Welcome Address

Gene Norrett

Group Vice President and Director
Semiconductors Group
Dataquest

Gene Norrett is group vice president and director of Dataquest's Semiconductors group and is responsible for all worldwide semiconductor research, including Asia/Pacific-, Europe-, and Japan-based semiconductor research. Before this, he was director of marketing, responsible for the worldwide marketing strategies. Previously, he was general manager for all North American technology services. Mr. Norrett was also the founder of Dataquest's Japanese Semiconductor Industry Service.

Before joining Dataquest, Mr. Norrett spent 14 years with Motorola's semiconductor product sector, serving in various marketing and management positions. Mr. Norrett was also a founder of the World Semiconductor Trade Statistics Program and was chairman of the Board of Directors of the Statistics Committee. He speaks frequently at Client Industry and Trade Association conferences. In 1987 he was voted by the *San Jose Mercury News* as one of Silicon Valley's top 100 influential people.

Mr. Norrett's education includes a bachelor of science degree in mathematics from Temple University and a master of science degree in applied statistics from Villanova University.

316

Semiconductor Manufacturing Technologies: From Research to Reality

GartnerGroup
Predicts
The IT Marketplace

Clark J. Fuhs
GartnerGroup's
Dataquest

22-24 March 1999
Hyatt Regency San Diego
San Diego, California USA

251 River Oaks Parkway
San Jose, CA 95134

Semiconductor Manufacturing Technologies: From Research to Reality

Clark J. Fuhs

Source: GartnerGroup

Semiconductor manufacturing issues have been known and understood to be driven primarily by technology, and Moore's Law has been viewed as the key mantra in the development of this technology. Whether one views Moore's Law as a technology (transistors double every 18 months) or an economic model (cost per function declines constantly), the semiconductor industry has driven to this end since its inception. While we do not view Moore's Law as slowing down any, recent acceleration of the technology road map and other complexity issues are causing concern as to whether the price to stay on various aspects of Moore's Law will be too high.

Further, the semiconductor industry is maturing, and the computer industry, which drives about one-third of the chip market and virtually all of the capital spending and process technology advances, has recently become less technology-driven and more consumer-driven.

Many changes are occurring in response to this shift. In this presentation, we will focus on the manufacturing infrastructure issues and trends.

Agenda

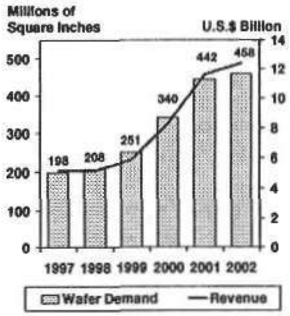
- Market forecast and overview
  - *Foundry*
  - 300mm equipment
  - Automation
- Market characteristics and driving forces
- Megatrends affecting markets
  - "Supply-push" vs. "demand-pull"
  - Changing rules of competition
  - Infrastructure responses
- Strategic business assumptions
- Conclusions and recommendations

Source: GartnerGroup

We will look at three markets specifically: foundry, automation, and the speed of adoption of 300mm wafer technology, paying particular attention to key driving forces and the market responses and opportunities created.

Market—Foundry Semiconductor Contract Manufacturing

- Economic slowdown affected demand in 1998
- Oversupply keeping pressure on wafer prices through 1999
- Foundries now generally competitive with IDM capacity
- Delayed 300mm transition increases IDM demand in 2001 and 2002
- Foundries continue to gain share



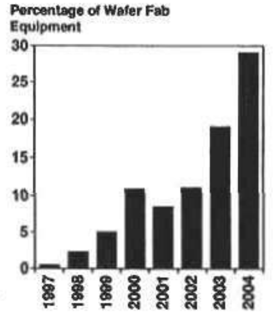
Source: GartnerGroup

The foundry market, or semiconductor contract manufacturing services at the wafer level, still represents about 9 to 10 percent of the silicon consumed in the market, but represents about 13 percent of the value of semiconductors manufactured. This higher ratio is due to the higher value per square inch of silicon of the products produced in foundries today. Current low prices in this market are creating stiff competition for internally produced products by integrated device manufacturers (IDMs).

The contract manufacturing model is gaining acceptance and is expected to capture 3 to 5 points of market share in the general semiconductor market over the next four years. This trend could accelerate as companies choose to delay 300mm fabs or choose not to build 200mm fabs in the next several years, opting instead to off-load production to contract manufacturers outside.

Market—300mm Equipment

- Equipment sales lead 300mm wafer penetration
  - 2004 wafer market estimated to be 10-12% penetrated by 300mm
- Equipment sales to follow traditional "double hump" pattern for new technology
- 300mm generation should follow 200mm penetration path by 10 to 11 years
- Economics questionable before 2003
- Ultimate driver for transition likely to be: wafer starts per fab



Source: GartnerGroup

One of the responses to lowering costs through manufacturing technology has historically been to increase the wafer size, thereby increasing revenue, generating capability per fab while keeping costs per chip under control.

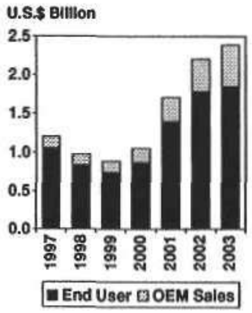
Several years ago, many chip company initiatives were prevalent, and many R&D dollars have been spent to commercialize 300mm wafer processing. To date, only one pilot line has been constructed, and the general outlook is for slow adoption. In fact, current consensus timing for 300mm production is now several years later than the chip companies were originally planning—as realities of the cost to develop and implement have been realized.

This is an example of a technology that, to date, has been too expensive to implement yet was blindly developed because it was the "next great technology."

Dataquest believes that 300mm will be implemented around 2003, but the driving forces will be economically based, rather than driven by a technology need.

Market—Factory Automation

- Market grew from $545 million in 1994 to about $1 billion in 1998
- ~25% of market is software
  - Very little currently integrated
- Several acquisitions of software companies recently
- ~14% of market currently sold to equipment companies as an embedded solution
  - Grown from 8% of market in 1994
- Japanese domination declining



Source: GartnerGroup

A major emerging market that has developed because of the recent change from a process technology-driven industry to one driven by productivity and capital is the automation market.

Still very embryonic, this area provides an ample array of opportunities for equipment suppliers.

Several aspects of this market are new to equipment companies. They are as follows:

- This market has a substantial software element.
- An increasing proportion of the sales are to other process equipment companies as an embedded system solution.
- It is a market that branches across all process technology types and competitive offerings, so a new class of equipment companies will emerge to fill the market need.

Market Overview—Technology Directions

- Process design chaos increasing
  - More application-driven niche process technologies
  - Transistor issues: SiGe, GaAs, SOI
  - Interconnect issues: copper, packaging (CSP, BGA)
  - Merging types of chip functionality
- Merging of wafer-, chip-, and board-level processes
  - Competitive borders changing
  - New markets emerging
  - Some markets declining
- Manufacturing transitioning to service business
  - Traditional ASIC business model in question
  - Engineering services model emerging
- Flexibility is more important than capability

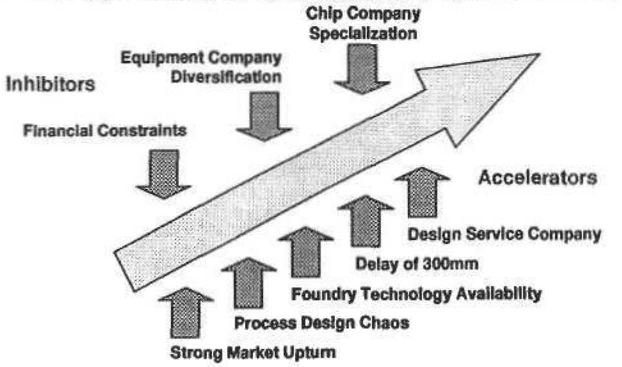
Source: GartnerGroup

This movement of the industry to a more mature, consumer-driven model is actually making chip companies respond in various and inconsistent ways to meet customer demands. There are more application-driven niche markets, which have many of their own specialized process technology issues, and there is also the movement toward system-level integration.

This process design chaos means that competitive boundaries are changing up and down the food chain. New markets are emerging as wafer-, package-, and board-level designs are intermingling. Manufacturing and chip design flexibility is the new paradigm that breeds success, and the emergence of the foundry service business is consistent with this trend.

In the future, as process design responsibility moves into the equipment company, an "engineering services" business model will emerge. Examples of this today are the services provided by Applied Materials in its integrated process flow, Schlumberger's extension of the oil services model into the semiconductor industry through its SABER product, and the integration of design/wafer/package services in the foundry.

"Manufacturing Science" Market—Accelerators and Inhibitors



Source: GartnerGroup

We like to refer to this movement toward a mature manufacturing infrastructure as the implementation of "manufacturing science" technology into the industry; it can be loosely described as adopting industrial engineering practices through the manufacturing infrastructure of the industry.

The issues that can accelerate this trend include the following:

- A strong market upturn, or the delay of 300mm, increasing foundry demand
- Process design chaos, as mentioned earlier
- The fact that foundry is now competitive with IDMs on process availability
- The emergence of the design service company, completing the availability of contract services completely

The issues that can accelerate this trend include the following:

- Financial constraints, inhibiting investment in the new system
- The temptation for process equipment companies to provide automation and software services, which will confuse the market and waste R&D resources
- The temptation for chip companies to continue to hold on to their specialized automation and planning systems, which are not optimized for the flexible model

Market Characteristics—Foundry

- Market trends
  - Concentration of capital and capacity
  - Now driving technology in many areas
  - Production efficiency highest in the market
  - Expanding services to design and turnkey
  - Gaining share in chip industry
- Opportunities
  - Offers low entry costs for chip companies
  - Enables faster innovation
  - Focuses equipment company resources
  - Could grow to 40-45% of infrastructure in 10-12 years

Source: GartnerGroup

Market trends in the semiconductor industry generally include both the concentration of capacity (more square inches of silicon per fab, now 5x the size they were in 1983) and the concentration of capital (fabs cost 9x more now than in 1983). These trends occur together with significantly lower costs per function, so they are not detrimental to the industry. This concentration is part of the driving force toward contract manufacturing. This concentration also reduces the number of customers for the equipment companies, making for more efficient R&D money spent.

Foundries are now competitive with vertical IDMs and offer a very low barrier to entry into the chip market. More competition speeds innovation, creating the process technology chaos and more opportunities.

Foundries are gaining share in the market and could grow to 40 to 45 percent of the semiconductor production market in 10 to 12 years.

Market Characteristics—300mm

- Market trends
  - Adoption by chip companies slow
  - R&D commitment primarily from equipment and material suppliers, different from the past
  - Only one pilot line operating today; two more possible in 1999
  - Production delayed to 2002-2003
- Opportunities
  - Implement automation strategies in 200mm equipment
  - Accelerate productivity advances through automation
  - Cash generated by 200mm equipment for longer
  - Foundries emerging as providers of risk avoidance

Source: GartnerGroup

The move to 300mm technology has been the casualty of this movement but will eventually be adopted, as the sheer size in wafer starts of a fab can be cut in half by going to the larger wafer. This facilities-driven move to a larger wafer is different than in the past, when increasing die size resulting from chip complexity was a key force.

This delay in 300mm, while it has burned R&D money recently, actually offers the equipment industry a longer life for cash-generating 200mm equipment, and automation strategies can be adopted without adding the complexity of the 300mm transition.

The 300mm delay actually will place the foundry as the provider of risk avoidance, and demand will accelerate to the manufacturing model that it is driving.

Market Characteristics—Automation

- Market trends
  - Transitioned from a robotic to a systems solution
  - Japanese domination declining: U.S. innovating
  - Large software market, starting to be integrated
  - 300mm initial movement helped solidify market standardization
- Opportunities
  - Business combinations to integrate hardware and software systems
  - New markets, customers opening up

Source: GartnerGroup

The automation market is being driven by the flexible and multiproduct manufacturing model offered by the foundry. This has led to new thought processes in automation, expanding the model to a systems solution rather than just robotics. As a result, U.S. and European companies are taking share from the Japanese in the market.

The start of the 300mm development has actually aided the migration to automated systems, as automation is a requirement for the larger size. Standards have been set, new markets are being created in equipment and software, and customers are starting to open up.

Dataquest Predicts

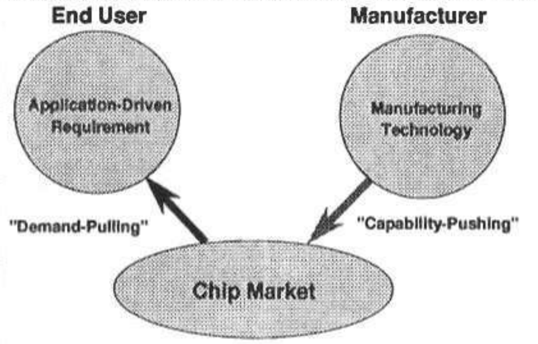
- **What are the key driving forces shaping demand and acceptance trends in manufacturing technology?**
  - **Chip market has matured into a "demand-pull" market; "supply-push" has diminished**
  - **Technology alone is not enough**
  - **"System design" strategies winning over "chip design"**

Source: GartnerGroup

Some driving forces for advanced manufacturing technology are mentioned here. These are explained in more detail (to follow).

Dataquest Predicts

Chip Market Has Become Demand-Pull



Source: GartnerGroup

Ten or more years ago, the chip industry was driven by manufacturing process technology, enabling chip capability and system-level advantages. This was a "supply-push" business and one driven almost exclusively by performance.

The mantra was: "If you build it, they will buy—at a price premium."

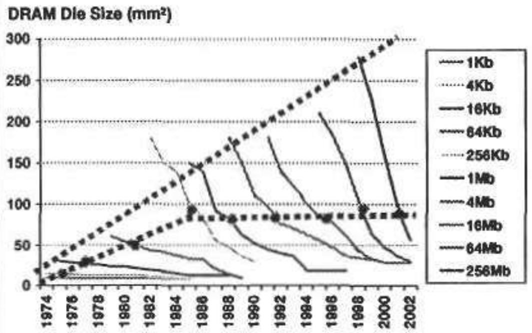
In the last several years, this has changed, driven by the move of the PC into the consumer market. One result is the plummeting price points we see in the PC market today, but earlier in the decade, we saw the first indications of this trend.

Since the 1Mb to 4Mb DRAM transition, price-per-bit crossover now precedes bit or demand crossover for a product. Price premiums no longer exist. Up to 1Mb DRAM, demand crossover would come in advance of equal pricing, as buyers would be willing to pay a price premium. This example is only one that we can now attribute to the market pulling only application-driven benefits from the chip market.

Now, the mantra is: "Performance matters, but costs are an equal consideration."

Dataquest Predicts

DRAM Economics No Longer Drive Die Size Increase



Source: GartnerGroup

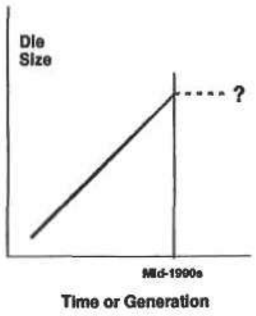
This is actually in part why the delay in 300mm wafers has happened.

Since the inception of the DRAM, at introduction, the die size has increased with each subsequent density. This was also true if one tracked the die size at bit demand crossover for each generation.

However, starting after the 1Mb DRAM, the die size has remained constant at bit demand crossover in the 80-sq.-mm to 90-sq.-mm size. It is no coincidence that this occurred at the same time that the price premiums went away—when the industry began acting like a consumer-driven market.

Dataquest Predicts

300mm Adoption Criteria Have Changed



- The 100 rule governs
- Die size increasing at the same rate as before? At all?
- Is there a departure in strategy for the MPU with the Pentium II and slot 1?
- More shrinks per DRAM generation—causing wafer sizes to have longer lives
- SLI-ASIC strategies enter as a driver?

Source: GartnerGroup

Since die sizes are not increasing for bulk production, there is really no "technology-driven" reason to move to 300mm wafers in DRAM.

This die size trend is also evident in Intel's MPU introductions. By shifting SRAM cache off-chip and designing levels of interconnect in the package, Intel has managed to keep its die size (at introduction to the mass market) at a constant size for the last three generations—preserving the life of the 200mm fab.

Ultimately, die sizes for SLI-ASIC chips will come to the rescue, but that is still many years away, as die size trends are behind the MPU.

Facilities size issues will ultimately drive the conversion to 300mm wafers around 2003.

Dataquest Predicts

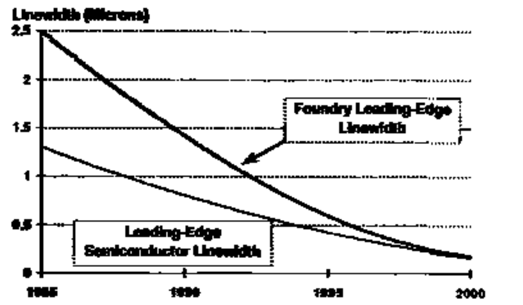
- **What will be the role of foundry driving process technology?**
  - **Linewidth gap between foundry and leading IDMs has disappeared**
  - **SLI strategies for chip design place foundry in the center of activity**

Source: GartnerGroup

Some driving forces for foundry driving process technology are mentioned here. These are explained in more detail (to follow).

Dataquest Predicts

Linewidth Gap Disappears



Source: GartnerGroup

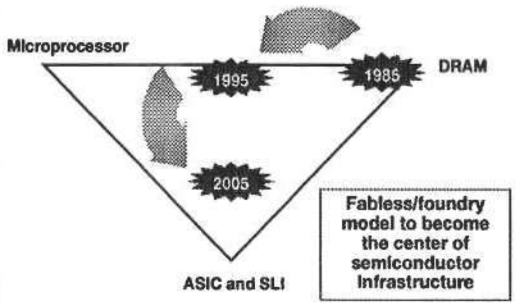
The fabless/foundry model first emerged in the early 1980s but gained accelerated use as fabs were idled in the 1985 slowdown. At that time, foundry capacity was a full three process generations behind leading-edge technology. Over the next 14 years, this gap has essentially closed to no gap.

This competitive equality is now changing the face of how internal process wafer capacity inside IDMs competes on the "build or buy" decision-making process.

Further, in an application-driven chip market, design innovation and software capability are becoming the IP and competitive edge, and process capability is now being "commoditized."

Dataquest Predicts

SLI Strategies in Chip Design Place Foundry as Center



Source: GartnerGroup

Also, in 1985, the DRAM was the primary driver for process technology. As Intel adopted the fast SRAM as the main memory cell in the MPU and more than two levels of metal were required for chip complexity, both the MPU and the DRAM shared the process technology driver's seat for the market.

Going forward, ASIC and SLI designs, driven by specialized application requirements, will drive the processing technology more than the other two types of chips. The fabless/foundry model and its attributes are placed squarely in the sweet spot to drive this new technology forward.

Dataquest Predicts

- **Which industrial engineering practices will likely impact semiconductor manufacturing strategies, and how?**
  - **Queuing theory demands integration of software and hardware solutions in material planning and transport**
  - **Material resource planning to become integrated in real time**

Source: GartnerGroup

The flexible manufacturing model of the foundry drives the implementation of industrial engineering practices into the industry. Some results of this trend are listed here and are explained in more detail later.

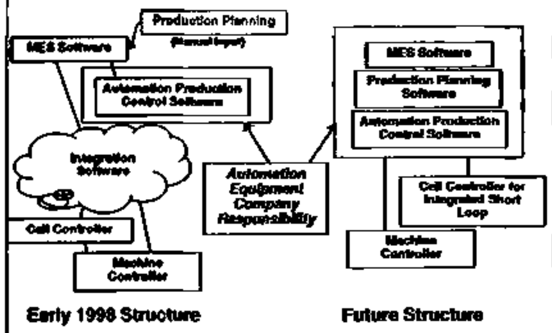
Probably the most exciting area for automation system providers will be software control systems and information intelligence systems.

Industrial engineering practices, queuing theory, and the foundry model of production flexibility will require that the entire fab operation and process control feedback be linked in a closed-loop system, with a master set of rules for operation. This will maximize the output of the factory (wafers per day, as an example).

Material resource planning will be done real time, rather than off line and once a day, as is the current method.

Dataquest Predicts

Current Fragmented Software Markets to Be Integrated



Source: GartnerGroup

This slide shows the automation market segments and the market's interactions, as well as its expected ultimate evolution, perhaps in five to 10 years. Key elements of this new structure are already starting to take shape.

The industry is expected to fully implement industrial engineering disciplines, specifically queuing theory, in the manufacturing infrastructure. This will require that the intelligence and decision making issues in manufacturing be done in a closed-loop fashion to the hardware carrying out the execution. The ATC software instructs the hardware to route the cassettes inside the fab; the material requirements planning (MRP) software takes processing requirements that are input from operations management and makes decisions on how to route cassettes in the fab; and the MES software is the primary interface to the human user, also called a graphical user interface (GUI). It is quite easy to see that the best supplier of an automation solution would integrate all three elements with the hardware to provide a turnkey solution.

The customer will demand neutrality among equipment suppliers, and this will tend to create a new set of suppliers whose core competencies are automation and software.

Conclusions

- Chip market has matured into a "demand-pull" market; "supply-push" has diminished
- "System design" strategies winning over "chip design"
- SLI strategies becoming a driving force for technology advances
- Linewidth gap between foundry and leading IDMs has disappeared
- Foundry in the center of activity
- Industrial engineering emergence demands integration of software and hardware solutions in automation

Source: GartnerGroup

This is a summary of the key points made in the presentation.

Vendor Recommendations

- Spend R&D money on "systems solutions" rather than on independent technologies
- Understand your customer's business and competitive pressures
- Be flexible
- Focus on how the foundries are being successful, and emulate them
- Be clear about your core competence, and stay within it
  - Do not mix two core competencies within the same business unit or corporate structure

Source: GartnerGroup

Here are some recommendations we would make to equipment companies in order for them to participate successfully in the new manufacturing infrastructure.

Technology and the Global Economies: An Update

Donald H. Straszheim, Ph.D.

President
Milken Institute

Donald Straszheim is president of the Milken Institute. While serving as chief economist of Merrill Lynch & Co. from 1985 until early 1997, he gained expertise in the transnational economic issues that have increasingly become the focus of the Institute. As the framer of the Institute's initiatives, he is leading its efforts in exploring a large global agenda that encompasses technology's impact on society and on the economy; developments in capital markets and financial institutions; globalization, trade, and the effects on international economic performance; and education, labor markets, and jobs.

Dr. Straszheim's expertise has led him to regular guest appearances on CNN and CNBC as well as to national speaking engagements before business and academic groups.

Before joining Merrill Lynch, Dr. Straszheim was responsible for U.S. operations at Wharton Econometrics and earlier was chief economist at Weyerhauser Corporation and at Fluor Corporation.

Dr. Straszheim received his Ph.D. from Purdue University.

Dataquest

MILKEN INSTITUTE

TECHNOLOGY AND THE GLOBAL ECONOMIES

Dataquest
San Diego, CA
October 19, 1998

Donald Straszheim - President
The Milken Institute
1250 4th Street
Santa Monica, CA 90401
Phone (310) 998-2620; Fax (310) 998-2641
e-mail: dstraszheim@milken-inst.org

About the Institute...

The Milken Institute's mission is to explore and explain the dynamics of world economic structure, conduct, and performance by conducting research in economics, business and finance. The objective is a better-informed public, more thoughtful public policies, improved economic outcomes, and better lives for people.

The Milken Institute's extensive research agenda includes the analysis of corporate finance, capital markets, and financial institutions; the growing influence of globalization and international trade on economic development; the key role of education, jobs, labor markets, and human capital; the role and consequences of demographic change; and regional economic performance and its impact, with particular emphasis on California.

The Milken Institute is an economic think tank, a not-for-profit 501(c)(3) nonpartisan enterprise founded in 1991. All programs and publications are provided at cost or less. The Institute brings together ideas from economics and related disciplines as well as the applied areas of policy, business, and finance. It actively communicates with opinion leaders in business, finance, government, academia, media, and the non-profit sector, and has a wide-ranging cooperative research program with these groups.

The Milken Institute's staff comes from a variety of university and practical backgrounds. The Institute hosts affiliated scholars on a visiting and long-term basis and also welcomes adjunct researchers for sabbatical leave. Invited speakers at Institute events represent a wide range of fields at the senior levels.

Institute researchers' perspectives appear in major national newspapers and journals and via the broadcast media. The Institute has an extensive publications program that includes a policy paper series, trade and textbooks, an economics and policy periodical, and a World Wide Web site.

Recent national programs at the Institute's conference center in Santa Monica, California and in other major cities have addressed questions of education and job skills, the so-called Asian crisis, prospects for urban America, the democratization of capital, and opportunities in emerging economies. The annual Global Conference, held in March, attracts leaders from around the world.

The Milken Institute's president is Donald H. Straszheim; its chairman is Michael R. Milken. From 1985 to 1997, Straszheim served as chief economist of Merrill Lynch & Co., one of the world's largest securities firms. Straszheim's expertise is in the global economic issues that have increasingly become the focus of the Institute. Milken is widely credited with having revolutionized the modern capital marketplace. In 1989, the Wall Street Journal referred to him as "arguably the most important financial thinker of the century."

Ted Van Dyk	*Executive VP & COO*
Peter Passell	*Editor-in-Chief, Institute Magazine*
Glenn Yago	*Director, Capital Studies*
Ross C. DeVol	*Director, Regional Studies*

Senior Fellows include James R. Barth, R. Dan Brumbaugh Jr., Joseph W. Duncan, William H. Frey, Hilton L. Root, and Robert Sobel.

MILKEN INSTITUTE

1250 Fourth Street • Santa Monica, California 90401
PHONE (310) 998-2600 • FAX (310) 998-2627 • E-MAIL info@milken-inst.org • WEB www.milken-inst.org

Rev. 9/15/98

1999 MILKEN INSTITUTE GLOBAL CONFERENCE

March 10–12, 1999
The Beverly Hilton
Los Angeles, CA 90210

Over the past year, various effects of the Asian financial crisis have been felt globally. In addition, Russian financial and economic distress, uncertainties about the Japanese and Chinese economies, and the evolution of European Monetary Union continue to impact all nations. The 1999 Milken Institute Global Conference will update participants on all these and other events that have affected the world economy.

The Issues
Since the Asian crisis that began in 1997, ongoing events in China, Europe, Japan, Latin America, and Russia are posing new and continuing questions of economic and financial stability in this increasingly intertwined global economy. Are the multinational agencies' actions beneficial or detrimental? Are some of their short-run tactics likely to lead to long-run losses? What kind of financial rules and reforms make sense? How much will the industrialized countries be hurt in 1999 and beyond by the swirl of events of 1997–98? What will the global economy and financial markets look like between now and the new millennium? How will both portfolio investors and direct investors respond? Are new policy surprises or economic and financial downdrafts coming?

The Audience
Somewhat larger than the 1998 Global Conference, the 1999 conference will bring together an audience of over 1,000. Included in this audience will be institutional portfolio managers from all over the globe; business leaders with direct investments worldwide; representatives of major securities firms and commercial banks; leading academics in the areas of business, finance and political science; senior policy officials from governments around the world; representatives of both print and electronic business and financial media; and officials, economists and analysts from multinational lending and governing agencies.

The Sessions
The conference will take a global perspective, concentrating on recent developments, steps (and missteps) taken, opportunities offered and challenges posed. In addition to addresses by senior policy officials, we will hold sessions on the unsettled and still-changing regional situation in Asia's emerging economies; on China and its prospects; on the efforts to reinvigorate Japan; on Russia and other former command economies; on Latin America; and on other areas.

We will also discuss the still-evolving role of the IMF, the World Bank and other multinational agencies; the "euro" and European Monetary Union (and Britain's non-participation); financial market development and innovation; labor market and other reforms; the commodity economies; technology's role in globalization; privatization's lessons; trade flows, trade rules and trade blocs; and cross-border financial and business activity.

The Details
The **1999 Milken Institute Global Conference** starts with dinner on Wednesday night, March 10, continues through Thursday, March 11, and ends following lunch on Friday, March 12. Major policy addresses by cabinet-level officials will be featured, as well as presentations and panel discussions by CEO-level business leaders, global portfolio managers, economists and financial strategists, and academic experts.

MILKEN INSTITUTE

1250 Fourth Street • Santa Monica, California 90401
PHONE (310) 998-2600 • FAX (310) 998-2627 • E-MAIL info@milken-inst.org • WEB www.milken-inst.org

The World's Stocks Fall

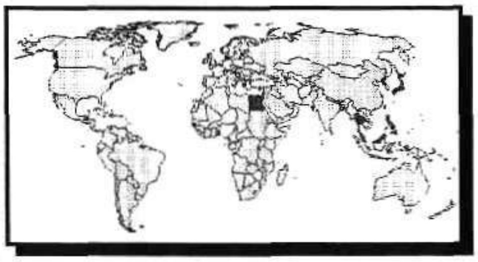
Market Peak to October 8, 1998

U.S.	**-15%**
U.K.	**-23%**
Germany	**-35%**
Japan	**-38%**
Russia	**-87%**
Latin America	**-53%**
Asia	**-67%**
Europe	**-26%**
World	**-20%**

MILKEN INSTITUTE

Equities Peaked

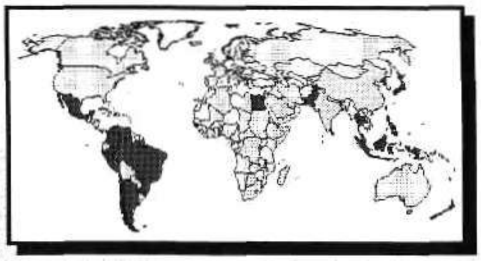
First Half of 1997



MILKEN INSTITUTE

Equities Peaked

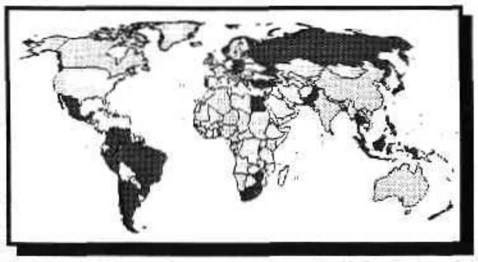
Second Half of 1997



MILKEN INSTITUTE

Equities Peaked

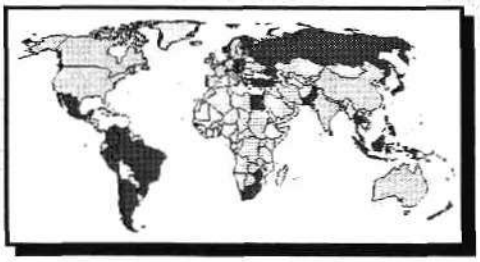
First Half of 1998



MILKEN INSTITUTE

Equities Peaked

Second Half of 1998



MILKEN INSTITUTE

What I learned from Economists was: "October....is one of the peculiarly dangerous months to speculate on stocks in...

Mark Twain

MILKEN INSTITUTE

Japan on the U.S.

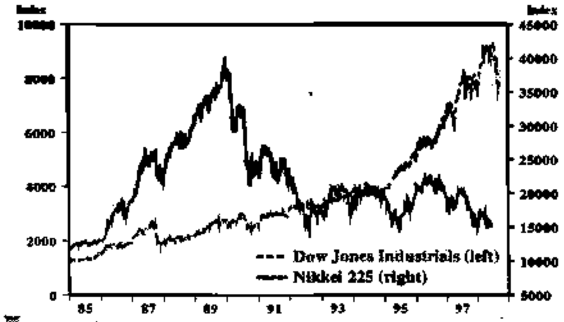
"The fact is, Japan has developed a sounder more efficient economy than America..."

"The Japan That Can Say No"
Shintaro Ishihara
1989

MILKEN INSTITUTE

Different Paths

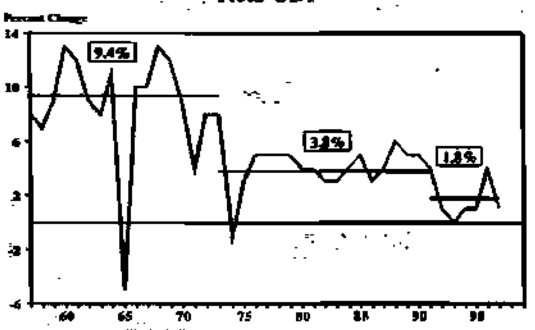
Dow Jones Industrials and Nikkei 225



MILKEN INSTITUTE

Are Japan's Best Days Past?

Real GDP



MILKEN INSTITUTE

A Japanese Perspective

"We don't give a hoot about things like ROE (return on equity)."

Kentaro Aikawa
Chairman, Mitsubishi Heavy Industries
January 15, 1998

MILKEN INSTITUTE

A Japanese Perspective

"We'll be in trouble if that kind of Harvard Business School thinking is brought to Japan."

Kentaro Aikawa
Chairman, Mitsubishi Heavy Industries
January 15, 1998

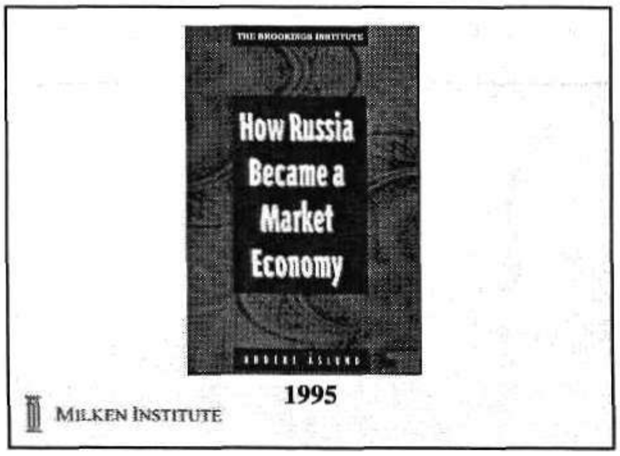
MILKEN INSTITUTE

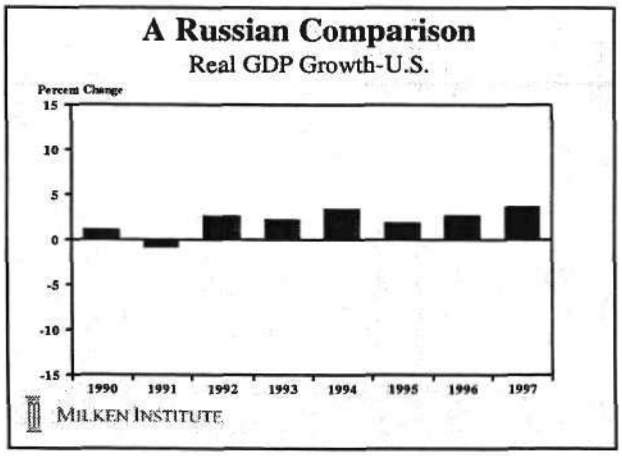
Reindustrializing Japan

After WWII

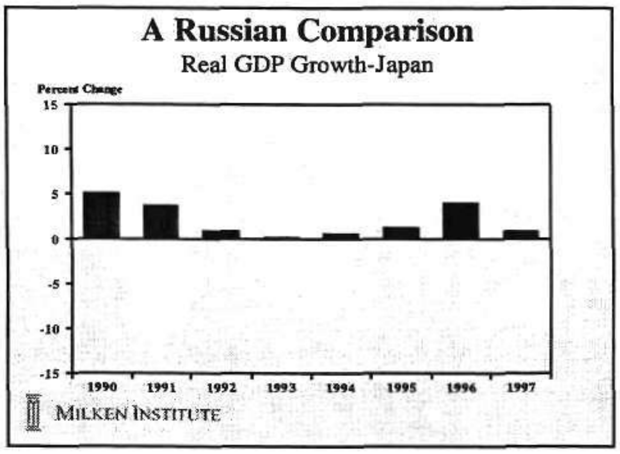
- ***1950's - Textiles***
- ***1960's - Steel***
- ***1970's - Autos***
- ***1980's - Electronics***
- ***1990's - ?***

MILKEN INSTITUTE

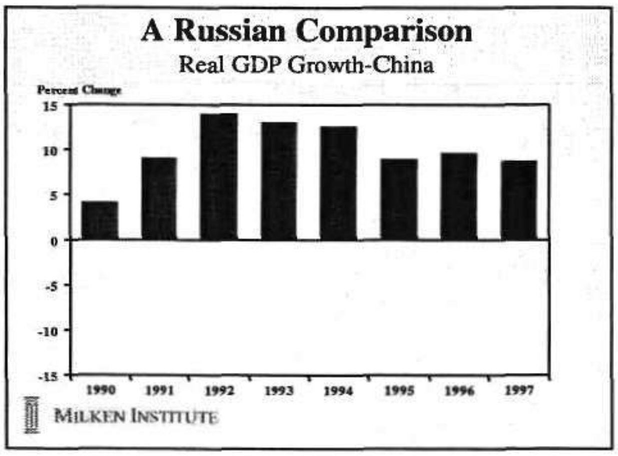

How Russia Became a Market Economy
1995
MILKEN INSTITUTE


A Russian Comparison
Real GDP Growth-U.S.
Percent Change
15
10
5
0
-5
-10
-15
1990 1991 1992 1993 1994 1995 1996 1997
MILKEN INSTITUTE


A Russian Comparison
Real GDP Growth-Europe
Percent Change
15
10
5
0
-5
-10
-15
1990 1991 1992 1993 1994 1995 1996 1997
MILKEN INSTITUTE

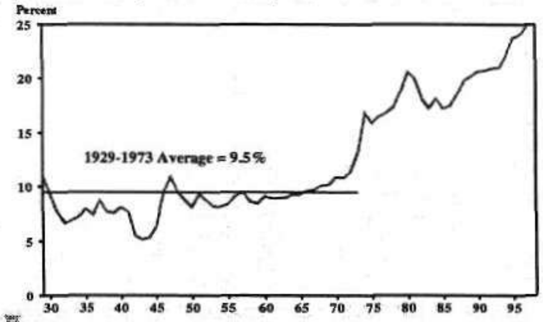

A Russian Comparison
Real GDP Growth-Japan
Percent Change
15
10
5
0
-5
-10
-15
1990 1991 1992 1993 1994 1995 1996 1997
MILKEN INSTITUTE


A Russian Comparison
Real GDP Growth-Developing Asia
Percent Change
15
10
5
0
-5
-10
-15
1990 1991 1992 1993 1994 1995 1996 1997
MILKEN INSTITUTE


A Russian Comparison
Real GDP Growth-China
Percent Change
15
10
5
0
-5
-10
-15
1990 1991 1992 1993 1994 1995 1996 1997
MILKEN INSTITUTE

Globalization is Here to Stay

U.S. Exports Plus Imports as Percent of GDP



MILKEN INSTITUTE

"Man" Of The Year

January 3, 1983

MILKEN INSTITUTE

On Telephones

"That is an amazing invention, but who would ever want to use one of them?"

President Rutherford B. Hayes, 1876

MILKEN INSTITUTE

On Everything New

"Everything that can be invented has been invented."

Charles H. Duell
Commission of U.S. Office of Patents, 1899

MILKEN INSTITUTE

On Radio

"The radio craze ... will die out in time."

Thomas Alva Edison, 1922

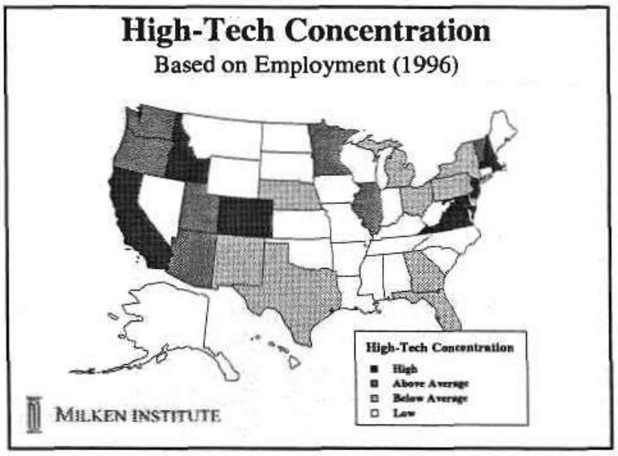
MILKEN INSTITUTE

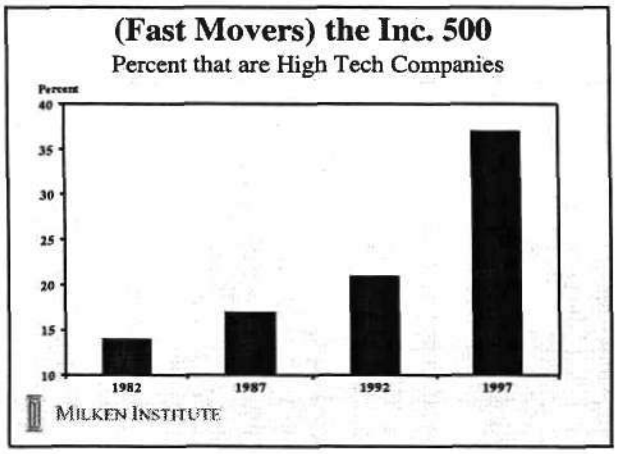
Computers - 1949

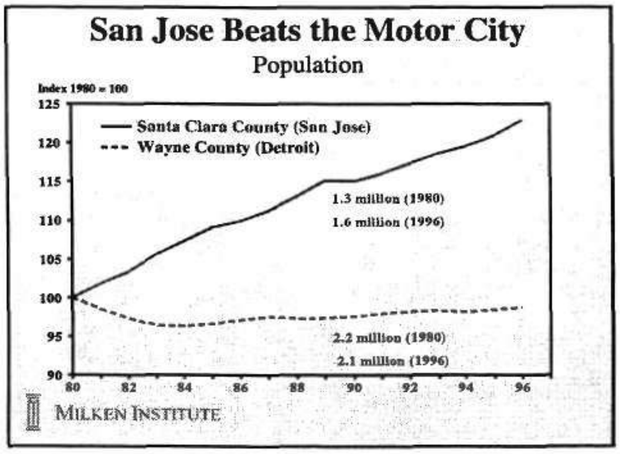
"Computers in the future may weigh no more than 1.5 tons."

Popular Mechanics, 1949

MILKEN INSTITUTE







Artificial Intelligence

"A.I. (artificial intelligence) is the science of how to get machines to do the things they do in the movies."

Astro Teller
Carnegie Mellon University

MILKEN INSTITUTE

"On the internet, nobody knows that you are a dog".

MILKEN INSTITUTE

Time to Download Video Clip

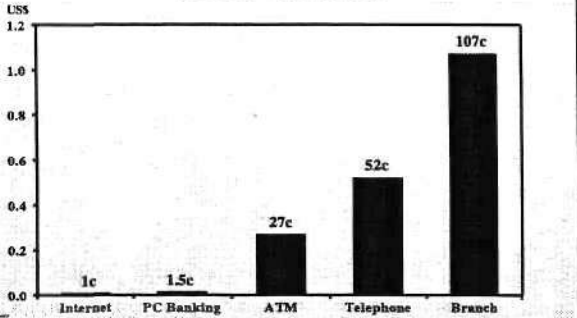
3.5 Minute Video off the Internet

	Transfer Time
28.8 Kbps modem	46 minutes
128 Kbps ISDN	10 minutes
4 Mbps cable modem	20 minutes
8 Mbps ADSL	10 seconds
10 Mbps cable modem	8 seconds

MILKEN INSTITUTE

Internet Banking is Cheaper

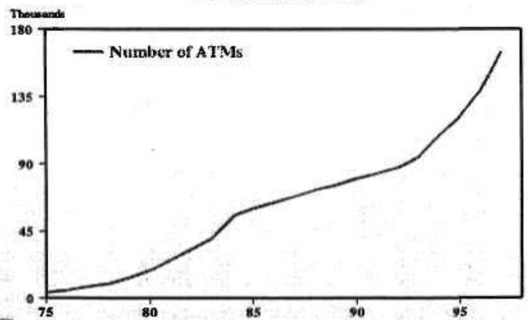
Cost Per Transaction



MILKEN INSTITUTE

Electronic Banking Takes Over

ATMs in the U.S.



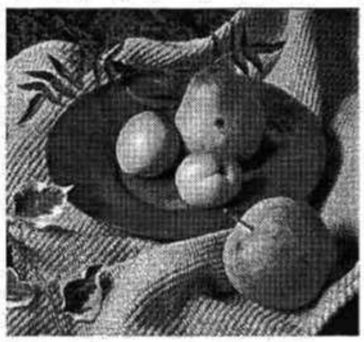
MILKEN INSTITUTE

Rapid Mail Order Growth

Retail Sales: Mail Order and Total

MILKEN INSTITUTE

www.greengrocer.com



MILKEN INSTITUTE

Computer Industry Leaders

Merrill Lynch List (October 1967)

- *International Business Machines*
- *General Electric*
- *Radio Corporation of America*
- *Sperry Rand*
- *Burroughs Corporation*
- *Honeywell, Inc.*
- *Control Data*
- *National Cash Register*
- *Scientific Data Systems*
- *Digital Equipment*
- *Mohawk Data Sciences*
- *American Research and Development*
- *Memorex Corporation*
- *Computer Sciences*
- *University Computing*
- *Data Processing Financial and General*
- *Farrington Manufacturing*
- *California Computer Products*
- *Leasco Data Processing Equipment*
- *Levin Townsend Computer*
- *Systems Engineering Laboratories*
- *Data Products*
- *Computing and Software*
- *Electronic Memories*
- *Computer Applications*

MILKEN INSTITUTE

Technology Today--Top 25

Market Cap; September 30, 1998 (US$ Billions)

Microsoft Corp	272	*BMC Software Inc*	13
Intel Corp	144	*HBO & Co*	12
Cisco Systems Inc	97	*3Com Corp*	11
Lucent Technologies	91	*Compuware Corp*	11
Dell Computer Corp	84	*First Data Corp*	10
Compaq Computer Corp	53	*Gateway 2000 Inc*	8
EMC Corp	29	*Peoplesoft Inc*	8
Oracle Corp	28	*Ingram Micro Inc*	7
Motorola Inc	26	*Micron Technology Inc*	6
Automatic Data Processing	23	*Stmicroelectronics N V*	6
Computer Assoc Intl	21	*Seagate Technology*	6
Texas Instruments	21	*Panamsat Corp*	6
Sun Microsystems Inc.	19		

MILKEN INSTITUTE

Technology's Limits

"As any musician will tell you, the music is not in the piano."

Computer Visionary Alan Kay

MILKEN INSTITUTE

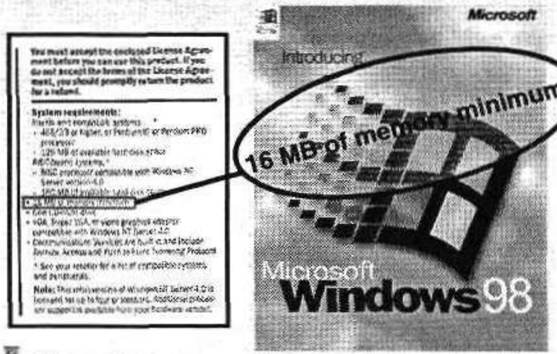
Computer Memory - 1981

"Who in their right mind would ever need more than 640k of ram!?"

Bill Gates, 1981
Microsoft Founder

MILKEN INSTITUTE

Microsoft Today



MILKEN INSTITUTE

The Justice Department

"At this time I do not have a personal relationship with a computer."

Attorney General Janet Reno
May 16, 1998

MILKEN INSTITUTE

Dataquest

Technology and the Global Economies

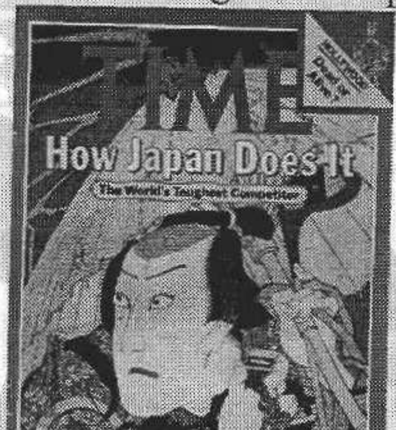
San Diego, CA
October 19, 1998

Donald H. Straszheim
President
Milken Institute
1250 Fourth Street
Santa Monica, CA 90401
310-998-2620

MILKEN INSTITUTE

"How Japan Does it"

The World's Toughest Competitor



MILKEN INSTITUTE March 30 , 1981

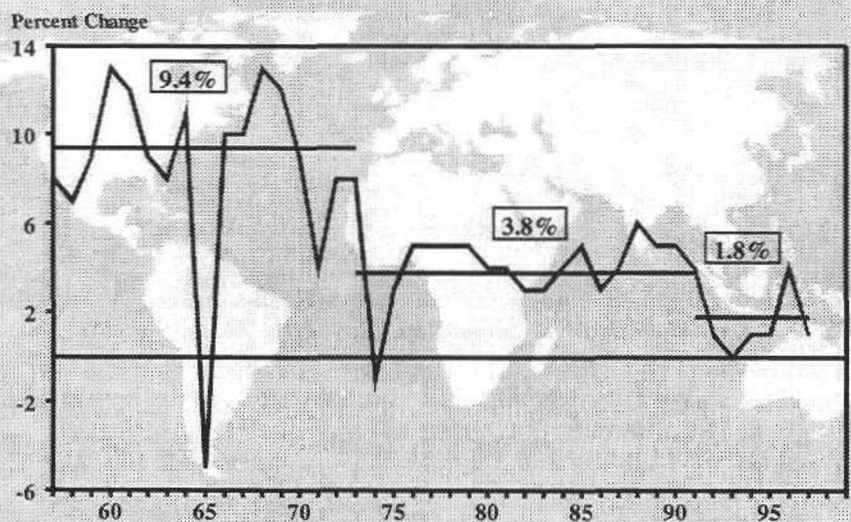
Reindustrializing Japan

1950's - Textiles
1960's - Steel
1970's - Autos
1980's - Electronics
1990's - ?

MILKEN INSTITUTE

Are Japan's Best Days Past?

Real GDP



MILKEN INSTITUTE

A Japanese Perspective

"We don't give a hoot about things like ROE (return on equity)."

Kentaro Aikawa
Chairman, Mitsubishi Heavy Industries

MILKEN INSTITUTE

Big Business in Japan

A Closer Look at the Keiretsu Networks

	Mitsubishi	Mitsui	Sumitomo	Fuyo	DKB	Sanwa
Fin Services	x	x	x	x	x	x
Tech Related	x	x	x	x	x	x
Cars	x	x		x	x	x
Trade & Retail	x	x	x	x	x	x
Food & Bev	x	x		x		x
Construction	x	x	x	x	x	x
Metals	x	x	x	x	x	x
Real Estate	x	x	x	x	x	
Oil & Coal	x			x	x	x
Rubber & Glass	x		x		x	x
Chemicals	x	x	x	x	x	x
Fibers & Text	x	x		x	x	x
Pulp & Paper	x	x		x	x	
Min & Forestry		x	x			
Indust Eqpt	x	x	x	x	x	x
Cam & Opt	x			x	x	x
Cement		x	x	x	x	x
Ship & Trans	x	x	x	x	x	x

MILKEN INSTITUTE

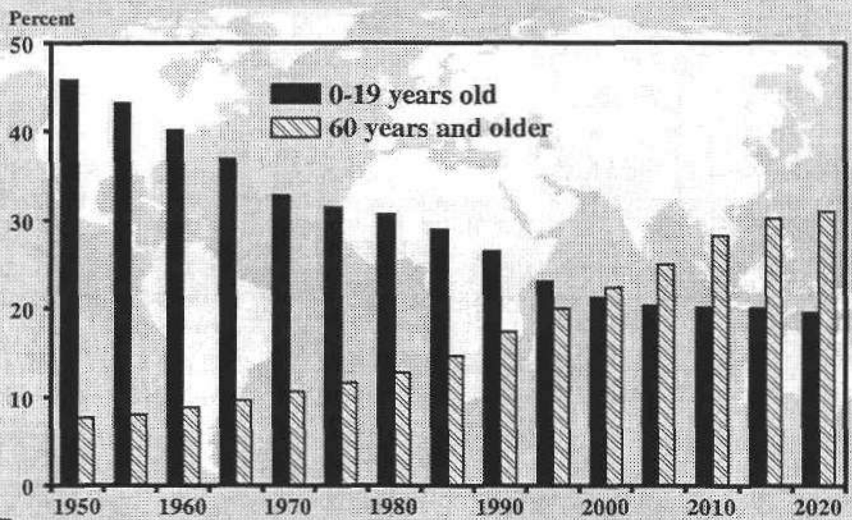
Japan Reforms Needed

- Keiretsu preferences ended
- Open distribution, retailing, trade, transportation
- Banks down; capital markets up
- Ownership; not managers, employees top
- Accounting transparency; corporate governance
- Labor market competition--not lifetime
- Meritocracy in all areas

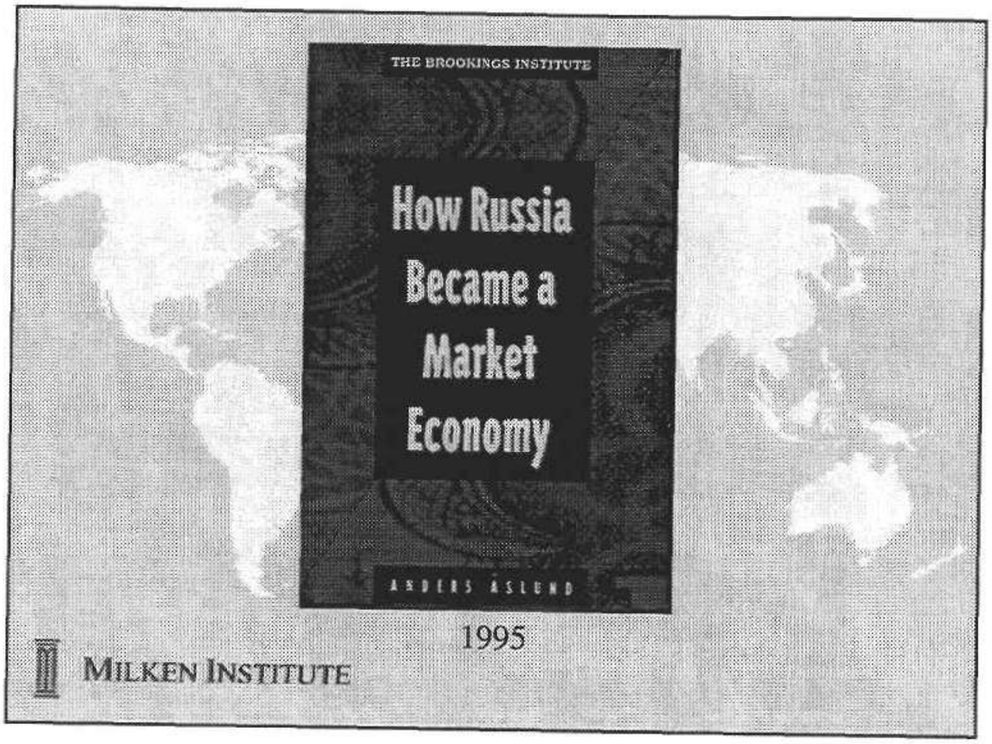
MILKEN INSTITUTE

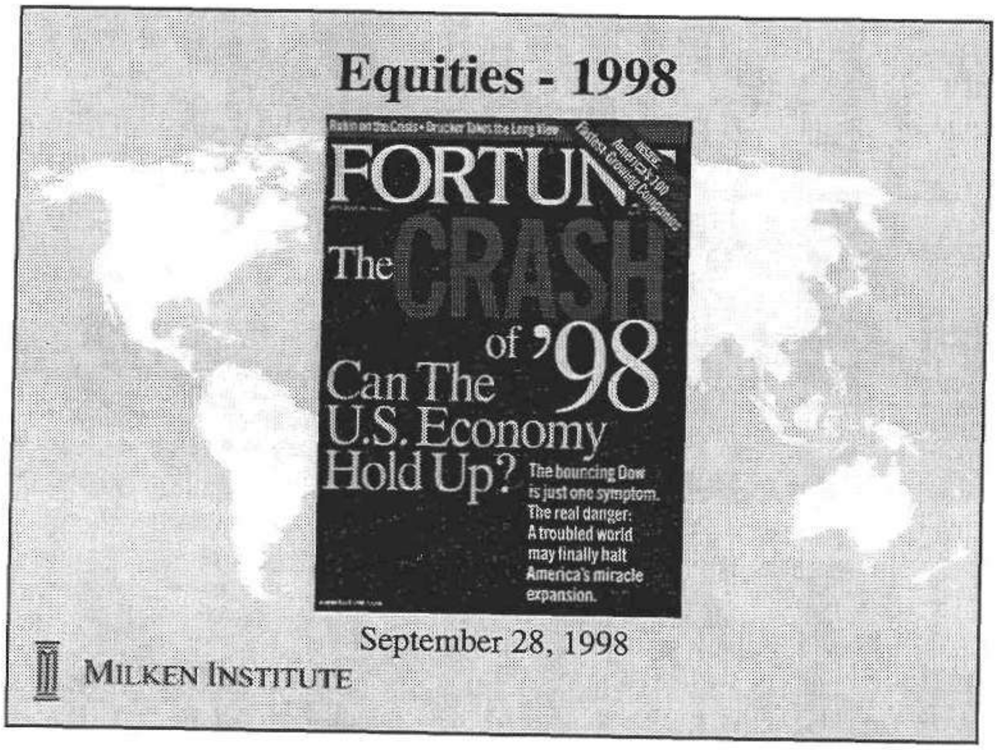
Young and Old Dependents -- Japan

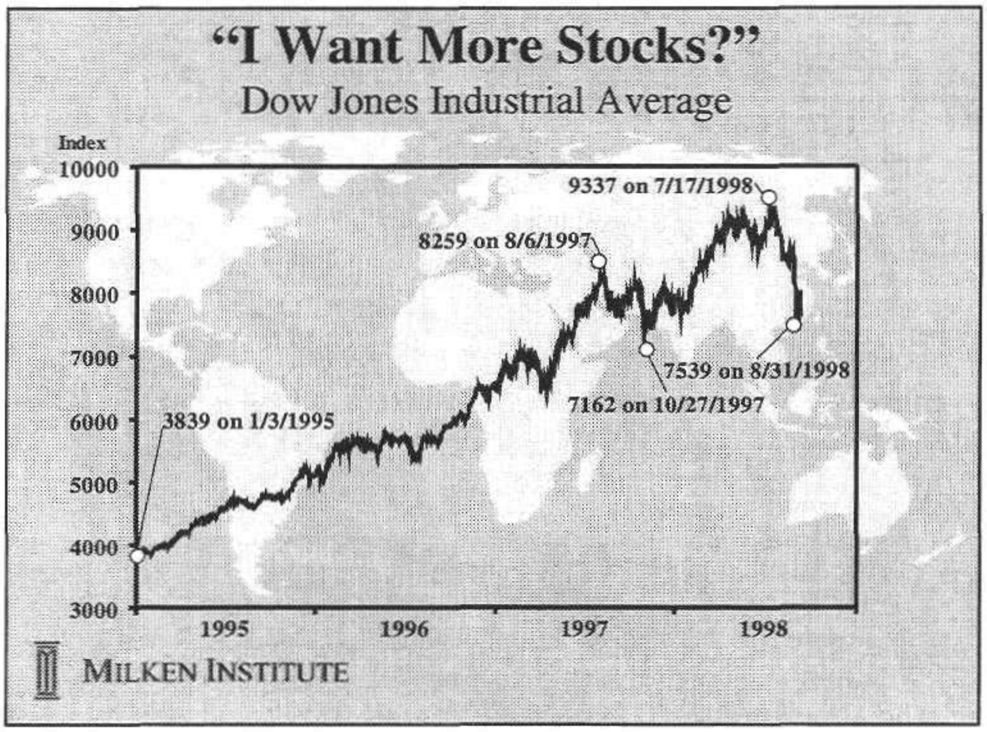
Young and Elderly as % of Total Population

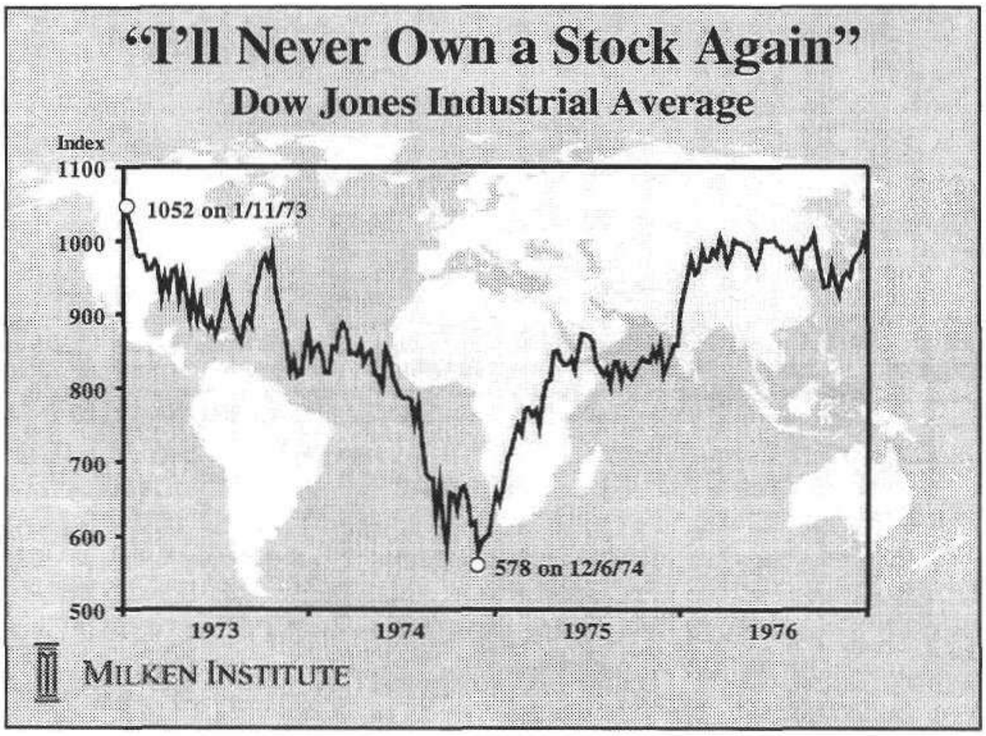


MILKEN INSTITUTE


THE BROOKINGS INSTITUTE
How Russia Became a Market Economy
ANDERS ASLUND
1995
MILKEN INSTITUTE

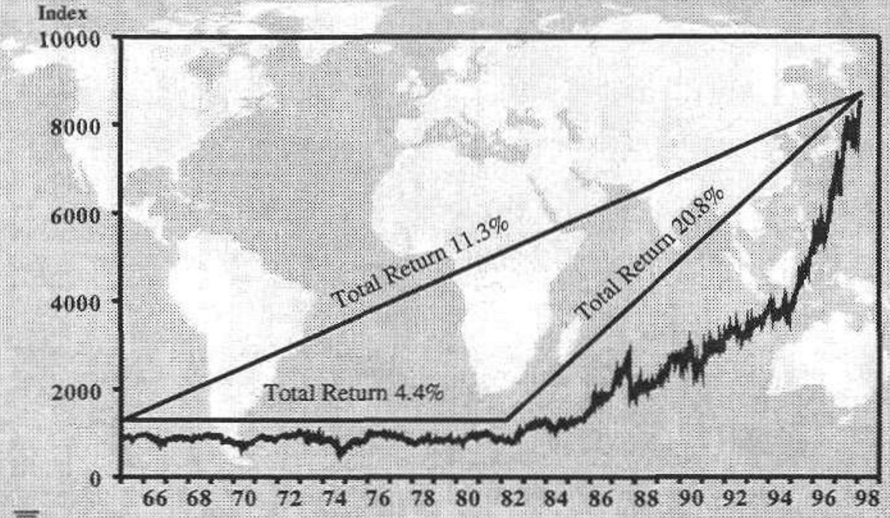

Equities - 1998
Rubin on the Crisis • Drucker Takes the Long View
The CRASH of '98
Can The U.S. Economy Hold Up?
The bouncing Dow is just one symptom. The real danger: A troubled world may finally halt America's miracle expansion.
September 28, 1998
MILKEN INSTITUTE


"I Want More Stocks?"
Dow Jones Industrial Average
Index
10000
9000
8000
7000
6000
5000
4000
3000
9337 on 7/17/1998
8259 on 8/6/1997
7539 on 8/31/1998
7162 on 10/27/1997
3839 on 1/3/1995
1995
1996
1997
1998
MILKEN INSTITUTE


"I'll Never Own a Stock Again"
Dow Jones Industrial Average
Index
1100
1000
900
800
700
600
500
1052 on 1/11/73
578 on 12/6/74
1973
1974
1975
1976
MILKEN INSTITUTE

Historical Stock Returns

Dow Jones Industrial Average



MILKEN INSTITUTE

What I learned from Economists was: "October….is one of the peculiarly dangerous months to speculate on stocks in...

Mark Twain

MILKEN INSTITUTE

The others are July, January, September, April, November, May, March, June, December, August and February."

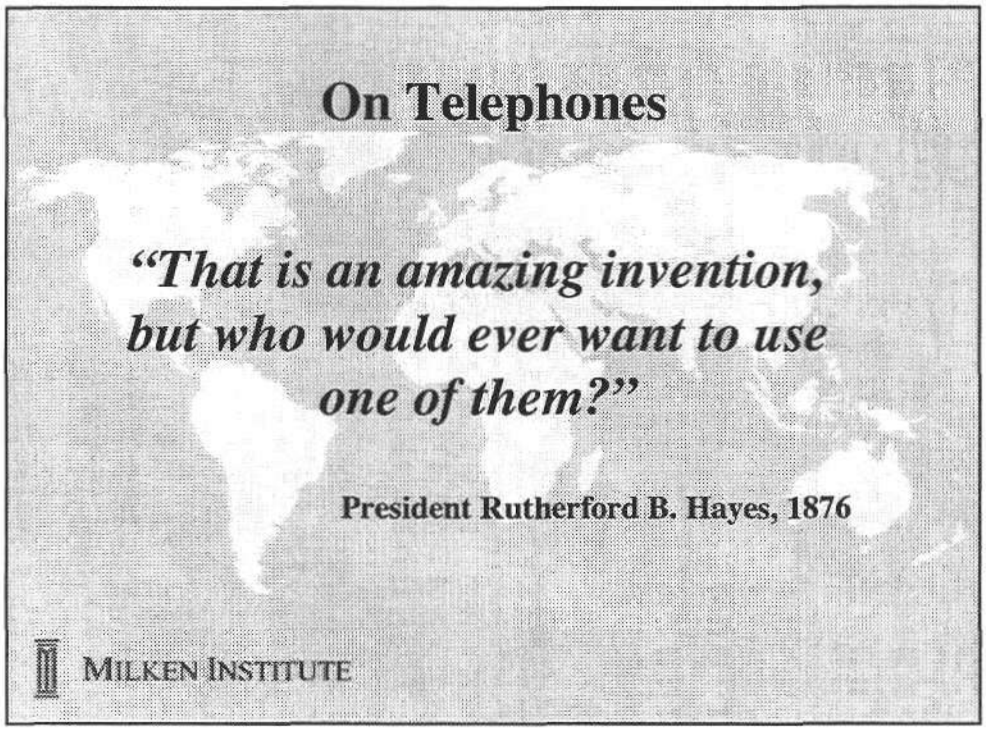
Mark Twain

MILKEN INSTITUTE

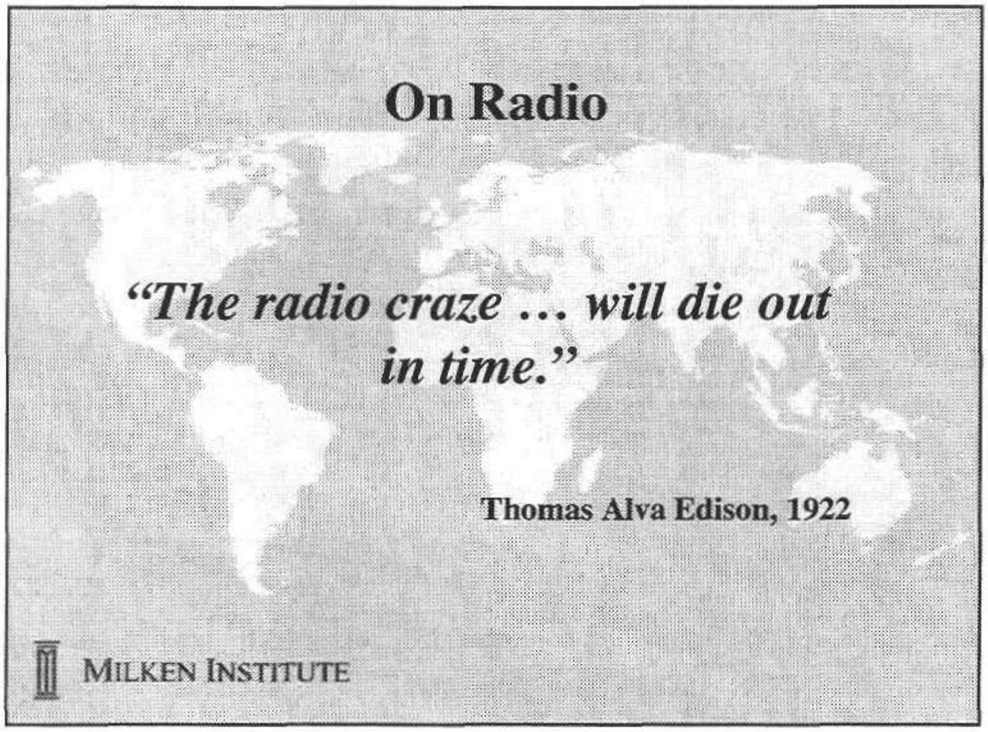
"Man" Of The Year

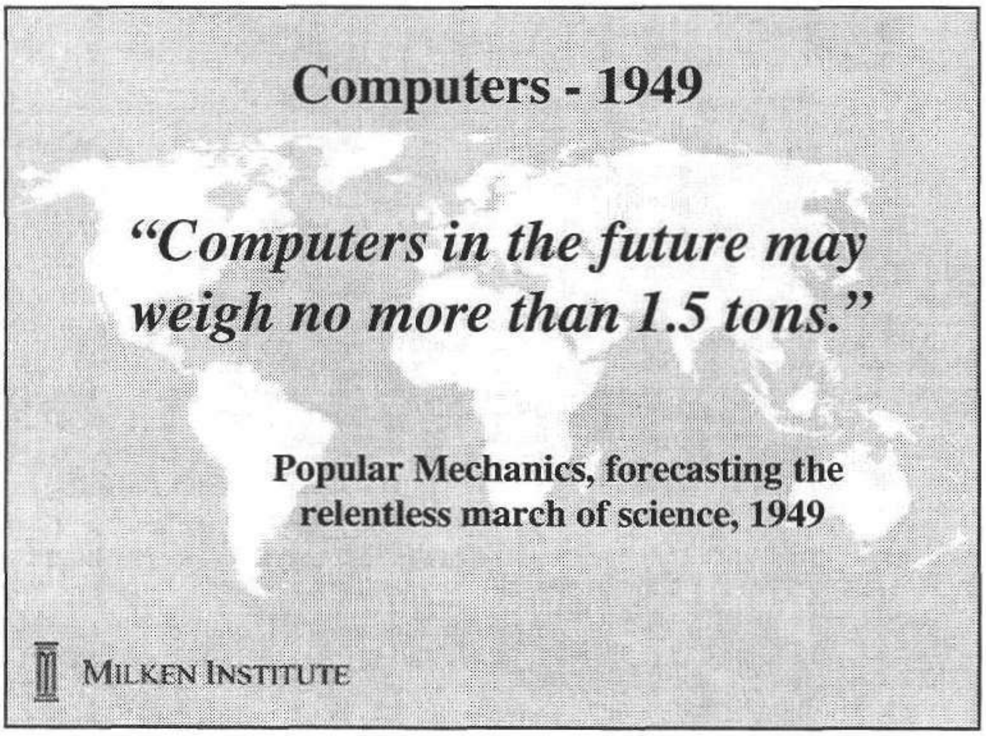
January 3, 1983

MILKEN INSTITUTE


On Telephones
"That is an amazing invention, but who would ever want to use one of them?"
President Rutherford B. Hayes, 1876
MILKEN INSTITUTE


On Everything New
"Everything that can be invented has been invented."
Charles H. Duell
Commission of U.S. Office of Patents, 1899
MILKEN INSTITUTE


On Radio
"The radio craze … will die out in time."
Thomas Alva Edison, 1922
MILKEN INSTITUTE


Computers - 1949
"Computers in the future may weigh no more than 1.5 tons."
Popular Mechanics, forecasting the relentless march of science, 1949
MILKEN INSTITUTE

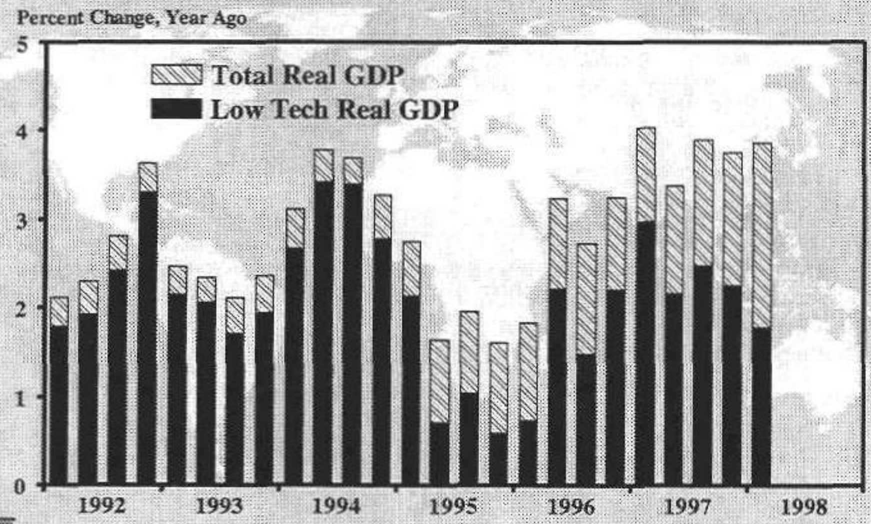
Years to Penetrate 25% of the Market

Technology	Year Invented	Years to Penetrate
Household Electricity	1873	46
Telephone	1875	35
Automobile	1896	44
Airplane	1903	54
Radio	1906	22
Television	1925	26
VCR	1952	34
Microwave Oven	1953	30
PC	1975	15
Cellular Phone	1983	13
Internet	1991	7

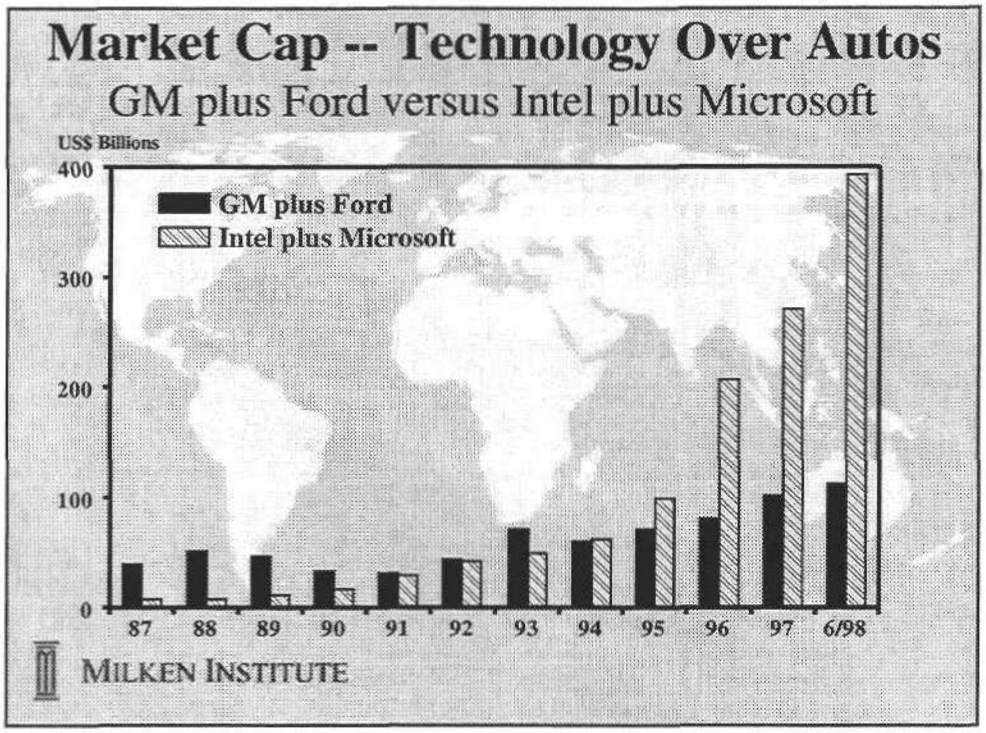
MILKEN INSTITUTE

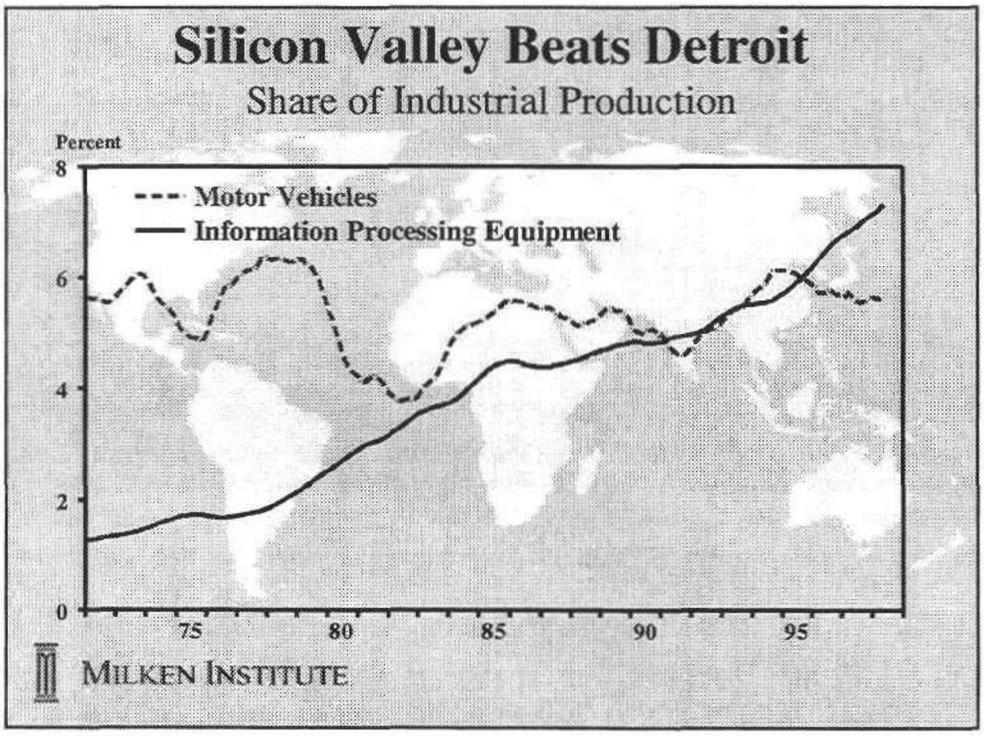
High-Tech Boosting GDP Growth

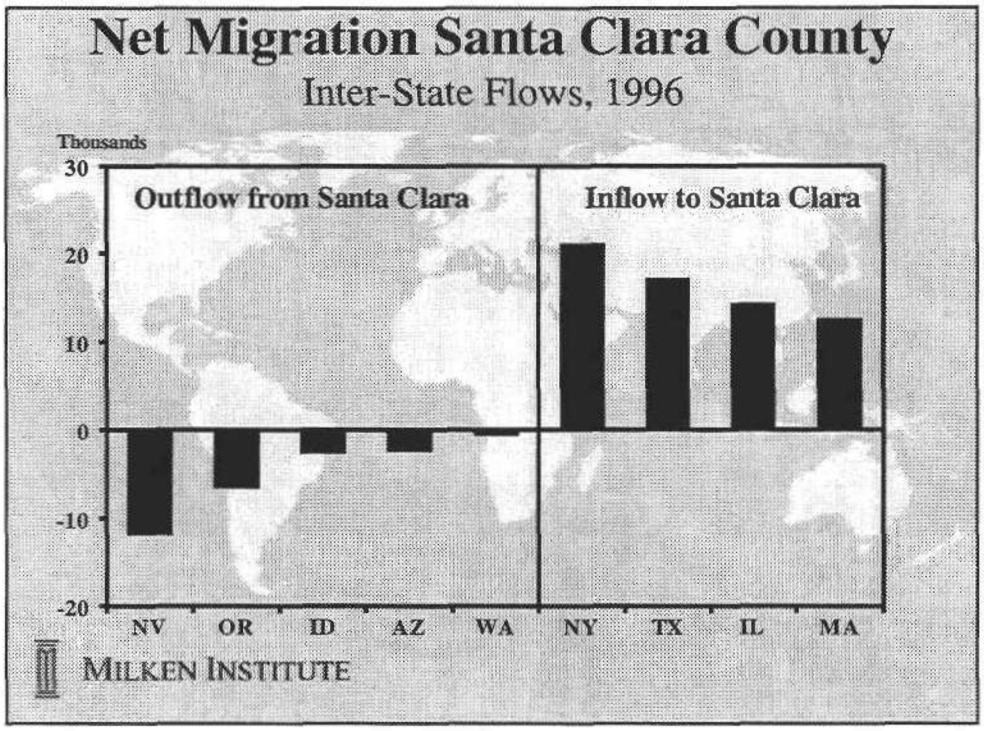
Real GDP vs. Low Tech GDP

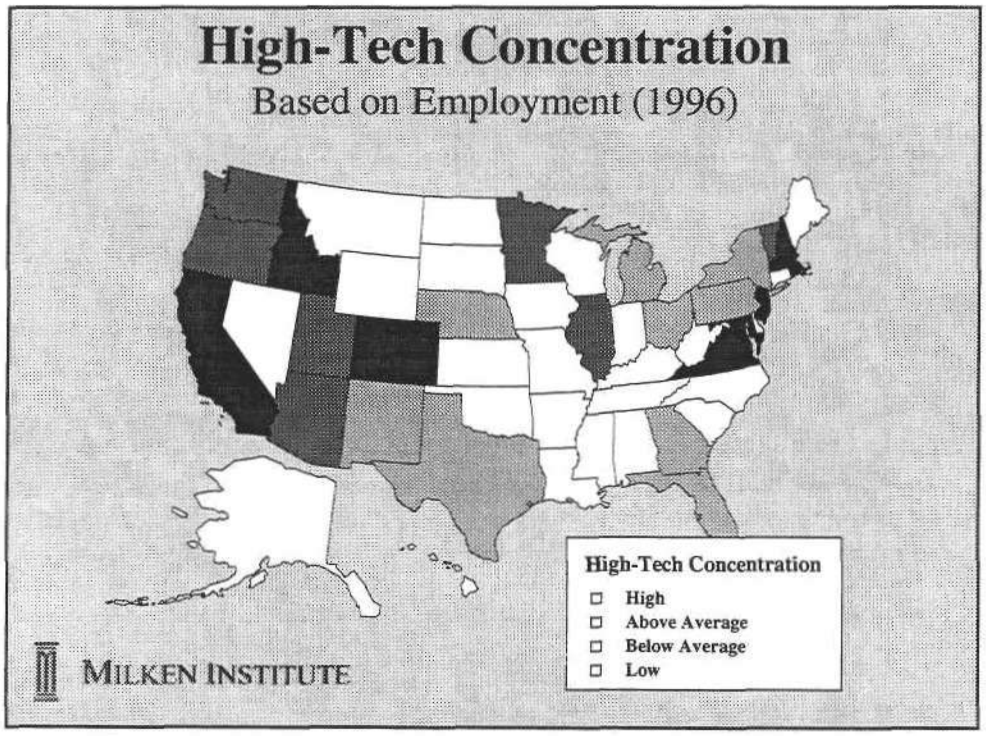


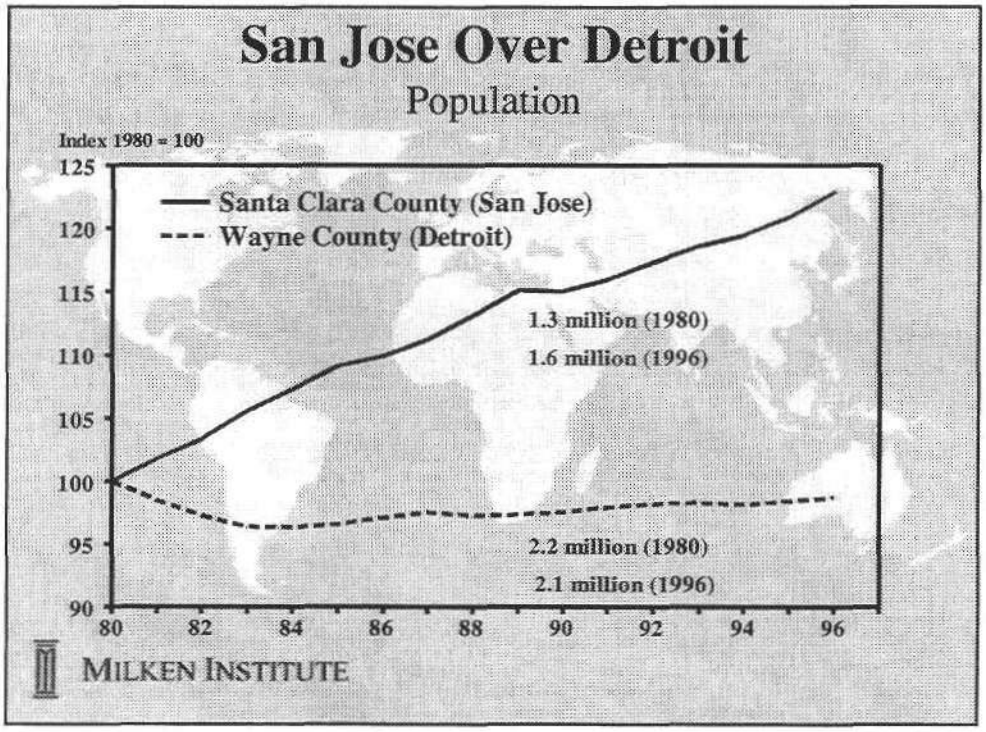
MILKEN INSTITUTE

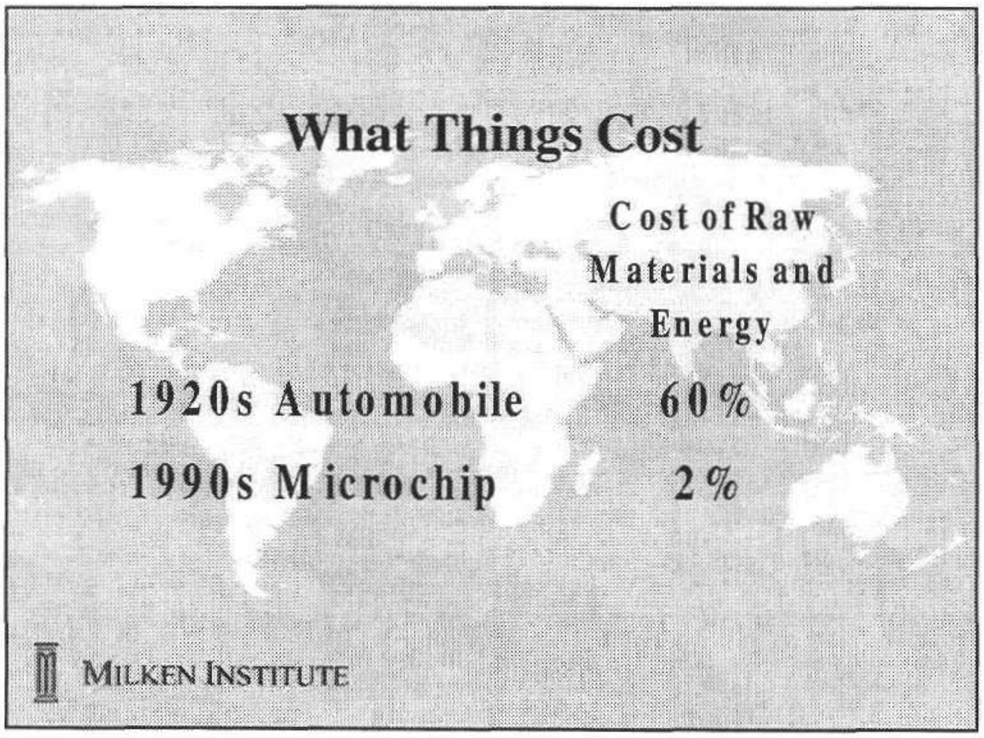

Market Cap -- Technology Over Autos
GM plus Ford versus Intel plus Microsoft
US$ Billions
400
300
200
100
0
GM plus Ford
Intel plus Microsoft
87
88
89
90
91
92
93
94
95
96
97
6/98
MILKEN INSTITUTE

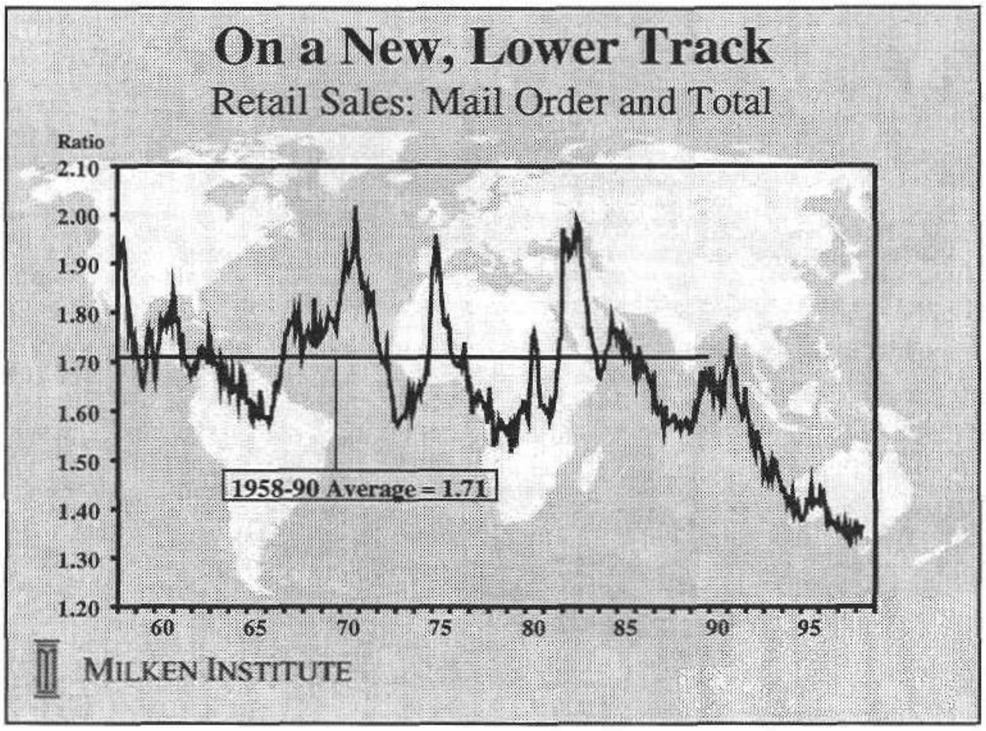

Silicon Valley Beats Detroit
Share of Industrial Production
Percent
8
6
4
2
0
Motor Vehicles
Information Processing Equipment
75
80
85
90
95
MILKEN INSTITUTE

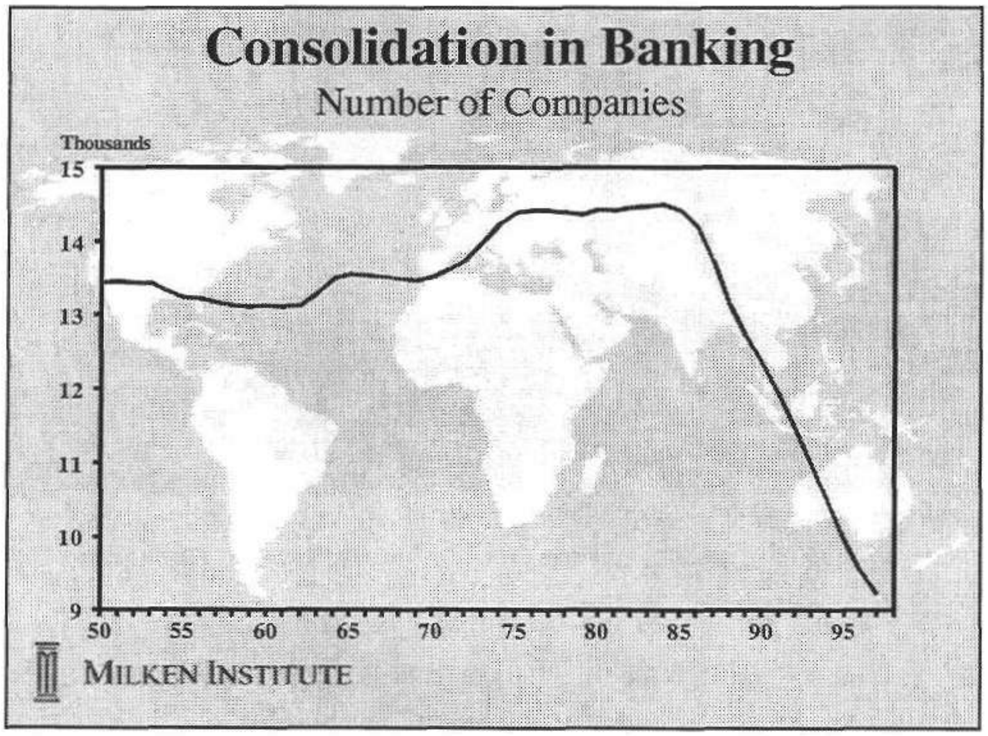

Net Migration Santa Clara County
Inter-State Flows, 1996
Thousands
30
20
10
0
-10
-20
Outflow from Santa Clara
Inflow to Santa Clara
NV
OR
ID
AZ
WA
NY
TX
IL
MA
MILKEN INSTITUTE

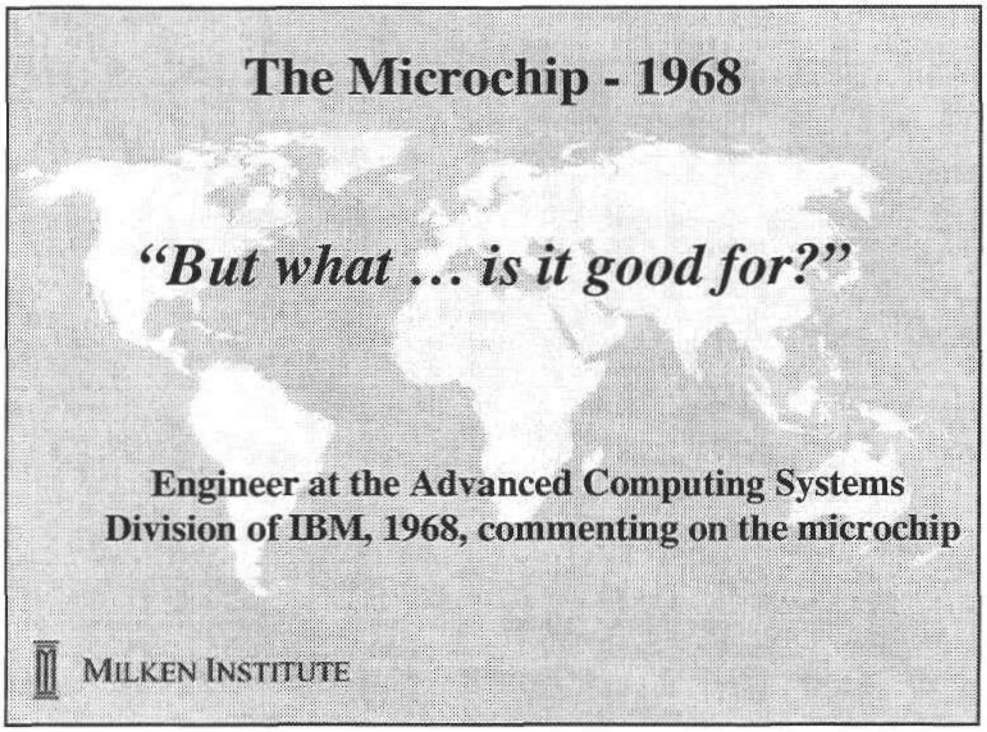

High-Tech Concentration
Based on Employment (1996)
High-Tech Concentration
High
Above Average
Below Average
Low
MILKEN INSTITUTE

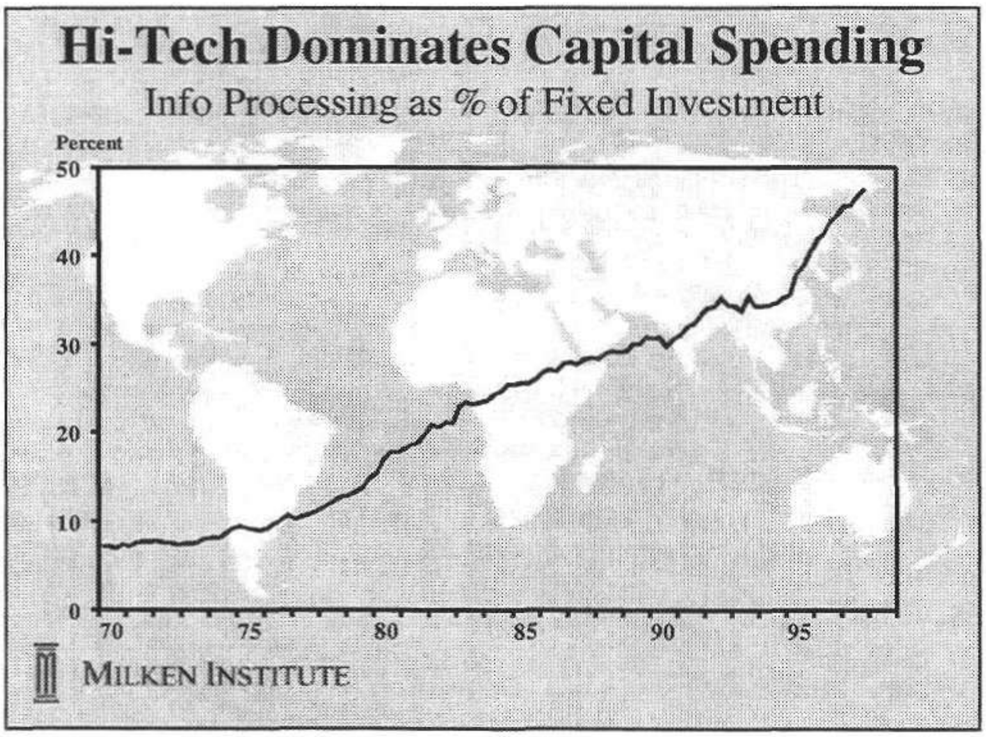

San Jose Over Detroit
Population
Index 1980 = 100
125
120
115
110
105
100
95
90
80
82
84
86
88
90
92
94
96
Santa Clara County (San Jose)
Wayne County (Detroit)
1.3 million (1980)
1.6 million (1996)
2.2 million (1980)
2.1 million (1996)
MILKEN INSTITUTE


What Things Cost
Cost of Raw Materials and Energy
1920s Automobile 60%
1990s Microchip 2%
MILKEN INSTITUTE


On a New, Lower Track
Retail Sales: Mail Order and Total
Ratio
2.10
2.00
1.90
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1958-90 Average = 1.71
60
65
70
75
80
85
90
95
MILKEN INSTITUTE

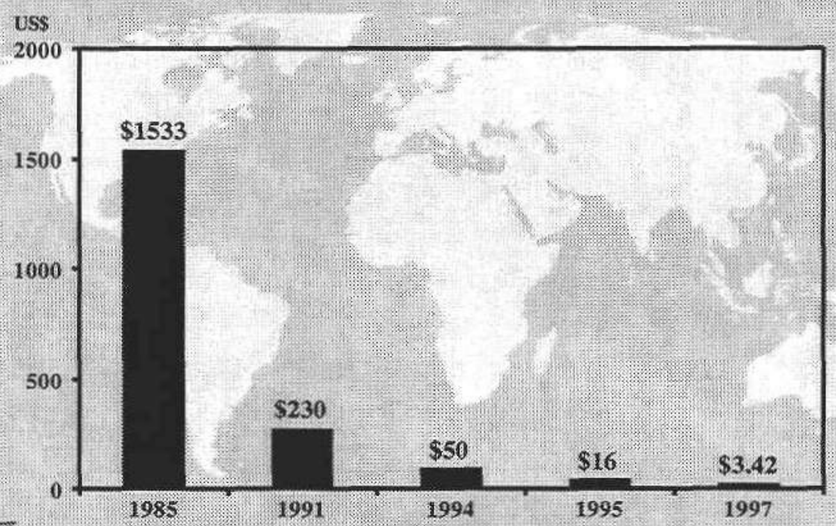

Consolidation in Banking
Number of Companies
Thousands
15
14
13
12
11
10
9
50
55
60
65
70
75
80
85
90
95
MILKEN INSTITUTE


The Microchip - 1968
"But what ... is it good for?"
Engineer at the Advanced Computing Systems
Division of IBM, 1968, commenting on the microchip
MILKEN INSTITUTE


Hi-Tech Dominates Capital Spending
Info Processing as % of Fixed Investment
Percent
50
40
30
20
10
0
70
75
80
85
90
95
MILKEN INSTITUTE

Microprocessor Prices Plummet

Price Per Millions of Instructions Per Second (MIPS)



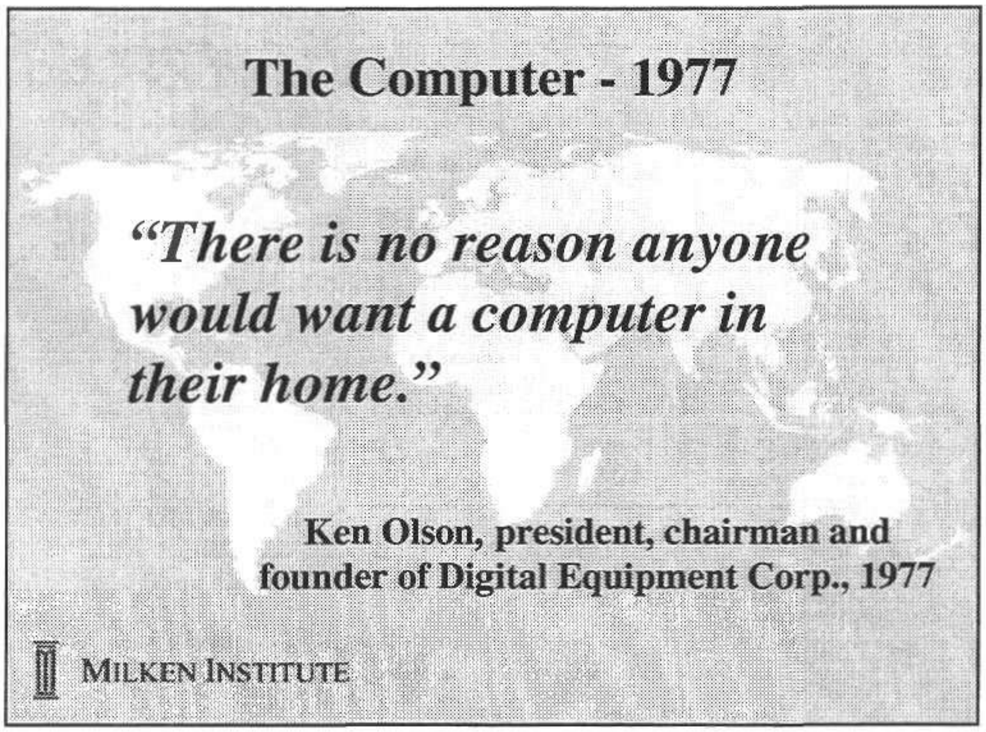
MILKEN INSTITUTE

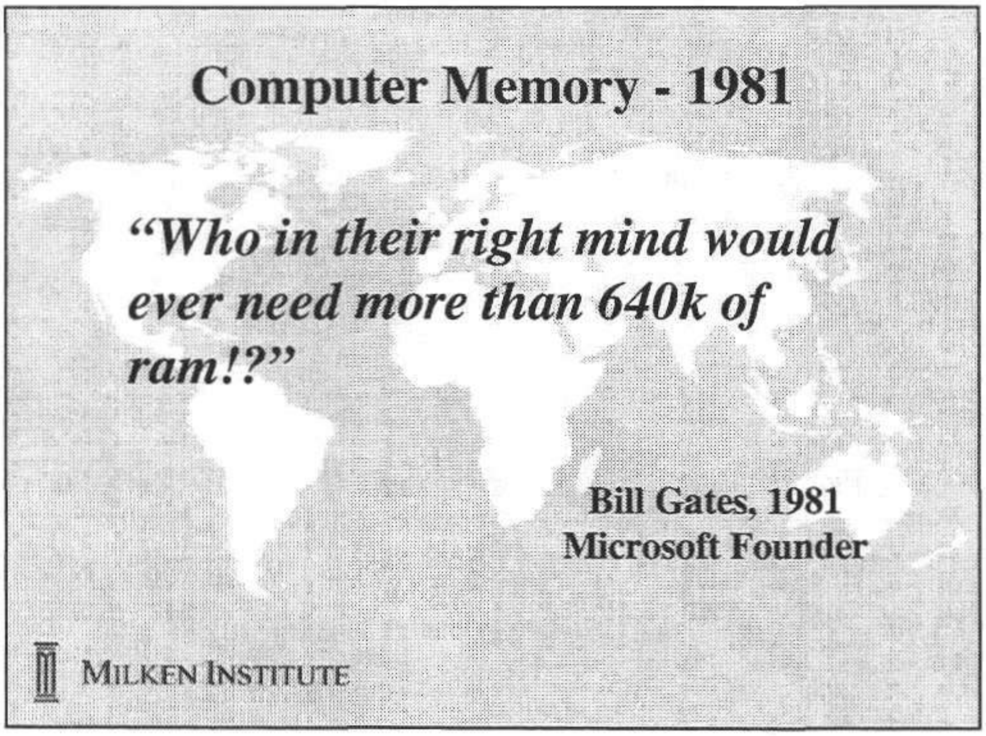
Moore's Law at Work

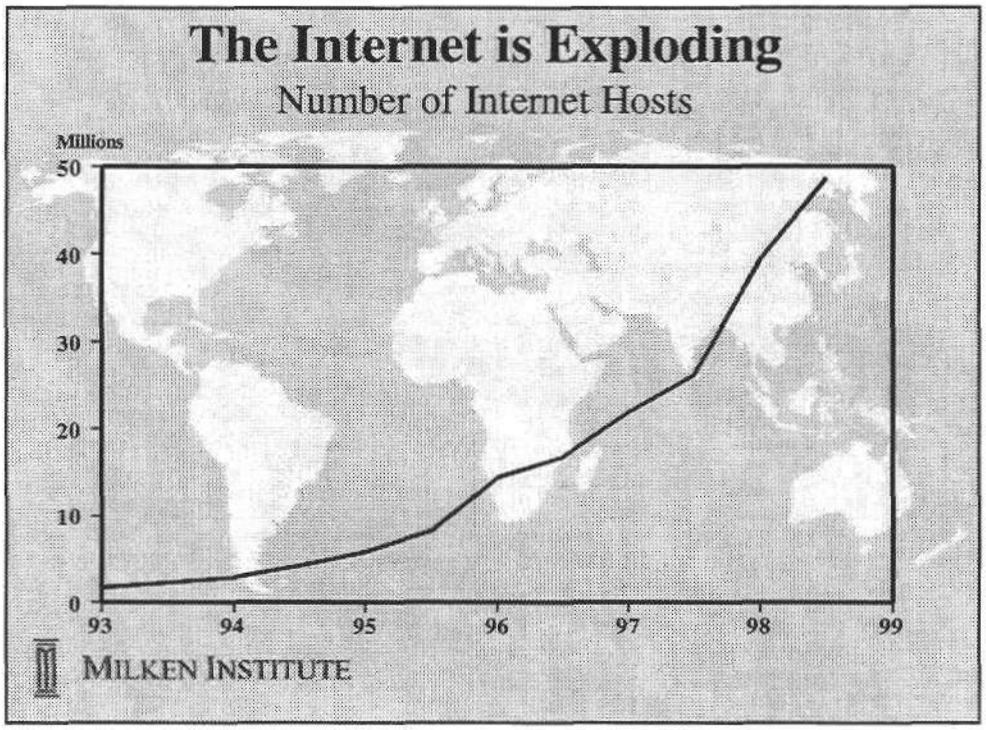
Transistors on Intel's Microprocessors

Year	Transistors
1972	3,500
1974	6,000
1978	29,000
1982	134,000
1985	275,000
1989	1,200,000
1993	3,100,000
1995	5,500,000
1997	7,500,000

MILKEN INSTITUTE


The Computer - 1977
"There is no reason anyone would want a computer in their home."
Ken Olson, president, chairman and founder of Digital Equipment Corp., 1977
MILKEN INSTITUTE


Computer Memory - 1981
"Who in their right mind would ever need more than 640k of ram!?"
Bill Gates, 1981
Microsoft Founder
MILKEN INSTITUTE

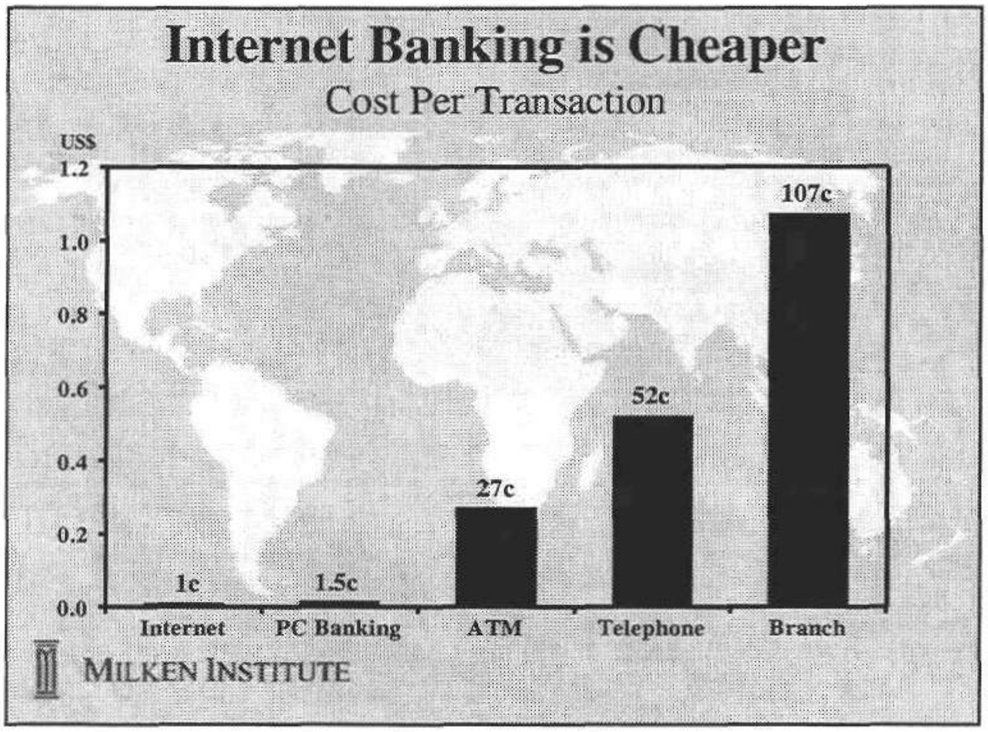


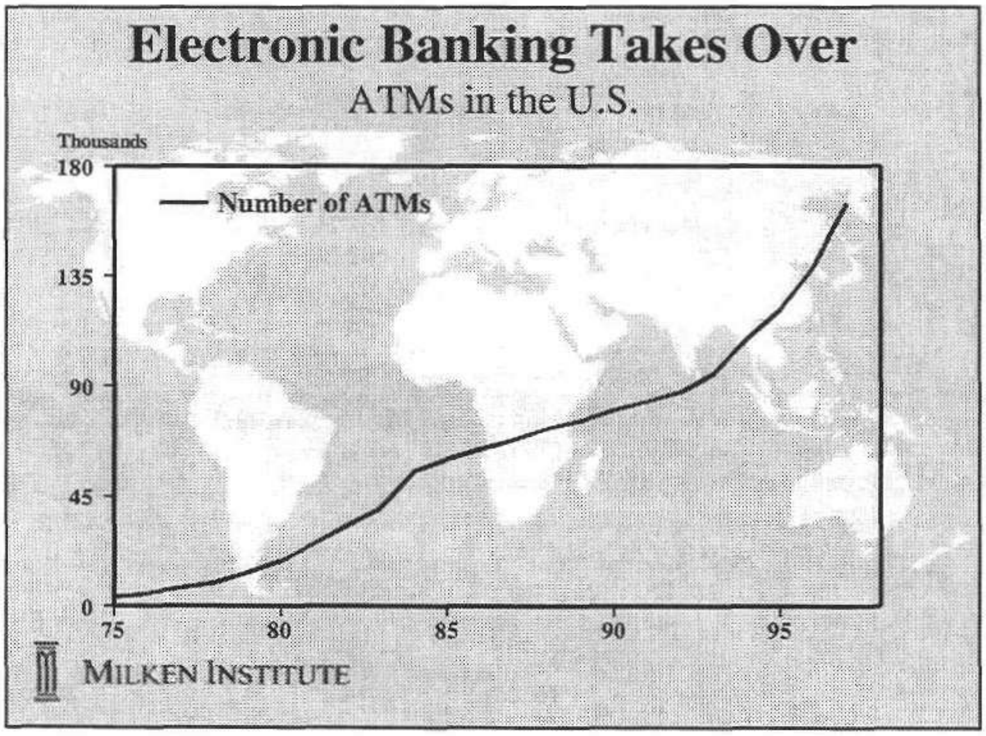
Time to Download Video Clip

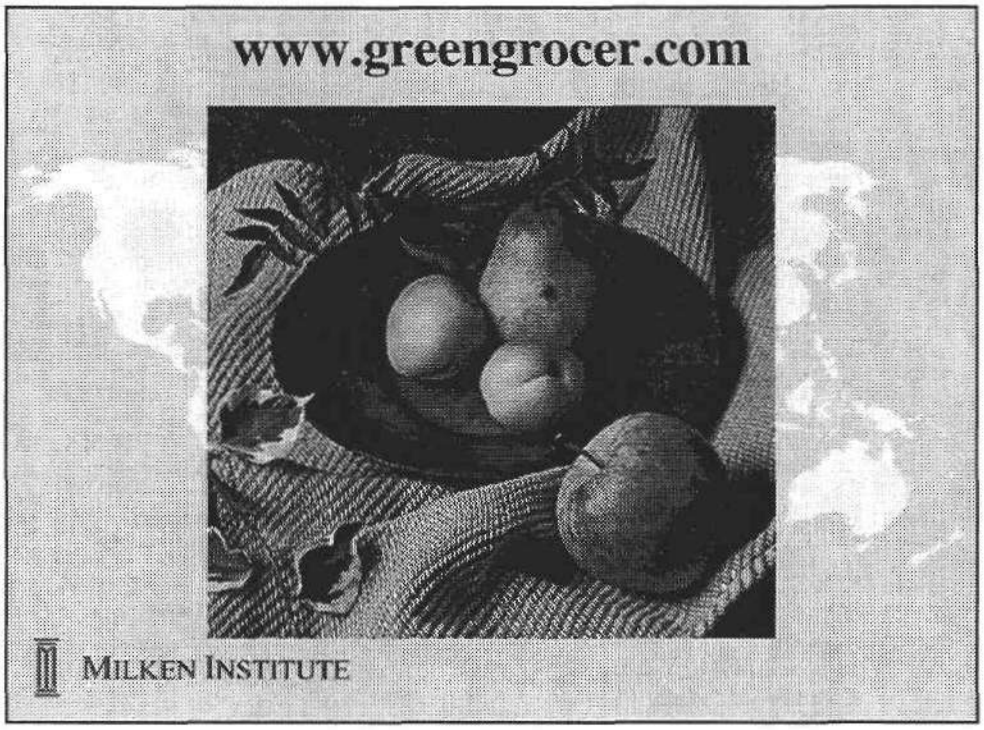
3.5 Minute Video off the Internet

	Transfer Time
28.8 Kbps modem	46 minutes
128 Kbps ISDN	10 minutes
4 Mbps cable modem	20 minutes
8 Mbps ADSL	10 seconds
10 Mbps cable modem	8 seconds

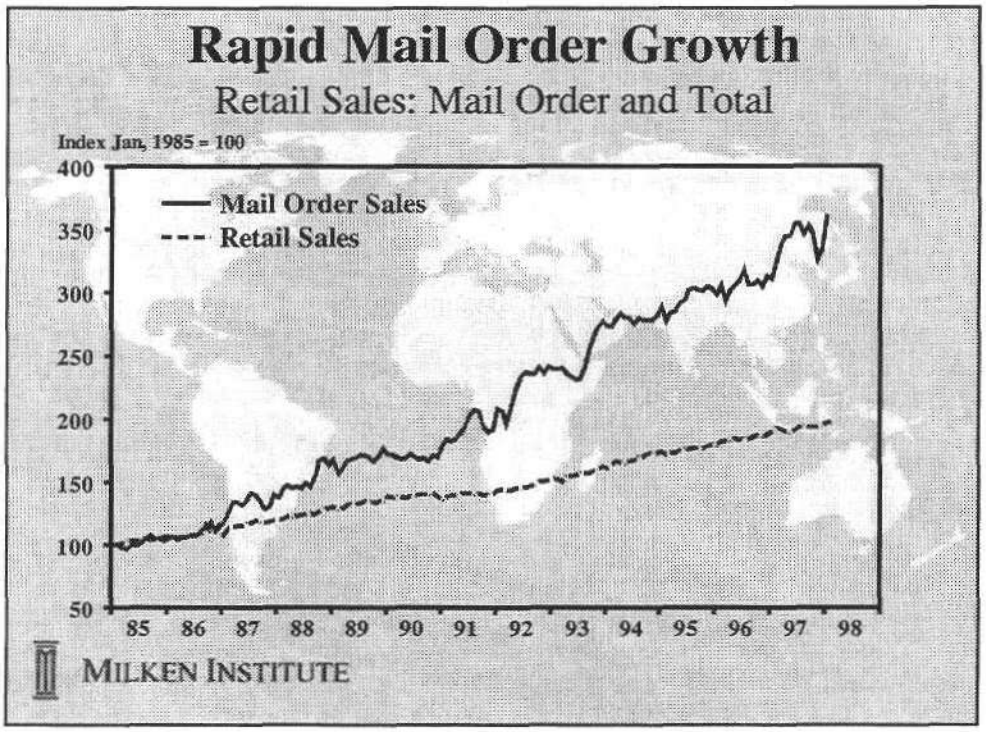
MILKEN INSTITUTE

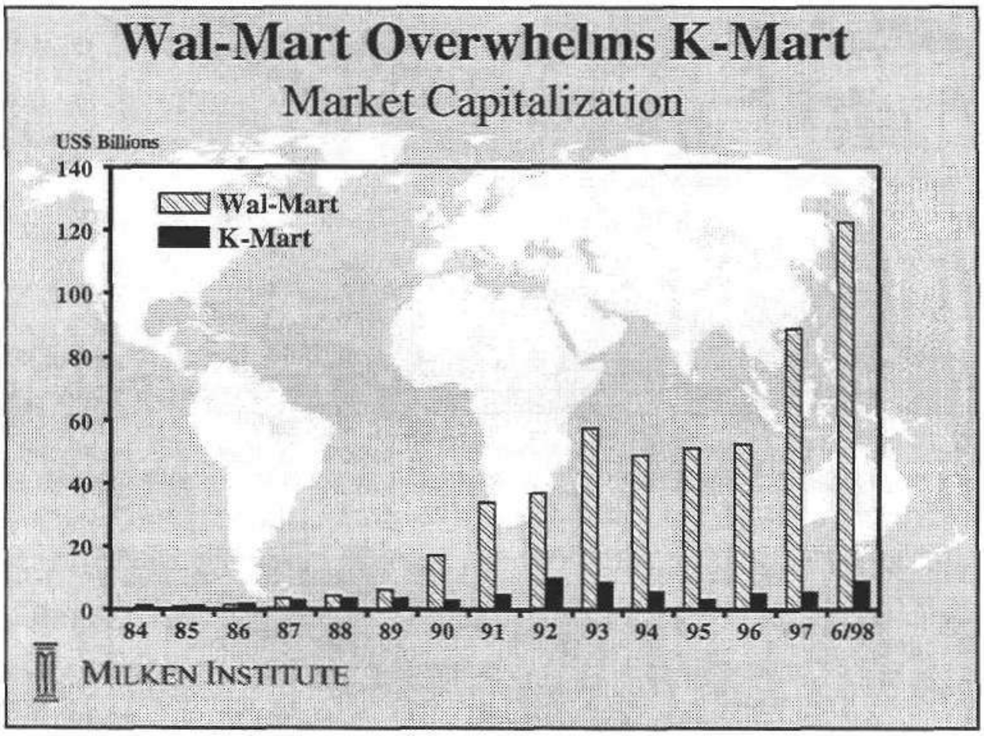

Internet Banking is Cheaper
Cost Per Transaction
US$
1.2
1.0
0.8
0.6
0.4
0.2
0.0
107c
52c
27c
1c
1.5c
Internet
PC Banking
ATM
Telephone
Branch
MILKEN INSTITUTE


Electronic Banking Takes Over
ATMs in the U.S.
Thousands
180
135
90
45
0
Number of ATMs
75
80
85
90
95
MILKEN INSTITUTE


www.greengrocer.com
MILKEN INSTITUTE


Why People Shop Online
Survey of Online Users
Percent
60
50
40
30
20
10
0
Convenience
Research
Prices
Selection
Fun
Impulse
Customer Service
Other
MILKEN INSTITUTE


Rapid Mail Order Growth
Retail Sales: Mail Order and Total
Index Jan, 1985 = 100
400
350
300
250
200
150
100
50
Mail Order Sales
Retail Sales
85 86 87 88 89 90 91 92 93 94 95 96 97 98
MILKEN INSTITUTE

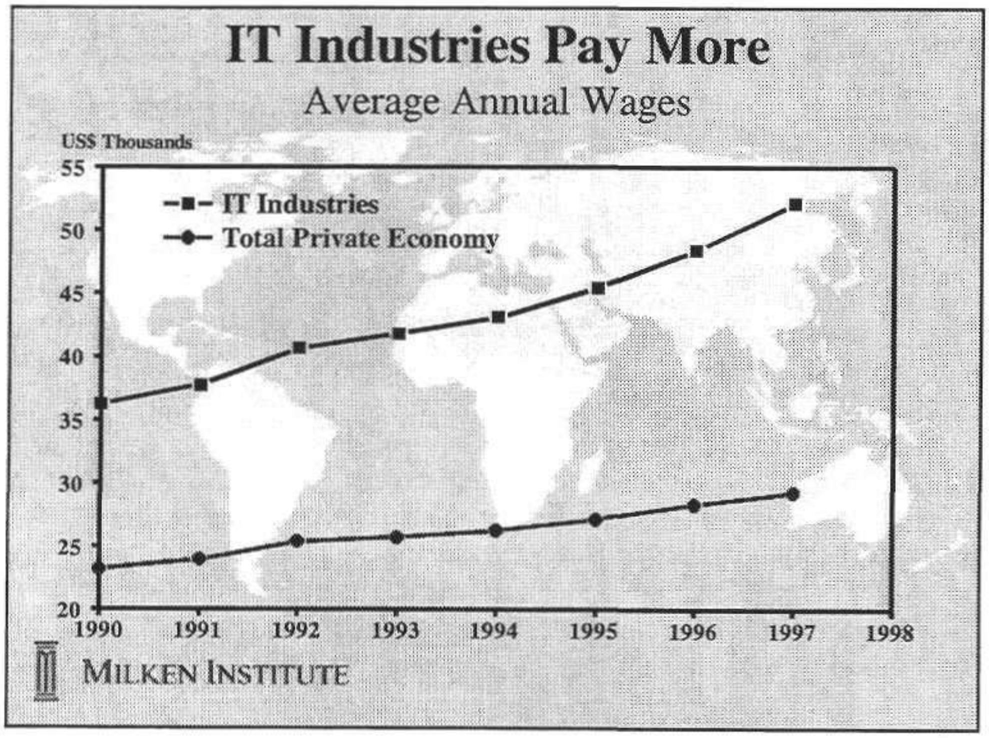

Wal-Mart Overwhelms K-Mart
Market Capitalization
US$ Billions
140
120
100
80
60
40
20
0
Wal-Mart
K-Mart
84 85 86 87 88 89 90 91 92 93 94 95 96 97 6/98
MILKEN INSTITUTE

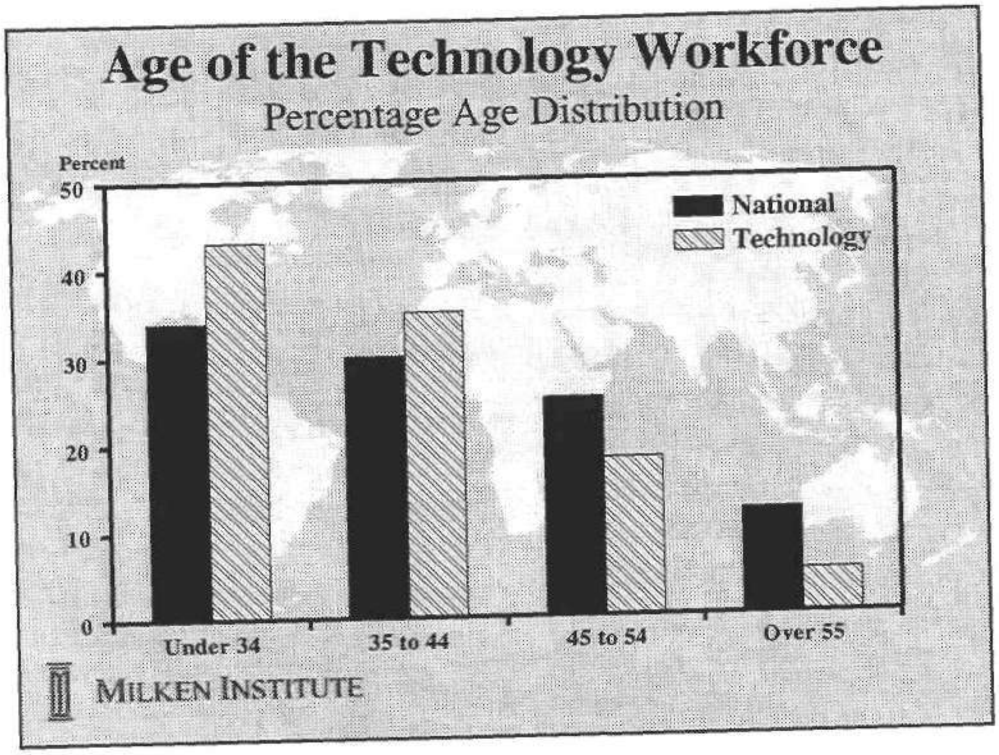
Top 10 Fastest Growing Occupations

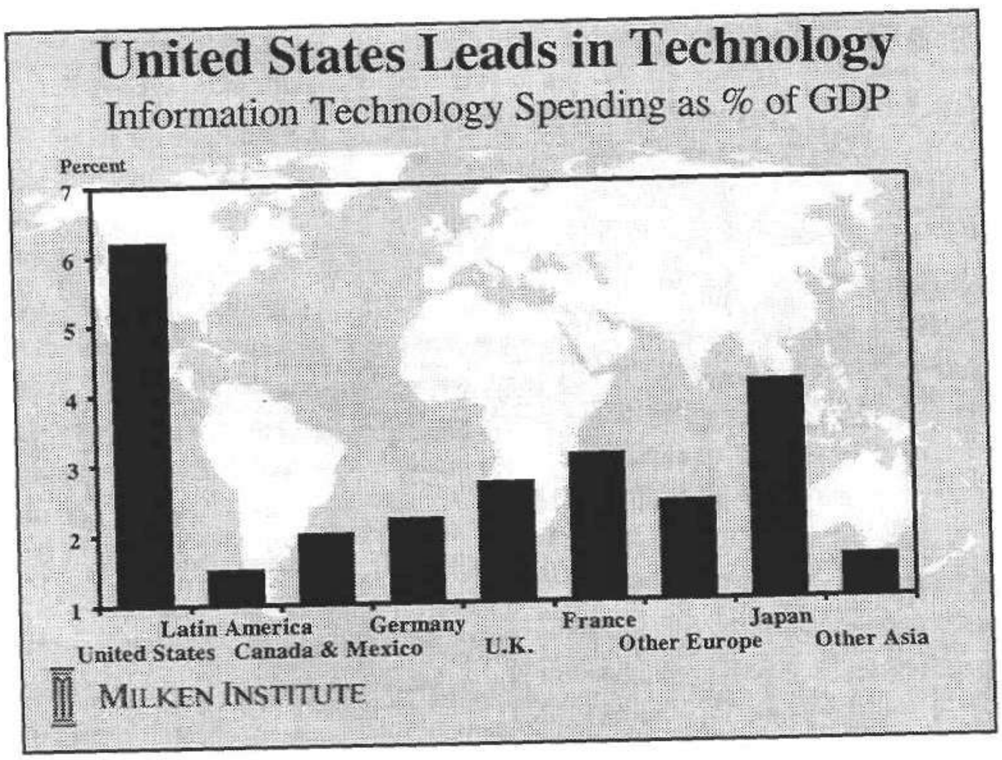
Based on % Growth, 1996-2006

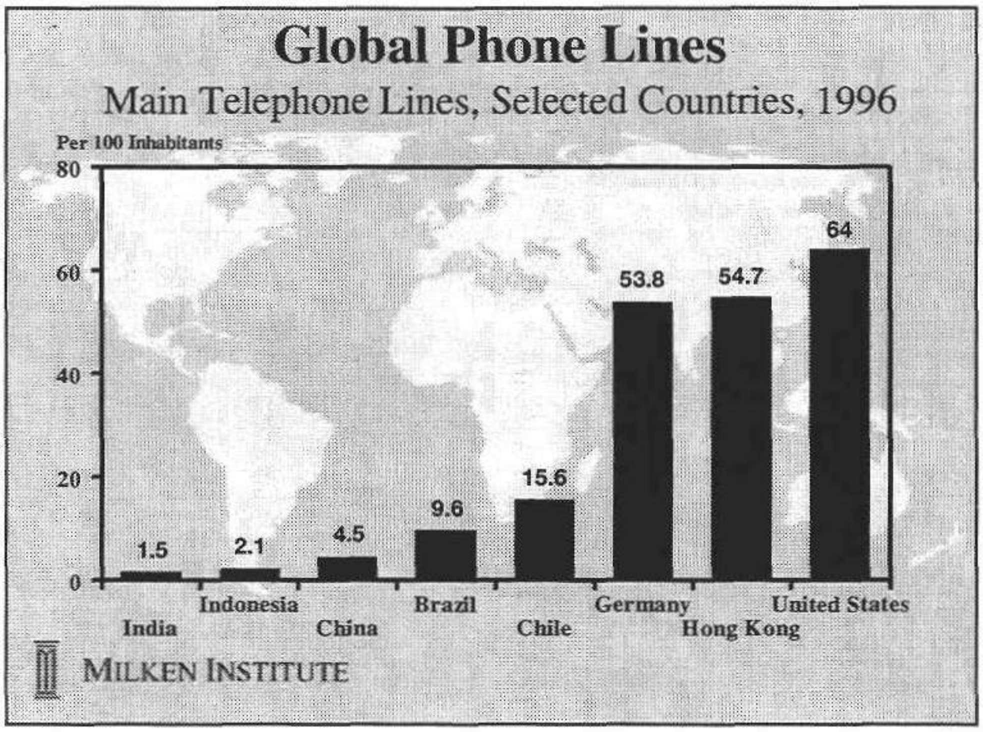
	Percent Growth	Annual Earnings
Computer Engineers	109%	$69,200
Systems Analysts	103%	$58,300
Computer Administrators & Specialists	118%	$46,100
Desktop Publishing Specialists	74%	$43,100
Physical Therapists	71%	$43,000
Physical Therapy Assistants	79%	$21,300
Occupational Therapy Assistants	69%	$18,500
Medical Assistants	74%	$16,900
Home-Care Aides	85%	$16,000
Home Health Aides	76%	$15,600

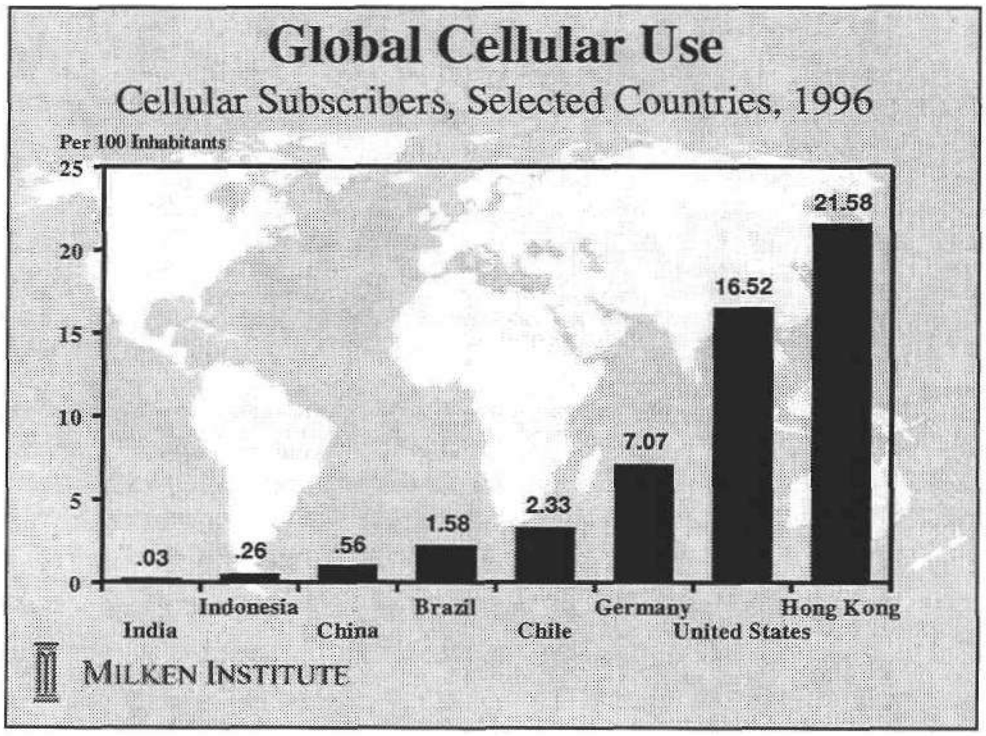
MILKEN INSTITUTE

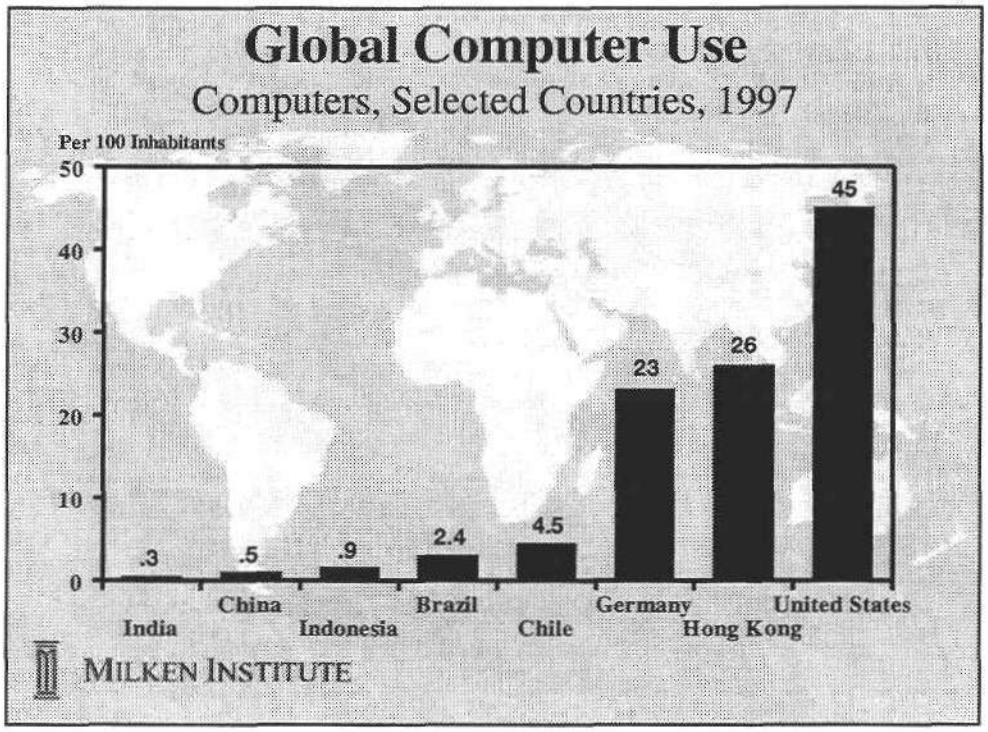



Age of the Technology Workforce
Percentage Age Distribution
Percent
50
40
30
20
10
0
National
Technology
Under 34
35 to 44
45 to 54
Over 55
MILKEN INSTITUTE


United States Leads in Technology
Information Technology Spending as % of GDP
Percent
7
6
5
4
3
2
1
United States
Latin America
Canada & Mexico
Germany
U.K.
France
Other Europe
Japan
Other Asia
MILKEN INSTITUTE


Global Phone Lines
Main Telephone Lines, Selected Countries, 1996
Per 100 Inhabitants
80
60
40
20
0
1.5
2.1
4.5
9.6
15.6
53.8
54.7
64
India
Indonesia
China
Brazil
Chile
Germany
Hong Kong
United States
MILKEN INSTITUTE


Global Cellular Use
Cellular Subscribers, Selected Countries, 1996
Per 100 Inhabitants
25
20
15
10
5
0
.03
.26
.56
1.58
2.33
7.07
16.52
21.58
India
Indonesia
China
Brazil
Chile
Germany
United States
Hong Kong
MILKEN INSTITUTE



Computer Industry Leaders

Merrill Lynch List (October 1967)

- *International Business Machines*
- *General Electric*
- *Radio Corporation of America*
- *Sperry Rand*
- *Burroughs Corporation*
- *Honeywell, Inc.*
- *Control Data*
- *National Cash Register*
- *Scientific Data Systems*
- *Digital Equipment*
- *Mohawk Data Sciences*
- *American Research and Development*
- *Memorex Corporation*
- *Computer Sciences*
- *University Computing*
- *Data Processing Financial and General*
- *Farrington Manufacturing*
- *California Computer Products*
- *Leasco Data Processing Equipment*
- *Levin Townsend Computer*
- *Systems Engineering Laboratories*
- *Data Products*
- *Computing and Software*
- *Electronic Memories*
- *Computer Applications*

MILKEN INSTITUTE

Technology Today--Top 25

Market Cap; June 30, 1998 (US$ Billions)

Microsoft Corp	266	*Sun Microsystems Inc*	16
Intel Corp	126	*HBO & Co*	15
Lucent Technologies	109	*First Data Corp*	15
Cisco Systems Inc	95	*3Com Corp*	11
Dell Computer Corp	59	*BMC Software Inc*	11
Compaq Computer Corp	43	*Peoplesoft Inc*	11
MCI Communications	42	*Compuware Corp*	9
Motorola Inc	31	*Gateway 2000 Inc*	8
Computer Assoc Intl	30	*Bay Networks Inc*	7
Oracle Corp	24	*Ciena Corp*	7
Texas Instruments	23	*Baan Co*	7
EMC Corp	22	*Cadence Design Sys Inc*	7
Automatic Data Processing	22		

MILKEN INSTITUTE

Artificial Intelligence

"A.I. (artificial intelligence) is the science of how to get machines to do the things they do in the movies."

Astro Teller
Carnegie Mellon University

MILKEN INSTITUTE

Technology's Limits

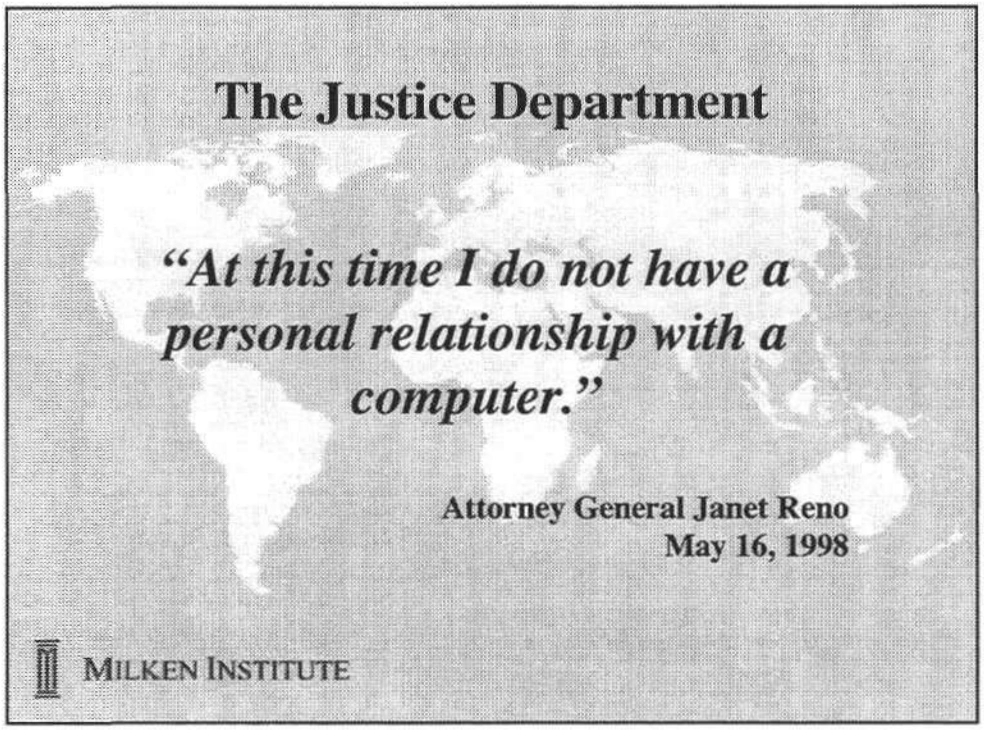
"As any musician will tell you, the music is not in the piano."

Computer Visionary Alan Kay

MILKEN INSTITUTE

"On the internet, nobody knows that you are a dog".

MILKEN INSTITUTE

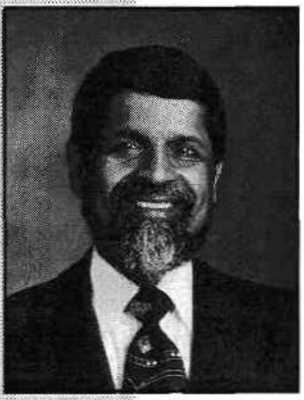

The Justice Department
"At this time I do not have a personal relationship with a computer."
Attorney General Janet Reno
May 16, 1998
MILKEN INSTITUTE

Notes

The Future Convergence of Heterogeneous Communications Systems & Services

Arun Netravali, Ph.D.

Executive Vice President of Research
Bell Labs
Lucent Technologies



Dr. Arun Netravali is executive vice president at Lucent Technologies' Bell Laboratories. He joined Bell Laboratories in 1972 as a member of the technical staff, became head of the Visual Communications Research Department in 1978, director of Computing Systems Research in 1983, and Communications Sciences Research vice president in 1992, with added responsibility as a project manager for HDTV in 1990. He became vice president of Quality, Engineering Software and Technologies (QUEST) in 1994, and in 1995 he was named Vice President of Research.

Dr. Netravali was at NASA from 1970 to 1972, where he worked on problems related to filtering, guidance, and control for the space shuttle.

Notes

Semiconductor Product Category Definitions

Current Category	Current Definition	Category Changes
Total Semiconductor:	(Total IC + Discrete + Total Optical Semiconductor)	Total Semiconductor becomes (Total General Purpose Standard Product + Total ASIC + Total ASSP)
	Defined as an active semiconductor product that contains semiconducting material (such as silicon, germanium, or gallium arsenide, but excluding ceramics). This definition excludes standalone passive components, such as capacitors, resistors, inductors, oscillators, crystals, transformers, and relays.	No change in definition
Total IC:	(Digital Bipolar IC + MOS Digital IC + Analog IC)	Category eliminated
	A monolithic IC is one that is formed on a single chip of semiconducting material. This designation has been applied more broadly to mean any device, even multiple-chip packaged devices, that does not contain other, nonsemiconductor, components. This differentiates monolithic ICs from hybrid ICs that may also be multiple-chip but represent a "hybrid" in the sense of mixing other technologies within the IC package, such as film resistors or chip capacitors.	
Digital Bipolar IC:	(Bipolar Digital Memory IC + Bipolar Digital Logic IC)	Category eliminated with revenue distributed to other semiconductor categories
	A bipolar digital IC is defined as a monolithic semiconductor product in which 100 percent of the die area performs digital functions, and, concurrently, 100 percent of the die area is manufactured using bipolar semiconductor technology.	
MOS Digital IC:	(MOS Digital Memory IC + MOS Digital Microcomponent IC + MOS Digital Logic IC)	Category eliminated
	A monolithic semiconductor product in which 100 percent of the die area performs digital functions, and, concurrently, any portion of the die area that is manufactured using metal-oxide semiconductor (MOS) technology. Includes mixed-technology manufacturing, such as BiMOS and BiCMOS, where there is some MOS technology employed.	
General Purpose Standard Product	New category. General Purpose Standard Product includes Memory IC, Microcomponent IC, Logic IC, Standard Analog IC, Discrete, and Optical Semiconductors	

Current Category	Current Definition	Category Changes
MOS Memory IC:	(DRAM + SRAM + EPROM + EEPROM + Flash Memory + Mask ROM + Other MOS Digital Memory)	No change in category—but moved to General Purpose Standard Product, Memory IC
DRAM:	Dynamic RAM, multiport-DRAM (M-DRAM), video RAM (VRAM), synchronous DRAM (SDRAM), cached DRAM (CDRAM), and self-refreshed DRAM.	No change
SRAM:	Static RAM, multiport-SRAM (M-SRAM), battery backed-up SRAM (BB-SRAM), and pseudo SRAM (PSRAM). SRAMs have memory cells consisting of a minimum of four transistors, except PSRAM, which has a memory cell consisting of a single transistor and is similar to a DRAM with nonmultiplexed addresses. Note that color palette DACs are included in the Data Converter/ Switch/Multiplexer IC category of analog ICs.	No change
EPROM:	Erasable programmable read-only memory. This product classification includes ultraviolet EPROM (UV EPROM) and one-time programmable read-only memory (OTP ROM).	No change
EEPROM:	Electrically erasable programmable read-only memory. Includes serial EEPROM (S-EEPROM), parallel EEPROM (P-EEPROM), and electrically alterable read-only memory (EAROM). Also includes nonvolatile RAM (NV-RAM), also known as shadow RAM. These semiconductor products are a combination of SRAM and EEPROM technologies in each memory cell.	No change. Addition of Smart Card ASSP may affect this category
Flash Memory:	Nonvolatile products designed as flash EPROM/EEPROM that incorporate either 5V or 12V programming supplies and one-transistor (1T) or two-transistor (2T) memory cells with electrical programming and fast bulk/block erase.	No change. Addition of Smart Card ASSP may affect this category
Mask ROM:	Mask-programmable read-only memory. Mask ROM is a form of memory that is programmed by the manufacturer to a user specification using a mask step.	No change
Other MOS Digital Memory:	All other MOS digital memory not already accounted for in the preceding categories. Includes MOS digital content addressable memory (CAM), MOS digital cache-tag RAM, MOS digital first-in/first-out memory (FIFO), MOS digital last-in/first-out (LIFO) memory, and ferroelectric memory.	No change
MOS Digital Microcomponent IC:	(MOS Digital Microprocessor + MOS Digital Microcontroller + MOS Digital Microperipheral + MOS Programmable Digital Signal Processor)	Category moved to General Purpose Standard Product, Microcomponent IC. MOS Digital Microperipheral sub-category eliminated and contents distributed to ASSP categories
Word Width:	The word width of a microprocessor or microcontroller architecture is determined by the maximum word width of the software that can be run by the architecture. This is defined by the computed accuracy of a single ADD instruction. If an architecture can perform a 32-bit ADD in a single instruction, then it is a 32-bit architecture. This is independent of the I/O bus width or the width of the integer unit.	No change

Current Category	Current Definition	Category Changes
MOS Digital Microprocessor (MPU):	(8- and 16-bit CISC MPU + 32-bit and greater CISC MPU + 32-bit and greater RISC MPU)	Some revenue may get reallocated to ASSP categories. Pending final definition.
	Microprocessor (MPU): An MPU is a MOS digital integrated circuit that includes an instruction decoder, arithmetic logic unit (ALU), registers, and additional logic. It may contain instruction, data, or unified caches, memory management systems, and auxiliary ALUs for floating-point and other special data types. An MPU's functions are determined by fetching and executing instructions and manipulating data held in registers, internal cache, or external memory. MPUs operate out of external memory systems typically ranging from 1MB to 64MB of RAM and often backed by secondary memory systems (such as disks). More highly integrated versions of MPUs may contain on-chip peripherals, interface, and support circuits. MPUs are subdivided into 8-bit, 16-bit, or 32-bit and up word width. Beginning in 1997, 32-bit and larger MPUs are further divided into computational and embedded according to the applications into which they are designed. MPUs can be complex-instruction-set-computer (CISC) or reduced-instruction-set-computer (RISC) implementations, although Dataquest no longer divides RISC and CISC in favor of architectural family distinctions (68000, x86, MIPS, and SPARC, among others). Similar terms are processor, central processor unit (CPU), and integrated processor.	No change
MOS Digital Microcontroller (MCU):	(4-bit MCU + 8-bit MCU + 16-bit MCU + 32-bit and greater MCU)	Some revenue may get reallocated to ASSP categories. Pending final definition.
	An MCU is a MOS digital integrated circuit designed for standalone operation that includes a programmable processing unit, program memory, read/write data memory, and some input/output capability. The processing unit contains an instruction decoder, arithmetic logic unit, registers, and additional logic. The MCU's functions are determined by fetching and executing instructions and manipulating data held in on-chip program and data memory (not including cache memories). MCU devices must be available with on-chip program store (ROM, EPROM, and flash, among others) typically ranging from 1KB to 64KB. As an option, some MCU devices can be purchased without on-chip memory for use during the debug and development phase of the system. Peripheral circuits are typically included on chip to assist in sophisticated input, output, and control functions. Standalone digital signal processors are not included with MCUs. MCUs are subdivided into 4-bit, 8-bit, 16-bit, or 32-bit word width. In 1996, Dataquest began separating 32-bit MCUs from 16-bit MCUs. All MCUs are designed into embedded applications. A similar term is microcomputer.	No change

Current Category	Current Definition	Category Changes
MOS Digital Microperipheral (MPR):	ICs that serve as a logical support function to an MPU in a system. This definition includes MPRs comprising more than one device, such as PC or core logic chipsets. The MPR category includes MPRs incorporating, or originating from, an ASIC design.	Category eliminated—all revenue moved to ASSP categories
System Core Logic Chipsets:	Devices dedicated to a particular microprocessor interface that perform some of the basic interface functions such as memory management DRAM control, cache control, bus interface controllers, DMA controllers, and interrupt controllers.	Category eliminated—revenue counted in PC ASSP
Graphics and Imaging Controllers:	Devices that typically interface to some form of system bus to interpret, control, and display the visual output of systems (computer-generated graphics, live video, and other images).	Category eliminated—revenue counted in PC ASSP
Communications Controllers:	Devices that control, format, and perform handshaking for the transmission and reception of information between systems or intelligent devices, which include network controllers, integrated fax/modem chips, serial UARTs, and other communications interfaces.	Category eliminated—revenue counted in Wired Communication ASSP
Mass Storage Controllers:	Devices that are used to control data storage into and retrieval from all forms of mass storage media (magnetic, optical, and other), which include controllers used within host computers (host-side) and within mass storage drives (device-side).	Category eliminated—revenue counted in Mass Storage ASSP
Audio/Other Microperipherals:	Devices used to input or output information through other forms, including audio input/output controllers, keyboard controllers, pen input controllers, parallel port controllers, and various other devices.	Category eliminated—revenue counted in PC ASSP
Digital Signal Processor (DSP):	A digital signal processor (DSP) is a programmable MOS digital integrated circuit (IC) designed for standalone operation, constituting a high-speed arithmetic unit (typically a multiplier-accumulator unit) designed to perform complex mathematical operations such as Fourier transforms in real time to generate, manipulate, or interpret digital representations of analog signals. Modern DSPs typically access multiple pieces of data in different locations of on-chip memory over separate data paths using specialized addressing modes. Most DSP functions, such as the multiply-and-accumulate function, complete in a single instruction clock. DSPs usually include peripherals, which may include analog circuits like analog-to-digital converters. DSPs typically operate on 16 or 24 bits of fixed-point data or 32 bits of floating-point data, although Dataquest does not currently subdivide DSPs into these categories. DSPs that have no version that can be reprogrammed by the user in assembly or a higher-level language are not included but are classified as fixed-function application-specific standard products (ASSP). DSPs integrated on-chip with an independent microprocessor or micro-controller are classified as either an MPU or an MCU, respectively. All DSPs are designed into embedded applications. A similar term is programmable DSP (pDSP).	Some revenue may get reallocated to ASSP categories. Pending final definition.

Current Category	Current Definition	Category Changes
MOS Digital Logic IC:	(Total ASIC + MOS Digital Standard Logic IC + Other MOS Digital Logic IC)	Category eliminated—revenue counted under ASIC or General Purpose Standard Products
	A MOS semiconductor product that serves a general-purpose function using bit-processing technology. This bit processing is defined by hardwiring, mask programming, or field programming. MOS microcomponents and MOS memory ICs are MOS logic ICs, but are either dedicated to a function (such as MOS microperipherals or MOS memory ICs) or are software programmable (such as MOS microprocessors and MOS microcontrollers). MOS logic ICs also include customer-specific MOS logic ICs.	
Logic IC:	New category. Logic IC includes PLD, Standard Logic, Flat Panel/LCD Driver	
Total ASIC:	(Traditional Digital Gate Array + Embedded Gate Array + Digital Programmable Logic Device + Digital Cell-Based IC + Digital Full-Custom IC+ Mixed-Signal ASIC + Linear Array)	Total ASIC redefined as (Gate Array + CBIC +Full Custom IC).. Under both Gate Array & CBIC there will be five application subcategories: Dataprocessing, Communications, Consumer, Automotive, & Other
	Defined as a single-user digital logic IC that is manufactured using vendor-supplied tools and/or libraries. Does not include digital ASICs incorporating microprocessor cells or microcontroller cells, as these are reported in the microprocessor IC or microcontroller IC category, respectively.	No change
Traditional Digital Gate Array:	Traditional gate arrays are ASICs that contain a configuration of uncommitted elements in a prefabricated base wafer. They are customized by interconnecting these elements with one or more metal routing layers. Included in this category are channeled and sea-of-gates architectures.	Becomes Gate Array, which now includes Embedded Gate Arrays & Linear Array ASIC; (Gate Array =Dataprocessing Gate Arrays + Communication Gate Arrays + Consumer Gate Arrays + Automotive Gate Arrays + Other Gate Arrays)
Embedded Gate Array:	Embedded gate arrays are ASICs with a portion of the chip having traditional gate array architecture (channeled or sea-of-gates) and with megacells such as SRAM diffused into the gate array base wafer.	Category eliminated—revenue counted in Gate Array

Current Category	Current Definition	Category Changes
Digital PLD:	An ASIC device that is customized by the end user after assembly. Included in this category are MOS field-programmable logic (MOS FPL), MOS field-programmable gate array (MOS FPGA), MOS programmable array logic (MOS PAL), MOS programmable logic array (MOS PLA), MOS electrically programmable logic device (MOS EPLD), and MOS complex PLDs.	Revenue moved from ASIC to General Purpose Standard Product, Logic (PLD)
Digital CBIC:	An ASIC device that is produced from a library of standard circuits/cells to a single-user specification. This process involves automatic routing and placement of cells utilizing a full mask set. Included in this definition is MOS standard cell IC.	CBIC will also include Mixed-Signal ASIC (CBIC = Dataprocessing CBICs + Communication CBICs + Consumer CBICs + Automotive CBICs + Other CBICs)
Digital FCIC:	An ASIC device that is produced for a single user using a full set of masks. This process involves manual routing and placement of cells.	No change
Linear Array ASIC	A single-user linear IC that is manufactured using vendor-supplied tools and/or libraries. Linear arrays fall into one of the three types, as follows: 1. Arrays of discrete-level cells such as transistors and diodes 2. Arrays of discrete device combinations referred to as tiles 3. Arrays of higher-level functional macro cells such as operational amplifiers, comparators, VCOs, references, and other analog functions. These arrays are interconnected with a metal mask or by means of some user-programmable interconnect scheme. Unlike cell-based designs, they do not have a unique set of masks for all layers.	Category eliminated—revenue counted in Gate Array
Mixed-Signal ASIC:	A mixed-signal ASIC that is manufactured for a single user, using vendor-supplied tools and/or libraries and contains Analog in more than 50% of the die area. ASICs with Analog comprising less than 50% of the die area should be counted in the appropriate category under Digital ASIC.	Category eliminated—revenue counted in CBIC
MOS Digital Standard Logic IC:	Commodity MOS family logic with fewer than 150 gates. Sometimes referred to as glue logic. Examples include: HC/HCT, AC/ACT, FACT, and 74BC/BCT BiCMOS family logic.	Removed from ASIC and moved to General Purpose Standard Product, Logic (Standard Logic)
LCD Driver:	Display driver IC designed to control and drive LCD panels. LCD drivers convert digital inputs into the multilevel signals needed to drive liquid crystal displays. Excluded from this category are microperipheral controller/driver ICs that include the LCD drive function and TV LCD drivers that accept analog video inputs. These devices are counted as part of the micro-component category or analog IC category, respectively.	Removed from ASIC and moved to General Purpose Standard Product, Logic (Flat Panel/LCD Driver)

Current Category	Current Definition	Category Changes
Other MOS Digital Logic IC:	All other MOS digital logic ICs not accounted for in the preceding categories. Includes MOS commodity family logic with 150 or more gates and MOS digital general-purpose logic not belonging to any families.	Category eliminated —revenue counted in Wired Communication ASSP or Wireless Communication ASSP
Total Analog IC:	(Amplifier/Comparator IC + Voltage Regulator/Reference IC + Data Converter/Switch/ Multiplexer IC + Interface IC + Telecom IC + Disk Drive IC + Other Special-function IC + Linear Array/ASIC + Mixed-Signal ASIC + Total Special Consumer IC + Special Automotive IC + Smart Power IC)	Linear ICs moved to General Purpose Standard Product, Standard Analog IC Analog application category (telecom, consumer automotive) eliminated—revenue counted in ASSP categories
	An analog IC is a semiconductor product that deals in the realm of electrical signal processing, power control, or electrical drive capability. It is one in which some of the inputs or outputs can be defined in terms of continuously or linearly variable voltages, currents, or frequencies. Includes only monolithic analog ICs manufactured using bipolar, MOS, or BiCMOS technologies. Includes monolithic linear IC and monolithic mixed-signal IC. A monolithic linear IC is characterized by having 100 percent analog I/O, while a mixed-signal IC carries information in both digital (numeric) and signal/power forms.	Linear ICs moved to General Purpose Standard Product, Standard Analog IC
Amplifier/Comparator IC:	An amplifier is a general-purpose linear IC that provides a voltage or current gain to an input signal. Includes operational amplifiers (mono, dual, and quad, among others), instrumentation amplifiers, buffer amplifiers, and power amplifiers. Consumer-dedicated amplifier ICs are counted in special consumer IC. Amplifier ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in linear array ASIC. A comparator IC is defined as a general-purpose linear IC that compares two analog signal inputs and provides a single logic bit output. Although the output could be considered digital, these products are classed as linear ICs because they are specialty high-gain amplifiers, used in an open-loop mode, and for which the output is constrained to only two states. By using a comparator, an unknown voltage can be compared with a known reference voltage. Comparator ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in linear array ASIC.	No change—but moved to General Purpose Standard Product, Standard Analog IC

Current Category	Current Definition	Category Changes
Voltage Regulator/ Reference IC:	A voltage regulator IC is defined as a general-purpose linear IC that outputs a variable current at a regulated DC voltage to other circuits from a variable current and voltage input. Regulator ICs are either linear regulators in which the device provides an input-to-output voltage drop, or switching regulators, in which the device provides switched quantities of power to a smoothing circuit to gain higher efficiency and reduce power dissipation. Voltage regulator ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in linear array ASIC. A voltage reference IC is defined as a general-purpose linear IC that outputs a precise reference voltage to other circuits from a variable voltage input. A reference IC differs from a regulator IC in that it is not expected to power other circuits. In fact, voltage regulator ICs incorporate a voltage reference circuit. Voltage Reference ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in linear array ASIC.	No change—but moved to General Purpose Standard Product, Standard Analog IC
Data Converter/Switch/ Multiplexer IC:	A data converter IC is defined as a general-purpose mixed-signal IC that converts an analog signal into a digital signal, or vice versa. Includes analog-to-digital converters (ADCs), digital-to- analog converters (DACs), sample-and-hold circuits (SHCs), voltage-to-frequency circuits (VFCs), frequency-to-voltage circuits (FVCs), synchro-to-digital circuits (SDCs), and digital-to-synchro circuits (DSCs). All these are general-purpose data ICs. Also included in this category are color-palette DACs. Consumer-dedicated data converter ICs are counted in special consumer IC, under monolithic linear ICs. Data converter ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in mixed-signal ASIC.	No change—but moved to General Purpose Standard Product, Standard Analog IC
Interface IC:	A general-purpose mixed-signal IC that serves as an interface between a digital system and other external nonsemiconductor systems. Includes line drivers, peripherals drivers, receivers, transmitters, and transceivers. Interface ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in mixed-signal ASIC.	No change—but moved to General Purpose Standard Product, Standard Analog IC
Telecom IC:	A general-purpose mixed-signal IC that is used for voice band communication or data communication over voice band media. This category includes codecs, combos and SLACs, SLICs, modem and fax/modem ICs, dialer and ringer ICs, repeaters, cellular communications ICs, ISDN ICs, telecom filter ICs, and other telecom-specific circuits. Telecom ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in mixed-signal ASIC.	Category eliminated —revenue counted in Wired ASSP or Wireless ASSP

Current Category	Current Definition	Category Changes
Disk Drive IC:	A mixed-signal IC that is designed specifically for the rotating mass storage market. Applications include the read/write path from preamp up to the ENDEC, head positioning controller, and spindle motor control. Disk drive ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in mixed-signal ASIC.	Category eliminated—revenue counted in Mass Storage ASSP
Other Special-Function IC:	An IC that is either a general-purpose IC that does not fit into the other categories or market/application-specific ICs for which a category does not yet exist. The main products that fall into this category include timers, phase-locked loops (PLLs), voltage-controlled oscillators (VCOs), signal/function generator ICs, and analog multipliers. Other special-function ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in the Linear Array/ASIC IC category.	Category eliminated. Revenue distributed to other semiconductor categories.
Total Special Consumer IC:	(Video Special Consumer IC + Audio Special Consumer IC + Other Special Consumer IC)	Category eliminated—revenue counted in Consumer ASSP (Video ASSP, Audio ASSP, or Other ASSP)
	A general-purpose IC that is dedicated to general consumer applications but is not application-specific. Consumer ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in linear array ASIC.	
Video Special Consumer IC:	An IC implemented for video applications.	Category eliminated—revenue counted in Consumer ASSP (Video ASSP)
Audio Special Consumer IC:	An IC implemented for audio applications, including radio and speech synthesis and recognition.	Category eliminated—revenue counted in Consumer ASSP (Audio ASSP)
Other Special Consumer IC:	An IC implemented in other consumer applications such as electronic games, personal and home appliances, and electronic cameras.	Category eliminated—revenue counted in Consumer ASSP (Other Consumer ASSP)
Special Automotive IC:	An IC that is used in the following automotive applications: entertainment, engine control, safety, traction, and in-car electrical and suspension systems. Special automotive ICs designed specifically for one customer using vendor-supplied tools and/or libraries are counted in linear array ASIC.	Category eliminated—revenue counted in Automotive ASSP
Total Discrete:	(Transistor + Diode + Thyristor + Other Discrete)	No change—but moved to General Purpose Standard Product, Discrete
	A discrete semiconductor is defined as a single semiconductor component such as a transistor, Diode, or thyristor. Although multiple devices may be present in a package, they are still considered discretes if they have no internal functional interconnection and are applied in the same manner as other discrete devices.	No change

Current Category	Current Definition	Category Changes
Transistor:	(Small-Signal Transistor + Power Transistor)	No change
Small-Signal Transistor:	Signal transistors, RF microwave transistors, dual transistors, MOS field-effect transistors (MOS-FETs), conductivity modulated field-effect transistors (COMFETs), insulated gate bipolar transistors (IGBTs), and MOS-bipolar transistors (MBTs). All rated below 1W power dissipation.	No change
Power Transistor:	(Bipolar Power Transistor + MOS Power Transistor + Power IGBT) All are rated at 1W power dissipation and above.	Power Transistor not changed—but subcategories are eliminated
Bipolar Power Transistor:	Bipolar Darlington transistor, bipolar microwave transistor, and bipolar radio frequency (RF) transistor.	Subcategory eliminated
MOS Power Transistor:	MOS field-effect transistor (MOS-FET), MOS microwave transistor, and MOS radio frequency (RF) transistor.	Subcategory eliminated
Power IGBT Transistor:	Insulated gate bipolar transistor (IGBT). Also includes conductivity modulated field-effect transistor (COMFET), MOS-bipolar transistor (MBT), and GEMFET.	Subcategory eliminated
Diode:	(Small-Signal/Reference Diode + Power Diode/Rectifier)	No change
Small-Signal/Reference Diode:	Signal diodes, Schottky diodes, zener diodes, switching diodes, voltage reference diodes, voltage regulator diodes, and rectifier diodes. All are rated below 0.5A.	No change
Power Diode/Rectifier:	Zener diodes and rectifier diodes. All are rated 0.5A and above.	No change
Thyristor:	Thyristors, silicon-controlled rectifiers (SCRs), diacs, and triacs. Also includes solid-state relays (SSRs) incorporating triacs, thyristors, resistors, and capacitors.	No change
Other Discrete:	All other discrete semiconductor products not accounted for in the preceding categories. Includes microwave diodes, varactors, tuning diodes, tunnel effect diodes, and selenium rectifiers. Does not include thermistors and varistors.	No change
Total Optical Semicionductor:	(Total LED Lamp/Display + Optocoupler + CCD + Laser Diode + Photosensor + Other Optical Semiconductor)	No change—but moved to **General Purpose Standard Product, Optical Semiconductor**
	A semiconductor product in which photons induce the flow of electrons, or vice versa. Other functions may also be integrated onto the product. This category does not include LCD, incandescent displays, fluorescent displays, cathode ray tubes (CRTs), or plasma displays.	No change

Current Category	Current Definition	Category Changes
Total LED Lamp/Display:	(Infrared LED Lamp/Display + Other LED Lamp/Display)	No change
Infrared LED Lamp/Display:	Infrared LED lamps/displays are single light-emitting diodes or an array of LEDs consisting of more than one die (in the case of displays) functioning in the invisible infrared range.	No change
Other LED Lamp/Display:	Includes visible LEDs and other LED products not included elsewhere. A visible LED lamp is defined as a light-emitting diode for which the light is visible: a semiconductor product consisting of a single die in which photons are emitted at frequencies dependent upon the semiconductor material employed. An LED display is defined as an array of LEDs: a semiconductor product consisting of more than one die in which photons are emitted at frequencies dependent upon the semiconductor material employed and where the light transmission is visible.	No change
Optocoupler:	An optocoupler or optoisolator. A semiconductor product consisting of an LED separated from a photosensor by a transparent, insulating, dielectric layer. These are mounted inside an opaque package. Includes optointerrupters, in which the separation between LED and photosensor is large enough to allow external physical systems to influence the device.	No change
CCD:	A charge-coupled device. A semiconductor product consisting of an array of photodiodes, an analog CCD shift register, and an output circuit. Includes linear array CCDs with serial shift registers and area array CCDs with parallel shift registers. Includes charge injection device (CID), charge-coupled photodiode (CCP), charge-priming device (CPD), and self-scanning photodiode (SSP).	No change
Laser Diode:	A diode that produces coherent light. A semiconductor product in which the heterojunction structure stimulates light amplification by stimulated emission of radiation (laser), resulting in coherent light. Includes Fabrey-Perot laser diodes, pulsed laser diodes, and phase-shifted laser diodes.	No change
Photosensor:	(Photodiode + Phototransistor)	No change
	A diode or transistor in which photons are used to affect current flow or electric potential.	No change
Other Optical Semiconductor:	All other optical semiconductor devices not accounted for in the preceding categories. Includes solar cells and optical thermal piles.	No change

New Category	Proposed Definition
Total Application Specific Standard Product (ASSP)	ASSP includes sub-categories of Dataprocessing ASSP, Communication ASSP, Consumer ASSP, Automotive ASSP, and Other ASSP
	An IC that is designed for use in a distinct electronic equipment category and is marketed to multiple companies. The IC may be a digital, analog, or mixed signal chip. Digital and mixed signal ICs in this category typically contain varying combinations of functional blocks including one or more processor (MPU, MCU, or DSP) cores, memory, interface circuits, and custom logic that tailors and optimizes the IC for use in a targeted electronic equipment market. These ICs may be programmable or fixed function. ASSP differ from ASICs in that ASSP are intended for sale to multiple equipment manufacturers, whereas ASICs are sold to single equipment manufacturers only. ASIC designs are customer driven, even when executed by the ASIC vendor, rather than market driven as in the case of ASSP. The existence of marketing collateral such as a data sheet is one strong indication that a given device falls into the ASSP category. Even stronger evidence that a device is an ASSP is the actual sale to multiple equipment manufacturers. ASSP are distinguished from general purpose DSP, MPU, and MCU products by their exclusive potential application in a single product category. If an IC containing a DSP, MPU, or MCU core can be reprogrammed through software modifications by the user so that it can be reasonably used in more than one type of equipment it should not be categorized as an ASSP but as the appropriate general purpose microcomponent (MPU, MCU, or DSP). For example, if an IC is designed and marketed for exclusive use as a baseband processor in a digital cellular/PCS system such as GSM, CDMA, NA-TDMA, or PDC, it should be categorized as an ASSP even if it has a DSP core. This includes possible usage in different dual-mode, dual-band, multi-mode, etc. handsets. However, if the same IC can be reconfigured through software for reasonable use in other applications such as wireless local area networks (WLAN), pagers, or other mobile and nonmobile applications it should be categorized as the appropriate general purpose microcomponent (MPU, MCU, or DSP). As another example, if an IC with an MPU core is designed and marketed for exclusive use as a graphics/video processor in a video game console it should be categorized as an ASSP. However, if the same chip could be reconfigured through software for reasonable use in other applications such as a digital TV, digital camcorder, or other application it should be categorized as a general purpose MPU. As a third example, RFICs, such as power amplifiers or transceivers, that are designed for specific wireless applications, should be categorized as ASSP. On the other hand, phase-locked loops (PLLs) and voltage-controlled oscillators (VCOs) can be used across multiple applications and should be categorized as general purpose components.

New Category	Proposed Definition
Dataprocessing ASSP	Dataprocessing ASSP includes subcategories of PC ASSP, Mass Storage ASSP, and Other DP ASSP
PC ASSP	An ASSP that is tailored for use on PC or workstation motherboards, daughter cards, or standard add-in cards. Functions of PC ASSP primarily include system logic for PC architecture platforms (commonly called "core logic") and multimedia processing coupled with PC-oriented interfaces such as ISA, EISA, PCI, AGP, VIP, VMI, VAFC, AC-link. Core logic functions include host-side mass storage interfaces and controllers as well as host-side general I/O interfaces and controllers when the chip products are targeted at the PC market. Some specific examples of PC ASSP products are PC core logic chipsets, PC graphics controllers/accelerators, PC audio chips including AC-97 codecs, I/O controllers such as PCMCIA and PC Card controllers, Super I/O and Ultra I/O products, and USB/1394/SCSI host-side controllers that have PC-specific host interfaces (PCI, ISA). Note: Network interface chips and modem chipsets are counted in the Wired Communications ASSP category even though they could fit the PC ASSP definition.
Mass Storage ASSP	An ASSP that is tailored for use in a mass storage application. Functions of mass storage ASSP primarily include read or read/write pre-amplifier, read or read/write channel processing, servo (head positioning and motor control optimized for storage), data formatter, data controller, audio and video processing for optical versions, and host interface. Note: Any IC that may be used in other applications than mass storage, is classified in the appropriate standard IC category. For example, a SCSI, or IEEE 1394, or Fibre Channel (FC) IC that could also be used not only in a mass storage application, but also in a printer is classified as an Interface IC in the general purpose analog IC category. Note: A mass storage controller that is used on a PC board is classified as a PC ASSP.
Other Dataprocessing ASSP	An ASSP that is tailored for use in computer peripheral (except data storage device) applications. These peripherals include monitors, printers, scanners and any other data processing dedicated systems (except smart cards) such as copiers, funds-transfer machines, point-of-sales terminals, etc.

New Category	Proposed Definition
Communication ASSP	Communication ASSP includes sub-categories of Wired Communication ASSP and Wireless Communication ASSP
Wired Communication ASSP	An ASSP that includes one or more of the following functions: LAN transceivers (and elemental components), LAN MACs, LAN port functions, LAN shared media repeaters, LAN switch functions, ATM functions (like LAN), T/E carrier functions (LIUs, frammers, multiplexers, mappers), SONET/SDH functions (amps, drivers, clock recovery, termination, multiplexers, mappers), traditional line card (SLIC, filter/codec, other voice switch elements), ISDN functions, HDLC functions, ADPCM functions, echo cancellation, voice band modem, xDSL, cable modem, telephone functions (dialer, ringer, speech circuit, answering machine, speaker phone, caller ID).
Wireless Communication ASSP	An ASSP that includes one or more of the following functions: Baseband processing including vocoding, channel coding, and power management for cellular/PCS (including "Third Generation" products), cordless, satellite voice and data communications, wireless local loop (WLL), Enhanced Specialized Mobile Radio (ESMR), etc., for subscriber and infrastructure products; MAC and PHY functions in WLAN and wireless modem products; Pager baseband processing for POCSAG, FLEX, ReFLEX, InFLEXion, and ERMES; RF small signal and power amplification; RF transmit and receive processing including up/down-converters, I/Q modulation/demodulation, switching, and attenuation. Note: Wireless ICs used in TV-centric satellite set-top boxes and terrestrial (DVB) set-top boxes, broadcast radio and broadcast television, and remote control toys should be counted in the consumer ASSP category.
Consumer ASSP	Consumer ASSP includes sub-categories of Consumer Video ASSP, Consumer Audio ASSP, Other Consumer ASSP and Smart Card ASSP
	An ASSP that is tailored for use in a consumer electronics application. These applications include video, audio, interactive products, personal electronics, and appliances. Specific products that consumer ASSP can be tailored for include next-generation platforms such as Video CD players, DVD players, digital satellite set-top boxes, digital cable set-top boxes, digital still cameras, digital camcorders, and digital televisions. Consumer ASSP include one or more of the following functions: tuning, audio processing, video processing, demodulation, error correction, video compression/ decompression, audio compression/decompression, encryption/decryption, image sensing, analog image processing, A/D and D/A conversion, data processing, graphics/on-screen display, LCD control and analog video encoding. Note: ASSP used in cordless telephones, pagers, and answering machines should not be included in the consumer category, but rather in the communications segment; ASSP used in computers, printers and fax machines should be counted in the PC or other data processing ASSP categories.

New Category	Proposed Definition
Consumer Video ASSP	To be determined
Consumer Audio ASSP	To be determined
Other Consumer ASSP	To be determined
Smart Card ASSP	An ASSP that is tailored for use in chip cards. Chip card ASSP can either be memory devices that integrate logic and/or security features designed for chip card applications, or they can be microcontrollers that integrate additional logic or security features designed for smart card applications. Security features include specific design, packaging, or manufacturing attributes that are intended to foil attempts to illicitly obtain data from the smart card. They also include logic designed specifically to encrypt data in order to prevent interception of sensitive or valuable information. At a minimum, to be categorized as an ASSP, memory must include additional logic on chip that tailors the chip for exclusive use in a chip card application. Chip card functions include contact interface, contactless interface, data storage, data encryption, data processing, user interface, authentication, and biometric identification.
Automotive ASSP	An ASSP that is tailored for use in automotive applications. Functions of automotive ASSP primarily include engine controls, entertainment, navigation, body electric, and safety such as air bags and antilock brakes.
Other ASSP	Other ASSP includes subcategories of Industrial, Medical, Mil-Aero, & Other