1 WORLDWIDE IC INDUSTRY ECONOMIC UPDATE AND FORECAST

INTRODUCTION

The semiconductor industry data in Status 1997 is analyzed and presented using two different methods. One describes the "market" for semiconductors while the other examines the semiconductor "production" or "sales" of the device manufacturers. In ICE's analysis, total worldwide semiconductor production equals worldwide semiconductor consumption in any given year. Figure 1-1 shows some of the assumptions and definition guidelines to which ICE will adhere throughout Status 1997.

- **All figures that include "market" in the title: market is considered equal to consumption. The North American market is what is sold within the geographical borders of North America.**
- **The sum of individual companies' "sales" exceeds the total world "production." A company's sales could include its device sales, whether produced internally or externally, and its sales of wafers to another semiconductor company. Production figures attempt to not double-count "foundry" sales.**
- **"Merchant" semiconductor production, sales, or market figures include North American captive (e.g., Digital and Hewlett-Packard) merchant sales, but not internal transfers at the captives.**
- **All figures that describe "sales or production by company" include all sales or production regardless of where the devices are produced or sold. For example, all of Texas Instruments' semiconductor sales or production, including those from its Japanese and European facilities, would be listed in the North American company semiconductor segment.**
- **In all of ICE's sales and production figures, internal transfers and ASIC NRE revenue are included.**
- **"Semiconductor" sales and production figures include ICs and discretes but do not include hybrids.**
- **The former Eastern European market and production figures are not included in the European or world forecasts (but are discussed at the end of this section).**

Source: ICE, "Status 1997" 11339L

Figure 1-1. Figure Key

Figure 1-2 lists ICE's Status 1997 economic assumptions. These economic expectations are the bases for ICE's semiconductor industry estimates and forecasts. As shown, 1996's IC market was more influenced by ASPs (-9 percent) than by unit shipments (0 percent). The 1997 forecasted assumptions will be discussed in greater detail later in this section.

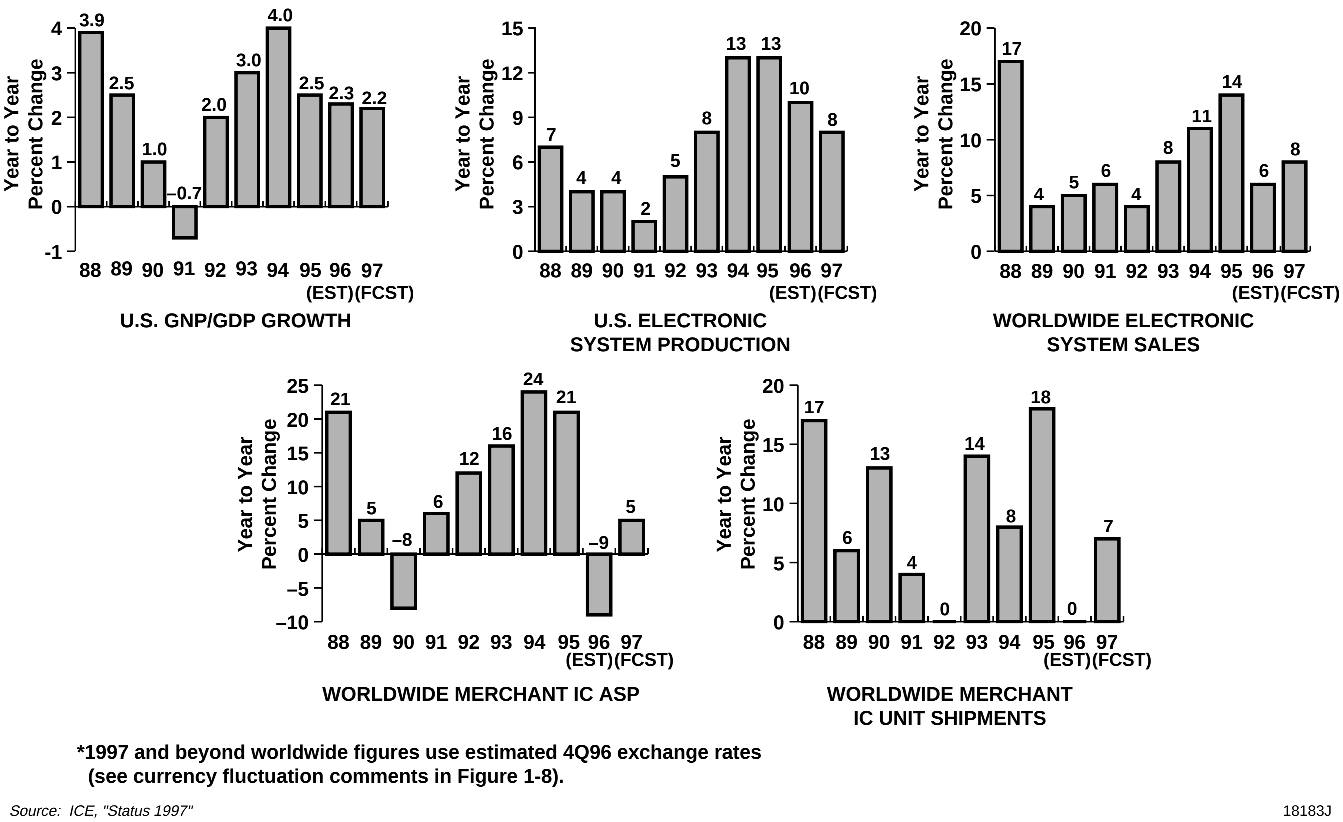


Figure 1-2. ICE's Economic Assumptions*

Figure 1-3 shows the 1992 through 1996 actual GNP or GDP (Gross Domestic Product) changes, and the 1997 forecast for five major economies. The big story for the first half of the 1990's was the weakness of the Japanese economy and the strength of the yen. However, beginning in 1996, the yen began to weaken significantly and the Japanese economy began to rebound.

In October of 1996, the Liberal Democratic Party (LDP) gained further strength in Japan's political landscape. Many economic observers now believe that because of the LDP's historical record of "careful" change, the needed push for swift fiscal policy measures and deregulation will not take place. Even the LDP conceded that without major changes in the current economic infrastructure, Japanese GDP annual growth will hover around 1.75 percent for the rest of the decade.

	Percent Growth					
Country/Segment	**1992**	**1993**	**1994**	**1995**	**1996 (EST)**	**1997 (FCST)**
U.S.	2.0	3.0	4.0	2.5	2.3	2.2
Europe	0.8	–0.6	2.5	2.9	1.4	2.4
Japan	1.5	0.2	0.8	0.9	2.0	1.0
Pacific Rim	5.9	6.2	7.6	7.9	7.1	6.8
China	12.8	10.2	11.3	9.5	8.7	7.0

Sources: Consensus Economics/
Blue Chip Economic Indicators/
ICE, "Status 1997"

18934F

Figure 1-3. Real GDP Growth

For 1996, four of the five major economic regions displayed less growth than was registered in 1995. In the U.S., the 1996 2.3 percent GDP increase was the slowest annual growth since 1992. The European economy was the slowest growing of the five major regions.

With the Asia/Pacific region representing about 56 percent of the world's population (expected to be 62 percent in 2020), and with this segment focusing on improving infrastructure for industry, 1996 GDP growth rates for the Pacific Rim and China were still very strong. As shown, the 1996 GDP growth rates of the Pacific Rim region and China were over three times those of the U.S., Europe, and Japan.

Since 1994, the Chinese government has engaged in an "austerity" program in an attempt to cool its economy to an eight percent annual GDP growth rate. Because it is almost impossible to precisely hit such targets, it is now believed that the Chinese economy will expand by "only" seven percent in 1997.

The varying and moderating GDP growth rates of the major economic regions, as well as strong capital expenditure budgets (discussed further in Section 2), are expected to help keep semiconductor industry growth in a narrow range for the remainder of the 1990's. Many still believe that 1984's 50 percent increase in the semiconductor market can not be duplicated. However, if the Japanese economy was booming in 1995 instead of slumping, the semiconductor market would have once again approached or exceeded that 50 percent growth figure!

One factor that has historically had a significant effect on the reporting of worldwide sales and market levels is exchange rates (Figure 1-4). When examining the sales and market figures, it must be remembered, for example, that if a Japanese company had the same sales (in yen) in 1996 as in 1995, when converted to and reported in dollars, a 14 percent decrease would have been shown!

Country (Currency)	1993	1993/1992 (%)	1994	1994/1993 (%)	1995	1995/1994 (%)	1996 (EST)	1996/1995 (EST)	4Q96 (EST)	4Q96/1996 (EST)
U.K. (Pound)	0.67	–18	0.65	3	0.63	3	0.65	–3	0.63	3
France (Franc)	5.72	–8	5.54	4	4.99	10	5.12	–3	5.18	–1
Germany (Mark)	1.66	–6	1.62	3	1.44	11	1.51	–5	1.53	–1
Japan (Yen)	110	13	102	8	94	8	109	–16	113	–4

Source: ICE, "Status 1997" 11406AC

Figure 1-4. Japanese and European Exchange Rates (Per Dollar)

ICE uses estimated 4Q96 exchange rates for the 1997 market forecast and beyond. Most European and Japanese currency levels have had a noticeable impact on the overall semiconductor market figures over the past few years. Strong European currencies and a very strong yen helped inflate the 1994 and 1995 semiconductor market figures when reported in dollars.

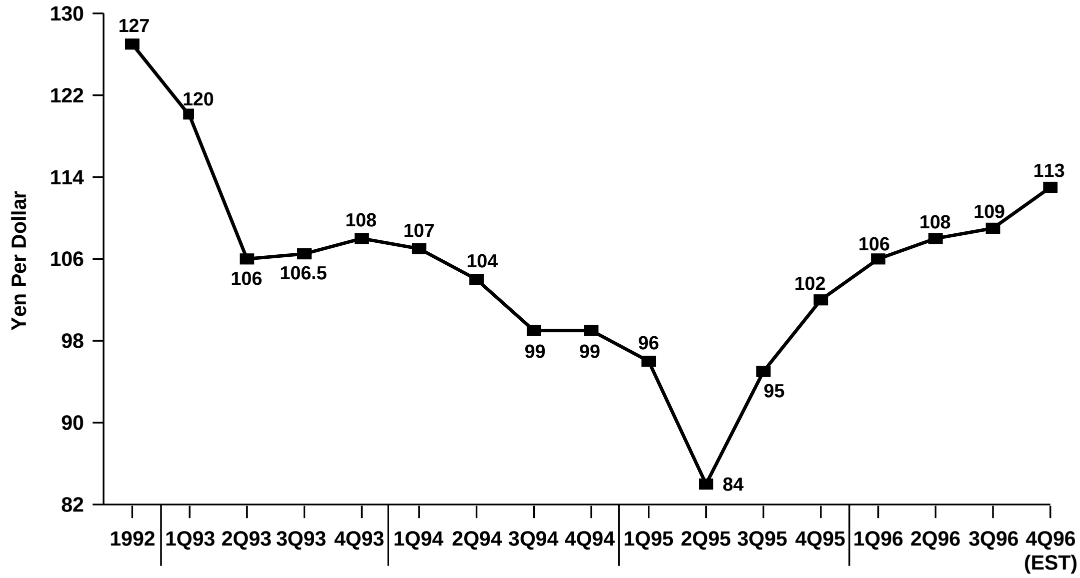
For 1996, currency fluctuations had a tremendous “negative” impact on the semiconductor dollar market figures. It now appears that 1996 European and Japanese market figures (when reported in dollars) will be “deflated” by about four and 14 percent, respectively.

Figure 1-5 illustrates how quickly the Japanese yen gained strength in early 1993. Besides making the Japanese sales and production dollar figures look stronger, it is estimated that each time the dollar falls one yen, the Japanese auto and electronics industries lose 50 billion yen (≈ $500 million) a year in revenue. However, as shown, the yen has recovered to levels not seen since 1Q93. This has been welcome news to most Japanese companies.

ELECTRONIC SYSTEM PRODUCTION

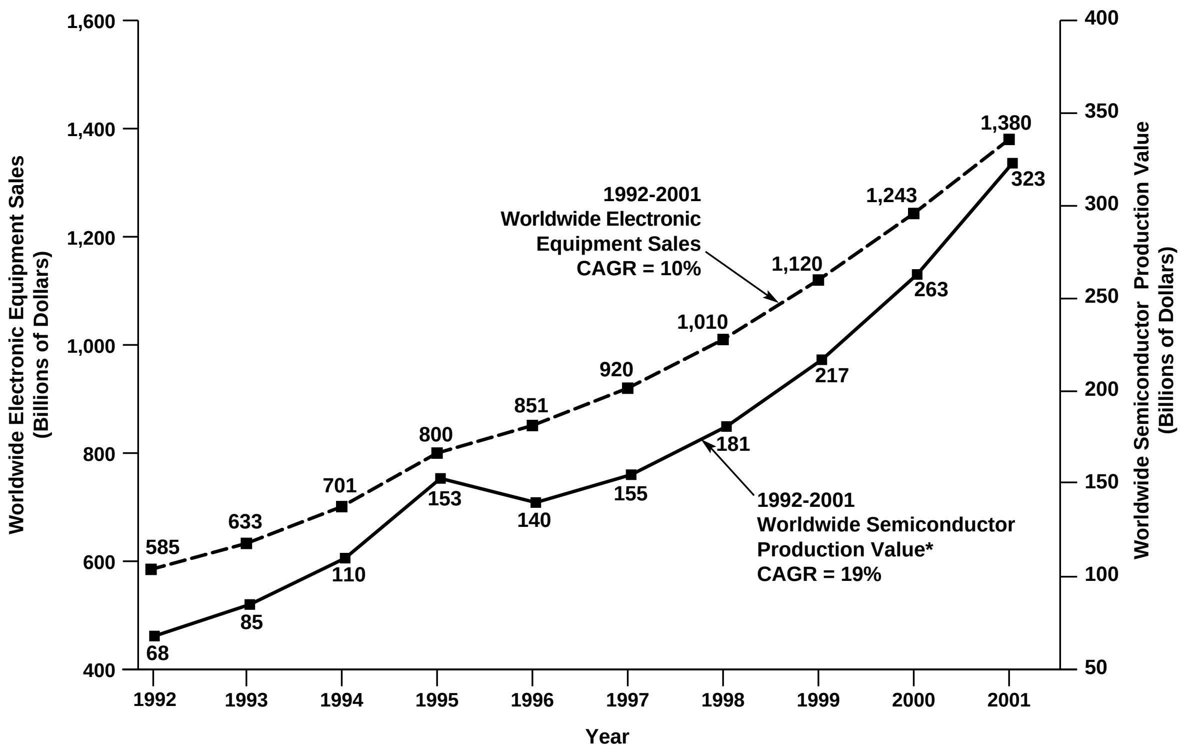
Figure 1-6 examines the market relationship between semiconductor component and electronic system production. The semiconductor compound annual growth rate (CAGR) is forecast to be almost twice the rate of electronic systems due to the continuing increase in the use of semiconductors in electronic systems. As will be shown later in this section, IC value in PCs is about 30-35 percent of the total system price.

Because of the increasing pervasiveness of semiconductors in electronic equipment, the overall “percent semiconductor” figure will increase over time. For example, the “percent semiconductor” figure averaged 10.9 for 1983-1991 and is forecast to average 17.5 percent for 1992-2001. The average yearly gain of the “percent semiconductor” figure from 1996 through 2001 is forecast at about 1.4 percentage points.



Source: ICE, "Status 1997" 18935G

Figure 1-5. The Yen's Dramatic Fluctuations



Percent Semiconductor	11.6	13.4	15.7	19.1	16.5	16.9	17.9	19.4	21.1	23.4

***Including captive "if sold" value.**

Source: ICE, "Status 1997" 11082AC

Figure 1-6. Semiconductor and Electronic Equipment Sales Trends (1992-2001)

In estimating the worldwide electronic system production, ICE subtracted the electronic component values from published (EIA, EIAJ, etc.) total electronics production figures so as not to double count or overestimate actual system sales. The electronic components segment includes all active devices (e.g., ICs and discretes) as well as relays, speakers, antennas, disks, capacitors, etc. Because all of these components are used in building various electronic systems, including their sales volume with system sales would falsely inflate (by double counting the component values) true system sales figures.

As was shown, semiconductor components accounted for 16.5 percent of total electronic system sales value in 1996 and are forecast to be 23.4 percent in 2001. It should be noted that 1996's percent semiconductor figure dropped 2.6 percentage points. This significant decline was a result of the correction from the "inflated" DRAM pricing effects that impacted the 1994 and 1995 figures (in which the percent semiconductor number displayed an unsustainable average annual increase of almost three points). It should be obvious that consistent semiconductor industry growth ultimately depends upon a healthy electronic system market. This relationship has continuously proven to be inseparable.

As shown in Figure 1-7, North America is the largest producer of electronic equipment in the world. It should be noted that almost all of the 1984-1996 loss in the North American share of electronic equipment production was offset by gains in the ROW region.

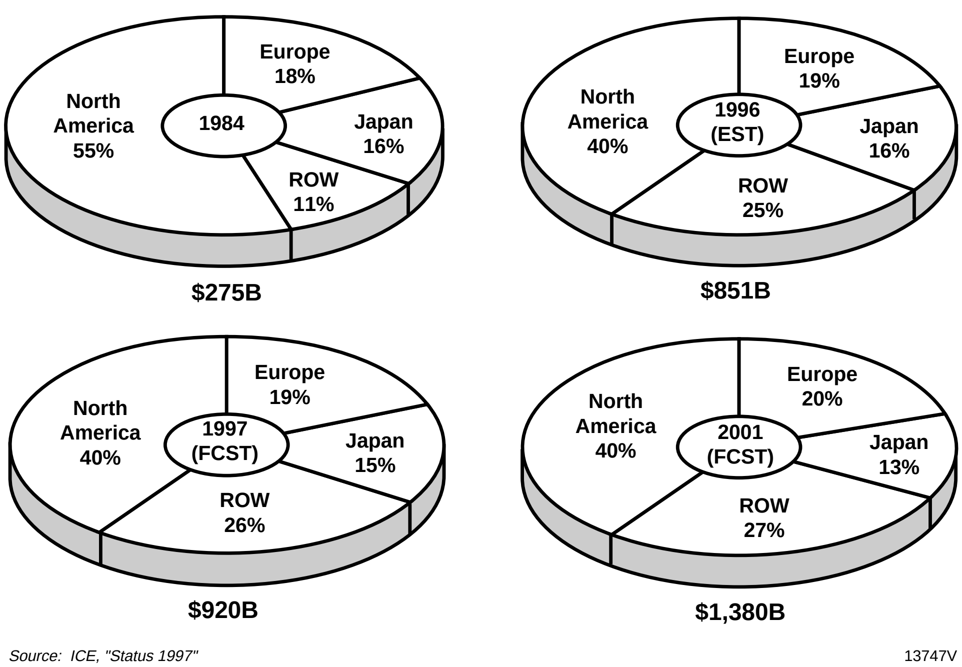


Figure 1-7. Electronic Equipment Production

North American system producers are heavily concentrated in the fast growing PC and telecommunications segments. Although the overall U.S. economy grew less in 1995 than in 1994, the PC and telecommunications markets were still very healthy. This trend continued throughout 1996, and is the reason the U.S. gained one point of marketshare in 1996.

Through 2001, ICE forecasts that the North American region will hold onto its 1996 marketshare while the ROW region will increase two points. It is forecast that the Japanese region will continue to lose marketshare, declining three points from 1996 to 2001 and displaying only a six percent CAGR.

The expected loss of system production marketshare in the Japanese region is not due to a forecasted slumping economy through 2001. The loss is primarily due to the continued shift of Japanese-owned system production to ROW locations. The Japanese companies attribute this movement to the need to take advantage of lower labor costs, getting “close” to many electronic system markets (e.g., China) that are currently in their infancy, and fleeing the highly regulated and restrictive Japanese infrastructure.

The trend of North American, Japanese, and European system producers taking advantage of low offshore labor costs, coupled with the demonstrated capability of Korea and other Asia-Pacific countries to supply personal computers and other electronic systems, is spurring the steady increase in ROW-based electronic system production. Figure 1-8 shows worldwide electronic equipment production by producing region for 1993-1996 as well as ICE’s forecast for 1997.

GEOGRAPHIC SEGMENT	ELECTRONIC SYSTEM PRODUCTION ($B)									
	1993	1993/1992 PERCENT CHANGE	1994	1994/1993 PERCENT CHANGE	1995	1995/1994 PERCENT CHANGE	1996 (EST)	1996/1995 PERCENT CHANGE	1997 (FCST)	1997/1996 PERCENT CHANGE
North America	242	8	274	13	311	13	341	10	369	8
Japan	118	6	126	7	140	11	133	–5	138	4
Europe	130	7	139	7	161	16	166	3	178	7
ROW	143	12	162	13	188	16	211	12	235	11
Total	633	8[1]	701	11[2]	800	14[3]	851	6[4]	920	8

[1] 1993/1992 would show about a 6 percent gain without exchange rate fluctuations.
[2] 1994/1993 would show about an 8 percent gain without exchange rate fluctuations.
[3] 1995/1994 would show about an 11 percent gain without exchange rate fluctuations.
[4] 1996/1995 would show about a 10 percent gain without exchange rate fluctuations.

Source: ICE, "Status 1997" 11337X

Figure 1-8. Worldwide Electronic System Production

Using local currencies instead of U.S. dollars shows that worldwide electronic system production has surged from only a six percent increase in 1993 to a 10 percent growth rate in 1996. Using local currencies instead of estimated 1996 exchange rates, Japan's electronic equipment production would have registered a strong 10 percent increase in 1996 instead of a five percent decline.

THE WORLDWIDE ELECTRONICS INFRASTRUCTURE

The worldwide electronics marketplace can be thought of as an inverted pyramid (Figure 1-9). In general, the semiconductor, semiconductor equipment, and semiconductor materials markets are all ultimately dependent upon healthy electronic system sales.

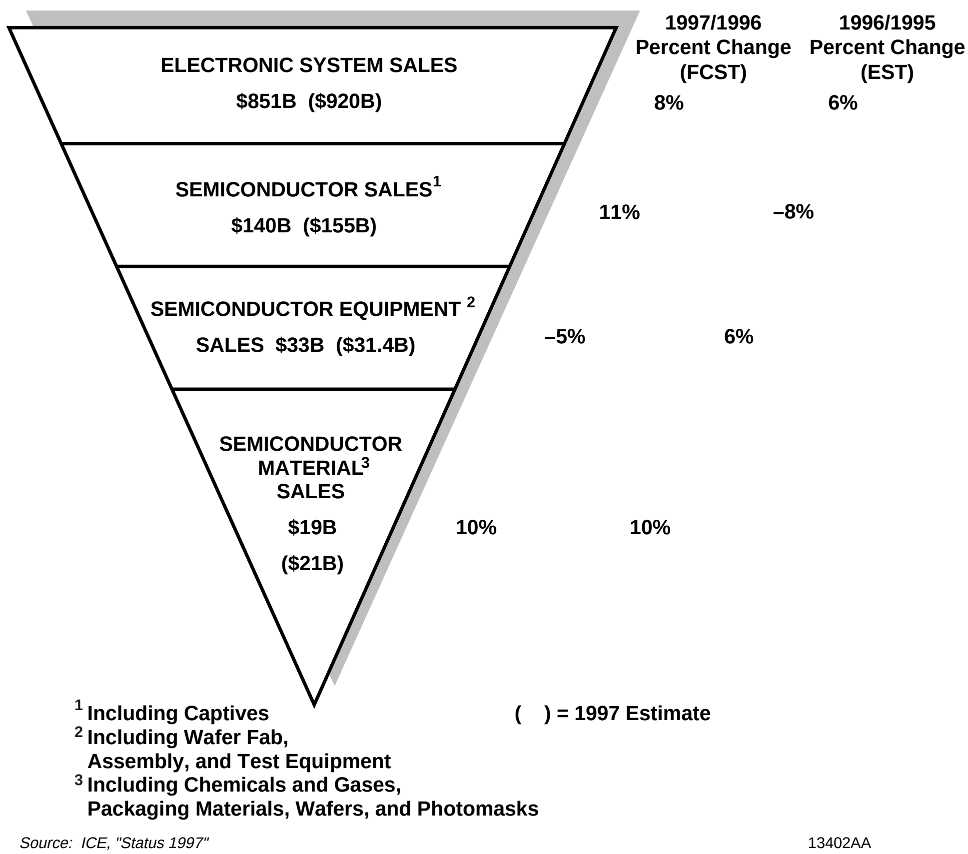


Figure 1-9. 1996 and 1997 Worldwide Electronics Marketplace

As shown, 1996 was a very difficult year for the overall semiconductor industry. It was one of the very rare years where the semiconductor market declined while the electronic system marketplace grew.

As will be discussed further in Section 2, semiconductor equipment sales carried some momentum in 1996 to display a six percent increase. ICE forecasts that capital spending for semiconductor production equipment will decline five percent in 1997 as DRAM manufacturers fully "adjust" to the overcapacity situation.

Semiconductor material suppliers usually follow the growth of IC unit volumes. However, the 10 percent increase in the 1996 semiconductor materials market was much better than the flat IC unit market. The conversion to 200mm wafers, more complex processes (e.g., increasing number of mask layers), the increased use of consumables (e.g., CMP and more etch steps), and higher pin count packages contributed to the difference. It is forecast that 1997 will continue this trend (+7 percent unit volume increase, +10 percent materials market growth).

Figure 1-10 shows the discrete, IC, and total semiconductor markets segmented by system-type usage from 1991 to 2001. As shown in Figures 1-11 and 1-12, the IC market is driven primarily by the computer industry whereas the discrete segment's greatest demand still comes from consumer and industrial systems. 1993 was the first year that the computer segment represented more than half of the IC market (up two points from 1992). In 1996 the computer segment represented almost 55 percent of the total IC market. The military market now represents about one percent of total semiconductor sales (down from 2.3 percent in 1991) and will most likely continue to shrink from even this low level moving into the next century.

One of the hottest areas of the semiconductor market since 1994 has been the communications segment. In many countries the telecom business is booming even more than the PC industry. ICE estimates that the communications segment of the worldwide semiconductor market has gained almost two points since 1991.

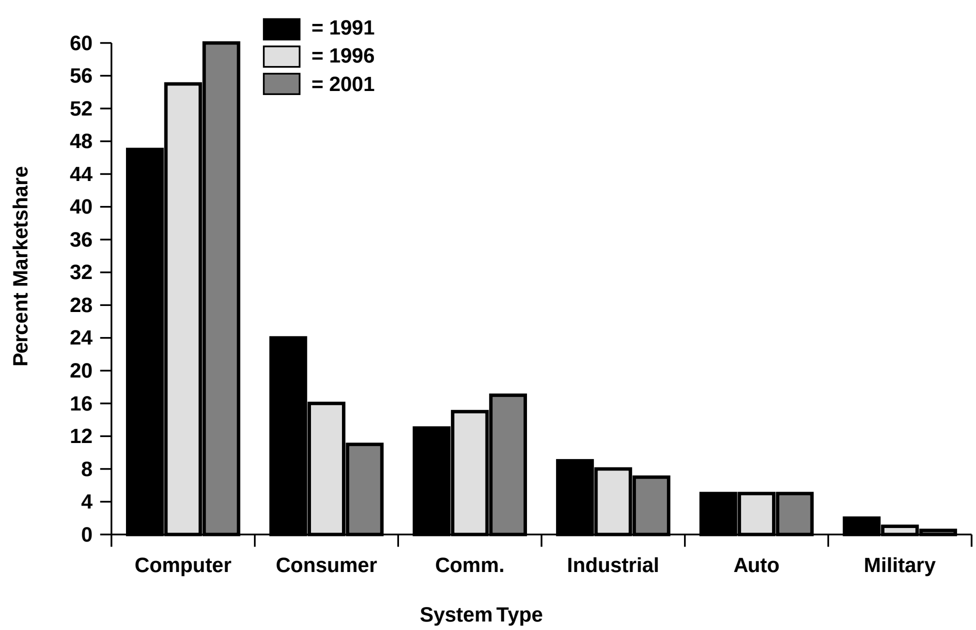
Each of the major IC market regions (i.e., Japan, North America, Europe, and ROW) has a very different makeup of end-use consumption (Figure 1-13). As shown, the North American market is highly dependent upon the computer industry. In fact, the computer and communications industries represented 81 percent of all IC usage in North America in 1996!

The Japanese IC market is more reliant on the consumer systems industry. With economic uncertainty running high among the Japanese population and no new blockbuster-hit consumer products being introduced, Japanese IC consumption for consumer systems has been flat since 1992. Being shut out of many of the high-volume desktop PC markets thus far, many Japanese companies have emphasized laptop PCs and other office-automation equipment (e.g., printers) and telecom system sales.

	Actual							Estimated			Forecast					
Semiconductor Markets	1991 ($B)	Percent of Total	1994 ($B)	Percent of Total	1995 ($B)	Percent of Total	1995/1994 % Change	1996 ($B)	Percent of Total	1996/1995 % Change	1997 ($B)	Percent of Total	1997/1996 % Change	2001 ($B)	Percent of Total	1996/2001 CAGR %
IC MARKETS																
Computer	21.9	47.4%	48.9	54.1%	72.7	56.5%	48.8%	64.2	54.9%	–12%	71.7	55.0%	12%	169.2	59.7%	21%
Consumer	11.0	23.8%	15.9	17.6%	20.1	15.6%	26.3%	18.8	16.1%	–6%	20.3	15.6%	8%	31.2	11.0%	11%
Communications	6.0	12.9%	12.8	14.2%	18.4	14.3%	43.5%	17.3	14.8%	–6%	20.1	15.4%	16%	46.8	16.5%	22%
Industrial	4.1	8.9%	7.8	8.6%	10.4	8.1%	34.2%	9.4	8.0%	–10%	10.4	8.0%	11%	19.8	7.0%	16%
Automotive	2.1	4.6%	3.7	4.1%	5.7	4.4%	53.0%	6.0	5.1%	5%	6.7	5.1%	12%	15.3	5.4%	21%
Military	1.1	2.4%	1.3	1.4%	1.4	1.1%	12.0%	1.3	1.1%	–10%	1.1	0.9%	–10%	1.1	0.4%	–2%
Total IC Market	46.3	100.0%	90.3	100.0%	128.7	100.0%	42.5%	116.9	100.0%	–9%	130.4	100.0%	12%	283.5	100.0%	19%
DISCRETE MARKETS																
Computer	1.2	11.5%	2.0	14.2%	2.7	14.4%	34.7%	2.5	14.4%	–7%	2.8	14.6%	11%	5.4	16.5%	16%
Consumer	4.2	40.2%	4.5	31.5%	5.8	30.6%	29.1%	5.3	29.7%	–10%	5.5	28.6%	5%	7.3	22.5%	7%
Communications	1.6	15.7%	2.7	18.6%	3.4	17.7%	26.4%	3.0	17.0%	–11%	3.4	17.5%	12%	5.8	17.9%	14%
Industrial	2.2	21.1%	3.5	24.6%	4.9	25.7%	38.8%	4.7	26.5%	–4%	5.2	26.7%	10%	9.5	29.1%	15%
Automotive	1.0	9.4%	1.5	10.3%	2.1	10.9%	40.6%	2.1	11.7%	—	2.3	12.0%	12%	4.5	13.7%	17%
Military	0.2	2.1%	0.1	0.8%	0.1	0.7%	9.6%	0.1	0.7%	–8%	0.1	0.6%	–8%	0.1	0.3%	–3%
Total Discrete Market	10.5	100.0%	14.3	100.0%	19.0	100.0%	32.9%	17.7	100.0%	–7%	19.3	100.0%	9%	32.6	100.0%	13%
SEMICONDUCTOR MARKETS																
Computer	23.2	40.8%	50.9	48.6%	75.5	51.1%	48.3%	66.7	49.6%	–12%	74.6	49.9%	12%	174.6	55.2%	21%
Consumer	15.2	26.8%	20.4	19.5%	25.9	17.5%	26.9%	24.0	17.8%	–7%	25.8	17.2%	7%	38.5	12.2%	10%
Communications	7.6	13.4%	15.5	14.8%	21.8	14.7%	40.6%	20.3	15.1%	–7%	23.5	15.7%	16%	52.6	16.6%	21%
Industrial	6.3	11.2%	11.3	10.8%	15.3	10.4%	35.7%	14.1	10.5%	–8%	15.5	10.4%	10%	29.3	9.3%	16%
Automotive	3.1	5.5%	5.2	4.9%	7.7	5.2%	49.4%	8.1	6.0%	2%	9.0	6.0%	11%	19.8	6.3%	20%
Military	1.3	2.3%	1.4	1.3%	1.5	1.0%	11.8%	1.4	1.0%	–10%	1.2	0.8%	–10%	1.2	0.4%	–2%
TOTAL SEMI MARKET	56.8	100.0%	104.6	100.0%	147.7	100.0%	41.2%	134.6	100.0%	–9%	149.7	100.0%	12%	316.1	100.0%	19%

Source: WSTS/ICE, "Status 1997" 21672

Figure 1-10. 1991-2001 Worldwide IC, Discrete, and Total Merchant Semiconductor Usage



Source: WSTS/ICE, "Status 1997" 21671

Figure 1-11. IC Dollar Volume End-Use Trends

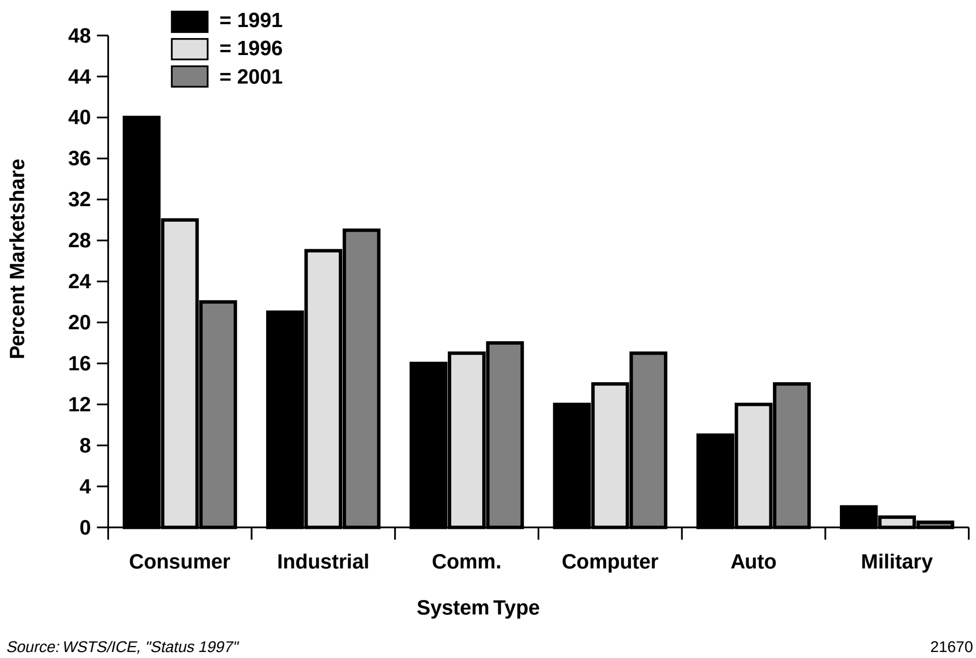


Figure 1-12. Discrete Dollar Volume End-Use Trends

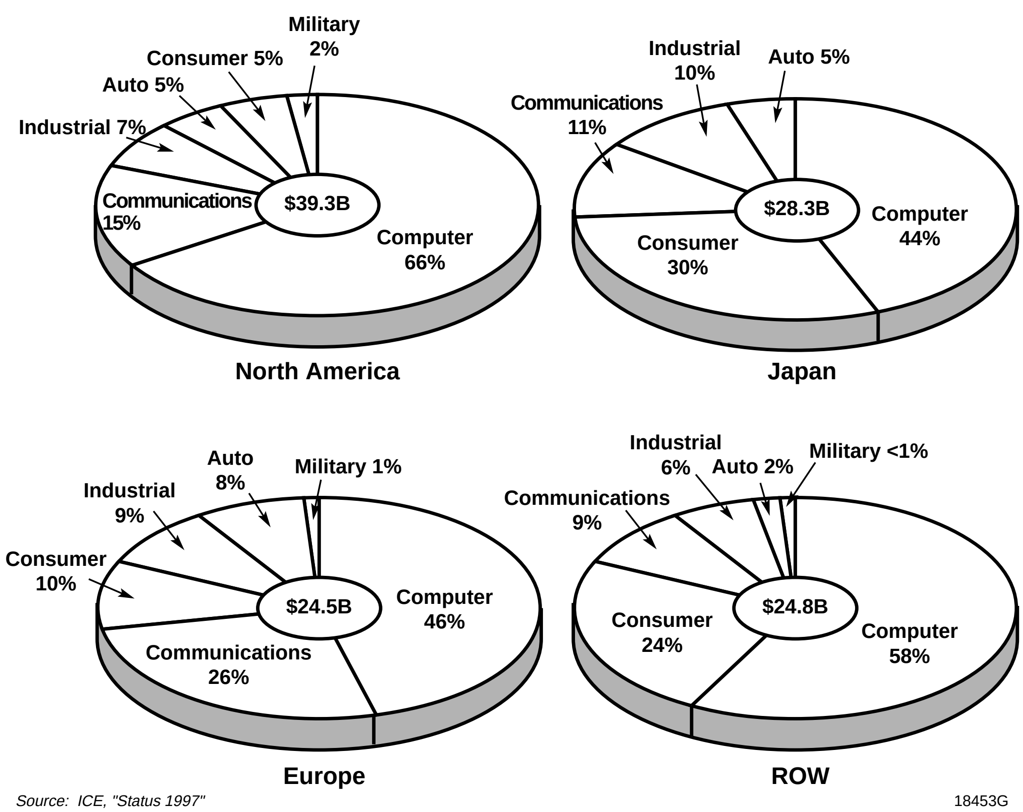


Figure 1-13. 1996 Merchant IC Usage by Region and End Use

One of the bright spots in the 1996 European market was the communications segment. With the "opening" of Eastern Europe, a tremendous pent-up demand for telecommunications systems still exists. Establishing this infrastructure requires a tremendous amount of IC-based telecom equipment. As shown, communications ICs represent over one-fourth of Europe's total IC market.

The ROW sector has benefited from its participation in the high-growth PC industry. As shown, almost 60 percent of ROW IC consumption was in the computer segment in 1996. The ROW IC market segment was just slightly ahead of Europe as the third largest consuming region for ICs in 1996.

WORLDWIDE SEMICONDUCTOR PRODUCTION UPDATE AND FORECAST

Figure 1-14 shows the semiconductor industry's annual growth rates for 1974 through 2001. The 1989-1992 period was the longest period ever in the semiconductor industry where growth was 10 percent or less in each year. Even the 1992 "boom" year turned out to be a record fourth year in a row where growth did not top 10 percent. As shown, 1993-1995 turned out to be the "boom" years even in the face of the oftentimes slumping Japanese and European economies.

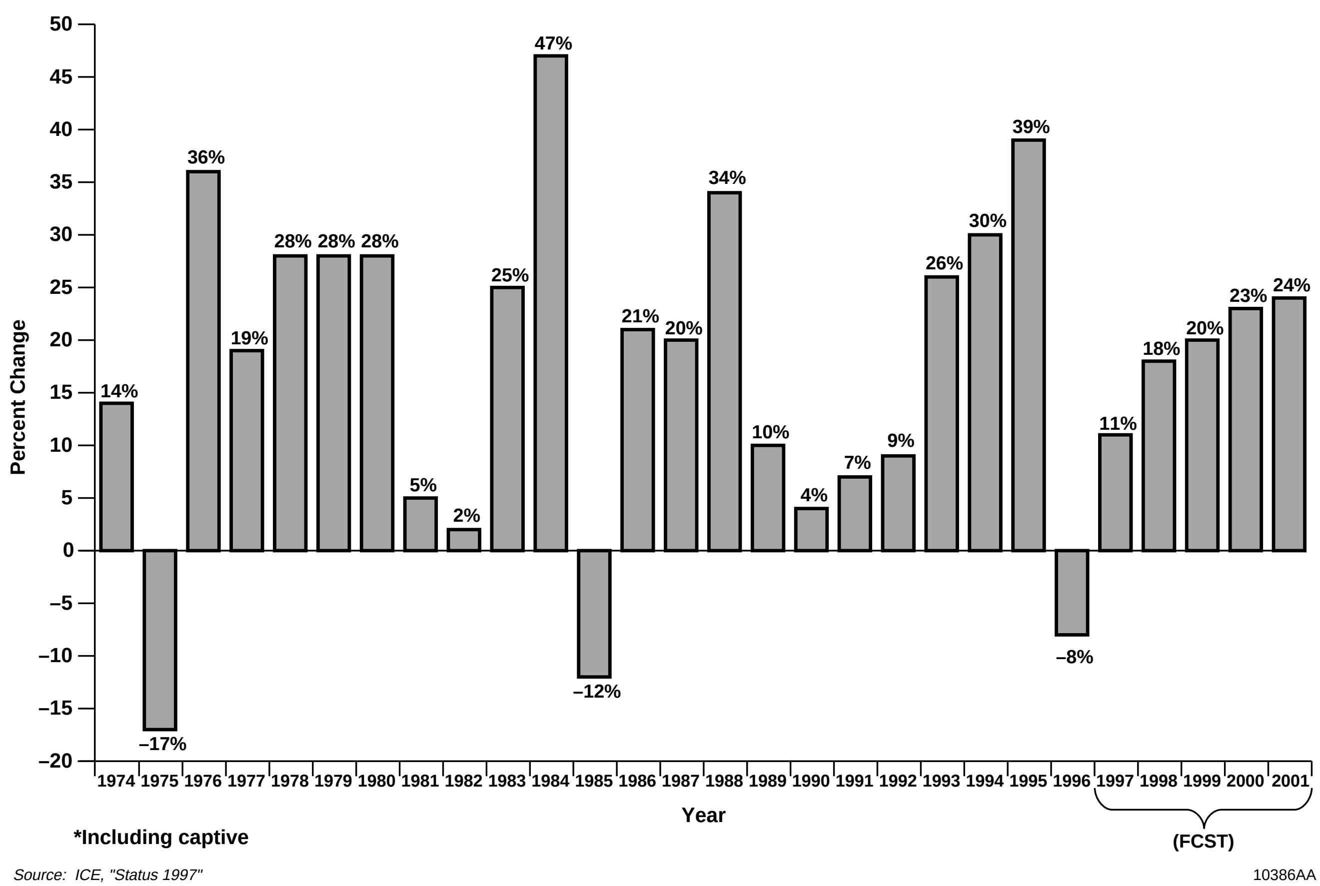


Figure 1-14. Worldwide Semiconductor Production* Growth Rates ($)

It is now conclusive that the four-year semiconductor industry "boom" cycle coinciding with U.S. presidential election years (1980, 1984, 1988, 1992, and 1996, etc.) is no longer intact. This cycle would have had 1992 and 1996 being boom years while 1993-1995 would have been "slower" years. Of course it is currently obvious that just the opposite occurred.

Although foreign currencies helped inflate the early 1990's semiconductor market figures as expressed in dollars, there was very strong "real" growth from 1993 through 1995. Using constant estimated 4Q96 exchange rates, ICE forecasts that the CAGR for the 1996-2001 worldwide semiconductor industry will be a healthy 18.5 percent. A long-term positive outlook for the PC market coupled with an absence of extended significant overcapacity for leading-edge IC production are the main reasons for ICE's bullish forecast for the 1996-2001 semiconductor marketplace.

ICE's long-term worldwide merchant semiconductor sales forecast is given in Figure 1-15. 1994 was the first year the merchant semiconductor industry passed the $100 billion level and 1995 was the first year the merchant IC-only market passed the $100 billion mark. ICE forecasts that the merchant semiconductor market will reach $316 billion in 2001.

YEAR	IC MERCHANT	PERCENT GROWTH OVER PREVIOUS YEAR	DISCRETE MERCHANT	PERCENT GROWTH OVER PREVIOUS YEAR	TOTAL MERCHANT SEMICONDUCTOR	PERCENT GROWTH OVER PREVIOUS YEAR
1992	51,875	12	10,410	–1	62,285	10
1993	67,950	31	11,830	14	79,780	28
1994	90,295	33	14,320	21	104,615	31
1995	128,680	43	19,040	33	147,720	41
1996	116,920	–9	17,700	–7	134,620	–9
1997*	130,380	12	19,300	9	149,680	11
1998*	154,260	18	21,600	12	175,860	18
1999*	186,035	21	24,420	13	210,455	20
2000*	228,215	23	28,080	15	256,295	23
2001*	283,500	24	32,575	16	316,075	24

***Using estimated 4Q96 exchange rates**

Source: ICE, "Status 1997" 11077AC

Figure 1-15. Worldwide Merchant Semiconductor Production Forecast ($M)

1996's negative worldwide semiconductor market was due to two major factors. The first was the plunging price of DRAMs (discussed further in Section 7). The second was the currency conversion situation, especially the yen. It should be noted that when using local currencies instead of U.S. dollars, and not including DRAMs in the 1996 market figures, the worldwide semiconductor market would have shown a 10 percent increase!

Is a $316 billion merchant semiconductor market a “reasonable” expectation for 2001? Figure 1-16 attempts to show why ICE believes that it is reasonable.

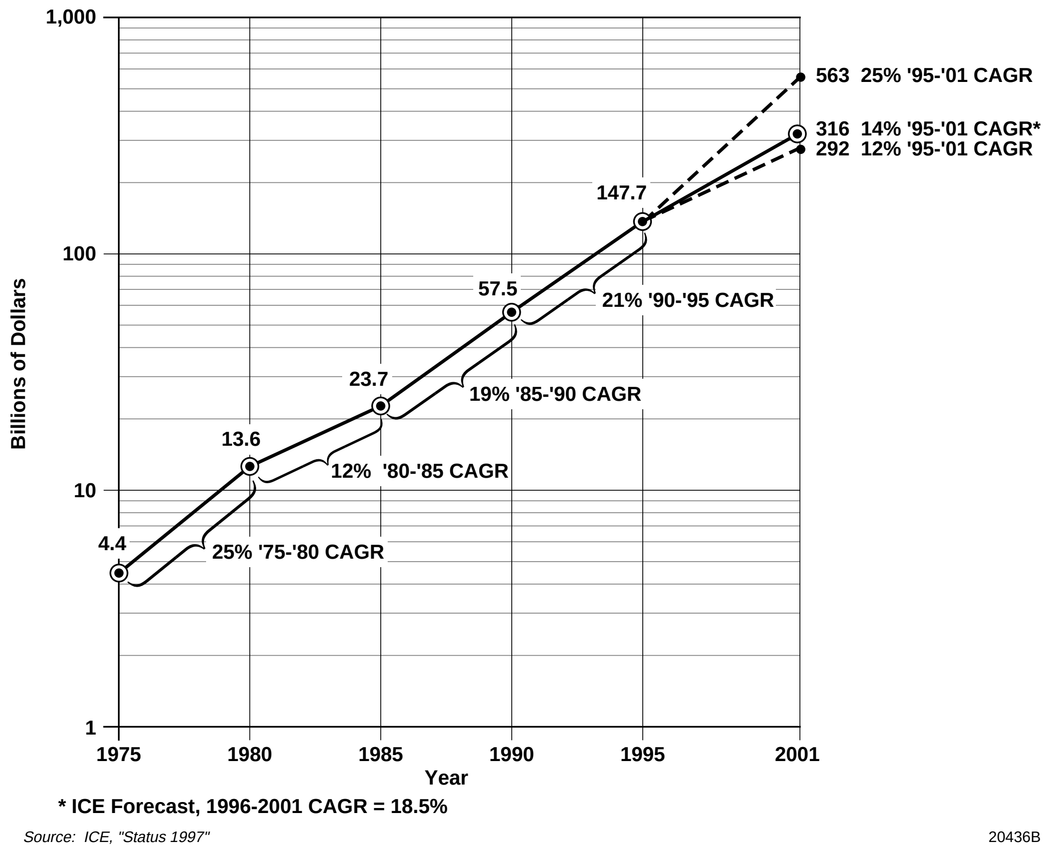


Figure 1-16. Worldwide Merchant Semiconductor Market History and Forecast

The figure shows the history of the worldwide merchant semiconductor market from 1975 to 1995 in five-year increments with a six year range extended to the year 2001. The range of five-year CAGR’s from 1975 to 1995 went from a low of 12 percent in the early 1980’s to a high of 25 percent in the late 1970’s.

From 1985 through 1995 the merchant semiconductor market grew at an annual rate of 20 percent. Given the positive long-term outlook for a continuation of strong semiconductor end-use markets (e.g., wireless telecommunications, PCs, etc.), ICE believes that a 1996-2001 CAGR of 18.5 percent is a reasonable expectation. It is interesting to note that when using an 18 percent CAGR, the merchant semiconductor market would pass the $1.0 trillion level in 2008!

Figure 1-17 examines ICE's Status 1997 assumptions. As shown, the key trends that are expected to cause a lower growth rate over the next five years compared to 1993-1995 are increased capacity and a lower growth rate for PC systems. Despite the "correction" in 1996, ICE is still forecasting a very positive long-term worldwide semiconductor market outlook as is evidenced by the 18.5 percent 1996-2001 CAGR.

- **Capacity**
  - **Fab equipment suppliers catch up with orders.**
  - **Synchronous 16M DRAMs ship in high volume, DRAM producers ramp up 64M DRAMs.**
  - **Excess capacity for DRAMs exists throughout 1997.**
  - **Total IC supply and demand in relative balance in 1998.**
  - **Leading-edge capacity (≤0.35μm) still tight at foundries.**
- **PC market growth rates slow from 1994-1995's 20%+ to 15-18% in 1996-1998.**
- **The worldwide PC unit market (not including NC computers) will display a 15% CAGR from 1996-2001.**
  - **PC unit shipments will grow from 71M in 1996 to 140M in 2001.**

Source: ICE, "Status 1997" 20327C

Figure 1-17. Status 1997 Assumptions for 1997-2001

THE WORLDWIDE SEMICONDUCTOR MARKET

Figure 1-18 shows the quarterly IC market trends for 1991 through 1996. IC average selling price (ASP) continued to rise until 1Q96 when the DRAM ASP plummeted. Although the worldwide merchant IC market increased 43 percent in 1995, IC unit volume was up only about 18 percent. Thus, the majority of IC market growth in 1995 came from ASP increases, not unit volume increases.

As shown in Figure 1-18, ICE believes that 3Q96 was the low point for IC ASPs in 1996. Moreover, ICE expects that 4Q96 was the beginning of a gradual recovery in the IC market that will carry over into 1997.

Figure 1-19 shows semiconductor ASPs and unit volume shipments for 1991-1997. The cause of fluctuations in the market as measured in dollars is usually more easily understood by examining ASP and unit volume changes. As was shown earlier, the total IC market in 1996 was more influenced by ASP than by unit volume changes.

It is interesting to compare semiconductor ASPs and shipments from the late 1980's with the early to mid-1990's. As shown, IC ASPs in the first half of the 1990's displayed dramatic annual increases compared with the late 1980's while unit volume average increases declined. For discretes, annual average unit volume increases of 10 percent are close to the norm (the same increase as total system sales dollars) with ASPs increasing in the 1990's instead of decreasing.

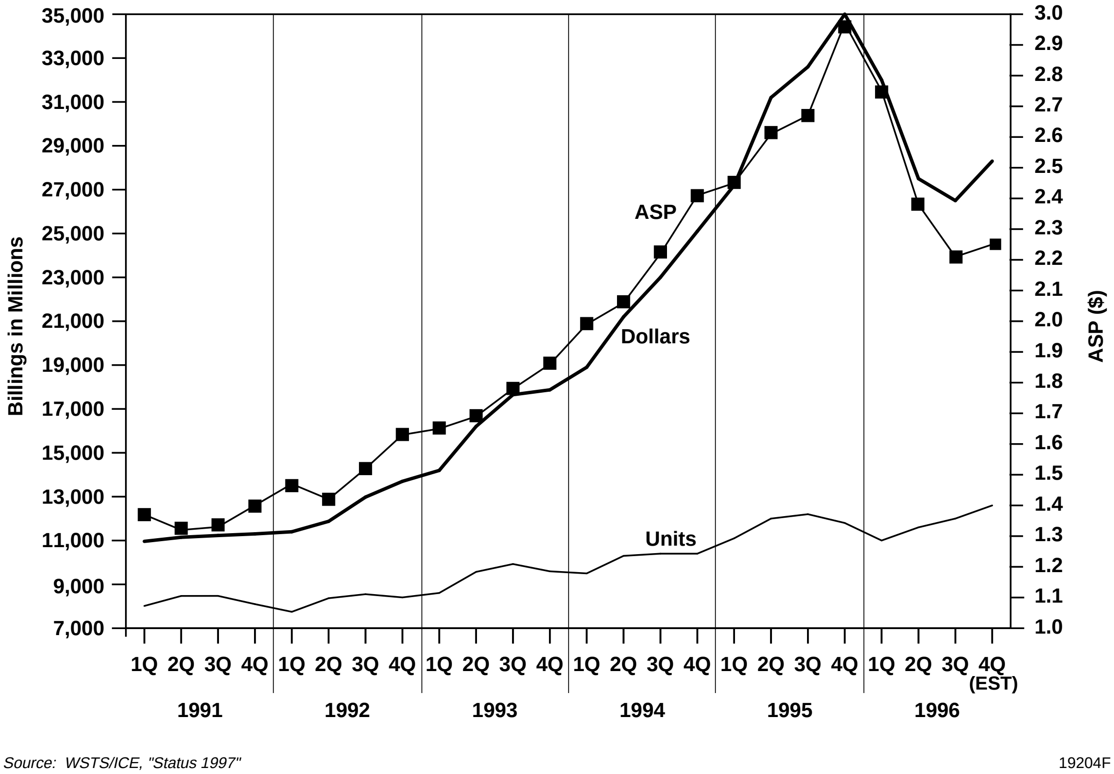


Figure 1-18. Total Merchant IC Market (Dollars and Units in Millions)

YEAR	ICs			DISCRETES			TOTAL SEMICONDUCTOR		
	MERCHANT MARKET ($B)	ASP	UNIT VOLUME (B)	MERCHANT MARKET ($B)	ASP	UNIT VOLUME (B)	MERCHANT MARKET ($B)	ASP	UNIT VOLUME (B)
1991	46.4	$1.35	34.4	10.5	$0.093	112.9	56.9	$0.386	147.3
1992	51.9	$1.51	34.4	10.4	$0.093	111.8	62.3	$0.407	153.2
1993	68.0	$1.75	38.9	11.8	$0.098	120.4	79.8	$0.501	159.3
1994	90.3	$2.17	41.6	14.3	$0.102	140.2	104.6	$0.575	181.8
1995	128.7	$2.63	48.9	19.0	$0.103	184.5	147.7	$0.633	233.4
1996 (EST)	116.9	$2.40	48.8	17.7	$0.100	177.2	134.6	$0.616	226.0
1997 (FCST)	130.4	$2.51	52.0	19.3	$0.100	193.0	149.7	$0.611	245.0
1991-1997 CAGR	19%	11%	7%	11%	1%	9%	18%	8%	9%
1986-1990 CAGR	20%	7%	13%	9%	–2%	11%	18%	6%	11%

Source: ICE, "Status 1997" 13745V

Figure 1-19. Worldwide Merchant Semiconductor Market, ASP, and Unit Volume Shipments

Figure 1-20 shows the discrete and IC unit volume shipments from 1982-1997. After a flat semiconductor unit shipment year in 1992, healthy growth for IC and discrete unit volume was registered in 1993, 1994, and 1995. A surge in automotive and telecommunications use of discrete semiconductors, as well as some inventory building, were the main reasons for the strong gain in discrete unit shipments in 1994 and 1995.

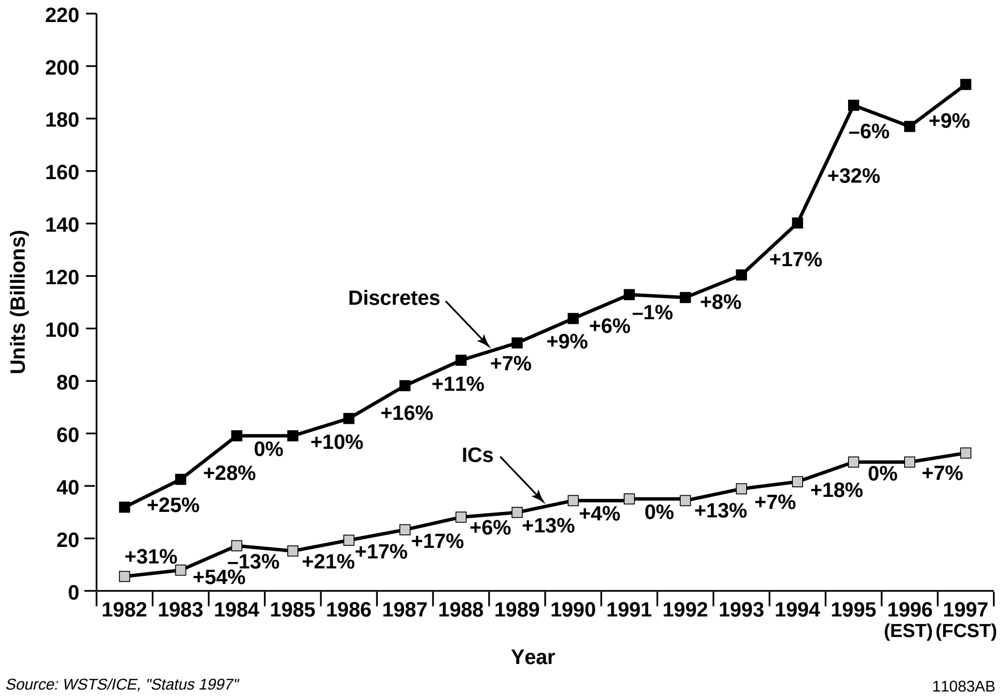


Figure 1-20. Worldwide Merchant Semiconductor Unit Shipments

Both IC and discrete unit volume shipments in 1996 were flat or slightly down when compared with 1995. One reason for IC unit shipment rate of growth declines is the continuation of the trend of high-density devices replacing numerous low-density units. "System-on-a-chip" ICs are discussed further in Section 3.

Another reason for flat 1996 unit sales is the paring down of inventory by the electronic system houses. Although a significant amount of excess IC inventory was not built-up in 1995, system suppliers began lowering the "typical" level of parts supply they keep in inventory. For example, while many PC suppliers were keeping three to four weeks worth of IC inventory in 1995, in 1996, IC inventory levels were down to only two days at some companies!

As is almost always the case, an overcapacity situation leads to steady or declining pricing. Conversely, a shortage of capacity will usually lead to dramatically increasing prices. To help gauge the capacity situation in the semiconductor market, ICE has tracked worldwide capital spending as a percent of worldwide semiconductor sales from 1979-1996 (see Section 2).

As one would imagine, the 26-27 percent spending of 1984-1985 led to significant overcapacity while the 16 percent spending rate in 1986-1987 ultimately led to a capacity shortage during the 1988 expansion. ICE estimates that it currently takes about a 21 percent spending rate to meet the relentless capacity needs of the semiconductor industry.

Figure 1-21 shows the IC ASP trends from 1982-1997. Also shown on the chart is the average capital spending as a percent of semiconductor sales for each three- or four-year period.

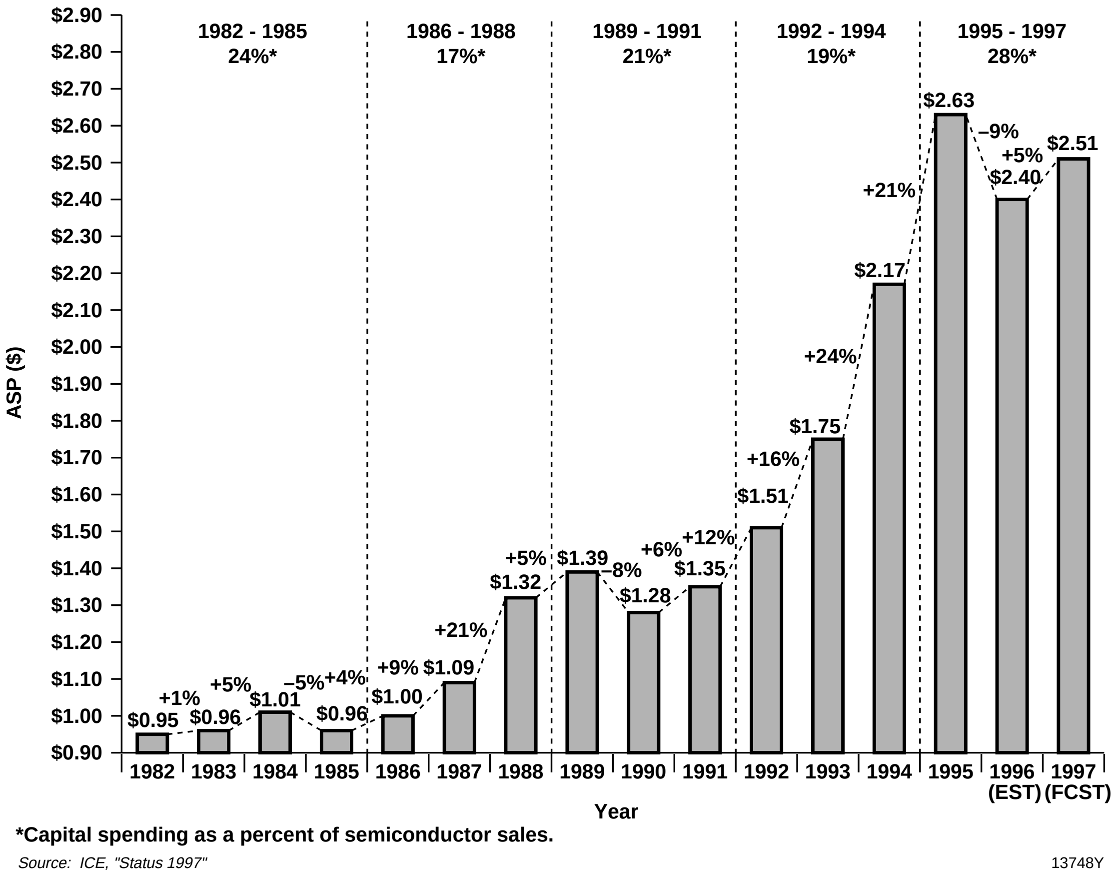


Figure 1-21. Merchant IC ASPs (1982-1997)

As shown, each period where capital spending averaged over 21 percent or more, IC ASP stayed flat or declined. Even during the boom year of 1984, IC ASP increased only five percent. However, when the spending rate averaged less than 21 percent, IC ASP displayed significant increases (from 1986 to 1988 and from 1992 to 1994). The 1996 ASP decline was a direct result of the "excess" spending (particularly for DRAMs) by the IC industry in 1995.

Figure 1-22 shows the percentage of the market represented by each geographical region for 1982, 1992, 1995, 1996, 1997, and 2001. Drawing upon the same assumptions used for ICE's electronic system production forecasts (shown earlier), the Japanese market is expected to significantly decline in share while the North American and European segments are forecast to stay relatively flat. The ROW region will continue its role as the fastest growing region by gaining an average of one point of marketshare per year through 2001. Figure 1-23 shows the 1996 to 2001 CAGR forecast for the four major semiconductor market regions.

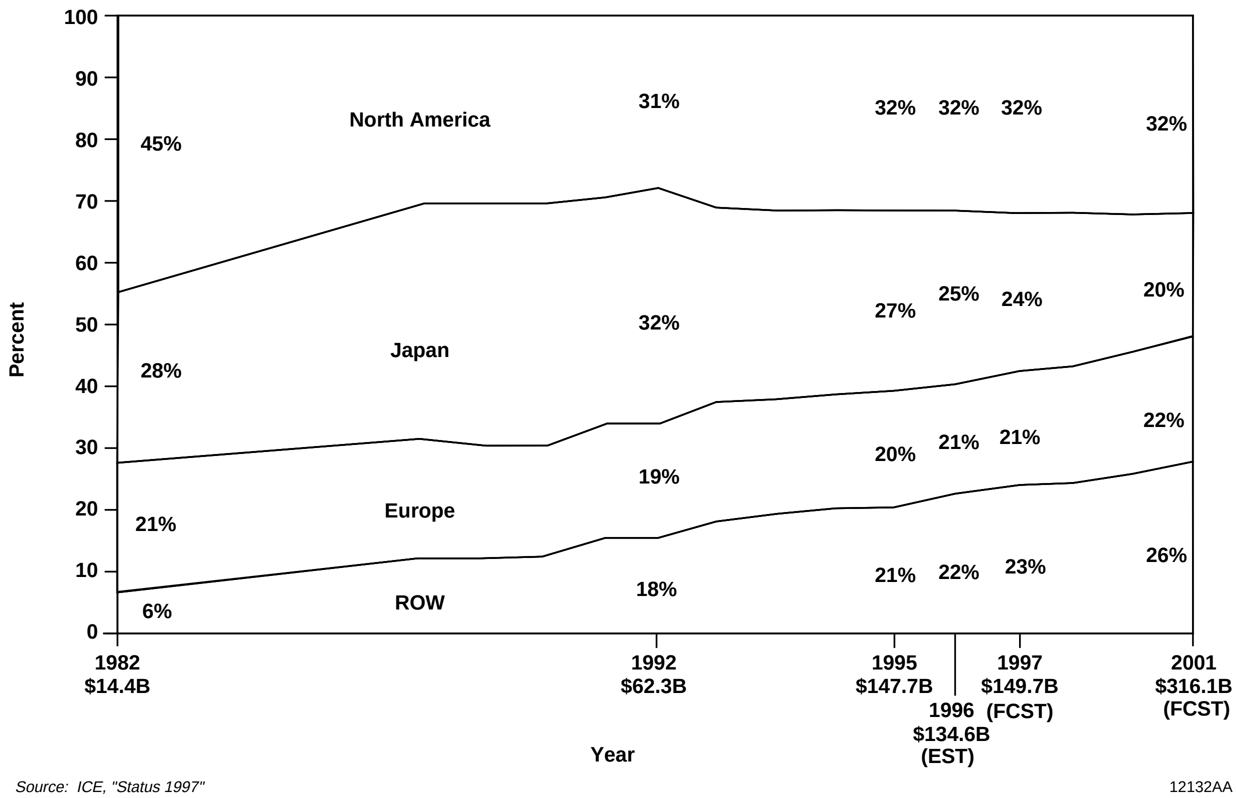
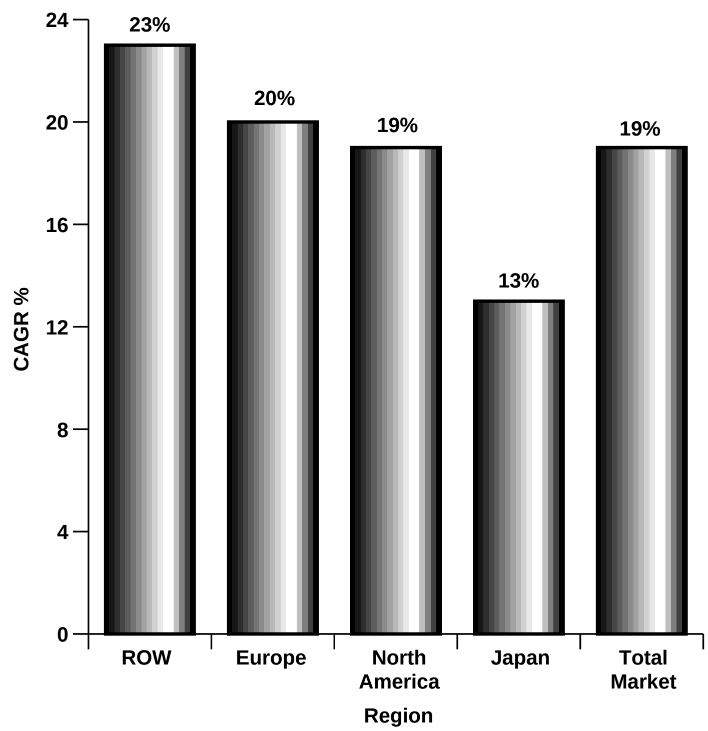


Figure 1-22. Worldwide Merchant Semiconductor Markets

Figure 1-24 shows 1992-1996 actuals and ICE's 1997 and 2001 forecasts for the merchant semiconductor market by region. The Japanese market would have displayed only a 12 percent 1993-1996 CAGR if expressed in yen! Figure 1-25 shows some key points drawn from the data shown in Figure 1-24.

Ultimately, the evolution of the semiconductor market (i.e., consumption) will follow the electronic system industries. ICE expects the electronic system production base to continue to slowly migrate to Singapore, Korea, Taiwan, etc., and along with it, an increasing percentage of the semiconductor market. As has been discussed, the opposite is forecast to happen in Japan.



Source: ICE, "Status 1997"   20207C

Figure 1-23. 1996-2001 Semiconductor Market CAGR by Region

Semiconductor Markets	1993 ($B)	1994/1993 Percent Change	1994 ($B)	1995 ($B)	1995/1994 Percent Change	1996 (EST, $B)	1996/1995 Percent Change	1997 (FCST, $B)	1997/1996 Percent Change	2001 (FCST, $B)	1996-2001 CAGR (%)
Discrete Markets											
North America	2.5	25	3.1	3.9	26	3.7	–5%	4.0	8%	6.7	13%
Japan	4.7	14	5.4	6.7	24	5.9	–12%	6.3	7%	8.8	8%
Europe	2.1	24	2.6	3.8	45	3.7	–3%	4.0	8%	7.2	14%
ROW	2.5	28	3.2	4.6	44	4.4	–4%	5.0	14%	9.9	18%
Total Discrete	11.8	21	14.3	19.0	35	17.7	–7%	19.3	9%	32.6	13%
IC Markets											
North America	22.9	37	31.2	43.5	39	39.3	–10%	43.5	11%	95.0	19%
Japan	19.5	26	24.5	33.4	36	28.3	–15%	30.5	8%	55.5	14%
Europe	12.8	37	17.5	24.8	42	24.5	–2%	27.7	13%	61.7	20%
ROW	12.8	34	17.1	27.0	58	24.8	–9%	28.7	16%	71.3	24%
Total IC	68.0	33	90.3	128.7	43	116.9	–9%	130.4	12%	283.5	19%
Semiconductor Market											
North America	25.4	36	34.3	47.4	38	43.0	–8%	47.5	11%	101.7	19%
Japan	24.2	24	29.9	40.1	34	34.2	–15%	36.8	8%	64.3	13%
Europe	14.9	35	20.1	28.6	42	28.2	–2%	31.7	12%	68.9	20%
ROW	15.3	33	20.3	31.6	56	29.2	–9%	33.7	15%	81.2	23%
Total Semiconductor	79.8	31	104.6	147.7	41	134.6	–9%	149.7	11%	316.1	19%

Source: ICE, "Status 1997"   18946G

Figure 1-24. Worldwide Merchant Semiconductor Market Forecast

- **In yen, the Japanese semiconductor market from 1993-1996 increased at only a 12% CAGR. The total semiconductor market showed a 19% CAGR during this same timeframe.**
- **Exchange rate fluctuations are the main cause behind the –15% drop in the 1996 Japanese market.**
- **ROW IC market became larger than that of Europe in 1995.**
- **ROW and European semiconductor regions are forecast to be larger than Japan by 2001.**
- **The North American semiconductor market is forecast to be more than $100 billion in 2001.**

Source: ICE, "Status 1997" 21050A

Figure 1-25. Worldwide Merchant Semiconductor Market Forecast Highlights

It is generally agreed that the ROW semiconductor market with the greatest potential in the late 1990's is China. China is the world's largest consumer market, with 1.2 billion citizens whose incomes are rising rapidly. Currently, though, only a small fraction of Chinese make enough money to be significant consumers for electronic systems. That means that there is tremendous potential demand for all sorts of products, including consumer electronics, computers, communications, and other electronic equipment as the Chinese standard of living increases.

Computers and communications are of particular importance to the Chinese government. The country's market for personal computers was 350,000 units in 1993, and is forecast to reach 2.5 million units by the year 2001. In the area of communications, telephone subscriptions totaled 26 million units in 1993, and are forecast to jump to 73 million by the year 2001.

Of course, strong demand for electronic products means strong demand for semiconductors. As shown in Figure 1-26, China's consumption of semiconductors has increased on the average of about 28 percent per year. In 1996, the majority of those semiconductors were built into consumer products such as TVs, audio equipment, and game machines (Figure 1-27). However, as the figure shows, demand for semiconductor devices for communications equipment, personal computers, and VCRs will experience the strongest growth in the coming years.

To support demand for semiconductors, the country has had to depend on imports, especially in the case of ICs, where up to 80 percent are imported. This is a situation the Chinese government is eager to change. In fact, the country would like to build enough semiconductors to support its own needs, and also export a significant amount of devices to the Asia-Pacific market. Figure 1-28 shows the flurry of semiconductor activity in China in 1996.

As was shown earlier, the 1996 Chinese semiconductor market grew a strong 32 percent. Using a conservative 30 percent average annual growth rate, the Chinese semiconductor market in 2001 would be a significant $9.3 billion.

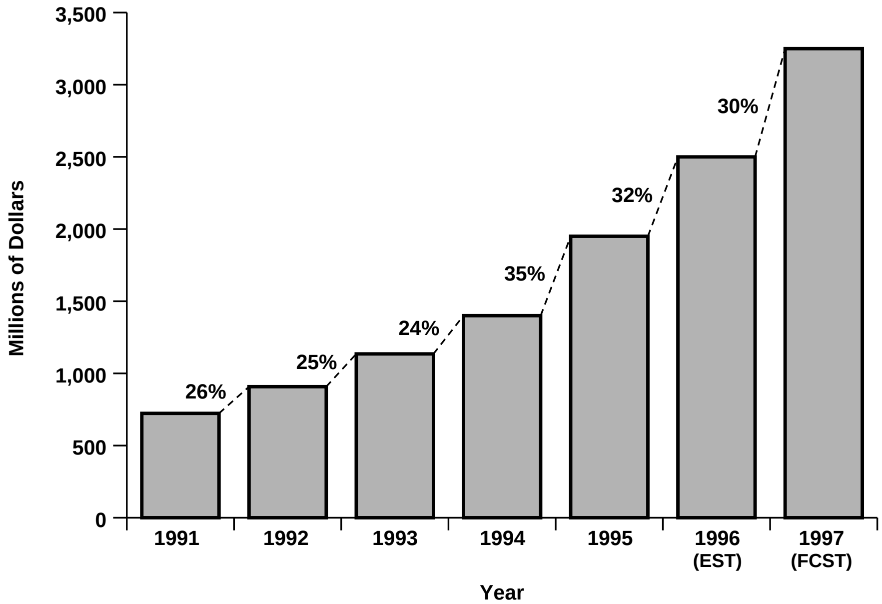


Figure 1-26. China's Semiconductor Market

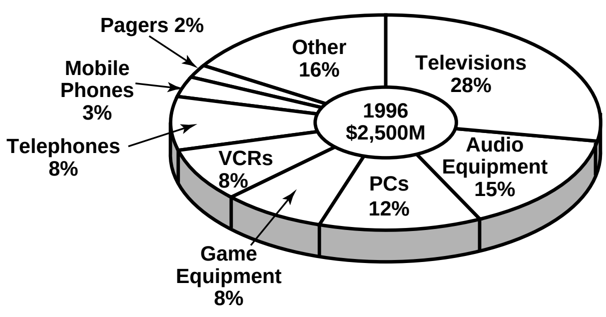


Figure 1-27. China's Semiconductor Market by End-Use Application

THE NORTH AMERICAN SEMICONDUCTOR MARKET

In the fourth quarter of 1993 it appeared as if the North American semiconductor market boom period was about to end (Figure 1-29). However, in December of 1993 and throughout 1994 and 1995, the good times returned with the book-to-bill ratio reaching 1.19 in July of 1995 (Figure 1-30).

The good times ended with a jolt beginning in January of 1996. It was in this month that DRAM suppliers reached that magical supply/demand balance and prices started to tumble. Also in January, the book-to-bill ratio dropped below 1.00. However, as shown, October's book-to-bill ratio surged to 1.10 as computer makers returned to the market after their inventories were pared-down as far as possible. Subsequently, ICE estimates that positive quarter-to-quarter growth occurred in the fourth quarter of 1996 (refer back to Figure 1-29).

- **Samsung is considering building a wholly-owned IC wafer fab at the site of its IC assembly and test facility (Suzhou, China).**
- **NEC is considering establishing 16M DRAM production (0.5µm) at its Chinese joint-venture fab (Shougang-NEC Electronics) by late 1997. Capacity would be increased to 16,000 150mm wafers/month, from the current 8,000 wafers/month. NEC also plans to increase its stake in the joint-venture from 40% to 51%.**
- **AMD began construction of an IC assembly and test facility in Suzhou, China. The facility is expected to be operational in late 1997.**
- **Beginning in April 1996, China imposed 20%-30% tariffs on computers, semiconductor production equipment, and medical electronics on those companies "registered" after January 1, 1996. A temporary exemption was extended to those Chinese joint-venture companies valued at $30 million or greater. Imported IC tariffs in China range from 15%-20%.**
- **Harris began construction of an IC test and assembly plant in Suzhou, China. Production is scheduled to begin in early 1997.**
- **The China Ministry of Electronics Industry and the city of Shanghai plan to jointly fund (about $1.0 billion) a 200mm 0.5µm IC fab facility in Pudong, China (a Shanghai suburb). The company, The Shanghai Hua Hong Microelectronics Co., Ltd., plans to begin production in late 1998, with a capacity of 20,000 wafers/month.**
- **Mitsubishi, the Stone Group, and Mitsui of China agreed to establish a jointly-owned IC assembly and test facility in Beijing, China. Production is scheduled to start in mid-1997.**
- **Hitachi and the Economic Development Bureau of Singapore established a joint-venture to assemble and test 4M DRAMs in Suzhou, China. Production is planned to begin in mid-1997.**
- **Intel began construction of a wholly-owned 486 and flash memory assembly and test facility in Pudong, China. Production is scheduled to begin in early 1998.**
- **Motorola operates an MCU and analog IC assembly facility in Tianjin, China. Its 0.5µm 200mm IC fab is on schedule to begin in late 1997 or early 1998.**

Source: ICE, "Status 1997" 21673

Figure 1-28. Sampling of Semiconductor Activity in China in 1996

It should be remembered that the North American book-to-bill ratios are now seasonally adjusted. While the previously unadjusted book-to-bill ratios typically declined in the second half of each year, the currently reported seasonally adjusted ratios are intended to eliminate such seasonally caused patterns. Thus, it must be looked at as a coincidence that both the seasonally adjusted and unadjusted North American book-to-bill ratios slumped in late 1993 and 1994 only to recover shortly thereafter.

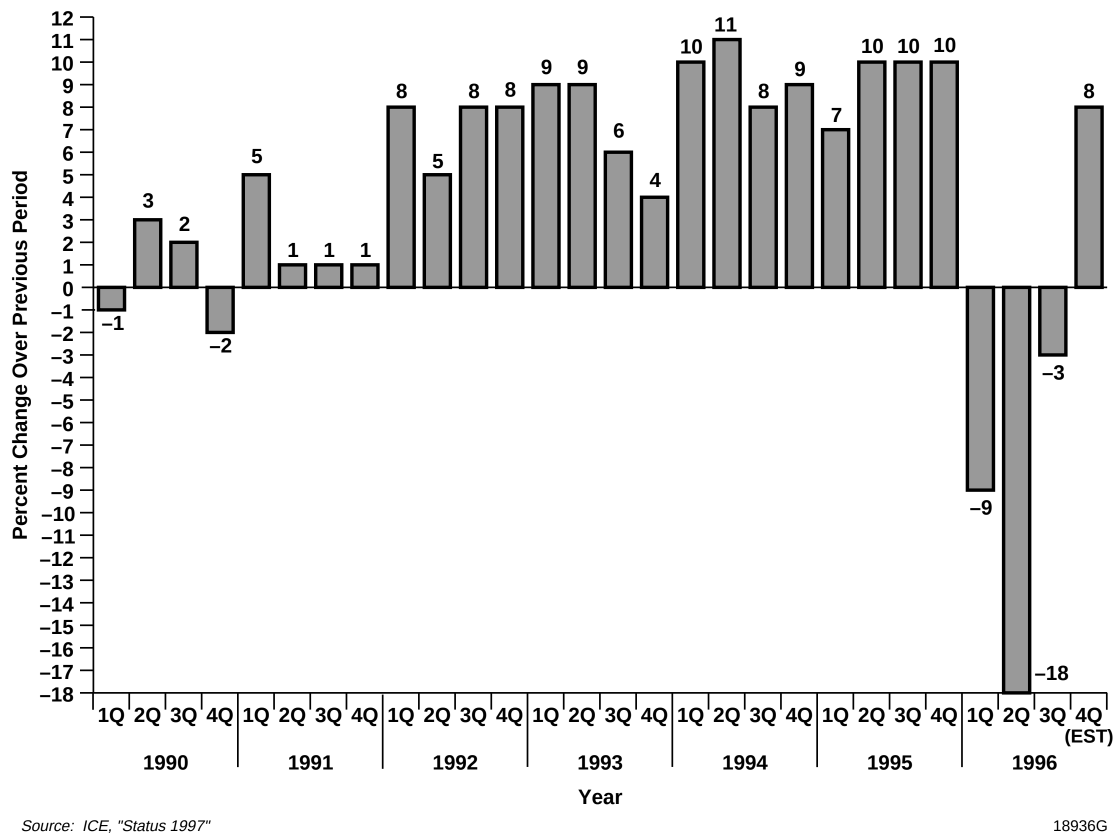


Figure 1-29. Quarterly 1990-1996 North American Merchant Semiconductor Market Growth

Figure 1-31 shows quarterly North American IC bookings from 1992 through 1996. The figure illustrates the steep drop that occurred in 1Q96. The 31 percent decline in bookings was the biggest quarterly drop since 4Q84 (–35 percent). The quarterly decline in bookings was a staggering $4.1 billion! ICE believes that 3Q96 was the low-point for North American IC bookings in this downturn, with a good increase expected for the fourth quarter of 1996 (especially if system sales stay healthy).

Figure 1-32 shows quarterly North American discrete bookings from 1992 through 1996. Similar to IC bookings, discrete bookings plunged in 1Q96. In fact, the weakness continued through 3Q96. Similar to the North American IC market, discrete bookings were estimated to have shown an increase in 4Q96/3Q96.

As was shown earlier, computer/office automation system production drives the majority of the IC consumption (i.e., market) in North America. With so much of the North American IC market dependent upon one segment of the systems industry, it is helpful to examine the computer/office automation sector in greater detail.

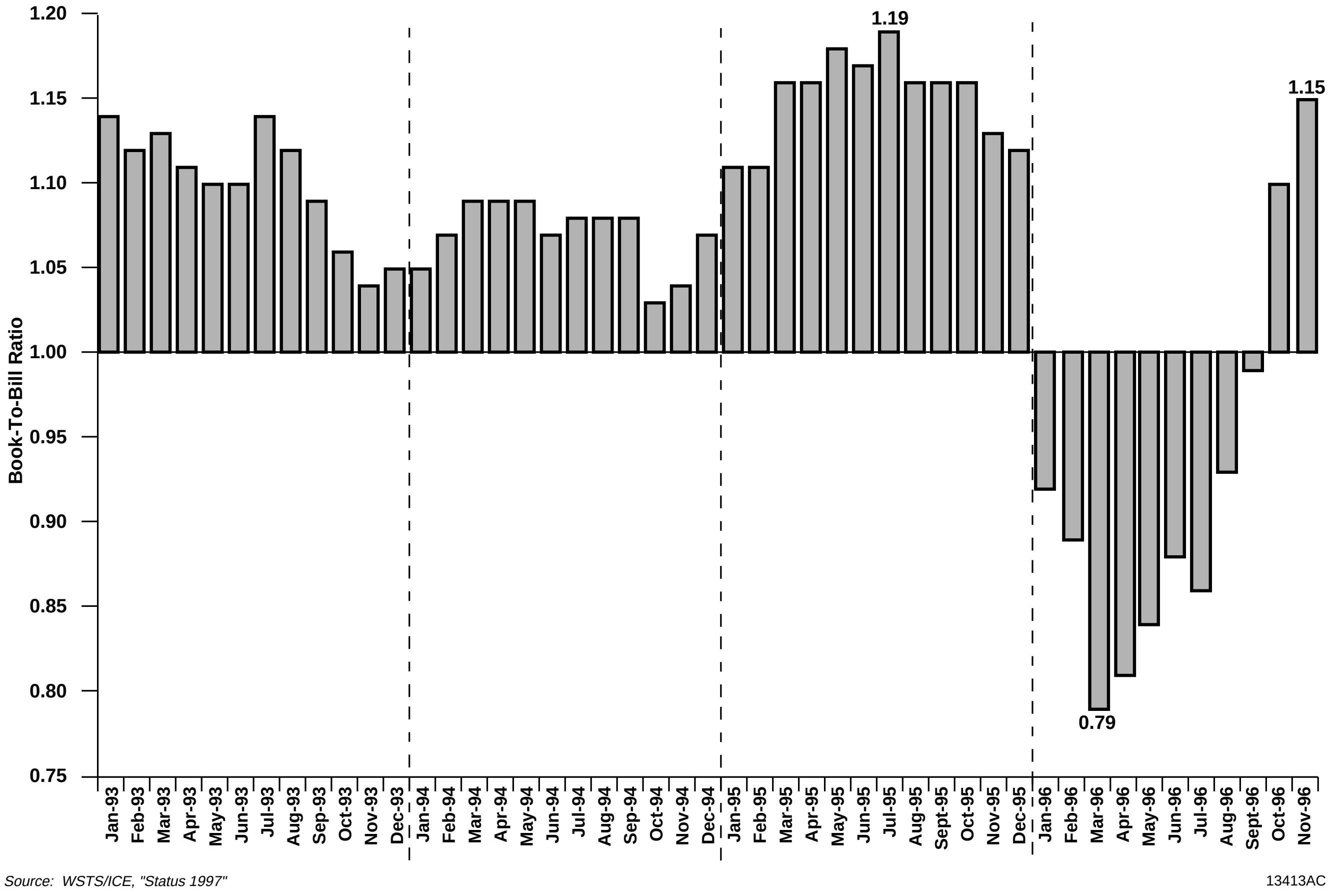


Figure 1-30. North American Semiconductor Market Seasonally Adjusted Book-To-Bill Ratios

Figure 1-33 compares the annual North American computer and IC market growth rates from 1983 through 1996. Until 1996, the only year that computer shipment growth performed significantly better than the IC market was in 1985. This anomaly was caused when significant IC inventory built up in 1984 was "burned-off" throughout 1985. In 1995, electronic systems houses did not accumulate any significant IC inventory overhang. However, in 1996, the system companies lessened the amount of inventory held to a couple of weeks or less* .

Typically the IC market increases much faster than computer shipments. For 1992, 1993, 1994, and 1995, the IC market grew at least twice as fast as computer shipments. Overall, ICE believes that 1996 (13 percent computer shipment growth versus a -10 percent IC market) came closer to resembling 1985 than to 1995.

* Essentially burning-off what the system companies' believed was "excess" inventory.

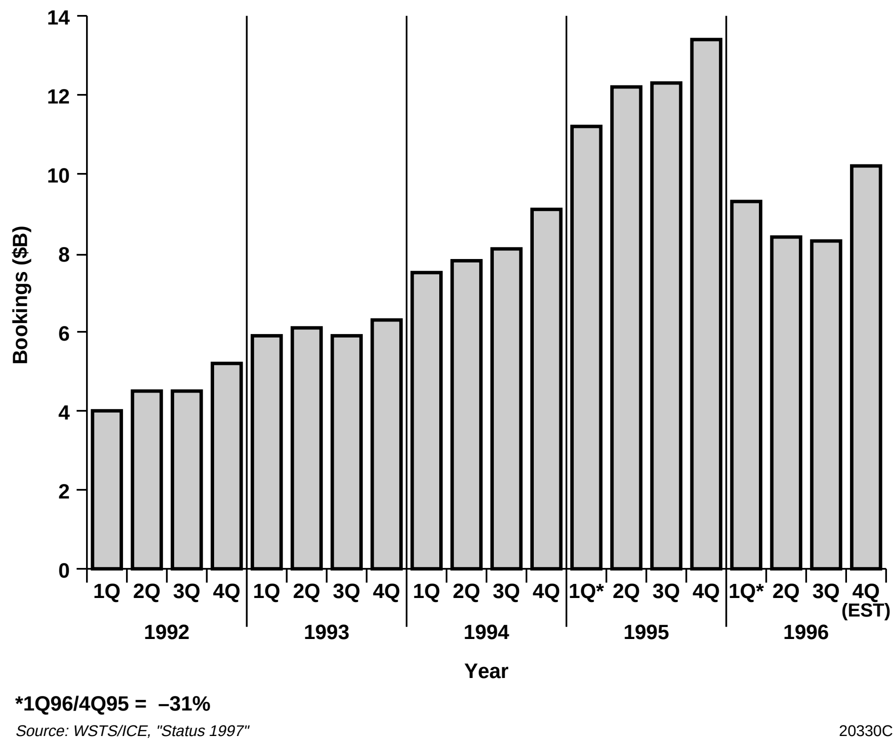


Figure 1-31. Quarterly North American IC Bookings

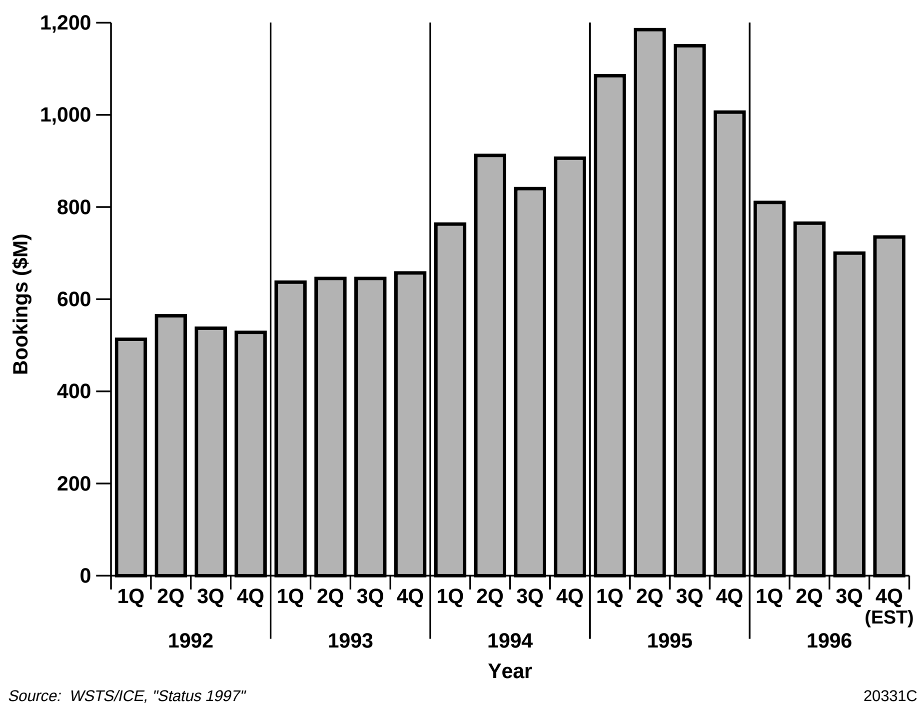


Figure 1-32. Quarterly North American Discrete Bookings

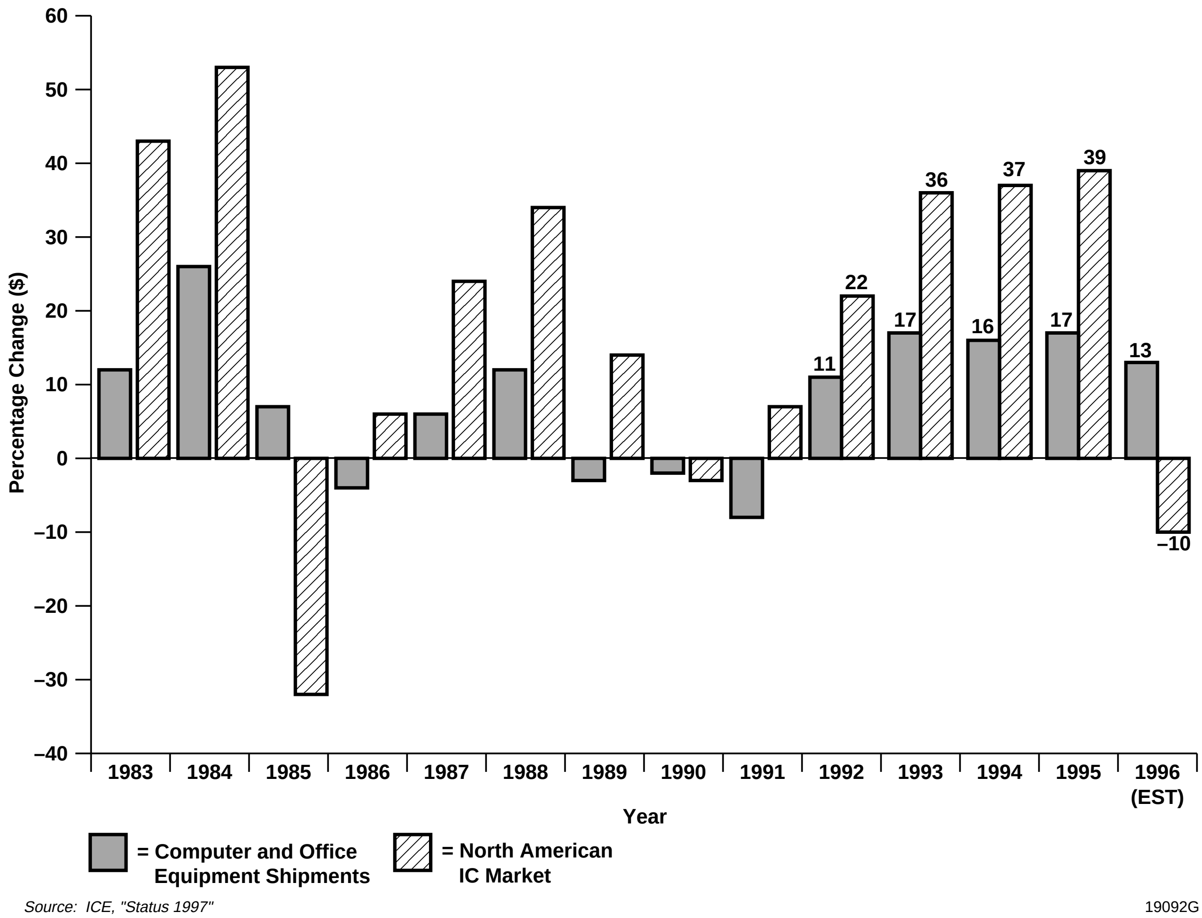


Figure 1-33. North American Computer Shipment and IC Market Growth Rates (1983-1996)

The reason for the typically much faster growth rate of the IC market versus computer shipments is two-fold. First, computer unit shipments usually grow faster than computer dollar shipments. Thus, while the dollar value of PC shipments may grow 18 percent, unit shipments will grow 20-22 percent (indicating PC system pricing declines). Because each PC needs an MPU and an increasing amount of memory, and when memory IC prices stay firm, the IC dollar market grows much faster than computer dollar shipments. In 1996, however, memory (especially DRAM and SRAM) prices plummeted.

Another reason for the typically faster IC dollar market growth as compared to computer dollar growth is that many of the newer, more popular computer systems have a very high IC content value. Listed in Figure 1-34 are some of the estimates for IC content of computer systems in 1996.

Computer Type	IC Content ($)
Mainframe	8 – 10%
Midrange Systems	10 – 14%
Workstations	15 – 18%
Personal Computer (PC)	30 – 35%
Personal Digital Assistant (PDA)	40 – 50%
Network Computer (NC)	50 – 70%

Source: ICE, "Status 1997" 19265B

Figure 1-34. 1996 IC Content in Computer Systems

Component	Cost ($)
Java CPU	50
4Mbytes DRAM	80*
3Mbytes Flash	40
PCI Video	70
Audio	30
Ethernet	60
Super I/O	10
Misc. Logic	50
PCB	20
Enclosure	20
Power Supply	15
Total Cost	445

***As of 4Q96 this cost would be about $25.**

Source: Sun/Microprocessor Report/ ICE, "Status 1997" 21060A

Figure 1-35. Proposed Java NC Material Costs

Figure 1-35 shows the 2Q96 proposed materials cost of Sun's so-called Java NC (network computer) or "$500 PC." These NCs are intended to perform basic PC tasks (e.g., spreadsheets, and word processing), as well as surf the Web. Even though the 4 megabyte DRAM cost shown in Figure 1-35 was only about $25 in 4Q96, the IC content in this computer would still be greater than 50 percent of the system price (assuming a $500 price tag).

As PCs (and maybe NCs) and PDAs become a larger portion of the overall computer market*, the IC content value in computers will continue to rise. ICE expects this trend to continue throughout the 1990's. The result of this trend was shown earlier as a 23.4 percent semiconductor content in electronic systems value forecast for 2001.

Figure 1-36 shows how well computer shipments and IC market trends have correlated. This was especially true from July of 1993 through May of 1996. Beginning in June of 1996 the U.S. IC market and computer and office equipment trend lines headed in the opposite directions. Obviously, with the strength of the electronic systems market, other "factors" were at work to depress the U.S. IC market.

* PCs represented 25 percent of the 1985 computer market but 68 percent of the 1996 computer market.

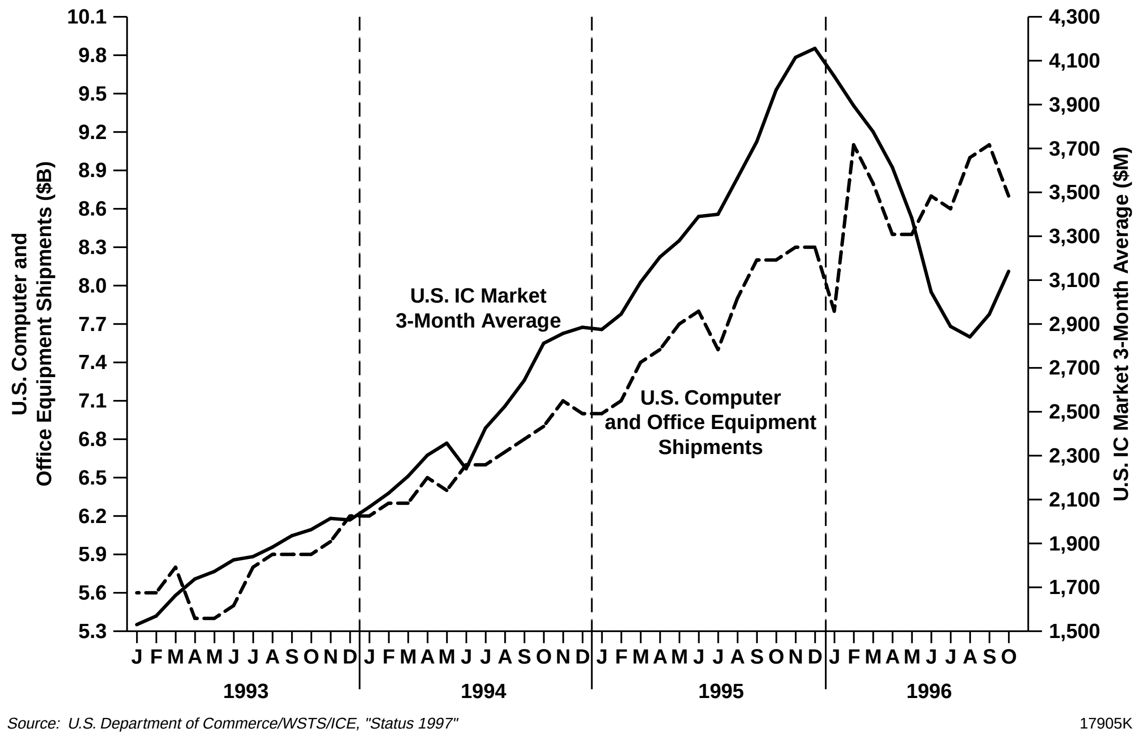


Figure 1-36. U.S. Computer Shipments Versus U.S. IC Market

As was previously mentioned, the two main factors that depressed the U.S. IC market were the collapse of the DRAM market and the "inventory corrections" of electronic system producers. ICE believes that the upturn in the IC market beginning in September of 1996 was an indication that the "bottom" of the corrective period was probably reached in 3Q96.

Given the typically good correlation between computer shipments and the IC market, computer bookings may be valuable as a short-term leading indicator. Figure 1-37 shows the January through October computer bookings growth rates from 1992 through 1996. The first ten months of computer bookings in 1995 did not foretell the strong year for the semiconductor industry. This was due in part to DRAM pricing remaining stubbornly high throughout 1995 and system companies increasing their "required" inventory holdings.

What Figure 1-37 also shows, however, is the underlying and continued health of the North American computer market through the first ten months of 1996. This underlying strength is one reason ICE remains positive concerning 1997. If system sales continue to remain healthy, 3Q96 will represent the low point in this "corrective" period.

A lesson learned from 1996's downturn in the semiconductor market is that strong semiconductor "bookings" can be misleading. Oftentimes, many computer and other electronic system producers fight for semiconductor supplies for quite some time. Afraid of "losing their place in line," they do not immediately cut back on semiconductor purchase orders at the first sign of a slowdown in their system bookings. Thus, to the semiconductor producer everything looks fine because orders are still streaming in (e.g., late 1995).

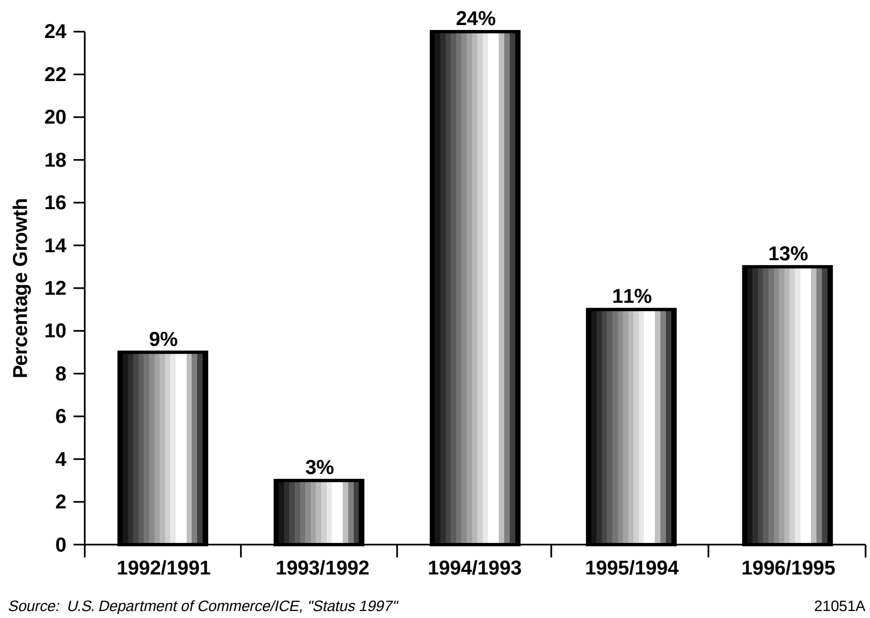


Figure 1-37. January - October North American Computer Order Trends ($, Seasonally Adj.)

When the electronic system producer is convinced that its system order rates are flattening, which may take two or three quarters of softness, it will cut back on semiconductor orders. How deep these cutbacks are depends on how soft the system sales orders become. As has been discussed, "adjusting" inventory levels downward (e.g., the first three quarters of 1996) can also give the IC supplier whiplash.

What does the future hold for the North American semiconductor market? As Figure 1-38 shows, the 1992-1995 boom period lasted two years longer than the two previous expansions. However, the good times did not end just because they continued beyond historical norms. As was discussed earlier, inventory corrections and the DRAM overcapacity situation "forced" an end to the longest North American semiconductor boom period since the 1970's. However, ICE is still very optimistic about the long-term health and vitality of the North American and worldwide semiconductor industries.

Figure 1-39 compares computer bookings to the semiconductor market. As shown, fairly healthy computer bookings increases in 3Q and 4Q 1996 portend well for the semiconductor market heading into 1997.

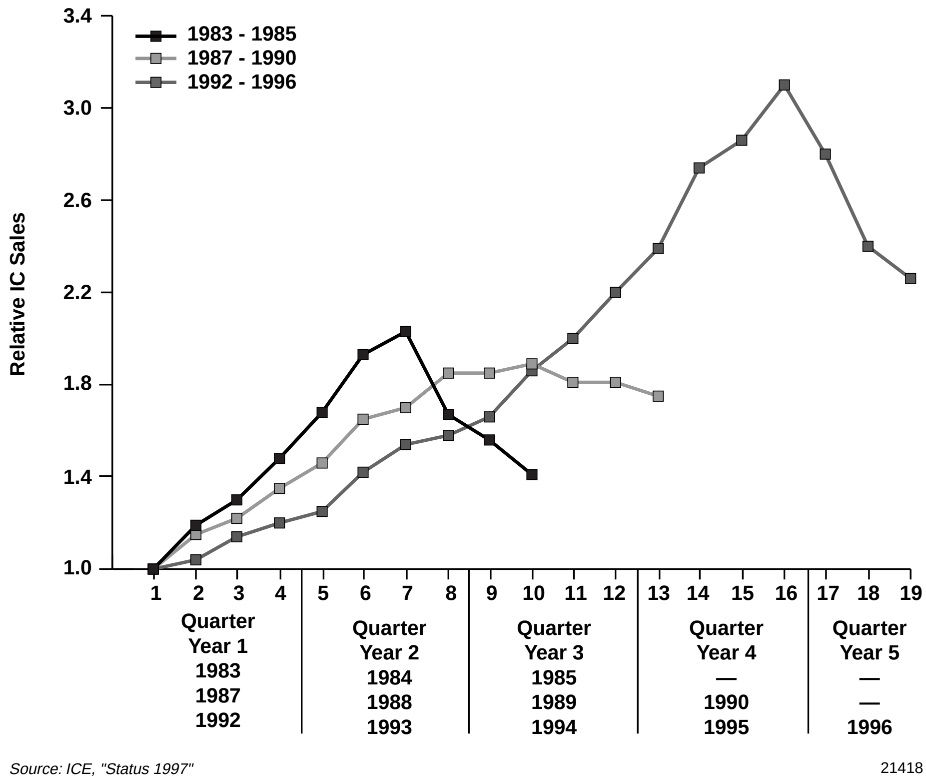


Figure 1-38. Worldwide IC Market "Boom" Period Comparisons

TRADE ISSUES

U.S.-Japan Semiconductor Trade

In 3Q94, U.S. and Japanese trade negotiators agreed to extend the semiconductor trade agreement, originally signed in September of 1986, until July of 1996. The original U.S. goal was for the foreign share of the Japanese market to be about three times the nine percent level it was at the beginning of the trade pact. In 1Q96, this marketshare goal had been exceeded. Moreover, since 1986, foreign marketshare in Japan has increased almost two points per year.

All the hoopla associated with the targeted 20 percent foreign marketshare in Japan was well documented. As shown in Figure 1-40, the first three quarters of 1993 witnessed the slide in foreign marketshare in Japan before rebounding in 4Q93 and 1994. In fact, the 1993 average figure was 19.4 percent and 1994 was the first year that averaged over 20 percent (22.4)*.

* 1995 averaged 25.4 percent.

Period	Percent Change Over Previous Period	
	Semiconductor Market	Computer Bookings
1983 1Q	—	–6
2Q	15	20
3Q	12	4
4Q	13	—
1984 1Q	10	13
2Q	16	5
3Q	5	–2
4Q	–5	4
Average	8	5

1983-1984

Period	Percent Change Over Previous Period	
	Semiconductor Market	Computer Bookings
1987 1Q	4	3
2Q	13	6
3Q	7	—
4Q	1	1
1988 1Q	8	6
2Q	12	6
3Q	6	–1
4Q	–1	–3
Average	6	2

1987-1988

Period	Percent Change Over Previous Period	
	Semiconductor Market	Computer Bookings
1992 1Q	8	7
2Q	5	6
3Q	8	3
4Q	8	3
1993 1Q	9	9
2Q	9	–1
3Q	6	5
4Q	4	13
1994 1Q	10	1
2Q	11	7
3Q	8	2
4Q	9	3
1995 1Q	7	3
2Q	10	3
3Q	10	–1
4Q	10	9
Average	8	5

1992-1995

Period	Percent Change Over Previous Period	
	Semiconductor Market	Computer Bookings
1996 1Q	–9	2
2Q	–18	2
3Q	–4	6
(EST) 4Q	8	3

1996

Source: ICE, "Status 1997"

18647F

Figure 1-39. North American Semiconductor Market and Computer Bookings "Boom" Period Comparison

It is generally known that the SIA wanted to see the foreign marketshare grow in Japan to 25 to 30 percent by mid-1996. In late-1995 these goals were met with a 29.6 percent foreign marketshare figure (30.2 percent by the Japanese calculations). However, the Japanese government became very negative toward continually meeting "hard" marketshare figures and did not want to extend the trade pact monitoring by U.S. or Japanese governments beyond July of 1996.

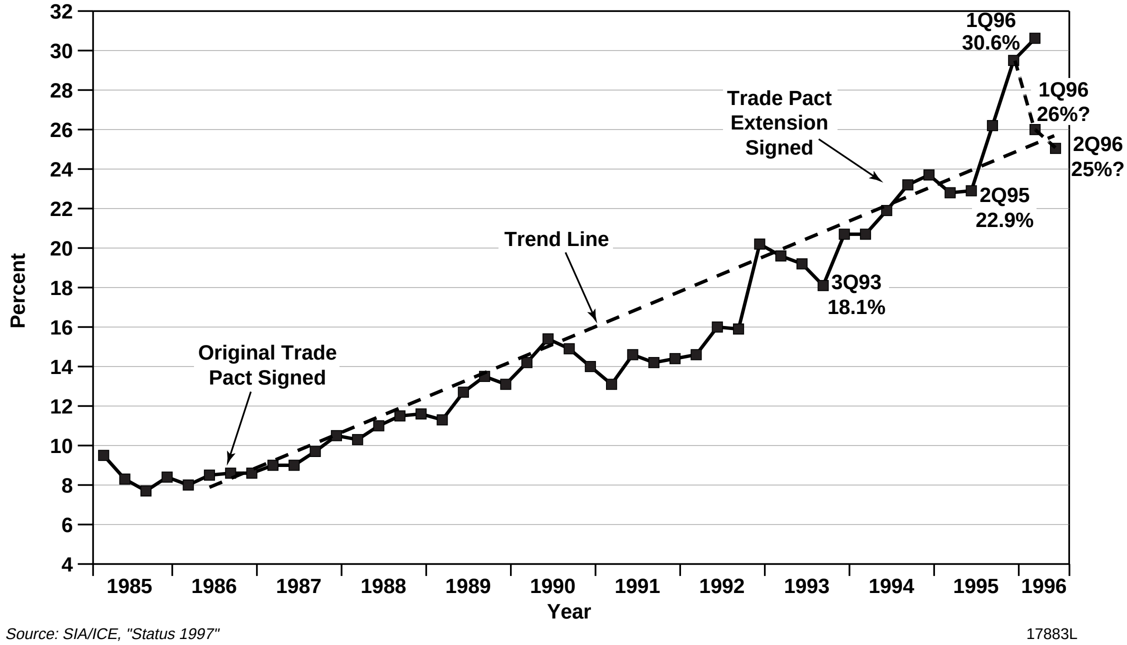


Figure 1-40. Foreign Semiconductor Marketshare In Japan

It is interesting to note that the 1Q96 foreign marketshare figure in Japan was believed to be overstated by three to four percentage points. The mistake was believed to have occurred when the Japanese overestimated Korean sales of DRAMs into Japan, given the sudden and steep drop in DRAM ASP. This was an intriguing coincidence considering that the 1Q96 foreign share figure was the number referred to throughout the summer of 1996 trade agreement talks between Japan and the U.S.

In October of 1995 it was reported that Japan was going to include the European Union (EU) in its semiconductor policy talks with the U.S. The SIA viewed the proposed inclusion of the EU as a "diversionary tactic" to avoid extending the semiconductor trade pact beyond July of 1996.

In late July 1996, the U.S. and Japan reached an understanding to eliminate the existing trade agreement (and its numerical marketshare targets). In its place will be a "Semiconductor Council" that will monitor semiconductor trade flow between Japan and the U.S.

The Semiconductor Council will initially be composed of the U.S. SIA (Semiconductor Industry Association) and the Japanese EIAJ (Electronic Industries Association of Japan) groups. Besides trade issues, the Council will address standards, patent, safety, and market development concerns.

The Council will submit reports to a Global Government Forum that will in turn allow each government to use the information in bilateral trade discussions. Although initially a bilateral agreement (between the U.S. and Japan), the new trade pact does include provisions for other countries participation in a World Semiconductor Council (WSC). The one stipulation for other countries planning to join the WSC are that they cannot have semiconductor tariffs in place. This rule currently precludes Korea (eight percent tariffs), Europe (seven percent tariffs), and China from joining the WSC*. An overview of the key points of the new trade agreement are shown in Figure 1-41.

- **A Semiconductor Council will be established to gather trade data and work on industry issues (e.g., standards, intellectual property, market development,etc.).**
- **The Council will be open to other country participation providing they do not have semiconductor tariffs in place.**
- **A Global Government Forum will report trade information to U.S. and Japanese government trade officials.**
- **Numerical marketshare targets are eliminated.**
- **A methodology for tracking and reviewing semiconductor cost data used for identifying "dumping" will be created.**

Source: ICE, "Status 1997" 21717

Figure 1-41. The New Japan-U.S. Trade Accord

Certainly, Japan has enjoyed a large IC trade surplus with the U.S. for several years as revealed in Figure 1-42. As shown, the 1995 trade gap was the largest ever, surpassing 1994's figure by over eight percent. A significant factor contributing to Japan's declining trade surplus in 1990 and 1991 was the dramatic reduction in 1M DRAM pricing. In contrast, the widened trade gap of 1993, 1994, and 1995 was mostly due to high-volume shipments of expensive DRAMs. Following historical patterns, 1996 witnessed a U.S. surplus (the first since 1978) in IC trade with Japan due to weak DRAM pricing levels.

Figure 1-43 shows how much the U.S. and Japan have "infiltrated" each other's markets. The U.S. lost one percentage point of marketshare in Japan in 1993, gained it back in 1994, gained two points in 1995, and surged five points in 1996. The increase in the U.S. marketshare in the early 1990's was a good sign that U.S.-made ICs are getting more "design-ins" into Japanese electronic systems.

The big gain in the U.S. companies' share of the Japanese IC market in 1996 was due to the collapse of DRAM prices. Since most of the U.S. IC exports to Japan are MPUs, ASICs, and DSPs, products that did not endure severe price degradation in 1996, the U.S. share of the total Japanese IC market surged.

* Europe originally planned to eliminate its chip tariffs by the year 2000. Korea planned to phase out its IC tariffs by 1999. Both are considering stepping up this schedule.

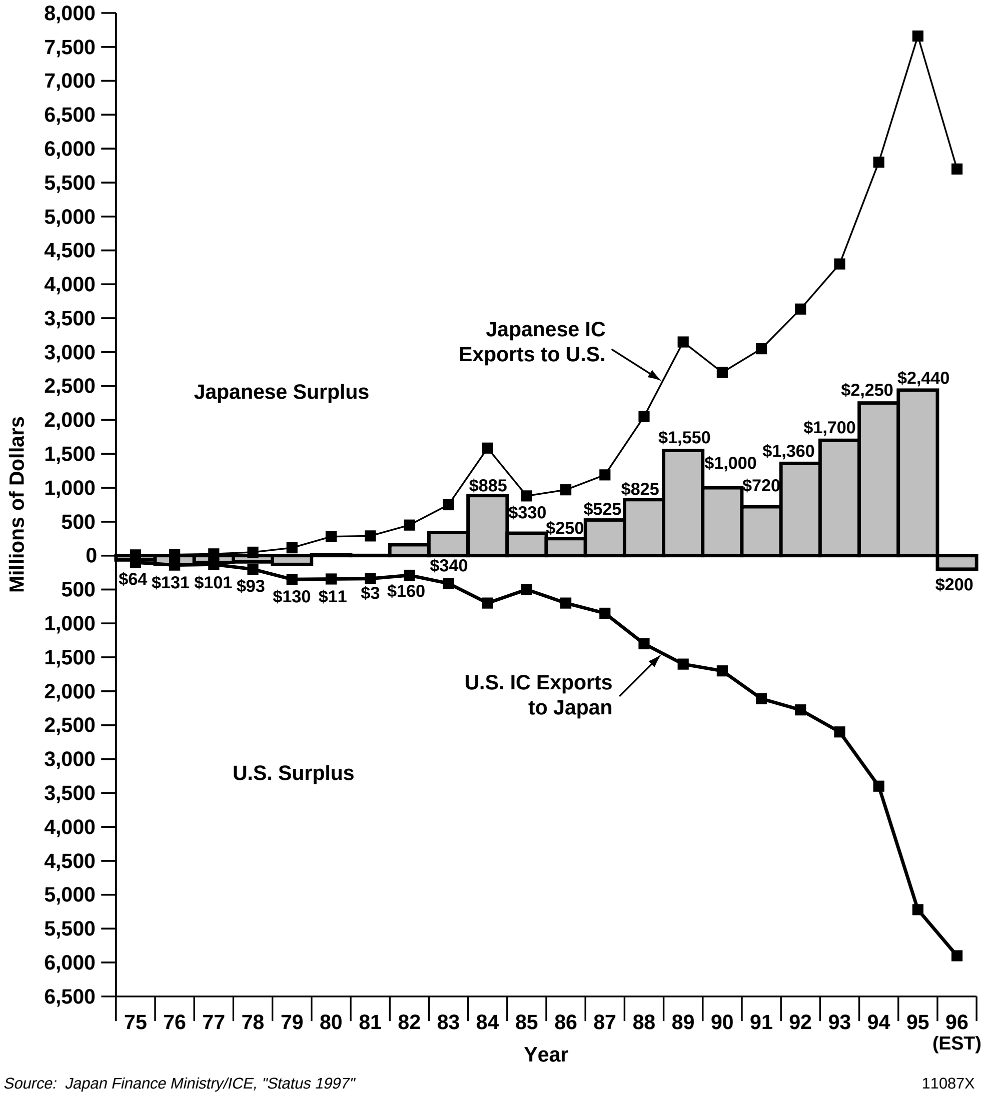


Figure 1-42. Japan-U.S. IC Trade

Japan's shrinking U.S. marketshare (as measured by imports) since 1992 can be partly explained by the numerous Japanese companies that now have large fab facilities on U.S. soil. NEC's Roseville, California, facility is a prime example. The company makes millions of DRAMs and ASICs at the Roseville fab and sells them to the U.S. market (as well as "exports" them to Japan). These sales are not counted as imports and therefore are not considered in Figures 1-42 and 1-43 as part of the U.S. market held by Japanese companies.

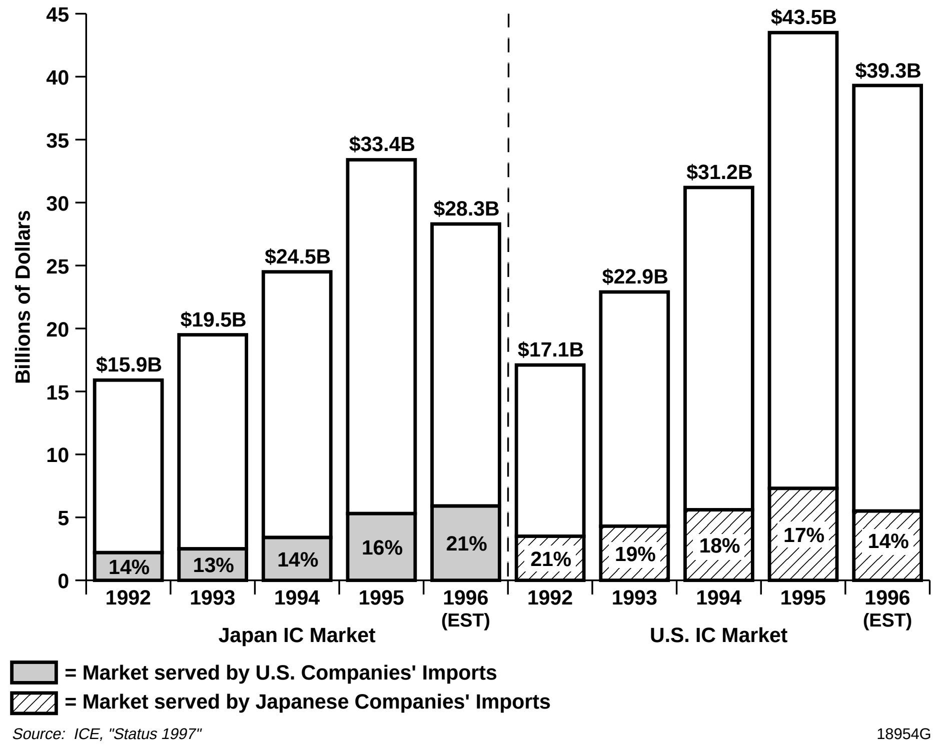


Figure 1-43. U.S. and Japanese IC Imports as a Percent of the Local IC Market

Figure 1-44 shows the country of origin for Japanese IC imports in 1995 and 1996. As shown, the Korean share dropped significantly in 1996, once again due to the steep DRAM price declines. It is interesting to note the strength shown by the Taiwanese companies in the Japanese IC market. This increase in Taiwanese share is indicative of the overall gains the Taiwanese producers have made in the IC industry since 1994 (see Section 2).

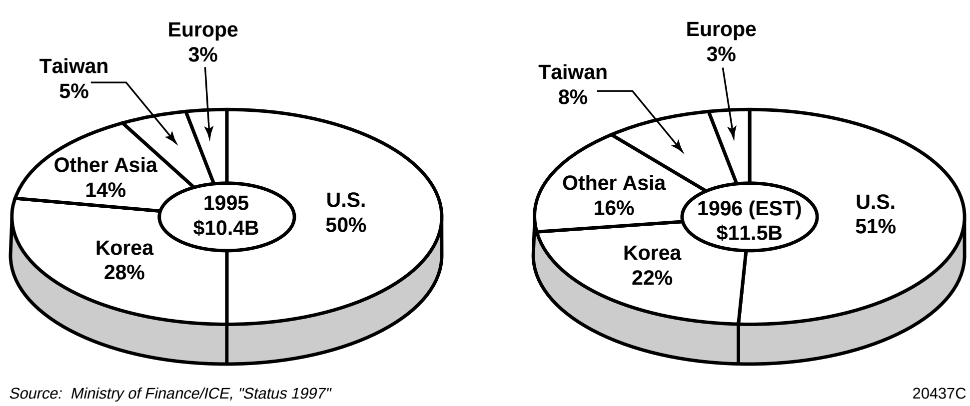


Figure 1-44. 1995 Versus 1996 Japanese IC Imports by Country of Origin

EAST EUROPE SEMICONDUCTOR MARKET UPDATE
(Contributed by Future Horizons; Kent, England)

Industry Background

At the heart of the former Eastern Europe economy was a defense industry of quite extraordinary scale. Its priority development over several decades distorted the development of the entire economy and ultimately promoted its decline and eventual collapse. The defense industry was dominated by a group of powerful industrial ministries in the former Soviet Union known as the "Defense Complex" reporting to the Supreme Soviet via the Council of Ministers. The Defense Complex controlled the majority of both military and civilian electronics production in the former Eastern Bloc, by direct command in the former USSR, and by political and economic means in the other East European countries.

The Defense Complex was the most capable part of the East European economy, able to produce military and space technology to world standards. In addition, most of the advanced production equipment was also built by enterprises within the Defense Complex. These world class achievements, however, were highly focused and did not extend to the electronics industry at large where, for example, by 1989, the level of East European microelectronics capability was at least two generations behind that of the West (Figure 1-45).

	East Europe		West	
Item	**1989**	**1996**	**1989**	**1996**
Cleanroom Class	100-10	100-10	10	<1
Wafer Size (inches)	3-6	3-6	4-6	6-8
Linewidth (μm)	3-1.2	3-1.2	1.2-0.8	0.6-0.35
DRAM	64-256kbit	64-256kbit	1Mbit	16/64Mbit
Microprocessor	8086	8086	80286	Pentium Pro

Source: Future Horizons/ICE, "Status 1997" 20446A

Figure 1-45. East European Technology Gap (Mainstream Semiconductor Production)

With the collapse of communism in 1989 and the subsequent disintegration of the Eastern Bloc, by 1991, the East Europe governments had virtually stopped their support for the electronics industry - both by way of direct financing and State orders - and thus the enterprises were obliged to enter the world markets. As a result, there has been virtually no change in the East European technology capability since 1989, while the West has moved on a further two to three generations.

This inherent technology lag, coupled with poor product quality and lack of business training, from operations management to sales and marketing, meant that the East European enterprises were totally ill-prepared to face this challenge. The net result was the downfall of most of the enterprises while others were forced to embark on a painful and radical restructuring process. Due to the intense, and global, industry competitiveness, the East European electronics enterprises bore the full brunt of the inevitable industry collapse. Nowhere was this more felt than in the semiconductor industry.

Prior to 1989, over 100 factories located in 24 different regions dealt with the production of semiconductor devices in the former Soviet Union (Figure 1-46). With the collapse in local demand, only a handful of these factories have survived.

City	State	City	State
Alexandrov	Russia	Orel	Russia
Bryansk	Russia	Orlovka	Kyrgizia
Ekaterinburg (Sverdlovsk)	Russia	Pavlov Posad	Russia
Fryazino	Russia	Riga	Latvia
Ivano-Frankivsk (Stanislav)	Ukraine	Solnetchnogorsk	Russia
Kiev	Ukraine	Shaulay	Lithuania
Kishinev	Moldova	St. Petersburg (Leningrad)	Russia
Krasnodar	Russia	Tallinn	Estonia
Lvov	Ukraine	Ulyanovsk	Russia
Minsk	Belarus	Vilnius	Lithuania
Moscow	Russia	Voronezh	Russia
Nizhny Novgorod (Gorky)	Russia	Yaroslavl	Russia
Novosibirsk	Russia	Zaporozhye	Ukraine
Odessa	Ukraine	Zelenograd	Russia

100+ Factories/24 Different Regions-Typically 5,000 4" Wafers/Week Capacity

Source: Future Horizons/ICE, "Status 1997" 21767

Figure 1-46. Major Semiconductor Production Centers in Former USSR

The situation in other parts of the former East Bloc is similar, with only a few of the original firms able to establish themselves in market niches. Those factories that have remained open now form the nucleus of the emerging, second generation, East European semiconductor industry. They are still, however, burdened with a now four to five generation technology gap compared to their western counterparts and, specific limited military production aside, unable to effectively support their local OEM industry.

Some of the Russian enterprises are surviving by selling simple processors to the Asian manufacturers of calculators, watches, and low-end consumer products such as remote control hand-set ICs. In Belarus, Integral, once the jewel of Soviet advanced IC production capability, is trying to sell simple logic and obsolete memory ICs to the West, and in the Ukraine, Kwazar, the huge Kiev-based semiconductor conglomerate is now the production center for the PC assembly firm Kwazar-Mikro. Other firms in Russia and the Newly Independent States (NIS) are making linear ICs, discrete devices, and other niche products or consumer electronics goods. In the other East European regions, high-power discretes, optoelectronics, and linear ICs are the major areas of activity.

East European IC Production

The catastrophic collapse in local market demand, poor product quality, and cash flow difficulties meant that Eastern Europe missed out on the recent worldwide industry boom, which saw merchant semiconductor production grow by 137 percent, from \$62.3 billion in 1992 to \$147.7 billion in 1995.

By contrast, East European production shrank by more than 50 percent, from \$856 million to only \$433 million in the same time period. Only the former Soviet Union and the Czech Republic played a significant part in the export boom, with exports rising from virtually zero in 1992 to an estimated \$64 million and \$13 million, respectively, in 1995.

It is to the industry's credit that not only does an East European semiconductor industry still exist, there are the first pockets of recovery underway, primarily in the former Soviet Union. Although modest by worldwide standards, overall semiconductor production in Eastern Europe increased 8.8 percent in 1995, finally reversing the six-year downward spiral (Figure 1-47). Unlike the worldwide market, production is estimated to have again increased in 1996 by 11.3 percent. Most of this growth has been the result of increased export activity.

In Russia, with Angstrem's 150mm, 1.2μm, double-layer metal, pilot production line now on stream, we can expect to see a shift in the export mix away from low-price, low-technology, foundry watch and calculator chip sales to the Asia-Pacific region to more value-added MPU-based products (e.g., remote control handsets and other consumer products). This trend will accelerate once Mikron's 150mm high-volume line comes on stream in 1997.

There has already been a noticeable shift into the more profitable voltage regulator, power MOSFET, and linear IC areas with increased production activity in other parts of Russia, Belarus, Poland (for very high-power devices), and the Czech Republic. We can expect to see Serbia join this list now that the UN sanctions have been dropped.

Overall, however, with total production at under half a billion dollars, miniscule public cash available for local government support, and no current incentive for investment from the west, the East European microelectronics industry remains relegated to the slow lane for the foreseeable future.

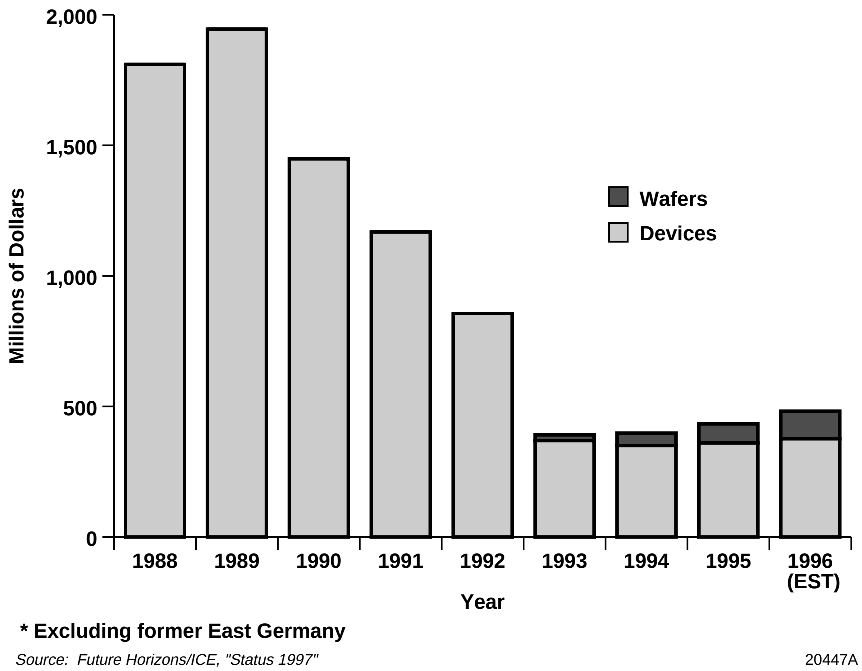


Figure 1-47. East European* Semiconductor Production (Millions of U.S. Dollars)

Not surprisingly, especially given the current worldwide market slowdown, western firms remain content to service the slowly recovering East European market via exports.

Russia & The Newly Independent States (NIS)

The transformation to a market economy has led to increased specialization at the electronics enterprises, the closing down of unprofitable and uncompetitive organizations, a concentration of R&D at the Research and Development Centers, and the development of new forms of research and production activities. Around one-fifth of the factories of the former Soviet Union still remain open, forming the nucleus of a second generation Russian/NIS semiconductor industry (Figure 1-48).

Russian companies have increased their business relations with western partners, and long-term agreements for Russian designs and products are now in place with more than 50 major Russian companies. The western companies that have shown the most interest so far include companies from the USA, Germany, South Korea, Finland, and China. The leading exporters are Angstrem, Elex, Elion, Mikron, and Zelta.

In Belarus, Integral, Planar, and Transistor are also enjoying an export-led revival in their fortunes.

Company	Location	Products
Alfa	Riga	ADC/DAC, Op amps, comparators, timers, HF/SHF transistors
Angstrem	Zelenograd	CMOS ICs, foundry
Kremny	Bryansk	Voltage regulators, discrete power devices
Electronica	Voronezh	DSP, MCU & consumer ICs, power MOSFETs, microwave transistors
Elex	Alexandrov	Voltage regulators, discrete devices
Eliz	Fryazino	Consumer SC devices
Estel	Tallinn	Very high power discretes
Exiton	Pavlov Pasad	CMOS & smart card ICs, power devices
Gamma	Zaporozhye	Low & medium power discretes
Integral	Minsk	MOS & bipolar ICs, foundry
Iskra	Ulyanovsk	Power transistors, diodes
Mikron	Zelenograd	CMOS, bipolar & GaAs ICs, TV ICs, foundry
NIIPP	Tomsk	GaAs microwave devices
Novosibirsk SC	Novosibirsk	CMOS ICs
Pulsar	Moscow	Microwave transistors, special ICs
Rodon	Ivano-Frankivsk	Telephone & TV ICs
Sapphir	Moscow	Optoelectronics, SC devices
Soyuz	Novosibirsk	Power SC devices
Transistor	Minsk	Discretes (TO & SOT)
Vostok	Novosibirsk	CMOS, analog ICs

Source: Future Horizons/ICE, "Status 1997" 20448A

Figure 1-48. Major Russian/NIS Semiconductor Production Facilities

Despite its good intentions, the cash strapped, 30-month-old Russian State Program for the Development of Electronics Technology has yet to make a significant impact on the Russian electronics industry. Moves are underway for a joint program in conjunction with the Belarus government but, given no end in sight to the current cash crisis, this too is likely to suffer the same fate.

The difficulty of enticing western investment into Russian electronics remains a significant problem for both Russia and Belarus and no clear solution is in prospect, especially given the continuing political and economic uncertainties.

As such, both the new Meissner+Wurst cleanroom, built to western standards for Angstrem in Zelenograd and the similarly specified Finnish-built cleanroom at Electronica's facility in Voronezh both lie idle. Investment to expand the 150mm complex at Integral in Belarus has also been unforthcoming.

To make matters worse, the current Russian tax and legislative environment penalizes companies that make capital equipment investments, even if these factories managed to raise the required capital. Foreign direct investment in the globally-volatile high technology industry is also unlikely while the government continues to embark on a policy of arbitrary, and unpredictable, taxation and duties.

Russian/NIS Company Highlights

Angstrem - has recently started pilot production of 150mm wafers in its refurbished cleanroom for the production of ICs down to 1.2μm geometry. The line is partially equipped with second-hand western production gear from ASM, Alcatel, GCA, and Eaton. Angstrem is currently running at full capacity in all of its fab lines.

Electronica - has a broad semiconductor capability covering not only the full spectrum of IC technologies but power and microwave devices as well. It is one of the biggest semiconductor manufacturers in Russia. The factory specializes in power semiconductors, voltage regulators, single-chip microcomputers, and microwave transistors. More than 20 different types of IR, Siemens, and SGS-Thomson equivalent power MOSFETs are currently in production with a further 30 devices under development. Twenty-four types of industry standard Schottky diodes are also in mass production.

Negotiations are progressing with International Rectifier on a variety of cooperative opportunities including a plan to create a joint venture to establish a back-end facility in Voronezh to package IR's power products.

Estel - based in the Baltics, Estel produces a range of very high-power discretes including power rectifiers (up to 2,400V and 1,000A), fast recovery diodes (up to 1,500V and 320A - stud case or 2,400V and 1,000A - press pack), power inverter thyristors, fast thyristors, fast impulse thyristors, and symmetrical surge voltage suppressers. Traditionally Estel's main markets were the Baltic States and the former Soviet Republics. Plans for export are just starting and aim to reach up to half the total production.

Gamma - in Zaporozhye produces a wide range of low- and medium-power discrete semiconductor devices including diodes, transistors, thyristors, and Darlington and medium power transistors in TO-92, TO-126, and TO-220 packages using both planar and mezaplanar technology.

Integral - has the only operational class 10 facility in the former USSR, currently equipped with mostly East European IC gear. As such, it is unable to operate effectively below 1.5μm resolution. Until Angstrem, it was also the only former East European plant capable of processing 150mm wafers. Plans to double its capacity and improve the level of technology to 0.8μm using western equipment, have so far attracted no takers.

Integral suffered a further setback in 1996 when Amkor Anam withdrew as technology partner from the "Integral-Kras" joint-venture between Integral and Kras Corporation of the USA. Funded under the USSR Conversion Program, the investment uses western manufacturing equipment targeted at the PQFP and SOIC sub-contract assembly market. With Motorola's early interest in this line (for ALSTTL assembly) now apparently waned, LG Semicon now appears to be the major customer and technology partner.

Kremny - in Bryansk makes mostly power discretes, voltage regulators, and power ICs targeted at the power supply, control, and communications markets. The company produced over 1,000 line items in 1996 and is currently exporting to Europe, the USA, and Southeast Asia.

Kwazar - focused on the production of microprocessor and memory ICs including 8/16-bit MPU/MPRs, single-chip MCUs, RAM, ROM, and EPROMs, as well as circuits targeted at the consumer, automotive, and telecommunications markets. Production is on 2μm CMOS or bipolar technology. Current emphasis is as a production center for the PC assembly firm Kwazar-Mikro.

Mikron - the "Corona" joint venture with the Hong Kong firm Hua Ko is slowly moving ahead with most of the $40 million investment in the new, Russian-built, class 10 cleanroom now completed. The venture is targeting 150mm, 1μm CMOS wafer production technology. Most of the equipment is second-generation Russian/CIS built but with furnaces supplied from ASM. The line should be fully operational during 1997.

Rodon - in Ivano-Frankivsk, is currently producing a range of telephone and TV ICs as well as certain OEM production based on its in-house developed ICs, for example blood pressure monitors and TV remote control units. It is also producing the 74HC family of ICs and put into production over 50 device types during 1996.

Other Eastern Europe Company Highlights

Much of the semiconductor production capability in the other East European regions has been either closed down or reduced to R&D support activity. The combination of a small and shrinking home market, coupled with the collapse of COMECON, the former Communist Trading Bloc, resulted in a virtual loss of market.

In Bulgaria, Microelectronica is surviving and offers a wide range of MOS and bipolar ICs as well as discrete semiconductors.

The Czech Republic firms all suffered badly under the Czech privatization program which focused only on raising cash, not with restructuring its industry base. As a result, many investors looked only to asset strip for a fast return on their investment. Some niches remain, however, for example the Polovdice power semiconductor plant specializes in bipolar power diodes and GTOs, similar in structure to Westcode.

In Roznov, the Tesla facility is now virtually a dedicated bipolar foundry for Motorola, while in neighboring Slovakia, the Tesla Piestany CMOS IC facility is reduced to pilot production levels only.

Much of the activity now in Poland is reduced to low volume, 3.0µm resolution, CMOS ASICs, photodiode and sensor production at ITE in Warsaw.

Production continues in Romania both at Baneasa (for power discretes and bipolar ICs) and Microelectronica for CMOS ICs and optoelectronics.

INTERMOS in Hungary is finding a viable niche in assembling power electronics and UHF devices for manufacturers such as TEMIC and IXYS, mostly in TO-220 and TO-50 packages.

The semiconductor industry in Serbia, which accounted for about 70 percent of the 1989 former Yugoslav semiconductor industry, suffered badly in the 1990-93 period due to the collapse of communism in Eastern and Central Europe and the subsequent collapse of military orders, the secession of former Yugoslav republics of Slovenia and Croatia, civil war in Bosnia, and the UN sanctions against Serbia.

The two key survivors are Ei-Semiconductors (NIS) and IHTM (Belgrade), which are enjoying good success in the power semiconductor, optoelectronics, and sensor market niches.

East European Semiconductor Market

The market for electronic equipment in Eastern Europe, and with it the demand for semiconductor devices, is underdeveloped due to the interventionist policies of the former defense oriented industrial economic system. As such, the penetration of electronics into every day use is at least three decades behind that of the West.

At the macro level, this can be quantified by the Russian/CIS per capita consumption of electronic equipment (Figure 1-49). Figures for the rest of Eastern Europe are comparable.

Despite this market opportunity, which will force the demand for electronic equipment to grow at a minimum 25-30 percent over the medium- to long-term, the indigenous electronics industry faces a fundamental problem - lack of investment. Almost all of the past industry investment was made during the former Soviet times and is crying out for modernization.

Given that the electronics equipment and semiconductor markets are totally intertwined, it is therefore not surprising that the East European semiconductor market is currently so small (Figure 1-50).

283 Million People

$9.5B Electronic Equipment Market

(≈1% Worldwide TAM)

$32 Per Capita Consumption (1/25 West)

120 Phones/1,000 People (1/4 West)

52 Cars/1,000 People (1/8 West)

<20 PCs/1,000 (1/20 West)

Source: Future Horizons/ ICE, "Status 1997" 20453B

Figure 1-49. Russia and the NIS Macro-Economics

Country/Region	1989	1993	1994	1995	1996 (EST)
Former USSR	1,400	385	400	485	560
Hungary	95	15	18	21	25
Poland	125	35	40	45	50
Romania	45	5	5	6	7
Bulgaria	85	3	3	4	5
Serbia	—	10	10	10	11
Former Yugoslavia	105	—	—	—	—
Other "Yugoslavia"	—	2	2	2	2
Czech Republic	—	15	18	22	28
Former Czechoslovakia	105	—	—	—	—
Slovak Republic	—	8	8	9	10
Total	1,960	478	504	604	698

Source: Future Horizons/ICE, "Status 1997" 20452B

Figure 1-50. East Europe Semiconductor Market (Millions of U.S. Dollars)

When the planned economy collapsed in the early 1990's, most electronics factories were cut off from their traditional customer and supplier (i.e., the State) and forced to deal directly with each other. The vast geographic spread, in some cases political turmoil, and inherited product obsolescence resulted in significant confusion and a virtual collapse in market demand.

As a result, imported components quickly began to displace locally made products and the incumbent manufacturers have seen their near 100 percent marketshare erode significantly. Due to its vastness, the situation in Russia and the CIS was not so severe, at an estimated near 40 percent marketshare erosion (Figure 1-51). This loss would undoubtedly have been higher had it not been for the fact that, during the western market 1993-95 boom years, Russia and the CIS were all but ignored as a serious market opportunity by the West.

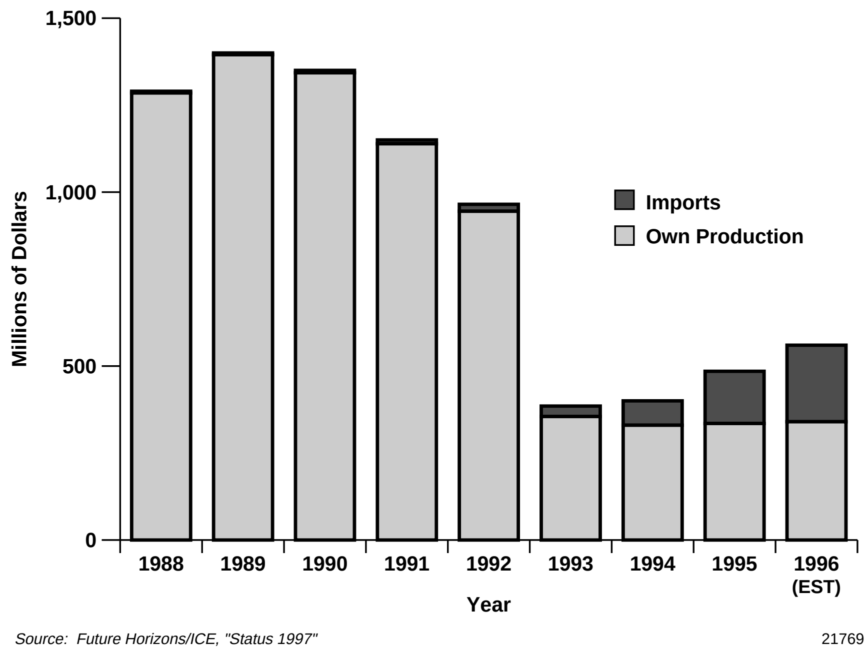


Figure 1-51. Russian/CIS Semiconductor Market (Millions of U.S. Dollars)

The main component buyers are still from the electronics manufacturing industry, with a sizeable demand for parts to repair domestically-manufactured equipment. More recently, the automotive industry has started to become a major buyer of electronic equipment and components.

The military remains a major market segment, having reversed a period of turbulent decline. This recovery is fueled by both internally required replenishments and increasing export success.

There are also a huge number of SMEs, ranging from one man/garage operations to co-operatives, filling the gaps that the traditional enterprises have abandoned. These companies are involved in a substantial volume of pilot and small scale production, typically 30 to 100 units per month, making power supply modules, Hi-Fi and consumer products, measuring and monitoring devices, modems, and an infinite number of proprietary products.

Last but not least, there is a sizeable market for components used in the repair of the imported electronics equipment. During the last five years there have been hundreds of thousands of TVs, VCRs, and computers sold into Eastern Europe from a wide variety of Southeast Asian, 'no-name' manufacturers. These are now approaching the end of their active life and in need of repair. In an economy that was steeped in conservation and is still cash limited, unlike the West, repair is still the normal way of (electronic) life.

Despite popular wisdom, the end markets, and the East European economies, are far from dead (Figure 1-52), with GDPs again growing after several years of decline.

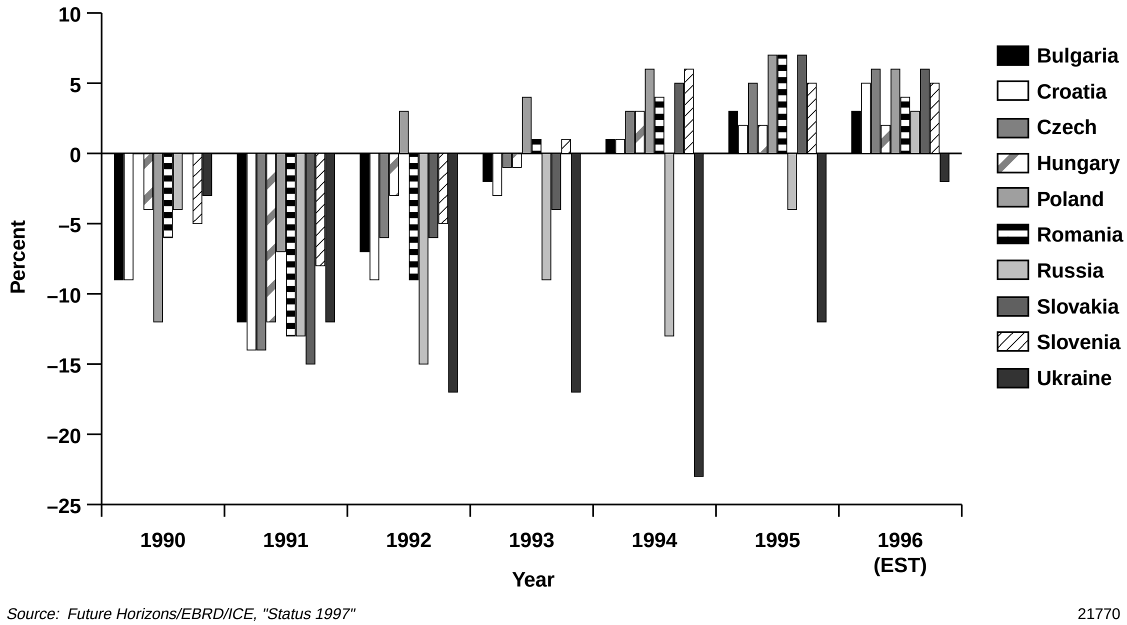


Figure 1-52. GDP Growth Rates 1990-1996

Even during the economic collapse, demand for electronic equipment held up, showing continued year on year growth (Figures 1-53 and 1-54).

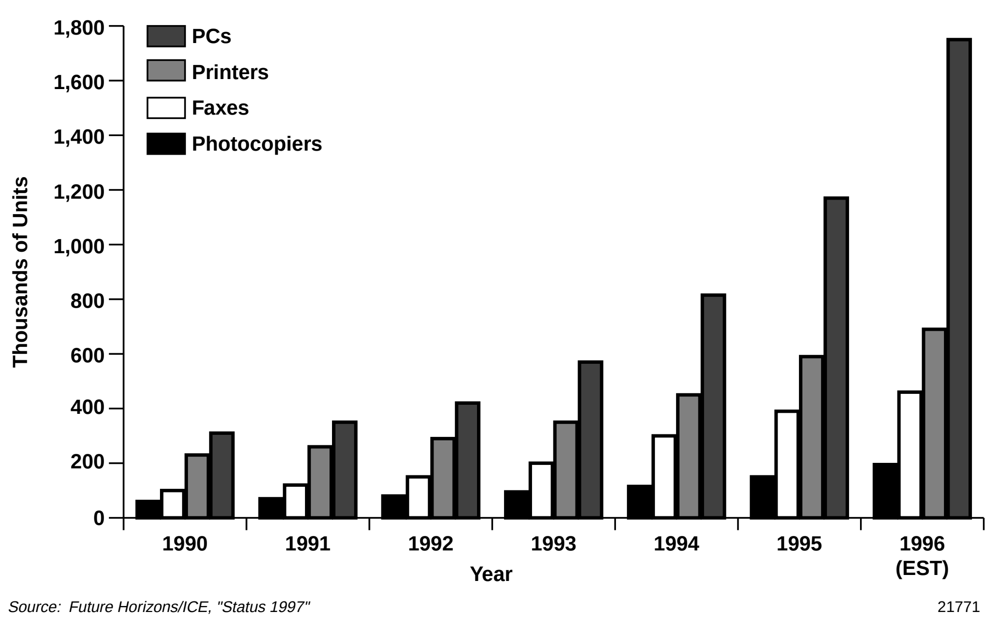


Figure 1-53. Russian Office Equipment Market

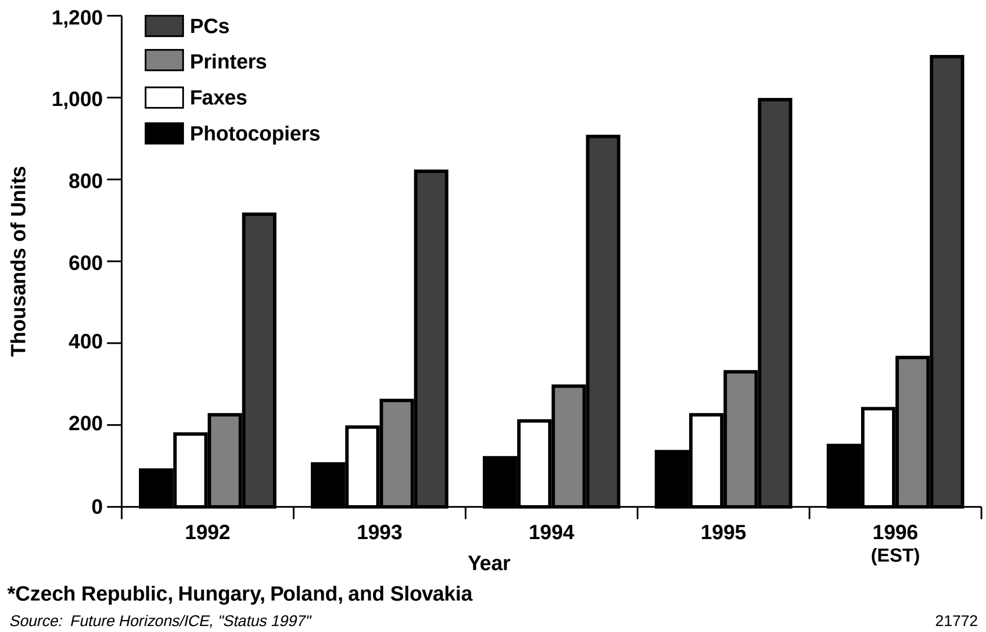


Figure 1-54. Visegrad* Office Equipment Market

These markets are expected to accelerate in line with the overall pace of economic recovery now in progress. While most of these products are currently imported, the longer term trend will be for local assembly, as in Western Europe, initially from semi-knocked down kits but eventually from local production.

Over the longer term, given that Eastern Europe is not a third world region, the per capita consumption levels in Eastern Europe will reach a similar level to those of the west.

The implication behind this is that the East European electronics market will need to grow at a minimum 30 percent per year to come close to parity with the western world in a 15 to 20 year time frame. Much of this market demand will be locally produced, bringing with it a corresponding increase in semiconductor demand.