Data Processing (Vendor Revenue in Millions of Dollars)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Computers							
General Use	7,367	6,817	7,170	7,071	6,718	6,301	-3.1
Office Use	2,272	1,992	2,148	2,220	1,820	2,064	-1.9
Personal Use	7,094	8,000	9,606	13,986	19,190	18,745	21.5
Control Use	1,042	1,413	1,699	3,595	3,079	2,973	23.3
Total	**17,775**	**18,223**	**20,625**	**26,868**	**30,805**	**30,083**	**11.1**
Data Storage							
Rigid Disk Drives	6,959	7,134	7,785	5,781	4,904	4,459	-8.5
Flexible Disk Drives	1,065	855	569	351	244	239	-25.8
Other Drives	1,968	2,216	2,560	2,268	1,884	1,982	0.1
Other Data Storage	302	416	646	890	932	1,239	32.6
Total	**10,295**	**10,623**	**11,562**	**9,293**	**7,965**	**7,915**	**-5.1**
Input/Output							
Printers	5,197	5,248	5,740	6,822	6,209	6,441	4.4
Display Units	1,863	2,147	3,101	4,717	4,627	4,789	20.8
Other Units	376	331	352	87	108	99	-23.4
Terminals General Use	2,230	2,265	2,320	1,134	642	743	-19.7
Terminals Special Use	2,604	2,553	3,017	3,300	3,018	3,245	4.5
Terminal Supporting Systems	195	121	115	127	32	58	-21.6
Total	**12,467**	**12,667**	**14,646**	**16,187**	**14,642**	**15,379**	**4.3**
Dedicated Systems							
Calculators	729	702	477	319	267	239	-20.0
Cash Registers	758	709	634	691	633	595	-4.7
Copying Machines	4,371	4,707	5,235	5,862	5,022	4,517	0.7
Typewriters	149	116	66	36	16	12	-39.2
Word Processors	1,892	2,078	1,821	1,804	951	851	-14.8
Other Dedicated Systems	1	3	6	7	5	3	21.5
Total	**7,900**	**8,317**	**8,241**	**8,722**	**6,895**	**6,217**	**-4.7**
Other Data Processing	**645**	**935**	**1,430**	**1,906**	**2,298**	**1,346**	**15.8**
Data Processing Total	**49,083**	**50,766**	**56,503**	**62,976**	**62,605**	**60,940**	**4.4**
Exchange Rate (Yen/U.S.$)	126.45	111.20	101.81	93.90	108.81	121.10	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

Table 2-10
Japanese Electronic Equipment Production Forecast—Data Processing (Vendor Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Computers							
General Use	6,301	6,290	6,375	6,629	6,706	6,699	1.2
Office Use	2,064	2,528	2,559	2,582	2,551	2,629	5.0
Personal Use	18,745	18,539	19,147	18,962	18,754	19,117	0.4
Control Use	2,973	3,315	3,739	3,461	3,446	3,461	3.1
Total	**30,083**	**30,675**	**31,722**	**31,635**	**31,459**	**31,906**	**1.2**
Data Storage							
Rigid Disk Drives	4,459	4,317	4,116	4,116	3,792	3,685	-3.7
Flexible Disk Drives	239	193	62	39	23	15	-42.2
Other Drives	1,982	1,811	2,104	1,850	1,935	1,842	-1.4
Other Data Storage	1,239	964	1,372	1,596	1,757	1,927	9.2
Total	**7,915**	**7,285**	**7,658**	**7,602**	**7,509**	**7,473**	**-1.1**
Input/Output							
Printers	6,441	6,090	6,128	6,051	4,872	5,242	-4.0
Display Units	4,789	4,761	4,795	4,849	5,627	5,982	4.5
Other Units	99	77	85	77	62	54	-11.4
Terminals General Use	743	709	694	647	554	540	-6.2
Terminals Special Use	3,245	3,045	3,091	3,184	4,402	5,087	9.4
Terminal Supporting Systems	58	39	39	31	21	20	-19.1
Total	**15,379**	**14,719**	**14,831**	**14,839**	**15,538**	**16,925**	**1.9**
Dedicated Systems							
Calculators	239	185	176	170	162	139	-10.3
Cash Registers	595	661	694	886	910	886	8.3
Copying Machines	4,517	4,232	4,255	4,471	4,455	4,394	-0.6
Typewriters	12	13	14	15	16	19	9.2
Word Processors	851	610	447	393	347	301	-18.8
Other Dedicated Systems	3	4	4	3	3	3	-1.7
Total	**6,217**	**5,704**	**5,589**	**5,935**	**5,897**	**5,743**	**-1.6**
Other Data Processing	**1,346**	**1,426**	**1,534**	**1,572**	**1,619**	**1,657**	**4.2**
Data Processing Total	**60,940**	**59,810**	**61,434**	**61,584**	**62,022**	**63,707**	**0.9**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-11
Japanese Electronic Equipment Production History—Data Processing (Yen-Based Annual Growth; Percent)

Equipment Type	1992	1993	1994	1995	1996	1997
Computers						
General Use	-28.3	-18.6	-3.7	-9.0	10.1	4.4
Office Use	-0.5	-22.9	-1.3	-4.7	-5.0	26.3
Personal Use	7.9	-0.8	9.9	34.3	59.0	8.7
Control Use	6.0	19.3	10.1	95.1	-0.8	7.5
Total	**-11.6**	**-9.8**	**3.6**	**20.1**	**32.9**	**8.7**
Data Storage						
Rigid Disk Drives	-2.2	-9.9	-0.1	-31.5	-1.7	1.2
Flexible Disk Drives	-15.5	-29.4	-39.1	-43.0	-19.4	9.0
Other Drives	-9.1	-1.0	5.8	-18.3	-3.8	17.1
Other Data Storage	14.4	21.2	42.1	27.1	21.3	47.9
Total	**-4.7**	**-9.3**	**-0.4**	**-25.9**	**-0.7**	**10.6**
Input/Output						
Printers	-5.9	-11.2	0.1	9.6	5.5	15.5
Display Units	-2.2	1.4	32.2	40.3	13.7	15.2
Other Units	-25.2	-22.7	-2.7	-77.1	42.7	2.6
Terminals General Use	-32.5	-10.7	-6.2	-54.9	-34.4	28.8
Terminals Special Use	-10.7	-13.8	8.2	0.9	6.0	19.7
Terminal Supporting Systems	11.3	-45.7	-12.7	1.7	-70.6	100.0
Total	**-13.0**	**-10.7**	**5.9**	**1.9**	**4.8**	**16.9**
Dedicated Systems						
Calculators	-20.9	-15.3	-37.8	-38.3	-3.3	0
Cash Registers	-5.5	-17.7	-18.1	0.6	6.2	4.5
Copying Machines	0.4	-5.3	1.8	3.3	-0.7	0.1
Typewriters	-34.3	-31.4	-48.1	-49.3	-50.0	-11.8
Word Processors	-13.6	-3.4	-19.8	-8.6	-38.9	-0.5
Other Dedicated Systems	51.9	124.1	61.6	22.4	-24.7	-24.1
Total	**-7.0**	**-7.4**	**-9.3**	**-2.4**	**-8.4**	**0.4**
Other Data Processing	**22.2**	**27.5**	**40.0**	**22.9**	**39.7**	**-34.8**
Data Processing Total	**-9.6**	**-9.0**	**1.9**	**2.8**	**15.2**	**8.3**

Source: MITI, Dataquest (May 1998)

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Table 2-12
Japanese Electronic Equipment Production Forecast—Data Processing (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Computers						
General Use	4.4	6.9	1.3	4.0	1.2	-0.1
Office Use	26.3	31.2	1.2	0.9	-1.2	3.0
Personal Use	8.7	5.9	3.3	-1.0	-1.1	1.9
Control Use	7.5	19.4	12.8	-7.4	-0.4	0.4
Total	**8.7**	**9.2**	**3.7**	**-0.6**	**-0.6**	**1.4**
Data Storage						
Rigid Disk Drives	1.2	3.7	-4.6	0	-7.9	-2.8
Flexible Disk Drives	9.0	-13.8	-68.0	-37.5	-40.0	-33.3
Other Drives	17.1	-2.1	16.2	-12.1	4.6	-4.8
Other Data Storage	47.9	-16.7	42.4	16.3	10.1	9.6
Total	**10.6**	**-1.4**	**5.1**	**-0.7**	**-1.2**	**-0.5**
Input/Output						
Printers	15.5	1.3	0.6	-1.3	-19.5	7.6
Display Units	15.2	6.5	0.7	1.1	16.1	6.3
Other Units	2.6	-16.7	10.0	-9.1	-20.0	-12.5
Terminals General Use	28.8	2.2	-2.2	-6.7	-14.4	-2.5
Terminals Special Use	19.7	0.5	1.5	3.0	38.3	15.6
Terminal Supporting Systems	100.0	-28.6	0	-20.0	-32.5	-3.7
Total	**16.9**	**2.5**	**0.8**	**0.1**	**4.7**	**8.9**
Dedicated Systems						
Calculators	0	-17.2	-5.0	-3.5	-4.5	-14.3
Cash Registers	4.5	19.0	5.0	27.8	2.6	-2.5
Copying Machines	0.1	0.4	0.5	5.1	-0.3	-1.4
Typewriters	-11.8	13.3	5.9	5.6	10.5	19.0
Word Processors	-0.5	-23.2	-26.7	-12.1	-11.8	-13.3
Other Dedicated Systems	-24.1	21.5	-3.9	-5.6	-5.9	-5.1
Total	**0.4**	**-1.7**	**-2.0**	**6.2**	**-0.6**	**-2.6**
Other Data Processing	**-34.8**	**13.5**	**7.6**	**2.5**	**2.9**	**2.4**
Data Processing Total	**8.3**	**5.1**	**2.7**	**0.2**	**0.7**	**2.7**

Source: MITI, Dataquest (May 1998)

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Table 2-13
Japanese Electronic Equipment Production History—Communications (Vendor Revenue in Billions of Yen)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Premise Telecommunications							
Telephones	321	294	252	223	252	268	-0.5
Standard	31	25	18	17	10	12	-17.3
Multifunction	33	27	27	17	16	15	-14.7
Cordless	224	219	184	176	207	219	-0.5
Others	32	23	23	13	18	22	-7.3
Applied Telephones	36	33	36	46	48	52	7.7
Facsimiles	391	355	312	290	290	350	-2.2
PBX Telephone Systems	87	83	102	113	142	180	15.6
Key Telephone Systems	95	104	106	92	93	98	0.5
Modems	22	30	35	41	52	50	17.4
Total	**952**	**899**	**844**	**806**	**875**	**998**	**0.9**
Public Telecommunications							
Carrier Transmission	413	474	483	568	753	824	14.8
Central Office Switches	319	342	348	324	390	560	11.9
Total	**732**	**816**	**832**	**892**	**1,142**	**1,384**	**13.6**
Mobile and Radio							
Radio Communications	735	697	811	823	1,419	1,810	19.7
Radio Base Station Equipment	279	236	229	272	471	595	16.3
Mobile Radio Equipment	386	405	500	515	923	1,180	25.0
Mobile Communications Equipment	70	57	82	37	25	35	-12.8
Applied Radio Equipment	219	225	202	168	183	208	-1.0
Total	**908**	**880**	**976**	**991**	**1,601**	**2,018**	**17.3**
Broadcast and Studio	**100**	**78**	**90**	**70**	**92**	**84**	**-3.3**
Other Communications Equipment	**137**	**132**	**148**	**226**	**332**	**360**	**21.2**
Communications Total	**2,829**	**2,804**	**2,889**	**2,985**	**4,042**	**4,844**	**11.4**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

Table 2-14
Japanese Electronic Equipment Production Forecast—Communications (Vendor Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Premise Telecommunications							
Telephones	268	377	347	346	355	358	5.9
Standard	12	10	8	7	7	6	-12.7
Multifunction	15	19	21	20	21	21	6.6
Cordless	219	322	290	291	294	296	6.2
Others	22	26	29	28	33	35	9.7
Applied Telephones	52	42	40	41	47	49	-1.1
Facsimiles	350	303	270	268	264	255	-6.1
PBX Telephone Systems	180	149	146	152	159	166	-1.6
Key Telephone Systems	98	98	99	101	101	105	1.4
Modems	50	46	45	42	40	38	-5.4
Total	**998**	**1,014**	**947**	**950**	**966**	**971**	**-0.6**
Public Telecommunications							
Carrier Transmission	824	943	1,004	1,075	1,115	1,210	8.0
Central Office Switches	560	529	548	587	623	657	3.2
Total	**1,384**	**1,472**	**1,552**	**1,662**	**1,738**	**1,867**	**6.2**
Mobile and Radio							
Radio Communications	1,810	1,670	1,683	1,805	1,873	1,912	1.1
Radio Base Station Equipment	595	605	758	940	1,020	1,125	13.6
Mobile Radio Equipment	1,180	1,038	896	835	822	754	-8.6
Mobile Communications Equipment	35	27	29	30	31	33	-1.3
Applied Radio Equipment	208	193	180	182	169	161	-5.0
Total	**2,018**	**1,864**	**1,863**	**1,987**	**2,042**	**2,072**	**0.5**
Broadcast and Studio	**84**	**90**	**110**	**135**	**125**	**137**	**10.3**
Other Communications Equipment	**360**	**389**	**415**	**487**	**503**	**534**	**8.2**
Communications Total	**4,844**	**4,830**	**4,887**	**5,221**	**5,374**	**5,581**	**2.9**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-15
Japanese Electronic Equipment Production History—Communications (Vendor Revenue in Millions of Dollars)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Premise Telecommunications							
Telephones	2,536	2,645	2,474	2,378	2,316	2,213	0.3
Standard	245	223	172	185	95	99	-16.6
Multifunction	263	239	267	176	148	124	-14.0
Cordless	1,774	1,972	1,805	1,875	1,902	1,808	0.4
Others	254	210	230	142	167	182	-6.5
Applied Telephones	284	293	357	486	438	429	8.6
Facsimiles	3,088	3,194	3,066	3,092	2,662	2,890	-1.3
PBX Telephone Systems	689	750	1,002	1,208	1,302	1,486	16.6
Key Telephone Systems	754	932	1,040	976	855	809	1.4
Modems	177	268	343	437	475	413	18.4
Total	**7,531**	**8,085**	**8,286**	**8,585**	**8,039**	**8,244**	**1.8**
Public Telecommunications							
Carrier Transmission	3,265	4,263	4,746	6,050	6,916	6,804	15.8
Central Office Switches	2,522	3,071	3,421	3,449	3,581	4,624	12.9
Total	**5,786**	**7,335**	**8,168**	**9,499**	**10,497**	**11,431**	**14.6**
Mobile and Radio							
Radio Communications	5,813	6,272	7,963	8,769	13,036	14,946	20.8
Radio Base Station Equipment	2,208	2,121	2,245	2,894	4,329	4,913	17.3
Mobile Radio Equipment	3,054	3,638	4,914	5,480	8,483	9,744	26.1
Mobile Communications Equipment	550	512	803	395	225	289	-12.1
Applied Radio Equipment	1,730	2,019	1,986	1,788	1,681	1,718	-0.1
Total	**7,183**	**7,914**	**9,583**	**10,558**	**14,716**	**16,661**	**18.3**
Broadcast and Studio	**788**	**699**	**888**	**743**	**847**	**694**	**-2.5**
Other Communications Equipment	**1,087**	**1,183**	**1,454**	**2,403**	**3,052**	**2,973**	**22.3**
Communications Total	**22,375**	**25,215**	**28,378**	**31,789**	**37,151**	**40,002**	**12.3**
Exchange Rate (Yen/U.S.$)	126.45	111.20	101.81	93.90	108.81	121.10	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-16
Japanese Electronic Equipment Production Forecast—Communications (Vendor Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Premise Telecommunications							
Telephones	2,213	2,902	2,678	2,669	2,733	2,757	4.5
Standard	99	77	58	55	50	47	-13.9
Multifunction	124	146	162	154	163	159	5.1
Cordless	1,808	2,482	2,235	2,243	2,266	2,282	4.8
Others	182	197	223	216	254	270	8.2
Applied Telephones	429	321	308	316	363	379	-2.5
Facsimiles	2,890	2,336	2,081	2,062	2,037	1,966	-7.4
PBX Telephone Systems	1,486	1,147	1,125	1,172	1,226	1,280	-3.0
Key Telephone Systems	809	758	763	779	779	809	0
Modems	413	352	344	325	306	291	-6.7
Total	**8,244**	**7,817**	**7,300**	**7,322**	**7,443**	**7,482**	**-1.9**
Public Telecommunications							
Carrier Transmission	6,804	7,269	7,739	8,286	8,595	9,327	6.5
Central Office Switches	4,624	4,080	4,221	4,526	4,802	5,064	1.8
Total	**11,431**	**11,349**	**11,960**	**12,813**	**13,397**	**14,391**	**4.7**
Mobile and Radio							
Radio Communications	14,946	12,876	12,972	13,914	14,441	14,737	-0.3
Radio Base Station Equipment	4,913	4,664	5,843	7,246	7,862	8,672	12.0
Mobile Radio Equipment	9,744	8,001	6,907	6,436	6,336	5,812	-9.8
Mobile Communications Equipment	289	211	222	232	242	253	-2.6
Applied Radio Equipment	1,718	1,491	1,387	1,403	1,300	1,238	-6.3
Total	**16,661**	**14,367**	**14,359**	**15,317**	**15,740**	**15,975**	**-0.8**
Broadcast and Studio	**694**	**694**	**850**	**1,041**	**964**	**1,056**	**8.8**
Other Communications Equipment	**2,973**	**2,999**	**3,199**	**3,754**	**3,877**	**4,116**	**6.7**
Communications Total	**40,002**	**37,231**	**37,671**	**40,245**	**41,424**	**43,020**	**1.5**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

Table 2-17
Japanese Electronic Equipment Production History—Communications (Yen-Based Annual Growth; Percent)

Equipment Type	1992	1993	1994	1995	1996	1997
Premise Telecommunications						
Telephones	-12.1	-8.3	-14.3	-11.4	12.9	6.3
Standard	19.2	-20.0	-29.4	-0.6	-40.8	16.5
Multifunction	-7.2	-20.1	2.3	-39.3	-2.4	-6.8
Cordless	-4.0	-2.2	-16.2	-4.2	17.5	5.8
Others	-53.5	-27.1	0	-43.2	36.8	20.9
Applied Telephones	-10.9	-9.2	11.3	25.6	4.6	9.0
Facsimiles	-6.3	-9.0	-12.1	-7.0	-0.2	20.9
PBX Telephone Systems	-9.5	-4.2	22.3	11.2	25.0	27.0
Key Telephone Systems	-0.2	8.6	2.2	-13.5	1.5	5.4
Modems	-42.3	33.0	17.1	17.5	26.1	-3.3
Total	**-9.5**	**-5.6**	**-6.2**	**-4.5**	**8.7**	**14.0**
Public Telecommunications						
Carrier Transmission	-11.9	14.8	1.9	17.6	32.5	9.5
Central Office Switches	-10.6	7.1	2.0	-7.0	20.3	43.7
Total	**-11.4**	**11.5**	**2.0**	**7.3**	**28.0**	**21.2**
Mobile and Radio						
Radio Communications	-7.8	-5.1	16.2	1.6	72.3	27.6
Radio Base Station Equipment	-1.8	-15.5	-3.1	18.9	73.4	26.3
Mobile Radio Equipment	-10.0	4.8	23.7	2.9	79.4	27.8
Mobile Communications Equipment	-17.2	-18.2	43.8	-54.6	-34.0	42.9
Applied Radio Equipment	9.8	2.6	-9.9	-17.0	8.9	13.7
Total	**-3.3**	**-3.1**	**10.9**	**1.6**	**61.5**	**26.0**
Broadcast and Studio	**0.6**	**-22.0**	**16.3**	**-22.8**	**32.1**	**-8.9**
Other Communications Equipment	**-28.3**	**-4.3**	**12.5**	**52.4**	**47.2**	**8.4**
Communications Total	**-9.0**	**-0.9**	**3.0**	**3.3**	**35.4**	**19.8**

Source: MITI, Dataquest (May 1998)

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Table 2-18
Japanese Electronic Equipment Production Forecast—Communications (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Premise Telecommunications						
Telephones	6.5	40.5	-7.7	-0.3	2.4	0.9
Standard	16.5	-16.7	-25.0	-4.0	-9.7	-6.2
Multifunction	-6.8	26.7	10.5	-4.8	5.5	-2.4
Cordless	5.8	47.0	-9.9	0.3	1.0	0.7
Others	20.9	15.9	13.3	-3.1	17.9	6.1
Applied Telephones	9.0	-19.8	-4.1	2.5	14.9	4.5
Facsimiles	20.9	-13.4	-10.9	-0.9	-1.2	-3.5
PBX Telephone Systems	27.0	-17.3	-1.9	4.1	4.6	4.4
Key Telephone Systems	5.4	0.4	0.6	2.0	0	4.0
Modems	-3.3	-8.6	-2.4	-5.4	-5.9	-4.8
Total	**14.0**	**1.6**	**-6.6**	**0.3**	**1.7**	**0.5**
Public Telecommunications						
Carrier Transmission	9.5	14.4	6.5	7.1	3.7	8.5
Central Office Switches	43.7	-5.5	3.5	7.2	6.1	5.5
Total	**21.2**	**6.4**	**5.4**	**7.1**	**4.6**	**7.4**
Mobile and Radio						
Radio Communications	27.6	-7.7	0.7	7.3	3.8	2.0
Radio Base Station Equipment	26.3	1.7	25.3	24.0	8.5	10.3
Mobile Radio Equipment	27.8	-12.0	-13.7	-6.8	-1.6	-8.3
Mobile Communications Equipment	42.9	-21.7	5.1	4.5	4.3	4.5
Applied Radio Equipment	13.7	-7.0	-6.9	1.1	-7.4	-4.7
Total	**26.0**	**-7.6**	**-0.1**	**6.7**	**2.8**	**1.5**
Broadcast and Studio	**-8.9**	**7.1**	**22.6**	**22.4**	**-7.4**	**9.6**
Other Communications Equipment	**8.4**	**8.1**	**6.7**	**17.3**	**3.3**	**6.2**
Communications Total	**19.8**	**-0.3**	**1.2**	**6.8**	**2.9**	**3.9**

Source: MITI, Dataquest (May 1998)

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Table 2-19
Japanese Electronic Equipment Production History—Industrial (Vendor Revenue in Billions of Yen)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Security/Energy Management							
Alarm Systems	144	132	129	126	113	98	-7.4
Energy Management	442	390	401	433	430	350	-4.6
Total	**586**	**522**	**530**	**559**	**542**	**448**	**-5.2**
Manufacturing Systems/Instrumentation							
NC Machines	657	491	451	595	726	801	4.0
Robotics	207	192	207	262	267	355	11.4
Ultrasonic Applied Equipment	15	20	19	29	26	29	14.9
Metering Units	42	39	42	45	46	48	2.6
Measuring Instruments	238	238	275	375	414	450	13.6
Industrial Meters	317	328	259	263	292	350	2.0
Others	182	174	180	167	186	217	3.6
Total	**1,657**	**1,483**	**1,434**	**1,736**	**1,958**	**2,250**	**6.3**
Medical Equipment							
X-Ray Systems	163	159	141	152	175	177	1.6
Measuring Systems	62	58	52	59	60	61	-0.4
Others	93	98	94	96	104	104	2.4
Total	**318**	**315**	**287**	**307**	**340**	**342**	**1.5**
Other Industrial Equipment							
Vending Machines	252	237	232	231	240	260	0.7
Automatic Service Equipment	31	30	26	20	13	12	-17.4
Commercial-Type Washing Machines	15	13	13	15	17	15	0.3
Electron Microscope	32	36	36	43	56	60	13.6
Ultrasonic Equipment	74	71	90	77	81	90	4.1
Others	226	241	301	354	402	431	13.8
Total	**629**	**629**	**698**	**741**	**808**	**868**	**6.7**
Industrial Total	**3,190**	**2,949**	**2,948**	**3,343**	**3,648**	**3,908**	**4.1**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-20
Japanese Electronic Equipment Production Forecast—Industrial (Vendor Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Security/Energy Management							
Alarm Systems	98	103	105	95	100	105	1.4
Energy Management	350	362	369	345	345	346	-0.2
Total	**448**	**465**	**474**	**440**	**445**	**451**	**0.1**
Manufacturing Systems/Instrumentation							
NC Machines	801	836	921	1,020	1,065	1,085	6.3
Robotics	355	358	357	392	386	402	2.5
Ultrasonic Applied Equipment	29	26	27	27	26	25	-2.9
Metering Units	48	47	48	49	50	52	1.5
Measuring Instruments	450	480	520	575	636	682	8.7
Industrial Meters	350	400	384	371	410	470	6.1
Others	217	226	230	239	239	275	4.9
Total	**2,250**	**2,373**	**2,487**	**2,673**	**2,811**	**2,990**	**5.9**
Medical Equipment							
X-Ray Systems	177	190	198	210	215	235	5.8
Measuring Systems	61	60	62	59	58	69	2.5
Others	104	102	105	118	129	136	5.5
Total	**342**	**352**	**365**	**387**	**402**	**440**	**5.2**
Other Industrial Equipment							
Vending Machines	260	280	290	267	263	274	1.1
Automatic Service Equipment	12	13	15	17	19	21	11.9
Commercial-Type Washing Machines	15	18	18	19	21	22	7.6
Electron Microscope	60	55	50	40	36	34	-10.7
Ultrasonic Equipment	90	114	120	128	152	177	14.5
Others	431	470	520	589	615	648	8.5
Total	**868**	**950**	**1,013**	**1,060**	**1,105**	**1,176**	**6.3**
Industrial Total	**3,908**	**4,140**	**4,339**	**4,560**	**4,763**	**5,057**	**5.3**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-21
Japanese Electronic Equipment Production History—Industrial (Vendor Revenue in Millions of Dollars)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Security/Energy Management							
Alarm Systems	1,139	1,187	1,271	1,341	1,034	809	-6.6
Energy Management	3,496	3,510	3,934	4,611	3,947	2,890	-3.7
Total	**4,636**	**4,697**	**5,205**	**5,952**	**4,982**	**3,699**	**-4.4**
Manufacturing Systems/Instrumentation							
NC Machines	5,199	4,418	4,434	6,337	6,673	6,614	4.9
Robotics	1,633	1,729	2,031	2,790	2,453	2,931	12.4
Ultrasonic Applied Equipment	115	176	183	309	241	239	15.9
Metering Units	334	351	411	478	425	396	3.5
Measuring Instruments	1,879	2,143	2,702	3,991	3,805	3,716	14.6
Industrial Meters	2,505	2,951	2,545	2,801	2,684	2,890	2.9
Others	1,439	1,567	1,772	1,782	1,708	1,792	4.5
Total	**13,106**	**13,337**	**14,080**	**18,491**	**17,993**	**18,580**	**7.2**
Medical Equipment							
X-Ray Systems	1,291	1,427	1,380	1,620	1,609	1,462	2.5
Measuring Systems	491	519	512	623	553	504	0.5
Others	732	883	921	1,021	958	859	3.3
Total	**2,515**	**2,831**	**2,814**	**3,265**	**3,122**	**2,827**	**2.4**
Other Industrial Equipment							
Vending Machines	1,990	2,132	2,281	2,464	2,201	2,147	1.5
Automatic Service Equipment	247	273	258	212	115	99	-16.7
Commercial-Type Washing Machines	117	116	123	160	158	124	1.1
Electron Microscope	251	319	355	460	514	495	14.6
Ultrasonic Equipment	582	640	885	824	747	743	5.0
Others	1,784	2,169	2,956	3,767	3,690	3,559	14.8
Total	**4,972**	**5,652**	**6,860**	**7,889**	**7,426**	**7,168**	**7.6**
Industrial Total	**25,229**	**26,517**	**28,959**	**35,597**	**33,523**	**32,274**	**5.0**
Exchange Rate (Yen/U.S.$)	126.45	111.20	101.81	93.90	108.81	121.10	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

Table 2-22
Japanese Electronic Equipment Production Forecast—Industrial (Vendor Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Security/Energy Management							
Alarm Systems	809	795	809	732	771	809	0
Energy Management	2,890	2,790	2,844	2,659	2,659	2,667	-1.6
Total	**3,699**	**3,584**	**3,654**	**3,392**	**3,430**	**3,476**	**-1.2**
Manufacturing Systems/Instrumentation							
NC Machines	6,614	6,444	7,099	7,862	8,209	8,364	4.8
Robotics	2,931	2,760	2,752	3,022	2,974	3,095	1.1
Ultrasonic Applied Equipment	239	200	208	208	200	193	-4.3
Metering Units	396	358	371	379	388	398	0.1
Measuring Instruments	3,716	3,700	4,008	4,432	4,902	5,256	7.2
Industrial Meters	2,890	3,083	2,960	2,860	3,157	3,623	4.6
Others	1,792	1,742	1,773	1,842	1,839	2,120	3.4
Total	**18,580**	**18,288**	**19,171**	**20,606**	**21,670**	**23,047**	**4.4**
Medical Equipment							
X-Ray Systems	1,462	1,465	1,526	1,619	1,657	1,811	4.4
Measuring Systems	504	462	478	455	447	532	1.1
Others	859	786	809	910	994	1,048	4.1
Total	**2,827**	**2,713**	**2,814**	**2,983**	**3,099**	**3,392**	**3.7**
Other Industrial Equipment							
Vending Machines	2,147	2,158	2,235	2,058	2,025	2,112	-0.3
Automatic Service Equipment	99	100	116	130	144	163	10.4
Commercial-Type Washing Machines	124	138	140	150	158	166	6.1
Electron Microscope	495	424	385	309	280	263	-11.9
Ultrasonic Equipment	743	879	925	988	1,171	1,367	13.0
Others	3,559	3,623	4,008	4,537	4,741	4,995	7.0
Total	**7,168**	**7,322**	**7,810**	**8,172**	**8,518**	**9,067**	**4.8**
Industrial Total	**32,274**	**31,912**	**33,446**	**35,150**	**36,715**	**38,981**	**3.8**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

Table 2-23
Japanese Electronic Equipment Production History—Industrial (Yen-Based Annual Growth; Percent)

Equipment Type	1992	1993	1994	1995	1996	1997
Security/Energy Management						
Alarm Systems	-4.5	-8.3	-2.0	-2.7	-10.6	-12.9
Energy Management	-12.8	-11.7	2.6	8.1	-0.8	-18.5
Total	**-10.9**	**-10.9**	**1.5**	**5.5**	**-3.0**	**-17.4**
Manufacturing Systems/Instrumentation						
NC Machines	-33.4	-25.3	-8.1	31.8	22.0	10.3
Robotics	-28.5	-6.9	7.5	26.7	1.9	33.0
Ultrasonic Applied Equipment	-19.9	35.2	-5.1	55.9	-9.7	10.7
Metering Units	-11.3	-7.6	7.2	7.4	2.9	3.9
Measuring Instruments	-30.1	0.3	15.4	36.2	10.5	8.7
Industrial Meters	-5.3	3.6	-21.0	1.5	11.0	19.9
Others	-7.8	-4.2	3.5	-7.3	11.1	16.7
Total	**-25.1**	**-10.5**	**-3.3**	**21.1**	**12.8**	**14.9**
Medical Equipment						
X-Ray Systems	2.0	-2.8	-11.5	8.3	15.1	1.1
Measuring Systems	6.0	-7.1	-9.7	12.3	2.9	1.3
Others	-13.8	6.2	-4.5	2.2	8.7	-0.2
Total	**-2.5**	**-1.0**	**-9.0**	**7.0**	**10.8**	**0.7**
Other Industrial Equipment						
Vending Machines	-10.4	-5.8	-2.1	-0.3	3.5	8.6
Automatic Service Equipment	5.8	-2.6	-13.5	-24.3	-37.2	-4.0
Commercial-Type Washing Machines	-6.3	-12.8	-3.1	20.0	14.7	-12.8
Electron Microscope	-10.7	12.0	1.7	19.7	29.4	7.3
Ultrasonic Equipment	-12.1	-3.3	26.5	-14.1	5.0	10.7
Others	-20.3	6.9	24.8	17.5	13.5	7.3
Total	**-13.7**	**0**	**11.1**	**6.1**	**9.1**	**7.4**
Industrial Total	**-18.7**	**-7.6**	**0**	**13.4**	**9.1**	**7.1**

Source: MITI, Dataquest (May 1998)

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Table 2-24
Japanese Electronic Equipment Production Forecast—Industrial (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Security/Energy Management						
Alarm Systems	-12.9	5.2	1.8	-9.5	5.3	5.0
Energy Management	-18.5	3.4	1.9	-6.5	0	0.3
Total	**-17.4**	**3.8**	**1.9**	**-7.2**	**1.1**	**1.3**
Manufacturing Systems/Instrumentation						
NC Machines	10.3	4.4	10.2	10.7	4.4	1.9
Robotics	33.0	0.8	-0.3	9.8	-1.6	4.1
Ultrasonic Applied Equipment	10.7	-10.3	3.8	0	-3.7	-3.8
Metering Units	3.9	-3.1	3.4	2.3	2.2	2.6
Measuring Instruments	8.7	6.7	8.3	10.6	10.6	7.2
Industrial Meters	19.9	14.3	-4.0	-3.4	10.4	14.8
Others	16.7	4.1	1.8	3.9	-0.2	15.3
Total	**14.9**	**5.4**	**4.8**	**7.5**	**5.2**	**6.4**
Medical Equipment						
X-Ray Systems	1.1	7.3	4.2	6.1	2.4	9.3
Measuring Systems	1.3	-1.6	3.3	-4.8	-1.7	19.0
Others	-0.2	-1.9	2.9	12.4	9.3	5.4
Total	**0.7**	**2.9**	**3.7**	**6.0**	**3.9**	**9.5**
Other Industrial Equipment						
Vending Machines	8.6	7.7	3.6	-7.9	-1.6	4.3
Automatic Service Equipment	-4.0	8.3	15.4	12.7	10.7	12.8
Commercial-Type Washing Machines	-12.8	19.3	1.7	6.6	5.7	5.4
Electron Microscope	7.3	-8.3	-9.1	-19.8	-9.5	-6.1
Ultrasonic Equipment	10.7	26.7	5.3	6.8	18.5	16.8
Others	7.3	9.0	10.6	13.2	4.5	5.4
Total	**7.4**	**9.4**	**6.7**	**4.6**	**4.2**	**6.4**
Industrial Total	**7.1**	**5.9**	**4.8**	**5.1**	**4.5**	**6.2**

Source: MITI, Dataquest (May 1998)

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Table 2-25
Japanese Electronic Equipment Production History—Consumer (Vendor Revenue in Billions of Yen)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Audio							
Audio Amplifiers	97	92	86	66	45	44	-14.6
DAD Players	210	187	210	207	210	230	1.9
Radios	27	26	21	21	8	7	-23.9
Stereos	171	132	112	72	48	67	-17.1
Tape Recorders	180	135	113	67	40	30	-30.1
Headphone Stereos	74	65	47	45	46	50	-7.6
Musical Instruments	153	121	118	110	105	108	-6.7
Other Audio Equipment	20	15	14	15	10	15	-5.9
Total	**932**	**774**	**722**	**602**	**512**	**551**	**-10.0**
Video							
VCRs	782	598	542	341	298	258	-19.9
Video Cameras	614	498	454	443	462	649	1.1
Video Disc Players	129	135	116	89	49	25	-28.0
Color TVs	811	749	699	612	583	590	-6.2
LCD TVs	35	28	29	32	31	33	-1.2
DVD Recorder	0	4	5	11	33	50	NM
Total	**2,371**	**2,008**	**1,840**	**1,528**	**1,455**	**1,605**	**-7.5**
Personal Electronics							
Cameras	283	228	202	183	191	195	-7.2
Clocks	82	68	55	48	43	41	-13.0
Electronic Toys	548	506	543	596	660	710	5.3
Watches	262	231	187	173	161	165	-8.9
Game Software	269	248	276	281	261	257	-0.9
Total	**1,445**	**1,280**	**1,263**	**1,281**	**1,316**	**1,368**	**-1.1**
Appliances							
Air Conditioners	896	702	785	936	943	850	-1.0
Microwave Ovens	139	129	113	110	107	105	-5.4
Refrigerators	440	441	496	493	497	450	0.4
Washers and Dryers	224	223	221	214	210	200	-2.3
Total	**1,699**	**1,495**	**1,615**	**1,753**	**1,758**	**1,605**	**-1.1**
Other Consumer Equipment	**940**	**920**	**927**	**970**	**978**	**969**	**0.6**
Consumer Total	**7,387**	**6,477**	**6,366**	**6,134**	**6,019**	**6,098**	**-3.8**

Note: Columns may not add to totals shown because of rounding.
NM = Not meaningful
Source: MITI, Dataquest (May 1998)

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Table 2-26
Japanese Electronic Equipment Production Forecast—Consumer (Vendor Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Audio							
Audio Amplifiers	44	41	37	34	31	29	-8.0
DAD Players	230	233	239	253	265	285	4.4
Radios	7	6	4	3	2	3	-18.6
Stereos	67	47	46	46	48	48	-6.5
Tape Recorders	30	29	26	22	17	16	-11.8
Headphone Stereos	50	53	55	55	55	62	4.2
Musical Instruments	108	118	124	129	137	152	7.1
Other Audio Equipment	15	11	11	8	9	7	-15.4
Total	**551**	**537**	**542**	**550**	**564**	**601**	**1.7**
Video							
VCRs	258	252	235	223	152	117	-14.7
Video Cameras	649	697	538	442	350	194	-21.5
Video Disc Players	25	20	18	15	10	10	-16.7
Color TVs	590	620	632	612	608	605	0.5
LCD TVs	33	32	34	36	38	41	4.3
DVD Recorder	50	80	232	279	350	435	54.1
Total	**1,605**	**1,701**	**1,689**	**1,607**	**1,508**	**1,402**	**-2.7**
Personal Electronics							
Cameras	195	198	217	220	243	270	6.7
Clocks	41	39	36	33	32	31	-5.4
Electronic Toys	710	721	730	800	850	1,064	8.4
Watches	165	148	142	138	135	136	-3.8
Game Software	257	178	77	60	60	60	-25.2
Total	**1,368**	**1,283**	**1,201**	**1,251**	**1,320**	**1,561**	**2.7**
Appliances							
Air Conditioners	850	883	900	950	981	1,022	3.8
Microwave Ovens	105	95	105	111	112	115	1.8
Refrigerators	450	430	440	550	580	650	7.6
Washers and Dryers	200	150	182	192	202	226	2.4
Total	**1,605**	**1,558**	**1,627**	**1,803**	**1,875**	**2,013**	**4.6**
Other Consumer Equipment	**969**	**1,031**	**1,001**	**1,070**	**1,078**	**1,125**	**3.0**
Consumer Total	**6,098**	**6,110**	**6,060**	**6,281**	**6,346**	**6,702**	**1.9**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-27
Japanese Electronic Equipment Production History—Consumer (Vendor Revenue in Millions of Dollars)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Audio							
Audio Amplifiers	767	828	849	700	414	363	-13.9
DAD Players	1,659	1,682	2,067	2,200	1,930	1,899	2.7
Radios	217	234	204	227	74	58	-23.2
Stereos	1,351	1,189	1,097	761	440	553	-16.3
Tape Recorders	1,420	1,210	1,111	714	368	248	-29.5
Headphone Stereos	588	587	461	480	423	413	-6.8
Musical Instruments	1,208	1,092	1,158	1,171	965	892	-5.9
Other Audio Equipment	161	133	138	155	92	124	-5.1
Total	**7,373**	**6,959**	**7,087**	**6,409**	**4,702**	**4,549**	**-9.2**
Video							
VCRs	6,183	5,379	5,320	3,628	2,736	2,130	-19.2
Video Cameras	4,853	4,482	4,457	4,720	4,242	5,359	2.0
Video Disc Players	1,023	1,212	1,138	946	453	206	-27.4
Color TVs	6,415	6,737	6,870	6,514	5,354	4,872	-5.4
LCD TVs	278	247	285	339	286	273	-0.4
DVD Recorder	0	35	47	117	299	413	NM
Total	**18,754**	**18,060**	**18,072**	**16,270**	**13,377**	**13,255**	**-6.7**
Personal Electronics							
Cameras	2,240	2,047	1,984	1,947	1,755	1,610	-6.4
Clocks	650	612	544	513	396	339	-12.2
Electronic Toys	4,330	4,548	5,330	6,350	6,061	5,863	6.3
Watches	2,074	2,074	1,832	1,845	1,482	1,363	-8.1
Game Software	2,130	2,234	2,713	2,990	2,397	2,122	-0.1
Total	**11,426**	**11,514**	**12,403**	**13,647**	**12,097**	**11,293**	**-0.2**
Appliances							
Air Conditioners	7,083	6,310	7,712	9,967	8,669	7,019	-0.2
Microwave Ovens	1,096	1,156	1,106	1,175	987	867	-4.6
Refrigerators	3,481	3,967	4,875	5,249	4,569	3,716	1.3
Washers and Dryers	1,775	2,009	2,169	2,278	1,927	1,652	-1.4
Total	**13,437**	**13,444**	**15,863**	**18,670**	**16,156**	**13,254**	**-0.3**
Other Consumer Equipment	**7,431**	**8,271**	**9,101**	**10,332**	**8,984**	**8,002**	**1.5**
Consumer Total	**58,420**	**58,248**	**62,526**	**65,328**	**55,315**	**50,352**	**-2.9**
Exchange Rate (Yen/U.S.$)	126.45	111.20	101.81	93.90	108.81	121.10	-

Note: Columns may not add to totals shown because of rounding.
NM = Not meaningful
Source: MITI, Dataquest (May 1998)

Table 2-28
Japanese Electronic Equipment Production Forecast—Consumer (Vendor Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Audio							
Audio Amplifiers	363	316	285	262	239	224	-9.3
DAD Players	1,899	1,796	1,842	1,950	2,043	2,197	3.0
Radios	58	43	33	24	15	19	-19.7
Stereos	553	362	355	355	370	370	-7.7
Tape Recorders	248	224	200	166	131	123	-13.0
Headphone Stereos	413	409	424	424	424	474	2.8
Musical Instruments	892	908	954	997	1,057	1,172	5.6
Other Audio Equipment	124	83	85	62	69	50	-16.6
Total	**4,549**	**4,142**	**4,178**	**4,243**	**4,351**	**4,634**	**0.4**
Video							
VCRs	2,130	1,944	1,811	1,719	1,172	901	-15.8
Video Cameras	5,359	5,373	4,147	3,407	2,698	1,495	-22.5
Video Disc Players	206	154	139	116	77	77	-17.9
Color TVs	4,872	4,779	4,873	4,717	4,687	4,664	-0.9
LCD TVs	273	244	264	278	291	314	2.9
DVD Recorder	413	617	1,788	2,151	2,698	3,353	52.0
Total	**13,255**	**13,110**	**13,022**	**12,387**	**11,626**	**10,804**	**-4.0**
Personal Electronics							
Cameras	1,610	1,527	1,669	1,696	1,873	2,081	5.3
Clocks	339	297	274	257	245	239	-6.7
Electronic Toys	5,863	5,555	5,627	6,167	6,552	8,202	6.9
Watches	1,363	1,142	1,095	1,062	1,043	1,047	-5.1
Game Software	2,122	1,372	594	462	462	462	-26.3
Total	**11,293**	**9,892**	**9,258**	**9,644**	**10,176**	**12,035**	**1.3**
Appliances							
Air Conditioners	7,019	6,806	6,937	7,323	7,562	7,878	2.3
Microwave Ovens	867	732	809	855	864	886	0.4
Refrigerators	3,716	3,315	3,392	4,240	4,471	5,010	6.2
Washers and Dryers	1,652	1,156	1,403	1,480	1,557	1,740	1.0
Total	**13,254**	**12,010**	**12,541**	**13,898**	**14,453**	**15,517**	**3.2**
Other Consumer Equipment	**8,002**	**7,943**	**7,716**	**8,249**	**8,310**	**8,672**	**1.6**
Consumer Total	**50,352**	**47,098**	**46,711**	**48,420**	**48,915**	**51,661**	**0.5**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-29
Japanese Electronic Equipment Production History—Consumer (Yen-Based Annual Growth; Percent)

Equipment Type	1992	1993	1994	1995	1996	1997
Audio						
Audio Amplifiers	-15.6	-5.1	-6.2	-24.0	-31.5	-2.2
DAD Players	0.2	-10.9	12.5	-1.8	1.6	9.5
Radios	-24.5	-5.1	-20.0	2.4	-62.0	-13.6
Stereos	-21.9	-22.6	-15.5	-36.0	-33.0	39.9
Tape Recorders	-23.4	-25.1	-16.0	-40.8	-40.3	-25.0
Headphone Stereos	-27.6	-12.1	-28.2	-3.8	2.0	8.7
Musical Instruments	-13.1	-20.5	-2.9	-6.7	-4.5	2.9
Other Audio Equipment	-37.2	-27.1	-5.4	4.3	-31.5	50.0
Total	**-17.1**	**-17.0**	**-6.8**	**-16.6**	**-14.9**	**7.6**
Video						
VCRs	-24.8	-23.5	-9.5	-37.1	-12.6	-13.3
Video Cameras	-33.5	-18.8	-8.9	-2.3	4.2	40.6
Video Disc Players	-5.5	4.2	-14.0	-23.4	-44.5	-49.3
Color TVs	-10.9	-7.6	-6.6	-12.5	-4.8	1.3
LCD TVs	-0.6	-21.7	5.5	9.7	-2.2	6.1
DVD Recorder	NM	NM	23.1	129.2	195.5	53.8
Total	**-22.1**	**-15.3**	**-8.4**	**-17.0**	**-4.7**	**10.3**
Personal Electronics						
Cameras	-17.7	-19.6	-11.2	-9.5	4.5	2.1
Clocks	-10.7	-17.3	-18.5	-13.0	-10.6	-4.9
Electronic Toys	7.8	-7.6	7.3	9.9	10.6	7.7
Watches	-17.2	-12.1	-19.1	-7.1	-6.9	2.3
Game Software	10.4	-7.8	11.2	1.7	-7.1	-1.5
Total	**-4.0**	**-11.4**	**-1.4**	**1.5**	**2.7**	**4.0**
Appliances						
Air Conditioners	-19.2	-21.7	11.9	19.2	0.8	-9.9
Microwave Ovens	-7.8	-7.2	-12.4	-2.0	-2.6	-2.2
Refrigerators	-9.2	0.2	12.5	-0.7	0.9	-9.5
Washers and Dryers	-3.4	-0.4	-1.2	-3.1	-2.0	-4.6
Total	**-14.0**	**-12.0**	**8.0**	**8.6**	**0.3**	**-8.7**
Other Consumer Equipment	**-10.3**	**-2.1**	**0.8**	**4.7**	**0.8**	**-0.9**
Consumer Total	**-15.1**	**-12.3**	**-1.7**	**-3.6**	**-1.9**	**1.3**

NM = Not meaningful
Source: MITI, Dataquest (May 1998)

Table 2-30
Japanese Electronic Equipment Production Forecast—Consumer (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Audio						
Audio Amplifiers	-2.2	-6.8	-9.8	-8.1	-8.8	-6.5
DAD Players	9.5	1.3	2.6	5.9	4.7	7.5
Radios	-13.6	-20.0	-23.2	-27.9	-35.5	25.0
Stereos	39.9	-29.9	-2.1	0	4.3	0
Tape Recorders	-25.0	-3.3	-10.3	-16.9	-21.3	-5.9
Headphone Stereos	8.7	6.0	3.8	0	0.0	11.8
Musical Instruments	2.9	9.1	5.0	4.5	6.0	10.9
Other Audio Equipment	50.0	-28.0	1.9	-26.4	11.1	-27.8
Total	**7.6**	**-2.5**	**0.9**	**1.5**	**2.5**	**6.5**
Video						
VCRs	-13.3	-2.3	-6.8	-5.1	-31.8	-23.1
Video Cameras	40.6	7.4	-22.8	-17.8	-20.8	-44.6
Video Disc Players	-49.3	-20.0	-10.0	-16.7	-33.3	0
Color TVs	1.3	5.1	2.0	-3.2	-0.7	-0.5
LCD TVs	6.1	-3.9	8.2	5.2	4.7	7.9
DVD Recorder	53.8	60.0	190.0	20.3	25.4	24.3
Total	**10.3**	**6.0**	**-0.7**	**-4.9**	**-6.2**	**-7.0**
Personal Electronics						
Cameras	2.1	1.6	9.3	1.6	10.5	11.1
Clocks	-4.9	-6.1	-7.8	-6.2	-4.5	-2.5
Electronic Toys	7.7	1.5	1.3	9.6	6.3	25.2
Watches	2.3	-10.2	-4.1	-3.0	-1.8	0.4
Game Software	-1.5	-30.7	-56.7	-22.1	0	0.0
Total	**4.0**	**-6.2**	**-6.4**	**4.2**	**5.5**	**18.2**
Appliances						
Air Conditioners	-9.9	3.9	1.9	5.6	3.3	4.2
Microwave Ovens	-2.2	-9.5	10.5	5.6	1.1	2.6
Refrigerators	-9.5	-4.4	2.3	25.0	5.5	12.1
Washers and Dryers	-4.6	-25.0	21.3	5.5	5.2	11.7
Total	**-8.7**	**-2.9**	**4.4**	**10.8**	**4.0**	**7.3**
Other Consumer Equipment	**-0.9**	**6.4**	**-2.9**	6.9	**0.7**	**4.4**
Consumer Total	**1.3**	**0.2**	**-0.8**	**3.6**	**1.0**	**5.6**

Source: MITI, Dataquest (May 1998)

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Table 2-31
Japanese Electronic Equipment Production History—Military/Civil Aerospace (Vendor Revenue in Billions of Yen)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Military/Civil Aerospace	212	207	203	200	197	195	-1.6

Source: Dataquest (May 1998)

Table 2-32
Japanese Electronic Equipment Production Forecast—Military/Civil Aerospace (Vendor Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Military/Civil Aerospace	195	192	190	187	185	183	-1.3

Source: Dataquest (May 1998)

Table 2-33
Japanese Electronic Equipment Production History—Military/Civil Aerospace (Vendor Revenue in Millions of Dollars)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Military/Civil Aerospace	1,675	1,865	1,992	2,126	1,814	1,610	-0.8
Exchange Rate (Yen/U.S.$)	126.45	111.20	101.81	93.90	108.81	121.10	-

Source: Dataquest (May 1998)

Table 2-34
Japanese Electronic Equipment Production Forecast—Military/Civil Aerospace (Vendor Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Military/Civil Aerospace	1,610	1,480	1,465	1,441	1,426	1,411	-2.6
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73	-

Source: Dataquest (May 1998)

Table 2-35
Japanese Electronic Equipment Production History—Military/Civil Aerospace (Yen-Based Annual Growth; Percent)

Equipment Type	1992	1993	1994	1995	1996	1997
Military/Civil Aerospace	-2.1	-2.1	-2.2	-1.6	-1.1	-1.2

Source: Dataquest (May 1998)

Table 2-36
Japanese Electronic Equipment Production Forecast—Military/Civil Aerospace (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Military/Civil Aerospace	-1.2	-1.5	-1.0	-1.6	-1.1	-1.1

Source: Dataquest (May 1998)

Table 2-37
Japanese Electronic Equipment Production History—Transportation (Vendor Revenue in Billions of Yen)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Entertainment	370	363	346	339	339	340	-1.7
Control Units	357	339	322	341	351	353	-0.2
Driver Information Systems	18	17	22	43	74	80	35.5
Safety and Convenience	586	561	534	518	520	517	-2.5
Transportation Total	**1,330**	**1,281**	**1,224**	**1,240**	**1,283**	**1,290**	**-0.6**

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1998)

Table 2-38
Japanese Electronic Equipment Production Forecast—Transportation (Vendor Revenue in Billions of Yen)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Entertainment	340	335	325	320	306	302	-2.3
Control Units	353	384	398	409	415	416	3.3
Driver Information Systems	80	115	140	145	152	160	14.9
Safety and Convenience	517	560	592	611	615	615	3.5
Transportation Total	**1,290**	**1,394**	**1,455**	**1,486**	**1,488**	**1,493**	**3.0**

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

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Table 2-39
Japanese Electronic Equipment Production History—Transportation (Vendor Revenue in Millions of Dollars)

Equipment Type	1992	1993	1994	1995	1996	1997	CAGR (%) 1992-1997
Entertainment	2,925	3,268	3,396	3,607	3,112	2,808	-0.8
Control Units	2,820	3,051	3,162	3,630	3,223	2,915	0.7
Driver Information Systems	138	153	220	454	681	661	36.7
Safety and Convenience	4,630	5,046	5,240	5,512	4,777	4,269	-1.6
Transportation Total	**10,516**	**11,519**	**12,018**	**13,204**	**11,795**	**10,653**	**0.3**
Exchange Rate (Yen/U.S.$)	126.45	111.20	101.81	93.90	108.81	121.10	-

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (May 1998)

Table 2-40
Japanese Electronic Equipment Production Forecast—Transportation (Vendor Revenue in Millions of Dollars)

Equipment Type	1997	1998	1999	2000	2001	2002	CAGR (%) 1997-2002
Entertainment	2,808	2,582	2,505	2,469	2,359	2,328	-3.7
Control Units	2,915	2,960	3,068	3,154	3,199	3,207	1.9
Driver Information Systems	661	886	1,079	1,118	1,172	1,233	13.3
Safety and Convenience	4,269	4,317	4,563	4,710	4,741	4,741	2.1
Transportation Total	**10,653**	**10,745**	**11,217**	**11,456**	**11,468**	**11,507**	**1.6**
Exchange Rate (Yen/U.S.$)	121.10	129.73	129.73	129.73	129.73	129.73	-

Note: Columns may not add to totals shown because of rounding.
Source: MITI, Dataquest (May 1998)

Table 2-41
Japanese Electronic Equipment Production History—Transportation (Yen-Based Annual Growth; Percent)

Equipment Type	1992	1993	1994	1995	1996	1997
Entertainment	-7.0	-1.8	-4.9	-2.0	0	0.4
Control Units	2.8	-4.9	-5.1	5.9	2.9	0.7
Driver Information Systems	47.1	-2.9	31.8	90.2	73.9	8.0
Safety and Convenience	-4.0	-4.2	-4.9	-3.0	0.4	-0.5
Transportation Total	**-2.7**	**-3.7**	**-4.5**	**1.3**	**3.5**	**0.5**

Source: MITI, Dataquest (May 1998)

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Table 2-42
Japanese Electronic Equipment Production Forecast—Transportation (Yen-Based Annual Growth; Percent)

Equipment Type	1997	1998	1999	2000	2001	2002
Entertainment	0.4	-1.5	-3.0	-1.4	-4.5	-1.3
Control Units	0.7	8.8	3.6	2.8	1.4	0.2
Driver Information Systems	8.0	43.8	21.7	3.6	4.8	5.3
Safety and Convenience	-0.5	8.3	5.7	3.2	0.7	0
Transportation Total	**0.5**	**8.1**	**4.4**	**2.1**	**0.2**	**0.3**

Source: MITI, Dataquest (May 1998)

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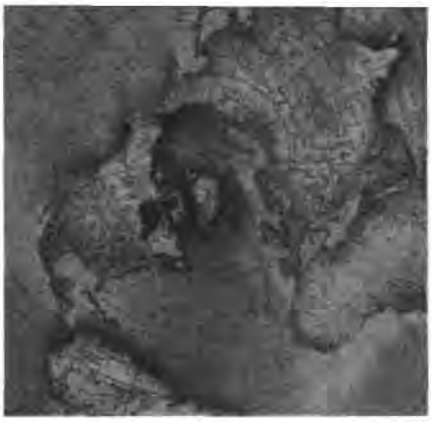

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Final 1997 Japanese Semiconductor Market Share

Market Statistics

Program: Semiconductors Japan
Product Code: SEMI-JA-MS-9801
Publication Date: May 4, 1998
Filing: Market Statistics

Final 1997 Japanese Semiconductor Market Share

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Chapter 1
Final 1997 Japanese Semiconductor Market Share

Introduction

This document contains detailed information on Dataquest's view of the semiconductor market. Included in this document are the following:

- 1995-1997 market share estimates
- 1996-1997 market share rankings

Worldwide market share estimates combine data from many countries, each of which has a different and fluctuating exchange rate. Estimates of non-U.S. market consumption or revenue are based on the average exchange rate for the given year. Refer to the section titled "Exchange Rates" for more information regarding these average rates. As a rule, Dataquest's estimates are calculated in local currencies and then converted to U.S. dollars.

More detailed data on this market may be requested through Dataquest's client inquiry service. Qualitative analysis of this data is provided in the Dataquest Perspectives.

Segmentation and Definitions

A detailed explanation of device segmentation and related definitions is contained in the Semiconductor Market Definitions Guide (SCND-WW-GU-9801).

Market Share Methodology

Dataquest uses both primary and secondary sources to produce market statistics data. In the fourth quarter of each year, Dataquest surveys all major participants within each industry. Selected companies are resurveyed during the first quarter of the following year to verify final annual results. This primary research is supplemented with additional primary research and secondary research to verify market size, shipment totals, and pricing information. Sources of data used by Dataquest include the following:

- Information published by major industry participants
- Estimates made by knowledgeable and reliable industry spokespersons
- Government data or trade association data (such as WSTS, MITI, and U.S. DOC)
- Published product literature and price lists
- Interviews with knowledgeable manufacturers, distributors, and users
- Relevant economic data
- Information and data from online and CD-ROM data banks
- Articles in both the general and trade press

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- Reports from financial analysts
- End-user surveys

Dataquest believes that the estimates presented in this document are the most accurate and meaningful statistics available.

Despite the care taken in gathering, analyzing, and categorizing the data in a meaningful way, careful attention must be paid to the definitions and assumptions used herein when interpreting the estimates presented in this document. Various companies, government agencies, and trade associations may use slightly different definitions of product categories and regional groupings, or they may include different companies in their summaries. These differences should be kept in mind when making comparisons between data and numbers provided by Dataquest and those provided by other sources.

Notes on Market Share

In the process of conducting data collection and preparing market statistics information, Dataquest will sometimes consolidate or revise a particular company, model, series, or industry's numbers. In this section, we explain any such changes contained within this document for your reference.

Notes to Market Share Tables

1. Cyrix was acquired by National Semiconductor in 1997.

2. National Semiconductor divested itself of Fairchild in 1997.

3. National Semiconductor's 1997 revenue includes all of Cyrix's 1997 revenue and part of Fairchild's calendar first quarter revenue.

4. Power Innovations was formed through the acquisition of the Power Semiconductor interests of Texas Instruments.

5. Melexis was formerly known as Elex.

6. Micronas acquired ITT in 1997.

7. The following companies were added to the market share database in 1997:

- Fairchild
- Vitesse
- TriQuint
- Power Innovations
- Robert Bosch
- Stanley

8. Toko is now tracked in other Japanese companies.

9. IBM's 1996 revenue was restated in 1997.

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Exchange Rates

Dataquest uses an average annual exchange rate in converting revenue to U.S. dollar amounts. Table 1-1 outlines these rates for 1995 through 1997.

Table 1-1
Exchange Rates

	1995	1996	1997
Japan (Yen/U.S.$)	93.90	108.81	121.10
France (Franc/U.S.$)	4.97	5.12	5.84
Germany (Deutsche Mark/U.S.$)	1.43	1.50	1.73
United Kingdom (U.S.$/Pound Sterling)	1.59	1.56	1.64

Source: Dataquest (April 1998)

Project Analyst: Kevin McClure

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Chapter 2
Market Share Tables

Tables 2-1 through 2-10 show each company's vendor revenue by technology category. Tables 2-11 through 2-20 show the top companies' vendor revenue by technology category.

Table 2-1
Each Company's Vendor Revenue from Shipments of Total Semiconductors to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**42,073**	**38,413**	**36,499**	**100.0**	**100.0**	**100.0**
Americas Companies	**7,571**	**7,767**	**7,844**	**18.0**	**20.2**	**21.5**
ACC Microelectronics	1	1	1	0	0	0
Actel	12	15	14	0	0	0
Adaptec	18	55	57	0	0.1	0.2
Advanced Micro Devices	189	177	160	0.4	0.5	0.4
Allegro MicroSystems	26	36	31	0	0	0
Alliance Semiconductor	6	2	6	0	0	0
Altera	80	95	114	0.2	0.2	0.3
Analog Devices	170	161	194	0.4	0.4	0.5
ATI Technologies	0	10	20	0	0	0
Atmel	89	209	108	0.2	0.5	0.3
Burr-Brown	56	66	50	0.1	0.2	0.1
C-Cube	0	16	16	0	0	0
Catalyst	7	7	11	0	0	0
Chip Express	0	1	1	0	0	0
Chips & Technologies	53	55	90	0.1	0.1	0.2
Cirrus Logic	158	133	117	0.4	0.3	0.3
Cypress Semiconductor	38	38	49	0	0	0.1
Dallas Semiconductor	20	24	25	0	0	0
Digital	0	30	41	0	0	0.1
DSP Group	13	13	13	0	0	0
Elantec	4	8	13	0	0	0
ESS	0	0	15	0	0	0
Exar	25	13	13	0	0	0
Fairchild	0	0	55	0	0	0.2
General Semiconductor	37	30	29	0	0	0
Gennum	4	4	4	0	0	0
Gould AMI	2	2	3	0	0	0
Harris Semiconductor	37	22	22	0	0	0
Hewlett-Packard	31	66	65	0	0.2	0.2
Honeywell	1	1	1	0	0	0

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Table 2-1 (Continued)
Each Company's Vendor Revenue from Shipments of Total Semiconductors to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
IBM	539	142	132	1.3	0.4	0.4
IMP	2	0	0	0	0	0
Integrated Circuit Systems	10	11	12	0	0	0
Integrated Device Technology	58	73	58	0.1	0.2	0.2
Integrated Silicon Solution	6	4	0	0	0	0
Intel	1,351	2,028	2,237	3.2	5.3	6.1
International CMOS Technology	1	1	0	0	0	0
International Rectifier	61	61	56	0.1	0.2	0.2
ISD	0	0	9	0	0	0
Lattice	18	40	40	0	0.1	0.1
Level One Communications	0	4	4	0	0	0
Linear Technology	32	40	42	0	0.1	0.1
Linfinity	1	1	1	0	0	0
Logic Devices	1	1	1	0	0	0
LSI Logic	250	275	367	0.6	0.7	1.0
Lucent Technologies	60	136	186	0.1	0.4	0.5
Maxim	29	59	65	0	0.2	0.2
Micrel	3	5	0	0	0	0
Micro Linear	1	1	1	0	0	0
Microchip Technology	31	31	12	0	0	0
Micron Technology	56	32	15	0.1	0	0
Microsemi	1	1	1	0	0	0
Mitel	6	14	10	0	0	0
Motorola	919	668	621	2.2	1.7	1.7
National Semiconductor	231	254	227	0.5	0.7	0.6
Oak Technology	35	85	69	0	0.2	0.2
OPTi	5	6	8	0	0	0
PMC Sierra Semiconductor	5	5	5	0	0	0
Powerex	18	18	16	0	0	0
Q Logic	23	24	25	0	0	0
Quality Semiconductor	0	5	5	0	0	0
QuickLogic	0	0	10	0	0	0
Ramtron	4	0	0	0	0	0
Raytheon	13	13	13	0	0	0
Rockwell	298	446	348	0.7	1.2	1.0
S3	5	8	2	0	0	0
Seeq Technology	0	1	1	0	0	0
Semtech	1	1	10	0	0	0

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Table 2-1 (Continued)
Each Company's Vendor Revenue from Shipments of Total Semiconductors to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Silicon Storage Technology	0	18	17	0	0	0
Standard Microsystems	5	5	5	0	0	0
Sun Microsystems	0	20	75	0	0	0.2
Supertex	10	9	9	0	0	0
Symbios	13	11	26	0	0	0
Teccor Electronics	2	2	4	0	0	0
TelCom	3	3	5	0	0	0
Texas Instruments	1,992	1,634	1,549	4.7	4.3	4.2
Trident Microsystems	23	45	30	0	0.1	0
Unitrode	2	4	4	0	0	0
Vitesse	0	0	11	0	0	0
VLSI Technology	39	70	46	0	0.2	0.1
VTC	19	25	10	0	0	0
WaferScale Integration	8	11	6	0	0	0
Xicor	23	22	27	0	0	0
Xilinx	52	55	61	0.1	0.1	0.2
Zilog	19	22	7	0	0	0
Zoran	0	5	5	0	0	0
Japanese Companies	**31,804**	**28,575**	**26,855**	**75.6**	**74.4**	**73.6**
Fuji Electric	374	320	259	0.9	0.8	0.7
Fujitsu	3,091	2,645	2,768	7.3	6.9	7.6
Hitachi	4,390	4,252	3,355	10.4	11.1	9.2
Matsushita	2,582	2,268	2,244	6.1	5.9	6.1
Mitsubishi	2,540	2,147	2,030	6.0	5.6	5.6
NEC	5,584	5,756	5,666	13.3	15.0	15.5
New JRC	154	120	127	0.4	0.3	0.3
Nippon Steel Semiconductor	206	36	15	0.5	0	0
Oki	753	579	563	1.8	1.5	1.5
Ricoh	187	136	141	0.4	0.4	0.4
Rohm	1,188	1,049	968	2.8	2.7	2.7
Sanken	449	352	302	1.1	0.9	0.8
SANYO	1,352	1,249	1,292	3.2	3.3	3.5
Seiko Epson	194	158	113	0.5	0.4	0.3
Sharp	1,820	1,561	1,491	4.3	4.1	4.1
Shindengen Electric	212	173	157	0.5	0.5	0.4
Sony	1,589	1,386	1,369	3.8	3.6	3.8
Stanley	129	0	128	0.3	0	0.4
Toshiba	4,518	3,838	3,484	10.7	10	9.5

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Table 2-1 (Continued)
Each Company's Vendor Revenue from Shipments of Total Semiconductors to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Yamaha	235	189	153	0.6	0.5	0.4
Other Japanese Companies	192	307	230	0.5	0.8	0.6
European Companies	**412**	**507**	**550**	**1.0**	**1.3**	**1.5**
Austria Mikro Systeme	1	0	0	0	0	0
Ericsson	1	1	3	0	0	0
Eupec	0	2	0	0	0	0
GEC Plessey	24	20	21	0	0	0
Micronas	1	1	13	0	0	0
Philips	142	172	182	0.3	0.4	0.5
SGS-Thomson	157	228	215	0.4	0.6	0.6
Siemens	44	41	57	0.1	0.1	0.2
TEMIC	38	39	55	0	0.1	0.2
Zetex	0	1	2	0	0	0
Other European Companies	2	2	2	0	0	0
Asia/Pacific Companies	**2,286**	**1,564**	**1,250**	**5.4**	**4.1**	**3.4**
Acer	0	5	5	0	0	0
Holtek	0	0	2	0	0	0
Hualon Microelectronics Corp.	0	2	2	0	0	0
Hyundai	345	244	212	0.8	0.6	0.6
Korean Electronic Co.	18	19	37	0	0	0.1
LG Semicon	395	243	175	0.9	0.6	0.5
Macronix	110	147	190	0.3	0.4	0.5
Mosel Vitelic	112	41	24	0.3	0.1	0
Samsung	1,276	819	589	3.0	2.1	1.6
Silicon Integrated Systems	0	1	0	0	0	0
United Microelectronics	26	27	4	0	0	0
Vanguard	0	7	3	0	0	0
VIA	0	1	0	0	0	0
Winbond Electronics	4	8	7	0	0	0

Source: Dataquest (April 1998)

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Table 2-2
Each Company's Vendor Revenue from Shipments of Total ICs to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**34,611**	**31,367**	**29,530**	**100.0**	**100.0**	**100.0**
Americas Companies	**7,299**	**7,468**	**7,557**	**21.1**	**23.8**	**25.6**
ACC Microelectronics	1	1	1	0	0	0
Actel	12	15	14	0	0	0
Adaptec	18	55	57	0	0.2	0.2
Advanced Micro Devices	189	177	160	0.5	0.6	0.5
Allegro MicroSystems	26	36	31	0	0.1	0.1
Alliance Semiconductor	6	2	6	0	0	0
Altera	80	95	114	0.2	0.3	0.4
Analog Devices	170	161	194	0.5	0.5	0.7
ATI Technologies	0	10	20	0	0	0
Atmel	89	209	108	0.3	0.7	0.4
Burr-Brown	56	66	50	0.2	0.2	0.2
C-Cube	0	16	16	0	0	0
Catalyst	7	7	11	0	0	0
Chip Express	0	1	1	0	0	0
Chips & Technologies	53	55	90	0.2	0.2	0.3
Cirrus Logic	158	133	117	0.5	0.4	0.4
Cypress Semiconductor	38	38	49	0.1	0.1	0.2
Dallas Semiconductor	20	24	25	0	0	0
Digital	0	30	41	0	0	0.1
DSP Group	13	13	13	0	0	0
Elantec	4	8	13	0	0	0
ESS	0	0	15	0	0	0
Exar	25	13	13	0	0	0
Fairchild	0	0	44	0	0	0.1
Gennum	4	4	4	0	0	0
Gould AMI	2	2	3	0	0	0
Harris Semiconductor	37	22	21	0.1	0	0
Hewlett-Packard	6	8	9	0	0	0
Honeywell	1	1	1	0	0	0
IBM	539	142	132	1.6	0.5	0.4
IMP	2	0	0	0	0	0
Integrated Circuit Systems	10	11	12	0	0	0
Integrated Device Technology	58	73	58	0.2	0.2	0.2
Integrated Silicon Solution	6	4	0	0	0	0
Intel	1,351	2,028	2,237	3.9	6.5	7.6
International CMOS Technology	1	1	0	0	0	0

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Table 2-2 (Continued)
Each Company's Vendor Revenue from Shipments of Total ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
International Rectifier	7	10	13	0	0	0
ISD	0	0	9	0	0	0
Lattice	18	40	40	0	0.1	0.1
Level One Communications	0	4	4	0	0	0
Linear Technology	32	40	42	0	0.1	0.1
Linfinity	1	1	1	0	0	0
Logic Devices	1	1	1	0	0	0
LSI Logic	250	275	367	0.7	0.9	1.2
Lucent Technologies	55	130	184	0.2	0.4	0.6
Maxim	29	59	65	0	0.2	0.2
Micrel	3	5	0	0	0	0
Micro Linear	1	1	1	0	0	0
Microchip Technology	31	31	12	0	0	0
Micron Technology	56	32	15	0.2	0.1	0
Mitel	6	7	8	0	0	0
Motorola	851	594	556	2.5	1.9	1.9
National Semiconductor	230	246	215	0.7	0.8	0.7
Oak Technology	35	85	69	0.1	0.3	0.2
OPTi	5	6	8	0	0	0
PMC Sierra Semiconductor	5	5	5	0	0	0
Q Logic	23	24	25	0	0	0
Quality Semiconductor	0	5	5	0	0	0
QuickLogic	0	0	10	0	0	0
Ramtron	4	0	0	0	0	0
Raytheon	13	13	13	0	0	0
Rockwell	298	446	348	0.9	1.4	1.2
S3	5	8	2	0	0	0
Seeq Technology	0	1	1	0	0	0
Semtech	1	1	10	0	0	0
Silicon Storage Technology	0	18	17	0	0	0
Standard Microsystems	5	5	5	0	0	0
Sun Microsystems	0	20	75	0	0	0.3
Supertex	8	7	7	0	0	0
Symbios	13	11	26	0	0	0
TelCom	3	3	5	0	0	0
Texas Instruments	1,957	1,594	1,506	5.7	5.1	5.1
Trident Microsystems	23	45	30	0	0.1	0.1
Unitrode	2	4	4	0	0	0

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Table 2-2 (Continued)
Each Company's Vendor Revenue from Shipments of Total ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Vitesse	0	0	11	0	0	0
VLSI Technology	39	70	46	0.1	0.2	0.2
VTC	19	25	10	0	0	0
WaferScale Integration	8	11	6	0	0	0
Xicor	23	22	27	0	0	0
Xilinx	52	55	61	0.2	0.2	0.2
Zilog	19	22	7	0	0	0
Zoran	0	5	5	0	0	0
Japanese Companies	**24,694**	**21,911**	**20,291**	**71.3**	**69.9**	**68.7**
Fuji Electric	68	58	37	0.2	0.2	0.1
Fujitsu	2,912	2,458	2,566	8.4	7.8	8.7
Hitachi	3,700	3,488	2,808	10.7	11.1	9.5
Matsushita	1,712	1,502	1,483	4.9	4.8	5.0
Mitsubishi	2,082	1,719	1,586	6.0	5.5	5.4
NEC	4,828	4,978	4,880	13.9	15.9	16.5
New JRC	143	112	124	0.4	0.4	0.4
Nippon Steel Semiconductor	206	36	15	0.6	0.1	0
Oki	714	541	520	2.1	1.7	1.8
Ricoh	187	136	141	0.5	0.4	0.5
Rohm	562	474	404	1.6	1.5	1.4
Sanken	162	135	38	0.5	0.4	0.1
SANYO	946	863	879	2.7	2.8	3.0
Seiko Epson	194	158	113	0.6	0.5	0.4
Sharp	1,333	1,094	969	3.9	3.5	3.3
Shindengen Electric	24	16	0	0	0	0
Sony	1,202	1,017	994	3.5	3.2	3.4
Toshiba	3,355	2,831	2,479	9.7	9.0	8.4
Yamaha	235	189	153	0.7	0.6	0.5
Other Japanese Companies	99	80	102	0.3	0.3	0.3
European Companies	**347**	**437**	**459**	**1.0**	**1.4**	**1.6**
Austria Mikro Systeme	1	0	0	0	0	0
Ericsson	1	1	2	0	0	0
GEC Plessey	24	20	20	0	0	0
Micronas	1	1	12	0	0	0
Philips	126	161	166	0.4	0.5	0.6
SGS-Thomson	151	220	207	0.4	0.7	0.7
Siemens	30	26	33	0	0	0.1
TEMIC	12	8	19	0	0	0

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Table 2-2 (Continued)
Each Company's Vendor Revenue from Shipments of Total ICs to Japan
(Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Asia/Pacific Companies	**2,271**	**1,551**	**1,223**	**6.6**	**4.9**	**4.1**
Acer	0	5	5	0	0	0
Holtek	0	0	2	0	0	0
Hualon Microelectronics Corp.	0	2	2	0	0	0
Hyundai	345	244	212	1.0	0.8	0.7
Korean Electronic Co.	5	7	11	0	0	0
LG Semicon	395	243	175	1.1	0.8	0.6
Macronix	110	147	190	0.3	0.5	0.6
Mosel Vitelic	112	41	24	0.3	0.1	0
Samsung	1,274	818	588	3.7	2.6	2.0
Silicon Integrated Systems	0	1	0	0	0	0
United Microelectronics	26	27	4	0	0	0
Vanguard	0	7	3	0	0	0
VIA	0	1	0	0	0	0
Winbond Electronics	4	8	7	0	0	0

Source: Dataquest (April 1998)

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Table 2-3
Each Company's Vendor Revenue from Shipments of Bipolar Digital to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**1,068**	**770**	**530**	**100.0**	**100.0**	**100.0**
Americas Companies	**287**	**185**	**153**	**26.9**	**24.0**	**28.9**
Advanced Micro Devices	16	8	4	1.5	1.0	0.8
Motorola	82	49	59	7.7	6.4	11.1
National Semiconductor	35	26	0	3.3	3.4	0
Texas Instruments	154	102	90	14.4	13.2	17.0
Japanese Companies	**771**	**577**	**371**	**72.2**	**74.9**	**70.0**
Fujitsu	155	64	50	14.5	8.3	9.4
Hitachi	336	360	206	31.5	46.8	38.9
Matsushita	22	14	8	2.1	1.8	1.5
Mitsubishi	30	19	19	2.8	2.5	3.6
NEC	87	68	59	8.1	8.8	11.1
Oki	36	4	3	3.4	0.5	0.6
Toshiba	105	48	26	9.8	6.2	4.9
European Companies	**8**	**7**	**2**	**0.7**	**0.9**	**0.4**
GEC Plessey	2	2	0	0.2	0.3	0
Philips	6	5	2	0.6	0.6	0.4
Asia/Pacific Companies	**2**	**1**	**4**	**0.2**	**0.1**	**0.8**
LG Semicon	2	1	0	0.2	0.1	0
Mosel Vitelic	0	0	4	0	0	0.8

Source: Dataquest (April 1998)

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Table 2-4
Each Company's Vendor Revenue from Shipments of MOS Digital ICs to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**27,774**	**25,105**	**24,023**	**100.0**	**100.0**	**100.0**
Americas Companies	**5,927**	**6,056**	**6,003**	**21.3**	**24.1**	**25.0**
ACC Microelectronics	1	1	1	0	0	0
Actel	12	15	14	0	0	0
Adaptec	18	55	57	0	0.2	0.2
Advanced Micro Devices	162	159	130	0.6	0.6	0.5
Alliance Semiconductor	6	2	6	0	0	0
Altera	80	95	114	0.3	0.4	0.5
Analog Devices	13	33	43	0	0.1	0.2
ATI Technologies	0	10	20	0	0	0
Atmel	89	209	108	0.3	0.8	0.4
C-Cube	0	16	16	0	0	0
Catalyst	7	7	11	0	0	0
Chip Express	0	1	1	0	0	0
Chips & Technologies	53	55	90	0.2	0.2	0.4
Cirrus Logic	155	125	94	0.6	0.5	0.4
Cypress Semiconductor	38	38	49	0.1	0.2	0.2
Dallas Semiconductor	20	20	21	0	0	0
Digital	0	30	41	0	0.1	0.2
DSP Group	13	13	13	0	0	0
ESS	0	0	15	0	0	0
Exar	0	2	3	0	0	0
Fairchild	0	0	44	0	0	0.2
Gennum	0	0	1	0	0	0
Gould AMI	2	2	3	0	0	0
Harris Semiconductor	6	4	3	0	0	0
Hewlett-Packard	6	8	9	0	0	0
IBM	539	142	132	1.9	0.6	0.5
IMP	1	0	0	0	0	0
Integrated Circuit Systems	5	8	9	0	0	0
Integrated Device Technology	58	73	58	0.2	0.3	0.2
Integrated Silicon Solution	6	4	0	0	0	0
Intel	1,351	2,028	2,237	4.9	8.1	9.3
International CMOS Technology	1	1	0	0	0	0
ISD	0	0	9	0	0	0
Lattice	18	40	40	0	0.2	0.2
Logic Devices	1	1	1	0	0	0
LSI Logic	250	275	367	0.9	1.1	1.5

Table 2-4 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Digital ICs to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Lucent Technologies	47	130	184	0.2	0.5	0.8
Micrel	1	1	0	0	0	0
Microchip Technology	31	31	12	0.1	0.1	0
Micron Technology	56	32	15	0.2	0.1	0
Motorola	585	416	358	2.1	1.7	1.5
National Semiconductor	96	89	61	0.3	0.4	0.3
Oak Technology	35	85	69	0.1	0.3	0.3
OPTi	5	6	8	0	0	0
PMC Sierra Semiconductor	4	2	2	0	0	0
Q Logic	23	24	25	0	0	0.1
Quality Semiconductor	0	5	5	0	0	0
QuickLogic	0	0	10	0	0	0
Ramtron	4	0	0	0	0	0
Raytheon	0	1	3	0	0	0
Rockwell	298	400	311	1.1	1.6	1.3
S3	5	8	2	0	0	0
Silicon Storage Technology	0	18	17	0	0	0
Standard Microsystems	5	5	5	0	0	0
Sun Microsystems	0	20	75	0	0	0.3
Symbios	13	11	26	0	0	0.1
Texas Instruments	1,556	1,051	868	5.6	4.2	3.6
Trident Microsystems	23	45	30	0	0.2	0.1
Vitesse	0	0	5	0	0	0
VLSI Technology	39	70	46	0.1	0.3	0.2
WaferScale Integration	8	11	6	0	0	0
Xicor	23	22	27	0	0	0.1
Xilinx	52	55	61	0.2	0.2	0.3
Zilog	19	22	7	0	0	0
Zoran	0	5	5	0	0	0
Japanese Companies	**19,433**	**17,316**	**16,626**	**70.0**	**69.0**	**69.2**
Fuji Electric	32	28	25	0.1	0.1	0.1
Fujitsu	2,398	2,066	2,263	8.6	8.2	9.4
Hitachi	3,019	2,775	2,406	10.9	11.1	10
Matsushita	1,235	1,102	1,065	4.4	4.4	4.4
Mitsubishi	1,611	1,309	1,287	5.8	5.2	5.4
NEC	4,175	4,367	4,424	15.0	17.4	18.4
New JRC	26	12	15	0	0	0
Nippon Steel Semiconductor	206	36	15	0.7	0.1	0

Table 2-4 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Digital ICs to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Oki	638	507	501	2.3	2.0	2.1
Ricoh	154	102	97	0.6	0.4	0.4
Rohm	231	193	151	0.8	0.8	0.6
SANYO	456	441	516	1.6	1.8	2.1
Seiko Epson	182	149	104	0.7	0.6	0.4
Sharp	1,258	1,029	903	4.5	4.1	3.8
Sony	794	661	655	2.9	2.6	2.7
Toshiba	2,734	2,311	1,993	9.8	9.2	8.3
Yamaha	231	186	152	0.8	0.7	0.6
Other Japanese Companies	53	42	54	0.2	0.2	0.2
European Companies	**165**	**207**	**192**	**0.6**	**0.8**	**0.8**
GEC Plessey	5	6	8	0	0	0
Micronas	0	1	12	0	0	0
Philips	45	74	44	0.2	0.3	0.2
SGS-Thomson	102	118	114	0.4	0.5	0.5
Siemens	12	8	7	0	0	0
TEMIC	0	0	7	0	0	0
Asia/Pacific Companies	**2,249**	**1,526**	**1,202**	**8.1**	**6.1**	**5.0**
Acer	0	5	5	0	0	0
Holtek	0	0	2	0	0	0
Hualon Microelectronics Corp.	0	2	2	0	0	0
Hyundai	345	244	212	1.2	1.0	0.9
LG Semicon	391	239	172	1.4	1.0	0.7
Macronix	110	147	190	0.4	0.6	0.8
Mosel Vitelic	112	41	20	0.4	0.2	0
Samsung	1,262	805	586	4.5	3.2	2.4
Silicon Integrated Systems	0	1	0	0	0	0
United Microelectronics	26	27	4	0	0.1	0
Vanguard	0	7	3	0	0	0
VIA	0	1	0	0	0	0
Winbond Electronics	3	7	6	0	0	0

Source: Dataquest (April 1998)

Table 2-5
Each Company's Vendor Revenue from Shipments of MOS Memory to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**12,168**	**8,487**	**6,523**	**100.0**	**100.0**	**100.0**
Americas Companies	**1,907**	**1,150**	**742**	**15.7**	**13.6**	**11.4**
Advanced Micro Devices	50	56	28	0.4	0.7	0.4
Alliance Semiconductor	6	2	6	0	0	0
Atmel	87	207	102	0.7	2.4	1.6
Catalyst	7	7	11	0	0	0.2
Cypress Semiconductor	25	22	27	0.2	0.3	0.4
Dallas Semiconductor	3	0	0	0	0	0
Fairchild	0	0	15	0	0	0.2
IBM	428	95	88	3.5	1.1	1.3
Integrated Device Technology	41	52	38	0.3	0.6	0.6
Integrated Silicon Solution	6	4	0	0	0	0
Intel	68	122	108	0.6	1.4	1.7
Microchip Technology	28	27	0	0.2	0.3	0
Micron Technology	56	32	15	0.5	0.4	0.2
Motorola	142	65	29	1.2	0.8	0.4
National Semiconductor	35	22	0	0.3	0.3	0
Ramtron	4	0	0	0	0	0
Silicon Storage Technology	0	18	17	0	0.2	0.3
Texas Instruments	893	388	230	7.3	4.6	3.5
WaferScale Integration	5	9	1	0	0.1	0
Xicor	23	22	27	0.2	0.3	0.4
Japanese Companies	**7,933**	**5,748**	**4,569**	**65.2**	**67.7**	**70.0**
Fujitsu	967	659	643	7.9	7.8	9.9
Hitachi	1,702	1,239	949	14.0	14.6	14.5
Matsushita	245	149	217	2.0	1.8	3.3
Mitsubishi	701	471	415	5.8	5.5	6.4
NEC	1,392	1,286	1,067	11.4	15.2	16.4
Nippon Steel Semiconductor	206	36	15	1.7	0.4	0.2
Oki	248	185	166	2.0	2.2	2.5
Ricoh	6	3	8	0	0	0.1
Rohm	30	24	22	0.2	0.3	0.3
SANYO	143	180	99	1.2	2.1	1.5
Seiko Epson	20	10	7	0.2	0.1	0.1
Sharp	697	531	387	5.7	6.3	5.9
Sony	192	121	35	1.6	1.4	0.5
Toshiba	1,381	849	534	11.3	10.0	8.2
Yamaha	1	1	1	0	0	0
Other Japanese Companies	2	4	4	0	0	0

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Table 2-5 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Memory to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
European Companies	**102**	**101**	**82**	**0.8**	**1.2**	**1.3**
Philips	0	0	2	0	0	0
SGS-Thomson	93	96	75	0.8	1.1	1.1
Siemens	9	5	4	0	0	0
TEMIC	0	0	1	0	0	0
Asia/Pacific Companies	**2,226**	**1,488**	**1,130**	**18.3**	**17.5**	**17.3**
Hualon Microelectronics Corp.	0	1	1	0	0	0
Hyundai	345	244	212	2.8	2.9	3.3
LG Semicon	389	237	169	3.2	2.8	2.6
Macronix	110	141	157	0.9	1.7	2.4
Mosel Vitelic	112	41	20	0.9	0.5	0.3
Samsung	1,242	788	563	10.2	9.3	8.6
United Microelectronics	26	24	1	0.2	0.3	0
Vanguard	0	7	3	0	0	0
Winbond Electronics	2	5	4	0	0	0

Source: Dataquest (April 1998)

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Table 2-6
Each Company's Vendor Revenue from Shipments of MOS Microcomponents to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**7,826**	**8,797**	**9,336**	**100.0**	**100.0**	**100.0**
Americas Companies	**2,675**	**3,527**	**3,784**	**34.2**	**40.1**	**40.5**
ACC Microelectronics	1	1	1	0	0	0
Adaptec	18	55	57	0.2	0.6	0.6
Advanced Micro Devices	72	43	62	0.9	0.5	0.7
Analog Devices	13	31	41	0.2	0.4	0.4
ATI Technologies	0	10	20	0	0.1	0.2
C-Cube	0	16	16	0	0.2	0.2
Chips & Technologies	53	55	90	0.7	0.6	1.0
Cirrus Logic	155	125	94	2.0	1.4	1.0
Cypress Semiconductor	7	9	0	0	0.1	0
Dallas Semiconductor	3	11	11	0	0.1	0.1
Digital	0	30	41	0	0.3	0.4
DSP Group	13	13	13	0.2	0.1	0.1
ESS	0	0	15	0	0	0.2
Harris Semiconductor	4	0	0	0	0	0
IBM	18	6	8	0.2	0	0
Integrated Device Technology	9	13	11	0.1	0.1	0.1
Intel	1,283	1,906	2,129	16.4	21.7	22.8
LSI Logic	30	35	12	0.4	0.4	0.1
Lucent Technologies	36	35	97	0.5	0.4	1.0
Microchip Technology	3	4	12	0	0	0.1
Motorola	260	242	224	3.3	2.8	2.4
National Semiconductor	37	38	51	0.5	0.4	0.5
Oak Technology	35	85	69	0.4	1.0	0.7
OPTi	5	6	8	0	0	0
PMC Sierra Semiconductor	4	2	2	0	0	0
Q Logic	23	24	25	0.3	0.3	0.3
Rockwell	298	400	311	3.8	4.5	3.3
S3	5	8	2	0	0	0
Standard Microsystems	5	5	5	0	0	0
Sun Microsystems	0	20	75	0	0.2	0.8
Symbios	8	6	21	0.1	0	0.2
Texas Instruments	136	193	203	1.7	2.2	2.2
Trident Microsystems	23	45	30	0.3	0.5	0.3
VLSI Technology	17	15	11	0.2	0.2	0.1
WaferScale Integration	3	2	5	0	0	0
Zilog	19	22	7	0.2	0.3	0
Zoran	0	5	5	0	0	0

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Table 2-6 (Continued)
Each Company's Vendor Revenue from Shipments of MOS Microcomponents to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Japanese Companies	**5,118**	**5,193**	**5,489**	**65.4**	**59.0**	**58.8**
Fuji Electric	3	3	3	0	0	0
Fujitsu	458	475	635	5.9	5.4	6.8
Hitachi	818	919	917	10.5	10.4	9.8
Matsushita	488	472	409	6.2	5.4	4.4
Mitsubishi	676	615	625	8.6	7.0	6.7
NEC	1,353	1,373	1,510	17.3	15.6	16.2
New JRC	2	3	3	0	0	0
Oki	110	88	97	1.4	1.0	1.0
Ricoh	59	63	69	0.8	0.7	0.7
Rohm	47	42	12	0.6	0.5	0.1
SANYO	69	65	125	0.9	0.7	1.3
Seiko Epson	19	15	17	0.2	0.2	0.2
Sharp	154	128	139	2.0	1.5	1.5
Sony	186	154	142	2.4	1.8	1.5
Toshiba	556	716	722	7.1	8.1	7.7
Yamaha	110	55	55	1.4	0.6	0.6
Other Japanese Companies	10	7	9	0.1	0	0
European Companies	**30**	**64**	**52**	**0.4**	**0.7**	**0.6**
GEC Plessey	1	1	1	0	0	0
Philips	17	42	16	0.2	0.5	0.2
SGS-Thomson	9	18	31	0.1	0.2	0.3
Siemens	3	3	3	0	0	0
TEMIC	0	0	1	0	0	0
Asia/Pacific Companies	**3**	**13**	**11**	**0**	**0.1**	**0.1**
Acer	0	5	5	0	0	0
LG Semicon	0	0	1	0	0	0
Macronix	0	2	0	0	0	0
Samsung	2	0	1	0	0	0
Silicon Integrated Systems	0	1	0	0	0	0
United Microelectronics	0	3	3	0	0	0
VIA	0	1	0	0	0	0
Winbond Electronics	1	1	1	0	0	0

Source: Dataquest (April 1998)

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Table 2-7
Each Company's Vendor Revenue from Shipments of MOS Digital Logic to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**7,780**	**7,821**	**8,164**	**100.0**	**100.0**	**100.0**
Americas Companies	**1,345**	**1,379**	**1,477**	**17.3**	**17.6**	**18.1**
Actel	12	15	14	0.2	0.2	0.2
Advanced Micro Devices	40	60	40	0.5	0.8	0.5
Altera	80	95	114	1.0	1.2	1.4
Analog Devices	0	2	2	0	0	0
Atmel	2	2	6	0	0	0
Chip Express	0	1	1	0	0	0
Cypress Semiconductor	6	7	22	0	0	0.3
Dallas Semiconductor	14	9	10	0.2	0.1	0.1
Exar	0	2	3	0	0	0
Fairchild	0	0	29	0	0	0.4
Gennum	0	0	1	0	0	0
Gould AMI	2	2	3	0	0	0
Harris Semiconductor	2	4	3	0	0	0
Hewlett-Packard	6	8	9	0	0.1	0.1
IBM	93	41	36	1.2	0.5	0.4
IMP	1	0	0	0	0	0
Integrated Circuit Systems	5	8	9	0	0.1	0.1
Integrated Device Technology	8	8	9	0.1	0.1	0.1
International CMOS Technology	1	1	0	0	0	0
ISD	0	0	9	0	0	0.1
Lattice	18	40	40	0.2	0.5	0.5
Logic Devices	1	1	1	0	0	0
LSI Logic	220	240	355	2.8	3.1	4.3
Lucent Technologies	11	95	87	0.1	1.2	1.1
Micrel	1	1	0	0	0	0
Motorola	183	109	105	2.4	1.4	1.3
National Semiconductor	24	29	10	0.3	0.4	0.1
Quality Semiconductor	0	5	5	0	0	0
QuickLogic	0	0	10	0	0	0.1
Raytheon	0	1	3	0	0	0
Symbios	5	5	5	0	0	0
Texas Instruments	527	470	435	6.8	6.0	5.3
Vitesse	0	0	5	0	0	0
VLSI Technology	22	55	35	0.3	0.7	0.4
Xilinx	52	55	61	0.7	0.7	0.7

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Table 2-7
Each Company's Vendor Revenue from Shipments of MOS Digital Logic to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Japanese Companies	**6,382**	**6,375**	**6,568**	**82.0**	**81.5**	**80.5**
Fuji Electric	29	25	22	0.4	0.3	0.3
Fujitsu	973	932	985	12.5	11.9	12.1
Hitachi	499	617	540	6.4	7.9	6.6
Matsushita	502	481	439	6.5	6.2	5.4
Mitsubishi	234	223	247	3.0	2.9	3.0
NEC	1,430	1,708	1,847	18.4	21.8	22.6
New JRC	24	9	12	0.3	0.1	0.1
Oki	280	234	238	3.6	3.0	2.9
Ricoh	89	36	20	1.1	0.5	0.2
Rohm	154	127	117	2.0	1.6	1.4
SANYO	244	196	292	3.1	2.5	3.6
Seiko Epson	143	124	80	1.8	1.6	1.0
Sharp	407	370	377	5.2	4.7	4.6
Sony	416	386	478	5.3	4.9	5.9
Toshiba	797	746	737	10.2	9.5	9.0
Yamaha	120	130	96	1.5	1.7	1.2
Other Japanese Companies	41	31	41	0.5	0.4	0.5
European Companies	**33**	**42**	**58**	**0.4**	**0.5**	**0.7**
GEC Plessey	4	5	7	0	0	0
Micronas	0	1	12	0	0	0.1
Philips	28	32	26	0.4	0.4	0.3
SGS-Thomson	0	4	8	0	0	0
TEMIC	0	0	5	0	0	0
Asia/Pacific Companies	**20**	**25**	**61**	**0.3**	**0.3**	**0.7**
Holtek	0	0	2	0	0	0
Hualon Microelectronics Corp.	0	1	1	0	0	0
LG Semicon	2	2	2	0	0	0
Macronix	0	4	33	0	0	0.4
Samsung	18	17	22	0.2	0.2	0.3
Winbond Electronics	0	1	1	0	0	0

Source: Dataquest (April 1998)

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Table 2-8
Each Company's Vendor Revenue from Shipments of Analog-Monolithic to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**4,745**	**4,577**	**4,977**	**100.0**	**100.0**	**100.0**
Americas Companies	**1,053**	**1,201**	**1,401**	**22.2**	**26.2**	**28.1**
Advanced Micro Devices	11	10	26	0.2	0.2	0.5
Allegro MicroSystems	26	36	31	0.5	0.8	0.6
Analog Devices	148	122	151	3.1	2.7	3.0
Burr-Brown	36	49	50	0.8	1.1	1.0
Cirrus Logic	3	8	23	0	0.2	0.5
Dallas Semiconductor	0	4	4	0	0	0
Elantec	4	7	13	0	0.2	0.3
Exar	25	11	10	0.5	0.2	0.2
Gennum	4	4	3	0	0	0
Harris Semiconductor	31	18	18	0.7	0.4	0.4
Honeywell	1	1	1	0	0	0
IMP	1	0	0	0	0	0
Integrated Circuit Systems	5	3	3	0.1	0	0
International Rectifier	7	10	13	0.1	0.2	0.3
Level One Communications	0	4	4	0	0	0
Linear Technology	32	40	42	0.7	0.9	0.8
Linfinity	1	1	1	0	0	0
Lucent Technologies	8	0	0	0.2	0	0
Maxim	29	59	65	0.6	1.3	1.3
Micrel	2	4	0	0	0	0
Micro Linear	1	1	1	0	0	0
Mitel	5	6	8	0.1	0.1	0.2
Motorola	184	129	139	3.9	2.8	2.8
National Semiconductor	98	131	154	2.1	2.9	3.1
PMC Sierra Semiconductor	1	3	3	0	0	0
Raytheon	13	12	10	0.3	0.3	0.2
Rockwell	0	46	37	0	1.0	0.7
Seeq Technology	0	1	1	0	0	0
Semtech	1	1	10	0	0	0.2
Supertex	8	7	7	0.2	0.2	0.1
TelCom	3	3	5	0	0	0.1
Texas Instruments	247	441	548	5.2	9.6	11.0
Unitrode	2	4	4	0	0	0
Vitesse	0	0	6	0	0	0.1
VTC	19	25	10	0.4	0.5	0.2

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Table 2-8 (Continued)
Each Company's Vendor Revenue from Shipments of Analog-Monolithic to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Japanese Companies	**3,498**	**3,129**	**3,294**	**73.7**	**68.4**	**66.2**
Fuji Electric	16	12	12	0.3	0.3	0.2
Fujitsu	255	234	253	5.4	5.1	5.1
Hitachi	230	255	196	4.8	5.6	3.9
Matsushita	455	386	410	9.6	8.4	8.2
Mitsubishi	274	232	280	5.8	5.1	5.6
NEC	437	419	397	9.2	9.2	8.0
New JRC	117	100	109	2.5	2.2	2.2
Oki	27	17	16	0.6	0.4	0.3
Ricoh	33	34	44	0.7	0.7	0.9
Rohm	271	225	253	5.7	4.9	5.1
Sanken	0	0	38	0	0	0.8
SANYO	406	345	363	8.6	7.5	7.3
Seiko Epson	12	9	9	0.3	0.2	0.2
Sharp	75	65	66	1.6	1.4	1.3
Sony	382	305	339	8.1	6.7	6.8
Toshiba	442	436	460	9.3	9.5	9.2
Yamaha	4	3	1	0	0	0
Other Japanese Companies	36	30	48	0.8	0.7	1.0
European Companies	**174**	**223**	**265**	**3.7**	**4.9**	**5.3**
Austria Mikro Systeme	1	0	0	0	0	0
Ericsson	1	1	2	0	0	0
GEC Plessey	17	12	12	0.4	0.3	0.2
Micronas	1	0	0	0	0	0
Philips	75	82	120	1.6	1.8	2.4
SGS-Thomson	49	102	93	1.0	2.2	1.9
Siemens	18	18	26	0.4	0.4	0.5
TEMIC	12	8	12	0.3	0.2	0.2
Asia/Pacific Companies	**20**	**24**	**17**	**0.4**	**0.5**	**0.3**
Korean Electronic Co.	5	7	11	0.1	0.2	0.2
LG Semicon	2	3	3	0	0	0
Samsung	12	13	2	0.3	0.3	0
Winbond Electronics	1	1	1	0	0	0

Source: Dataquest (April 1998)

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Table 2-9
Each Company's Vendor Revenue from Shipments of Total Discrete to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**4,694**	**4,408**	**4,244**	**100.0**	**100.0**	**100.0**
Americas Companies	**214**	**195**	**191**	**4.6**	**4.4**	**4.5**
Fairchild	0	0	11	0	0	0.3
General Semiconductor	37	30	29	0.8	0.7	0.7
Harris Semiconductor	0	0	1	0	0	0
Hewlett-Packard	7	8	8	0.1	0.2	0.2
International Rectifier	54	51	43	1.2	1.2	1.0
Microsemi	1	1	1	0	0	0
Motorola	68	73	64	1.4	1.7	1.5
National Semiconductor	1	8	12	0	0.2	0.3
Powerex	18	18	16	0.4	0.4	0.4
Supertex	2	2	2	0	0	0
Teccor Electronics	2	2	4	0	0	0
Japanese Companies	**4,420**	**4,146**	**3,964**	**94.2**	**94.1**	**93.4**
Fuji Electric	306	262	222	6.5	5.9	5.2
Fujitsu	49	74	77	1.0	1.7	1.8
Hitachi	641	691	489	13.7	15.7	11.5
Matsushita	445	383	392	9.5	8.7	9.2
Mitsubishi	366	340	319	7.8	7.7	7.5
NEC	597	576	604	12.7	13.1	14.2
New JRC	2	3	3	0	0	0
Oki	12	11	12	0.3	0.2	0.3
Rohm	428	372	345	9.1	8.4	8.1
Sanken	239	181	234	5.1	4.1	5.5
SANYO	279	270	283	5.9	6.1	6.7
Shindengen Electric	188	157	157	4.0	3.6	3.7
Sony	39	31	27	0.8	0.7	0.6
Toshiba	764	736	740	16.3	16.7	17.4
Other Japanese Companies	30	31	60	0.6	0.7	1.4
European Companies	**49**	**59**	**67**	**1.0**	**1.3**	**1.6**
Ericsson	0	0	1	0	0	0
Eupec	0	2	0	0	0	0
GEC Plessey	0	0	1	0	0	0
Micronas	0	0	1	0	0	0
Philips	16	11	16	0.3	0.2	0.4
SGS-Thomson	6	8	8	0.1	0.2	0.2
Siemens	4	8	10	0	0.2	0.2

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Table 2-9 (Continued)
Each Company's Vendor Revenue from Shipments of Total Discrete to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
TEMIC	21	27	26	0.4	0.6	0.6
Zetex	0	1	2	0	0	0
Other European Companies	2	2	2	0	0	0
Asia/Pacific Companies	**11**	**8**	**22**	**0.2**	**0.2**	**0.5**
Korean Electronic Co.	9	7	21	0.2	0.2	0.5
Samsung	2	1	1	0	0	0

Source: Dataquest (April 1998)

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Table 2-10
Each Company's Vendor Revenue from Shipments of Total Optical Semiconductors to Japan (Millions of U.S. Dollars)

	Revenue			Market Share (%)		
	1995	1996	1997	1995	1996	1997
Total Market	**2,768**	**2,638**	**2,725**	**100.0**	**100.0**	**100.0**
Americas Companies	**58**	**104**	**96**	**2.1**	**3.9**	**3.5**
Hewlett-Packard	18	50	48	0.7	1.9	1.8
Lucent Technologies	5	6	2	0.2	0.2	0
Mitel	0	7	2	0	0.3	0
Motorola	0	1	1	0	0	0
Texas Instruments	35	40	43	1.3	1.5	1.6
Japanese Companies	**2,690**	**2,518**	**2,600**	**97.2**	**95.5**	**95.4**
Fujitsu	130	113	125	4.7	4.3	4.6
Hitachi	49	73	58	1.8	2.8	2.1
Matsushita	425	383	369	15.4	14.5	13.5
Mitsubishi	92	88	125	3.3	3.3	4.6
NEC	159	202	182	5.7	7.7	6.7
New JRC	9	5	0	0.3	0.2	0
Oki	27	27	31	1.0	1.0	1.1
Rohm	198	203	219	7.2	7.7	8.0
Sanken	48	36	30	1.7	1.4	1.1
SANYO	127	116	130	4.6	4.4	4.8
Sharp	487	467	522	17.6	17.7	19.2
Sony	348	338	348	12.6	12.8	12.8
Stanley	129	0	128	4.7	0	4.7
Toshiba	399	271	265	14.4	10.3	9.7
Other Japanese Companies	63	196	68	2.3	7.4	2.5
European Companies	**16**	**11**	**24**	**0.6**	**0.4**	**0.9**
Siemens	10	7	14	0.4	0.3	0.5
TEMIC	5	4	10	0.2	0.2	0.4
Asia/Pacific Companies	**4**	**5**	**5**	**0.1**	**0.2**	**0.2**
Korean Electronic Co.	4	5	5	0.1	0.2	0.2

Source: Dataquest (April 1998)

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Table 2-11
Top 40 Total Market Vendor Revenue from Shipments of Total Semiconductors to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	NEC	5,756	5,666	-1.6	15.5
3	2	Toshiba	3,838	3,484	-9.2	9.5
2	3	Hitachi	4,252	3,355	-21.1	9.2
4	4	Fujitsu	2,645	2,768	4.7	7.6
5	5	Matsushita	2,268	2,244	-1.1	6.1
7	6	Intel	2,028	2,237	10.3	6.1
6	7	Mitsubishi	2,147	2,030	-5.4	5.6
8	8	Texas Instruments	1,634	1,549	-5.2	4.2
9	9	Sharp	1,561	1,491	-4.5	4.1
10	10	Sony	1,386	1,369	-1.2	3.8
11	11	SANYO	1,249	1,292	3.4	3.5
12	12	Rohm	1,049	968	-7.7	2.7
14	13	Motorola	668	621	-7.0	1.7
13	14	Samsung	819	589	-28.1	1.6
15	15	Oki	579	563	-2.8	1.5
19	16	LSI Logic	275	367	33.5	1.0
16	17	Rockwell	446	348	-22.0	1.0
17	18	Sanken	352	302	-14.2	0.8
18	19	Fuji Electric	320	259	-19.1	0.7
20	20	National Semiconductor	254	227	-10.6	0.6
23	21	SGS-Thomson	228	215	-5.7	0.6
21	22	Hyundai	244	212	-13.1	0.6
29	23	Analog Devices	161	194	20.5	0.5
31	24	Macronix	147	190	29.3	0.5
33	25	Lucent Technologies	136	186	36.8	0.5
28	26	Philips	172	182	5.8	0.5
22	27	LG Semicon	243	175	-28.0	0.5
26	28	Advanced Micro Devices	177	160	-9.6	0.4
27	29	Shindengen Electric	173	157	-9.2	0.4
25	30	Yamaha	189	153	-19.0	0.4
34	31	Ricoh	136	141	3.7	0.4
32	32	IBM	142	132	-7.0	0.4
NA	33	Stanley	0	128	NA	0.4
36	34	New JRC	120	127	5.8	0.3
35	35	Cirrus Logic	133	117	-12.0	0.3
37	36	Altera	95	114	20.0	0.3
30	37	Seiko Epson	158	113	-28.5	0.3

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Table 2-11 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of Total Semiconductors to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
24	38	Atmel	209	108	-48.3	0.3
46	39	Chips & Technologies	55	90	63.6	0.2
69	40	Sun Microsystems	20	75	275.0	0.2
		All Others	1,949	1,801	-7.6	4.9
		Americas Companies	**7,767**	**7,844**	**1.0**	**21.5**
		Japanese Companies	**28,575**	**26,855**	**-6.0**	**73.6**
		European Companies	**507**	**550**	**8.5**	**1.5**
		Asia/Pacific Companies	**1,564**	**1,250**	**-20.1**	**3.4**
		Total Market	**38,413**	**36,499**	**-5.0**	**100.0**

NA = Not available
Source: Dataquest (April 1998)

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Table 2-12
Top 40 Total Market Vendor Revenue from Shipments of Total ICs to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	NEC	4,978	4,880	-2.0	16.5
2	2	Hitachi	3,488	2,808	-19.5	9.5
4	3	Fujitsu	2,458	2,566	4.4	8.7
3	4	Toshiba	2,831	2,479	-12.4	8.4
5	5	Intel	2,028	2,237	10.3	7.6
6	6	Mitsubishi	1,719	1,586	-7.7	5.4
7	7	Texas Instruments	1,594	1,506	-5.5	5.1
8	8	Matsushita	1,502	1,483	-1.3	5.0
10	9	Sony	1,017	994	-2.3	3.4
9	10	Sharp	1,094	969	-11.4	3.3
11	11	SANYO	863	879	1.9	3.0
12	12	Samsung	818	588	-28.1	2.0
13	13	Motorola	594	556	-6.4	1.9
14	14	Oki	541	520	-3.9	1.8
15	15	Rohm	474	404	-14.8	1.4
17	16	LSI Logic	275	367	33.5	1.2
16	17	Rockwell	446	348	-22.0	1.2
18	18	National Semiconductor	246	215	-12.6	0.7
19	19	Hyundai	244	212	-13.1	0.7
21	20	SGS-Thomson	220	207	-5.9	0.7
25	21	Analog Devices	161	194	20.5	0.7
28	22	Macronix	147	190	29.3	0.6
33	23	Lucent Technologies	130	184	41.5	0.6
20	24	LG Semicon	243	175	-28.0	0.6
26	25	Philips	161	166	3.1	0.6
24	26	Advanced Micro Devices	177	160	-9.6	0.5
23	27	Yamaha	189	153	-19.0	0.5
30	28	Ricoh	136	141	3.7	0.5
29	29	IBM	142	132	-7.0	0.4
34	30	New JRC	112	124	10.7	0.4
32	31	Cirrus Logic	133	117	-12.0	0.4
35	32	Altera	95	114	20.0	0.4
27	33	Seiko Epson	158	113	-28.5	0.4
22	34	Atmel	209	108	-48.3	0.4
42	35	Chips & Technologies	55	90	63.6	0.3
64	36	Sun Microsystems	20	75	275.0	0.3
36	37	Oak Technology	85	69	-18.8	0.2

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Table 2-12 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of Total ICs to Japan
(Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
40	38	Maxim	59	65	10.2	0.2
43	39	Xilinx	55	61	10.9	0.2
37	40	Integrated Device Technology	73	58	-20.5	0.2
		All Others	1,397	1,237	-11.5	4.2
		Americas Companies	**7,468**	**7,557**	**1.2**	**25.6**
		Japanese Companies	**21,911**	**20,291**	**-7.4**	**68.7**
		European Companies	**437**	**459**	**5.0**	**1.6**
		Asia/Pacific Companies	**1,551**	**1,223**	**-21.1**	**4.1**
		Total Market	**31,367**	**29,530**	**-5.9**	**100.0**

Source: Dataquest (April 1998)

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Table 2-13
Top 15 Total Market Vendor Revenue from Shipments of Bipolar Digital to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Hitachi	360	206	-42.8	38.9
2	2	Texas Instruments	102	90	-11.8	17.0
3	3	NEC	68	59	-13.2	11.1
5	4	Motorola	49	59	20.4	11.1
4	5	Fujitsu	64	50	-21.9	9.4
6	6	Toshiba	48	26	-45.8	4.9
8	7	Mitsubishi	19	19	0	3.6
9	8	Matsushita	14	8	-42.9	1.5
10	9	Advanced Micro Devices	8	4	-50.0	0.8
NA	10	Mosel Vitelic	0	4	NA	0.8
12	11	Oki	4	3	-25.0	0.6
11	12	Philips	5	2	-60.0	0.4
7	13	National Semiconductor	26	0	-100.0	0
13	14	GEC Plessey	2	0	-100.0	0
14	15	LG Semicon	1	0	-100.0	0
		All Others	-	-	NA	0
		Americas Companies	**185**	**153**	**-17.3**	**28.9**
		Japanese Companies	**577**	**371**	**-35.7**	**70.0**
		European Companies	**7**	**2**	**-71.4**	**0.4**
		Asia/Pacific Companies	**1**	**4**	**300.0**	**0.8**
		Total Market	**770**	**530**	**-31.2**	**100.0**

NA = Not available
Source: Dataquest (April 1998)

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Table 2-14
Top 40 Total Market Vendor Revenue from Shipments of MOS Digital ICs to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	NEC	4,367	4,424	1.3	18.4
2	2	Hitachi	2,775	2,406	-13.3	10.0
4	3	Fujitsu	2,066	2,263	9.5	9.4
5	4	Intel	2,028	2,237	10.3	9.3
3	5	Toshiba	2,311	1,993	-13.8	8.3
6	6	Mitsubishi	1,309	1,287	-1.7	5.4
7	7	Matsushita	1,102	1,065	-3.4	4.4
9	8	Sharp	1,029	903	-12.2	3.8
8	9	Texas Instruments	1,051	868	-17.4	3.6
11	10	Sony	661	655	-0.9	2.7
10	11	Samsung	805	586	-27.2	2.4
13	12	SANYO	441	516	17.0	2.1
12	13	Oki	507	501	-1.2	2.1
16	14	LSI Logic	275	367	33.5	1.5
14	15	Motorola	416	358	-13.9	1.5
15	16	Rockwell	400	311	-22.3	1.3
17	17	Hyundai	244	212	-13.1	0.9
24	18	Macronix	147	190	29.3	0.8
26	19	Lucent Technologies	130	184	41.5	0.8
18	20	LG Semicon	239	172	-28.0	0.7
21	21	Yamaha	186	152	-18.3	0.6
20	22	Rohm	193	151	-21.8	0.6
25	23	IBM	142	132	-7.0	0.5
22	24	Advanced Micro Devices	159	130	-18.2	0.5
28	25	SGS-Thomson	118	114	-3.4	0.5
30	26	Altera	95	114	20.0	0.5
19	27	Atmel	209	108	-48.3	0.4
23	28	Seiko Epson	149	104	-30.2	0.4
29	29	Ricoh	102	97	-4.9	0.4
27	30	Cirrus Logic	125	94	-24.8	0.4
36	31	Chips & Technologies	55	90	63.6	0.4
53	32	Sun Microsystems	20	75	275.0	0.3
32	33	Oak Technology	85	69	-18.8	0.3
31	34	National Semiconductor	89	61	-31.5	0.3
37	35	Xilinx	55	61	10.9	0.3
34	36	Integrated Device Technology	73	58	-20.5	0.2
38	37	Adaptec	55	57	3.6	0.2

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Table 2-14 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of MOS Digital ICs to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
42	38	Cypress Semiconductor	38	49	28.9	0.2
35	39	VLSI Technology	70	46	-34.3	0.2
33	40	Philips	74	44	-40.5	0.2
		All Others	710	719	1.3	3.0
		Americas Companies	**6,056**	**6,003**	**-0.9**	**25.0**
		Japanese Companies	**17,316**	**16,626**	**-4.0**	**69.2**
		European Companies	**207**	**192**	**-7.2**	**0.8**
		Asia/Pacific Companies	**1,526**	**1,202**	**-21.2**	**5.0**
		Total Market	**25,105**	**24,023**	**-4.3**	**100.0**

Source: Dataquest (April 1998)

Table 2-15
Top 40 Total Market Vendor Revenue from Shipments of MOS Memory to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	NEC	1,286	1,067	-17.0	16.4
2	2	Hitachi	1,239	949	-23.4	14.5
5	3	Fujitsu	659	643	-2.4	9.9
4	4	Samsung	788	563	-28.6	8.6
3	5	Toshiba	849	534	-37.1	8.2
7	6	Mitsubishi	471	415	-11.9	6.4
6	7	Sharp	531	387	-27.1	5.9
8	8	Texas Instruments	388	230	-40.7	3.5
14	9	Matsushita	149	217	45.6	3.3
9	10	Hyundai	244	212	-13.1	3.3
10	11	LG Semicon	237	169	-28.7	2.6
12	12	Oki	185	166	-10.3	2.5
15	13	Macronix	141	157	11.3	2.4
16	14	Intel	122	108	-11.5	1.7
11	15	Atmel	207	102	-50.7	1.6
13	16	SANYO	180	99	-45.0	1.5
19	17	IBM	95	88	-7.4	1.3
18	18	SGS-Thomson	96	75	-21.9	1.1
22	19	Integrated Device Technology	52	38	-26.9	0.6
17	20	Sony	121	35	-71.1	0.5
20	21	Motorola	65	29	-55.4	0.4
21	22	Advanced Micro Devices	56	28	-50.0	0.4
30	23	Cypress Semiconductor	22	27	22.7	0.4
31	24	Xicor	22	27	22.7	0.4
27	25	Rohm	24	22	-8.3	0.3
23	26	Mosel Vitelic	41	20	-51.2	0.3
32	27	Silicon Storage Technology	18	17	-5.6	0.3
24	28	Nippon Steel Semiconductor	36	15	-58.3	0.2
25	29	Micron Technology	32	15	-53.1	0.2
NA	30	Fairchild	0	15	NA	0.2
35	31	Catalyst	7	11	57.1	0.2
40	32	Ricoh	3	8	166.7	0.1
33	33	Seiko Epson	10	7	-30.0	0.1
41	34	Alliance Semiconductor	2	6	200.0	0
37	35	Siemens	5	4	-20.0	0
38	36	Winbond Electronics	5	4	-20.0	0
36	37	Vanguard	7	3	-57.1	0

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Table 2-15 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of MOS Memory to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
NA	38	Philips	0	2	NA	0
28	39	United Microelectronics	24	1	-95.8	0
34	40	WaferScale Integration	9	1	-88.9	0
		All Others	59	7	-88.1	0.1
		Americas Companies	**1,150**	**742**	**-35.5**	**11.4**
		Japanese Companies	**5,748**	**4,569**	**-20.5**	**70.0**
		European Companies	**101**	**82**	**-18.8**	**1.3**
		Asia/Pacific Companies	**1,488**	**1,130**	**-24.1**	**17.3**
		Total Market	**8,487**	**6,523**	**-23.1**	**100.0**

NA = Not available
Source: Dataquest (April 1998)

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Table 2-16
Top 40 Total Market Vendor Revenue from Shipments of MOS Microcomponents to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Intel	1,906	2,129	11.7	22.8
2	2	NEC	1,373	1,510	10.0	16.2
3	3	Hitachi	919	917	-0.2	9.8
4	4	Toshiba	716	722	0.8	7.7
6	5	Fujitsu	475	635	33.7	6.8
5	6	Mitsubishi	615	625	1.6	6.7
7	7	Matsushita	472	409	-13.3	4.4
8	8	Rockwell	400	311	-22.3	3.3
9	9	Motorola	242	224	-7.4	2.4
10	10	Texas Instruments	193	203	5.2	2.2
11	11	Sony	154	142	-7.8	1.5
12	12	Sharp	128	139	8.6	1.5
16	13	SANYO	65	125	92.3	1.3
14	14	Oki	88	97	10.2	1.0
27	15	Lucent Technologies	35	97	177.1	1.0
13	16	Cirrus Logic	125	94	-24.8	1.0
19	17	Chips & Technologies	55	90	63.6	1.0
32	18	Sun Microsystems	20	75	275.0	0.8
15	19	Oak Technology	85	69	-18.8	0.7
17	20	Ricoh	63	69	9.5	0.7
22	21	Advanced Micro Devices	43	62	44.2	0.7
20	22	Adaptec	55	57	3.6	0.6
18	23	Yamaha	55	55	0	0.6
25	24	National Semiconductor	38	51	34.2	0.5
28	25	Analog Devices	31	41	32.3	0.4
29	26	Digital	30	41	36.7	0.4
33	27	SGS-Thomson	18	31	72.2	0.3
21	28	Trident Microsystems	45	30	-33.3	0.3
30	29	Q Logic	24	25	4.2	0.3
45	30	Symbios	6	21	250.0	0.2
41	31	ATI Technologies	10	20	100.0	0.2
35	32	Seiko Epson	15	17	13.3	0.2
24	33	Philips	42	16	-61.9	0.2
34	34	C-Cube	16	16	0	0.2
NA	35	ESS	0	15	NA	0.2
38	36	DSP Group	13	13	0	0.1
23	37	Rohm	42	12	-71.4	0.1

Table 2-16 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of MOS Microcomponents to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
26	38	LSI Logic	35	12	-65.7	0.1
50	39	Microchip Technology	4	12	200.0	0.1
36	40	VLSI Technology	15	11	-26.7	0.1
		All Others	131	96	-26.7	1.0
		Americas Companies	**3,527**	**3,784**	**7.3**	**40.5**
		Japanese Companies	**5,193**	**5,489**	**5.7**	**58.8**
		European Companies	**64**	**52**	**-18.8**	**0.6**
		Asia/Pacific Companies	**13**	**11**	**-15.4**	**0.1**
		Total Market	**8,797**	**9,336**	**6.1**	**100.0**

NA = Not available
Source: Dataquest (April 1998)

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Table 2-17
Top 40 Total Market Vendor Revenue from Shipments of MOS Digital Logic to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	NEC	1,708	1,847	8.1	22.6
2	2	Fujitsu	932	985	5.7	12.1
3	3	Toshiba	746	737	-1.2	9.0
4	4	Hitachi	617	540	-12.5	6.6
7	5	Sony	386	478	23.8	5.9
5	6	Matsushita	481	439	-8.7	5.4
6	7	Texas Instruments	470	435	-7.4	5.3
8	8	Sharp	370	377	1.9	4.6
9	9	LSI Logic	240	355	47.9	4.3
12	10	SANYO	196	292	49.0	3.6
11	11	Mitsubishi	223	247	10.8	3.0
10	12	Oki	234	238	1.7	2.9
14	13	Rohm	127	117	-7.9	1.4
18	14	Altera	95	114	20.0	1.4
16	15	Motorola	109	105	-3.7	1.3
13	16	Yamaha	130	96	-26.2	1.2
17	17	Lucent Technologies	95	87	-8.4	1.1
15	18	Seiko Epson	124	80	-35.5	1.0
21	19	Xilinx	55	61	10.9	0.7
19	20	Advanced Micro Devices	60	40	-33.3	0.5
23	21	Lattice	40	40	0	0.5
22	22	IBM	41	36	-12.2	0.4
20	23	VLSI Technology	55	35	-36.4	0.4
41	24	Macronix	4	33	725.0	0.4
NA	25	Fairchild	0	29	NA	0.4
25	26	Philips	32	26	-18.8	0.3
27	27	Fuji Electric	25	22	-12.0	0.3
28	28	Samsung	17	22	29.4	0.3
36	29	Cypress Semiconductor	7	22	214.3	0.3
24	30	Ricoh	36	20	-44.4	0.2
29	31	Actel	15	14	-6.7	0.2
31	32	New JRC	9	12	33.3	0.1
50	33	Micronas	1	12	1,100.0	0.1
26	34	National Semiconductor	29	10	-65.5	0.1
30	35	Dallas Semiconductor	9	10	11.1	0.1
NA	36	QuickLogic	0	10	NA	0.1
32	37	Integrated Device Technology	8	9	12.5	0.1

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Table 2-17 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of MOS Digital Logic to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
33	38	Integrated Circuit Systems	8	9	12.5	0.1
34	39	Hewlett-Packard	8	9	12.5	0.1
NA	40	ISD	0	9	NA	0.1
		All Others	79	105	32.9	1.3
		Americas Companies	**1,379**	**1,477**	**7.1**	**18.1**
		Japanese Companies	**6,375**	**6,568**	**3.0**	**80.5**
		European Companies	**42**	**58**	**38.1**	**0.7**
		Asia/Pacific Companies	**25**	**61**	**144.0**	**0.7**
		Total Market	**7,821**	**8,164**	**4.4**	**100.0**

NA = Not available
Source: Dataquest (April 1998)

Table 2-18
Top 40 Total Market Vendor Revenue from Shipments of Analog-Monolithic to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Texas Instruments	441	548	24.3	11.0
2	2	Toshiba	436	460	5.5	9.2
4	3	Matsushita	386	410	6.2	8.2
3	4	NEC	419	397	-5.3	8.0
5	5	SANYO	345	363	5.2	7.3
6	6	Sony	305	339	11.1	6.8
9	7	Mitsubishi	232	280	20.7	5.6
8	8	Fujitsu	234	253	8.1	5.1
10	9	Rohm	225	253	12.4	5.1
7	10	Hitachi	255	196	-23.1	3.9
11	11	National Semiconductor	131	154	17.6	3.1
13	12	Analog Devices	122	151	23.8	3.0
12	13	Motorola	129	139	7.8	2.8
16	14	Philips	82	120	46.3	2.4
15	15	New JRC	100	109	9.0	2.2
14	16	SGS-Thomson	102	93	-8.8	1.9
17	17	Sharp	65	66	1.5	1.3
18	18	Maxim	59	65	10.2	1.3
19	19	Burr-Brown	49	50	2.0	1.0
23	20	Ricoh	34	44	29.4	0.9
21	21	Linear Technology	40	42	5.0	0.8
NA	22	Sanken	0	38	NA	0.8
20	23	Rockwell	46	37	-19.6	0.7
22	24	Allegro MicroSystems	36	31	-13.9	0.6
27	25	Siemens	18	26	44.4	0.5
34	26	Advanced Micro Devices	10	26	160.0	0.5
38	27	Cirrus Logic	8	23	187.5	0.5
26	28	Harris Semiconductor	18	18	0	0.4
28	29	Oki	17	16	-5.9	0.3
35	30	International Rectifier	10	13	30.0	0.3
39	31	Elantec	7	13	85.7	0.3
30	32	Fuji Electric	12	12	0	0.2
31	33	GEC Plessey	12	12	0	0.2
37	34	TEMIC	8	12	50.0	0.2
40	35	Korean Electronic Co.	7	11	57.1	0.2
24	36	VTC	25	10	-60.0	0.2
32	37	Raytheon	12	10	-16.7	0.2

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Table 2-18 (Continued)
Top 40 Total Market Vendor Revenue from Shipments of Analog-Monolithic to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
33	38	Exar	11	10	-9.1	0.2
54	39	Semtech	1	10	900.0	0.2
36	40	Seiko Epson	9	9	0	0.2
		All Others	119	108	-9.2	2.2
		Americas Companies	**1,201**	**1,401**	**16.7**	**28.1**
		Japanese Companies	**3,129**	**3,294**	**5.3**	**66.2**
		European Companies	**223**	**265**	**18.8**	**5.3**
		Asia/Pacific Companies	**24**	**17**	**-29.2**	**0.3**
		Total Market	**4,577**	**4,977**	**8.7**	**100.0**

NA = Not available
Source: Dataquest (April 1998)

Table 2-19
Top 38 Total Market Vendor Revenue from Shipments of Total Discrete to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Toshiba	736	740	0.5	17.4
3	2	NEC	576	604	4.9	14.2
2	3	Hitachi	691	489	-29.2	11.5
4	4	Matsushita	383	392	2.3	9.2
5	5	Rohm	372	345	-7.3	8.1
6	6	Mitsubishi	340	319	-6.2	7.5
7	7	SANYO	270	283	4.8	6.7
9	8	Sanken	181	234	29.3	5.5
8	9	Fuji Electric	262	222	-15.3	5.2
10	10	Shindengen Electric	157	157	0	3.7
11	11	Fujitsu	74	77	4.1	1.8
12	12	Motorola	73	64	-12.3	1.5
13	13	International Rectifier	51	43	-15.7	1.0
15	14	General Semiconductor	30	29	-3.3	0.7
14	15	Sony	31	27	-12.9	0.6
17	16	TEMIC	27	26	-3.7	0.6
25	17	Korean Electronic Co.	7	21	200.0	0.5
18	18	Powerex	18	16	-11.1	0.4
19	19	Philips	11	16	45.5	0.4
20	20	Oki	11	12	9.1	0.3
21	21	National Semiconductor	8	12	50.0	0.3
NA	22	Fairchild	0	11	NA	0.3
23	23	Siemens	8	10	25.0	0.2
22	24	SGS-Thomson	8	8	0	0.2
24	25	Hewlett-Packard	8	8	0	0.2
29	26	Teccor Electronics	2	4	100.0	0
26	27	New JRC	3	3	0	0
27	28	Supertex	2	2	0	0
32	29	Zetex	1	2	100.0	0
31	30	Samsung	1	1	0	0
33	31	Microsemi	1	1	0	0
NA	32	Harris Semiconductor	0	1	NA	0
NA	33	GEC Plessey	0	1	NA	0
NA	34	Ericsson	0	1	NA	0
NA	35	Micronas	0	1	NA	0
16	36	TOKO	28	0	-100.0	0

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Table 2-19 (Continued)
Top 38 Total Market Vendor Revenue from Shipments of Total Discrete to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
28	37	ITT	2	0	-100.0	0
30	38	Eupec	2	0	-100.0	0
		All Others	33	62	87.9	1.5
		Americas Companies	**195**	**191**	**-2.1**	**4.5**
		Japanese Companies	**4,146**	**3,964**	**-4.4**	**93.4**
		European Companies	**59**	**67**	**13.6**	**1.6**
		Asia/Pacific Companies	**8**	**22**	**175.0**	**0.5**
		Total Market	**4,408**	**4,244**	**-3.7**	**100.0**

NA = Not available
Source: Dataquest (April 1998)

Table 2-20
Top 22 Total Market Vendor Revenue from Shipments of Total Optical Semiconductors to Japan (Millions of U.S. Dollars)

1996 Rank	1997 Rank		1996 Revenue	1997 Revenue	Percentage Change	1997 Market Share (%)
1	1	Sharp	467	522	11.8	19.2
2	2	Matsushita	383	369	-3.7	13.5
3	3	Sony	338	348	3.0	12.8
4	4	Toshiba	271	265	-2.2	9.7
5	5	Rohm	203	219	7.9	8.0
6	6	NEC	202	182	-9.9	6.7
7	7	SANYO	116	130	12.1	4.8
NA	8	Stanley	0	128	NA	4.7
8	9	Fujitsu	113	125	10.6	4.6
9	10	Mitsubishi	88	125	42.0	4.6
10	11	Hitachi	73	58	-20.5	2.1
11	12	Hewlett-Packard	50	48	-4.0	1.8
12	13	Texas Instruments	40	43	7.5	1.6
14	14	Oki	27	31	14.8	1.1
13	15	Sanken	36	30	-16.7	1.1
15	16	Siemens	7	14	100.0	0.5
20	17	TEMIC	4	10	150.0	0.4
18	18	Korean Electronic Co.	5	5	0	0.2
16	19	Mitel	7	2	-71.4	0
17	20	Lucent Technologies	6	2	-66.7	0
21	21	Motorola	1	1	0	0
19	22	New JRC	5	0	-100.0	0
		All Others	196	68	-65.3	2.5
		Americas Companies	**104**	**96**	**-7.7**	**3.5**
		Japanese Companies	**2,518**	**2,600**	**3.3**	**95.4**
		European Companies	**11**	**24**	**118.2**	**0.9**
		Asia/Pacific Companies	**5**	**5**	**0**	**0.2**
		Total Market	**2,638**	**2,725**	**3.3**	**100.0**

NA = Not available
Source: Dataquest (April 1998)

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For More Information...

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Japanese Semiconductor User Trends, 1997

Focus Report

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Japanese Semiconductor User Trends, 1997

Focus Report

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Chapter 1

Executive Summary

Scope of This Report

This report analyzes the following Japanese semiconductor user trends in 1997:

- Overall electronic equipment production and semiconductor consumption trends in Japan
- Electronics production trends of 22 major Japanese semiconductor users
- Semiconductor purchasing trends of each of the 22 companies

Chapter 2 discusses electronic equipment production trends, focusing on four major categories: data processing, communications, industrial, and consumer. Chapter 3 analyzes semiconductor purchasing trends in 1997 for the 22 top-ranking semiconductor users as a group. Chapter 4 discusses the company profile of each semiconductor user, noting major electronic products by category as well as semiconductor purchasing trends, and ends with a "Dataquest Perspective" section.

Research Methodology and Definitions

This Focus Report analyzes the results of Dataquest's recent survey of Japanese semiconductor users. To arrive at the estimates in this report, Dataquest conducted extensive research into semiconductor purchasing practices in the Japanese market. Also incorporated into the estimation is public information on each semiconductor-user company, regarding both electronic equipment production trends as well as semiconductor usage. Based on primary information, Dataquest has estimated the semiconductor purchasing trends of major Japanese companies for 1996 and 1997. All numbers are shown in Japanese yen unless otherwise stated.

The definitions used in this report are as follows:

- Semiconductor consumption—This refers to the number of semiconductors actually used in electronic systems manufactured by user companies.
- Semiconductor purchasing—This refers to the number of semiconductors purchased by user companies. Regional semiconductor consumption discussed in this report refers to the number of semiconductors booked and billed in each region, based on user location.
- Data processing—This is defined as computer systems, data storage, input/output devices, dedicated systems, and other data processing equipment.
- Industrial—This is defined as security/energy management systems, manufacturing systems/instruments, medical equipment, and other industrial equipment.

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- Communications—This is defined as premise telecom equipment, public telecom equipment, mobile communications equipment, broadcast and studio equipment, and other telecom equipment.
- Consumer—This is defined as audio equipment, video equipment, personal electronics, appliances, and other consumer equipment.
- Military and civil aerospace—This is defined as military and civil aerospace electronic equipment.
- Transportation—This is defined as in-car entertainment, body control electronics, power train systems, and safety and convenience systems.

Highlights of the Report

The major points discussed in this document include the following:

- In 1997, while electronics equipment production in Japan grew 7.8 percent, semiconductor consumption in Japan recorded modest growth of 5.7 percent.
- The 22 top-ranking Japanese electronics companies together increased semiconductor purchasing by 2.4 percent in 1997. Individually, however, some leading companies, such as Hitachi and Mitsubishi Electric, decreased their semiconductor purchasing.
- Comparatively strong growth (more than 8 percent) in semiconductor purchasing was seen in the communications category; this was mainly due to a rise in the unit production of that type of equipment, including digital cellular phones and other wireless communications systems.
- Modest growth (approximately 4 percent) in semiconductor purchasing was seen in the data processing category; this was mainly due to an increase in the unit production of computer peripherals and dedicated systems.
- Several products in the consumer category, such as the digital video camera (DV-C) and digital still camera (DSC), recorded strong growth in production, but semiconductor purchasing of consumer equipment was down by 2.4 percent in 1997.
- While production of automotive navigation systems was growing rapidly, semiconductor purchasing trends in the transportation category declined by 1.6 percent in 1997; this was mainly due to sluggish sales and decreases in price.

Project Analyst: Motoya Ohgami, Yoshihiro Shimada, and Hiroyuki Shimizu

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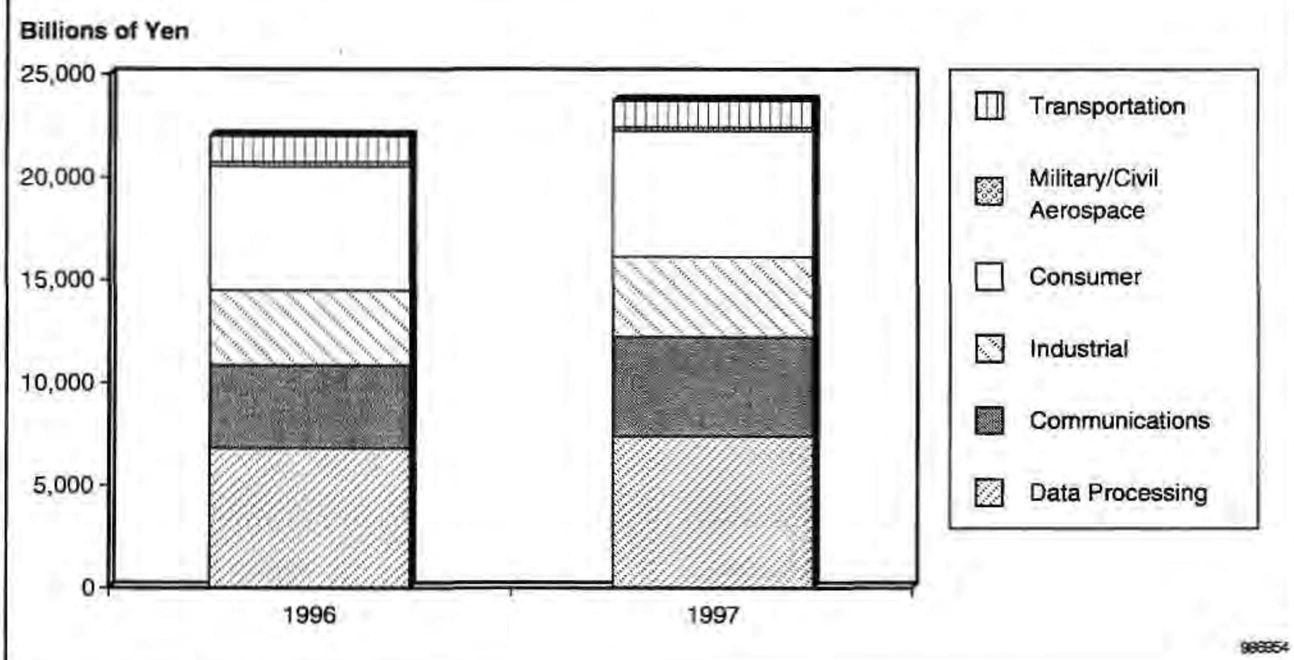
Chapter 2
Japanese Electronic Equipment Production and Semiconductor Consumption

In 1997, after a temporary surge in domestic demand prior to the consumption tax hike in April, the Japanese economy was beleaguered by turmoil in the financial system, a decline in consumer expenditure, and a slowdown in capital spending. The economic hardship was amplified by the Asian financial crisis (AFC) toward the year-end.

In 1997, against all of the economic backlash in Japan as well as in Asia/Pacific, electronic equipment production showed stronger growth than expected: 7.8 percent over 1996, reaching ¥23,715 billion (see Figure 2-1 and Table 2-1). Cellular phones contributed greatly, fueled by a series of price cuts and the shift in demand from personal handyphone systems (PHSs). Data processing equipment also outgrew the forecast, despite a slowdown in domestic PC shipments, and consumer equipment added some momentum, which came from video game systems and digital equipment.

The following section provides detailed analysis of electronic equipment production in Japan for the four major categories: data processing, communications, industrial, and consumer.

Figure 2-1
Japanese Electronic Equipment Production, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Table 2-1
Japanese Electronic Equipment Production by Application, 1996-1997 (Billions of Yen)

Application	1996	1997
Data Processing	6,811.7	7,379.9
Communications	4,042.2	4,844.2
Industrial	3,647.5	3,908.4
Consumer	6,018.5	6,097.8
Military/Civil Aerospace	197.4	195.0
Transportation	1,283.4	1,290.1
Total Electronic Equipment	**22,000.7**	**23,715.4**

Note: Columns may not add to totals shown because of rounding.
Source: Dataquest (October 1998)

Data Processing Equipment

In 1997, data processing equipment production revenue in Japan soared 8.3 percent to ¥7,380 billion (see Figure 2-2). While PC shipments to the domestic market slowed down to less than 5 percent on a unit basis, the price decline spurred the purchase of peripherals such as printers and display units. Also, storage devices led by high-speed optical disc drives—24x-to-32x CD-ROM and CD-R drives and newly introduced DVD-ROM drives, for example—enjoyed strong growth. This segment is expected to drive the market during the forecast period.

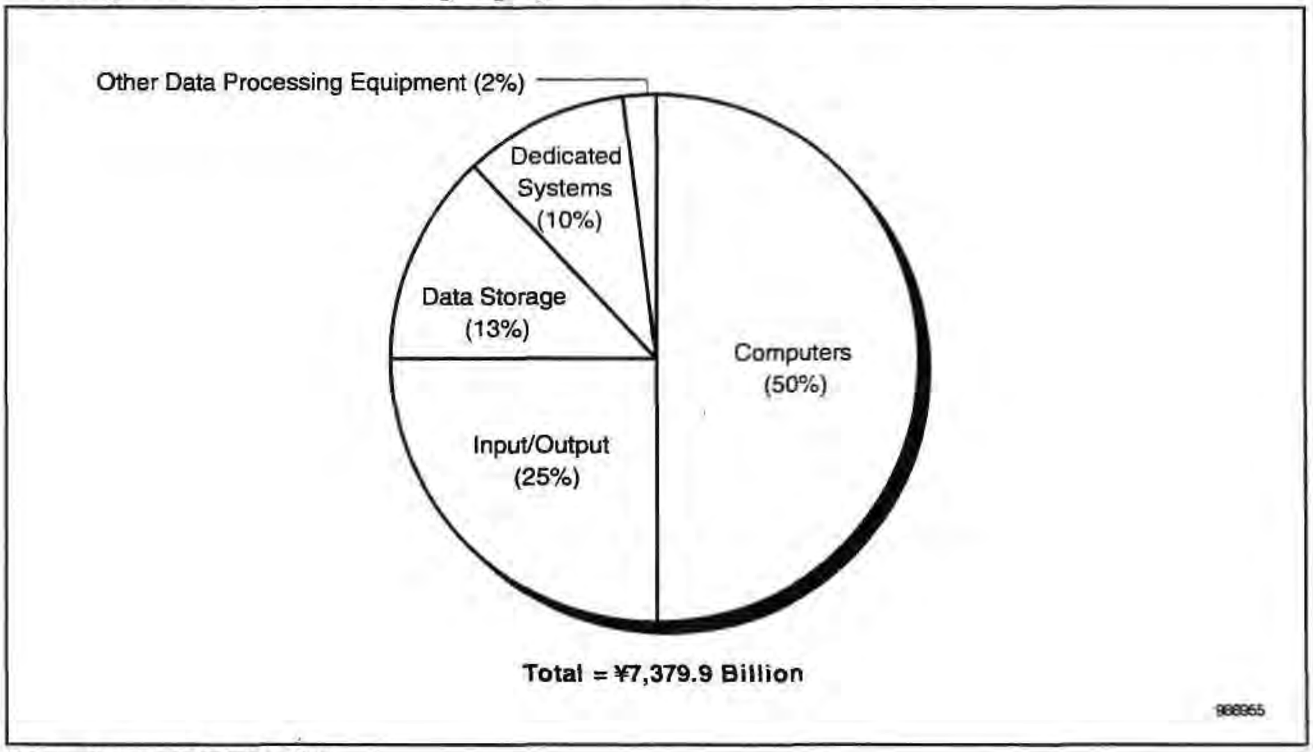
These trends affected various system vendors in this category, such as Canon and Seiko Epson, which are very well known for computer peripheral products such as printers. NEC, Toshiba, and SANYO decreased their semiconductor purchasing mostly because of price cuts and sluggish production. Fujitsu and Matsushita Kotobuki increased their semiconductor purchasing, owing much to the production increase of hard disk drives (HDDs) and CD-ROMs.

Communications Equipment

In 1997, communications equipment production revenue jumped 19.8 percent to ¥4,844 billion (see Figure 2-3). A prime driver was mobile communications equipment; subscribers grew much faster than expected, recording a net increase of 10 million in 1997. While PHS production decelerated by 7 million units in 1997, the market is expected to expand and shift its focus from personal to office use. Nevertheless, the penetration of mobile phones combining PHS and personal digital cellular (PDC) phones has surpassed 30 percent in Japan, and continuation of the previous high growth in domestic demand has become inevitably difficult. Meanwhile, the digitization of infrastructure facilities by Nippon Telegraph and Telephone (NTT) was completed at the end of 1997. This can be translated into the end of robust growth in infrastructure equipment production.

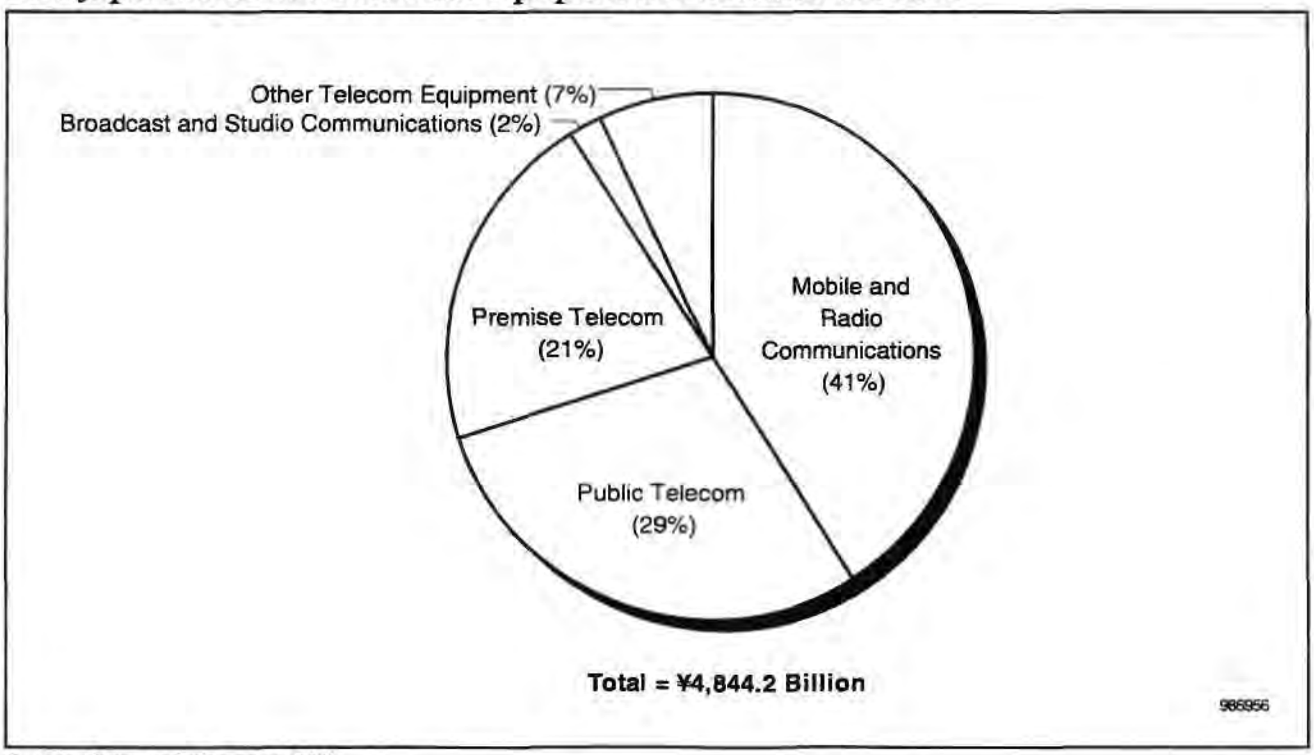
These trends affected system vendors in this category, such as Matsushita Communication, NEC, and Mitsubishi Electric—the top three vendors in the domestic market for digital cellular phones.

Figure 2-2
1997 Japanese Data Processing Equipment Production Revenue



Source: Dataquest (October 1998)

Figure 2-3
1997 Japanese Communications Equipment Production Revenue



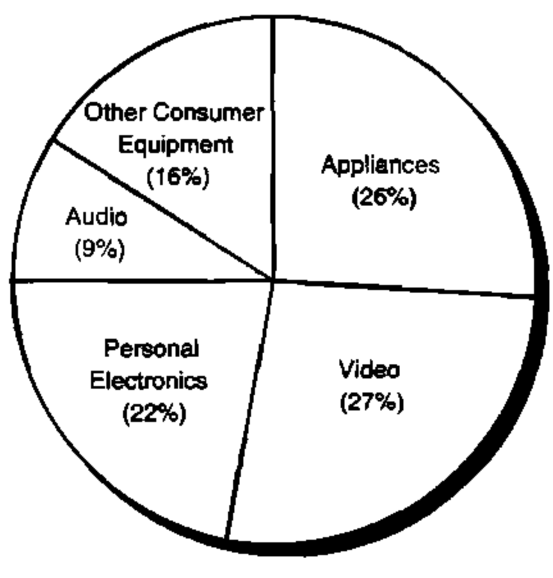
Source: Dataquest (October 1998)

Consumer Equipment

Consumer equipment production revenue recorded a 1.3 percent increase in 1997, reaching ¥6,098 billion (see Figure 2-4). In the video equipment segment, where TVs and VCRs sold in the domestic market are made mostly overseas, replacement demand for wide-screen TVs produced at domestic sites contributed greatly. In the digital consumer equipment market, DV-Cs recorded notable growth, and unit shipments at the end of 1997 were estimated at slightly below 1 million. The DV-C quickly will become pervasive, driven by price declines and the improved availability of key components. Similarly, DSCs will ramp up rapidly because they can be easily connected to PCs or TVs via a flash memory card or standard serial interface. In the audio equipment segment, a sudden rise in demand for minidiscs (MDs) has spurred the introduction of various systems equipped with MD drives. TV games continued to expand the market, helped by price cuts.

These trends affected system vendors in this category, such as Victor Company of Japan, Sony, and Nintendo.

Figure 2-4
1997 Japanese Consumer Equipment Production Revenue



Source: Dataquest (October 1998)

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Industrial Equipment

Industrial equipment production revenue in 1997 was up 7.2 percent, totaling ¥3,908 billion (see Figure 2-5). Among the segments in this category, manufacturing systems and instruments recorded the highest growth rate, with 14.9 percent. As the wave of production site relocation to Asia/Pacific countries subsides, the focal point of the market will shift to computerization and sophistication for adding value and further automation for new products.

These trends affected system vendors in this category, such as Hitachi, Toshiba, and Mitsubishi Electric; these big companies did not contribute much to the growth of semiconductor purchasing in this category in 1997.

Semiconductor Market

Thus, even in the year when the overall gross domestic product (GDP) in Japan recorded negative growth, electronics production increased fairly well. This gain in electronics production, however, did not mean as robust of an increase in semiconductor purchasing in Japan.

In 1997, the Japanese semiconductor market recorded a growth rate of 5.7 percent over the previous year—the only negative growth rate on a dollar basis among the four regional markets in the world: the Americas, Europe, Asia/Pacific, and Japan. The difference in trends between electronics production and semiconductor consumption was caused by two factors: An increase in electronics production took place in categories with lower semiconductor contents, such as industrial equipment, and the price erosion of semiconductor devices betrayed the increase on a unit basis. Also, PC shipments lost momentum in Japan, exerting a negative impact on the consumption of a variety of semiconductor products, including memories, microprocessors (MPUs), and logic.

As a result, the Japanese semiconductor market has become less than one-fourth of the worldwide market for the first time since 1980. It is still the second-largest regional market following the Americas, but both European and Asia/Pacific markets are close behind. In fact, there were months within 1997 when the Japanese semiconductor market fell behind those two markets.

Affecting this is the sluggishness in the domestic market as well as the fast growth in other regions, especially in the Americas and Europe. Semiconductor procurement to support Japanese electronics companies' Asian production sites has moved to each site or to international purchasing offices (IPOs) outside Japan, and the yen depreciation observed in 1997 did not reverse the trend.

Japanese semiconductor consumption by application category in 1997 is given in Figure 2-6.

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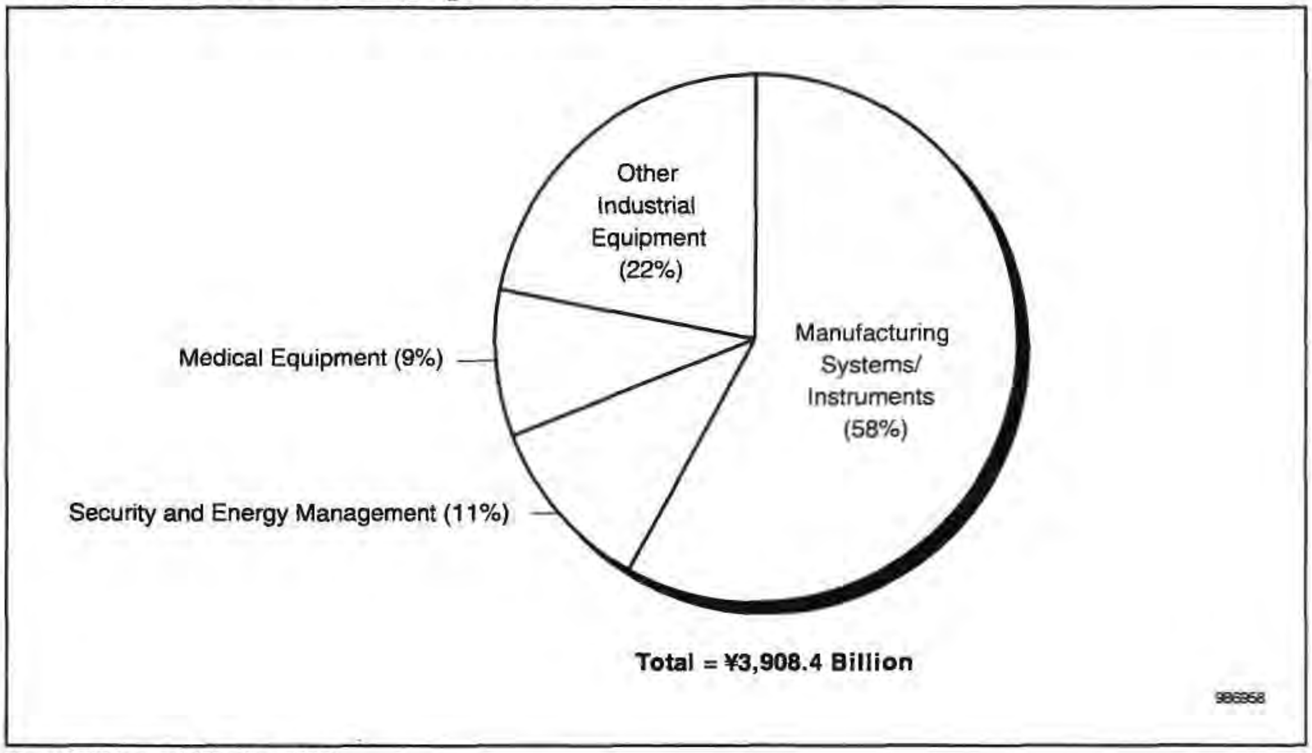
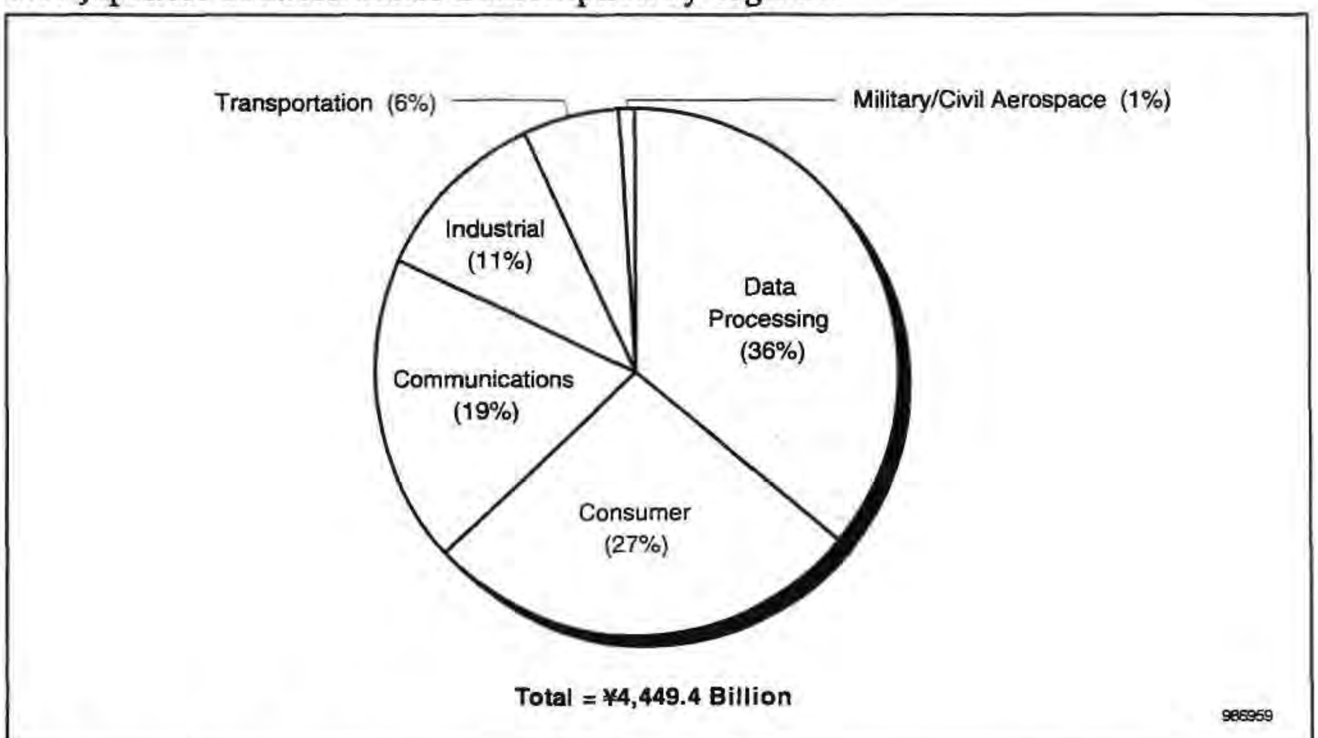
Figure 2-5
1997 Japanese Industrial Equipment Production Revenue



Source: Dataquest (October 1998)

Figure 2-6
1997 Japanese Semiconductor Consumption by Segment



Source: Dataquest (October 1998)

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Chapter 3
Japanese Semiconductor User Trends by Application

This chapter analyzes Japanese semiconductor consumption by application categories, focusing on the 22 top-ranking companies.

It should be noted that the semiconductor purchasing estimated in this report was measured as the amount of semiconductors booked and billed within Japan, regardless of where the bought semiconductors were actually mounted to circuit boards and systems. This implies that if the Japanese electronics companies analyzed here chose to buy semiconductors in Japan and then send them to their overseas production sites, that amount is still included in the semiconductor purchasing in Japan. Therefore, the semiconductor purchasing in this report may not equal semiconductor consumption in the true sense of the word. In Dataquest's methodology, however, even that portion of semiconductor purchasing is regarded as part of the "consumption," measured as the semiconductor companies' aggregated shipments into the Japanese market.

Table 3-1 and Figure 3-1 show the ranking of 22 major semiconductor-user companies based on their semiconductor purchasing trends in 1997. The top three users were NEC, Sony, and Fujitsu. The development of systems targeted at the domestic market tends to be conducted within Japan. The tendency is clearer in areas such as communications, where the differences in each country's format are so conspicuous—to the level of being incompatible with each other—that system development needs to be done within the country or region of its use. On the other hand, consumer electronics have been developed in Japan to be shipped to export markets, resulting in a large number of developed and produced systems.

Data Processing

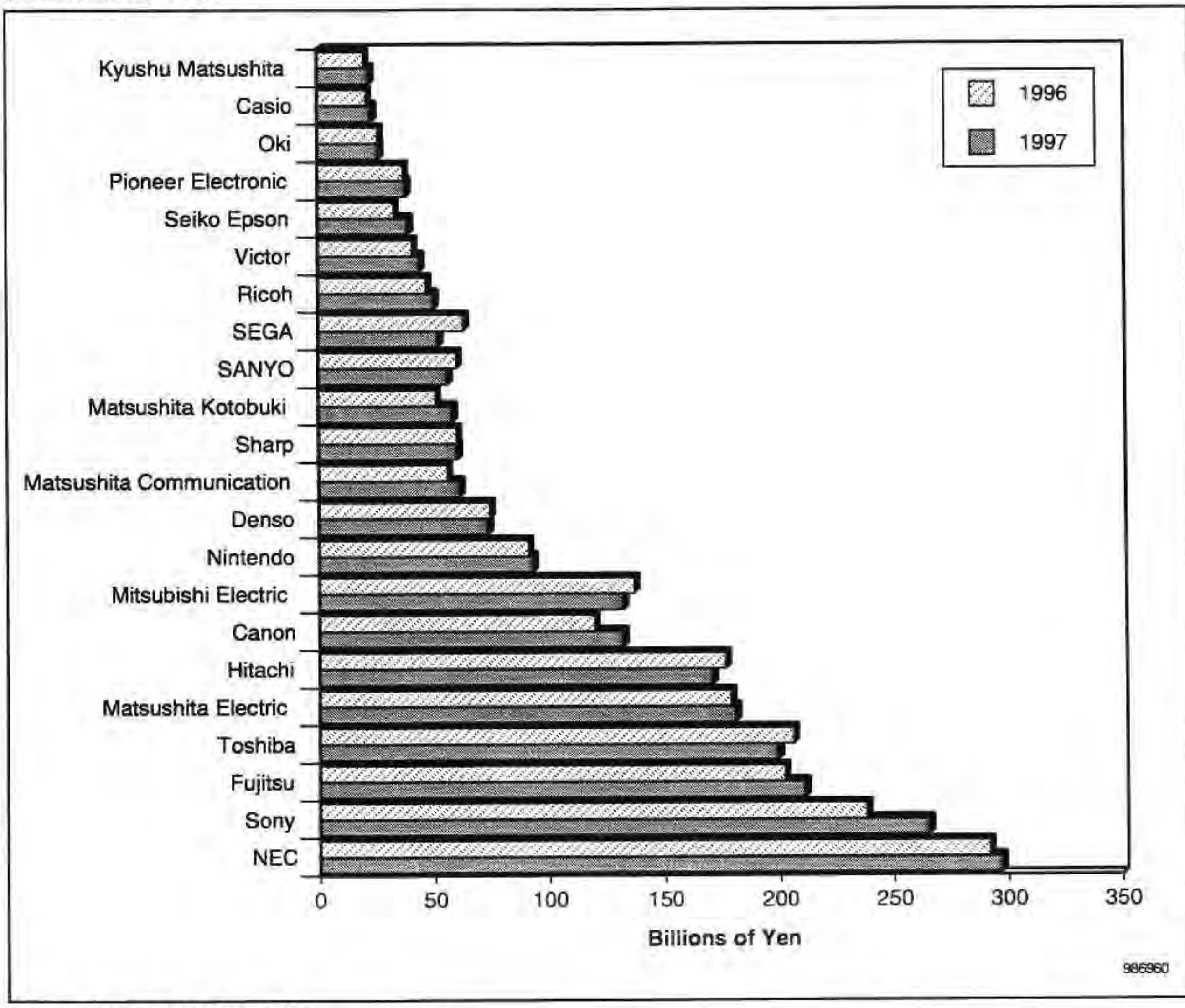
In this category, there are several products that contribute to the growth of semiconductor purchasing; they are mainly PC peripherals such as printers, monitors, digital copy systems, multifunctional dedicated machines, and optical disc storage, such as CD-ROM/R/RW and DVD players. Table 3-2 and Figure 3-2 show semiconductor purchase ranking in the data processing equipment area. Fujitsu, NEC, and Toshiba have sizable amounts of computer business, resulting in large purchase numbers. Canon follows the top three companies with its expertise in copiers and computer peripherals.

Table 3-1
Japanese Semiconductor Purchase Ranking of All Electronic Equipment, 1996-1997 (Billions of Yen)

1997 Rank	Company	1996	1997	Change (%)
1	NEC	291.9	297.0	1.8
2	Sony	238.4	264.9	11.1
3	Fujitsu	202.4	211.1	4.3
4	Toshiba	205.7	198.8	-3.3
5	Matsushita Electric	178.6	181.0	1.4
6	Hitachi	176.8	171.5	-3.0
7	Canon	120.0	132.3	10.2
8	Mitsubishi Electric	136.8	131.6	-3.8
9	Nintendo	91.3	92.6	1.4
10	Denso	74.3	73.0	-1.9
11	Matsushita Communication	56.2	61.2	9.0
12	Sharp	59.7	59.9	0.3
13	Matsushita Kotobuki	51.0	58.1	13.9
14	SANYO	59.8	55.6	-7.1
15	SEGA	63.0	52.3	-16.9
16	Ricoh	46.6	50.4	8.3
17	Victor	41.2	44.2	7.2
18	Seiko Epson	32.9	38.9	18.4
19	Pioneer Electronic	36.9	38.3	3.7
20	Oki	26.0	26.4	1.6
21	Casio	21.4	23.2	8.3
22	Kyushu Matsushita	20.0	22.3	11.1
	Total	**2,230.7**	**2,284.4**	**2.4**

Source: Dataquest (October 1998)

Figure 3-1
Japanese Semiconductor Purchase Ranking of All Electronic Equipment, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Table 3-2
Japanese Semiconductor Purchase Ranking of Data Processing Equipment, 1996-1997 (Billions of Yen)

1997 Rank	Company	1996	1997	Change (%)
1	NEC	171.9	167.5	-2.6
2	Fujitsu	141.2	146.7	3.9
3	Toshiba	110.6	105.2	-4.9
4	Canon	94.5	103.3	9.3
5	Hitachi	57.5	59.7	3.8
6	Mitsubishi Electric	57.8	57.6	-0.3
7	Matsushita Electric	48.0	56.5	17.7
8	Ricoh	36.1	39.4	9.1
9	Sony	31.4	34.0	8.3
10	Seiko Epson	24.8	31.1	25.4
11	Sharp	23.8	25.3	6.3
12	Matsushita Kotobuki	21.7	25.0	15.2
13	Oki	15.6	16.3	4.5
14	SANYO	13.6	11.6	-14.7
15	Casio	11.4	11.1	-2.6
16	Matsushita Communication	4.5	4.9	8.9
17	Kyushu Matsushita	3.7	4.3	16.2
18	Pioneer Electronic	0.1	0.1	0
	Total	**868.3**	**899.7**	**3.6**

Source: Dataquest (October 1998)

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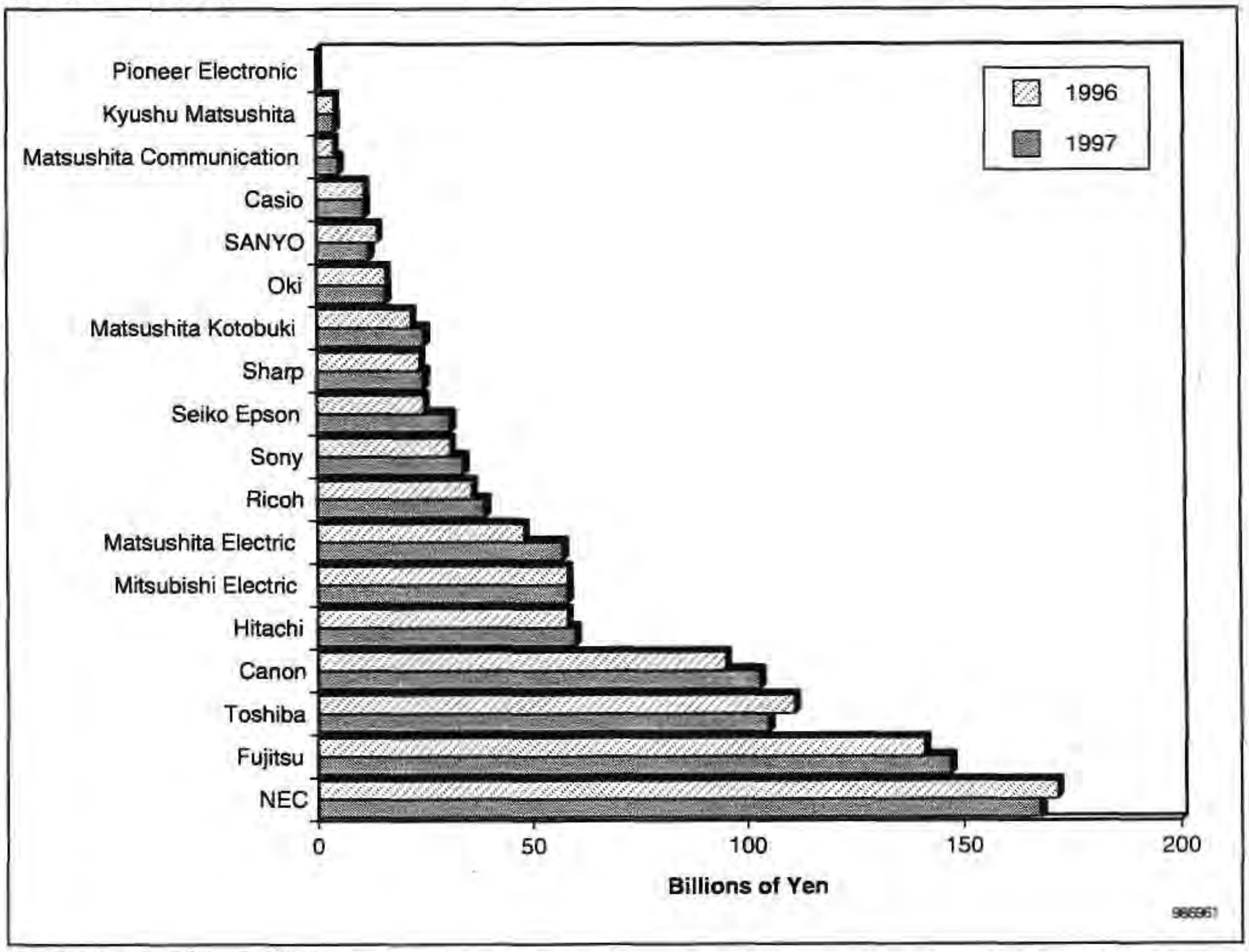
Figure 3-2
Japanese Semiconductor Purchase Ranking of Data Processing Equipment, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

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Communications

In the communications area, wireless communications and LAN/WAN equipment, including hubs, switches, and routers, are increasing in production volume, consuming an increasing portion of the semiconductors shipped worldwide. In Japan, the rapid growth in digital cellular phones helped vendors of both handsets and base stations. This contributed to increases in semiconductor consumption at companies such as Matsushita Electric, Sony, Toshiba, and Denso, some of which may not have been giants in the communications area but are growing fairly well in production. Table 3-3 and Figure 3-3 show the Japanese semiconductor purchase ranking of communications equipment.

Table 3-3
Japanese Semiconductor Purchase Ranking of Communications Equipment, 1996-1997 (Billions of Yen)

1997 Rank	Company	1996	1997	Change (%)
1	NEC	113.1	122.8	8.6
2	Fujitsu	61.2	64.4	5.2
3	Sony	43.6	44.1	1.1
4	Matsushita Communication	37.3	41.3	10.7
5	Hitachi	42.5	41.0	-3.5
6	Toshiba	26.3	29.9	13.7
7	Matsushita Electric	16.9	27.4	62.1
8	Mitsubishi Electric	13.3	15.5	16.5
9	Victor	11.4	12.2	7.0
10	Kyushu Matsushita	8.4	9.5	13.1
11	Ricoh	8.6	8.9	3.5
12	Denso	9.0	8.8	-2.2
13	Oki	8.5	7.9	-7.1
14	SANYO	7.0	6.3	-10.0
15	Pioneer Electronic	4.8	6.0	25.0
16	Sharp	4.6	4.9	6.5
17	Canon	3.8	4.5	18.4
18	Casio	1.8	1.9	5.6
	Total	**421.9**	**457.3**	**8.4**

Source: Dataquest (October 1998)

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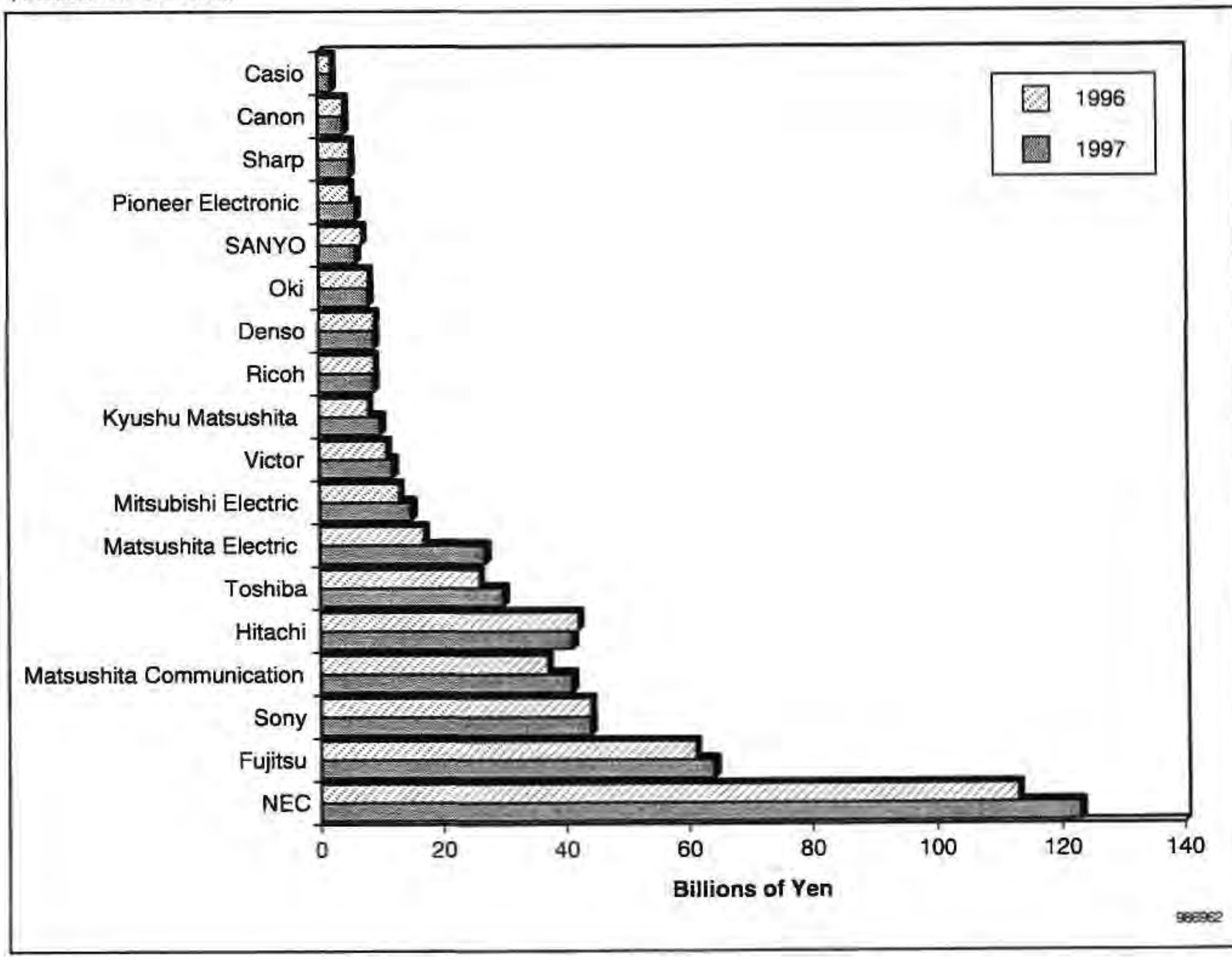
Figure 3-3
Japanese Semiconductor Purchase Ranking of Communications Equipment, 1996-1997 (Billions of Yen)



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Consumer

In the consumer equipment area, Sony, Nintendo, and Matsushita Electric lead other companies by far. In the sluggish domestic market, MD has been showing an accelerating growth, pulling demand for other audio systems as well. Other digital consumer equipment, such as digital camcorders and DSCs, grew, too, and contributed to the semiconductor purchasing of those vendors. Table 3-4 and Figure 3-4 show the Japanese semiconductor purchase ranking of consumer equipment.

Table 3-4
Japanese Semiconductor Purchase Ranking of Consumer Equipment, 1996-1997 (Billions of Yen)

1997 Rank	Company	1996	1997	Change (%)
1	Sony	140.7	165.1	17.3
2	Nintendo	91.3	92.6	1.4
3	Matsushita Electric	98.2	75.8	-22.8
4	Hitachi	58.8	53.9	-8.3
5	SEGA	63.0	52.3	-16.9
6	Toshiba	51.4	46.2	-10.1
7	Mitsubishi Electric	43.3	36.3	-16.2
8	Matsushita Kotobuki	29.3	33.1	13.0
9	SANYO	29.7	28.3	-4.5
10	Victor	24.7	26.7	8.2
11	Sharp	28.2	26.4	-6.4
12	Canon	16.1	18.9	17.5
13	Pioneer Electronic	16.3	15.2	-7.3
14	Casio	8.2	10.3	24.6
15	Kyushu Matsushita	5.0	5.6	13.7
16	NEC	4.3	4.2	-2.5
17	Seiko Epson	4.6	4.1	-10.8
18	Ricoh	1.2	1.4	21.0
19	Matsushita Communication	0.7	0.9	29.7
	Total	**714.8**	**697.3**	**-2.5**

Source: Dataquest (October 1998)

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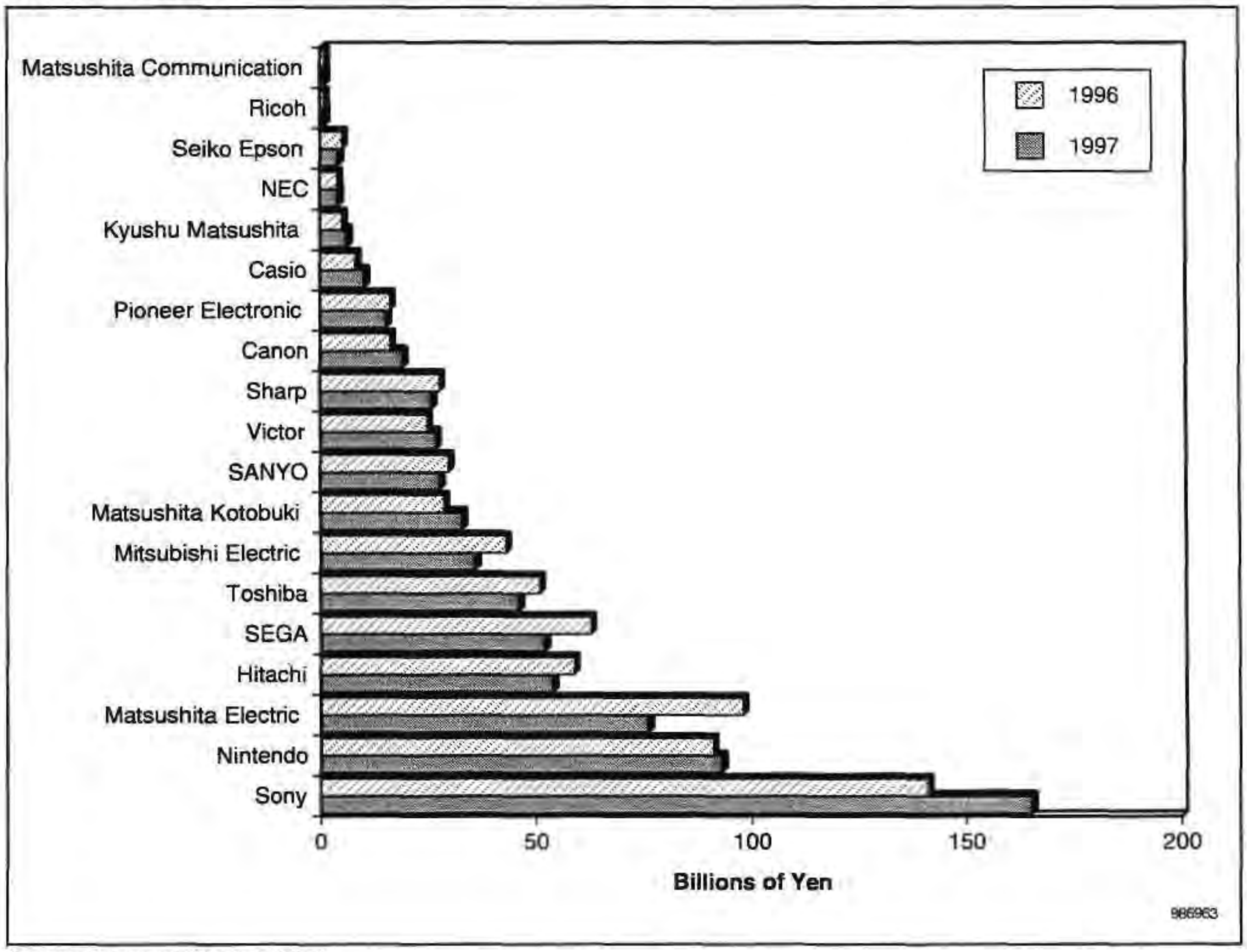
Figure 3-4
Japanese Semiconductor Purchase Ranking of Consumer Equipment, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

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Industrial

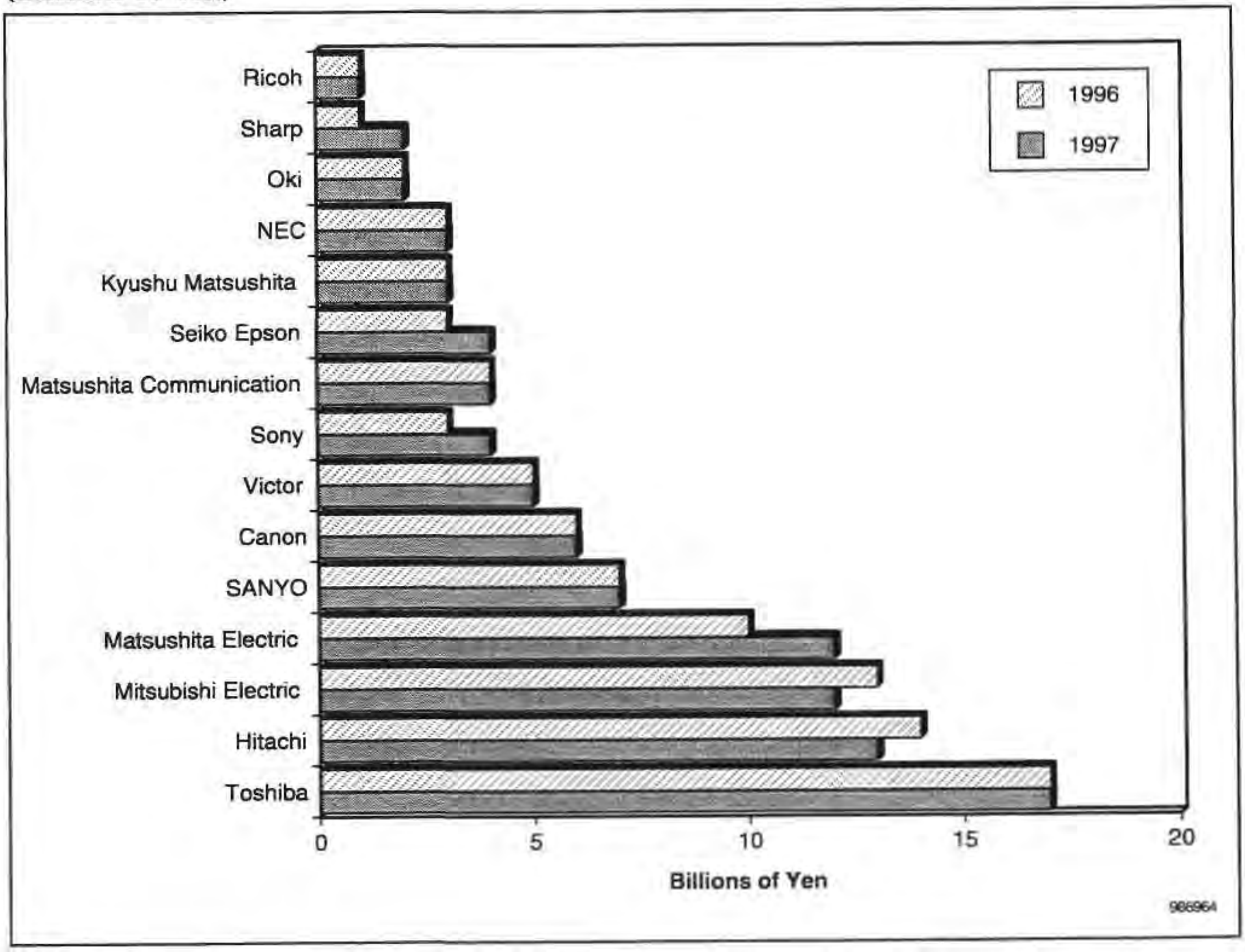
Overall capital expenditure in the Japanese industry declined in 1997, and manufacturing systems and instruments showed growth that was positive but smaller than that of the previous year. A drop in housing and building construction also hurt security and energy management equipment. The onset of the AFC brought down the demand for infrastructure-related equipment for Asian countries. Leading semiconductor users in this area are Toshiba, Matsushita Electric, SANYO, Mitsubishi Electric, and Hitachi. Table 3-5 and Figure 3-5 show the Japanese semiconductor purchase ranking of industrial equipment.

Table 3-5
Japanese Semiconductor Purchase Ranking of Industrial Equipment, 1996-1997 (Billions of Yen)

1997 Rank	Company	1996	1997	Change (%)
1	Toshiba	17.4	17.5	0.6
2	Hitachi	14.0	13.0	-7.1
3	Mitsubishi Electric	12.5	12.4	-0.8
4	Matsushita Electric	10.0	11.7	17.0
5	SANYO	7.2	7.4	2.8
6	Canon	5.6	5.6	0
7	Victor	5.1	5.4	5.9
8	Sony	3.4	3.9	14.7
9	Matsushita Communication	3.7	3.8	2.7
10	Seiko Epson	3.5	3.7	5.7
11	Kyushu Matsushita	2.9	2.8	-3.4
12	NEC	2.6	2.5	-3.8
13	Oki	1.8	2.0	11.1
14	Sharp	1.4	1.5	7.1
15	Ricoh	0.7	0.6	-14.3
	Total	**91.8**	**93.8**	**2.2**

Source: Dataquest (October 1998)

Figure 3-5
Japanese Semiconductor Purchase Ranking of Industrial Equipment, 1996-1997 (Billions of Yen)



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Transportation

Domestic car sales in 1997 declined by around 5 percent. However, automotive equipment production saw a slight increase in all areas except car audio/video systems. Navigation system production, especially, continued to grow very rapidly. This trend benefited the semiconductor purchasing of companies such as Sony, Pioneer Electronic, and Matsushita Electric. The production of automobiles was becoming sluggish, which affected semiconductor demand in equipment in power train and body control, such as electronic control units (ECUs) and antilock brake systems (ABSs). Table 3-6 and Figure 3-6 show the Japanese semiconductor purchase ranking of transportation equipment.

Table 3-6
Japanese Semiconductor Purchase Ranking of Transportation Equipment, 1996-1997 (Billions of Yen)

1997 Rank	Company	1996	1997	Change (%)
1	Denso	65.4	64.2	-1.8
2	Sony	19.2	17.9	-6.8
3	Pioneer Electronic	15.7	17.0	8.3
4	Matsushita Communication	10.1	10.4	3.0
5	Matsushita Electric	9.9	9.9	0
6	Mitsubishi Electric	9.9	9.9	0
7	Hitachi	4.0	3.9	-2.5
8	SANYO	2.4	1.9	-20.8
9	Sharp	1.7	1.8	5.9
10	Oki	0.2	0.2	0
	Total	**138.5**	**137.1**	**-1.0**

Source: Dataquest (October 1998)

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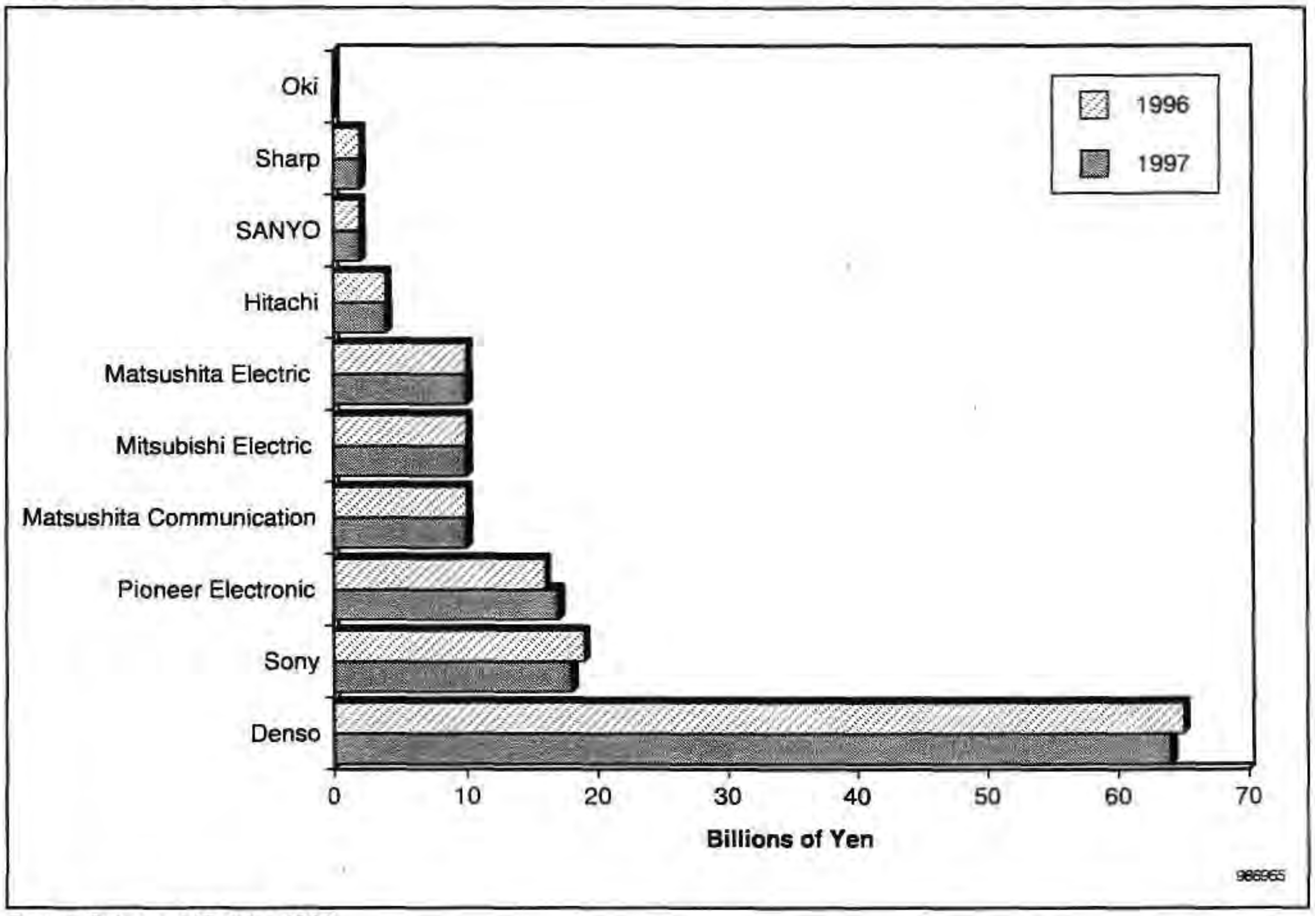
Figure 3-6
Japanese Semiconductor Purchase Ranking of Transportation Equipment, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Chapter 4
Japanese Semiconductor User Profiles

This section analyzes each of the major Japanese electronics companies as semiconductor users.

Canon Inc.

Canon is the world's leading manufacturer of cameras, and in the area of dedicated business systems, Canon's copier has a sizable share in the worldwide market. Also, Canon's coverage includes a lot of optical equipment; semiconductor manufacturing equipment, such as steppers; and computer peripherals, such as printers. About 40 percent of Canon's products are shipped to various export markets. Its domestic sales grew in segments such as computer peripherals; multifunctional products such as copiers, fax machines, and printers; and handy terminals.

Canon's production sites are concentrated in Japan and so is its semiconductor usage. In digital camcorders and cameras, Canon has made every effort to differentiate its products by incorporating ASICs with proprietary system function designs.

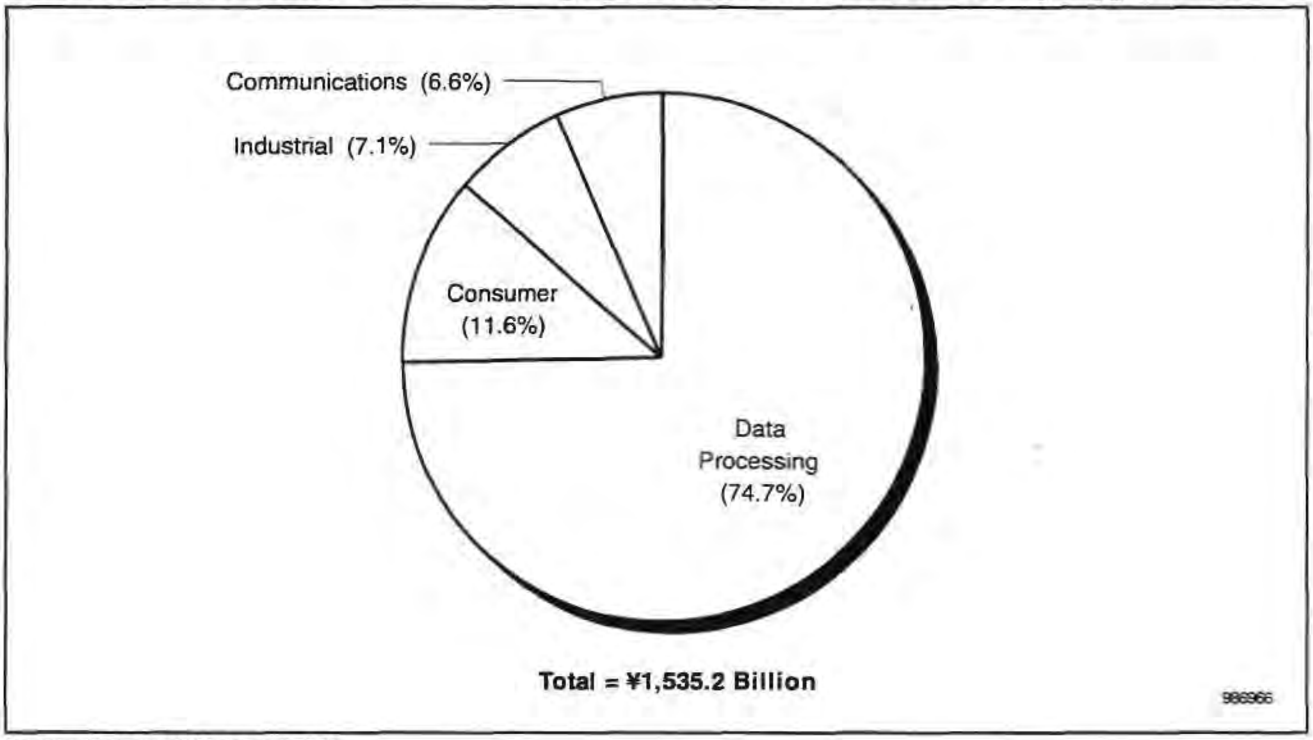
Table 4-1 shows Canon's major electronic products. Figures 4-1 through 4-3 show Canon's equipment production and semiconductor purchase trends. Computer peripherals, such as printers and scanners, and dedicated business equipment have large shares in Canon's semiconductor purchasing.

Table 4-1
Canon's Major Electronic Products

Application	Products
Data Processing	PCs, midrange computers, flexible disk drives, terminals, laser beam printers, other printers, word processors, calculators, copiers
Communications	Multifunction phones, fax machines
Consumer	Camcorders, cameras, digital still cameras
Industrial	Manufacturing systems, test and measuring equipment

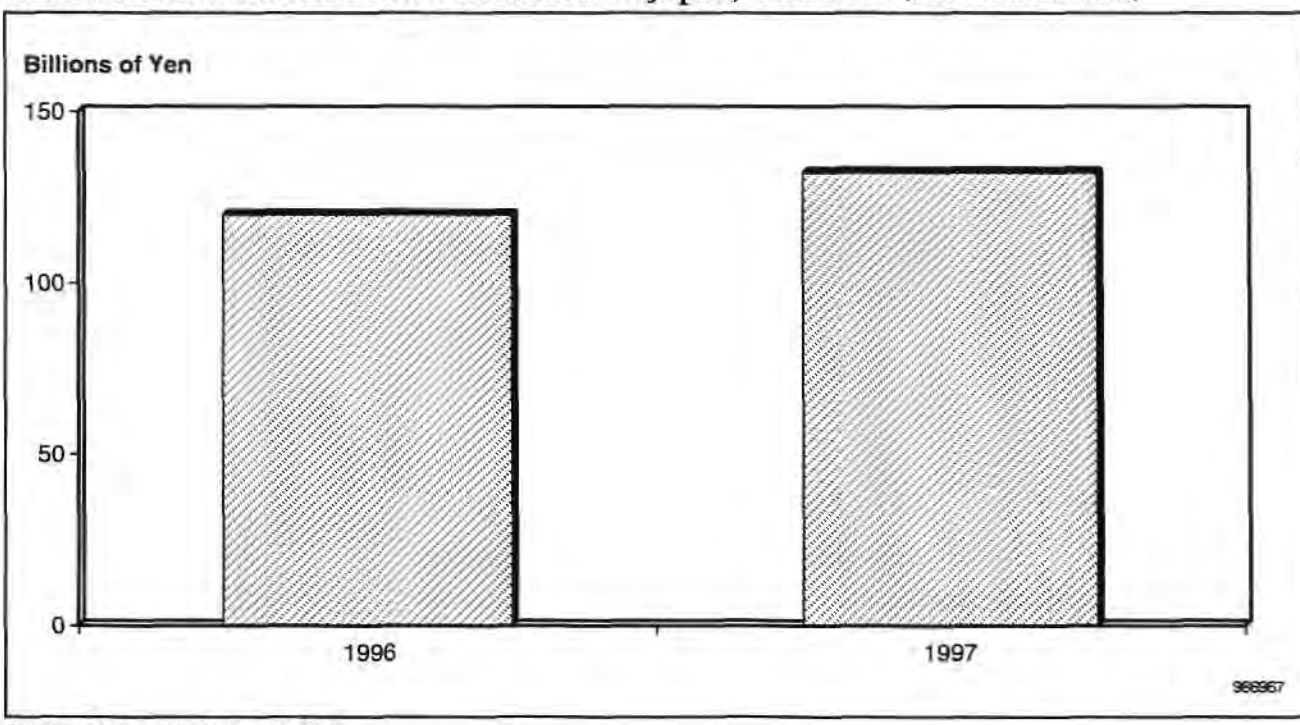
Source: Dataquest (October 1998)

Figure 4-1
Canon's 1997 Worldwide Electronic Equipment Production Revenue by Application



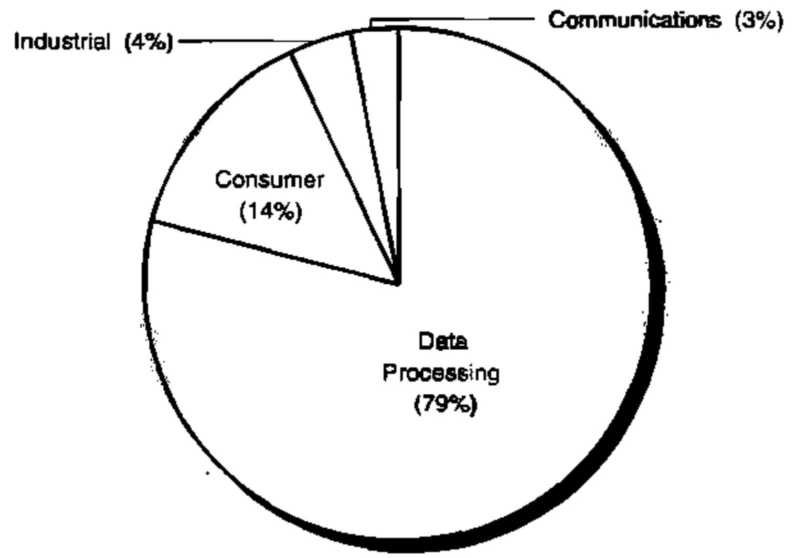
Source: Dataquest (October 1998)

Figure 4-2
Canon's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-3
Canon's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Casio Computer Company Ltd.

Casio was founded to develop and market purely electric calculators applying relays used in telephone exchange systems. Later, Casio diversified its product line to include desktop and portable calculators, electric watches and clocks, LCD TVs, DSCs, and electronic musical instruments. Consumer equipment production was responsible for 52 percent of Casio's revenue, of which a large portion came from the sales of watches/clocks. Another 41 percent came from the sales of data processing equipment, including calculators, handheld computers, and peripherals. Sales of data processing equipment grew in the private-use markets, but business-use products saw a decline in sales because of a drop in unit shipments as well as in selling prices. Exports grew to represent 40 percent of the total sales. Semiconductor purchasing experienced a mild decrease, which was partly influenced by the price cuts of semiconductor devices used in data processing equipment.

Table 4-2 shows Casio's major electronic products. Figures 4-4 through 4-6 show Casio's equipment production and semiconductor purchase trends.

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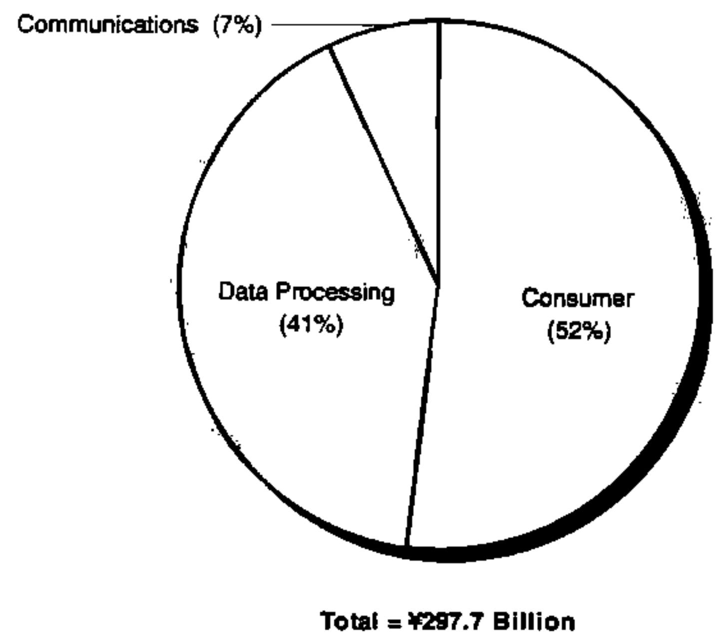
Table 4-2
Casio's Major Electronic Products

Application	Products
Data Processing	PCs, word processors, organizers, printers
Communications	PHSs
Consumer	Digital still cameras, TVs, watches

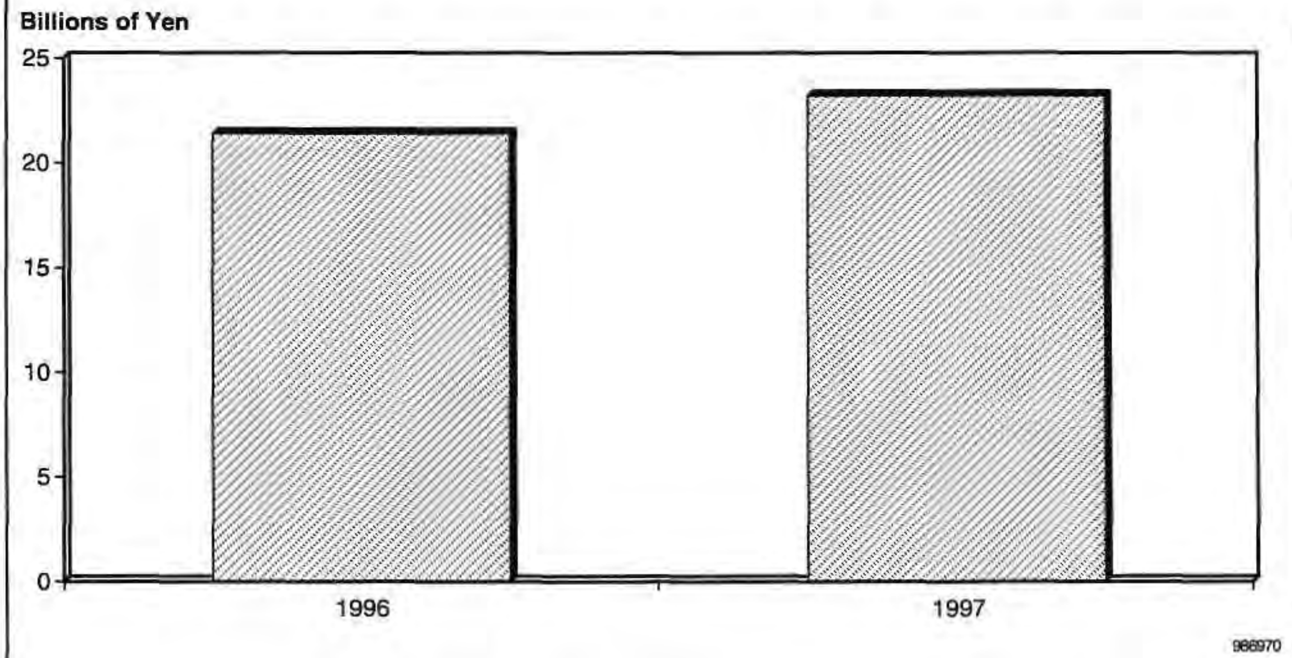
Source: Dataquest (October 1998)

Figure 4-4
Casio's 1997 Worldwide Electronic Equipment Production Revenue by Application



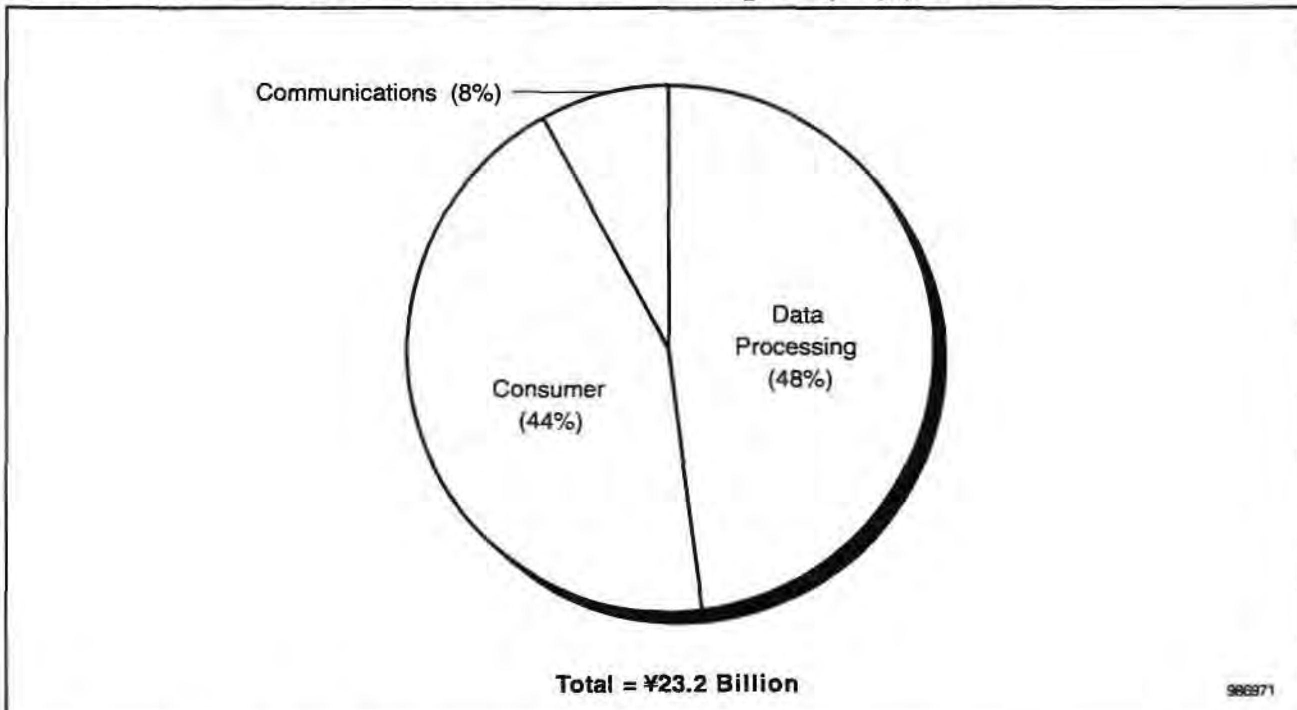
Source: Dataquest (October 1998)

Figure 4-5
Casio's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-6
Casio's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Denso Corporation

Car air conditioners represent one-third of Denso's revenue, having the largest share among all product lines. Another one-third is accounted for by all other automotive electronics. Although Denso is expanding its product lines to areas such as communications and appliances, sales in those areas are still comparatively small. Although car production still holds the key for Denso's overall production, the company has sought a wider customer base among worldwide car manufacturers, which has helped Denso's revenue growth to show steady trends. Semiconductor purchasing has amounted to about ¥73 billion, and 88 percent of this is for transportation equipment.

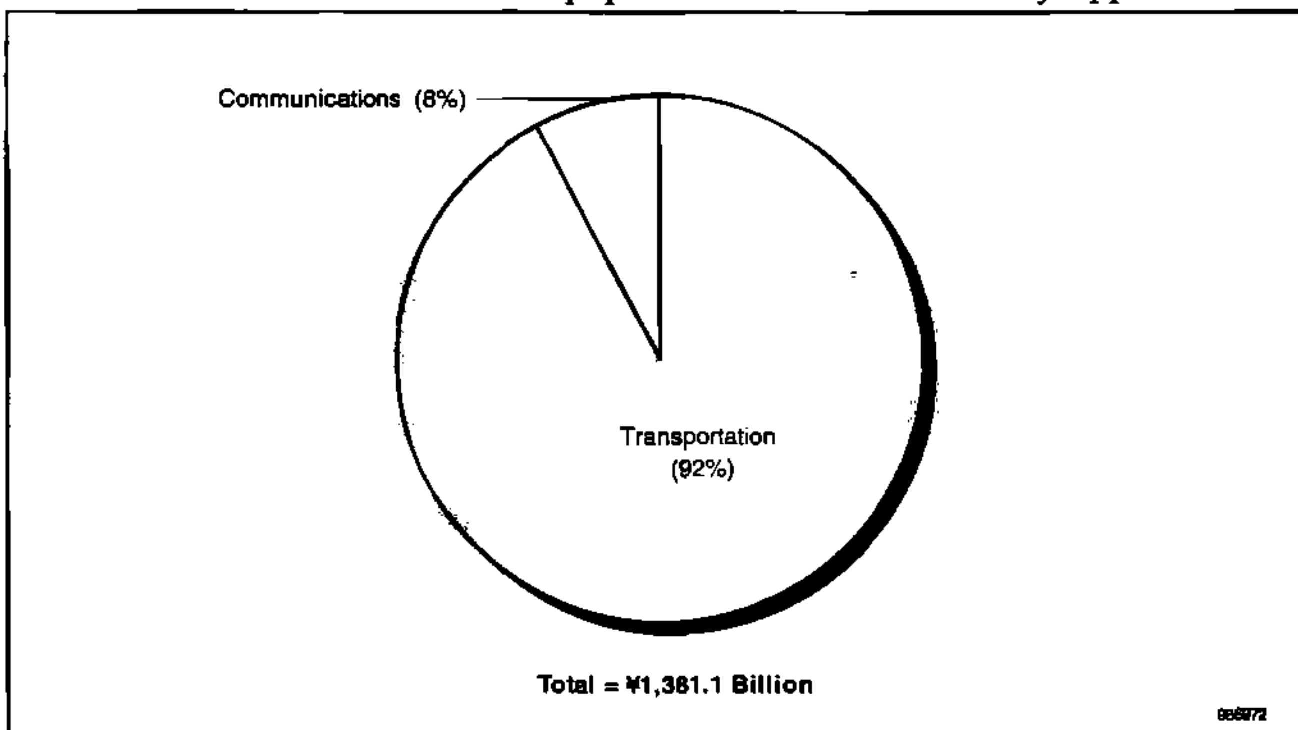
Table 4-3 shows Denso's major electronic products. Figures 4-7 through 4-9 show Denso's equipment production and semiconductor purchase trends.

Table 4-3
Denso's Major Electronic Products

Application	Products
Communications	Cellular phones
Transportation	Navigation systems, car stereos, auto ECUs, other automotive products

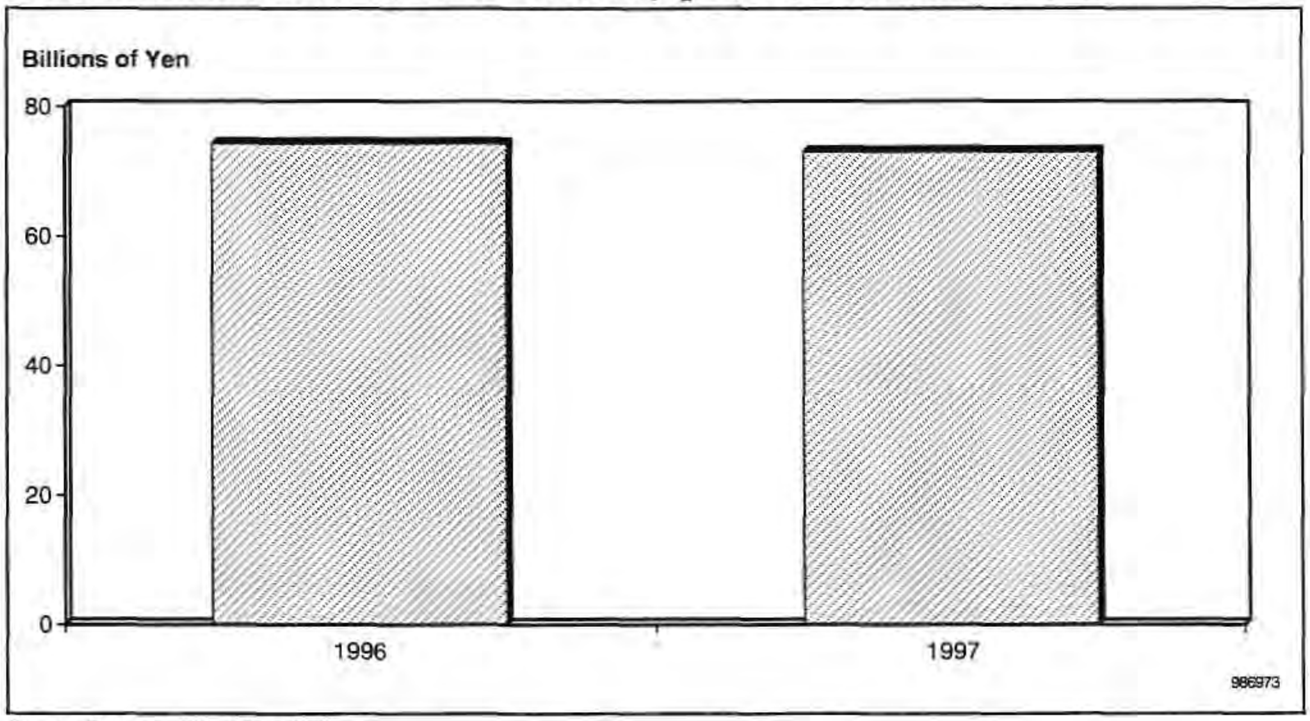
Source: Dataquest (October 1998)

Figure 4-7
Denso's 1997 Worldwide Electronic Equipment Production Revenue by Application



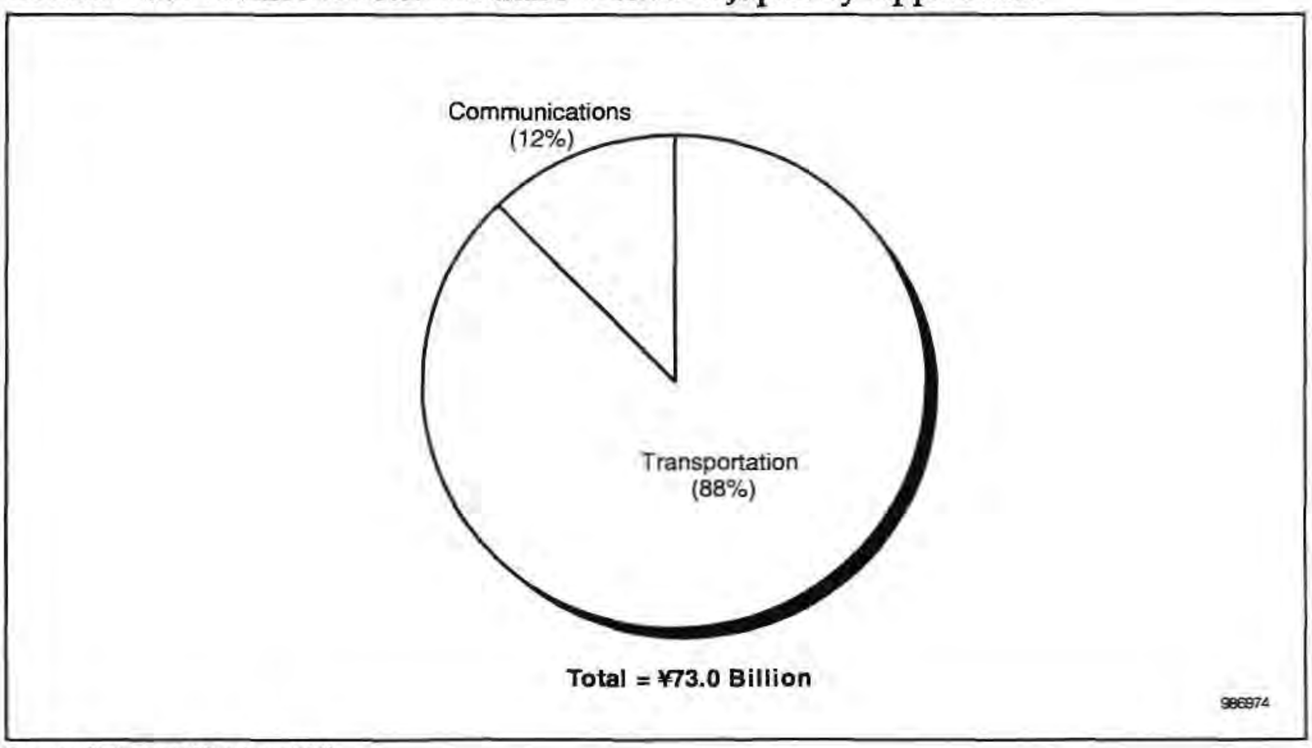
Source: Dataquest (October 1998)

Figure 4-8
Denso's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-9
Denso's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Fujitsu Ltd.

Fujitsu has traditionally been dependent on the domestic market. In 1997, however, while its domestic sales grew—helped by sound market share gains in PCs—its sales of data processing and communications equipment in the Americas and Europe grew rapidly, too, contributing to a decline in dependence on the Japanese market. About 70 percent of its semiconductor purchases are in the data processing area, while the communications segment is increasing its share because of increases in infrastructure business in mobile communications handsets and base stations.

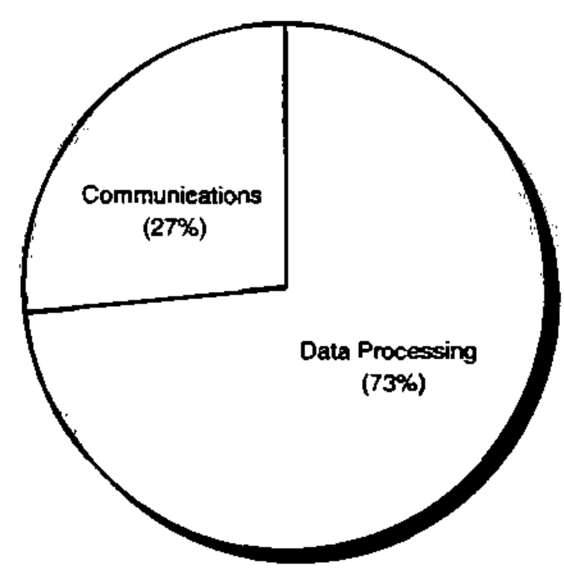
Table 4-4 shows Fujitsu's major electronic products. Figures 4-10 through 4-12 show Fujitsu's equipment production and semiconductor purchase trends.

Table 4-4
Fujitsu's Major Electronic Products

Application	Products
Data Processing	PCs, workstations, mainframe computers, midrange computers, rigid disk drives, displays, terminals, laser beam printers, other printers, word processors
Communications	Corded phones, cordless phones, multifunction phones, cellular phones, pagers, fax machines, modems, PBX equipment, transmission equipment, broadcast equipment

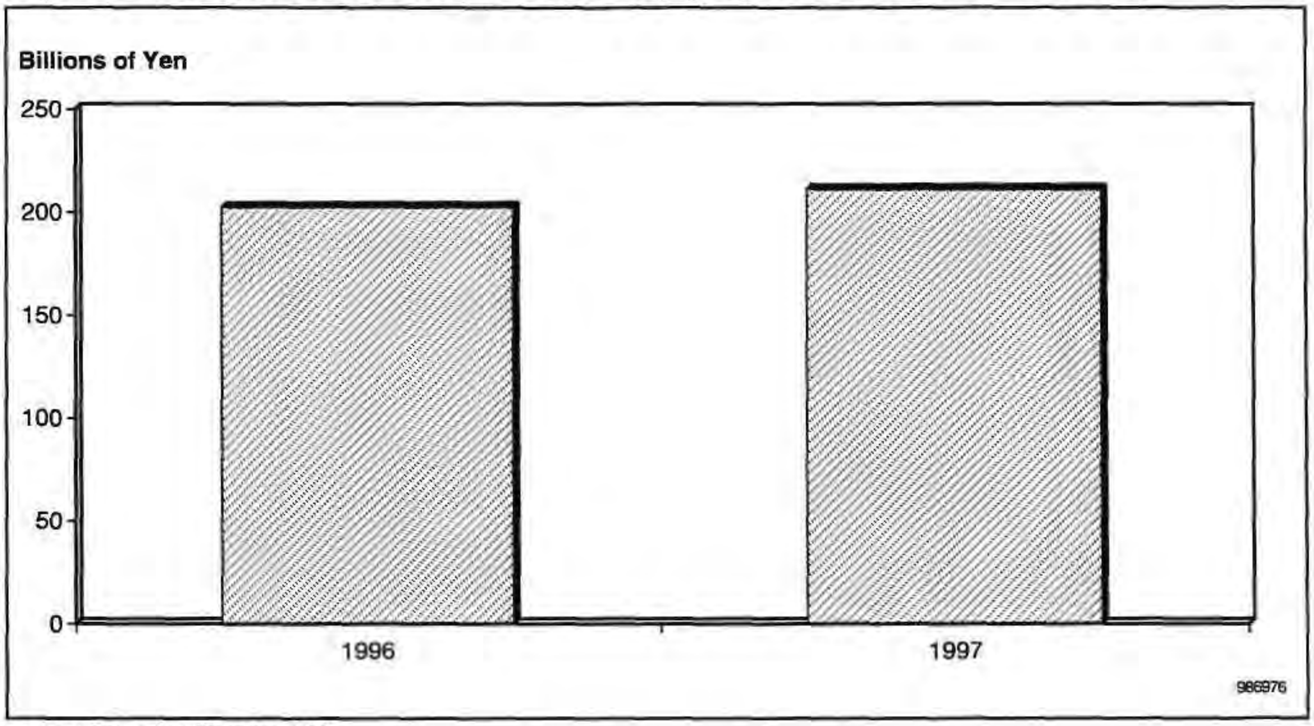
Source: Dataquest (October 1998)

Figure 4-10
Fujitsu's 1997 Worldwide Electronic Equipment Production Revenue by Application



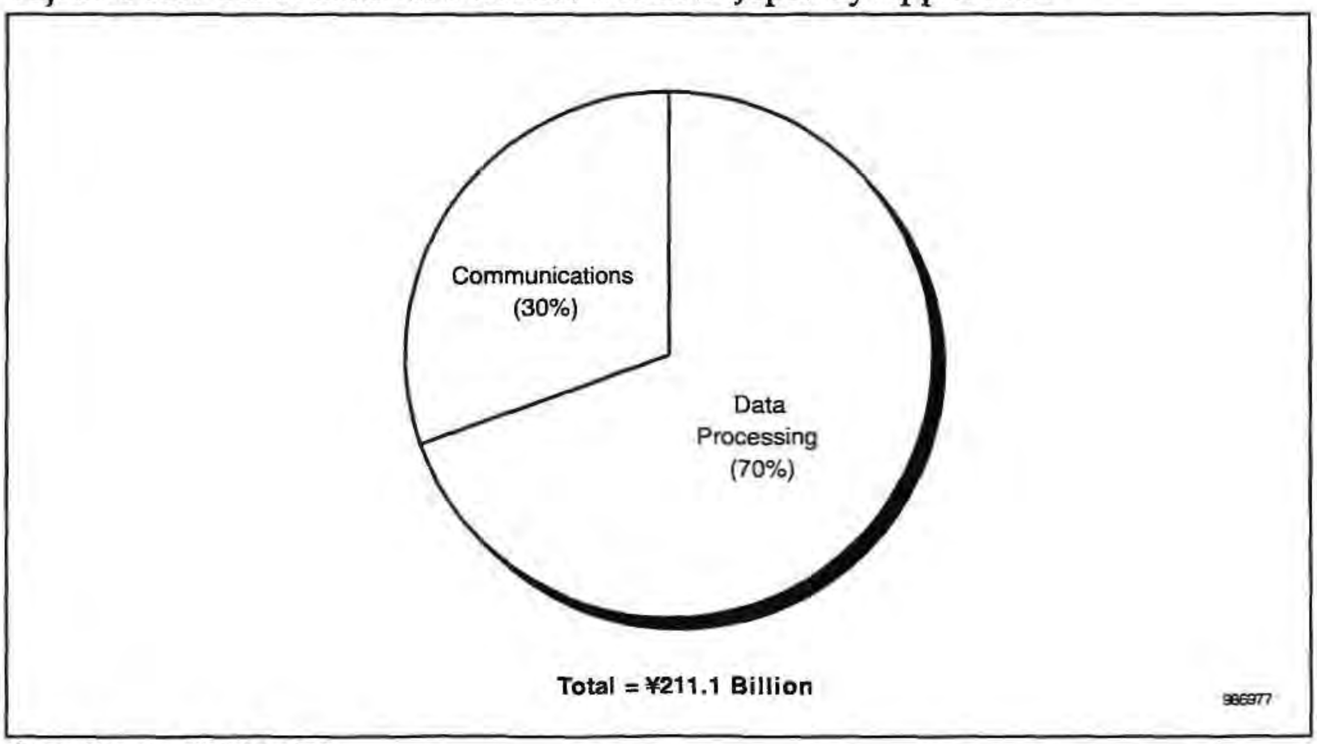
Source: Dataquest (October 1998)

Figure 4-11
Fujitsu's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-12
Fujitsu's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Hitachi Ltd.

Hitachi is a typical Japanese "general electric" company, having its basis on heavy-industry electric equipment and having a wide range of product offerings. Computers and communications are contributing to corporate profits. Data processing and communications products have large shares of semiconductor purchasing.

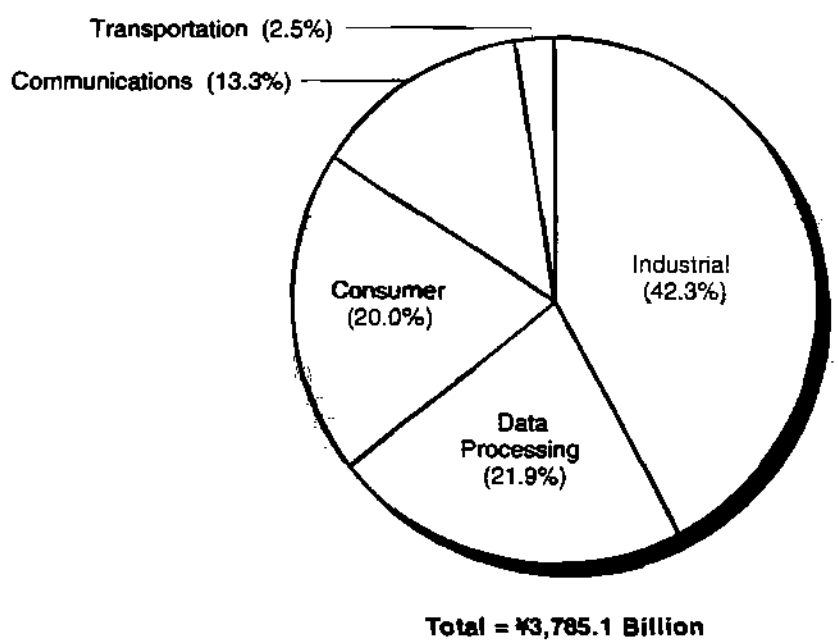
Table 4-5 shows Hitachi's major electronic products. Figures 4-13 through 4-15 show Hitachi's equipment production and semiconductor purchase trends.

Table 4-5
Hitachi's Major Electronic Products

Application	Products
Data Processing	PCs, workstations, mainframe computers, midrange computers, flexible disk drives, rigid disk drives, displays, terminals, laser beam printers, other printers, word processors, copiers
Communications	Corded phones, cordless phones, cellular phones, multifunction, faxes, modems, PBX equipment, transmission equipment, broadcast equipment
Consumer	TVs, set-top boxes, VCRs, camcorders, CD players, appliances
Industrial	Manufacturing systems, test and measuring equipment, medical equipment

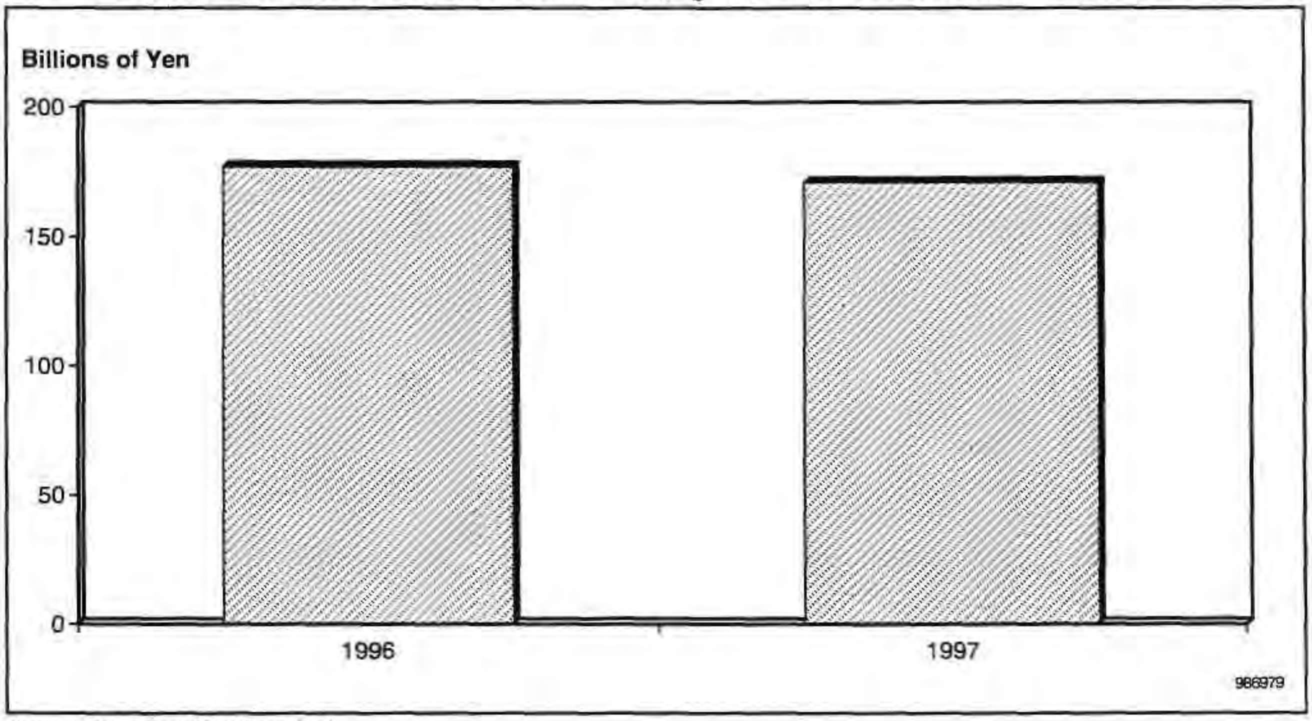
Source: Dataquest (October 1998)

Figure 4-13
Hitachi's 1997 Worldwide Electronic Equipment Production Revenue by Application



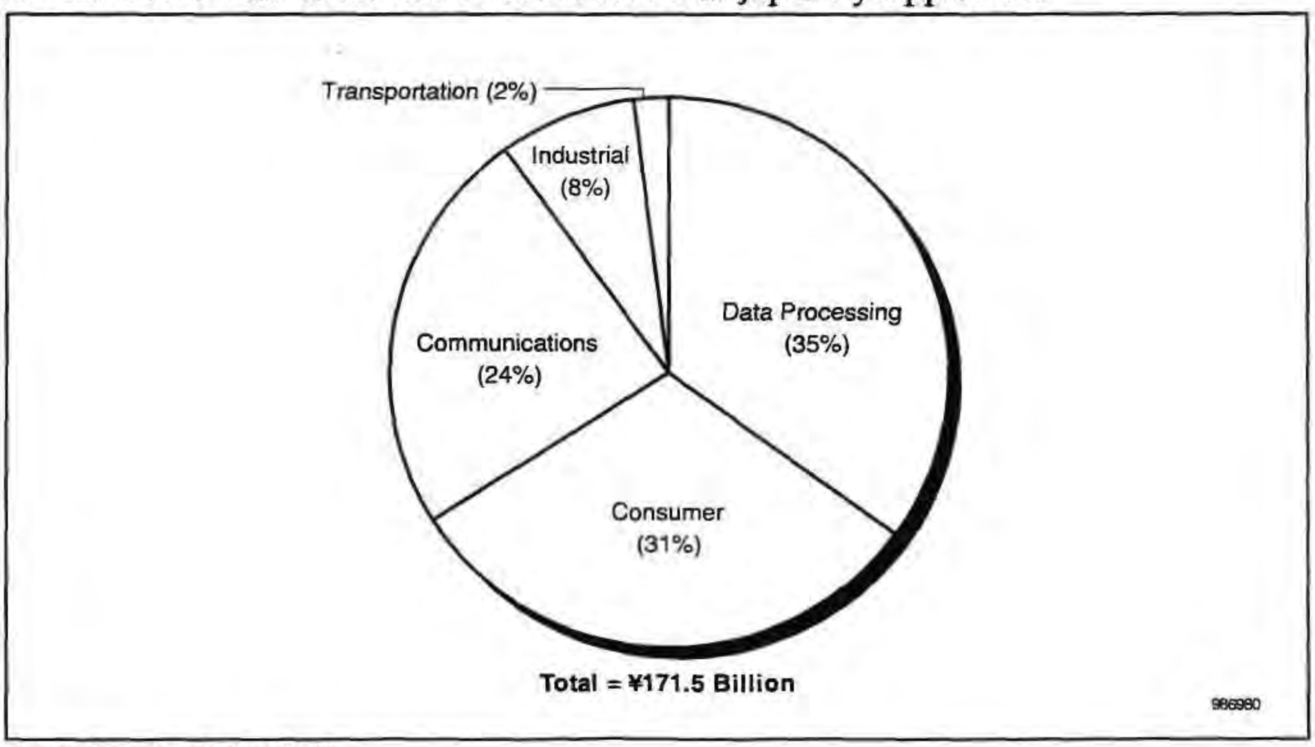
Source: Dataquest (October 1998)

Figure 4-14
Hitachi's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-15
Hitachi's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

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Kyushu Matsushita Electric Co. Ltd.

Kyushu Matsushita has focused on the data processing, communications, and industrial areas, including factory automation (FA) equipment. One-half of its products are exported, while cordless phones are increasing in production targeted at both the domestic and overseas markets. In the FA area, the company has a wide coverage, including chip mounters. The majority of its semiconductor purchasing is in communications and peripheral equipment for export markets.

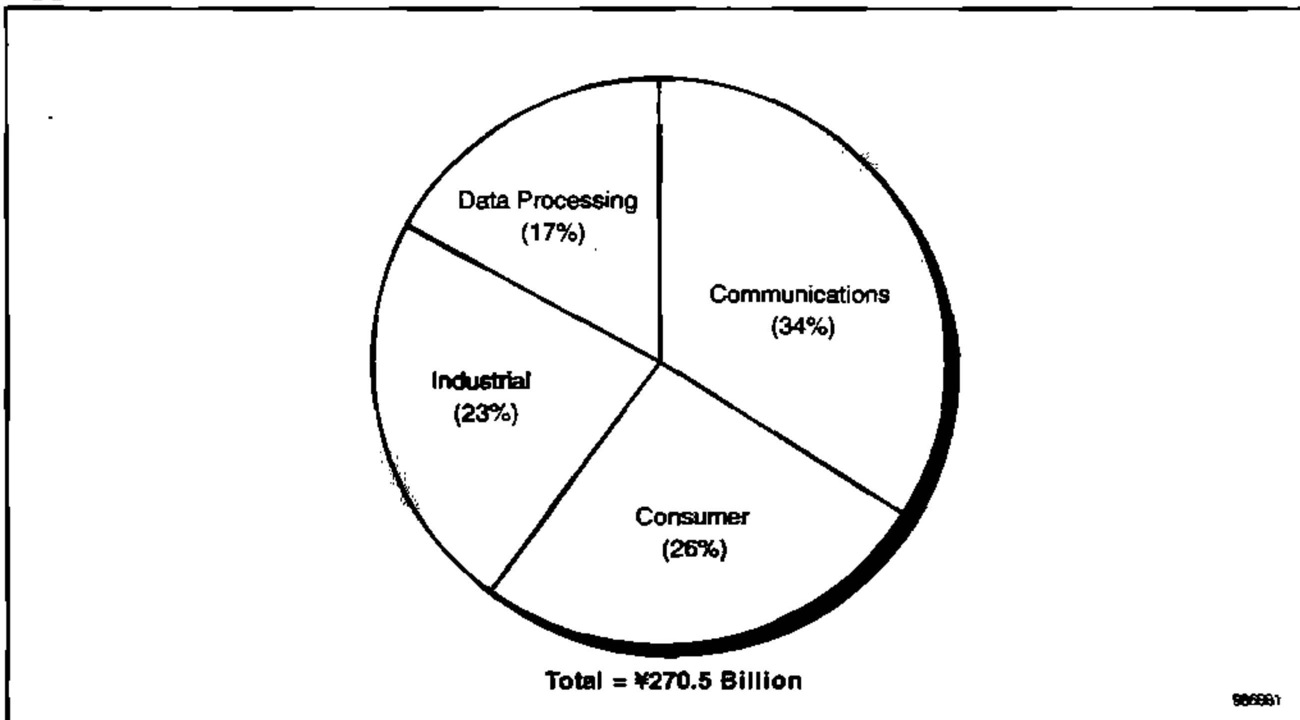
Table 4-6 shows Kyushu Matsushita's major electronic products. Figures 4-16 through 4-18 show Kyushu Matsushita's equipment production and semiconductor purchase trends.

Table 4-6
Kyushu Matsushita's Major Electronic Products

Application	Products
Data Processing	Laser beam printers, word processors
Communications	Corded phones, cordless phones, PHSs, fax machines
Transportation	Navigation equipment

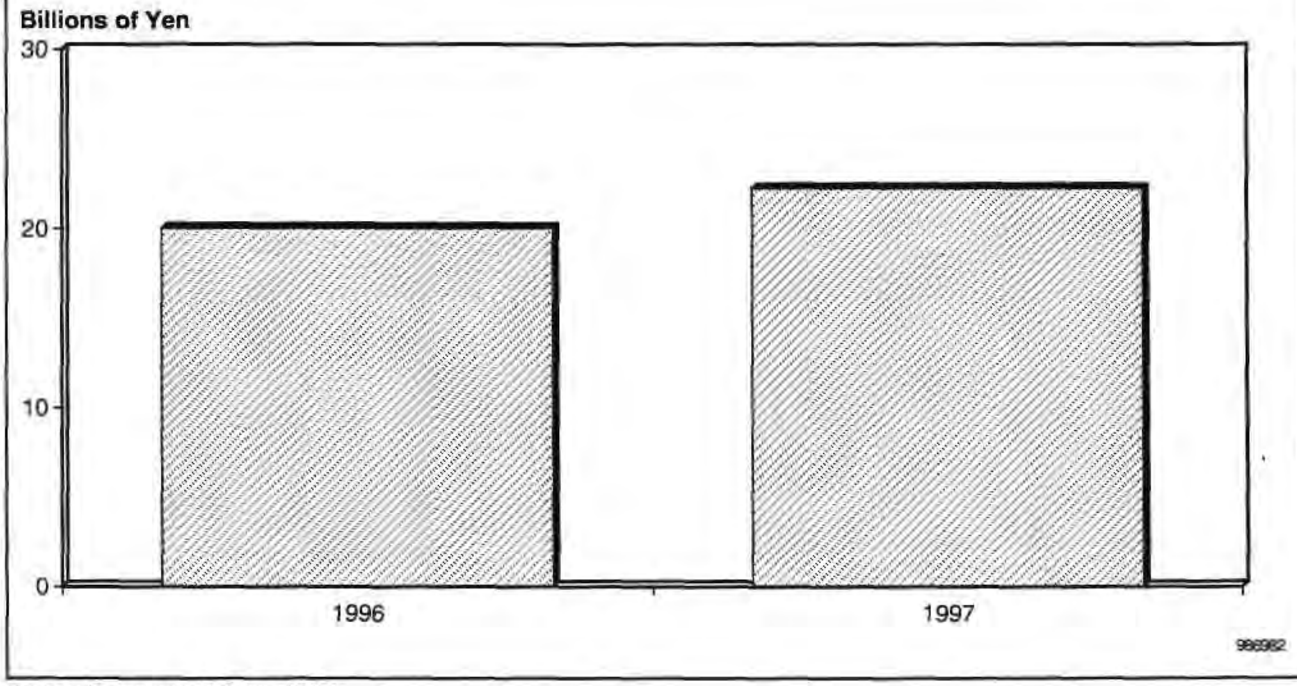
Source: Dataquest (October 1998)

Figure 4-16
Kyushu Matsushita's 1997 Worldwide Electronic Equipment Production Revenue by Application



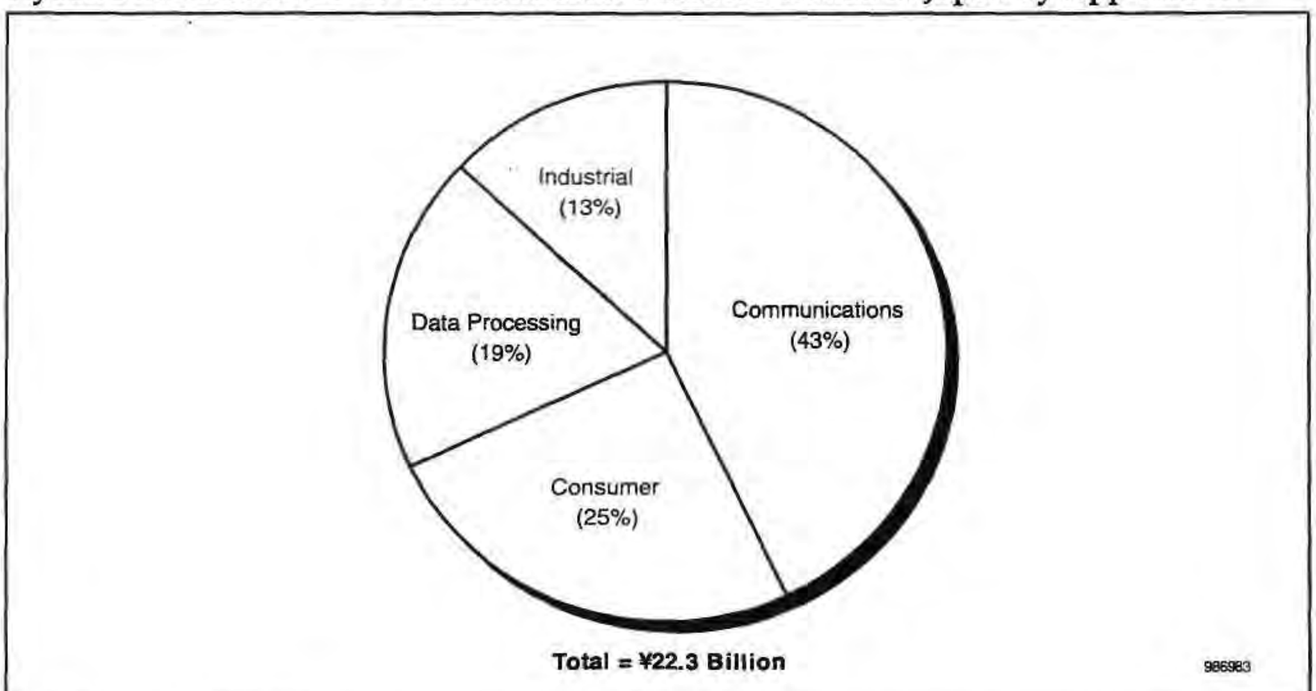
Source: Dataquest (October 1998)

Figure 4-17
Kyushu Matsushita's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-18
Kyushu Matsushita's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

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Matsushita Electric Industrial Company Ltd.

Matsushita Electric had a difficult year in 1997. In the consumer area, audio/video equipment experienced steady sales, helped by MD and digital video equipment, while the sales of appliances such as air conditioners and refrigerators decreased. On the other hand, communications equipment experienced an increase in revenue. Contributing to that growth were fax machines, cordless phones, PDCs, and broadcasting equipment that grew with increasing sales of the new digital video format (DVCPRO) products. The majority of Matsushita's semiconductor purchasing is in consumer applications, while the highest growth rate in its semiconductor purchasing was recorded in communications.

Table 4-7 shows Matsushita Electric's major electronic products. Figures 4-19 through 4-21 show Matsushita Electric's equipment production and semiconductor purchase trends.

Table 4-7
Matsushita Electric's Major Electronic Products

Application	Products
Data Processing	PCs, workstations, displays, terminals, printers, word processors, DVD-ROM/RAMs, CD-ROMs
Communications	Cordless phones, broadcasting equipment, fax machines
Consumer	TVs, set-top boxes, VCRs, camcorders, CD players, appliances, DVD players, minidiscs, digital video cameras, digital still cameras
Industrial	Manufacturing systems, test and measuring equipment
Transportation	Navigation systems, car stereos

Source: Dataquest (October 1998)

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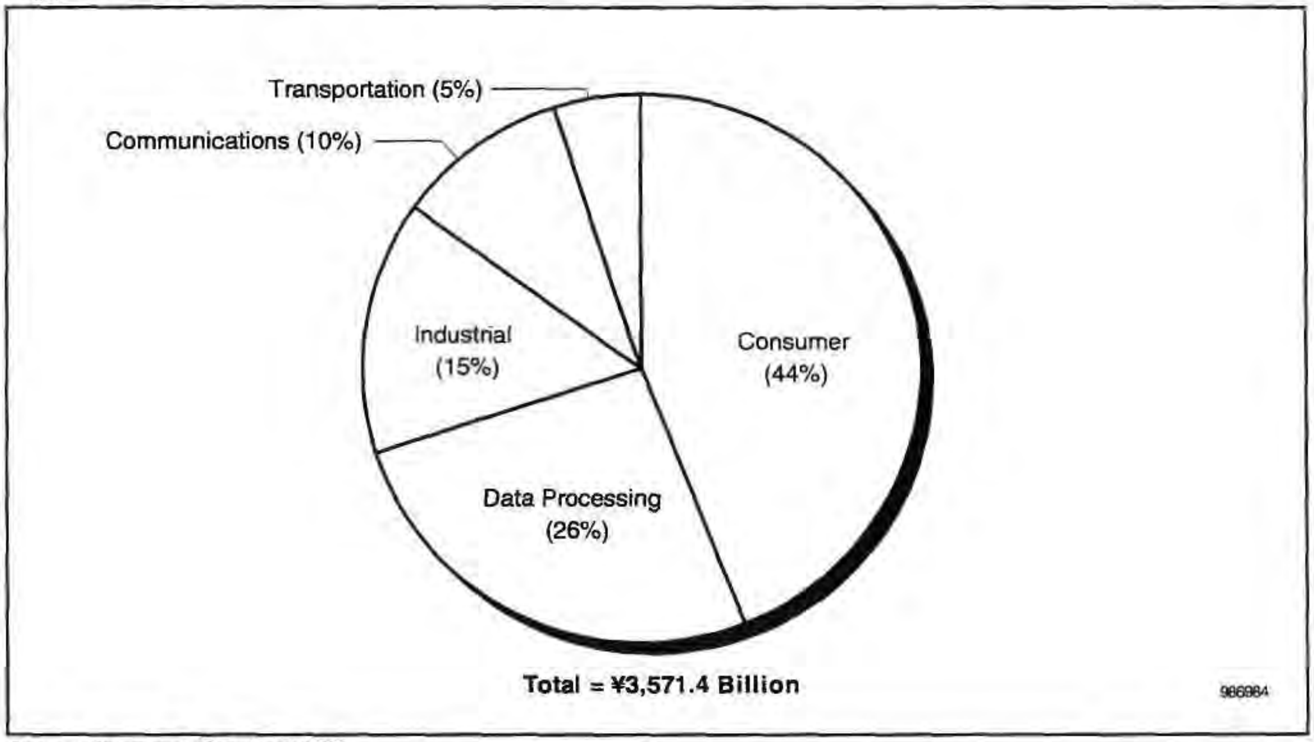
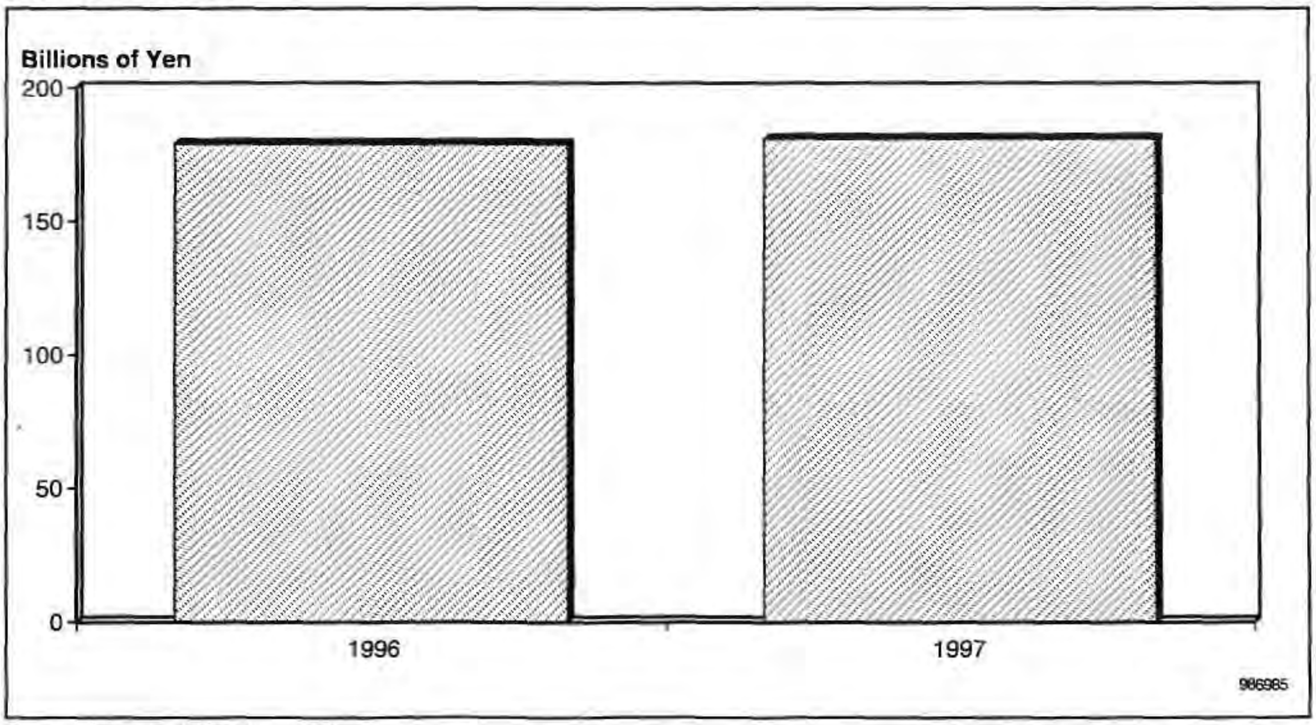
Figure 4-19
Matsushita Electric's 1997 Worldwide Electronic Equipment Production Revenue by Application



Source: Dataquest (October 1998)

Figure 4-20
Matsushita Electric's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

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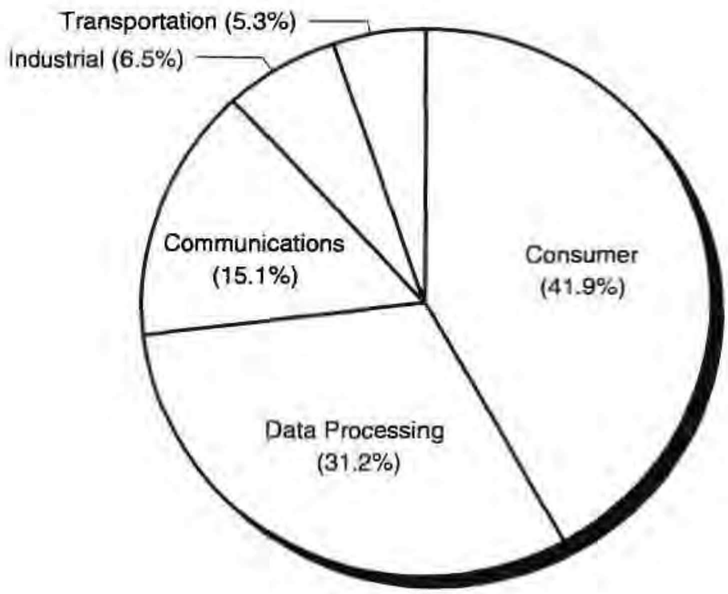
Figure 4-21
Matsushita Electric's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Matsushita Communication Industrial Co. Ltd.

Nearly one-half of Matsushita Communication's sales comes from communications equipment, including digital cellular phones for NTT DoCoMo. While the overall Japanese economy is in recession, Matsushita Communication's business has a clear focus on the growing sector of communications, showing a large increase in semiconductor purchasing, too.

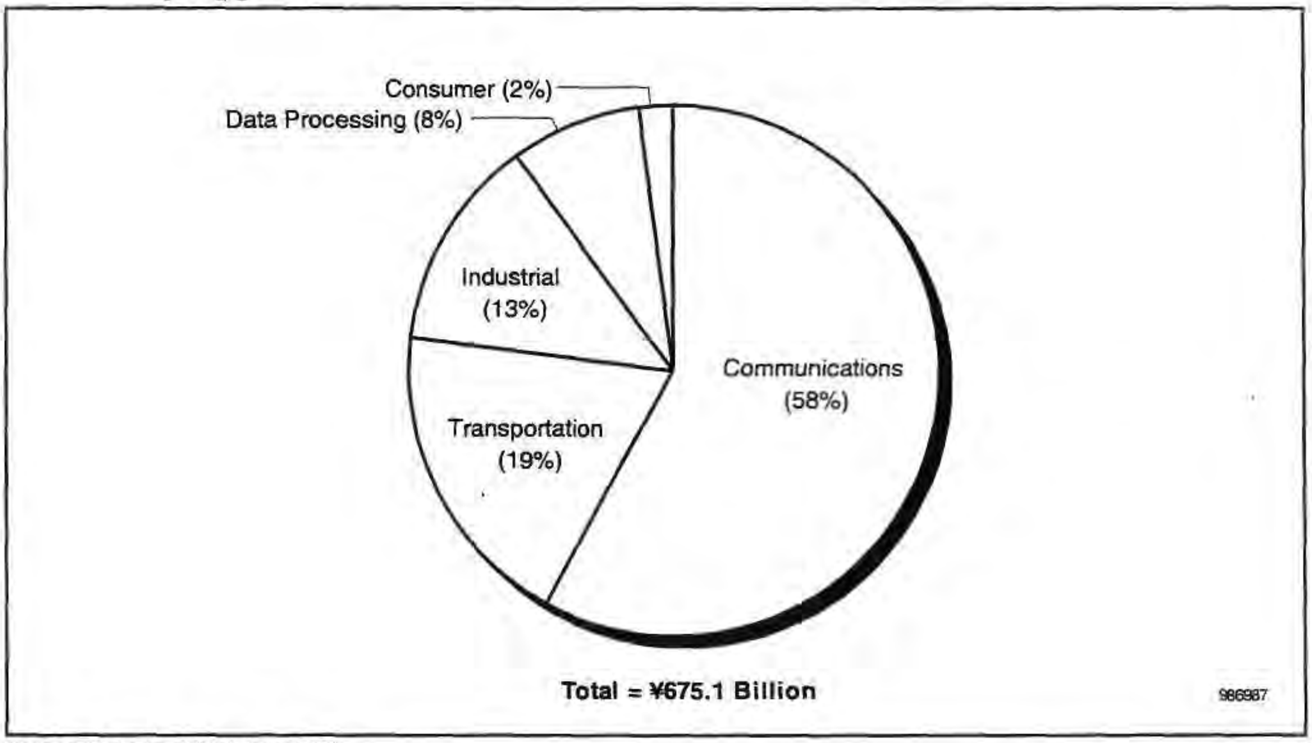
Table 4-8 shows Matsushita Communication's major electronic products. Figures 4-22 through 4-24 show Matsushita Communication's equipment production and semiconductor purchase trends.

Table 4-8
Matsushita Communication's Major Electronic Products

Application	Products
Data Processing	Flexible disk drives
Communications	Cordless phones, multifunction phones, PHSs, cellular phones, pagers, modems, PBX equipment, transmission equipment, broadcast equipment
Industrial	Test and measurement equipment
Transportation	Navigation systems, car stereos

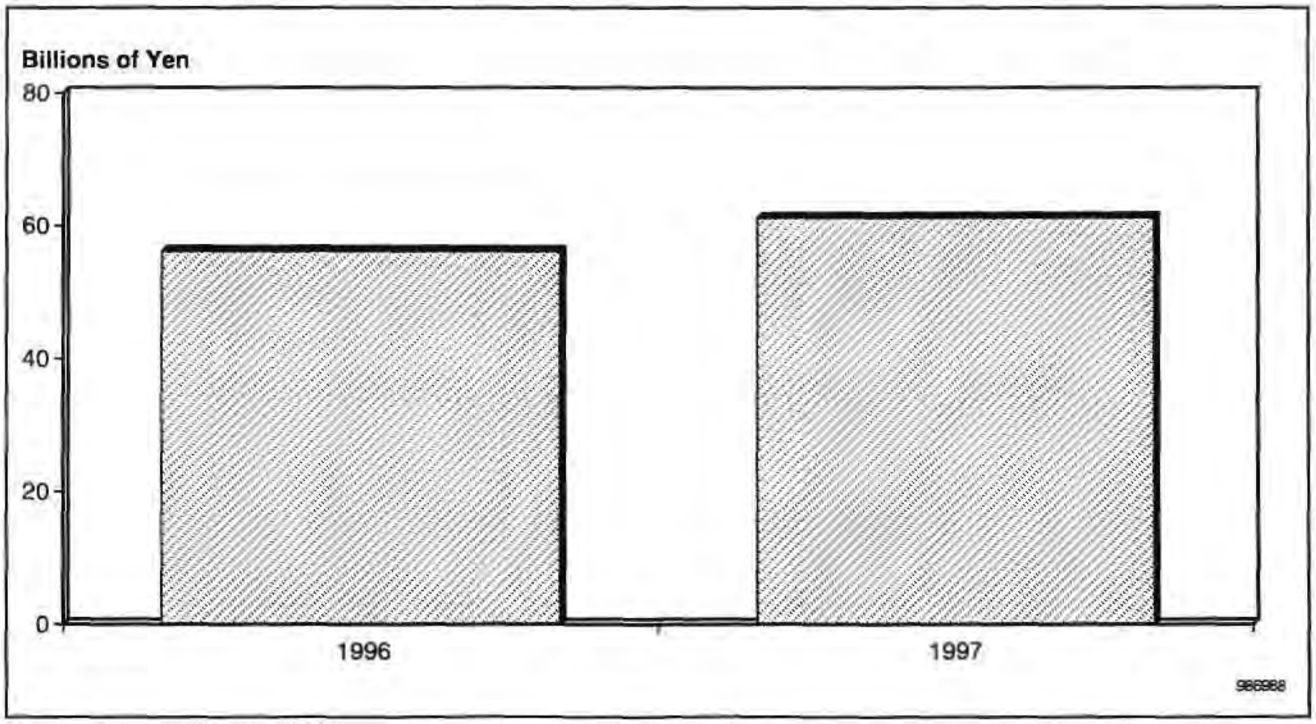
Source: Dataquest (October 1998)

Figure 4-22
Matsushita Communication's 1997 Worldwide Electronic Equipment Production Revenue by Application



Source: Dataquest (October 1998)

Figure 4-23
Matsushita Communication's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

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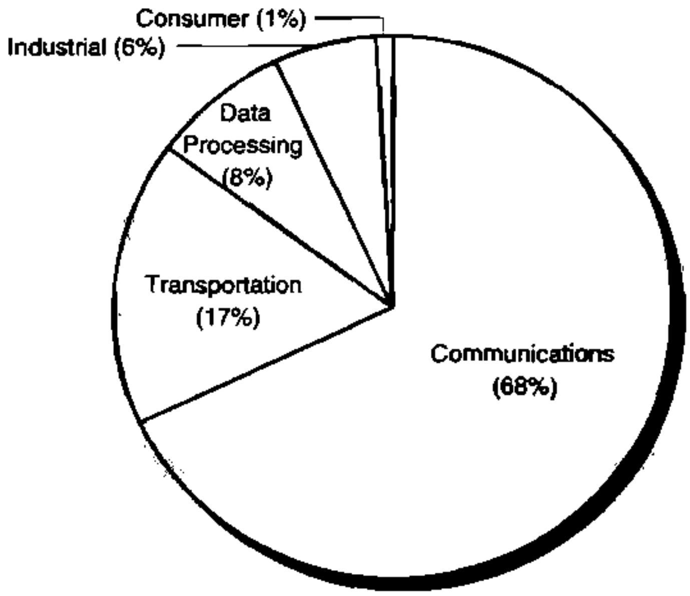
Figure 4-24
Matsushita Communication's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Matsushita Kotobuki Electronics Industries Ltd.

Matsushita Kotobuki has strength in storage devices such as CD-ROM, CD-R, and the emerging DVD-RAM, as well as in consumer appliances and industrial equipment. The majority of its semiconductor purchasing is in consumer equipment.

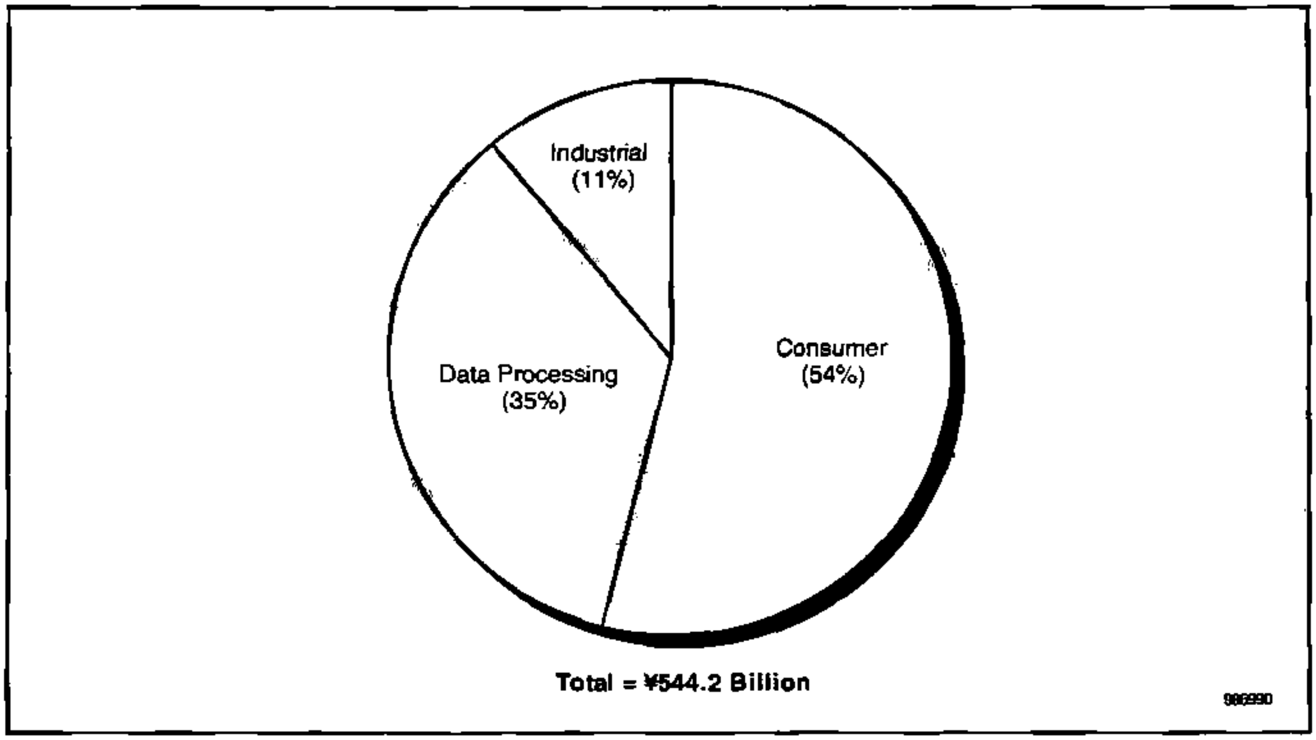
Table 4-9 shows Matsushita Kotobuki's major electronic products. Figures 4-25 through 4-27 show Matsushita Kotobuki's equipment production and semiconductor purchase trends.

Table 4-9
Matsushita Kotobuki's Major Electronic Products

Application	Products
Data Processing	Rigid disk drives, CD-ROMs
Consumer	TVs, VCRs, camcorders, CD players
Industrial	Manufacturing systems

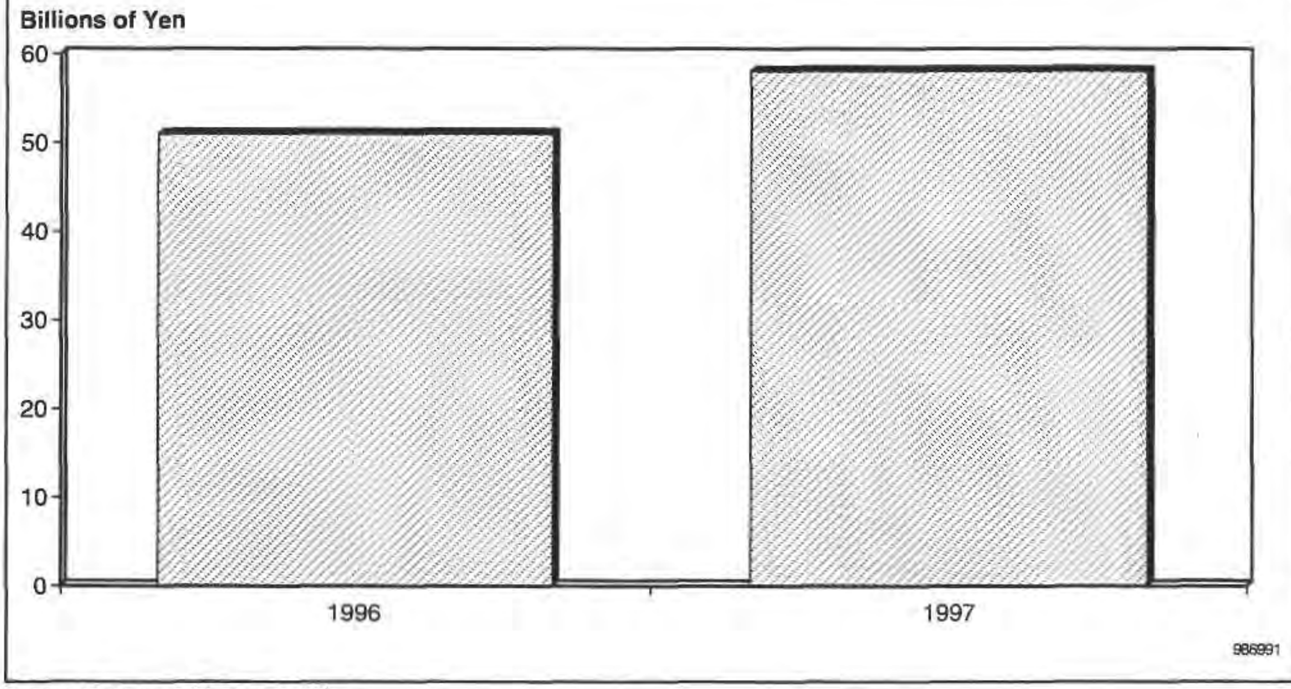
Source: Dataquest (October 1998)

Figure 4-25
Matsushita Kotobuki's 1997 Worldwide Electronic Equipment Production Revenue by Application



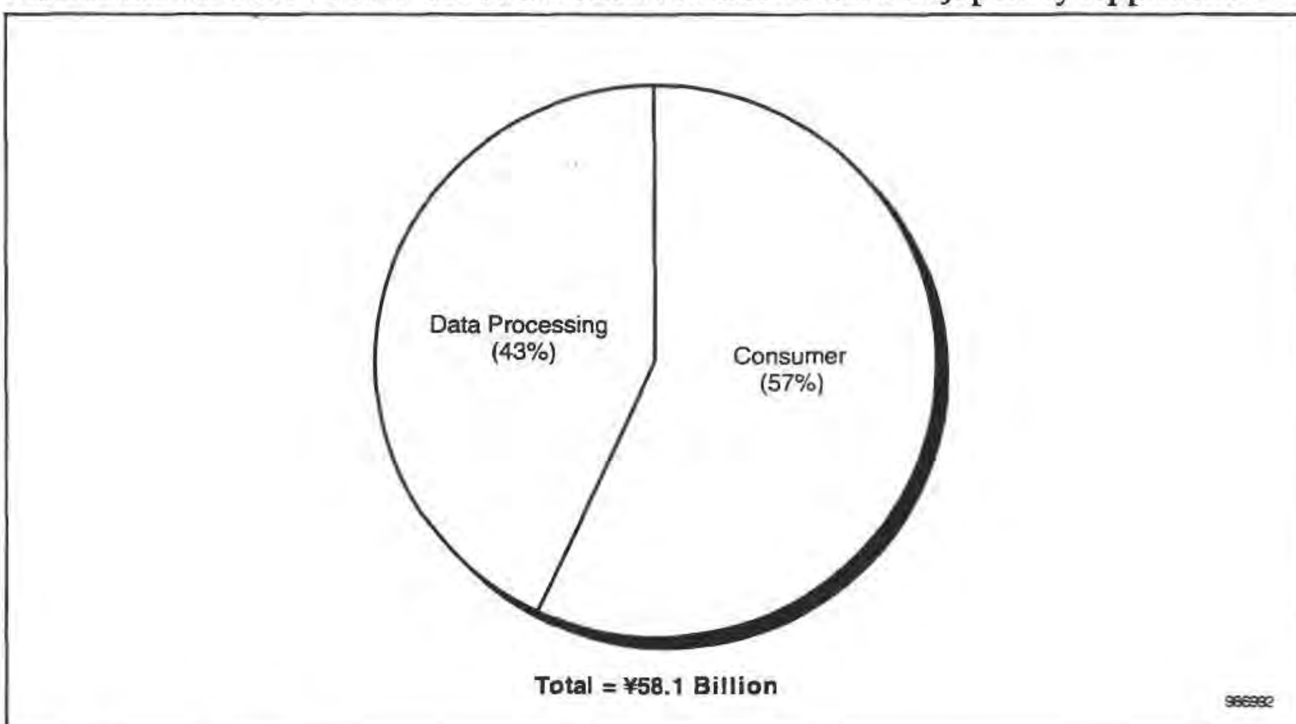
Source: Dataquest (October 1998)

Figure 4-26
Matsushita Kotobuki's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-27
Matsushita Kotobuki's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

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Mitsubishi Electric Corporation

Mitsubishi Electric is the third-largest "general electric" company in Japan; its products range from data processing, communications, and consumer, to heavy electric and industrial products. It experienced growth in wired communications and data processing, helped by the systems integration business. However, the decline in sales in appliances, heavy electric products, and industrial products brought the overall sales down. Data processing has the largest share of semiconductor purchasing, while the largest gain was seen in communications and the largest loss was felt in the consumer segment.

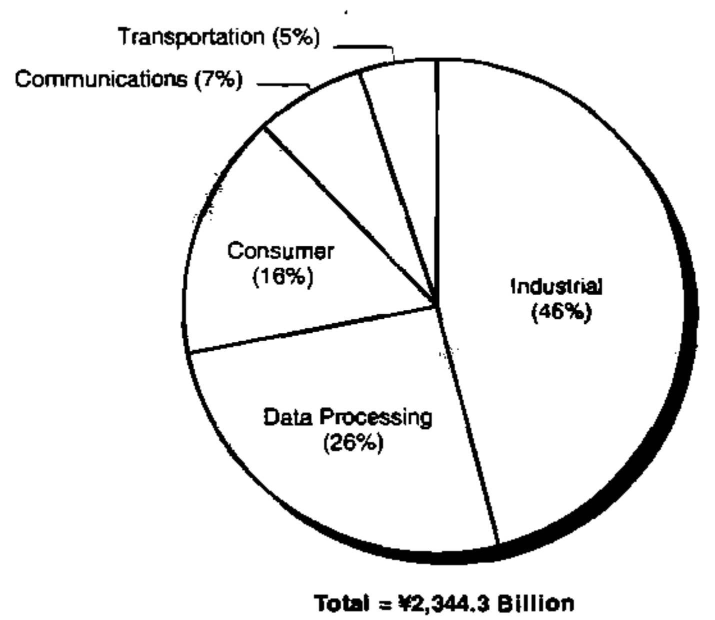
Table 4-10 shows Mitsubishi Electric's major electronic products. Figures 4-28 through 4-30 show Mitsubishi Electric's equipment production and semiconductor purchase trends.

Table 4-10
Mitsubishi Electric's Major Electronic Products

Application	Products
Data Processing	PCs, midrange computers, flexible disk drives, displays, terminals, laser beam printers, other printers, word processors, calculators
Communications	Corded phones, cordless phones, PHSs, cellular phones, pagers, fax machines, modems, transmission equipment, broadcast equipment
Consumer	TVs, VCRs, camcorders, CD players, appliances
Industrial	Manufacturing systems, test and measuring equipment, medical equipment
Transportation	Navigation systems, car stereos

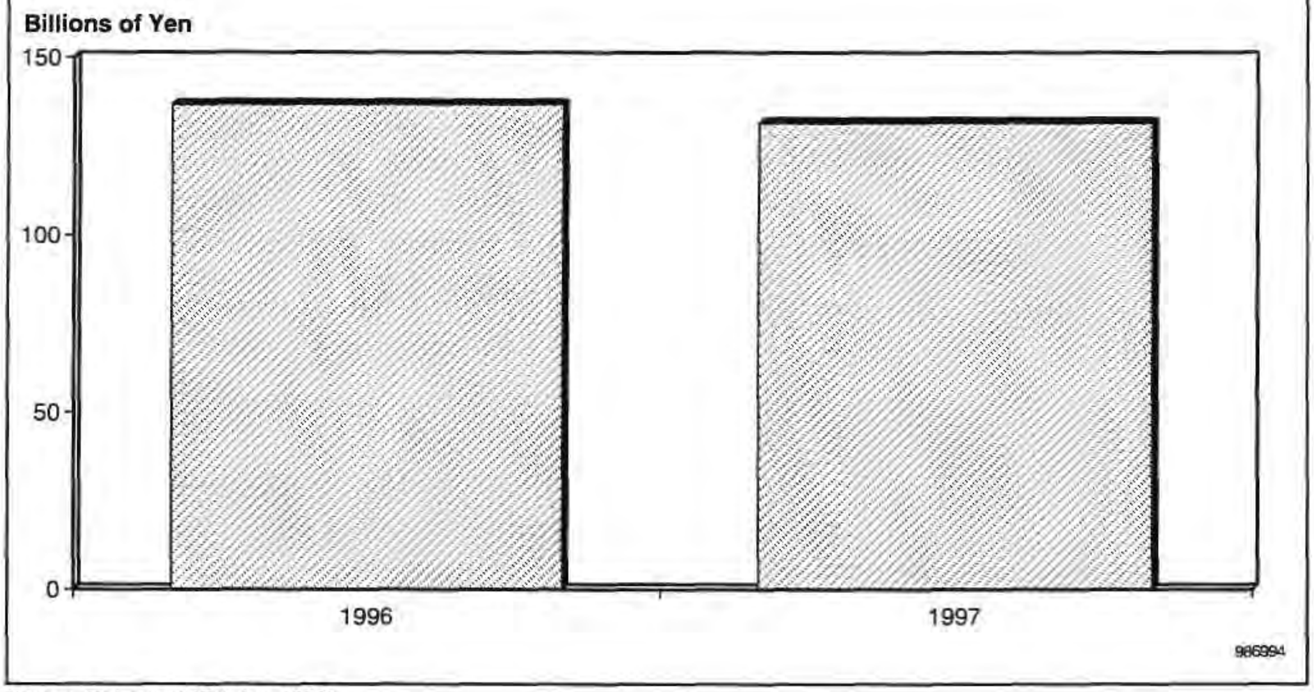
Source: Dataquest (October 1998)

Figure 4-28
Mitsubishi Electric's 1997 Worldwide Electronic Equipment Production Revenue by Application



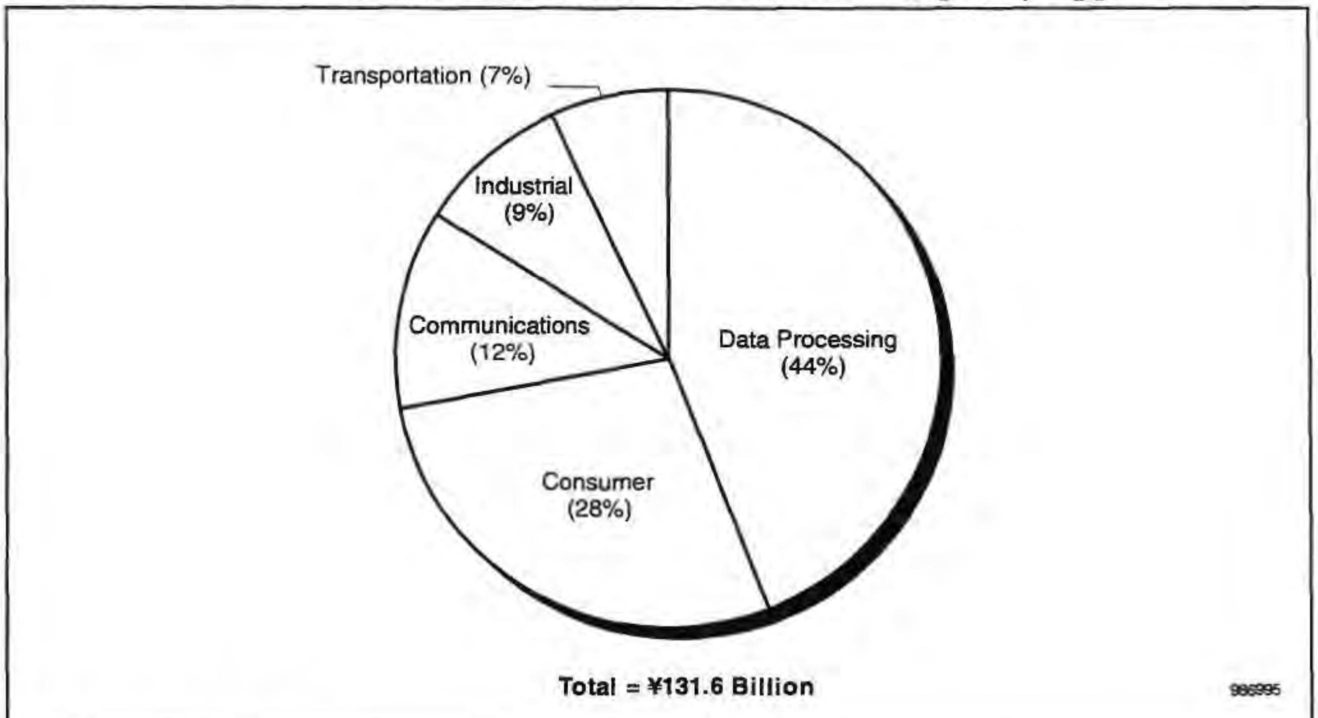
Source: Dataquest (October 1998)

Figure 4-29
Mitsubishi Electric's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-30
Mitsubishi Electric's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

NEC Corporation

NEC's core business has been in the communications area, while it leads the Japanese computer industry as well. The infrastructure equipment market in various Asian countries brought increases in communications equipment production and sales as well as in domestic NTT infrastructure equipment production. NEC was positioned as the second-largest company in terms of Japanese digital cellular phone market share in 1997.

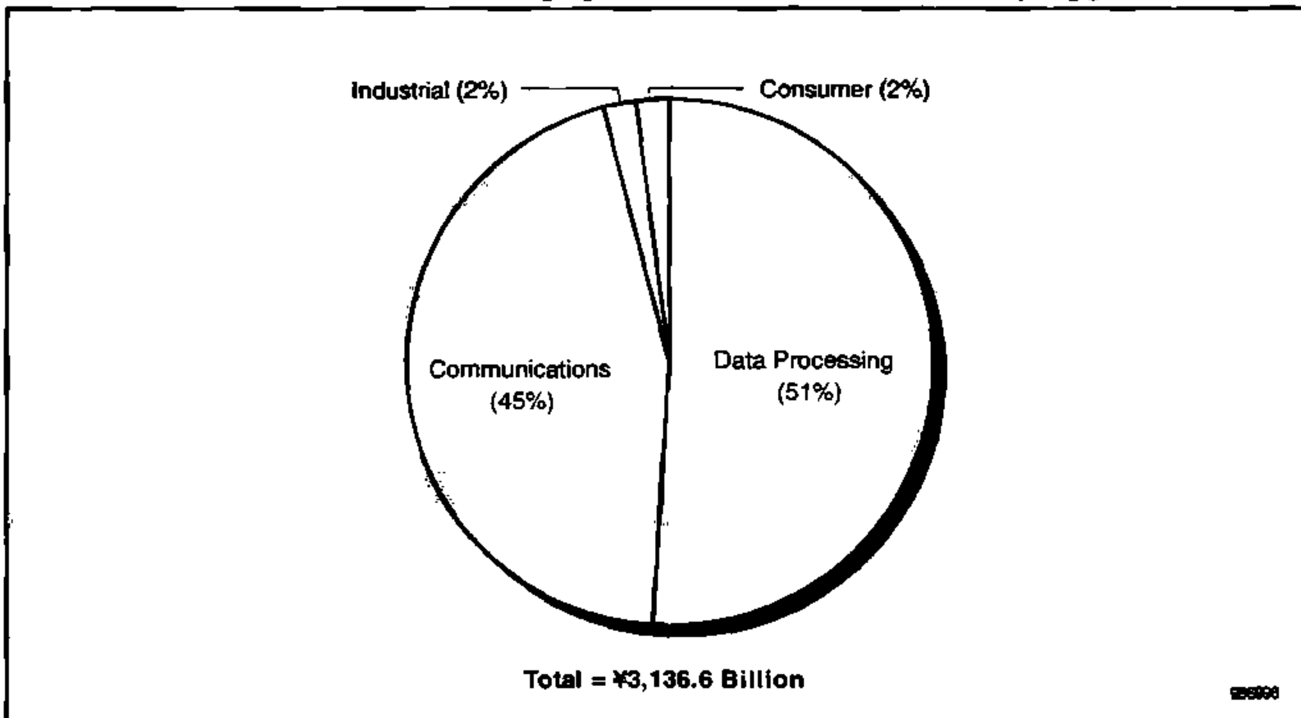
Table 4-11 shows NEC's major electronic products. Figures 4-31 through 4-33 show NEC's equipment production and semiconductor purchase trends.

Table 4-11
NEC's Major Electronic Products

Application	Products
Data Processing	PCs, workstations, mainframe computers, midrange computers, flexible disk drives, rigid disk drives, displays, terminals, laser beam printers, other printers, word processors
Communications	Corded phones, cordless phones, multifunction phones, PHSs, cellular phones, pagers, fax machines, modems, PBX equipment, transmission equipment, broadcast equipment
Industrial	Manufacturing systems, test and measuring equipment

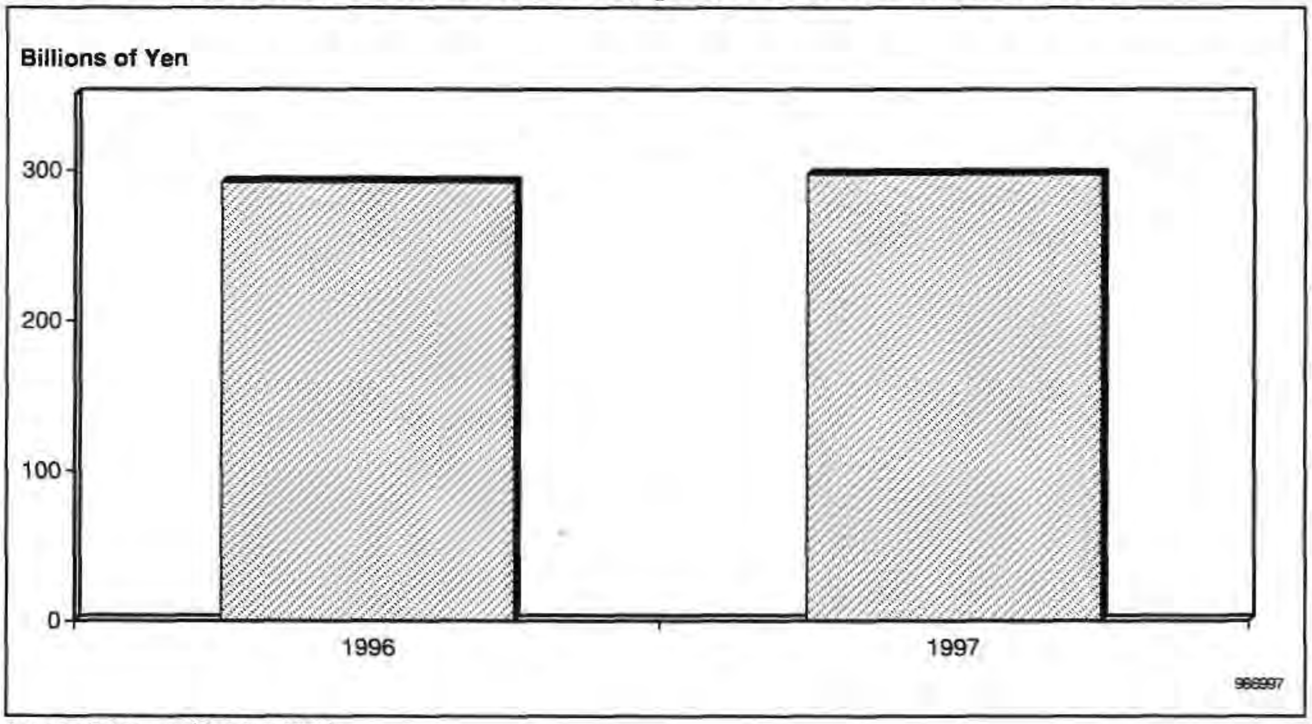
Source: Dataquest (October 1998)

Figure 4-31
NEC's 1997 Worldwide Electronic Equipment Production Revenue by Application



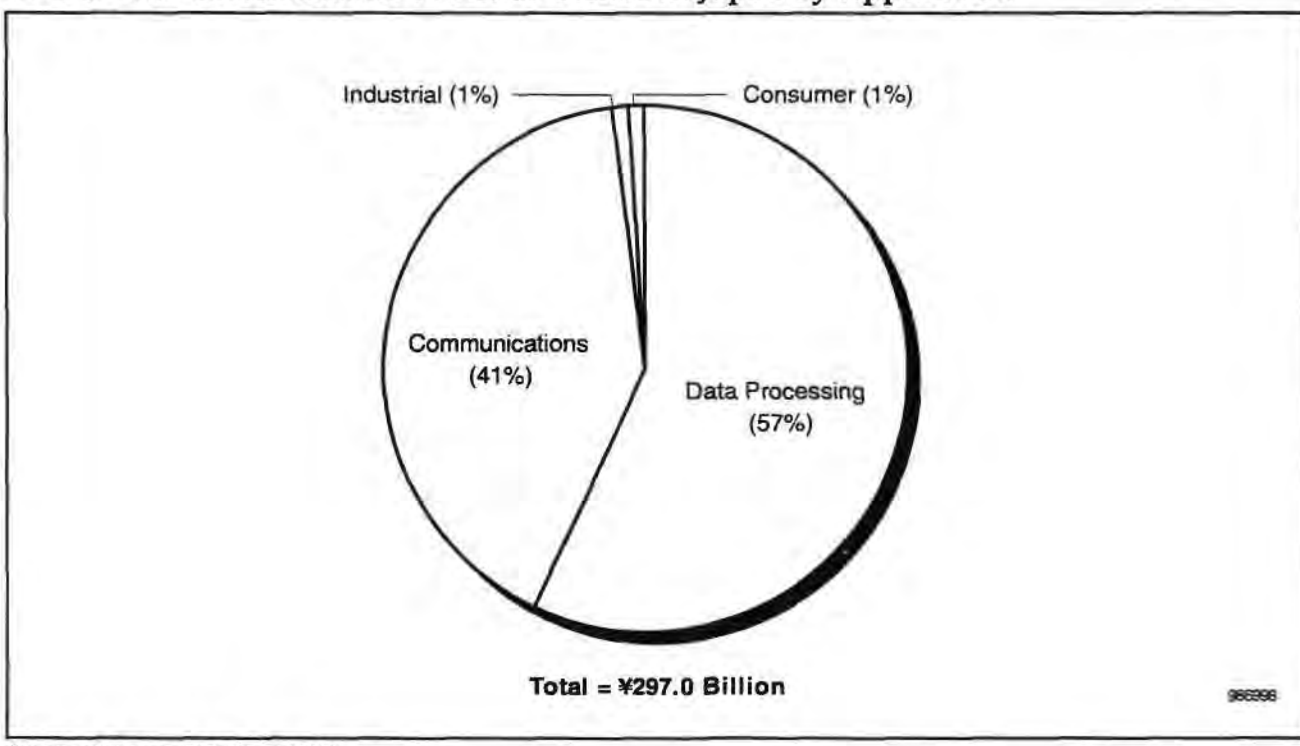
Source: Dataquest (October 1998)

Figure 4-32
NEC's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-33
NEC's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Nintendo Corporation

Nintendo boasts a wide range of product offerings in game machines, including the 8-bit Game Boy, 16-bit Super Famicon, and 64-bit Nintendo64. In particular, 8-bit machines have experienced constant expansion in market, with their portability and inexpensive pricing. Nintendo's TV games have fared better in export markets such as the United States than in the domestic market, but Nintendo's overall exports are still small in volume. Semiconductor purchasing rose because of production increases of Nintendo64s and 8-bit Game Boys with popular games such as "Pocket Monster."

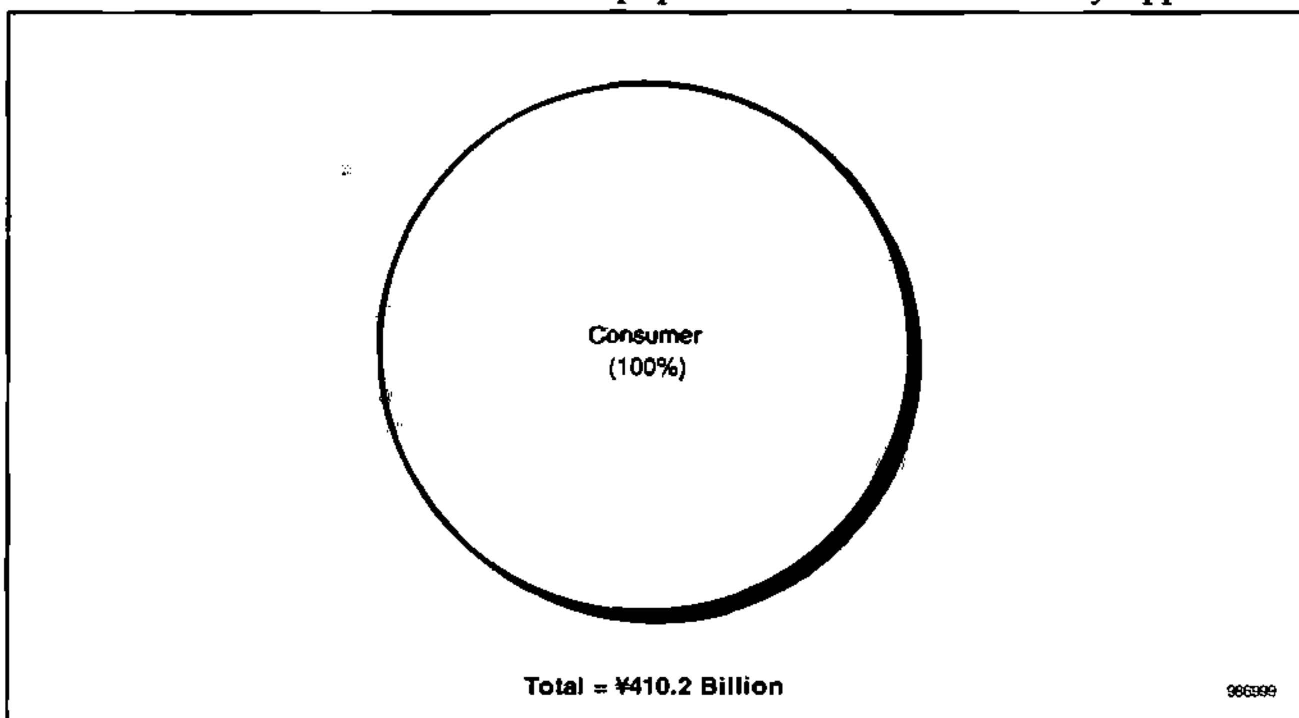
Table 4-12 shows Nintendo's major electronic products. Figures 4-34 through 4-36 show Nintendo's equipment production and semiconductor purchase trends.

Table 4-12
Nintendo's Major Electronic Products

Application	Products
Consumer	Game controllers, game cartridges

Source: Dataquest (October 1998)

Figure 4-34
Nintendo's 1997 Worldwide Electronic Equipment Production Revenue by Application



Source: Dataquest (October 1998)

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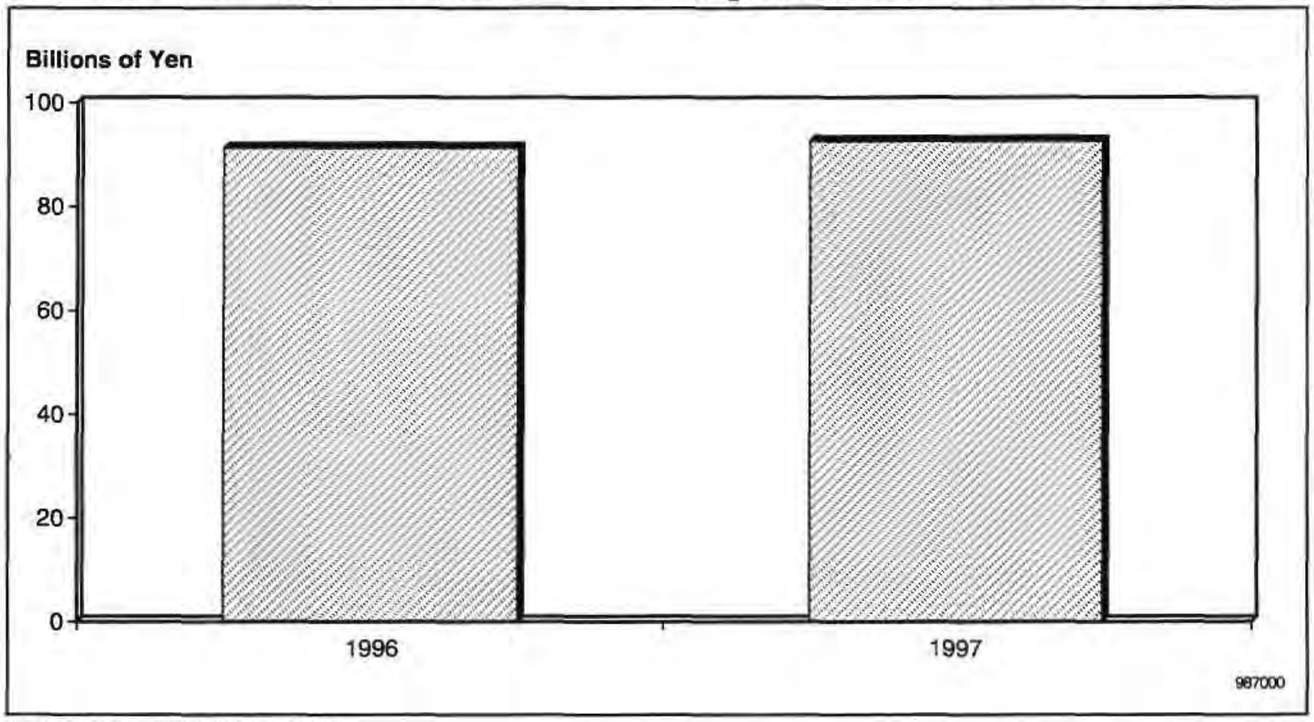
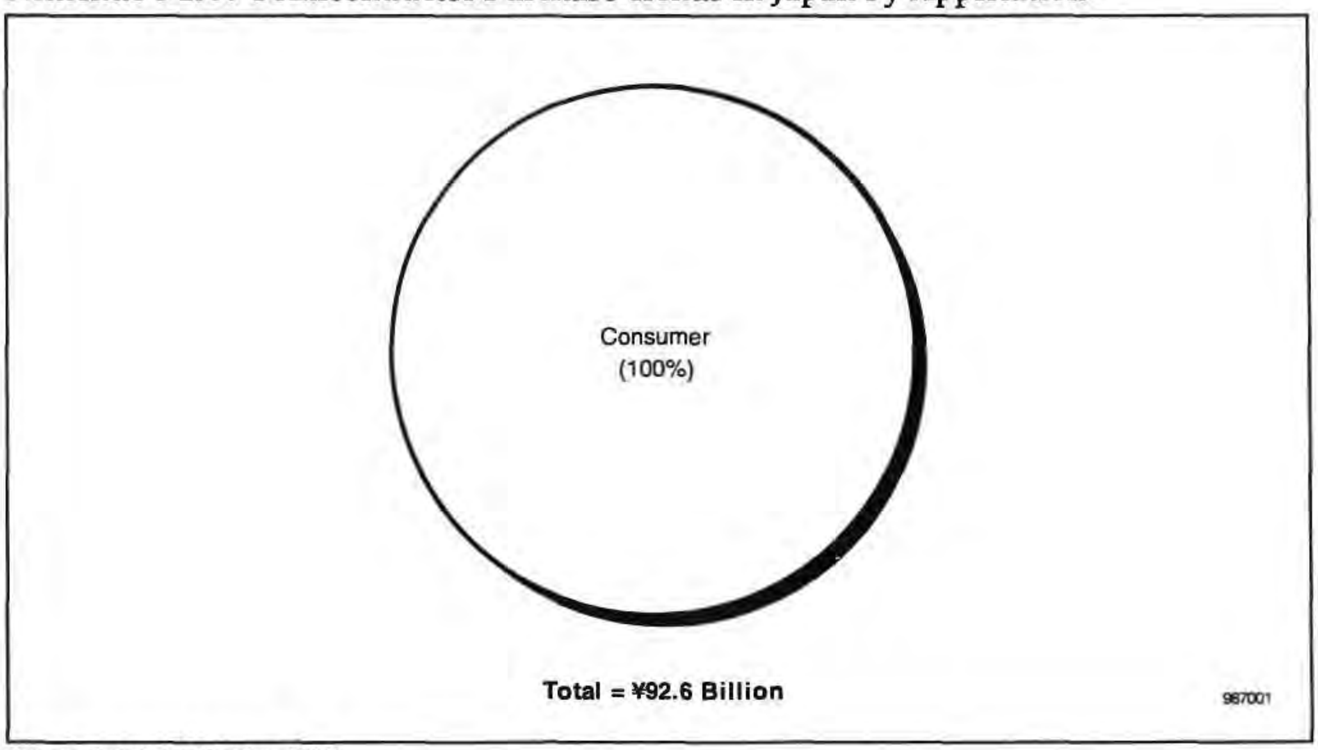
Figure 4-35
Nintendo's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-36
Nintendo's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Oki Electric Industries Company Ltd.

Oki has its focus on the domestic communications market, leveraging on its strong tie with NTT. Oki also sought to expand its business in midrange computers and peripherals such as printers, but the lack of integration in product offerings brought growth only to limited segments, and Oki's overall data processing business has yet to become comparable to other leading companies in Japan.

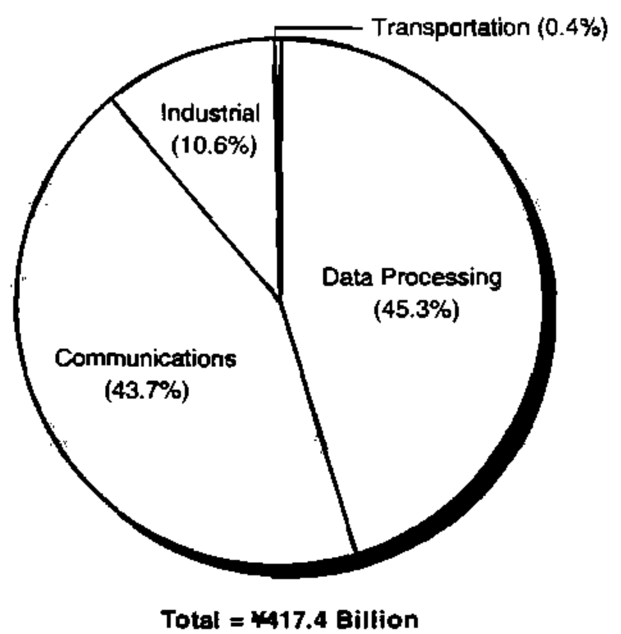
Table 4-13 shows Oki's major electronic products. Figures 4-37 through 4-39 show Oki's equipment production and semiconductor purchase trends.

Table 4-13
Oki's Major Electronic Products

Application	Products
Data Processing	PCs, workstations, midrange computers, rigid disk drives, displays, terminals, laser beam printers, other printers, word processors
Communications	Corded phones, cordless phones, multifunction phones, cellular phones, pagers, fax machines, modems, PBX equipment, transmission equipment, broadcast equipment
Industrial	Manufacturing systems, test and measuring equipment

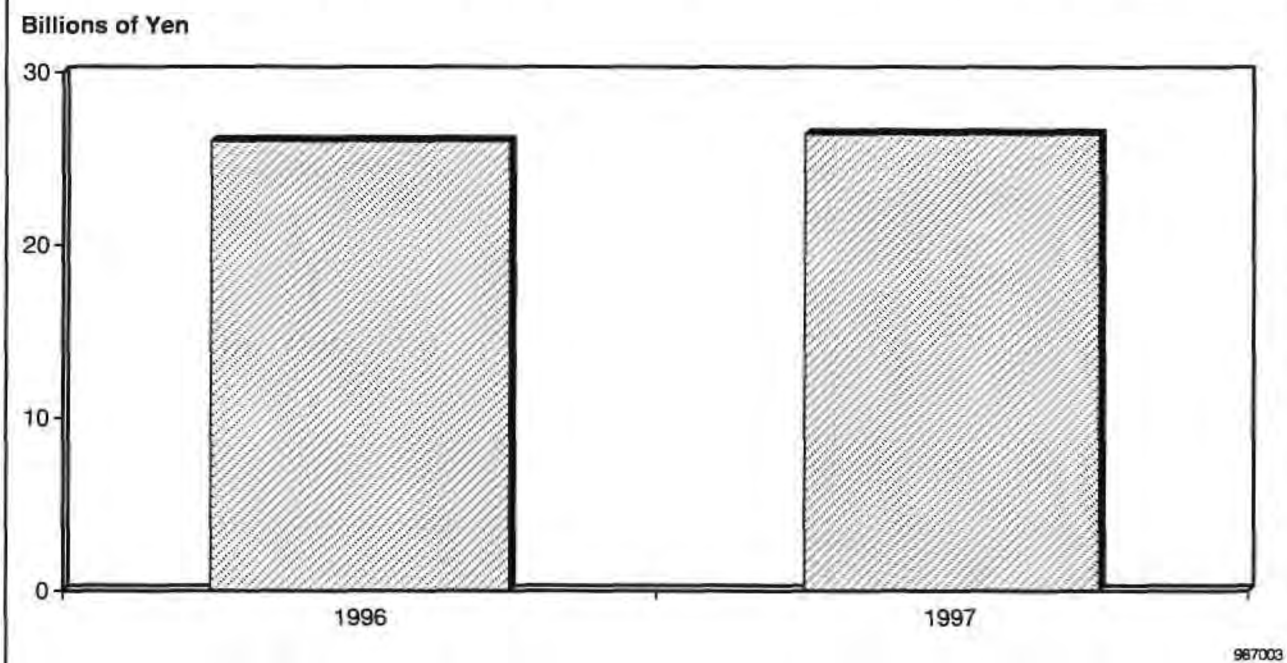
Source: Dataquest (October 1998)

Figure 4-37
Oki's 1997 Worldwide Electronic Equipment Production Revenue by Application



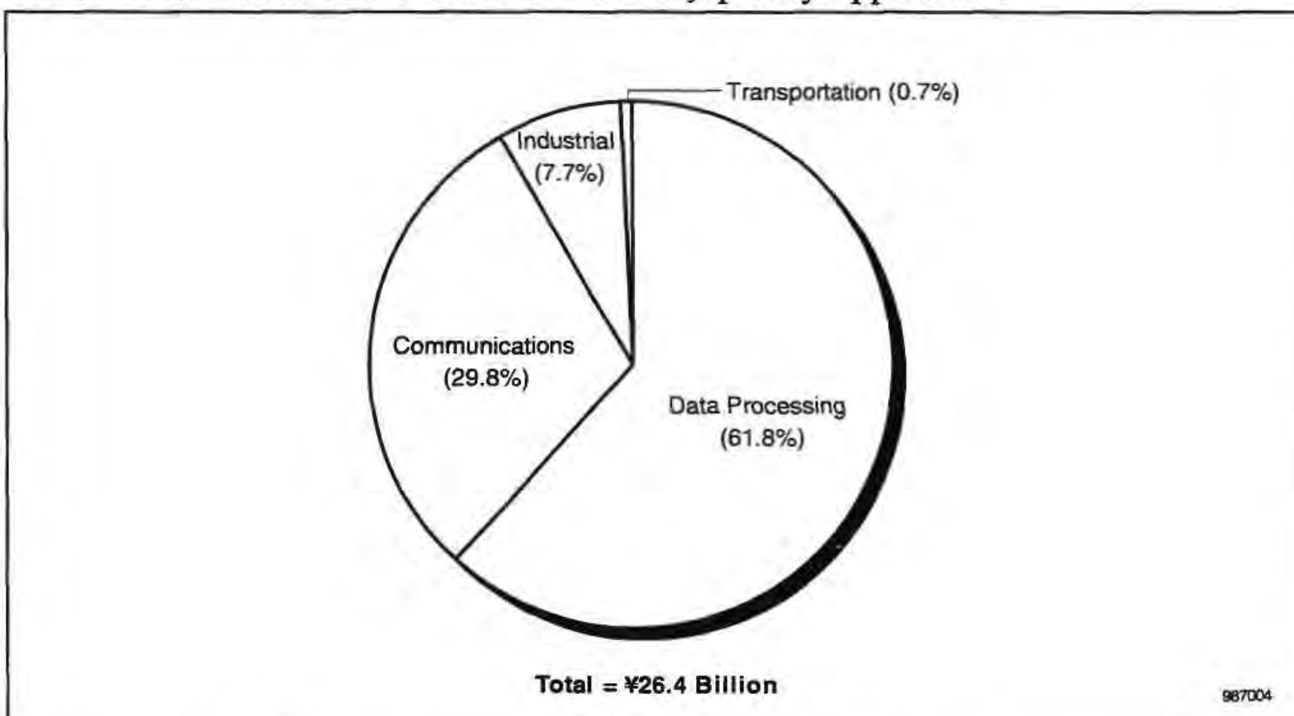
Source: Dataquest (October 1998)

Figure 4-38
Oki's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-39
Oki's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Pioneer Electronic Corporation

Sales declines in laser discs and karaoke systems hurt Pioneer Electronic's overall revenue, but growth was seen in DV-Cs, MDs, DVDs, and in-car navigation systems. The company's expertise in the optical disc business has encouraged it to penetrate into business-use systems and FA equipment. It is also placing new emphasis on the video business. Pioneer Electronic also has unique product lines in cellular phones and cordless phones, but the business sizes of those areas have yet to grow.

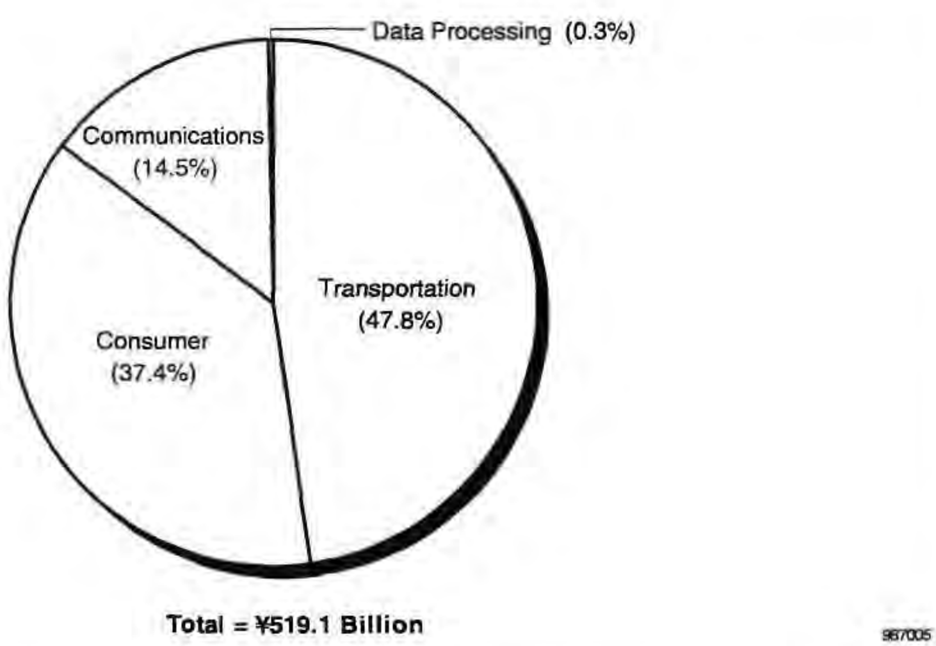
Table 4-14 shows Pioneer Electronic's major electronic products. Figures 4-40 through 4-42 show Pioneer Electronic's equipment production and semiconductor purchase trends.

Table 4-14
Pioneer Electronic's Major Electronic Products

Application	Products
Data Processing	CD-ROMs
Communications	Corded phones, cordless phones, multifunction phones
Consumer	TVs, set-top boxes, VCRs, CD players, DVD players
Transportation	Navigation systems, car stereos

Source: Dataquest (October 1998)

Figure 4-40
Pioneer Electronic's 1997 Worldwide Electronic Equipment Production Revenue by Application



Source: Dataquest (October 1998)

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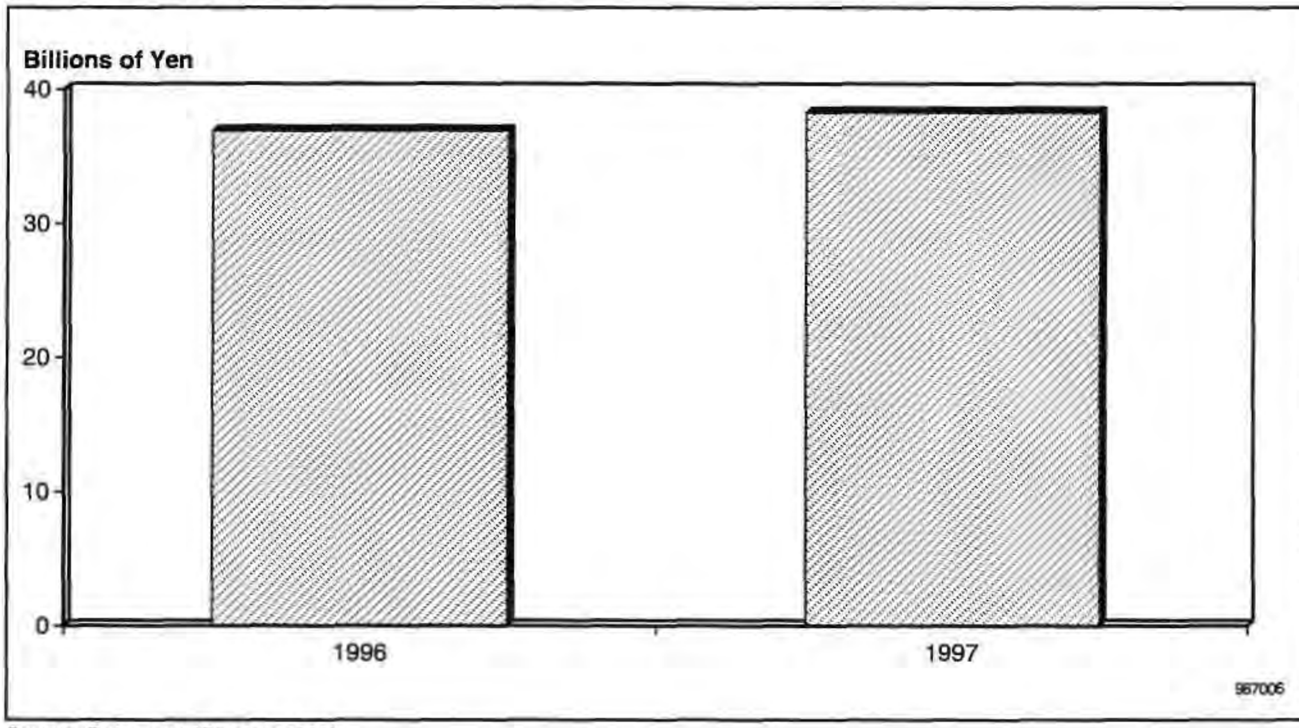
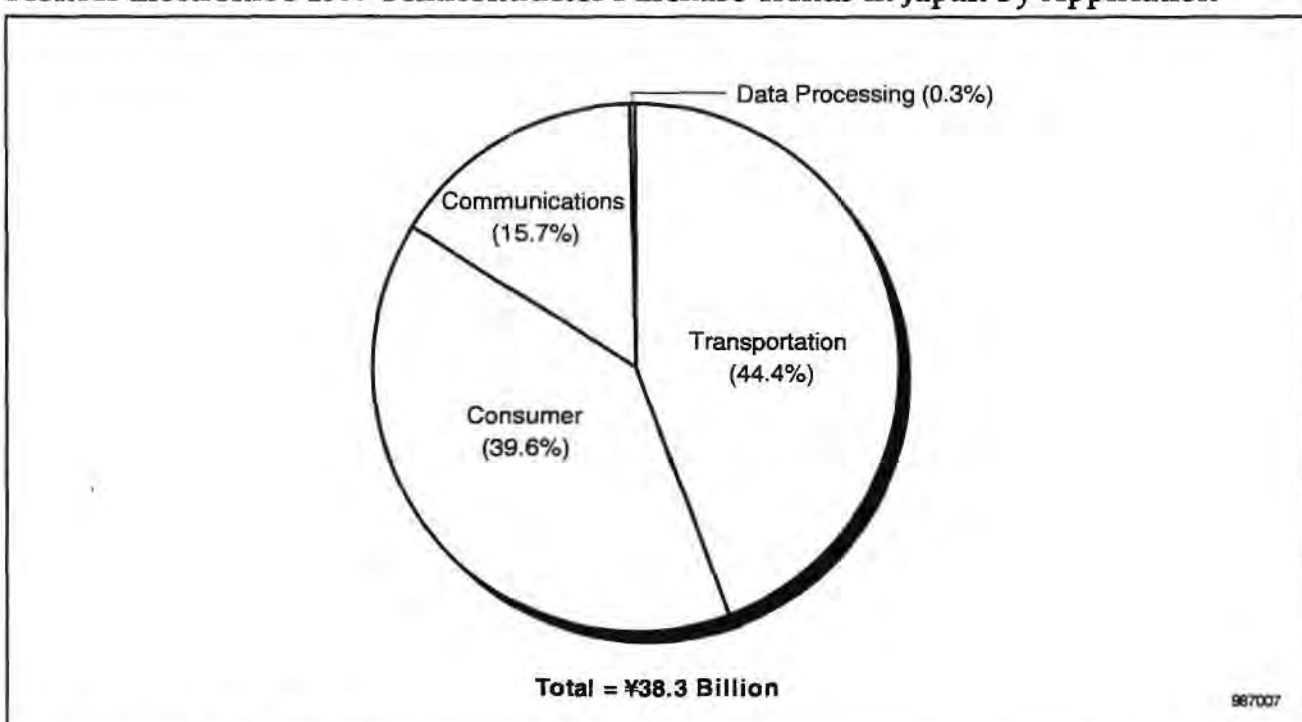
Figure 4-41
Pioneer Electronic's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-42
Pioneer Electronic's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Ricoh Company Ltd.

Ricoh is a manufacturer of dedicated data processing systems. In 1997, copy machines represented nearly 70 percent of its sales. Ricoh has leveraged on image processing technologies and has become the top vendor of facsimile machines in Japan. Optical products, including cameras and DSCs, recorded two-digit growth in sales in 1997. In the area of data processing peripherals, Ricoh has developed CD-RW media drives, offering new media that enable "Write" and "Delete" in CDs. As the penetration of office-use dedicated systems becomes high, Ricoh's continuous growth in production is not so easy. Ricoh has established global production sites in countries such as the United States, Europe, and Asia, including China, resulting in a comparatively low export ratio of about one-fourth of total sales.

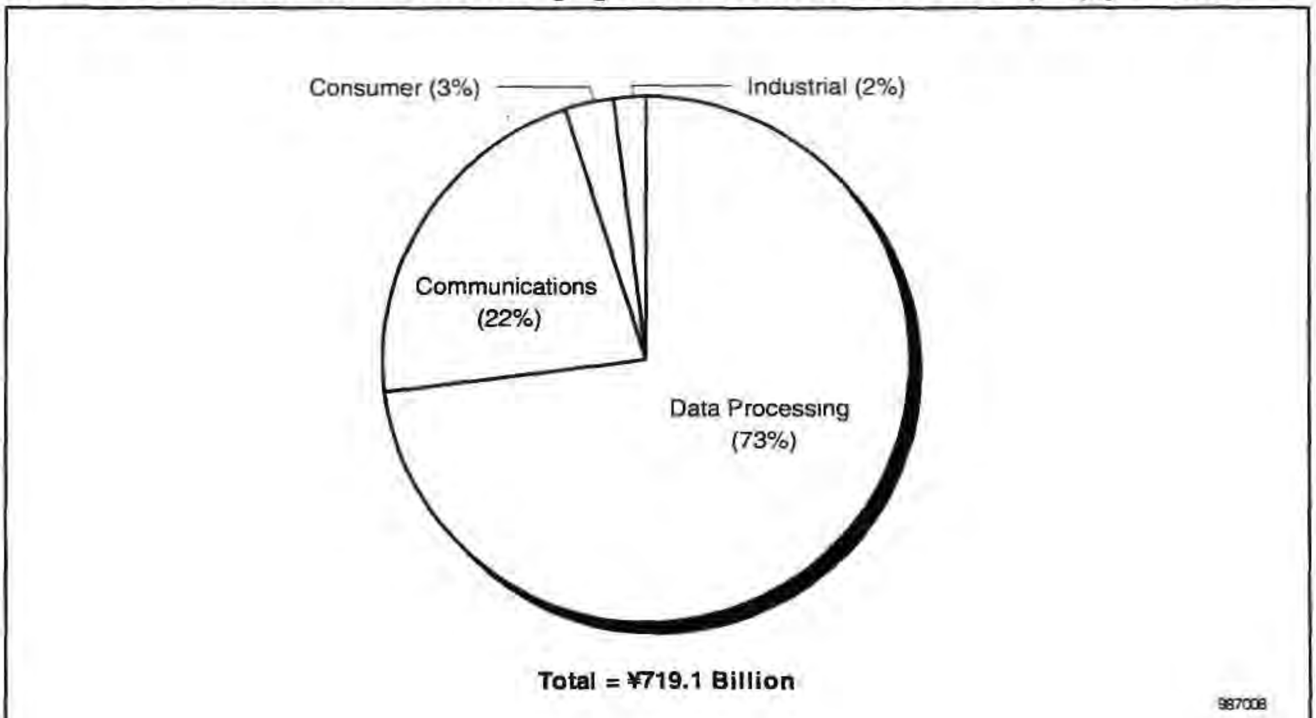
Table 4-15 shows Ricoh's major electronic products. Figures 4-43 through 4-45 show Ricoh's equipment production and semiconductor purchase trends.

Table 4-15
Ricoh's Major Electronic Products

Application	Products
Data Processing	Printers, copiers, word processors, CD-ROM/RAMs, scanners
Communications	Fax machines, transmission equipment
Consumer	Digital still cameras, cameras
Industrial	Test and measurement equipment

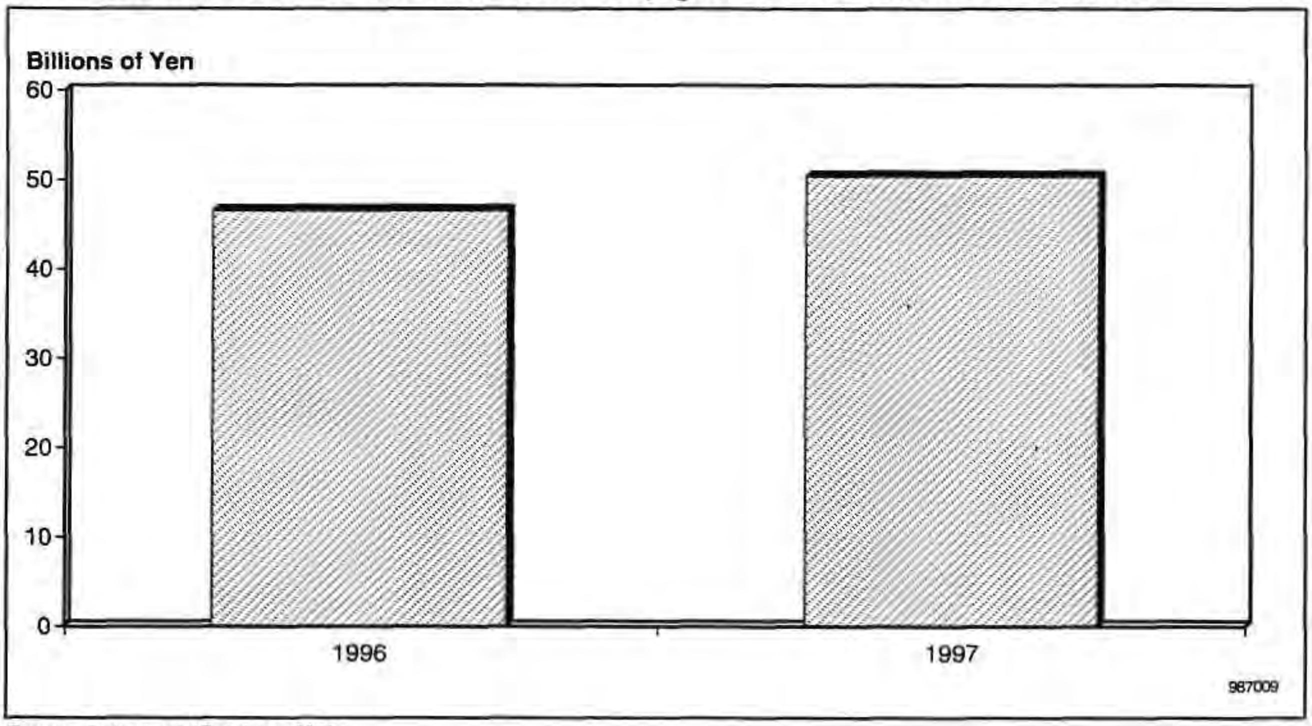
Source: Dataquest (October 1998)

Figure 4-43
Ricoh's 1997 Worldwide Electronic Equipment Production Revenue by Application



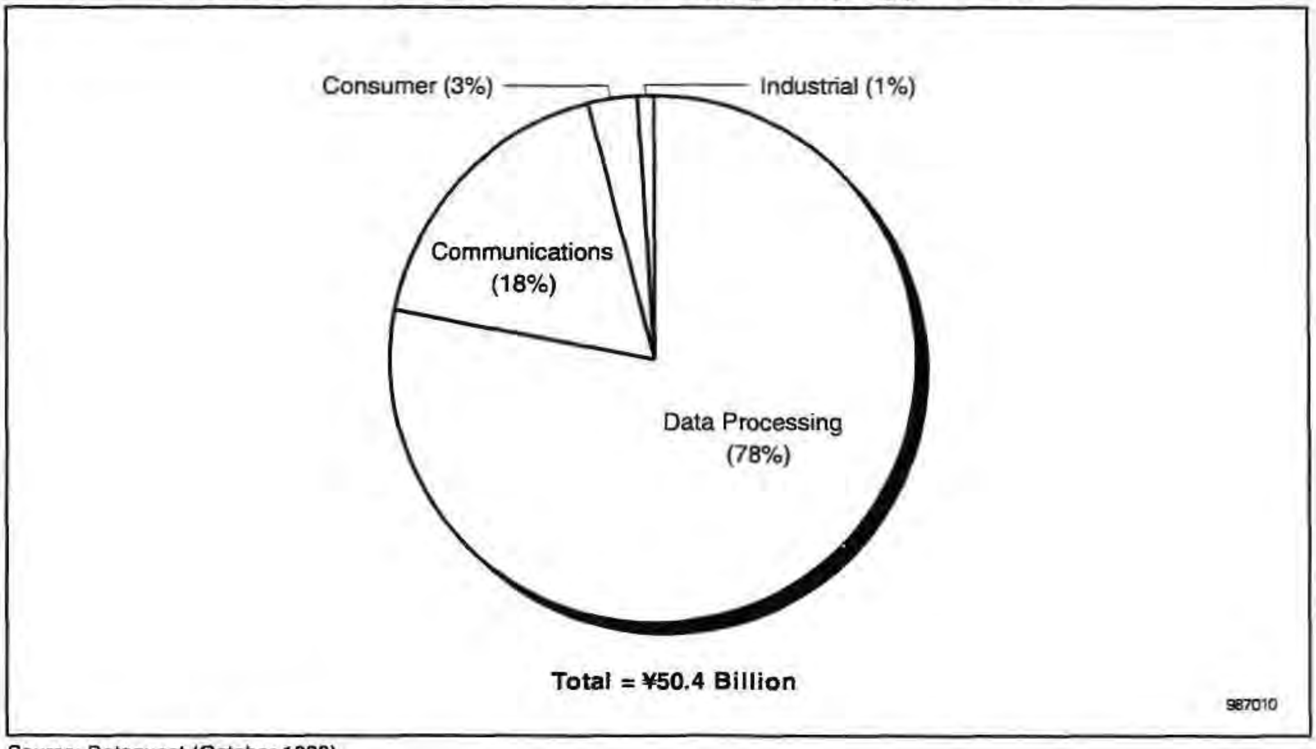
Source: Dataquest (October 1998)

Figure 4-44
Ricoh's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-45
Ricoh's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

SANYO Electric Company Ltd.

SANYO has successfully leveraged on its expertise in digital audio systems by penetrating into storage devices such as CD-ROM. Its audio technology has also helped it to develop communications products such as cordless phones and fax machines, which are growing steadily. SANYO is known to be very aggressive in seeking export markets as well as overseas equipment production. Because of this, its semiconductor purchasing in Japan has demonstrated only a constant trend, betraying its worldwide equipment revenue growth.

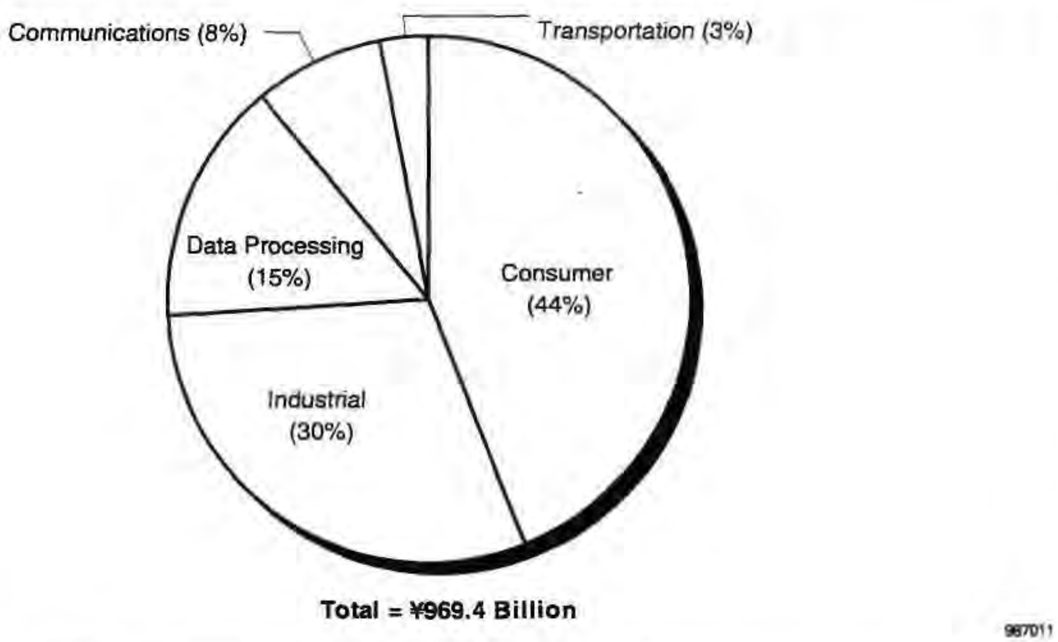
Table 4-16 shows SANYO's major electronic products. Figures 4-46 through 4-48 show SANYO's equipment production and semiconductor purchase trends.

Table 4-16
SANYO's Major Electronic Products

Application	Products
Data Processing	PCs, workstations, rigid disk drives, displays, terminals, laser beam printers, word processors, calculators, copiers
Communications	Corded phones, cordless phones, multifunction phones, PHSs, cellular phones
Consumer	TVs, camcorders, CD players, appliances
Industrial	Manufacturing systems
Transportation	Navigation systems, car stereos

Source: Dataquest (October 1998)

Figure 4-46
SANYO's 1997 Worldwide Electronic Equipment Production Revenue by Application



Source: Dataquest (October 1998)

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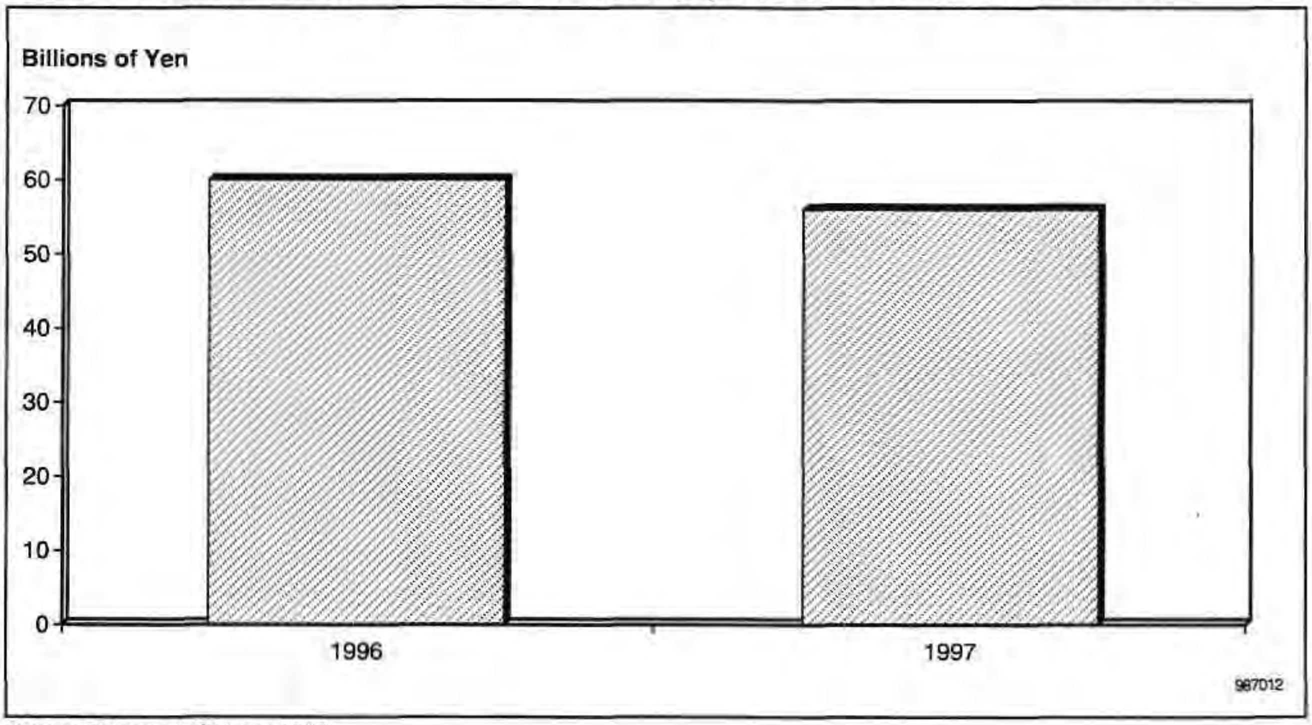
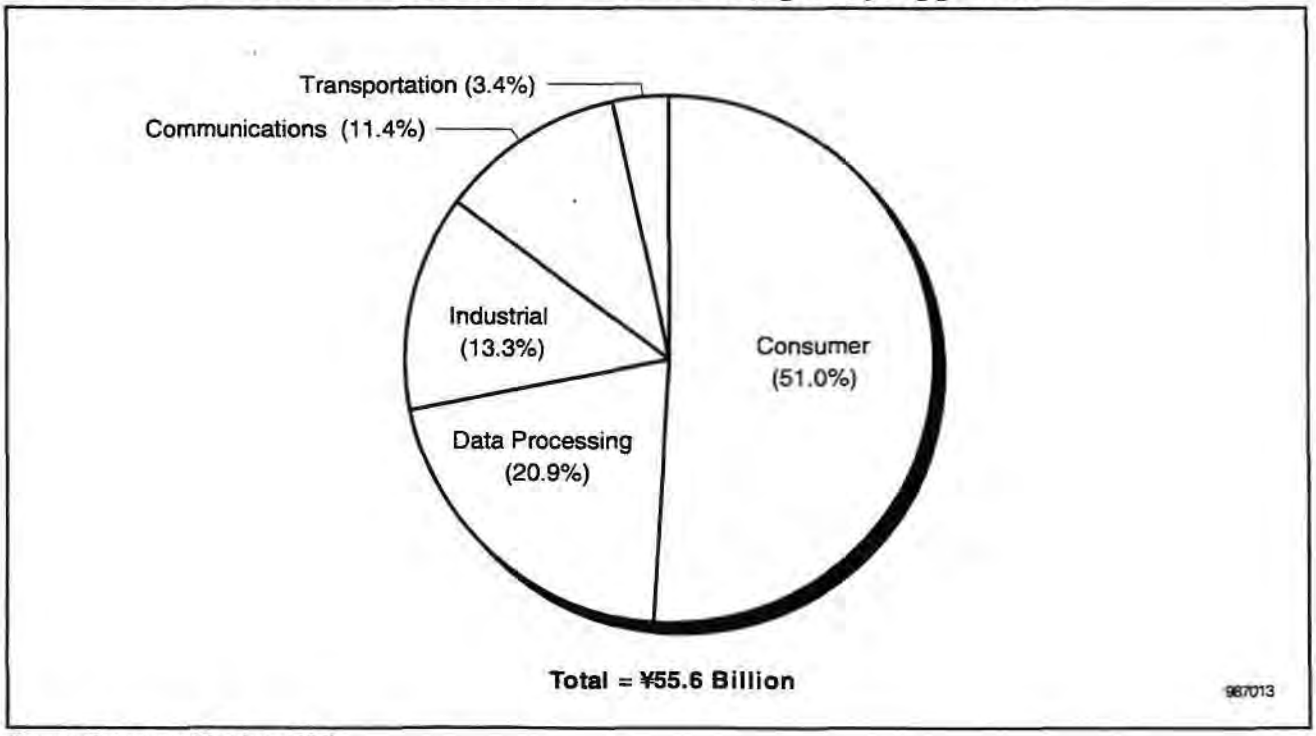
Figure 4-47
SANYO's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-48
SANYO's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

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SEGA Corporation

SEGA has a diversified business, including game machines and software for home use, amusement machines for business use, karaoke systems, and entertainment centers (similar to a video arcade but also including restaurants, movie theaters, and so forth) with its own machines. Home-use and business-use machines each represent 35 percent of SEGA's total revenue, and 18 percent of those machines are exported. While SEGA fares well in business-use machines, including pachinko, it is losing ground in the hardware of TV games to two other large competitors. As a result, SEGA's semiconductor purchasing declined in 1997.

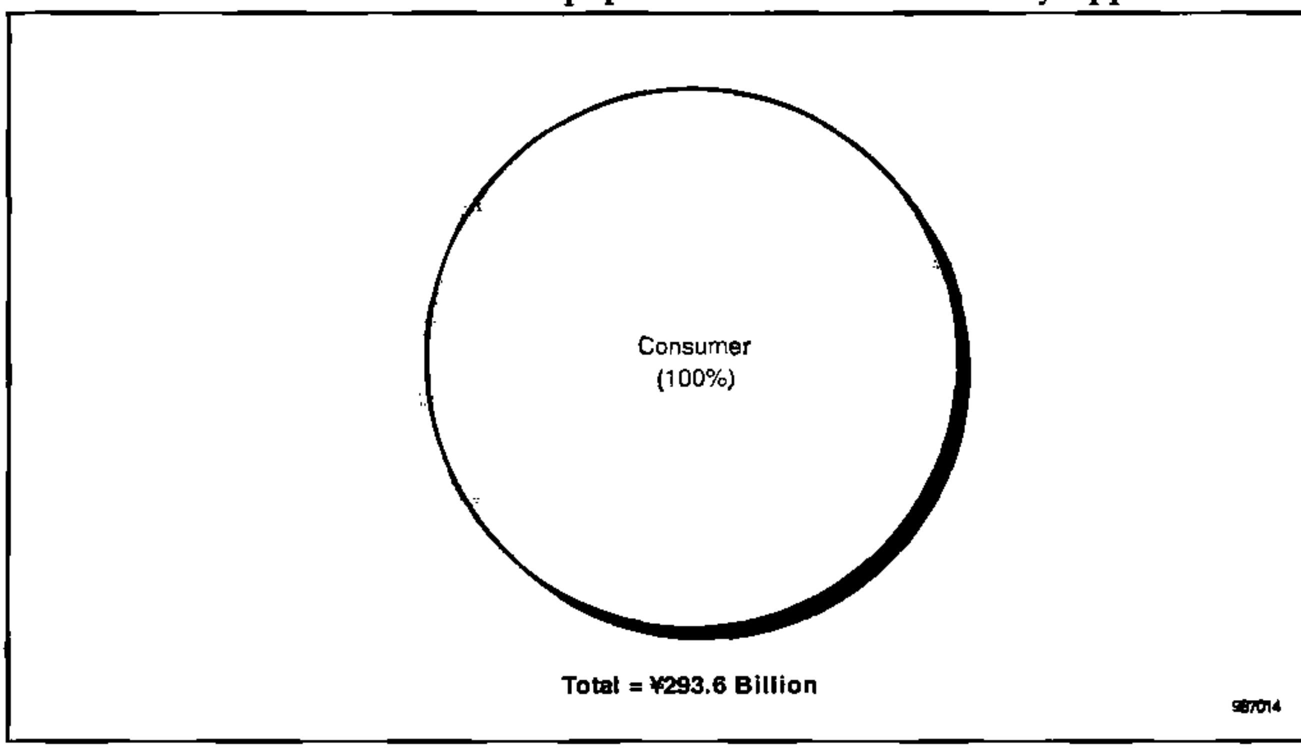
Table 4-17 shows SEGA's major electronic products. Figures 4-49 through 4-51 show SEGA's equipment production and semiconductor purchase trends.

Table 4-17
SEGA's Major Electronic Products

Application	Products
Consumer	Game controllers, arcade games

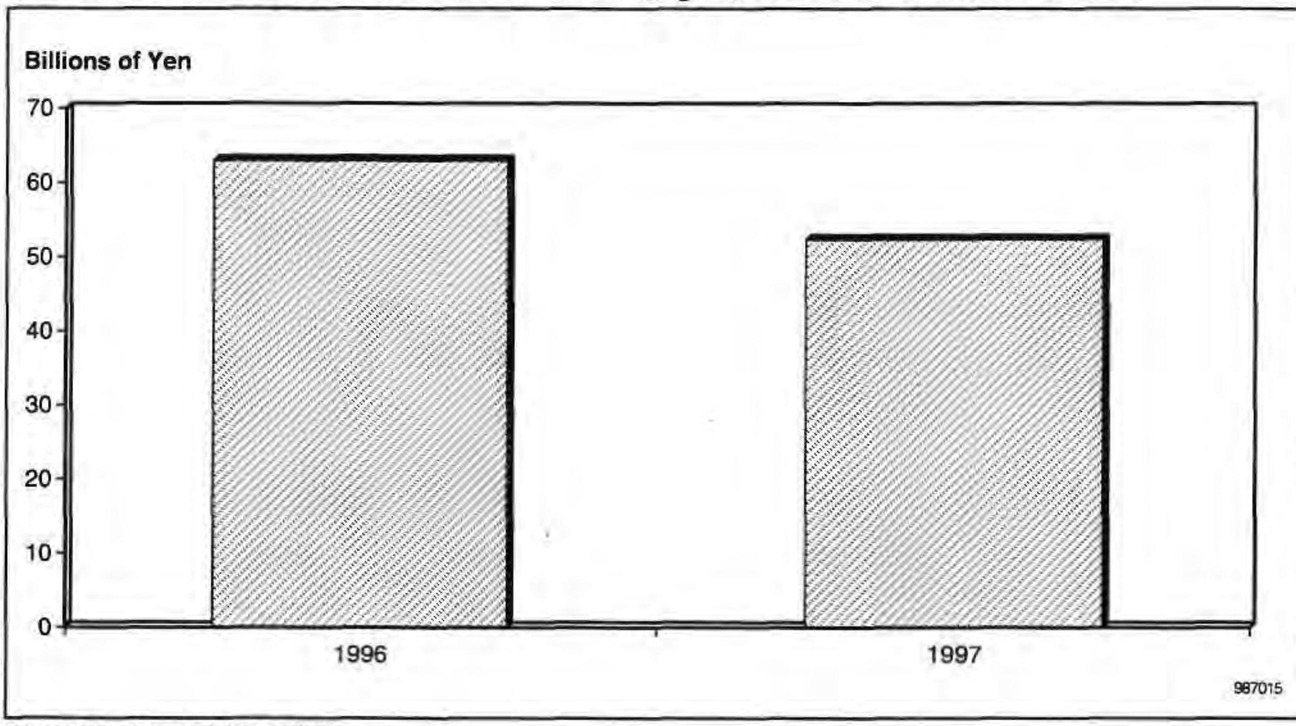
Source: Dataquest (October 1998)

Figure 4-49
SEGA's 1997 Worldwide Electronic Equipment Production Revenue by Application



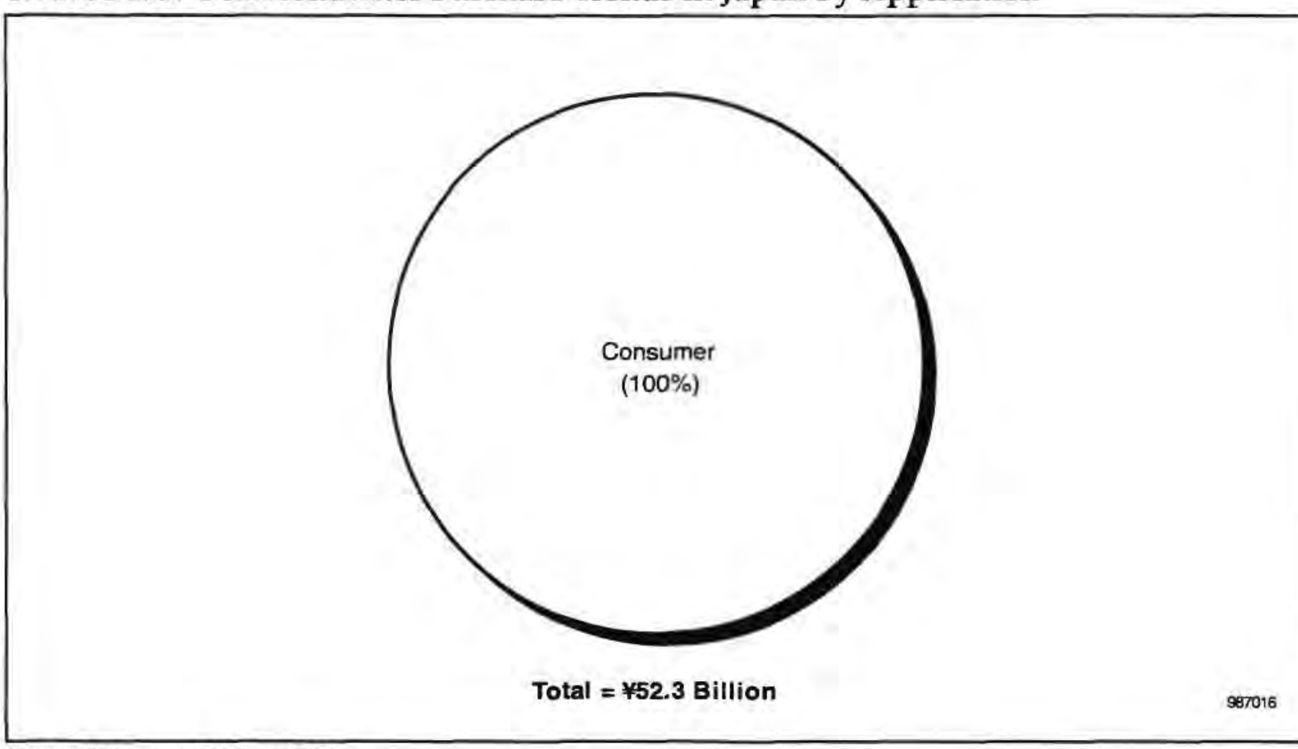
Source: Dataquest (October 1998)

Figure 4-50
SEGA's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-51
SEGA's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Seiko Epson Corporation

Data processing equipment, including PCs and peripherals, represents about one-half of Seiko Epson's revenue, with printers as the leading product. Seiko Epson also has entered the DSC market, along with its traditional product line of scanners. Other product offerings include LCD panels and application equipment, such as TV and video equipment, electric watches/clocks, and FA equipment, but the combined sales of these represent only 10 percent of total sales. Seiko Epson has been aggressive in setting up overseas production in various parts of the world, including the United States, Europe, and Asian countries, resulting in a low export ratio from Japan. Eighty percent of its semiconductor purchasing is in data processing.

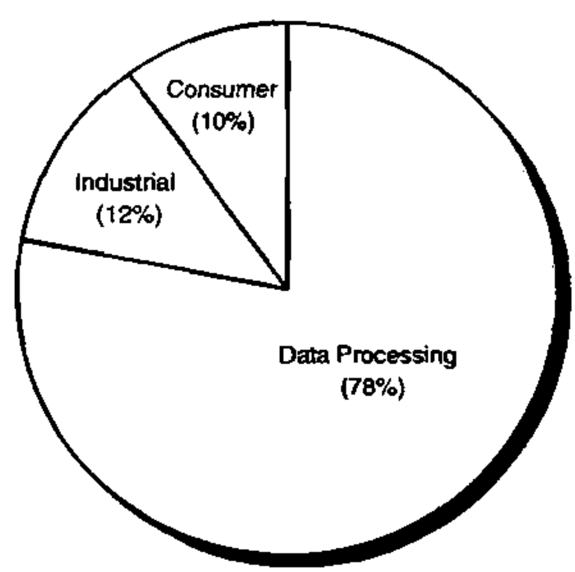
Table 4-18 shows Seiko Epson's major electronic products. Figures 4-52 through 4-54 show Seiko Epson's equipment production and semiconductor purchase trends.

Table 4-18
Seiko Epson's Major Electronic Products

Application	Products
Data Processing	PCs, flexible disk drives, rigid disk drives, displays, laser beam printers, other printers, word processors
Consumer	TVs, watches, minidiscs, digital video cameras, digital still cameras
Industrial	Manufacturing systems, test and measuring equipment

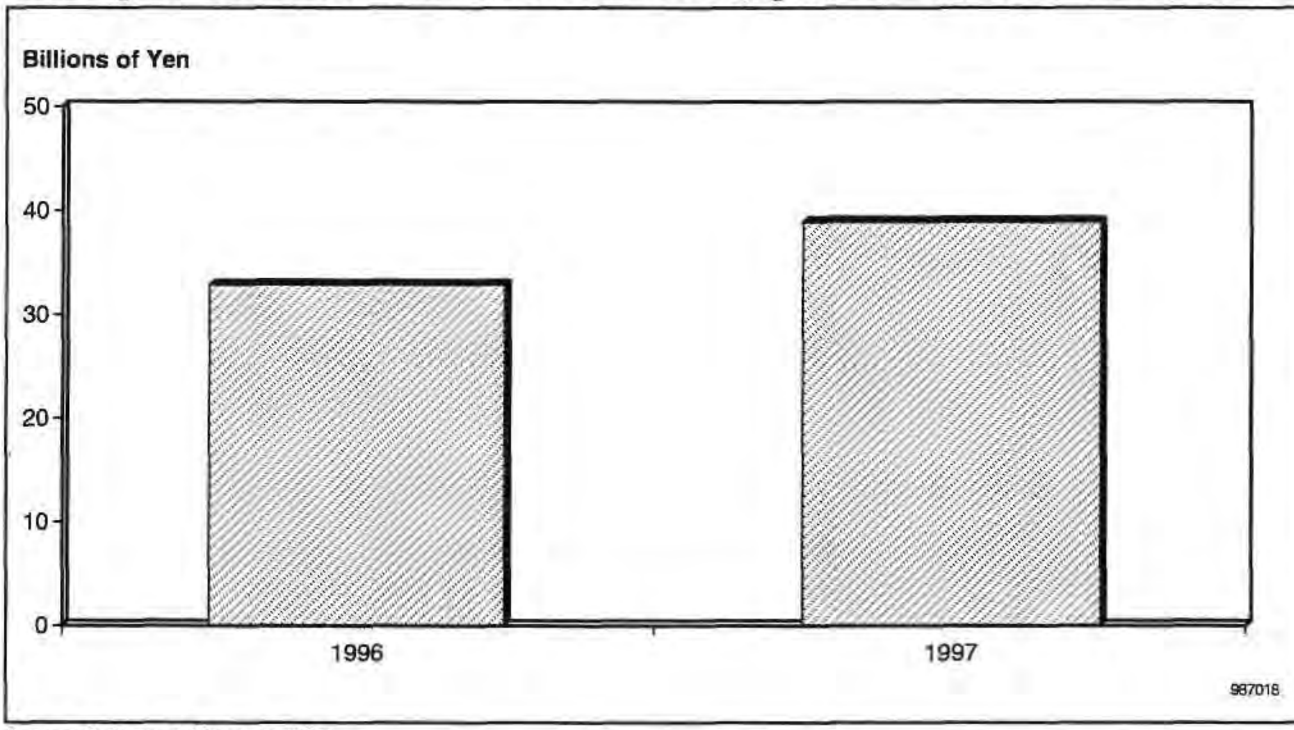
Source: Dataquest (October 1998)

Figure 4-52
Seiko Epson's 1997 Worldwide Electronic Equipment Production Revenue by Application



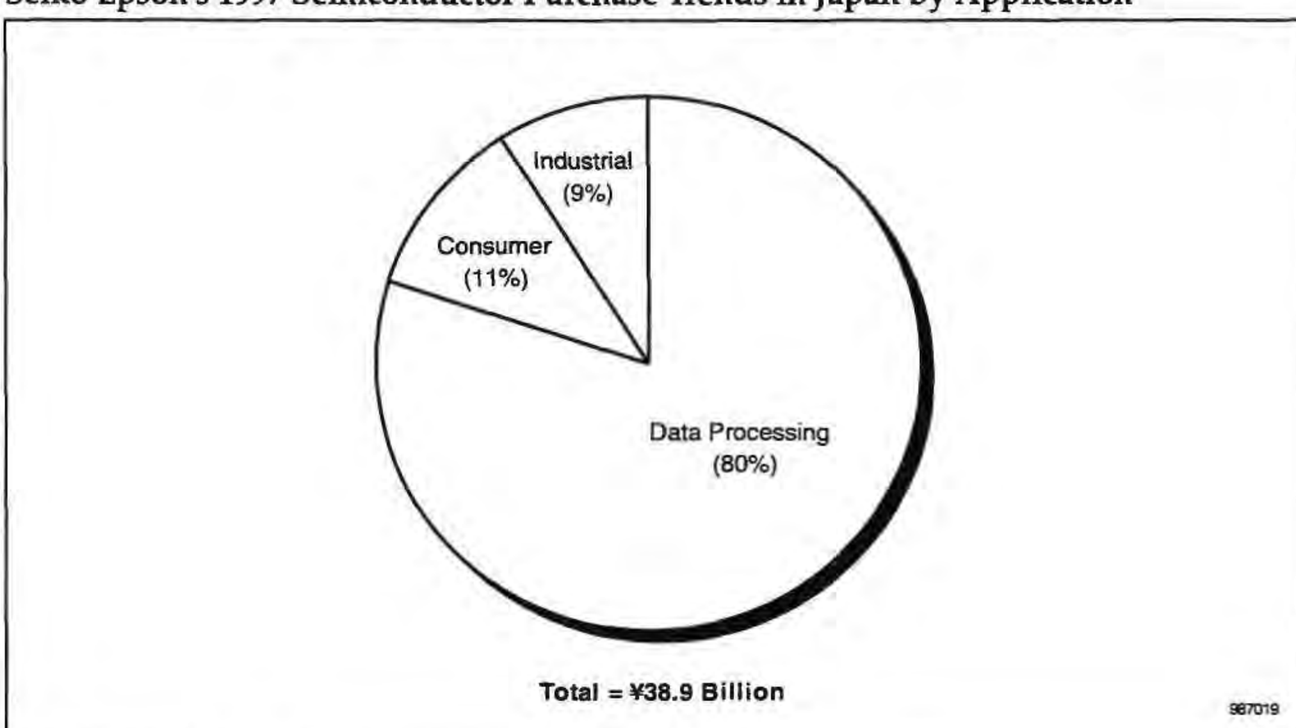
Source: Dataquest (October 1998)

Figure 4-53
Seiko Epson's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-54
Seiko Epson's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Sharp Electronics Corporation

Sharp's technology and products have a clear focus: LCD products. This core competence has led the company to effectively market application products such as note PCs, digital video products, and personal digital assistants (PDAs), represented by the well-known "Zaurus" product line. While Sharp's traditional consumer product lines declined, its communications equipment lines expanded. As a result, Sharp's semiconductor purchasing has increased.

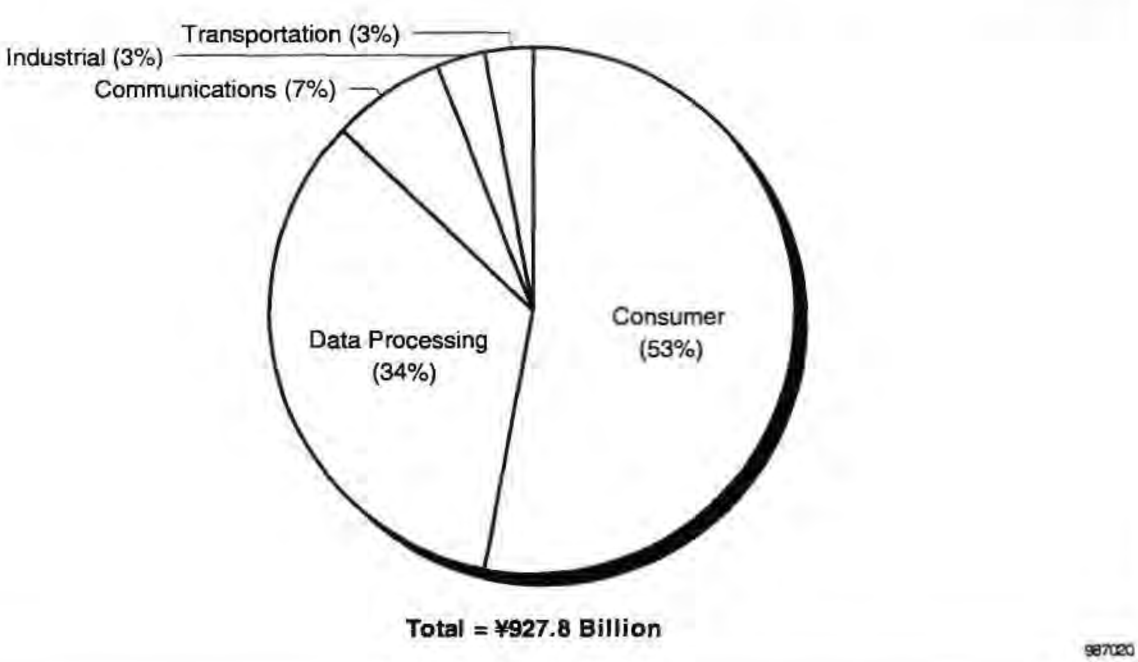
Table 4-19 shows Sharp's major electronic products. Figures 4-55 through 4-57 show Sharp's equipment production and semiconductor purchase trends.

Table 4-19
Sharp's Major Electronic Products

Application	Products
Data Processing	PCs, workstations, mainframe computers, midrange computers, CD-ROMs, displays, terminals, laser beam printers, other printers, word processors, organizers, calculators, copiers
Communications	Corded phones, cordless phones, PHSs, pagers, fax machines, modems, PBX equipment, broadcast equipment
Consumer	TVs, VCRs, camcorders, CD players, appliances, watches, minidiscs
Industrial	Manufacturing systems
Transportation	Navigation systems, car stereos

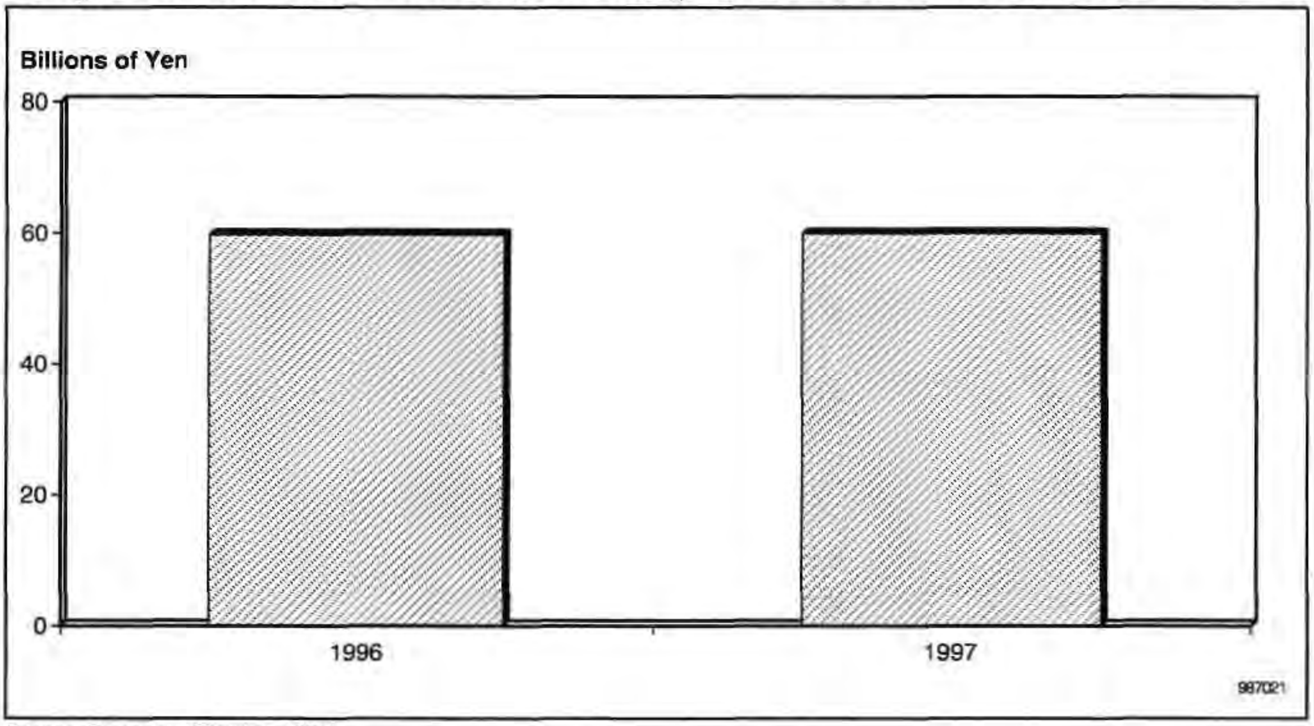
Source: Dataquest (October 1998)

Figure 4-55
Sharp's 1997 Worldwide Electronic Equipment Production Revenue by Application



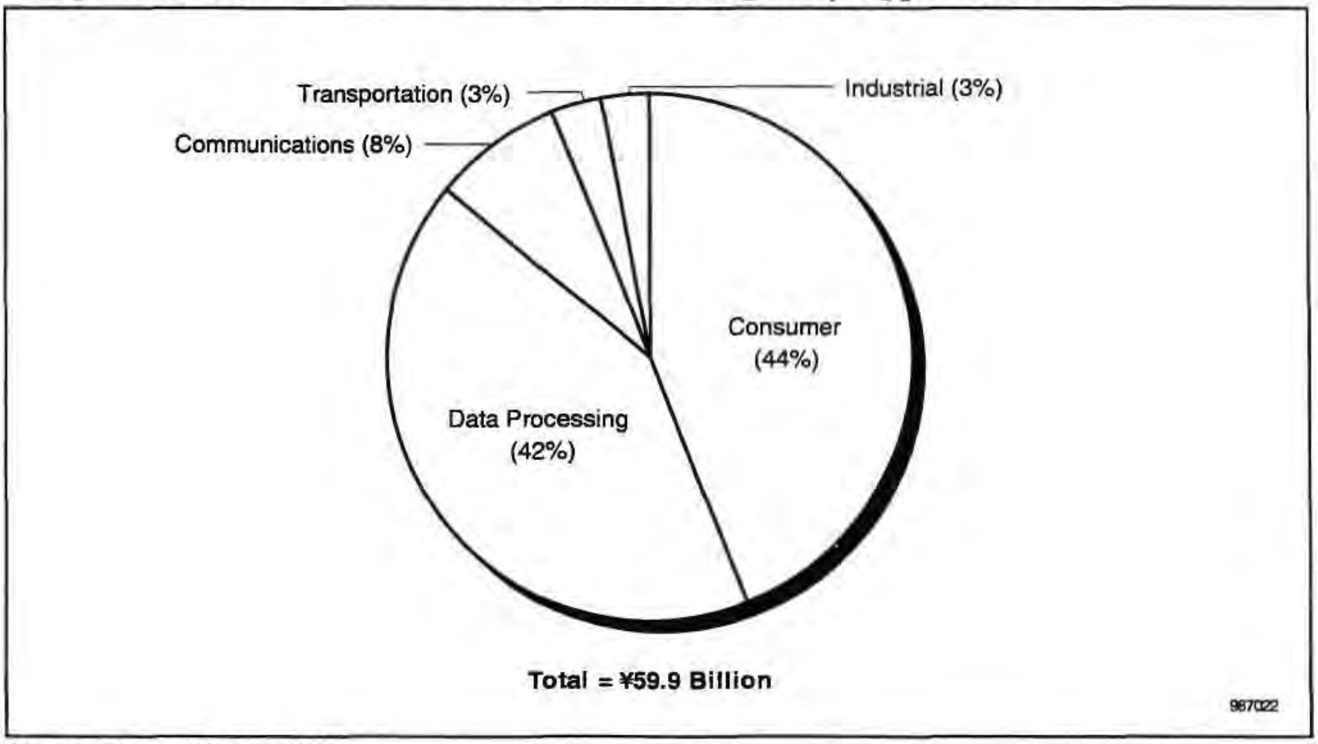
Source: Dataquest (October 1998)

Figure 4-56
Sharp's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-57
Sharp's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Sony Corporation

The trends toward digital consumer equipment are bringing audio/video equipment another stage of business opportunity. Growth in mobile communications has exceeded expectations. Broadcast equipment has brought sound profits, but Sony is increasingly exposed to harsh competition. Sony has leveraged on its optical disc technology to grow in computer peripherals, such as CD-ROM, but it is not free from intense competition. Sony has experienced outstanding success in the game machine area. Thus, growth in various product areas increased Sony's semiconductor purchasing in 1997, while most other consumer-oriented manufacturers decreased their semiconductor spending.

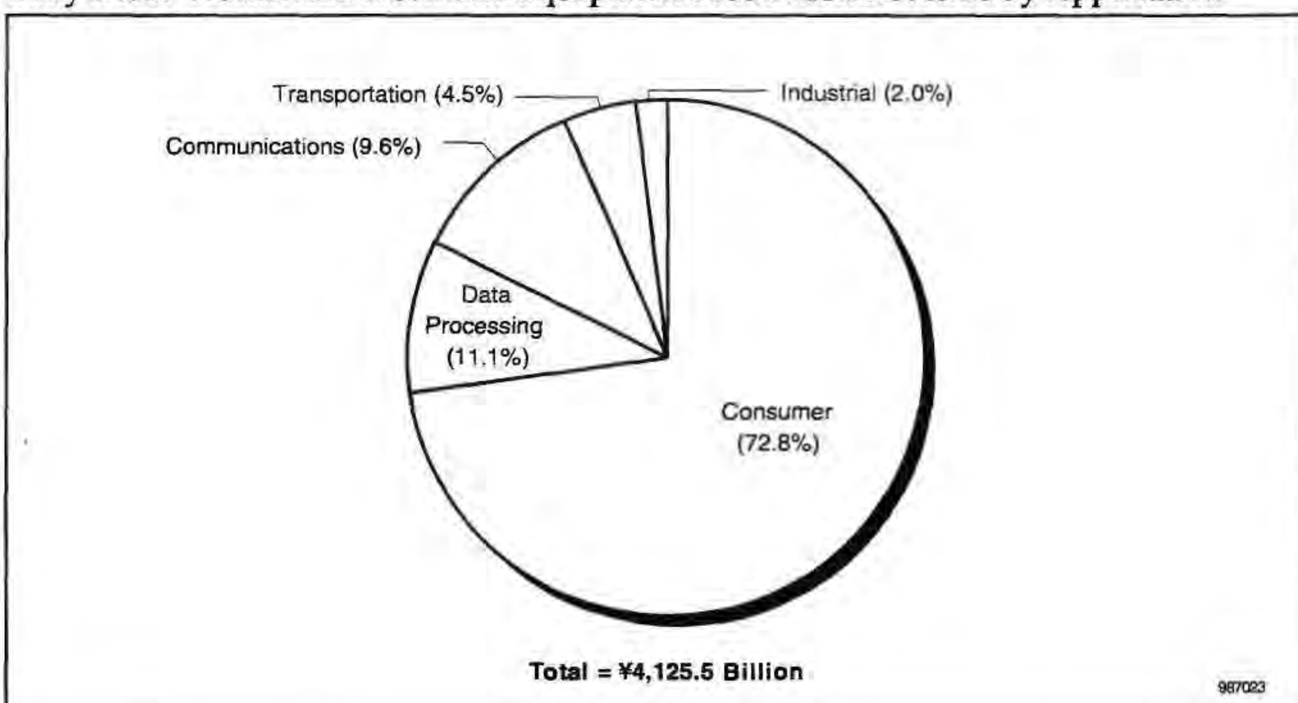
Table 4-20 shows Sony's major electronic products. Figures 4-58 through 4-60 show Sony's equipment production and semiconductor purchase trends.

Table 4-20
Sony's Major Electronic Products

Application	Products
Data Processing	PCs, workstations, monitor displays, CD-ROMs, DVD-ROMs
Communications	Corded phones, cordless phones, PDCs, PHSs, broadcast equipment products
Consumer	TVs, VCRs, STBs, camcorders, CD players, TV games, DVD players, minidiscs, DV-Cs, digital still cameras
Industrial	Security/energy management, manufacturing systems
Transportation	GPS navigation systems, car AV systems

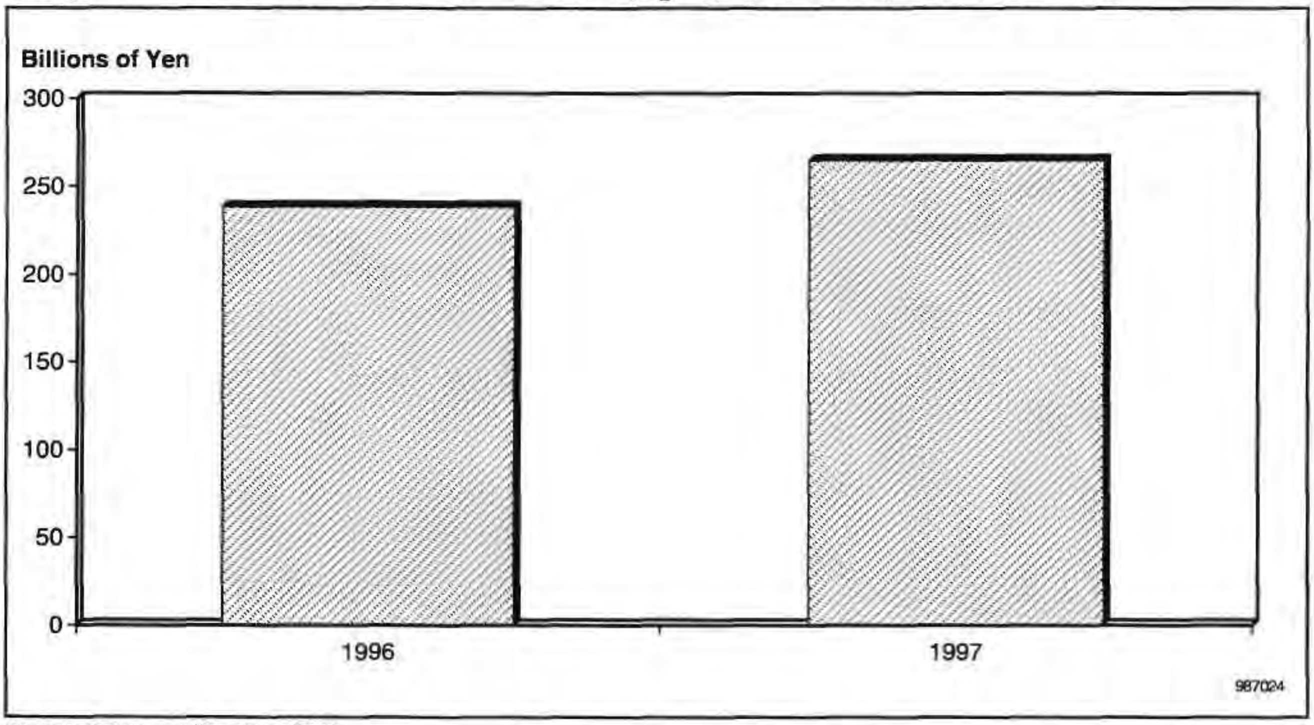
Source: Dataquest (October 1998)

Figure 4-58
Sony's 1997 Worldwide Electronic Equipment Production Revenue by Application



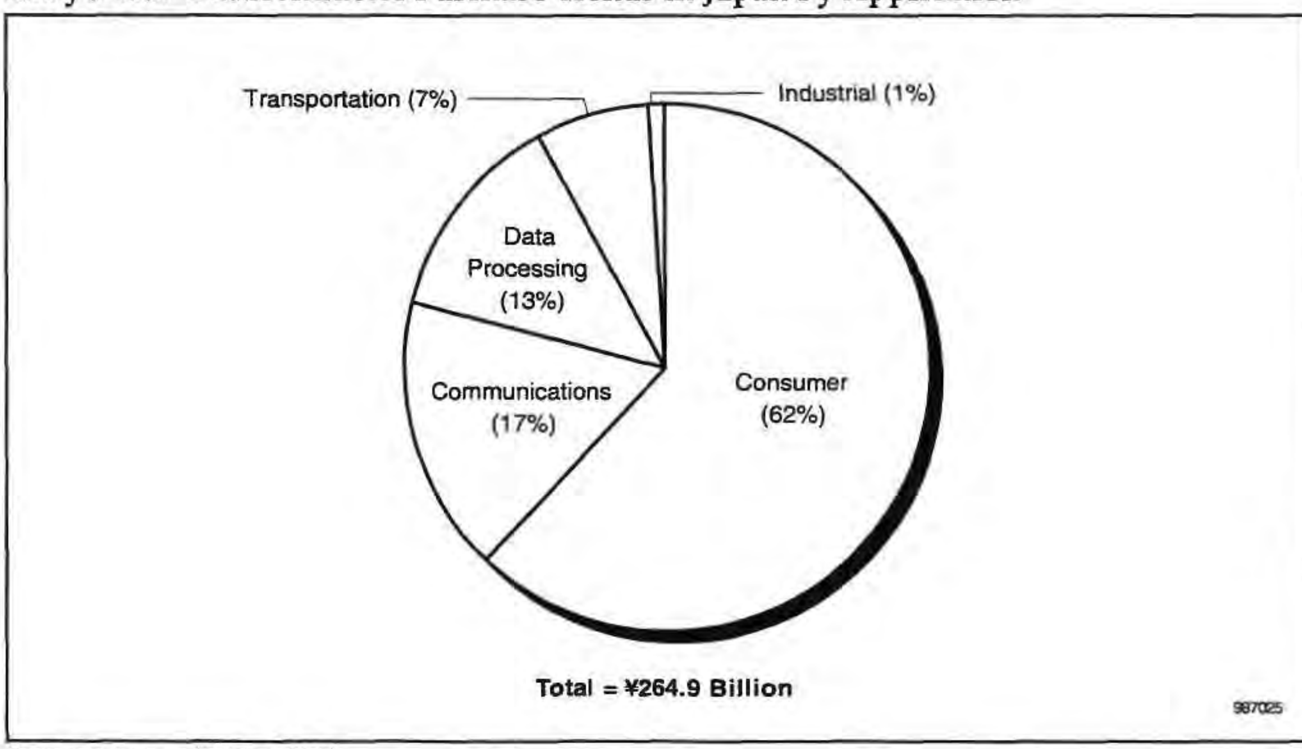
Source: Dataquest (October 1998)

Figure 4-59
Sony's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-60
Sony's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Toshiba Corporation

Toshiba has been known as the second-largest "general electric" company in Japan, covering all of the heavy electric, IT, and consumer equipment segments. Its recent focus, however, clearly has been in communications and data processing, where cellular phones and note PCs lead overall revenue growth.

Toshiba's semiconductor purchasing has decreased slightly because of sluggish production in the home appliance area, even though communications experienced an increase in semiconductor usage. In the consumer segment, Toshiba has been spreading production sites, resulting in large semiconductor spending outside Japan.

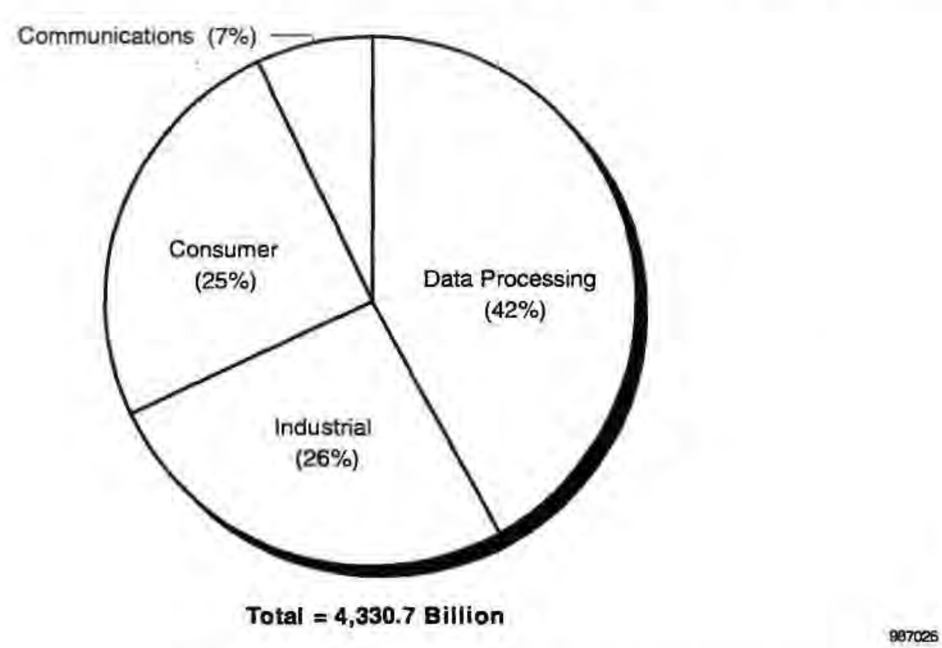
Table 4-21 shows Toshiba's major electronic products. Figures 4-61 through 4-63 show Toshiba's equipment production and semiconductor purchase trends.

Table 4-21
Toshiba's Major Electronic Products

Application	Products
Data Processing	PCs, workstations, midrange computers, flexible disk drives, rigid disk drives, displays, terminals, word processors
Communications	Corded phones, cordless phones, multifunction phones, PHSs, cellular phones, pagers, modems, PBX equipment, transmission equipment, broadcast equipment
Consumer	TVs, set-top boxes, VCRs, camcorders, CD players, appliances, DVD players
Industrial	Manufacturing systems, test and measuring equipment, medical equipment

Source: Dataquest (October 1998)

Figure 4-61
Toshiba's 1997 Worldwide Electronic Equipment Production Revenue by Application



Source: Dataquest (October 1998)

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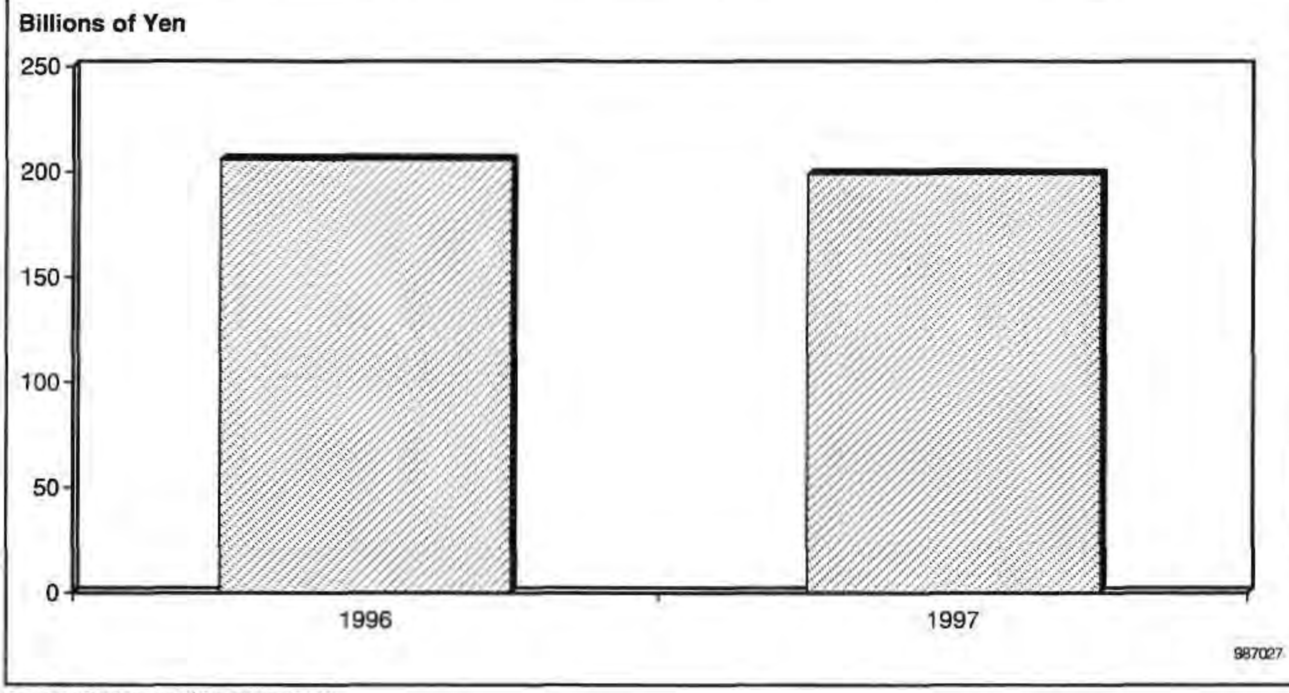
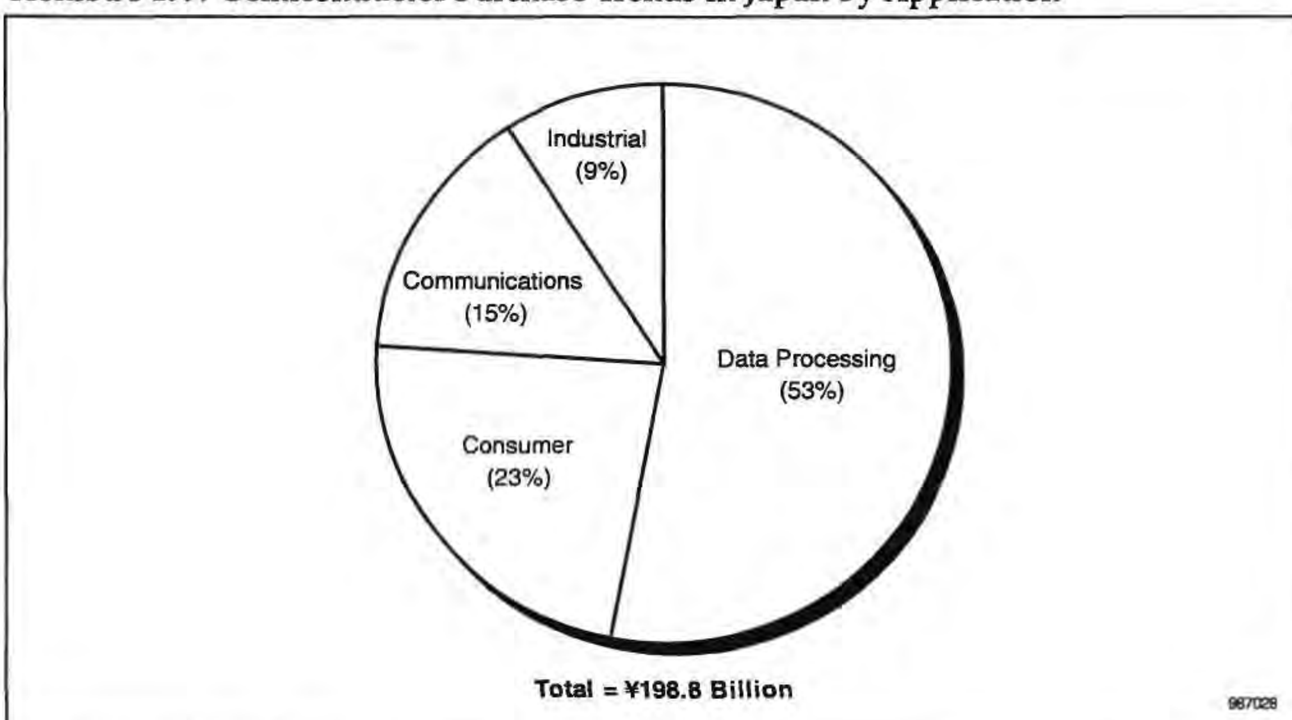
Figure 4-62
Toshiba's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-63
Toshiba's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Victor Company of Japan Limited

Victor Company of Japan (JVC) belongs to the Matsushita Group, but it has sought its own proprietary technology and markets; for example, it developed its own original digital camcorders. Victor's core competence lies in audio/video equipment, for both broadcasting and business use; however, it is expanding its product line to include cordless phones and PHSs. The production of computer peripherals—mainly optical discs—is expanding, but fierce competition is hurting its profits. Digital consumer equipment holds the key to Victor's future success. It may also need to explore the possibility of overseas operation.

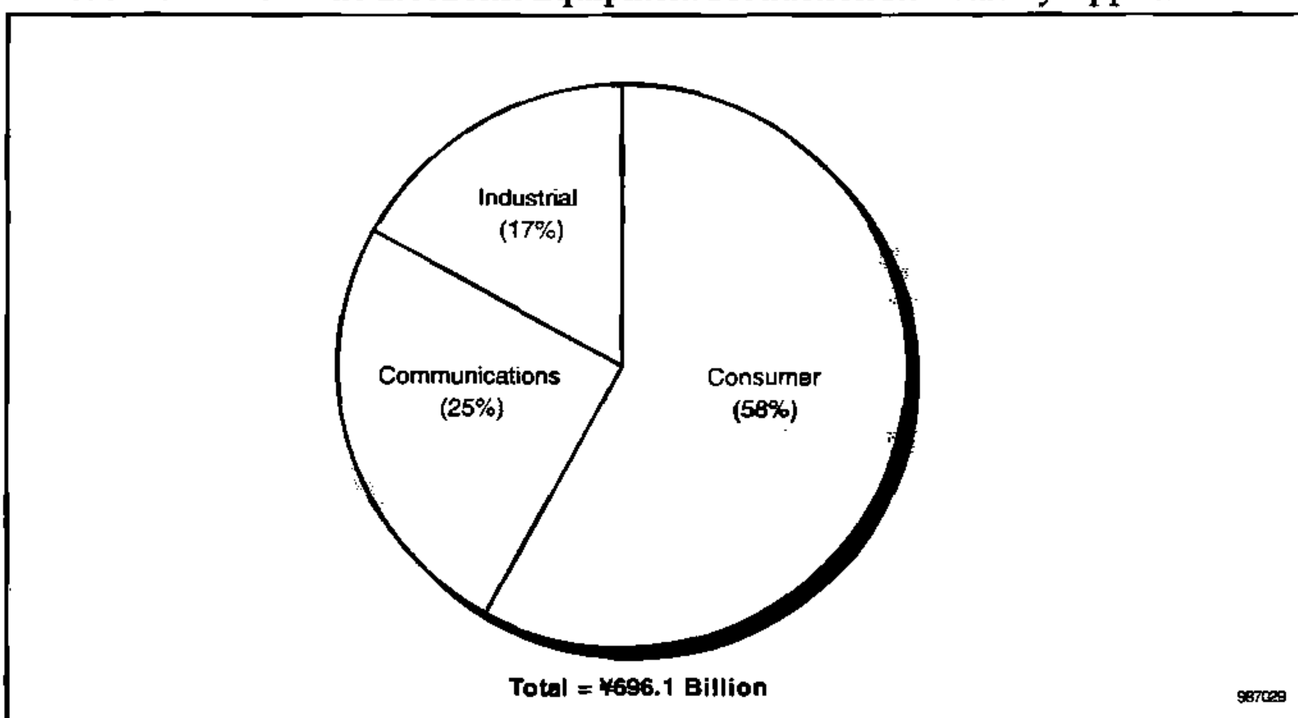
Table 4-22 shows Victor's major electronic products. Figures 4-64 through 4-66 show Victor's equipment production and semiconductor purchase trends.

Table 4-22
Victor's Major Electronic Products

Application	Products
Data Processing	Rigid disk drives, CD-ROM displays, terminals
Communications	Corded phones, cordless phones, PHSs
Consumer	TVs, VCRs, camcorders, CD players, musical instruments, minidiscs, digital still cameras
Industrial	Manufacturing systems

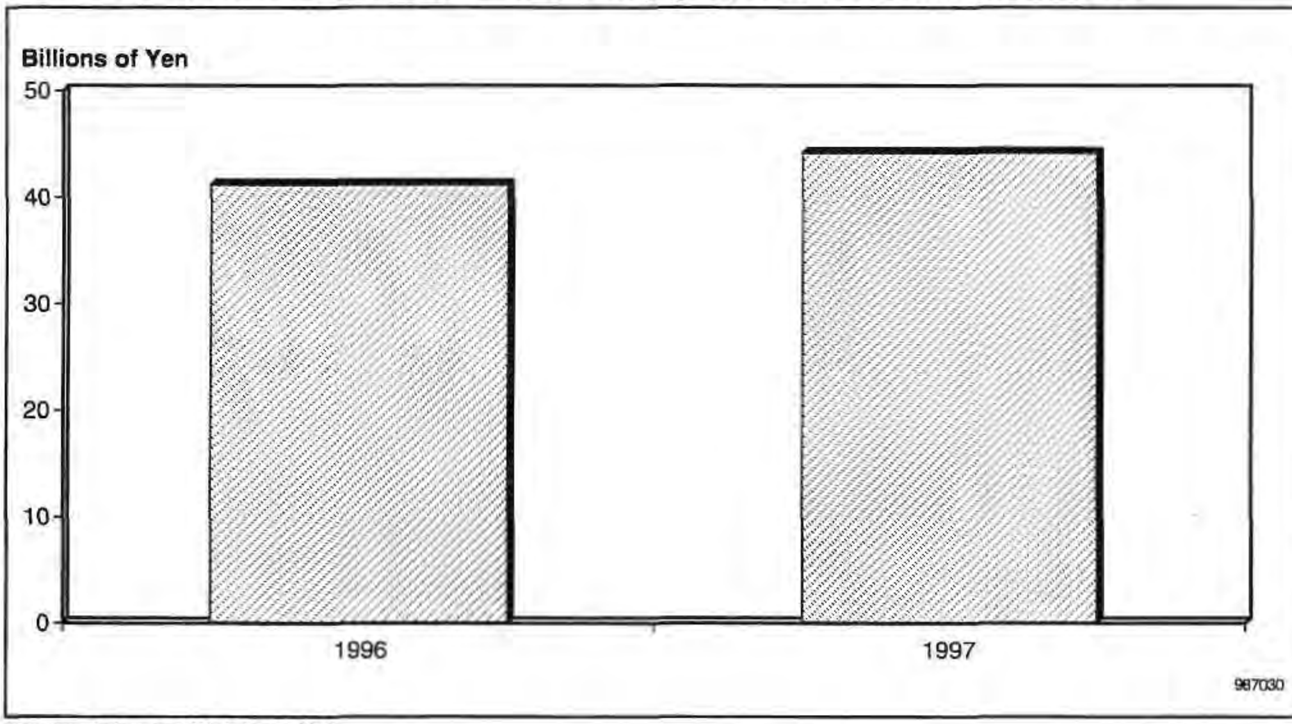
Source: Dataquest (October 1998)

Figure 4-64
Victor's 1997 Worldwide Electronic Equipment Production Revenue by Application



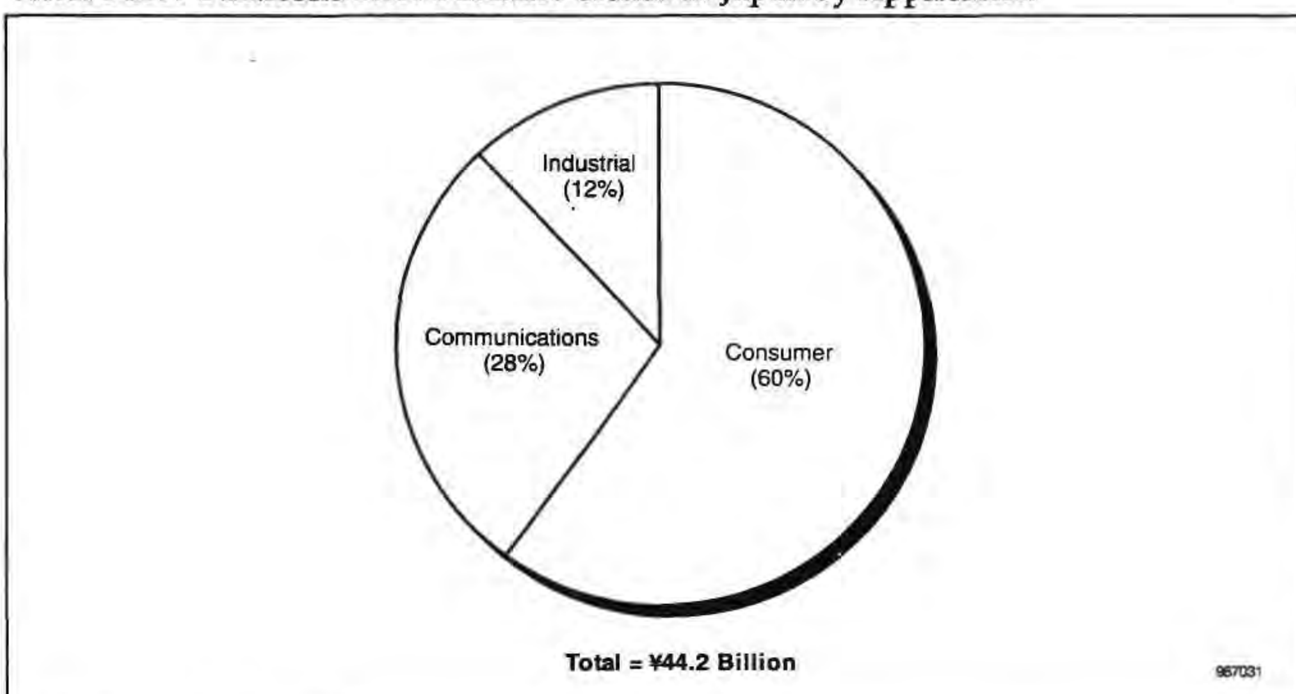
Source: Dataquest (October 1998)

Figure 4-65
Victor's Semiconductor Purchase Trends in Japan, 1996-1997 (Billions of Yen)



Source: Dataquest (October 1998)

Figure 4-66
Victor's 1997 Semiconductor Purchase Trends in Japan by Application



Source: Dataquest (October 1998)

Dataquest Perspective

This survey and analysis is based on the results in 1996 and 1997, which were not years when the Japanese market showed a clear direction of future growth. Instead, those were the years when the Japanese market lost ground to foreign markets. Nevertheless, the results of this analysis seem to point out the following key concepts:

- Large companies are not necessarily going to be growth engines in Japanese electronics production, nor will they be stable and strong, if they do not have competitive products in key, growing categories.
- In the consumer category, companies of various sizes are increasing production, leveraging on new, niche product offerings.
- The growth rate of semiconductor purchasing was stronger among smaller users not included in the top 22 companies analyzed in this report.
- The category that is driving growth has shifted from data processing to communications, and in the future, users in this category will be the target customers for semiconductor vendors selling into Japan.
- Companies using semiconductors are changing their business focus, affecting semiconductor purchasing by application. Semiconductor vendors will need to focus more on tracking each user's trends rather than on measuring application markets en masse.

It should be noted that digital consumer equipment is rising steadily even though the market size is still small. Also, the production sites of Japanese electronics companies are becoming more and more regionally diversified. Moreover, sluggishness in Japanese production does not correlate with some companies' worldwide activity.

The previous statements, however, suggest the need for vendors to review customer-support strategies, especially at a time when system-oriented marketing and system-level integration (SLI) are becoming the keys to success, but these are also beginning to represent a larger load for vendors.

A more detailed analysis by application will identify the exact drivers of semiconductor consumption growth for each company using semiconductors. Also, it is essential to look into the technology potential of these companies to decide strategies for each company, both in terms of system technology to be incorporated into system-oriented chips and in terms of supporting the development of such chips, including SLI ASICs. This report does not describe whether internal user divisions are contributing to semiconductor divisions' sales, system marketing capability, and product development.

Dataquest believes that, in the era of SLI, semiconductor vendors face the challenge of strengthening their customer support and system-oriented marketing capability.

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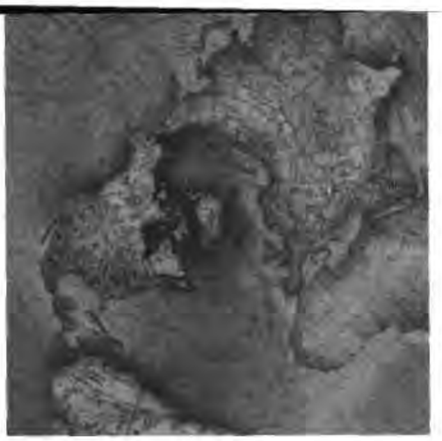

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1997 Semiconductor Strategic Alliances: Japanese Companies

Focus Report

Program: Semiconductors Japan
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Publication Date: April 6, 1998
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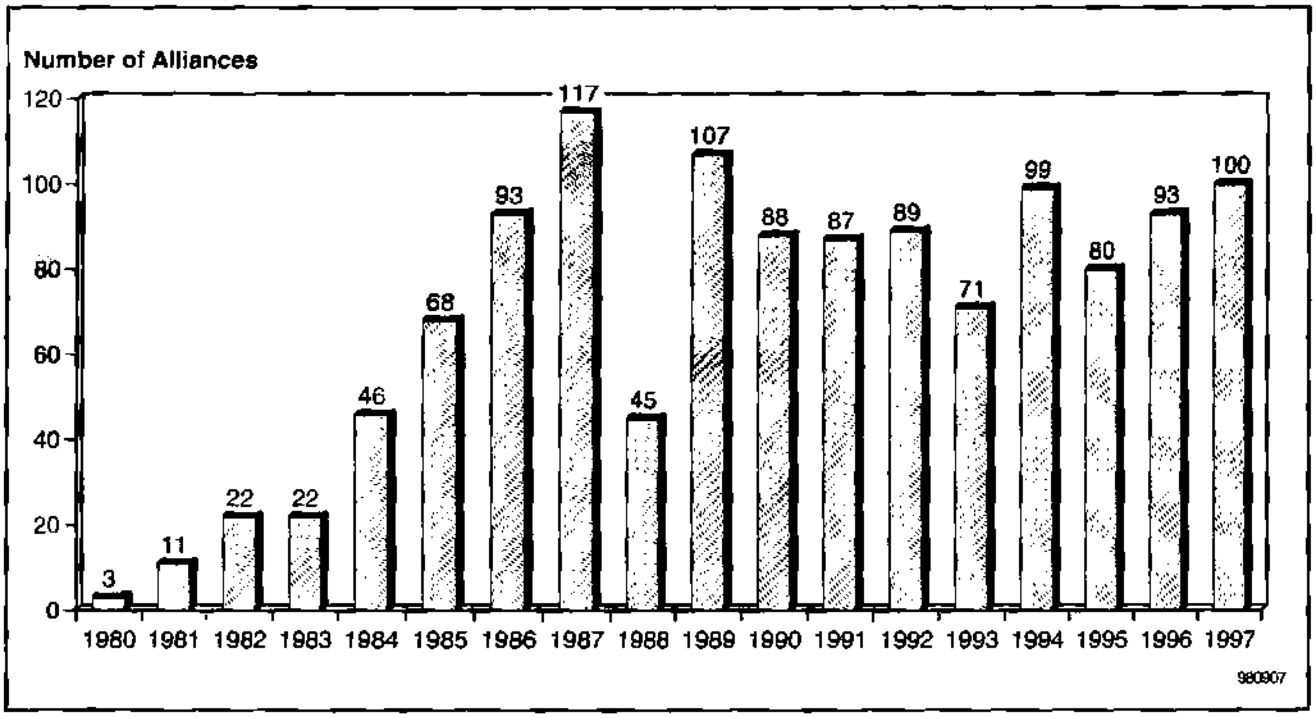
Chapter 1
Executive Summary

Despite continued economic troubles in Japan and elsewhere in Asia, Japanese vendors still engaged in a relatively high number of semiconductor-related alliances in 1997. For the second year in a row, the number of Japanese semiconductor-related alliances rose. Figure 1-1 illustrates the Japanese semiconductor alliance rate from 1980 through 1997.

There are growing indications from alliance activity in 1997 that Japanese vendors are banking on the market success of merged logic-DRAM technology as the future mainstay of their semiconductor businesses. The timing of a transition from a DRAM-centric to an embedded DRAM-centric strategy is significant, because a miscalculation by Japanese vendors could cause them to lose ground in the development of next-generation commodity DRAMs while they divert resources toward the development of embedded DRAM products. The possible gains, however, are significant because the technology has the potential to increase market share in the application-specific IC (ASIC) and logic businesses, a goal that most Japanese vendors have targeted for several years. Alliances not only will allow Japanese vendors to redistribute their resources from a DRAM to an embedded DRAM production orientation, which would effectively merge their now separate memory and logic businesses into a single unit, but they might also provide a fast-response safety net in case the companies' projected time line is off and they need to retreat to a more conservative strategy. If the embedded DRAM technology, for whatever reason, fails to mature before commodity DRAMs return to a supply-limited market, alliances will almost certainly be used as a mechanism for Japanese companies to get back into the commodity DRAM business.

Project Analyst: Junko Matsubara

Figure 1-1
Japanese Companies' Semiconductor Alliances (1980 through 1997)



Source: Dataquest (March 1998)

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Chapter 2
Diversification and Resource Allocation with Alliances

Many parts of the electronics industry were showing signs of weakness as 1997 came to a close. DRAM production lines were either being shut down or had their expansion plans delayed. Semiconductor fabrication equipment manufacturers experienced order cancellations that eventually led to layoffs of substantial portions of their workforces. Even application vendors, such as disk drive producers, were experiencing market pressures that have resulted in corporate restructuring. While the economic crisis in many parts of Asia, particularly Korea, has forced a change in the semiconductor business practices at companies in these countries and will undoubtedly have a ripple effect on electronics companies worldwide, Japan's economy has, for several years, remained in a state bordering on recession. Despite the weak economic condition of Japan, its domestic PC markets were expected to continue the growth trend that had been established during the previous year. During 1996, PC prices had fallen to world market levels, which caused a growth spurt in PC sales. However, by mid-1997, sales had flattened even though DRAM prices continued to fall, lower-priced machines had been introduced into the Japanese market, and PCs had far less penetration in the Japanese home market than in the United States.

The economic crisis that was beginning to affect many Asian countries in the last quarter of 1997 does not seem to have had much impact on the overall number of alliances that Japanese companies signed in specific countries or regions in the past two years. Nearly 60 percent of the Japan's semiconductor alliances formed in 1997 were with U.S.-based partners. This level is more or less unchanged from 1996 and reflects the continued importance that Japanese vendors place on partnerships with American companies. Figure 2-1 shows the percentage of the alliances that pair a Japanese company with a U.S.-based company over the last 13 years.

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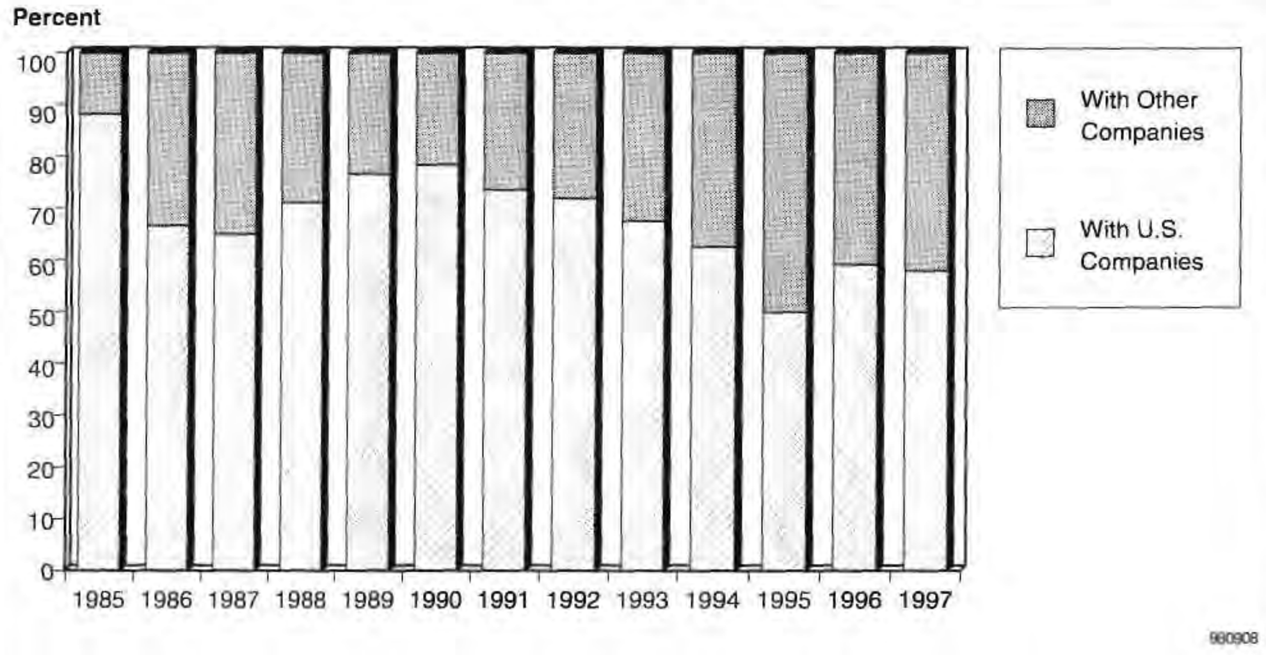
Figure 2-1
Japanese Semiconductor Alliances (U.S. Partners versus Non-U.S. Partners)



Source: Dataquest (March 1998)

DRAMs and 300mm Equipment

In 1997, Japanese vendors continued their quest to diversify away from their traditional overdependence on DRAM revenue. However, in implementing diversification plans, there are often conflicting goals that require a delicate balance of priorities in business strategy, particularly with regard to alliances. A transition to 300mm wafer production is clearly a long-term technology change that all major Japanese vendors will seek to make to remain cost competitive, but it will be difficult to justify the necessary investment in the face of a money-losing DRAM business. Furthermore, most vendors will need to secure permanent sources of commodity DRAMs for both internal consumption and to maintain their semiconductor sales organizations. The difficulty of achieving these goals increased during the year as DRAM prices continued to fall in an oversupplied market. The mass transition to 300mm production technology will occur eventually, but the weak DRAM market will likely delay or slow the adoption rate, because the large-scale equipment consumption of the commodity DRAM manufacturers will be a prerequisite to reducing the cost of 300mm equipment and make it affordable to the majority of logic and ASIC producers. For this reason, commodity DRAM alliances will likely continue with specific emphasis on 300mm equipment development. On the other hand, if DRAMs do not return to profitability before deployment of embedded DRAM products that can generate self-sustaining revenue, then a company could justify minimizing its DRAM-specific investments, farm out commodity DRAM production, and focus resources on building and accelerating its embedded DRAM capabilities. Alliances seem to provide a lot of flexibility for companies to distribute their resources to match their particular array of priorities.

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Alliances Send DRAM Production to Partners

Four alliances explicitly involving commodity DRAM occurred in 1997, but almost all can be interpreted within the context of a strategy that diversifies away from an emphasis on the commodity DRAM business (see Table 2-1). This has generally meant developing 300mm technology in joint ventures or licensing DRAM production technology to foreign-based companies, of which the Japanese company may hold a minority stake, in order to secure production output. As an example of transferring DRAM production to foreign companies, Toshiba Corporation agreed in February 1997 to purchase 20 percent of the Austin, Texas-based 64Mb DRAM facility of Samsung Electronics Company Ltd., allowing OEM procurement for Toshiba of 20 percent of the production output. In September 1997, Toshiba also provided Taiwan-based Winbond Electronics Corporation with DRAM production technology, which will secure a supply of both 64Mb and 256Mb from the Taiwan-based facility. Finally, in October 1997, Mitsubishi Electric Corporation agreed to provide Seiko Epson Corporation with 64Mb production technology. Mitsubishi will initially purchase all the production output of Seiko Epson's Sakata plant. Earlier, in May 1997, Mitsubishi had licensed Seiko Epson to produce video memory, also to be built at the Sakata plant, that would integrate 10Mb of DRAM with 2Kb of SRAM and graphics interface logic. All these alliances are consistent with a strategy of diversifying resources away from commodity DRAMs.

The only major joint venture of 1997 involving DRAMs was signed in February by Hitachi Ltd., Mitsubishi, and Texas Instruments Inc. and specified that the partners would jointly develop 1Gb DRAMs. However, this project was put on hold in February 1998. Although the partners have specified that they will resume joint development of 1Gb DRAM in one year, the future of this project will probably depend on the market outlook in 1999.

Table 2-1
DRAM and Next-Generation Wafer/Production Alliances

File Number	Company 1	Company 2	Product	Date
9	Fujitsu	Advantest	Advanced electron beam exposure system	February
23	Hitachi /Mitsubishi	Texas Instruments	1Gb DRAM	February
85	Toshiba	Samsung	64Mb DRAMs	February
82	Tokyo Seimitsu	Super Silicon Institutes	400mm-wafer wire saw	March
66	Sankyo Engineering	Sugai	Wet-type cleaning system for 300mm wafers	April
54	NEC	Samsung	300mm wafer production	July
94	Toshiba	IBM	300mm wafer production	July
34	Lapmaster SFT	Super Silicon Crystal Research	CMP machine for 400mm wafers	August
95	Toshiba	Winbond	64Mb, 256Mb DRAMs	September
70	Seiko Epson	Mitsubishi	64Mb DRAM design, technology	October

Source: Dataquest (March 1998)

When Will 300mm Standardization Arrive?

Several other alliances made in 1997 address 300mm technology development.

Toshiba and IBM will cooperate in commercializing 300mm production, and will possibly set up a 300mm line at their joint production plant. Similarly, NEC Corporation and Samsung have agreed to share development of 300mm wafer fabrication equipment and technology across their memory plants. Both alliances are expected to have operational 300mm wafer production lines up and running by 1999. The oversupply of DRAMs, along with weak Asian currencies and economies, are contributing to very tentative ramp-ups of Japanese, Korean, and Taiwanese next-generation DRAM and 300mm wafer facilities. However, although no company has voiced concern, it seems that, if Japanese companies intend to focus their semiconductor businesses on embedded DRAM products, then they would not want any delay in the arrival of next-generation DRAM capabilities that would impede the transition to the next level of embedded DRAM products. This, of course, assumes there exists a next-level single-chip device or application that can use the higher amounts of DRAM, and presumably faster logic, provided by the next-generation merged processes. The applications that will drive the adoption of next-generation embedded DRAM products are not clear, but there are a few candidates, as described in the following sections. This uncertainty is a looming factor in the decision process that will dictate how Japanese vendors structure their alliance activities.

From DRAMs to Embedded DRAMs: How Fast Can We Get There?

There are skeptics, including individuals representing companies such as Intel Corporation, who have voiced their conviction that embedded DRAM technology will never become a mainstream technology. The basis of their argument is that the logic and memory processes of the future are incompatible. Nevertheless, if the critics are proven wrong, this would be somewhat ironic because Intel itself has essentially used its own processing expertise, including the use of BiCMOS, to counter the assault of RISC, with its inherent performance advantages, over the last few years. There have been many processing transitions over the years, such as NMOS to CMOS and bipolar to BiCMOS, and with each transition, there were always a few who either did not believe the new technology would ever become competitive or who miscalculated the timing of the transition. Today, there are enough companies that seem convinced that combining DRAM with fast logic is both feasible and an inevitable mainstream technology that one must consider the implications if these companies are correct. History has frequently proven that processing and circuit innovation has consistently surmounted the barriers they have encountered. The accuracy of Moore's law is a testament to the steady progress being made in integration capabilities. Table 2-2 lists the alliances occurring in 1997 that explicitly covered embedded DRAM technology. However, many of the other alliances of 1997, particularly those relating to RISC MPUs—described in a subsequent section—have also been extended to cover embedded DRAM technology. This is a logical extension of these alliances, since many RISC alliances involve the use of cores in ASIC libraries, which have recently been expanded to include embedded DRAM in addition to the usual RISC cores.

Table 2-2
Embedded-Related Alliances

File Number	Company 1	Company 2	Product	Date
87	Toshiba	Sun Microsystems	Embedded Java processors	April
41	Mitsubishi	Seiko Epson	3-D video chips	May
90	Toshiba	NeoMagic	Embedded memory	May
91	Toshiba	Chartered Semiconductor	Embedded DRAM process technology	June
77	Sony	Oki Electric	System-on-a-chip	August
45	Mitsubishi	Powerchip Semiconductor	Embedded DRAM technology	November
57	NEC	Lucent Technologies	V-series RISC core	December

Source: Dataquest (March 1998)

Notebook Graphics Accelerators Still the Only Application for Embedded DRAM in 1997

In contrast to the splash that embedded DRAM alliances made in 1996, the alliance activity involving embedded DRAM technology in 1997 was very subdued. Part of the reason for this is that the graphic accelerator market, the initial market to capitalize on the benefits of embedded DRAM technology, had become overcrowded in 1997. Too many players meant steep drops in accelerator prices and shrinking market windows that resulted in some once high-flying start-ups dropping off the radar screen. With these conditions, it wasn't surprising that the shifts in the market diverted attention away from the progress being made on the merged logic-DRAM processing front. Moreover, falling graphics controller and accompanying memory prices may have also confined the embedded DRAM graphics controllers to the notebook segment only, where power efficiency is the primary selling point, and prevented migration to the desktop world, where the ratio of processing power to cost is usually the only criterion that determines market success.

Although only three or four alliances explicitly involving embedded DRAM technology were signed by Japanese companies in 1997, two of the 1997 alliances were inked by Toshiba. In June, Toshiba licensed its 0.35-micron DRAM-mixed logic technology, later to be migrated to 0.25-micron, to Chartered Semiconductor Mfg. Pte. Ltd. of Singapore. Chartered is expected to launch production with this technology in 1998. As an update to a Toshiba-Chromatic Research Inc. alliance formed in 1995, Toshiba has disclosed plans to use the second generation of Chromatic's Mpact 2 core in an embedded DRAM chip targeting notebook computers. The Mpact DSP uses a very long instruction word architecture, and the Toshiba part will be built sometime in 1998 with 4MB of DRAM and a 128-bit internal bus using Toshiba's 0.25-micron merged logic-DRAM process. The Mpact 1 and 2 were originally designed to use the Rambus DRAM and interface, and the move to an embedded DRAM part is expected to reduce power consumption by several watts, an important savings for notebook applications.

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Interestingly, Toshiba also signed an alliance agreement in May 1997 to act as foundry for NeoMagic Corporation notebook graphics controllers. Strong demand for NeoMagic controllers has evidently required the company to supplement its supply of controllers being produced by Mitsubishi. Mitsubishi, an original investor in NeoMagic, will continue to make embedded DRAM controllers for NeoMagic; however, both Mitsubishi and Toshiba are, or shortly will become, competitors to NeoMagic because both have plans to build graphic controllers for notebook applications using their own designs and embedded DRAM technology. As seen below, the Mpact digital signal processor (DSP) is not the only device intended to make a transition from an external Rambus memory interface to an embedded DRAM solution.

Teams Research Multiple-MPU Parallel Processing with Embedded DRAM

Although no Japanese vendor has yet announced a formal alliance with the start-up PixelFusion Limited, based in Bristol, England, its work is particularly interesting in that it is specifically addressing the needs of the very high end of 3-D graphics accelerators by using massively parallel designs, developed at the University of North Carolina at Chapel Hill, in conjunction with an implementation in a merged logic-DRAM process. Silicon prototypes have been built by Chartered Semiconductor Manufacturing of Singapore, but the demands of building numerous processing units with large amounts of memory on a single chip may call for cutting-edge processes. It would therefore not be surprising if PixelFusion sought Japanese vendors as alliance partners to build its production designs. Indeed, the work at PixelFusion parallels the three-year research project being conducted at a Japanese consortium formed at the end of 1996. Based on the work of Professor Murakami from Kyushu University, the consortium initially anticipated that media processors using parallel processing architecture would reach the market by 1998. Similarly, a European research consortium, based at a university in Belgium, announced in December 1997 its intention to develop MPEG-4 chips that will be implemented with mixed logic-DRAM technology. Japanese partners have been included in the consortium, and project is also scheduled to run for three years, beginning in January 1998.

Because Japanese vendors arguably have been working on the development of embedded DRAM technology the longest, they have entered into several noteworthy alliances covering embedded DRAMs. This alliance activity is expected to continue; however, it should also be noted that there are conflicts within the industry that seem to be having a distinctly antialliance effect. Japanese vendors are currently suing several of their major Korean DRAM competitors for royalty payments, and, in some cases, seeking injunctions designed to prevent Korean vendors from selling their parts in the United States. With the Koreans expected to follow the Japanese vendors into the merged DRAM-logic markets, it may be that recent legal actions against the Korean companies are designed to force these competitors to pay for some of the cost of developing an embedded DRAM technology that is likely to benefit all manufacturers eventually, including Korean vendors.

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As strange as it might sound, the legal action may actually have the effect of promoting alliances involving embedded DRAM development between Japanese and Korean vendors. Considering the lack of profit from the sales of commodity DRAMs, the cost of developing embedded DRAM technology will be difficult to sustain—predicting when a profitable return-on-investment will occur is not trivial, because it is dependent on finding the right uses for the technology at the right time. Furthermore, once an effective embedded DRAM process is achieved, the learning curve for nondevelopers will be simplified by information passing by way of both direct and indirect alliances. The Korean memory vendors will benefit from the pioneering work and probably cannot afford to pioneer the technology independently. The recent legal action by Japanese vendors is expected to force some Korean vendors to at least discuss either royalty payments, which would help defray the cost of developing technology, or more alliances in which vendors share the development cost of next-generation technologies.

ASICs Combine RISC Cores with Embedded DRAM to Open New Application Areas

Embedded DRAM may need to become the primary driver of the transition to 300mm technology if DRAMs continue to provide inadequate return on investment. Intel is sufficiently afraid of a mass vendor exit from the commodity DRAM business and the potential for a subsequent DRAM shortage that might affect its own microprocessor sales that the company is considering boosting its investments in major DRAM vendors by $1 billion. Meanwhile, most Japanese vendors are pushing ahead with research and development of merged logic and DRAM processes that seeks to minimize performance compromises. Besides graphics controllers for portable computing platforms, embedded DRAM products were expected to make their next appearance in hard disk drives. Because the disk drive industry seems to be in turmoil, there is less discussion of this happening soon. However, many other applications are being discussed as possible system-on-a-chip implementations that would include on-chip DRAM. A number of alliances that originally covered collaboration or licensing of RISC technology have been expanded to include RISC microcontroller (MCU) cores combined with embedded DRAM.

Alliances in Video Games, Windows CE Machines, ...

NEC is working with Nintendo Company Ltd. to eventually migrate its MIPS RISC-based video game controllers away from use of a Rambus memory interface architecture to a more efficient embedded DRAM solution. As with most custom ASICs, this can result in a lower cost-to-performance ratio in very high-volume applications only, such as video game consoles. This application is interesting because it represents a mass market product that, unlike the notebook graphics controller, is probably not using the superior power consumption efficiency of the embedded DRAM technology as its primary selling point. NEC expects to have available to ASIC customers by spring 1998 the capability of merging 200-MHz logic with 32Mb of 100-MHz DRAM connected over a 128-bit bus.

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The electrical and market performance of both the Nintendo embedded DRAM video controller and Toshiba's embedded DRAM Mpact 2 chip, both having potentially abandoned the Rambus interface and memory combination, may provide an interesting comparison benchmark for ASIC customers thus far unconvinced of the advantages of using embedded DRAM technology.

In early February 1998, Sega Inc. confirmed a long-rumored alliance with Microsoft Corporation to cooperate on the construction of a game machine. The confirmation by Sega included the revelation that the new platform will use the Windows CE operating system. Just as with the Nintendo-NEC alliance, the Sega-Microsoft game console is an application that can benefit from the use of an integrated game controller that merges embedded DRAM with logic. Dataquest would therefore expect to see in the not too distant future an alliance with a semiconductor producer, such as a manufacturer already building RISC cores for Windows CE platforms and probably at least planning on an embedded DRAM version of the Windows CE device. A large and growing number of vendors would qualify for such a project.

In the first quarter of 1997, Mitsubishi began working with ACCESS Corporation to customize a Mitsubishi chipset for use in portable Internet terminals, which include the M32R/D, a 32-bit RISC processor currently embedded with 2MB of DRAM. This processor family is scheduled to reach a clock speed of 400 MHz with 16MB of embedded DRAM, built with a 0.2-micron geometry, by the year 2000. Mitsubishi will also codevelop, as well as cross license, microcomponent cores embedded with DRAM with Motorola Incorporated, as a continuation of an alliance formed in October 1996. This alliance involves an embedded DRAM version of Mitsubishi's M32R and Motorola's 68EC000 and Coldfire processors.

In the second quarter of 1997, Toshiba partnered with Sun Microsystems Inc. to develop a Java processor for use in network computers. The microJava chip will incorporate a picoJava core, a memory controller, and embedded DRAM. Toshiba also announced in July 1997 the development of its MIPS based, Virtual Socket Interface (VSI)-compliant, TX19. This is a low-power, low-cost, embedded RISC processor that Toshiba intends to combine with embedded DRAM in the company's 0.25-micron DRAM-ASIC process.

In the third quarter of 1997, Hitachi announced that its SH-3 and SH-4 RISC MPU cores would be available in an embedded DRAM-enabled 0.35-micron process that ASIC clients can use to add DRAM in 256Kb increments, called "micromodules" by Hitachi. By 1999, Hitachi expects to field an SH-4 core with flash and micromodules based on 256Mb 0.25-micron DRAM technology. The number of RISC core license agreements, combined with embedded DRAM agreements, would suggest that mobile computing devices, particularly Windows CE machines, are expected to become a significant product segment making heavy use of system-on-a-chip designs that include embedded DRAM.

In the fourth quarter of 1997, NEC and Lucent Technologies formalized an alliance that has Lucent licensing NEC's V800 series of RISC MCUs. As part of this alliance and possibly two previous alliances formed between the partners in June and October 1996, the two companies are said to be working together on an embedded DRAM process that Lucent expects to incorporate into its own 0.25-micron ASIC process by mid-1999.

Table 2-3 shows the alliances that covered RISC technology in 1997.

Table 2-3
RISC-Related Alliances

File Number	Company 1	Company 2	Product	Date
38	Mitsubishi	Access	M32R-base embedded DRAM chipset	February
49	NEC	Wind River Systems	Embedded RISC operating system	January
19	Hitachi	Mentor Graphics	CAD tools for SH RISC processor	April
88	Toshiba	MIPS Technologies	MIPS RISC technology	April
44	Mitsubishi	Mentor Graphics	M32R-base system-on-a-chip development	June
75	Sony	Advanced RISC Machines	ARM7 RISC core	July
55	NEC	Tseng Labs	PowerVR RISC core	September
59	NKK	Toshiba	32-bit RISC microcontroller	September
20	Hitachi	Seiko Epson	SH-3 microcontroller	November
21	Hitachi	NTT Electronics	SH-3 RISC processor core	November
57	NEC	Lucent Technologies	V-series RISC core	December
22	Hitachi	SGS-Thomson	64-bit RISC processor	December

Source: Dataquest (March 1998)

Chapter 3

Displays, Micromachines, and Sensors Also Head toward Merged Processes

The synergy between traditional semiconductor circuits and integrated displays, sensors, and micromachines continues to grow and, in some cases, is already showing signs of merging with mainstream IC manufacturing. Moreover, VSI will facilitate the connection of not only standard IC cores, but also a growing array of new, CMOS-compatible devices that include sensors, micromachines, and even displays. Although start-up companies have always been expected to gamble on some of these esoteric technologies, many traditional IC companies, never having strayed too far from standard analog or digital IC fabrication technologies (at least in production), are also aggressively building exotic production-worthy process portfolios. For example, National Semiconductor Corporation is attempting to build active-matrix LCDs on standard wafers, Toshiba and Atmel Corporation are building CMOS image sensors, and Texas Instruments has made a heavy, highly publicized investment in its micromachined mirrors, also on standard wafers. The integration of such technologies with a memory-logic process should allow for the creation of such things as a true system-on-a-chip digital camera.

Although traditional IC manufacturing processes are incorporating more nonstandard components, from the opposite end of the processing spectrum, flat panel display manufacturers are starting to build circuits on their thin semiconductor films on glass or quartz substrates. There has been a recent surge in active-matrix LCDs research as this segment of the flat panel display industry continues to give upstart flat panel technologies a moving target. Nine new alliances involving LCDs occurred in 1997, which outpaced the LCD alliance activity of 1996. These alliances are listed in Table 3-1. The breadth of the technologies that are being combined with liquid polarizing crystals is beginning to overwhelm the work in other nascent technologies, such as field emission devices (FEDs), to the degree that some may already have missed their window of opportunity for commercialization because of the rapidly falling cost and improving performance of active-matrix LCDs. Active-matrix LCD reflective displays are being touted for their extreme power efficiency in mobile computing and communications applications, as well as for use in head-mounted displays or viewfinders in digital cameras and camcorders. Windows CE machines and personal digital assistants (PDAs) are expected to be among the first application markets to benefit from efficient reflective devices, some equipped with part-time backlighting capabilities. Sharp Electronics Corporation announced in September 1997 a reflective display for Windows CE machines that features a 30 percent reflection and 10:1 contrast ratio.

Table 3-1
Display-Related Alliances

File Number	Company 1	Company 2	Product	Date
37	Mitsubishi	Compaq	TFT LCDs	January
5	Dainippon Screen	Kyoto Technica	Semiconductor/LCD equipment maintenance	March
28	Itochu	Grand Pacific Petrochemical	LCD production	April
65	Ryosho Electronics	NeoParadigm Labs	LCD signal-processing ICs	April
42	Mitsubishi	Chungwa Picture Tube	TFT display technology	May
74	Sony	Toyota Group	Low-temperature polysilicon LCDs	June
99	Ulvac	Idemitsu Kosan	TFT panel transparent conductive film	June
76	Sony	Sharp/Philips	Next-generation large LCDs	July
8	Fuji Film	Kopin	Display technology	November

Source: Dataquest (March 1998)

On the materials research front, the films used to make active-matrix LCD panels are continuing to reach higher quality levels—meaning fewer defects. Although low-temperature polysilicon films are just beginning to reach commercialization, the films still in development are even closer in characteristics to bulk crystalline silicon. The fundamental materials and thin-film transistor research is yielding advances that suggest that active-matrix LCD and system ICs may well merge into another hybrid class of devices based on yet another merged process. Along these lines, Sharp's continuous grain silicon has continued the trend of improving thin films from amorphous films toward the ultimate goal of crystalline silicon-like electrical characteristics. Achieving this goal would improve the performance of active-matrix LCDs, as well allow the construction of all peripheral circuits right on the same substrate, with improved yield. If this trend continues, the 300mm technology of the silicon wafer industry may begin to have even more in common with the flat panel TFT processing technology than it already has.

Chapter 4
Dataquest Perspective

There is a prevailing notion that for some Japanese vendors, DRAMs and embedded DRAMs have become one and the same industry. During the current DRAM oversupply, it appears that many Japanese chip vendors will continue to use alliances either to shift their commodity DRAM production to offshore joint ventures or to completely transfer their commodity production to licensed Asian partners. At the same time, the major Japanese vendors will attempt to accelerate the transition to embedded DRAM technology for a widening array of multichip products that currently use separate memory parts, particularly those that either require better power-consumption performance, such as notebook computer components, or that rely on high-speed logic-to-memory buses, such as the Rambus interface. There is certainly risk in this strategy, because the Japanese vendors may be forcing themselves to exit the commodity DRAM prematurely, at a time when embedded DRAM revenue may be insufficient to support the upgrades to 300mm equipment. However, the DRAM business for many Japanese vendors is a losing proposition with a cloudy outlook, and the successful deployment of a competitive embedded DRAM technology has the potential to boost the competitiveness of Japanese ASIC and logic businesses substantially. Moreover, alliances may also provide a fast recovery mechanism if the transition to systems-on-a-chip, using embedded DRAM technology, is delayed or the commodity DRAM business again becomes too lucrative to ignore. Regardless of how individual Japanese companies will implement their particular memory and ASIC strategies, the common denominator is certain to be their use of alliances to adapt quickly to market conditions and technology shifts. There are just too many advantages to alliances that outweigh the potential drawbacks.

The last U.S.-Japan Semiconductor Trade Agreement was allowed to expire over a year ago. The robust rate at which Japanese and U.S. companies have entered into new alliances since the expiration, as well as the continuing high market share of foreign companies in Japan, often exceeding 30 percent in the past year, provides some support for those that argue that the decision not to renew the trade agreement at the end of July 1996 was correct.

Appendix A

1997 Japanese Semiconductor Strategic Alliances

Table A-1 lists the companies involved in publicly announced strategic alliances occurring in 1997. The individual alliance agreements are summarized in Appendix.

Dataquest classifies strategic alliances into the following 12 major categories.

- LA—Licensing agreement: A Japanese company receives or issues a license to a partner for an up-front fee or royalties.
- SS—Second-source agreement: Both companies agree to develop consistent specifications to ensure a second source.
- SA—Sales agency agreement: A Japanese company sells its partner's products, either as a sales representative or value-added reseller (VAR).
- FA—Fab agreement: A Japanese company offers fab capacity for a partner's product technology.
- AT—Assembly and testing agreement: A Japanese company sends or receives devices for assembly or testing.
- TE—Technology exchange: Both companies exchange technology, which may or may not include a transfer of money.
- JV—Joint venture: The two companies form a new joint-venture company to develop, manufacture, and market new products.
- JD—Joint development: Both companies agree to develop new products jointly, which may or may not be marketed separately.
- IV—Investment: A Japanese company invests in a partner company to secure new technology or access to new markets.
- CO—Coordination of standards: A Japanese company and a partner agree to device standards to ensure compatibility.
- PC—Procurement agreement: A Japanese company agrees to buy more foreign semiconductors as part of market access program.
- OT—Other: Joint symposia and programs

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Table A-1
1997 Semiconductor Strategic Alliances: Japanese Companies

File Number	Company 1	Company 2	Product	Type	Date
1	Access	National Semiconductor	Internet TV chip	JD	September
2	Asahi Glass	Aspec Technology	ASIC libraries	SA	January
3	Asahi Glass	Advanced Micro Devices	AMD-K6 microprocessor	SA	March
4	Canon	Scientech	Stepper sales and support	JV	January
5	Dainippon Screen	Kyoto Technica	Semiconductor/LCD equipment maintenance	JV	March
6	DSI	Korean company	Vertical electric furnaces	JV	October
7	Enplas	Hicad	IC test socket	LV	June
8	Fuji Film	Kopin	Display technology	LA	November
9	Fujitsu	Advantest	Electron beam exposure system	JD	February
10	Fujitsu	LG Semicon	Chip-scale package	CO	March
11	Fujitsu	Sand Microelectronics	USB chip	LA	March
12	Fujitsu	Nantong Huada Microelectronics	Assembly of MCUs and linear ICs	JV	May
13	Fujitsu	Rambus	High-speed memory interface technology	LA	July
14	Fujitsu	Orckit	ADSL modem chip	JD, SA	August
15	Fujitsu	AMD	64Mb NAND flash	JD	October
16	Fujitsu	Sun Microsystems	picoJava core	LA	November
17	Furukawa Electric	Lucent Technologies	Assembly of optical semiconductors	JV	February
18	Gunze Sangyo	Plasmaquest	Plasma etching, plasma CVD systems	IV	February
19	Hitachi	Mentor Graphics	CAD tools for SH RISC processor	JD	April
20	Hitachi	Seiko Epson	SH-3 microcontroller	LA	November
21	Hitachi	NTT Electronics	SH-3 RISC processor core	JD	November
22	Hitachi	SGS-Thomson	64-bit RISC processor	JD	December
23	Hitachi/Mitsubishi	Texas Instruments	1Gb DRAM	JD	February
24	Hitachi Chemical	DuPont	Polyimide material	JV	September
25	Hitachi Construction Machinery	Hitachi Medico	X-ray-based inspection system	PC	December
26	Hitachi Maxell	Singlechip Systems	IC tag	TE	December
27	Innotech	Credence Systems	Memory tester	JV	November

Table A-1 (Continued)
1997 Semiconductor Strategic Alliances: Japanese Companies

File Number	Company 1	Company 2	Product	Type	Date
28	Itochu	Grand Pacific Petrochemical	LCD production	JV	April
29	Itochu	Comdisco	Semiconductor equipment leasing	JV	September
30	Kaijo	Robotic Vision Systems	BGA inspection system	SA	November
31	Kaijo	Quad Systems	Flip-chip bonder system	SA	December
32	Kanematsu Semiconductor	Integraphics Systems	Internet TV chip	SA	September
33	Kyocera	Johnson Matthey	Cross-license for packaging	LA	October
34	Lapmaster SFT	Super Silicon Crystal Research Institutes	CMP machine for 400mm wafers	JD	August
35	Matsushita	Texas Instruments	Digital video camera ICs	JD	January
36	Matsushita	CBL	Blue laser	JD	July
37	Mitsubishi	Compaq	TFT LCDs	JD	January
38	Mitsubishi	Access	Communications chipset, embedded MCU	LA	February
39	Mitsubishi	Wind River Systems	Embedded operating system	LA	March
40	Mitsubishi	Rambus	High-speed memory interface	LA	April
41	Mitsubishi	Seiko Epson	3-D video chip	LA	May
42	Mitsubishi	Chungwa Picture Tube	TFT display technology	LA	May
43	Mitsubishi	Stone Group	Semiconductor sales	JV, SA	June
44	Mitsubishi	Mentor Graphics	System-on-a-chip development	JD	June
45	Mitsubishi	Powerchip Semiconductor	Embedded DRAM technology	LA	November
46	Mitsubishi Materials	Symmetrix	Ferroelectric material	LA	December
47	Mitsui & Co.	Micron Communication	Noncontact tag	JD	April
48	Mitsui High-Tec	Ball Semiconductor	Ball-shaped silicon wafer	IV	August
49	NEC	Wind River Systems	Embedded RISC operating system	LA	January
50	NEC	Datapath	EPRML LSIs	LA, JD	February
51	NEC	Synopsys	ASIC design verification technology	JD	April
52	NEC	Shanghai Huahong Micro	Semiconductor front-end fab	JV, FA	May
53	NEC	Cadence Design Systems	Cadence CAD design tool	SA	July
54	NEC	Samsung	300mm wafer production	JD, TE	July

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Table A-1 (Continued)
1997 Semiconductor Strategic Alliances: Japanese Companies

File Number	Company 1	Company 2	Product	Type	Date
55	NEC	Tseng Labs	PowerVR RISC core	JD	September
56	NEC	Philips Semiconductor	Consumer LSIs	JD	November
57	NEC	Lucent Technologies	V-series RISC core	LA	December
58	Nichimen Electronics	Luxsonor	MPEG-2 decoder chip	SA, JD	May
59	NKK	Toshiba	32-bit RISC microcontroller	LA	September
60	Nomura Microscience	Ionics	Electrical deionization equipment	SA	July
61	Nozaki Industry	High Yield Technology	Particle monitor system	SA	May
62	Oki	Synopsys	CBA technology	LA	January
63	Oki	Artisan Components	Memory generator	LA	April
64	Rohm	DSP Group	DSP technology	LA	March
65	Ryosho Electronics	NeoParadigm Lab	LCD signal processing ICs	SA	April
66	Sankyo Engineering	Sugai	Wet-type semiconductor cleaning system	JD	April
67	Santoku /Mitsui & Co.	Merck	Ultrapure hydrogen peroxide water	JV	October
68	Seiko Epson	Lattice	Fabrication service	FA, IV	March
69	Seiko Epson	Exemplar Logic	ASIC library environment	LA	June
70	Seiko Epson	Mitsubishi	64Mb DRAM design, technology	LA, SS	October
71	Seiko Seiki	Jenoptik Infab	SMIF system	SA	December
72	Sharp	SanDisk	Cross-license for flash memory	LA	January
73	Shin-Etsu Handotai	Soitec	SOI wafer production	LA, JD	May
74	Sony	Toyota Group	Low-temperature polysilicon LCDs	JD	June
75	Sony	Advanced RISC Machines	ARM RISC	LA	July
76	Sony	Sharp/Philips	Next-generation large LCD	JD	July
77	Sony	Oki Electric	System-on-a-chip	JD	August
78	Sumitomo Chemical	Olin	I-line photoresist	LA, JV	September
79	Sumitomo Corporation	Tokyo Kaseihin and others	Lead frame	JV	January
80	Sumitomo Corporation	R. Howard Strasbaugh	CMP system	JV	June
81	Sumitomo Corporation	Pixtec	FED	SA, IV	November
82	Tokyo Seimitsu	Super Silicon Institutes	400mm-wafer wire saw	JD	March

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Table A-1 (Continued)
1997 Semiconductor Strategic Alliances: Japanese Companies

File Number	Company 1	Company 2	Product	Type	Date
83	Tokyo Seimitsu	Seiko Seiki	Wafer dicing system	JD, TE	December
84	Toshiba	Unigen	Memory module	SS	February
85	Toshiba	Samsung	64Mb DRAMs	FA, IV	February
86	Toshiba	Motorola /Fairchild	CMOS standard logic	JD	March
87	Toshiba	Sun Microsystems	Java processors	LA, JD	April
88	Toshiba	MIPS Technologies	MIPS RISC technology	LA	April
89	Toshiba	Technology Modeling Associates	3-D process simulation	JD	April
90	Toshiba	NeoMagic	Embedded memory	LA, FA	May
91	Toshiba	Chartered Semiconductor	Embedded DRAM process technology	LA	June
92	Toshiba	iReady	Internet access LSI	LA	June
93	Toshiba	ViewLogic	Logic design tool	JD	July
94	Toshiba	IBM	300mm wafer production	JD, TE	July
95	Toshiba	Winbond	64, 256Mb DRAMs	PC	September
96	Toshiba	WSMC	Logic foundry service	FA	October
97	Tosoku	Samsung Aerospace	Wire bonding	SA, JD	October
98	Ulvac	Ramtron International	Ferroelectric materials	JD	March
99	Ulvac	Idemitsu Kosan	TFT panel transparent conductive film	JD	June
100	Yamaha	Xicor	EEPROM	SA, FA	February

Source: Dataquest (March 1998)

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Appendix B
1997 Alliance Agreements

Access

1. National Semiconductor (United States), September 1997

National Semiconductor Japan has teamed up with Tokyo-based software developer Access in the systems development for Internet-capable home electronics. The Japanese subsidiary of National Semiconductor intends to supply home electronics makers in Japan with a system-on-a-chip LSI that supports Access' Internet connection and search program, Netfront. The system-on-a-chip LSI centers around National's NS486 processor core, complying with Intel's x86 architecture, and integrates PCMCIA controller, IrDA, and other peripherals, providing all the functionality necessary to give a TV or satellite receiver Internet connectivity.

Asahi Glass

2. ASPEC Technology (United States), January 1997

Asahi Glass will market ASIC libraries developed by ASPEC Technology of the United States in Japan. ASPEC already handles ASIC libraries supporting the production processes of 15 chipmakers. The price is ¥300 million per kit. Asahi Glass has also started taking orders from customers in Japan for the ASIC Division of Hyundai Electronics, which uses ASPEC's libraries.

3. Advanced Micro Devices (United States), March 1997

Asahi Glass will step up sales of Advanced Micro Devices microprocessors this fiscal year. The company deals with AMD's Windows PC MPUs and in-built processors. For Windows PC MPUs, Asahi Glass hopes to tap demand for the K6 chip from domestic PC makers. In a move to market built-in processors for numerical control and point-of-sale systems, Asahi Glass has signed a distribution agreement with Microsoft to obtain an MS-DOS license. Plans also call for commercializing AMD MPU boards that incorporate Asahi Glass hybrid ICs.

Canon

4. Scientech (Taiwan), January 1997

Canon set up a stepper sales and support joint venture in Taiwan in early February. The company's third service center in Asia, Canon Semiconductor Equipment Taiwan will be headquartered in Taipei and will be capitalized at about ¥300 million, 80 percent by Canon and 20 percent by a local distributor, Scientech. The new company will initially be staffed by 22 employees. Canon, which has already won an order for more than 20 steppers from ProMos Technologies, a joint venture between Siemens and Mosel Vitelic of Taiwan, is aiming to nearly double its share to about 50 percent of the Taiwanese stepper market by 1999.

Dainippon Screen

5. Kyoto Technica (Japan), March 1997

Dainippon Screen Manufacturing and Kyoto Technica will jointly set up a semiconductor/LCD equipment maintenance service company. Based in Kyoto, DS Tec Kansai is capitalized at ¥50 million, with Dainippon Screen investing 82 percent and Kyoto Technica 15 percent; it will start operations with more than 100 employees. Dainippon Screen, which has entrusted maintenance service to a subsidiary and Kyoto Technica, will commission delivery and maintenance of equipment for its customers in the Kinki, Chugoku, and Shikoku regions to the new company. DS Tec Kansai is expected to achieve annual revenue of ¥1.1 billion in its first year.

DSI

6. Korean company (Korea), October 1997

DSI, a Japan-based semiconductor equipment production venture, will establish a joint venture in Korea in October to manufacture vertical electric furnaces for use in next-generation semiconductor production. To be capitalized at ¥40 million, DSI Korea will be owned 70 percent by a local company and 30 percent by DSI. With an initial staff of three salespeople and two engineers, the joint venture will have a clean room at its main office. DSI, which has been assembling vertical high-vacuum annealing systems at its Shizuoka plant, intends to scale down its domestic operations and shift manufacturing technologies and equipment to the Korean company.

Emplas

7. Hicad (China), June 1997

Emplas will set up an IC test socket sales joint venture in Shanghai with its Singapore distributor, Hicad. To be capitalized at $600,000, Emplas Hicad National Trading will import IC test sockets from Japan and launch sales in late July. The joint venture will target chipmakers, including NEC and Motorola, with IC manufacturing operations in China and will aim for annual sales of ¥2 billion in three years.

Fuji Film Microdevices

8. Kopin (United States), November 1997

Kopin and Fuji Film Microdevices, Japan, announced a strategic business agreement under which the companies will incorporate Kopin's CyberDisplay active-matrix LCD into Fuji's digital camera chipsets. Fuji and Kopin will work together to integrate Fuji charge-coupled device analog and logic circuits with Kopin's CyberDisplay. The goal of the strategic alliance is to make the chipsets available to Fuji internal and external customers by the second quarter of 1998. Based on Kopin's patented Smart Slide technology, the CyberDisplay is a 0.24-inch diagonal transmissive active-matrix LCD imaging device that displays information at 320 x 240 full-color-pixel resolution. It enables portable communications devices and personal information products to display photographic images and other data or video sources.

Fujitsu

9. Advantest (Japan), February 1997

Fujitsu and Advantest will concentrate their joint electron beam (EB) exposure system business at Advantest. The two companies jointly developed the F5120 EB exposure system for use in 256Mb or larger DRAM production, and Advantest has started marketing it. From April 1997, about 50 Fujitsu employees engaged in EB systems development will be on loan at Advantest's R&D center now under construction. Advantest expects to sell five of the ¥1 billion systems the first year.

10. LG Semicon (Korea), March 1997

Fujitsu and LG Semicon in Korea will unify the design guides of their proprietary chip-scale packages under the name "USON," for ultrathin small-outline nonleaded package. The companies plan to ask the Joint Electronic Device Engineering Council (JEDEC) to designate USON as a new standard package for memory devices. Fujitsu developed a chip-scale SON package, which has been used for its flash memory since September 1996. Compared with the conventional thin small-outline package (TSOP), the company claims, the SON package takes up about half the space in mounting, is two-thirds of the thickness, and is half the weight for 16Mb flash memory. LG Semicon developed the bottom-leaded plastic (BLP) package and has been using it for DRAM packaging. BLP is almost the same size as SON.

11. Sand Microelectronics (United States), March 1997

Fujitsu will license Virtual Socket Interface (VSI)-compliant Universal Serial Bus (USB) microcomponents from Sand Microelectronics and will commercialize a microcontroller with integrated USB microcomponents for use in monitors. The USB interface allows peripheral equipment to be connected with the PC with ease. By supporting the USB macro, Fujitsu will be able to offer LSIs that support various standard interfaces, including IEEE 1394, SCSI, and IrDA.

12. Nantong Huada Microelectronics (China), May 1997

Fujitsu has reached agreement with leading Chinese chipmaker Nantong Huada Microelectronics to establish a semiconductor assembly joint venture in China in late June. To be capitalized at $10 million, Nantong Fujitsu Microelectronics will be owned 40 percent and 60 percent by the Japanese and the Chinese companies, respectively. The joint venture will initially employ 400 people to assemble 10 million microcontrollers and linear ICs per month and will construct a new facility starting in fiscal 1998 to raise output to 40 million units.

13. Rambus (United States), July 1997

Fujitsu will team up with Rambus of California in 64Mb high-speed DRAM technology. Fujitsu will receive high-bandwidth Direct Rambus DRAM technology to develop memory systems with gigabyte-per-second-class data transfer speeds. A major reason for the alliance seems to be Intel's plan to use DRAMs with the Rambus interface as the main memory for PCs that will ship starting from 1999. Rambus' high-speed DRAM technology has been transferred to most of DRAM makers including NEC, Toshiba, Hitachi, Samsung, LG Semicon, and Hyundai.

14. Orckit (Israel), August 1997

Fujitsu Microelectronics and Orckit Communications are teaming up to produce a single-chip, discrete multitone-standard-based Asymmetric Digital Subscriber Line (ADSL) modem. The companies will recast Orckit's two-chip digital solution and its analog front-end, currently based on discrete components, into a 0.35-micron mixed-signal CMOS chip. They will also add Asynchronous Transfer Mode (ATM) and rate-adaptation features in line with a new definition of ADSL known as Issue II. Fujitsu will market the device commercially and to Orckit. The chip is expected to be available in mid-1998.

15. Advanced Micro Devices (United States), October 1997

Advanced Micro Devices and Fujitsu will codevelop a serial NAND-type flash memory architecture, and they expect to begin production with a 64Mb device by October 1999. The two companies currently manufacture NOR-type flash at a joint-venture fab in Aizuwakamatsu, Japan, and have not sold serial flash, which offers a smaller cell size at the expense of random access speeds. A team with staff from both companies is being formed to develop the NAND-type architecture.

16. Sun Microsystems (United States), November 1997

Fujitsu has reached agreement with Sun Microsystems to license Sun's picoJava I, a Java microprocessor core. The company will develop 32-bit RISC microcontroller core specialized in Java software using 0.35-micron technology in 1998 and begin marketing the core for use in PDAs and cellular phones in 1999. The Java processor based on picoJava I is reported to outperform conventional RISC processors such as the SPARClite by a factor of five, and Fujitsu plans to use 0.25-micron technology to expand the core's applications to Network Computers. The company is aiming for Java MPU core sales of ¥10 billion in 2001, and ¥50 billion, or 30 percent of the dedicated Java MPU market, in 2003.

Furukawa Electric

17. Lucent Technologies (United States), February 1997

Furukawa Electric and Lucent Technologies have established an optical semiconductor assembly joint venture in the United States. Finet Technologies will assemble laser diodes, photo detectors, and other optical semiconductors starting in April and will market the products through the partners' sales channels in Japan and the United States. Furukawa and Lucent, already joined in an optical fiber cable manufacturing venture, Fitel Lucent Technologies, plan to invest a total of about $10 million in the new joint venture by fiscal year 2000.

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Gunze Sangyo

18. Plasmaquest (United States), February 1997

Gunze Sangyo has acquired a capital stake in Texas-based semiconductor equipment maker Plasmaquest. Gunze, which has been distributing plasma etching and plasma chemical vapor deposition systems made by Plasmaquest in Japan since 1993, has bought with its U.S. subsidiary, Gunsan America, 14.81 percent of the U.S. company for $1 million. Plasmaquest needed financial support to expand production capacity to keep up with brisk demand for etching equipment in the North American market. Gunze wants to expand Japanese sales of Plasmaquest products to ¥1 billion in two years.

Hitachi

19. Mentor Graphics (United States), April 1997

Hitachi will work with Mentor Graphics to strengthen its 32-bit RISC processor development environment. Plans call for jointly developing SeamlessCVE, a hardware/software coverification tool for the Hitachi SH series microcontrollers. The tool, which will support MCUs in the SH-1, SH-2, and SH-3 series, will allow system designers to verify hardware and software and debug the software in the early stage of SH MCU-based equipment development, slashing development time by over one month. The tool is priced at ¥12 million.

20. Seiko Epson (Japan), November 1997

Hitachi and Seiko Epson announced an agreement concerning the licensing of Hitachi's 32-bit RISC microprocessor core technology to Seiko Epson. Seiko Epson intends to combine its low-power semiconductor technology with Hitachi's SH-3 core to build new ASICs and application-specific standard products (ASSPs) that better meet system requirements. Hitachi has been actively forming partnerships as part of establishing its 32-bit SH RISC engine family as an industry standard. The present agreement makes Seiko Epson the first Japanese partner and, for customers, will mean that more PC peripheral devices and portable information products built around SH MPUs will be available. Seiko Epson has developed 4-, 8-, and 32-bit CPUs. With the SH-3, Seiko Epson will address the need for products with a standard embedded CPU capable of running a standard operating system with its associated development environment.

21. NTT Electronics (Japan), November 1997

Hitachi and NTT Electronics will work together to develop a low-power SH-3 RISC microprocessor using a 0.25-micron process technology. Hitachi will provide its SH-3, designed for a 0.35-micron process, while NTT Electronics, which develops and manufactures ICs for its parent company, Nippon Telegraph & Telephone, will provide its 0.25-micron technology. Hitachi expects the collaboration will help it lower the power consumption of the SH-3 nearly 3 percent and shorten the 0.25-micron SH-3's time to market. The CPU is expected by spring of 1999.

22. SGS-Thomson (France), December 1997

Hitachi and SGS-Thomson Microelectronics formally unveiled plans to undertake joint development of 64-bit microprocessor cores for the Super-H family. The processor architecture will be backward compatible with Hitachi's SH-4 and is being targeted as a general-purpose engine for a wide range of products. The architecture of the first core that the companies will work on together, called SH-5 by Hitachi and ST50 by SGS-Thomson, is due to be disclosed in 1998, with first implementations sampled in the second half of 2000 and volume production in 2001.

Hitachi/Mitsubishi

23. Texas Instruments (United States), February 1997

Hitachi, Mitsubishi Electric, and Texas Instruments have signed an agreement to jointly develop 1Gb DRAM. The agreement, part of a trend toward huge investments to develop complex and expensive technologies, will allow the three chipmakers to share resources and leading-edge technologies. The three companies are aiming for sample shipments of the next-generation chips by early 2000, sharing the estimated development cost of more than ¥100 billion. Since 1988, TI and Hitachi have been teaming up to research and develop 16Mb, 64Mb, and 256Mb DRAMs, while Hitachi and Mitsubishi have jointly developed 8Mb, 16Mb, and 64Mb flash memory chips. In 1995, Hitachi and TI formed a joint venture, Twinstar, a $0.5 billion wafer fab located in Richardson, Texas.

Hitachi Chemical

24. DuPont (United States), September 1997

Hitachi Chemical and DuPont of the United States will jointly set up ventures in both countries to produce and market liquid polyimide materials for semiconductors and other electronic devices. The two companies have established Hitachi Chemical DuPont Microsystems LLC in the United States, slated to open in April 1999. An initial capital contribution of $14 million for the venture will be shouldered equally by DuPont and Hitachi Chemical's sales subsidiary, Hitachi Chemical America. The new joint venture will then establish Hitachi Kasei DuPont Microsystems K.K., as a wholly owned subsidiary in Japan, with capital of ¥400 million and a targeted operation date in 2002.

Hitachi Construction Machinery

25. Hitachi Medico (Japan), December 1997

Hitachi Construction Machinery has formed a partnership with Hitachi Medico in the semiconductor inspection equipment business. The company will procure as an OEM two types of x-ray-based semiconductor inspection systems from Hitachi Medico. Its goal is to nearly double its factory automation system sales to ¥3.6 billion by 2001 by broadening its x-ray inspection system product line. The MF130M and the MF80M feature focuses of 10 micron, and 8 micron, respectively.

Hitachi Maxell

26. Singlechip Systems (United States), December 1997

Hitachi Maxell has teamed up with Singlechip Systems of California to enter the IC tag business. The partners will combine Hitachi Maxell's non-contact IC card production technology with SCS' single-chip technology to manufacture and market an IC tag that will measure 10 x 60 x 0.25mm and have a memory capacity of 1,024 bits. A reader/writer will use 2.45-GHz signals to simultaneously read data on more than 30 write-once tags that can be 35cm apart. A set of the reader/writer and 100 tags will be priced at ¥600,000 to ¥1,000,000.

Innotech

27. Credence Systems (United States), November 1997

Innotech has established in Yokohama a semiconductor tester production joint venture with Credence Systems of California. Capitalized at ¥100 million, Innotech Credence is 49.9 percent owned by the Japanese semiconductor equipment distributor and 50.1 percent by the U.S. tester maker. The joint venture will manufacture logic and memory testers and put them on the market by spring 1998, aiming to ship a total of 50 units the first year. The first-year sales target is set at ¥4 billion.

Itochu

28. Grand Pacific Petrochemical (Taiwan), April 1997

Itochu, in cooperation with Fukushima-based technical consulting company Sumcon and Taiwanese chemical company Grand Pacific Petrochemical, will set up a joint LCD production company in Taiwan. The new company, Grand Pacific Optoelectronics, will be capitalized at about (4 billion, in which Itochu, Sumcon, and Grand Pacific Petrochemical invest 25 percent, 5 percent, and 70 percent, respectively. The joint venture expected to start constructing a plant in the Hsinchu industrial park in April 1997 and to produce sub-10-inch STN color LCDs for portable information devices and notebook computers from June 1998, aiming for first-year sales of about ¥10 billion.

29. Comdisco Inc. (United States), September 1997

Itochu and U.S. semiconductor equipment leasing company Comdisco have established a joint semiconductor equipment leasing company, Commit Equipment Management Service. Capitalized at ¥490 million, the joint venture is owned 60 percent by the U.S. company and 40 percent by the Japanese trading house. The joint venture is aiming for 20 billion in leasing contracts by 2000. Predicting that demand for used equipment may expand in Asia, the partners plan to sell used equipment to Taiwanese and Korean chipmakers. The used semiconductor equipment market in Japan is estimated at ¥5 billion, about 1/10th of the size of the U.S. used equipment market.

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Kaijo

30. Robotic Vision Systems Inc. (United States), November 1997

Kaijo has teamed up with Robotic Vision Systems Inc. of New York to expand its inspection system business. Kaijo will start marketing and providing support for RVSI's ball grid array (BGA) inspection and bump attachment systems in December. Through an alliance with Kaijo, RVSI wants to boost its Japanese market share, currently about 20 percent of the market.

31. Quad Systems (United States), December 1997

Kaijo has begun marketing a flip-chip bonder made by Quad Systems of Pennsylvania, signing an exclusive domestic sales contract with the U.S. company. The Advanced Packaging System APS-1 supports various types of packaging, including chip-scale package (CSP) and chip on board (COB) and uses an optical noncontact alignment system to achieve a high level of alignment. The price is ¥40 million.

Kanematsu Semiconductor

32. Intergraphics Systems (United States), September 1997

Intergraphics Systems of California will team up with semiconductor distributor Kanematsu Semiconductor and software house Access to market in Japan the CyberPro2010, a system-on-a-chip LSI enabling users to browse Internet home pages on TV. The chip integrates monitor output circuit and image control functions and a flicker-prevention function and features a built-in interface called Flexibus that makes the chip usable with all existing CPUs, including x86 and PowerPC microprocessors and Hitachi SH series microcontrollers. Intergraphics Systems claims that the chip helps Internet TV makers slash development time and design costs by nearly 60 percent, enabling them to lower retail prices from the current ¥300,000 to ¥100,000.

Kyocera Electronics Inc.

33. Johnson Matthey (United Kingdom), October 1997

Kyocera has signed a cross-license agreement with Johnson Matthey of London in the semiconductor plastic package business. The company will introduce plastic package technology from Johnson Matthey and start mass production of plastic land grid arrays (PLGAs) for microprocessors at its Sendai plant in Kagoshima Prefecture in January 1998. In return, Kyocera will provide the U.K. company with build-up substrate technology. Plans call for launching production at 500,000 units per month (45 x 45mm, 540 pins) and boosting output to 1.5 million units by July 1998, when the company will complete a new 10 billion production facility at the plant. Kyocera is aiming for PLGA sales of ¥5 billion to ¥6 billion in fiscal 1998.

Lapmaster SFT

34. Super Silicon Crystal Research Institute (Japan), August 1997

Lapmaster SFT of Tokyo will collaborate with Super Silicon Crystal Research Institute of Gunma Prefecture to develop a fully automated chemical mechanical polishing machine for processing 400mm wafers. Super Silicon will provide wafer samples, while Lapmaster will be in charge of hardware design and software development. Development costs are estimated at (100 million. Scheduled to be developed by May 1998, the machine will achieve a wafer-processing flatness of less than 0.13 micron, a surface particle diameter size of 0.04 micron, and a surface metal impurity level of 10 x 8 stoms/cm^2. The 400mm wafer-processing machine is likely to be priced at about ¥200 million.

Matsushita

35. Texas Instruments (United States), January 1997

Texas Instruments Japan and Matsushita Electric have jointly developed a digital video camera DV terminal IC that conforms to IEEE 1394, a high-speed serial bus standard for next-generation PCs and consumer electronics. The TSB13LV01 integrates on a single chip the functions of conventional LINK and PHY chips and is available in a 144-pin CSP. TI Japan will initially mass-produce the new IC exclusively for use in the latest NV-DE digital video camera from Matsushita Electric.

36. CBL (United States), July 1997

Matsushita Electronics signed an agreement with a California-based venture CBL under which the companies will jointly develop a blue-light laser. Matsushita is aiming by 1999 to commercialize a blue-light laser, necessary for next-generation DVD drives with a storage capacity of 15GB, three times the current level. Set up by Stanford University researchers, CBL has developed large-diameter gallium nitride substrates. Use of this type of substrates increases the life of a blue-light laser from the conventional 30 hours to 5,000.

Mitsubishi

37. Compaq (United States), January 1997

Compaq Computer Corporation has teamed up with Mitsubishi Electric and with Advanced Display, Mitsubishi's LCD production subsidiary, in PC LCD monitor development. The alliance brings together Compaq's understanding of customer needs, Mitsubishi's flat panel technology, and Advanced Display's motherboard and glass processing technologies. The companies developed an LCD monitor and put it on the market in the second half of 1997. Compaq will be in charge of sales and will initially target the financial and health care sectors.

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38. Access (Japan), February 1997

Mitsubishi Electric has teamed up with Access, an Internet appliance operating system developer, in the development of a portable Internet terminal chipset. The two companies will jointly develop a three-chip set including Mitsubishi's M32R/D DRAM-embedded microcontroller and a mask ROM and market the chipset at $30 to $40. Mitsubishi plans to develop a two-chip set in 1998 by integrating an ASIC and the M32R/D on a single chip. Mitsubishi, which started shipping samples of the DRAM-embedded MCU in October 1996, will launch production in April and produce 1 million units a month in late 1997. Access' Internet OS has been adopted by Sharp in its Internet TVs and word processor.

39. Wind River Systems (United States), March 1997

Wind River Systems, Japan, will develop the Tornado embedded system development environment for Mitsubishi Electric's 32-bit M32R/D RISC processor, based on an agreement the two companies have signed. The agreement will allow domestic M32R/D users to collectively purchase from Mitsubishi the license to use the VxWorks real-time operating system that is integrated into the Tornado development environment, helping them reduce system development time. Mitsubishi, which teamed up with Integrated Systems Inc. of the United States regarding its pSOS real-time OS in 1996, will support the real-time operating systems that account for some 70 percent of the world market.

40. Rambus (United States), April 1997

Mitsubishi Electric has licensed the Rambus interface technology needed to make 1.6GB/sec Direct Rambus DRAMs. The company has previously been a vocal proponent of other next-generation DRAM technologies. Nine DRAM makers have taken Rambus licenses, and some of the holdouts are believed to be negotiating with Rambus. IBM has a license for the Rambus logic interface but has yet to take a license for the memory-interface technology.

41. Seiko Epson (Japan), May 1997

Mitsubishi Electric will license 3-D video memory technology to Seiko Epson. Mitsubishi's 3D-RAM integrates 10Mb DRAM, 2Kb SRAM, and logic functions on a chip. Seiko Epson is expected to ship samples of the SDM 10092, a 3D-RAM-compatible chip, this fall and launch volume production at 20,000 units per month at its Sakata plant next spring. The sample price is likely to be set at about ¥5,000.

42. Chunghwa Picture Tube (China), May 1997

Mitsubishi Electric and Advanced Display have agreed to license their advanced thin-film transistor (TFT) LCD technologies to Chunghwa Picture Tube, a cathode-ray tube (CRT) manufacturer in Taiwan. Under the agreement, Chunghwa Picture will receive key technologies for the manufacture of TFT LCDs from Advanced Display. The displays to be manufactured by Chunghwa include 12.1-inch SVGA and XGA and 15.1-inch XGA and SXGA models. Volume production is expected to begin in January 1999. Chunghwa, an affiliate of Tatung, develops CRTs for the television and display market as well as super-twisted nematic (STN) LCD flat-panel displays.

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43. Stone Group (China), June 1997

Mitsubishi Electric has teamed up with Chinese electric equipment maker Stone Group in semiconductor sales. Mitsubishi, Stone, and Mitsui & Co. established a joint venture in Beijing in 1996, and the joint venture is building a semiconductor plant expected to be ready for operations in April 1998. Mitsubishi plans to market semiconductors to be made by the plant for use in electric appliances. First-year China semiconductor sales are expected to be ¥10 billion, including sales to be generated through distribution via Hong Kong.

44. Mentor Graphics (United States), June 1997

Mitsubishi Electric will develop system-on-a-chip LSI development software with Mentor Graphics. Hardware-Software Cosimulation Environment, the software the two companies will develop, will combine Mentor's Seamless CVE and Mitsubishi's 32-bit M32R RISC microcontroller core instruction set simulator. The new software will allow system-chip LSI design engineers to test software as hardware is being designed, helping reduce design and development time from the current eight months to five months. Sample shipment is slated for late this year.

45. Powerchip Semiconductor (Taiwan), November 1997

Mitsubishi Electric expects to provide Powerchip Semiconductor of Taiwan with DRAM-embedded microcontroller production technology in early 1998. A joint venture established by Mitsubishi, a trading company, Kanematsu, and a Taiwanese electronics maker, the UMAX Group, Powerchip will begin to produce eRAM, a system-on-a-chip LSI that integrates Mitsubishi's proprietary 32-bit RISC MCU and DRAM on a single chip. Slated to begin in mid-1998, production will reach 4,000 eight-inch wafers per month by September 1998.

Mitsubishi Materials

46. Symmetrix (United States), December 1997

Mitsubishi Materials has licensed technology to produce and market ferroelectric materials from Symmetrix of Colorado. Plans call for producing Y-1, a ferroelectric material developed by the U.S. company for forming thin-film capacitors through enhanced metallorganic deposition (EMOD) at a mass production facility under construction in the company's Mita plant. Construction will be completed by year's end, and operations have been slated to start in March 1998. The company is aiming for sales of ¥200 million in 2000.

Mitsui & Co.

47. Micron Communications/ID Micro Systems (United States), April 1997

Mitsui & Co. will work with Micron Communications and ID Micro Systems, both of the United States, to develop a low-cost noncontact tag. The new tag will have a storage capacity of 256 bits and use the spread spectrum format to read and write data. The companies aim to price the product at about (100, enabling it to be used as a disposable tag in production and distribution management and IC card applications. Mitsui and Micron Communications will share the development cost, while ID Micro will provide noncontact tag technology. Mitsui will sell the tag in Japan and overseas, except for the United States. The tag was expected to reach the market in late 1997, with a first-year sales goal set at 10 million units.

Mitsui High-Tec

48. Ball Semiconductor (United States), August 1997

Mitsui High-Tec has invested in Ball Semiconductor of Texas, acquiring nearly 50 percent of the U.S. company for $26 million. Ball Semiconductor was established by former Texas Instruments vice president Akira Ishikawa in October 1996. Ball has developed technology to create semiconductor circuits on the surface of a silicon ball in order to increase the level of integration. The U.S. company claims that the silicon balls are easier to manufacture than silicon wafers and that a silicon ball semiconductor plant can be constructed at lower cost than conventional chip plants. Semiconductor equipment maker Disco is also reported to have chipped in more than ¥100 million to the U.S. venture.

NEC

49. Wind River Systems (United States), January 1997

NEC will procure an embedded RISC microprocessor operating system from Wind River Systems. NEC and the Japanese arm of Wind River have signed an agreement, under which the U.S. software company will develop a version of the Tornado operating systems supporting NEC's V830 series of 32-bit RISC MPUs. The B830 family is popular among office business machines and car navigation system applications, and the combination of the RISC MPU and Tornado will allow designers to develop such application systems easily. Japanese customers have been able to purchase the Tornado runtime version license together with the MPU from April 1997.

50. Datapath Systems (United States), February 1997

NEC has teamed up with U.S. venture Datapath Systems to develop an extended partial response maximum likelihood (EPRML) LSI for use in large-capacity hard disk drives (HDDs). NEC will continue its process technology with the U.S. company's circuit design technology to develop as early as this year the LSI that will enable 30 percent HDD capacity expansion over the conventional PREL system. NEC, which has to date manufactured HDD write and read LSIs, intends to expand its semiconductor business by moving into the HDD LSI market, a promising segment with huge growth potential.

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51. Synopsys (United States), April 1997

NEC and Synopsys of California have reached an agreement to jointly develop microcontroller-embedded ASIC design verification technology. The move is aimed at providing a tool to enable single-chip embedded system designers to simultaneously verify both hardware and software functions and at reducing development lead time. For the development of embedded systems, hardware functions are typically verified using EDA capability and software functions using an in-circuit emulator. NEC expects the new tool will help expand sales of its V850 family of ASICs.

52. Shanghai Hua Hong Microelectronics (China), May 1997

NEC announced that it will set up a joint venture with Chinese chipmaker Shanghai Hua Hong Microelectronics to supply technology to a Chinese national project to boost domestic semiconductor output. Shanghai Hua Hong is affiliated with the Chinese government. The Chinese government will own about a 70 percent stake in the venture, to be capitalized at $700 million, and NEC will own the rest. The project, which is part of China's five-year economic plan, is called Project 909. Running through 2000, the venture will produce 20,000 chips a month. NEC will provide technology for processing memory chips.

53. Cadence Design Systems (United States), July 1997

Cadence Design Systems has signed an IC design tool contract with NEC. The three-year, $18 million contract will allow NEC to use Silicon Ensemble-DSM, an IC design tool, for deep-submicron design at its design centers worldwide. The tool boosts circuit design speed more than 20 times that of conventional tools.

54. Samsung (Korea), July 1997

NEC and Samsung have decided to cooperatively design a plant for 300mm wafers and help each other in equipment development. The alliance is aiming to get its 300mm wafer line up and running around 1999.

55. Tseng Labs (United States), September 1997

NEC Electronics announced the availability of an OEM reference design that combines the PowerVR PCX2 3-D graphics accelerator with Tseng Labs' 128-bit ET6100 2-D graphics and multimedia engine. NEC has formed a strategic alliance with Tseng Labs to develop PCI-compliant single-card reference designs based on the PowerVR architecture. This design offers PC OEM and graphics board manufacturers an all-in-one graphics solution that delivers arcade-quality 3-D rendering and high-performance 2-D acceleration for Windows applications. The single-slot PCI card supports game and entertainment titles written for Direct3D, PowerSGL, and DirectDraw, including more than 100 game titles that have been developed for or ported to the PowerVR architecture. VideoLogic's Apocalypse 5-D graphics board is the first product using the technology from NEC and Tseng Labs.

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56. Philips Semiconductor (Netherlands), November 1997

NEC and Philips Semiconductor have reached agreement to jointly develop system-on-a-chip LSIs for use in digital consumer electronic products. They will use the 64-bit VR4300 RISC microprocessor based on MIPS Technologies architecture as a core for the system-chip LSIs and share peripheral circuit libraries. Consumer sales account for 15 percent of NEC's semiconductor sales and 45 percent of Philips', respectively. The two companies plan to begin to commercialize system-chip LSIs in the second half of 1998, cooperating in production as well as marketing.

57. Lucent Technologies (United States), December 1997

Lucent Technologies' Microelectronics Group and NEC announced that Lucent has licensed NEC's 32-bit V850 MCU family core. Lucent will integrate the core into its 0.25- and 0.35-micron Silicon Suite system-level IC offering, enabling customers to design system-level integrated circuits based on NEC's 32-bit RISC MCU architecture. The agreement means the V850 core will now be available from the two companies. The core will be available to Lucent customers for integration in April 1998.

Nichimen Electronic Components

58. Luxsonor (United States), May 1997

Nichimen Electronic Components has teamed up with Luxsonor of California in DVD chip sales. The U.S. fabless company focuses on MPEG-2 decoder part development, and Nichimen planned to release as early as June the LS220, a DVD decoder chip built into a PC motherboard. To be made in Taiwan, the chip will be sold for less than 4,000. The Japanese distributor is aiming for first-year sales of ¥500 million. Luxsonor is working on the LS240, a power-saving chip, and Nichimen intends to market it, targeting notebook computer makers, within the year.

NKK Corporation

59. Toshiba (Japan), September 1997

NKK will reorganize its semiconductor business by introducing state-of-the-art semiconductor technology from Toshiba. Plans call for starting 32-bit RISC microcontroller production within the year. The steel company will pay Toshiba a one-time fee of an estimated ¥1 billion as well as license fees and will manufacture RISC chips at its Ayase Research Laboratory. NKK, which entered the semiconductor business in 1992, hopes to put its semiconductor operations into the black by fiscal year 2000, reducing its dependence on the memory business significantly.

Nomura Microsciences

60. Ionics (United States), July 1997

Nomura Microsciences has teamed up with Ionics Inc. of Massachusetts to market pure water-processing electrical deionization (EDI) equipment targeting semiconductor, pharmaceutical, and food processing companies in Japan, Korea, and Taiwan. The EDI system uses no chemicals and requires no waste water processing and therefore can remove 99 percent of silica, a task considered difficult. The U.S. company has supplied its EDI equipment to more than 50 plants worldwide, and Nomura is aiming to sell ¥20 billion to ¥30 billion worth of ultrapure water-processing systems over the next five years.

Nozaki Industry

61. High Yield Technology (United States), May 1997

Nozaki Industry will import a particle monitor system from High Yield Technology of California. The In Situ Particle Monitor (ISPM) is attached to vacuum process semiconductor equipment and eliminates use of a dummy safer. The standard system is priced at about ¥4 million. Nozaki is aiming first-year shipment of 100 ISPM systems.

Oki

62. Synopsys (United States), January 1997

Silicon Architects of Synopsys has announced that Oki Electric of Japan has licensed Synopsys' cell-based array (CBA) architecture for its 0.35-micron ASIC products. Oki will use the CBA architecture to develop 0.35-micron ASICs for both internal and commercial use. Other products will include microcontrollers, MPU and peripheral ICs, speech ICs, and telecom ICs. Oki will develop designs using CBA design tools, which integrate CBA libraries, CBA compilers, the CBA Design Systems, and commercial EDA tools. Over the past year, Synopsys has also announced CBA licensing agreements with Fujitsu, Matsushita, Mitsubishi, NEC, Toshiba, and TriTech.

63. Artisan (United States), April 1997

Artisan Components, formerly VLSI Libraries, a supplier of embedded memories and other physical component intellectual property (IP), has received a multimillion dollar worldwide purchase agreement from Oki Electric. Oki has selected Artisan as its sole external supplier of memory generators and has agreed to incorporate Artisan's family of physical IP components into all of its new 0.35- and 0.45-micron internal standard products and ASSPs. Under the agreement, Oki will purchase a complete family of Artisan's memory generator, including standard single-port and dual-port SRAMs. Also, Oki's R&D centers in both Japan and the U.S. are adopting Artisan's technology.

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Rohm

64. DSP Group (United States), March 1997

Rohm will license DSP core technology from DSP Group of California. Rohm will use DSP Group-developed 16-bit fixed-point PineDSPCore and OakDSPCore to develop system-on-a-chip LSIs for mobile communications and multimedia equipment. Specifically, Rohm expected to commercialize controllers for cellular phones, high-speed modems, and CD-ROM/DVD drives by the end of 1997. DSP Group licenses its audio-compression technology to a dozen companies, including AT&T, Intel, and Microsoft, and its DSP core technology to more than 20 companies, including Asahi Chemical, Kenwood, and NEC.

Ryosho Electronics

65. NeoParadigm Labs (United States), April 1997

Ryosho Electronics signed an exclusive agreement to sell in Japan LCD signal processing ICs developed by NeoParadigm Lab (NPL) of California, a start-up developer of multimedia LSIs. Designed for large STN LCD panels, the new LCD signal-processing IC directly processes analog RGB signals from the PC, reducing the signal-processing circuit cost to less than ¥10,000. Sample shipment was expected to begin in September, and Ryosho aims to sell 50,000 units the first year. Ryosho was established to sell DRAMs produced by Powerchip Semiconductor, a Taiwan-based joint venture, and by Mitsubishi Electric, Kanematsu and the UMAX Group of Taiwan, and aimed for fiscal 1997 sales of ¥6 billion.

Sankyo Engineering

66. Sugai (Japan), April 1997

Japan-based Sankyo Engineering and Sugai revealed that the companies will form a partnership for developing new auto wet stations, which can be used for 256Mb DRAM cleaning processes and new processes for 12-inch wafers. The companies will also begin developing common part specifications for their equipment in order to reduce parts inventory, and hence cost, while maintaining availability. According to the announcement, Sankyo Engineering and Sugai will consider exchanging stock or further investment in future partnerships if they find enough benefits.

Santoku Chemical

67. Mitsui & Co./Merck (Germany), October 1997

Santoku Chemical, Mitsui & Co., and Merck of Germany have established a joint venture in Singapore to produce ultrapure hydrogen peroxide water for cleaning semiconductor chips. Capitalized at about ¥700 million, Santoku Merck is owned 49 percent by Merck, 31 percent by Santoku, and 20 percent by Mitsui. The partners will invest ¥2 billion to construct a plant with an annual processing capacity of 10,000 tons, which will start operations in November 1998. Plans call for producing hydrogen peroxide water with particle per trillion-level purity. Santoku Merck is aiming for sales of ¥2.5 billion in 2005.

Seiko Epson

68. Lattice Semiconductor (United States), March 1997

Lattice Semiconductor has signed an agreement to advance Seiko Epson up to $150 million to assist in the funding of a new 8-inch wafer fab, currently under construction in Sakata, Japan. The agreement calls for Lattice to make a $90 million advance payment to Seiko Epson to set up the new fab over the next two years, with an option for an additional $60 million advance. In return, Lattice will receive guaranteed 8-inch, submicron wafer capacity. The advance payments will be repaid by Seiko Epson with wafers over a multiyear period. Lattice planned to manufacture next-generation, high-density, in-system programmable logic devices (PLDs) at the new facility beginning in 1998, initially using 0.35-micron CMOS process technology and later migrating to 0.25-micron process technology.

69. Exemplar (United States), June 1997

California-based logic synthesis tool supplier Exemplar Logic announced an agreement to jointly develop libraries for Seiko Epson/SMOS ASIC libraries for Exemplar's Leonardo design environment. As a result of this agreement, Seiko Epson/SMOS ASIC libraries are being distributed by both Seiko Epson and Exemplar Logic, and Exemplar's Leonardo becomes part of Seiko Epson/SMOS ASIC design flow worldwide. The high-precision delay models jointly developed by both companies interface to the Seiko Epson ASIC development system, Auklet. They are available to Seiko Epson/SMOS customers.

70. Mitsubishi (Japan), October 1997

Seiko Epson has tied up with Mitsubishi Electric in the DRAM business. The companies have agreed that Mitsubishi will provide Seiko Epson with 64Mb DRAM design and production technology and that the latter will launch production at 1 million units per month at its Sakata plant from the second quarter of 1998. Mitsubishi will initially purchase all units to be produced at the plant, but Seiko Epson is considering marketing the memory chips under its own brand name. Seiko Epson, which recently completed a ¥100 billion semiconductor production facility at the plant, had been looking for memory products, which will help with stability of operation.

Seiko Seiki

71. Jenoptik Infab (Germany), December 1997

Seiko Seiki, a Seiko Instruments Group company, will team up with German automated semiconductor production system maker Jenoptik Infab. The companies are signing an agreement concerning the standard mechanical interface SMIF() system, a localized clean environment system for wafer transport. Under the agreement, Seiko will provide installation, maintenance, and servicing in Japan for Jenoptik's SMIF systems, which are widely used in Europe, the United States, and Taiwan.

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Sharp

72. SanDisk (United States), January 1997

SanDisk and Sharp signed a cross-licensing agreement that gives the companies worldwide rights to each other's patents for flash memory products. Terms of the agreement were not disclosed.

Shin-Etsu Handotai

73. Soitec (France), May 1997

Shin-Etsu Handotai will form a partnership with France-based Silicon on Insulator Technologies to mass-produce next-generation SOI wafers. Soitec has a cutting-edge SOI wafer technology known as Smart Cut, which combines a hydrogen ion implantation process with a conventional wafer-bonding method. This process seems to have an advantage in fabricating so-called ultrathin-film SOI wafers. Soitec has shipped the wafers under the Unibond name since the middle of 1996, and the company plans to expand its production facility in Grenoble, France. SEH and Soitec will develop mass-production technology for this process, and SEH also will construct a factory for SOI wafer production in Japan. Both companies plan to provide 1 million 8-inch wafers per year by 2000.

Sony

74. Toyoda Automatic Loom (Japan), June 1997

Sony and Toyoda Automatic Loom, the funding company of the Toyota Motor Group, are negotiating joint manufacturing of low-temperature, polysilicon active-matrix LCDs. The arrangement would give Sony the production capability to take advantage of emerging high-volume display opportunities, including the enormous automotive market, and it would provide Toyota with captive access to leading-edge display components.

75. Advanced RISC Machines (United Kingdom), July 1997

Sony has forged an alliance with Advanced RISC Machines of the United Kingdom in the 32-bit RISC processor business. Sony will develop and supply system-on-a-chip LSIs based on the ARM7TDMI RISC processor core targeting digital AV equipment, cellular phone, and PDA applications. Sony positions the ARM7 core as an MPU core for its 0.4-micron ASCS ASIC products. ARM's MPU core has been licensed to about 20 chipmakers and used for a range of applications.

76. Sharp/Philips (Netherlands), July 1997

Sony, Sharp, and Philips are jointly developing a next-generation large LCD for such applications as a wall TV. Not to be outdone by its competitors, including Fujitsu, that are leading in the large-screen display competition by concentrating on plasma display panels, the three partners will develop a plasma address LCD that they believe can be as large as 40 inches. Plans call for installing a pilot line at Sony Mizunami, where the partners will send their engineers to develop mass production technology. The companies are aiming for commercialization in 1998.

77. Oki (Japan), August 1997

Sony and Oki Electric will team up in the system-on-a-chip LSI business. They are discussing mutually commissioning production of a chip that integrates a microprocessor and DRAM on a single chip using a 0.25-micron process technology. The two companies, which reached agreement to jointly develop 0.25-micron system-chip LSIs in May 1995, are independently marketing system-chip LSI made using a 0.35-micron process. Sony and Oki, which are about to see the result of their joint development effort, seek to effectively use their management resources by commissioning production to each other.

Sumitomo Chemical

78. Olin (United States), September 1997

Sumitomo Chemical announced that it will cooperate with Olin, a U.S. chemical company, in the area of i-line photoresists used in production of 16Mb to 64Mb memories. Olin will have exclusive manufacturing rights to Sumitomo Chemical's advanced i-line photoresists in the United States and Europe. Olin, a supplier of i-line photoresists in the U.S. and European markets, will also have nonexclusive rights to sell such materials in those regions. Use of Olin's production facilities will enable Sumitomo Chemical to secure a foothold in these markets. Sumitomo Chemical is planning to increase annual sales of i-line photoresists from the current ¥12 billion to ¥30 billion in five years.

Sumitomo Corporation

79. Tokyo Kaseihin and others (Japan), January 1997

Tokyo Kaseihin will establish a lead frame production venture in Singapore with two Japanese manufacturers through its local subsidiary. To be capitalized at $50,000, the new venture will be owned by Tokyo Kaseihin subsidiary TOK Singapore, Osaka-based parts maker Iijima Metal Seisakujo, and Osaka-based packaging materials maker Shinko at a ratio of 1:2:2.

80. R. Howard Strasbaugh (United States), June 1997

Sumitomo Corporation set up in July a joint venture with R. Howard Strasbaugh of California to sell next-generation wafer-polishing machines developed by Strasbaugh. SC Semicon Technology is capitalized at 300 million, in which Sumitomo and Strasbaugh invested 85 percent and 10 percent, respectively. The CMP machine developed by Strasbaugh features a wafer surface roughness of 250 angstroms, 10 times the precision of conventional machines, and can process about 60 wafers per hour, three times the usual throughput. It is priced at ¥200 million. SC Semicon is aiming for first-year sales of ¥3.5 billion, targeting manufacturers of 64Mb DRAM chips.

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81. Pixtec (United States), November 1997

Sumitomo Corporation has bought exclusive domestic sales rights to field-emission display (FED) panels from California-based Pixtec. The company, which is also authorized to market the products in Asia, will invest $10 million in the U.S. company in return. Pixtec plans to commission 5.2-to 8.0-inch FED panel production to leading Taiwanese LCD maker Unipac and ship 10,000 units per month starting in April 1998. Sumitomo, which handles ¥50 billion worth of CRT and LCD materials and products annually, is aiming to expand FED sales to ¥3 billion and ¥10 billion in the first and third years, respectively.

Tokyo Seimitsu

82. Super Silicon Institutes (Japan), March 1997

Tokyo Seimitsu will develop a 400mm-wafer wire saw jointly with the Super Silicon Institutes (SSI). The company will deliver a wire saw to the SSI by November, and the parties will jointly make enhancements with the goal of completing a practical unit by 2001. The SSI is a Gunma-based institute specialized in 400mm wafer technologies, established in March 1996.

83. Seiko Seiki (Japan), December 1997

Tokyo Seimitsu will form an alliance with Seiko Seiki in the semiconductor equipment business. The partners will combine Tokyo's alignment-measuring technology with Seiko's high-precision processing technology to develop wafer dicing and other technologies. In the meantime, Seiko Seiki, which has been marketing dicing saws since 1995, will stop production and procure products from Tokyo Seimitsu.

Toshiba

84. Unigen (United States), February 1997

Unigen announced that it will work with Toshiba America Electronic Components as a manufacturer of Toshiba-certified memory modules for sale under the Toshiba brand name. Toshiba expected to audit and qualify Unigen's production facility in the first quarter of 1997, and the Unigen/Toshiba team could begin shipping Toshiba product in the second quarter. Unigen is a Fremont, California-based third-party memory module manufacturer that focuses on the OEM channel.

85. Samsung (Korea), February 1997

Toshiba will acquire 20 percent of Samsung Austin Semiconductor of Texas, a Samsung Electronics subsidiary, and procure the 20 percent of 64Mb DRAMs the Texas company will manufacture for sales under its own brand name. Slated for completion in June 1997, the first facility of the Korean subsidiary, in which Intel also has a capital stake, expected to launch 64Mb DRAM production by year's end and have a monthly output capacity of 2.3 million units by the end of 1998, when it expects to be fully operational. Samsung Austin Semiconductor plans to invest $1.3 billion to construct three facilities by 2003.

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86. Motorola/Fairchild (United States), March 1997

Toshiba, Motorola, and Fairchild Semiconductor will jointly develop next-generation high-speed CMOS standard logic ICs. The three companies will work together to develop 2.5- and 3.3V CMOS standard logic ICs with a propagation delay time of 2ns. The new devices will be suited for ATM and ISDN network and engineering workstation memory address control use. They will introduce compatible products simultaneously to develop an untapped market. Plans called for commercializing the fast standard logic ICs by the end of 1997. The high-speed standard logic IC market is forecast to grow to ¥35 billion in 2000.

87. Sun Microsystems (United States), April 1997

Toshiba and Sun Microsystems have agreed to develop a Java processor chip for use in network computer terminals. The chip will consist of picoJava, microJava, and ultraJava. PicoJava will be the microprocessor's core, and microJava will integrate DRAM and a controller into picoJava. UltraJava will be an advanced model. Toshiba will be involved in developing a low-power microJava chip, with commercialization by Sun in 1998.

88. MIPS Technologies (United States), April 1997

Toshiba has licensed RISC microcontroller technology from the MIPS Group. The MIPS 16ASE is a 32-bit MCU core that helps to reduce the size and power consumption of printers and portable information devices. It allows for significant reduction of overall code size by compressing some instruction sets to 16-bit. The company plans to commercialize TX19 series MCUs based on the licensed core. The RISC type accounts for less than 10 percent of the company's total MCU sales in volume terms.

89. Technology Modeling Associates (United States), April 1997

Toshiba and Technology Modeling Associates have entered into a multi-year agreement in which the two companies will work jointly on development of software for 3-D simulation of semiconductor processes. The software tool will perform advanced modeling for diffusion, oxidation, ion implantation, rapid thermal annealing, silicidation, and point defects modeling. Toshiba is expected to use the simulator for the development of future generations of memory, microprocessor, and ASIC devices. Under the term of the agreement, Toshiba will provide funding, deep-submicron process technology development requirements, and test data. The TMA product, part of TMA's suite of semiconductor simulation tools, is expected to be released in late 1998.

90. NeoMagic (United States), May 1997

Toshiba announced in May that the company was about two months away from first silicon on a notebook graphics controller, with embedded DRAM, that will be manufactured for NeoMagic. To date, NeoMagic has worked with Mitsubishi Electric as the foundry for its graphics controllers. Toshiba will employ a 0.25-micron process optimized for embedded memory and a 128-bit on-chip memory bus.

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91. Chartered Semiconductor (Singapore), June 1997

Toshiba will license DRAM-mixed logic IC technology to Chartered Semiconductor of Singapore, to which it licensed CMOS logic technology in November 1994. The Singapore company will use Toshiba's 0.25- to 0.35-micron process technology to launch production in 1998. The DRAM-mixed system-chip LSI market is expected to reach about ¥400 billion in 2000.

92. iReady (United States), June 1997

Toshiba will license Internet access LSI technology from iReady of California. The company has signed a five-year contract to use the U.S. company's Internet tuner technology for providing Internet access using an LSI, which eliminates control by a CPU and cuts power to 1/700th the level of software-driven Internet access. Toshiba planned to develop by the fall a functional block that will be embedded on a system-on-a-chip LSI to be built into cellular phones and TVs.

93. ViewLogic (United States), July 1997

Toshiba has teamed up with ViewLogic of the United States in the ASIC business. The companies will support Motive, a static timing tool that helps significantly reduce the time needed to design system ASICs with 1 million gates, and Testgen, a tool to automatically generate test patterns to test path delay trouble. Toshiba explained that, with the tools, logic testing time can be slashed to 1/40th the time it takes now. They were expected to become available starting in October.

94. IBM (United States), July 1997

Toshiba and IBM will form an alliance in new memory plant construction. The two companies will cooperate in commercializing a 300mm wafer by exchanging equipment technology information and are considering installing a joint production line at their joint production plant.

95. Winbond (Taiwan), September 1997

Toshiba has expanded its relationship with Winbond Electronics of Taiwan to include 256Mb DRAM production. Toshiba will provide Winbond with 256Mb DRAM production technologies and procure chips as an OEM starting around 2000, when demand is expected to pick up. As part of its move to establish a global DRAM production system, Toshiba expected to begin procuring 64Mb DRAMs from the Taiwanese chipmaker in January 1998.

96. Worldwide Semiconductor Manufacturing Co. (Taiwan), October 1997

Toshiba has teamed up with WSMC of Taiwan in semiconductor production. Toshiba will provide 0.25-micron logic PC process technology to the Taiwanese chipmaker and commission some of its logic IC production. A dedicated foundry set up in May 1996, WSMC is expected to start foundry production in July 1998 and launch a new line in 1999.

Tosoku

97. Samsung (Korea), October 1997

Automotive part and precision machinery maker Tosoku has teamed up with Samsung Aerospace of Korea in the semiconductor wire bonder business. The partners planned to begin in December marketing a IC wire bonder they developed cooperatively by combining the Japanese company's semiconductor equipment and the Korean maker's linear motor technologies. The wire bonder achieves a leadframe transfer speed of 0.5 seconds/26.42mm and can process 400 42SOJ packages per hour. The companies are inclined to set the price below ¥9 million and intend to sell 100 units the first year.

Ulvac

98. Ramtron International (United States), March 1997

Semiconductor equipment maker Ulvac teamed up with Ramtron International of Colorado in ferroelectric RAM (FRAM) technology development. The companies will jointly develop ferroelectric materials such as lead zirconium titanate, ferroelectric thin-film process technology, and sputtering, etching, and ashing equipment over the next four years. Ulvac will start in 1999 to supply the new equipment it is developing in the joint project to chipmakers such as Hitachi, Rohm, Samsung, and SGS-Thomson, which uses Ramtron's FRAM technology.

99. Idemitsu Kosan (Japan), June 1997

Ulvac and Idemitsu Kosan will jointly develop a TFT panel transparent conductive film for larger substrates. They will combine Idemitsu-developed indium lead-based IDIXO film and Ulvac's sputtering equipment and process techniques to develop a transparent conductive film for use with LCD substrates of 13 and 14 inches to 17 and 20 inches. At present, polycrystal indium thin oxide film is typically used for TFT transparent conductive film. Ulvac and Idemitsu expect that LCD panel makers will start using the new film on production lines as early as 1998.

Yamaha

100. Xicor (United States), February 1997

Yamaha has teamed up with Xicor of California in the EEPROM business. Initially, the U.S. company will commission the Japanese company to manufacture EEPROMs, and both companies will cooperate in process technology development. Yamaha Kagoshima Semiconductor will start production in May 1998 at 2,000 six-inch wafers per month and will supply EEPROMs to cellular phone makers under Xicor's brand name. The world's No. 3 EEPROM maker, Xicor is reported to control the largest share, 30 percent, of the Japanese market for EEPROM used in cellular phones. Yamaha projects that Xicor-brand sales will reach ¥2 billion in the first year.

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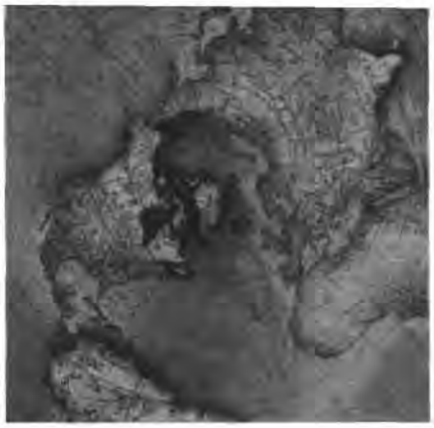

Dataquest

A Competitive Study of Japanese Semiconductor Manufacturers

Competitive Trends

FILE COPY:
MARIA VALENZUELA

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Chapter 1

Executive Summary

Japanese companies once enjoyed the largest share of the worldwide semiconductor market, but they are now exposed to aggressive competition, not only from new players in Asia/Pacific, but also from the American companies that the Japanese companies once thought they had beaten. However, the worldwide market continues to see oversupply in various MOS digital products, and prices do not show any sign of tightening up. This market condition is forcing Japanese companies to review their strategies in search of clues to the next growth stage.

This Competitive Trends focuses on the top 20 Japanese semiconductor companies and analyzes their competitiveness from the viewpoint of sales power, manufacturing power, and overall strategy. Sales, regional orientation, and penetration are examined for each company. In analyzing manufacturing trends, manufacturing power, defined as brand shipments plus foundry/OEM shipments, is analyzed for the first time. All metrics except for fabs, capital spending, and R&D spending, are taken from Dataquest's 1996 database because Dataquest is still in the process of finalizing 1997 revenue survey and analysis.

The appendix provides metrics such as product revenue, regional revenue, and market share by region and product for each of the top 20 Japanese companies.

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Chapter 2
Brand Sales Power

In 1996, Japanese companies recorded a combined share of 36 percent of the worldwide semiconductor market. The year was marked by rapid price declines for DRAMs and various MOS digital products, such as flash memories, microcontrollers (MCUs), and application-specific ICs (ASICs). Japanese semiconductor vendors that were largely dependent on those product categories were no exception to the sluggish revenue growth that accompanied continued robust unit shipments. This was also the year in which the yen depreciated against the U.S. dollar, and Japanese companies' revenue in dollar terms was scaled down compared with that of global competitors. As a result, Japanese companies' market share fell four points from 1995, widening the gap with Americas companies to nine points.

In the 1980s, Japanese companies rapidly increased their revenue, pumped by DRAM sales and the consumer applications on which they focused. Their combined revenue showed a record high market share of 51 percent in 1988 to 1989, which has not been achieved by any companies since.

Or take a look at rankings. In 1986 through 1992, six Japanese companies were listed in the top 10 worldwide ranking. For 1985 through 1991, the largest semiconductor company in the world was Japanese—NEC Corporation. For 1986 through 1989, the top three companies in the worldwide market were Japanese. In 1996, however, only one company was among the top three, there were only four companies in the top 10, and the leading company was Intel Corporation. Americas companies enjoyed a combined share of 45 percent in 1996, a seven-point increase over 1988.

Korean companies are quickly catching up. In 1993, when Samsung Electronics entered the global top 10 ranking, Korean companies recorded combined revenue of $5.1 billion, which was about one-seventh that of Japanese companies. In 1996, Korean companies' combined revenue had grown to equal 22 percent of Japanese companies' revenue.

What has caused this decline in Japanese companies' share of the worldwide market? Is the trend going to persist in the near future?

Japanese Companies' 1996 Market Share

In the worldwide market, the Japanese companies' decline in market share was seen in all regions, caused mainly by the DRAM revenue contraction. Non-DRAM revenue showed growth of 10 percent on a yen basis for Japanese companies but a contraction of 5 percent on a dollar basis (see Table 2-1). In DRAM, Americas companies showed the largest contraction of the four regional bases, but they also recorded the largest growth in non-DRAM revenue. This is a result of Americas companies' penetration of the MOS logic area, as well as Intel's increase in MPUs. European companies fared well, too, and surpassed Asia/Pacific companies.

Table 2-1
Japanese Companies' Revenue Growth: A Comparison between DRAM and Non-DRAM (Percent)

	Total Semiconductor	DRAM	Non-DRAM
Total Companies	-6.3	-38.6	6.2
Japanese Companies (Dollar-Based)	-16.0	-40.3	-5.1
Japanese Companies (Yen-Based)	-2.7	-30.8	10.0
Americas Companies	6.0	-47.6	15.0
Europe, Africa, and Middle East Companies	6.6	-35.0	11.3
Asia/Pacific Companies	-24.1	-30.9	-2.9

Source: Dataquest (March 1998)

In the worldwide market, eight Japanese companies ranked in the top 20: NEC Corporation, Hitachi Ltd., Toshiba Corporation, Fujitsu Ltd., Mitsubishi Corporation, Matsushita Electric Industrial Co. Ltd., SANYO Electric Company Ltd., and Sharp Electronics Corporation. Only the first four of these made it into the top 10, with Mitsubishi slipping to the 11th position, replaced by SGS-Thomson Microelectronics B.V. This is the first time since 1985 that only four Japanese companies were included in the top 10 worldwide.

Figure 2-1 shows Japanese companies' market share the in major product categories. Bipolar digital is the category in which Japanese companies still rank second to Americas. The devotion of Japanese companies to this product area stems from their internal user in their computer and communications equipment divisions. In this shrinking portion of the market, Japanese companies' combined share amounted to 41 percent in 1996.

MOS memory, especially DRAM, has been the technology driver for Japanese semiconductor industry. In this market, however, Japanese companies are being exposed to a very competitive situation. The 1996 DRAM market declined 39 percent, and it was Americas companies whose combined revenue recorded the biggest decline—negative 48 percent against 1995. Asia/Pacific companies showed the smallest decrease of all—31 percent. Japanese companies recorded a 40 percent decline and had still the largest market share, 43 percent. But a trend among Japanese companies is evident: Larger Japanese companies maintained their respective positions, but smaller Japanese DRAM suppliers showed faster declines in revenue and lower rankings. Because the DRAM market is expanding more rapidly in foreign markets, it is the larger players that can access large-volume users, including PC vendors and module manufacturers, with favorable terms of trade. Dataquest's market share survey in memory revenue and unit shipments indicated a general trend in which smaller companies' average selling prices (ASPs) are significantly lower than those of larger companies.

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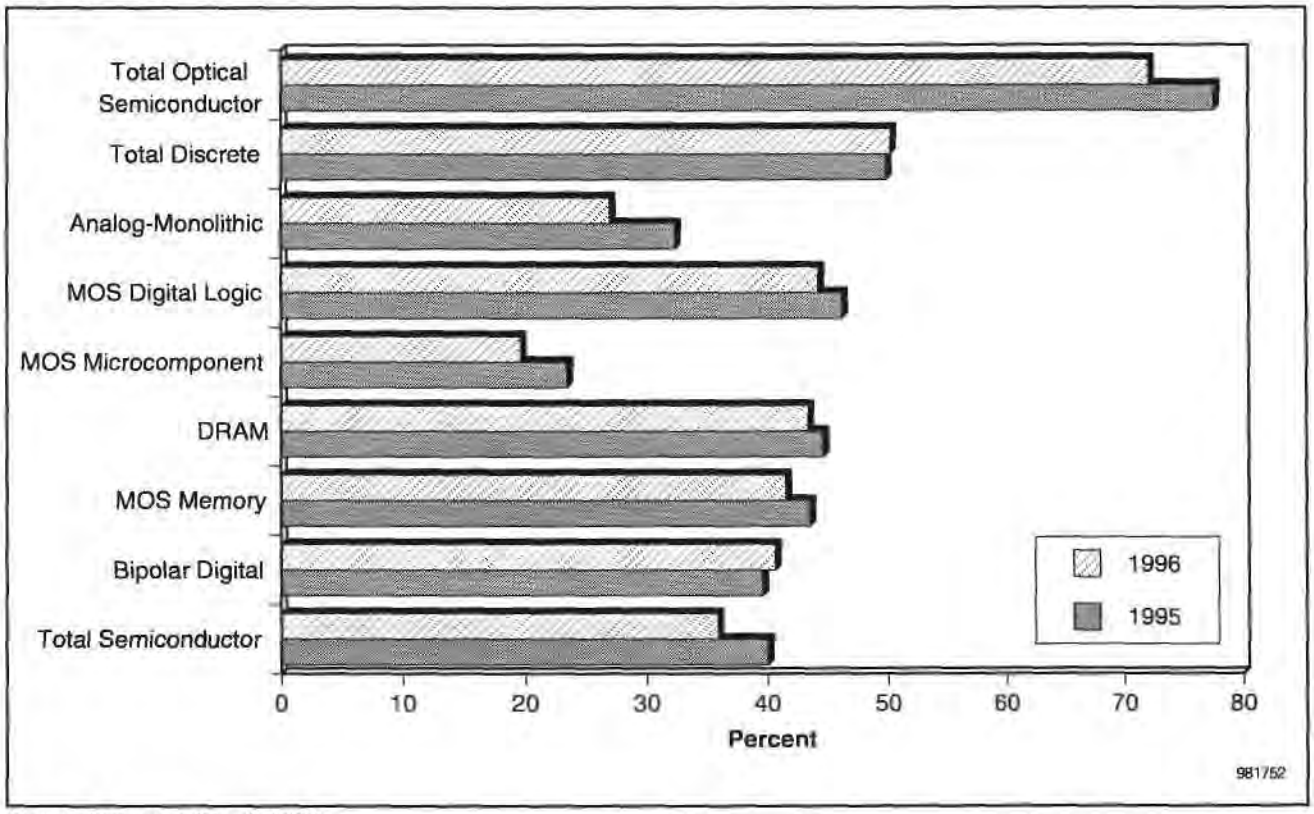
Figure 2-1
Japanese Companies' Worldwide Market Share in Major Product Categories, 1995 to 1996



Source: Dataquest (March 1998)

DRAMs account for 22 percent of the total revenue of combined Japanese companies in 1996, a decline from 31 percent in 1995. Figure 2-2 shows DRAM ratio, focusing on Japanese DRAM vendors. After Nippon Steel Semiconductor came Hitachi, with 34 percent, followed by Mitsubishi. Japanese companies are not necessarily going out of DRAM business just because of the severe competition with Korean and Americas companies, but the diversification of products that Japanese companies planned to pursue has not yet brought significant revenue increases, forcing some Japanese companies to be even more selective in their DRAM business.

In the 1996 MOS microcomponents market, Japanese companies have nurtured expertise and consequently have enjoyed a large share of the market in MCUs. This resulted from their users' focus on consumer equipment, which brings a large number of MCU orders. As Japanese electronic equipment production shifted focus from consumer equipment to data processing and communications and as MCUs were upgraded to higher bits, Japanese semiconductor users started to explore a wider selection, including MPUs and digital signal processors (DSPs). As system-level integration (SLI) becomes the key technology for emerging applications such as digital consumer equipment, Japanese companies face decisions about reorganizing their microcomponent and logic operations to offer the best SLI solutions to users.

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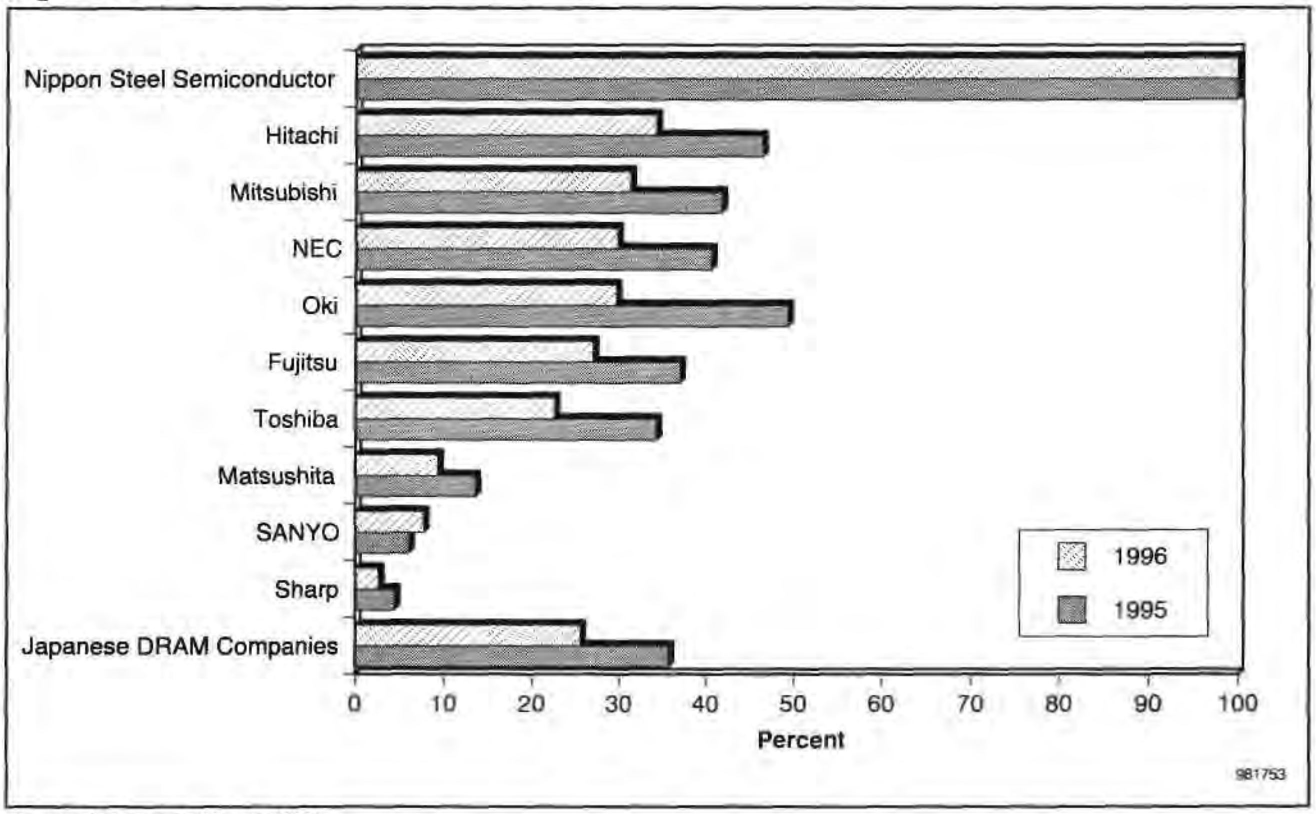
Figure 2-2
Japanese DRAM Vendors' DRAM Ratios



Source: Dataquest (March 1998)

In the MOS logic market, Japanese companies also leveraged consumer product large-volume orders. Among ASIC products, gate arrays have been the major product offering from Japanese vendors. This dependence caused Japanese companies to lag behind worldwide trends, which show large-scale systems preferring cell-based ICs (CBICs) and smaller systems preferring programmable logic devices (PLDs). Gate arrays fall between those two fast-growing categories, and here again, Japanese ASIC vendors must go through structural changes to refocus their operations. Also a part of the "other MOS logic" category are application-specific standard products (ASSPs); this category includes various consumer-use logic ICs, especially those used for audio and video applications equipment and LCD drivers.

Analog devices also benefited from the traditional consumer orientation of the Japanese electronics and semiconductor industry. As electronic equipment production shifts focus to data processing, communications, and automotive applications, Japanese companies have started to emphasize what they called industry-use linear ICs and then mixed-signal ICs. (The traditional consumer orientation has caused Japanese companies to call all other applications "industrial" in their own categorization.) In the standard product area, general-purpose products have found their way into a wide selection of applications, helping Japanese analog vendors run their fabs, albeit with low profits.

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Some dedicated vendors have sought to expand markets and applications for discrete devices, first in consumer equipment and then in peripherals such as flexible disk drives (FDDs), rigid disk drives (RDDs), and, recently, CD-ROMs. Small-signal products, both transistors and diodes, have always found new markets in emerging applications. Because new system designs required new circuit blocks and glue logic, small-signal transistors were the best choice to start with, to be replaced by ICs afterwards. In the fastest-growing area of power devices, there are mainly two lines of products being offered by Japanese companies, power supply devices and radio frequency (RF) power devices. RF products have also become an area in which Japanese manufacturers nurtured expertise, first with radio equipment, then TV equipment, and now mobile communications.

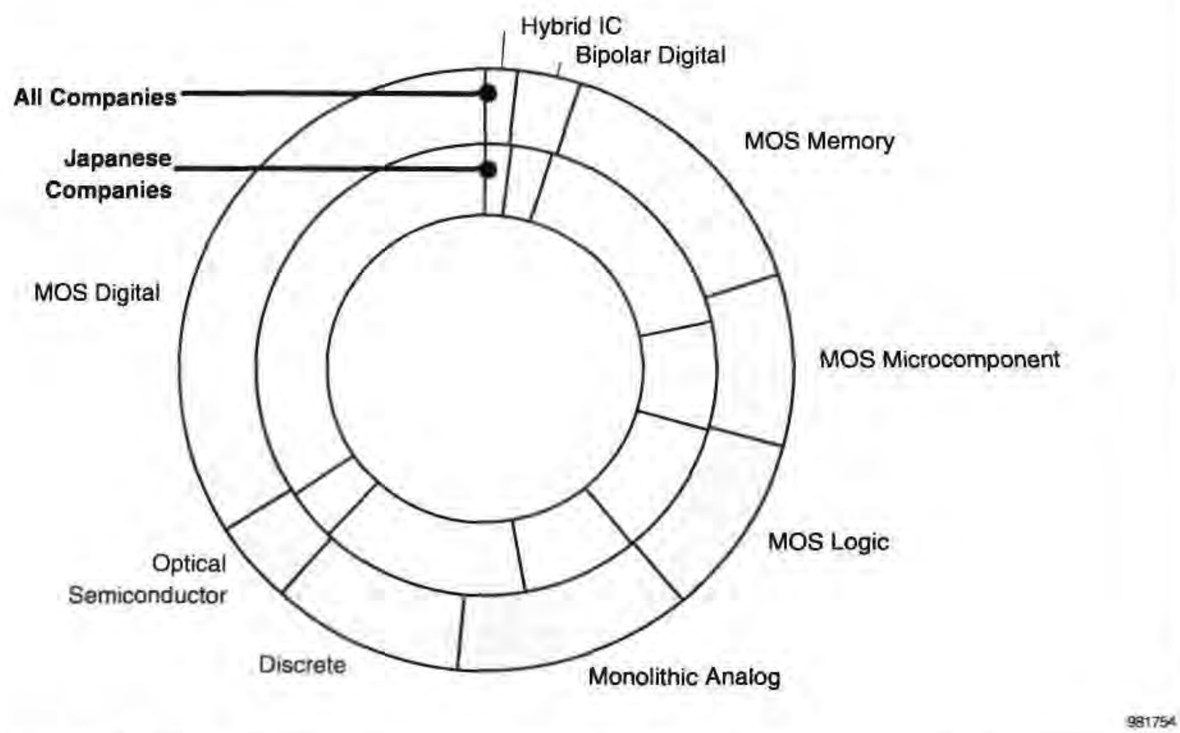
In optical semiconductors, there are dedicated suppliers such as Stanley Electric Co. Ltd. and Hamamatsu Photonics K.K. Although larger semiconductor suppliers also cover optical semiconductors, smaller, dedicated vendors have expanded the market by responding to precise requirements from customers, a practice that big companies found inefficient. As a result, LED suppliers may know of a wider range of users than IC suppliers do. Coupler and sensor markets have expanded because they are used along with microcontrollers and logic ICs and for systems with different voltage blocks. In the traditional model, volume orders for charge-coupled devices (CCDs) came from only a few consumer applications, such as camcorders, and small-volume, high-ASP orders came from broadcasting and various industrial applications. As imaging became a feature of PCs and PC peripherals, CCDs for scanners have come to hold a larger share of the increment of the CCD market. Laser diodes were high value-added products but were a small-volume market until CD players came into production. With the expansion of CD technology applications, demand for laser diodes rose rapidly, which brought costs lower and further expanded the market. Here again, Japanese vendors have leveraged domestic users' orientation in this area.

The Product Mix

Figures 2-3 and 2-4 show Japanese companies' and all companies' share of worldwide product revenue for 1992 and 1996, respectively. Figure 2-5 shows MOS digital product revenue share for Japanese companies and the worldwide market. In 1992, for both, MOS digital ICs represented a little more than half of total revenue, and the difference was negligible—one point—between the two. But in 1996, MOS digital products accounted for more than 70 percent of the worldwide market, while for Japanese companies, revenue from these products accounted for only a little more than 60 percent. Subtracting Intel's microprocessors, a unique situation, reveals basically the same picture—Japanese companies are lagging behind the worldwide market in digitization.

Although it is true that Japanese companies are losing market share to Korean and American companies even in DRAM, which has driven market share for Japanese companies, the lag is more evident in the microcomponent and logic areas, posing a threat to Japanese companies in light of trends toward system-level integration.

Figure 2-3
Worldwide Revenue Market Share by Product, 1992



Source: Dataquest (March 1998)

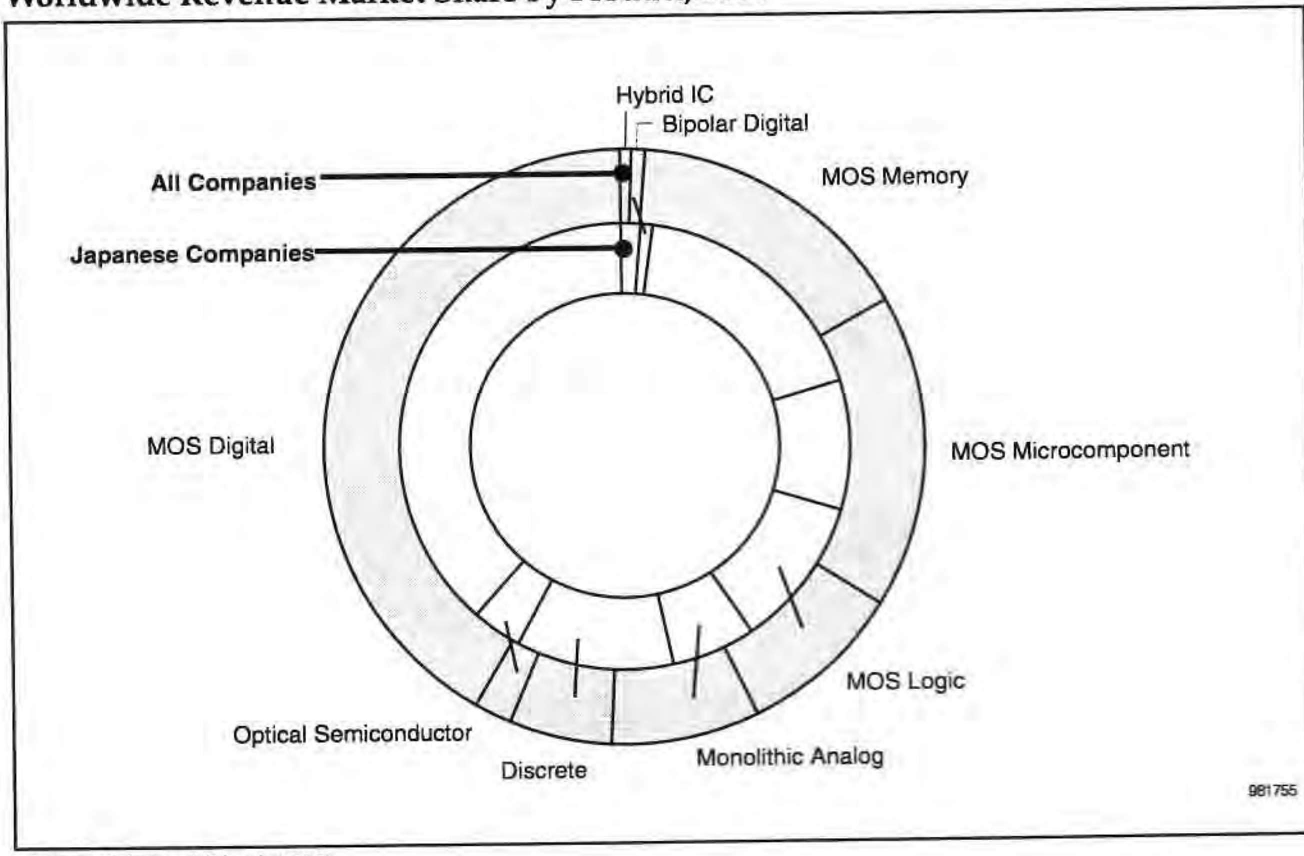
Regional Trends of Japanese Companies' Semiconductor Revenue

Historically, Japanese companies benefited from the fast-growing domestic market, where the Japanese consumer equipment manufacturers that dominated the worldwide market increased production of consumer electronics. Thus, the Japanese market was dominated by Japanese vendors (see Figure 2-6), and a large portion of Japanese companies' revenue came from the domestic market (see Figure 2-7).

The first drastic change occurred in the mid-1980s, when the Japanese yen started to appreciate and electronic equipment manufacturers started to move their production sites overseas, mostly into various Asia/Pacific countries. This meant that Japanese semiconductor companies had to have sales offices, technology support centers, and eventually, production facilities in Asia/Pacific.

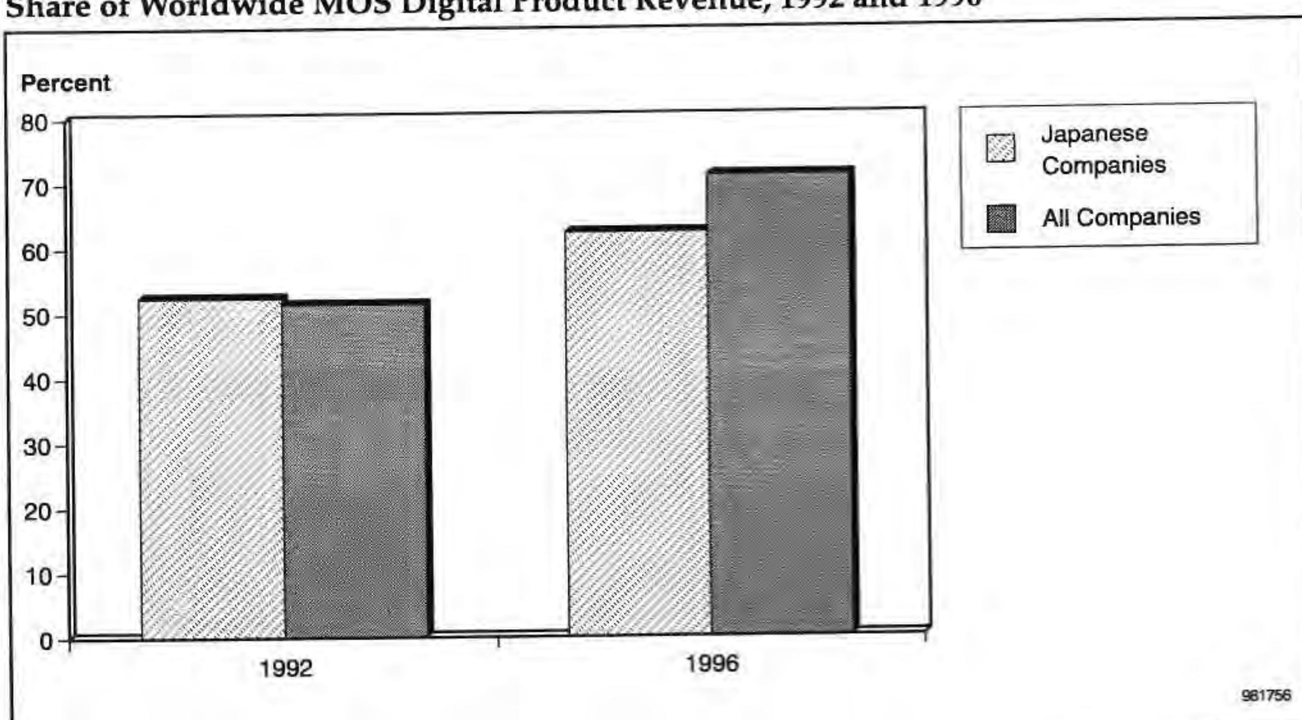
The second wave came in 1993, when the yen soared again, but this was also a year when the Japanese semiconductor market continued to be sluggish while all the other regional markets began to expand rapidly, driven by the PC boom. This trend prompted Japanese companies to expand foreign operations.

Figure 2-4
Worldwide Revenue Market Share by Product, 1996



Source: Dataquest (March 1998)

Figure 2-5
Share of Worldwide MOS Digital Product Revenue, 1992 and 1996



Source: Dataquest (March 1998)

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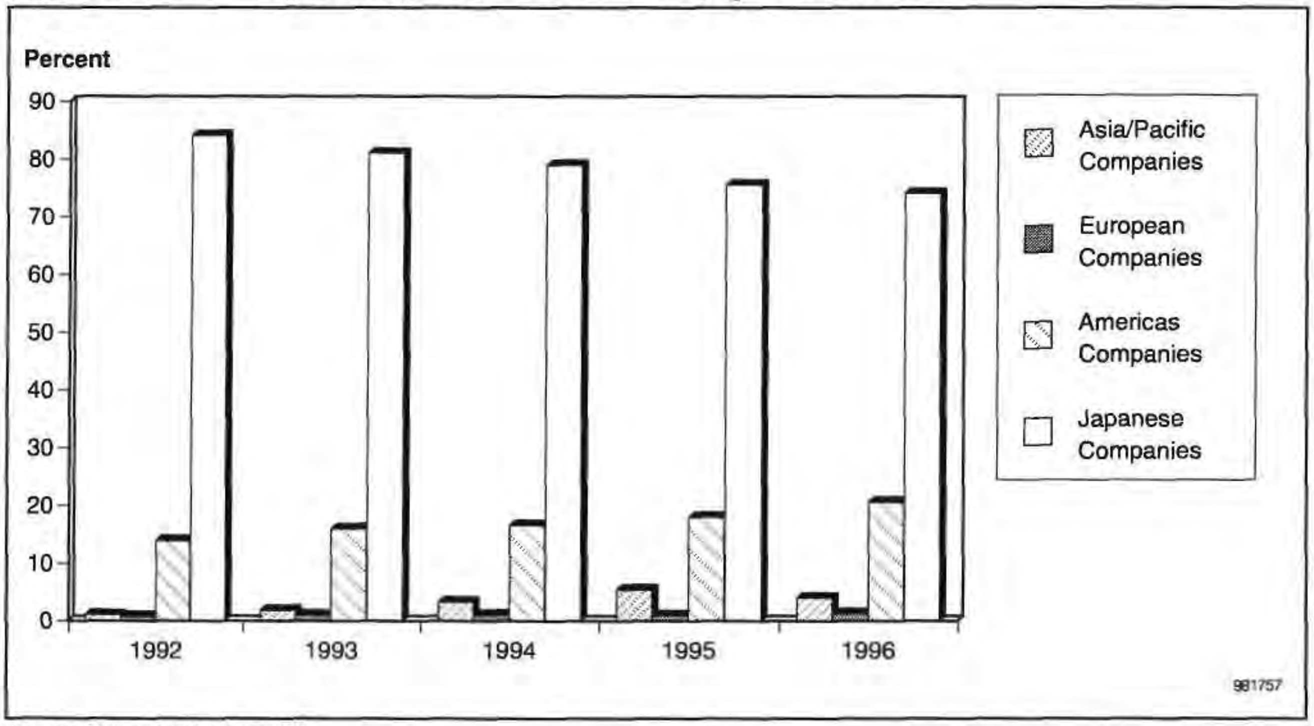
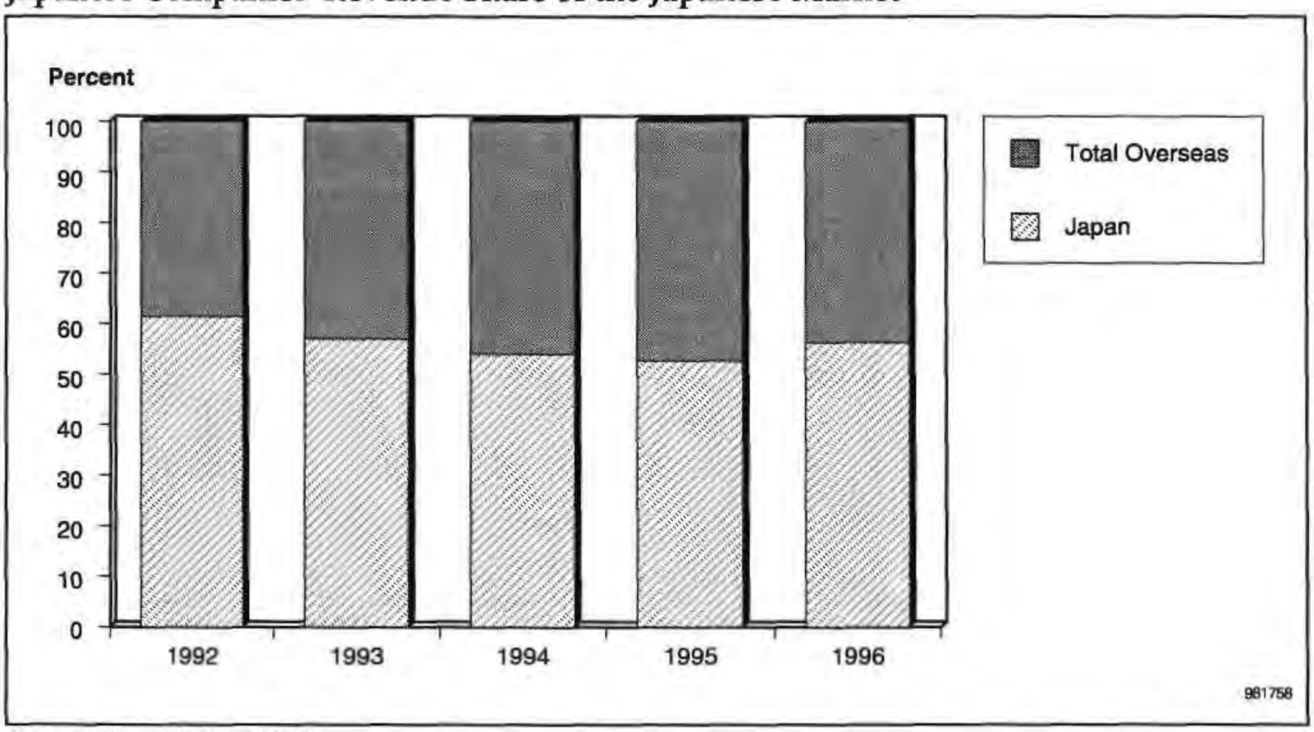
Figure 2-6
Japanese and Foreign Companies' Share of the Japanese Market



Source: Dataquest (March 1998)

Figure 2-7
Japanese Companies' Revenue Share of the Japanese Market

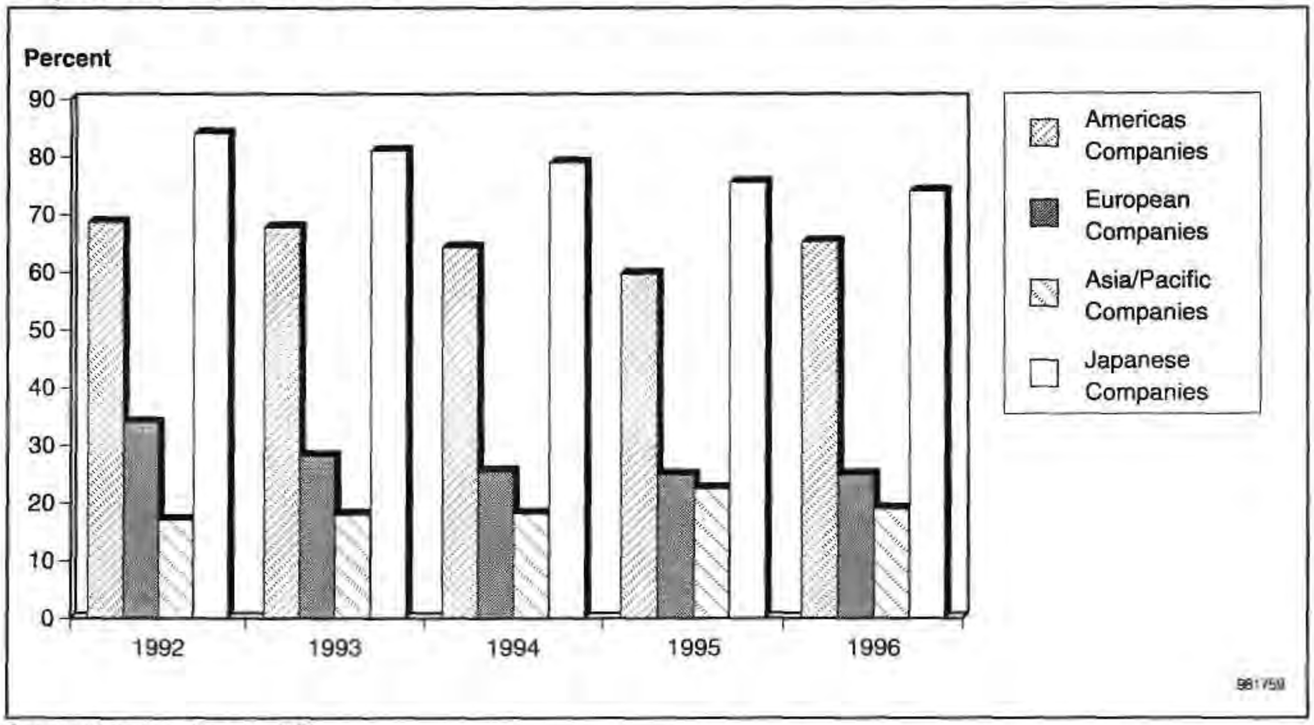


Source: Dataquest (March 1998)

Figure 2-8 compares regional companies' trends in regional sales. Among all regional companies, a sales focus on the company's own region is commonly seen. The extent of focus varies, however, according to market size and growth potentials. A notable difference between Japanese and non-Japanese companies is that non-Japanese companies tend to focus on at least one more regional market, while the domestic market seemed to be the only focus for Japanese companies. With the shift of application equipment production overseas, a focus on the Japanese semiconductor market alone could not bear much fruit. In fact, the sum of the market in Japan and in Asia/Pacific still represents about half the worldwide market, and this has encouraged Japanese companies to do close follow-up of their domestic users at foreign sites.

Tables 2-2 and 2-3 compare Japanese companies' trends in regional sales. Companies that focus on non-Japanese markets are Nippon Steel Semiconductor, Toshiba, Oki Electric Industries Company Ltd., and SANYO. They either followed their domestic users at foreign sites very closely or sought foreign markets for general-purpose products, including DRAM.

Figure 2-8
Revenue from Shipments of Semiconductors by Companies Shipping into Their Regional Base, 1992 to 1996



Source: Dataquest (March 1998)

Table 2-2
Japanese Companies' Regional Sales Orientation
(X = Regional Sales Greater than Japanese Companies' Average)

	Japan	Non-Japanese Market	Americas	Europe	Asia/Pacific
Fuji Electric	X	-	-	-	X
Fujitsu	X	-	-	X	-
Hitachi	-	X	X	X	-
Matsushita	X	-	-	-	-
Mitsubishi	-	X	X	X	-
NEC	-	X	X	X	-
New JRC	X	-	-	-	X
Nippon Steel Semiconductor	-	X	X	-	X
Oki	-	X	X	X	-
Ricoh	X	-	-	-	-
Rohm	X	-	-	-	X
Sanken	X	-	-	-	X
SANYO	-	X	-	-	X
Seiko Epson	X	-	X	-	-
Sharp	X	-	-	-	X
Shindengen Electric	X	-	-	-	X
Sony	X	-	-	-	-
Toko	X	-	-	-	X
Toshiba	-	X	X	X	X
Yamaha	X	-	-	-	X

Source: Dataquest (March 1998)

Companies such as Nippon Steel Semiconductor, Oki, NEC, Hitachi, Seiko Epson Corporation, Toshiba, and Mitsubishi generate more than 20 percent of their worldwide revenue in the Americas market. Those are the companies that are focusing heavily on either memories or logic in the region. It should be noted that, of these, NEC, Hitachi, and Mitsubishi have wafer fabs in the United States, and Toshiba has set up a joint venture with IBM.

The European market shows a somewhat different trend. Fujitsu leads Japanese companies, with 14 percent of its worldwide revenue coming from the Europe, Africa, and Middle East region. This is a benefit of having an internal user there. Hitachi, Mitsubishi, NEC, and Toshiba have a comparatively high dependence on the European market, and here again, the first three companies have wafer fab operations within the region, while Toshiba has back-end operation.

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Table 2-3
Japanese Companies' Regional Sales Penetration
(X = Company Market Share of Greater than 3 Percent)

	Worldwide	Japan	Non-Japanese Market	Americas	Europe	Asia/Pacific
Fuji Electric	-	-	-	-	-	-
Fujitsu	X	X	-	-	-	-
Hitachi	X	X	X	X	X	X
Matsushita	-	X	-	-	-	-
Mitsubishi	-	X	-	-	-	-
NEC	X	X	X	X	X	X
New JRC	-	-	-	-	-	-
Nippon Steel Semiconductor	-	-	-	-	-	-
Oki	-	-	-	-	-	-
Ricoh	-	-	-	-	-	-
Rohm	-	-	-	-	-	-
Sanken	-	-	-	-	-	-
SANYO	-	X	-	-	-	X
Seiko Epson	-	-	-	-	-	-
Sharp	-	X	-	-	-	-
Shindengen Electric	-	-	-	-	-	-
Sony	-	X	-	-	-	-
Toko	-	-	-	-	-	-
Toshiba	X	X	X	X	-	X
Yamaha	-	-	-	-	-	-
Total Japanese Companies	X	X	X	X	X	X

Source: Dataquest (March 1998)

Many Japanese companies sell hard into the Asia/Pacific market, but are not enjoying a high market share. In fact, when compared with the average orientation of Japanese companies, only Toshiba shows a determined regional orientation across the regions, while most other companies focus either on Americas and Europe or Asia/Pacific. Notably, it is the smaller companies that show high dependence on Asia/Pacific, which seems to represent their efforts to maintain business relationship with the Japanese users.

Matsushita and Sony do not seem to focus on overseas sales, but their internal sales need to be noted: These are the companies with large internal demand from user divisions and companies, and their sales of components tend to take place within Japan rather than at user divisions' actual production sites in Asia/Pacific.

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A Quick Look at the 1997 Rankings

Dataquest has completed its annual 1997 market share survey. Details of the survey have been discussed in Perspectives, and trends in the Japanese market will be discussed extensively in an upcoming Market Trends report. Tables 2-4 and 2-5 show worldwide and Japanese market share rankings, respectively.

Table 2-4
Revenue of Japanese Companies in the Top 20 Worldwide Ranking from Shipments of Semiconductors to the Worldwide Market, 1997 (Millions of Dollars)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Growth (%) 1996-1997
2	2	NEC	10,428	10,222	-2.0
5	5	Toshiba	8,065	7,253	-10.1
4	6	Hitachi	8,071	6,298	-22.0
8	8	Fujitsu	4,427	4,622	4.4
11	11	Mitsubishi	4,100	3,925	-4.3
14	14	Matsushita	3,003	2,847	-5.2
15	17	SANYO	2,491	2,471	-0.8
19	19	Sharp	2,124	2,145	1.0
23	20	Rohm	1,731	2,053	18.6

Source: Dataquest (March 1998)

Table 2-5
Revenue of the Top 10 Companies from Shipments of Semiconductors to the Japanese Region, 1997 (Millions of Dollars)

1996 Rank	1997 Rank	Company	1996 Revenue	1997 Revenue	Growth (%) 1996-1997
1	1	NEC	5,756	5,666	-1.6
3	2	Toshiba	3,838	3,484	-9.2
2	3	Hitachi	4,252	3,355	-21.1
4	4	Fujitsu	2,645	2,768	4.7
5	5	Matsushita	2,268	2,244	-1.1
7	6	Intel	2,028	2,237	10.3
6	7	Mitsubishi	2,147	2,030	-5.4
8	8	Texas Instruments	1,634	1,549	-5.2
9	9	Sharp	1,561	1,491	-4.5
10	10	Sony	1,386	1,369	-1.2

Source: Dataquest (March 1998)

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NEC maintained the top position among Japanese companies, but the gap between it and the worldwide top company, Intel, has widened, with Intel recording nearly double NEC's revenue. The second- and third-ranked Japanese companies, Toshiba and Hitachi, changed places, mainly because of the hardship Hitachi faced in 1997 from DRAM price declines and slow expansion of its proprietary microcomponent product line. Other companies maintained their positions, including Toshiba and Fujitsu, but Mitsubishi could not find its way back into the top 10 ranking.

In the Japanese market, there were only a couple of changes in the ranking. Toshiba and Hitachi switched positions, as did Mitsubishi and Intel; all the others maintained their 1996 rankings. NEC not only remained at the top but widened the gap with the followers, showing only a modest decline in revenue.

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Chapter 3

Manufacturing Power

This chapter measures and analyzes Japanese companies' manufacturing power, as opposed to their brand sales power in the previous chapter.

Dataquest defines manufacturing power as:

- Manufacturing power = brand sales + foundry sales - foundry purchase

Some Japanese companies choose to announce production numbers on a fiscal year basis. Production numbers usually include both foundry shipments and foundry purchases, but some details remain unexplained. In this analysis, Dataquest applies its own measurement of all three factors in the equation above, based on its proprietary definitions.

1996 Foundry Trends

Japanese companies' foundry activity can be classified as either OEM business or foundry. OEM designates the kind of partnership business in which the provider company designs and manufactures a product sold under the partner's brand. Thus, the basic difference between OEM manufacturing and foundry lies in designing—in foundry, the user of foundry capacity designs the products, the provider manufactures them, and the products are marketed by the foundry user under its brand.

Starting in mid-1980s, Japanese semiconductor companies' foundry activity included a unique business type in which Japanese companies formed a cooperative framework to market their foreign counterparts' products, primarily to enhance foreign vendors' presence in the Japanese market. This took various forms of collaboration, including codevelopment of new products, fine-tuning of foreign-origin products to meet Japanese users' needs, sharing of production capacity and sales channels, and so on. This practice has decreased as foreign vendors built their own business systems in the Japanese market, and the recent rise in foreign companies' combined market share clearly shows that non-Japanese companies can be competitive in this market without the help of domestic competitors. In 1996, the Japanese market share of all non-Japanese semiconductor companies rose to 26 percent, and it is expected to increase further in 1997.

Historically, there was another type of foundry/OEM practice, especially among Japanese companies: fab transition, when old-generation DRAM fabs are refurbished with additional equipment to be used for other products, characteristically for microcomponents, logic, and then analog, or in the final stage, even for discrete. Those non-DRAM products could be produced at fabs that were largely, if not completely, depreciated, and thus the profitability of the overall semiconductor business was secured. Dataquest has identified this trend as the "Japan model," because this transition was possible with wide range of product offerings, which major Japanese companies have managed to grow.

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One form taken by this Japan model was OEM, with the provider offering manufacturing capacity for other companies' non-DRAM products. There were various strategic reasons for this kind of arrangement. Company A might be lagging behind in microcomponents. Rather than develop and manufacture microcomponents starting from ground zero, it might opt to turn to leading company B's product area, and then company A might provide B with A's own products in which B might not have invested as strongly. This kind of collaboration was actually based on very strategic decisions and was usually done among Japanese companies. Dataquest believes the scope and the amount of this kind of practice has largely been reduced in the 1990s.

Pure foundry has been regarded by Japanese semiconductor companies as a zero-profit operation, mostly because Japanese companies, with a few exceptions, used foundry as a way to fill their fabs. This kind of opportunistic foundry sales was encouraged when the market was in oversupply and the utilization of fabs dropped below the sound level. Rather than running the fab at low utilization, Japanese companies opted to find low-margin foundry business. Of course, there were several cases of Japanese companies' seriously seeking foundry opportunities to strengthen ties with foreign companies, especially some American and European companies. This took the form of production capacity sharing as part of an alliance on new product development or on new technology.

The emergence of dedicated foundry providers, however, has changed the framework. New foundry providers applied leading-edge technology and focused on manufacturing efficiency. (Detailed analysis of dedicated foundry providers is provided in various publications in the Dataquest's Semiconductor Contract Manufacturing Services Worldwide program.) The decline in foundry shipments stems from various factors, such as severance of a company's collaborative framework with its foreign counterparts or discontinuation of old-type Japanese OEM, but the most characteristic reason is weakening competitiveness against dedicated foundries. In view of the continued oversupply in the DRAM market, Japanese companies have sought foundry opportunities. The success of dedicated foundries in both revenue and profit has also encouraged some Japanese companies to include foundry among their business planning options.

1996 Manufacturing Revenue Estimates

Using the formula given earlier, Figure 3-1 shows Japanese companies' total foundry and manufacturing power trends, while Figures 3-2 and 3-3 show estimated manufacturing revenue for each Japanese company for 1995 and 1996, respectively.

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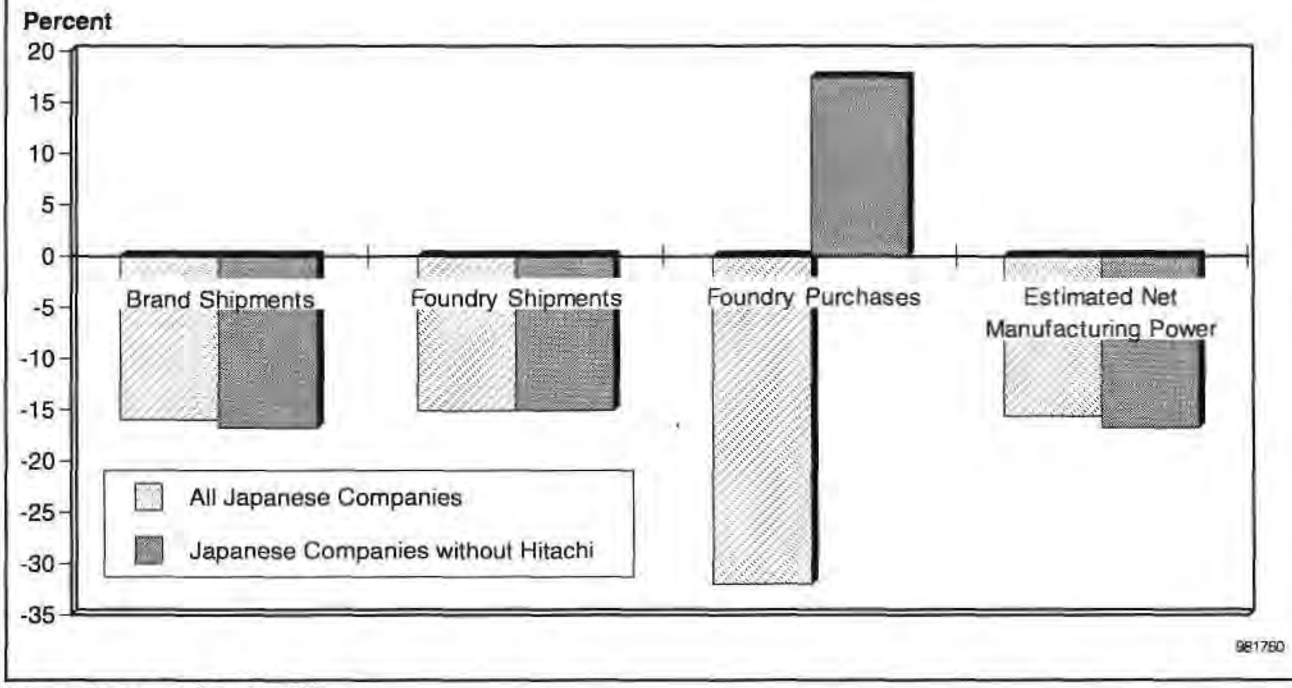
Figure 3-1
Japanese Companies' Foundry and Manufacturing Power, 1995 and 1996 (Percentage Change)



Source: Dataquest (March 1998)

The analysis of manufacturing power reveals some trends. In 1996, Japanese companies' brand shipment revenue was heavily impacted by weak pricing and declined. This was caused by the oversupply in MOS digital products caused by fast expansion of production capacity in the preceding few years. In these situations, Japanese companies have typically made efforts to increase foundry shipments to "fill the fab." Dataquest believes that this opportunism is one of the characteristics of Japanese companies' foundry business, which can still be observed in their business decisions.

But in 1996, foundry shipments declined faster than brand shipments. Revenue information for 1997 is yet to be finalized, but a preliminary look at the survey results indicates another year of declining foundry shipments. This clearly represents the hardship Japanese companies are facing in competition with dedicated foundry providers, such as some Taiwanese companies, as discussed earlier. This also seems to represent another trend—there is very little foundry business left among Japanese companies, except for some examples, such as the Mitsubishi-Seiko Epson agreement on foundry of proprietary embedded DRAM products.

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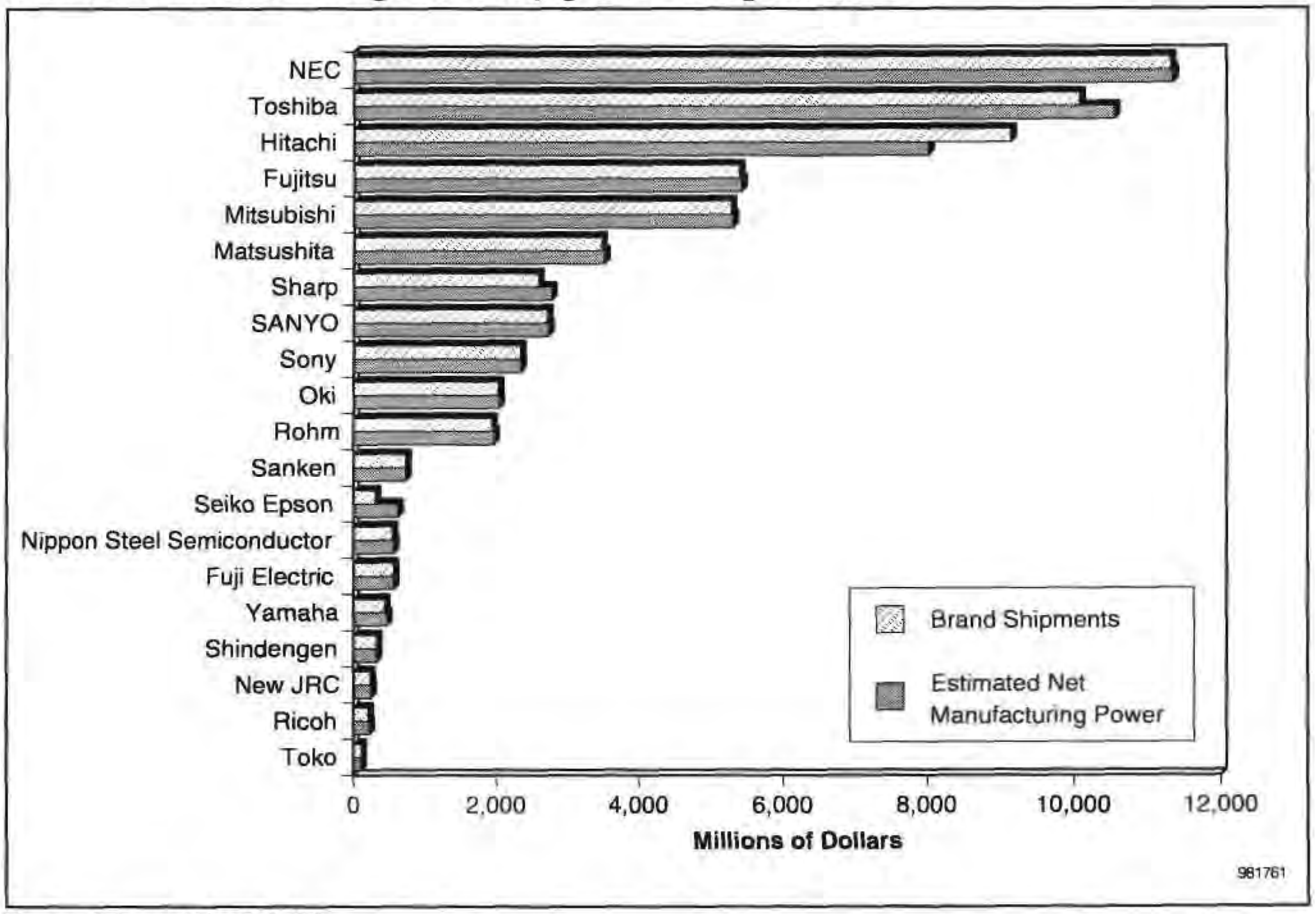
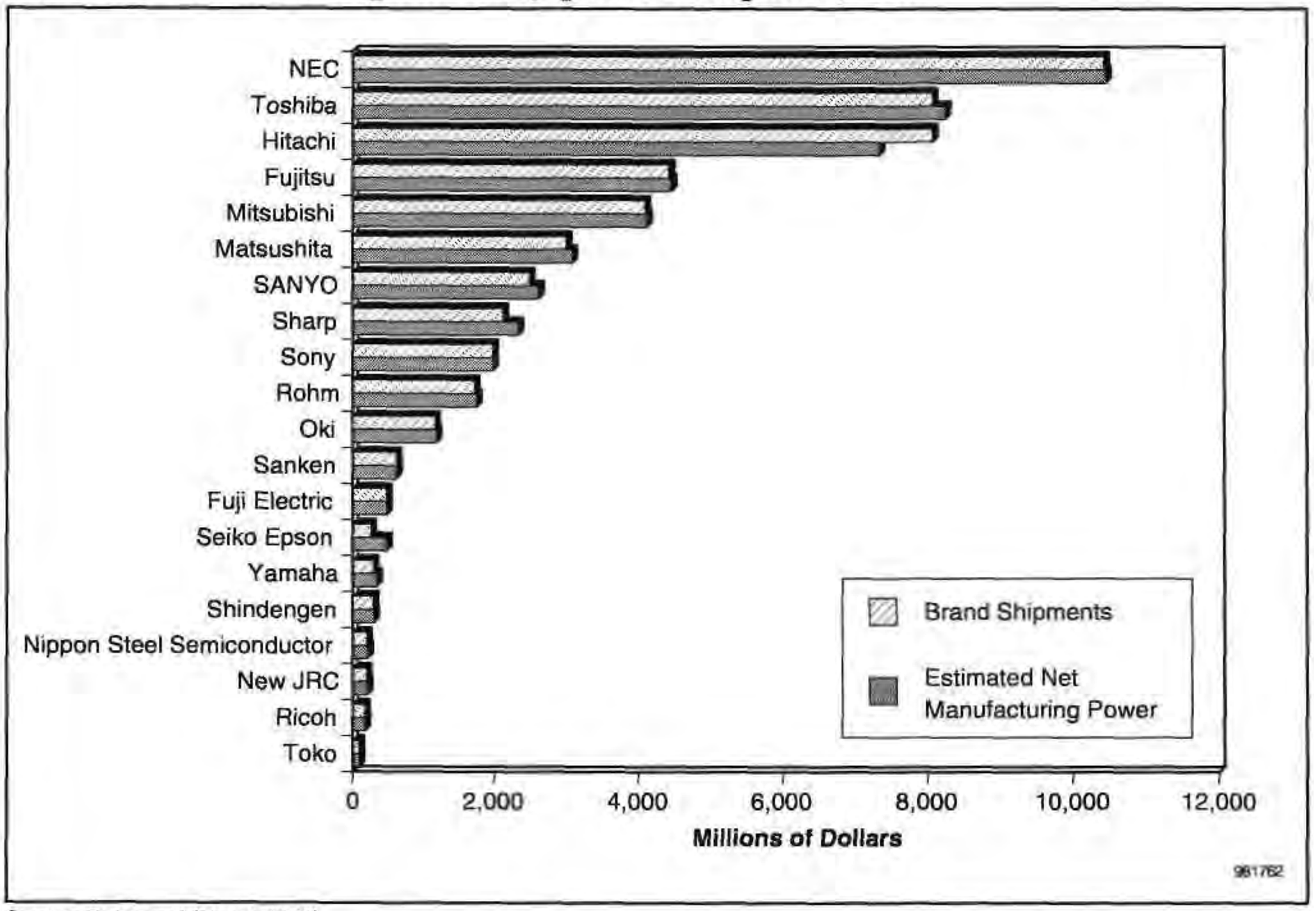
Figure 3-2
Estimated Manufacturing Power of Japanese Companies, 1995



Source: Dataquest (March 1998)

Another trend is becoming clearer: Japanese companies are increasing foundry purchases. It should be noted that DRAM OEM purchasing, such as Hitachi-LG Semicon, has been impacted by the fast price decreases, while, on a unit basis, it is growing. Again, because inter-Japanese foundry is decreasing, this increase in foundry purchases can only be attributed to alliances with non-Japanese companies. Contributing to this trend are examples such as Toshiba-Winbond and Fujitsu-Taiwan Semiconductor Mfg. Co. (Dataquest does not regard Powerchip Semiconductor Corporation as a foundry to Mitsubishi at this time). Although still small, the trend toward increasing foundry purchases is evident, and there will be more of this, both in size and in product categories, as Japanese companies try to focus on a limited number of products for efficient management of their semiconductor business.

Figure 3-3
Estimated Manufacturing Power of Japanese Companies, 1996



Source: Dataquest (March 1998)

1997 Fab Trends

Manufacturing power has been the biggest factor in the rise of Japanese semiconductor companies in the worldwide market. In a fast-growing market, supply capacity played a key role in increasing revenue, and Japanese companies' strategies centered around the decision to increase capital spending on manufacturing capacity.

Trends over Time

Japanese companies' fab construction has been driven basically by two factors—DRAMs for major companies and cyclical business trends.

DRAM companies accelerate fab construction during DRAM boom years, including new shells and even new sites. To simplify the pattern, some of this effort results in oversupply after the boom years, and new shells remain empty for some time, to be filled only in the next cycle. This pattern has caused radical ups and downs in DRAM companies' capital spending.

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Non-DRAM companies have built fabs at a comparatively constant pace, but again on a cyclic pattern. To these companies, business cycles were triggered by demand cycles observed up to the 1980s. When such cycles became less visible in the 1990s, the companies started to increase fab capacities at a constant but gradual pace. Some companies have chosen to make certain product areas the driver of technology and fab expansion, such as microcontrollers, analog, or power discretes, depending on product coverage.

Regional Fab Trends

In the rise of the Japanese semiconductor companies, the fast-expanding domestic market was more than enough to consume output from Japanese companies' fabs. As regional market trends changed, however, and Japan became the slowest-growing market and as the Japanese yen appreciated, Japanese semiconductor companies had to expand overseas production operations while they had a way of concentrating production facilities in the domestic region. Only a handful of companies have continuously invested in foreign countries for manufacturing. The few foreign production sites secured by Japanese companies were mostly acquired or built during or right after the semiconductor market boom. Table 3-1 lists major foreign fabs of Japanese companies.

Type of Operation

Japanese companies' foreign wafer fab operations started through acquisition of existing fabs of local companies. Then those fabs were expanded and upgraded to produce DRAMs or logic products to be marketed locally. There were exceptions, such as NEC's Roseville fab, part of the output of which has been sent to other regions to be packaged and marketed globally.

During the PC-driven boom years of 1993 to 1995, Japanese companies announced plans to enhance their overseas wafer fab operations, including new fabs such as NEC Scotland's Phase 2 and Hitachi's HISUS U3, to develop new wafer fabs at back-end sites, such as Mitsubishi's Aachen fab, or to enter joint ventures with non-Japanese companies, such as Powerchip Semiconductor (Mitsubishi-UMAX), TwinStar (Hitachi-Texas Instruments Inc.), Dominion Semiconductor (Toshiba-IBM), or joint ventures between Japanese companies, such as Hitachi-Nippon Steel Semiconductor in Singapore. The strategy varied according to each company's global strategy and the technology alliances the company had formed.

For back-end operation, an increasing portion of foreign operations seems to have been shifted from Japanese companies to local assembly and test houses, but details are yet to be surveyed. Also noteworthy is the increase in module production overseas, where local sales offices and production sites have chosen local subcontractors to assemble memory modules to meet fast-changing local demand as well as stringent price requirements.

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Table 3-1
Major Japanese Companies' Overseas Fabs

Company	Fab Name	Campus Name	City	Country	Products	Date of Initial Production	Minimum Line Width (Micron)	Maximum Diameter (mm)
Fujitsu	No. 1	Durham	Newton Aycliffe	U.K.	4Mb 16Mb DRAM	1991	0.42	150
Fujitsu	No. 1	Gresham Mfg. Division	Gresham	U.S.	4Mb DRAM	1988	0.80	150
Fujitsu	No. 2	Gresham Mfg. Division	Gresham	U.S.	64Mb DRAM	1997	0.25	200
Fujitsu	Phase 2	Durham	Newton Aycliffe	U.K.	16Mb 64Mb DRAM	1999	0.25	200
Hitachi	E2	Landshut	Landshut	Germany	16Mb DRAM 8-bit MCU	1993	0.50	200
Hitachi	U2	Irving	Irving	U.S.	1Mb 4Mb DRAM 256Kb SRAM MPU	1990	0.80	150
Hitachi	U3	Irving	Irving	U.S.	MPU MCU	1998	0.25	200
Hitachi-Nippon Steel Semiconductor	Hitachi-Nippon Steel Semiconductor	Tampins	Singapore	Singapore	64Mb DRAM	1998	0.30	200
Matsushita	Fab C	MASCA	Puyallup	U.S.	1Mb 4Mb DRAM 4-bit 8-bit MCU	1992	0.60	150
Matsushita	Fab D	MASCA	Puyallup	U.S.	16-bit MPU 32-bit DSP 64Mb DRAM	1998	0.25	200
Mitsubishi	MSAI	Durham	North Durham	U.S.	16Mb DRAM MCU	1990	0.50	150
Mitsubishi	MSE	Aachen	Alsdorf	Germany	4Mb 16Mb DRAM	1997	0.35	200
Mitsubishi-UMAX (Powerchip)	Powerchip	PCS	Science Park	Taiwan	16Mb DRAM 64Mb DRAM	1996	0.35	200
NEC	K-Line	Roseville	Roseville	U.S.	ASIC MCU	1984	1.00	125
NEC	M-Line	Roseville	Roseville	U.S.	16Mb DRAM	1991	0.25	150
NEC	1 Phase	Scotland	Livingston	U.K.	ASIC Micro Logic 4Mb DRAM	1987	0.50	150
NEC	2 Phase	Scotland	Livingston	U.K.	16Mb 64Mb DRAM	1996	0.25	200
NEC	Shougang Phase 1	Shougang NEC	Beijing	China	MCU Logic	1992	1.20	150
NEC	Shougang Phase 2	Shougang NEC	Beijing	China	4Mb DRAM 4-bit MCU	1994	0.65	150
NEC		Shanghai	Shanghai	China	Memory Logic	1999	0.25	200
Sony	Fab 11	San Antonio	San Antonio	U.S.	SRAM	1991	0.45	150
Sony	Fab 12	San Antonio	San Antonio	U.S.	ASIC PLD	1982	1.25	150
Texas Instruments-Hitachi (TwinStar)	TwinStar		Richardson	U.S.	16Mb 64Mb DRAM	1996	0.30	200
Toshiba-IBM	Module 1	Dominion Semiconductor	Manassas	U.S.	64Mb DRAM	1997	0.25	200

Source: Dataquest (March 1998)

Detailing trends in design is beyond the scope of this analysis, but significant numbers of design centers have been set up around the world in the past few years to meet local system requirement. In a limited number of cases, however, locally designed products can be marketed autonomously—a central control from the headquarters is still the norm for most Japanese companies, which foreign local users may find inefficient and time-consuming.

The Advantages in Constructing an Overseas Fab

There are various reasons for Japanese companies to set up foreign production facilities, which can be classified as demand-side (or environmental) and supply-side (or corporate-oriented) reasons. Demand or environment are also characterized as "pull" factors, because companies are pulled to overseas sites for those reasons, while supply or corporate reasons are "push" factors, for these push the companies to foreign production. The following are the factors pulling and pushing Japanese fab construction overseas:

- Demand/environment
  - Timely response to local demands
  - Enhanced dependability for local customers
  - Fast growth in local demand
  - Avoidance of trade barriers such as tariffs
  - Avoidance of trade friction by substituting export into the region with local production
  - Integration of the production process from design to assembly and test
  - Strengthening of partnerships with allied local companies
  - Alliances with local user companies
- Supply/corporate
  - Sharing fruits of codevelopment with local companies
  - Technology transfer
  - Risk diversification by having multiple suppliers
  - Slow growth in domestic demand
  - Reduction in manufacturing cost
  - Reduction in logistics cost
  - Incorporation of or deployment of local human resources
  - Deployment of various local resources from local allied companies
  - Recycling profits from local sales
  - Ample funding

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Characteristics of Japanese Fab Expansion Overseas

Historically, Japanese companies' fab construction has been aggressive during semiconductor boom years. This can be attributed to two reasons. One was the increase in profits generated by the stable prices companies enjoy in up cycles. The other was semiconductor trade friction: Foreign investments were accelerated when a sudden increase of semiconductor exports from Japan caused a trade imbalance. Foreign fabs that have been built or acquired with this kind of background were not exactly based on Japanese companies' own long-term strategies, and, with a couple of exceptions, those fabs remained comparatively small in terms of wafer processing capacity. In back-end operations, reimport of output at Asia/Pacific sites to Japan was seriously considered, and in some cases, actually done to leverage on yen appreciation.

The rush in Japanese companies' overseas fab construction in 1993 through 1995 was characterized by one factor significantly different from the past—foreign markets were expanding much faster than the domestic market and "manufacturing near the market" had become the norm. NEC upgraded its Roseville, California, fab and started constructing a 200mm wafer fab in Scotland for 64Mb DRAM production. Toshiba, for the first time in its history, decided to build a DRAM wafer fab outside Japan, in alliance with IBM. Hitachi made two plans—TwinStar to produce DRAMs and HISUS U3 for production of proprietary microcomponent products. Fujitsu announced expansion at its Oregon site for production of 64Mb. Mitsubishi finally started a DRAM wafer fab at Aachen, Germany, after several years' hesitation. Matsushita decided to strengthen its fab operation in the United States by adding a 0.25-micron fab for 64Mb DRAM production. And Hitachi and Nippon Steel Semiconductor began construction of a joint wafer fab to produce 64Mb DRAM in Singapore. All those plans were aimed at seriously expanding sales of targeted products both locally and internationally.

This sudden flourish of overseas fab construction is, actually, nothing new for boom years. As discussed earlier, there are various reasons for Japanese companies to build foreign fabs, but one reason for all companies and all occasions is the ample financial resources available in boom years. This, in turn, implies that in bust years, Japanese companies' fab expansions dwindle, and in actuality, the record confirms that trend. So will negative attitudes among Japanese companies toward overseas fabs prevail in this adverse environment? There are signs to support that view, but details are yet to be announced.

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Regional Spending Trends

Capital spending in Japan has been mostly done by Japanese companies. Table 3-2 shows 1997 capital spending in Japan. In that year, almost the whole amount was estimated to have been spent by Japanese companies. During the 1980s through the early 1990s, when access to the Japanese market was a hot topic on the international scene, Japan was the largest single semiconductor market in the world. In an effort to increase sales here, non-Japanese companies started chip production in Japan. Texas Instruments could be described as one of the most aggressive, in the sense that it moved the headquarters of its DRAM operation into Japan. Some companies chose to set up joint ventures, such as Tohoku Semiconductor (Motorola Incorporated and Toshiba), Nippon Precision Circuits (LSI Logic Corporation and Kawasaki Steel Corporation), and KTI Semiconductor (Texas Instruments and Kobe Steel Ltd.). Fujitsu-AMD Semiconductor became the last to take this approach. Currently the interest of non-Japanese companies seems to have shifted to other regions, especially Asia/Pacific, for both a market and a supply base.

However, Japanese companies' spending still goes mostly into their domestic sites. In the 1980s, Japanese companies are estimated to have spent about 85 to 90 percent of their total capital spending within Japan, while in the early 1990s the ratio has dropped to 80 to 85 percent, leading to an increase in foreign production. This trend was caused by two factors: yen appreciation, which made it more lucrative for companies to produce and sell in the dollar economies, and market expansion. Foreign markets were expanding faster than Japanese markets, and if the name of the game is to "manufacture near the market," it was not advantageous to continue producing within Japan and then export the output. There were other reasons, including political decisions, but overall, the Japanese companies' spending overseas continued to increase up to the year 1996. Because total spending continued to increase in 1996, the ratio of overseas spending against the total peaked in 1995 (see Figure 3-4).

Then the tide changed. The yen started to depreciate, and the semiconductor market showed contraction. Reduced profits constrained capital spending, but Japanese companies also had to maintain capital spending for next-generation technologies and products. This has led them to spend more in advanced fabs within Japan and to review foreign operations. This was a difficult choice, because non-Japanese markets were still growing faster than the domestic market.

Table 3-2
Manufacturing Capital Spending in Japan, 1992 to 1997

	1992	1993	1994	1995	1996	1997
Japanese Spending ($M)	3,958	4,413	6,667	9,912	9,654	8,342
Growth (%)	-30.6	11.5	51.1	48.7	-2.6	-13.6

Source: Dataquest (March 1998)

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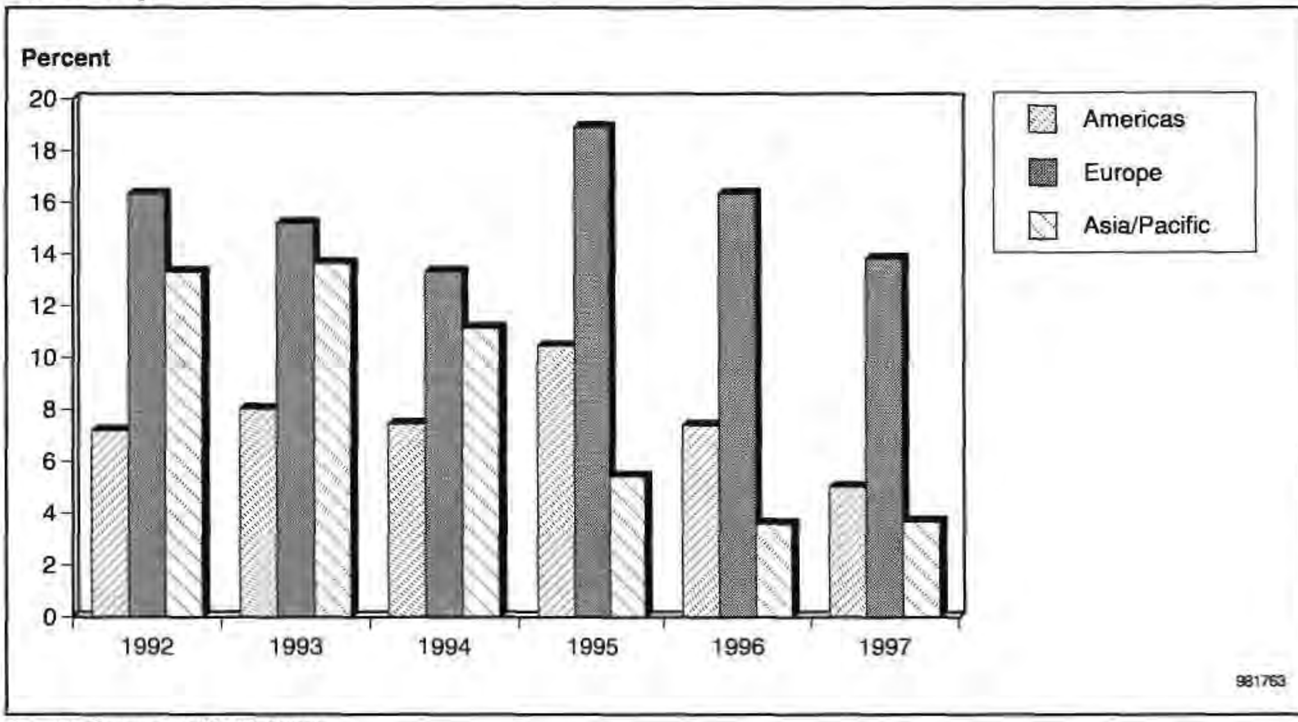
Figure 3-4
Japanese Companies' Overseas Capital Spending, 1992 to 1997 (Percentage of Total Spending)



Source: Dataquest (March 1998)

Product Trends

Japanese companies' capital spending trends by product area are shown in Figure 3-5. DRAM alone represented about half the capital spending in Japan in the 1980s and more than 40 percent in the first half of 1990s. As excess capacity prevailed in the MOS digital product area, additional capacity plans for DRAMs were the first to be reviewed and eventually abandoned. Those fabs were then either redesigned for other memory products, such as flash memory, and microcomponents and logic products or postponed. In 1997, the whole memories category still represented more than half the total spending of Japanese companies. This decline in DRAM ratio does not necessarily mean that Japanese companies are abandoning the DRAM business—in fact, an increasing amount of DRAM foundry purchasing indicates that Japanese companies are determined to stay in the market while reducing the burden of capital spending into this volatile product category.

Spending for microcomponents and logic products is on the rise. Japanese companies have repeatedly attempted to focus on non-DRAM MOS digital products when the DRAM market has crashed. This time, however, the situation is quite different, because the market is moving fast toward system-level integration. The emphasis on non-DRAM products meant adding equipment to fabs originally constructed for the most advanced DRAM products, but the current focus on microcomponents and logic, especially cell-based ICs, requires the most advanced manufacturing equipment. Thus, the Japan model does not work anymore, and Japanese companies face the decision of whether to build a fab initially for logic products or memories. This implies that they will either need to prepare products that can fill those fabs afterwards to lighten the depreciation cost or they will have to turn to outsourcing—in other words, foundries.

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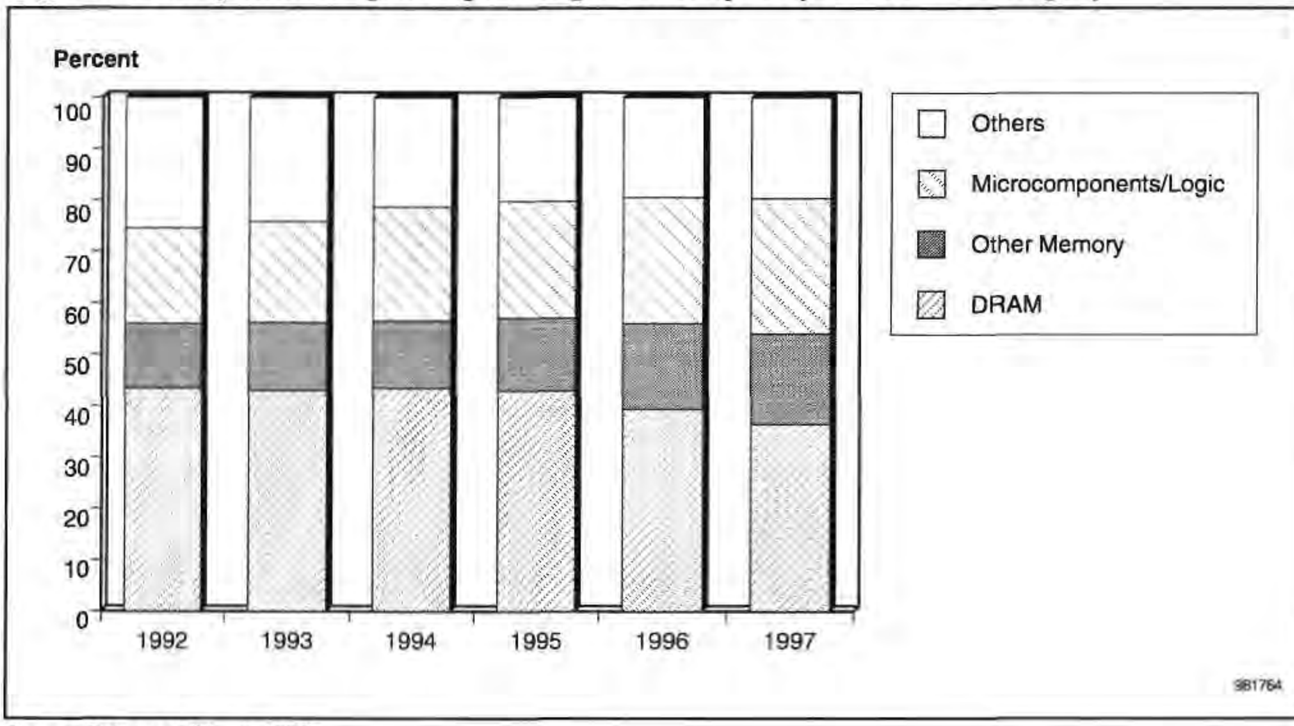
Figure 3-5
Japanese Companies' Capital Spending Trends by Major Product Category



Source: Dataquest (March 1998)

As discussed in the section on foundry and manufacturing power, Japanese companies are adopting a new business model to make more use of contract manufacturing.

Research and Development Expenditure

Technology and product development, another aspect of manufacturing operations, will be covered in more detail in future documents. In this section, Dataquest looks only briefly at R&D expenditure; detailed information on alliances will be covered in a future Dataquest document.

The R&D spending of Japanese semiconductor companies was revisited in Dataquest's recent survey to clarify the distinction between manufacturing capital spending and R&D spending. Figure 3-6 shows estimated R&D spending for major Japanese companies. The companies can be divided into three groups according to level of spending.

Top companies spend about 10 to 15 percent of their semiconductor revenue on R&D activities, and they tend to maintain this level of spending over time (see Figure 3-7). These are the companies that lead technology development, competing hard with each other to develop and market new products ahead of everyone else. Not all of their spending brings additional revenue directly, because some part is spent on fundamental technologies and because some R&D is not fruitful. In view of the need to clarify their business focus, companies are changing this attitude and have started to explore the possibility of reducing their spending in areas on which they may not focus.

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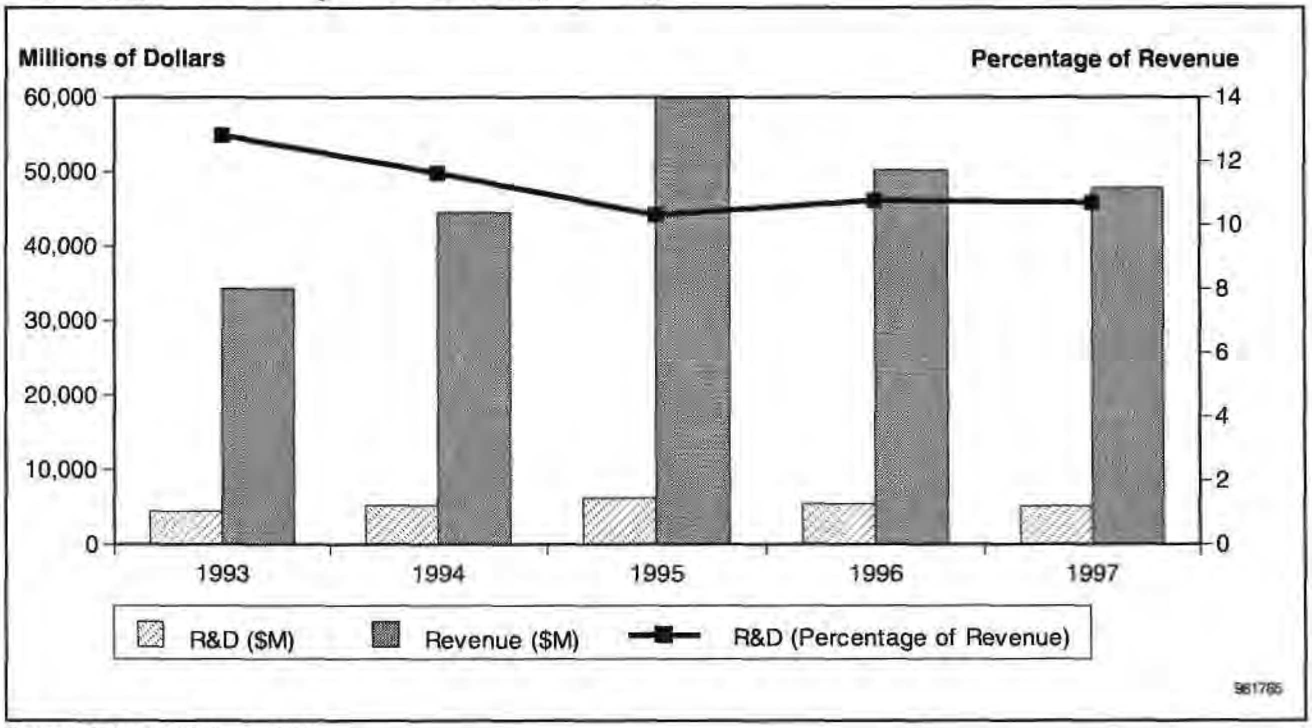
Figure 3-6
Top 20 Japanese Companies' R&D Spending

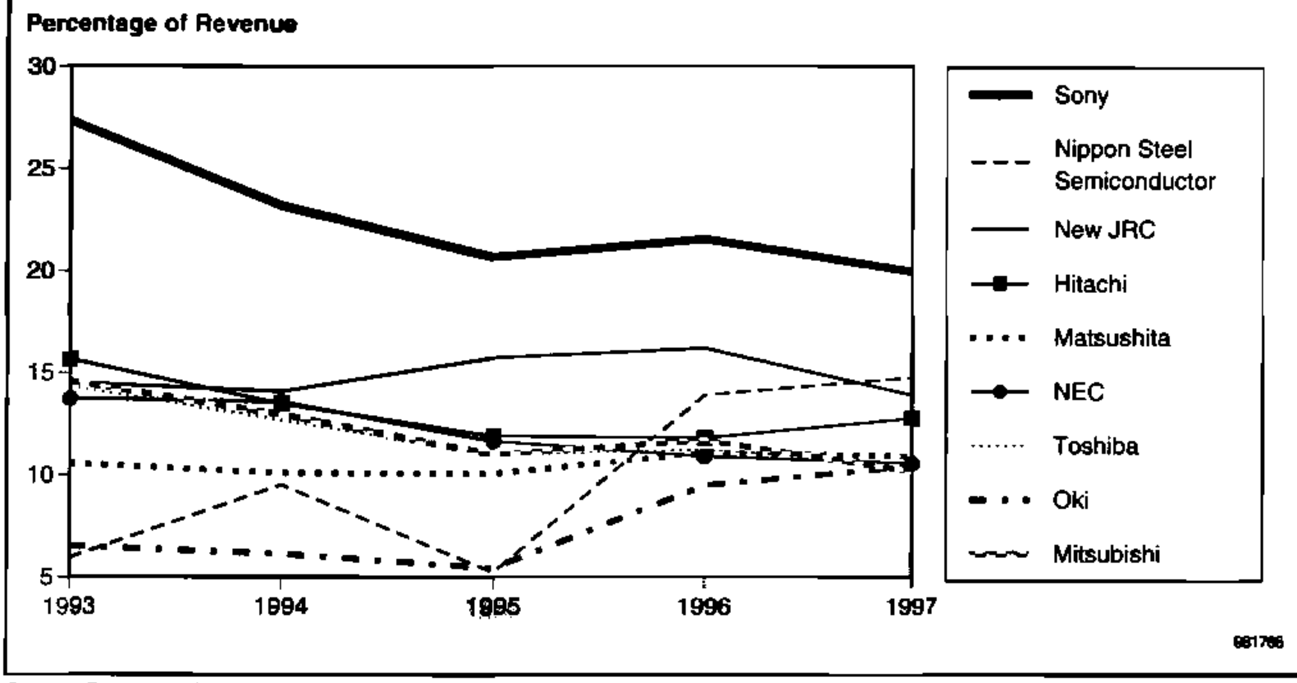


Source: Dataquest (March 1998)

This does not necessarily mean they will reduce their total spending or the ratio against revenue. But the increasing need for a strict business focus will drive those top companies to turn more to outside resources. Hitachi is an example. It is characterized by the large amount of DRAM needed from LG Semicon, as well as from joint ventures with other companies such as TI (TwinStar) and Nippon Steel Semiconductor (Hitachi/Nippon Steel Semiconductor Singapore). DRAMs produced at LG Semicon fabs to be supplied to Hitachi are generally made with Hitachi masks, and TwinStar uses a different mask set, based on codeveloped technologies. Hitachi uses yet another set of masks at its own proprietary fabs. This arrangement has enabled Hitachi to diversify risks, as well as making it easier for partners to participate in Hitachi's production scheme. This arrangement, of course, is not a complete solution and has its drawbacks in technology management, but the eventual result of this attempt will be of interest in the industry.

NEC, however, is going solo in manufacturing while participating in various technology and product alliances. Toshiba has sought alliance and foundry opportunities rather boldly among top Japanese companies. Its collaboration with Motorola on overall semiconductor operation and its codevelopment of DRAMs with Siemens and IBM have both brought about joint ventures—Tohoku Semiconductor and Dominion Semiconductor. Fujitsu followed, with Fujitsu-AMD Semiconductor Ltd. (FASL), as did Mitsubishi with Powerchip Semiconductor. Powerchip is actually a new form of joint venture in that it involves a semiconductor user company as well as financial circles, while other joint ventures have characteristically been between or among semiconductor companies.

Figure 3-7
Japanese Top-Tier Companies' R&D Spending

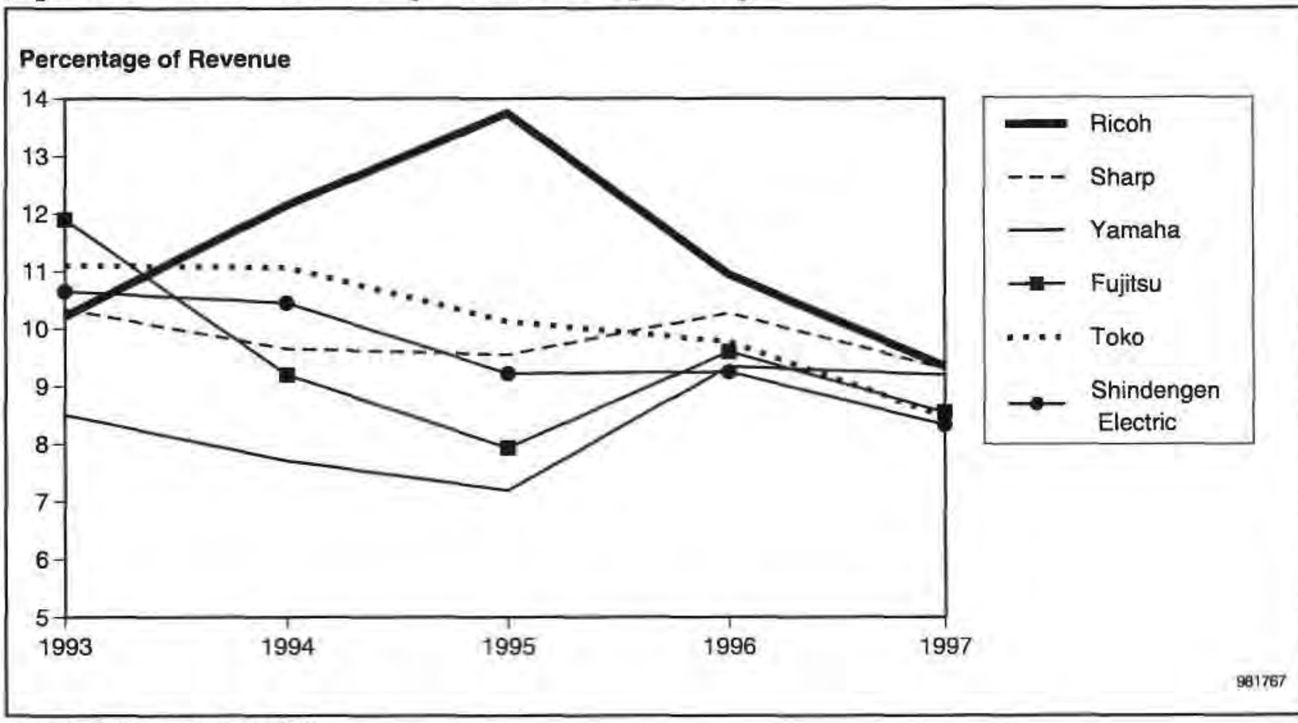


Source: Dataquest (March 1998)

Middle-tier companies spend around 10 percent of revenue (see Figure 3-8), and the amount varies over time, depending mainly on revenue fluctuations. Those are the companies still dependent on internal demands, and similar trends can be seen in technology. These companies tend to have smaller application engineering groups, indicating that their system technology advisers lie in their user divisions, in-house.

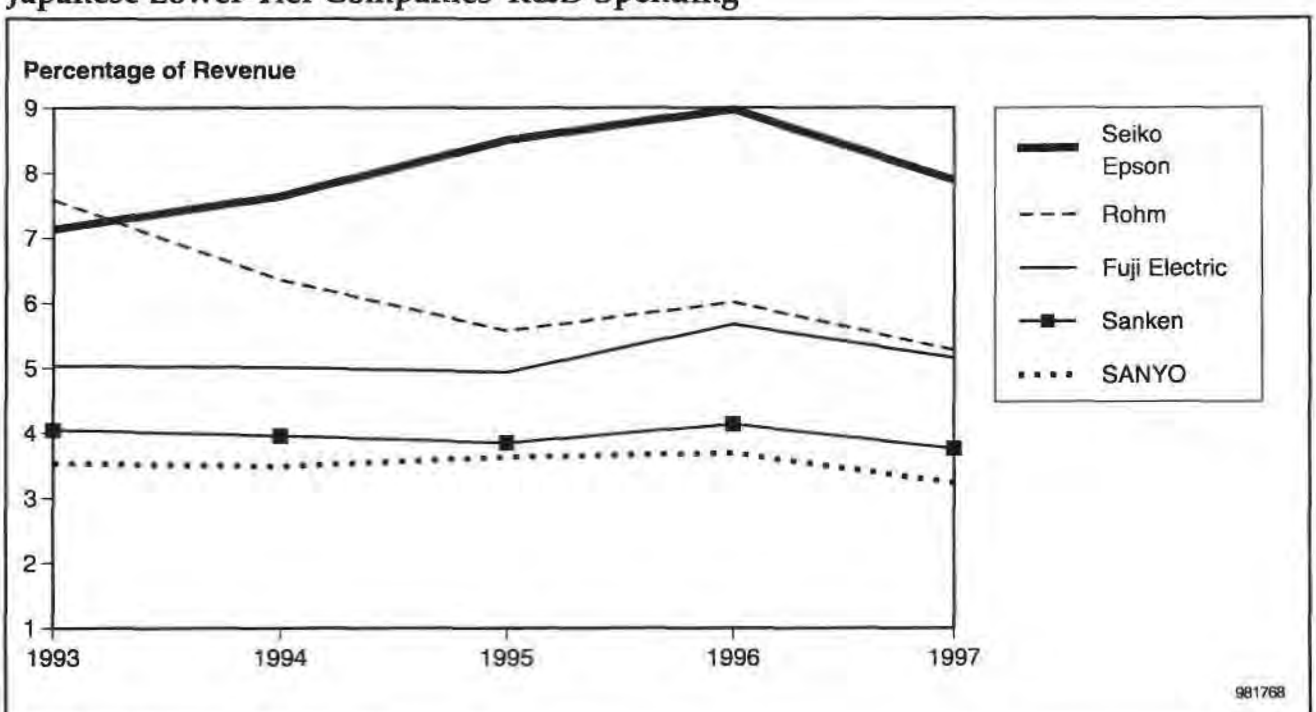
Companies at the lower end of the list spend between 5 and 10 percent of their revenue (see Figure 3-9). They do not burden themselves with R&D expenditure and instead turn to outside resources, such as alliances. Their alliances tend to focus on specific technology and product areas that they have identified as their "battlefield," and they do not attempt to widen their coverage overnight. The spirit of kaizen, the Japanese term for gradual improvement, persists here. The companies in this group also leverage foundry opportunities, by either starting technology partnerships that include "production cooperation," a euphemism for foundry, or starting foundry businesses with additional (but usually not disclosed) contracts on technology transfer.

Figure 3-8
Japanese Middle-Tier Companies' R&D Spending



Source: Dataquest (March 1998)

Figure 3-9
Japanese Lower-Tier Companies' R&D Spending



Source: Dataquest (March 1998)

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Chapter 4
The Future of Japanese Semiconductor Companies

The analysis in Chapters 2 and 3 has illustrated the difficult environment as well as the difficulty in positioning faced by Japanese semiconductor companies. In the coming five years, there will be opportunities and threats for Japanese semiconductor companies. The threats can be summarized as follows:

- Demand side
  - Lack of proprietary system technology
  - Faster advances of system technology at non-Japanese systems companies
  - Diversification of regional demand
  - Sluggish outlook for domestic application equipment production
- Supply side
  - Growth of foreign competitors in the DRAM market
  - Growth of dedicated foundry providers
  - Growth of non-Japanese equipment manufacturers
  - Rising prices for manufacturing equipment
  - 300mm wafer production lead by non-Japanese companies
  - Non-Japanese ASIC companies
  - Expansion in cell-based ICs, an area in which Japanese companies have lagged behind

The opportunities that Japanese companies could enjoy can be summarized as follows:

- Demand side
  - Japanese systems companies flourishing in digital consumer equipment production
  - Expansion in communications applications, including networking
- Supply side
  - 300mm wafer production
  - Having strong manufacturing equipment and wafer companies within Japan
  - Facing, and in some cases actually making, fundamental changes as the profitability of the semiconductor business remains low for major product areas

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On the demand side, the realization that the domestic market cannot drive Japanese semiconductor companies' growth is leading to a careful but determined approach toward foreign markets. Globalization has long been a cliché in the Japanese semiconductor industry. There have been efforts made in various aspects of the semiconductor business ranging from sales offices, technical support and design centers, back-end production, and wafer fab operation targeted at capturing local demand efficiently, but these were made mostly after demand prevailed. The globalization that is now required calls for a more aggressive approach toward non-Japanese systems companies, for those are the users that bring faster growth to vendors.

On the supply side, the time has come to give up the conventional Japan model of capital spending and fab utilization. In view of the rapid rise of both manufacturing capital spending and R&D spending requirements, Japanese companies have to seek ways to incorporate outsourcing in their long-term strategies, as opposed to seeking short-term helping hands in partnership. A potential shortage of engineers is also looming globally, especially in Japan, with the size of its younger population decreasing. This also increases the need for strategic alliances and global business operations to make better use of resources outside Japan. And the advent of system-level integration will require a wide range of intellectual property resources that no Japanese company is ready to provide alone. Only through alliances among semiconductor companies and through close ties with semiconductor users in various applications systems can this resource be realized.

These key factors, both on the demand and supply sides, call for organizational changes. Up to this point, Japanese companies have basically run the semiconductor business with product-oriented organizations. A few companies, such as NEC and Toshiba, are developing either virtual or actual organizations that are system- or application-oriented but most companies still follow a manufacturing-oriented organizational model with some application flavor, such as application engineering groups.

A company may have a strong, product-oriented "vertical" organization while struggling to nurture application marketing functions for "horizontal" operation. Those that have been dependent on internal user divisions may not have been burdened with big application engineering groups, but they have faced the challenge of outside system technology. As foreign markets grow faster and emerging system technologies are developed by non-Japanese users, Japanese companies have no choice but to expand overseas operations in all aspects, supported by application-oriented organizations at their headquarters.

Sales integration is also in progress. Japanese companies have had huge sales organizations, either in the form of direct sales or distributors. On one hand, the size of the salesforce not only helped in finding business opportunities, but also allowed the "mother ship" company to gather market information through the sales channel. But the slow growth of the domestic market has made a huge salesforce too burdensome in some cases, and some level of rationalization has been inevitable. One such attempt was to move direct accounts to a big sales agency and relocate the salesforce along with the accounts. Another form was to integrate distributors in the corporate groups to form a bigger entity, in expectation of improved efficiency.

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Whether these "rationalization" processes will improve efficiency has yet to be seen, but they have been viewed as inevitable. And whether Japan can revive both as a regional market and as a supplier depends primarily on the overall development of electronics technology in Japan.

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Appendix A
Japanese Semiconductor Company Profiles

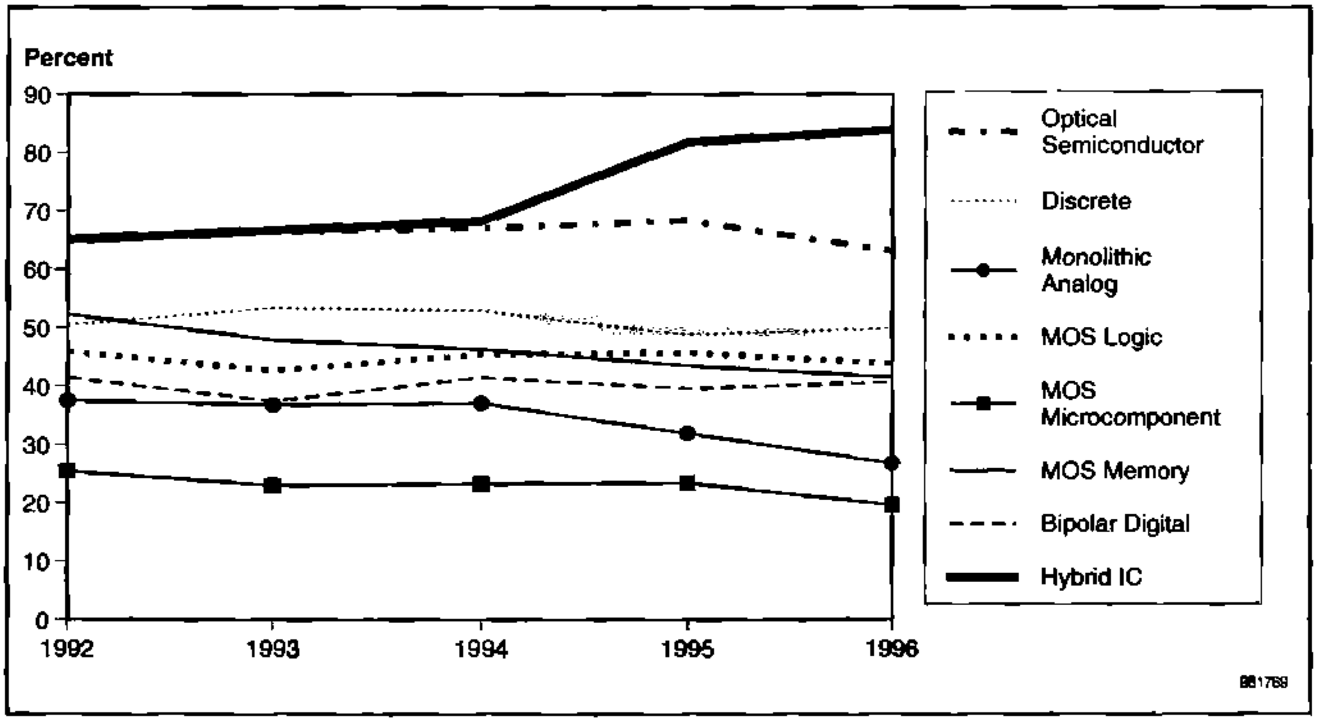
Basic information such as revenue and capital spending has been covered by a Competitive Trends document in the Semiconductors Worldwide program for the top 20 companies in the 1996 worldwide ranking (Competitive Markets in Semiconductors, 1996, SEMI-WW-CT-9701. December 1997). In this appendix, the basic information for all 20 Japanese companies is illustrated (see Tables A-1 through A-21 and Figures A-1 through A-105).

Table A-1
Revenue of Top 20 Japanese Companies by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	869	988	1,136	1,354	1,232
Bipolar Digital	1,324	1,158	1,207	972	752
MOS Memory	8,008	11,161	15,498	24,039	15,682
MOS Microcomponent	3,649	4,585	6,137	8,083	8,108
MOS Logic	4,610	5,679	7,312	9,413	9,450
Monolithic Analog	3,819	4,543	5,657	5,623	5,160
Discrete	4,118	4,861	5,692	6,987	6,732
Optical Semiconductor	1,747	1,998	2,608	3,289	3,101

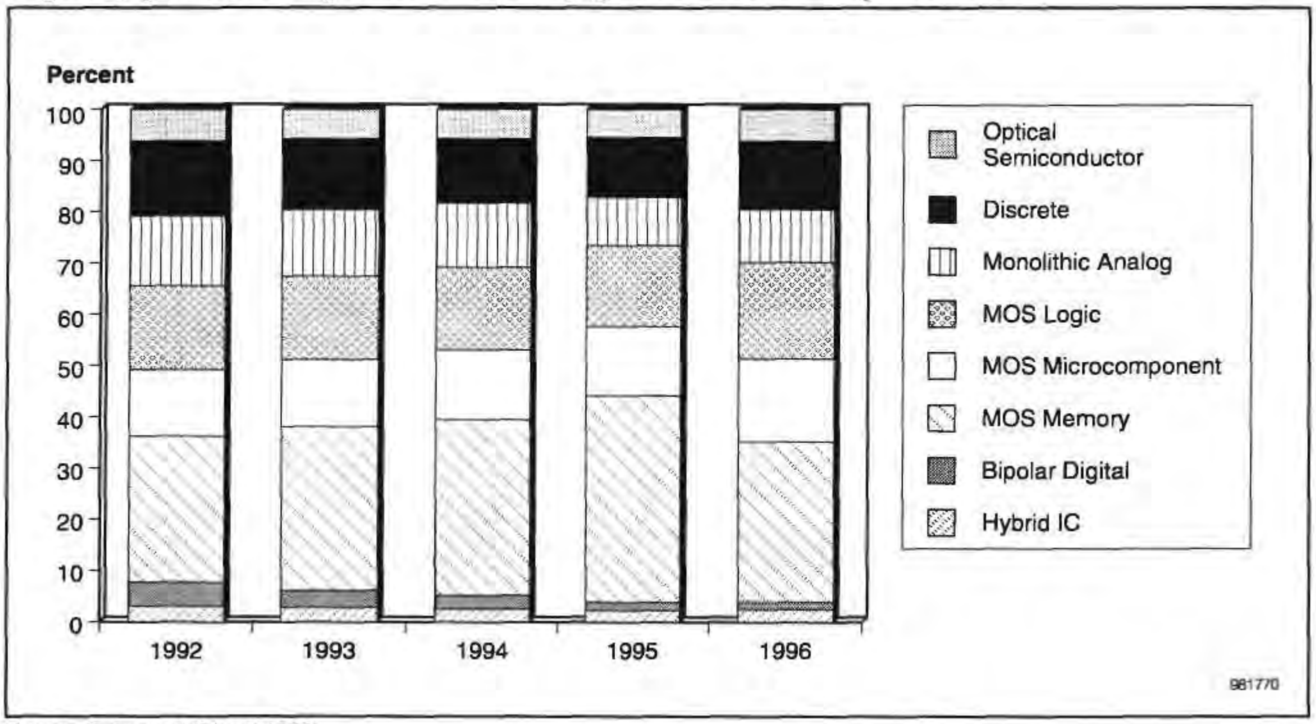
Source: Dataquest (March 1998)

Figure A-1
Top 20 Japanese Companies' Share of Worldwide Revenue by Product, 1992 to 1996



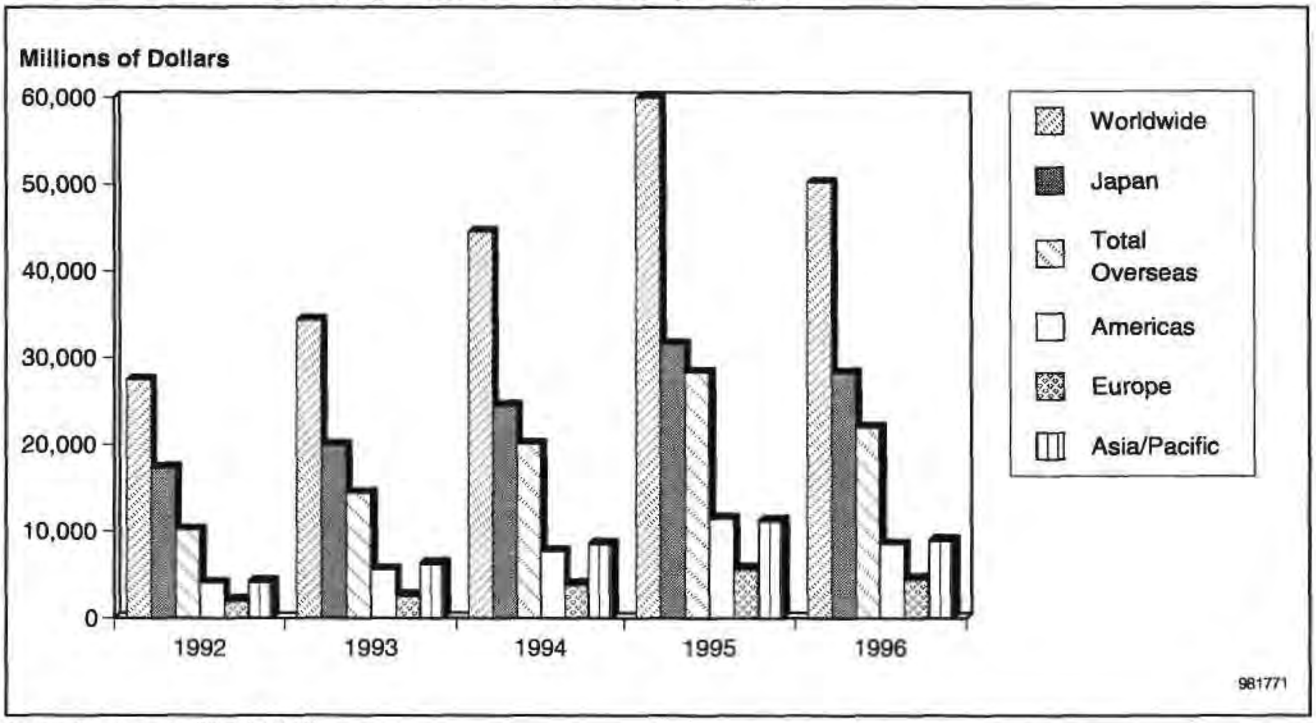
Source: Dataquest (March 1998)

Figure A-2
Top 20 Japanese Companies' Share of Japanese Revenue by Product



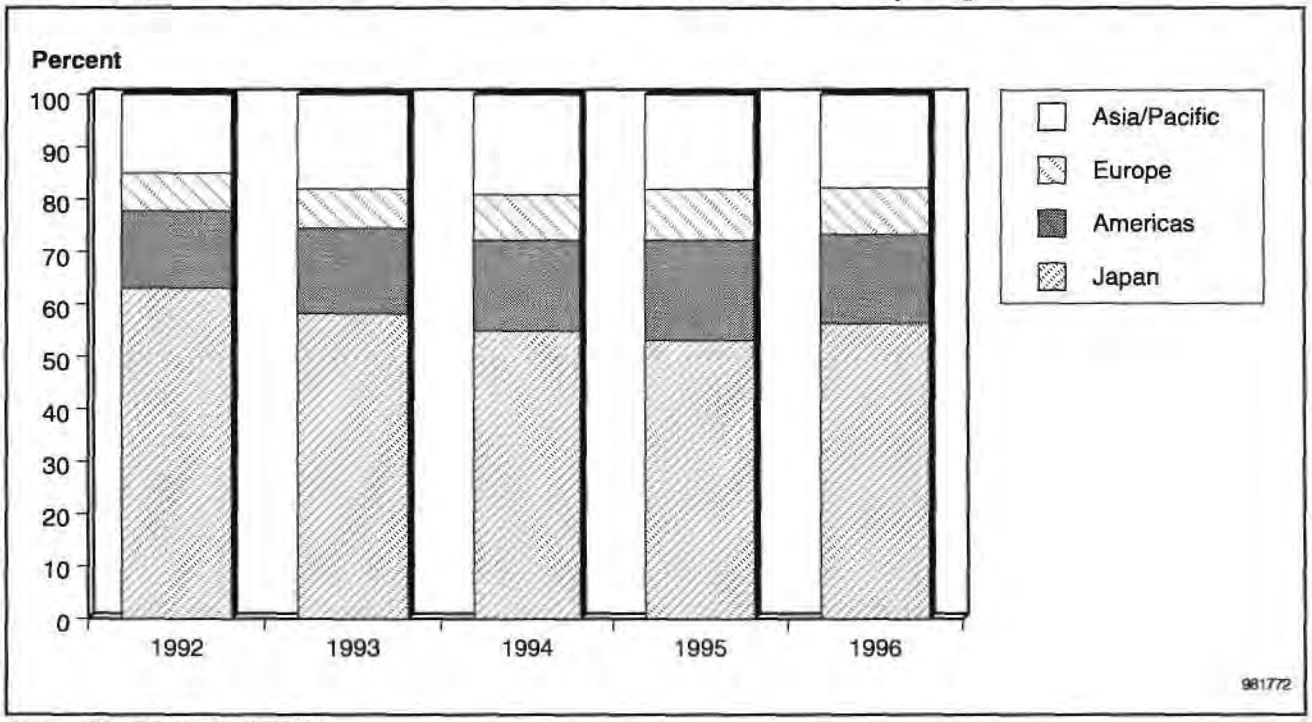
Source: Dataquest (March 1998)

Figure A-3
Revenue of the Top 20 Japanese Companies by Region



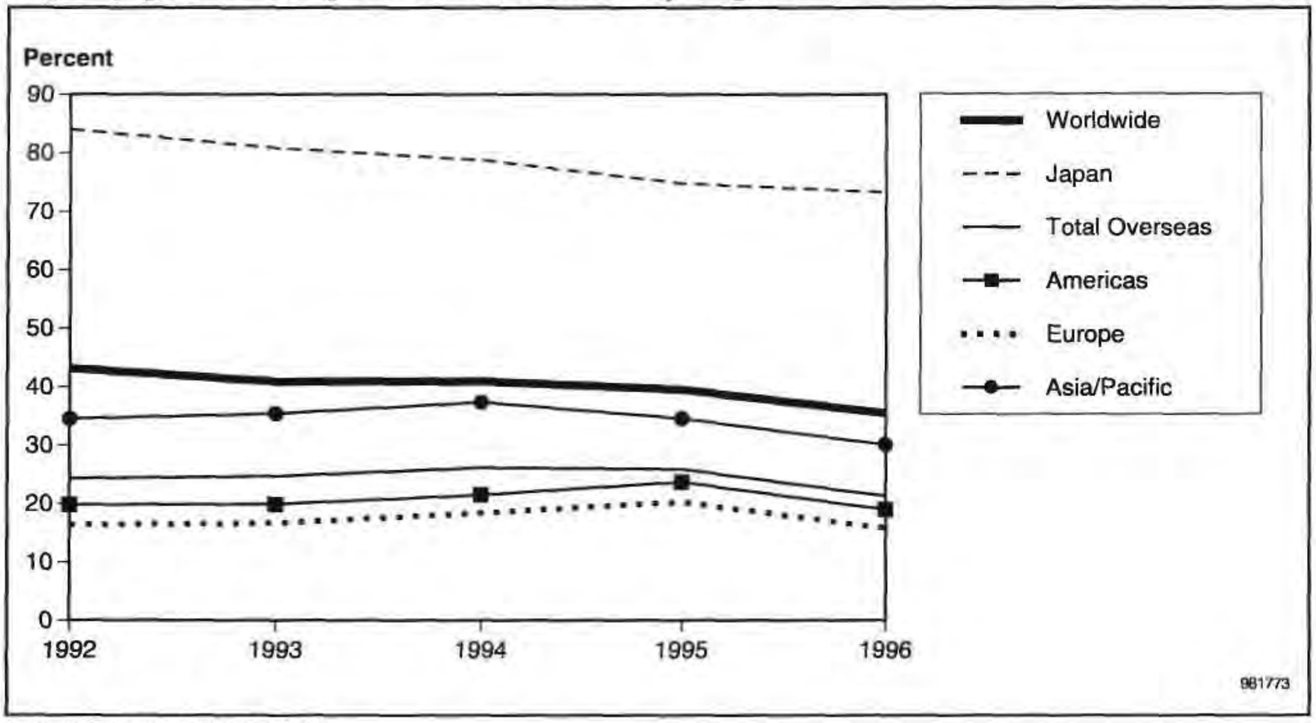
Source: Dataquest (March 1998)

Figure A-4
Top 20 Japanese Companies' Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-5
Top 20 Japanese Companies' Market Share by Region



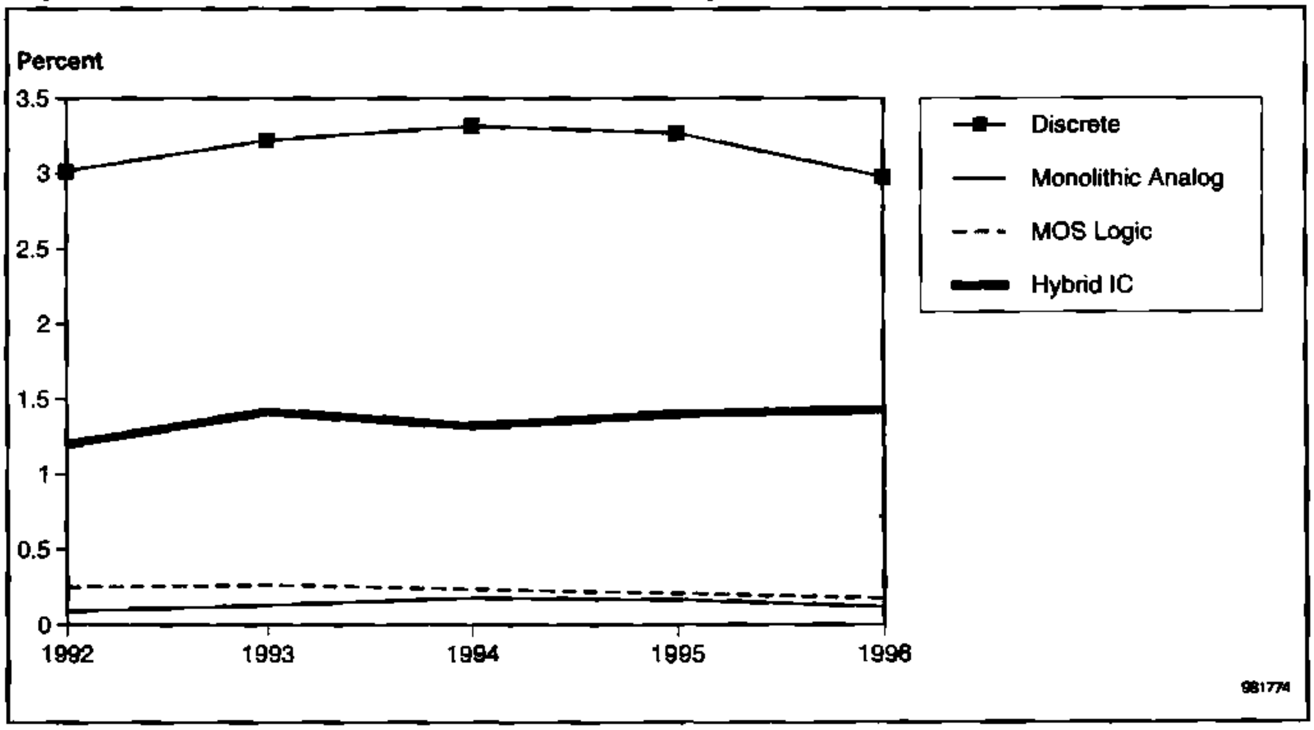
Source: Dataquest (March 1998)

Table A-2
Revenue of Fuji Electric by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	16	21	22	23	21
Bipolar Digital	0	0	0	0	0
MOS Memory	0	0	0	0	0
MOS Microcomponent	1	1	2	3	3
MOS Logic	25	35	38	43	38
Monolithic Analog	9	16	27	29	23
Discrete	246	293	357	468	401
Optical Semiconductor	0	0	0	0	0

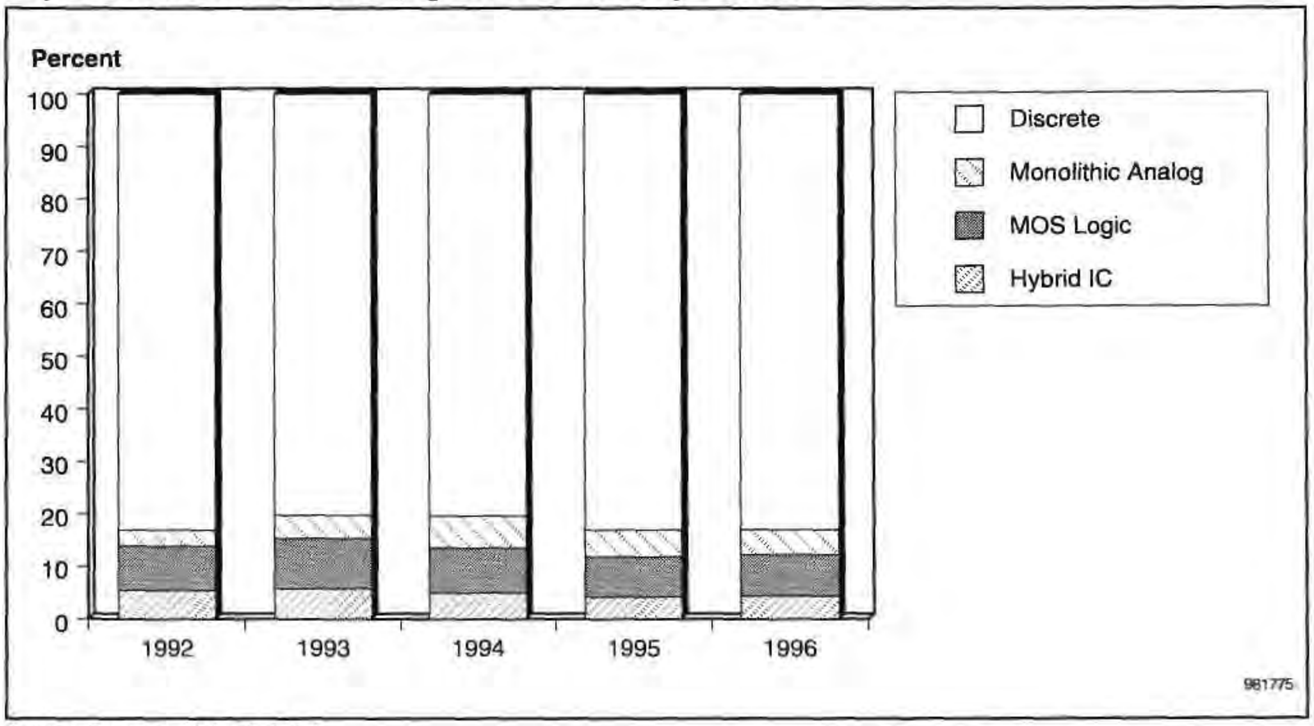
Source: Dataquest (March 1998)

Figure A-6
Fuji Electric's Share of the Worldwide Market by Product, 1992 to 1996



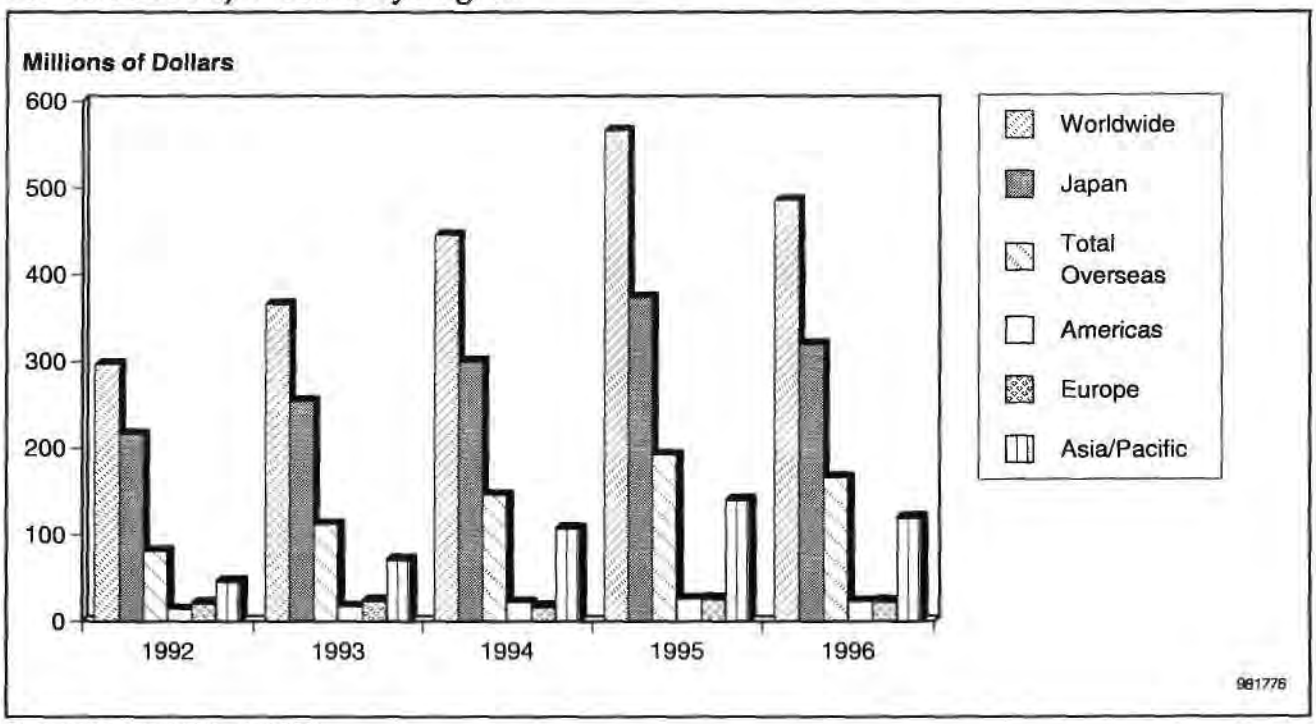
Source: Dataquest (March 1998)

Figure A-7
Fuji Electric's Share of the Japanese Market by Product



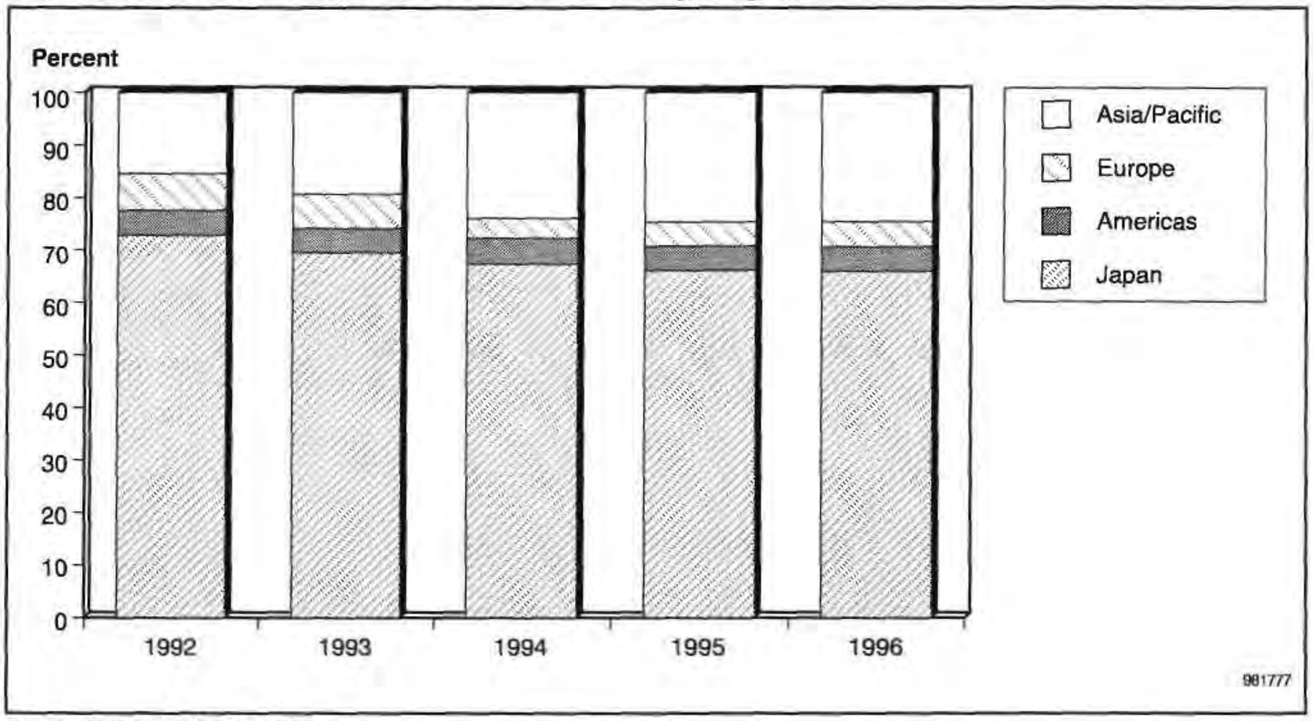
Source: Dataquest (March 1998)

Figure A-8
Revenue of Fuji Electric by Region



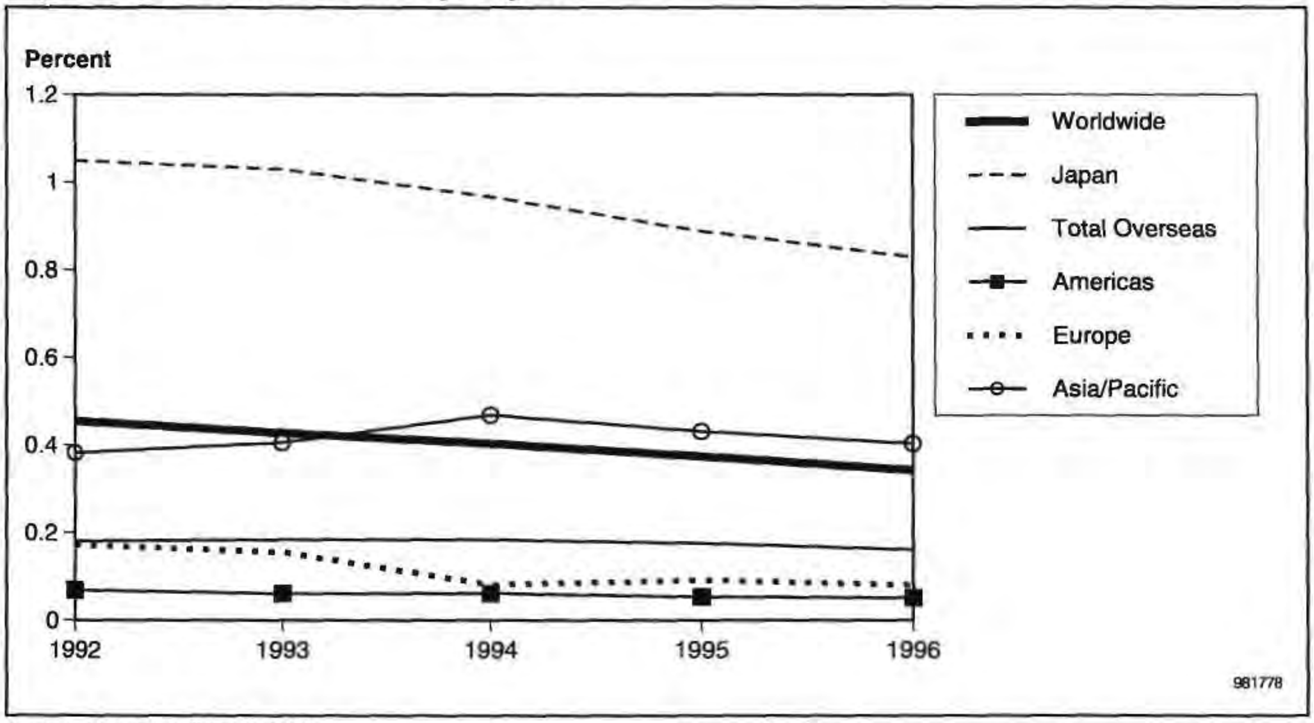
Source: Dataquest (March 1998)

Figure A-9
Fuji Electric's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-10
Fuji Electric's Market Share by Region



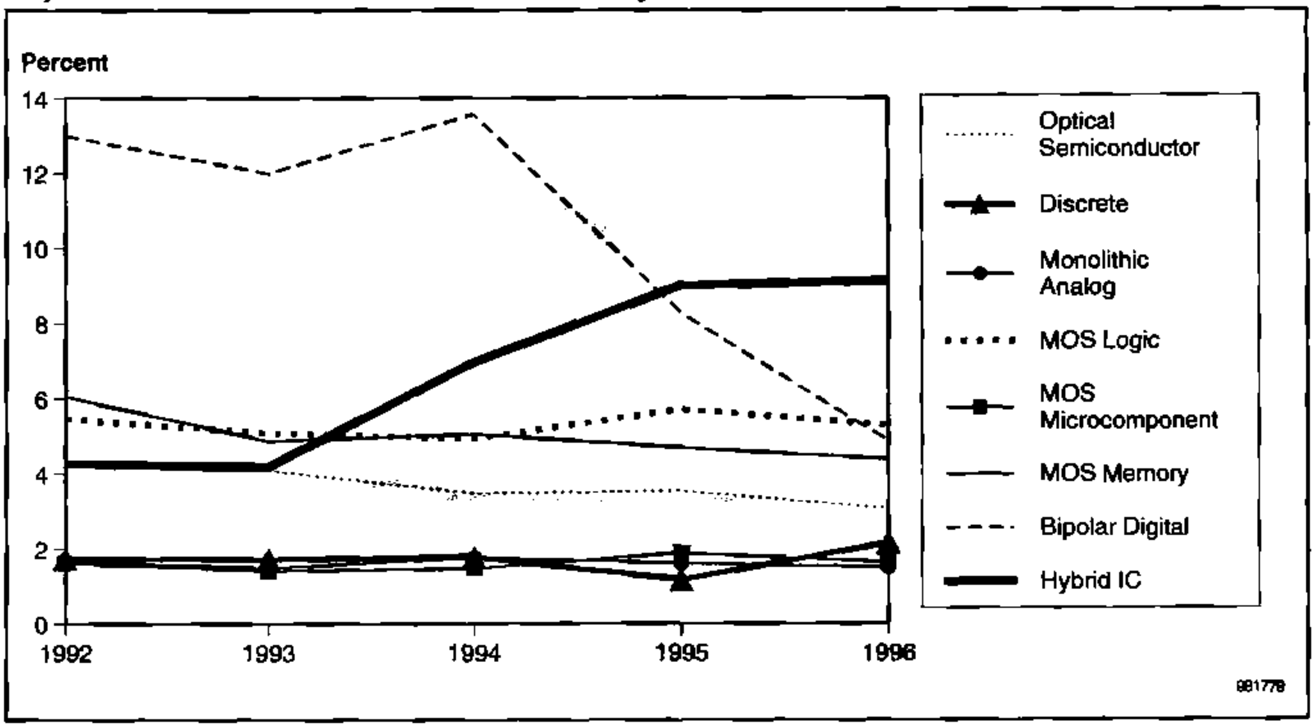
Source: Dataquest (March 1998)

Table A-3
Revenue of Fujitsu by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	57	62	116	149	134
Bipolar Digital	415	371	395	203	90
MOS Memory	927	1,135	1,692	2,589	1,656
MOS Microcomponent	233	282	390	650	677
MOS Logic	549	676	794	1,178	1,138
Monolithic Analog	118	122	155	428	291
Discrete	142	157	192	168	290
Optical Semiconductor	112	123	135	170	151

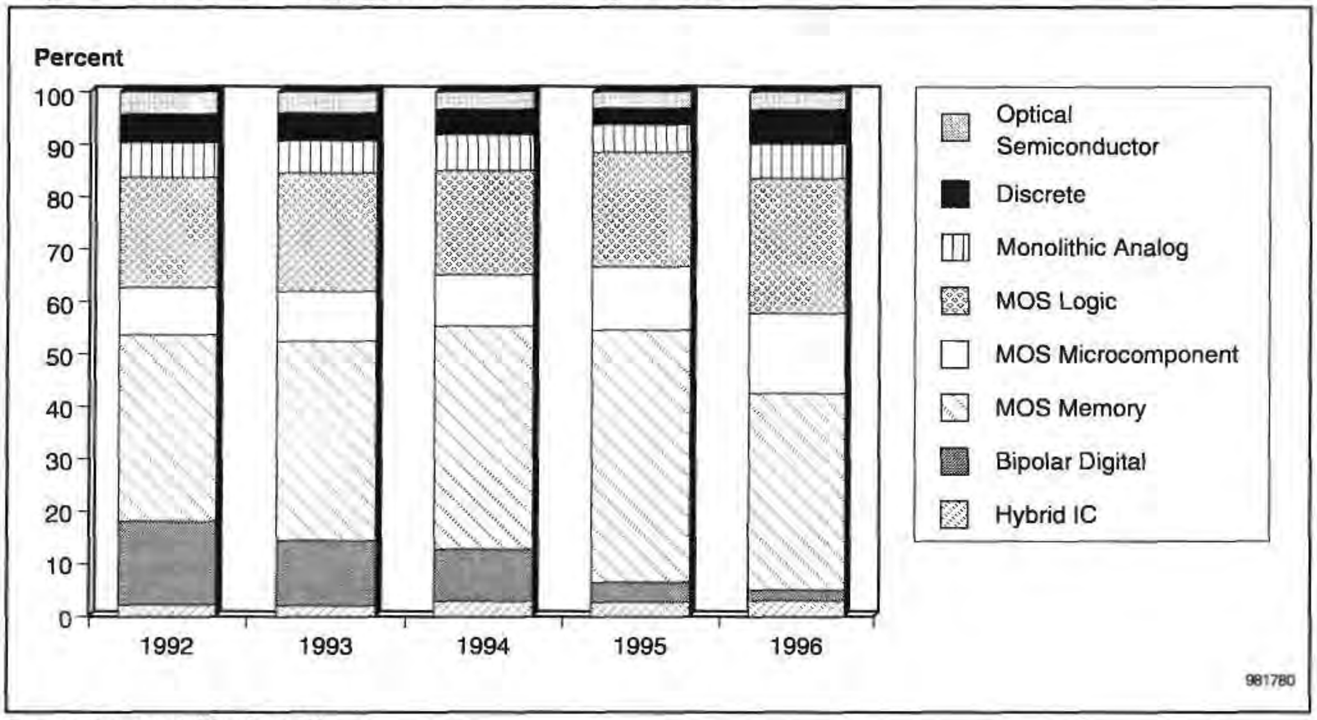
Source: Dataquest (March 1998)

Figure A-11
Fujitsu's Share of the Worldwide Market by Product, 1992 to 1996



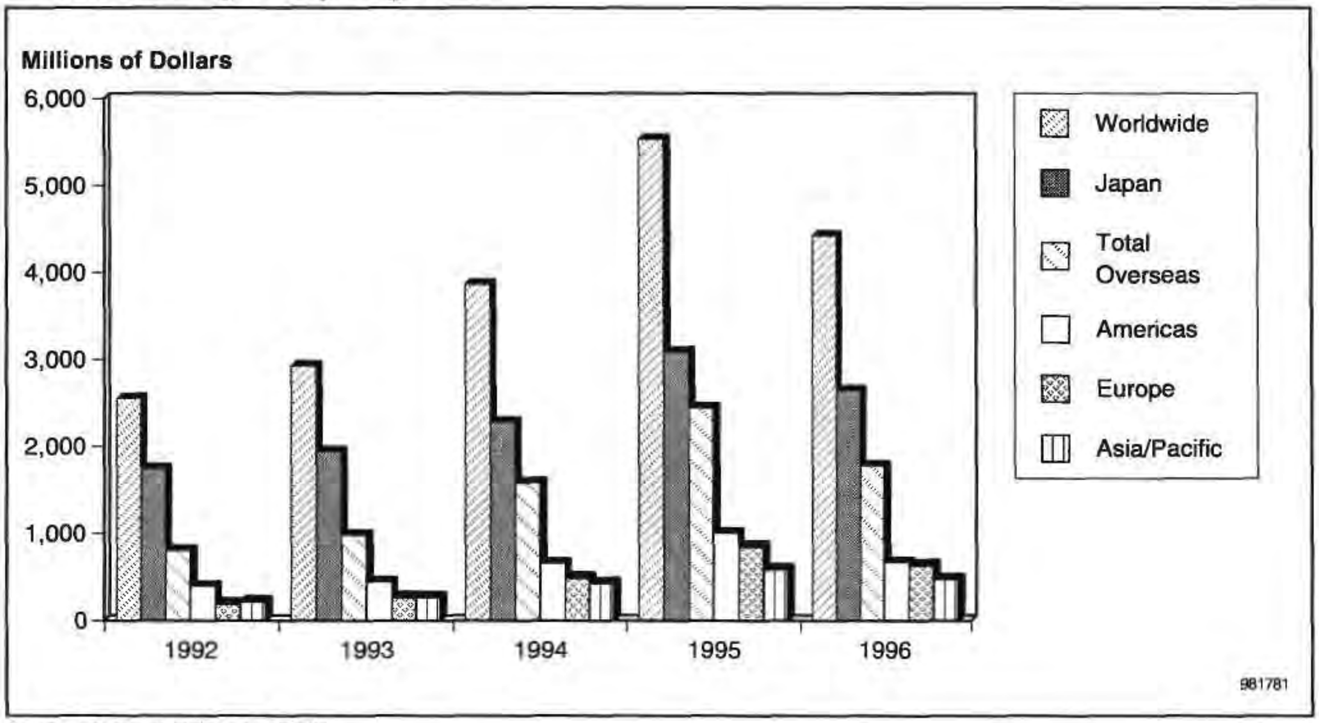
Source: Dataquest (March 1998)

Figure A-12
Fujitsu's Share of the Japanese Market by Product



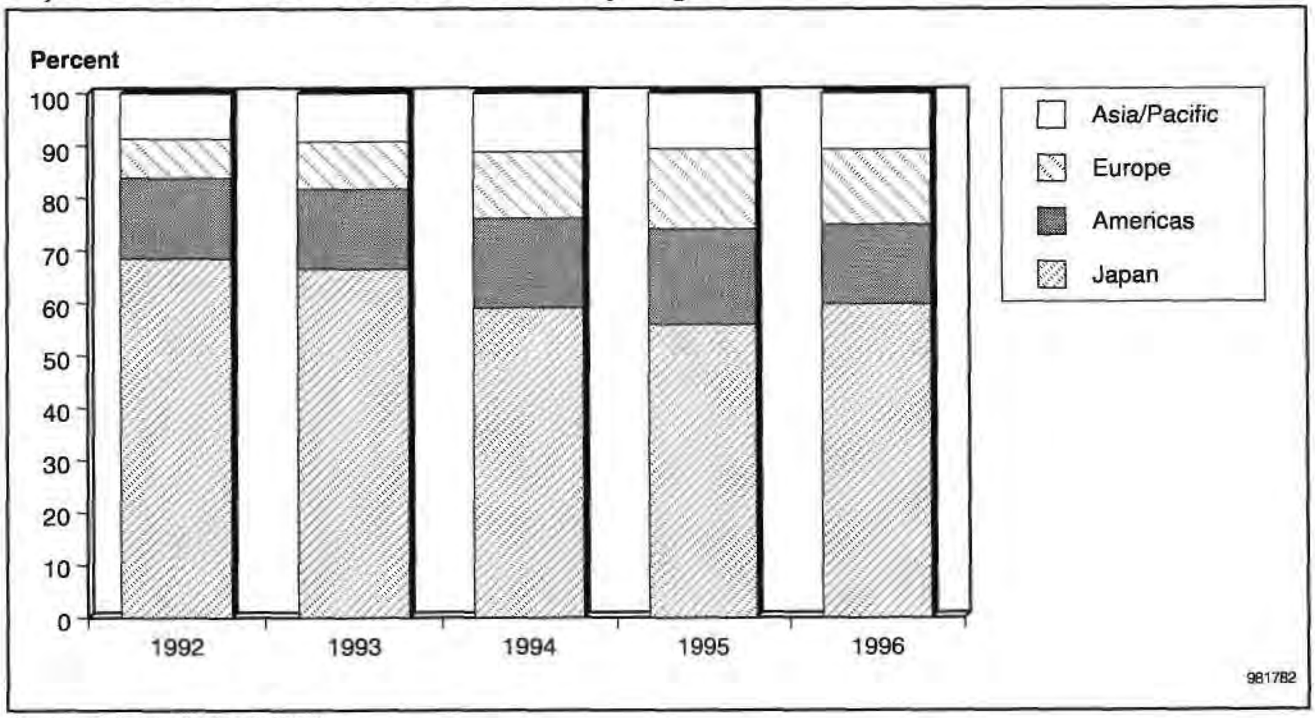
Source: Dataquest (March 1998)

Figure A-13
Revenue of Fujitsu by Region



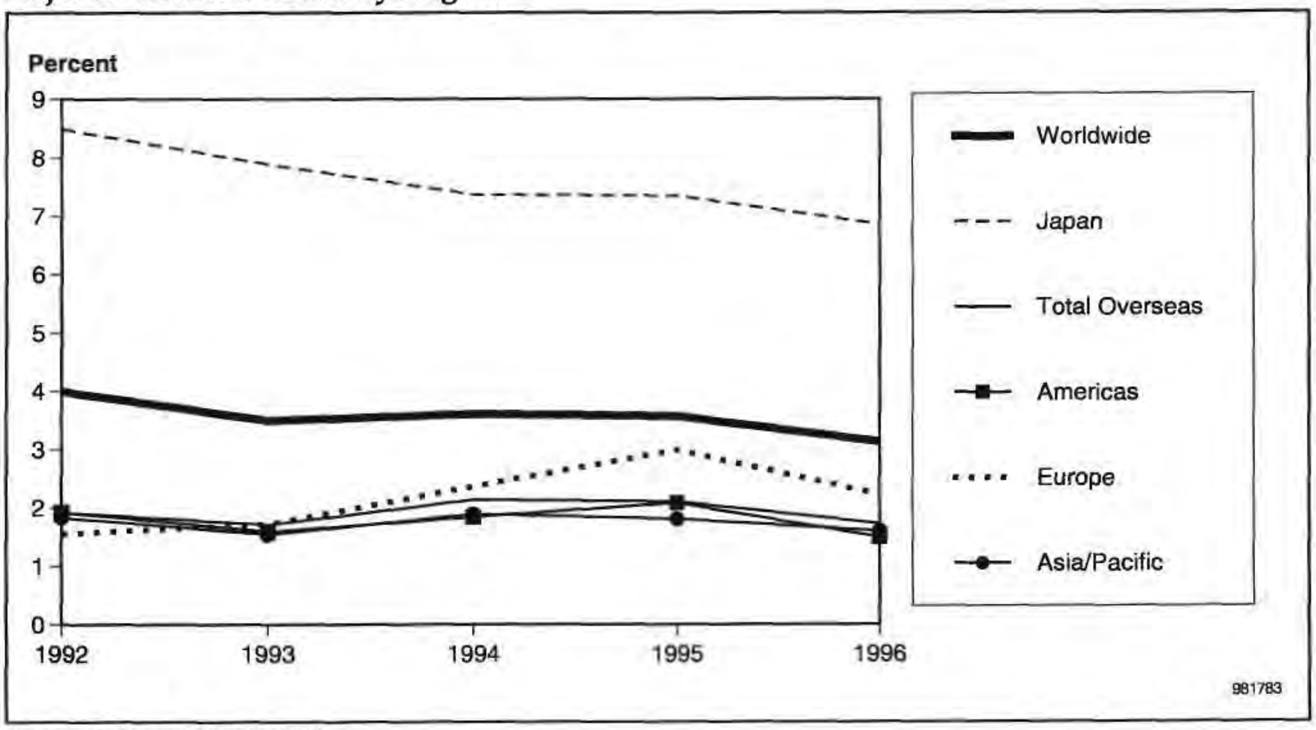
Source: Dataquest (March 1998)

Figure A-14
Fujitsu's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-15
Fujitsu's Market Share by Region



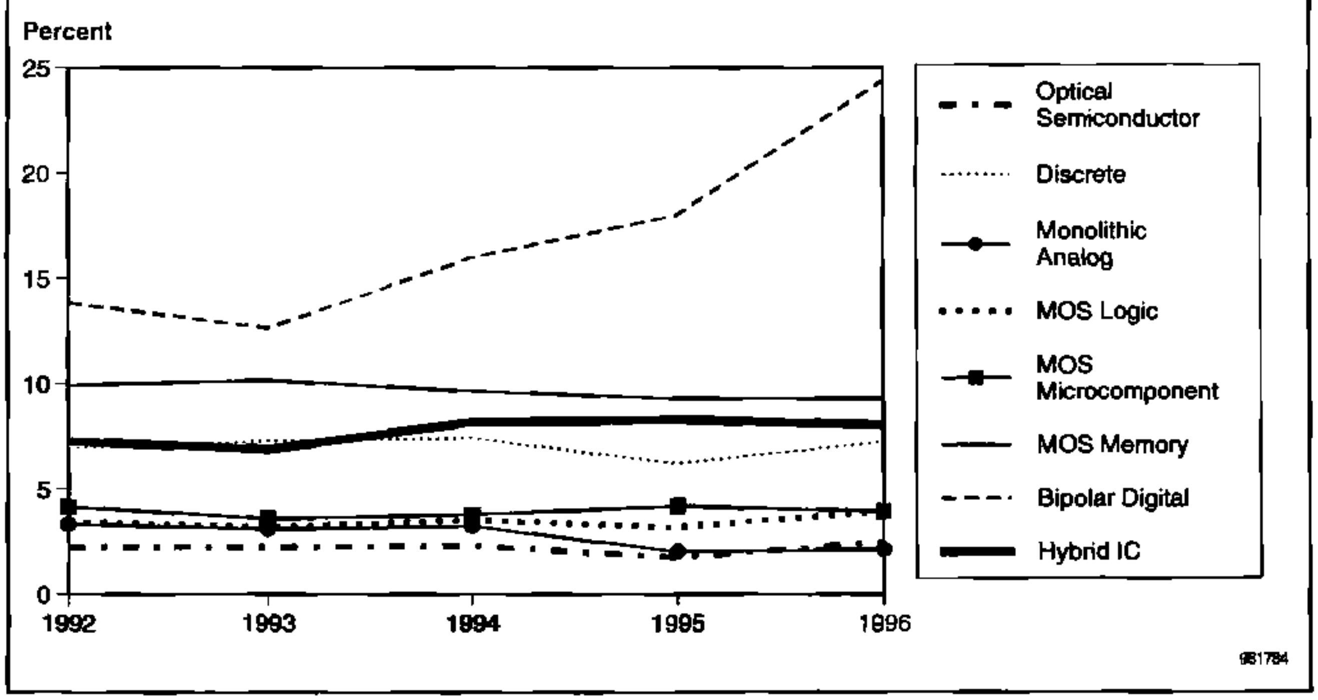
Source: Dataquest (March 1998)

Table A-4
Revenue of Hitachi by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	97	102	136	137	118
Bipolar Digital	442	391	465	442	451
MOS Memory	1,519	2,369	3,232	5,132	3,514
MOS Microcomponent	596	718	998	1,441	1,629
MOS Logic	346	426	569	655	852
Monolithic Analog	225	280	357	355	409
Discrete	566	662	798	889	977
Optical Semiconductor	60	67	89	84	121

Source: Dataquest (March 1998)

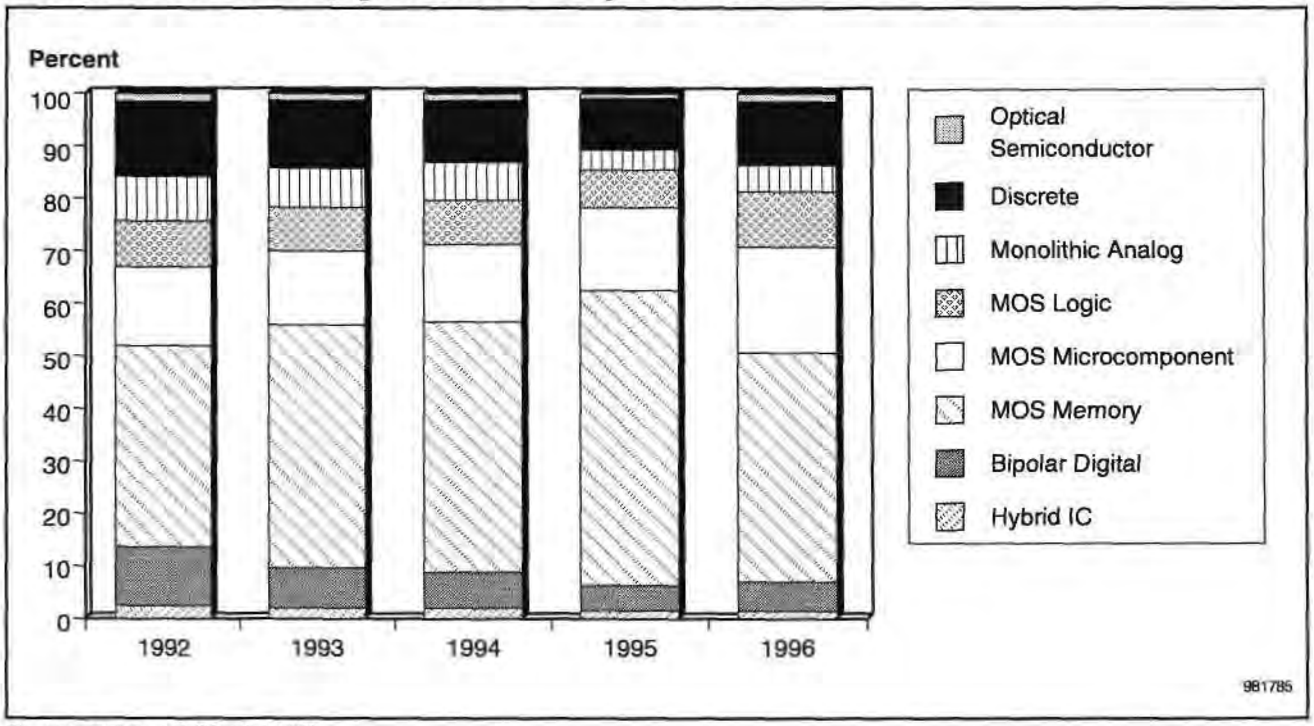
Figure A-16
Hitachi's Share of the Worldwide Market by Product, 1992 to 1996



Source: Dataquest (March 1998)

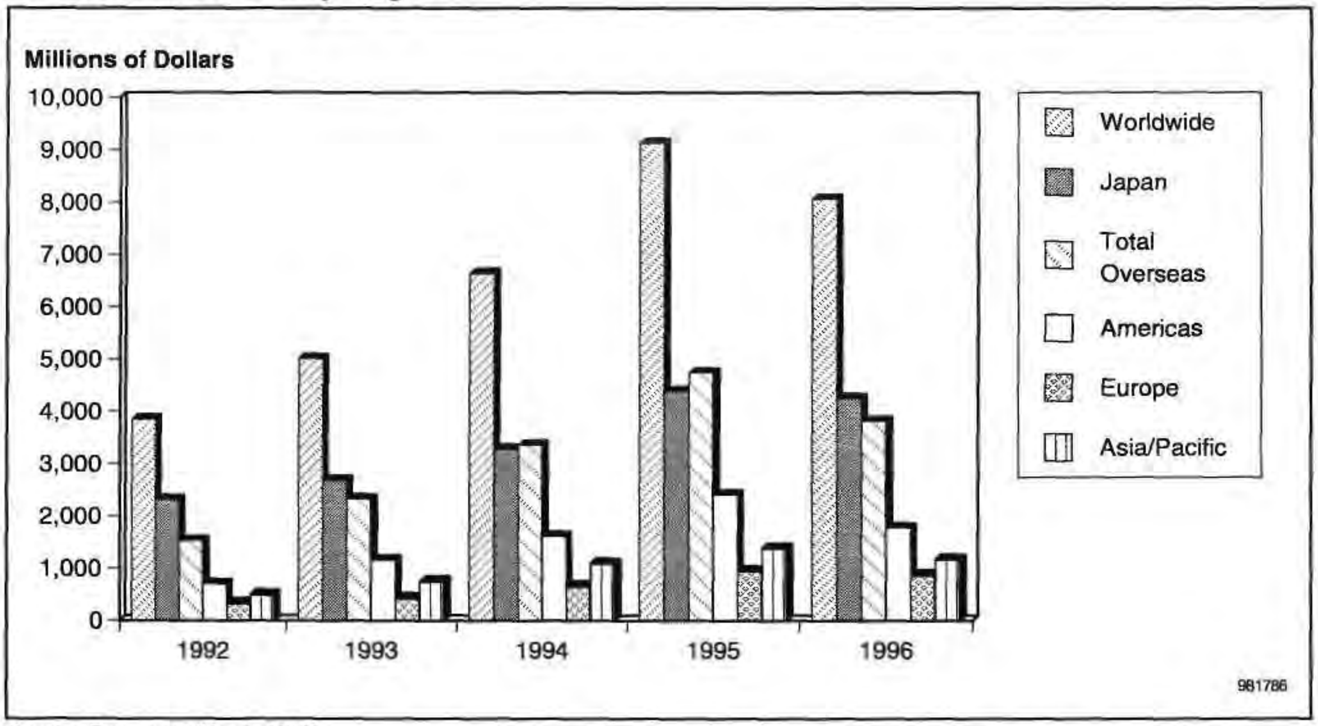
 ©1998 Dataquest

Figure A-17
Hitachi's Share of the Japanese Market by Product



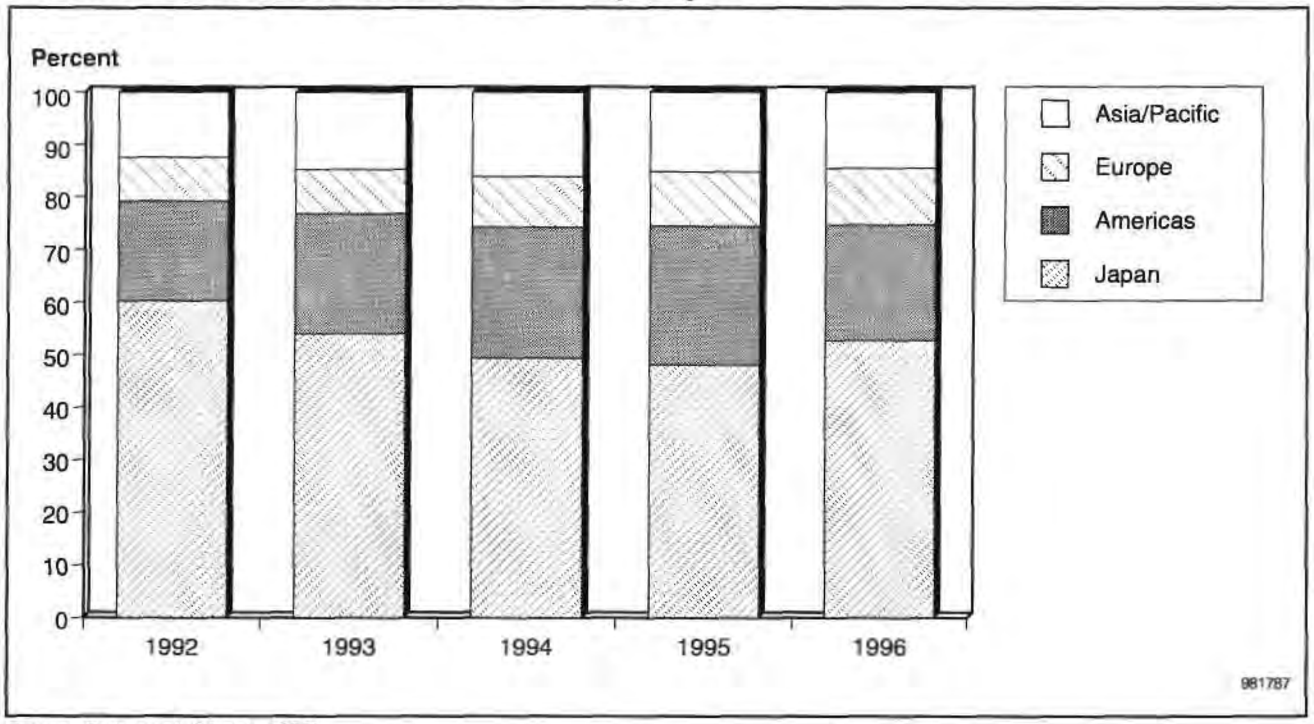
Source: Dataquest (March 1998)

Figure A-18
Revenue of Hitachi by Region



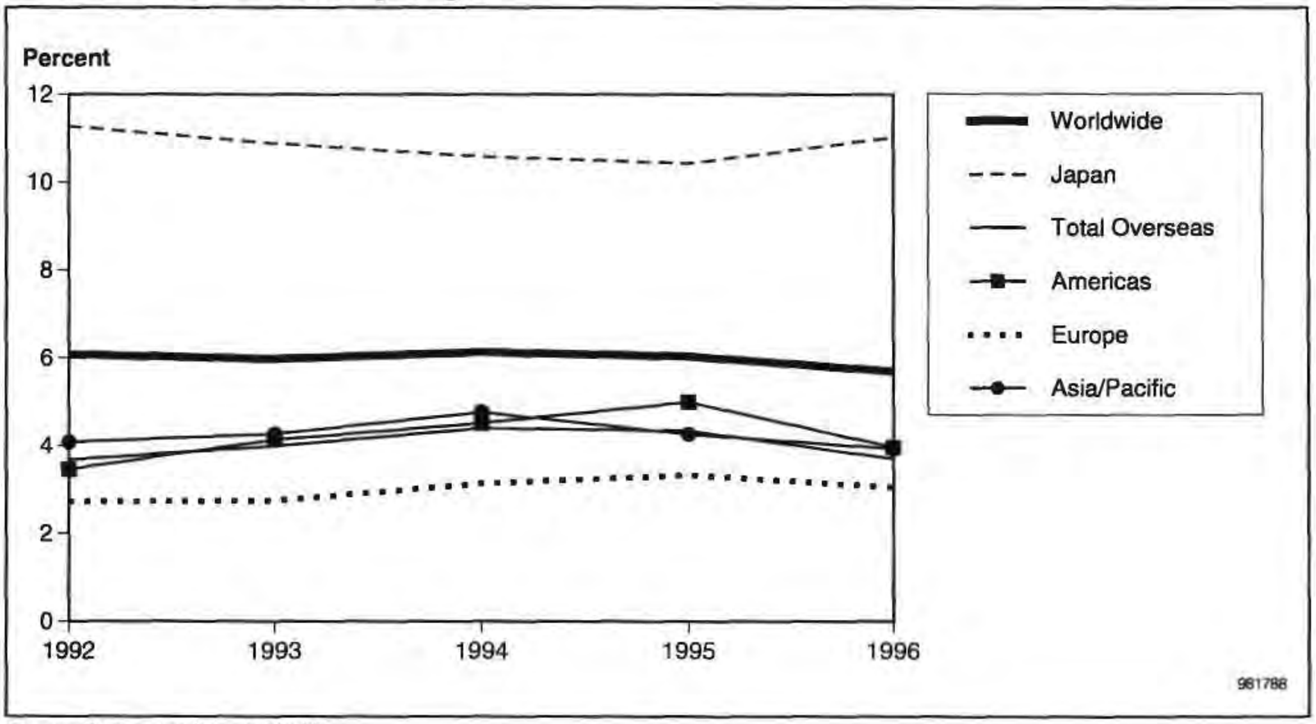
Source: Dataquest (March 1998)

Figure A-19
Hitachi's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-20
Hitachi's Market Share by Region



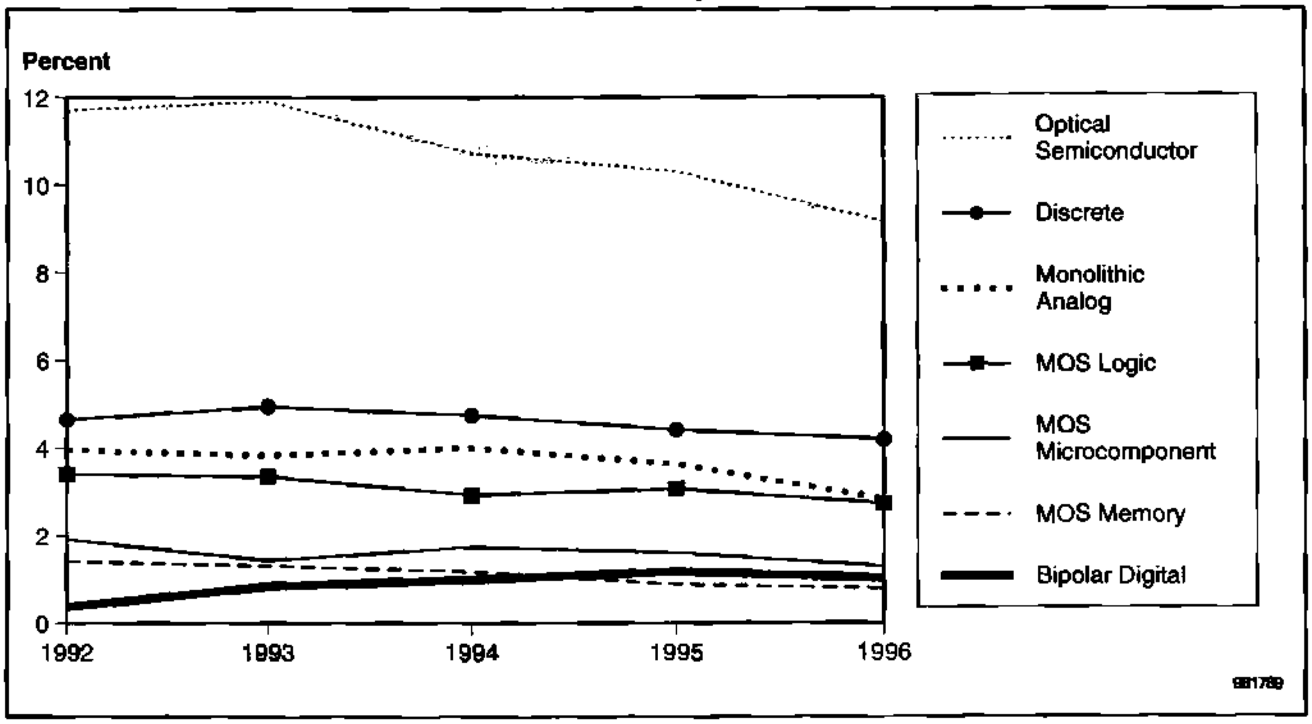
Source: Dataquest (March 1998)

Table A-5
Revenue of Matsushita by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	0	0	0	0	0
Bipolar Digital	12	26	29	29	19
MOS Memory	217	305	396	492	300
MOS Microcomponent	275	286	460	555	534
MOS Logic	342	446	472	632	588
Monolithic Analog	402	473	611	639	547
Discrete	379	450	511	631	565
Optical Semiconductor	315	358	417	496	450

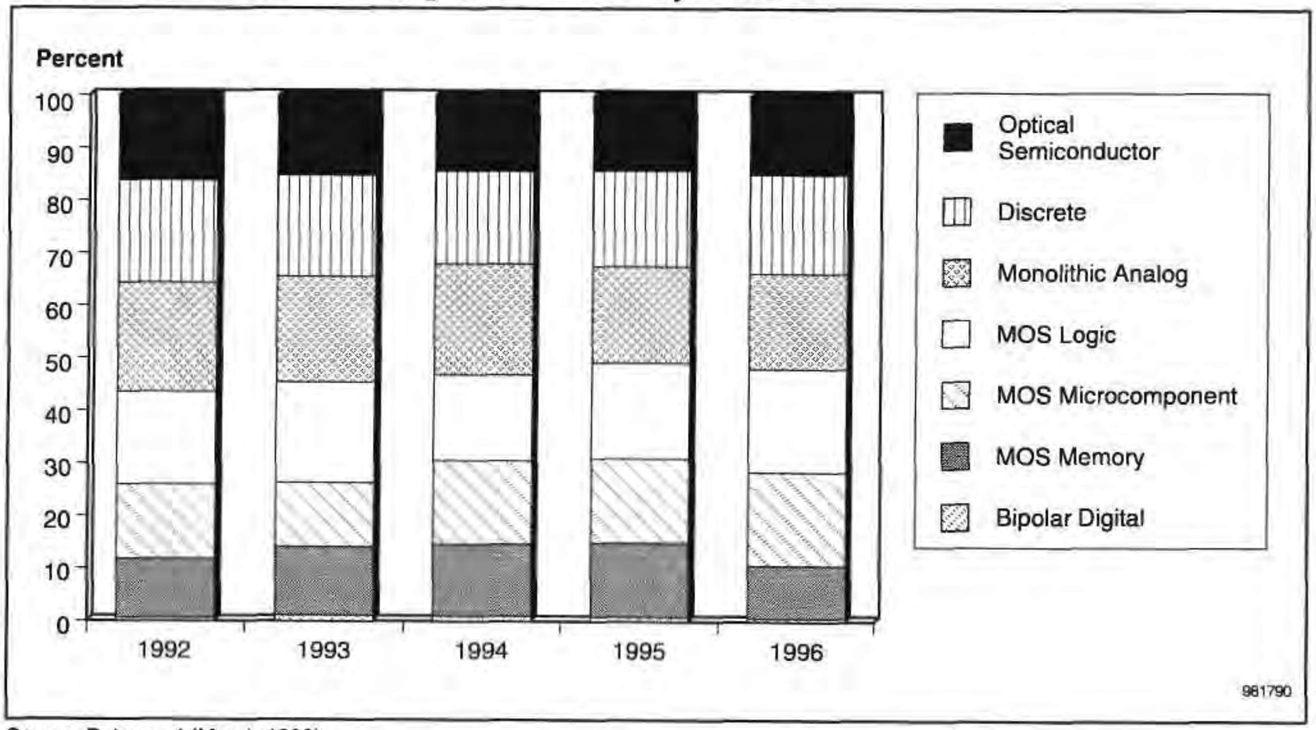
Source: Dataquest (March 1998)

Figure A-21
Matsushita's Share of the Worldwide Market by Product, 1992 to 1996



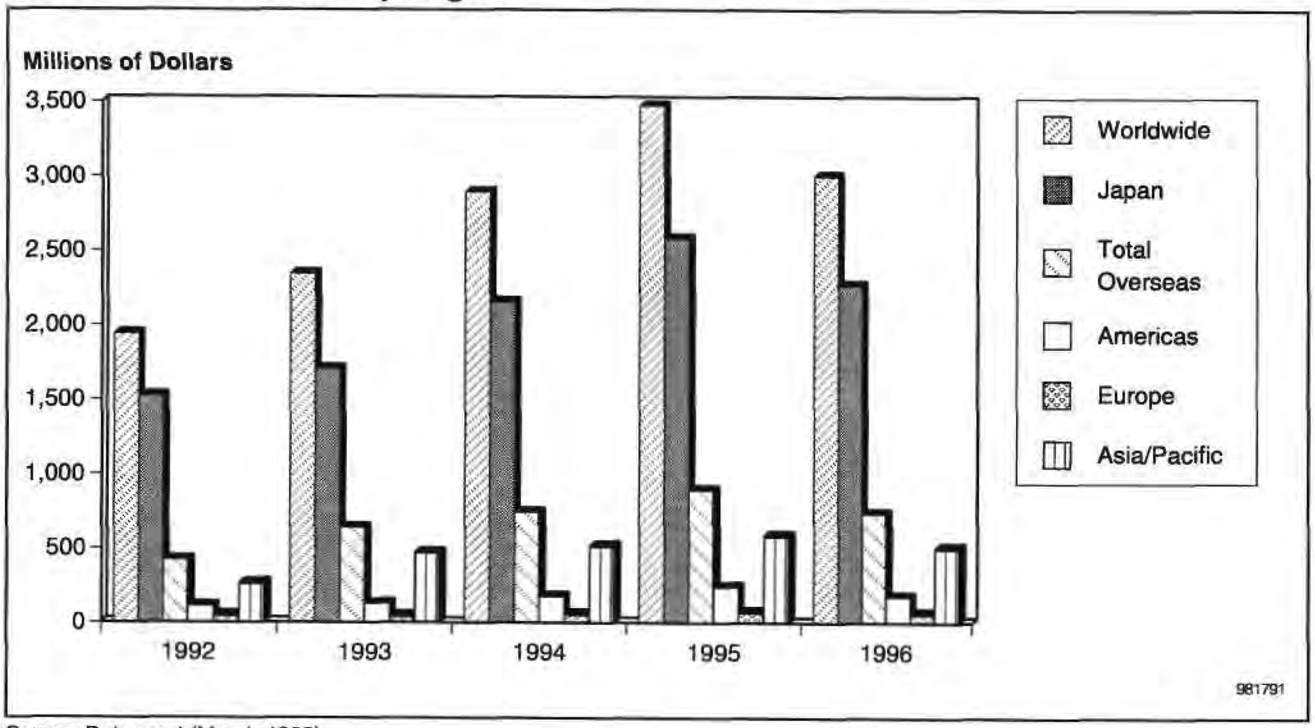
Source: Dataquest (March 1998)

Figure A-22
Matsushita's Share of the Japanese Market by Product



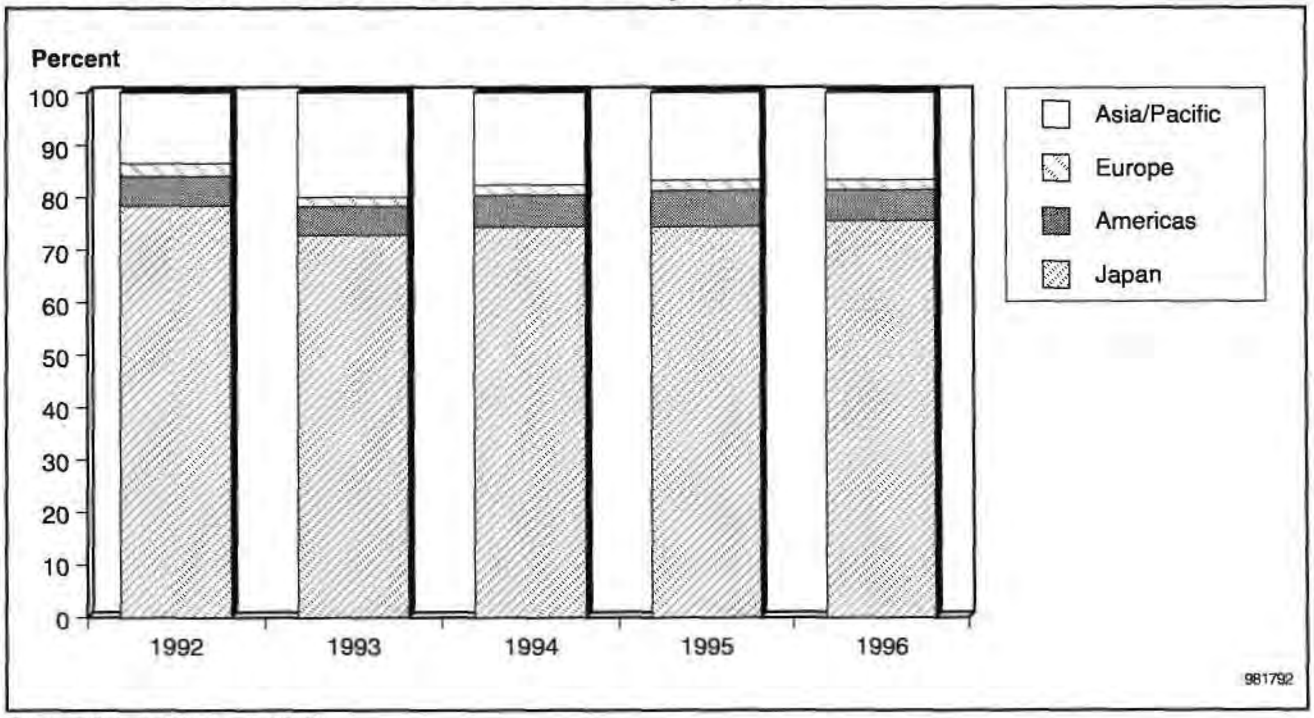
Source: Dataquest (March 1998)

Figure A-23
Revenue of Matsushita by Region



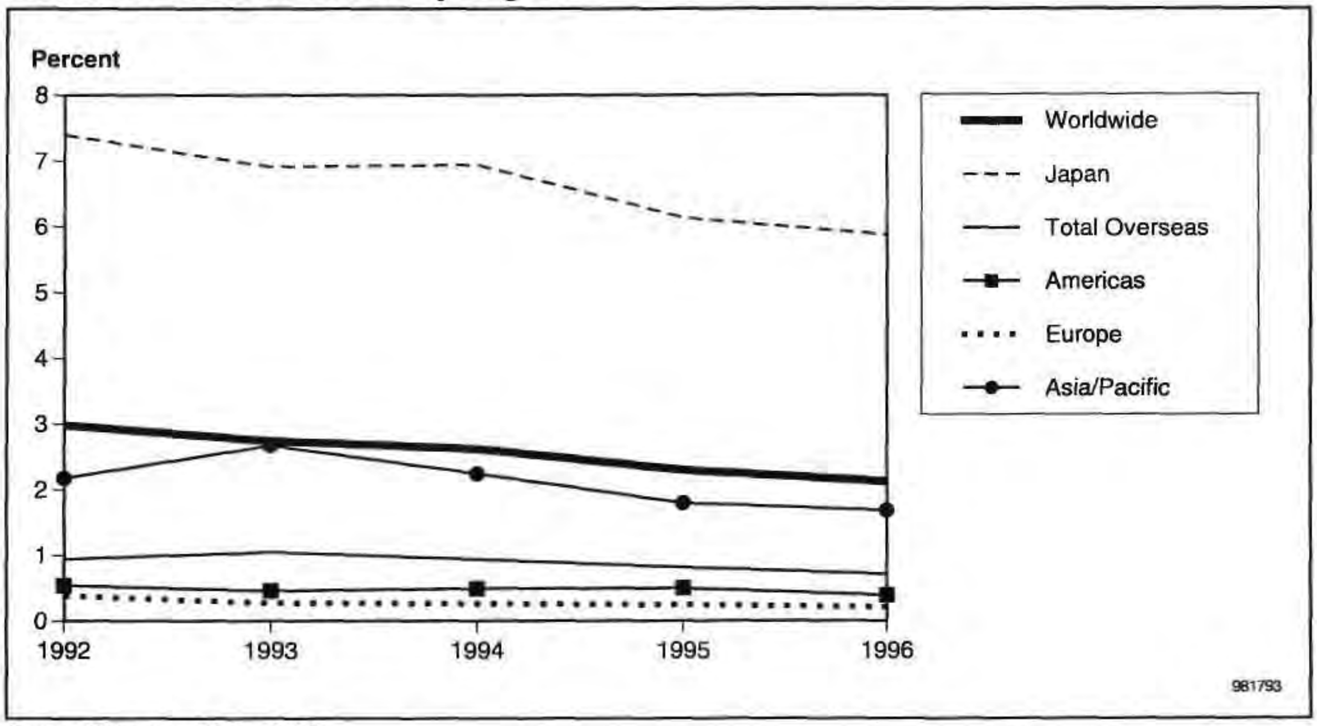
Source: Dataquest (March 1998)

Figure A-24
Matsushita's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-25
Matsushita's Market Share by Region



Source: Dataquest (March 1998)

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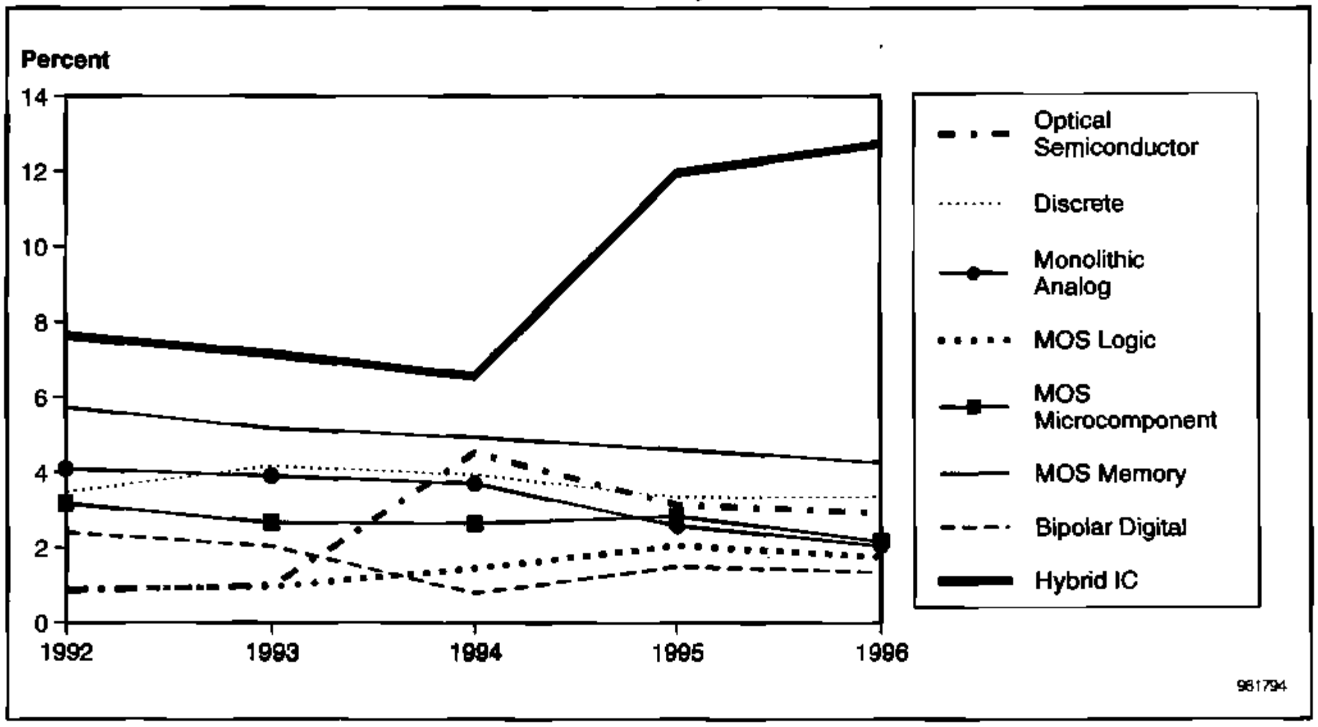
Table A-6
Revenue of Mitsubishi by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	102	106	109	198	187
Bipolar Digital	77	63	23	37	25
MOS Memory	878	1,206	1,652	2,547	1,614
MOS Microcomponent	456	532	698	982	901
MOS Logic	89	129	234	425	380
Monolithic Analog	304	377	456	455	397
Discrete	284	380	424	479	452
Optical Semiconductor	23	30	176	151	144

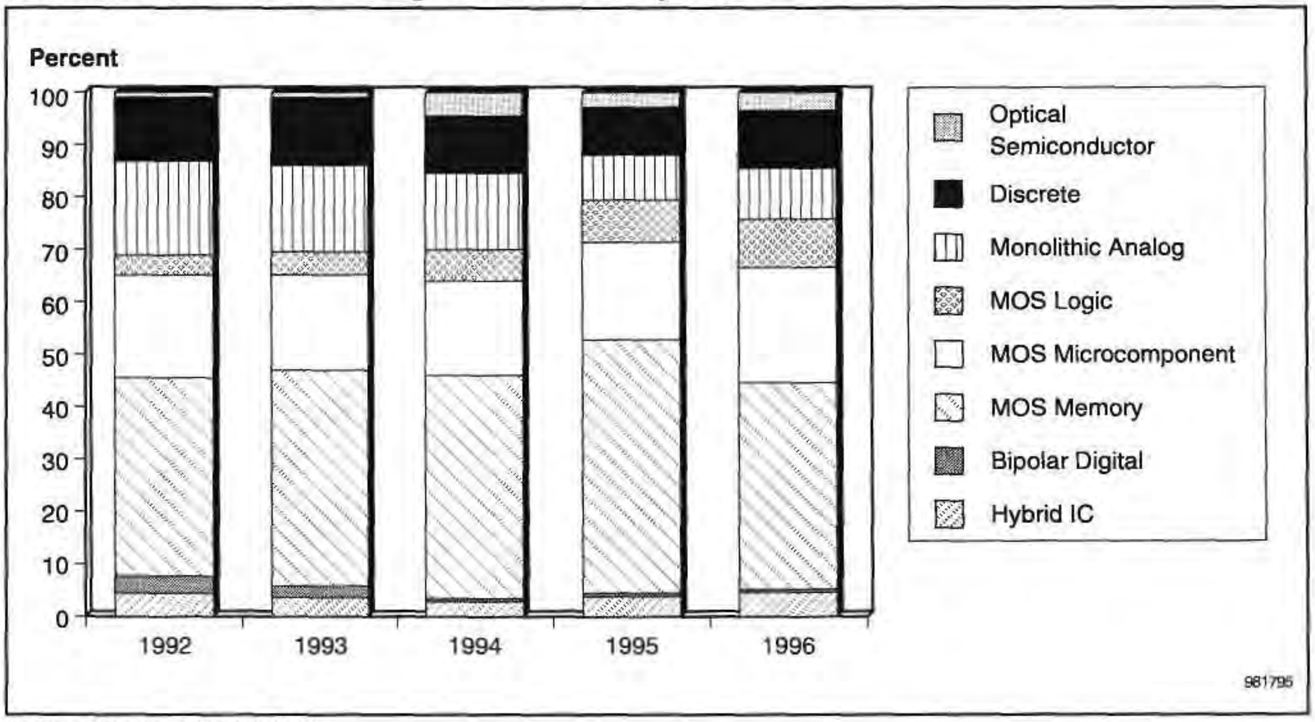
Source: Dataquest (March 1998)

Figure A-26
Mitsubishi's Share of the Worldwide Market by Product, 1992 to 1996



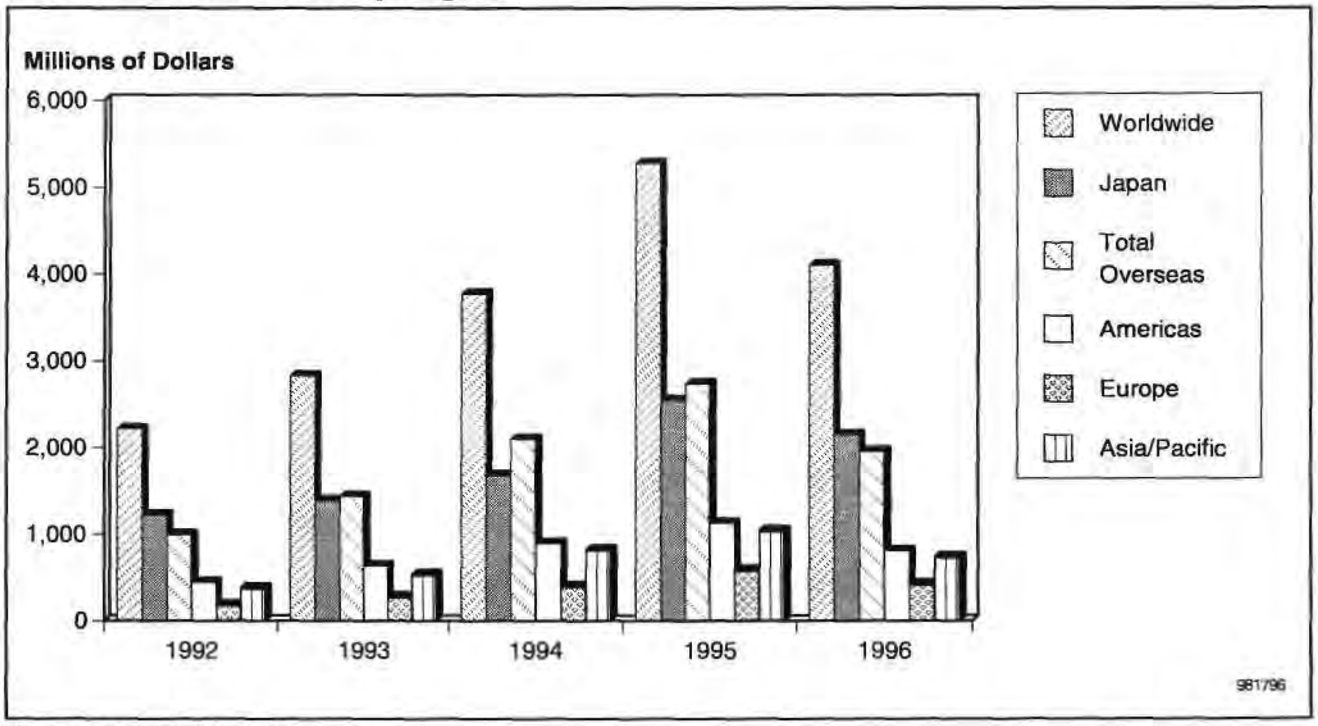
Source: Dataquest (March 1998)

Figure A-27
Mitsubishi's Share of the Japanese Market by Product



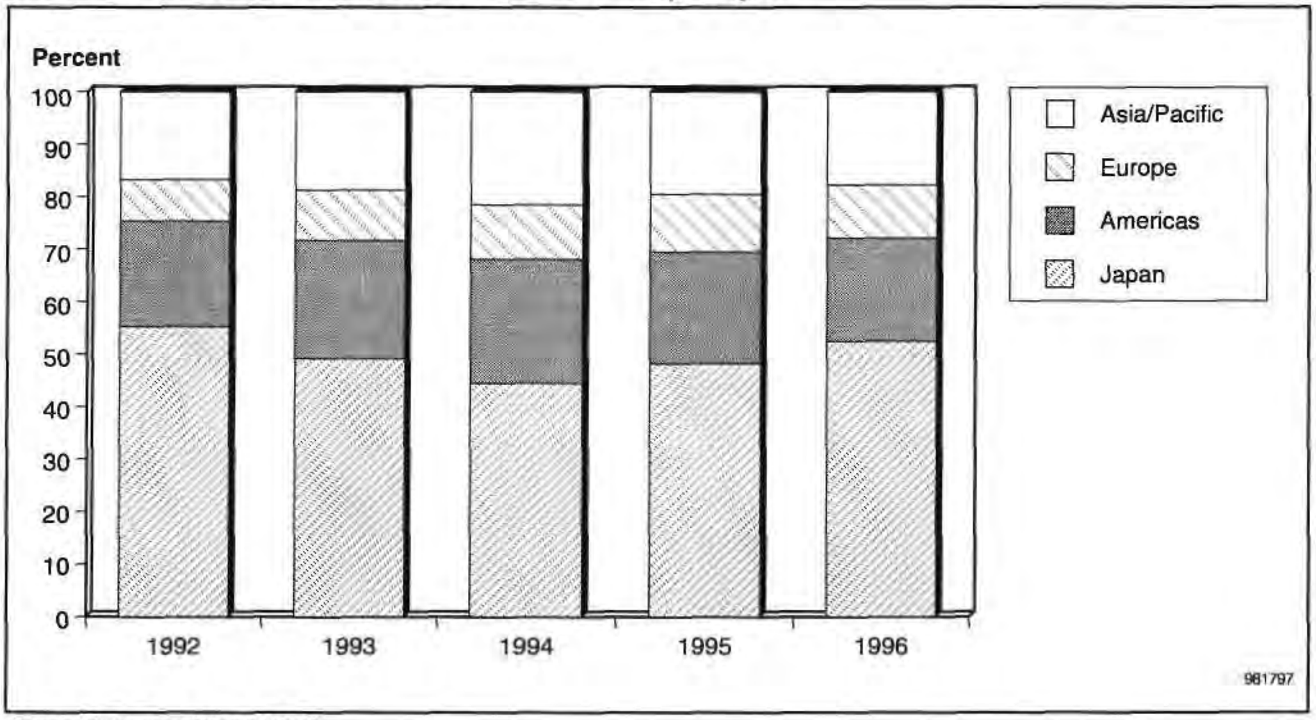
Source: Dataquest (March 1998)

Figure A-28
Revenue of Mitsubishi by Region



Source: Dataquest (March 1998)

Figure A-29
Mitsubishi's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

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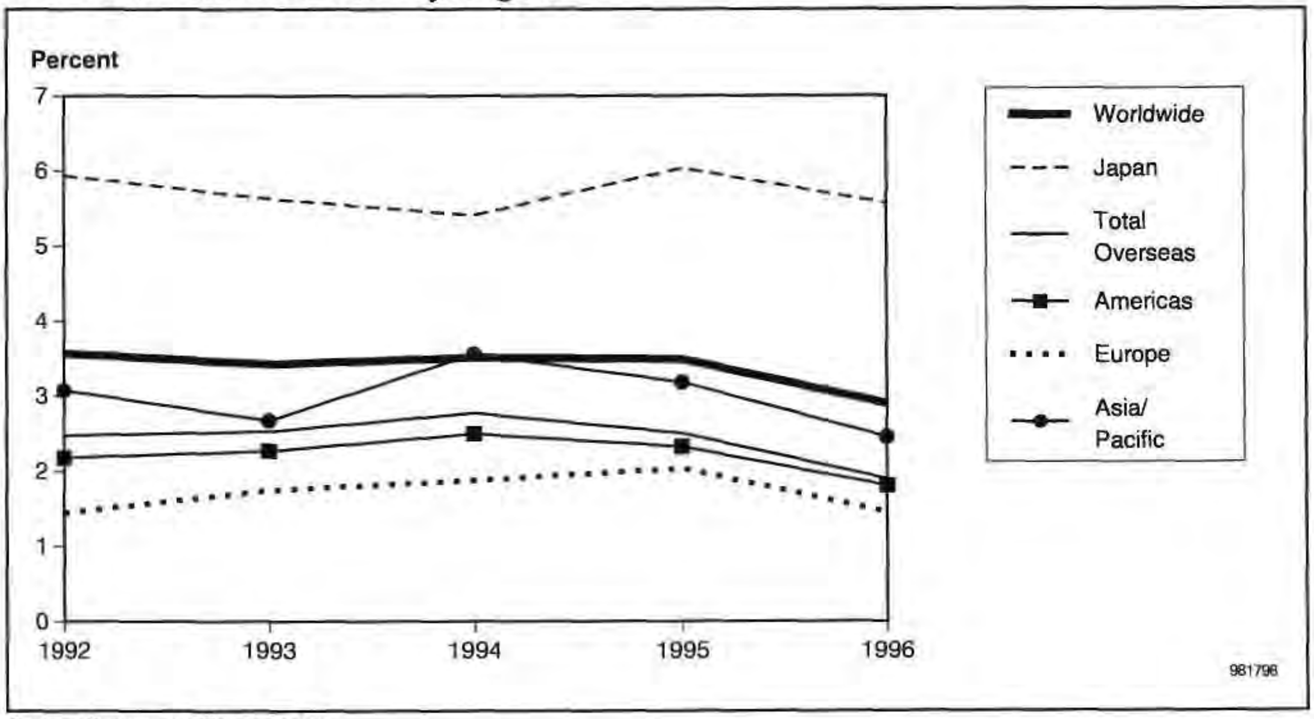
Figure A-30
Mitsubishi's Market Share by Region



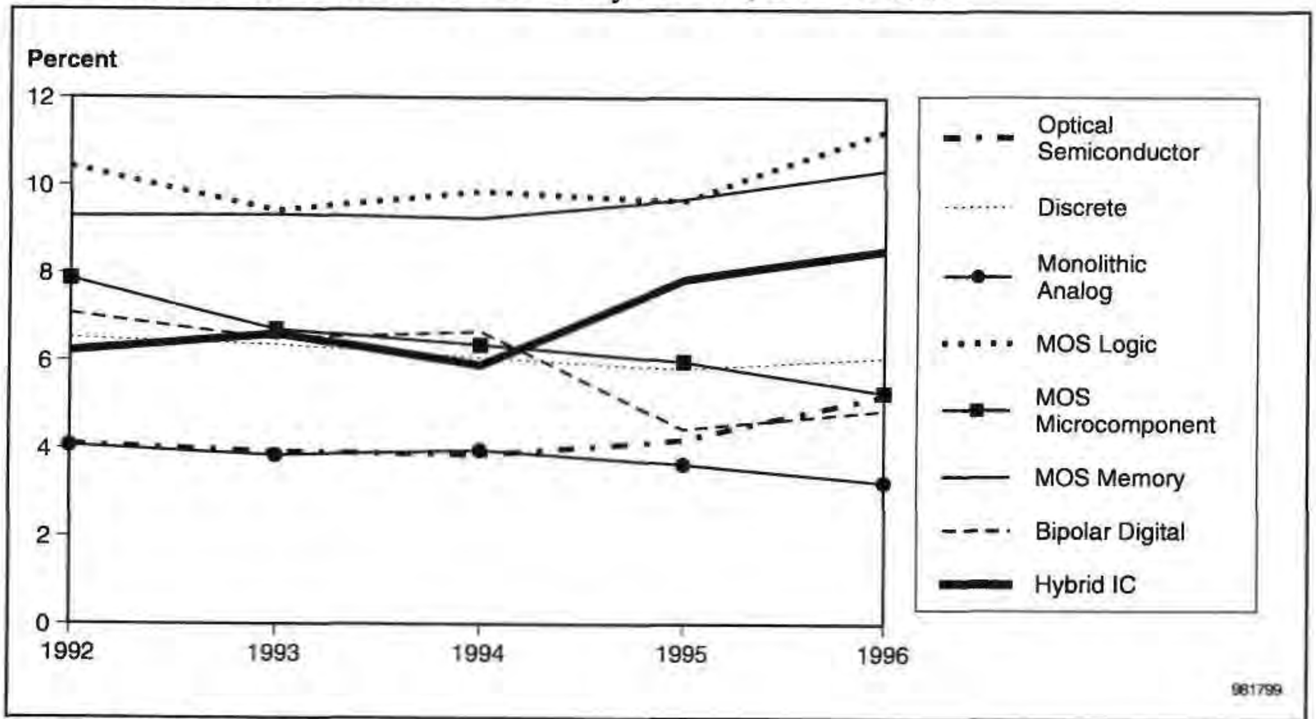
Source: Dataquest (March 1998)

Table A-7
Revenue of NEC by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	83	98	98	130	125
Bipolar Digital	226	201	194	109	90
MOS Memory	1,422	2,173	3,096	5,353	3,913
MOS Microcomponent	1,130	1,341	1,678	2,061	2,179
MOS Logic	1,047	1,254	1,587	1,987	2,423
Monolithic Analog	319	377	506	641	624
Discrete	532	579	652	831	818
Optical Semiconductor	110	118	150	202	256

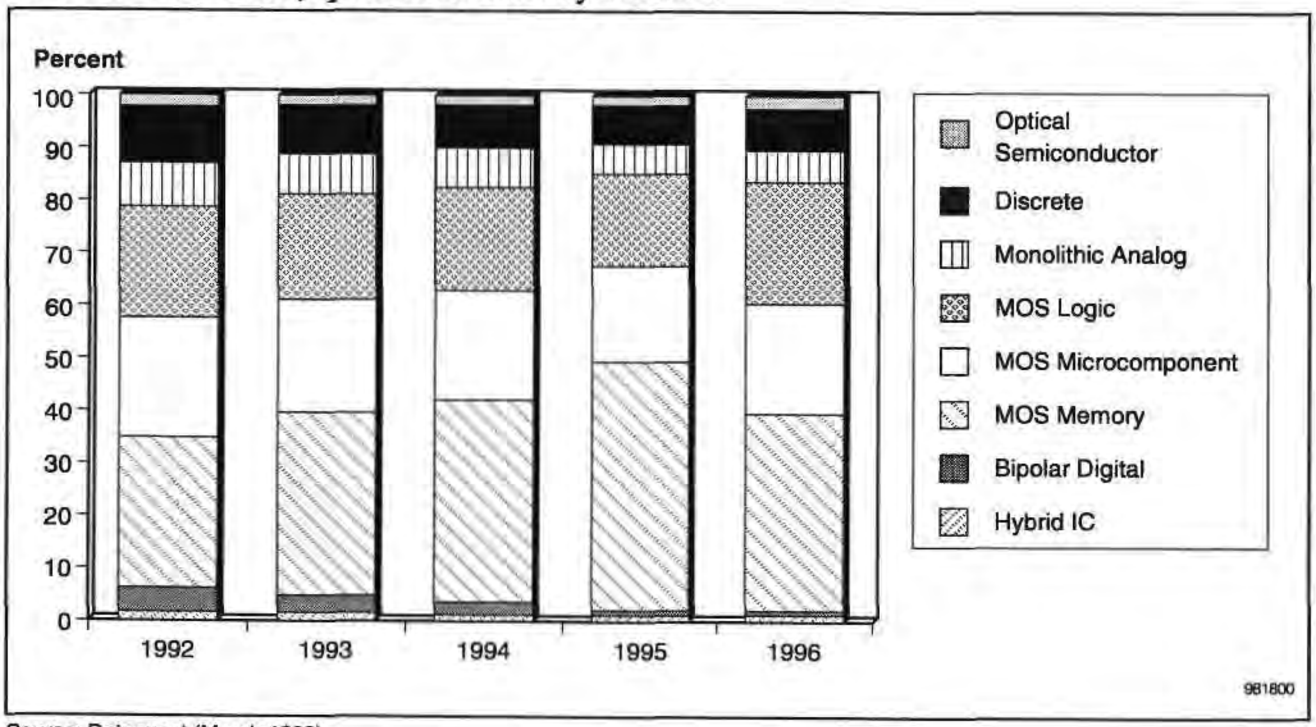
Source: Dataquest (March 1998)

Figure A-31
NEC's Share of the Worldwide Market by Product, 1992 to 1996



Source: Dataquest (March 1998)

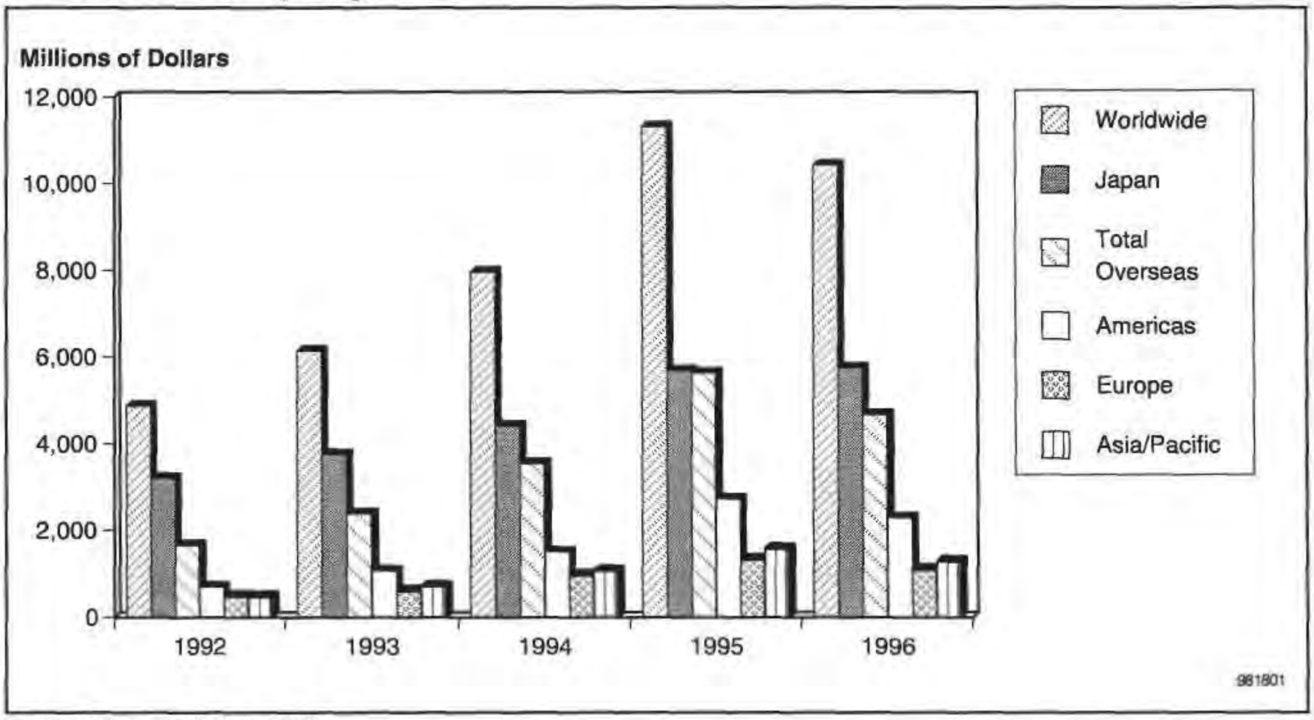
Figure A-32
NEC's Share of the Japanese Market by Product



Source: Dataquest (March 1998)

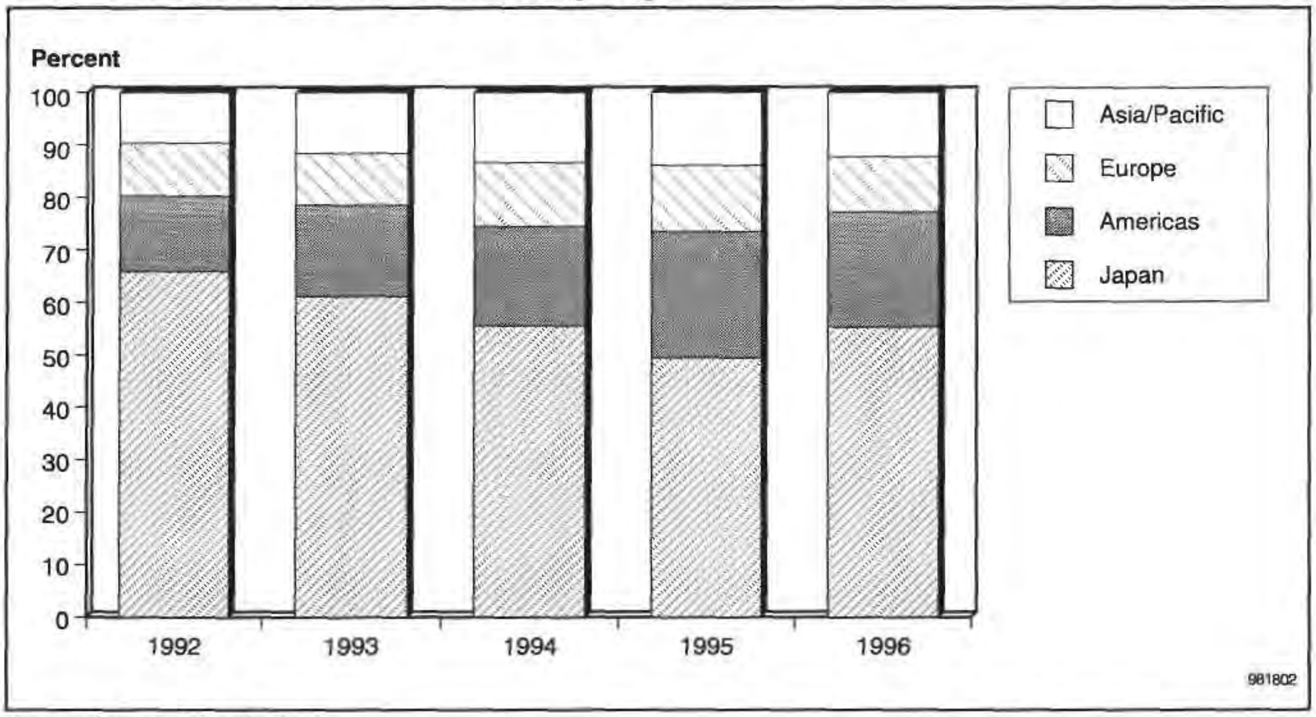
 ©1998 Dataquest

Figure A-33
Revenue of NEC by Region



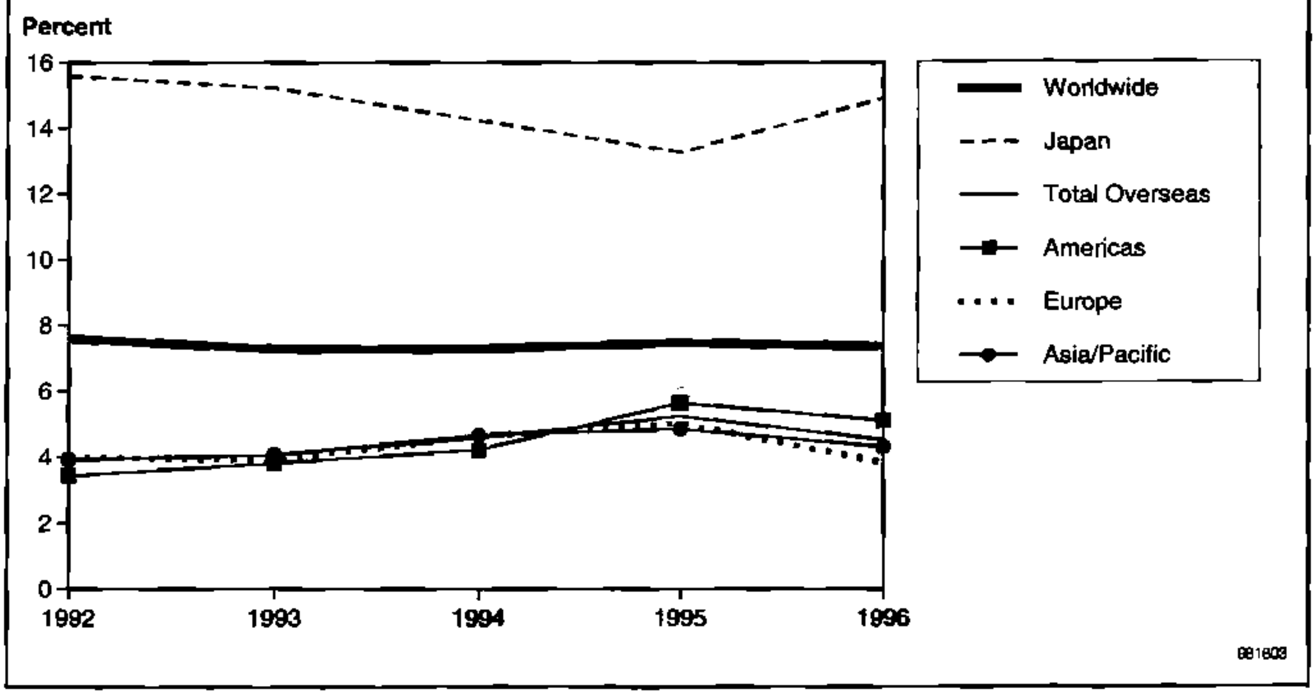
Source: Dataquest (March 1998)

Figure A-34
NEC's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-35
NEC's Market Share by Region



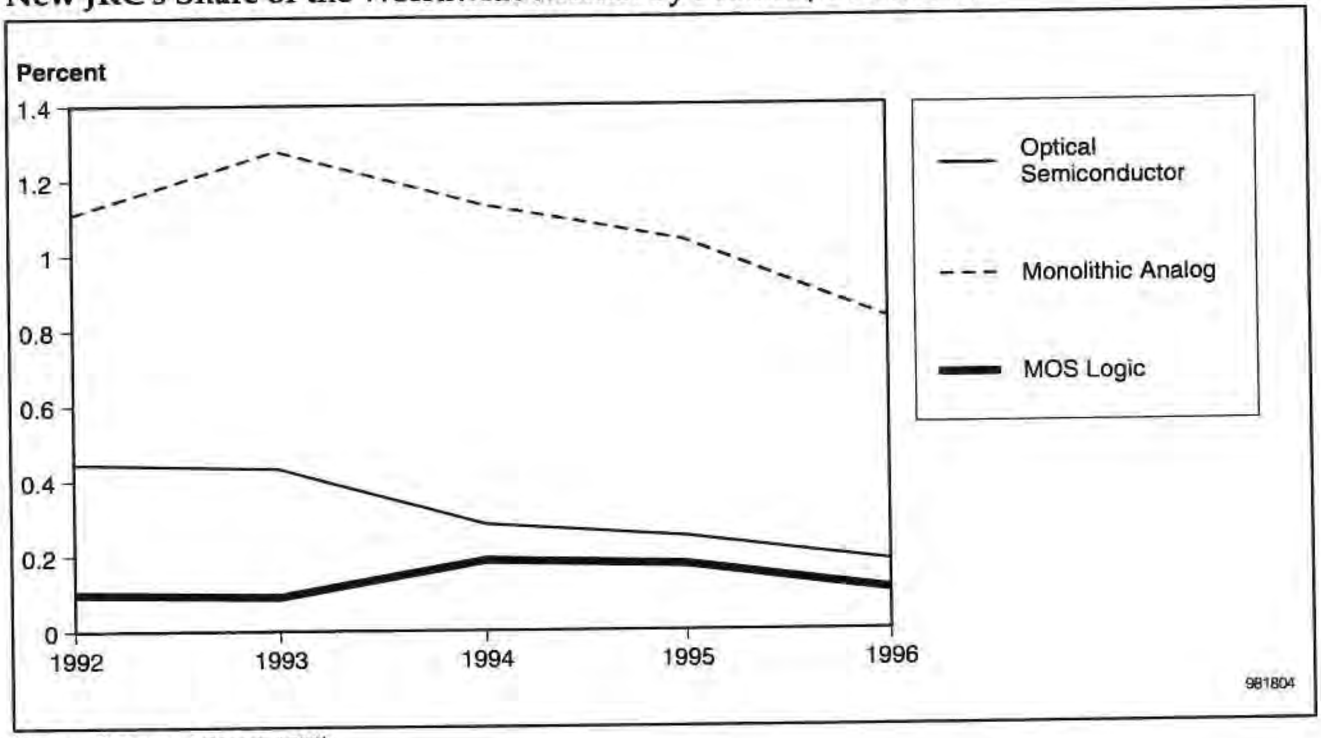
Source: Dataquest (March 1998)

Table A-8
Revenue of New JRC by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	0	0	0	0	0
Bipolar Digital	0	0	0	0	0
MOS Memory	0	0	0	0	0
MOS Microcomponent	0	0	2	4	5
MOS Logic	10	12	30	36	23
Monolithic Analog	113	158	173	183	160
Discrete	3	3	2	2	3
Optical Semiconductor	12	13	11	12	9

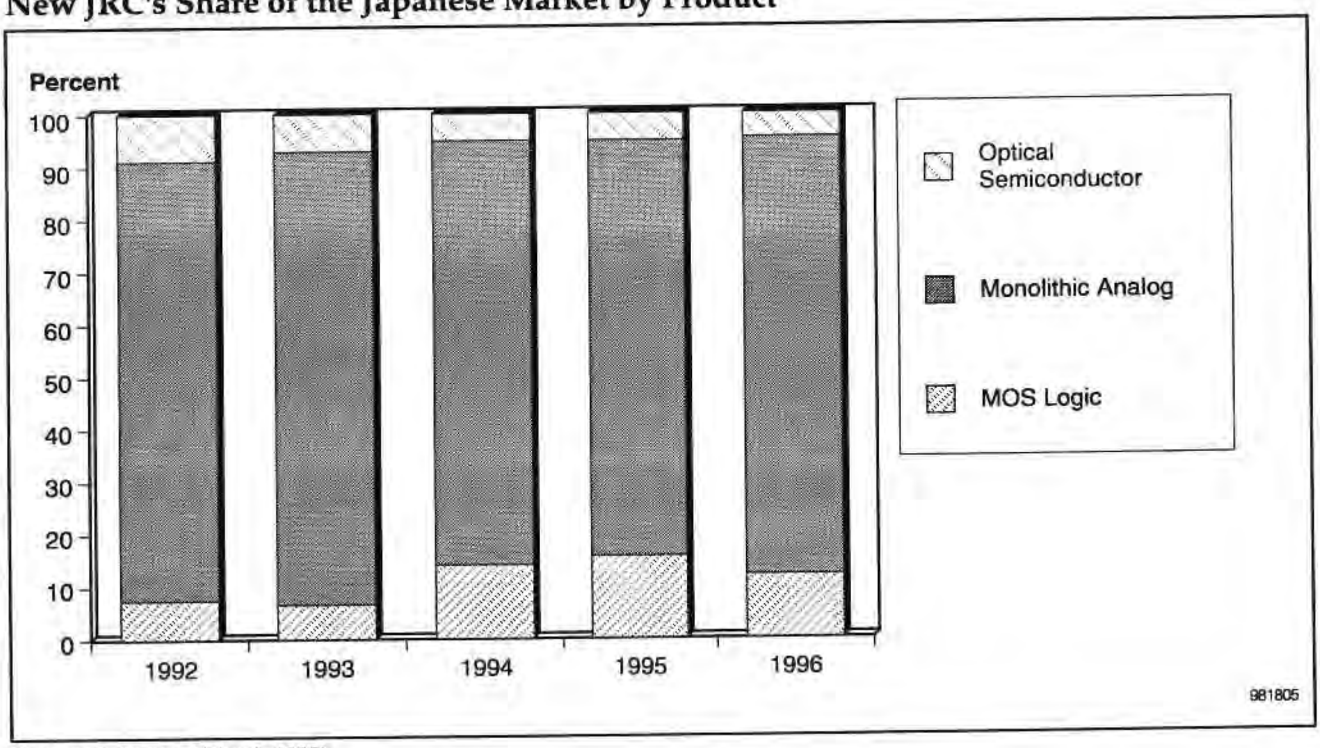
Source: Dataquest (March 1998)

Figure A-36
New JRC's Share of the Worldwide Market by Product, 1992 to 1996



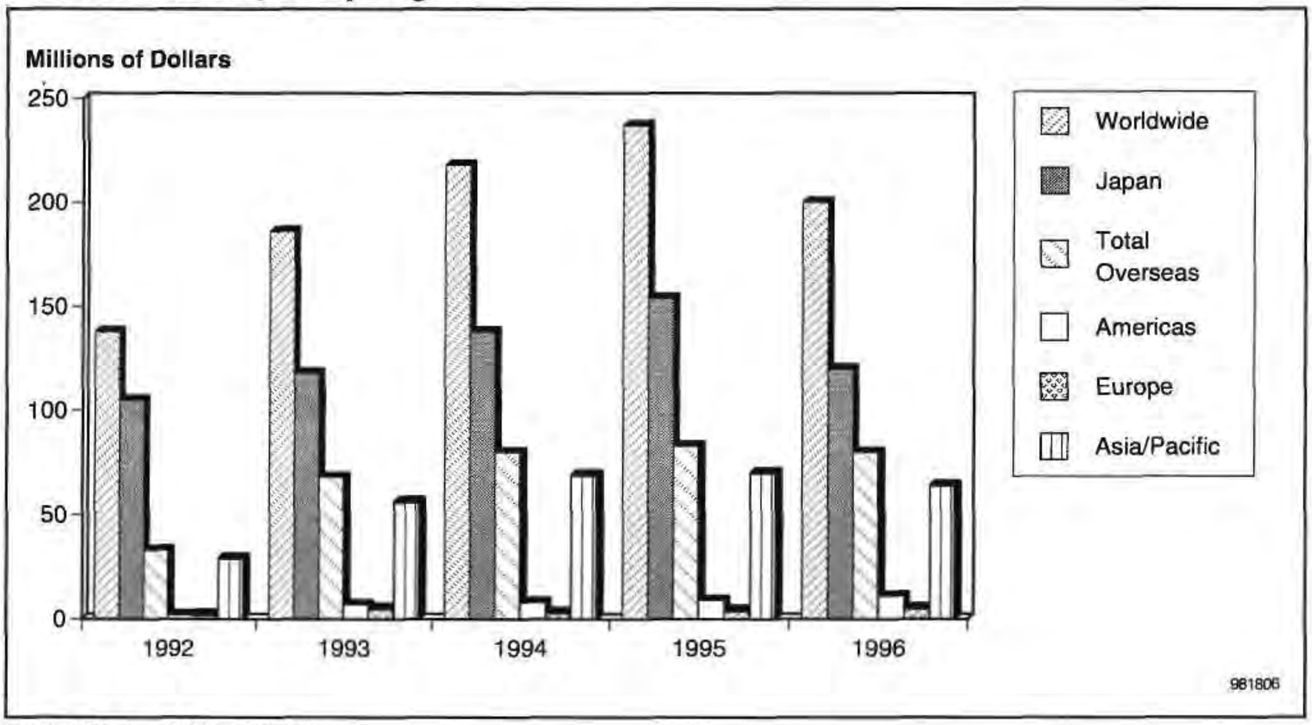
Source: Dataquest (March 1998)

Figure A-37
New JRC's Share of the Japanese Market by Product



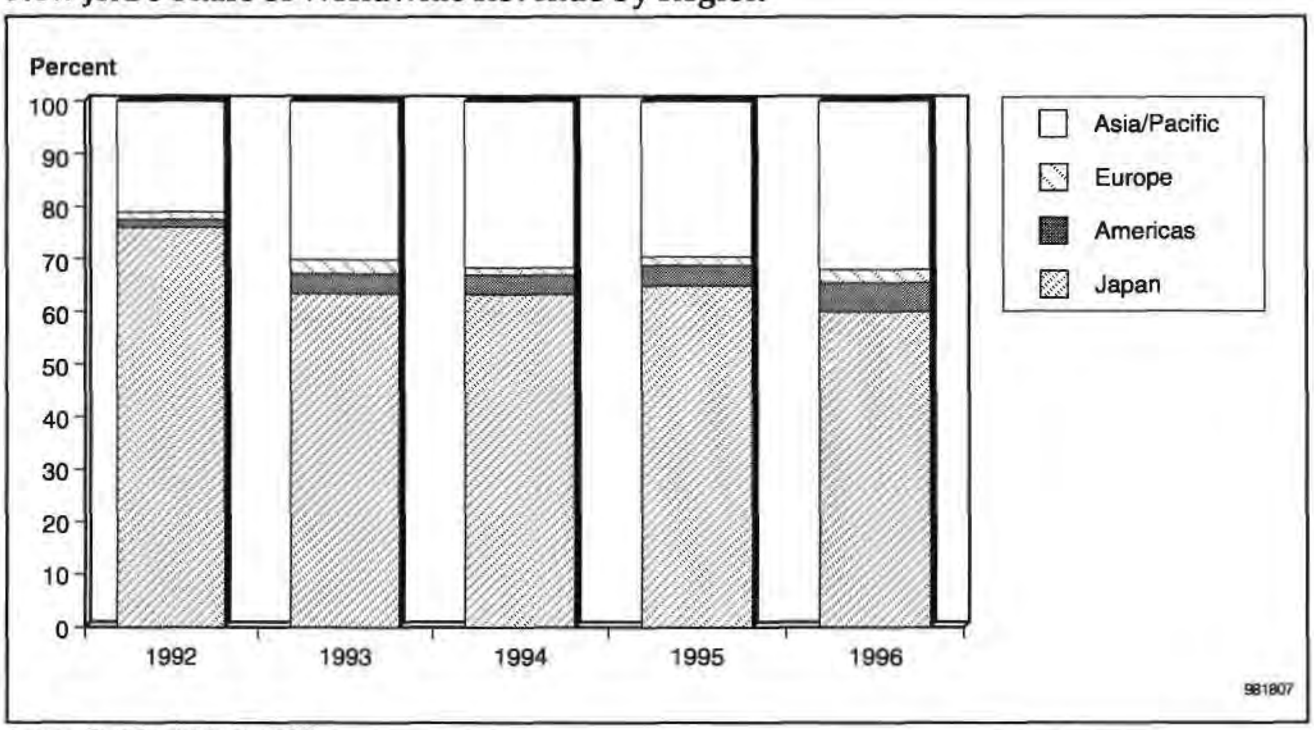
Source: Dataquest (March 1998)

Figure A-38
Revenue of New JRC by Region



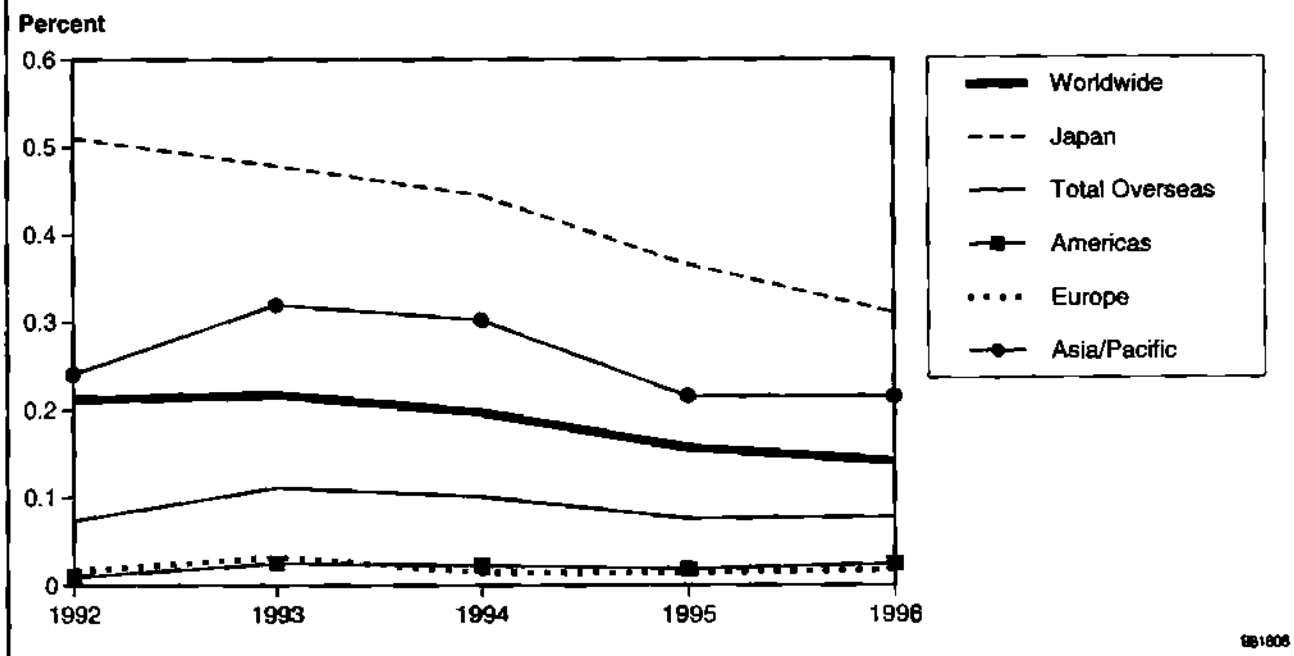
Source: Dataquest (March 1998)

Figure A-39
New JRC's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-40
New JRC's Market Share by Region



Source: Dataquest (March 1998)

Table A-9
Revenue of Nippon Steel Semiconductor by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	0	0	0	0	0
Bipolar Digital	0	0	0	0	0
MOS Memory	120	148	160	549	198
MOS Microcomponent	0	0	0	0	0
MOS Logic	0	0	0	0	0
Monolithic Analog	0	0	0	0	0
Discrete	0	0	0	0	0
Optical Semiconductor	0	0	0	0	0

Source: Dataquest (March 1998)

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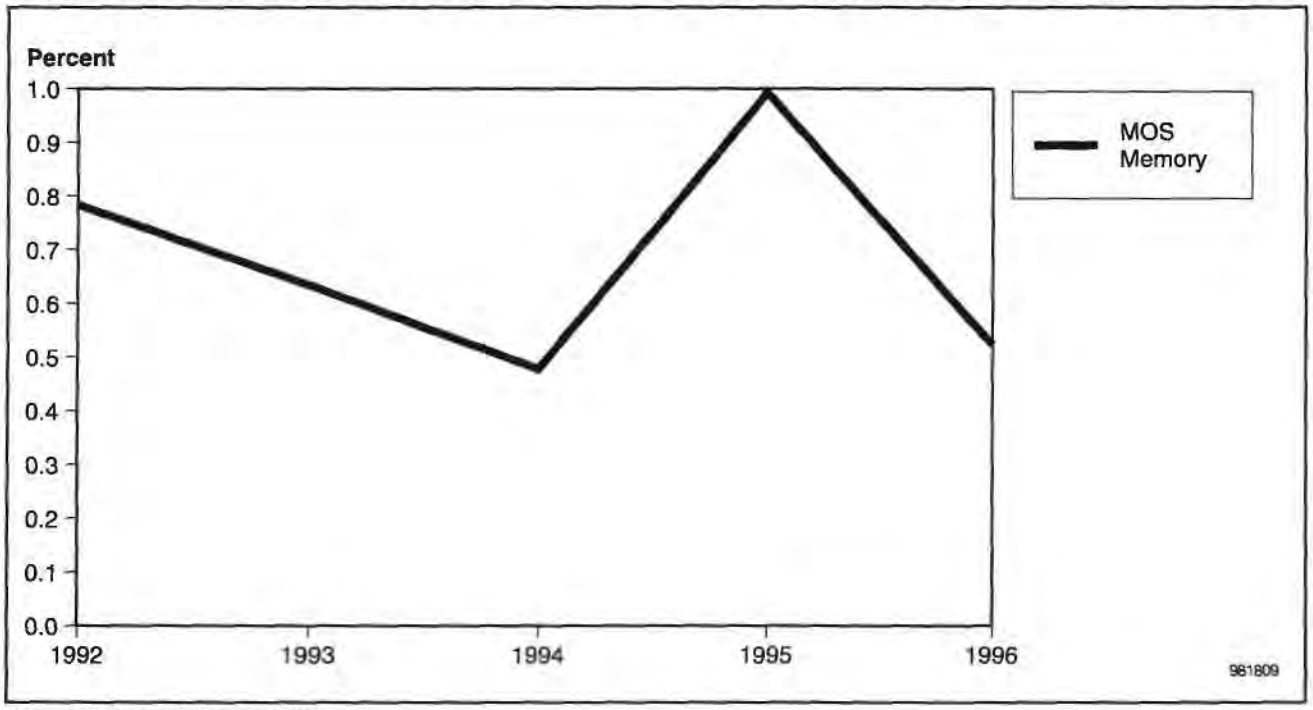
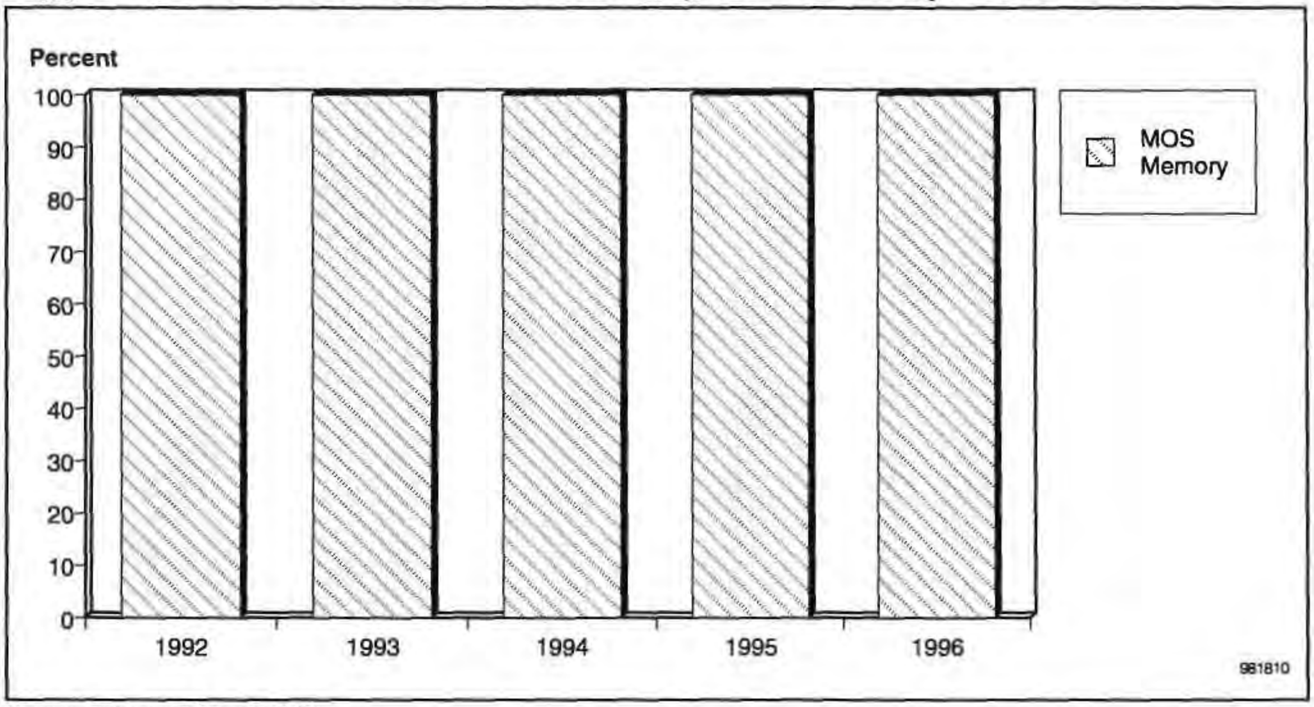
Figure A-41
Nippon Steel Semiconductor's Share of the Worldwide Market by Product, 1992 to 1996



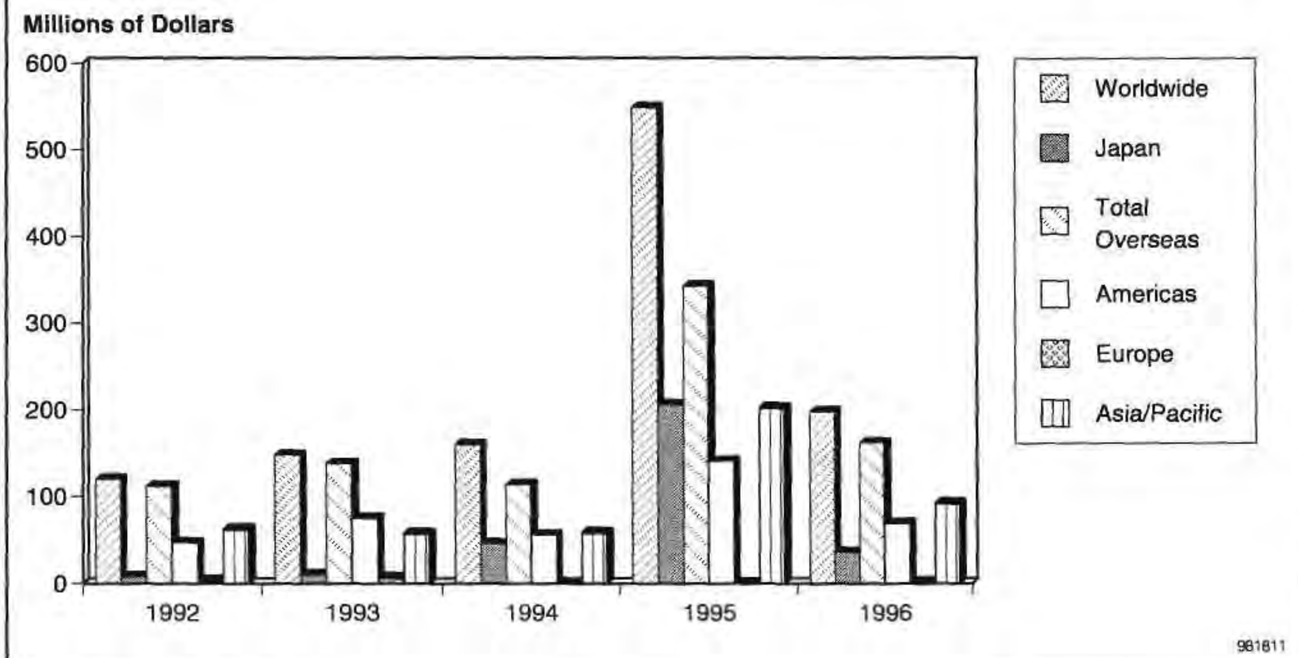
Source: Dataquest (March 1998)

Figure A-42
Nippon Steel Semiconductor's Share of the Japanese Market by Product



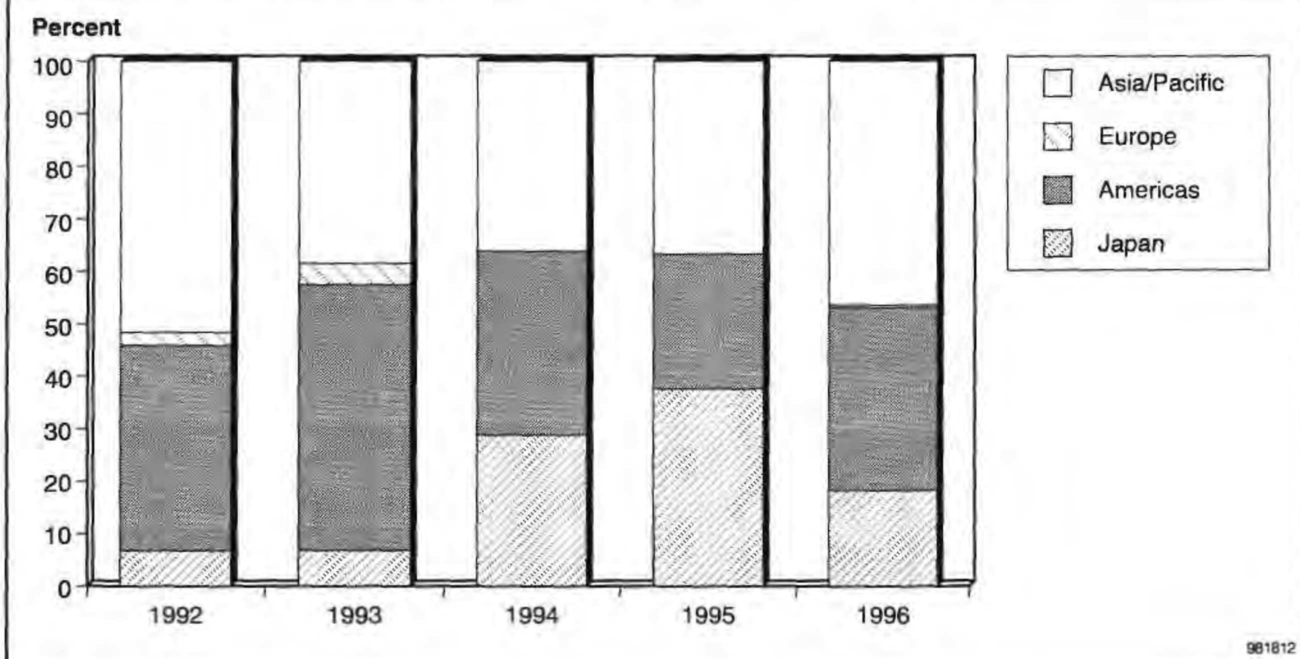
Source: Dataquest (March 1998)

Figure A-43
Revenue of Nippon Steel Semiconductor by Region



Source: Dataquest (March 1998)

Figure A-44
Nippon Steel Semiconductor's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

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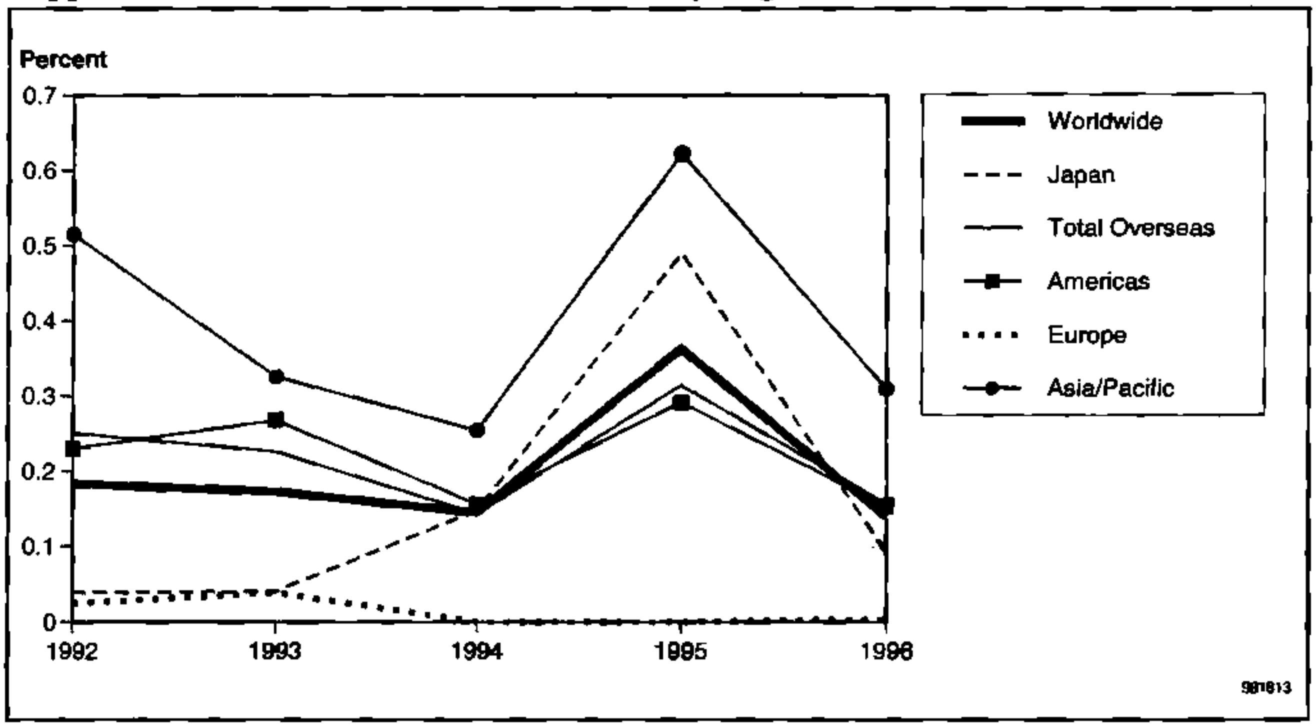
Figure A-45
Nippon Steel Semiconductor's Market Share by Region



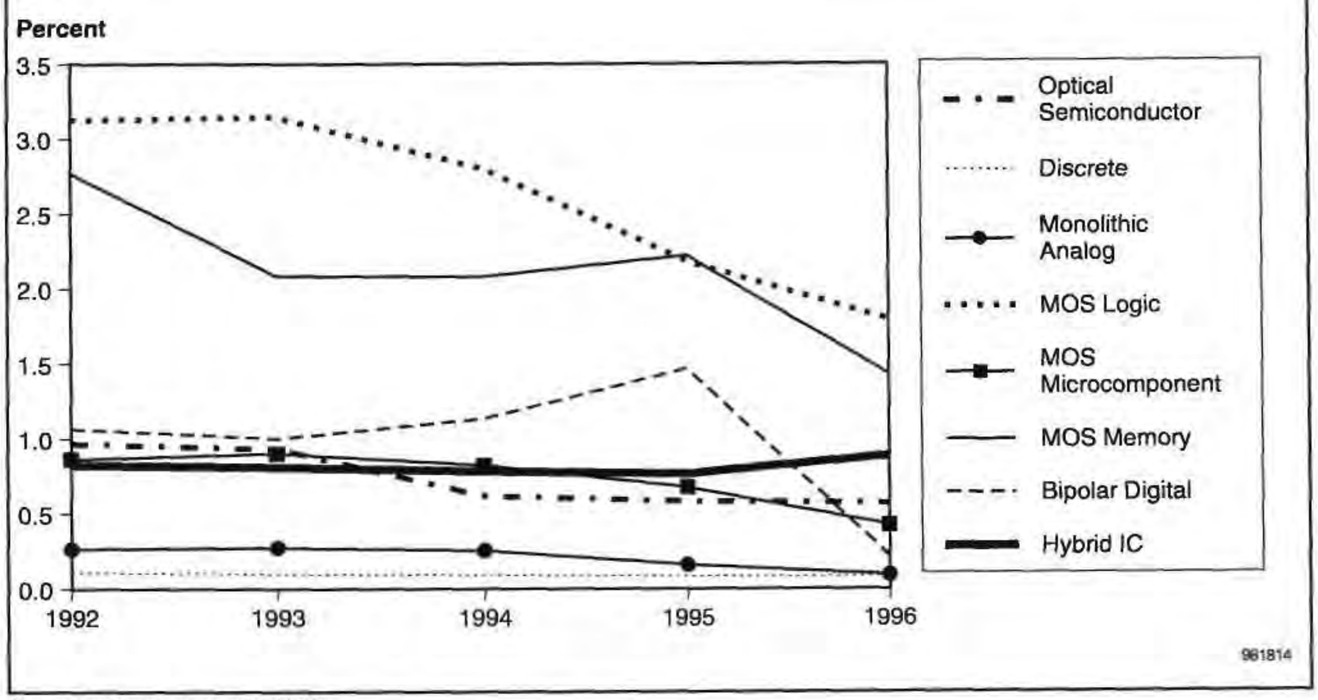
Source: Dataquest (March 1998)

Table A-10
Revenue of Oki by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	11	12	13	13	13
Bipolar Digital	34	31	33	36	4
MOS Memory	424	486	697	1,228	541
MOS Microcomponent	124	180	217	233	175
MOS Logic	314	419	451	450	387
Monolithic Analog	14	22	26	28	18
Discrete	9	9	10	12	11
Optical Semiconductor	26	28	24	28	28

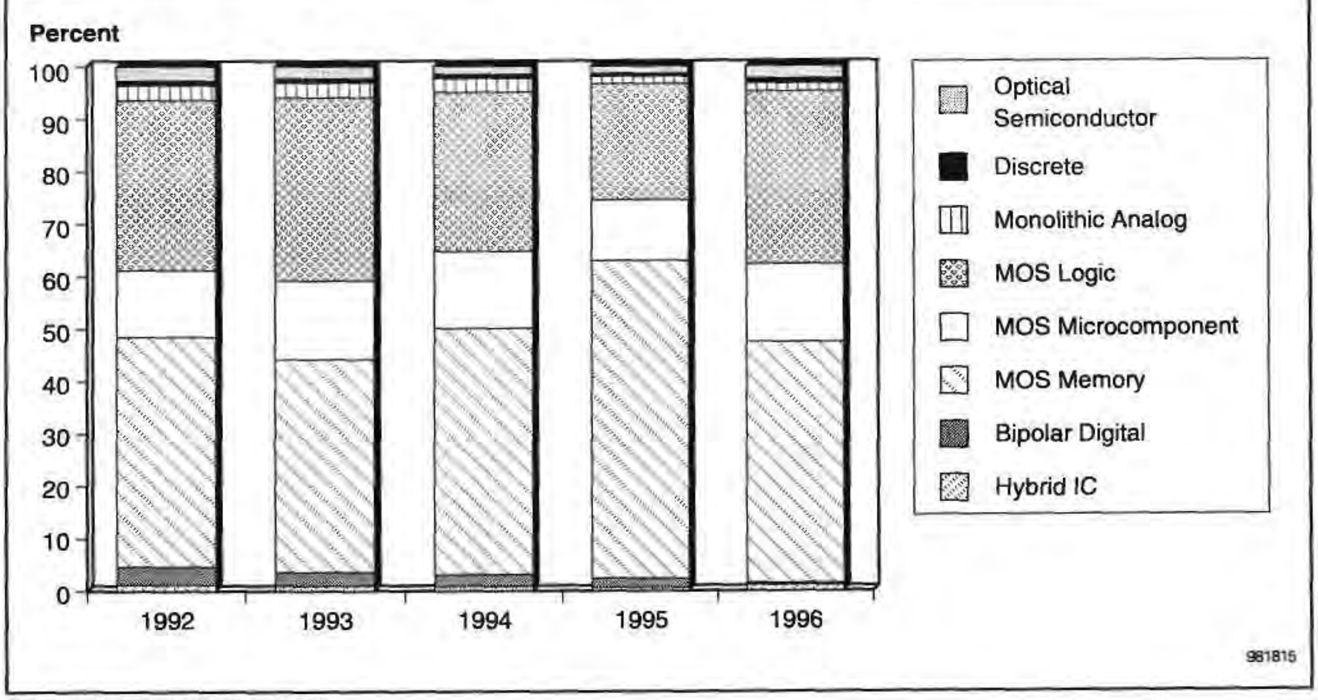
Source: Dataquest (March 1998)

Figure A-46
Oki's Share of the Worldwide Market by Product, 1992 to 1996



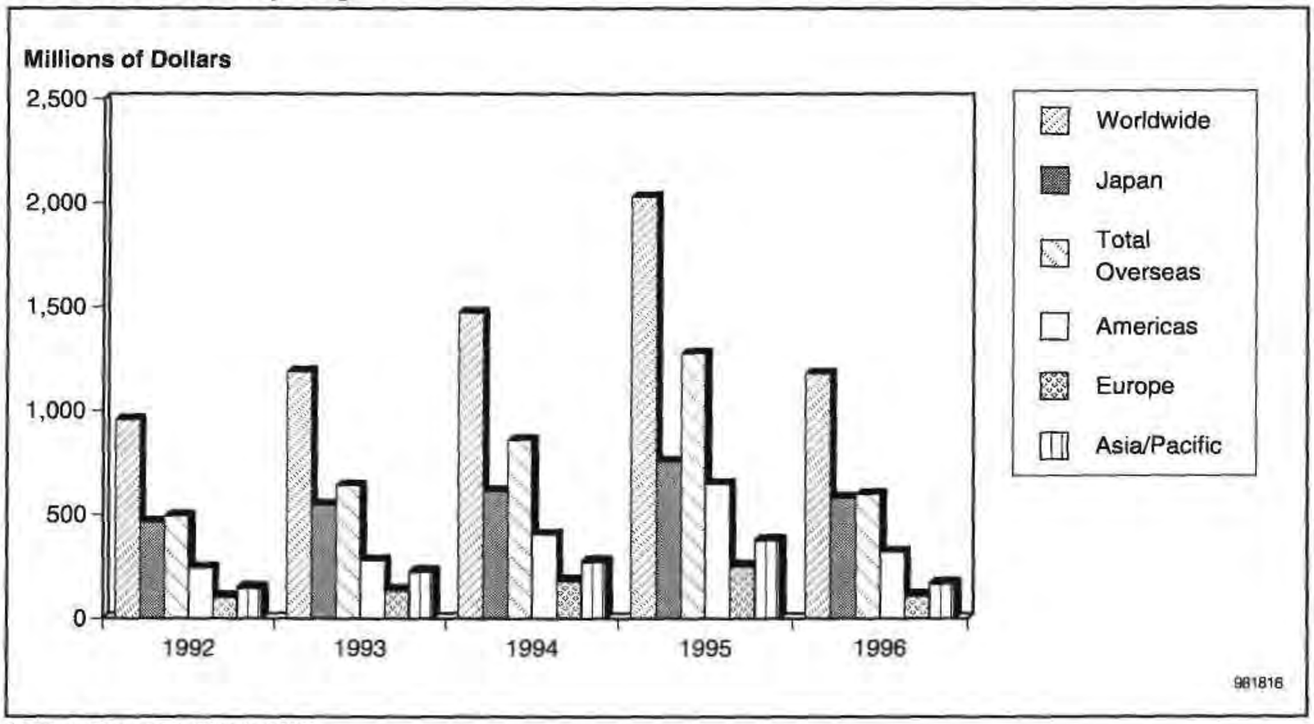
Source: Dataquest (March 1998)

Figure A-47
Oki's Share of the Japanese Market by Product



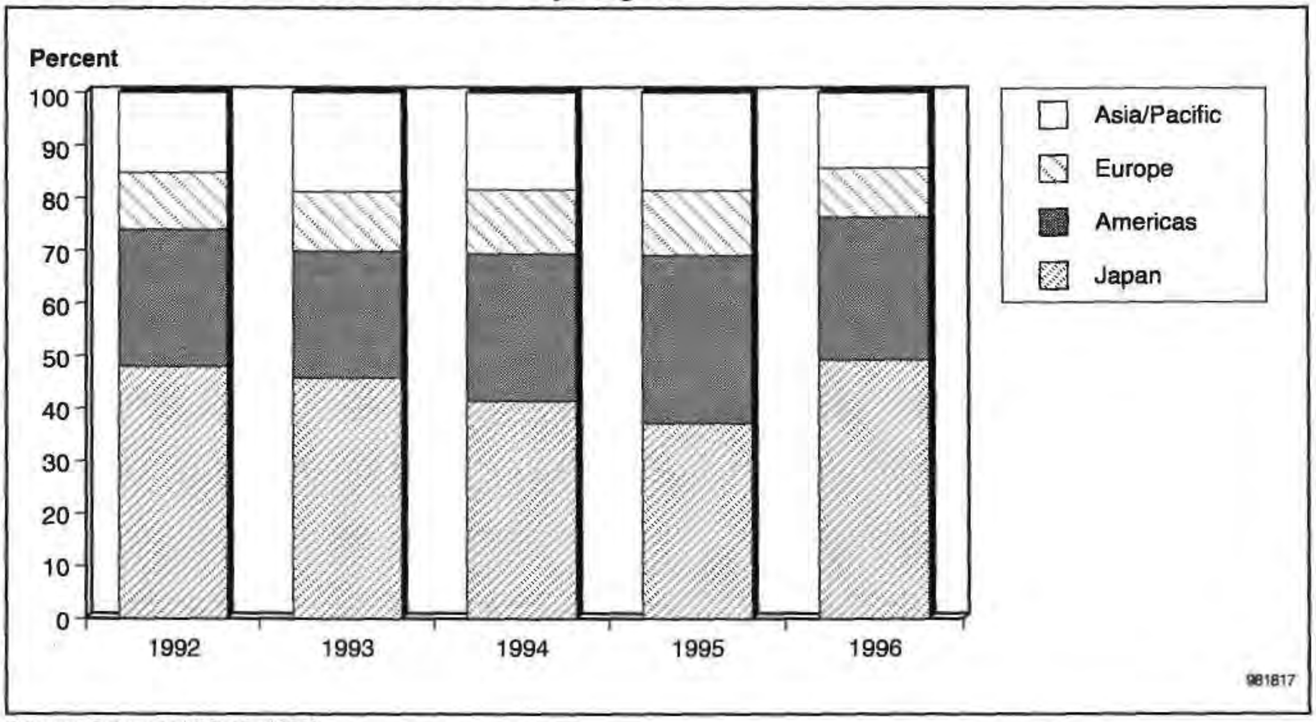
Source: Dataquest (March 1998)

Figure A-48
Revenue of Oki by Region



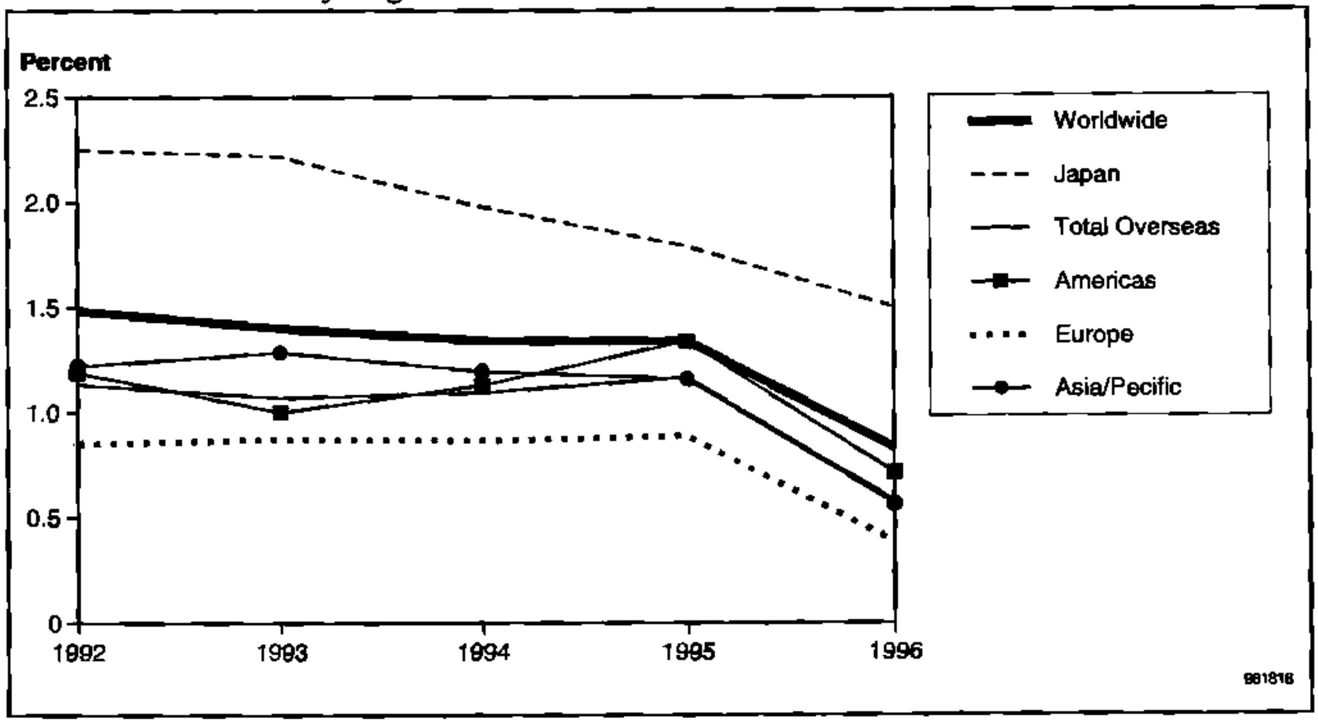
Source: Dataquest (March 1998)

Figure A-49
Oki's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-50
Oki's Market Share by Region



Source: Dataquest (March 1998)

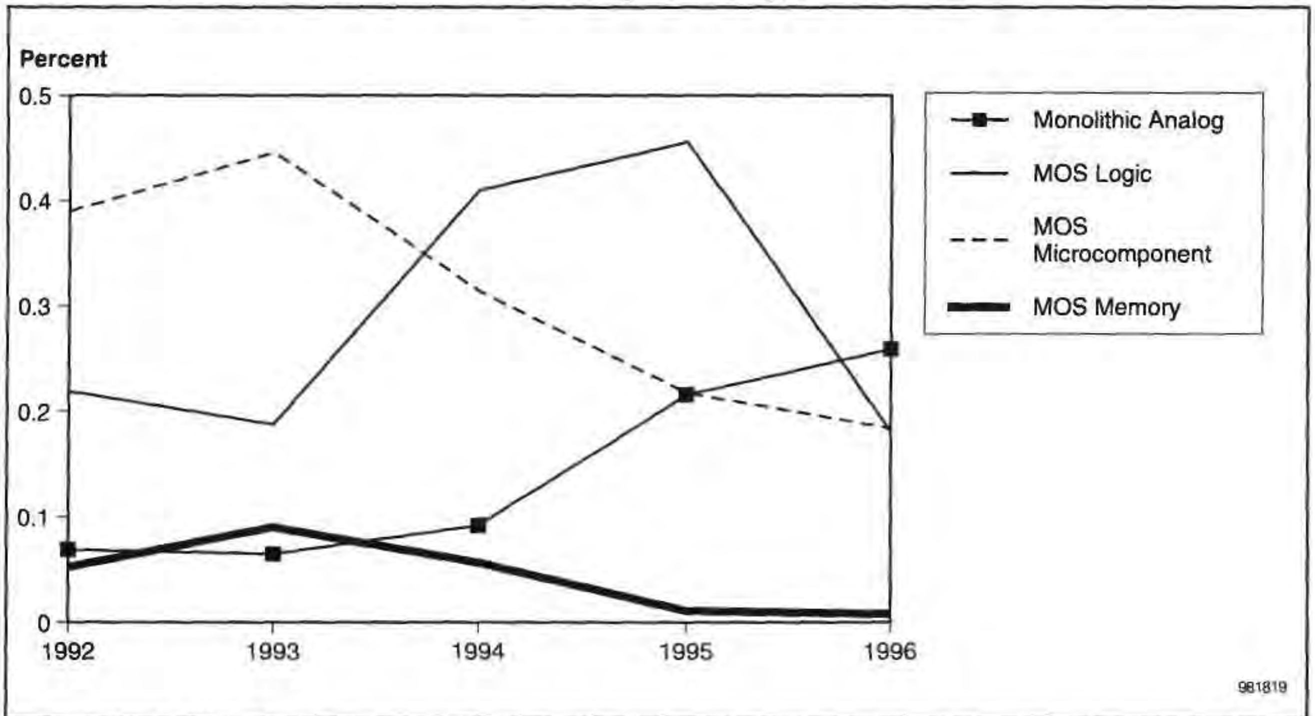
Table A-11
Revenue of Ricoh by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	0	0	0	0	0
Bipolar Digital	0	0	0	0	0
MOS Memory	8	21	19	6	3
MOS Microcomponent	56	89	83	75	76
MOS Logic	22	25	66	94	39
Monolithic Analog	7	8	14	38	50
Discrete	0	0	0	0	0
Optical Semiconductor	0	0	0	0	0

Source: Dataquest (March 1998)

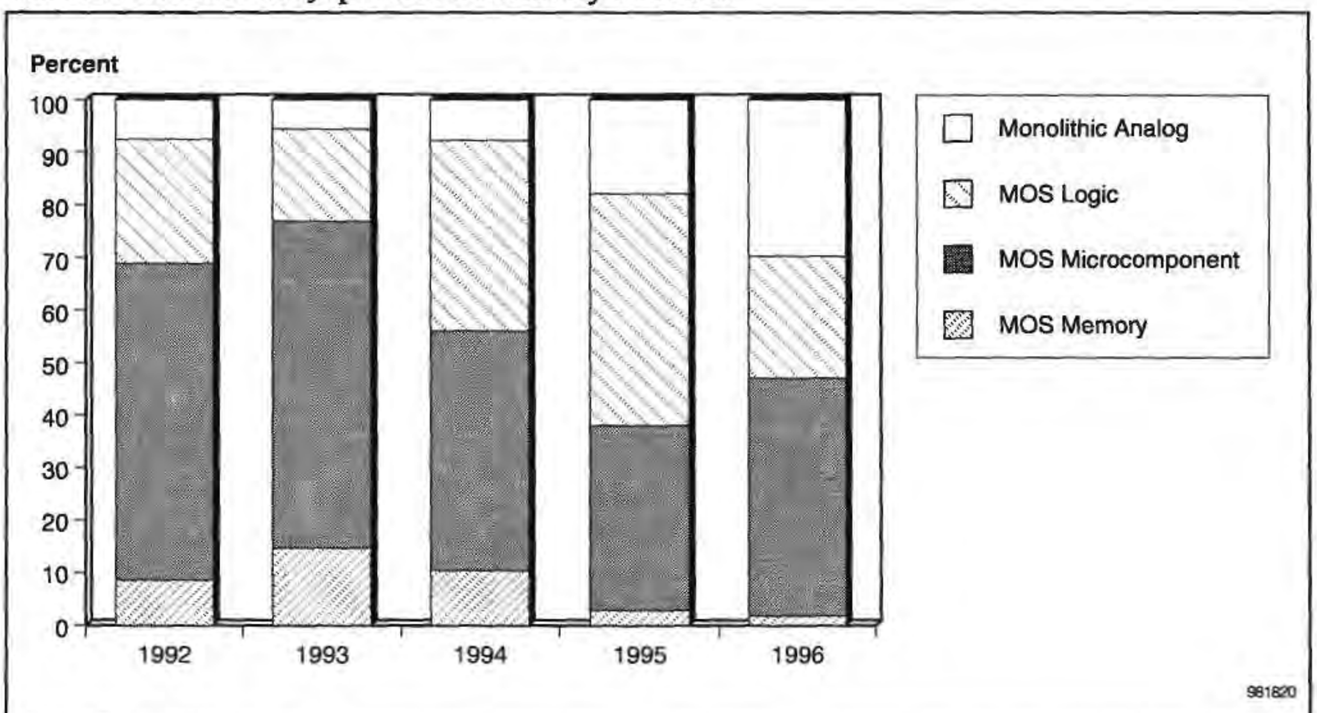
 ©1998 Dataquest

Figure A-51
Ricoh's Share of the Worldwide Market by Product, 1992 to 1996



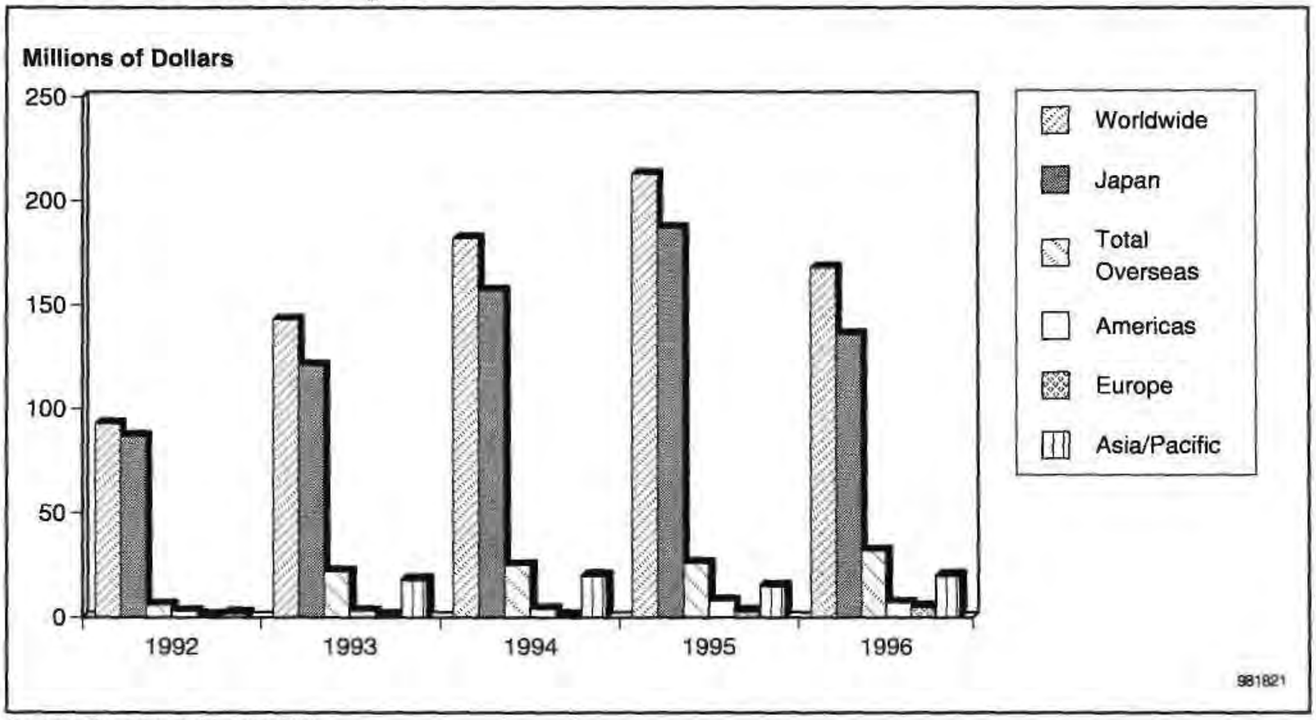
Source: Dataquest (March 1998)

Figure A-52
Ricoh's Share of the Japanese Market by Product



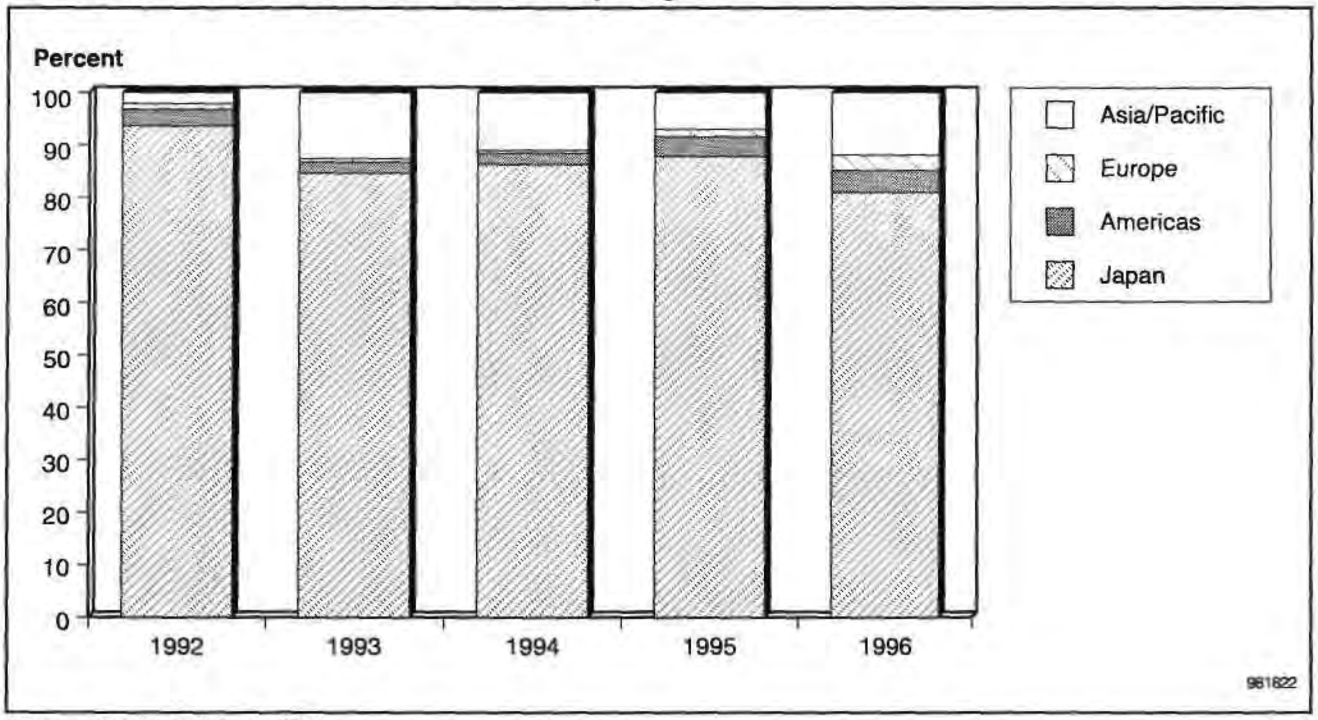
Source: Dataquest (March 1998)

Figure A-53
Revenue of Ricoh by Region



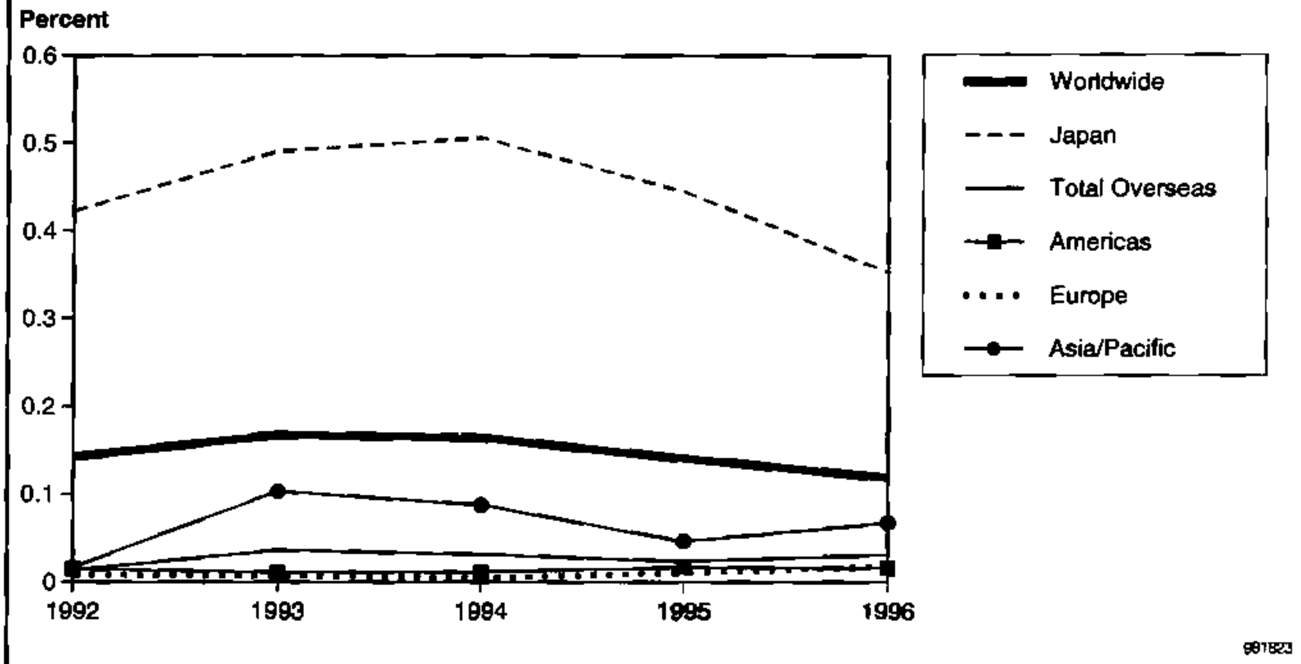
Source: Dataquest (March 1998)

Figure A-54
Ricoh's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-55
Ricoh's Market Share by Region



Source: Dataquest (March 1998)

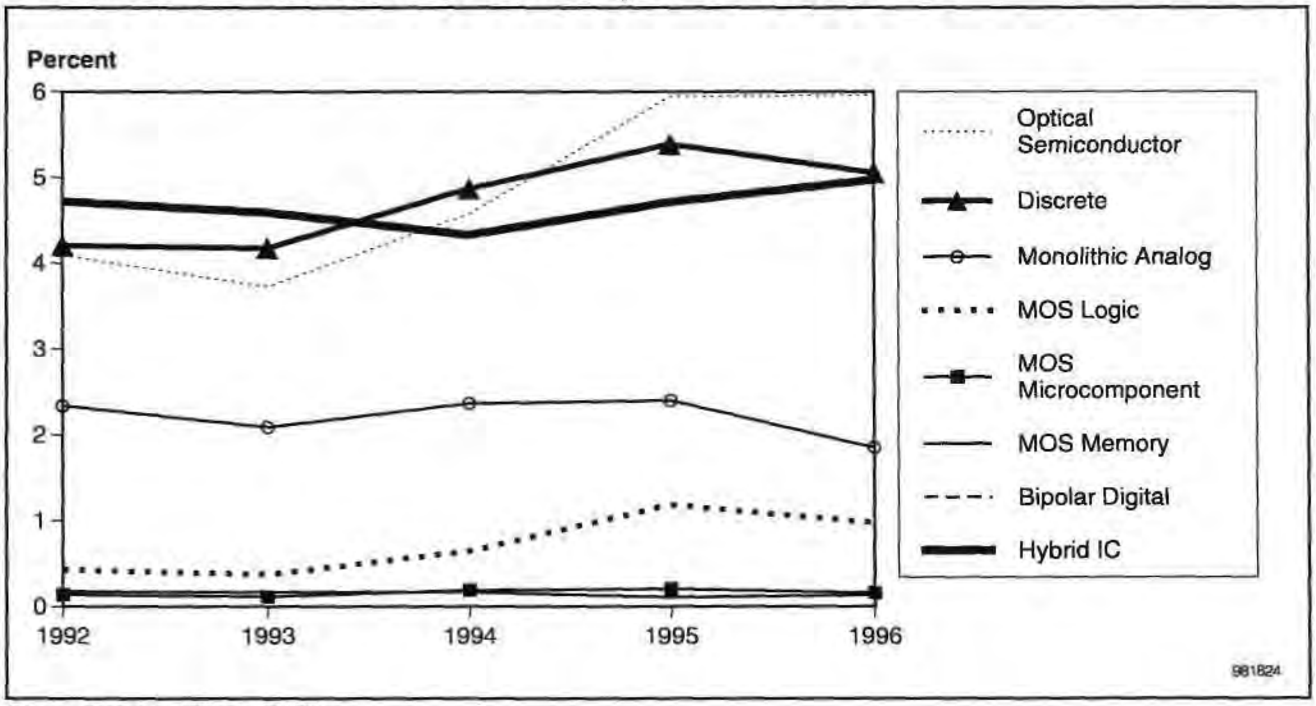
Table A-12
Revenue of Rohm by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	63	68	72	78	73
Bipolar Digital	0	0	0	0	0
MOS Memory	27	39	56	61	51
MOS Microcomponent	20	23	50	71	66
MOS Logic	43	50	104	244	210
Monolithic Analog	238	258	361	423	357
Discrete	343	380	524	771	681
Optical Semiconductor	110	112	178	286	293

Source: Dataquest (March 1998)

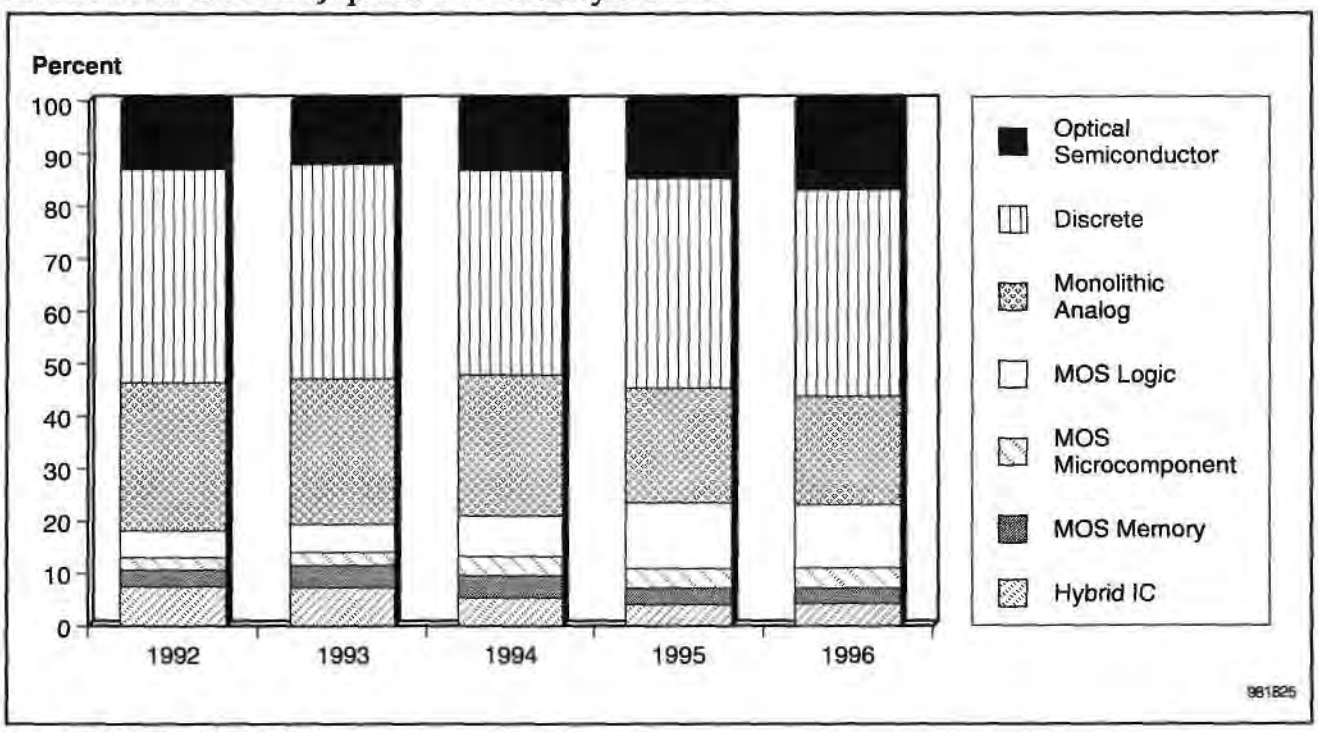
 ©1998 Dataquest

Figure A-56
Rohm's Share of the Worldwide Market by Product, 1992 to 1996



Source: Dataquest (March 1998)

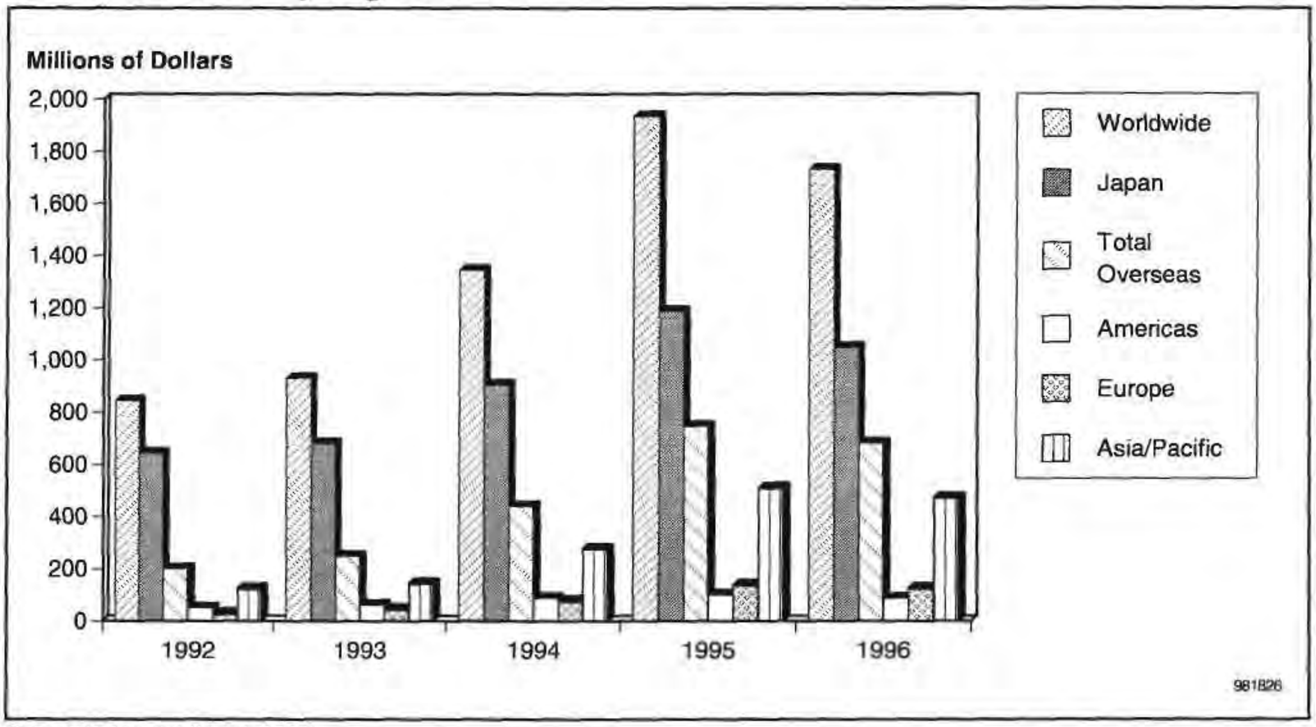
Figure A-57
Rohm's Share of the Japanese Market by Product



Source: Dataquest (March 1998)

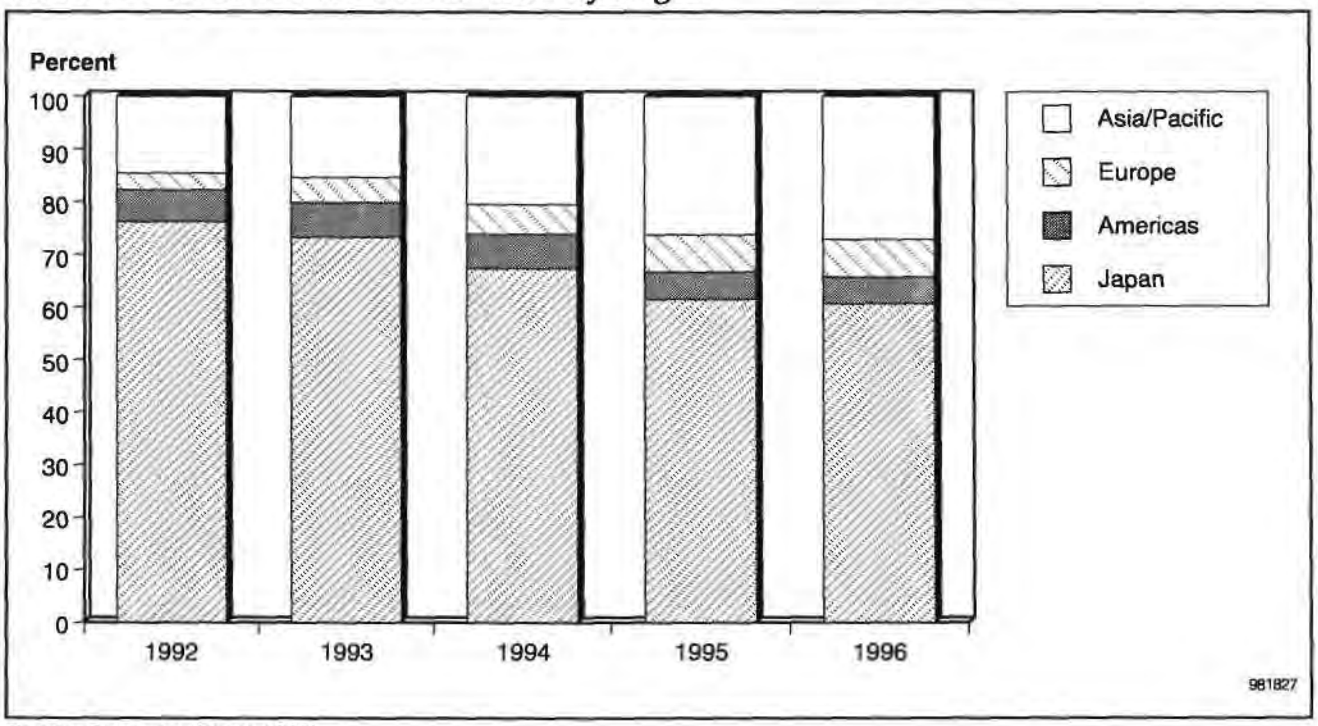
©1998 Dataquest

Figure A-58
Revenue of Rohm by Region



Source: Dataquest (March 1998)

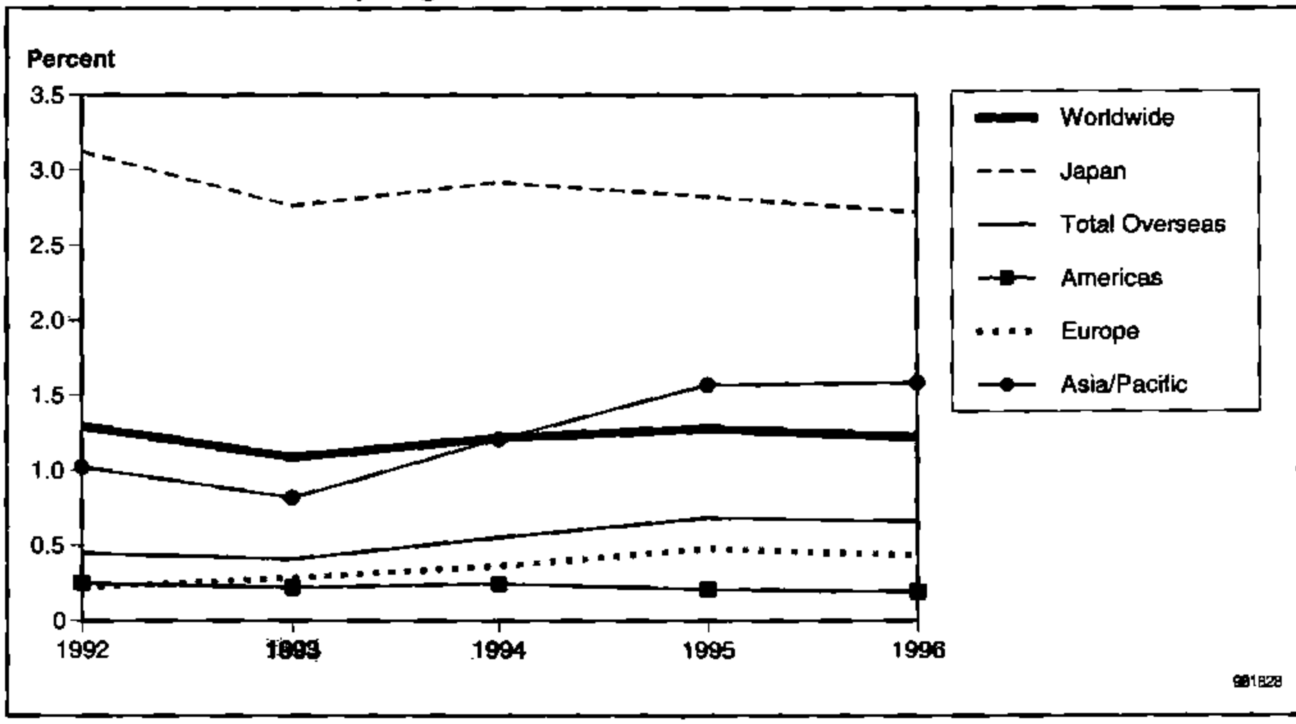
Figure A-59
Rohm's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

 ©1998 Dataquest

Figure A-60
Rohm's Market Share by Region



Source: Dataquest (March 1998)

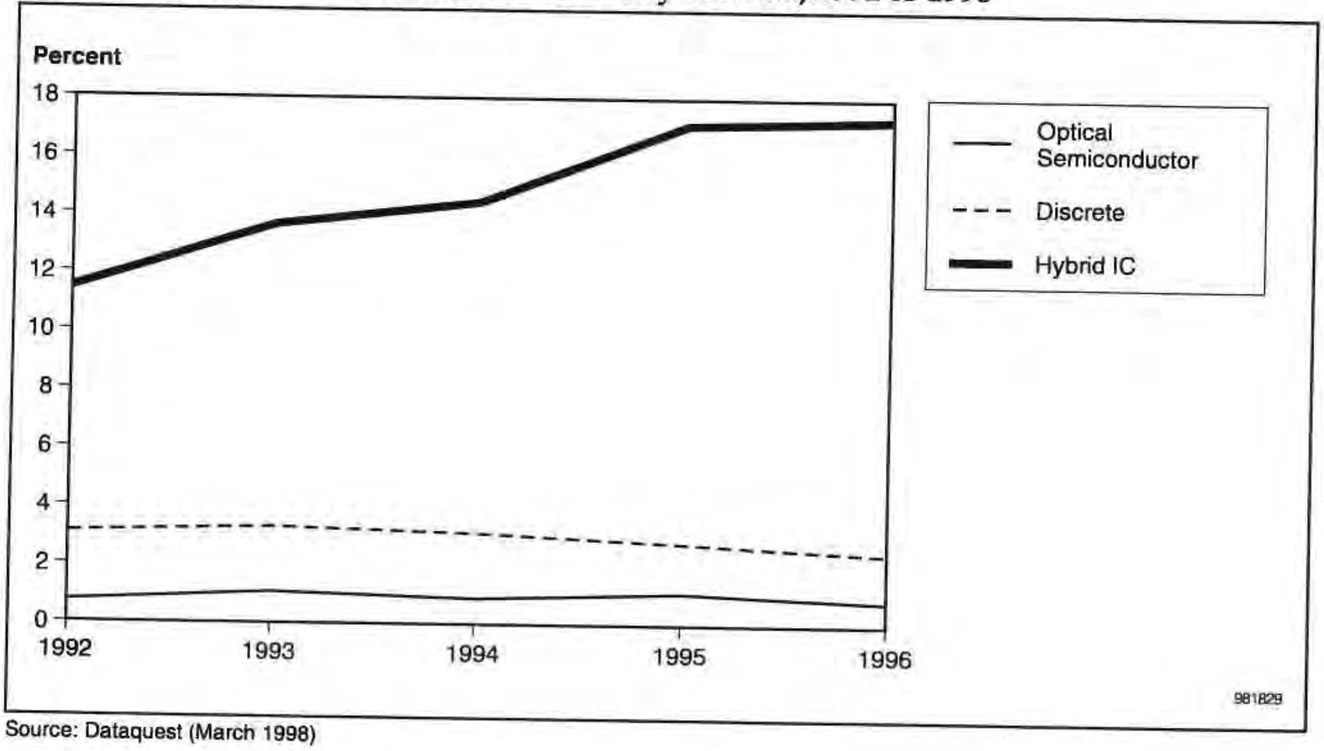
Table A-13
Revenue of Sanken by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	153	202	240	283	254
Bipolar Digital	0	0	0	0	0
MOS Memory	0	0	0	0	0
MOS Microcomponent	0	0	0	0	0
MOS Logic	0	0	0	0	0
Monolithic Analog	0	0	0	0	0
Discrete	253	299	334	398	328
Optical Semiconductor	20	32	34	52	40

Source: Dataquest (March 1998)

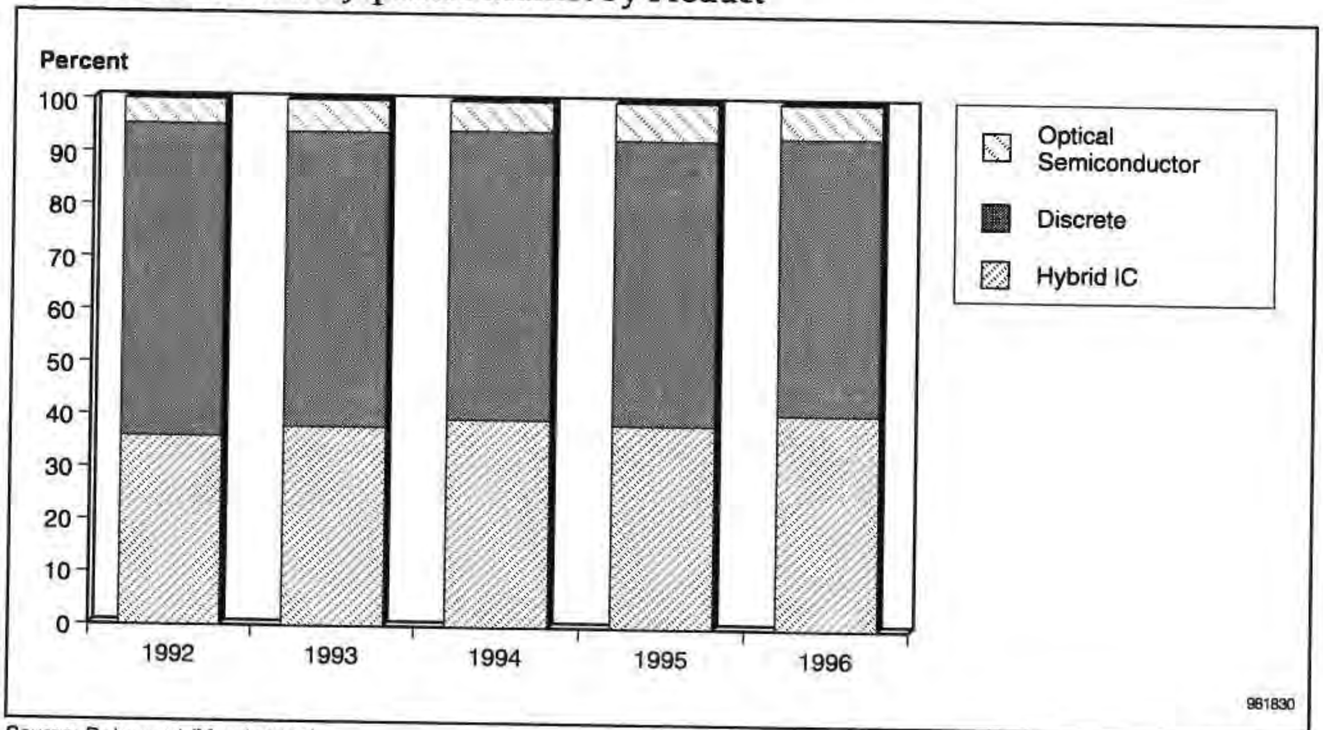
 ©1998 Dataquest

Figure A-61
Sanken's Share of the Worldwide Market by Product, 1992 to 1996



Source: Dataquest (March 1998)

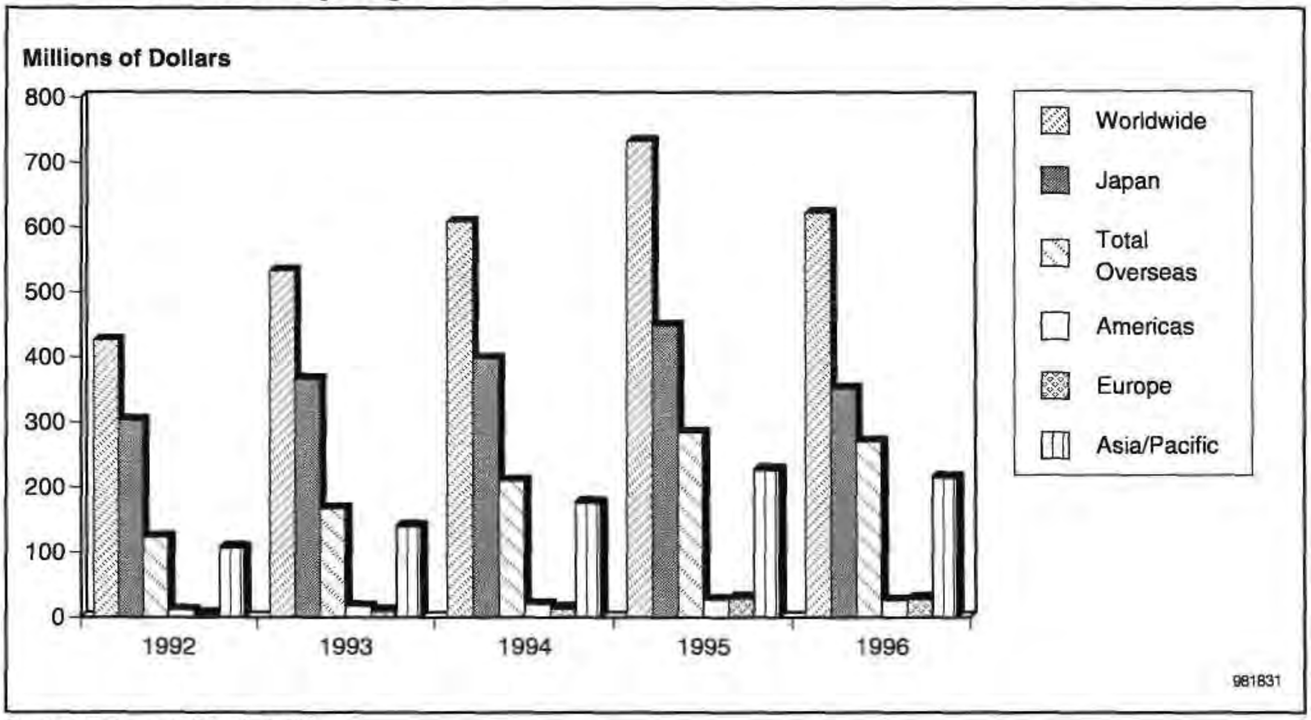
Figure A-62
Sanken's Share of the Japanese Market by Product



Source: Dataquest (March 1998)

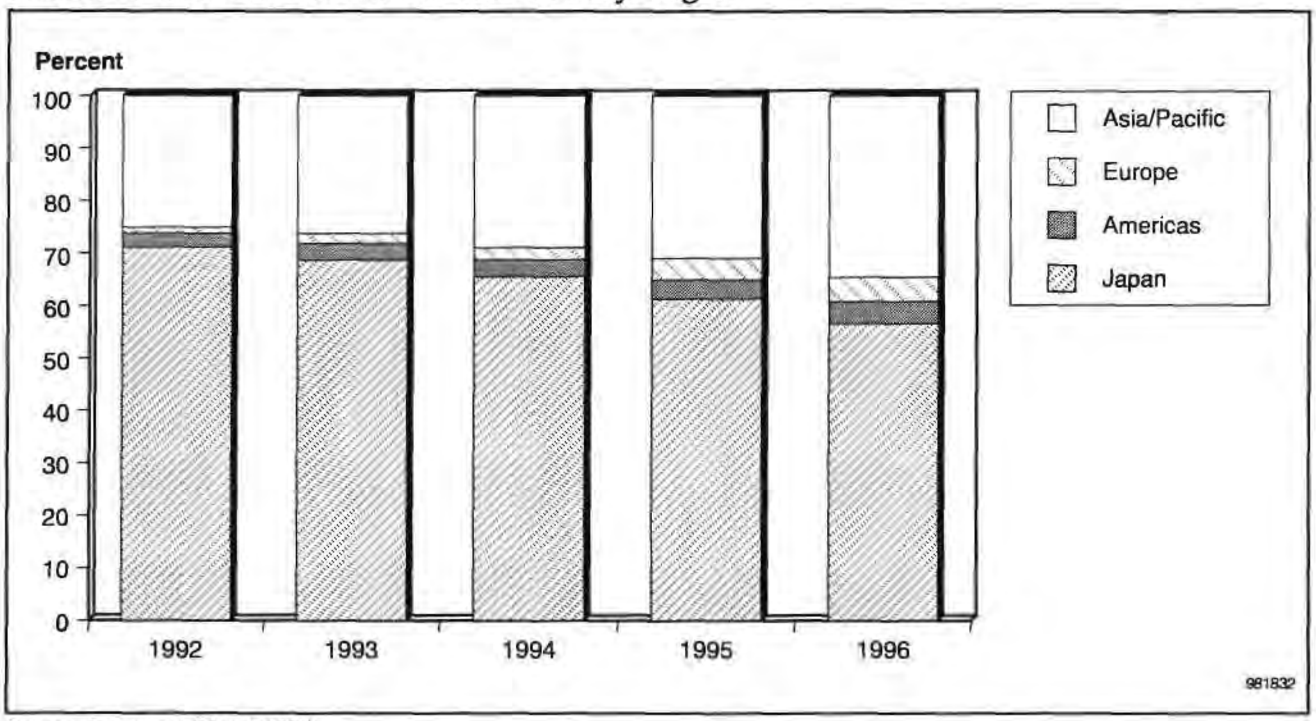
©1998 Dataquest

Figure A-63
Revenue of Sanken by Region



Source: Dataquest (March 1998)

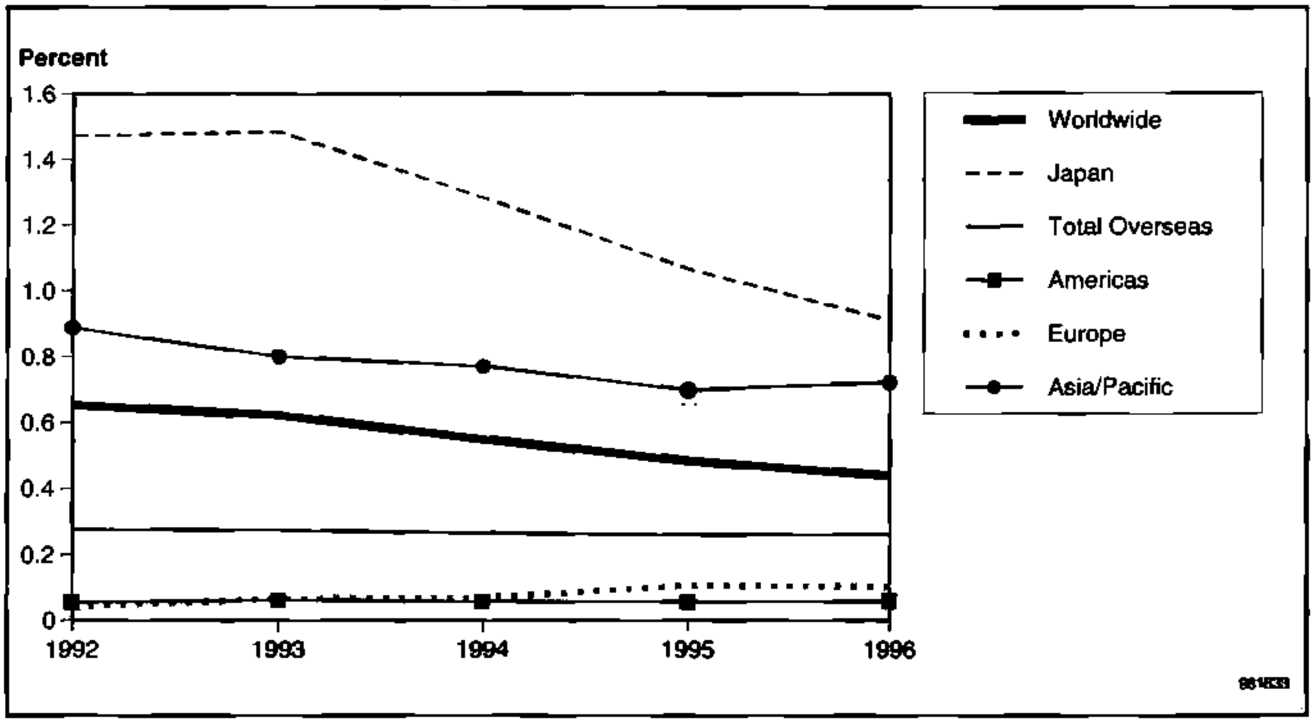
Figure A-64
Sanken's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

 ©1998 Dataquest

Figure A-65
Sanken's Market Share by Region



Source: Dataquest (March 1998)

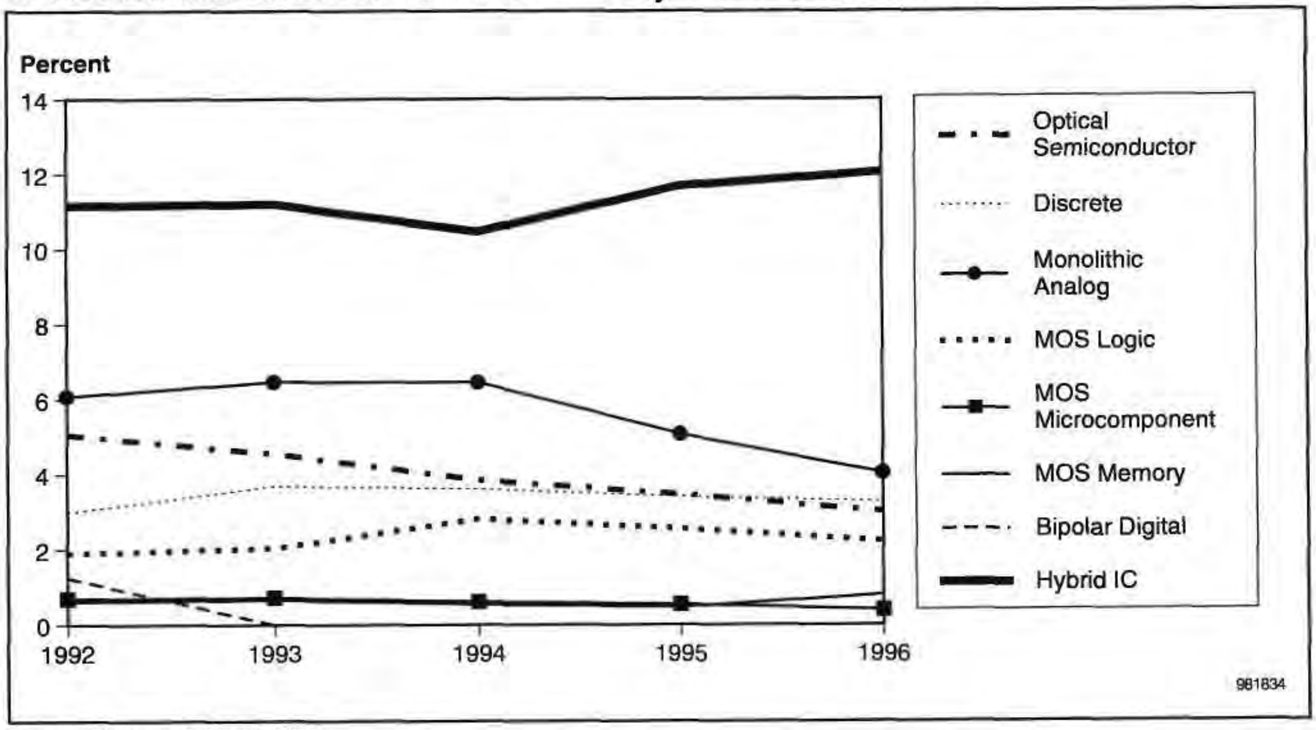
Table A-14
Revenue of SANYO by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	149	166	174	193	177
Bipolar Digital	40	0	0	0	0
MOS Memory	95	155	183	257	302
MOS Microcomponent	100	145	161	187	164
MOS Logic	191	271	453	528	479
Monolithic Analog	430	633	811	894	780
Discrete	244	336	389	488	441
Optical Semiconductor	136	137	150	167	148

Source: Dataquest (March 1998)

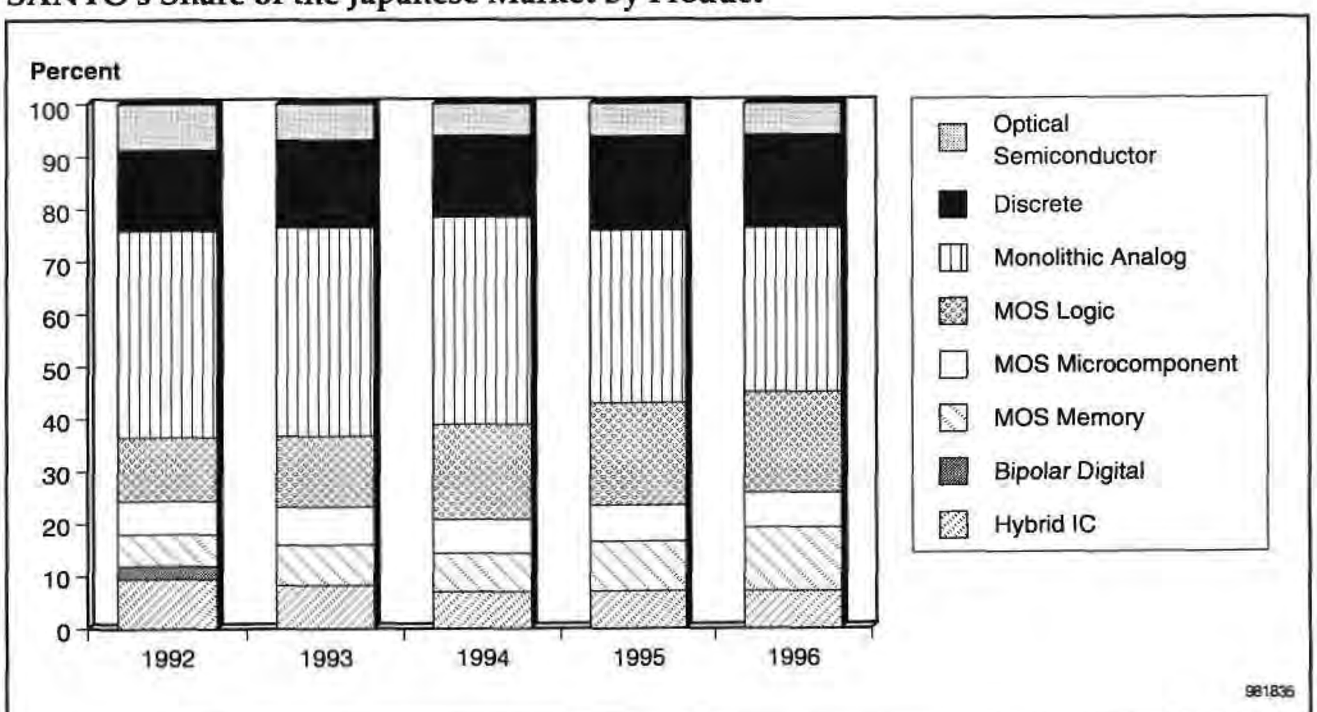
 ©1998 Dataquest

Figure A-66
SANYO's Share of the Worldwide Market by Product, 1992 to 1996



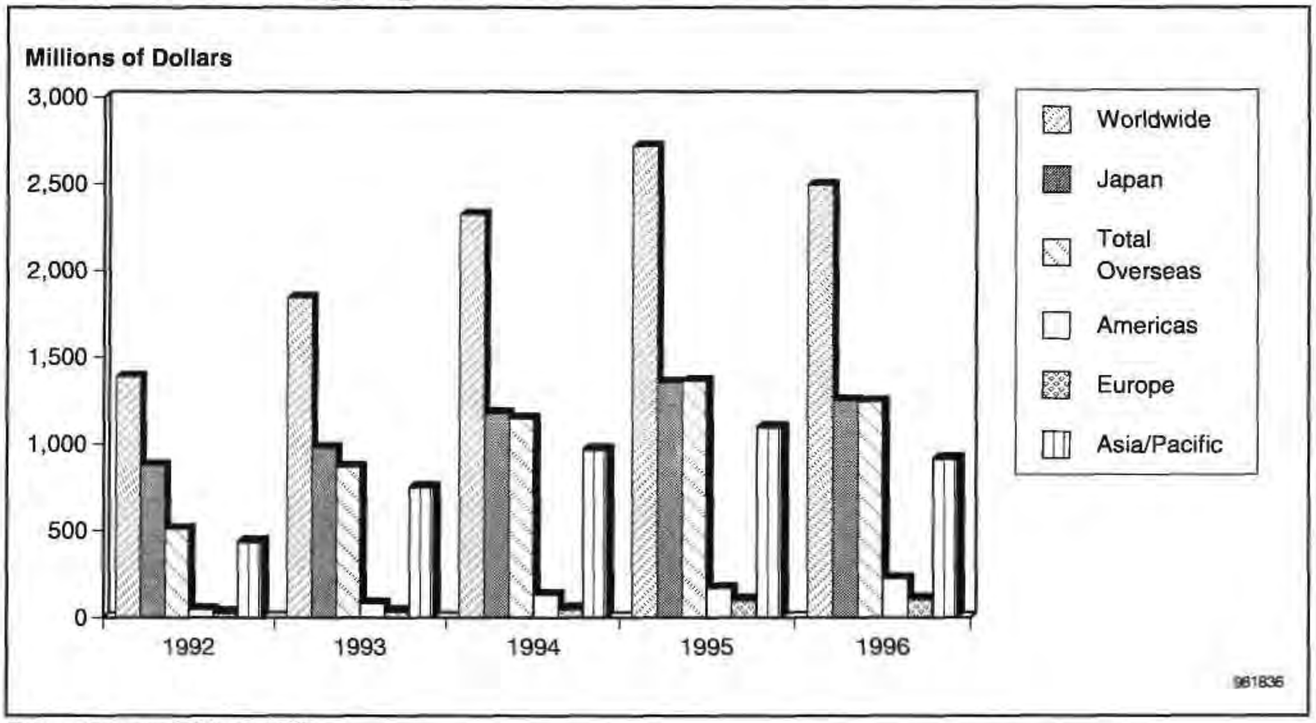
Source: Dataquest (March 1998)

Figure A-67
SANYO's Share of the Japanese Market by Product



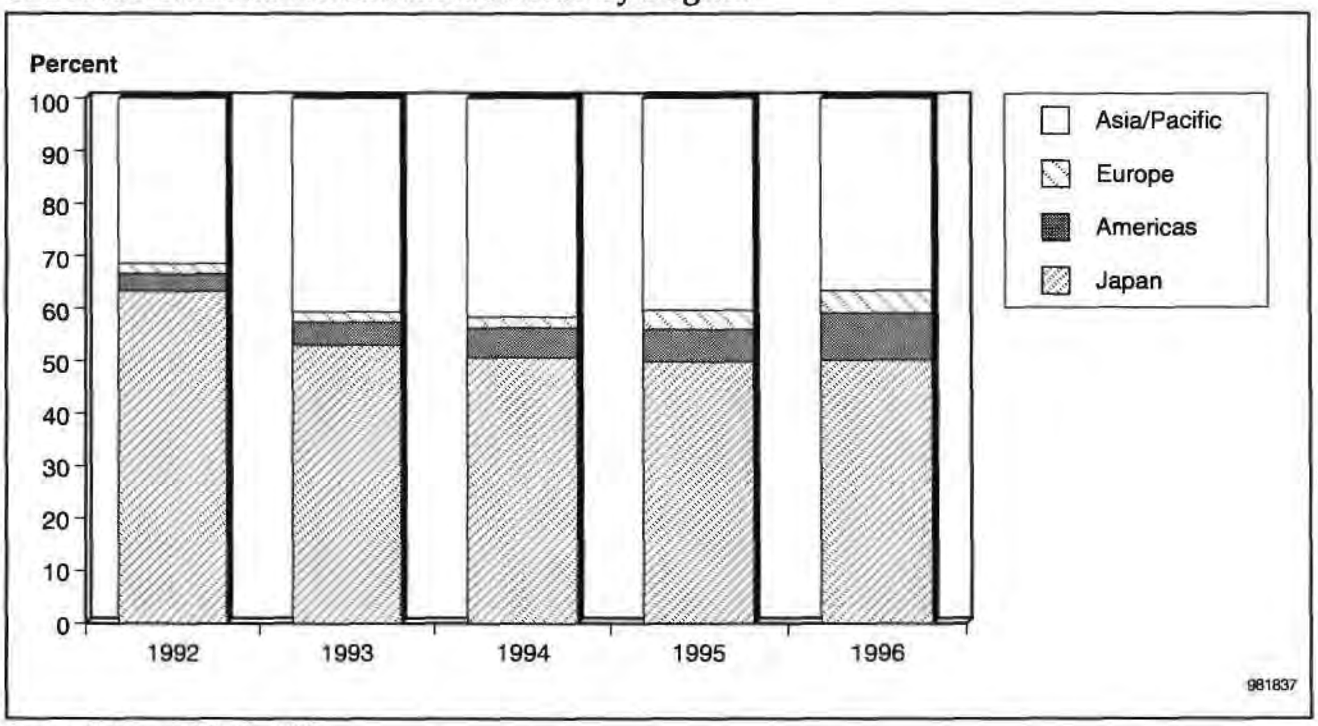
Source: Dataquest (March 1998)

Figure A-68
Revenue of SANYO by Region



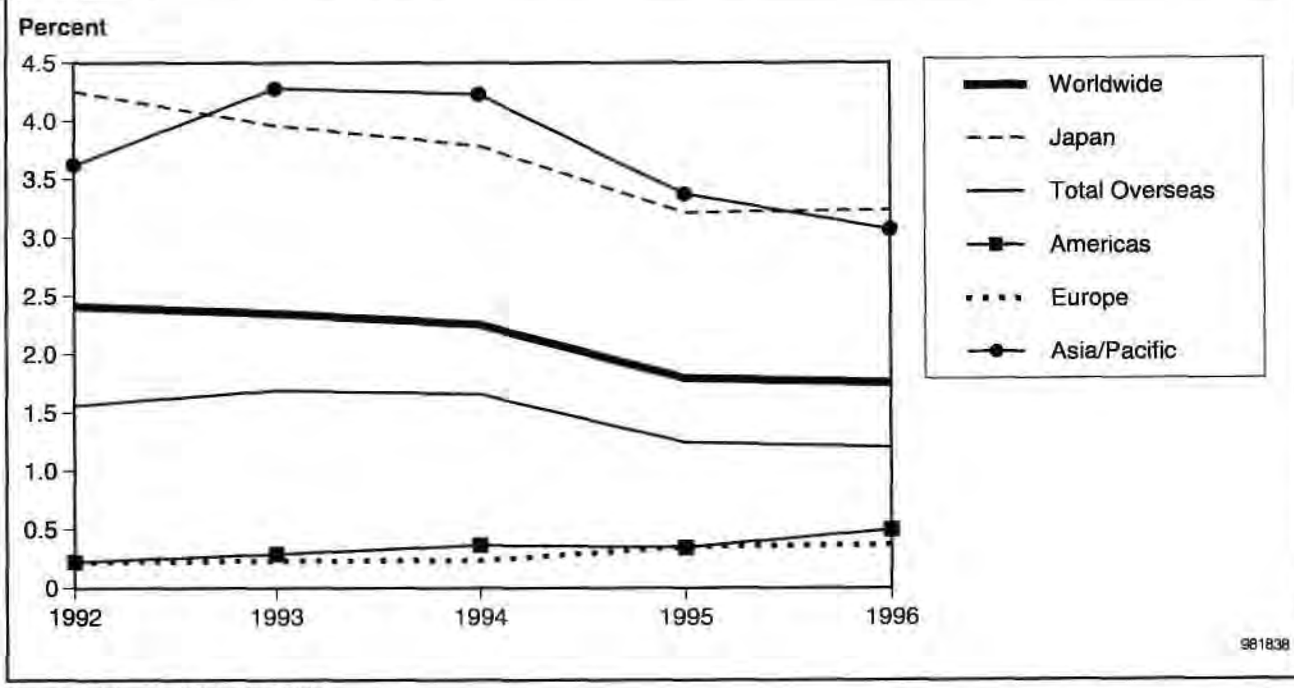
Source: Dataquest (March 1998)

Figure A-69
SANYO's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-70
SANYO's Market Share by Region



Source: Dataquest (March 1998)

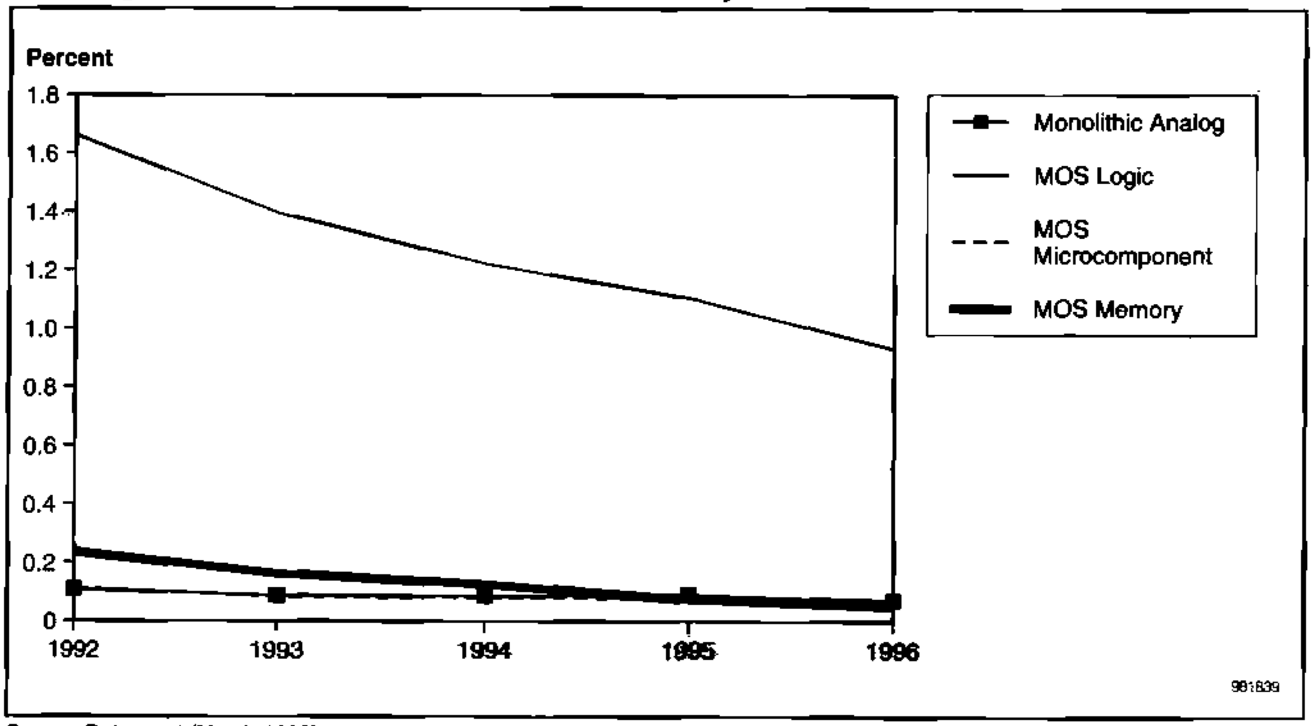
Table A-15
Revenue of Seiko Epson by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	0	0	0	0	0
Bipolar Digital	0	0	0	0	0
MOS Memory	36	38	42	41	19
MOS Microcomponent	16	17	21	28	22
MOS Logic	167	186	197	228	201
Monolithic Analog	11	11	13	16	14
Discrete	0	0	0	0	0
Optical Semiconductor	0	0	0	0	0

Source: Dataquest (March 1998)

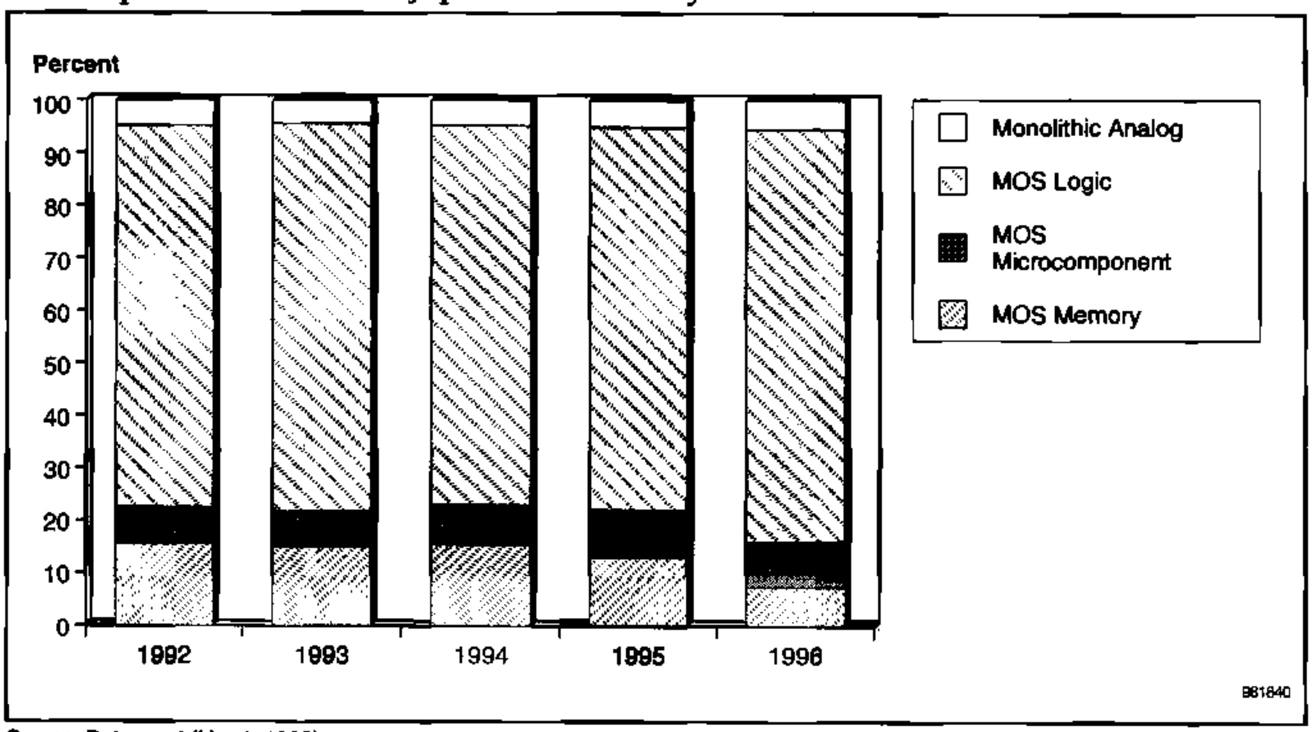
 ©1998 Dataquest

Figure A-71
Seiko Epson's Share of the Worldwide Market by Product, 1992 to 1996



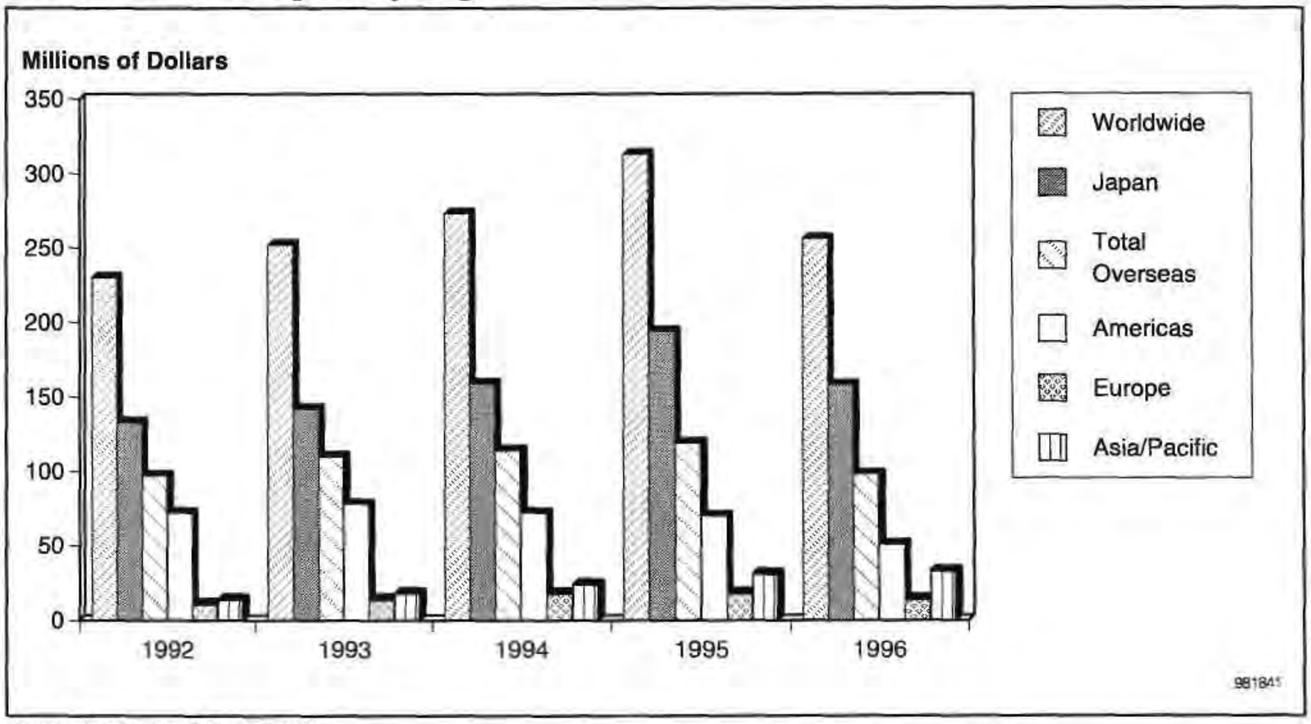
Source: Dataquest (March 1998)

Figure A-72
Seiko Epson's Share of the Japanese Market by Product



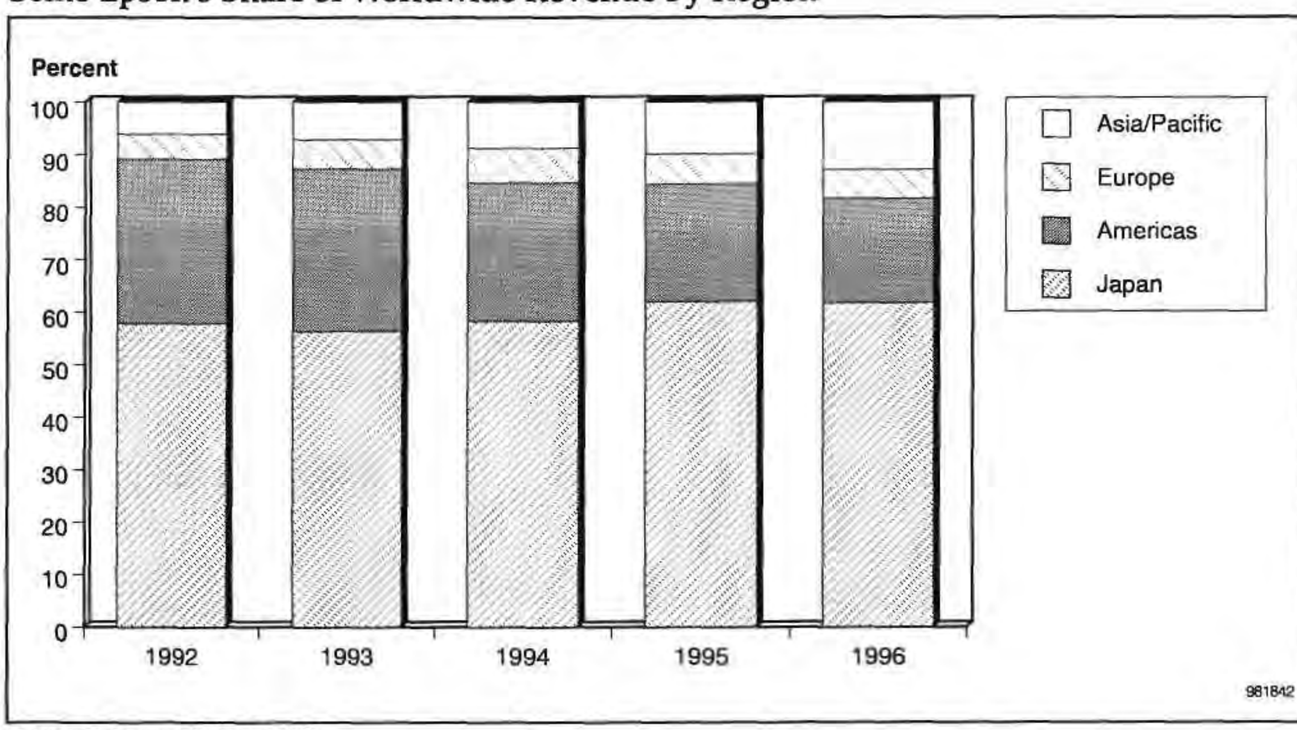
Source: Dataquest (March 1998)

Figure A-73
Revenue of Seiko Epson by Region



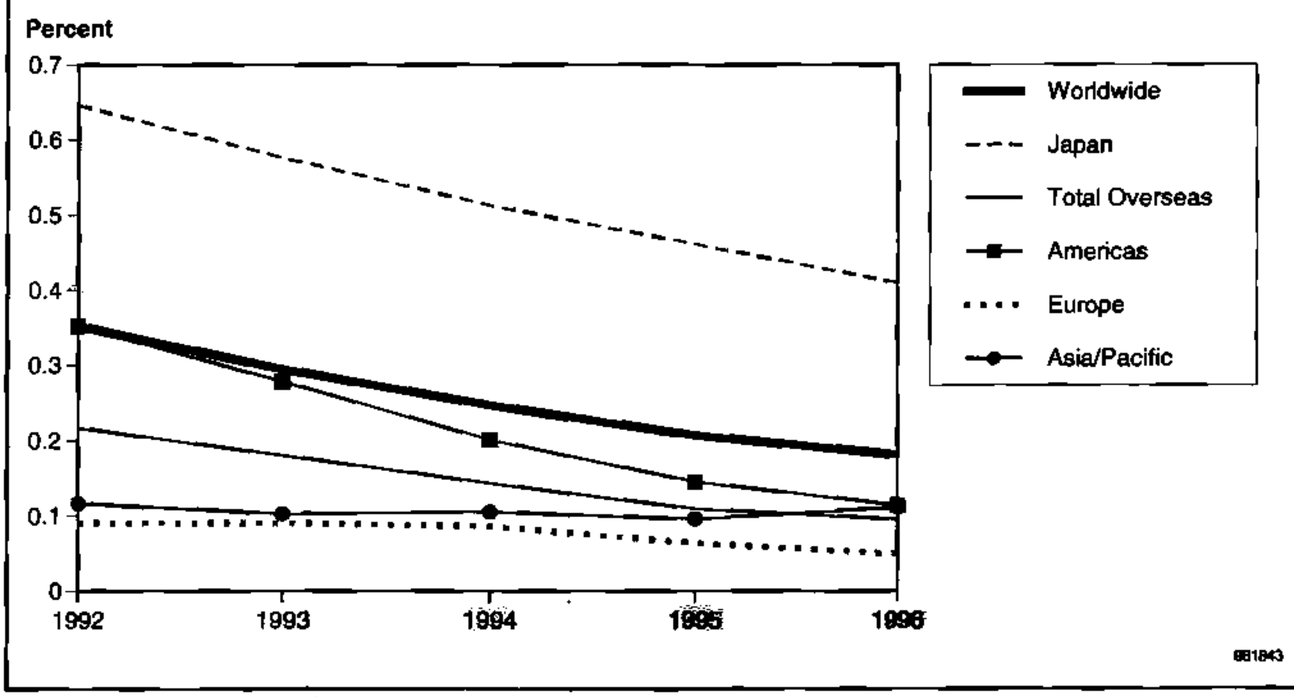
Source: Dataquest (March 1998)

Figure A-74
Seiko Epson's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-75
Seiko Epson's Market Share by Region



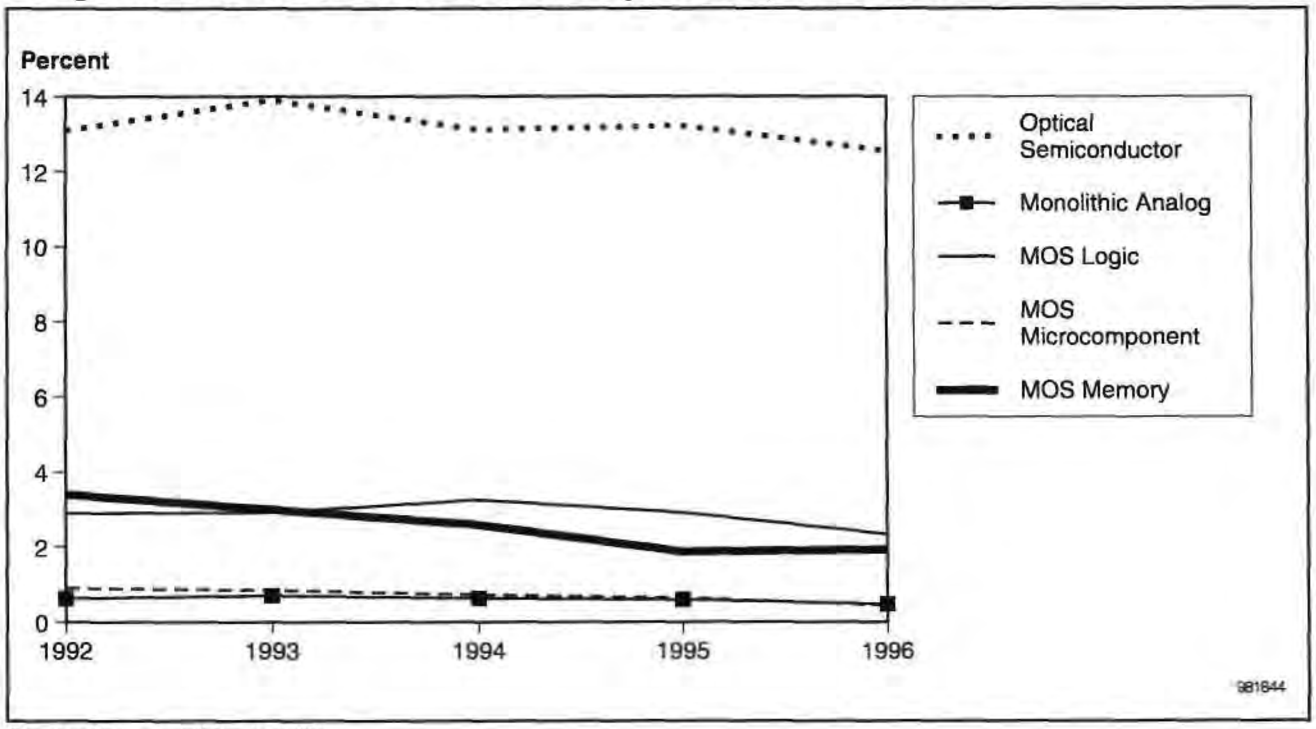
Source: Dataquest (March 1998)

Table A-16
Revenue of Sharp by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	0	0	0	0	0
Bipolar Digital	0	0	0	0	0
MOS Memory	519	697	867	1,030	727
MOS Microcomponent	129	170	192	221	184
MOS Logic	290	388	523	600	504
Monolithic Analog	64	87	96	105	92
Discrete	0	0	0	0	0
Optical Semiconductor	352	418	510	636	617

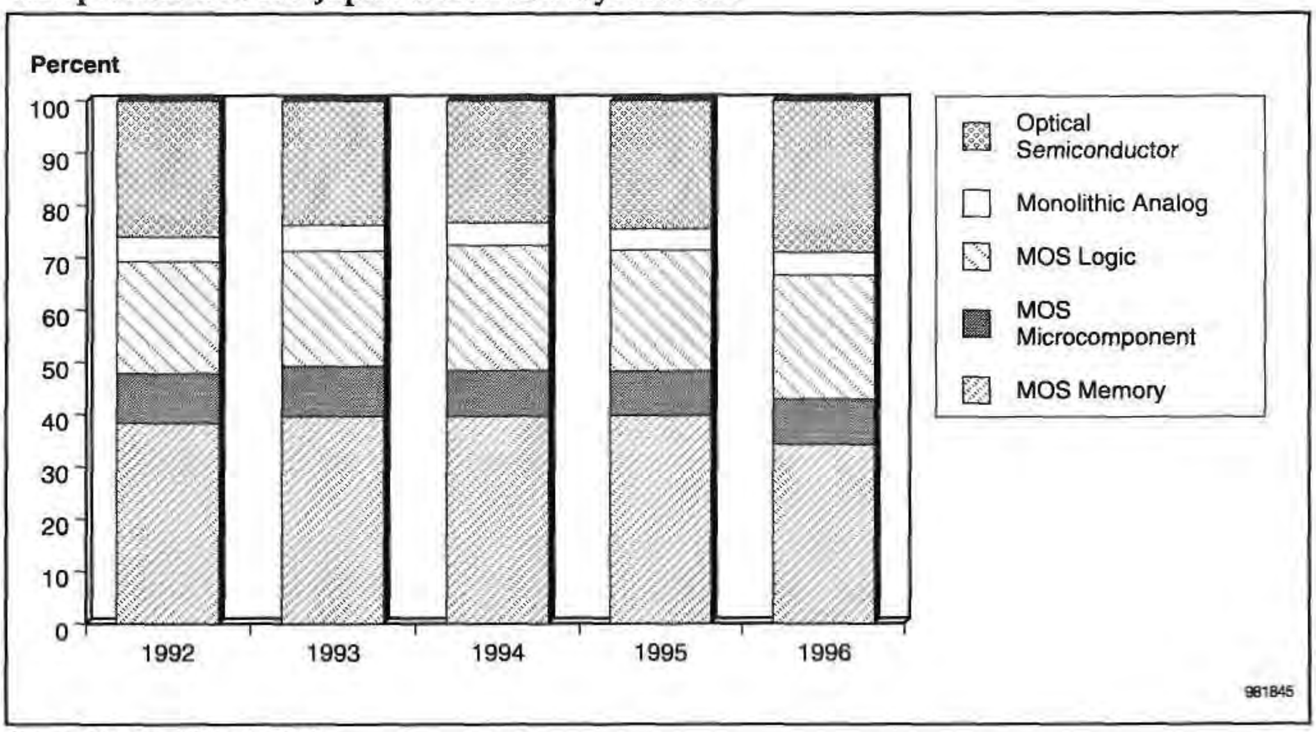
Source: Dataquest (March 1998)

Figure A-76
Sharp's Share of the Worldwide Market by Product, 1992 to 1996



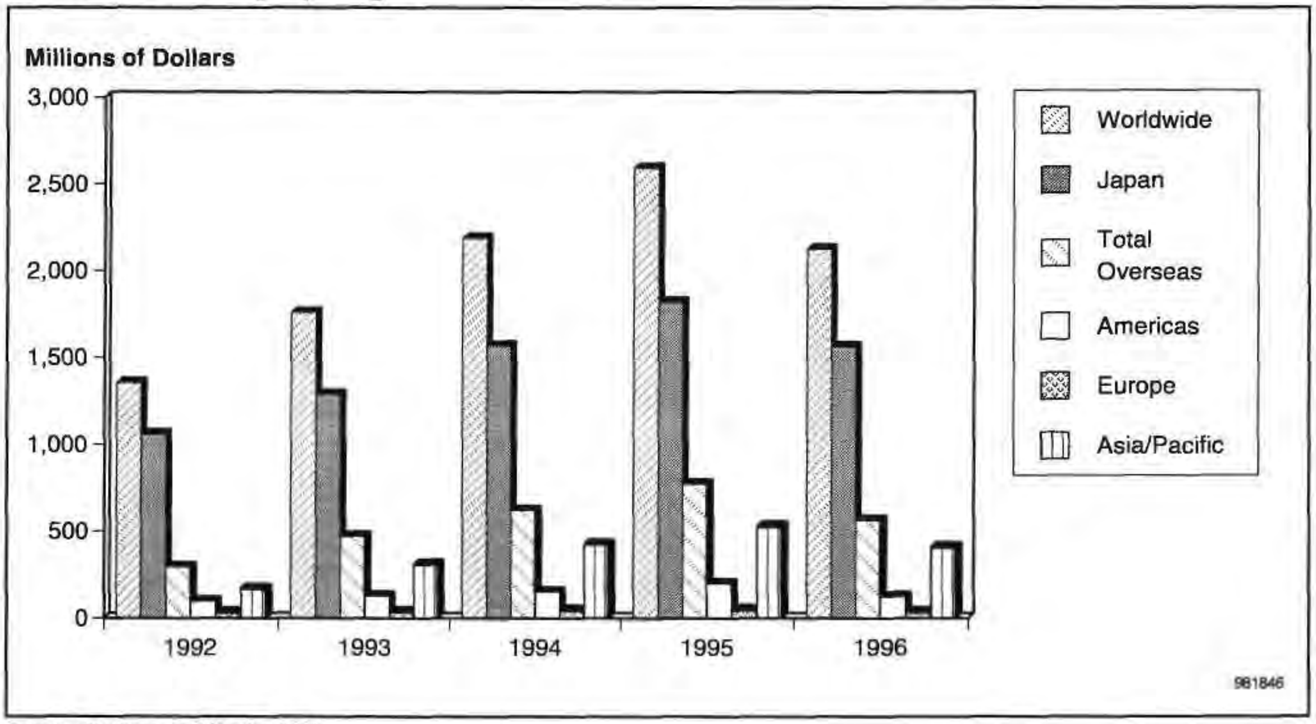
Source: Dataquest (March 1998)

Figure A-77
Sharp's Share of the Japanese Market by Product



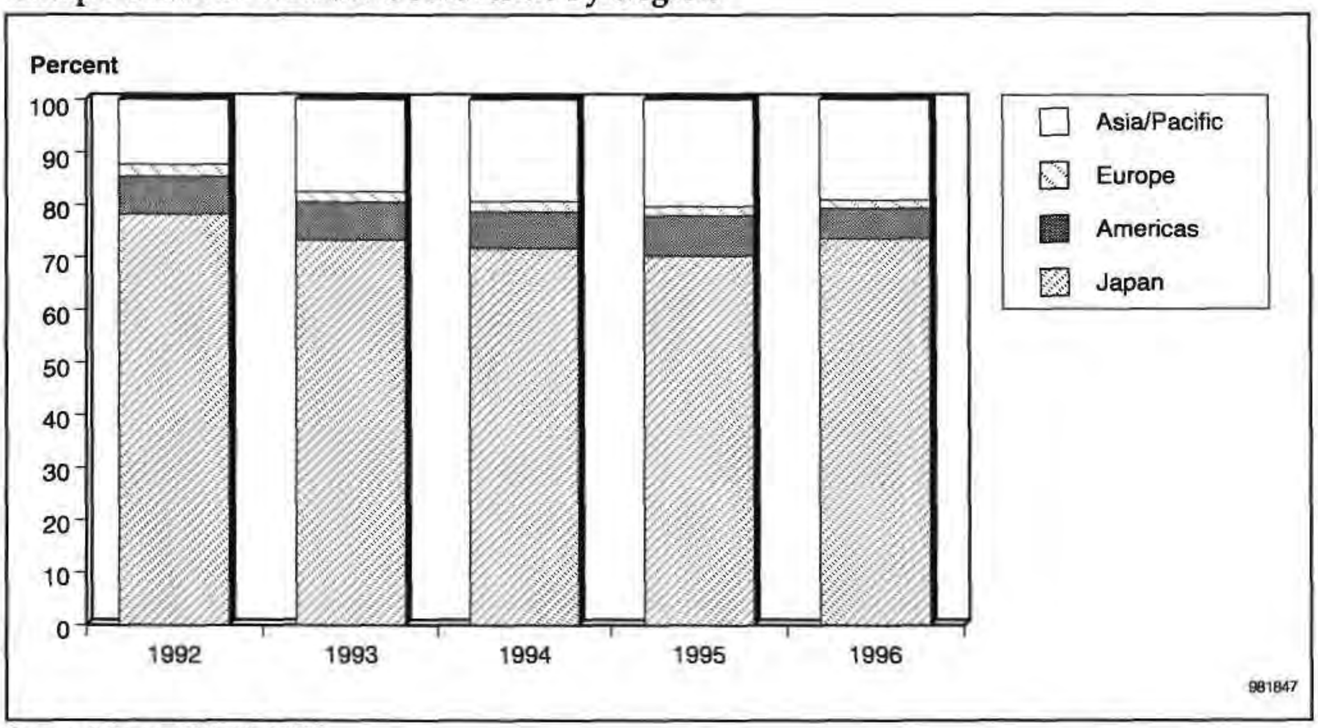
Source: Dataquest (March 1998)

Figure A-78
Revenue of Sharp by Region



Source: Dataquest (March 1998)

Figure A-79
Sharp's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

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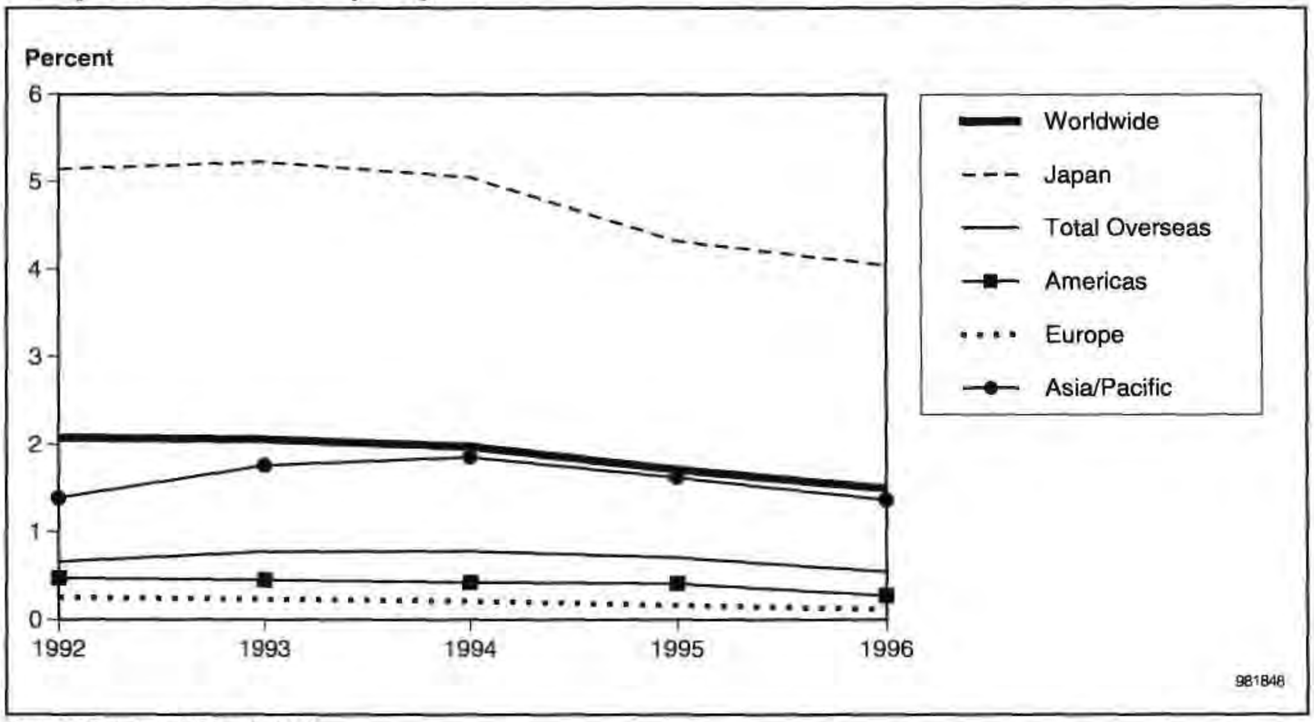
Figure A-80
Sharp's Market Share by Region



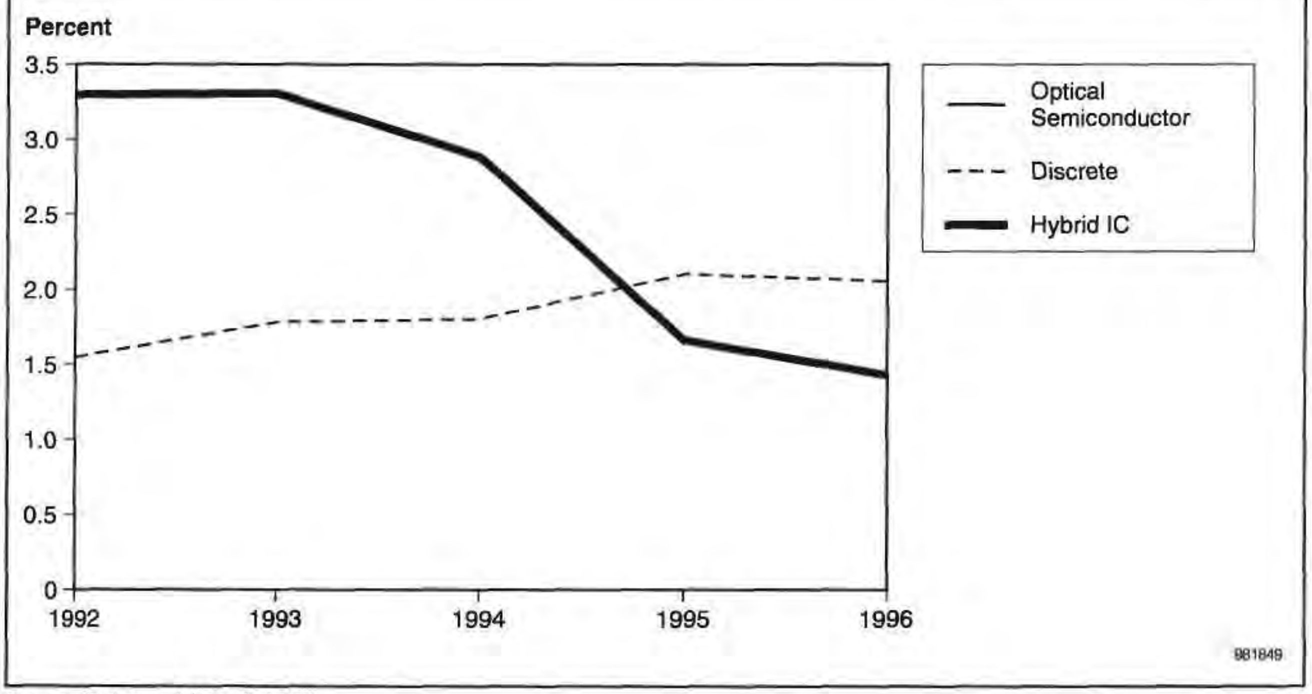
Source: Dataquest (March 1998)

Table A-17
Revenue of Shindengen Electric by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	44	49	48	28	21
Bipolar Digital	0	0	0	0	0
MOS Memory	0	0	0	0	0
MOS Microcomponent	0	0	0	0	0
MOS Logic	0	0	0	0	0
Monolithic Analog	0	0	0	0	0
Discrete	126	162	194	301	277
Optical Semiconductor	0	0	0	0	0

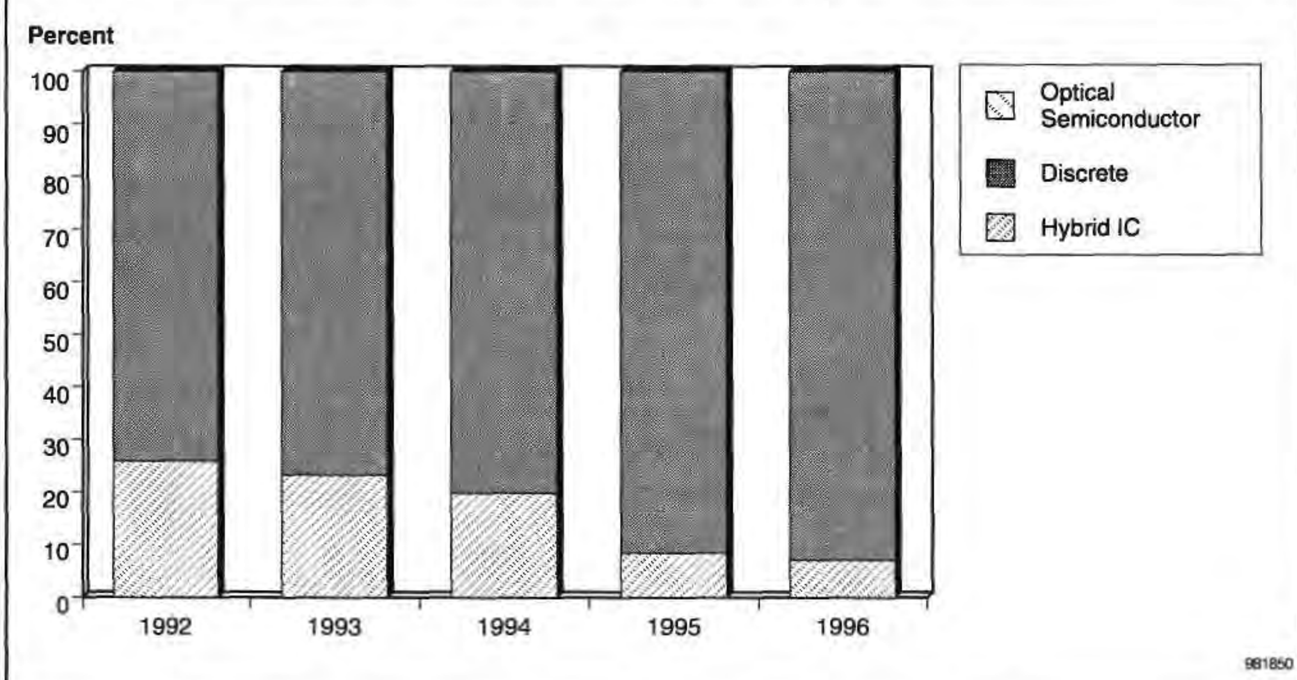
Source: Dataquest (March 1998)

Figure A-81
Shindengen Electric's Share of the Worldwide Market by Product, 1992 to 1996



Source: Dataquest (March 1998)

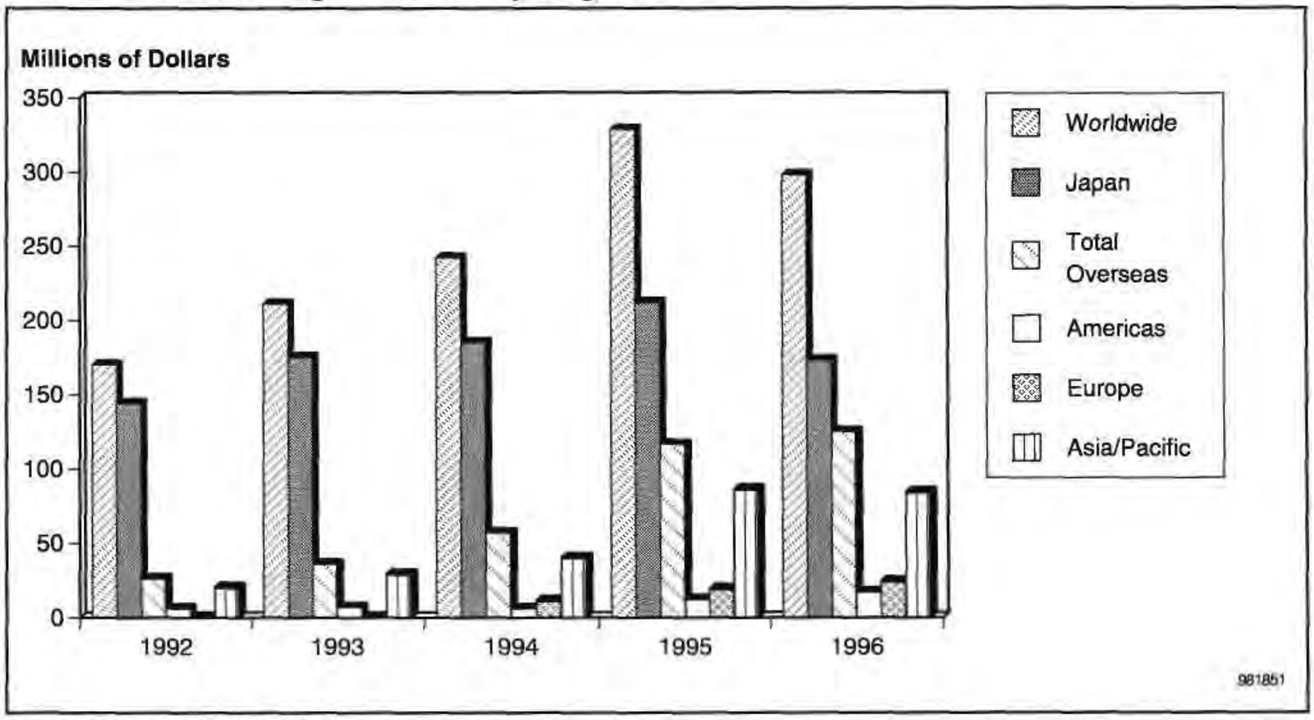
Figure A-82
Shindengen Electric's Share of the Japanese Market by Product



Source: Dataquest (March 1998)

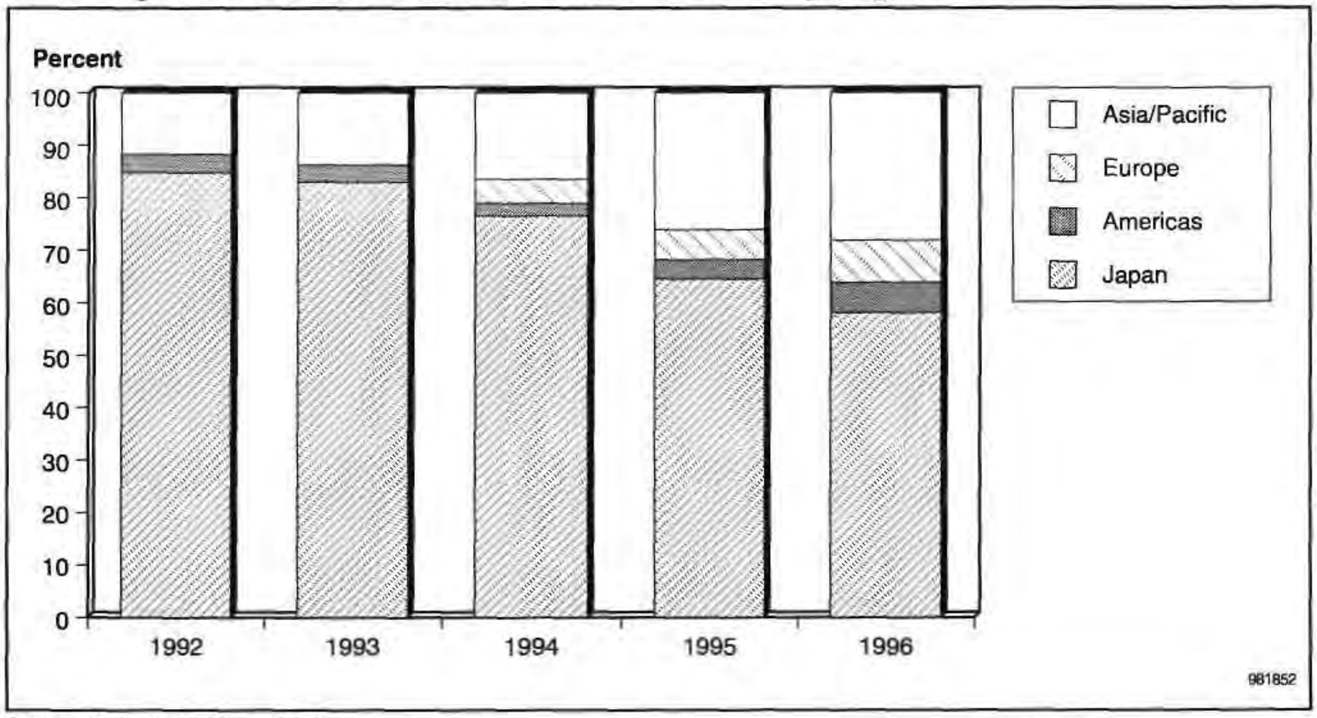
 ©1998 Dataquest

Figure A-83
Revenue of Shindengen Electric by Region



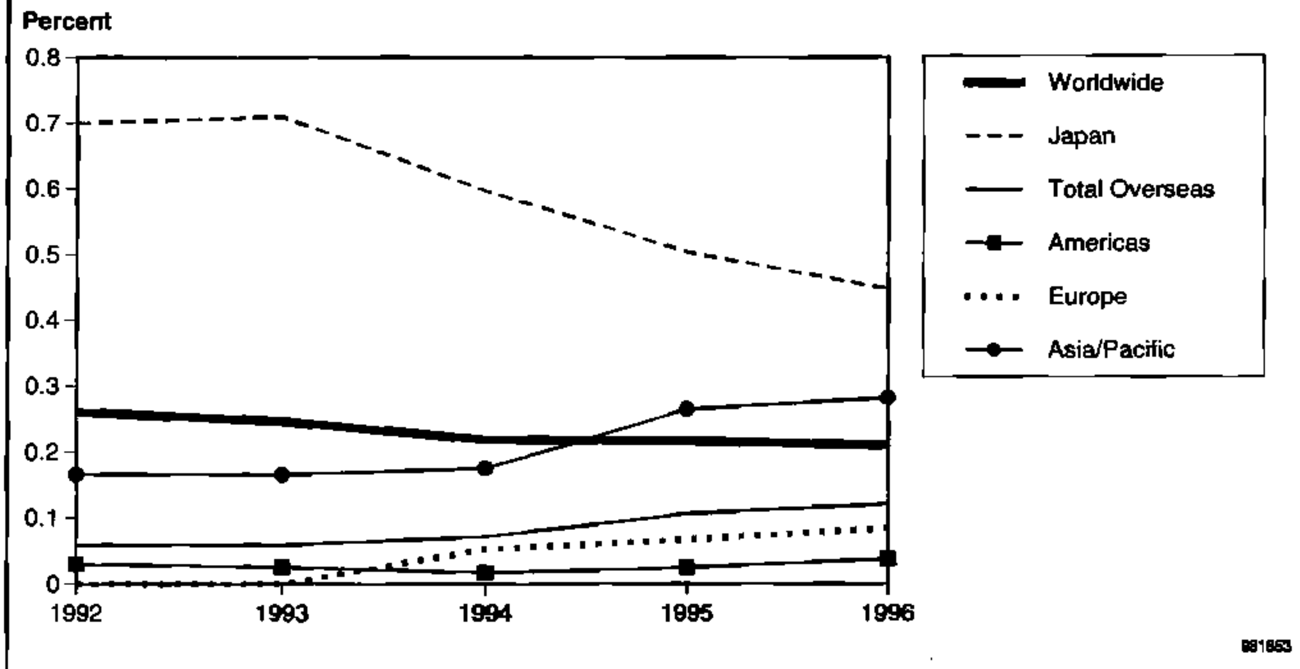
Source: Dataquest (March 1998)

Figure A-84
Shindengen Electric's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-85
Shindengen Electric's Market Share by Region



Source: Dataquest (March 1998)

Table A-18
Revenue of Sony by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	33	36	41	41	65
Bipolar Digital	1	0	0	0	0
MOS Memory	197	287	387	489	330
MOS Microcomponent	73	112	194	233	189
MOS Logic	165	213	426	581	531
Monolithic Analog	339	425	465	554	452
Discrete	79	89	50	53	43
Optical Semiconductor	216	236	313	382	373

Source: Dataquest (March 1998)

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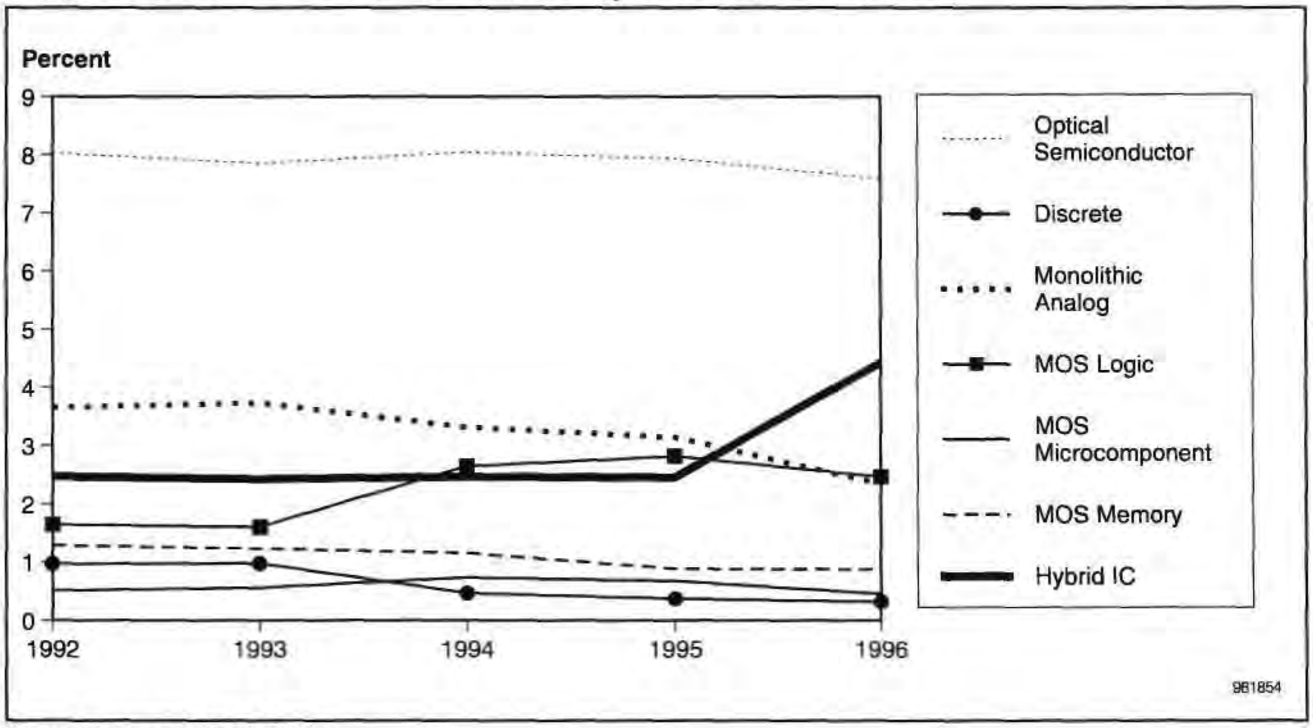
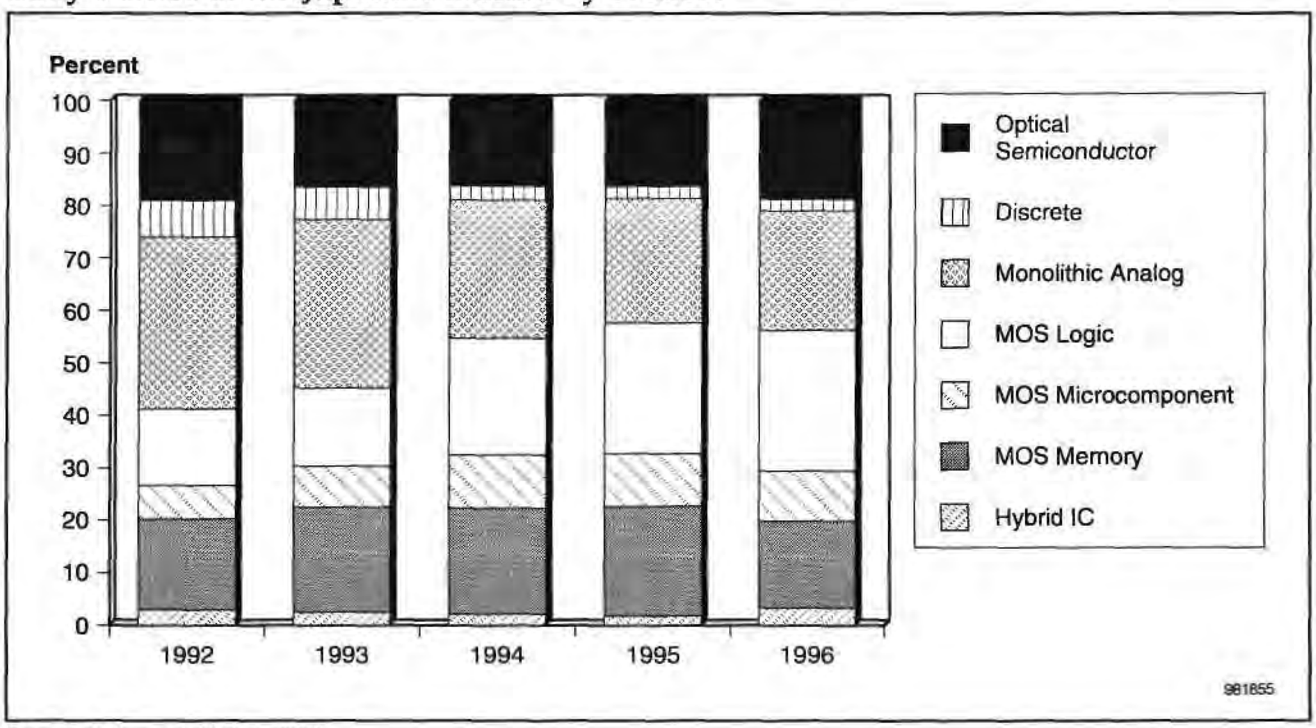
Figure A-86
Sony's Share of the Worldwide Market by Product, 1992 to 1996



Source: Dataquest (March 1998)

Figure A-87
Sony's Share of the Japanese Market by Product



Source: Dataquest (March 1998)

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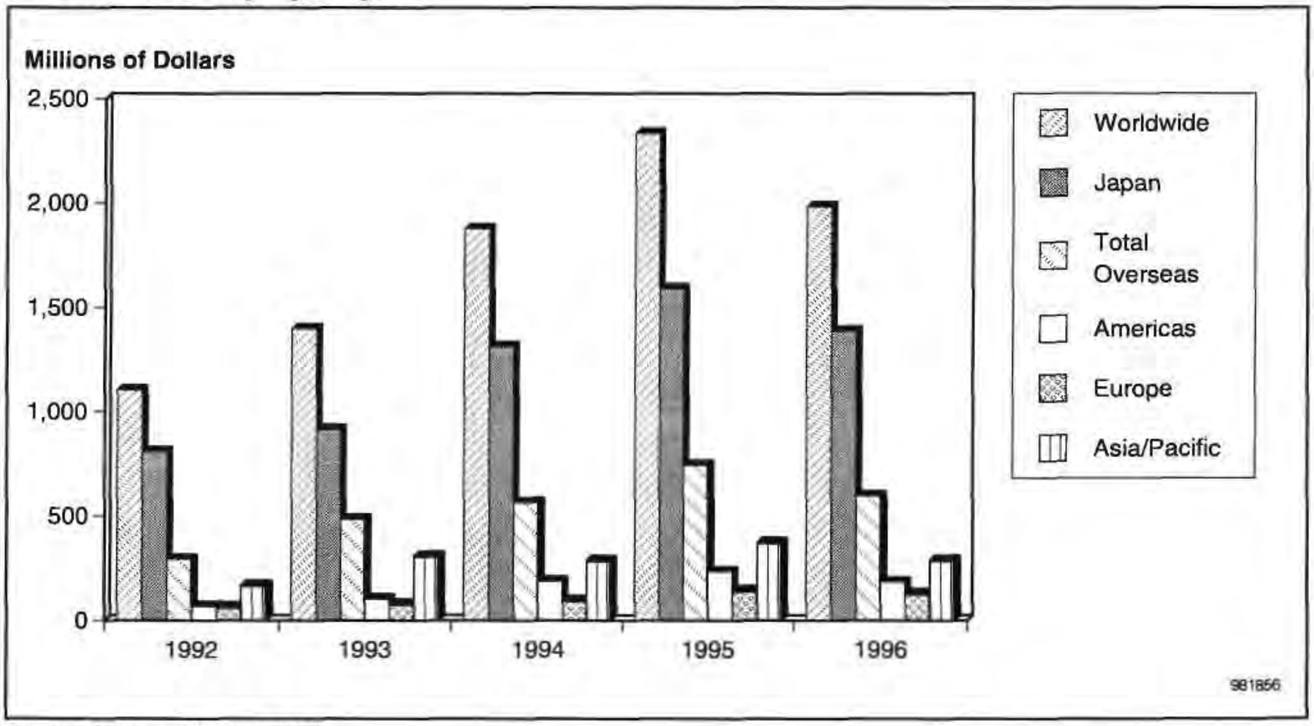
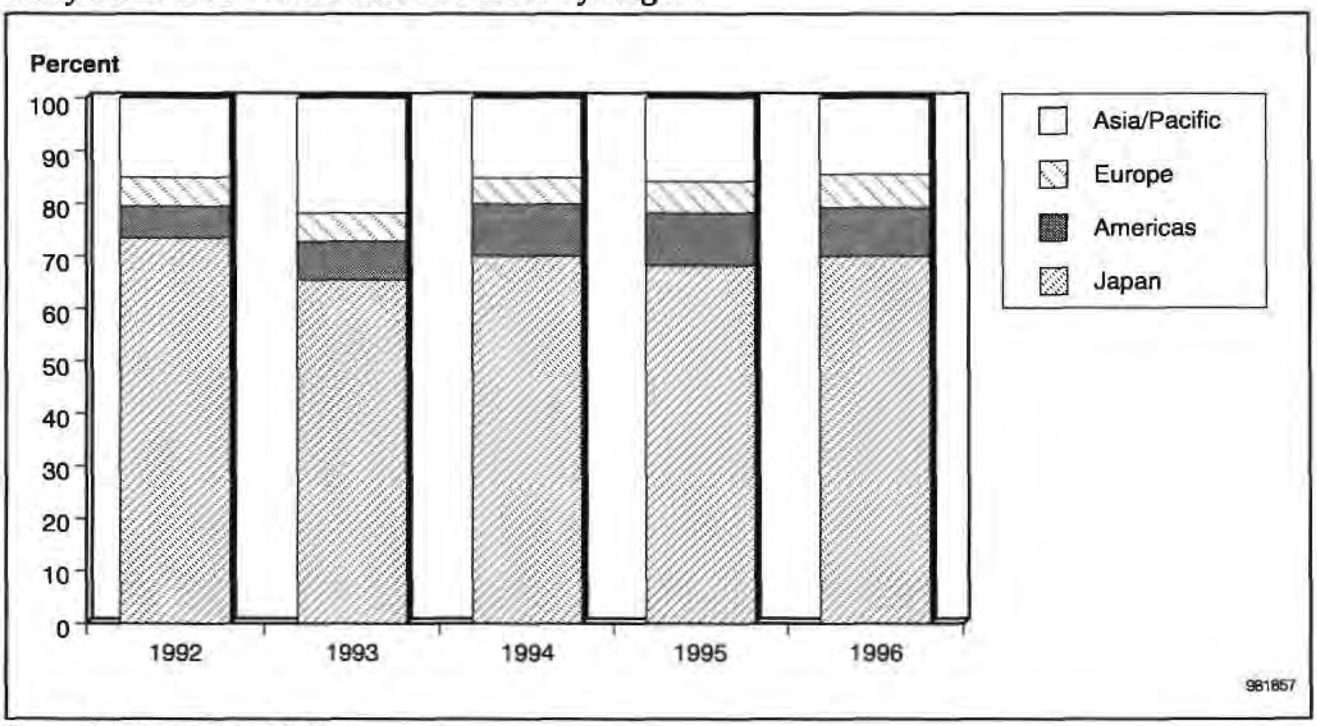
Figure A-88
Revenue of Sony by Region



Source: Dataquest (March 1998)

Figure A-89
Sony's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

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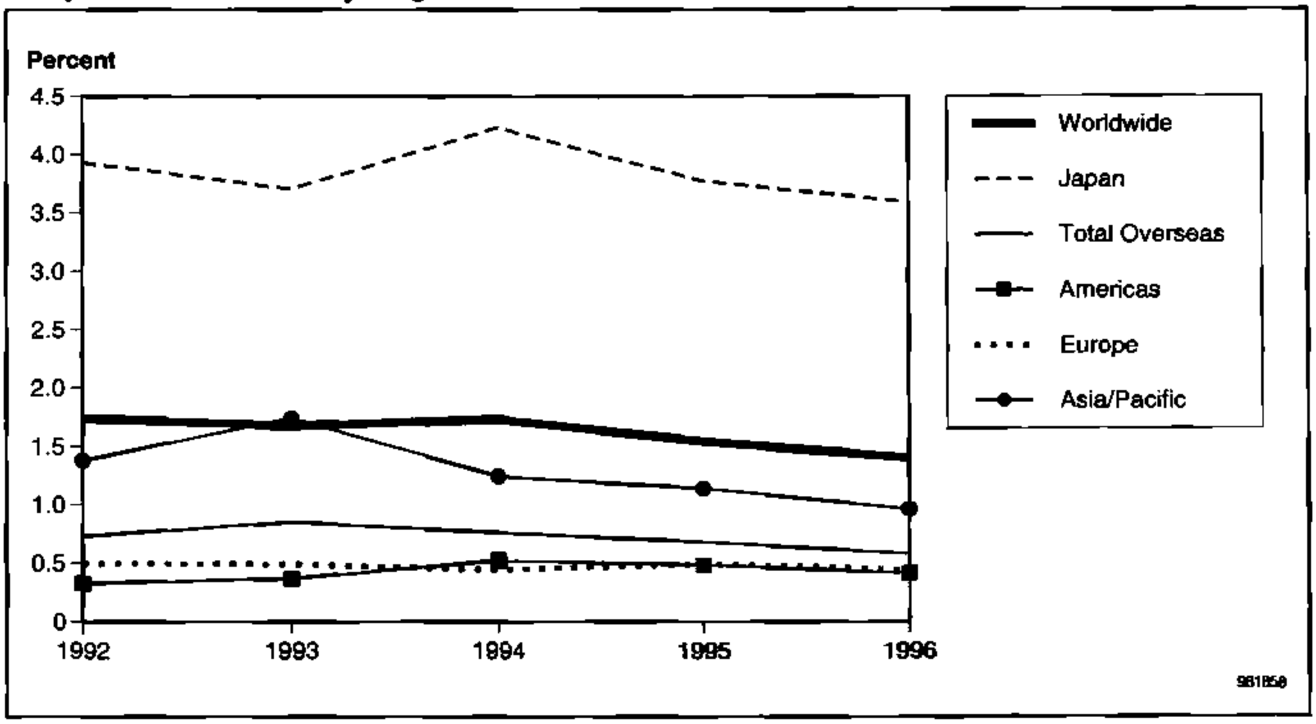
Figure A-90
Sony's Market Share by Region



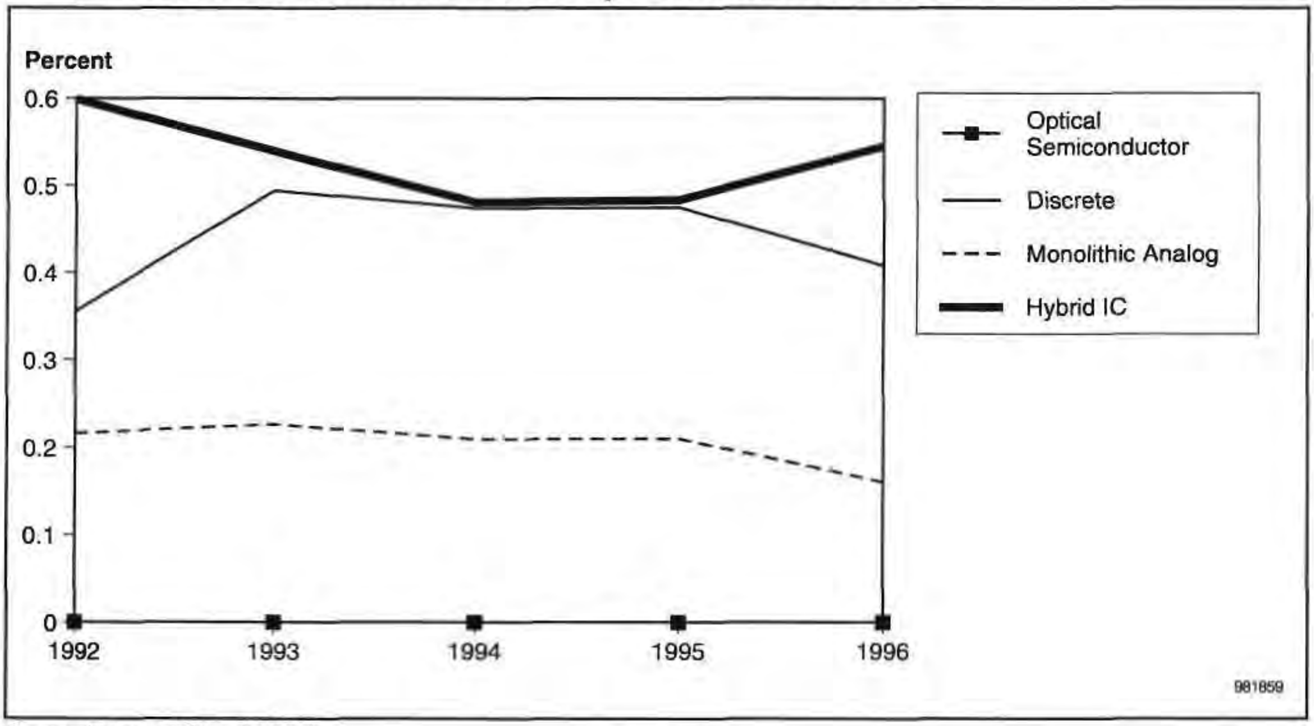
Source: Dataquest (March 1998)

Table A-19
Revenue of Toko by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	8	8	8	8	8
Bipolar Digital	0	0	0	0	0
MOS Memory	0	0	0	0	0
MOS Microcomponent	0	0	0	0	0
MOS Logic	0	0	0	0	0
Monolithic Analog	22	28	32	37	31
Discrete	29	45	51	68	55
Optical Semiconductor	0	0	0	0	0

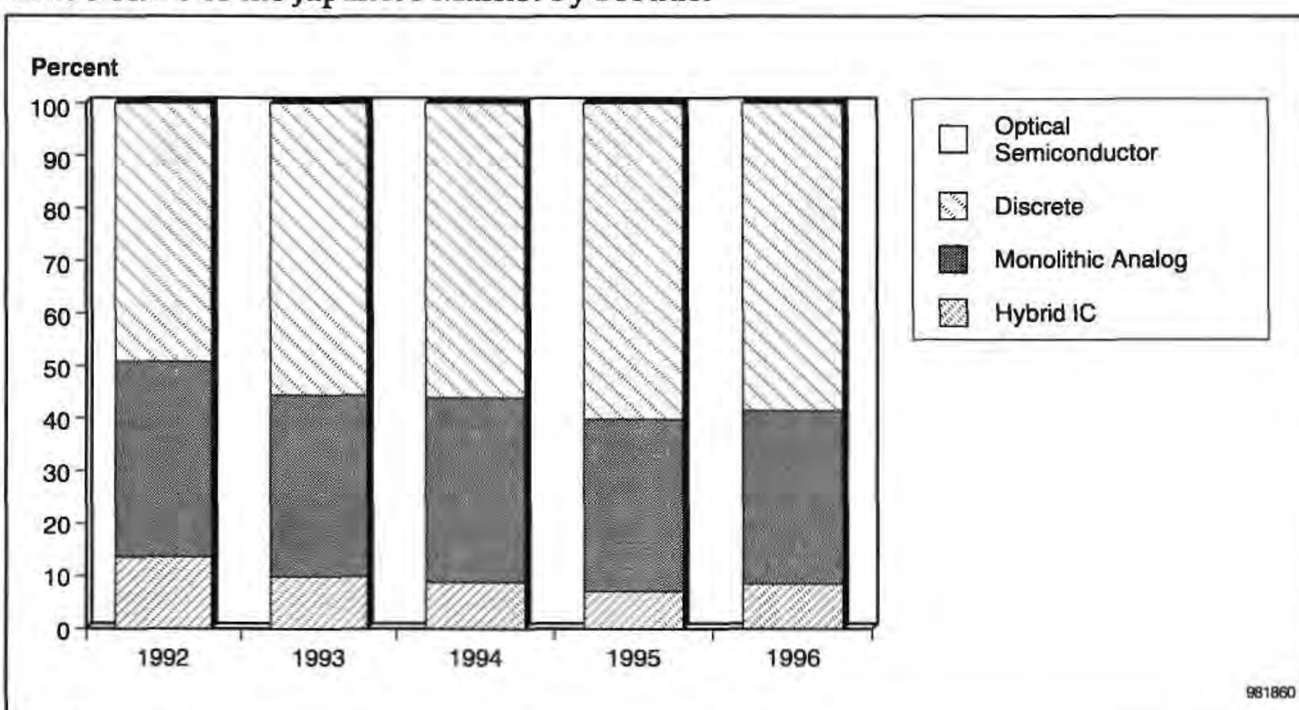
Source: Dataquest (March 1998)

Figure A-91
Toko's Share of the Worldwide Market by Product, 1992 to 1996



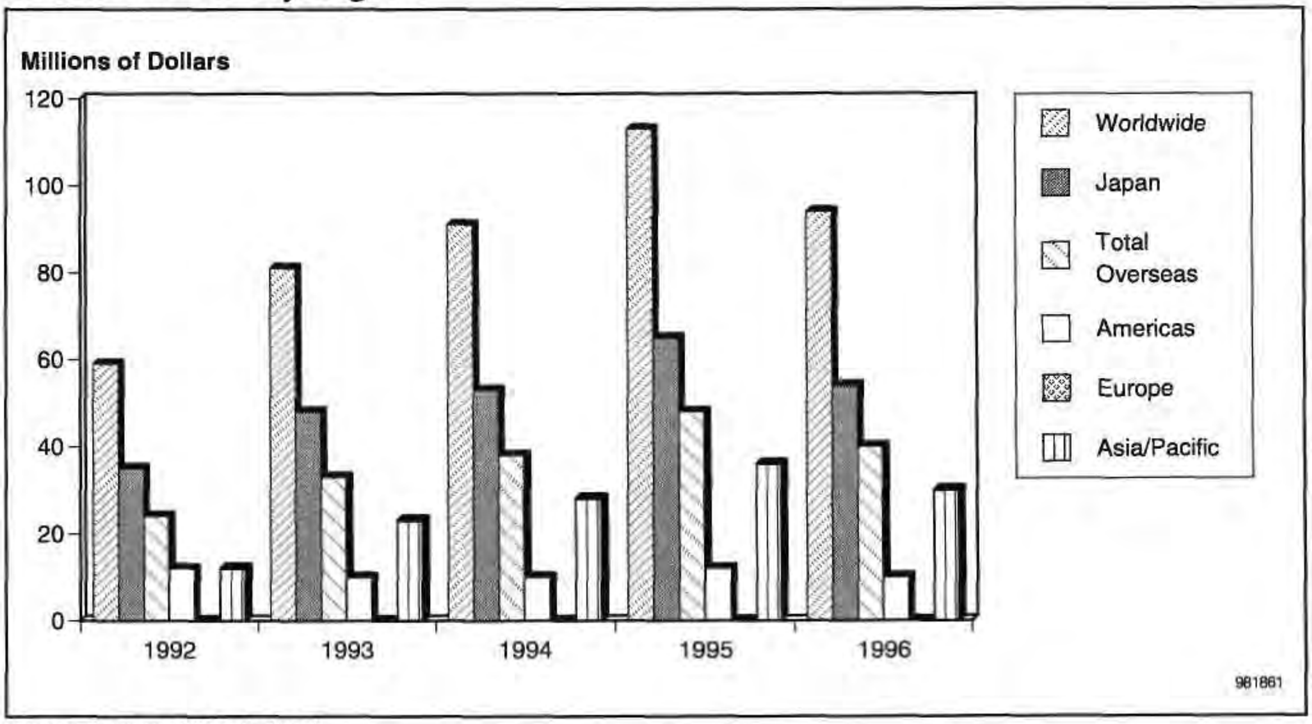
Source: Dataquest (March 1998)

Figure A-92
Toko's Share of the Japanese Market by Product



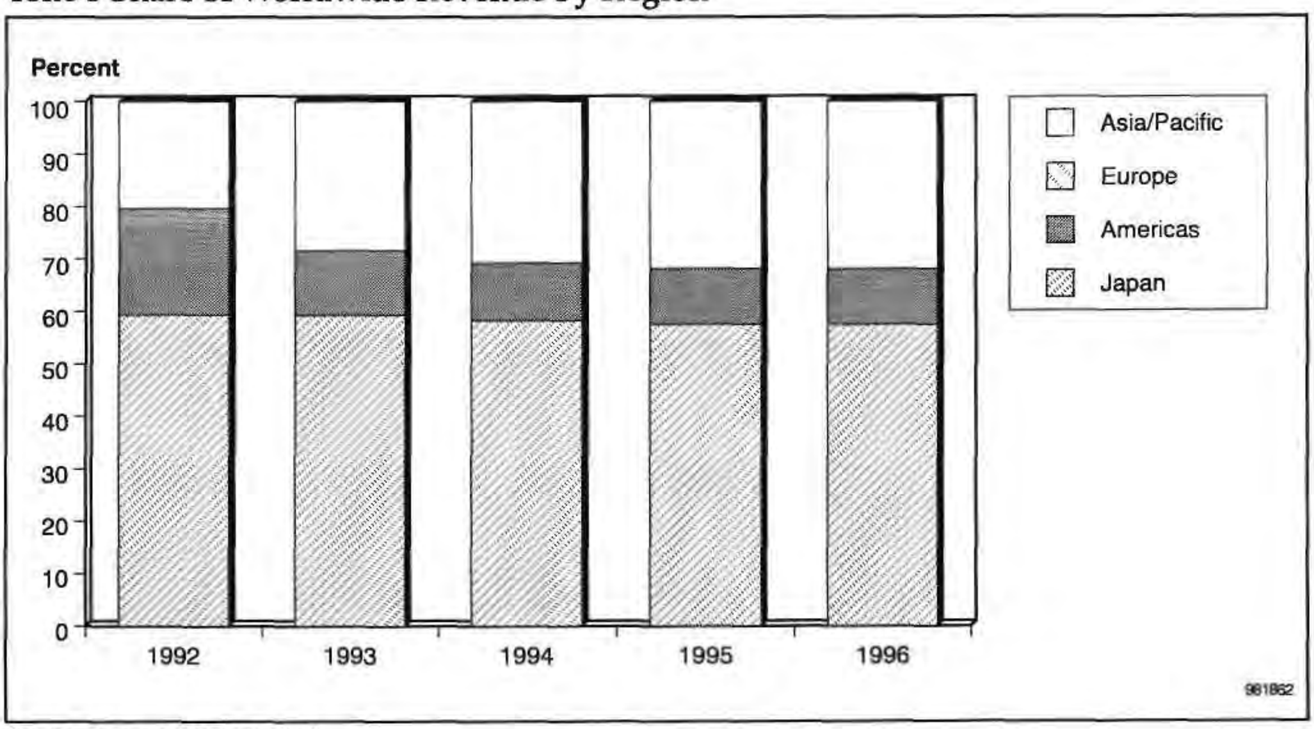
Source: Dataquest (March 1998)

Figure A-93
Revenue of Toko by Region



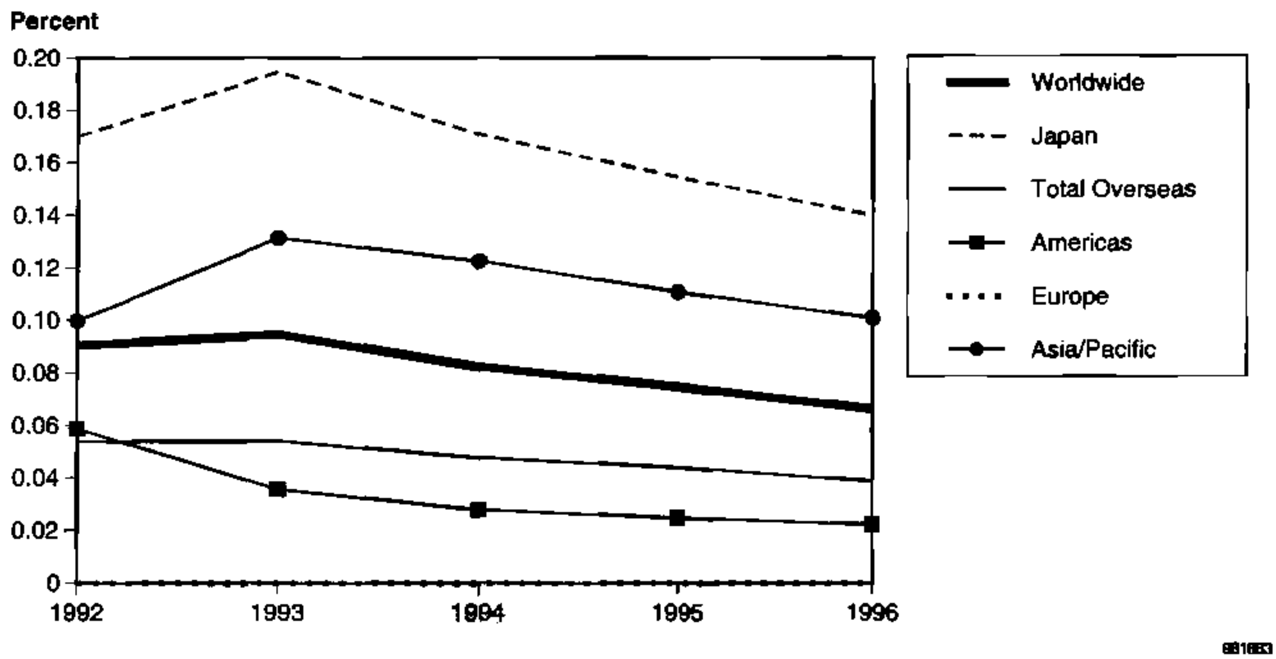
Source: Dataquest (March 1998)

Figure A-94
Toko's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-95
Toko's Market Share by Region



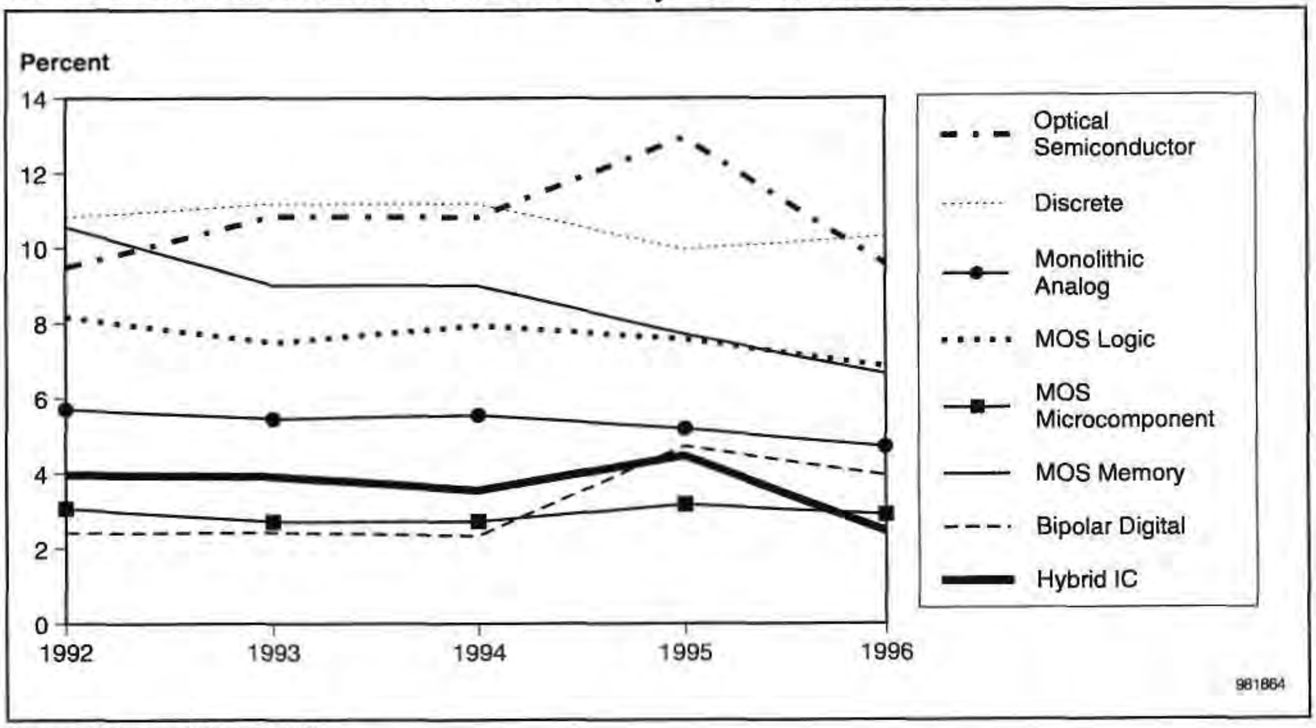
Source: Dataquest (March 1998)

Table A-20
Revenue of Toshiba by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	53	58	59	74	36
Bipolar Digital	77	75	68	116	73
MOS Memory	1,618	2,101	3,018	4,264	2,513
MOS Microcomponent	440	540	718	1,094	1,197
MOS Logic	821	995	1,279	1,562	1,476
Monolithic Analog	528	615	789	915	909
Discrete	883	1,017	1,204	1,428	1,390
Optical Semiconductor	255	326	421	623	471

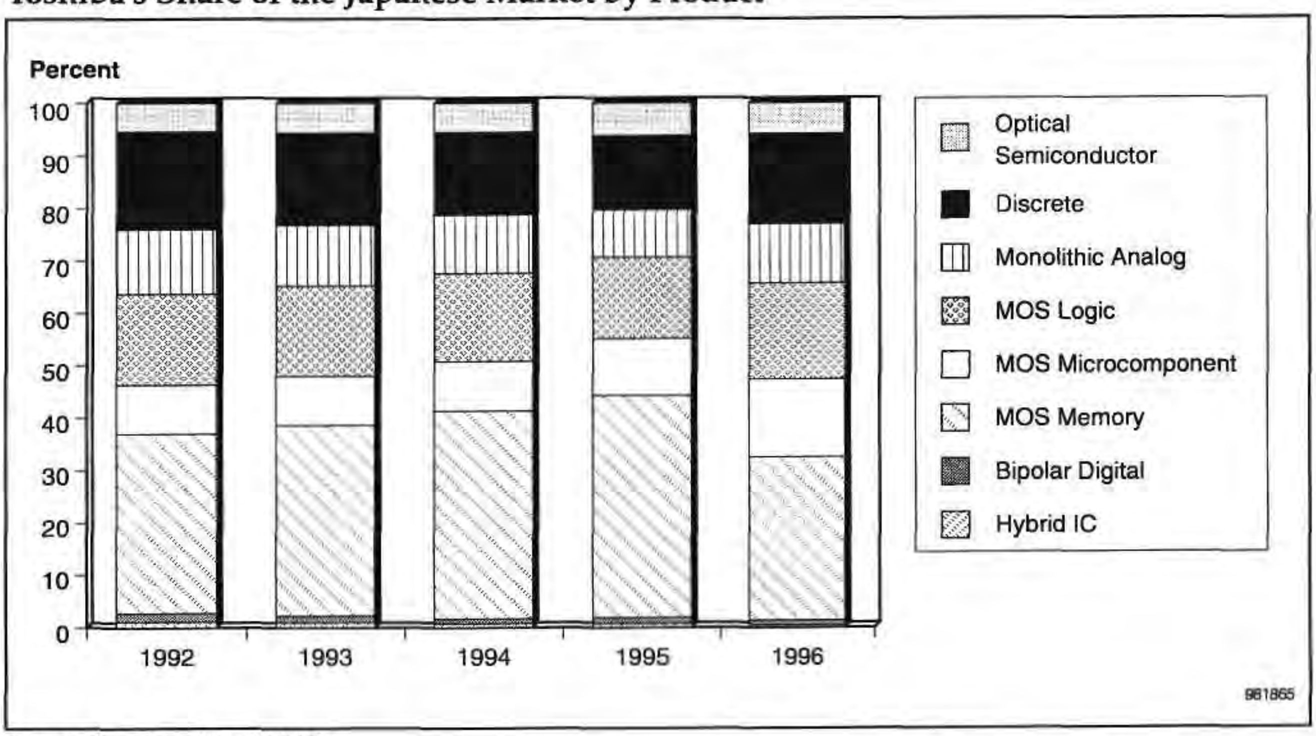
Source: Dataquest (March 1998)

Figure A-96
Toshiba's Share of the Worldwide Market by Product, 1992 to 1996



Source: Dataquest (March 1998)

Figure A-97
Toshiba's Share of the Japanese Market by Product



Source: Dataquest (March 1998)

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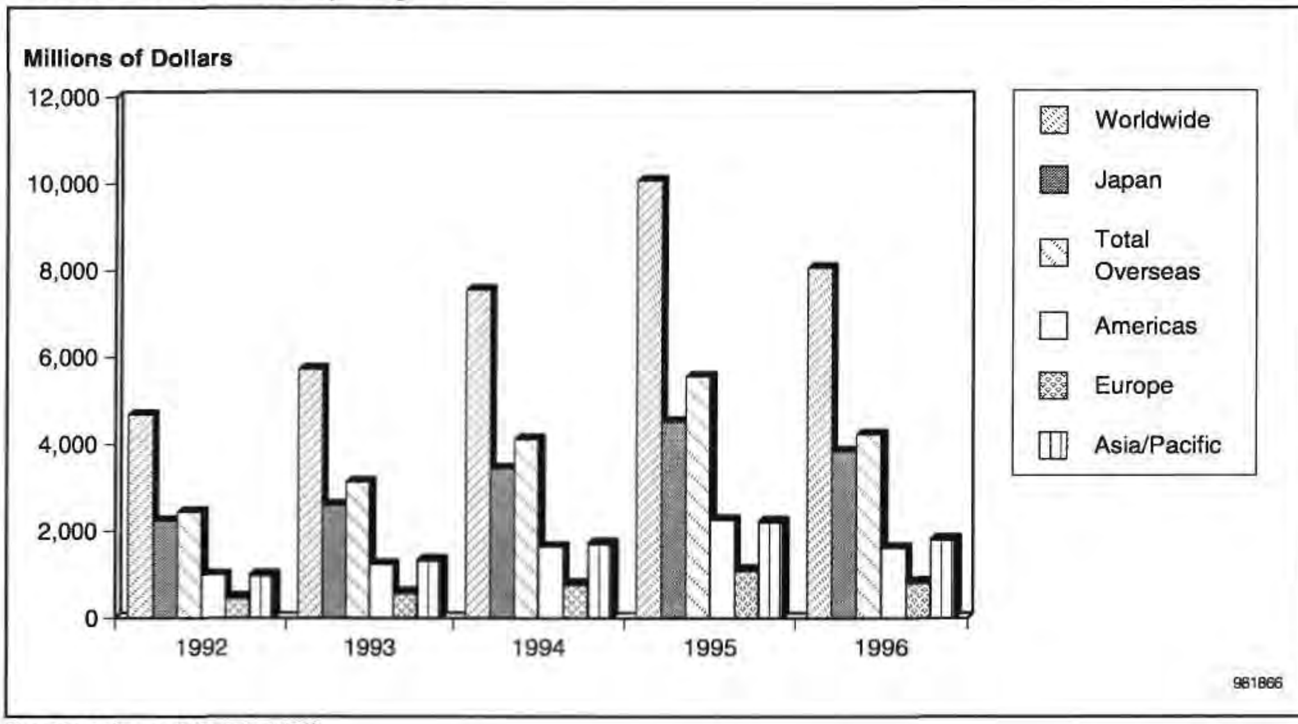
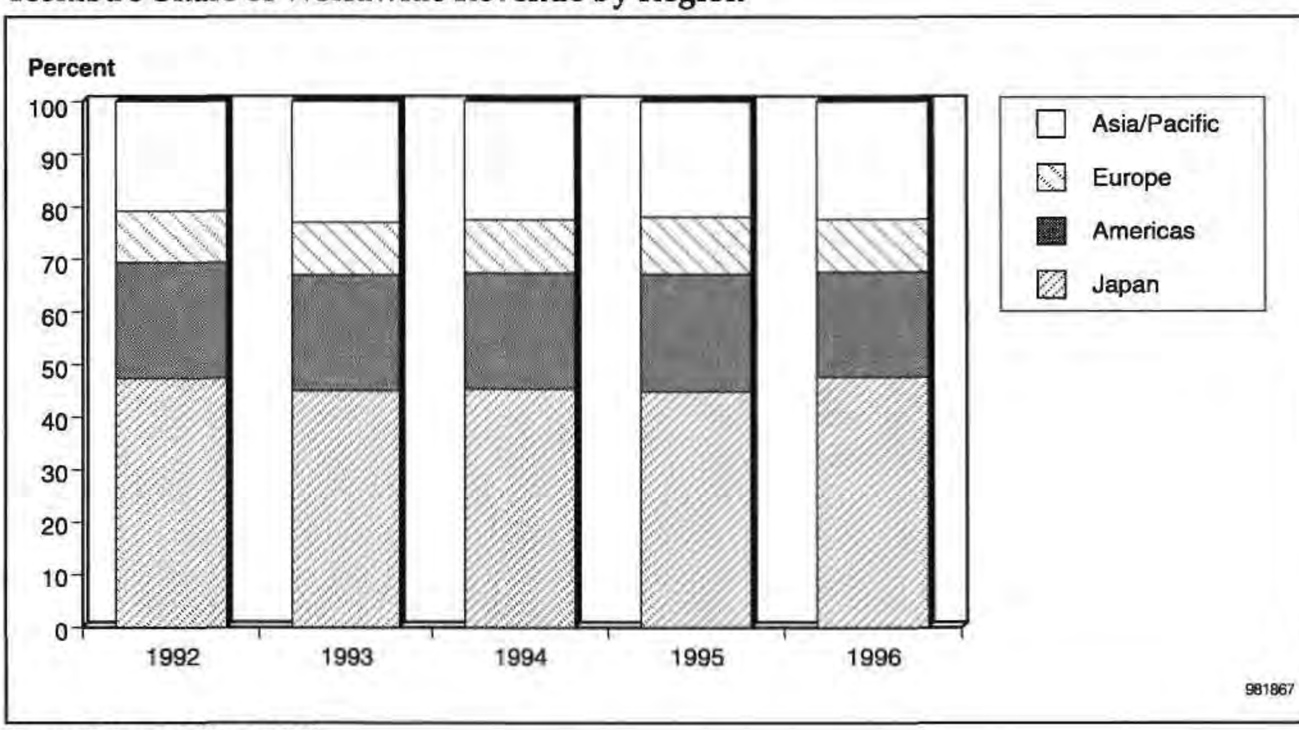
Figure A-98
Revenue of Toshiba by Region



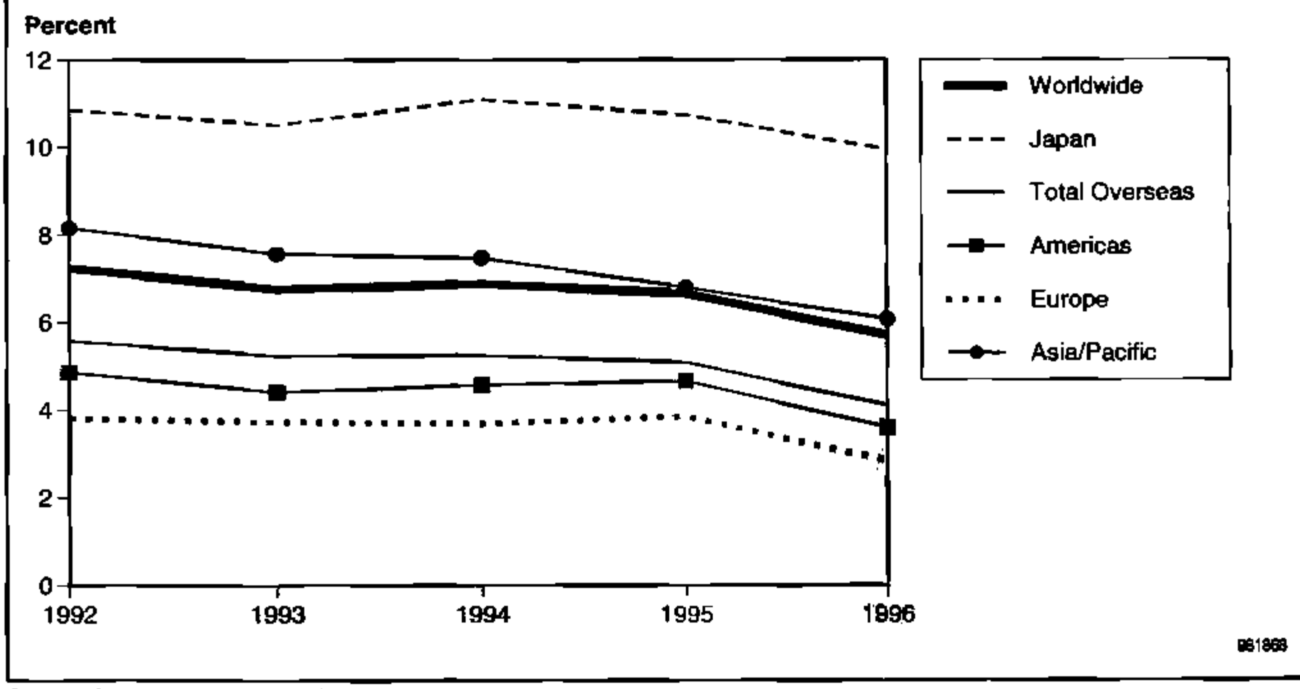
Source: Dataquest (March 1998)

Figure A-99
Toshiba's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-100
Toshiba's Market Share by Region



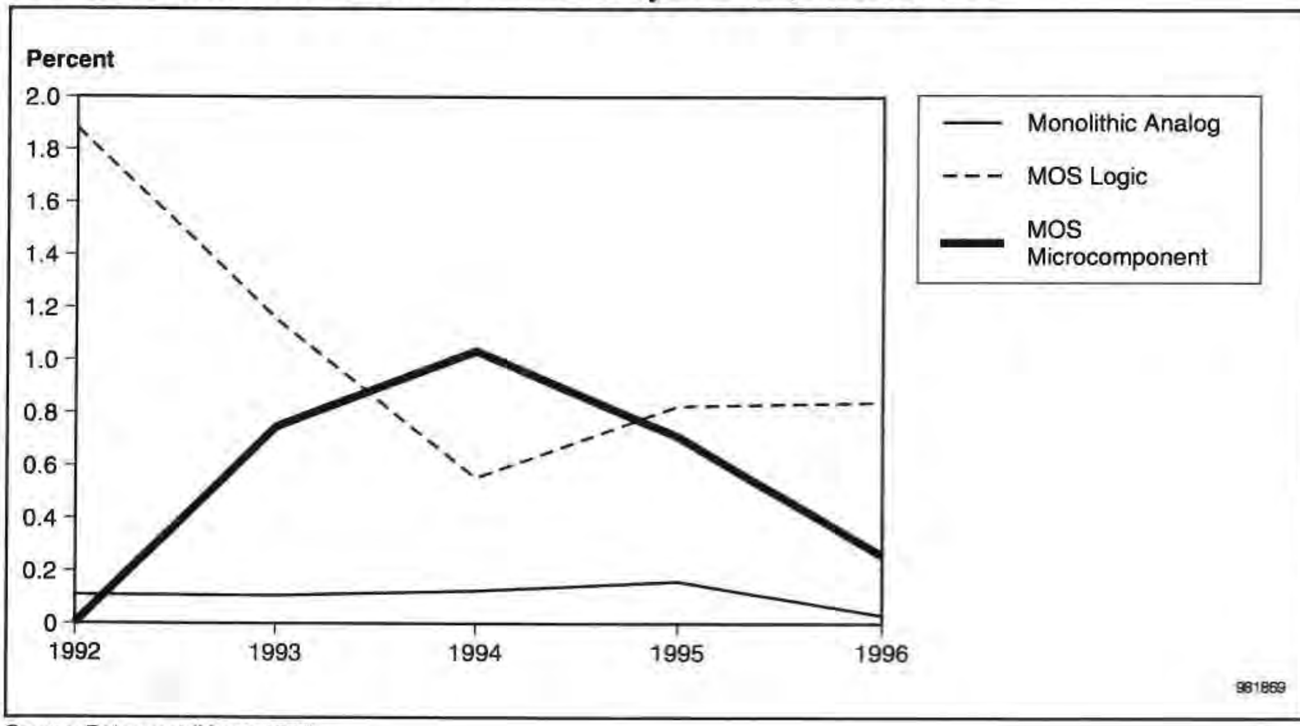
Source: Dataquest (March 1998)

Table A-21
Revenue of Yamaha by Product, 1992 to 1996

	1992	1993	1994	1995	1996
Hybrid IC	0	0	0	0	0
Bipolar Digital	0	0	0	0	0
MOS Memory	1	1	1	1	1
MOS Microcomponent	0	149	273	245	107
MOS Logic	189	154	89	170	181
Monolithic Analog	11	13	19	28	6
Discrete	0	0	0	0	0
Optical Semiconductor	0	0	0	0	0

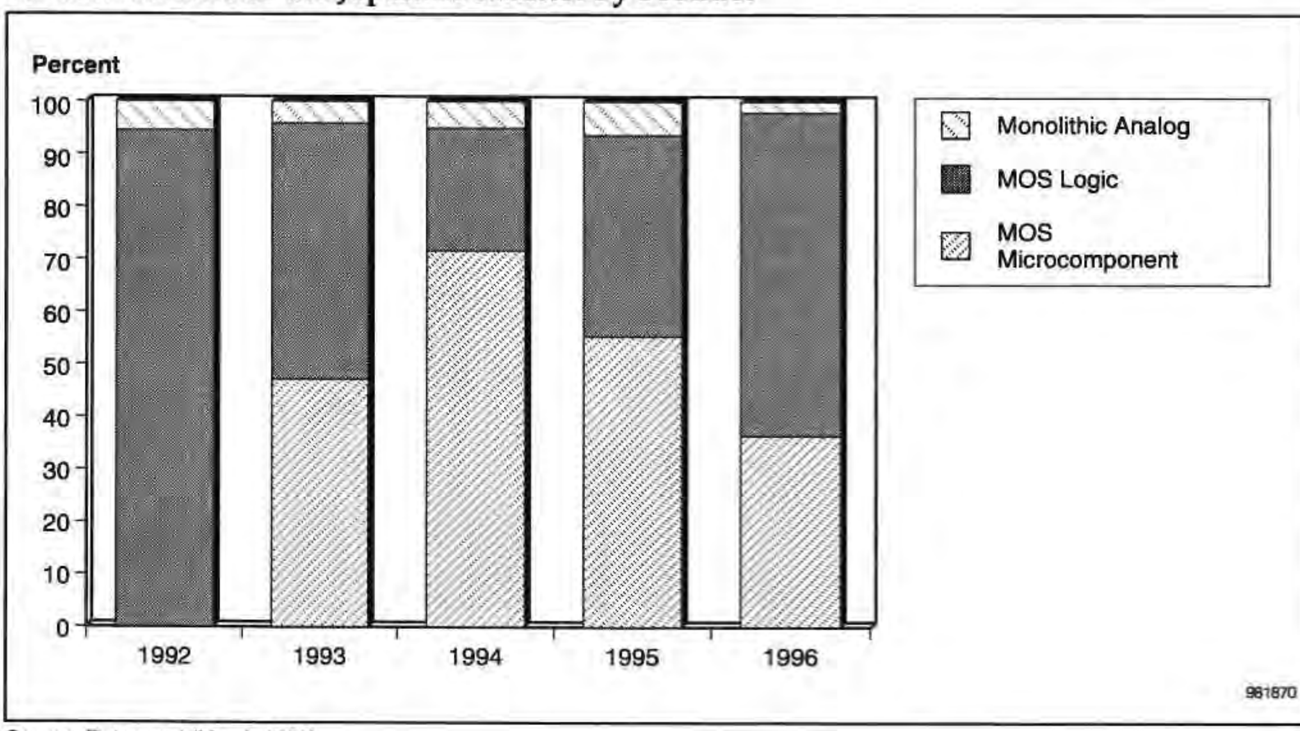
Source: Dataquest (March 1998)

Figure A-101
Yamaha's Share of the Worldwide Market by Product, 1992 to 1996



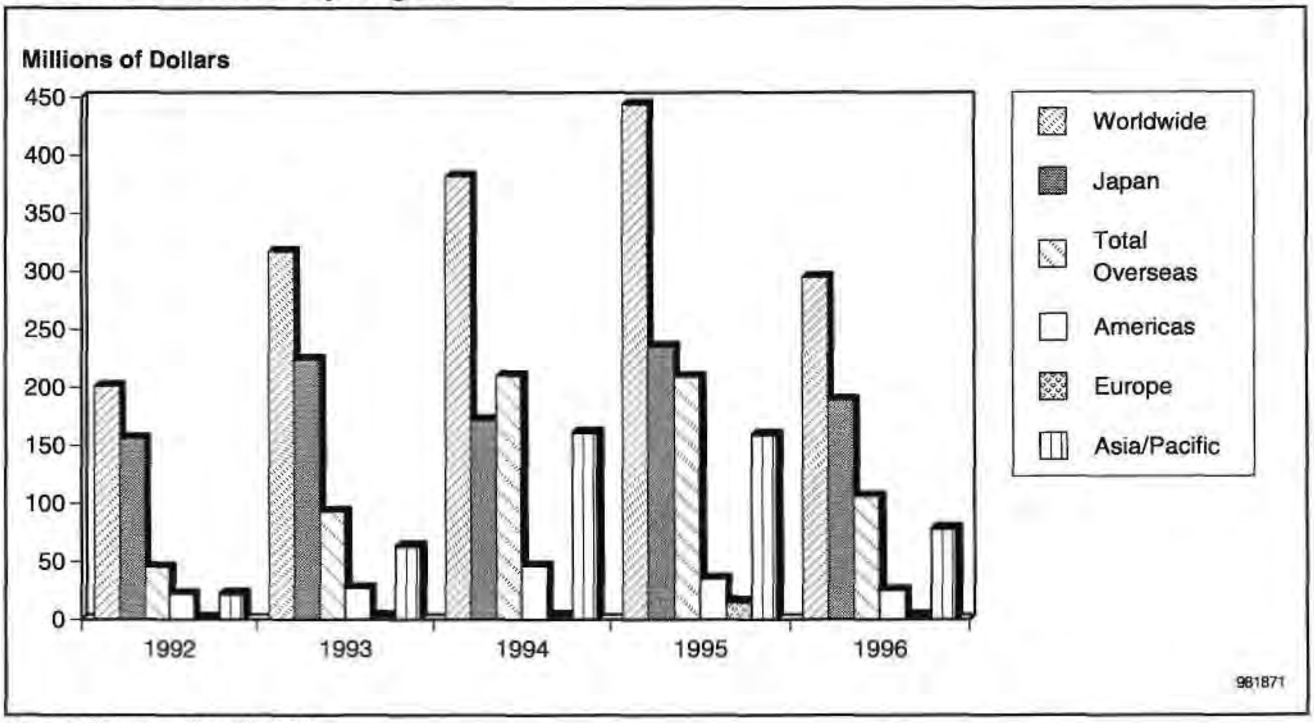
Source: Dataquest (March 1998)

Figure A-102
Yamaha's Share of the Japanese Market by Product



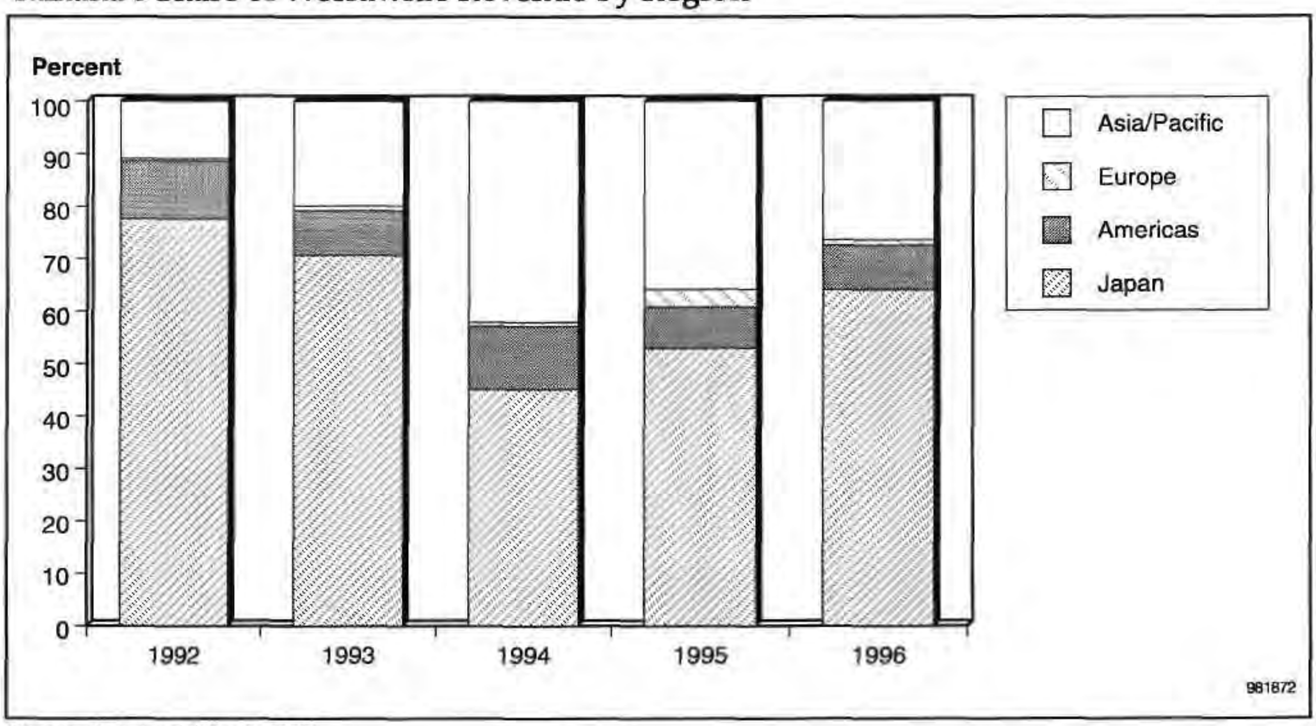
Source: Dataquest (March 1998)

Figure A-103
Revenue of Yamaha by Region



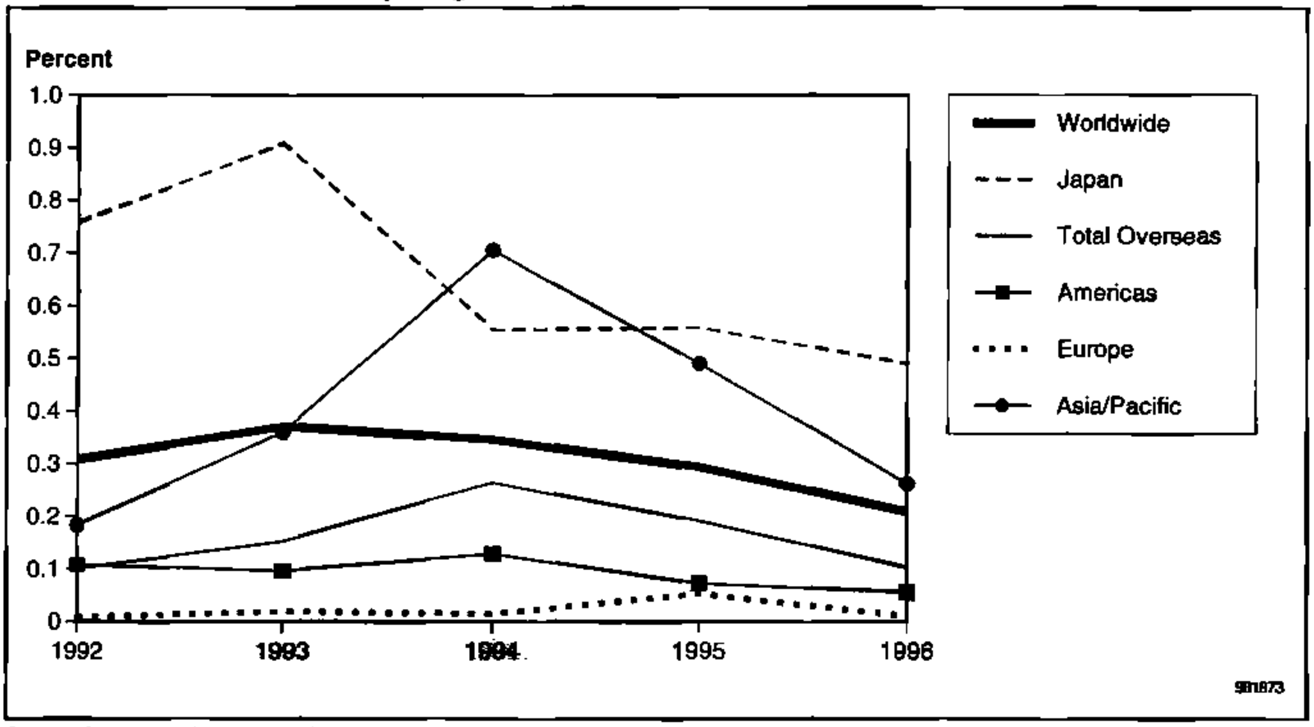
Source: Dataquest (March 1998)

Figure A-104
Yamaha's Share of Worldwide Revenue by Region



Source: Dataquest (March 1998)

Figure A-105
Yamaha's Market Share by Region



Source: Dataquest (March 1998)

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