Asia/Pacific and Rest of World Fab Database
Fab Activity Planned or Initiated to Begin Production During 1990 and Beyond

Company	City or District	Country or Territory	Fab Name	Products	Process Technology	Fab Type	Target Date Prod. Begins	Min. Line-width	Waf. Size	Wafer Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (Square Feet)
** Production Begins 1990												
HUALON MICROELECT.	HSINCHU	TAIWAN	FAB 2	NEW TELECOM SRAM	CMOS	F	05/01/90	0.00	6	30000	821444	0
HYUNDAI	ICHON	S. KOREA	S/C 4	1Mb DRAM 4Mb PROTO SRAM	CMOS	F	06/01/90	1.00	6	20000	547629	0
HYUNDAI	ICHON	S. KOREA	S/C 5	16Mb DRAM DEVELOP	BICMOS CMOS	R	03/01/90	0.60	0	0	0	0
INDIAN TELEPHONE	BANGALORE	INDIA	N/A	ARRAYS TELECOM	CMOS VLSI	QAT	11/01/90	1.50	5	0	0	0
MOTOROLA	SEREMBAN	MALAYSIA	N/A	PWR TRAN DIS SST	N/A	FAT	02/01/90	0.00	6	8000	219052	6000
RAMAX	MELBOURNE	AUSTRALIA	N/A	FERRAM	CMOS GaAs	F		0.00	0	0	0	0
SAMSUNG	KIHEUNG	S. KOREA	FAB 4	4Mb DRAM SRAM ROM ASIC	CMOS	FAT	03/01/90	0.80	6	30000	821444	0
SID MICROELECT.	CONTAGEM	BRAZIL	N/A	PWR ICs	CMOS	F		2.00	4	13000	158258	15000
TSMC	HSINCHU	TAIWAN	FAB 2-A	SRAM ROM DRAM LOG CUSTOM	CMOS	OFAT	02/01/90	1.20	6	20000	547629	40000
** Production Begins 1991												
FORMOSA PLASTICS	N/A	TAIWAN	N/A	EPROM ROM	N/A	F		0.00	0	0	0	0
GOLDSTAR	CHONGJU	S. KOREA	PHASE 1	1Mb DRAM 256K SRAM	CMOS HITACHI	F	02/01/91	1.00	6	45000	1232166	0
HANILL	SIHEUNG	S. KOREA	N/A	N/A	GaAs	P	06/01/91	0.00	2	0	0	0
HYUNDAI	ICHON	S. KOREA	S/C 5	4Mb DRAM 16Mb PROTO	BICMOS CMOS	F	03/01/91	0.80	6	20000	547629	0

(Continued)

Asia/Pacific and Rest of World Fab Database
Fab Activity Planned or Initiated
to Begin Production During 1990 and Beyond (Continued)

Company	City or District	Country or Territory	Fab Name	Products	Process Technology	Fab Type	Target Date Prod. Begins	Min. Line-width	Waf. Size	Wafer Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (Square Feet)
INTEL	PENANG	MALAYSIA	N/A	N/A	N/A	F		0.00	0	0	0	15000
MOSEL	HSINCHU	TAIWAN	FAB 1	256K SRAM	CMOS M3	F	04/01/91	1.00	6	10000	273815	10000
MOTOROLA	TIANJIN	CHINA	N/A	LOG DIS	BIP MOS	F	03/01/91	0.00	6	10000	273815	0
SAMSUNG	KIHEUNG	S. KOREA	FAB 5	4Mb DRAM	N/A	F	07/01/91	0.70	8	20000	972409	0
SAMSUNG	KIHEUNG	S. KOREA	N/A	N/A	GaAs GIGABIT	F	06/01/91	0.00	0	0	0	0
SHINDENGEN	N/A	THAILAND	N/A	TRAN DIODES	N/A	F	08/01/91	0.00	0	0	0	0
TI/ACER	HSINCHU	TAIWAN	FAB 1	1Mb DRAM	CMOS	FAT	06/01/91	1.00	6	30000	821444	30000
VITELIC	HSINCHU	TAIWAN	MODULE 1	DRAM SRAM	CMOS OKI	F	10/01/91	0.00	6	10000	273815	22000
WINBOND	HSINCHU	TAIWAN	FAB 2	SRAM ASIC	CMOS M2	F	03/01/91	1.20	6	30000	821444	0
WUXI FACTORY	WUXI	CHINA	N/A	16K SRAM 64K DRAM	MOS TOSHIBA	F	02/01/91	3.00	5	25000	475437	0
** Production Begins 1992												
TSMC	HSINCHU	TAIWAN	FAB 2-B	SRAM ROM DRAM LOG CUSTOM	CMOS	OF	02/01/92	1.00	6	20000	547629	40000
XICOR	N/A	ISRAEL	N/A	EPROM	CMOS	F		0.80	6	0	0	0
** Production Begins 1993												
GOLDSTAR	CHONGJU	S. KOREA	PHASE 2	4Mb DRAM 1Mb SRAM	CMOS	F		0.80	6	45000	1232166	0
SAMSUNG	KIHEUNG	S. KOREA	FAB 6	4Mb 16Mb DRAM	N/A	F	06/01/93	0.60	8	20000	972409	0
** Production Begins 1994												
MOSEL	HSINCHU	TAIWAN	FAB 2	1Mb SRAM	N/A	F		0.80	0	10000	0	10000

(Continued)

Asia/Pacific and Rest of World Fab Database
Fab Activity Planned or Initiated to Begin Production During 1990 and Beyond (Continued)

Company	City or District	Country or Territory	Fab Name	Products	Process Technology	Fab Type	Target Date Prod. Begins	Min. Line-width	Waf. Size	Wafer Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (Square Feet)
VITELIC	HSINCHU	TAIWAN	MODULE 2	DRAM SRAM	N/A	F		0.00	0	10000	0	22000
** Production Begins 1995												
ERSO	HSINCHU	TAIWAN	N/A	16Mb DRAM	N/A	R		0.00	6	1000	27381	0
SAMSUNG	KIHEUNG	S. KOREA	FAB 7	16Mb DRAM SAMPLE 64Mb	N/A	F		0.50	8	20000	972409	0
TI/ACER	HSINCHU	TAIWAN	FAB 2	4Mb 16Mb DRAM	CMOS	F		0.80	8	0	0	30000
** Production Begins 1996												
GOLDSTAR	CHONGJU	S. KOREA	PHASE 3	16Mb DRAM 4Mb SRAM	CMOS	F		0.60	8	45000	2187921	0
** Production Begins 1997												
SAMSUNG	KIHEUNG	S. KOREA	FAB 8	64Mb DRAM	N/A	F		0.35	8	0	0	0

N/A = Not Available

Source: Dataquest April 1990

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European Fab Database
Fab Activity Planned or Initiated to Begin Production During 1990 and Beyond

Company	City	Country	Fab Name	Products	Process Technology	Fab Type	Target Date Prod. Begins	Min. Line-width	Waf. Size	Wafer Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (Square Feet)
** Production Begins 1990												
DIGITAL EQUIPMENT	QUEENSFERRY	SCOT.	N/A	DRAM	CMOS	P		1.00	6	3000	82144	28000
FUJITSU	NEWTON AYCLIFFE	ENGL.	N/A	ASIC	CMOS	F	12/01/90	1.00	6	25000	684536	0
TI	AVEZZANO	ITALY	PHASE 1	4Mb DRAM	CMOS	F	12/01/90	0.80	6	30000	821444	30000
TI	FREISING	W. GER.	N/A	LOG	CMOS	P	02/01/90	0.80	6	3000	82144	0
** Production Begins 1991												
ANALOG DEVICES	LIMERICK	EIRE.	N/A	LIN AD/DA TELECOM	BIP BICMOS	F	02/01/91	1.25	6	20000	547629	0
IBM	SINDELFINGEN	W. GER.	N/A	4Mb DRAM	CMOS	F	02/01/91	0.80	8	30000	1458614	45000
ITT	FREIBURG	W. GER.	N/A	DSP	CMOS	F		0.80	6	0	0	0
MOTOROLA	EAST KILBRIDE	SCOT.	MOS-12	4Mb DRAM	CMOS TOSHIBA	F		0.00	6	0	0	25000
NEC	LIVINGSTON	SCOT.	N/A	4Mb DRAM	CMOS	F	02/01/91	0.00	6	10000	273815	0
SAMSUNG	N/A	W. GER.	N/A	N/A	N/A	F		0.00	6	0	0	0
SGS-THOMSON	AGRATE	ITALY	VLSI LAB	N/A	N/A	R		0.00	0	0	0	0
TOSHIBA	BRAUNSCHWEIG	W. GER.	N/A	DRAM SRAM	CMOS	FAT		0.00	6	0	0	0
** Production Begins 1992												
ATMEL	N/A	NETH.	N/A	EPROM EEPROM	CMOS	P	12/01/92	0.60	8	5000	243102	0
FUJITSU	NEWTON AYCLIFFE	ENGL.	N/A	1Mb 4Mb DRAM	CMOS	F		1.00	6	45000	1232166	0
HITACHI	LANDSHUT	W. GER.	N/A	4Mb DRAM 256K 1Mb SRAM	N/A	F	05/01/92	0.80	6	16000	438103	0
MITSUBISHI	ALSDORF	W. GER.	N/A	4Mb DRAM MCU MPU ARRAYS	CMOS	F	03/01/92	0.80	6	22000	602392	25000
SONY	N/A	SCOT.	N/A	1Mb SRAM	CMOS	F		0.00	0	0	0	0
TI	AVEZZANO	ITALY	PHASE 2	16Mb DRAM	CMOS	F	02/01/92	0.60	8	20000	972409	30000

(Continued)

European Fab Database
Fab Activity Planned or Initiated to Begin Production During 1990 and Beyond (Continued)

Company	City	Country	Fab Name	Products	Process Technology	Fab Type	Target Date Prod. Begins	Min. Line-width	Waf. Size	Wafer Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (Square Feet)
** Production Begins 1993												
HITACHI	N/A	FRANCE	N/A	N/A	N/A	R		0.00	0	0	0	0
INTEL	LEIXLIP, KILDARE	EIRE.	FAB 11	N/A	N/A	F		0.00	6	0	0	35000
** Production Begins 1994												
FUJITSU	NEWTON AYCLIFFE	ENGL.	N/A	4Mb DRAM	CMOS	F		0.80	8	30000	1458614	0
MITSUBISHI	ALSDORF	W. GER.	N/A	4Mb DRAM MCU MPU ARRAYS	CMOS	F		0.80	8	18000	875168	25000

N/A = Not Available

Source: Dataquest April 1990

Japanese Fab Database
Fab Activity Planned or Initiated to Begin Production During 1990 and Beyond

** Production Begins 1990

Company	Prefect.	Plant Name	Fab Name	Products	Process Technology	Fab Type	Target Date Prod. Begins	Min. Line-width	Waf. Size	Wafer Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (Square Feet)
FUJI ELECTRIC	NAGANO	MATSUMOTO	N/A	DIODE PWR TRAN PWR MOSFET	MOS	FAT		2.00	5	20000	380350	0
FUJI ELECTRIC	TOYAMA	MAIN OFFICE	N/A	DIODE	N/A	PAT		0.00	4	10000	121737	0
FUJITSU	FUKUSHIMA	WAKAMATSU	NO. 3	ARRAYS CBIC 32-bit MCU	CMOS	F	06/01/90	0.70	6	30000	821444	113000
FUJITSU	IWATE	IWATE	NO. 4	4Mb DRAM 1Mb SRAM ASIC	CMOS MOS P3	F	10/01/90	0.80	8	25000	1215512	0
FUJITSU	MIE	MIE	PROCESS LAB	BASIC RSCH.	N/A	R	05/01/90	0.00	0	0	0	0
HAMAMATSU PHOTONICS	SHIZUOKA	HAMAKITA R&D	N/A	OPTO	N/A	R	03/01/90	0.00	0	0	0	0
HITACHI	TOKYO	MUSASHI WORKS	N/A	4Mb DRAM 16Mb PROTO MCU	CMOS	P	09/01/90	0.80	8	8000	388964	0
HITACHI	YAMANASHI	KOFU WORKS	IMASUWA	4Mb DRAM 16Mb PROTO SRAM	CMOS	F	04/01/90	0.60	6	25000	684536	0
HITACHI	YAMANASHI	KOFU WORKS	IMASUWA	16Mb DRAM	N/A	P	07/01/90	0.50	8	8000	388964	0
HONDA	TOCHIGI	CENTRAL RSCH.	N/A	ENGINE CONTROL SENSORS	GaAs	P	03/01/90	0.00	3	0	0	0
IBM	SHIGA	N/A	N/A	1Mb 4Mb DRAM SRAM ASIC	N/A	F	04/01/90	0.80	8	20000	972409	40000
MATSUSHITA	TOYAMA	UOZU	FAB C-2	4Mb DRAM 256K SRAM	CMOS	F	05/01/90	0.80	6	20000	547629	0

(Continued)

Japanese Fab Database
Fab Activity Planned or Initiated to Begin Production During 1990 and Beyond (Continued)

Company	Prefect.	Plant Name	Fab Name	Products	Process Technology	Fab Type	Target Date Prod. Begins	Min. Line-width	Waf. Size	Wafer Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (Square Feet)
NEC	HIROSHIMA	CHUGOKU	PHASE 1	4Mb DRAM SRAM MPU 4Mb ROM	CMOS BICMOS	FAT	05/01/90	0.80	6	27000	739299	38754
NEC	KANAGAWA	SAGAMIHARA	BLDG G FLR2	16Mb DRAM	CMOS	PAT	02/01/90	0.55	8	5000	243102	20000
NIPPON DENSO	AICHI	KODA WORKS	BLDG. 2	MCU	MOS	F	12/01/90	0.00	6	10000	273815	0
NIPPON PRECISION CIRC.	TOCHIGI	SHIOBARA	N/A	A/D D/A DSP LOG ASSP	CMOS	P	02/01/90	0.80	6	20000	547629	21530
NIPPON SILICON	N/A	N/A	N/A	16Mb DRAM	N/A	R	09/01/90	0.60	0	0	0	0
NMB S/C	CHIBA	N/A	N3	4Mb DRAM	CMOS	OF	10/01/90	0.80	6	20000	547629	0
OKI	MIYAGI	MIYAGI OKI	N/A	4Mb DRAM VRAM 1Mb SRAM	CMOS	F	02/01/90	0.80	6	20000	547629	0
RICOH	OSAKA	N/A	N/A	ARRAYS	CMOS	NF		1.00	6	10000	273815	0
SANYO	GIFU	ULSI RSCH.	N/A	16Mb DRAM 64Mb LATER	CMOS	R	02/01/90	0.60	0	0	0	0
SANYO	GIFU	VLSI DIV.	N/A	256K SRAM 4Mb 8Mb ROM	N/A	F	04/01/90	0.80	0	0	0	0
SHARP	HIROSHIMA	FUKUYAMA	BLDG 2 #2	4Mb DRAM 16Mb ROM ASIC	CMOS	F	09/01/90	0.80	6	24000	657155	0
SHINDENGEN	YAMAGATA	HIGASHINE DIV.	BLDG 3	CUSTOM	CMOS MOS	F		0.00	5	10000	190175	0
SUMITOMO METAL MINING	OITA	N/A	N/A	N/A	N/A	P	10/01/90	0.00	5	3000	57052	5000
TOHOKU S/C	MIYAGI	SENDAI	PHASE 2	DRAM SRAM MPU	CMOS	F	11/01/90	0.80	6	15000	410722	42000

(Continued)

Japanese Fab Database
Fab Activity Planned or Initiated to Begin Production During 1990 and Beyond (Continued)

Company	Prefect.	Plant Name	Fab Name	Products	Process Technology	Fab Type	Target Date Prod. Begins	Min. Line-width	Waf. Size	Wafer Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (Square Feet)
TOSHIBA	OITA	OITA BLDG #4	#1	4Mb DRAM	CMOS	F	12/01/90	0.80	6	30000	821444	40000
TOYOTA	AICHI	CENTRAL LAB	N/A	MCU PWR ICs CUSTOM	CMOS BIP	PAT	03/01/90	2.00	5	500	9509	0
YAMAHA	KAGOSHIMA	KAGOSHIMA	N/A	ROM CBIC ASSP	CMOS	NF	08/01/90	1.00	6	14000	383340	0
** Production Begins 1991												
ASAHI MICRO SYSTEMS	MIYAZAKI	N/A	N/A	ASIC LIN A/D D/A ASSP	CMOS HITACHI	F		0.00	6	0	0	0
FUJI ELECTRIC	NAGANO	MATSUMOTO	N/A	N/A	N/A	RAT		0.00	0	0	0	0
FUJI ELECTRIC	YAMANASHI	YAMANASHI	N/A	LOG	CMOS	F		0.00	6	0	0	0
FUJITSU	MIE	MIE	NO. 4	16Mb DRAM 1Mb SRAM	N/A	P	11/01/91	0.60	8	10000	486205	0
FUJITSU	YAMANASHI	YAMANASHI ELECT	N/A	FET LIN OPTO	GaAs	F		0.00	4	0	0	0
FUJITSU/ISUZU	N/A	N/A	N/A	AUTOMOTIVE ICs	N/A	R		0.00	0	0	0	0
HITACHI	GUNMA	TAKASAKI WORKS	N/A	256K SRAM 4Mb DRAM MCU	CMOS	F	02/01/91	0.80	0	0	0	0
HITACHI MAXELL	IBARAGI	N/A	N/A	CHIP SETS	N/A	R	06/01/91	0.00	0	0	0	0
INTL. RECTIFIER	AKITA	AKITA	N/A	DIS	N/A	FAT		0.00	0	0	0	0
JPN. ATOM. ENRGY. RSCH.	N/A	N/A	N/A	SOR LITHO.	SOR LITHO.	R	08/01/91	0.00	0	0	0	0
KAWASAKI STEEL	TOCHIGI	PHASE 1	N/A	256K SRAM CBIC ARRAYS	CMOS NTT	NP	09/01/91	0.80	6	10000	273815	0
MATSUSHITA	OSAKA	S/C RSCH. CTR.	PROTOTYPE	16Mb DRAM 64-bit MPU	CMOS	P	02/01/91	0.60	0	0	0	0

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Japanese Fab Database
Fab Activity Planned or Initiated
to Begin Production During 1990 and Beyond (Continued)

Company	Prefect.	Plant Name	Fab Name	Products	Process Technology	Fab Type	Target Date Prod. Begins	Min. Line-width	Waf. Size	Wafer Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (Square Feet)
MITSUBISHI	EHIME	SAIJO A	N/A	4Mb DRAM	CMOS	FAT	02/01/91	0.80	6	20000	547629	60000
MITSUBISHI	HYOGO	KITAITAMI WORKS	N/A	N/A	N/A	F		0.00	4	0	0	0
MOTOROLA	FUKUSHIMA	AIZU WORKS	N/A	CONSUMER ICs	N/A	R	01/01/91	0.00	0	0	0	0
NEC	KUMAMOTO	KYUSHU	FAB 8	4Mb DRAM RISC MPU ARRAYS	CMOS BICMOS	F	11/01/91	0.80	8	20000	972409	40000
NIPPON STEEL	KANAGAWA	ELECT. LAB	N/A	ASIC	N/A	DP	09/01/91	0.80	0	0	0	0
OKI	MIYAGI	N/A	N/A	N/A	N/A	R	12/01/91	0.00	0	0	0	0
OKI	MIYAZAKI	MIYAZAKI OKI	M3	4Mb DRAM	CMOS	F	02/01/91	0.80	6	0	0	0
SANYO	NIIGATA	NIIGATA SANYO	BLDG 3 #4	16-BIT MCU DSP	CMOS	F		1.00	6	18000	492866	0
SEIKO-EPSON	YAMAGATA	TOHOKU EPSON	N/A	ARRAYS CBIC 1Mb SRAM	CMOS	NF	05/01/91	0.80	6	20000	547629	0
SONY	KANAGAWA	ATSUGI	N/A	MEM LIN OPTO DIS	GaAs CMOS	P		0.00	0	0	0	0
SONY	NAGASAKI	SONY NAGASAKI	3G	1Mb SRAM	N/A	F		0.80	0	40000	0	0
TI	IBARAGI	N/A	N/A	16Mb 64Mb DRAM HDTV ICs	N/A	R	06/01/91	0.50	0	0	0	0
TOSHIBA	IWATE	IWATE TOSHIBA	BLDG 3	ARRAYS CBIC	CMOS BICMOS	P	04/01/91	0.70	6	10000	273815	0
TOSHIBA	MIE	N/A	PHASE 1	4Mb DRAM SAMPLE 16Mb	CMOS	F	08/01/91	0.70	0	25000	0	40000
TOSHIBA	OITA	OITA BLDG #3	C-4 #2	4Mb DRAM	CMOS	F	03/01/91	0.80	6	15000	410722	0
TOSHIBA	OITA	OITA BLDG #4	#2	4Mb DRAM SAMPLE 16Mb	BICMOS CMOS	F		0.60	8	20000	972409	40000

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Japanese Fab Database
Fab Activity Planned or Initiated to Begin Production During 1990 and Beyond (Continued)

Company	Prefect.	Plant Name	Fab Name	Products	Process Technology	Fab Type	Target Date Prod. Begins	Min. Line-width	Waf. Size	Wafer Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (Square Feet)
TOSHIBA	SHIGA	N/A	N/A	N/A	N/A	R	02/01/91	0.00	0	0	0	0
** Production Begins 1992												
KYOCERA	KYOTO	N/A	N/A	N/A	N/A	R	04/01/92	0.00	0	0	0	0
MITSUBISHI	KUMAMOTO	KUMAMOTO WORKS	D	ARRAYS CBIC ASSP MCU	N/A	F		0.00	0	0	0	0
MOTOROLA	MIYAGI	SENDAI	MOS-10	4Mb DRAM MPU CUSTOM	CMOS	F	04/01/92	0.80	6	25000	684536	25000
NEC	HIROSHIMA	CHUGOKU	PHASE 2	4Mb DRAM EPROM	CMOS	F	06/01/92	0.80	8	22000	1069650	0
NEW JAPAN RADIO	KUMAMOTO	KYUSHU	N/A	CUSTOM CONSUMER LOG	CMOS	F		1.00	6	20000	547629	0
NIHON S/C	IBARAGI	N/A	PHASE 2	ARRAYS CBIC RISC MPU	N/A	F	03/01/92	0.80	8	20000	972409	0
NKK	TOKYO	N/A	N/A	4Mb DRAM	N/A	P	03/01/92	0.80	6	3000	82144	0
NMB S/C	CHIBA	N/A	M4	4Mb DRAM SAMPLE 16Mb	BICMOS CMOS	OF		0.60	0	20000	0	0
SANYO	NIIGATA	NIIGATA SANYO	BLDG 3 #5	4Mb DRAM	CMOS	F	06/01/92	0.80	6	20000	547629	0
SONY	KAGOSHIMA	SONY KOKUBU	#5	LOG MEM MPU LIN DIS OPTO	BIP CMOS MOS	FAT		0.80	6	0	0	0
TDK/SILICON SYSTEMS	IBARAGI	N/A	N/A	ASIC MPR LOG A/D D/A	CMOS BIP	P		0.00	0	0	0	0
TI/KOBE STEEL	HYOGO	N/A	N/A	LOG ASIC	CMOS	F	06/01/92	0.80	0	0	0	0
TOSHIBA	MIE	N/A	PHASE 2	16Mb DRAM	CMOS	F		0.50	8	20000	972409	40000
TOSHIBA	OITA	OITA BLDG #4	#3	4Mb 16Mb DRAM	CMOS	F		0.80	8	20000	972409	40000

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Japanese Fab Database
Fab Activity Planned or Initiated
to Begin Production During 1990 and Beyond (Continued)

Company	Prefect.	Plant Name	Fab Name	Products	Process Technology	Fab Type	Target Date Prod. Begins	Min. Line-width	Waf. Size	Wafer Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (Square Feet)
** Production Begins 1993												
MITSUBISHI	EHIME	SAIJO D	N/A	16Mb DRAM	N/A	F		0.60	8	20000	972409	0
SEIKO-EPSON	NAGANO	FUJIMI	BLDG E	SRAM ARRAYS	CMOS	NFAT		0.00	0	0	0	0
SGS THOMPSON	N/A	N/A	N/A	DRAM	N/A	F		0.00	0	0	0	0
TOSHIBA	OITA	OITA BLDG #4	#4	16Mb DRAM	BICMOS CMOS	F		0.60	8	20000	972409	40000
** Production Begins 1994												
NEC	HIROSHIMA	CHUGOKU	PHASE 3	16Mb DRAM MPU EPROM	CMOS	F		0.60	8	22000	1069650	0
NKK	KANAGAWA	KEIHIN	PHASE 1	4Mb DRAM	N/A	F		0.80	6	0	0	0
TOSHIBA	MIE	N/A	PHASE 3	16Mb DRAM	CMOS	F		0.60	8	20000	972409	40000
** Production Begins 1995												
KAWASAKI STEEL	TOCHIGI	PHASE 2	N/A	SRAM DRAM ARRAYS	CMOS NTT	F		0.00	6	15000	410722	0
NEC	HIROSHIMA	CHUGOKU	PHASE 4	16Mb DRAM MPU EPROM	CMOS	F		0.60	8	22000	1069650	0
** Production Begins 1996												
TOSHIBA	MIE	N/A	PHASE 4	16Mb DRAM	CMOS	F		0.50	8	20000	972409	40000
** Production Begins 1997												
NKK	KANAGAWA	KEIHIN	PHASE 2	4Mb 16Mb DRAM	N/A	F		0.60	8	0	0	0

(Continued)

Japanese Fab Database
Fab Activity Planned or Initiated to Begin Production During 1990 and Beyond (Continued)

Company	Prefect.	Plant Name	Fab Name	Products	Process Technology	Fab Type	Target Date Prod. Begins	Min. Line-width	Waf. Size	Wafer Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (Square Feet)
** Production Begins 1999												
KAWASAKI STEEL	TOCHIGI	PHASE 3	N/A	16Mb DRAM SRAM ARRAYS	CMOS NTT	F		0.00	6	15000	410722	0
** Production Begins 2000												
NKK	KANAGAWA	KEIHIN	PHASE 3	16Mb DRAM	N/A	F		0.60	8	0	0	0

N/A = Not Available

Source: Dataquest
April 1990

North American Fab Database
Fab Activity Planned or Initiated to Begin Production During 1990 and Beyond

Company	City	St.	Fab Name	Products	Process Technology	Fab Type	Target Date Prod. Begins	Min. Line-width	Waf. Size	Wafer Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (Square Feet)
** Production Begins 1990												
AMCC	SAN DIEGO	CA	N/A	ARRAYS CBIC	BIP	F		1.00	6	8000	219052	15000
AMD	SUNNYVALE	CA	R&D CTR	N/A	N/A	P	08/01/90	0.80	6	6800	186194	35000
AMD	AUSTIN	TX	FAB 10	FULL VLF LITHO AREA	N/A	F	12/01/90	0.80	6	10000	273815	0
AT&T	ORLANDO	FL	OR2	256K 1Mb SRAM	CMOS MITSUBISHI	NF	11/01/90	0.80	6	22400	613345	25000
BROOKTREE	PORTLAND	OR	N/A	HIGH SPEED A/D D/A GRAPH.	BIP	R	02/01/90	0.00	0	0	0	0
DALLAS S/C	DALLAS	TX	FAB 2	SRAM CCD	CMOS	F	04/01/90	1.00	6	12000	328577	20000
HARRIS S/C	MOUNTAINTOP	PA	N/A	ASIC PWR ICs AUTOMOTIVE	BICMOS CMOS	F	02/01/90	0.00	6	8500	232742	0
HP	CORVALLIS	OR	N/A	ASIC MPR DSP	N/A	NF	11/01/90	0.00	6	15000	410722	20000
IBM	HOPEWELL JUNCTION	NY	ASTC/MEM	MEM PROCESS VERIFICATION	CMOS	P	02/01/90	0.80	8	10000	486205	20000
IBM	HOPEWELL JUNCTION	NY	ASTC/LOG	LOG PROCESS VERIFICATION	BIP CMOS	P	02/01/90	0.80	8	10000	486205	20000
IBM	HOPEWELL JUNCTION	NY	ASTC/R&D	16Mb 64Mb DRAM	BICMOS BIP CMOS	R	02/01/90	0.60	8	10000	486205	20000
IBM	ESSEX JUNCTION	VT	BLDG 973	1Mb 4Mb DRAM	CMOS	F	03/01/90	0.80	8	20000	972409	40000
IBM	ESSEX JUNCTION	VT	BLDG 973	4Mb DRAM	CMOS M2	F	11/01/90	0.80	8	20000	972409	40000
IDT	SANTA CLARA	CA	FAB 3	PROCESS DEVELOP	BICMOS CMOS	F	03/01/90	0.50	6	18000	492866	0
INTEL	RIO RANCHO	NM	FAB 9.2	386 486 MPU EPROM	CMOS	F	11/01/90	1.00	6	13600	372388	25000

(Continued)

North American Fab Database
Fab Activity Planned or Initiated to Begin Production During 1990 and Beyond (Continued)

Company	City	St.	Fab Name	Products	Process Technology	Fab Type	Target Date Prod. Begins	Min. Line-width	Waf. Size	Wafer Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (Square Feet)
INTL. MICROCIRC.	MILPITAS	CA	N/A	ARRAYS	CMOS	Q		1.50	0	0	0	12000
LINEAR TECHNOLOGY	MILPITAS	CA	FAB 2	LIN	BIP CMOS	F	10/01/90	2.00	5	6400	121712	6000
MAXIM INTEGRATED PROD.	SUNNYVALE	CA	N/A	OP AMPS A/D D/A	CMOS	P	06/01/90	3.00	4	4000	48695	13500
MICRON TECHNOLOGY	BOISE	ID	FAB 3	SAMPLE 4Mb DRAM 16Mb DEV.	CMOS IBM	P	04/01/90	0.80	6	20000	547629	0
MITSUBISHI	DURHAM	NC	N/A	1Mb DRAM ARRAYS MCU	CMOS	F	06/01/90	1.00	6	8500	232742	0
MOTOROLA	SCHAUMBERG	IL	N/A	SMARTPOWER	BIP	P	02/01/90	5.00	4	10000	121737	10000
NATIONAL S/C	ARLINGTON	TX	CMOS 2	N/A	CMOS	F	02/01/90	1.20	6	18000	492866	25000
NATIONAL S/C	PUYALLUP	WA	N/A	1Mb SRAM ARRAYS PLD	BICMOS BIP ECL	F	01/01/90	0.80	6	12000	328577	40000
NATL. SECURITY ADMIN.	FORT MEADE	MD	N/A	MIL STD	N/A	P	12/01/90	0.80	6	5000	136907	0
OKI	TUALATIN	OR	N/A	ARRAYS 256K SRAM 4Mb DRAM	CMOS	PAT	06/01/90	1.00	6	16000	438103	15000
PARADIGM TECH.	SAN JOSE	CA	N/A	256K 1Mb SRAM 4 TR.	CMOS M2 POLY 2	P	03/01/90	1.00	5	2500	47544	4000
PERFORMANCE S/C	SUNNYVALE	CA	FAB 2	SRAM MPU ASIC	BICMOS CMOS	P	11/01/90	0.80	6	7000	191670	0
RAMTRON	COLORADO SPRINGS	CO	N/A	FERRAM 4Mb DRAM DEV.	CMOS M2	P	12/01/90	1.00	6	2700	73930	11500
RAYTHEON	MOUNTAIN VIEW	CA	N/A	N/A	BIP ECL	Q		1.00	4	6400	77911	12000
ROHM	SUNNYVALE	CA	PILOT	LIN ARRAYS	BIP EPI	F	04/01/90	0.00	4	17000	206952	14000
SHARP MICROELECT.	CAMUS	WA	N/A	256K 1Mb SRAM FIFO DSP	N/A	DRAT	08/01/90	0.00	0	0	0	0

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North American Fab Database
Fab Activity Planned or Initiated to Begin Production During 1990 and Beyond (Continued)

Company	City	St.	Fab Name	Products	Process Technology	Fab Type	Target Date Prod. Begins	Min. Line-width	Waf. Size	Wafer Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (Square Feet)
SIGNETICS	ALBUQUERQUE	NM	FAB 24	N/A	N/A	F		1.00	6	8000	219052	15000
U.C. SANTA BARBARA	SANTA BARBARA	CA	N/A	N/A	GaAs	R		0.00	0	0	0	0
VLSI TECHNOLOGY	SAN ANTONIO	TX	MODULE B	ARRAYS CBIC SRAM MPU E2	CMOS M3	F	06/01/90	0.80	6	6400	175241	7000
WESTERN DIGITAL	COSTA MESA	CA	DVLPMNT	CUSTOM	CMOS M2	F	09/01/90	1.25	6	6400	175241	12000
ZILOG	NAMPA	ID	MOD 3	N/A	N/A	F		1.00	6	8000	219052	12000
** Production Begins 1991												
CYPRESS S/C TEXAS INC.	ROUNDROCK	TX	FAB 3	N/A	CMOS	F		0.70	6	8000	219052	0
DIGITAL EQUIPMENT	SAN JOSE	CA	N/A	N/A	N/A	P		0.80	6	3200	87621	10000
GENESIS MICROCHIP	MARKHAM, ONTARIO	CN	N/A	PLD ARRAYS CBIC CUSTOM	CMOS M2	F	11/01/91	1.00	6	8000	219052	12000
HARRIS S/C	MELBOURNE	FL	N/A	N/A	N/A	F	11/01/91	0.00	6	0	0	0
IBM	SAN JOSE	CA	N/A	N/A	N/A	R		0.80	8	9000	437584	25000
IBM	HOPEWELL JUNCTION	NY	ASDC/ALF	64Mb DRAM	SOR LITHO.	R	06/01/91	0.50	8	0	0	0
IDT	SALINAS	CA	FAB 4	SRAM LOG DSP FIFO	CMOS	F		0.70	6	10800	295720	14000
MOTOROLA	CHANDLER	AZ	BP-6	ECL 50K ARRAYS	ECL BIP BICMOS	F	05/01/91	1.00	6	20000	547629	25000
MOTOROLA	CHANDLER	AZ	BP-6	ARRAYS CBIC	BIP BICMOS ECL	R	02/01/91	0.80	0	0	0	0
MOTOROLA	OAK HILL	TX	MOS-11	4Mb DRAM MCU MPU RISC	CMOS TOSHIBA	F	05/01/91	0.80	6	17000	465485	35000
NEC	ROSEVILLE	CA	PHASE 2	4Mb DRAM	CMOS	FAT	08/01/91	0.70	8	16000	777927	70000
RICOH	SAN JOSE	CA	N/A	N/A	N/A	R		1.00	6	9600	262862	15000
SAMSUNG S/C	N/A	CA	N/A	DRAM SRAM FIFO PLD	CMOS	F	02/01/91	0.00	6	30000	821444	45000

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North American Fab Database
Fab Activity Planned or Initiated to Begin Production During 1990 and Beyond (Continued)

Company	City	St.	Fab Name	Products	Process Technology	Fab Type	Target Date Prod. Begins	Min. Line-width	Waf. Size	Wafer Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (Square Feet)
SGS-THOMSON	SCOTTSDALE	AZ	N/A	1Mb EPROM	CMOS	F	02/01/91	1.00	6	12000	328577	22000
SHARP MICROELECT.	CAMUS	WA	N/A	1Mb SRAM FIFO ROM DSP	N/A	F	11/01/91	1.00	6	9600	262862	20000
SIGNETICS	OREM	UT	FAB 18	N/A	BIP	F	11/01/91	1.00	6	12000	328577	20000
SONY	SAN ANTONIO	TX	FAB 12	1Mb SRAM	CMOS BICMOS	F	03/01/91	0.80	6	12800	350483	17500
TI	DALLAS	TX	DMOS 5.1	4Mb DRAM	CMOS	F	06/01/91	0.80	8	16000	777927	25000
U.C. DAVIS	DAVIS	CA	N/A	N/A	N/A	R		0.00	0	0	0	15000
UNITED Si STRUCTURES	N/A	N/A	N/A	CBIC ARRAYS CUSTOM	N/A	P		0.00	0	0	0	0
VLSI TECHNOLOGY	SAN ANTONIO	TX	MODULE C	ARRAYS CBIC SRAM MPU E2	CMOS M3	F	09/01/91	0.80	6	6400	175241	7000
** Production Begins 1992												
ACTEL	N/A	N/A	N/A	PROGRAMABLE ARRAYS	CMOS	F		0.00	0	0	0	0
EXAR	FREMONT	CA	N/A	LIN DSP MPU	CMOS	F		1.00	6	0	0	0
INTEL	RIO RANCHO	NM	FAB 9.3	586 MPU EPROM	CMOS	F		0.80	6	24000	657155	25000
LSI LOGIC	MILPITAS	CA	N/A	ASIC	BICMOS	R		0.50	0	0	0	0
MITSUBISHI	DURHAM	NC	N/A	16Mb DRAM	N/A	F	11/02/92	0.60	8	14000	680687	0
NATIONAL S/C	ARLINGTON	TX	CMOS 3	N/A	CMOS	F		0.80	6	14400	394293	25000
NMB S/C	N/A	N/A	N/A	4Mb DRAM	CMOS	OF		0.80	0	0	0	0
OKI	TUALATIN	OR	N/A	ARRAYS	N/A	Q		0.00	0	0	0	0
SIERRA S/C	SAN JOSE	CA	N/A	N/A	N/A	F		0.80	6	0	0	0
TOSHIBA	WEST COAST	N/A	N/A	4Mb DRAM RISC MPU ASIC	CMOS	F		0.80	6	17000	465485	40000

(Continued)

North American Fab Database
Fab Activity Planned or Initiated to Begin Production During 1990 and Beyond (Continued)

Company	City	St.	Fab Name	Products	Process Technology	Fab Type	Target Date Prod. Begins	Min. Line-width	Waf. Size	Wafer Start Capacity (4 wks.)	Sq. In. Start Capacity (4 wks.)	Clean Room (Square Feet)
VLSI TECHNOLOGY	SAN ANTONIO	TX	MODULE D	ARRAYS CBIC SRAM MPU E2	CMOS M3	F	11/01/92	0.60	6	6400	175241	7000
** Production Begins 1993												
HP	CORVALLIS	OR	N/A	ASIC	N/A	F		0.00	6	0	0	20000
INTEL	ALOHA	OR	FAB 10	586 MPU	CMOS	F		0.00	8	21250	1033185	35000
MICRON TECHNOLOGY	N/A	N/A	FAB 4	4Mb DRAM	CMOS	F	02/01/93	0.80	0	0	0	0
TI	DALLAS	TX	MMST	ASIC	CMOS	P		0.50	6	800	21905	0
TI	DALLAS	TX	DMOS 5.2	16Mb DRAM	CMOS	F		0.00	8	16000	777927	25000
** Production Begins 1994												
AMD	AUSTIN	TX	FAB 25	N/A	N/A	F		0.35	8	15000	729307	0
CYPRESS S/C TEXAS INC.	ROUNDROCK	TX	FAB 4	N/A	CMOS	F		0.55	6	8000	219052	0
INTEL	RIO RANCHO	NM	FAB 9.4	N/A	CMOS	F		0.70	8	17000	826548	25000
LSI LOGIC	MILPITAS	CA	N/A	ASIC	BICMOS	F		0.50	0	0	0	0
MOTOROLA	OAK HILL	TX	N/A	16Mb DRAM	N/A	F	06/01/94	0.60	8	15000	729307	0
NEC	HILLSBORO	OR	PHASE 3	16Mb DRAM	CMOS	FAT		0.60	8	16000	777927	90000
OKI	TUALATIN	OR	N/A	ASIC DRAM	N/A	F		0.00	8	15000	729307	0
** Production Begins 1995												
CRYSTAL S/C	AUSTIN	TX	N/A	LIN A/D D/A	MOS	F		1.20	0	0	0	0
MAXIM INTEGRATED PROD.	SUNNYVALE	CA	N/A	OP AMPS A/D D/A	BIP CMOS	P		2.00	0	0	0	0
** Production Begins 1996												
SONY	SAN ANTONIO	TX	N/A	SRAM	CMOS	F		0.60	8	0	0	0

N/A = Not Available

Source: Dataquest
April 1990

Emerging Lab Binder Set

The Emerging Fab

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The Emerging Fab

The Emerging Fab

INTRODUCTION

The semiconductor industry is characterized by rapid and constant innovations and improvements. These changes scan a broad spectrum from new products and markets to new design techniques, new process technologies, more productive manufacturing equipment, and more efficient manufacturing. As a result, semiconductor devices have become pervasive, the marketplace has expanded, and the price and cost for a given function have continued their vigorous decline.

This service section describes an ultramodern production facility that utilizes the latest process technology, process equipment, and clean room technology. The output of this fab is 14,000, 150mm wafers per four-week period. An eleven mask, 1.5μ m CMOS process is used. The fab output and costs are assumed for only one large-volume product, such as an SRAM, to be in production. The costs, yields, and efficiency of operation are typical of those attainable at present. Wafer probe, test, assembly, and marketing of the packaged devices are not included in this model, as this hypothetical factory is dedicated to high-volume wafer fab operation.

PROCESS TECHNOLOGY

CMOS technology has emerged as a versatile and pervasive technology for the next decade. Although CMOS is quite an old technology, CMOS has reached a major new significance when examined in the context of the present technical capability, market needs, and manufacturing viability of the semiconductor industry. The reasons for its new prominence are as follows:

- Semiconductor components for equipment that can be used in offices and homes and are transportable have created enormous new markets. Power dissipation of components has become a design specification.
- Bipolar and NMOS VLSI components have reached such a high degree of integration that they are limited in their degree of integration or speed by the amount of thermal dissipation permitted in conventional semiconductor packages. CMOS technology does not have these limitations and thus can offer both a higher performance and a higher degree of integration than either bipolar or NMOS technology, while still permitting the use of industry-standard packages.
- With the smaller sizes and improved methods of minimizing latch-up, the area penalty of CMOS versus NMOS has disappeared below 2μ m dimensions.

- CMOS requires a complex process, with 10 to 13 masks versus 7 to 8 masks in earlier NMOS. But the modern NMOS process has become more complex too, as integration and performance needs have resulted in adding extra processing steps to NMOS.
- Modern processing equipment, with its emphasis on automation and cassette-to-cassette transfer, has eliminated much individual wafer handling; thus, the penalty associated with a longer and more complex process has been reduced. It is possible to expect and get 90 percent mechanical fab yield for complex CMOS processes by using modern automated production facilities.
- CMOS circuits have higher noise margins. This attribute significantly impacts the design costs, which is a major consideration for VLSI devices. Not only are the design costs reduced, but the probe yields for high-complexity devices performing to specifications are higher in CMOS than in NMOS.

The combination of these parameters has brought CMOS technology to the center stage. Most new designs are being committed to CMOS technology. There is, however, no single CMOS process, and a large number of variations of CMOS process are being practiced. These variations include:

- N-well CMOS
- P-well CMOS
- N-well with epitaxy
- P-well with epitaxy
- Twin well with epitaxy

Interconnect technologies also have several possibilities, including:

- Single poly, or polycide and single metal
- Single poly, or polycide and double metal
- Double poly/polycide and single metal
- Double poly/polycide and double metal

Of these possibilities, the CMOS process described in this report has the following features:

- Twin well with epitaxy
- One poly, one polycide, and one level of metal

The process flow, which is described later in this section is a representative process flow applicable to a variety of applications. A fairly accurate cost model can be formulated to draw conclusions about this and other variations of the CMOS process.

The Emerging Fab

The major trend in the industry is toward smaller feature sizes. Most new designs are at 2μ m geometries. Present manufacturing equipment, however, will support 1.5μ m. In view of this, the major design rules assumed for the purpose of this discussion, are as follows:

- Gate oxide 25nm
- Junction depth 0.25μ m
- Channel length (drawn) 1.5μ m
- Diffusion pitch 5μ m
- Poly/polycide pitch 3.5μ m
- Metal pitch 5μ m

WAFER SIZE

The facility described in this discussion uses 150mm silicon wafers with epitaxial film grown by the silicon vendor. With the advent of small-geometry CMOS, the market for wafers with epitaxy will grow. All major silicon vendors have plans to enter the epitaxial wafer market; thus epitaxial wafer prices are expected to drop significantly in the next few years.

The 150mm wafers will be the preferred wafer size for the next five years, and production plants now under construction will utilize these wafers. Equipment to process 150mm wafers is now available with superior wafer-handling mechanisms, high reliability, and process automation.

MANUFACTURING FACILITY/CLEAN ROOM

With the dawn of the VLSI era, stringent requirements for the control of submicron particle contamination, temperature, and humidity have been placed on the design of manufacturing facilities, manufacturing personnel, processing equipment, and manufacturing material. To profitably manufacture sub-2-micron VLSI devices, the manufacturer needs a world-class, paperless facility with filtration down to 0.1-micron particle size in the process area; a minimum number of suitably attired and trained personnel; processing equipment that does not contaminate personnel or silicon wafers; and multiple-filtered DI water, chemicals, photoresist, and process gases.

Since clean room floor space is at a premium, the question of maintaining 100 percent HEPA ceiling and Class 10 environment versus local Class 10 zones is debatable. In our opinion, until the Standard

Mechanical InterFace (SMIF) concept is fully developed and proven to provide a true human isolation of wafers in a sealed and controlled ambient during entire wafer processing, the best alternate is a paperless, Class 10, 100 percent HEPA ceiling with automated equipment and a low density of process personnel that is well-trained in clean room practices. Because of the high cost of Class 10 clean room space and the cost pressures on IC products, we believe that within the next two to three years, SMIF technology will be employed in a facility of this type. For dimensions in the 1-micron range and below, it is essential that the process personnel and the wafers be totally isolated.

With modern, automated, cassette-to-cassette processing equipment, clean room occupancy is substantially reduced. Most of the equipment is installed through the wall, and the clean room area requirement for this equipment is significantly decreased. Furthermore, because of these advancements, the total heat load and air-handling requirements inside the clean room are substantially reduced and are most conveniently handled by individual clean room bays/tunnels. Each bay has its own temperature and humidity controls.

The clean room ceiling is 100 percent covered with HEPA filters operating at an air velocity of 90 feet per minute. HEPA filter efficiency is 99.999 percent down to 0.1μ m particle size to minimize the particle density to less than 10 particles per cubic foot. Sidewall return air ducts are used to provide vertical laminar flow with an exit velocity not exceeding 700 feet per minute. Air ionization grids are installed throughout the process area and clean room entrances to achieve the high efficiency of air filtration and to reduce the electrostatic adhesion of particles to wafers, cassettes, and cassette boxes. Recovery time after disturbance is 6 seconds in workstation areas and 10 seconds in the aisle area. Laminar flow is adjusted and controlled aerodynamically at each piece of process equipment to provide maximum laminar isolation and cleanliness between wafer and worker.

The temperature control is 68 ± 0.5°F in the photoresist area and 68 ± 1°F in other areas. The control of humidity is expecially critical in the photoresist area from the application of the adhesion promoter (HMDS) up to and including the developing of the printed image. The relative humidity should be kept at 40 ± 2 percent in this critical area. For the rest of the wafer fab area, the humidity can be at 40 ± 5 percent. The vibration specification in the photo area is less than 10 microns floor displacement over a frequency range of up to 40Hz.

With the increase in microprocessor-controlled equipment in the wafer fab area, care must be taken to avoid the introduction of electrical noise into the control circuitry. Most equipment manufacturers now provide equipment with a separate mains supply for the low-current and high-current portions of the equipment. It is highly advisable to supply the low-current control circuitry with isolated ground, regulated AC power. This will remove transients and protect the equipment from brownout conditions.

MATERIAL QUALITY AND HANDLING

All the gases, chemicals, and related materials are piped through high-purity stainless steel or teflon piping with welded joints. Multiple filters with 0.1-micron point-of-use filters, in-line moisture analyzers, and gas chromatographs are used to ensure purity and low particulates in the gas, chemicals, and water supply. Toxic gas monitors, dampers to rapidly clear the air of smoke or toxic fumes, sprinklers, and emergency doors are installed throughout the facility. Double-walled containers, chemical neutralization, and exhaust scrubbers are installed to maintain a zero- effluent facility.

The advent of dry etching has reduced both the DI water consumption and the usage of wet chemicals within the fab area. However, these chemicals have been replaced by gases. The exhaust gases from the etch equipment must be adequately scrubbed to reduce toxic effluents. This shifts the burden from chemical neutralization to scrubbing. It is essential for the protection of both the personnel and equipment that the exhaust fans used to carry away the toxic fumes be supplied with power that is backed up with an emergency generator. This will allow the continuous exhausting of toxic fumes during an interruption of mains power.

PERSONNEL PRACTICES

The clean room is restricted to the absolute minimum number of personnel and, as much as possible, clean room needs are serviced from the outside. Chemicals are transferred through the chase walls, and clean room conditions, including gases and liquids, are automatically monitored. With through-the-wall equipment installation, the majority of equipment services and maintenance is provided in the chase area.

Procedures are developed to provide maximum isolation between personnel and the wafers. In areas where personnel and wafers must come in close contact, aerodynamics is engineered in a manner to direct the flow of particles away from the wafers and toward the personnel. Ultra-low-particulate, full-coverage clean room gowns are used. Movements within the clean room are minimized, and the number of personnel in each work area is controlled. Training in clean room practices is continuously provided and regularly monitored.

PROCESS AND PROCESS EQUIPMENT CLEANLINESS

Process equipment can be a source of particulate contamination. In addition to normal process control, contamination deposited on a clean wafer, when cycled through the total equipment process, needs to be continuously monitored and the process equipment must be cleaned if the particulate specifications are not met. All portions of the equipment, where particle generation is likely, need to be thoroughly vented.

The entire manufacturing process is tracked using an on-line manufacturing tracking system without any paper run-sheets or process instructions. To enhance the instant visibility and to identify the next process step, plastic placards are used. Video terminals are installed throughout the fab area to provide process instructions and other information. All the printers associated with the equipment are placed in the chase area. All the process control equipment (thickness monitors, resistivity monitors, and CV and CD measurement equipment) are directly linked with the host computer to gather in-process data.

PRODUCT EXPOSURE TIMES

Despite all the steps that have been taken to reduce and eliminate the particulates from the process, the longer the wafers are exposed in the process area, the more contaminants they accumulate. Thus the probe yields are reduced. This fact has driven the need for reduced cycle times and quick turnaround times for normal production.

In order to achieve this, process equipment uptime is vigorously managed. Computerized material and work in process (WIP) management, computer-aided processing, process feedback and control, and around-the-clock manufacturing seven days a week are all necessary to achieve production goals.

OPERATIONAL STRATEGY--RESOURCE SELECTION

People and Their Skill Levels

This operation is distinguished from the conventional resource selection in various aspects. Equipment processing is significantly more sophisticated and automated; therefore, the asset utilization factor and hence the equipment uptime requirement is high, and the degree of cleanliness required is significantly higher. The criteria for the manpower resource are:

- High skill level
  - Preferably a four-year college degree (not necessarily an E.E. degree) or a two-year junior college program in IC technology
  - Expertise in equipment operation and first order maintenance
  - Expertise in process and quality control
  - Expertise in unsupervised material flow with the aid of a computerized system
- Small in number

Fab technologists who qualify for this facility will have a minimum of six months of exhaustive training in the above areas through:

- The equipment vendor's training/demonstration centers
- Organized classroom/on-the-job process training
- Operational efficiency training

This will be followed by a formal certification of the technologists through the written certification test, as well as through periodic on-the-job audits.

MANUFACTURING EQUIPMENT

During the last five years there have been major changes made in the way that wafer fabrication areas are both built and equipped. These changes, while they have dramatically increased the minimum cost to enter the business, have also had an equally dramatic effect on circuit density and the reduction of defect density. As a result, a substantially reduced cost per function has been attained.

Equipment plays the central role in this revolution. It has become <u>the</u> technology. If the equipment to implement a new process in a cost-effective manner does not exist, that process will not be used. The new equipment has several common characteristics, which have become a must. The key to success is selection of the right equipment, even when both the definition and the choice changes frequently.

With the modern equipment, the clean room area requirement has been dramatically reduced. Changes include smaller footprint and through-the-wall installation, wafer handling done cassette-to-cassette or by robots, and microprocessor-controlled process execution. Process control and recipe downloading have become standard. Specifications on uptime, meantime to failure, meantime to repair, process control, reproducibility, contamination control, and safety have improved manifolds. The integration of many process steps has also become viable, thus reducing the inventory points, cycle time, and manpower requirements while improving throughput and yields. With the advent of on-line inventory management, process tracking, and recipe downloading, a truly paperless wafer fab is now possible.

The major process steps and the corresponding equipment selection are briefly described in the following discussion.

Photolithography

The photolithography area has undergone one of the most dramatic changes. Today's alignment machines step the image of a defect-free reticle enclosed in a pellicle, over a wafer. Each step is automatically aligned, thus ensuring alignment and registration accuracies that were impossible heretofore. In the most advanced versions, it is possible to couple photoresist coat, bake, align, expose, develop, and inspection processes in a single integrated system, with the only human intervention at cassette loading, unloading, and the optical inspection station. Since controlling elapsed time between coat, bake, expose, and develop is critical, dimension control has greatly improved.

For the purposes of the production facility described here, both 5X and 1X steppers can be used. However, our model uses 1X steppers integrated with photoresist coater and developer, together with an automatic inspection station. Single-layer positive photoresist is used throughout the process. Two steppers continuously feed the exposed and developed wafers to the automatic inspection station, where a technologist inspects them for defects and dimensional control.

Etching

All etching steps are performed using cassette-to-cassette, single-wafer-at-a-time, plasma or RIE/plasma equipment. Poly, polycide, oxide, and metal etches are accomplished using RIE/plasma machines, and a controlled slope is achieved at all of these steps. Nitride etch is similarly etched although the requirement for a controlled slope is not necessary or desirable.

Photoresist removal is done by plasma ashing. Prior to furnace operations such as oxidations, anneals, and LPCVD operations, a wet cleaning operation is done in an automatic, cassette-to-cassette wet station. Noncritical etches, such as oxide strips, are also done in these automated wet stations.

Diffusion Operation

Horizontal diffusion furnaces are used for oxidation, diffusion, anneals, alloy and LPCVD doped/undoped LTO, doped/undoped polysilicon, and masking nitride. Polycide is formed by sputter deposition of silicide (tungsten or titanium silicide) on doped polysilicon. All the furnaces are integrated with automatic, cassette-to-cassette prediffusion-clean wet stations and wafer transfer mechanisms, which transfer wafers from teflon boats to the quartz boats used in the diffusion furnaces. Noncontact cantilevers and elevators minimize the particulate generation. The furnace process recipe is downloaded from a secured computer to minimize operator errors and to maintain full tracking of wafer processing conditions. Process control on the processed wafers is also done using cassette-to-cassette systems.

Implant activations, silicide alloys, and glass reflows are performed using cassette-to-cassette rapid thermal annealing to maintain the control on junction depths and the reproducibility of polycide sheet resistance.

No gas or liquid source dopants are used in the furnace operations. The dopings are done using cassette-to-cassette ion-implanters. These implanters are located in the chase areas with only their end stations located in the Class 10 areas.

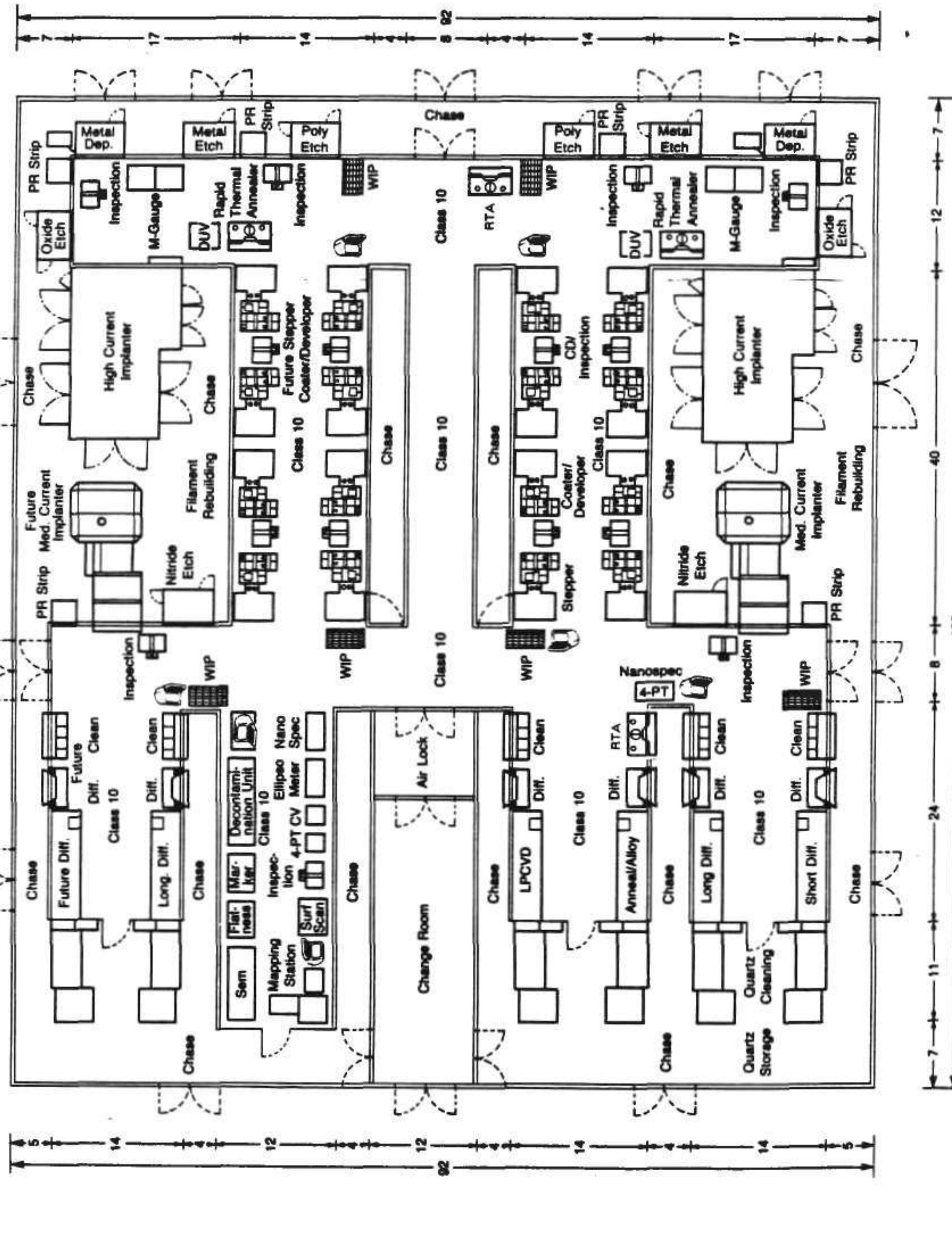
FACILITY/CLEAN ROOM LAYOUT

Figure 1 shows the wafer fab area layout, which is capable of 500 wafers-a-day out, working 24 hours a day. The total area is 10,028 square feet, with 4,460 square feet for the Class 10 clean room (976 square feet for clean room corridors), 5,064 square feet for chases, and 504 square feet for the change room. All the equipment is placed to follow the process flow and thus reduce the inventory points and personnel traffic.

The total facility is located in a 50,000-square foot building. A summary of the facility is provided in Tables 1 and 2. Various considerations for this facility were discussed in the previous section.

Figure 1

WAFER FAB LAYOUT



Source: Dataquest August 1986

Table 1

SUMMARY OF MANUFACTURING AREAS
(In Square Feet)

Wafer Fab	
Diffusion	1,008
Photo	1,120
Etch	936
Process Control	420
Clean Room Aisle	976
Chase	5,064
Locker/Change Room	504
Total Wafer Fab	10,028
Office/Aisles	12,000
Personnel Services	
Lobby	500
Security	100
Restrooms	1,500
Copy Room	200
Conference Rooms	800
Data Processing	800
Library	300
Document Control	300
Lunch Room	3,000
Training	500
Total Personnel Services	8,000
Support	
Store	2,500
Hazardous Chemical Store	1,000
Chemical Mix	300
Maintenance	1,500
QC/QA	500
Electrical	500
Mechanical/DI Pad	7,500
Miscellaneous/Future	6,172
Total Support	19,972
Gross Area	50,000

Source: Dataquest
August 1986

Table 2

SUMMARY OF MANUFACTURING FACILITY REQUIREMENTS

Clean Room	
Temperature	68 ± 1° F
Relative Humidity	40 ± 2% for photoresist area, otherwise 40 ± 5%
Floor Vibration	10 microns maximum
Particle Count (0.1μ m)	10 per cubic foot maximum
Recovery Time	6-10 seconds
Chases Particle Count (0.5μ m)	100-1,000 per cubic foot
Electrical Hook-Up	2,000 KVA with isolated clean power for control circuitry
DI Water	
DI Water Production Capability	70 GPM
DI Water Storage	25,000 gallons
Bulk Gas Tank	
Nitrogen	15,000 gallons
Hydrogen	2,000 gallons
Oxygen	2,000 gallons
Argon	2,000 gallons
HVAC	
Air Conditioning	500 tons
Exhaust	100,000 CFM
Chilled Water	150 GPM at 60-70°F
Waste Treatment	
Solvent Storage Tank	1,000 gallons
Acid Neutralization	3 x 500 gallons
Sewer Water	100 GPM

Source: Dataquest
August 1986

OPERATIONAL STRATEGY--PRODUCTIVITY CONSIDERATIONS

Asset Utilization

State-of-the-art equipment and Class 10 clean room assets are the most expensive elements of wafer manufacturing. Hence, the utilization factor of these assets, as determined by the work schedules and uptime, is an important feature of the present-day wafer fab.

The operation discussed here involves an around-the-clock, 7-day-a-week, 360-day-a-year work schedule, with no weekend or general module shutdown (except for a 5-day period and for item-by-item preventive maintenance). Therefore, there is minimum equipment downtime due to the "shut down--start up" syndrome. Equipment uptime is also improved by expert handling and through proper maintenance with user/vendor collaboration.

The around-the-clock operation can be organized in various ways. In this model, it is accomplished using two shifts a day of 12 hours each, and a split week alternating a 4-day week with a 3-day week. Four groups of people provide full 7-day coverage as illustrated in Table 3. Production is done by skilled and trained fab technologists.

The features that make this model work well are as follows:

- The fab technologists are highly qualified and cross-trained.
- The equipment is highly automated.
- Real-time, computer-based communications are utilized.

Table 3

WAFER FAB SHIFT SCHEDULE

	1st Week M T W T	1st Week F S S	2nd Week M T W	2nd Week T F S S
6 a.m.-6 p.m.	Group I	Group III	Group I	Group III
6 p.m.-6 a.m.	Group II	Group IV	Group II	Group IV

Source: Dataquest
August 1986

CYCLE TIME

Return on assets cannot be maximized without proper management of cycle time. A short cycle time minimizes the inventory costs, yield losses, special handling and expediting costs to meet customer needs, and obsolete inventories. It improves the output predictability and fast reaction to opportunities and customer needs. These assets lead to increased profitability, increased market share, satisfied customers, and better return on assets.

This model emphasizes reducing the active WIP, minimizing the inventory points, and reducing the dwell time per inventory point in order to achieve a short cycle time. Photo steps (coat, bake, align, expose, develop, and bake) are integrated as well as the diffusion steps (pre-clean, wafer transfer, and furnace loading) in order to reduce the inventory points and the inventory dwell times. Material flow is improved by the use of computerized production control and WIP balance. Continuous manufacturing operation around the clock improves the time utilization and minimizes the equipment requalification on each start-up that would occur after weekend shut-down.

An analysis of wafer fab cycle time for an 11-mask CMOS process is shown in Table 4. (The cycle time is reduced to two weeks by reducing the inventory points, and the average dwell time per inventory point is reduced by using an integrated and automated manufacturing facility.) The calculations are based on the following assumptions:

- Additional inventory points in the conventional line are needed due to separate coat, develop, and diffusion clean steps in photo and diffusion areas.

- This model fab obtains better material flow due to computerized production control; thus, WIP balance, automation, high equipment uptime, and fab technologist concept are achieved.

- A 7-day, 24-hour operation is assumed in a leading-edge line as compared to a 5-day, 24-hour operation in a conventional line.

- Net process time and inventory dwell times are improved due to equipment integration, less rework, and higher equipment throughput.

Table 4

CYCLE TIME ANALYSIS FOR 11-MASK CMOS PROCESS

		Conventional Line	Leading-Edge Line
A.	Net Process Time (Hours)	250.00	200.00
B.	Number of Inventory Points	110.00	65.00
C.	Number of Process Blocks	35.00	35.00
D.	Average Dwell Time per Inventory Point (Hours)	1.00	0.50
E.	Average Time per Block Transfer (Hours)	2.00	2.00
F.	Total Dead Time (BxD) + (CxE) (Hours)	180.00	102.50
G.	Material Flow Efficiency	0.70	0.90
H.	Percent Utilization of Weekly Time	0.71	1.00
I.	Cycle Time (A+F)/(GxH) (Weeks)	5.15	2.00

Source: Dataquest
August 1986

COMPUTER-AIDED PRODUCTION MANAGEMENT

Computer management of total wafer fab has become essential to high productivity in a modern facility. A large measure of a semiconductor company's competitive advantage comes from the efficient use of its manufacturing systems. Until recently, planning, execution, data collection, data analysis, process control, and WIP management have been largely manual or, at best, semiautomatic. Preventive actions have been difficult to plan, and incipient problems have had to become catastrophic before they became visible.

In the new fabrication line, this has changed. The new lines have computerized the deployment of personnel, material, and equipment; WIP management and adjustments to changing dynamics of the production floor; status monitoring of equipment and facility; and recipe downloading and process control. Real-time availability of data permit expedited problem diagnostics and therefore the solution to those problems. Yield improvements are achieved at a faster rate. Cycle times are dramatically reduced and the slope of the learning curve is enhanced.

Dataquest believes that the computerization of the following functions are most desirable in the emerging fab:

- Centralization of data and their update in real time

- WIP management, line balancing, and yield computations

- Cost collecting systems
- Yield analyses, lot histories, and statistical analyses
- Process documentation and process control
- Lot scheduling to meet fab out schedules and automatic lot status logging
- Maintenance scheduling, spare parts, uptime history, and downtime causes
- Downloading of process recipes
- Equipment monitoring for performance and quality of operation
- Monitoring of all facility functions
- Quality, productivity, and efficiency monitoring
- Flags on all out-of-specification conditions

The hardware and the software necessary to handle most of these functions are available today. Although a lack of standardization and various incompatibilities between various systems and equipments still exist, vigorous third-party software houses that supply application programs have emerged. Standardization in equipment interface has also begun to emerge. While there are still some substantive issues to be resolved regarding equipment interfaces and standardization, work is under way at present to resolve these incompatibilities. Dataquest believes that most if not all of these issues will be resolved in 1987.

PROCESS FLOW

The rapid reduction in the feature sizes has required the use of low-resistivity gate materials and shallow junctions. N^+ poly is still the best-characterized and most understood gate material. Silicidation of the top of poly gates (polycide) provides a well-controlled, low-resistivity gate material. Barrier metal is required before interconnect aluminum-silicon alloy is deposited to avoid spiking through shallow junctions.

With the reduction in design rules, latch-up susceptibility in the conventional bulk CMOS has also increased. With smaller geometries, latch-up is effectively minimized by the use of epitaxial substrate. Twin-well CMOS process is preferred with the use of epitaxial substrate to optimize and balance the performance of n-channel and p-channel devices. Two layers of low-resistivity conductors are utilized for a variety of CMOS applications in order to achieve higher performance and packing densities.

With these considerations, a double poly (polycide gate), single-metal, twin-well CMOS process flow is described in Table 5; the major process steps are summarized in Table 6.

The epi material used for the process is assumed to be purchased from silicon vendors; therefore, no equipment related to epi growth is shown. The conventional oxide isolation technique is used for this process until the trench isolation technique is perfected. The surface doping requirements to avoid the short channel effects are such that for 5V CMOS devices, no field implants are needed for sub-2-micron geometries. Following the gate oxidation, a single low-energy BF_2 implant is used to adjust both n- and p-channel threshold voltages.

This 11-mask process is suitable for a variety of applications, such as SRAM microprocessors. Certain products may need modifications in the process flow to meet the specific device and topological requirements of the specific product. Although the process requires 11 photomasking steps, it requires 12 resist coating steps. To remove oxide, poly, and nitride from the back of the wafer, a layer of resist is spun on the front of the wafer to protect the devices during backside etch. This resist layer does not need to be either exposed or developed.

Table 5

DOUBLE POLY (POLYCIDE GATE), SINGLE METAL, TWIN-WELL CMOS PROCESS FLOW

Process Step

Pad Oxide
Masking Nitride
P-well Photo--Defines P-well
Etch Nitride
Boron Implant--P-well implant

Photoresist Strip
Diffusion Pre-Clean
P-well Drive-in/Oxidation
Etch Oxynitride
Strip Nitride

Phosphorous Implant--Self-aligned N-well I^2
Diffusion Pre-Clean
N-well Drive-in
Strip Oxide
Pad Oxide

Masking Nitride
Active Area Photo--Defines all active devices
Etch Nitride
Photoresist Strip
Diffusion Pre-Clean

Field Oxidation
Etch Oxynitride
Strip Nitride
Etch Pad Oxide
Gate Oxidation

BF_2 Implant--Adjust both N- and P-channel device thresholds
Pre-Poly Clean
Doped Poly I Deposition
Silicide Sputter
Silicide Alloy

(Continued)

Table 5 (Continued)

DOUBLE POLY (POLYCIDE GATE), SINGLE METAL,
TWIN-WELL CMOS PROCESS FLOW

Process Step

Gate Photo--Defines all gates
Etch Polycide
Photoresist Strip
Diffusion Pre-Clean
Source/Drain Oxidation--Re-oxidize source/drain

N^+ Photo/DUV--Defines N^+ regions; DUV = deep UV curing of resist to improve resist survivability during plasma/RIE etching
Arsenic Implant--N^+ implant (high dose)
Photoresist Strip
P^+ Photo/DUV--Defines P^+ regions

BF_2 Implant--P^+ Implant (High Dose)
Photoresist Strip
Diffusion Pre-Clean
Rapid Thermal Anneal--Activate N^+/P^+ Areas
Diffusion Pre-Clean

LTO Deposition
Poly Contact Photo--Defines poly-to-poly and poly-to-diffusion contact
Pre-Poly Clean
Poly II Deposition
Poly II Photo--Defines second Poly

Poly II Etch
Photoresist Strip
Poly II Implant Photo--Defines low resistivity Poly II areas
Phosphorous Implant
Photoresist Strip

Diffusion Pre-Clean
Rapid Thermal Anneal--Activate Poly II implant
LTO Deposition
Rapid Thermal Anneal--Reflows LTO over poly II steps
Contact Photo--Define all contacts with sloped sidewalls for reliable metal step coverage

(Continued)

Table 5 (Continued)

DOUBLE POLY (POLYCIDE GATE), SINGLE METAL,
TWIN-WELL CMOS PROCESS FLOW

Process Step

Oxide Etch
Photoresist Strip
Surface Oxide Etch
Barrier Layer + Metal Deposition--Barrier metal and aluminum-silicon alloy are sequentially deposited

Metal Photo/DUV--Defines metal
Metal Etch
Photoresist Strip
Pre-Alloy Clean
Alloy

Pre-Passivation Rinse
Passivation Deposition
Passivation Photo--Scratch protection mask
Passivation Etch
Photoresist Re-Coat

Back-Side Etch
Photoresist Strip
Parametric Mapping--Parametric Screening
Final QC/Ship to Wafer Sort

Source: Dataquest
August 1986

Table 6

PROCESS SUMMARY

Process Steps/Photoresist Strips

1. Well
2. Active
3. Gate
4. N^+
5. P^+
6. Poly cont.
7. Poly II
8. Poly II I^2
9. Contact
10. Metal
11. Passivation
12. Back etch

Nitride Plasma Etch

1. Pre-well
2. Post-well
3. Pre-field
4. Post field

Poly/Polycide RIE/Plasma Etch

1. Gate polycide
2. Poly II
3. Back-etch

Oxide RIE/Plasma Etch

1. Poly contact
2. Contact
3. Surface oxide

Metal RIE/Plasma Etch

1. Metal + barrier layer

Medium Implants

1. P-well
2. N-well
3. VT adjust
4. Poly II

High Dose Implants

1. N^+
2. P^+

Metal Deposition

1. Silicide
2. Barrier + Al alloy

(Continued)

Table 6 (Continued)

PROCESS SUMMARY

Short Diffusion

1. Well pad oxidation	2. P-well oxidation	3. Field pad oxidation
4. Gate oxidation	5. S/D oxidation	

Anneal/Alloy

1. Metal alloy		

Long Diffusion

1. Well drive-in	2. Field drive-in	

LPCVD

1. Well nitride	2. Field nitride	3. Poly I
4. Poly II	5. Interpoly LTO	6. Pre-metal LTO
7. Passivation		

Rapid Thermal Anneal

1. Silicide alloy	2. S/D Activation	3. Poly I^2 activation
4. LTO reflow		

Wet Etch

1. Oxynitride I	2. Well oxidation	3. Oxynitride II
4. Field pad oxidation	5. Passivation etch	6. Back etch

Diffusion Pre-Clean

1. P-well oxidation	2. Well drive-in	3. Field oxidation
4. Poly I	5. S/D oxidation	6. S/D anneal
7. Interpoly LTO	8. Poly II	9. Pre-metal LTO

Pre-Deposition Clean

1. Pre-barrier + Al-alloy	2. Pre-passivation

Source: Dataquest
August 1986

Table 7

CAPACITY ANALYSIS FOR 100 PERCENT EQUIPMENT UTILIZATION

Equipment	Wafers/ Hour	Uptime	Available Hours/Day	Rework Rate	Turns/ Wafer	Mechanical Yield	Wafers Out Per Day*
Coat/Develop	45	0.90	20	0.05	12	1.000	64
Stepper (1X)	30	0.90	20	0.05	11	1.000	47
Auto Inspect/CD Measurement	40	0.95	20	0.02	15	0.990	49
Resist Strip	60	0.95	20	0.05	12	1.000	90
Nitride/Poly Etch	60	0.90	20	0.03	7	0.995	149
Oxide Etch	60	0.90	20	0.03	3	0.995	349
Metal Etch	30	0.80	18	0.03	1	0.995	417
Implant (Medium)	150	0.90	18	0.00	4	0.995	604
Implant (High)	45	0.90	15	0.00	2	0.995	302
Metal Deposition	60	0.90	18	0,02	2	0.995	474
Short Diffusion (4 Tubes)	30	0.95	18	0.00	1	1.000	513
Anneal/Alloy/Short Diffusion (4 Tubes)	60	0.95	18	0.00	1	1.000	1,026
Long Diffusion (8 Tubes)	15	0.90	20	0.00	1	1.000	270
LPCVD (4 Tubes)	60	0.90	20	0.02	2	0.990	524
Rapid Thermal Anneal	60	0.90	18	0.02	4	1.000	238
Diffusion Clean/Wet Etch and Pre-deposition Clean	100	0.95	18	0.02	17	0.995	98
Parametric Mapping	30	0.95	20	0.05	1	0.950	514
Net Cumulative Fab Yield						0.899	

*Wafers out per day = (Wafers/hour x available hours/day x uptime x (1 - rework rate) x mechanical yield) ÷ turns/wafer

Source: Dataquest
August 1986

EQUIPMENT CAPACITY ANALYSIS

The daily wafer out capacity of the key manufacturing equipment depends on the process complexity. Major process steps for the double poly, single metal process described are summarized in Table 6. Based on this process and the intrinsic data for the process equipment (i.e., wafer pass per hour, uptime, daily production availability, rework rate, and mechanical yield), the daily wafer out capacity for the key equipment shown in Table 7 is based on around-the-clock equipment utilization.

Equipment, clean room, and chase requirements for the equipment needed to do 500 wafers out per day, 14,000 wafers out per period, is calculated in Table 8. Equipment utilization based on these calculations is also included in Table 8.

As noted from these calculations, about $20 million worth of equipment is needed for this facility. One stepper is dedicated per masking layer. Additional steppers will be needed if a more complex process is required for some applications. Enough room is provided in the manufacturing facility layout to accommodate up to 16 steppers, plus one additional furnace bank and an implanter. The cost analysis presented in this report will be affected slightly by the additional equipment required for a more complex process. A list of equipment needed, including the potential vendors and typical lead times, is presented in the appendix at the end of this section.

Table 8

MANUFACTURING EQUIPMENT COST/CAPACITY ANALYSIS
FOR 500 WAFERS OUT/DAY

Equipment	Wafer/ Day/Unit	$K/ Unit	Clean Room Sq. Ft./ Unit	Equipt Chase Sq. Ft./ Unit	Number Needed	Equipment Utilization	Total K$	Total Clean Room Sq. Ft.	Total Equipt Chase Sq. Ft.
Coat/Develop	64	150	16	6	11	0.71	1,650	176	66
Stepper (1X)	47	500	16	6	11	0.97	5,500	176	66
Auto Inspect/CD	49	145	12	0	13	0.78	1,885	156	0
Resist Strip	90	60	10	40	6	0.93	360	60	240
Nitride/Poly Etch	149	150	25	50	4	0.84	600	100	200
Oxide Etch	349	200	25	50	2	0.96	400	50	100
Metal Etch	417	400	25	50	2	0.60	800	50	100
Implant (Medium)	604	600	40	200	1	0.83	600	40	200
Implant (High)	302	1,250	40	400	2	0.83	2,500	80	800
Metal Deposition	474	500	30	60	2	0.53	1,000	60	120
Short Diffusion (4 Tubes)	513	260	70	70	1	0.97	260	70	70
Anneal/Alloy (4 Tubes)	1,026	260	70	70	1	0.49	260	70	70
Long Diffusion (8 Tubes)	270	260	70	70	2	0.93	520	140	140
LPCVD (4 Tubes)	524	400	70	70	1	0.95	400	70	70
Rapid Thermal Anneal	238	150	20	10	3	0.79	450	60	30
Diffusion Clean/ Wet Etch	104	180	30	40	5	0.96	900	150	200
Miscellaneous	500	1,750	2,972	2,602	1	1.00	1,795	2,952	2,592
							19,880	4,460	5,064

Source: Dataquest
August 1986

WAFER THROUGHPUT YIELD

With the use of automated equipment, equipment integration, and increased emphasis on equipment reliability, the wafer throughput yield has increased continually over the years, in terms of both mechanical yield and parametric yield. For the process described before, the wafer throughput yield for various photomasking blocks is projected in Table 9. (The corresponding mechanical yield for various equipment is shown in Table 7.)

Table 9

MECHANICAL WAFER YIELD

Step	Yield
Well Photo	0.997
Active Photo	0.995
Gate Photo	0.993
N^+ Photo	0.997
P^+ Photo	0.997
Poly Contact Photo	0.995
Poly II Photo	0.993
Poly II I^2 Photo	0.997
Contact Photo	0.993
Metal Photo	0.993
Passivation Photo	0.997
Parametric Mapping	0.950
Overall Throughput Yield	0.900

Source: Dataquest
August 1986

STAFFING REQUIREMENTS/ORGANIZATION

The total staffing requirement for the facility described here is shown in Table 10. This plant will require 124 people, of which 76 are direct labor responsible for wafer manufacture. The other 48 people are indirect labor associated with management, engineering, quality control, and general administration. The organization of manpower is depicted in Figure 2.

Table 10

STAFFING REQUIREMENT

Category	Number	Annual Salary/Person ($K)	Total Salary Per Period ($K)
Direct			
Lead Technician	4	32	$ 9.85
Fab Technician	60	24	110.77
Material Handler	4	18	5.54
Maintenance	8	29	17.85
Total Direct Labor	76		$144.00
Indirect			
Wafer Fab			
Operations Manager	1	60	$ 4.62
Engineers	5	43	16.54
MIS Engineers	2	43	6.62
Secretary	1	18	1.38
Subtotal	9		$ 29.16
QC/QA			
Manager	1	54	$ 4.15
QC/QA Engineers	2	43	6.62
Technicians	4	24	7.38
Trainers	2	27	4.15
Document Control	1	18	1.38
Secretary	1	18	1.38
Subtotal	11		$ 25.08

(Continued)

Table 10 (Continued)

STAFFING REQUIREMENT

Category	Number	Annual Salary/Person ($K)	Total Salary Per Period ($K)
Production/Material/Facility			
Manager	1	54	$ 4.15
Production Planners	2	24	3.69
Purchasers	2	43	6.62
Shipping/Receiving/Store	2	18	2.77
Facility Engineers	2	43	6.62
Technicians	4	24	7.38
Safety	1	43	3.31
Security Manager	1	54	4.15
Guards	4	18	5.54
Secretary	1	18	1.38
Receptionist	1	18	1.38
Subtotal	21		$ 47.00
General Administration			
Plant Manager	1	100	$ 7.69
Controller	1	54	4.15
Financial Analyst	1	43	3.31
Personnel Manager	1	54	4.15
Personnel Assistant	1	43	3.31
Executive Secretary	1	27	2.08
Secretary	1	18	1.38
Subtotal	7		$ 26.08
Total Indirect Labor	48		$127.32
Total Staffing	124		$271.32

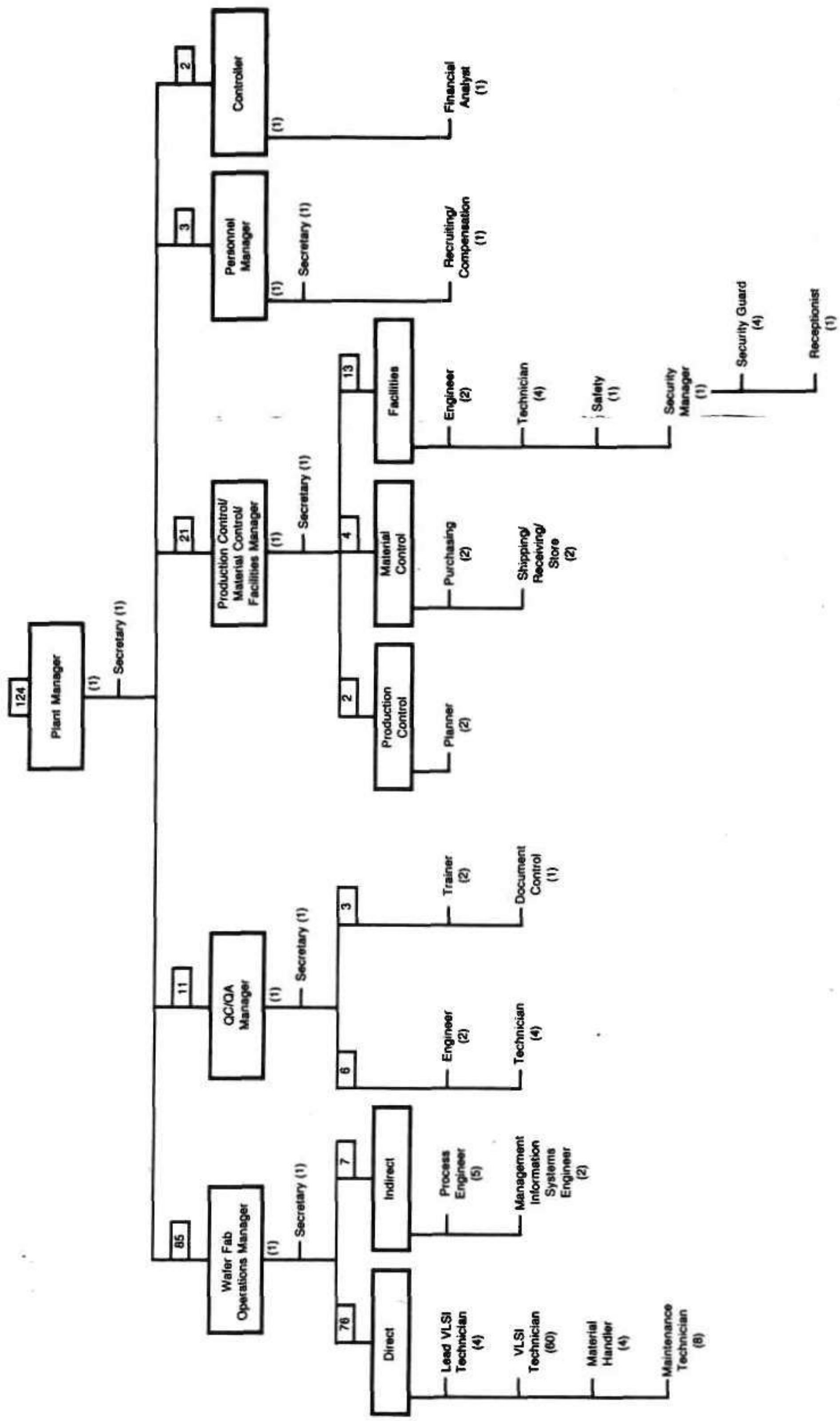
Notes:

1. Annual salaries are for 1986-1987.
2. Staffing level is based on four alternate work pattern manufacturing groups.

Source: Dataquest
August 1986

Figure 2

ORGANIZATION CHART



Source: Dataquest
August 1986

With this staffing, the average wafer out per direct labor is 46 per week in this facility. This is possible with around-the-clock facility utilization, high throughput, automated equipment and computer controlled WIP, and production management.

COST ANALYSIS

The manufacturing costs per 150mm wafer are analyzed in Tables 11 and 12. Table 11 itemizes various cost assumptions. The building is depreciated over 25 years, and the equipment and clean room are depreciated over 5 years. Electricity cost is assumed at $0.06 per KWH. Since the wear-out of reticles is minimal, their costs are not included in this model nor is the original cost of procurement of the reticles.

With these and other assumptions, as outlined in Table 11, the total manufacturing cost per 150mm wafer in this facility is about $173, of which about $101 are variable costs like materials and labor, and the other $72 are fixed costs such as indirect labor, utilities, and depreciation. The wafer cost in this model is less than the cost in the model we published in 1985. The difference in cost is due mainly to two factors: the decrease in price in epitaxial wafers ($50 versus $60) and the cost increase due to the higher equipment cost and associated maintenance and spare parts. The net effect has been as $5 reduction in wafer cost for the current model.

Table 11

ITEMIZED COST ELEMENTS

Item	
Wafers Finished/Period	14,000
Mechanical Yield	0.9
Wafer Starts/Period	15,556
Average Wafer Movement Per Period	14,778
Active WIP Wafers	7,389
Cost per Wafer Start (Epi wafer)	$50
Chemical Cost/Wafer	$10
Process Gas Cost/Wafer	$10
DI Water Usage (GPM)	50
DI Water Cost/1,000 Gallons	$6
Operating Supplies/Wafer	$10
Electricity Requirement (KW)	1,500
Electric Rate/KWH	$0.06
Sewage Water (1,000 gallons/day)	144
Sewage Water Cost/1,000 gallons	$1
Gas/Vacuum/Air (Cost/Wafer)	$1
Fab Area (Clean Room+Chase) (ft.^{2})	10,028
Building (ft.^{2})	50,000
Building Cost (at $100/ft.^{2})	$5,000,000
Fab Area Cost (at $400/ft.^{2})	$4,011,200
Equipment Costs (15% added for freight, installation, & taxes)	$22,862,000
Equipment maintenance and spares (at 1% of cost per period)	$228,620
Building Insurance (at 1%/year of value) per period	$3,846
Equipment Insurance (at 2%/year of value) per period	$35,172
Inventory Insurance (at $1/active WIP wafer)	$7,389
Property Tax (at 1.2%/year of building) per period	$4,615

Notes:

1. Building depreciation at 25 years straight line
2. Equipment and clean room depreciation at 5 years straight line
3. Clean room counted as equipment for maintenance and insurance purposes

Source: Dataquest
August 1986

Table 12

WAFER COST ANALYSIS

	Cost/Period ($K)	Cost/Wafer Out ($)
Variable Costs		
Material		
Wafers	$ 778	
Chemicals	148	
Process Gases	148	
DI Water	12	
Supplies	148	
Subtotal	$1,234	$ 88.14
Direct Labor		
Salary	$ 144	
Fringe Benefits (25%)	36	
Subtotal	$ 180	$ 12.86
Total Variable Cost	$1,414	$101.00
Fixed Manufacturing Overhead		
Indirect Labor Salary		
Wafer Fab	$ 29	
QC/QA	25	
Production/Material/Facility	47	
General Administration	26	
Total Indirect Labor Salary	127	
Fringe Benefit (25%)	32	
Travel & Other Expenses (8% of Salary)	10	
Subtotal	$ 169	$ 12.05
Electricity	$ 60	$ 4.32
Water/Sewage	$ 4	$ 0.29
Gas/Vacuum/Air	$ 15	$ 1.06

(Continued)

Table 12 (Continued)

WAFER COST ANALYSIS

	Cost/Period ($K)	Cost/Wafer Out ($)
Insurance and Tax		
Building Insurance	$ 4	
Equipment Insurance	35	
Inventory Insurance	7	
Property Tax	5	
Subtotal	$ 51	$ 3.64
External Services/Maintenance		
External Services (Waste Disposal, etc.)	$ 50	
Maintenance	229	
Subtotal	$ 279	$ 19.93
Depreciation		
Building (25 years)	$ 15	
Clean Room and Equipment (5 years)	413	
Subtotal	$ 428	$ 30.57
Total Fixed Manufacturing Overhead	$1,006	$ 71.86
Total Wafer Cost	$2,420	$172.86

Source: Dataquest
August 1986

Appendix A

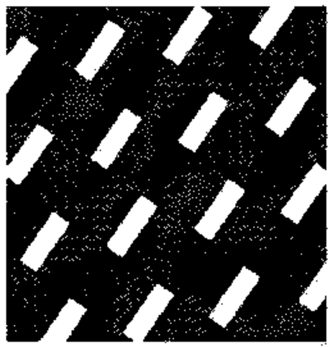
LIST OF EQUIPMENT

Equipment	Vendor	Unit Cost (K$)	Lead Time (Weeks)	Number Needed	Total Cost ($K)
Wafer Fab					
Coat/Develop	MTI, SSI, SVG, Solitec, GCA	$ 150	20-25	11	$ 1,650
Stepper (1x)	Ultratech	500	36-40	11	5,500
Auto Inspection/CD	OSI, Nikon, Leitz, Matrix	145	20-25	13	1,885
Resist Strip	IPC, Drytek, Matrix, Tegal	60	20-25	6	360
Nitride Etch	LAM, Tegal, Drytek, AMT	150	20-25	2	300
Polycide Etch	LAM, Tegal, Drytek, AMT	150	20-25	2	300
Oxide Etch	LAM, Tegal, Drytek, AMT	200	20-25	2	400
Metal Etch	Zylin, ET, Tegal, AMT	400	20-25	2	800
Acid Processor	FSI, Fluorocarbon, Semi-Tool	180	25-30	5	900
Medium Dose Implanter	Eaton, Varian, Veeco	600	36-40	1	600
High Dose Implanter	Eaton, Veeco, Varian	1,250	36-40	2	2,500
Metal Deposition	Varian, ET, MRC	500	25-30	2	1,000
Diffusion Furnace (4 Tube/Stack)	Tylan, BTU, Thermco	260	36-40	4	1,040
LPCVD (4 Tubes)	ACS, Anicon, Thermco, Tempress	400	36-40	1	400
Rapid Thermal Anneal	AG, Varian, Eaton, Peak	150	20-25	3	450
Subtotal					$18,085
Process Control and Maintenance					
Vacuum Bake Oven	VWR, Fisher, Blue-M	$ 5	15-20	5	$ 25
Microscrope	Nikon, Leitz, Olympus	15	20-25	5	75
Wafer Transfer System	MGI, Procronics, Quartz Int.	15	20-25	5	75
DUV Illuminator	Fusion System, OAI, HTG	25	20-25	2	50
Thickness Measurement	Nanometrics	50	20-25	2	100
Ellipsometer	Rudolph, Gaertner	50	20-25	1	50
Four-Point Probe	Veeco, ASM, Magne-Tron, Eaton	25	15-20	2	50
Spreading Resistance	SSM	125	25-30	1	125
CV Plotter	MDC, PAR, MSI	30	20-25	1	30
Metal Thickness Measurement	Tencor	15	20-25	2	30
Surface Particle Monitor	Tencor, Hamamatsu, Aeronca	65	25-30	1	65
Wafer Flatness Analyzer	ADE, GCA, Prometrix, Siltec	30	25-30	1	30
Surface Profiler	Tencor, Sloan, Siltec	15	20-25	1	15
Decontamination System	Atcor	25	20-25	1	25
Wafer Marker	LIS, ADE	25	25-29	1	25
Mapping Station	Keithley, Hewlett-Packard	150	25-30	1	150
Wafer Prober	Electoglas/Xynetics, PWS, Teledyne	25	25-30	2	50
Curve Tracer	Tektronix	15	20-25	2	30
Meters, Power Supplies	HP, Fluke, Keithley	10	15-20	3	30
SEM	Cambridge, Amray, ISI	150	25-30	1	150
Micro-Probe	Kevex, EF&F	50	25-30	1	50
CIM Package	Consilium, IP Sharp	250	25-30	1	250
Gas Analyzer	Balzers, Inficon, Edwards	15	15-20	1	15
Leak Detector	Veeco, Edwards, Varian	25	15-20	2	50
Particle Monitor	Climet, Hiac/Royco	15	15-20	1	15
Air Flow Meter	Alnor, Kurz	5	15-20	1	5
Tube Cleaning Station	IAS, Polyflow	15	20-25	1	15
Bead Blast	Various	5	15-20	2	10
Sputter Part Cleaning	Various	10	15-20	1	10
Strobe, Exposure Meter	Various	5	15-20	1	5
Gas Cabinets	Semi-Gas, Vari-Flow	5	15-20	5	25
Quartz Storage	IAS, Various	5	15-20	2	10
Mask Storage	Various	25	15-20	2	50
Vib. Free Table	Newport, Kinetic Systems, TMC	3	15-20	10	30
Clean Room Temperature	Various	25	15-20	1	25
Maintenance Tools	Various	50	15-20	1	50
Subtotal					$ 1,795
Grand Total					$19,880

Source: Dataquest
August 1986

Economic Outlook

The following is list of material contained in this section:



Economic Outlook 1988–1989

Dataquest

a company of
The Dun & Bradstreet Corporation

Published by Dataquest Incorporated

Executive Preface

Why You Should Take an Hour to Read This Report

We are entering an era of global markets. The electronics industry is a primary force in the creation of this era, and this is the same industry that stands to profit the most from it. Successful businesspeople in this era will add two new skills to the traditional set:

- They will understand the appropriate uses of technology in their field.
- They will anticipate opportunities and competitive moves on an international basis.

Every business and every individual will be influenced by global economic events, willingly or not. Some effects will be more obvious or dynamic than others. Regardless of whether the decision is where to design system software or where to open the next sales office, an understanding of economic factors is fundamental to the specific business skills needed for success.

This report is written for Dataquest clients. About 60 percent of the material concerns the United States, and 40 percent relates to major U.S. trading partners and markets. The report summarizes events leading to the current position of the United States in the world economy. For the future, economic trends and forces are described that will directly affect both global and domestic markets for electronics industry products in 1988-1989.

The most significant forecasts in this document are as follows:

- United States real economic growth in 1988 will be similar to 1987 at 2.8 percent; but 1989 will be slower, particularly in the second half. Consumer and government spending will continue to weaken, but export trade growth will compensate for a large part of these declines.
- 1989 federal tax increases and congressional legislation will have little real effect in reducing the federal budget deficit.
- Structural shifts in the United States economy will tend to stabilize wage and employment rates. The largest contribution to inflation in the United States will come in the form of consumer spending for imported goods.
- The focus of international trade for the United States will sharpen on the Pacific region, which accounts for 60 percent of its trade deficit and only 20 percent of its export markets.
- The most positive domestic prospects for 1988-1989 among major U.S. trading partners belong to Japan, Canada, the United Kingdom, and Italy.

Much of the macroeconomic data presented in this report is used by Dataquest analysts to put together specific industry market forecasts. As informed Dataquest clients, your understanding of this material will enhance the information value of every Dataquest service.

Contents

Introduction

As the end of the 1980s approaches, a new economic era is dawning. Global markets are becoming a reality, with electronics, steel, and automotive products leading the way and providing new opportunities on an unprecedented scale. Yet these developments are also making the economic relationships between nations, industries, and markets increasingly complex. As a result, there is a rapidly growing need for accurate insights and sources of information to improve marketing, planning, and decision-making within the electronic industry.

Change is rarely painless, since it requires doing things differently from the way they were done in the past. In particular, the structural economic changes of the 1980s are increasingly forcing analysts and managers to focus their research more on current conditions, since historical trends have become less meaningful. Evidence of this can be clearly seen in the daily newspapers. The most closely watched indicators of economic activity today are the dollar exchange rates, interest rates, international stock and commodity markets, and consumer spending and sentiment. The one characteristic these variables all share is their short-term volatility.

Given this constantly changing environment, one way to achieve a clearer U.S. perspective is to focus on the realities of the marketplace as viewed by the actual participants—businesspeople in large and small companies across the country. Dun & Bradstreet, Dataquest's parent company, makes important contributions toward understanding current trends with its quarterly surveys of business expectations.

For example, D&B post-stock market crash surveys of sales expectations for 1988 showed levels of optimism equal to the high levels of 1985 through 1987. In another D&B post-crash survey of corporate buyers, roughly 75 percent of the respondents said that their capital spending plans were not affected by the October stock market slump. A third year-end survey of 1,500 plant managers showed an immediate but small reduction in 1988 production plans.

In formulating Dataquest forecasts, we utilize many of the D&B business surveys. The perceptions of Main Street are substantially more important than those of Wall Street. Given the insights provided in part by these survey results, our economic forecast for 1988 of 2.8 percent growth expected in the inflation-adjusted gross national product (GNP) reflects a pace of activity that is similar to 1987. Looking further ahead, we expect U.S. economic growth in 1989 to be about 2.2 percent, with the first half of the year showing more strength than the second half.

Growth in 1988 will be driven by significantly different factors from those of recent years. A brief overview of these factors and the circumstances leading to their emergence is presented in the next section. For reference, key economic statistics appear later in this document.

The 1980s in Review

To a great degree, the economic events of 1987 represent the culmination of a number of trends that have been developing throughout this decade.

Inflation was undoubtedly the most dominant issue in terms of shaping the U.S. economy in the early 1980s. Oil prices and high wages forced double-digit increases in the consumer price index in the beginning of the decade, reflecting problems created in the late 1970s. High real and nominal interest rates were exacerbated by a large dose of Federal Reserve tightening, which sharply limited the supply of loanable funds in the economy. The recessions in 1980 and 1982 were the price that was paid to end this wage-price spiral.

During the early 1980s, three key events occurred that played major roles in shaping today's economic environment:

- First, President Reagan's massive individual tax cuts took effect. The average tax rate on taxable personal income fell from 13.2 percent in 1981 to 11.1 percent in 1984. With only a minor slowdown in federal spending, the federal budget deficit, which had been almost nil in 1979, exploded to 5.2 percent of GNP in 1983 and now hovers in the 3.4 percent range.

- Second, the pattern of financial deregulation that started in the late 1970s began to influence money and equity markets in significant ways. New financial institutions and instruments began to offer individuals and firms a wide range of competitive investment choices.
- Third, technology began to have a profound impact on business information processing and communication during this period. Through the application of information technology, financial institutions expanded through the scope and sophistication of their analyses to interpret and evaluate vast amounts of macroeconomic and microeconomic data. Stock markets began to react in unison to global economic events. The more aggressive businesses began to apply technology to sharpen their control of "mission-critical" sales, manufacturing, and customer service activities.

The tax cuts served as the starting gun that set the U.S. economic expansion off and running. America rapidly emerged as the engine of economic growth for the industrialized world. The United States, with its relatively high interest rates, strong domestic markets, and sophisticated financial infrastructure, became a magnet for foreign investors. As a result, the dollar exchange rate soared and prices of imported goods in the United States fell.

In response, U.S. consumers flexed their increased disposable income muscles, courtesy of the Reagan tax cuts, and voraciously bought these low-priced imported goods. Unfortunately, this was not what was intended. The tax cuts were designed to stimulate the U.S. economy by increasing disposable income and, hence, demand for *domestically* produced goods. However, consumers found better value in imports, and the dollars flowed both into the U.S. economy and abroad. At the same time, savings as a percentage of disposable income fell from 7.5 percent in 1981 to about 3.6 percent in 1987, due to new and convenient ways to borrow. By comparison, the Japanese savings rate is 17.5 percent, and most Europeans average about 14.0 percent.

In capital markets, savings must necessarily match investment. Given the shortage of domestic savings and an excess demand for capital by both consumers and government, foreign capital filled the void. In September 1985, this instability was formally recognized by the finance ministers of the G-7 industrialized countries (Canada, Germany, the United Kingdom, France, Italy, Japan, and the United States), and efforts were initiated to systematically devalue the dollar.

The goals of the devaluation were to discourage U.S. consumption of imports by raising imported prices, and to make U.S.-produced goods more competitive abroad.

This devaluation has succeeded in stimulating U.S. exports. In terms of volume, the U.S. trade deficit has started to improve slightly, but a turnaround has yet to occur in terms of current dollars, because import price increases have compensated for the decline in demand. Meanwhile, U.S. export prices have been flat, indicating that current export markets are both highly competitive and somewhat weak. U.S. exports on a constant-dollar basis increased 17.5 percent in 1987, while imports were up only 3.1 percent. Which U.S. industries led the export surge? Many of the same ones that had suffered earlier—textiles, paper, and agricultural products. Others are also the most visible beneficiaries of American productivity and quality improvements—metals, chemicals, aircraft, machinery, instruments, and computer equipment.

However, the earlier import wave has left the United States in 1988 in the position of a debtor nation after 50 years of creditor status. American assets owned by foreigners exceed the value of foreign assets owned by Americans.

Other factors make a shift in the U.S. balance of trade an uphill battle. For example, goods from newly industrialized countries (NICs), such as Taiwan and South Korea, are increasingly being substituted for other import sources, such as Japan. The dollar has fallen relatively little against the currencies of many of these countries. In other cases, such as Mexico, the dollar has appreciated. As a result, NIC products are still a bargain when priced in dollars. So, while the mix of trading partners has changed, the U.S. trade deficit has not yet been substantially reduced. The Japanese have held onto a major piece of the action by setting up plants in Taiwan and Singapore, for example, and by building their products with low-cost components from these countries.

In recognition of this shift in manufacturing sources, the United States has increased pressure on NICs to revalue their currencies. However, NIC revaluations constitute a two-edged sword. Although imports would indeed become more costly in the United States, many of the current international sources of inexpensive goods and labor would also be eliminated. The result would be increased inflationary pressures on the U.S. economy.

To summarize, the 1980s to date have been characterized by consumption-driven growth of the U.S. GNP. Though trade improvements contributed to final demand early in the decade, by 1983 the swelling trade deficit began to have a negative impact on U.S. economic growth, an impact that was overshadowed only by the exuberant levels of consumer spending. Nevertheless, the current expansion is now 64 months old and continuing, the second longest expansion in the post-war period.

Figure 1 shows the shift in factors that contribute to U.S. economic growth. This illustration clearly shows that growth in the mid-1980s was exceptional, despite the tremendous drag from the trade deficit. The Dun & Bradstreet forecast for 1988-1989 has real GNP growing annually at a lower rate compared with the initial phases of the current expansion. Consumption growth also is expected to be lower in the years ahead, but will remain on par with growth in the '60s and '70s. Meanwhile, contributions to GNP from improvements in trade will help to offset a large part of this reduction in consumer-spending growth.

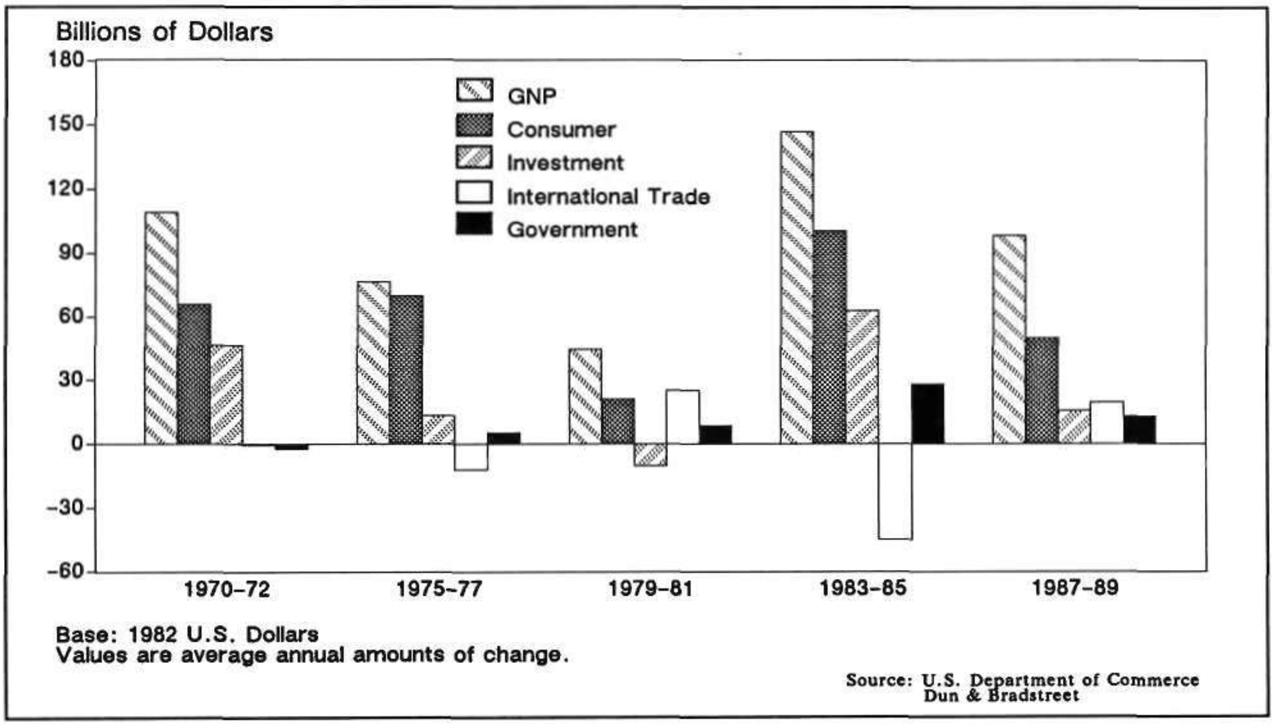


Figure 1. Components of U.S. Real GNP Growth

Key Factors in the U.S. Economy of the 1990s

The key issues for the future are the trade and federal budget deficits, and the steps that will be taken to reduce them. Reducing the federal deficit will, in the long run, reduce U.S. demand for capital, thereby relieving upward pressure on interest rates. However, for the near term, measures to reduce the federal deficit will hurt industries and individuals directly dependent upon the federal government.

Cutting the trade deficit will be more difficult. Basically, the deficit can be reduced by increasing exports or decreasing imports, with export growth having far more beneficial side effects. Currently, 90 percent of all American manufacturers concentrate exclusively on the domestic market. To enlarge their horizons and expand exports, of course, it is essential for U.S. manufacturers to develop export markets. Overseas market development requires development of the fundamental skills, with an international accent:

- Thorough market research
- Products designed with the features to appeal to those markets
- Professional sales and service organizations
- The capability of delivering those products on time at the right price

U.S. manufacturers can hope to be the beneficiaries of any further erosion of the dollar's value, or they can pursue a more aggressive strategy of improving their industrial productivity, and so reduce unit costs.

Productivity gains require that capital spending must increase, and that other input costs, such as labor and scrapped material, must decrease as a percentage of the total. Federal policies must be put into place to stimulate investment and induce individuals to save rather than to spend. This is crucial if the United States is to increase domestic sources of investment funds. In addition, some of this reduced consumption would inevitably lower the volume of imported goods, further helping the trade deficit. The forecast is for very modest increases in personal savings rates, from a 1987 level of 3.7 percent of disposable income to about 4.0 percent in 1988-1989.

To the extent that U.S. domestic spending is curtailed, many production-oriented businesses must find growth opportunities outside the United States. There are many emerging opportunities in Asia, Europe, and the Americas, but U.S. companies will have to adapt their products and sales strategies to compete effectively outside the familiar domestic arena.

Demographic shifts will also occur in the '90s as they have in each decade in the postwar period. Household formation will slacken as baby-boomers reach their thirties and forties. The demand for starter housing will ebb, being replaced by a market for step-up homes. Dual income households will increasingly dominate spending trends, especially for upscale consumer items and time-saving services.

Capital investments in manufacturing automation will continue to be extended and upgraded. The shakeout of firms that have not chosen—or cannot afford—to improve productivity and quality by modernizing will continue in a bigger way. Dispersal and subcontracting of production, where smaller firms produce components for larger firms, will increase. Thus, the current trend in which new small businesses provide much of the employment growth will continue.

Dataquest's View of the U.S. Economy

In recent years, most economic analysts have compiled rather poor records in forecasting important economic developments. All a good economist can do is to assimilate as much information as possible, and interpret it with the maximum amount of skill. However, the major structural changes occurring in the U.S. economy in conjunction with international events make it difficult to foresee major developments and dangerous to rely too much on historical patterns. Dataquest expects the U.S. economy to continue its evolution in ways that bear little resemblance to the past. Hence, analyses of historical relationships are of limited value.

Under these conditions, information directly from business decision makers and major participants in the economic system is especially valuable. It is important to grasp how business people perceive the environment and to recognize how the status of their order books directly affects their business plans.

For example, a Dun's 5000 survey at the end of 1987 asked businesses whether the October decline in the stock market and the subsequent turmoil in the capital markets affected their 1988 capital spending plans. Capital spending is a good proxy for the general health of the economy. Firms invest when they wish to increase capacity or enhance productivity, and both situations require confidence in future economic conditions.

About 75 percent of the respondents said their capital spending plans for 1988 were not affected by the October 1987 crash. The remaining respondents were unsure or said their spending plans were negatively impacted. The responses were uniform across most industries and firm sizes. The two exceptions were among the smallest firms (1 to 19 employees) and among construction companies, for reasons one might expect. Small firms typically pull back during periods of uncertainty to avoid risking their limited financial resources, and construction firms routinely turn pessimistic when interest rates appear to be heading upward. Both types of companies are the most flexible about spending plans and become conservative during periods of economic uncertainty.

The quarterly Dun & Bradstreet Business Expectations survey (See Figure 2), querying about 1,400 business people, asked executives

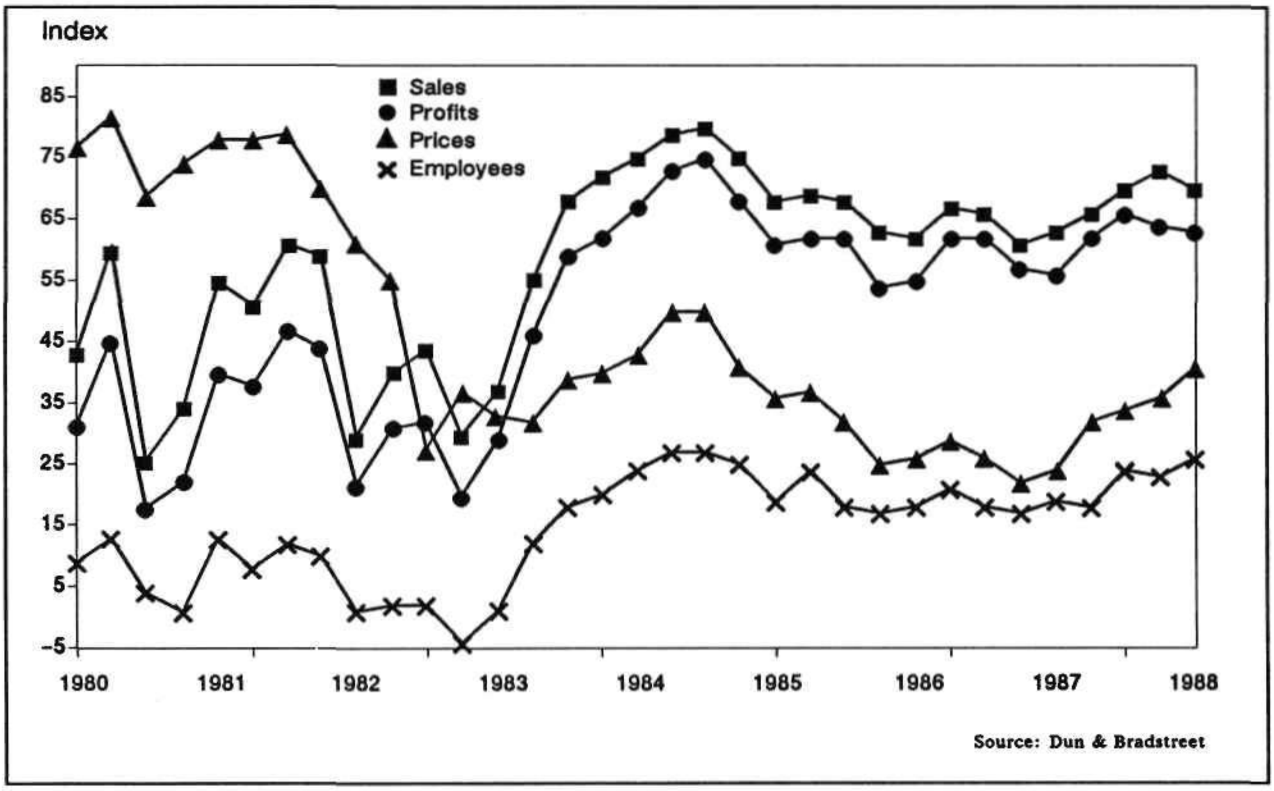


Figure 2. Dun & Bradstreet Business Expectations Survey

about their outlook for their businesses in the first quarter of 1988. The results showed that the outlook for sales and profits was down only slightly compared with their expectations for the fourth quarter of 1987, measured prior to the crash. What is more remarkable is that hiring plans for the first quarter of 1988 actually increased compared with plans in the fourth quarter of 1987.

The survey also showed an increase in the number of executives anticipating price increases in the beginning of 1988. Several inferences may be made from this. First, prices usually increase during periods of economic strength, not weakness, so comparatively few of the respondents expect a recession soon. Second, these anticipated price increases could be related to expectations of a continued decline in the dollar or concerns over an expansionary trend in monetary policy, both of which could increase inflation down the road. Lastly, given the recent rise in prices of many imported goods, some firms will seek to exploit this reduced competition by raising their own prices.

Dun & Bradstreet's statistical series on business starts and failures are two other key sources of insight into U.S. economic trends. Regional and industry breakdowns provide information on the business environment that is not easily available from other sources.

Business starts through November 1987 decreased 7.6 percent compared with the same period in 1986. Despite this decline, the overall level remains high, given that the current economic expansion is more than five years old. Stronger regions include the Northeast and the Pacific Coast, both of which have been strong for some time. The Midwest, with its large industrial sector, is benefiting from the surge in exports and is an emerging area of strength.

D&B data on business failures shows that the growth in bankruptcies, which had continued unabated for eight years, finally leveled off in 1987. Similar to business starts, the decrease in failures occurred in all industry sectors except agriculture and services. The increase in agriculture failures was related to tax law changes and the introduction of Chapter 12 reorganization for farmers, giving them the opportunity to reorganize rather than liquidate. Business failures in the service sector of the economy reflect the entrepreneurial quality of growth in the past few years. Overall, we conclude that the business sector is healthy and optimistic about prospects for 1988. We now will examine the factors that have shaped this outlook.

Factors Affecting the Economic Environment in 1988-1989

As noted earlier, the outlook for 1988 is for continued moderate growth of 2.8 percent. However, this growth will come more from improvements in trade and capital spending than from consumers. Consumer spending will be as weak this year as it was in 1987, while government spending growth will be impeded somewhat by Gramm-Rudman-Hollings expenditure cuts.

Nineteen eighty-nine growth will be a bit weaker than 1988, with the first half of 1989 stronger than the second half. Trade gains will be waning and higher interest rates will inhibit capital purchases later in the year. Consumer and government spending will remain weak. While 1989 will not be a recessionary year, the absence of any sparkling growth sectors will hold GNP expansion to about 2.2 percent in 1989.

Figure 3 shows the quarterly pattern of growth during 1986-1987. Two measures of growth are illustrated: real GNP and real final sales to domestic purchasers. Real GNP is the total of all goods and services produced in the economy. GNP includes items produced but not sold in this country. In contrast, final sales to domestic purchasers excludes unsold inventory and exports to foreign markets, while including imported goods in the total.

While GNP measures all economic activity, final sales to domestic purchasers measures only the portion of GNP that is actually spent within the

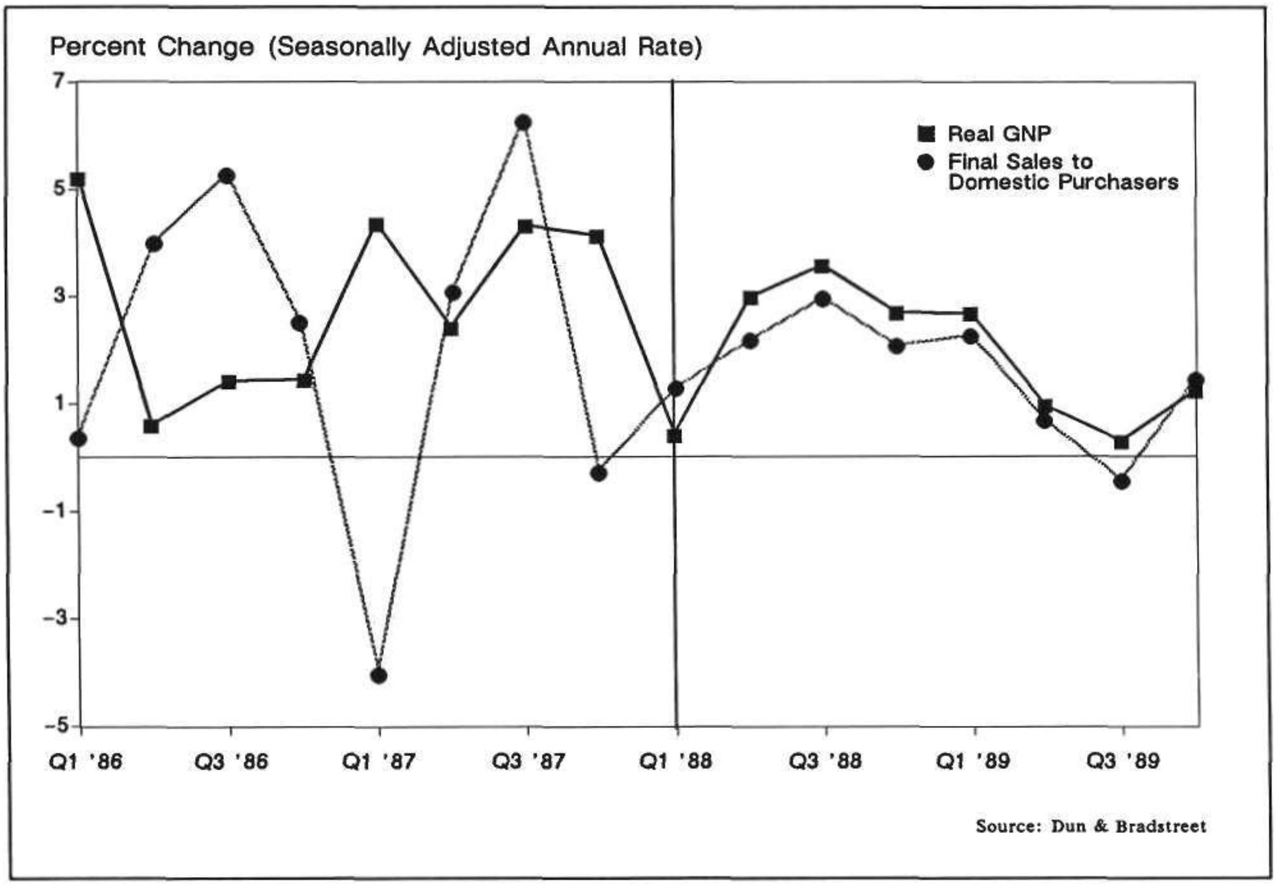


Figure 3. Forecast of U.S. Economic Growth (Seasonally Adjusted)

United States. The higher final sales measure in 1986 indicates that GNP was reduced by a degradation of the real trade balance. That is, the volume of imports into the United States exceeded the volume of exports.

The wide discrepancies between the two measures in several quarters are caused by massive inventory swings, particularly for consumer electronics, apparel, and automobiles, toward the end of 1987. When a car is built but not sold, it counts as part of GNP but not as part of final sales. The carmakers' incentive programs in the third quarters of 1986 and 1987 increased car purchases and, hence, final sales. But these cars were built earlier in each year, particularly in the first quarters, adding to GNP at that time. The important fact is that both measures of output should be used to properly gauge the direction of the economy.

The Trade Deficit and the Dollar

The trade deficit and the dollar will be among the most closely watched indicators in the next two years. Since last year's stock market plunge, the trade-weighted value of the dollar has fallen by an additional 10 percent, in addition to the more than 40 percent it had already dropped from its peak in March 1985. The dollar value now is about the same as in the fourth quarter of 1980. This stimulated export sales of price-sensitive U.S. goods and commodities, such as chemicals, lumber, and pharmaceuticals, then broadened into more durable goods and equipment.

It is important to remember that what happens in the United States as a result of a lower dollar occurs in reverse in the countries against whose currencies the dollar falls. A lower dollar means eventual improvements in the U.S. trade balance, but leads to trade deterioration abroad. In addition, a lower dollar leads to increases in domestic inflation and interest rates. Countries whose currencies have appreciated against the dollar experience deflationary effects from cheaper imports. These countries can also reduce their interest rates because of the lower inflation.

Typically, these inflation and interest rate hikes that follow a drop in the dollar take place only after a period of several months to two years. In other words, the aftershocks of recent falls in the dollar will probably occur after the 1988 election.

In the meantime, the Federal Reserve System can either support the dollar or fix interest rates at some antirecessionary level. These objectives are contradictory because interest rates are used as a tool to attract foreign funds into this country, ultimately affecting the dollar exchange rates. Immediately after the stock market crash, the Federal Reserve Board allowed the dollar to drop, preferring to encourage lower interest rates to ward off adverse effects of the crash. In pursuing this policy, bank reserves were increased to make certain that the stock market crash did not result in a liquidity crunch.

Because of the dichotomous monetary policy goals of the Federal Reserve Board, Dataquest assumes the Fed will walk a tightrope, trying its best to avoid a recession while also attempting to achieve stable dollar exchange rates. As a result, the best the Fed can do is to achieve partial success on both fronts. Interest rates will slowly edge upward, while the dollar will continue to decline, albeit at a much slower pace, bottoming out in the second half of 1989.

This policy can succeed only with international support and coordination. If other countries such as Japan or West Germany reduce their interest rates, this also reduces upward pressure on U.S. interest rates. This eases the Fed's balancing act. Such economic stimulation from abroad can help solve the U.S. trade imbalance by increasing worldwide demand. The key point, however, is that U.S. producers *must* capture the lion's share of any new demand. The current U.S. share of world markets is about 13 percent. To eliminate the U.S. trade deficit solely by increasing exports would require this share to double. Some U.S. import restrictions would seem to be inevitable.

On the import side, the dollar's 50 percent drop over the last three years will eventually channel U.S. demand away from imports and toward domestic goods as the price advantages of U.S. producers become more pronounced. Figure 4 illustrates a forecast of 7.9 percent and 8.6 percent increases in the average prices of imported goods in 1988 and 1989, stemming from continued erosion in dollar exchange rates. Government policies that encourage increased levels of saving and investment can go far to reduce import demand.

Clearly, many economic and political events have to occur to achieve improvements in the U.S. balance of trade. However, U.S. businesses must take upon themselves the responsibility for changes to their own internal cultures and attitudes in order to be successful internationally. Attention and effort must be directed toward selling a higher percentage of U.S. production abroad rather than domestically, even in circumstances when demand in the U.S. market is strong. American industry would do well to follow the example of U.S. computer and semiconductor manufacturers, and seek ways to pool commercial R&D resources in cooperative efforts to perfect manufacturing technology and regain a competitive edge.

The free trade agreement signed January 2 by President Reagan and Prime Minister Mulroney is intended to gradually phase out all trade barriers and investment restrictions between the United States and Canada, the world's largest trading relationship. The agreement is currently being converted to legislation for review and ratification by Congress and the Canadian Parliament. Although some industries and regions on both sides of the border will have to make adjustments, the agreement has a 10-year implementation period for that purpose. The net result will be significant bilateral market development, particularly for Canadian lumber and apparel and U.S. investors.

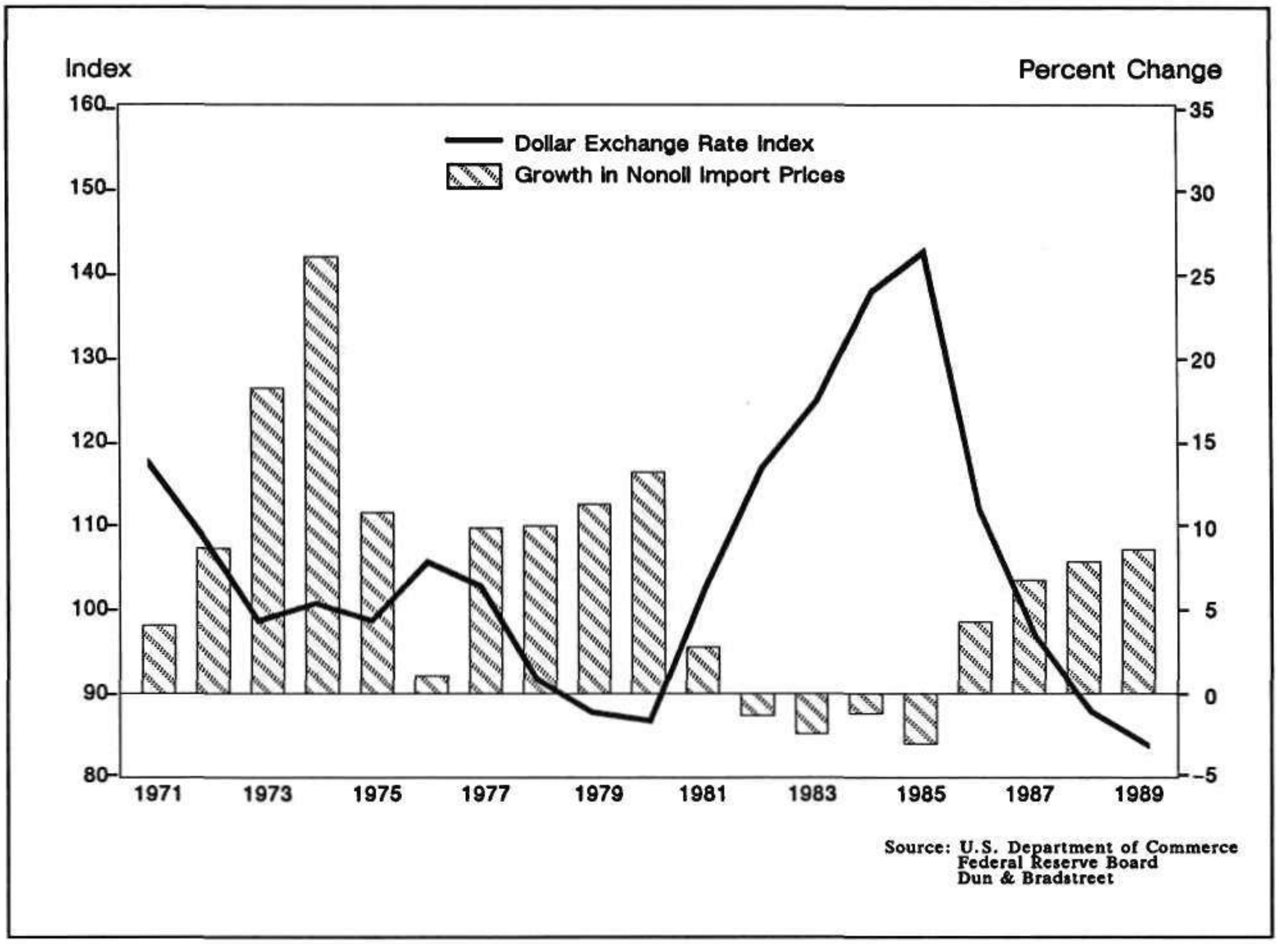


Figure 4. Imported Inflation and the Dollar

It is interesting to speculate on the free trade agreement and the prospect for an eventual North American common market encompassing Canada, the U.S., and Mexico. Figure 5 shows the 1987 U.S. balance of trade with Canada and Mexico. The elimination of import tariffs on goods traveling between the three countries would most directly benefit Canada and Mexico, which ship 80 percent and 75 percent of their respective exports to the United States. By comparison, the United States sells 25 percent of its exports to its bordering neighbors. The primary benefits to the United States would be freer commercial investment opportunities, a favorable climate for development of lower-cost manufacturing operations close to home, and preferential pricing on Canadian and Mexican petroleum.

Interest Rates, Bonds, and the Stock Market

The large federal deficit has created a global market of considerable size in U.S. Treasury securities, a market which recently has more movement and effect on monetary policy than the Federal Reserve Board. Government bond rates rose beyond 10 percent in early October, responding to a booming global economy, and helped to trigger the stock market meltdown. Bond prices dipped and then recovered immediately after the crash, as the Federal Reserve's flood of liquidity pushed interest rates down again.

While the long-term relationship between bonds and stocks is tenuous, the two instruments currently interact closely. As money flows from

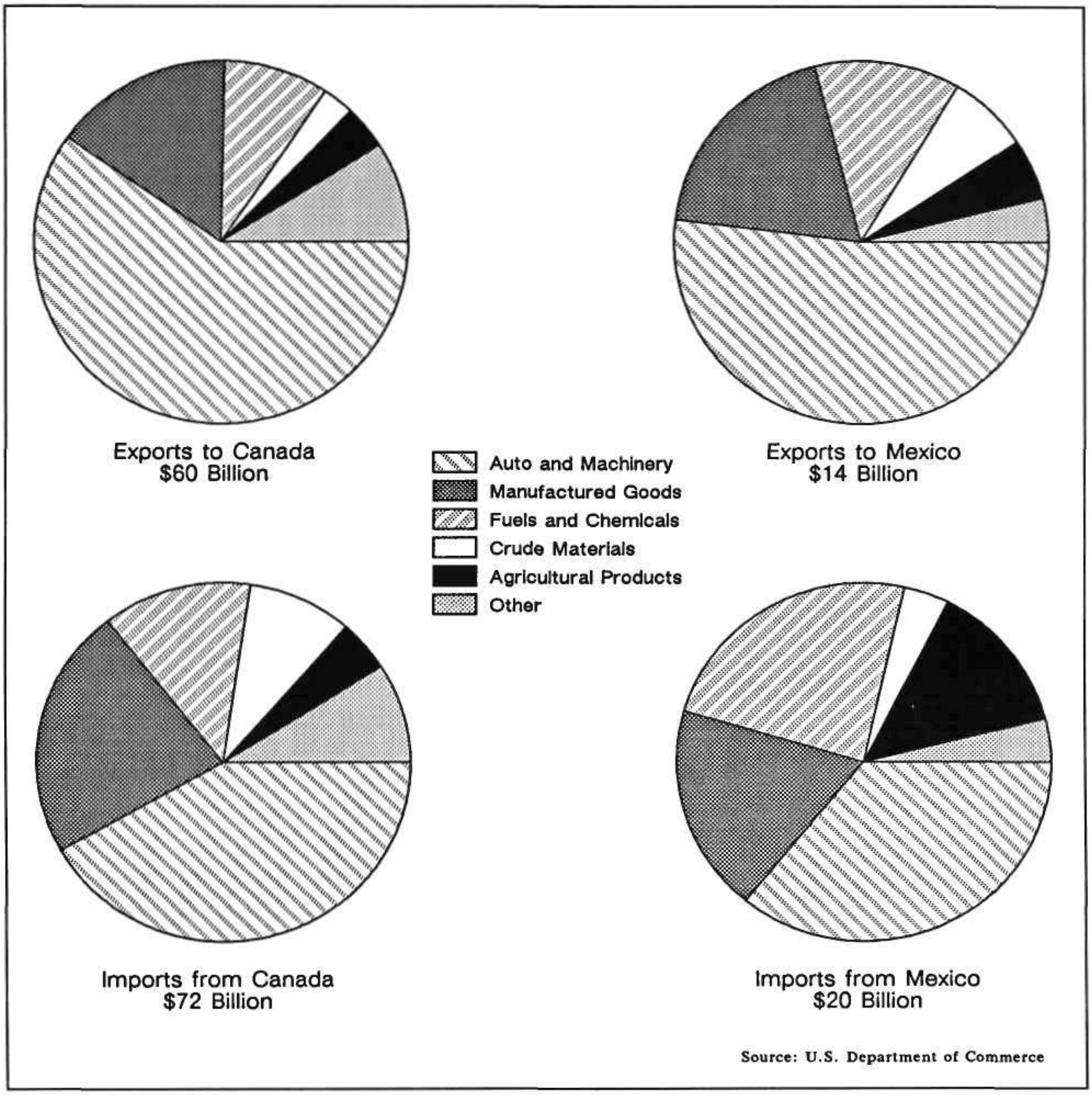


Figure 5. U.S. Merchandise Trade with Canada and Mexico—1987

stock markets into bonds, the price of stocks fall, raising the price of bonds and lowering bond yields, i.e., interest rates. Psychological factors play a big role in this relationship, too. If negative expectations about the economy form, then downward expectations about interest rates and stock prices follow, and the demand for bonds increases.

Thus, the bond market also serves as a handy economic buffer. When the total market value of the U.S. stock market fell by about $1 trillion from an original total of $3 trillion in last year's fourth quarter, the value of bonds increased about $700 billion, representing a 10 percent gain on a $7 trillion base. This may help explain why businesses and consumers remained relatively calm in the weeks after the crash.

Expectations for continued declines in the dollar and a subsequent increase in inflation suggest interest rates will rise over the next two years. Long-term bonds, which currently yield just over 9.0 percent, should yield between 9.5 and 10.0 percent by the end of the year, and between 10.0 and 10.5 percent by the end of 1989. Risk factors that might increase rates beyond these ranges include higher inflation rates or a rebound in the stock market, which could drain liquidity from bonds. About the only source of downward pressure on interest rates is a recession or "growth pause" in final demand, reducing the demand for loanable funds.

The Federal Sector: The 1988 Election and the Budget Deficit

Given the lagging consequences of actions taken in 1986 and 1987, the direction of the economy in 1989 depends very little on who occupies the White House and Congress, especially considering the start-up period of several months required before a new administration can begin to implement its own policies.

Gramm-Rudman-Hollings restrictions on federal spending will also hinder the implementation of new policy initiatives. The distribution of the Gramm-Rudman-Hollings cuts, or of any avoidance measures, may vary depending on the party or person in power. However, any cuts will probably net out to elaborate accounting maneuvers rather than real spending reductions.

The Gramm-Rudman-Hollings budget cuts will also mean little to the macroeconomy, and very little to capital markets. The recently passed legislation calls for $30 billion in deficit reduction in fiscal 1988, and an additional $46 billion in fiscal 1989. With these cuts, the federal deficit is still likely to exceed $170 billion in 1988 and $150 billion in 1989, compared with $149 billion in fiscal 1987. The deficit reductions mean even less compared with the $2.4 trillion cumulative federal budget debt. Figure 6 illustrates the enormous bulge since 1981 in federal deficit spending.

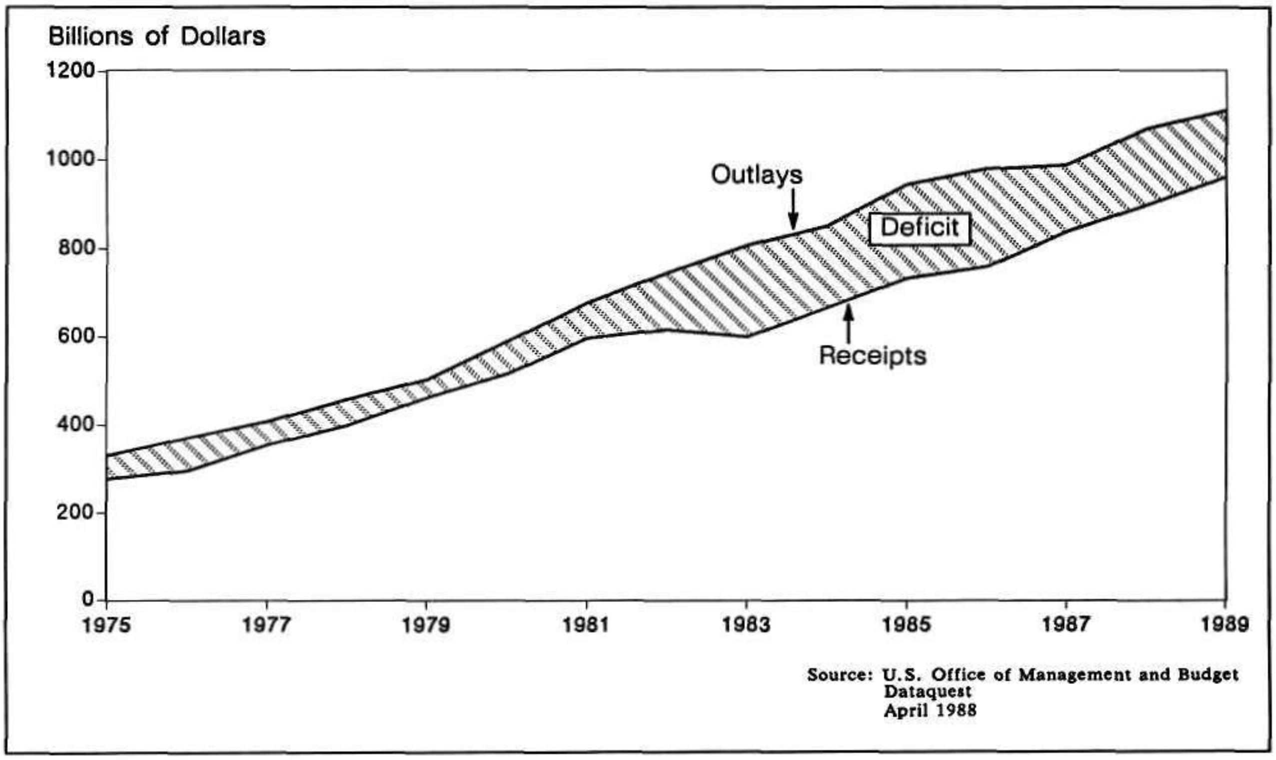


Figure 6. Federal Budget Receipts and Outlays—1975 to 1989

Since a portion of these cuts merely transfers the demand for capital from the government to the private sector, the cuts will have little impact on reducing the U.S. demand for capital and, hence, little impact on interest rates. For example, private acquisition of federal assets to be sold in the deficit reduction plan requires private financing, merely replacing federal debt with individual or corporate debt.

Difficult budget decisions have been postponed to the future. Eventually, elected officials will have to address out of balance national entitlement programs such as Medicare and Social Security that consume 9.5 percent of the GNP.

Thus, any economic fallout from the federal sector will probably be psychological. Until the 1988 presidential election is decided, and the winner's policies become clear, there will be a cloud of uncertainty surrounding the outlook for the economy. To the degree any leading presidential candidates propose a peculiar or uncertain economic or political agenda, this uncertainty may add a downbeat note to the economy.

The Consumer

In the measurement of U.S. GNP, consumer spending accounts for about two-thirds of the total. The economic realities of the late 1980s are affecting three primary factors that have a direct impact on the consumer--personal income, debt, and psychology.

The first and most obvious factor is household income. The best measure of this is *real disposable income*, which necessarily takes inflation and taxes into account. When the second part of the 1986 tax reform act's tax cut took effect on January 1, 1988, tax liabilities of individuals were reduced by about 4 percent. Offsetting a large part of this increase was a substantial increase in social security tax payments. On balance, tax payments will be reduced in 1988, but because of the change in the Oval Office in 1989, taxes can be expected to increase thereafter.

Also affecting disposable income, of course, are wage rates. Slight increases in compensation are expected over the next two years because of gradually tightening labor markets in some regions and industry sectors. In addition, inflation is expected to rise slightly in 1988-1989, offsetting much of the buying power of these gains. Therefore, real disposable income is expected to remain largely unchanged from 1987.

Another factor that affects the consumer is *debt*. Consumer debt-to-disposable-income ratios are currently high, but can be explained in part by the increased use of credit cards over the past five years. The use of credit cards is a convenience rather than a debt purchase if the credit card bill is paid off in full each month. However, as far as the credit accounts are concerned, debt is debt, even though consumers may not regard it as such.

The explosion of home equity loans and adjustable rate mortgages have in the past provided consumers with reduced interest rates for debt payments of all types. However, this debt involves flexible rather than fixed interest rates, and so ties debt payments more closely to current interest rates. Thus, if interest rates increase, more current income would be required to pay off old debt, reducing consumption growth.

The net effect of consumer debt on expenditures remains a complex issue. Compounding the problem of analysis is the third factor affecting consumption decisions: *consumer psychology*. What is certain is that consumers are less likely to incur debts if they have doubts about their future prosperity.

If consumers fear a recession is coming, they will withhold spending in favor of increasing savings as a hedge against bad times. Because the economy is in a period of notable transition, there is a great deal of uncertainty. The University of Michigan conducts regular surveys of consumer attitudes, and the results provide some insight into spending plans. Figure 7 shows historical values for consumer sentiment and spending, with projections for 1988 and 1989. The survey's consumer sentiment index took a large dip immediately after the October crash,

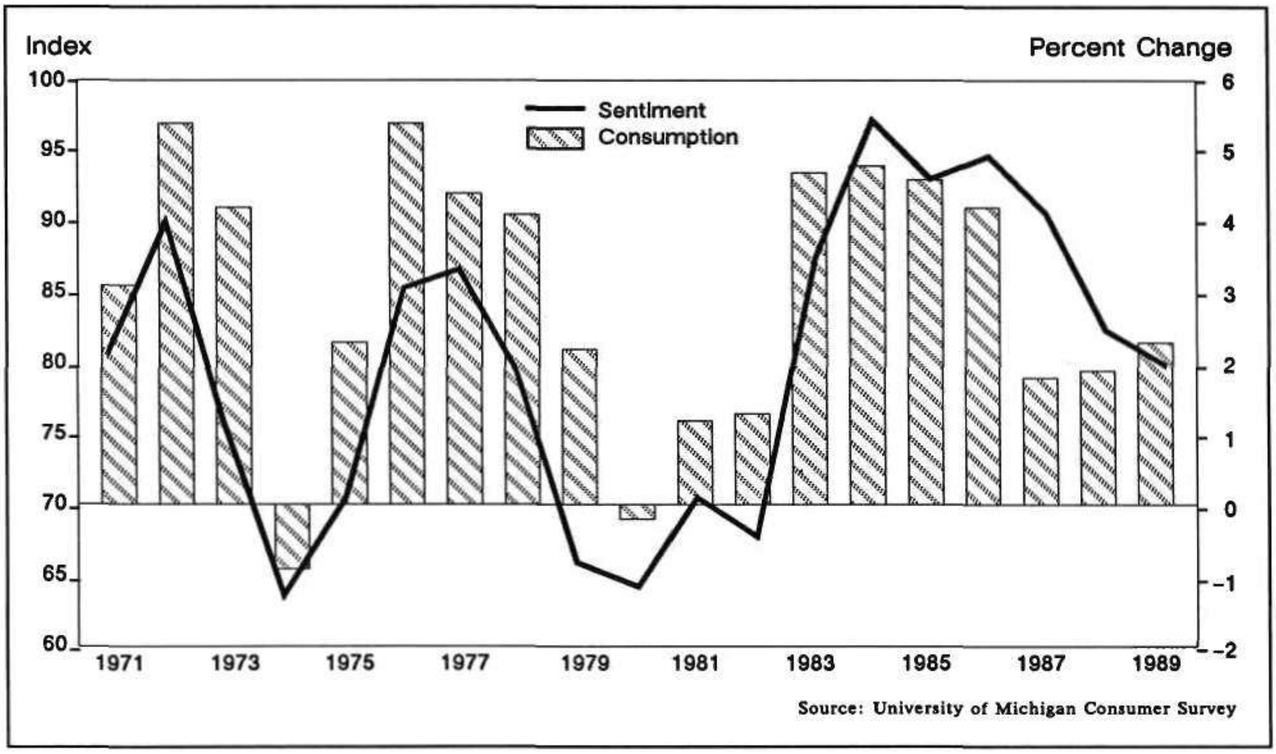


Figure 7. U.S. Consumer Sentiment and Consumption

stabilized in November, and then rose modestly in December. The resiliency evident in consumer sentiment makes it likely that changes would occur only after sustained stress or sustained improvement in the general economy.

The outlook for consumer spending is weak, but not weak enough to cause a recession. While GNP is expected to grow 2.8 percent in 1988, consumption is anticipated to grow only 2.0 percent. Dataquest views this as a favorable trend for two reasons:

- Roughly 21 percent of U.S. *merchandise imports* in 1987 were consumer goods, and another 21 percent were automobiles and auto parts. Therefore, a cutback in consumer spending would clearly help reduce the U.S. trade deficit.
- Because income must be either spent or saved, a reduction in consumer spending means an increase in savings, which flow back into capital investments in plant and equipment. Capital investments will be necessary to expand production capacity for export.

Consumer spending reductions will help hold prices and inflation down, and will restrict further excesses in the level of American personal debt.

The Household Balance Sheet

An analysis of consumer spending requires a brief examination of the health of the consumer. A look at the balance sheet of households—total assets and liabilities—can provide insight into the longer-term trends of consumer behavior.

This is especially important today because much has been written about the so-called "wealth effects" of the stock market decline killing off personal spending. Scant empirical evidence is available to support the view that wealth effects are important, and there are many arguments against this type of forecast:

- If wealth effects indeed exist, there would have been a surge in spending when the stock market was on the way up during the first nine months of last year. Consumption expenditures were flat during this period.
- The period in which wealth effects are measured is likely to be quite long. It is doubtful that individuals would make consumption decisions on potentially fleeting paper profits.
- Only 20 percent of individuals own stock. Many of these individuals are either long-term investors who ignore short-term fluctuations, or simply are well enough off to withstand the stock market's bearish intervals.
- Much of the lost wealth in the value of stocks was made up by the gains in the bond markets.

These arguments imply that the long-term health of the consumer is dependent on all of the net assets of the household, not just on income flows. As a result, it is necessary to look at all sources of household wealth and all liabilities supported by this wealth.

Using an accountant's point of view, the ratio of household liabilities to assets has generally been stable at around 20 to 24 percent since 1960. In 1986, this ratio reached a 24 percent cyclical peak. Increases in mortgage and installment debt exceeded increases in wealth, including stocks. And in 1986, economists were forecasting a mild consumer retrenchment for 1987, which in fact occurred.

In 1987, the household liability/asset ratio dropped to 22 percent, signaling an increase in the long-term solvency of the consumer. The most pessimistic projections of lost wealth in the fourth quarter from the stock market crash would raise the liability/asset ratio from 22 percent back to the 1986 level of 24 percent.

Two conclusions can be reached from this analysis. First, based on calculations from the aggregate household balance sheet, 1988 and 1989 will see a continuation of weak spending growth, much like 1987. Second, the economy, at this time, can survive mild consumer retrenchments and still avoid a recession.

Inflation and Unemployment

Near-term inflation will be the resultant combination of three forces: oil prices, wage rates, and import prices.

Oil prices should decrease relative to the general inflation rate in 1988. This is due to OPEC's failure to reduce its overall production quotas below 17.5 million barrels per day, the lack of success in controlling unofficial discounting by OPEC members, widespread non-OPEC third-world production increases, and very small increases in worldwide demand. OPEC oil prices should average $17 per barrel in 1988, and rise gradually to about $18 per barrel by the end of 1989.

In the labor market, it would appear that the currently low unemployment rate would suggest future labor shortages if the economy expands any further, causing large future increases in wages. However, outside the Northeast, this simply is not so. With the unemployment rate at 5.8 percent, there is still room for further expansion without generating wage pressures. Since the last time the unemployment rate fell this low was in 1979, the average age of the labor force has increased. With this maturation, fewer people are changing jobs, and this job stability is reflected in the unemployment rate.

The gradual shift in the U.S. economy from manufacturing toward service industries and the trimming of corporate payrolls have reduced many potential downside effects. In addition, the focus of labor contracts has shifted from wage increases to job stability. Average annual wage increases in negotiated labor contracts are running between 2 and 3 percent. Also, new entrepreneurial activity is responsible for many new jobs in smaller businesses, which generally pay less than their large business counterparts and offer fewer direct employee benefits. Therefore, unemployment and inflation rate comparisons with the past are not necessarily valid. We see the unemployment rate bottoming out at 5.6 percent by the end of 1988 and rising from 5.8 percent to 6.0 percent in 1989.

A major source of inflation comes from abroad. With a decreasing dollar value, foreign goods cost more. To the extent that U.S. markets see higher prices for foreign goods, U.S. competitors may also choose to raise their prices. Imports other than oil represent about 10.0 percent of GNP, so if prices for these goods increase by 8.0 percent, and if prices of substitute domestic goods increase by about 6.0 percent, this can add about one percentage point to current inflation rates. Overall, Dataquest expects inflation rates to rise through 1988 to the 4.5 to 5.0 percent range, until peaking at about 5.4 percent in mid-1989.

Capital Spending

The projected growth in capital spending is an important factor in our forecast of 2.8 percent real GNP growth for 1988 and 2.2 percent in 1989. Although the outlook for purchases of plant and equipment is influenced by many of the same considerations as consumer spending, two additional factors will make this sector a major source of growth. First, U.S. production facilities are currently running at an average 82.0 percent of capacity. The export boom, if sustained, will strain industrial capacity in many export-oriented industries and thus force expansion. Second, corporate profits in 1987 were quite strong, providing funds for investment in 1988. Much of this investment will go into equipment rather than construction because of the shorter payback period.

The pivot point in this forecast concerns interest rates. Since firms usually plan major capital expenditures many months in advance, it is unlikely that any minor uptick in interest rates would adversely affect corporate spending in 1988. The recent Dun's 5000 Survey on 1988 capital expenditure plans confirms this. In 1989, investment expenditures for larger firms would still be interest-rate insensitive up to a point. In other words, larger businesses generally pay more attention to the sales prospects for their products than to interest rates when planning their capital spending.

Financial Industries

With the declines in the stock markets, the financial sector is one of the weakest in the economy. The banking industry must deal with a weak portfolio, including large amounts of nonperforming third world debt, plus weak loans in the agricultural, energy, and real estate sectors. Higher interest rates can exacerbate these problems by raising the cost of obtaining new funds. The good news for bankers is that they are not working for Wall Street brokerage houses, which instituted 10 percent personnel cutbacks after meteoric expansion over the past several years. At the same time, many of these same firms express commitments to continue purchases of communications and data processing equipment in 1988, in order to retain their competitive position.

The risk of a potential banking crisis appears to have passed. However, because of the general economic sluggishness ahead, any turnaround will be slow. While government regulatory agencies appear to consider most bank and brokerage house problems under control, the situation remains precarious.

One additional factor to consider in this sector may come from repeal of regulatory restrictions preventing banks, brokers, and insurance companies from engaging in each other's activities. With new markets open to these institutions, an expansion followed by a shakeout of the new megabanks will occur. The end result may be a stronger industry, but the route to this end is likely to be painful.

Tables 1 and 2 contain key statistics concerning the U.S. economic outlook and GNP components.

Table 1. U.S. Economic Outlook (Billions of U.S. Dollars)

	1987	1988				1989			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Nominal GNP	$4,486	$4,641	$4,723	$4,818	$4,904	$4,989	$5,060	$5,123	$5,197
% Change SAAR	7.2%	3.8%	7.2%	8.3%	7.4%	7.1%	5.8%	5.1%	5.9%
% Change Year Ago	5.9%	6.0%	6.2%	6.5%	6.7%	7.5%	7.1%	6.3%	6.0%
Real GNP	$3,820	$3,880	$3,909	$3,944	$3,970	$3,997	$4,006	$4,009	$4,022
% Change SAAR	3.6%	0.5%	3.0%	3.6%	2.7%	2.7%	1.0%	0.3%	1.3%
% Change Year Ago	2.8%	2.9%	3.0%	2.8%	2.4%	3.0%	2.5%	1.7%	1.3%
GNP Deflator	117.5	119.6	120.8	122.2	123.5	124.8	126.3	127.8	129.2
% Change SAAR	3.5%	3.2%	4.1%	4.5%	4.5%	4.3%	4.8%	4.7%	4.6%
% Change Year Ago	3.0%	3.0%	3.2%	3.6%	4.1%	4.4%	4.5%	4.6%	4.6%
Industrial Production	129.8	134.0	134.6	135.8	136.9	137.8	138.6	139.1	139.5
% Change SAAR	5.0%	3.0%	2.0%	3.6%	3.2%	2.8%	2.1%	1.6%	1.2%
% Change Year Ago	3.6%	5.6%	5.0%	3.7%	3.0%	2.9%	2.9%	2.4%	1.9%
Capacity Utilization (%)	81.0%	83.1%	83.6%	83.6%	83.7%	83.7%	83.4%	83.0%	82.7%
Unemployment Rate (%)	6.1%	5.8%	5.8%	5.7%	5.6%	5.8%	5.9%	6.0%	6.0%
Number Employed (M)	102.1	103.2	103.7	104.9	106.6	106.8	105.9	104.0	104.4
% Change Year Ago	2.5%	2.1%	2.0%	2.5%	3.2%	3.5%	2.1%	(0.9%)	(2.1%)
Real Final Sales	$3,785	$3,827	$3,848	$3,877	$3,897	$3,920	$3,927	$3,923	$3,938
% Change SAAR		1.3%	2.2%	3.0%	2.1%	2.3%	0.7%	(0.4%)	1.5%

Notes: Nominal GNP = GNP measured in current dollars
Real GNP = GNP measured in constant dollars from 1982 base year
SAAR = Seasonally adjusted annual rate
Industrial Production = Base 100 in 1977.

Source: Dun & Bradstreet

Table 2. U.S. GNP Components (SAAR*, 1982 Billions of U.S. Dollars)

	1987	1988				1989			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Consumer Spending	$2,495	$2,514	$2,531	$2,556	$2,569	$2,586	$2,596	$2,608	$2,611
Nonresidential Fixed Invest	447	467	473	481	490	502	507	509	506
Residential Fixed Invest	196	195	197	196	196	193	189	185	185
Government Purchases	773	784	781	789	796	792	788	796	800
Inventory Change	42	29	24	20	16	11	14	0	4
Net Foreign Trade	(134)	(109)	(97)	(98)	(97)	(87)	(88)	(89)	(84)
GNP	$3,819	$3,880	$3,909	$3,944	$3,970	$3,997	$4,006	$4,009	$4,022

*Seasonally adjusted annual rate

Source: Dun & Bradstreet

Conclusion—the U.S. Economy

The next two years are expected to be about as strong as 1987, but the economy will rely on different sources to achieve similar levels of growth.

On the downside, there are several realistic scenarios in which a recession could develop as early as this summer. Such possibilities include a massive divestment of dollars by foreign investors, a drop in consumer confidence, or a jump in oil prices from extraordinary military developments in the Persian Gulf.

Positive risks include larger-than-expected export gains or increased international coordination to reduce interest rates, which could bring about a capital spending and housing boom.

In any event, careful planning will be required to keep pace with the evolving economy. The nature and location of markets for all firms will be changing in the next two years. Profitability will depend on the ability to exploit these changes to their fullest advantage.

1988-1989 Outlook for Major U.S. Trading Partners

Figure 8 shows the volume and composition of U.S. international transactions in goods and services during 1987, illustrating the large share attributable to imported consumer goods (15.5 percent), even excluding automobiles. The bar graphs in Figures 9 and 10 rank U.S. trading partners in descending order by value of imported goods into the United States. Three conclusions are particularly worth noting:

- Japan accounts for 36 percent of the 1987 U.S. merchandise trade deficit, and the NICs of the Pacific region account for a rapidly growing 23 percent.

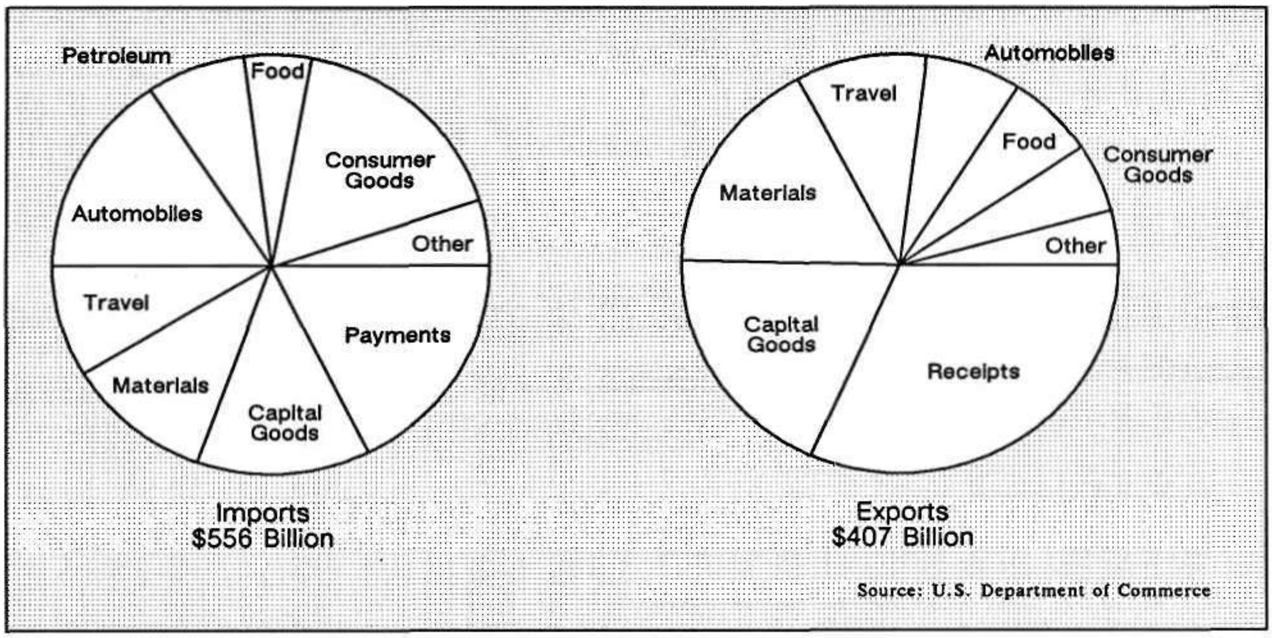


Figure 8. U.S. International Transactions—1987 ($ Billions)

- The negative aspect of the 1987 U.S. trade results, while weighted so heavily by Pacific area countries, still permeates almost all U.S. trading relationships. In scanning the list, the reader will note that the U.S. balance is negative until reaching the nineteenth area, Australia and New Zealand.
- The first- and third-ranking country-markets for U.S. exports are its bordering neighbors, Canada and New Mexico. Many of the U.S. exports to these countries are related to automotive and electronic assembly operations, the products of which are reimported into the United States.

Japan

As international markets shift toward new equilibrium points, the Japanese are reshaping their economy with increased emphasis on domestic demand as the primary driving force, and less dependence on exports. The years of 20 percent-plus export growth in the 1960s and early 1970s, which made Japan the world's largest creditor nation, are dampening to a steady 3.50 percent. Meanwhile, total domestic demand grew at 4.00 percent rates in 1986 and 1987, and is expected to continue at this rate through 1988 before slowing to 3.25 percent in 1989. This is in comparison with a healthy 3.50 percent to 3.00 percent real GNP growth in 1988 and 1989. The primary components of domestic spending are as follows:

- Sharp spending increases in 1987 by central and local governments on airport and railway construction projects, telecommunications facilities, conference centers, highways, and electric power generation and distribution networks will continue through 1988-1989. The U.S. government is seeking rights for American companies to bid on parts of the $17 billion construction and expansion program.
- Corporate capital spending plans for 1988 are moderate overall. Sizable spending in industries closely related to domestic markets, such as construction, banking, insurance, and food, will be counterbalanced by decreases in the shipbuilding, steel, mining, and automobile industries.

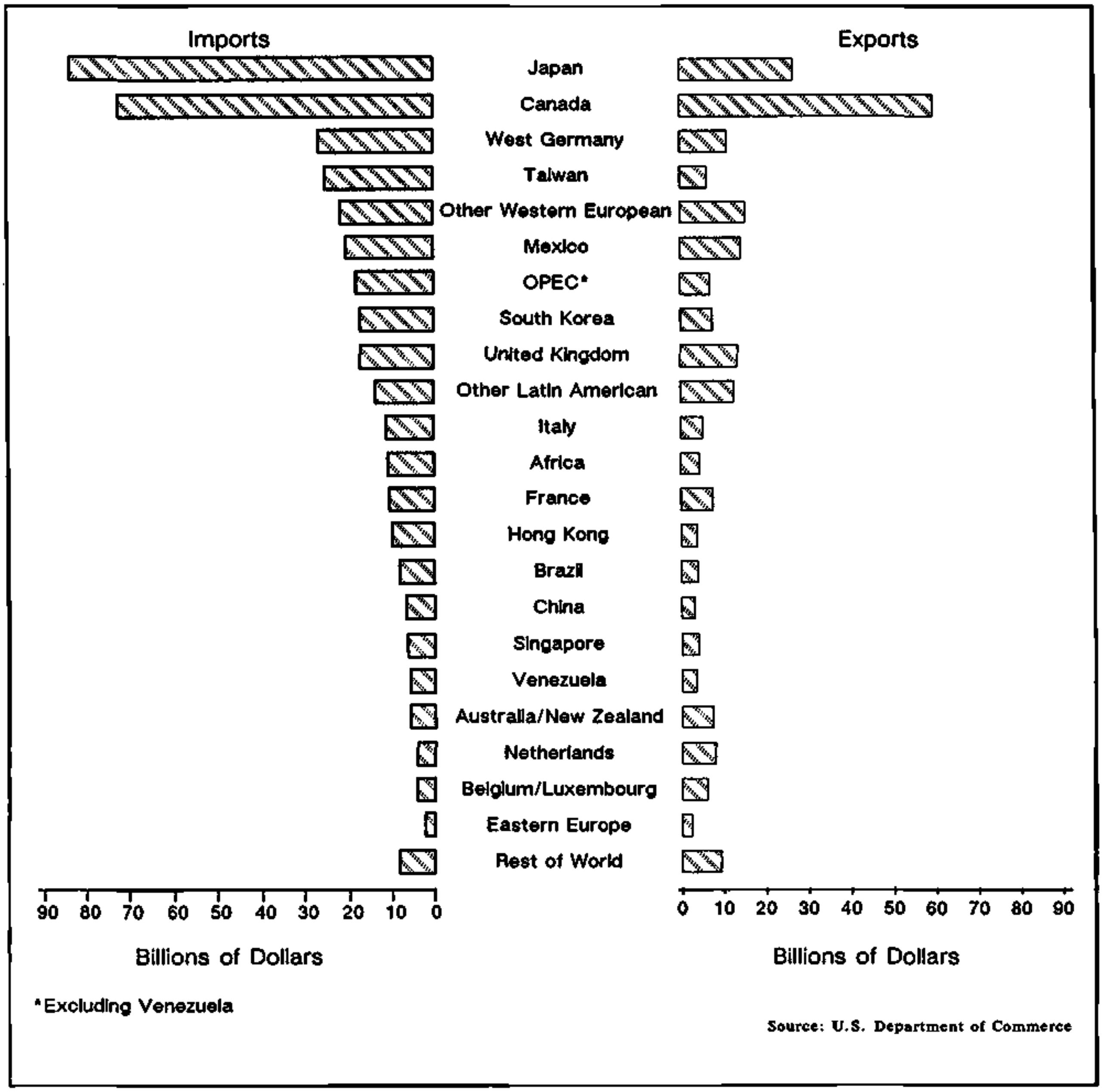


Figure 9. U.S. Merchandise Trade—1987 ($ Value, Billions)

- Modest wage increases, stable consumer prices, and historically low interest rates combined to spur Japanese consumption 3.75 percent in 1987. Consumer spending will continue to increase 5.00 percent per year through 1988-1989, primarily for housing and household goods, automobiles, and travel. To date, the benefits of yen appreciation on imported goods have been retained as profits within the complex multilayered Japanese distribution network, and have not been passed through to the ultimate consumer.

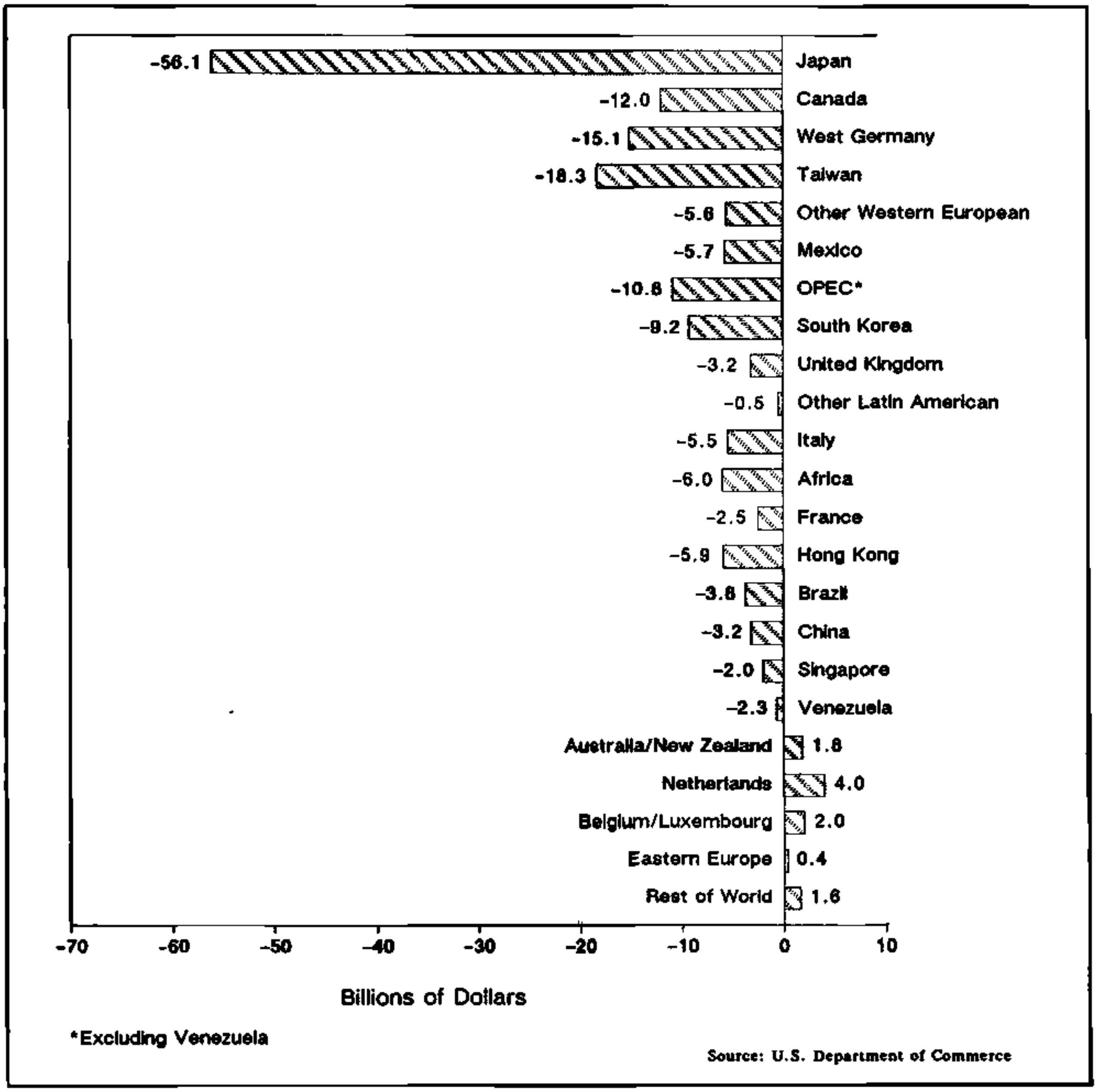


Figure 10. U.S. Merchandise Balance of Trade—1987 ($ Value, Billions)

As developing countries emulate the Japanese industrial success model, and the strong yen is a major factor in international trade balances, the Japanese face a number of pressing domestic issues.

The Japanese baby-boom generation of 1947 through 1949 numbers 10 million, about 20.0 percent greater in size than the generations just before and after. These workers, hired in the mid-1960s period of rapid expansion, are now competing for a limited number of promotions. Japan's rigid labor market still regards job-hopping as disloyalty, and pay systems are based heavily on seniority. The national unemployment rate has been steady at 2.8 percent.

Consequently, there is growing corporate pressure on the over-50 generation to take early retirements. By 2010, the ratio of adults over 65 to working adults will exceed 0.4 and put increasing stress on government and family health care budgets.

Japanese agricultural import restrictions and controls have kept domestic food prices at much higher levels than in many other countries. The most prominent example is rice, which is regarded as a strategic national resource and supported at a price four times the U.S. price. The magnitude of all agricultural subsidies is such that they would add 1 percent to the Japanese GNP if redirected.

Japan's post-war development has concentrated a disproportionate share of political, industrial, and financial power in the Kanto region surrounding Tokyo. Tokyo's population now strains the limits of municipal services. The Kansai region to the west, with its major cities of Kyoto, Osaka, and Kobe, has thus been eclipsed economically. Indeed, foreign companies seeking entry to Japanese markets would do well to investigate the more receptive Kansai.

Service industry employment now accounts for 60 percent of the total work force, as the Japanese domestic economy tracks the global trend. However, large portions of the work force remain in export-oriented manufacturing and subsidized agriculture, and are more vulnerable to fluctuations in foreign exchange rates, trade restrictions, and government budget constraints.

Japanese manufacturers have opened many foreign production subsidiaries, to move closer to ultimate markets and cope with exchange rates and trade barriers. This trend is accelerating, particularly regarding U.S. locations. Public concerns and debates about "exporting jobs" continue, as in the United States. As a perspective, Dataquest estimates the cumulative Japanese overseas manufacturing investment at $23.6 billion at year-end 1987, compared with an estimated U.S. figure of $110 billion.

West Germany

West Germany, another beneficiary of the U.S. import shopping spree, has experienced a decrease to zero real growth in exports of goods and services in the last two years. Germany was able to sustain a significant positive trade balance with the United States through the mid-1980s, second only to that of Japan. The effective appreciation of the deutsche mark has hindered exports of machinery and automobiles, slowing industrial production and creating some upward pressure on unemployment figures. The German economy in 1987 was generally weak and erratic across many sectors, but was rescued from a chill by a notable rise in consumer spending during the second half of the year.

Dataquest expects West German exports to show a modest recovery to 1.0 percent real growth in 1988 and 1989, accompanied by a 3.5 percent per year rise in the value of imported goods. The result will be a contraction of the German foreign trade balance by about negative 1.0 percent annually. More attention will be focused on sales efforts in European and newly industrialized world markets for German exports, where the deutsche mark has appreciated less than against the dollar. In the battle to retain its competitive export position, Dataquest also expects German industry to be a leader in making substantial investments in shop floor control systems, factory networks, and design automation.

The Germans have done the best job among major industrial countries in managing central government budgets, averaging less than a 1.4 percent annual deficit since 1980. Domestic demand will grow at about 2.0 percent per year. Family disposable income will grow at 3.5 percent, and consumer spending is projected to increase at 4.0 percent per year, with imported goods getting a considerable share. Automobiles, electronics, and household goods will be high on German shopping lists. Given the above, GNP is expected to grow at 1.3 percent per year. In addition to recent and pending tax reform legislation, these projections are based on assumptions of continued low rates of inflation, interest, and wage increases.

France

The French economy is a vessel with her sails luffed in the wind. Real GDP growth was 1.5 percent in 1987, and Dataquest projects the same 1.5 percent growth in 1988, before slowing further to 1.3 percent in 1989. French GDP growth has ranked as the lowest of the major Western European economies since 1983. The rate of unemployment is currently the highest in Western Europe, at 10.8 percent of the French labor force. Inflation and average annual wage increases were both a little more than 3.0 percent in 1987.

In a time of shifting international trade balances, France's $2 billion trade deficit in 1986 slid to a negative $10 billion in 1987, or 1.3 percent of GDP, and will continue in this direction by about a negative $1 billion per year through 1989. The problem is not as much the increasing value of imports, as it is the flat export growth rate. Between 1969 and 1974, the value of French exports grew an average of 13.4 percent per year, second only to the 14.9 percent annual growth in Japanese exports. However, a large proportion of French exports went to oil-exporting and developing countries, both sensitive to dollar exchange rates and growing more slowly than the average. As the franc appreciated against the dollar in the early 1980s, the price competitiveness of French exports declined. Finally, the total value of exports slipped below the value of imports in 1982.

The government began to take stringent measures to improve the economic picture in early 1986 by deregulating many sectors of the economy, and by privatizing a number of large state-owned companies. The privatization process has been successful in liberalizing and stimulating some industries, though the program is far from complete. Whether it will be continued depends upon the socialist-conservative composition of the government after the May 1988 election, and the market value of companies under consideration.

Private and corporate disposable incomes will improve when the government reduces income and corporate tax rates by 3.0 percent and 4.0 percent, respectively, in 1988. French value-added tax rates will be reduced progressively through 1992, to align with the internal European community. Corporate investment and private consumption spending should show modest increases as a result. Over time, the value-added tax reductions could add 0.5 percent per year to French GDP growth.

Generally, the French have been slower than the Germans and quicker than the English to make investments in manufacturing automation, and have been slow to adapt their products and distribution organizations to match changing market demands. Both domestic and international market share have been lost, and it is unlikely that near-term reversals in the trade deficit trend will occur. U.S. computer companies now control more than 60 percent of the French market, with only a 24 percent share going to French companies.

Domestically, the government has moved to improve employment figures by offering retraining, tax, and various subsidy incentives to new employers, including foreign firms. In view of the labor market and prospects for moderate wage increases through 1990, U.S. firms should seize the opportunity to open new offices and production facilities in France.

Italy

The Italian economy is a dramatic play of extremes. With 2.8 percent GDP growth in 1987, Italy pulled past Britain and France to rank as the fourth largest capitalist economy, behind the United States, Japan, and West Germany. The fastest annual growth rate over the last decade among major European countries has generated much talk of an Italian economic miracle. Inflation has dropped to 5.0 percent, down from 21.0 percent in 1980. Thousands of new small businesses have sprung from the fertile ground of a high household savings rate, 23.0 percent of disposable income, and plenty of individual entrepreneurial drive. Dispersion of production to networks of these small businesses is common, enabling the smaller subcontractors to contribute substantial added value to the finished products of big firms.

But beneath the gleam of GDP growth lie economic fault lines. As in the United States, the two largest problems are the balance of trade and the government budget deficit.

The Italian international trade balance, which popped into a surplus condition in 1986, dropped back to the deficit side in 1987. Imports of manufactured goods, energy, and food shot up 6.3 percent, occupying an increasing share of the domestic market. At the same time, Italian exports were weak, declining 1.0 percent in aggregate value shipped. Domestic demand will grow in 1988 and 1989 at a faster rate than GDP because imports will continue to outpace exports and detract from the total GDP figure. Unemployment seems destined to climb from the 1987 level of 10.8 percent to 11.5 percent within the next two years.

A disproportionate share of Italian exports are low-technology manufactured goods. For example, 14 percent of the 1987 total was clothing and textiles, which will become increasingly vulnerable to future competition from newly developing countries. In the high-technology sector, Olivetti is the largest Italian data processing equipment company and tenth largest worldwide, but is the only Italian company within the industry's top 100 firms. Funds for high-technology investment within the economy are limited, and R&D spending is half that of other major industrial economies, as a percentage of GDP. Much of the effective progress in technology advancement has come through acquisitions and strategic partnerships with foreign firms. Higher relative unit labor costs and slow productivity growth in the 1980s continue to hamper the competitive position of manufacturers. Given the foregoing, Dataquest projects that the Italian trade deficit will continue to widen through 1988 and 1989, due to heavy import traffic and only modest export growth.

In the United States, where credit cards are quite common, many consumers know firsthand how difficult it can be to recover from a large accumulated debt. Monthly payments to reduce the debt and cover interest must be squeezed from cash that otherwise would go to normal monthly activities. The debt to income ratio determines the degree of constraint in selecting options. On a national scale, Americans can easily see the problems posed by the U.S. budget deficit.

By comparison, Italy has a GDP one-sixth the size of the U.S. GNP, but had a 1987 budget deficit two-thirds the size of the U.S. deficit. The accumulated Italian government debt is equal to 93 percent of the annual GDP. By another measure, the debt is equivalent to $628 billion, or one-fourth the size of the huge U.S. public debt.

The tightly regulated Italian financial system, which severely restricts competition for financial assets, has thus far enabled government securities to sell very well in the domestic economy. However, as a member of the EEC, Italy must bring its banking and financial systems into accord with the other nations by 1992. The pending liberalization of capital flows means the government must ultimately increase the yield on its securities and come to grips with the deficit size. The most realistic hope for progress lies in a series of reductions in government spending. For fiscal 1988, a series of budget cutbacks and increases in direct taxes are expected to compress the Italian deficit to 12 percent of the GDP.

United Kingdom

The United Kingdom can boast the highest average rate of real GNP/GDP growth (3.6 percent) over the last three years among the major industrialized countries. This has been fueled chiefly by very strong private consumption and healthy exports. Industrial employment, which had dropped 25.0 percent in the United Kingdom since 1979, finally rose slightly in 1987 in conjunction with the growth in industrial output. Previous declines in manufacturing jobs have been partially countered by employment growth in the services sector since 1982. Total unemployment, which had risen to a 1986 peak of 11.6 percent of the work force, dropped below 10.0 percent by the end of 1987.

The above factors have enabled the British government to do an outstanding job of budget management in the 1980s, turning in a revenue-expense performance against plan second only to the record of the German government. Government spending will decrease slightly as a percentage of GDP in 1988, as will the small government budget deficit. The strength of the economy has also translated to good tax revenues, and the prospects are excellent for more supply-side incentives in the form of 1988 tax rate reductions.

Real GDP is forecast to increase by 2.8 percent in 1988, slowing to 1.8 percent in 1989. Economic growth will be led by continued expansion of consumer spending, in anticipation of tax cuts, moderate 3.5 percent to 4.0 percent inflation rates and further small decreases in the unemployment rate. Good order backlogs have caused business sentiment to remain very bullish regarding domestic markets, and many companies expect to make substantial investments in equipment and real estate to increase manufacturing capacity.

The primary drag on future economic growth will be from a deterioration in the United Kingdom's international competitive position, and decreasing demand from the United States, which in recent years has taken 14.0 to 16.0 percent of the United Kingdom's exports. A strong pound, declining North Sea oil production and recent weakening world oil prices will contribute negatively to the trade deficit in the near term. Exports are expected to show real growth of 2.0 percent in 1988, declining to 1.5 percent in 1989. A 4.0 to 4.5 percent growth in the value of imports will result in a growth in negative trade balance of approximately 0.8 percent of GDP per year.

Canada

Nineteen eighty-seven brought more good economic news for the United States' largest trading partner. The Canadian economy continued very robust growth in 1987, chalking up a real 3.6 percent increase. A glance at the table at the end of this section, which contains the 1983 through 1989 GNP/GDP growth, shows the Canadian average of 3.7 percent to be the highest average growth rate among the seven countries.

Fuel for the 1988-1989 economic engine will be provided by strong domestic investment in capital equipment and plant construction. Exports will continue to grow at 3.5 percent in 1988, with 78 percent of Canadian merchandise exports going into the United States. The Canada-U.S. free trade agreement, signed last year and officially taking effect in 1989, will begin having a substantial positive impact in 1988 in anticipation of the phased elimination of all tariffs and most other constraints on trade and investments. Canada's international trade balance is positive, with Can$125 billion in merchandise leaving the country and Can$114 coming in during 1987. U.S. manufacturers supply fully 70 percent of Canada's import purchases. Of the incoming goods from the U.S. in 1987, about 36 percent was automobiles and parts, 14 percent was industrial machinery and equipment, and 9 percent was communications and electronics equipment.

The Canadian economy is based around forestry, automobile manufacturing, petroleum, and mining. While smaller by comparison, the dynamic Canadian electronics industry is a major U.S. export market and a worldwide supplier of sophisticated products for telecommunications, geophysical exploration, natural resource processing and refining, and defense electronics. Many of the leading Canadian electronics companies are subsidiaries of U.S. or British firms, but there are an increasing number of examples in the opposite direction, such as Northern Telecom and Mitel Corporation.

With the exception of oil-related industries, Canadian manufacturers will continue to make heavy investments in capital equipment to sustain their growth, and U.S. exporters will continue to have the lion's share of that market. Many Canadian companies are actively seeking joint-venture manufacturing or sales partnerships with U.S. companies, and probably constitute the best learning opportunity for U.S. companies looking to expand into international markets.

Nineteen eighty-eight will see the lowering and restructuring of Canadian corporate and personal tax rates, as part of the government's long-range tax reform program. The general plan includes the probability of a national sales tax in 1990, replacing the current sales tax on manufacturers. If the government can keep spending relatively controlled, the federal budget deficit should improve to the range of 2.4 to 3.0 percent of GDP in 1988 and 1989.

As always, the big swing factor affecting prospects for Canadian economic growth is the health of U.S. markets. The good news/bad news about having such a good customer for exports on your southern border is that the United States accounts for so much of Canada's international business. Since a great part of the Canadian export industry centers on automobiles and lumber, it is especially sensitive to levels of U.S. consumer spending and residential construction. When the North American economies are moving along well, the Canadians generally do very well. Historically, the effects of slowdowns also tend to be more pronounced on Canada, and the economy underperforms that of the United States. Most current indications are cause for optimism, however, and the prospects for business activity in Canada remain good.

Newly Industrializing Countries

Figure 11 charts the 1987 gross domestic product data for five newly industrializing countries. Each country has its unique problems and unique strategies for long-range industrial success. The role of import-export trade in relation to total GDP should be especially noted. The most prominent trade example is Singapore, where import and export trade volumes were $37 billion in 1987, while GDP was $17 billion.

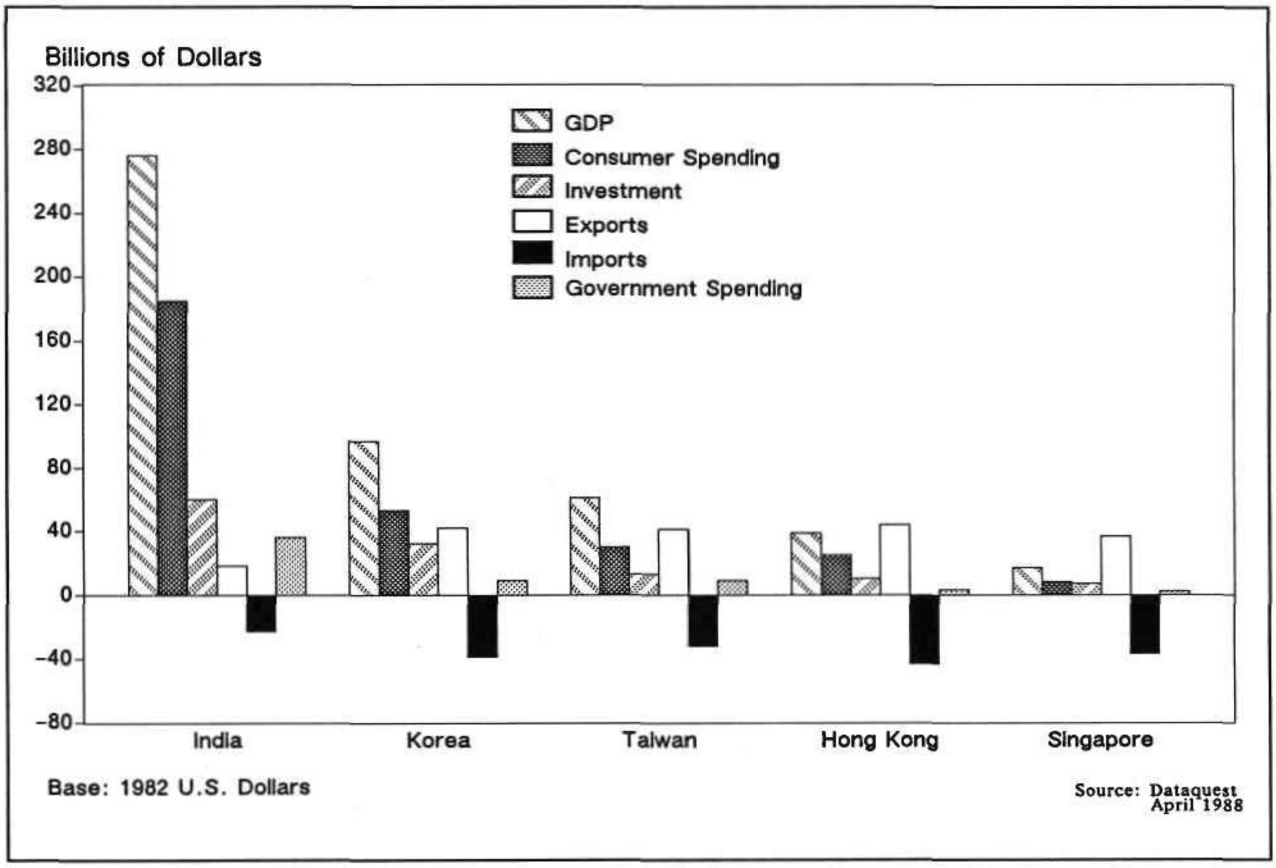


Figure 11. Newly Industrializing Countries' Components of 1987 GDP

Asian NICs continue to take advantage of the manufacturing opportunities and export markets opened by a weak dollar and strong yen. The countries of choice for United States and Japanese manufacturing investment have grown beyond the basic industry stage in many sectors, and have begun to successfully challenge for international market share. In particular, Taiwan and South Korea posted record levels of exports to the United States in 1987, ranking fourth and eighth on the list of U.S. suppliers. The most striking aspect in this can be seen in Figure 10, where the 1987 $18.3 billion U.S. trade deficit with Taiwan is second only to Japan, and has increased $3.6 billion over 1986. The U.S.-Korea deficit at $9.2 billion is half the Taiwan deficit size, but is growing at a faster rate. The pending U.S. removal of Taiwan, Korea, Hong Kong, and Singapore from the U.S. Generalized System of Preferences recognizes the U.S. status as 40 to 50 percent of their export markets, the relative restriction of their own domestic markets, and the consequent contribution to the U.S. trade deficit.

Korea, along with Taiwan, has been the major beneficiary of the yen's appreciation against the U.S. dollar, the Korean won, and the Taiwanese dollar. Trade surpluses, a drop in oil prices, and lower international interest rates have enabled the Korean government to halt foreign borrowing and begin to repay existing debts. Real GDP growth in 1987 was 12.5 percent, repeating 1986. Korean industry has been heavily dependent on imported Japanese capital equipment to continue manufacturing expansion, and this has been the source of a growing trade deficit with Japan, as well as an added stimulus in the Korean competitive attitude toward Japan. In efforts to reduce the trade deficit with Japan and the surplus in U.S. trade, the Korean government is pressuring manufacturers to shift part of their export sales efforts to Japan and away from the United States. Real GDP growth is expected to continue at a 9.0 percent rate through 1988-1989.

Taiwan has a far more decentralized industrial base than Korea, and as a percent of GDP, spends one-third less overall than the Koreans on fixed investments and capital equipment. The Taiwanese rate of growth in industrial production is, not surprisingly, 85 percent of the Korean rate, and is more concentrated in textiles and other light manufactured products, which are more vulnerable to foreign trade legislation. In programs to assist the capitalization and expansion of Taiwanese industry, the government is sponsoring centralized industrial parks and technology research institutions, with some notable successes. The administration of these programs is very active in promoting strategic alliances with Taiwanese and foreign companies for joint R&D, manufacturing, and East Asian market development.

Singapore is a recognized base for multinational manufacturing, and electronics and is becoming the central theme in the economy. More than 180 foreign companies have now established plants in the city-state, responding to a series of generous government incentives. In an aggressive move to accelerate this process, the Singaporean government will cover 74 percent of the construction costs for a $40 million wafer-fabrication plant to be built this year, in conjunction with National Semiconductor and Sierra Semiconductor, who have 9 and 17 percent shares, respectively.

Hong Kong, like Singapore, is a reexporting economy. A record 14.8 percent GDP growth in 1987 followed 11.0 percent the previous year, and is expected to continue at 9.0 percent through 1989. Textiles and apparel make up more than 40.0 percent of Hong Kong's exports and the bulk of shipments to the United States. Exports to the United States were up by 14.0 percent, while the Hong Kong-U.S. trade surplus increased by $119 million, or 2.0 percent. Strong domestic demand and increased trade with China will be major contributors to 1988 growth.

Hong Kong exporters have benefited from the Hong Kong dollar's stability against the U.S. dollar since 1985, in comparison with the Korean and Taiwanese currencies, which have appreciated 15 percent and 30 percent, respectively. The domestic economy has not suffered unduly, primarily because 45 percent of Hong Kong's consumer goods and food comes from the People's Republic of China

(PRC), and the Chinese reminbi has dropped 20 percent in value relative to the dollar. A revaluation of the Hong Kong dollar in the near term is unlikely.

India's 1987 4 percent growth in real GDP will continue through 1988 and 1989. International trade runs a $5 billion per year deficit. The government's past constraints on competition have effectively protected most of the domestic market, but the lack of stimulation has produced little technological innovation. This is beginning to change. The government has begun loosening restrictions on imports of systems, peripherals, and components. Efforts to encourage hardware assembly, especially software development in joint partnerships with foreign companies, have seen some modest successes. Indians believe that the most promising opportunities lie in matching their large pool of technically trained, English-speaking manpower with the worldwide demand for software. If the weighty Indian bureaucracy and start-up productivity levels can be overcome, Indian software technology will become a world force.

The reference statistics in Table 3 comprise GNP/GDP growth rates for the United States and its trading partners that were discussed in this document.

Table 3. Reference Statistics
(Percentage Changes from Previous Period, SAAR*)

	1983	1984	1985	1986	1987	1988	1989
Growth of Real GNP/GDP							
United States	3.6	6.8	3.0	2.9	2.8	2.8	2.2
Japan	3.2	5.1	4.7	2.4	3.5	3.5	3.0
West Germany	1.9	3.3	2.0	2.5	1.5	1.3	1.3
France	0.7	1.4	1.7	2.0	1.5	1.5	1.3
United Kingdom	3.3	2.7	3.6	3.3	3.8	2.8	1.8
Italy	0.5	3.5	2.7	2.7	2.8	2.0	1.8
Canada	3.2	6.3	4.3	3.3	3.6	2.8	2.3
Growth of Private Consumption							
United States	4.6	4.8	4.6	4.2	1.9	2.0	2.3
Japan	3.2	2.7	2.6	2.7	3.3	3.3	3.0
West Germany	1.7	1.5	1.8	4.3	2.5	2.8	2.3
France	0.9	1.0	2.4	3.3	1.8	1.5	1.0
United Kingdom	4.0	2.1	3.7	5.8	4.5	3.3	2.3
Italy	0.4	2.2	2.7	3.2	4.5	2.5	2.0
Canada	3.4	4.3	5.2	3.9	4.0	2.3	2.3
Growth of Government Consumption							
United States	1.1	4.4	7.3	3.8	1.8	1.9	0.8
Japan	2.9	2.8	2.0	6.6	(0.3)	2.5	3.0
West Germany	0.2	2.4	2.1	2.3	2.0	1.8	1.5
France	2.1	1.1	3.2	2.7	2.5	2.0	1.8
United Kingdom	1.9	0.8	(0.1)	0.9	0.5	1.0	1.0
Italy	2.8	2.0	3.5	3.0	2.8	2.5	1.8
Canada	1.4	1.5	2.7	1.0	2.0	1.8	1.0

(Continued)

Table 3. Reference Statistics
(Percentage Changes from Previous Period, SAAR*) (Continued)

	1983	1984	1985	1986	1987	1988	1989
Growth of Gross Fixed Investment							
United States	8.2	16.8	5.5	1.8	0.5	4.8	3.0
Japan	(0.3)	4.9	5.6	6.6	8.5	4.8	3.1
West Germany	3.1	0.8	0.1	3.1	1.0	1.5	1.0
France	(3.6)	(2.3)	1.1	3.1	3.0	2.5	2.3
United Kingdom	5.2	8.2	3.1	0.3	4.8	5.8	3.5
Italy	(1.6)	4.4	3.3	1.2	2.8	2.5	1.3
Canada	(0.7)	1.6	8.1	5.1	8.0	3.0	2.3
Growth of Real Exports							
United States	(3.8)	6.8	(1.7)	3.3	12.0	14.3	9.3
Japan	4.2	17.5	5.3	(4.8)	2.0	3.0	3.5
West Germany	(0.5)	9.0	7.2	(0.1)	0.0	1.0	1.0
France	3.7	7.1	2.1	(0.7)	(0.8)	2.5	2.5
United Kingdom	2.0	7.0	5.7	3.1	5.5	2.0	1.5
Italy	2.3	7.6	4.0	3.1	(1.0)	3.5	3.0
Canada	6.4	18.8	6.0	4.7	3.8	3.5	3.3
Growth of Real Imports							
United States	9.6	23.9	3.9	10.5	5.0	1.3	2.3
Japan	(5.1)	11.1	(0.1)	3.6	6.3	7.5	4.8
West Germany	0.6	5.3	4.7	3.5	3.3	3.5	3.5
France	(2.7)	2.8	4.7	6.9	4.8	3.0	3.0
United Kingdom	5.8	9.8	2.8	6.2	5.8	4.5	4.0
Italy	(1.6)	11.3	5.3	5.1	6.3	4.8	4.3
Canada	9.0	16.6	8.3	7.2	4.5	3.5	3.0

*Seasonally adjusted annual rate

Source: Dataquest
April 1988

Glossary

balance of payments. A double-entry accounting of the value of all exchanges and transfers of goods, services, capital loans, investments, and gold and international reserves between the public and private sectors of a given country and the rest of the world over a given time, usually one year. Balance of payments is divided into three accounts—current, capital, and the reserve and gold account.

balance of trade. The difference between the value of a country's exports and imports of *tangible goods* over a given period, usually one year.

balance on current account. See **current account.**

capacity utilization. The ratio of actual production output to potential production output, with existing plant, workers, and equipment.

capital account. Balance of payments category for the inward and outward flow of investment capital.

capital goods. All goods used for the *production* of other goods and services. See also **consumer goods.**

consumer. An individual who buys goods and services for personal use, rather than for manufacturing, processing, or resale.

consumer goods. Products used directly to satisfy human needs or wants, such as food and clothing. The distinction between consumer and capital goods lies in how products are *used* rather than in the products themselves.

consumer price indices (CPI). Monthly measures by the U.S. Bureau of Labor Statistics of the average retail prices of products commonly bought by households, compared with the average prices of a selected base year.

consumption. Expenditures for durable goods, nondurable goods, and services.

current account. Balance of payments category for **goods and services.** The difference between total exports and imports of goods and services is the **balance on current account.**

disposable income. An individual's income remaining after any payments to government (taxes, fines), and thus available for either spending or saving.

durable goods. Items that yield their services over an extended period of time, generally three years or more. Durables are often divided into the categories of *producer durables* (e.g., metals, machinery, equipment), and *consumer durables* (e.g., automobiles, appliances).

external debt. The total sum of a country's public and private debt owed to foreigners.

federal debt, federal deficit. See **public debt, public deficit.**

fixed investment. Assets for production of goods or services that cannot be quickly converted into money without disrupting operations, such as plant and equipment.

goods. Tangible items of trade, such as automobiles or shoes. Merchandise.

gross domestic product (GDP). The total market value of all goods and services produced each year within the domestic borders of a nation.

gross national product (GNP). GNP equals GDP plus the net of income accrued by domestic residents from investments abroad minus income earned in the domestic market by foreigners abroad.

gross national product deflator. A revision in the calculation of GNP derived by adjusting each component of GNP for price changes, then summing each into a weighted total. The result thus measures both changes in prices and shifts in consumption patterns.

industrial production index. A monthly measure of the quantity of U.S. output in mining, manufacturing, and utilities industries compared with a base year and seasonally adjusted.

inflation. A sustained increase in the average level of all prices.

internal debt. The total sum of a country's public and private debt owed to citizens of the same country.

investment. Expenditures for capital goods.

invisibles. Items of foreign trade that are intangible, such as banking, insurance, tourism, and transportation. Unlike visibles, such items are not recognized by customs and until recently were not reported in trade statistics.

nominal GDP/GNP. GDP/GNP valued in prices prevailing at the time of measurement. Year-to-year changes then reflect differences in both quantities and market prices.

nondurable goods. Items that yield their services over a short period of time, generally less than three years. Examples are food, clothing, paper, chemicals, petroleum, rubber.

private. Relating to individuals and businesses, rather than government.

producer price indices (PPI). Monthly measures by the U.S. Bureau of Labor Statistics of the prices of 2,800 representative commodities compared with those prices of a given base year.

public. Relating to local, state, or national governments.

public debt. The sum of debts outstanding of local, state, and national governments in a given country. Debt of the national government alone is the *national public debt* or *national debt*. In effect, the public debt is a measure of the extent to which government expenditures are financed by borrowing rather than taxation.

public deficit. Circumstance where government outlays for goods and services exceed receipts for a fiscal year.

real GDP/GNP. GDP/GNP valued in *constant* prices prevailing in a reference base year—1982 in this publication. Year-to-year changes thus reflect changes only in *quantities* produced.

recession. A broad downward movement of the economy over an extended time. Generally defined for the U.S. as two successive quarterly decreases in U.S. GNP.

seasonal variation. A regularly recurring pattern of change in economic activity owing to factors such as periodic climate changes, holidays, and vacations. Seasonal variations are commonly adjusted for in the analysis of data to clarify overall trends.

services. Intangible items of trade, such as education, transportation, banking, legal and medical care.

terms of trade. The ratio of the average price of a country's exports to the average price of its imports.

visibles or visible goods. Tangible items of foreign trade.

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