CHAPTER 1

Part B: Extended Summary

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Part B: Extended Summary

Part B of chapter 1 expands upon, without repeating, the findings in the Summary. In particular, the sections below highlight the role of technology as a force on competitiveness in consumer electronics, semiconductors, and computers, along with factors such as capital for investment in research and expanded production capacity, human resources and their development, and industrial and trade policies both here and abroad.

The several meanings that can be assigned to the rather amorphous concept "international competitiveness' are discussed in detail in chapter 5. The viewpoint adopted below is first that of the manufacturer, Private companies design, develop, produce, and market goods which may have more or less success in the marketplace, more or less positive impact on a nation's competitive position. Later the view switches to that of governments and their policies, which act on competitiveness directly and indirectly—by influencing business activities, supporting education, subsidizing exports, through the climate for capital formation and economic growth.

Technology

Chapter 3 covers electronics technology in some detail (also see the Glossary, app. A, for explanations of technical terms). Here the interactions between technical capabilities and market success are explored,

Consumer Electronics

In consumer electronic products such as color TVs, both product and process technologies are well-understood and widely diffused. Product differentiation strategies are more important than technical differences; component television, stereo sound, and digital chassis designs illustrate the frontiers of this now largely routine field. Japan's consumer electronics manufacturers have benefited from the economies of higher production volumes and perhaps from more extensive automation, but both product and process technologies in consumer electronics tend to be standardized, technical change to be incremental. Companies anywhere in the industrialized world have access to much the same pool of knowledge—the exceptions being newer product families like video cassette recorders (VCRs). Color TVs with similar product features are made not only in Western Europe, the United States, and Japan, but in developing countries like Taiwan and South Korea, Manufacturing technologies are similar wherever TVs are built, with labor-intensive operations carried out in low-wage developing countries by European and Japanese firms, as well as American. The *result is a competitive environment in which American firms have few unique advantages,*

Differences in both product and process technologies for televisions were greater during the late 1960's and early 1970's when Japanese firms were beginning to invade the U.S. market, Then, firms in Japan moved more quickly than their American counterparts toward solid-state chassis designs. By using transistors and integrated circuits (ICs), they were able to improve the reliability of their products, and more easily automate portions of the production process. Automation helped compensate for component costs that at the time were higher for transistorized designs than for those relying on vacuum tubes. Reliability was particularly important to Japanese firms because they did not have service organizations or dealer networks within the United States. To increase their market shares, they needed to sell through retail outlets such as discount chains. To

Color TV Imports Into the United States

Year	Number of color TVs imported by origin (thousands) Japan	Taiwan	Korea	Total[a]	Imports from all sources as a percentage of U.S. consumption
1967	315	—	—	318	6.7%
1969	879	22	—	912	15.7
1971	1,191	85	–	1,281	18.9
1973	1,059	325	2	1,399	15.8
1975	1,044	143	22	1,215	17.9
1977	1,975	318	92	2,476	27.0
1979	513	368	314	1,369	13.6
1981	727	514	393	1,946	15.6

[a]Includes imports from countries not listed individually

SOURCES 1987, *1969—Television Receivers and Certain Parts Thereof* (Washington, D C U S Tariff Commission Publication 438, November 1971), p. A-62.
1971,1973—Television Receivers, Co/or and Monochrome, Assembled or Not Assembled, Finished or #of Fin/shed, and Subassemblies Thereof (Washington, D C. U S International Trade Commission Publication 808, March 1977), pp. A-90, A-99
1975-79—Co/or Television Receivers and Subassemblies Thereof (Washington. D C U S International Trade Commission Publication 1088, May 1980), p D-6.
1980—Television Receiving Sets From Japan (Washington, D.C U S International Trade Commission Publication 1153, June 1981), p H-21
198f-information from Department of Commerce

achieve credibility, they had to supply TVs that did not need frequent service. Japan's consumer electronics manufacturers succeeded in this far from riskless strategy.

If technology is now a secondary factor for TVs, in more recently introduced product families—not only VCRs, but video disk players, home computers, and related applications of electronic technologies to consumer goods—designs are evolving at a faster pace. Japanese entrants spent many years and a great deal of money on engineering development of VCRs—Matsushita even reached production in 1973 with a design that was shortly thereafter judged not to be good enough—before achieving commercially viable products. But otherwise, competition in consumer electronics is largely a matter of prices and marketing, brand loyalties and customer perceptions. While Japanese exporters have established themselves firmly in American markets for TVs and audio products, individual companies have suffered frequent reverses in consumer goods ranging from stereo receivers to CB radios and pocket calculators, where markets have been unpredictable and competition always stiff.

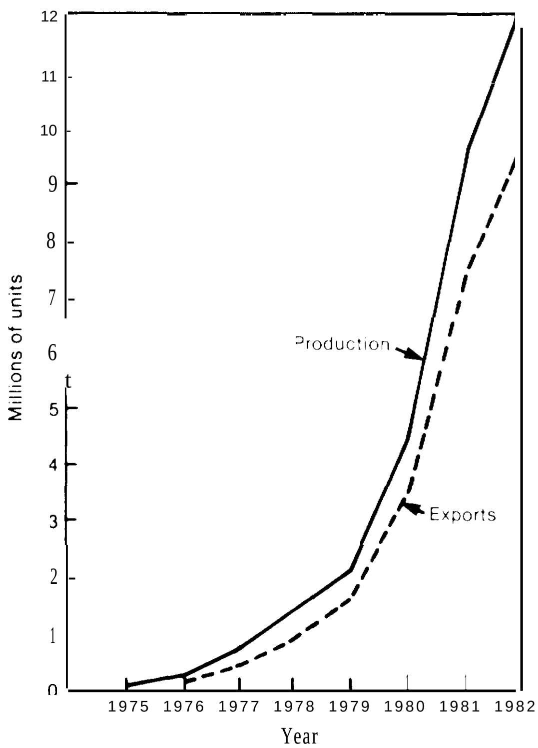
Semiconductors

Microelectronic devices, in contrast, are intermediate products sold in accordance with detailed technical specifications to sophisticated customers who design them into final products ranging from TVs and electronic games to missile guidance systems and powerful computers. To be successful, semiconductor firms must not only meet the current requirements of such customers but do a good job of anticipating their future needs.

Technological Factors in Competition

As explained in chapter 3, the interdependence of product and process technologies in leading-edge microelectronic devices—very large-scale ICs–is unusual even for a high-technology industry. Circuit designers must understand the nature and capabilities of the fabrication process—including proprietary details—to optimize the performance of a chip. Product and process technologies advance together, with process capability a restriction on devices that can be fabricated with acceptable yields (the fraction of circuits that function). The in-

Japan's Production and Exports of Video Cassette Recorders (VCRs)



SOURCE "VTR Product Ion Demand," Japan Report, Joint Publications Research Service JPRS L/1 1100, Jan 28, 1983, p 35

tractions go in both directions. Clever circuit design can compensate for some kinds of process limitations. Among the examples are simply doing more with fewer transistors or other circuit elements and incorporating on-chip testing and redundancy. Some American firms added redundant circuit elements to their 64K RAM (random access memory) designs, a step which may pay dividends in the future as they move to still higher levels of integration,

Competition in standardized products like RAMs depends on both price and technology–chapter 5. When 64K RAMs were first introduced, they sold in sample quantities for about $100 each. From this level in early 1980, prices fell to $10 to $15 by the end of that year. After another year, 64K RAMs could be purchased for $5 or less. These rapid price declines, typical of the semiconductor industry, are driven by intense competition to improve process yields, reduce manufacturing costs, and cut prices to build market share. As the prices of 64K RAMs dropped, prices also fell for the previous-generation 16K devices, which by 1982 sold for about $1 each. Similar patterns will be followed as 256K RAMs, in pilot production in both Japan and the United States during 1983, take over from 64K chips.

Despite the intense price competition in these commodity-like circuits, product technology continues to play a role. Not only is a good circuit design essential for high yields and low costs, but a high-performance RAM can command a greater price. While the most common varieties of 64K RAMs have access times (the average time to retrieve the contents of a memory cell) in the range of 200 nanoseconds [200 x 10–' seconds), otherwise comparable circuits with lower access times sell for more; during 1982, 64K RAMs with access times of 150 nanoseconds brought prices a dollar or so above those for 200 nanosecond circuits. Nonetheless, RAMs—and most other memory chips—are in essence standardized items. As for consumer products like TVs, progress is incremental and predictable, at least at present—although the pace is much swifter.

If process technology is vital for RAMs, product technology—i.e., circuit design—carries greater weight in competition involving other varieties of ICs. Foreign firms have been less successful in microprocessor families and the arrays of support chips designed to be used with the processors themselves, as well as some types of linear circuits, logic families, semicustom chips, interface circuits, and the many other varieties of specialized microelectronic products, In contrast to memory chips—in essence "brute force" devices—circuits that implement logic depend more heavily on creative engineering design, on anticipating user needs, and on recognizing new opportunities made possible by developments in either process *or* device technology, A well-designed microprocessor—one with an architecture that takes maximal advantage of the circuit elements it employs, with an instruction set that pro-

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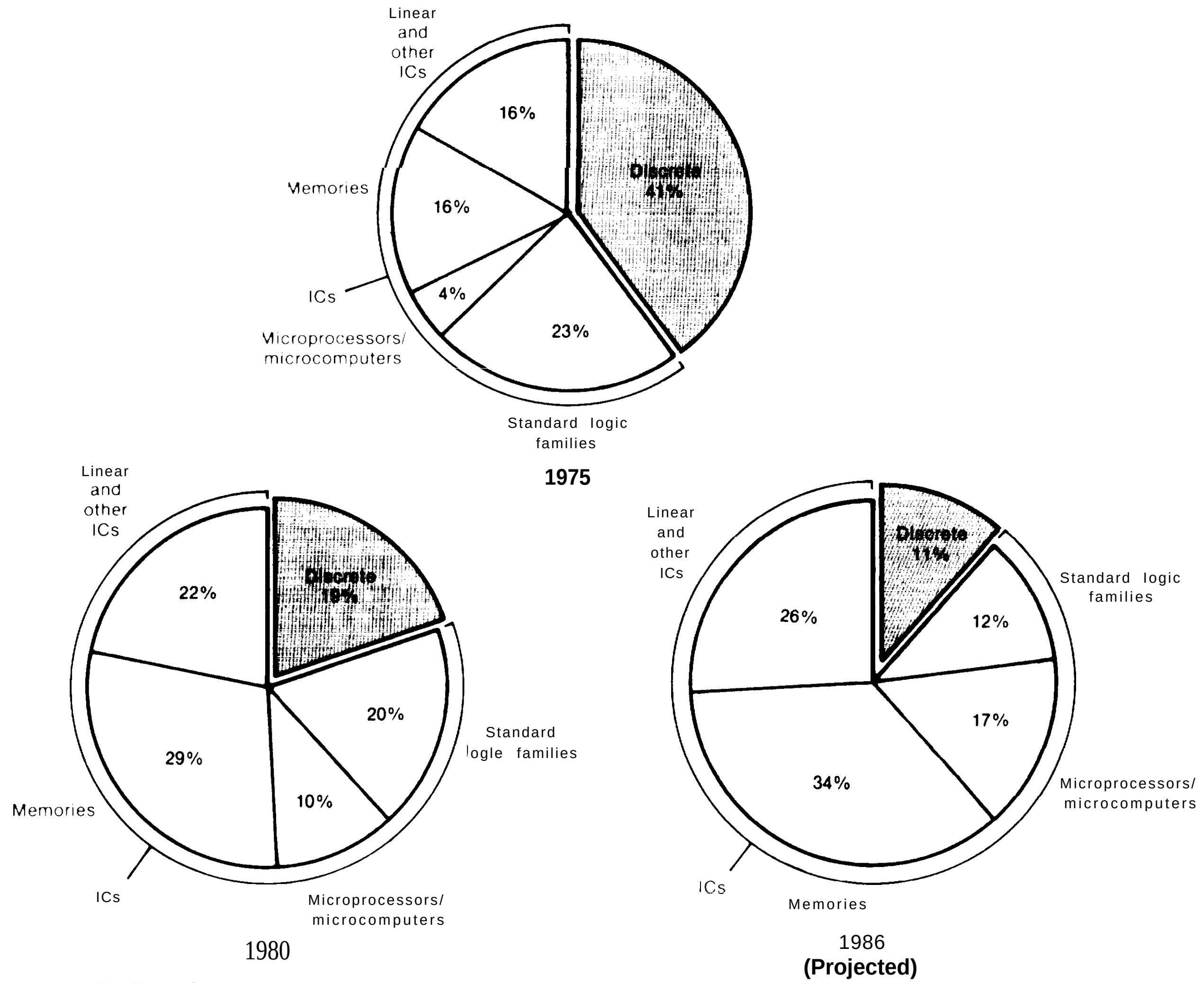
U.S. Semiconductor Sales by Type



SOURCE ***1975**—Electronics,* Jan 8, 1976, pp. 92, 93
1980 —*Electronics,* Jan 13, 1982, pp. 124, 125.
1966 —*Electronics,* Jan 13, 1983, pp. 128, 129; Mar. 10, 1983, p. 8

grамers find easy to use, a convenient bus structure and input/output ports—could be a commercial success even if developed by a company with only mediocre process technology. Were this the case, however, alternate source manufacturers might end up with more of the market and/or higher profits.

International Positions in Microelectronics Technology

While Japanese manufacturers now make and sell many types of microprocessors and logic circuitry, and have always had excellent technology for linear ICs, they have not been able to match American semiconductor firms in design-intensive products. For instance, the microprocessors that Japanese semiconductor firms sell in large volume on the world market are U.S. designs. Such patterns will probably continue to hold, although here as elsewhere the magnitude of the U.S. lead is likely to shrink as the Japanese get better at circuit design, and as Japanese semiconductor manufacturers hire engineers from other countries,

In semiconductor processing, Japanese firms are often on a par with the United States and may be better in some cases. One reason has been the VLSI research project and its several follow-ens, orchestrated and partially funded by Japan's Government. By 1983, Japanese manufacturers were, as a group, further along in production plans for process-intensive 256K RAMs than their American competitors. Process control also exerts a major influence over quality; nevertheless, if a few years ago the quality of some types of Japanese ICs—specifically, RAM chips—was higher than supplied by American firms, today any differences are much smaller (see ch. 6).

Semiconductor manufacturers in Japan have made great strides as well with complementary MOS (metal oxide semiconductor) circuitry, one reason being its attractions for certain of the consumer applications in which Japanese semiconductor firms for many years specialized. In contrast, companies in Western Europe are generally behind both the United States and Japan in all varieties of MOS. European nations are making determined efforts to catch up, in several cases with strong government support, Despite underlying technological abilities that in many cases are excellent, European manufacturers have not been as successful as American suppliers at converting their technology into successful commercial products. In circuit design, neither the Japanese nor the Europeans seem able to match wits with Americans. This is an advantage—a source of "technology gap''—that the United States should be able to maintain. To do so, U.S. firms must continue to vigorously pursue new markets and American engineering schools must retain their preeminent position in fields related to microelectronics.

Research and Development

Despite the continued prowess of American circuit designers, the comfortable lead once enjoyed by the United States in the underlying technology of semiconductor devices is now spotty at best. American merchant semiconductor firms devote most of their R&D efforts to product and process developments with immediate application to end-products; relatively small companies with limited resources, they have had little choice but to place the greatest priorities on R&D that will help them in next year's marketplace battles.

In the United States, more basic research—ranging from studies of the physics of electron devices to the development of process tools such as ion-beam lithography—has been funded and performed elsewhere. Some of the work has been supported by the Department of Defense—e.g., research on high-speed gallium arsenide devices, In other cases, large organizations such as IBM or AT&T's Bell Laboratories have carried much of the burden; Bell Labs, in particular, has been responsible for many of the seminal developments in solid-state electronics. In the past, Bell diffused these widely to both U.S. and foreign enterprises, Now, with AT&T entering new markets,

World Integrated Circuit Output by Headquarters Location of Producing Firms

	1978		1982a	
	Product ion (millions of dollars)	Share of world output	Product ion (millions of dollars)	Share of world output
United States	$4,582	68.3%	$9,700	69.5%
Merchant	3,238		6,450	
Captive	1,344		3,250	
Captive percentage	29.30/o		33.5 "/0	
Western Europe	453	6.7	620	4,4
Japan	1,195	17.8	3,440	247
Rest of the world[b]	482	7.2	190	14
	$6,712		$13,950	

[a]Estimated
[b]Includes the Soviet Union and Eastern Europe for 1978 but not 1982

SOURCES **1978**—*Status 80 A Report on the /n tegrated Circuit Industry* (Scottsdale Ariz Integrated Circuit Engineering Corp 1980), p 4
1982—*Status* 1982 *A Report on the /n tegrated Circuit Industry* (Scottsdale, Ariz Integrated Circuit Engineering Corp 1982), p 5

including merchant semiconductor sales, and competing under new conditions, the company may no longer feel that it has the luxury of supporting basic research so heavily; at the least, it will guard its technology much more closely (as IBM always has). Other forces at work include growing software demands on microelectronics firms—an area constrained by personnel shortages, low productivity, and weak theoretical foundations. Furthermore, the highly competitive merchant firms have perhaps been taking advantage of new technological opportunities faster than the stockpile has been replenished. The need for new sources and mechanisms of technology development and diffusion is plain.

Along with continued Federal support and incentives for R&D, particularly more basic work, *institutional innovations that would help to build the technological base for continuing U.S. competitiveness in microelectronics—as well as in computer systems—appear worthy of congressional attention.* U.S. competitiveness in electronics has depended heavily on the technical strengths of American firms, So long as the United States held a substantial overall lead in electronics technology, smaller companies could successfully design and develop their products and processes without doing much research on their own. The foundation provided by large companies, military spending, and the universities sufficed. Today, not only is this base eroding, but the overall technical edge of the Nation has diminished, In particular, research capabilities in American universities have deteriorated because of obsolete equipment and shortages of graduate students and faculty. A redefined Federal role in R&D could address the need for better mechanisms of technology diffusion within the United States, as well as encouraging inflows of technology from overseas,

A number of promising models exist, beginning with domestic ventures such as the Semiconductor Research Cooperative and Microelectronics & Computer Technology Corp. and including a number of experiments in other countries. Some of these are aimed at enhancing the diffusion of technology as well as at encouraging basic and applied research with potential commercial, rather than exclusively military, applications, The Fraunhofer Gesellschaft in West Germany, as well as Japan's joint R&D programs, both discussed in chapter 10, come to mind. The U.S. electronics industry, including but not restricted to microelectronics, could benefit from institutional mechanisms more closely linking R&D efforts in Government laboratories, industry, and universities. A relatively large but decentralized system of centers-of-excellence, directed toward commercial developments—with ample scope for local funding and entrepreneurial participation—would fit American traditions. Given some fraction of funding, perhaps 30 or 40 percent, from the Federal Government on a continuing basis, the time horizons could be longer than those for R&D programs funded entirely by industry.

Computers

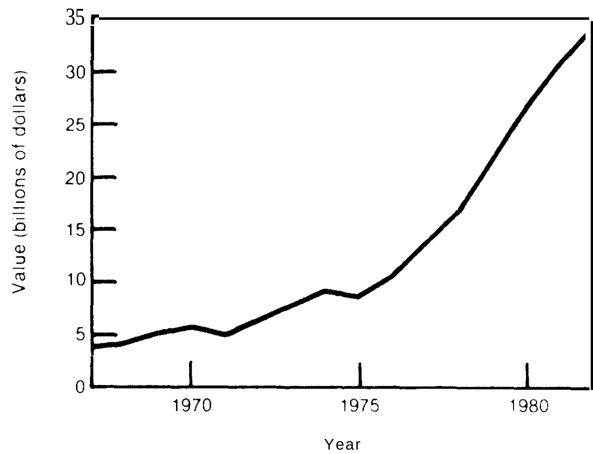
If manufacturing technology is critical for cost control in consumer electronics, and both process and product technologies are vital in semiconductors, the computer industry exemplifies reliance on product technologies, Particularly for larger systems, manufacturing is less significant for competitiveness because production volumes are modest compared to TVs or semiconductor devices. For small computers sold in large numbers—and particularly the desktop machines offered by companies like Apple—or for peripherals such as printers and terminals, manufacturing technologies are of greater and growing importance.

Technological Competition

What *are* the major factors in marketing computers? First and foremost, performance/cost ratio: the computing power per dollar that a manufacturer can supply. This depends heavily on system design—both hardware and software—i.e., in doing more with less rather than cutting production costs. For most computer systems, assembly is labor-intensive, costs increasing with overall complexity, The company that can design a system offering higher performance at a given cost has the advantage. IBM, as in so many other instances in the computer industry, provides something of an exception because its higher sales volumes mean more pronounced scale economies. A further exception has developed at the lower end of the market, where personal machines, small business systems, and micro or minicomputers sold to original equipment manufacturers are built in much greater numbers. In both cases, greater production volumes increase the significance of manufacturing technologies but in no way diminish the role of system design.

Because of these characteristics, the computer industry is just as design- and R&D-intensive as microelectronics, but computer engineers are seldom as constrained by manufacturing processes as chip designers. They are, however, constrained by the performance characteristics of available components, principally ICs. Microelectronic devices are the building blocks for processors as well as essential elements in many other parts of computing systems, from controllers for disk drives to semiconductor memories themselves. Because system performance depends so heavily on ICs, many computer firms have established captive microelectronics R&D and production facilities. While component technologies ultimately limit what **can** be done, computer designers have considerable latitude in configuring systems; the many alternatives from which they can choose are affected in different ways by the characteristics of both hardware and software,

U.S. Production of Computer Equipment



SOURCE: 1972, 1975, 1977, 1980, 1983 editions, *U S Industrial Outlook*, Department of Commerce 1981 and 1982 shipments estimated

Systems Aspects

Although firms located in other countries are nibbling at U.S. market share, our dominance in computer manufacture still continues, built largely on the abilities of American producers at system design and integration. Conceiving and developing new applications of computing power depends on engineering design and on understanding user needs—including field service and software support. American manufacturers opened the personal computer market, not through technical advances, but because they perceived a potential market where others did not. Substantial penetration by Japanese imports may eventually follow, but based more on low prices–stemming from the well-established capability of Japanese electronics firms to manufacture in high volume at low cost—than unique product features. Nevertheless, so long as technical evolution is rapid, and software one of the keys to sales, American entrants with creative product designs should have little to fear from overseas competitors. At least at first, the more successful Japanese personal computers will be based on U.S.-designed microprocessor or microcomputer chips, as well as software developed in the United States—e.g., the popular CP/M or Unix® operating systems and the many applications programs that run on them.

This is only one example where American computer manufacturers have been at the forefront in spotting new applications of computing technology. Among the other examples are:

- Small machines suited to the needs of businesses with a few dozen to a few hundred employees.
- Fault-tolerant systems that can be used where reliability is critical.
- Specialized data processing installations for banks, insurance companies, and Government agencies.
- Dedicated processors to be integrated into

industrial controllers, scientific instruments, aircraft flight-control systems.

- Networked systems, time-sharing, satellite terminals and other mechanisms for providing users with computing power when and where needed.
- Both large and small machines for specialized scientific and technical computing, ranging from supercomputers for complex numerical calculations in computational fluid dynamics or the development of nuclear weapons to array processors to be used in conjunction with dedicated minicomputers in modeling chemical reactions.

Sometimes market demand has driven the technology, with the design efforts of computer manufacturers shaped by perceptions of these needs; occasionally, more raw computing power has been available than has found immediate application.

System integration remains the forte of American firms, and—just as for U.S. semiconductor manufacturers—so long as American companies and American engineers continue to push aggressively into new software and hardware applications, they should be able to maintain a technological edge sufficient to hold a large fraction of the world computer market.

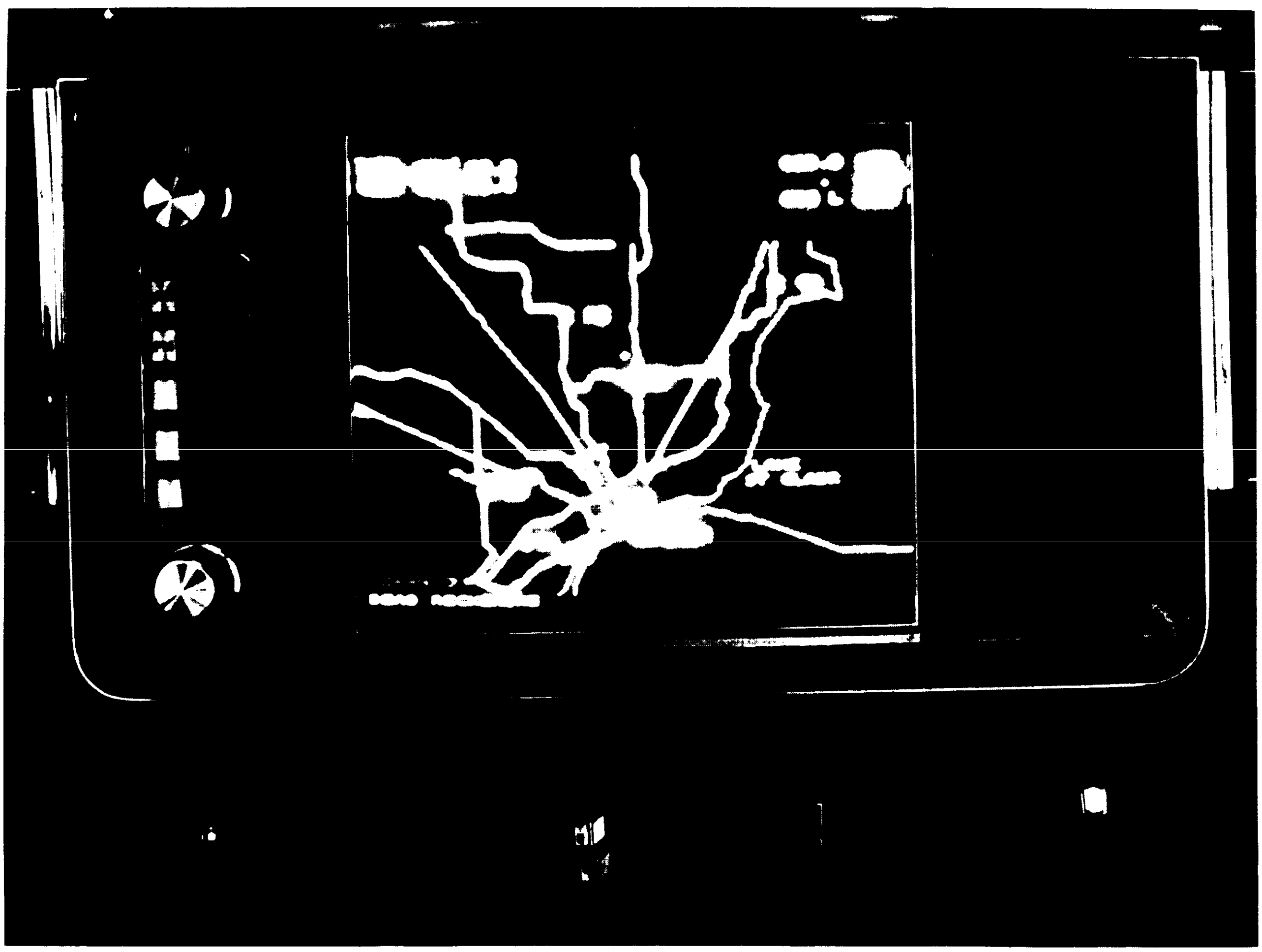


Photo credit General Motors

Experimental electronic map display for automobile dashboard

Nonetheless, this share may not be the 70 percent of 10 years ago. If so, the causes will be multiple, as discussed in chapter 5. Rapidly expanding and fragmenting markets mean that no one manufacturer can cover all the bases; windows of opportunity will open for foreign as well as U.S. suppliers, Manufacturers in other countries may benefit from supportive industrial policies, as well as drawing on growing pools of capable computer scientists, systems engineers, and managers. The result is likely to be a narrowing of the technology gaps that have favored American firms. Improvements in the standing of computer industries in countries like Japan relative to other sectors of these country's economies may lead to greater international competitiveness in computer manufacturing. Most of these forces are outside U.S. control. Given the circumstances, ***it*** *becomes particularly important that the Nation avoid unnecessary sacrifices in competitiveness through missed opportunities by American firms or defective policy choices by* ***the Federal Government.***

Finance

Well-developed capital markets have been a major source of strength for entrepreneurial high-technology firms in the United States. Under most circumstances, both new start-ups and young, rapidly expanding companies have been able to find the money needed to grow with their markets. Still, this has not been universally true; in recent years, some electronics companies--preferring, in common with most of American industry, to fund expansion with internally generated cash flows--have found themselves lacking the financing needed to keep pace with market opportunities. Perhaps of greatest significance, volatile interest rates in the United States reinforce other factors that bias decisionmaking by corporate managers toward short-term undertakings,

Venture Capital

Over the past quarter century, venture capital in its various forms has spawned many of the new entrants in the U. S. electronics industry: companies supplying software, instrumentation, semiconductor devices, computers and peripherals. Some of these—Digital Equipment Corp., Intel--have become mainstays of U.S. competitiveness. Other nations-West Germany, the United Kingdom, even Japan—have sought to build some of the characteristics of U.S. venture capital markets into their industrial policies. These attempts to generate the vitality and dynamism that venture start-ups have brought to American growth industries have seldom met with success.

Bottlenecks in U.S. capital markets are more probable and more significant when it comes to financing rapid expansion in sectors like microelectronics, where capital intensity is escalating along with sales, than in funding new ventures. Nevertheless, venture funding has not always been available, part capital for developing new ideas well before production is in sight. When venture funds dried up in the middle 1970's, new start-ups in electronics manufacture virtually halted. Around the turn of the decade, after the reduction in capital gains taxes that took effect in 1978—one of many forces affecting venture capital supplies—the market received. Most of those supplying venture funds look for capital appreciation over a 3- to 5-year period, with typical target returns being 35 to 50 percent per year. Plainly, capital gains tax rates are important both to individual and institutional suppliers of risk financing. However, for reasons that are poorly understood, venture capital funding is notoriously cyclical; factors other than tax changes also contributed to the revival of the market. By mid-1980, a veritable boom in venture funding was underway, with much of the money going to electronics. Prospective entrepreneurs, many in the Silicon Valley region of California, saw opportunities in microcomputers and other applications of microprocessors, in software and computer peripherals, in semiconductor chips themselves. Capitalists saw the technological windows in much the same light. More than 20 new microelectronics firms alone were established during the first two years of the venture capital resurgence.

Financing Growth

As chapter 7 points out, finding capital for continued expansion has been a greater concern for many U.S. electronics companies, particularly given the high growth rates in much of the industry. While there are few if any signs of overall shortages of capital for investment in the United States, financing growth is a common problem for young companies anywhere in the economy, Electronics firms, especially those producing ICs, face unusually steep hurdles. The first is simply the need to keep up with markets that in some years have grown at 25 percent or more. Firms trying to *increase* their shares of such markets have to add production capacity at rates that can severely strain financial resources; needless to say, the investments must precede the added revenues they bring in. At times, U.S. semiconductor manufacturers may have been unable to secure the funds needed to keep up with market growth—or, more likely, have judged the conditions imposed by prospective suppliers of capital unacceptable.

Rising capital intensity for semiconductor processing creates a second hurdle. Denser ICs require more expensive fabrication equipment. A state-of-the-art manufacturing facility, which cost perhaps $5 million a decade ago, now might run $50 million. High levels of R&D spending, mandatory for companies that hope to compete in markets for advanced devices, contribute a third hurdle, Thus capital demand is mounting even more rapidly than the market has been growing, compounding the already difficult financing problems of U.S. semiconductor firms.

In common with most of American industry, U.S. electronics firms have been reluctant to rely heavily on external funds—either debt (loans, bonds) or equity–for financing growth. At times over the past decade, it would have been difficult to issue either bonds or stock. Nonetheless, the U.S. electronics industry exhibits a pattern of consistently low debt/equity ratios contrasting sharply with foreign manufacturers. Aversion to borrowing may have constrained the growth of some American electronics companies over the past decade.

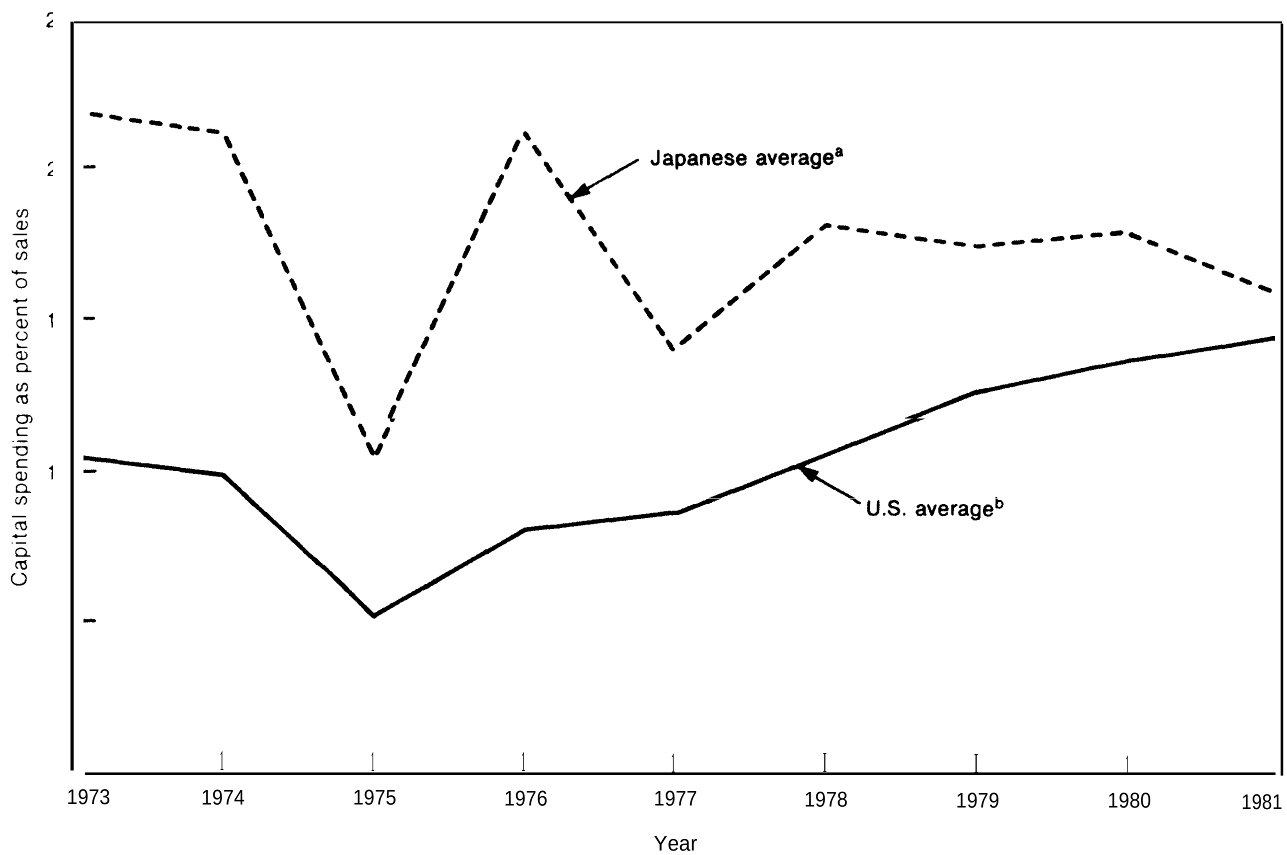
The changes in U.S. tax law implemented by the Economic Recovery Tax Act of 1981 have increased cash flows for electronics firms along with other businesses in the economy. High-technology electronics manufacturers benefit particularly from the R&D tax credit. Accelerated depreciation is a different matter: although more rapid capital cost writeoffs are now available to virtually all U.S. corporations, the benefits are much greater for numerous other sectors. Because electronics firms, particularly in the high-technology portions of the industry, have always been able to depreciate at fairly rapid rates, they have not been helped as much as sectors like primary metals. In earlier years, many such industries faced lengthy capital cost recovery periods. The *relative* position of electronics has suffered under the 1981 Tax Act to the extent that companies in other lines of business have an easier time securing external funds.

International Differences

Why do American companies limit their use of external funds? Most managers would answer by citing high costs of capital, whether debt or equity, as reflected in high U.S. interest rates over the past few years. American businessmen have claimed that they face costs of capital perhaps twice those of their competitors in Japan. In fact, although costs of funds in the United States *are* higher than in Japan, the differences—when adjusted for inflationary expectations—appear relatively small, certainly less than 5 percentage points, While not insignificant, the resulting advantages for Japanese electronics manufacturers are hardly overwhelming, even when the tax benefits of the higher debt/equity ratios characteristic of Japanese corporations are taken into account. Lower costs of capital in Japan make no more than minor contributions to differences in manufacturing costs. *A much more potent source of advantage for large, diversified Japanese electronics firms, particularly in periods when markets are expanding rapidly, stems from their ability to allocate funds internally, using moneys generated in other lines of business to finance high rates of spending on R&D and new production capacity.* U.S. semiconductor firms, especially those that remain independent and have a limited range of products, will always be hard-pressed to keep up with diversified companies, Japanese or American. A major difference between diversified Japanese and American electronics firms is the evident *willingness* of Japanese semiconductor manufacturers to compete in the mass market for merchant products, and to aggressively add new production capacity. It remains to be seen how American firms like Mostek or Intersil, which are now parts of large conglomerates, will behave over the longer run—and how Western Electric will fare, now that it is entering the merchant market.

While the contrasts between financing practices of American and Japanese electronics corporations are many—as are those with European enterprises—the net advantages that Japan's companies receive from government guidance applied to investment funds are small. Japanese industrial policies continue to influence capital allocations and costs of funds, but the high leverage characteristic of Japanese

Rates of Capital Spending by U.S. and Japanese Semiconductor Firms



[a]Integrated circuits only, 1973-1979, weighted average of 12 manufacturers 1973-1979 11 manufacturers 1980, 1981

[b]1 9731980 Weighted averages for 11 U S merchant semiconductor manufacturers, 1981 estimated

SOURCE ***United States***— 1973-1977, Bureau of Census, 197&1981, Department of Commerce and Semiconductor Industry Association ***Japan— 1973-1979,*** *Japan* fact *Book '80* (Tokyo" Dempa Publications, 1980), p *203; 1980, 1981, Japan Economic Journal* corporations, as measured by the ratio of debt to equity or debt to total capital, helps primarily in terms of taxation. In Japan as in the United States, interest can be written off as an expense (while dividends paid to shareholders cannot); therefore higher proportions of debt reduce corporate tax bills. That banks in Japan lend willingly to highly leveraged firms places these banks in a position more like that of equity-holders in the United States: Japanese banks absorb higher risks than American banks, but the impacts of this, by itself, on the competitiveness of Japanese companies are small. Furthermore, leverage ratios of Japanese firms have been slowly declining over the years—one example among many of the gradual movement of the Japanese economic system toward convergence with other advanced nations. Likewise, the unusually high rate of personal savings in Japan has impacts at the aggregate level which are only loosely coupled with costs of capital for individual firms. These costs vary widely across the Japanese electronics industry, just as in the United States. Indeed, *cost and availability of capital differ more from firm to firm within the U.S. electronics industry than, on the average, between the electronics industries of the United States and Japan.*

The apparently high costs of capital in the United States—as reflected in high interest rates, stemming in the past from expectations of continued price inflation-do have a serious consequence. *High and uncertain interest rates in the United States tend to skew investment decisions toward short-term undertakings.* Although no one knows how to measure or aggregate the time horizons of business executives in any meaningful way—much less compare those of American executives with their counterparts in West Germany or Japan—all else the same, interest levels that fluctuate unpredictably will act to shorten time horizons. Investments with longer payback periods—for example in basic research or in advanced production equipment—will appear less attractive. To the extent that capital markets in the United States continue to mirror expectations of high and uncertain interest rates, the future competitiveness of American industries like electronics may suffer,

Human Resources

Business enterprises depend on capable people for tasks ranging from assembly line work to service and repair of their products, design and development, and general management. From the standpoint of international competitiveness, the larger the pool of qualified people a firm or an industry can draw from, the better. An ample supply of engineers and technicians means that companies will have the luxury of picking and choosing, while from the employee viewpoint, salaries may be depressed. A small pool means potential shortages, most likely of specialists, perhaps driving organizations to move people laterally to meet their needs. Soaring demand for computer professionals, for example, has drawn in many people without formal training in the discipline; about two-thirds of those employed in programing and related jobs have degrees in other fields.

Quantity and Quality

For several years, during which engineering graduates in all disciplines were in short supply, the U.S. electronics industry experienced a scarcity of entry-level electrical engineers and computer scientists. In the short term, demand has dropped—largely because of recession—while the supply continues to rise, fed by swollen undergraduate engineering enrollments, The longer term picture—including prospects of continuing shortages of software engineers, integrated circuit designers, and others with specialized skills—has not changed. Moreover, the supply of grey-collar workers for the electronics industry—technicians, drafters, and designers, field service repairmen, laboratory aides—may also be short, although quantitative data on supply and demand for such jobs are scarce. There is, needless to say, no shortage of unskilled assembly workers; *the heart of the problem in this, as in a number of other American industries, is an excess of unskilled workers coupled with sporadic shortages of those with higher levels of education and training.*

The scarcity of recent U.S. graduates in engineering has been real, extending to virtually all specialties. Its origins lie in low enrollments during the early and middle 1970's (see ch. 8). Since then, engineering enrollments have rebounded to record levels. Educational resources have not kept pace, with the result that a substantial number of engineering schools have had to limit the numbers of students admitted. Not only is supply constricted, but *the quality of engineering education is suffering.*

Shortages of teaching faculty have constrained engineering education more than any other factor. Despite undergraduate enrollments that have nearly doubled over the past decade, trends in graduate engineering study have been nearly flat, In particular, students have been reluctant to enter doctoral programs. Fewer Ph.D.'s in engineering were graduated in 1982 than in 1972. Nearly half those now receiving Ph.D.'s from American engineering schools are foreign nationals. Recent Ph.D.'s have been avoiding teaching careers, for which the doctoral degree is today virtually mandatory. Not only are salaries low relative to industry, but new teachers can anticipate heavy course loads as a result of high undergraduate enrollments and the faculty shortages that already exist. Coupled with uncertain prospects for research support and a lack of prospective graduate students of their own, university teaching is no longer an attractive prospect to many who in earlier years would have been prime candidates. The result is 1,400 to 2,000 unfilled vacancies on the faculties of U.S. engineering schools.

Deteriorating laboratory facilities create a second bottleneck. Engineering education is expensive; curricula include numerous laboratory courses, as well as heavy use of computing facilities. Keeping laboratories relatively current, so that students get some experience with up-to-date equipment—instrumentation, small computers, applications of microprocessors—is a long-standing problem that has grown worse in recent years.

If the trends outlined above continue, serious harm to the competitive prospects of *many* American industries could result.

Continuing Education and Training

In contrast to constraints on supplies of new engineering graduates, the United States has hundreds of thousands of midcareer engineers already in the labor market. If the half-life of a college education in engineering is, say, 10 years, upgrading these peoples' skills offers vast opportunities both for individuals and for U.S. industry. In some cases periodic short courses or self-study may be enough to boost people along chosen career paths; in others, they may wish to move laterally—e.g., from analog to digital circuit design, from hardware design to software. As pointed out in chapter 8, little data exists on the frequency with which engineers take advantage of opportunities for continuing education and training; it appears that most who do are recent graduates, and that those with the greatest need—i.e., people 10 years or more out of school—rarely pursue continuing education beyond the occasional (and seldom very challenging) short course. Several implications follow: 1) the rewards of pursuing continuing education and training in engineering could be low—e.g., employers may not support such activities extensively, preferring to hire new graduates with the skills they need at lower salaries; 2) the programs available may not be attractive—i.e., working engineers may perceive them as academic and unrelated to their jobs; 3) the quality of programs may vary quite widely, so that those who have or hear about bad experiences are reluctant to try again.

The paucity of information on this subject is in itself disconcerting, but it appears that all of these factors are at work, and others as well. Certainly, existing incentives seem high enough to motivate only those with unusual ability or perseverance. While some companies have devised effective programs for encouraging employees to maintain and improve their skills, others do little or nothing. The picture is likewise mixed among educational institutions; some engineering schools have developed aggressive outreach programs aimed at providing high-quality coursework for technical professionals, those who are seeking advanced degrees and those who are not. Continuing education programs offered by professional societies as well as profitmaking organizations vary considerably in quality. The *quickest, surest way of providing the numbers of qualified engineers needed to maintain the competitiveness of American industries like electronics is to make high-quality continuing engineering education more widely available and attractive to midcareer professionals.*

Despite recent difficulties, engineering education in American universities remains the best in the world. In part because schools and universities in some countries do relatively poorly at preparing their graduates for careers in industry, foreign companies resort more frequently than U.S. firms to internal and on-the-job training, Extensive company-run training programs are prominent in the Japanese electronics industry, where continuing education is widespread among blue-collar and grey-collar employees as well as white-collar professionals. One way for the United States to increase its pool of skilled grey-collar workers would again be to develop a more effective approach to continuing education and training. Such programs will be more effective where closely coupled with prospects for upward mobility within organizations. At present, the probability that an unskilled worker in an electronics firm will be able to move up to a higher paid position is small.

More broadly, *programs of all types aimed at vocational education in technical fields appear to need reexamination and modification if the quantity and quality of graduates is to grow.* In the United States, as many as 8,000 public and private schools offer vocational-technical education and training (compared with roughly 300 engineering colleges). The quality of the courses and programs offered by these institutions varies widely, Activities are fragmented, with little detailed information available even to form a baseline for analysis, One point is clear: the fraction of the labor force in U.S. manufacturing industries with formal training in technical fields (through apprenticeship programs or schooling) and/or credentials (e. g., certification granted after examinations) is far lower than in a number of other industrialized nations, including West Germany and Japan. While correlations with on-the-job ability may be imperfect, the prevalence of such programs in other countries is good evidence of a commitment by individuals, governments, and business enterprises to building a labor force that will help maintain the competitive ability of technologically based industries into the future. So far this commitment has been lacking in the United States.

Congressional leadership could have a major impact. As the pace of technical advance in industries like electronics continues or accelerates, workers at all levels will face new demands on their capabilities. *Given the increasing disjunction between the skills of the U.S. labor force—what people are capable of doing—and the skills that industry needs, the American economy seems bound to face increasing problems in meeting its manpower needs, as well as controlling unemployment, unless progress can be made in training and retraining.* A company might, for example, lend an employee the money to cover vocational schooling, retraining, or an advanced degree program, with repayment forgiven if the employee remains with the firm for an agreed period. Tax policies and other instruments of Government support could increase the incentives for both corporations and individuals.

Public policies might be designed to lessen the risks that companies sponsoring education and training for their employees would lose their investments when people switch jobs. The Federal Government could provide incentive grants to the States, to be matched with corporate support.

Preparation for Work in Technology= Based Industries

At the root of many of the present and prospective difficulties outlined above lies poor preparation in science and mathematics provided by the public schools. Leaving aside the large number of functional illiterates among U.S. high school graduates—an illiteracy rate that some estimates place as high as 20 percent—and the one-quarter of this age group that does not even complete high school, many good students get little education in science or mathematics once they reach the upper grades. The number of students electing courses that are prerequisites for careers in technical fields is low and still falling; even those who choose science often shy away from physics and chemistry in favor of biology or geology. Technology, as opposed to science, is invisible within the public schools. *As the U.S. economy continues to shift from manufacturing toward services, and toward more knowledge-intensive industries, the American labor force will need to be prepared for technology-based jobs or risk doing without.* Even those performing unskilled work will be in a position to make greater contributions to productivity and competitiveness, while enhancing their own job security and job mobility, if they are comfortable with numbers and quantitative reasoning, and have a basic understanding of the physical world.

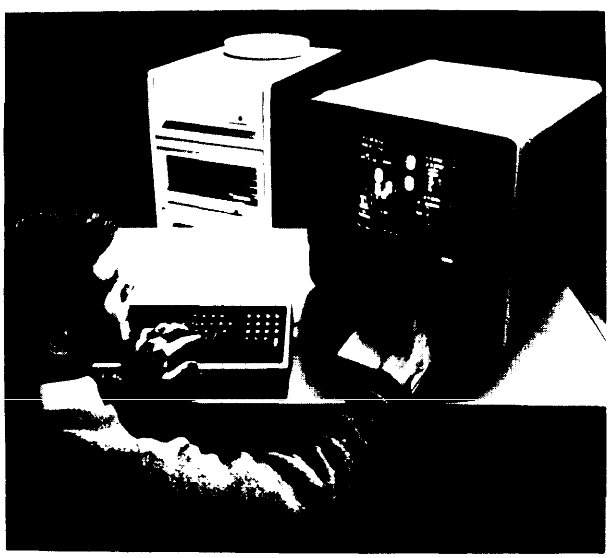


Photo credit: *Digital Equipment* Corp

Computer-aided engineering design

Part of the problem is again a shortage of teachers; secondary schools are being stripped of their science and mathematics instructors by the attractions of higher paying jobs in industry. But the fundamental point is this: a student who opts out of science—and particularly mathematics—at an early age has made a virtually irreversible decision, foreclosing a wide range of options in college and in his or her career. If American students continue to turn away from mathematics and science at secondary and high school levels, the United States will find itself with an even greater fraction of technological illiterates in the adult population. Already, the Nation finds itself with few leaders in industry or Government who grasp the workings of technology.

Management and Organization

Patterns of organization and management in business enterprises mediate between the skills and abilities that employees bring with them to the workplace and outcomes in terms of competitive firms and industries. How well companies utilize the talents of the people they hire is quite as important as how good these people are to begin with. Thus management style and philosophy becomes a second critical element in human resources for the U.S. electronics industry. While American management includes a “human relations” or participative management tradition, employee involvement tends to be honored in theory more than in practice. Techniques flowing from scientific management, the other main tradition, remain dominant in U.S. industry. The recent vogue for Japanese management practices represents a swing of the pendulum toward the human relations pole, offering paths to improved competitiveness for some U.S. firms, though no sure cures.

Within a given country—whether the United States, Japan, or one of the European nations—electronics firms show a good deal of diversity in management style. Nonetheless, successful electronics companies in the United States and Japan exhibit more similarities than differences, Despite the current fascination with the "secrets" of Japanese management, uniquely Japanese traits are rare even in the cruder stereotypes. If the differences between firms within each country are often greater than the differences between countries, and clear-cut distinctions between management styles in the United States and Japan less common than often assumed, two features of Japanese management do stand out: first, reward structures in Japanese companies create incentives for talented people to build careers in manufacturing; second, Japanese organizations tend to stress human relations more consistently and more effectively.

Generally speaking, *manufacturing and production engineering get more attention and more status in Japanese companies than American.* This is one reason consumer electronics and semiconductor firms in Japan could move swiftly to create perceptions that their products offered better quality and reliability, Often, as discussed in chapter 6, those perceptions were firmly grounded in reality; although American firms have largely caught up, the strong institutional commitments in Japanese corporations to production engineering mean continuing pressure in this area. Furthermore, that manufacturing managers in Japan carry more weight in corporate councils means in at least some cases faster shifts into automated production, The importance Japanese companies place on manufacturing in their internal decisionmaking also translates into a greater share of resources for developments such as the complex and demanding tasks of integrating robotics and other forms of programmable automation into the factory environment; companies that learn to utilize programmable automation most effectively will reap substantial competitive dividends in the future.

Stress on human relations is certainly not unique to Japanese organizations, but is more consistently visible—notably among large companies characterized by low labor mobility and "lifetime" employment (ch. 8). That workers at all levels tend to spend much if not all of their careers within a single organization creates strong incentives for internal training, job rotation, and other steps aimed at improving people's skills and preventing stultification. A number of successful American electronics firms also go to considerable lengths to retain their employees, even in periods of business downturn. Rather than treating the labor force as a variable cost, such firms, in both countries, regard their workers as a resource to be retained and nurtured although economic conditions might seem to point toward layoffs, Accomplishing this implies more than keeping people at work and providing education and training. It also implies opportunities within the corporate structure to fully utilize present and potential skills without sliding into paternalism or coercion, A number of the highly publicized techniques associated with Japanese management could, in fact, be as fairly termed manipulative as participative,

A renewed commitment to the development and utilization of the human resources available to American firms could make a major contribution to the future competitiveness of the U.S. electronics industry, indeed may be critical for the future prospects of this as well as other high-technology sectors of the American economy. *Management practices in successful organizations, whether American or Japanese, tend to be associated with attention to human relations and employee participation.*

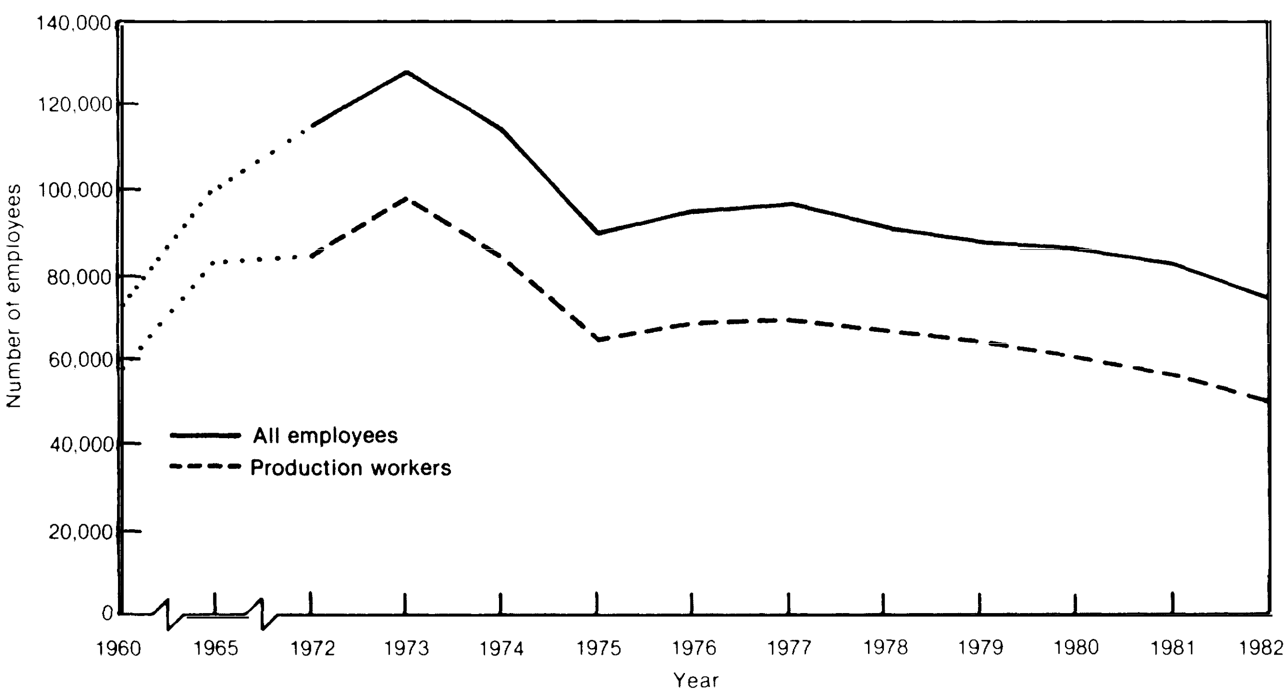
Employment

Continuing inadequacies in U.S. education in science and mathematics will aggravate structural unemployment caused by technological development and shifting competitiveness among American industries. In the past, technical change has generally created more jobs in the aggregate than have been destroyed. Unfortunately, there *are no guarantees that continued technological change—especially that resulting from applications of microelectronics and computers—will in the future lead to aggregate increases in job opportunities*. In Europe, the term "jobless growth" has come to describe the widespread phenomenon of high unemployment despite expanding output, This may or may not have been happening in the United States—the evidence either way is scanty—but structural unemployment *is* a reality here.

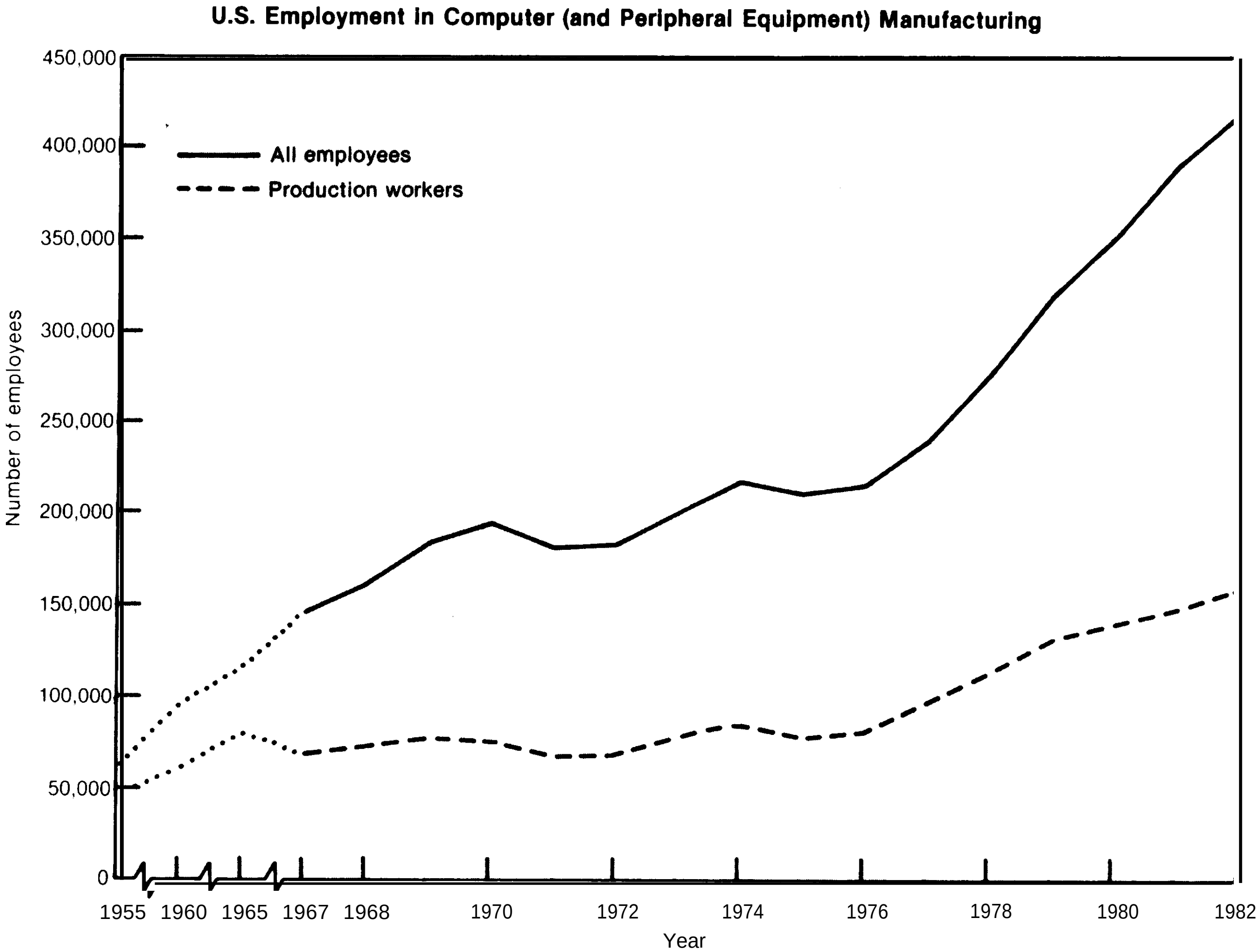
Shifts in the composition of the work force in electronics illustrate one of the consequences of technological and structural change. In the United States, it is fair to say that jobs in electronics are becoming more skill-intensive. Only in the manufacture of consumer products like TVs, a portion of the industry that has been relatively stagnant, has the ratio of blue-collar to white-collar employees remained high. In both computers and semiconductors, the fraction of white-collar workers is much greater and increasing.

But a division into skilled and unskilled—or white-collar, grey-collar, and blue-collar, not at all the same thing given the high levels of know-how associated with some but not all jobs in each of these categories—is too simple. It masks the increasing stratification and specialization characterizing technologically based industries, not only electronics but the sectors it feeds. The journeyman machinist may go the way of the tinker as computer-controlled machines replace engine lathes. The skilled mechanic who could rebuild such a lathe can probably no more fix the electronics of a

U.S. Employment in Consumer Electronics



SOURCES: 1960-1965—1977 Census of Manufactures. 1972-82—Bureau of Labor Statistics.



SOURCES: 1955-65-1977 *Census of Manufactures.* 1966—82-Bureau of Labor Statistics.

numerically controlled machine than program the computer that controls it. Specialists not only design the parts to be made and program the computer, but pick the feeds and speeds, specify tool materials and cutting fluids. Gaging and inspection may be automated, rather than the responsibility of practiced hands with dial gage and surface plate. As skilled jobs change—and at least some skilled work disappears along with unskilled—people who have no skills to start with will face still more trouble in finding satisfying, well-paying employment. Those who cannot learn new skills may find themselves outside the labor pool. Upward mobility in the United States may decline.

Many unskilled jobs are migrating overseas—in electronics, mostly to low-wage countries in Asia. Moves offshore by American corporations have attracted widespread attention, and opposition on the grounds of “exporting jobs. ” Offshore assembly has been much more prevalent in semiconductors and consumer electronics than in computers; even so, in both sectors, other factors have often made greater contributions to declining blue-collar job opportunities (see ch. 9 as well as app. B). Among these factors, improvements in labor productivity, many stemming from investments in automated manufacturing equipment, have generally had the greatest impacts. Moreover, transfers of production offshore tend to be driven by competitive pressures, domestic as well as foreign in origin, which are largely outside the control of individual firms. For instance, once a few U.S. semiconductor manufacturers began assembling chips in low-wage countries to cut costs, other suppliers had little choice but to follow suit. When the pressures are international, moves offshore may in some cases save domestic employment opportunities over the longer term by helping maintain U.S. competitiveness, though sacrificing jobs in the shorter term.

Manufacturing by American-owned as well as foreign-owned companies has become widely dispersed internationally. But this is only one cause of unemployment in the United States. Ongoing structural and demographic shifts are causing serious and persistent adjustment difficulties, People with few skills or with obsolete skills will find diminishing job opportunities in many of the older U.S. industries. Ten million and more Americans have been out of work at a time when American industry has been short of as many as a million employees with specific skills and abilities. In the aggregate, and even considering multiplier effects, a million new jobs only dents the unemployment problem facing the United States. Yet from the standpoint of the individual, each job counts. policy makers may find themselves unable to predict the causes and consequences of structural unemployment with any precision. This does not mean the problems cannot be attacked. It means that adjustment measures should aim to enhance job mobility—intra-firm as well as inter-firm—without depending on detailed predictions of supply and demand by occupational category and industrial sector.

The total number of jobs created over the next decade in electronics and other high-technology industries will not be large. After all, the entire U.S. electronics industry employs only about 1½ million people today, and employment has not expanded as rapidly as output. Still, many of the fastest growing occupational categories in the economy will be found in this sector. The people who fill the new jobs will benefit; at the same time, U.S. electronics companies need good people to remain competitive. Nonetheless, there has as yet been little concrete discussion of what is needed to prepare people for future job opportunities; the organizations and institutions that deal with such concerns tend to be dispersed and to operate independently of one another. Although the past few years have seen considerable criticism of training programs said to be preparing people for jobs that have already disappeared, little usable information on such subjects in fact exists. Local control of secondary and vocational education is the traditional pattern in the United States. Educators and schools of education seldom interact extensively with industry or organized labor. Vocational education and training has little visibility at the Federal level. Over the past two decades, schools have turned away from providing marketable skills. Company-run training programs are limited in number and tend to be emergency responses to hiring shortfalls rather than everyday features of corporate organization. *A thorough re-thinking of the American approach to education and training, particularly for blue- and grey-collar workers, seems called for.* Congress could decide to take the lead in reinvigorating the traditional American commitment to education and training.

Predicted Growth Rates by Occupational Category in the United States Over the 1980's

Occupation[a]	Predicted increase in employment (1980-90)
Paralegal	*1090/0*
Data processing machine mechanic	93
Computer operator	72
Computer systems analyst	68
Business machine service technician	60
Computer programer.	49
Employment interviewer.	*47*
Computer peripheral operator	44
Psychiatric aide	*40*

[a]Noninclusive; fastest growing Occupations in electronics are listed together with selected occupations outside of electronics (in italIcs) for comparison

SOURCE: "Testimony Before the Senate Subcommittee on Employment and Pro. ductlvlty, March 26, 1982, by Ronald E Kutscher, Assistant Commissloner, Off Ice of Economic Growth and Employment Projections, Bureau of Labor Statistics," *Productivity in the* American Economy, 1982, hearings, Subcommittee on Employment and Productivity, Committee on Labor and Human Resources, U S. Senate, Mar 19 and 26, Apr 2 and 16, 1982, p 327

Trade

Trade policies pursued by the Federal Government have affected the several portions of the U.S. electronics industry in radically different ways. Consumer electronics has suffered from uncertain enforcement–some would say nonenforcement—of antidumping statutes, although other parts of U.S. trade law have been called on to protect domestic firms from import competition. American manufacturers of semiconductors and computers have benefited from U.S. leadership over the postwar period in creating an open environment for international trade and investment. One of the strengths of American semiconductor and computer firms has been their global approach to markets, a strategy aided by reductions in barriers to trade and investment over the past three decades. Even though semiconductor imports from Japan have increased rapidly during the last few years, more than three-quarters of U.S. semiconductor imports continue to consist of interdivisional shipments of American companies. In Japan, the largest exporter by far among local computer manufacturers is IBM-Japan,

Antidumping Enforcement

Dumping complaints leveled at importers of Japanese TVs as early as 1968 have never been fully resolved. Dumping–selling imported TVs at prices below those charged in Japan—was proven under U.S. law, but legal challenges and interagency disputes have delayed final collection of duties for years.

During the 1960's and 1970's, Japanese TV manufacturers, followed by those in South Korea and Taiwan, relied heavily on price cutting to force their way into U.S. markets. Nonetheless, dumping was neither the sole cause nor even a primary cause of competitive shifts in consumer electronics. The worldwide success of Japanese consumer electronics firms amply demonstrates their ability, not only to manufacture at low cost, but to produce reliable TVs with good performance and product features that American consumers want. At the same time, uncertainty created by lengthy and inconclusive legal proceedings meant that domestic firms could not know whether they might eventually be able to raise prices as a result of antidumping duties levied on imports. These added duties might have totaled well over $100 million; higher prices generating higher profits could, in principle, have aided embattled American firms in revitalizing their businesses.

Eventually, U.S. color TV manufacturers and their suppliers did receive trade protection, in the form of negotiated quotas on imports from Japan, Korea, and Taiwan. Under the name Orderly Marketing Agreements (OMAs), the quotas followed escape clause proceedings filed in the wake of sharp rises in color TV imports during the 1970's. Unfair trade practices were not at issue. The OMAs speeded structural shifts already underway in the U.S. consumer electronics industry. By limiting imports, they created incentives for foreign firms to invest in assembly plants within U.S. borders. OMAs did little to revive the American consumer electronics industry; they did accelerate foreign investments, many of which would eventually have been made in any case. In effect, weaker American TV manufacturers driven from the market by imports have been replaced by subsidiaries of foreign firms. While these subsidiaries help to maintain domestic employment, half or more of the value added typically remains overseas.

The Environment for World Trade

A number of American computer firms that began as makers of office equipment, including IBM, maintained foreign operations before the war. During the postwar period, overseas investments by American computer manufacturers expanded; subsidiaries of U.S. firms became the backbone of computer industries in most parts of the industrialized world. Today, along with the older companies whose product lines still center on general-purpose mainframes, the major American manufacturers of minicomputers also operate all over the globe. Likewise, U.S. semiconductor firms began to invest overseas at an early stage; these investments, beginning around 1960, were made for two reasons: 1) to supply foreign markets via local production in industrialized nations; and 2) to cut costs by moving labor-intensive manufacturing operations to low-wage countries.

Direct and Indirect Barriers

Foreign investments by U.S. computer and semiconductor manufacturers, along with their continuing high levels of exports, have been facilitated by a relatively open environment for international trade and investment—chapter 11. Created largely under the auspices of the General Agreement on Tariffs and Trade (GATT), in which the United States has played a major role, this opening of opportunities for multinational firms via relaxation of direct barriers to trade and investment—tariffs, import quotas, restrictions on flows of capital outward as well as inward—has, on the whole, been of great benefit to the U.S. electronics industry. At the same time, relaxation of direct barriers to trade has been accompanied by a simultaneous increase in less direct obstacles and controls.

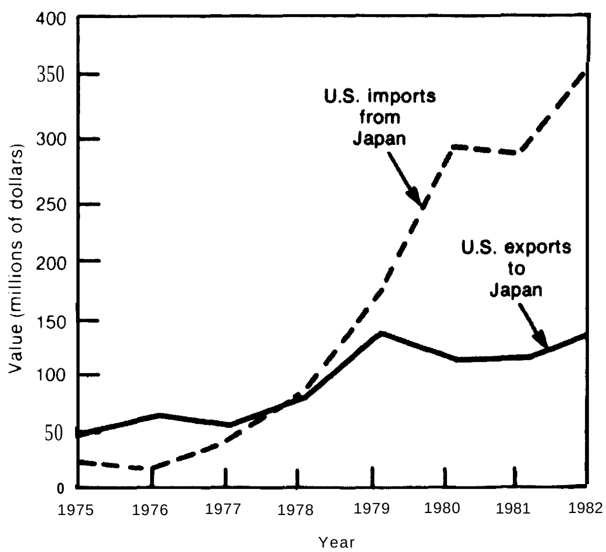
As the industrial and trade policies of foreign governments have evolved, they have swung toward more subtle combinations of indirect import barriers, performance requirements, investment incentives, and subsidies. In some cases, these measures—described in chapter 10—are intended to influence investment and exporting, In others, the objectives are primarily matters of domestic policy: national security, employment, regional development, Governments intent on pursuing industrial policies that will support local industries while attracting U.S. dollars and / or technology can choose from a well-stocked arsenal: trade barriers range from paperwork obstacles to “buy national” rules; performance requirements may entail transferring technology, purchasing supplies and materials locally, or exporting a prescribed fraction of production as a condition for investment; common forms of subsidies include R&D funding, capital preferences, and guaranteed procurements, European nations, in particular, have sometimes used investment incentives to attract American electronics firms in the name of jobs and technology,

Over the past half-dozen years, spokesmen for the U.S. semiconductor industry have frequently complained that the trade practices of some foreign enterprises have been unfair, while also voicing concern over government industrial policies in countries such as France and especially Japan. (U.S. computer firms have seldom been as vocal over trade practices or internal subsidies benefiting their foreign rivals.) Among the restrictive practices that still exist in many parts of the world, the relatively high tariffs levied by the European Community (EC) on semiconductors—17 percent—are perhaps the most visible. One consequence has been to encourage investments within the EC by American firms, but the European market is in any case large enough that these investment patterns could have been anticipated. In neither semiconductors nor computers have European suppliers been very successful in approaching the EC market as a whole. With only a few exceptions, local firms have exhibited relatively fragmented patterns of production and sales, In contrast, American-owned enterprises have often done a better job of treating Europe as a unified regional market, But whereas the trade practices of Western European nations may have ended by harming the ability of local firms to compete with the Americans more than they have helped, the situation has been vastly different in Japan.

Japan

For many years the Japanese Government effectively protected the country’s electronics industry, including manufacturers of consumer products such as TVs, through controls over foreign investment as well as restrictions on imports. With only a few exceptions—e.g., IBM-Japan—American-owned computer and semiconductor firms have had no more than modest success in selling their products through either exports or local production. A complex of factors ranging from chauvinism

U.S.-Japan Trade in Integrated Circuits



SOURCE: *1983 U.S Industrial Outlook* (Washington, D C : Department of Commerce, January 1983, p. 29-5. 1982 figures estimated.

to explicit government policies has impeded both exports and investments in Japan by American electronics suppliers. The negative impacts on U.S. competitiveness have been far greater than those visible anywhere else in the world.

American companies have been able to sell products that the Japanese could not make for themselves—advanced integrated circuits, state-of-the-art semiconductor fabrication equipment, some types of computers. But products available from Japanese suppliers tend to be purchased locally, in part because of deeply ingrained "buy Japanese" attitudes. Structural differences also play a role, particularly in microelectronics: the half-dozen large companies that produce most of Japan's semiconductors also consume perhaps two-thirds of these same semiconductors; such a market is difficult to attack from the outside. While foreign investment is in theory much less restricted today than in the past, only a few American semiconductor and computer firms have as yet established wholly owned operations of any size within Japan.

Given the rapidly improving technological abilities and competitive postures of Japanese electronics manufacturers, investment in Japan by American firms appears vital for maintaining U.S. competitiveness; while many in Japanese Government and industry will no doubt continue to oppose such investments, Japan's Government has officially endorsed liberalization many times, and should be held to these statements in practice as well as in principle. The Japanese market for electronics products is now second only to that of the United States; for many types of products, sales within Japan exceed those for all of Western Europe. Not only will local manufacturing help expand markets for American firms, enabling them to compete more effectively with Japanese companies in third countries as well as inside Japan, it will accelerate flows of technology *from* Japan *to* the United States. As in industries such as steel or automobiles, American electronics companies can now learn from their Japanese counterparts—and not only in consumer products. U.S.-owned R&D laboratories in Japan could help compensate for personnel shortages here, as well as improving access to the results of subsidized research programs such as the fifth-generation computer effort. *Full participation in the dynamic Japanese electronics market is critical to the continuing competitiveness of American computer* and

Semiconductor Sales in the United States, Western Europe, and Japan

	Sales (billions of dollars)	
	1974	1982
United States		
Discrete semiconductors . . .	$0.88	$1.3
Integrated circuits.	1.2	6.3
	$2.1	$7.6
Western Europe		
Discrete semiconductors . . .	$0.77	$0.77
Integrated circuits.	0.52	1.5
	$1.3	$2.3
Japan		
Discrete semiconductors . . .	$0.55	$1.2
Integrated circuits.	0.59	2.4
	$1.1	$3.6

SOURCES: ***1974**—Electronics,* Jan. 8, 1976, pp. 92, 93, 105.
***1982**—Electronics,* Jan. 13, 1983, pp. 128, 142, 150; Mar. 10, 1963, p. 8.

semiconductor manufacturers; Congress could help ensure that the Federal Government actively supports such endeavors by American firms, which are fully consistent with this country's historic commitment to open trade and investment. Competition in Japan on terms perceived to be fair will yield dividends within the United States by creating conditions under which American companies can better maintain their competitiveness.

Recent Developments

Broadly speaking, the Tokyo Round multilateral trade negotiations, completed in 1979 and implemented shortly thereafter, in the United States by the Trade Agreements Act of 1979, are having generally positive though small impacts on the American electronics industry. Continuing tariff reductions will help U.S. exports; accelerated duty reductions on semiconductor products and computers by Japan are especially significant, though perhaps as symbol more than substance.

Nonetheless, tariffs are no longer the principal barrier to international trade in electronics. They are being replaced by indirect and nontariff barriers, including a wide range of implicit and explicit subsidies. In particular, American electronics firms continue to complain over government-funded R&D programs in Europe, Japan, and a number of developing countries. Although the Tokyo Round yielded a new subsidies code intended to deal with this and related issues, the prospects for substantial progress seem slim.

Taken one at a time, individual programs in foreign countries—including such prominent examples as Japan's VLSI R&D effort, and, prospectively, the fifth-generation and supercomputer projects now underway—have often had no more than modest impacts on international competitiveness. At the same time, their goals often include intangibles such as technology diffusion or improvements in the skills of the labor force; these make outcomes difficult to evaluate. Subsidies directed at commercial technologies and typically rationalized as domestic support measures rather than export promotion policies have few counterparts in the United States. It is the justification in terms of domestic objectives rather than strengthened export competitiveness that makes such policies a problematic subject for international negotiations. Public funds for R&D, the use of government procurement to favor domestic industries, and the many related instruments of industrial policy detailed in chapter 10 have become part of the conventional approach by foreign governments. Countries in many parts of the world pursue such measures in hopes of building their competitiveness in high-technology sectors like electronics.

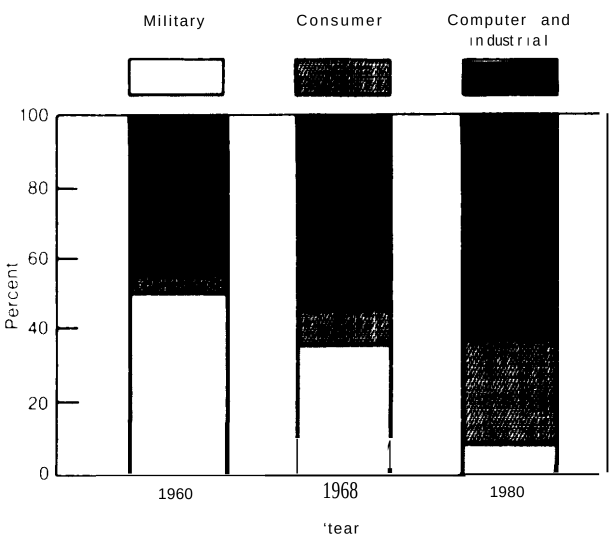
Given the growing prevalence of planned programs of industrial development, virtually all of which give electronics a prominent place, it seems unlikely that continued U.S. attacks on such policies as "export subsidies" will have much effect in arresting the trend. This is particularly true given the indirect and intangible impacts of programs directed at infrastructural support, precompetitive technology development, or human resources. Many of Japan's industrial policy initiatives have been directed at overcoming structural obstacles such as limited labor mobility and a less than stimulating working environment for technical professionals. Totaling the monetary value of such subsidies, even where possible, is an exercise that holds little meaning. And, in the end, most foreign governments will regard such efforts as too important to give up; certainly they do not welcome them as legitimate topics of international negotiations, bilateral, or multilateral. While it *is clearly in the interests of the United States to press for clarification and agreement on the "rules of the game," it may not be very productive to devote a great deal of effort to combating on a case-by-case basis what have become standard tools of industrial policy in other countries.*

U.S. Industrial Policies

As many observers have noted, industrial policy in the United States has been a largely ad hoc construct of unrelated measures aimed at diverse objectives; not infrequently, policy measures have worked at cross purposes or led to unanticipated outcomes. Seldom have they represented conscious attempts to stimulate the competitiveness of American industries. Trade policy, treated separately above, is only a partial exception.

In recent years, U.S. industrial policies have seldom had major impacts on the electronics industry; however, early developments in both computers and semiconductors benefited from Government procurement and from R&D funded by Federal agencies concerned with defense and space. Since the 1960's, overlaps between military/space applications and civilian needs have diminished. Today, military electronic systems are seldom as advanced as civilian; *it has been many years since Federal spending has had much influence over electronics technology or competitiveness.*

Distribution of U.S. Semiconductor Sales by End Market



SOURCES: ***1960, 1968:*** "Innovation, Competition, and Governmental Policy In the Semiconductor Industry," Charles River Associates, Inc., final report for Experimental Technology Incentives Program, Department of Commerce, March, 1980, p. 2.13.
1980: ***Status '80: A Report on the Integrated Circuit*** *Industry* (Scottsdale, Ariz. Integrated Circuit Engineering Corp., 1980), p 34

Faced with increasing competition in many industrial sectors, slower economic growth, and a multitude of adjustment problems, the question for the United States has become: Can the country continue with a de facto industrial policy or is a new approach needed? The surprising variety of programs intended to nurture technologically based industries in Japan, Western Europe, and several newly industrializing countries reveal an attentiveness to economic development simply lacking here. One response has been to argue that the United States needs to find ways of negating or countering foreign industrial policies, Alternatively, rather than a reactive posture, the United States could itself move toward policies intended to stimulate and support industrial development.

Foreign industrial policies have had their failures—and successes too. The important point is that countries which have adopted relatively systematic industrial policies continue to experiment with policy tools, to develop new programs—in short, to accumulate experience and improve effectiveness. The U.S. system has strengths and weaknesses different from any and all of the nations—Japan, France, South Korea—that have pursued industrial policies aimed at economic growth and development, What sort of industrial policy could help the United States to maximize its own strengths, minimize its weaknesses? To help frame this question, OTA suggests five possible orientations that Congress may wish to consider for a more coherent U.S. industrial policy:

1. A policy approach aimed at *ensuring a strong domestic market base for U.S. industries,* along with preservation of existing jobs and job opportunities.
2. Policies designed to *protect and/or support a limited number of industries judged critical to national security,* defined narrowly or broadly.
3. Measures that will *support the technological base and institutional infrastructure for American industries,* particularly those undergoing structural change.

4. Policies intended to *promote the global competitiveness of American industries.*
5. An orientation that would *defer wherever possible to the private sector* when choices concerning the development of industry are to be made.

These policy directions, examined in detail in chapter 12, are by no means mutually exclusive; they might draw, for example, on similar policy tools in areas such as international trade or technology development. Nonetheless, they represent distinctly different thrusts: the goals differ even where the instruments are alike.

The five alternatives, outlined below in the context of the electronics industry, carry implications for the entire economy, as well as the political environment where any policy would have to be implemented. These broader dimensions are emphasized below because focusing too strongly on specific policy tools—e.g., those addressing problems visible at the moment in electronics-would simply repeat the ad hoc approach to U.S. industrial policies now current.

Each of the five approaches has positive and negative aspects, They can be usefully contrasted in terms of differential effects on sectors of the economy as well as susceptibility to the political forces that corporations and their employees bring to bear on the policymaking process. The intrinsically political character of this process, now or in the foreseeable future, has often been couched in terms of Government's ability to pick and choose among "winners" and "losers. " Early debates over industrial policy in the United States tended to focus on such questions—rather pointless given that many Federal policies have always had this effect. The Economic Recovery Tax Act of 1981 treats some industries much more favorably than others; trade protection has in recent years been extended to manufacturers of color TVs, automobiles, and clothespins; political pressures routinely affect decisions on public works and defense projects.

When industrial policy decisions are made on an ad hoc basis—without linking one sector of the economy to others, without setting the problems of a domestic industry into the context of the world economy—political considerations can more easily predominate. To begin coordinating such decisions more closely carries two quite different implications: 1) greater reliance by the Federal Government on empirically grounded analysis of industrial competitiveness, productivity, and economic efficiency; and 2) risks that—beyond influencing policy decisions on a case-by-case basis, as happens already—political pressures will skew the policy approach as a whole. The first is one of the potential advantages of a more coherent industrial policy, the second, one of the pitfalls—a pitfall because companies and industries in trouble, and their employees, have a more obvious stake in policy decisions, hence bring more pressure to bear, than sectors of the economy on the upswing.

The first two of the policy orientations listed above carry the greater risks of political deflection. Ensuring the domestic market base for U.S. industries could easily amount to nothing more than a protectionist response to trade pressures and the rise of competitive enterprises in other countries. Basically an inward looking, defensive strategy, it equates import penetration with damage to U.S. interests. An industrial policy centered on safeguarding American markets and American jobs would be largely congruent with the political forces that will always advocate protectionist measures—firms and industries in competitive decline, their employees, the communities and regions in which they are located.

Decline may be temporary and reversible, or it may be the consequence of deeply rooted shifts in the international economy that, over the longer term, are likely to force contraction regardless of public policy responses. A market protection strategy implies, first of all, determining whether protection is needed because of short-term problems—which might range from macroeconomic dilemmas to misjudgments by corporate managements. For such reasons, temporary protection is sanctioned by international trade law under circumstances as described in chapter 11. Indeed, temporary trade restrictions might find a place in any industrial policy alternative. Longer term decline brings a different set of issues to the policymaking process; the options may range from managing decline (via adjustment measures intended to ameliorate the most immediate problems) to wholesale protection and subsidization (as several European nations have occasionally attempted).

A critical industries strategy—whether "critical" refers narrowly to military strength or carries some broader economic connotation—would also lead to a great deal of political jockeying among firms and industries bent on demonstrating their criticality. Such an outcome is virtually inevitable because few objective criteria exist that would allow essential or critical industries to be identified beyond the broadest and most general level. Under virtually any criteria imaginable, electronics would be judged vital to "economic security" as well as military security. Even so, when the industry is disaggregated, judgments at finer levels immediately become difficult.

Electronics would probably not suffer under either a protectionist or a critical industries approach; although backlashes by other countries are always a possibility, nations that import high-technology electronics products usually need them badly enough that they would pick other alternate targets for retaliation. Even so, a number of other Us. industries would be likely to benefit more. For at least some companies, the lobbying involved would be business-as-usual. Large and powerful corporations experienced in dealing with the Federal Government, defense contractors, and firms in heavily unionized industries would tend to have an edge over smaller, technology-based concerns. The more aggressive and outward looking high-technology portions of electronics could not expect as much positive support as they might get under other policy decisions.

Under any of the five alternatives, political forces would bear heavily on policy outcomes. Firms and industries will always have strong incentives to press for direct and indirect subsidies flowing from Federal decisions, This is quite understandable, and built into the American political system, but has consequences that are largely undesirable if a basic objective of industrial policy is to improve U.S. competitiveness. Industrial policies are most likely to be productive and effective when they complement ongoing changes in the world economy—e.g., by aiding structural adjustment. When industrial policies oppose long-term shifts in comparative advantage, they are generally doomed to high costs, inefficiencies, and marginality if not ultimate failure.

This could well be true, for instance, in the case of Federal actions that would steer capital to selected industries. Such policies have frequently been advocated by those favoring "reindustrialization, " as well as a critical industries orientation. However, targeting of investment in a conscious way—a key element in many foreign industrial policies—seems an unlikely prospect for the United States, if only because capital markets here work much better than in most other economies. Moreover, the Federal Government's experience with investment, leaving aside sectors such as housing, has been restricted mostly to aggregate measures and to a few well-known bailouts of troubled corporations. Finally, the records of foreign countries that have tried to channel investment into industries intended as mainstays of economic growth and competitiveness are decidedly mixed.

Everyone knows what the future growth industries will be. The current list includes computer-aided manufacturing and robotics, biotechnology, new nonmetallic materials, microelectronics, computers and communications. U.S. capital markets have been "picking" these winners quite effectively. An industrial policy intended to support future U.S. growth industries—under a critical industries rubric or some other policy approach—would have to do more. Specifically, it would have to search out cases where markets were not performing consistently well. These do exist. The time horizons of markets maybe shorter than desirable from a public standpoint (there are many examples in R&D, most notably in basic research but also in the development of generic technologies that could benefit a wide range of firms while being difficult to protect or monopolize). Bottlenecks are always possible (the unambiguous successes of foreign industrial policies often involve breaking bottlenecks). Response times can be excessively long (as in the case of the educational system, heavily dominated by government bodies which create inertia and slow responses, while also suffering from cloudy perceptions of future needs and opportunities). Such examples point to approaches that would not be explicitly sectoral.

The third of the policy orientations considered by OTA—policies that would provide generalized support for technology and infrastructural development, cutting across sectors of the economy—would reduce the leverage that special interests could exert by avoiding, where possible, policies with strong sector-specific thrusts, Instead, the tools of first choice would have more aggregate objectives—not only R&D and its diffusion, but education and training, open competition, structural adjustment. At the same time, sectoral policies would not be totally ruled out.

A variety of instruments are available:

- manpower training and retraining;
- new institutional mechanisms for technology development (emphasizing, for example, cooperative efforts among Government, business, and universities);
- incentives as well as direct funding for research and development;
- the infrastructure for diffusing available technologies as well as new R&D results through the U.S. economy (including technologies from overseas); and
- policies aimed at stimulating capital formation and investments in new and productive technologies.

By supporting the technological and human resources underlying competitive industries, interest groups angling for special favors would have fewer obvious and attractive targets, at least in terms of immediate financial rewards, Primarily future-oriented, this policy orientation is based on the assumption that the Federal Government can help build competitiveness by promoting evolutionary shifts in the economy, as well as by easing the negative impacts of adjustment on particular groups and regions.

In terms of R&D, the chief difference between private sector and Federal Government decisions lies not in the ability to evaluate opportunities but in the longer time horizons that Government can bring to such questions. Motivated by social rather than private returns to investment, unconcerned with capturing immediate rewards, public policy initiatives can be formulated with a longer term view than private corporations take. This is as true for mature industries like steel or automobiles as for "sunrise" or growth sectors. One of the tasks of an industrial policy oriented toward adjustment and infrastructural support would be to find such opportunities and develop appropriate responses, To develop an industrial policy capable of attacking problems of this sort, the Federal Government would need to understand industries and their workings on a concrete, practical level—the level of the shopfloor and the R&D laboratory as well as the boardroom, The Government does not now have this capability, a capability it would need in order to

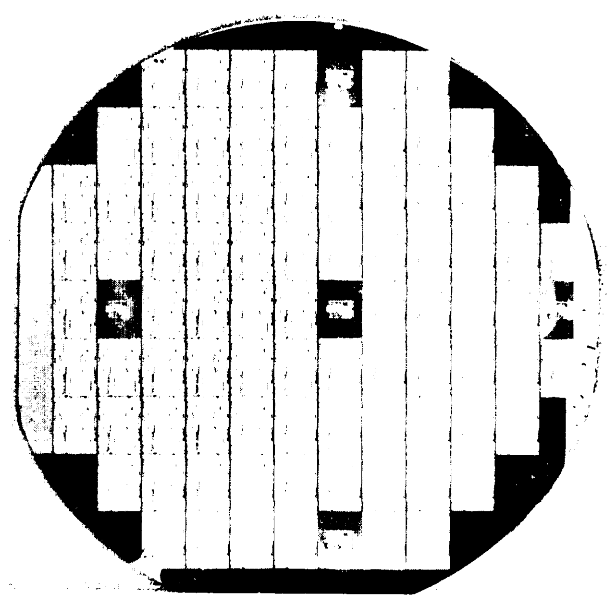


Photo credit Intel Corp

Silicon wafer after chip fabrication

implement with reasonable effectiveness *any* consistent and explicit industrial policy.

As pointed out above, competitive industries depend on the human resources available, while training and retraining are essential to economic adjustment. But what, specifically, should people be trained to do? What kinds of skills will be needed 20 years from now? What are the best ways of reaching people already in the labor force? Are institutional changes needed? Should the United States continue to leave training and retraining largely to local initiative, or is a continuing but redefined Federal role needed? These are among the questions with which this third approach to industrial policy would have to come to grips. They illustrate the need for a well-developed analytical capability within the Federal Government.

Like the first of these five policy alternatives, preservation of domestic markets, the fourth—promoting the global competitiveness of U.S. industries—centers on trade issues. However, *promoting* competitiveness implies an outward looking, export-oriented stance, an emphasis on openness in international trade coupled with stimuli for emerging, competitive sectors of the economy. Taking as its starting point the dynamics of international competitiveness—the rise and decline of industries over time—the global trade alternative would seek out, even accelerate, processes of change, attempting to keep American industries technologically and commercially ahead of their foreign rivals. To the extent that such policies hastened the decline of other portions of the economy, adjustment measures aimed at speeding resource flows out of these sectors, as well as cushioning the impacts of decline, might also be called for.

The global approach to industrial policy builds naturally on the traditional U.S. attitude that international trade benefits all parties and should be encouraged. It is the option furthest removed from the common notion of industrial policy as necessarily working *against* openness in trade. The Federal Government might not only continue to press for access for U.S. exports and investments in other countries, but reciprocally keep the domestic market open, while vigorously pursuing antitrust enforcement in the name of competition. Rather than resorting to bilateral trade negotiations, the United States could continue to work toward multilateral agreements aimed at reducing barriers to trade—in the current climate, primarily nontariff and indirect barriers, Tax incentives could be used to reward competitive, export-oriented firms, While more direct forms of export promotion might also find a place, direct measures always carry the danger of becoming subsidies—which, in the name of competition, this policy orientation would seek to avoid. Instead of protectionist measures for aiding troubled industries, the Government might attempt to manage decline and encourage restructuring,

If interest groups in the United States see the Nation opening its own markets to foreign goods and foreign investment—an intrinsic part of the global approach—without corresponding openings in other parts of the world, this option could invite a strong backlash, Even if the United States persuaded its trading partners to join in a thoroughly open and competitive world market system, the accelerated processes of domestic change might generate strong sentiments in favor of protection as well as adjustment assistance. Open world trade has many attractions as one element in a more cohesive U.S. industrial policy, but by itself might not offer advantages great enough or visible enough to attract the political support needed for implementation.

The last alternative is built around giving industry a free hand, where possible, in decisions that affect productivity y and international competitiveness. This alternative fits the recent mood in the United States: that Government involvement in economic affairs is counterproductive, that business activities should be deregulated, that markets work best and industries compete best when the Federal presence is minimized. Like the global trade alternative, it could mean more rapid rises and declines within the U.S. economy, Unlike that alternative, it implies less attention by Government to structural adjustment and less support for the efforts of American firms to export and/or invest overseas. Nor would protection against import competition be looked on with favor.

Such a policy approach would have to confront and resolve the following dilemma. American businessmen direct many of their complaints at foreign industrial policies that intervene in markets by, for example, encouraging mergers or allocating capital. Spokesmen for U.S. industry often hold, on the one hand, that industrial policies in other countries are not only unfair, but serve to tilt the competitive balance by strengthening or even creating comparative advantage. On the other hand, these same spokesmen frequently argue that Government policies could not do so here. Some of these statements may simply express a desire for unfettered (competition among all comers; in other cases, they appear to imply that government actions are counterproductive in the United States but not overseas, In any event, the fundamental question is: Given that foreign governments are not likely to abandon their industrial policies so long as they consider them useful, can the United States counter them simply by avoiding policy interventions?

More positively, then, this fifth policy approach might include tax incentives for capital format ion and investment, deregulation, and free competition. Control of inflation and macroeconomic stability would certainly remain a Federal responsibility. Closer examination of recent changes in tax policy points to one of the central issues raised by this alternative: Can Government really be a neutral arbiter of economic competition? Past experience gives little evidence in favor of the proposition.

The 1981 Tax Act seems on balance to have been a move away from neutrality in treatment of the various sectors of the economy. Noting that accelerated depreciation has varying consequences for manufacturers of consumer electronics and semiconductors—and that these two parts of the electronics industry are treated quite differently than producers of heavy electrical machinery, much less nonelectrical machinery—indicates some of the potential problems. Differential effects on various parts of the economy are an unavoidable con sequence of any industrial policy, and it may be better to confront such issues directly than try to avoid them, as this last alternative would in general do. While true neutrality can never be achieved, an industrial policy ostensibly intended to "get Government off the backs of business" would more likely end up rewarding those who could bring the most political pressure to bear. These interests would probably be able to perturb the policymaking process--tax policy being only one example--to their own benefit, aided by the illusion that the Federal presence was diminishing. Industries with less political strength or sophistication would, in a relative sense, fare less well.

Indeed, it seems wishful thinking to argue against Government involvement i n economic affairs, although not against counterproductive or excessive involvement. The fact is, of course, that governments here and elsewhere do intervene; it is part of their job. Moreover, as economies grow more complex and more heavily dependent on advanced technologies, the forces that governments seek to modify or control may become more powerful, the need for government action greater. When, t~'here, why, how—the circumstances in which governments intervene, the effects of the involvement—are the crucial questions.

What does this mean for industrial policy in the United States? First, more effective policies toward industry in the United States will require relatively broad agreement on objectives. Second, the Federal Government would need to develop an analytical capability adequate to the task of reaching these objectives. Both are efforts to which Congress could turn its attention. The first is largely a political task, the basis of the argument that our standard of liv ing depends on the international competitiveness of industries like electronics. The second demands that Government go beyond the largely static and abstract economic perspective that in many agencies is now called on to justify policies adopted for other reasons.

The political environment in the United States makes movement toward a more consciously developed industrial policy—following any of the five alternatives outlined above—not only slow and painful, but an endeavor that risks being turned to ends far removed from economic efficiency. (This is not to imply that economic efficiency is the only goal of industrial policy, but that one of the purposes of a more coherent approach would be to bring this and related objectives closer to the forefront.) But even where decisions are made largely on political grounds—as will frequently be the case—a more explicit industrial policy could help frame the questions, bound the responses, increase the probability that individual policy instruments function as expected and intended. Given an international economy populated by countries experimenting with industrial policies, and learning to use them more effectively, a pragmatic orientation by the United States, grounded in empirical analysis, could be viewed—by Congress and the Federal Government as a whole, and by both parties—as a vital support for our own economy, Such an attitude toward industrial policy would help to ensure that the U.S. electronics industry and other high-technology sectors would get their fair share of the resources needed to compete effectively in world markets, It is also the best hope, in the longer run, for older industries ranging from primary metals to machine tools and textiles.