The Origins of the U.S.-Japanese Semiconductor Dispute

by

Jeffrey A. Hart
Department of Political Science
Indiana University
Bloomington, IN 47405

(on sabbatical -- August 1987 to June 1988 at following address)
BRIE
2234 Piedmont Avenue
Berkeley, CA 94720

This article is to be included in a volume edited by Stephan Haggard and Chung-In Moon, Pacific Dynamics: The International Politics of Industrial Change (Boulder, CO: Westview, forthcoming). This version was completed on December 22, 1987. All comments and criticisms are welcomed.

Introduction

A major trade dispute arose in 1986 between Japan and the United States over the pricing of Japanese semiconductors in US and third-party markets. Japanese firms had begun to challenge the technological superiority of U.S. firms in the late 1970s. By the mid 1980s, they were out-producing and, in a few strategic product areas, out-innovating the U.S. firms. This chapter examines the rise of the Japanese industry and the trade conflicts which ensued.

There was rapid growth in the production of semiconductors in the 1970s and 1980s. This growth was greatly assisted by product innovations in consumer electronics, small computers, and telecommunications equipment and the rapid diffusion of these new information technologies. The lower GNP growth rates of the 1980s, however, together with rising unemployment, focused the attention of policymakers in the industrialized countries on increased competition in world markets and especially in high technology products and services. Aside from a few cyclical downturns in the growth of semiconductor production in 1982 and 1985, the industry continued to grow at a pace approaching twenty percent per year. In certain regions, such as the well known Silicon Valley of Northern California, employment in semiconductor manufacturing was the mainstay of the local economy.

The semiconductor industry was important not just as a source of income and jobs, however, but also as an input to military weaponry. Governments looked upon the industry in the same way they viewed the steel industry in the nineteenth century: as a key to national security. When a trade dispute arose between the leader, the United States, and the challenger, Japan, in the mid 1980s, it was bound to be colored by power political considerations.

Three major factors account for the rapid success of Japanese firms: government assistance in the form of the Very Large Scale Integration (VLSI) Program of 1976-9; the strong demand for advanced components that came from a highly successful consumer electronics industry; and the diversification and vertical integration of Japanese electronics firms, which was in sharp contrast with the mix of integrated and merchant firms in the United States. The VLSI Program was crucial in allowing Japanese firms to move to the technological frontier of semiconductor design and production. Preferential purchasing of Japanese components by the Japanese Ministry of Posts and Telecommunications helped Japanese firms descend their learning curves, just as defense and space program purchases of U.S. components had helped U.S. firms do the same earlier.

U.S. firms were slow to see the extent of the challenge posed by Japanese firms. As in other industries suffering from increased competition, the first response was to compensate for lower wage costs of Japanese manufacturers by using overseas manufacturing facilities. Unlike the Japanese firms, who were early to automate the more labor-intensive parts of the manufacturing process (i.e., bonding, assembly, and packaging), the U.S. firms used their overseas affiliates in Southeast Asia and Latin America to perform these tasks. In addition, Japanese firms were better able to get marginal improvements in their manufacturing of chips by the close cooperation between semiconductor and manufacturing equipment firms made possible by the more integrated nature of Japanese firms and their closer ties to suppliers and contractors. Not only were Japanese firms able to produce existing products more inexpensively than U.S. firms, but they also began to announce and market new products earlier than their U.S. competitors.

The early 1980s was a period of accelerating rates of investment in semiconductor production. The predictable result was overcapacity. When demand for semiconductors turned down in 1985, there was a very strong temptation for firms that had recently increased capacity, especially the Japanese, to dump their products on overseas markets. Learning curve effects associated with semiconductor production also created incentives to sell below production costs in order to increase volume, thus lowering future production costs. The logic of overcapacity and learning-curve pricing, therefore, led to very low prices and financial losses in almost all the major firms in 1985.

The U.S. merchant firms were hurt the most, and their first recourse was to turn to the U.S. government for shelter. The traditional method for sheltering U.S. firms was to use defense procurement to promote innovation in circuitry by paying premium prices for new devices for military use, allowing a number of firms to finance part of the development costs of these devices. However, by the mid 1980s, the type of circuitry demanded by the military was quite different from that used by civilian technologies. Thus it was not as easy as it had been in the past to subsidize development of new circuits through military procurement. In any case, the problems of the industry were too immediate to be dealt with through procurement policies alone.

Accordingly, the U.S. merchant firms turned to trade policy as a means of obtaining help from the U.S. government. Recent changes in trade law, particularly provisions concerning unfair trade practices and obtaining relief against "injury" caused by rapid increases in imports (whether or not they were the result of unfair trade practices), created a new set of policy instruments for the sheltering of U.S. firms from international competition.[1] U.S. firms were quick to petition the government to use these new instruments in a variety of trade disputes; the semiconductor industry was no exception. The resulting trade dispute, which peaked in 1985-6, is described in detail below, along with some speculations about its overall impact on U.S.-Japanese economic relations.

---

[1] For further details, see Stephen Woolcock, Jeffrey Hart and Hans Van der Ven, Interdependence in the Post-Multilateral Era (Lanham, MD: University Press of America, 1985), chapter 1.

The Rise of Japan in World Markets

In 1984, world production of semiconductors was estimated to be around $26 billion and of integrated circuits (semiconductor devices which contain entire electronic circuits on a single chip) $19 billion. The share of discrete devices (devices which are not integrated circuits) in the overall market for semiconductors has been declining steadily since the inventions of integrated circuits in 1971.

Table 1. World Semiconductor Production, By Region, 1973-86
(in Billions of Dollars)

A. As Estimated by Dataquest

Year	U.S.	Europe	Japan	Rest	World
1973	3.6	1.1	1.3	0.0	6.0
1976	4.5	1.2	1.5	0.2	7.4
1978	5.8	1.7	2.5	0.4	10.4
1981		1.7			14.2
1982		1.9			14.7
1983		2.2			17.5
1985	11.0	2.8	10.7	0.3	24.8
1986	11.7	3.9	15.0	0.5	31.1
1987p	14.2	4.7	16.3	0.7	35.9

B. As Estimated by In-Stat

Year	U.S.	Europe	Japan	Rest	World
1983	7.8	3.0	5.5	1.0	17.3
1984	11.9	4.7	8.1	1.7	26.3
1985	8.1	4.5	7.6	1.2	21.6
1986	8.4	5.8	9.8	1.4	25.4
1987p	8.9	---	---	---	28.9

Note: Dataquest statistics include estimates of captive production of integrated circuits by large computer firms like IBM and In-Stat statistics include only sales of merchant firms.

Sources: a. for Dataquest -- Giovanni Dosi, Technical Change and Industrial Transformation (New York: St. Martin's Press, 1984), p. 150; Financial Times (March 21, 1983), Section IV, p. IV; Special Supplement on Semiconductor Manufacturing and Testing, Electronic News (March 9, 1987), p. 5; b. for In-Stat -- Electronic News issues of November 10, 1986 (p. 64), September 30, 1985 (p. 6) and October 1, 1984 (p. 40).

Between 1978 and 1983, world production of integrated circuits grew at an annual average rate of 19 percent, despite a recession in 1981-2 (see Table 2 below). Between 1983 and 1986, production grew at an annual rate of 26 percent.

Table 2. World Production of Integrated Circuits, 1978-83
(millions of dollars)

A. As Estimated by Dataquest

Year	USA	Europe	Japan	Rest	Total
1978	4582	453	1195	382	6712
1979	6681	600	1750	675	9706
1980	9055	710	2450	130	12345
1981	8950	790	2590	160	12490
1982	9300	790	3130	160	13380
1983est	10450	855	3910	190	15405

B. As Estimated by In-Stat

Year	USA	Europe	Japan	Rest	Total
1983	6270	2200	4000	430	12900
1984	9800	3400	6500	1200	20900
1985	6610	2990	5650	1250	16500
1986	6850	3050	7300	2100	19300

Note: Dataquest statistics include estimates of captive production of integrated circuits by large computer firms like IBM and In-Stat statistics include only sales of merchant firms.

Sources: Dataquest -- Trade in High-Technology Products: Industrial Structure and Government Policies (Paris: OECD, 1984), p. 110; In-Stat -- Rebecca Day, "Worldwide Semiconductor Sales Predicted to Rise Only 15.8% in 1985," Electronic News (September 10, 1984), p. 13; Richard Bambrick, "Semicon Sales to Rise Slightly: Buying Patterns in Transition," Electronic News (January 5, 1987), p. 30.

The United States accounted for over two thirds of world production of integrated circuits between 1978 and 1985, and more than that in earlier years. According to Dataquest estimates, the United State, Europe and Japan produced more than 93 percent of all semiconductors in the world market for the entire period and more than 98 percent since 1980 (see Table 3). Japan has increased its share of world production of integrated circuits from 18 percent in 1978 to 27 percent in 1985. However, if one considers only the open market for semiconductors -- sales by merchant producers, excluding consumption of devices by captive producers -- the Japanese production share increased from 24 percent in 1978 to 46 percent in 1986. The U.S. share fell from 60 percent in 1978 to 43 percent at the end of 1986.[2]

Table 3. World Production Shares in Integrated Circuits
(in percentages)

Year	USA	Europe	Japan	Rest
1978	68	7	18	7
1979	69	6	18	7
1980	73	6	20	1
1981	72	6	21	1
1982	70	5	23	2
1983	68	6	25	1
1984	67	5	26	2
1985	67	5	27	1

Note: These production shares are based on Dataquest data. See original data through 1983 in Table 2.

Source: The Semi-Conductor Industry: Trade-Related Issues (Paris: OECD, 1985), p. 21.

U.S. production of semiconductors grew at an average annual rate of over 26 percent between 1955 and 1983 (see Table 4 below). The proportion of semiconductors consumed by military or government users declined from a high of 50 percent in 1960 to less than 25 percent in 1968; the proportion of integrated circuits consumed by the military went from 100 percent in 1962 to 9 percent in 1978.[3] The share of integrated circuits, as opposed to "discrete" devices, in total semiconductor sales has increased steadily in the U.S. market from 1 percent in 1961 to 70 percent in 1984. The decline in the military share and the rise of integrated circuits that are too advanced for the current generation of military hardware makes it more difficult than it was in the past to use military procurement policies to bolster the

---

[2] Michael Borrus, Chips of State (Cambridge, MA: Ballinger, forthcoming).

competitiveness of U.S. firms. The leading U.S. firms are no longer primarily defense contractors.

Table 4. Sales of Semiconductors in the United States, 1961-84 (in millions of dollars)

Year	ICs	Discrete	Total	Growth
1955			39	
1956			89	128.2
1957			140	57.3
1958			202	44.3
1959			388	92.1
1960			532	37.1
1961	5	533	538	1.1
1962	10	525	535	-.6
1963	20	537	557	4.1
1964	51	617	668	19.9
1965	94	742	836	25.1
1966	173	905	1078	28.9
1967	273	787	1060	-1.7
1968	367	762	1129	6.5
1969	498	858	1356	20.1
1970	524	769	1293	-4.6
1971	534	623	1157	-10.5
1972	718	749	1467	26.8
1973	1421	1335	2756	87.9
1974	1767	1347	3114	13.0
1975	1712	1290	3002	-3.6
1976	2644	1667	4311	43.6
1977	2677	1686	4363	1.2
1978	3538	1973	5511	26.3
1979	4717	2484	7201	30.7
1980	6606	2483	9089	26.2
1981	6976	3333	10309	13.4
1982	7322	3407	10729	4.1
1983	7945	3695	11640	8.5
1984	11275	4725	16000	37.5

Source: Electronic Market Data Book (Washington, DC: Electronic Industries Association, 1982), Table 4-2; Electronic Market Data Book (Washington, DC: Electronic Industries Association, 1985), p. 134.

The increase in the Japanese share of world production is remarkable, but perhaps more important is the domination of markets for the more advanced integrated circuits and especially the latest generation of random access memories (RAMs). By the end of 1979, the Japanese firms controlled 43 percent

---

[3] Giovanni Dosi, Technical Change and Industrial Transformation (New York: St. Martin's Press, 1984), p. 44.

of the U.S. market for 16K RAM devices.[4] By the end of 1981, they supplied almost 70 percent of 64K RAM devices in the open part of the U.S. market.[5] In 1984, the Japanese firms introduced 256K RAM chips before a number of major U.S. firms. It was estimated that Japanese firms controlled over 90 percent of the market in 256K RAMs by 1986.

U.S. firms like Intel, Motorola, Hewlett-Packard and AT&T (Western Electric) still dominated the market for microprocessors, however, Japanese firms began to eat into this market as well in the 1984-5 period as they introduced their own "state-of-the-art" microprocessors. NEC and Hitachi were particularly strong in this regard; NEC displaced Texas Instruments in 1985 as the number one seller of semiconductor devices in the world.[6]

Semiconductor Production by Specific Firms

Japanese and U.S. firms dominated the markets for semiconductors and integrated circuits in the early 1980s, as can be seen in Table 5 below. Only two European firms ranked among the top ten firms -- Philips and Siemens -- and those firms did so largely as a result of purchasing U.S. semiconductor firms. While Table 5 excludes consideration of captive production of semiconductors, which if included would bring AT&T into the list, nevertheless it gives an indication of shares in the open market for semiconductors and the ranking of firms. It also shows the fall from dominance of Texas Instruments, Motorola and Intel between 1982 and 1986.

---

[4] Michael Borrus, James Millstein, and John Zysman, International Competition in Advanced Industrial Sectors: Trade and Development in the Semiconductor Industry (Washington, DC: Joint Economic Committee of Congress, 1982), p. 106.

[5] Gene Bylinsky, "Japan's Ominous Chip Victory," Fortune, (December 14, 1981), p. 55.

[6] According to Dataqest, NEC sold 1.98 billion dollars worth of semiconductors in 1985 compared with 1.76 billion for Texas Instruments and 1.85 billion for Motorola. See "NEC Tops a List," New York Times, (January 16, 1986), p. D4.

Table 5. Largest Semiconductor Producers, 1982-6
(Rank Ordered by 1986 Revenues)

Name of Firm	Country	1982	1984	1986
NEC	Japan	1100	2350	2638
Hitachi	Japan	800	2140	2305
IBM (estimate)	USA	---	2000	---
Toshiba	Japan	680	1750	2261
Motorola	USA	1235	1729	2025
Texas Instruments	USA	1422	2390	1820
National Semiconductor	USA	746	1030	1478
Philips/Signetics	Netherlds.	500	1150	1356
Fujitsu	Japan	440	1070	1310
American Micro Devices	USA	358	920	---
Matsushita	Japan	---	920	1233
Intel	USA	900	1629	991
Siemens	Germany	---	700	---
Gould	USA	318	435	---
Harris Corporation	USA	147	234	---

Note: Data are for fiscal years ending on the column year. There is substantial variation in the fiscal reporting systems used by different firms.

Source: Dataquest estimates.

The Role of Differences in the Structure of Demand

A fairly large proportion of semiconductor production in the United States is sold on the open market by merchant firms. Generally speaking, a lower proportion of semiconductors is sold on open markets in Japan and Europe because the firms in those two regions tend to be larger and more vertically integrated than the U.S. firms. In addition, the end-use of semiconductors differs considerably among the regions. In the United States, the largest market for semiconductors is the one created by computer manufacturing. In Japan, the largest market for semiconductors, at least until quite recently, was created by consumer electronics. In Europe, consumer electronics and telecommunications equipment are the most important customers of the European semiconductor industry.

The structure of demand for semiconductors was a factor of considerable importance in the initial development of the industry in the three regions. In the early days of the U.S. industry, production was geared to military and space applications. It changed quite drastically when the computer industry displaced government purchasers as the largest source of demand. Computer applications of semiconductors generally required devices that were relatively complex, fast, and ran at cool temperatures. Industrial applications, which figured larger in the early development of the European semiconductor industry, required devices that could handle large amounts of power and that were reliable at high temperatures. Consumer electronics, which were the most important customers for the first Japanese semiconductor producers, generally required devices that used less power than either computer or industrial devices and that had the capacity to handle analog as well as digital signals, i.e., in radios, TVs, and video recorders. As a consequence of the different demand structures, the Europeans did well in power devices, the U.S. did well in developing microprocessors and computer memories with MOS circuitry, and the Japanese did well in CMOS circuits for watches, calculators, and consumer electronics items.[7]

In the mid 1970s, the Japanese perceived that the market was pushing them in the direction of specialization in devices for consumer electronics. Worried that production of consumer electronics would shift to the Third World while the U.S. would continue to dominate the world computer industry, a major effort was undertaken by MITI and the Ministry of Posts and Telecommunications (MPT) to promote the development of new devices more suitable for advanced information technology. The VLSI Program of 1976-9 was the result, one of the most successful examples of government promotion of technological development after World War II. A major shift occurred as a consequence of this intervention: the Japanese semiconductor firms were in a much stronger position <u>vis a vis</u> their U.S. competitors by the late 1970s.

---

[7] This argument is put forth in Michael Borrus, James E. Millstein, and John Zysman, "Trade and Development in the Semiconductor Industry," in John Zysman and Laura Tyson (eds.), <u>American Industry in International Competition</u> (Ithaca, NY: Cornell University Press, 1983); Giovanni Dosi, <u>Technical Change and Industrial Transformation</u> (London: Macmillan, 1984); and Franco Malerba, <u>The Semiconductor Business</u> (London: Frances Pinter, 1985).

The VLSI project was organized in March 1976 by MITI, MPT and the five major manufacturers of semiconductors: Fujitsu, Hitachi, Matsushita, Mitsubishi, NEC, and Toshiba. The project was aimed at developing semiconductor technology for the next generation of computers. There had been an earlier program for large-scale integrated circuits (LSI) which failed because it had not anticipated U.S. innovations in computer technology. Accordingly, the VLSI project focused on manufacturing processes and problems of design of VLSI circuitry.

A substantial portion of the funding was spent for purchasing U.S.-made manufacturing and testing equipment. Much of the initial effort of the project went into "reverse engineering" this equipment so that it could be improved incrementally and produced by Japanese suppliers. Great improvements were made in photolithography and electron-beam technology, both central to the transfer of circuit designs to the surface of silicon wafers. By pooling the research efforts of the major firms and making the results available to all, the VLSI project saved each individual firm millions of dollars in research expenditures.

The savings in research expenditures and the full support and backing of the Japanese government facilitated a major increase in overall investment by Japanese semiconductor firms. Total investment in new plant and equipment rose from 116 million dollars in 1977, to 212 million in 1978, to 420 million in 1979. Japanese producers were further encouraged by a sudden increase in demand for standard memory devices in the United States, an increase which could not be handled by U.S. firms alone, in the beginning of 1978. Japanese integrated circuits jumped from 1 percent of U.S. consumption in 1976 to 8 percent in 1980.[8]

The Importance of Merchant Firms in the United States

---

[8] Michael Borrus, Chips of State, chapter 5.

The distinction between integrated and merchant firms in the semiconductor industry is important because of the absence of predominantly merchant firms both in Japan and Europe. All of the major Japanese firms -- NEC, Hitachi, Matsushita, Mitsubishi, Sanyo, and Fujitsu -- are integrated in the sense that they are major consumers of their own semiconductor production. Sales of semiconductors on the open market account for less than 20 percent of total sales for NEC and less than 10 percent for the rest.[9] NEC, Hitachi, and Fujitsu have become computer manufacturers primarily, while Matsushita, Mitsubishi, and Sanyo remain primarily manufacturers of consumer electronics. All of them are relatively diversified, however, compared to the merchant firms of the United States.

Semiconductors accounted for over 80 percent of total sales for National Semiconductors, AMD and Mostek, and more than 65 percent for Fairchild and Intel. Texas Instruments and Motorola, the two largest firms in the merchant group, were the most diversified in the sense that they both have kept semiconductors in the range of 30-40 percent of total sales. Texas Instruments branched out into consumer products like calculators and personal computers, while Motorola remains a major producer of communications equipment and consumer products. TI tried to break into the mini- and microcomputer markets as well, although the microcomputer effort was a disaster. There is some evidence that other merchant firms, Intel for example, have been trying to integrate downstream into computers, starting with add-on circuit boards for IBM-PCs and PC-clones and with advanced work stations for the computer industry.[10]

---

[9] Michael Borrus, James E. Millstein, and John Zysman, "Trade and Development in the Semiconductor Industry," in John Zysman and Laura Tyson (eds.), American Industry in International Competition (Ithaca, NY: Cornell University Press, 1983), p. 190.

[10] See also "Intel may soon compete with its customers," Business Week, (March 22, 1982), p. 63.

Besides downstream vertical integration, most of the important merchant firms began to use foreign subsidiaries, mainly in Southeast Asia, but also in Latin America, to reduce their production costs for portions of the production process. In the late 1970s, Intel, for example, after separating chips on silicon wafers, sent them to its overseas affiliates for insertion in and bonding to the plastic or ceramic packages that protect them from heat and dust. The partially assembled integrated circuits would then be shipped back to the United States for final assembly and testing. After 1982, most merchant firms added final testing to their overseas activities. The use of overseas affiliates was aimed not just at reducing labor costs but also at making it possible to maintain steady production levels and workforces in the U.S. despite fluctuations in world demand.

This strategy of overseas or "offshore" production was adopted also by AMD, National Semiconductors, Texas Instruments, Motorola and others. The Japanese firms, however, opted for automation of assembly and, for the most part, avoided the use of overseas subsidiaries for manufacturing. It has been argued that this choice of domestic automation over foreign investment was useful to the Japanese firms in the next round of competition, since they were able to gain valuable knowledge about how to improve the overall production process and, in particular, to increase the reliability of their products. But in fact, the U.S. firms that remained competitive with the Japanese were not handicapped by their overseas operations. Their subsequent efforts to automate the production process were carried out within the U.S. initially but with the full intention of applying the new processes overseas as soon as possible.[11]

The Role of IBM and AT&T

---

[11] Dieter Ernst, "Automation, Employment and the Third World -- The Case of the Electronics Industry," ISS Working Paper No. 29 (The Hague: Institute of Social Studies, November 1985).

The integrated electronics, communications and consumer products firms in the United States have realized that semiconductor production is crucial to their competitiveness. While they continue to purchase a large proportion of their needs from merchant firms, most of them also have developed internal production lines, some of which are also sold on the open market. Hewlett-Packard, a company known for its industrial electronic products as well as for its calculators and small computers, is now one of the leading producers of products and production equipment for very large scale integrated (VLSI) circuits.

Among the mainframe computer manufacturers, IBM stands out as the sole major producer of advanced semiconductor devices. Nobody really knows very much about IBM's production because the firm does not want much to be known about it. IBM employees claim that IBM semiconductors are second to none in quality and that its production technology is the best, at least in the United States. IBM announced in 1986 that it had begun producing 1 Megabit DRAMs, the first U.S. firm to match the Japanese firms in this area.

But IBM has clearly felt a need to purchase certain devices on the open market, either because they are cheaper or because of fluctuations in internal demand. IBM's purchasing of 64K dynamic RAMs on the open market in 1979 contributed significantly to the rapid growth of Japanese penetration of the world RAM market. U.S. firms were taken by surprise and were not able to increase capacity as rapidly as Japanese firms. Also, because IBM has a philosophy of disarming its critics abroad by appearing to be a "good citizen" in each country in which it operates, the firm frequently purchases components and peripheral devices from national champion firms. Thus, IBM is likely to buy semiconductors from Inmos in Britain, Siemens in Germany, SGS in Italy, Thomson in France, and NEC in Japan. These components are frequently produced under "second source" or licensing arrangements with U.S. firms like Intel. Thus, IBM's desire to avoid political attacks abroad reinforce the tendency of U.S. firms to make second source agreements rather than export their products directly.

Next to IBM, the most important captive producer of semiconductors was AT&T. After the divestment of the regulated regional monopolies in 1984, AT&T began to diversify in the direction of computer and telecommunications equipment manufacturing. Now freed to compete on world markets for computers and telecommunications equipment, AT&T began paying more attention to its semiconductor research and production, which had alway been considered one of the most advanced in the world. It was not without significance that AT&T was one of the first firms in the world along with IBM to announce the successful production of a 1 Megabit DRAM device.[12] For the mid-range future, however, AT&T would probably focus most of its efforts on production and marketing of computers and telecommunications equipment.

The Vulnerability of Merchant Firms to Acquisitions

The U.S. merchant semiconductor firms have become increasingly candidates for acquisition by more diversified or cash-rich firms, and especially European firms. Xerox bought a major stake in Zilog in 1974, Philips purchased Signetics in 1975, Siemens aquired 20 percent of AMD in 1977, Schlumberger bought Fairchild in 1979, IBM bought a 20 percent stake in Intel in 1982-4, which it sold back to Intel in 1987, and Thomson bought Mostek in 1985 (see Table 6). The only two important European merchant firms, Inmos and SGS-ATES, were purchased respectively by Thorn-EMI in 1984 and Thomson in 1985. The attempt by Toshiba to purchase Fairchild semiconductor operations from Schlumberger in 1987 was blocked by the U.S. government. So far this has not reduced the aggressive innovative spirit of the smaller firms, but it may eventually pose such a threat if the trend continues.

Table 6. Mergers and Acquisitions in the Semiconductor Industry, 1969-86

Date	Acquirer	Acquired Firm	Price ($mill.)	Equity (%)
1969	Northern Telecom	Monolithic Memories	---	12
1972	Texas Instruments	TI/Sony Japan	---	100
1972	Toyo Electronics	Exar Integrated	---	53
1974	Siemens	Dickson	---	100
1974	Exxon	Zilog	---	80
1975	Philips	Signetics	49	100
1976	Commodore	MOS Technology	1	100
1976	Signal	Semtech	---	23
1977	Commodore	Frontier	---	100
1977	Siemens	Litronix	16	80
1977	Seiko	Micropower Systems	---	100
1977	Siemens	AMD	27	20
1977	Ferranti	Interdesign	4	100
1977	Ferranti	Interdesign	4	100
1977	Thomson-CSF	Sescosem	---	100
1977	Lucas	Siliconix	6	24
1977	Bosch	American Microsystems Inc	14	14
1977	Standard Oil of IN	Analog Devices	---	100
1978	NEC	Electronic Arrays	9	100
1978	Emerson Electric	Western Digital	---	100
1978	Honeywell	Spectronics	3	100
1978	Honeywell	Synertek	24	100
1978	Bourns	Precision Monolithic	---	96
1979	Schlumberger	Fairchild	397	100
1979	Siemens	Databit	25	100
1979	Siemens	Microwave Semiconductor	---	100
1980	VDO Adolf	Solid State Scientific	5	25
1980	CIT-Alcatel	Semi Process Inc.	---	25
1980	General Electric	Intersil	11	100
1980	Toshiba	Manuman IC	---	100
1980	Siemens	Threshold Technology	---	100
1980	United	Mostek	345	93

[12] Michael Schrage, "AT&T Starts Production of Megabit Chip," Washington Post, (September 6, 1985), p. B3.

	Technologies			
1981	Gould	American Microsystems Inc	---	100
1981	Olivetti	VLSI Technology	2	8
1981	Olivetti	Linear Technology	2	7
1981	Olivetti	Applied Microcircuit	1	4
1982	United Technologies	Eurosil	---	85
1982	United Technologies	Telefunken Elektronik	35	100
1982	IBM	Intel	250	12
1983	Philips	Vactec	---	100
1983	Thomson-CSF	Eurotechnique	---	49
1984	Thorn-EMI	Inmos	125	76
1984	IBM	Intel	600	20
1985	Kawasaki Steel	NBK	9	100
1985	AT&T	Synertek	25	100
1985	Thomson-CSF	Mostek	70	100

Sources: Michael Borrus, James Millstein, and John Zysman, International Competition in Advanced Industrial Sectors: Trade and Development in the Semiconductor Industry (Washington, DC: Joint Economic Committee of Congress, 1982); Rob van Tulder and Eric van Empel, "European Multinationals in the Semiconductor Industry: Their Position in Microprocessors," unpublished manuscript, University of Amsterdam, Vakgroep vor Internationale Betrekkingen, October 1984; Philippe Delmas, "Le Cow-Boy et le Samourai: Reflexions sur la Competition Nippon-Americaine dans les Hautes Technologies," Ministere des Relations Exterieures, Centre d'Analyse et de Prevision, Paris, January 1984; Business Press.

Trade in Semiconductors: U.S. Deficits, Japanese Surpluses

Analyzing the trade in semiconductors is somewhat complicated by the need to compensate for the fact that many U.S. firms exported semiconductor "parts and accessories" to overseas assembly facilities in Europe, Latin America, and Southeast Asia, and then reimported the assembled devices for sale both in the U.S. and abroad. This practice was encouraged under provisions of the 1974 Trade Act which permitted U.S. firms to import duty free items which had been sent abroad for processing or assembly.

Most U.S. exports of finished integrated circuits went to Britain, France, the Federal Republic of Germany, and Japan. The U.S. had a positive trade balance in semiconductor parts and assembled products of 126 million dollars in 1977. The surplus in semiconductors was around 600 million dollars in 1980. By 1984, it was estimated that semiconductor trade produced a deficit of almost 3 billion dollars.[13]

Japan rapidly went from being a net importer of integrated circuits to a net exporter in 1979 (see Table 7 below). Even the United States became a net importer of integrated circuits from Japan, with a deficit in 1984 of $900 million. U.S. firms began to complain loudly about the unfair pricing practices of Japanese firms, as RAM prices dropped faster than anyone had expected. Even though U.S. firms still dominated the markets for certain types of integrated circuits, such as microprocessors and ROMs (read-only memories), the RAM devices were an important source of profits and therefore of research and development funds, especially for the more specialized semiconductor firms. These firms found themselves increasingly squeezed from two directions: loss of market share and inability to put money into developing new types of circuits.

Table 7. Japanese Trade in Integrated Circuits, in Billion Yen

Year	Exports	Imports	Balance
1973	2.6	33.2	-30.6
1974	6.7	51.1	-44.4
1975	13.5	40.0	-26.5
1976	22.7	62.7	-40.0
1977	31.6	55.7	-24.1
1978	52.3	61.3	-9.1
1979	108.3	98.5	9.8
1980	183.3	108.9	74.4
1981	199.6	114.3	85.3
1982	285.1	127.4	157.7
1983	418.0	144.0	274.0

Source: 1973-77, Daiwa Securities, as cited in Economic Research Associates, EEC Protectionism (Brussels, 1982), p. 222; 1978-83, Nomura Electronics Handbook 1984 (Tokyo: Nomura Securities Ltd., 1984).

[13] Borrus, et al., 1982, p. 49; data from the American Electronics Association as cited in "America's High Tech Crisis," Business Week, (March 11, 1985), p. 69.

A general downturn in the computer industry in 1984 led to a slashing of semiconductor inventories by 36 percent in 1985. The demand for semiconductors declined sharply and producers responded by cutting prices in order to compete for the remaining demand.[14] But besides this general drop in demand corresponding to a cyclical downturn in computers and other types of electronic equipment, a general overcapacity problem had been developing in world markets. One research firm estimated that by late 1985 worldwide demand was approximate 40 percent of production capacity in the semiconductor industry.

Overly ambitious sales projections and government programs designed to aid weaker firms led to an "orgy" of capital spending in the early 1980s. Chipmakers invested 6 billion dollars in plant and equipment in 1984 (remember that total sales during that year were around 21 billion). They invested another 4.5 billion in 1985 despite the turndown in demand.[15] Unless demand recovered in an unprecedentedly spectacular way, there would continue to be a crisis of overcapacity leading to pressures for capacity reduction. The key question politically was where the capacity reductions would occur and who would pay the cost of the reductions.

The Trade Dispute Begins

Important U.S. firms like Intel, Texas Instruments, Motorola, and AMD were losing money and dropping production lines in certain products. Mostek was nearly liquidated before its purchase by Thomson-CSF in 1985. Even the computer and telecommunications equipment manufacturers in the U.S. were beginning to worry. Their interest in being able to buy cheap components had to be weighed against their interest in being assured access to the most

---

[14] John Wilson, "The Chips May Not Be Down Much Longer," Business Week, (December 16, 1985), p. 26.

advanced devices (particularly worrisome in light of the growing strength of Japanese computer and telecommunications firms).

In 1985, employment at U.S.-based semiconductor companies decreased by 55,000 workers. The industry as a whole suffered a loss of 1 billion dollars.[16] In June 1985, a small firm called Micron Technologies headquartered in Boise, Idaho, filed an anti-dumping suit against Fujitsu, Hitachi, Matsushita, Mitsubishi, NEC, Oki and Toshiba. It asked that countervailing duties of up to 94 percent be imposed on these firms retroactively for dumping (selling below the cost of production) 64K RAM devices. Although a number of members of the Semiconductor Industry Association (SIA) supported the Micron suit, the SIA as a whole remained neutral.[17]

A few days later, however, the SIA filed a Section 301 complaint against Japan claiming that they had been denied access to the Japanese market, repeating their earlier charges that the Japanese government had targeted the semiconductor industry and that U.S. firms were suffering the consequences. Apparently, the draft version of the Section 301 complaint called for import restrictions against Japan until U.S. firms were granted access to Japanese markets, but IBM and a number of other larger firms opposed this despite the fact that Intel, AMD, Hewlett-Packard and some of the other mechant firms had

---

15 Bro Uttal, "Who Will Survive the Microchip Shakeout," Fortune, (January 5, 1986), p. 82.

16 Intel Corporation, Annual Shareholders Meeting Report, (April 16, 1986), Figure 11.

17 Andrew Pollack, "Japan Seen Target of Chip Plea," New York Times, (September 28, 1985), p. 21.

favored either import restraints or countervailing tariffs, so the final version did not include this demand.[18]

Table 8. Unit Prices for 256K DRAMs

Date	Price ($)
Jan 84	38.00
Apr 84	31.00
Jul 84	23.50
Oct 84	17.50
Jan 85	14.00
Apr 85	9.75
Jul 85	4.75
Oct 85	2.75
Jan 86	2.10
Apr 86	2.25
Jul 86	2.30
Oct 86	5.00

Source: Dataquest as cited in Infoworld, (February 3, 1986), p. 1, and Infoworld, (September 22, 1986), p. 1. The October 1986 figure is an estimate.

On September 30, 1985, Intel, AMD and National Semiconductor filed an anti-dumping complaint against eight Japanese firms for dumping EpROMs (eraseable programmable read-only memories). The complainants claimed that the Japanese were selling these devices at 77 to 227 percent below fair value, and that production costs were at least 6 dollars per device while U.S. selling prices were 4-5 dollars.

The International Trade Commission ruled that the U.S. industry had been injured by the trade practices of the Japanese firms in all three cases. The ruling on 64K RAMs was made in August, on EpROMs in November but a ruling on 256K (and above) RAMs was made in January 1986 after an unusual and unprecedented intervention in the process by the President and the Secretary of Commerce. Apparently, the Reagan Administration became convinced of a

[18] Jack Robertson, "SIA Bid to Hit Japan on Trade Disputed," Electronic News, (June 24, 1985), p. 1; "The Bloodbath in Chips," Business Week, (May 20, 1985), p. 63.

need to accelerate the process behind the RAM complaint and to change the nature of the complaint somewhat to provide greater bargaining leverage with the Japanese government.

On December 16, 1985, Secretary of Commerce Malcolm Baldridge announced that the Department of Commerce was initiating its own investigation into the possible dumping of 256K RAMs at the request of the President. The Japanese government responded to the changed mood in Washington first by sending MITI officials to meet with industry representative on January 20, 1986. At this meeting, MITI offered to establish floor prices for devices sold by Japanese firms in the United States. The U.S. firms rejected this offer claiming that it would still allow the Japanese to dump in third country markets and thereby give U.S. equipment firms large incentives to locate their production outside the United States. In addition, they claimed that floor prices would violate antitrust laws. What they wanted, they said, was for Japan to stop dumping on a worldwide basis.[19]

Another Japanese response to the trade dispute was for the firms to raise prices independently.[20] Hitachi also announced a special program to increase imports of electronic components and other items in the United States and to increase contributions to the U.S.-based Hitachi Foundation. But most U.S. observers considered this to be mere window dressing. The appreciation of the yen against the dollar in the first months of 1986 was expected to help somewhat in reducing trade tensions overall, but not much relief could be expected in semiconductors because the underlying source of the dispute was the global overcapacity which resulted from an investment boom in the late 1970s and early 1980s.

---

[19] Jack Robertson, "Japanese Officials Visit IC Cos. on Dumping," Electronic News, (January 20, 1986), p. 12.

[20] Susan Chira, "Japanese Raising Chip Prices," New York Times. (December 4, 1985), p. D1.

On March 14, 1986, Commerce ruled that Japanese firms had indeed dumped 256K RAMs and 1 Megabit RAMs and that the dumping margins for at least two firms, Mitsubishi and NEC, exceeded 100 percent. Commerce had ruled similarly on 64K RAMs in January, so the second ruling was not much of a surprise. Nevertheless, the conversion of the Section 301 complaint into an anti-dumping complaint and the speed with which the two anti-dumping investigations were carried out signalled the intent of the Reagan Administration to make trade in semiconductors a major thrust in its trade diplomacy with Japan.[21]

In late May 1986, the ITC decided to impose countervailing duties on Japanese semiconductor firms, some as high as 35 percent over the current selling price of certain devices. On May 27, the ITC decided that Micron Technology had suffered economic injury as a result of sales of Japanese 64K dynamic RAMs on the U.S. market because of the severe downward effect of those sales on prices and profits. The six major Japanese producers were named in the ruling.

The U.S.-Japanese Semiconductor Trade Agreement of 1986

In late June 1986, the U.S. Trade Representative and MITI reached a framework agreement on the semiconductor trade issue. The agreement beat the deadline of July 12, after which the USTR would have been forced to impose new penalties and sanctions under the 1974 Trade Act. MITI agreed to adopt measures to raise U.S. firms' share of the Japanese market from 10 to 20 percent in exchange for the dropping of antidumping and Section 301 petitions against Japan. In addition, MITI agreed to help administer a floor-price

---

[21] Clyde Farnsworth, "U.S. Plans Inquiry on Japanese Chips," New York Times, (December 7, 1985), p. 43; Stuart Auerbach, "Tougher U.S. Stance Seen On Chips," Washington Post, (December 5, 1985), p. E3; "Cutting Rough with Japan's Chip Makers," The Economist, (January 11, 1986), p. 59; Clyde

system based on "fair market value" (FMV). The specifics of the agreement were left to later negotiations. There remained the problem of what to do about the previous antidumping and injury rulings by the ITC and the Department of Commerce.

The U.S. semiconductor industry received the news of this agreement with some skepticism. They were concerned about several issues: 1) the method for establishing fair market value, 2) the treatment of third parties to which semiconductors might be sold at lower than FMV, and 3) the inclusion of other devices besides 64K and 256K RAMs and EPROMs in the agreement. There continued to be conflict between the merchant semiconductor firms and the industrial consumers of semiconductors (mostly computer and electronics firms) about the terms of the agreement. The consumers wanted to maintain their right to purchase devices at low prices and worried that Japanese integrated firms would have an advantage over them if they could not. They were particularly anxious to exclude 1 Megabit DRAMs from the FMV price system.[22]

On July 31, 1986, the U.S. and Japan concluded negotiations for a semiconductor trade agreement. In that agreement, Japan agreed to open its market to further participation by U.S. firms, the FMV price system was to be established and administered by the U.S. Department of Commerce in collaboration with MITI, and the U.S. dropped the antidumping and Section 301 complaints in exchange for guarantees that the Japanese firms would not dump in world markets.

The immediate effect of the agreement was to raise EPROM and DRAM prices dramatically. By late September, 256K DRAM prices had increased from $2.25 to

---

Farnsworth, "New Chip Ruling Goes Against Japan," New York Times, (March 14, 1986), p. D2.

[22] Michael Shrage, "Semiconductor Industry Reacts Warily to Accord with Japan," Washington Post, (May 30, 1986), p. F3; Jack Robertson, "Say 6 Mfrs. Seek Inclusion of ASICs in Japan Trade Pact," Electronic News, (June 16, 1986), p. 55; Jeff Moad, "Clash of Chip, Systems Vendors Led to Sanctions Compromise," Datamation, (June 1, 1987), p. 17.

about $5.00 per device.[23] Makers of printed circuit boards for computers and electronic equipment threatened to move their board assembly operations overseas where prices of components could not be so closely monitored. Part of the problem may have been the inaccuracy of the prices established by the Department of Commerce for the FMV system. The American Electronics Association and the Semiconductor Industry Association worked together to provide data to Commerce for the October 15 revisions of the system, so as to bring prices down to more realistic levels. By the end of the first quarter of 1987, 256K DRAMs dropped again to about $4 per unit.

In October 1986, the European Community began to object strenuously to the semiconductor agreement between the U.S. and Japan, claiming that it violated the fair-trade rules of the GATT. On October 8, the European Community requested that the GATT undertake an investigation of the legality of the agreement. The Europeans objected in particular to the provisions of the agreement for an increased market share for U.S. firms in the Japanese market, suggesting that compliance with the agreement might occur at the expense of European producers.[24]

The Breakdown of the Semiconductor Agreement

Japanese firms began to complain in the fall of 1986 about the relative advantage given to Korean and European firms by the FMV system. They contended that complying with the paperwork for administering the FMV system was raising their production costs. They suggested that stabilizing prices would remove incentives to innovate.[25] U.S. firms began to complain about Japanese dumping in third markets and about noncompliance with the FMV system

---

[23] Tom Moran, "Chip Pact Said to Imperil Board Assembly in U.S.," Infoworld, (September 22, 1986), p. 1.

[24] "Europeans Protest on Chips," New York Times, (October 9, 1986), p. 36.

in the U.S. market. In November, the U.S. government warned the Japanese government that dumping in third countries would result in the termination of the July agreement.[26]

In mid March 1987, MITI asked Japanese producers to cut production by 10 percent in an effort to reduce price cutting in third markets. It also tightened up its export licensing system to make it harder to send small batches of semiconductors through third parties. These efforts did not satisfy the SIA or the U.S. government that the Japanese government was serious about living up to the July 1986 agreement. Access to the Japanese market had not improved and third-country dumping continued.[27]

On March 23, 1987, the Senate Finance Committee passed a nonbinding resolution by voice vote calling on the President to retaliate against Japan for failing to live up to the semiconductor trade agreement. On March 27, 1987, President Reagan announced that $300 million in trade sanctions would be imposed on Japanese firms for violating the July 1986 agreement and for restricting access to the Japanese market. The sanctions affected only some Japanese consumer electronic products, power tools, and desktop and laptop personal computers but not semiconductors. U.S. computer and electronics firms wanted to avoid increased input costs for Japanese components and hoped also to avoid direct retaliation against U.S. products in Japan. The SIA agreed to the sanctions to placate the various computer and electronics

---

[25] Susan Chira, "Japanese Uneasy on Chip Pact," <u>New York Times</u>, (August 2, 1986), p. 17.

[26] Clyde Farnsworth, "Japan to Cut U.S. Textile Exports," <u>New York Times</u>, (November 15, 1986), p. 17.

[27] Jiri Weiss, "Japan Asks Chip Makers for 10% Cut in Production, Tightens Regulations," <u>Infoworld</u>, (March 23, 1987), p. 25.

industry associations, feeling that their message would get across in any case.[28]

The President's move increased the tension in an already strained relationship with Japan. The Japanese government threatened to retaliate if the trade sanctions were actually implemented (the President had given the Japanese government a few weeks to respond).[29] In the end, no agreement could be worked out and sanctions were imposed on April 17.

The Rise of Sematech

One could see the U.S.-Japanese trade dispute of 1985-7 as an initial battle in what might become a much wider trade war. A Defense Science Board Task Force on Semiconductor Dependency was convened in mid February 1986 to assess the "impact on U.S. national security if any leading edge of technologies are no longer in this country." The executive secretary of the Task Force, E.D. (Sonny) Maynard, was also director of the Department of Defense's Very High Speed Integrated Circuits (VHSIC) program. The task force also included representatives from a variety of electronics and defense-oriented firms, a former Undersecretary of Defense, a former Undersecretary of Commerce, and the director of the National Science Foundation.[30] Several of the reports done for the Task Force were so depressing and controversial that they were classified.[31]

---

[28] Lee Smith, "Let's Not Bash the Japanese," Fortune, (April 27, 1987), p. 175; Rachel Parker, "Industry Associations Applaud Sanctions Against Japanese," Infoworld, (April 6, 1987), p. 28.

[29] Susan Chira, "U.S. Given Warning by Japan," New York Times, (April 16, 1987), p. 23.

[30] Jack Robertson, "DOD Task Force Eyes Impact of IC Technology Offshore," Electronic News, (February 24, 1986), p. 1.

[31] One study which remained unclassified was Richard Van Atta, Erland Heginbotham, Forrest Frank, Albert Perrella, and Andrew Hull, Technical

The Department of Defense decided, on the basis of these reports, to support a new effort in bolstering U.S. technology called Sematech, short for Semiconductor Manufacturing Technology. Sematech was originally proposed by Charles Sporck, president and CEO of National Semiconductor. Sematech would be jointly funded by SIA members and the Department of Defense, and would draw upon the resources of the Semiconductor Research Corporation, an existing research consortium set up by the SIA in North Carolina. The Defense Science Board recommended that the Department of Defense provide $200 million per year over the 1987-92 period, but the actual level of funding for 1988 was to be only $50 million.[32]

In the fall of 1986, Fujitsu announced its intention to acquire 80 percent of the equity of Fairchild Semiconductor, the remaining 20 percent to remain in the hands of Schlumberger. A variety of interests put pressure on the U.S. government to block the sale, on the grounds that it would increase U.S. dependence on Japanese semiconductors.[33] In the end, Fujitsu withdrew its offer. This event was remarkable given the general aversion of the U.S. government to interfere in mergers or acquisitions which do not involve possible violations of antitrust regulations.

Finally, many aspects of the Strategic Defense Initiative (SDI) --and the Strategic Computing program that proceeded it -- were clearly aimed at promoting R&D that would have important spinoffs for the semiconductor industry. The Europeans responded to the Japanese VLSI Project, and the American VHSIC program and SDI, with a number of cooperative ventures of their own. Thus, by the mid 1980s, a major information technology subsidy race had

---

Assessment of U.S. Electronics Dependency (Alexandria, VA: Institute for Defense Analyses, November 1985).

32 Jeffrey Bairstow, "Can the U.S. Semiconductor Industry be Saved?" High Technology, (May 1987), p. 34; David E. Sanger, "Chip Makers in Accord on Plan for Consortium," New York times, (March 5, 1987), p. 29.

33 Andrew Pollack, "Fujitsu Chip Deal Draws More Flak," New York Times, (January 12, 1987), p. 25.

begun that raised governmental R&D spending in Japan, the U.S., and Europe. The R&D spending aspect of the race had some of the characteristics of an arms race. It was possible that all the expenditure, which was aimed at achieving competitive advantages, might be neutralized by the spending of others.

Summary and Conclusions

The semiconductor industry has been a dynamic industry, both in terms of technological change and in its pattern of economic growth. It has not been immune from the business cycles experienced by other industries, as has been graphically demonstrated by the last two years. It remains, however, one leading contemporary example of the general dynamism of information technology and of the problems created for international economic relations by the sensitivities of nations to dependence on others for "strategically important" goods. The early lead of the United States in semiconductors provoked responses in Europe and Japan. In Europe, the initial response was to back national champions like Ferranti, Thomson and Siemens. Now that response is widely perceived to have failed, leading therefore to new efforts at the European level. In Japan, the VLSI Project was the response, and the result was a dramatic improvement in the competitiveness of Japanese firms in international competition.

The organization of production in the United States made it possible for smaller merchant firms to develop alongside larger integrated firms like IBM, AT&T, and Motorola. The conditions that favored the rise and growth of the merchant firms appear to have changed radically. The increasing investment required for the development and production of new devices, the intense competition from integrated electronics firms in Japan and Europe, and the greater ability of large U.S. firms to get access to the capital needed to keep up with that competition seem to have greatly undermined the once nearly unassailable position of the merchant firms.

Their response has been to turn to trade policy remedies to buy time for restructuring. It has also involved an appeal to the Department of Defense for new R&D subsidies in the form of Sematech. In all likelihood, this response will not restore the technological edge of U.S. firms nor will it prevent the trend toward further deterioration of the position of U.S. merchant firms in international markets.

There are three main reasons for this. First, the planning for Sematech did not include the semiconductor manufacturing equipment firms until rather late in the game, though the participation of these firms is crucial to the success of the program. Second, the administration of Sematech may be overly burdened by Congressional requirements to orient production for specialized military purposes and therefore to favor traditional defense contractors over the more innovative civilian-market-oriented firms. Third, there are indications that the Reagan administration will oppose funding of Sematech because it comes too close to implementing an "industrial policy," a position it opposed on ideological grounds.[34]

Public policy remains very important in providing sources of assured demand for products, subsidies for R&D and capital investment, and trade policies which insulate the domestic market or provide greater access to foreign markets. But not all countries are equally good at delivering public policies that aid semiconductor producers. The Japanese have been unusually effective compared to both Europe and the United States. Japanese public policy has made it possible for Japanese firms to combine public R&D subsidies with inexpensive capital, and lots of it, to out manufacture their competitors. The result has been the loss of U.S. technological superiority,

---

[34] For a more detailed critique of Sematech, see Jay Stowsky, The Weakest Link: Semiconductor Production Equipment, Linkages, and the Limits to International Trade (Berkeley, CA: Berkeley Roundtable on the International Economy, August 1987).

global overcapacity, and increasing tension in U.S.-Japanese and Euro-Japanese relations.