CHAPTER 5

Industry-Specific Competitiveness

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Overview

Going beyond broad trends in indicators such as productivity, this chapter examines influences on competitiveness that are specific to each industry. Although chapter 4 touched on factors such as R&D, these were treated in a general way. At the level of the specific industrial sector—even more, the individual firm—competitiveness springs from a diverse and complex array of influences. Some of these act directly [e.g., quality and reliability of products—themselves depending on other, more subtle factors), some indirectly (e.g., quality of the educational system, political and economic stability). A selection of these influences is listed in table 13. While many are intangible—and few can be quantified— all are important in determining the competitiveness of particular firms and industries. Public policies are woven into many; however, policy effects are left largely

Table 13.— Potential Influences on Industrial Competitiveness

Factor	Examples
1. Characteristics of industry and market structure.	**The number** of *firms,* their size and production facilities, and degree of concentration and integration influence competition. *Market* structure includes the size, availability, rate of growth, and degree of saturation of the market,
2 Characteristics of the labor force.	Both labor costs and availability of skilled workers are important; Government support for the *training and education* of the work force can be critical, The nature of *labor-rnanagement relations,* type of unions, and mechanisms for *worker participation* can also influence productivity and competitiveness,
3. Characteristics of professional personnel	Quality of management and technical personnel are significant determinants of competitiveness. Important characteristics include: the *attitudes and value structure of management;* aggressiveness in developing, marketing and exporting products: and the degree of *interaction and cooperation within the firm* among R&D, marketing, product planning, manufacturing engineering, and quality control personnel.
4. Availability of materials and components.	Assured *supplies of the inputs to the manufacturing process* (iron ore, petroleum, electronics components) are important for planning and long-term stability. Domestic availability versus dependence on imports can be important.
5 Supporting Infrastructure	The infrastructure includes the *vendors, subcontractors, other suppliers, and services* necessary to support complex technologically based industries. Also Included are *basic research organizations* and the level of Government support for *generic R&D.*
6. The environment for innovation.	Factors that more directly affect the *ability to innovate* and the *rate of technology diffusion* Include: the interactions and synergies among firms within an industry (mobility of personnel. licensing and other Interchanges of technology, openness to inward transfers of technology and management know-how); and the existence of clusters of skills as among the semiconductor firms in Silicon Valley.
7. Business and economic conditions.	Included here are Indicators of overall *economic performance* such as GNP or GDP, levels of disposable Income, and inflation rates. The nature of *capita/ markets* (concentration of banking and credit) affect the ability of firms and industries to expand. Also Important are less tangible factors such as consumer confidence, investment expectations, and the general climate of political stability and social welfare,
8 Government Interact Ions	*Government regulations* that impinge on factory work, supplies of resources, design and sale of products, tax policies, Government procurement policies, and antitrust policies and their interpretations all affect the attitudes and decisions of business. In addition. more intangible factors which are nevertheless important include the *tradition of cooperation or conflict* within and among Government, business, and labor.
9 International trade relations	Policies enacted by domestic and foreign governments affecting *imports and exports* such as taxes on overseas profits, tariffs on imports and reimports after offshore assembly, export credits and subsidies, exchange rates, policies toward technology transfer, and nontariff barriers set the environment for international competition. international agreements and organizations often provide the framework for such policies.

SOURCE: *Office of Technology Assessment* to chapter 6. In the end, of course, competitiveness rests on the capabilities of individual firms. Even a cursory review of variations over the past few years in sales, profits, and other indicators of success in industries such as steel or automobiles shows how greatly the performance of individual companies can vary.

Each industry and each firm has attributes that make it unique. Industries and firms develop attitudes, even cultures, which shift over time. These are the backdrop for the more concrete and quantifiable indicators of competitiveness discussed in earlier chapters and in the sections below. Thus, lagging competitiveness in steel has different causes than lagging competitiveness in automobiles or consumer electronics.

Just as the causes of shifts in competitiveness differ, so do the consequences—though the most prominent in each case is loss of employment opportunities. Some of these losses are irreversible without large increases in production— increases that could only come through exports. If high volumes of exports are unlikely—as seems the case in industries such as consumer electronics or steel—the alternative is retraining and relocation of workers. In fact, American industries such as steel, consumer electronics, and automobiles are experiencing structural unemployment in its classical sense.

Steel

Prices and Wages

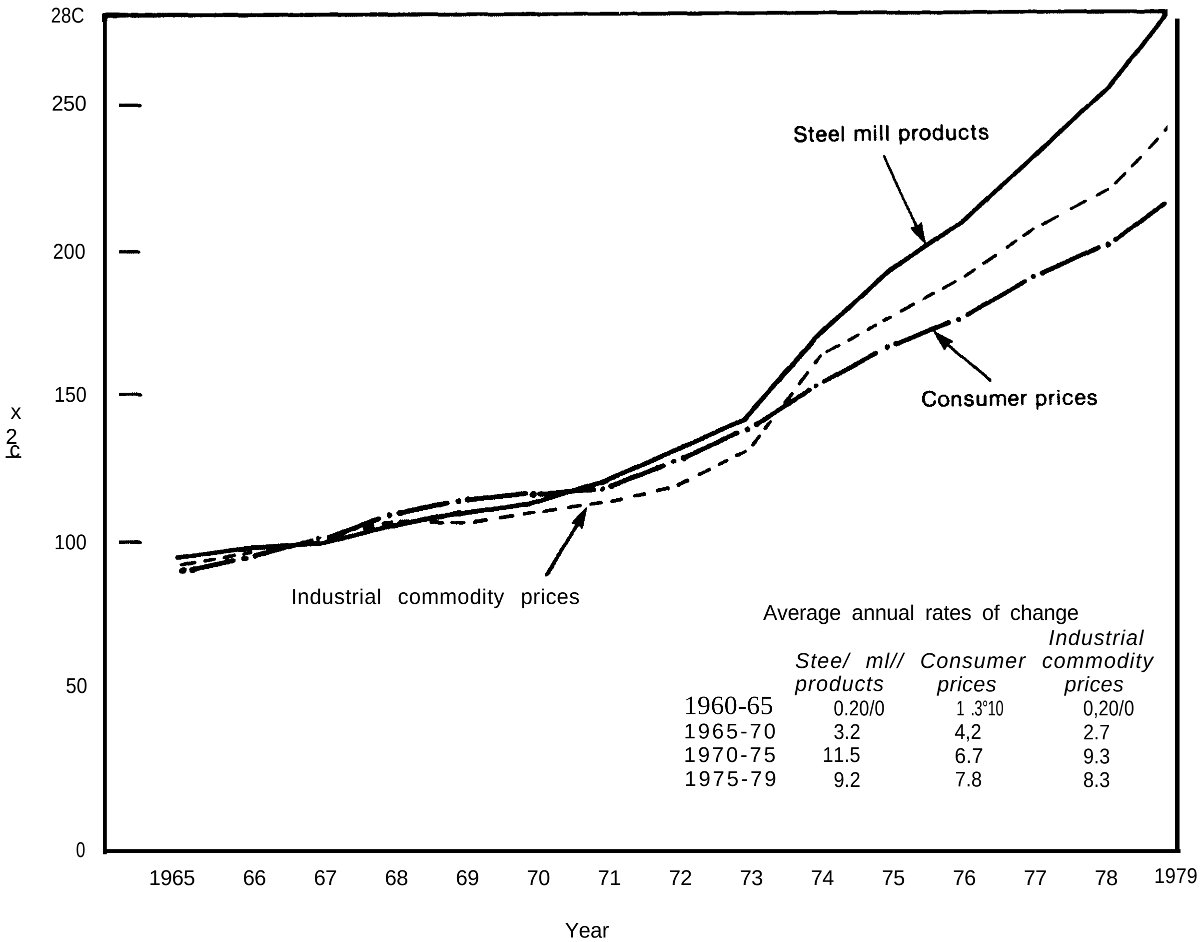
Chapter 4 compared the steel industry with the electronics and automobile industries, as well as with U.S. manufacturing in the aggregate. While labor productivity in the steel industry has improved at approximately the national average for manufacturing, hourly wages in real terms have grown much faster than average. In recent years, the industry has agreed to wage increases diverging more sharply from other sectors, even while import penetration has been rising (figure 5). As chapter 4 suggested, increased labor costs should be reflected in price increases for steel greater than price rises elsewhere in the economy. Figure 8 indicates that this has in fact occurred.

The chart compares price behavior in steel to other parts of the economy. Beginning in the 1970's, steel prices rose considerably faster than the general inflation rate as measured either by the consumer price index or the industrial commodity price index. This is in marked contrast to earlier time periods, when steel prices rose parallel to overall price inflation. Moreover, prior to 1970, real wage increases in the steel industry were well below the industry's productivity gains. Despite the rapid price increases shown in figure 8, profits for the industry as a whole have been gradually decreasing; in recent years the steel industry has been substantially less profitable than other U.S. manufacturing sectors.

In addition to wages, many of the other elements of production costs for steel have also been increasing, particularly costs of energy. Figure 9 shows trends for energy and material inputs to ironmaking and steelmaking. While all the indexes show doubling periods of 10 years or less, these rapid price rises do not affect all firms equally. For example, some integrated firms have their own reserves of coal and iron ore; nonintegrated steelmaker are more heavily dependent on prices of scrap and electricity, Nonetheless, figure 9 demonstrates that price increases for steel have been caused by rising energy and materials costs as well as wage rate inflation. Although labor costs, including fringe benefits, tripled between 1967 and 1978, the costs of metallurgical coal went up more than twice as fast.

'Technology and Stee) industry Competitiveness (Washington, DC.: Office of Technology Assessment, U.S. Congress, June 1980], pp. 120-122. Profitability varies considerably from firm to firm.

Figure 8.— Indexes for Steel Mill Product Prices, Consumer Prices, and Industrial Commodity Prices (1967 = 100)



SOURCE Bureau of Labor Stat[stlcs

In other countries, real wages for steelworkers have also risen faster than productivity. Comparisons of wage and productivity increases show that the American steel industry has done well compared to Europe. However, the fraction of steel costs attributable to labor has risen in the United States compared to Japan because Japanese productivity improvements have offset wage increases.[1]

The United States has not exported much steel in recent years—in the vicinity of 3 million to 4 million tonnes annually, about half to Canada and Mexico. Imports from these two countries have been at about the same level, indicating that the Canadian and Mexican industries complement this country's, each supplying certain types of products to particular regions or sectors. For example, about one-quarter of Mexico's imports from the United States consist of pipe and other oilfield products, In other parts of the world, U.S. exports have not been competitive, Some observers say this is because the industry insists on selling goods abroad at prices covering full costs rather than marginal costs.

[1]*Report to the President on Prices and Costs in the United States Steel Industry* (Washington, D. C.: Council on Wage and Price Stability, October 1977], p, 45.

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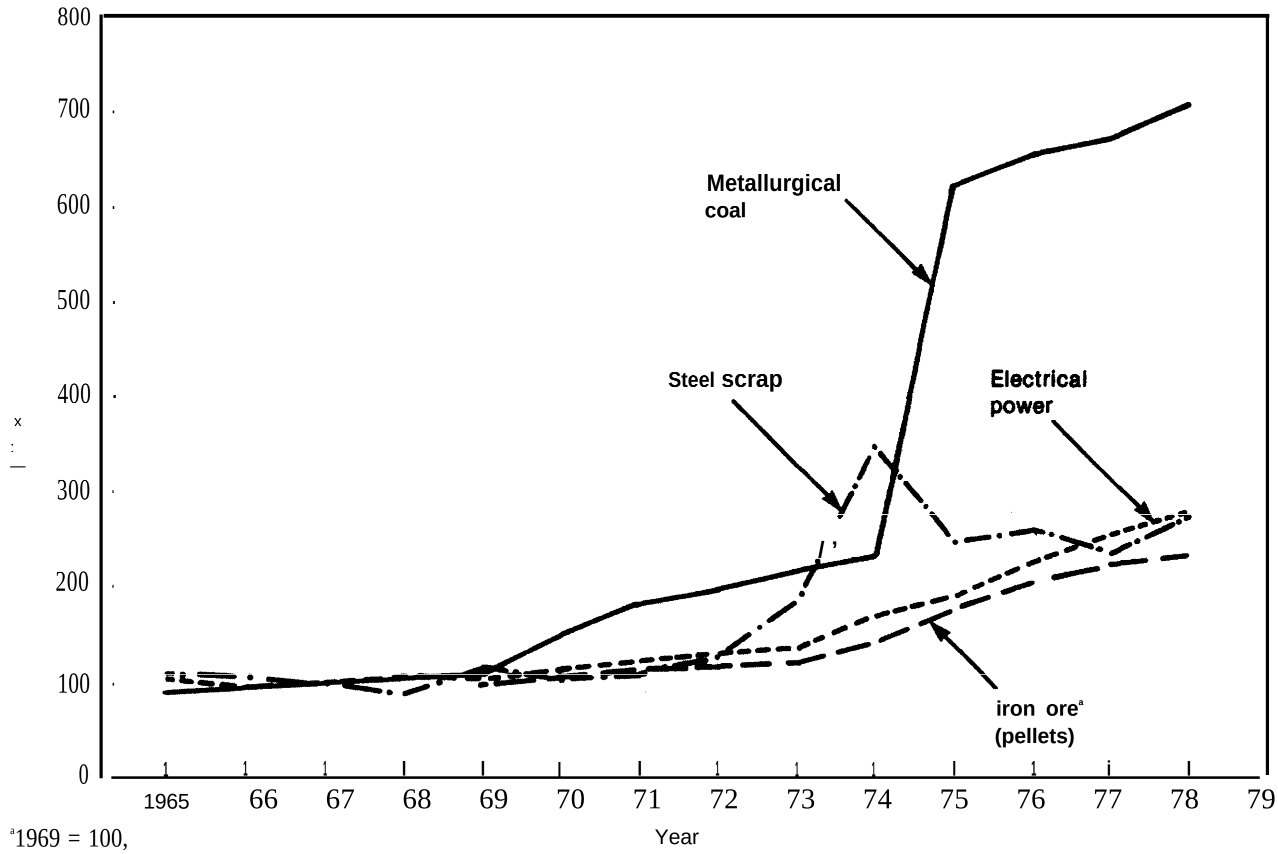
Figure 9.–indexes of Input Costs for the American Steel Industry (1967 = 100)



[a]1969 = 100,

SOURCE *Technology and Steel Industry Competitiveness* (Washington, D C Office of Technology Assessment, U S Congress, June 1980) p 122, from BLS and AISI data

Dumping

Dumping occurs when export prices are set below home market prices, or in some cases below costs. Since 1959, the U.S. industry has claimed that foreign steelmaker, particularly European firms, have been dumping steel in the United States,

Incentives for dumping are highest when demand slackens and substantial excess capacity exists. This is because the incremental costs of producing additional output can be quite low, particularly if labor costs in the short run are essentially fixed (see ch. 3). Under such circumstances, the added costs of maintaining relatively high production levels can be small, and sales at any price covering variable costs become attractive. At the same time, firms in this situation prefer to sell the excess output outside their usual markets, so that price cutting will not affect established pricing patterns. Circumstances thus combine to encourage dumping in export markets. Moreover, government-owned steel firms—as in some countries in Europe—can be supported indefinitely from public funds to maintain employment, even though unprofitable.

Dumping and other unfair trade practices are restricted under the General Agreement on Tariffs and Trade. Because low prices are presumed to benefit consumers, dumped goods are allowed to enter the United States unless a domestic industry is injured. If injury is found by the International Trade Commission, the Department of Commerce (formerly Treasury) assesses an antidumping duty intended to raise prices to the U.S. market level.

The steel industry, along with other domestic industries, has maintained that processes for establishing both dumping and injury are excessively complex and time consuming, and that the injury test is overly strict. As a consequence, industry leaders assert, the law is unworkable and does not effectively protect them from unfair trade practices by foreign firms. In 1977, largely in response to such criticism, the so-called trigger-price mechanism (TPM) for steel was instituted to supplement existing antidumping laws (see ch. 6). The TPM allows imported steel to enter the United States as long as prices are a certain percentage above the costs of the most efficient producer in the world market—then as now Japan,

Whether U.S. antidumping remedies are inadequate— in general or just for steel—is too involved a question to discuss in depth, but one or two points deserve mention, First, the evidence compiled for OTA'S steel study suggests that European mills, but not Japanese, do have higher average costs than American steelmaker. On the other hand, European firms historically have cut prices at home and abroad when they have excess capacity. American producers, in general, have not decreased prices in such circumstances, preferring to follow full-cost pricing strategies. As long as there is excess world steel capacity, producers in a t least some countries will have incentives to dump. However, if world steel demand grows to meet capacity— as the OTA steel study finds possible{— then dumping will cease to be a serious threat to the U.S. industry. The real problem would then be the lack of cost (and therefore price) competitiveness with respect to the Japanese and, potentially, with respect to new mills in the developing world.

'Technology and Steel Industry Competitiveness, op. cit., p. 78.

Exchange Rate Effects

The deteriorating competitive position of the American steel industry in the late 1960's improved beginning in 1971 when the dollar was allowed to float against other currencies. For some time, the United States had persistent balance-of-payments deficits, in part because the dollar was overvalued with respect to other currencies. When fixed exchange rates were replaced by a floating exchange rate system, the dollar fell against most currencies (table 14), improving the competitive position of the United States in steel and other industries. As the accumulated effects of inflationary imbalances dissipated, the relative prices of many American products became more competitive.

Since 1971, exchange rates have been largely market-determined. Over time, rates have tended to mirror differences in inflation among various countries. Although governments sometimes try to influence exchange rates—because holding them below the market level will make their exports more attractive—such a strategy is difficult to maintain for long in open currency markets.

Short-term fluctuations in exchange rates about the long-term equilibrium level can also influence competitive position. Between the fall of 1978 and the spring of 1980, the average production costs of Japanese steel, converted to dollars, fell from about 8 percent above U.S. costs to 23 percent below U.S. costs as a result of swings in the yen/dollar

Table 14.—Selected Currency Value Changes, 1971-74

Currency	Par value— August 1971 $/currency unit	Rate— June 1974 $/currency unit	Percent change
British pound	$2.40	$2.36	– 1 8°0
French franc	0180	0.203	12.9
German mark	0273	0373	364
Japanese yen	0.00278	00035	26,6

SOURCE: R H Mason R B. Miller. and D.R. Weigel The Economics of International Business {New York: John Wiley & Sons. 1975} p 9 0 exchange rate,[9] Similar effects occurred in other industries, with obvious consequences for the cost/price competitiveness of Japanese imports in U.S. markets. While the Japanese Government may have influenced such shifts in the past, as Japan's capital market becomes more closely linked to world capital markets—an explicit goal of their government—currency rate pegging will become more difficult.

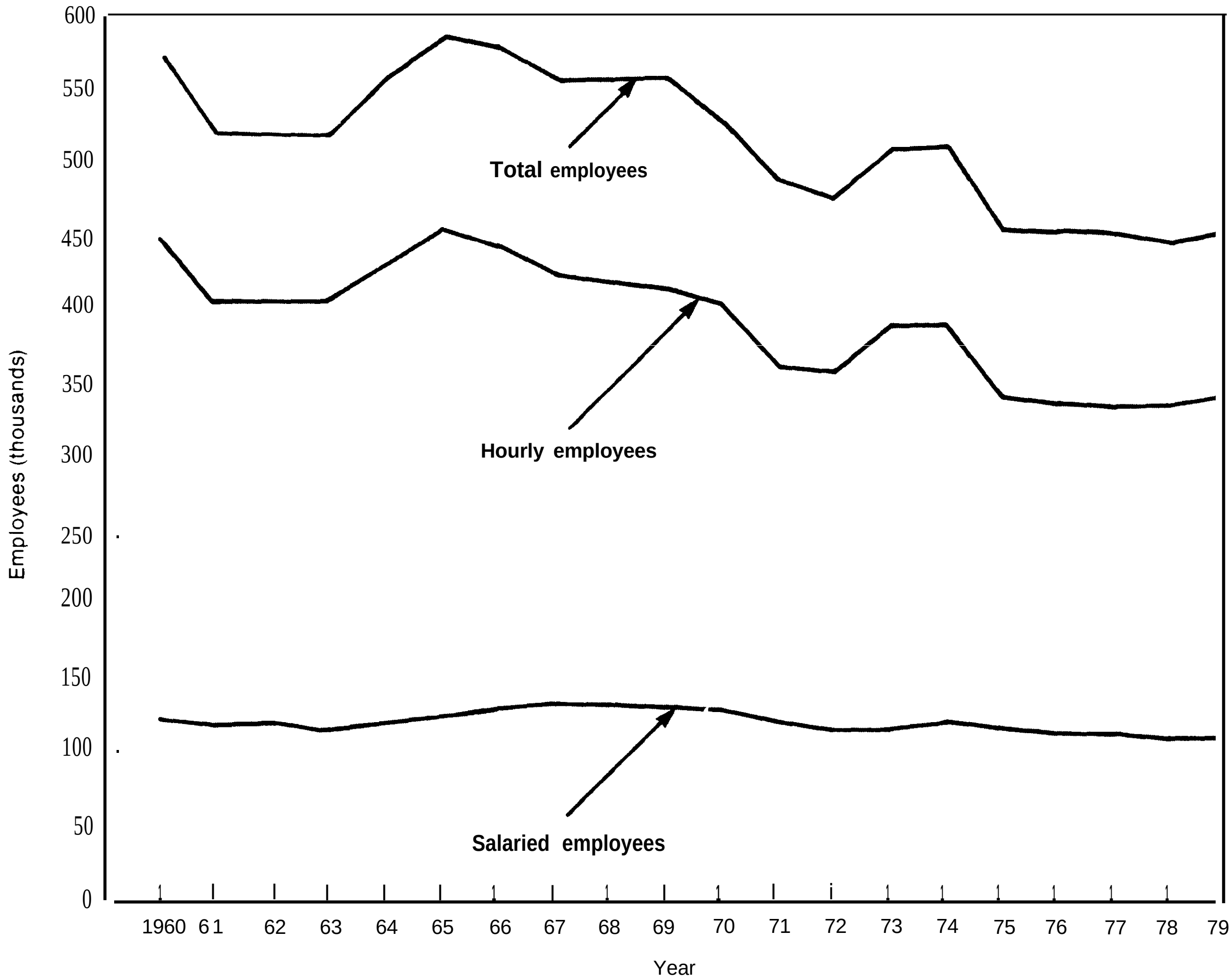
[9] P. F. Marcus and K. M. Kirsis, "The Steel Strategist," Paine Webber Mitchell Hutchins, Inc., June 1980, p. 1. Quoted in *U.S.-Japan Trade Report* (Washington, D. C.: Subcommittee on Trade, Committee on Ways and Means, U.S. House of Representatives, Sept. 5, 1980), p. 10.

Employment

When competitive advantages shift, employment levels may change. Declining employment in the domestic steel industry has often been blamed on increased competition from abroad.

As figure 10 shows, total employment in the American steel industry has fallen more than 20 percent since peaking in 1965. The rate of decline has been more than twice as rapid for hourly workers as for salaried. Two questions are most important: 1) To what extent have imports been the cause of employ-

Figure IO.— Employment in the American Steel Industry (annual averages in thousands)



SOURCES *Annual Statistical Report,* American Iron and Steel Institute, 1978, 1979 ment decreases? and 2) What would be the employment effects of higher domestic production?

Rising imports always decrease job opportunities. However, this is not the only factor at work. Table 15 gives steel production and employment for a pair of years a decade apart. Shipments were higher in 1979, but total employment fell by more than 100,000 because of increased productivity. Had domestic production replaced some or all of the imports in either year, employment would have been higher. But the basic conclusion remains: the most important cause of declining employment has been rising productivity, not increased imports.

This conclusion has significant policy implications, For the competitiveness of the steel industry to improve, its productivity must continue to increase, thus cutting costs. However, the inevitable result would be further employment losses unless total production could be substantially increased. At current production levels, the goals of improved international competitiveness and stable or rising employment are fundamentally opposed,

The fact that policies intended to maintain employment often work against increased efficiency is illustrated by the European experience. In Europe, despite subsidies or direct government ownership, steelmaker have not in general been able to achieve costs as low as in the United States or Japan. Moreover, the least competitive industries appear to be those where political pressures for maintaining employment have been greatest. For example, the British steel industry, largely owned by the government, lost $1.3 billion in its latest fiscal year, and is reported to be planning new layoffs totaling more than 50,000 workers.[5] Enhancing the American steel industry's international competitiveness, while certainly desirable, will not have large positive impacts on employment,

Table 15.— Domestic Steel Shipments and Employment, 1969 and 1979

Year	Domestic shipments (thousands of tonnes)	Total employment (thousands)	Tonnes shipped per worker	I report penetration
1969	85,165	554	154	14. 2%
1979	90,958	453	201	16. 1%

SOURCE *Annual Statistical Report* (American Iron and Steel Institute, 1979) p 8

Demand Patterns

The structure of demand for steel is changing in ways that are important to the competitiveness of the industry (ch, 7). Economic growth is the most important determinant of worldwide steel demand, but steel use does not necessarily rise as rapidly as gross national product, For example, steel consumption in the industrialized world is now significantly less than in 1973, At the same time, in the developing world, increased steel demand has spurred the expansion of capacity. South Korea, although still a minor producer on the world scale, has quadrupled its steel output in the last 5 years. Mexico and Brazil have been adding steel capacity much faster than the industrialized nations. In the future, all three countries could be efficient producers and potential competitors in world markets.

Even under the best of circumstances, therefore, the American steel industry is likely to continue to diminish in importance relative to the rest of the world. It will share this fate with the steel sectors of virtually all industrialized economies,

The developed countries appear to be in a much stronger position in alloy/specialty steels than in carbon steels. In part this is because the demand mix for steel products has also been changing in these countries. Demand for alloy and stainless varieties is rising rapidly. Specialty steel use will continue to increase—production of synthetic fuels, for instance, will depend critically on specialty alloys. Shipments of alloy steels now account for over 10 percent of U.S. tonnage. There

[5]Y. M. Ibrahim, "British Steel Reports $1.3 Billion Loss,"' New York Times, July 30, 1980, p. D 1. Some of the loss was due to a strike: losses the previous year were only $735 million.

has also been a shift towards high-quality sheet products as opposed to structural steel in most of the developed world. These changes partly reflect increases in the production of manufactured goods at the expense of construction, partly changes in applications. For example, increased demand for fuel-efficient automobiles is affecting the steel industry. Less steel is being used in each car due to down-sizing and the substitution of lighter materials such as aluminum and plastics. The move to lighter cars is also stimulating demand for high-strength steels, which are higher valued.

Despite the tradeoff between productivity and employment, the decline in size of the U.S. industry relative to the rest of the world, and continuing pressure by other steel-prpducing nations, there are factors operating to the advantage of the U.S. industry,

Changes in demand toward higher strength, higher priced steels give the industry an opportunity to advance through R&D. High-technology products, particularly alloy/specialty steels, may offer new export opportunities. Nevertheless, while the U.S. industry is probably on a par with other advanced nations in product technologies, it is generally somewhat behind Japan and the best of the European producers in the installation and use of process technologies.[G]

As the OTA steel study also shows, there may be significant opportunities for process innovations in the future—timely adoption of which might give the United States important technological advantages (some process innovations might, however, benefit other nations more), In any event, modernization and updating of facilities would cost several billion dollars per year— capital that does not seem currently available because of the generally poor profitability of the industry in recent years.' Attracting capital is a challenge that the steel industry shares with electronics, automobiles, and other sectors of U.S. industry—all of which compete for investment funds,

Photo credit: American Iron and Steel Institute

Electric furnace

'Technology and Steel industry (Competifiveness, op. cit., ch. 9.

'Ibid., ch. 10,

Electronics

Consumer Electronics

More than any other segment of these three industries, foreign competition has had major impacts on consumer electronics. As noted in chapter 4, large percentages of virtually all consumer electronics products sold in the United States are manufactured abroad. Table 16 gives figures for 1978; imports would have taken much more than 18 percent of color television sales for that year if the Orderly Marketing Agreement (OMA) with Japan had not caused Japanese firms to switch to assembly in the United States, Furthermore, table 16 understates the significance of imports because many products assembled in the United States and counted as domestic production include substantial

Table 16.—Import Penetration in Consumer Electronics, 1978

Product	Imports as % of U.S. consumption
Videotape players/recorders . .	100%
Household radios	100
CB radios ... ., ...,	90
Black and white TVs .,	85
Electronic watches . .	68
High fidelity and stereo components	64
Phonographs and compact stereo systems	43
Audio tape recorders	35
Microwave ovens ., ., .	25
Color TVs ., ...	18

SOURCE The U S Consumer Electronics Industry and Foreign Competition. Executive Summary final report under EDA grant No 0626 07002 10 Department of Commerce, Economic Development Administration May 1980 p 2

foreign value-added. Not only components and subassemblies such as circuit boards, but complete chassis are often imported, though most picture tubes are still made in this country.

Because of rising imports, increased productivity, and the movement by U.S. firms toward overseas production to control costs, employment in consumer electronics has declined dramatically since the mid-1960's. The work force today is barely half the size of 15 years ago, Employment has recently increased slightly, but this has been the result of OMAS insulating the U.S. TV market.

The Move Overseas.—TV receivers—color and monochrome—account for nearly half the total market value of consumer electronics products in the United States; this segment typifies the factors affecting the entire industry.

The first major threat to American manufacturers of TV sets came from Japan, Within Japan, the Ministry of International Trade and Industry (MITI) encouraged and helped to finance the development of transistorized TV designs during the 1960's.[8] While much of this work was carried out in the laboratories of Japanese firms, the basic color TV technology was licensed from U.S. consumer electronics manufacturers.

[8] E. Sugata and T. Namekawa, "Integrated Circuits for Television Receivers," IEEE Spectrum, May 1969, p. 64.

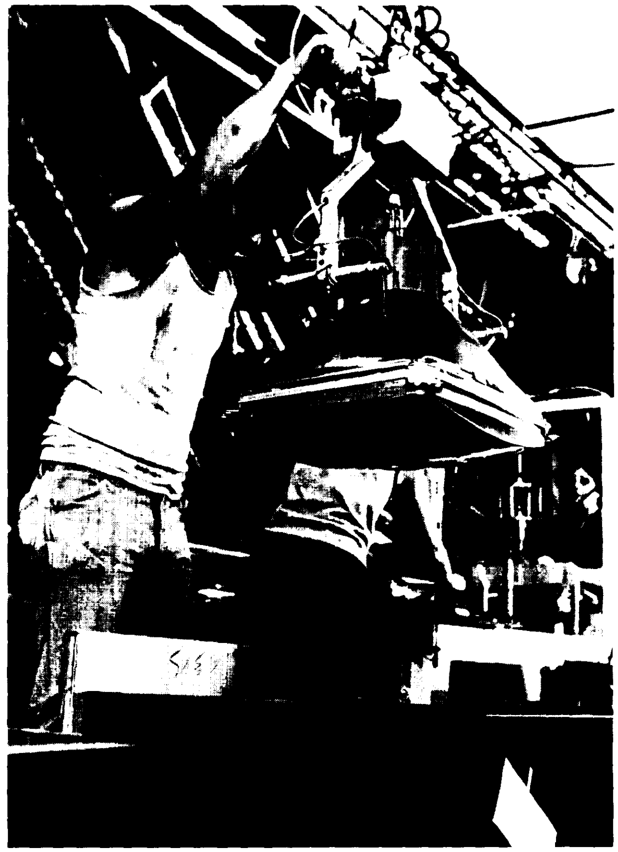


Photo credit RCA

Worker uses an air pressure lift to hoist a 25-inch picture tube into a console cabinet

Replacing vacuum tubes with semiconductors complemented the overall strategies of Japanese manufacturers. These strategies included the development of large export markets, creating economies of scale. The advantages of transistorized chassis designs (which were developed at the same time in the United States by Motorola) included:

1. Lower manufacturing costs (though at first the transistors themselves were more expensive than the vacuum tubes they replaced), the benefits tending to be magnified at higher production levels because assembly could be automated more readily.
2. A far more reliable product [primarily because of the intrinsic reliability of transistors), reducing the servicing re-

quired. Japanese firms thus did not need extensive networks of repair facilities in their export markets.

The initial Japanese penetration into the United States focused on particular market niches, notably small-screen sets and private brands (sets sold under the trade names of retailers such as Sears), where low price was critical. Sony, the one exception, chose instead to stress high quality and a prestigious image. Import penetration was accompanied, as for steel, by dumping complaints brought by American firms. The dumping issue is discussed in more detail in chapter 6. While dumping has been proven under U.S. law, it has not been an overriding factor in the success of Japanese TVs in the marketplace.

Prior to the rapid sales gains of imported TV sets, the American market had been dominated by franchised dealers carrying well-known brand names. However, the Japanese chose to sell through alternative channels such as discount outlets where price was important. Here their reliability advantage came into play, because discount stores rarely offered servicing. The strategy was not without risk, since reliability problems would have reinforced the rather skeptical view of Japanese products then held by many consumers.

As imports found increasing success, American manufacturers responded to the competition's strengths: quality, reliability, and low production costs. American firms typically combined rapid adoption of transistorized chassis designs—more rapid than might otherwise have been planned—with a search for lower cost production methods. Given the spectrum of available production technologies, most U.S. firms chose to lower their costs by moving some of their manufacturing to foreign countries. Low wages were the driving force. While tax havens offered by foreign governments-and U.S. tariff policies that limit duties on reimports after offshore assembly to the value-added overseas —may have encouraged transfers abroad, the basic motivation was to reduce labor costs.

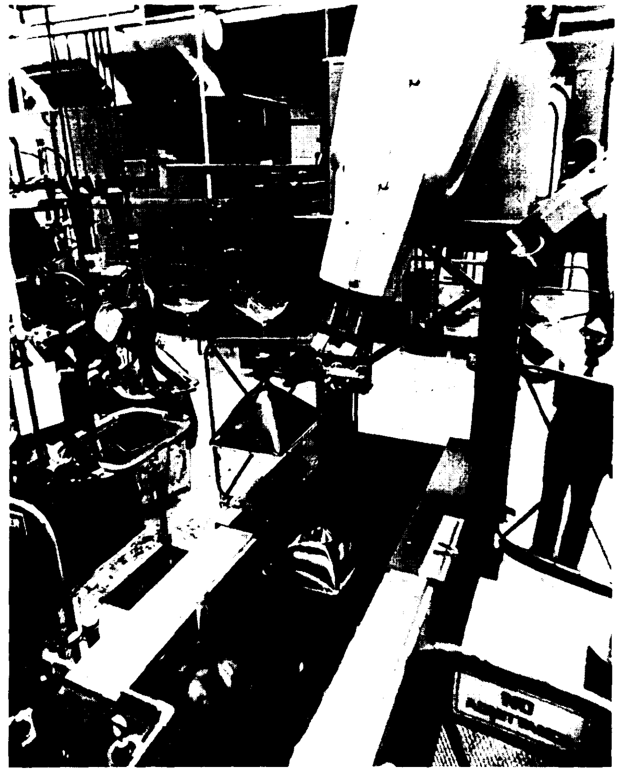


Photo credit *RCA*

Robot handling TV picture tubes

As if to emphasize that American manufacturers had little choice but to transfer production overseas, the Japanese now find themselves in a similar competitive bind. With wages in Japan rising rapidly, Japanese electronics firms are losing their cost advantages. Faced with increasing competition from rapidly industrializing nations such as Taiwan and South Korea, the Japanese are establishing assembly facilities elsewhere in the Far East. To some extent, moves to other countries were stimulated by OMAs, which at first applied to Japan alone. But even without OMAs, the transfer of production would have become necessary. The United States is not alone in being affected by changing patterns of comparative advantage: Japan has also been a victim—now in consumer electronics, earlier in textiles and shipbuilding, soon perhaps in steel.

Japanese TV manufacturers now have products that rank among the best in features and performance, as well as reliability and freedom from service,[9] Thus there now seems rough technological parity, with Japan equivalent to the United States in product technologies, perhaps superior in process technologies, (Some observers claim that the Japanese are ahead in the use of automation, but little directly comparable data exist,)

Success in the TV market has also given the Japanese an easier entree into markets for other electronics products, as well as carryovers into different industries, Consumers now seem to perceive many Japanese products as good values—well designed and of high quality for the price—whether electronics, automobiles, cameras, or motorcycles.

Research and Development.—R&D leading to transistorized chassis designs was an important part of Japanese success in TVs. In the United States, consumer electronics firms have not recently seemed vigorous in their R&D efforts, although firms such as RCA and General Electric have high overall levels of technological capability. In any event, there are signs that consumer electronics R&D has declined in the face of falling profits, Fewer than 1 percent of the employees in the U.S. radio and TV sector, for example, are engaged in R&D. In the electronic components sector, which includes semiconductors, the figure is 3 percent, Significantly more R&D personnel evidently work on consumer products in Japan. In some respects, the American industry seems caught in a downward spiral —low profits leading to cuts in R&D, which in turn may lead to fewer product innovations and still poorer performance. The question is: Can the situation be turned around?

The answer may be no. The United States is the world's largest market for video cassette recorder/players, a technology that originated in this country; but these products, even when sold under American brand names, are all made in Japan. The next major new consumer electronics product will be the video disk player. Although the technology remains in flux, Japanese firms are working on all three of the systems being developed. Given their demonstrated ability to rapidly bring new products to market in volume and at low cost, the Japanese may eventually dominate this technology as well. Even if U.S. video disk technologies such as the RCA system emerge as winners in the marketplace, production may move overseas—either to American-owned offshore facilities, or to foreign companies manufacturing under license.

Why are American firms—apparently at the forefront of electronics technologies—displaced when products move from R&D to commercialization, and especially to manufacturing and marketing? One common response centers on production costs, and suggests that the United States simply cannot match Japan in the manufacture of high-quality products at low cost; it is an old answer with some new dimensions. At one time, for many industries, it was claimed that Japan's competitiveness was based on cheap labor, Today this seems less important. Instead, Japan's ability to produce at low cost is often attributed to scale economies and experience (the learning curve phenomenon), and to advantages gained through horizontal and vertical integration—as well as to abundant supplies of investment capital, The export orientation of Japanese firms, and home markets that have been protected—more so in the past than currently—are also factors.

The overall scale of the leading Japanese consumer electronics firms is considerably larger than that of their American counterparts because the Japanese market their

[9] "19-Inch Color TVs," *Consumer Reports*, January 1981, p. 14, and "Small Black-and-White Television Sets," *Consumer Reports*, March 1980, p. 205. Features (such as remote tuning) and performance (picture characteristics) are mostly matters of engineering design. Quality in terms of freedom from defects, and reliability as measured by mean-time-between failure or similar parameters, are also dependent on design. However, quality and reliability depend as well on factors such as manufacturing methods, in-plant quality control procedures, and management and organization of personnel, particularly assembly personnel. These are often more nearly management than engineering functions. Quality and reliability, and their sources, will be discussed in detail in the forthcoming OTA electronics study. In the early to mid-1970's, Japanese TVs seem to have had better reliability; while U.S. products have since improved, Japanese firms have evidently been able to maintain their edge in reliability.

products worldwide.'[10] Manufacturers in Japan thus have potential advantages in economies of scale and experience, regardless of where their production facilities are located, To raise production volumes to match the Japanese, American firms would have to compete worldwide with the Japanese—and the Taiwanese and Koreans. At this late date, that seems unlikely,

The structural characteristics of Japanese firms may also contribute to their performance. Major consumer electronics manufacturers in Japan also make other electrical and electronics products. This integration can in principle yield R&D synergies, as well as learning economies in component production. Most Japanese TV-makers produce their own semiconductors; at least in theory, semiconductor developments can be closely coupled to the needs of the consumer division. At the same time, consumer goods provide a ready-made market for new semiconductor devices, removing much of the risk from their development.

Vertical integration linking consumer products and semiconductors also has negative aspects. The strength of the United States in semiconductors has often been attributed to the dynamic, entrepreneurial character of domestic merchant semiconductor firms. In the United States, large integrated electronics companies such as RCA and GE have not been notably successful in semiconductors, Often, a lack of flexibility is blamed.

Large integrated firms in Japan have developed their own ways of achieving flexibility: use of supplier firms, affiliates, and subcontractors; extensive training programs for employees; and a wage system in which a substantial fraction of annual pay may come as a bonus. Combined with employment policies which give many employees high job security, Japanese firms can move into new areas without creating anxiety in their work force or destabilizing existing activities. Further contributing factors are management systems that diffuse responsibility widely, so that corporate risk-taking need not imply personal risk-taking; managers do not feel tied to the income statement for the next quarter.

While vertical integration in any country carries both advantages and disadvantages, it does appear that long-term success in the consumer field will require at least some internal capability in semiconductors. ICs are now central to the development of new products. Digital audio, digital TV (the Philips video disk uses digital encoding), electronic toys and games, calculators, home computers—all depend on semiconductor technology;[11] many of these products are inconceivable without large-scale ICs. (Texas Instruments is an example of a vertically integrated U.S. firm strong in nontraditional consumer products while not making Tvs at all,)

The Future. —Consumer electronics manufacture in the United States has declined markedly; the remaining production is often little more than final assembly. Firms such as RCA, with its video disk, and Zenith, which is entering the home computer market, are certainly not conceding consumer products to foreign competitors: both have also maintained their historical market shares in color TVs. Nonetheless, the traditional home entertainment sector of the industry seems less than dynamic.

When other U.S. firms—mostly semiconductor manufacturers—have attempted to enter consumer markets, they have not always succeeded. The difficulties encountered by new entrants with products such as hand calculators and electronic watches resulted partly from foreign competition, partly from lack of experience in consumer markets, In some cases, products have been designed with little marketing research—perhaps because the companies involved were accustomed to dealing with technically sophisticated purchasers whose needs they under-

[10] *The* U.S. *Consumer* Electronics *Industry and* Foreign *Competition*, final report under EDA grant No. 06-26-07002-10, Department uf Commerce, Economic Development Administration, May 1980. p. 27.

[11] M. Kikuchi and Y. Kawana, "VLSI in Consumer Electronics, " *IEEE Transactions* on *Electron* Devices, vol. ED-26, April 1979, p. 279.

Photo credit National Semiconduct Corp

Workers in a clean room testing semiconductor wafers

stood. The Japanese have made such mistakes in the past, but are now more careful in their efforts to anticipate consumer preferences.

Were forward integration by U.S. semiconductor manufacturers to continue—and be successful—the structures of both consumer and component markets would change. In the past, semiconductor firms seldom tried to enter markets, such as radios and TVs, already served by other companies, but developed entirely new products. Such patterns will probably continue because this is where the greatest opportunities lie. New products offer rapid market growth and the chance to establish a strong position ahead of the competition. Costs of production are not so important when a firm can market unique products or otherwise attain a technological advantage.

At the same time, today's new product is tomorrow's mature one, and maturity tends to bring intensified competition. The U.S. market remains the largest in the world and will always be an attractive target; so long as Japanese consumer electronics firms are safe from foreign competition in their domestic markets (and in many other parts of the world) they will be a formidable presence here. American semiconductor and computer firms have demonstrated the advantages—perhaps now the necessity—of competing on a world scale, The same may be true in consumer electronics.

Semiconductors

There are really two semiconductor industries—one consisting of firms selling in the open or merchant market, the other comprised of the semiconductor divisions of integrated companies. The latter may produce exclusively for internal use (captive production), or sell on the outside as well.

Most of the firms in the merchant market began as independent, entrepreneurial concerns. Many have since been acquired by other companies; but the industry is still typified by manufacturers such as Intel (which remains independent), and Fairchild (now owned by Schlumberger, a French concern). Headquarters for most of the merchant firms are in "Silicon Valley, " near San Francisco.

The largest of the captive producers are IBM and Western Electric; each is strong in a variety of product and process technologies. Most computer firms design and produce some of their own semiconductors, often low-volume custom ICs; many other companies are also integrating into semiconductors to be able to supply at least some of their own needs and to have in-house R&D capability. Some vertically integrated electronics firms —e.g., Texas Instruments and Motorola—also sell large numbers of semiconductors in the merchant market. Other systems-oriented firms which make and sometimes sell ICs include Lockheed, Rockwell, and Westinghouse.

The number and diversity of firms which design and produce semiconductors attest to the importance of this technology, A strong case could be made in favor of semiconductors and their applications as the technologies most vital to a modern industrial economy.

Although captive semiconductor operations are a substantial source of technological strength for the United States, there is little data available for captives that bears directly on competitiveness. Thus, as in chapter 4, much of the attention below focuses on merchant firms. Nonetheless, captives account for 40 percent of domestic IC production.[12]

Despite recent large increases in semiconductor imports from Japan and the Far East, particularly ICs for computer memory such as the 16K RAM, the indicators examined in chapter 4 revealed no evidence of competitive decline by the United States. The 16K RAM is a high-technology device, demanding state-of-the-art processing capability, but at the same time is a standardized, commodity-like product, As mentioned in chapter 4, Japanese firms evidently have claimed more than 40 percent of the U.S. market for these circuits. The Japanese achieved this penetration by offering high-quality, competitively priced parts at a time when U.S. manufacturers could not meet the demand, The most important reasons for capacity shortfalls by U.S. firms were a reluctance to add new capacity in the wake of the 1974-75 recession, and market demand that was considerably greater than projected.[13]

While semiconductors continue to epitomize U.S. competitiveness, there is concern

[12] *Competitive Factors Influencing World Trade in Integrated Circuits*, publication No. 1013 (Washington, D. C.: U.S. International Trade Commission, November 1979), pp. 82, 84. The percentage has been relatively stable over the past few years.

[13] "'Effect of RAM Imports Into U.S. Disputed; Shortages May Trigger Increases in Prices,"' Electronics, Nov. 8, 1979, p. 40.

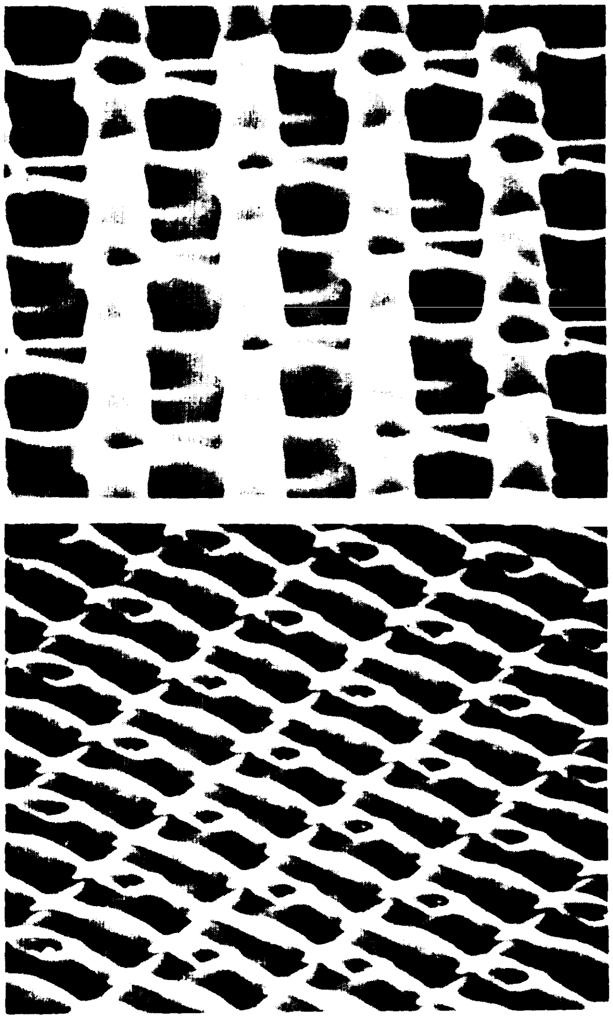


Photo credits Texas Instruments

Scanning electron micrographs of memory cells for a 64K random access memory (RAM)

for the future of even this sector.'" It is not based on any perception of imminent distress in the domestic industry, but rather on the extraordinary efforts by companies and governments elsewhere to match or exceed the United States. Production of ICs in Japan has recently grown even faster than in the United States. Through May 1980, Japanese IC production was up 50 percent over 1979: investments by Japanese semiconductor firms during the 1980 fiscal year were scheduled to increase their production capacity by a further 60 percent.[15]

Foreign Competitive Efforts.—As a result of the importance of semiconductors, both commercially and for national defense, governments in virtually all industrialized nations have been concerned lest he technology become a U.S. monopoly.

Such worries have not bee ı entirely unfounded. World semiconductor sales grew 23 percent last year—ICs even faster—and are expected to increase another 15 percent in 1981, 't) When technology-intensive products experience market growth at rates this high, it is quite possible for some firms—and some nations—to fall behind and never catch up (until the technology stabilizes). Many of the earlier entrants in the U.S. semiconductor market experienced this fate—including a number of large and capable firms—and either accepted a secondary position in the industry or withdrew from the marketplace.

In 1978, nearly one-half of European semiconductor needs—and well over half in ICs—were supplied by exports from the United States or by European subsidiaries of American firms. Many European governments have been concerned lest they fail to maintain viable indigenous semiconductor industries; a number have established government support programs, as has Japan.[17] These programs have sometimes included protective trade barriers, as well as government-funded or subsidized R&D. For example, in Japan, MITI has sponsored a 4-year cooperative R&D program aimed at very large-scale integrated circuits (VLSI), one of a number of government-supported efforts to enhance the technological capability of the Japanese electronics industry.

'J. Gresser, *High Technology and Japanese Industrial Policy: A Strategy for U.S. Policymakers* (Washington, D.C.: Subcommittee on Trade, Committee on Ways and Means, U.S. House of Representatives, Oct. 1, 1980).

' "Ilmming Semiconductor Industries, Their Future Examined," *Japan Report*, Joint Publications Research Service, JPRS L 9314, Sept. 26, 1980, p. 41.

"' "1981 World Market Forecast," *Electronics*, Jan. 13, 1981, pp. 121-144. The percentages are for the United States, Japan, and Western Europe, which account for most sales.

' *Microelectronics Into the 80's* (Luton, England: Mackintosh Publications Ltd., September 1979).

Japan's VLSI cooperative program involved five leading electronics companies; the government-sponsored portion of the effort ended in the spring of 1980 after expenditures reported at about $250 million—shared between industry and government. Some of the MITI funding is supposedly to be repaid in the event of commercial success; other government funding came in the form of loans. A follow-on project aimed at the commercialization of the VLSI technology developed has now begun.[18] Scheduled to take 3 years, no direct government funding is involved, although incentives such as tax writeoffs are being continued.

Government support programs in other countries tend to follow similar patterns. Some emphasize applications of ICs rather than R&D on the devices themselves or on processes for making them. Because the Japanese program appears to have been the most successful, and because the Japanese are widely perceived as the only real threat to U.S. supremacy in semiconductors, U.S. and Japanese IC technology are compared in the next section, with particular attention to the outcomes of the VLSI program. (This subject will be treated in more depth in the forthcoming OTA electronics study.)

U.S. and Japanese Semiconductor Technology. —Both discrete semiconductors and ICs were invented and commercialized in the United States. Virtually all major innovations in semiconductors have originated in this country. [19] American firms have also dominated worldwide sales, still holding more than 60 percent of the world market—a classic example of a technology gap creating the conditions for an internationally competitive industry, Note that this world leadership by the U.S. semiconductor industry occurred while domestic companies competed fiercely among themselves—a competition that has embraced price cutting as well as rivalry in device designs and process technologies.

Although the United States had at one time a technological lead in semiconductors over the rest of the world amounting to several years—a lead that the United States still largely possesses over Europe—the Japanese have managed to close the gap. They are now in many cases at or near technological parity with the United States, and their market power is rapidly increasing. One important force in Japan's ability to catch up was the captive market for semiconductors provided by her strong consumer electronics industry. However, the discrete devices and linear ICs used in consumer products are not as critical to competitive success in semiconductors as the digital ICs that go into computers and other advanced systems. Japan's VLSI cooperative program was intended to strengthen her capability in digital ICs, with the goal of creating a technological base in VLSI adequate to support a globally competitive computer industry.

The VLSI cooperative program concentrated on process technologies, as shown by table 17, rather than device technologies. One reason for the Japanese to emphasize processing may have been to get better cooperation among the participating firms. Although process technology is critical to competitive success in ICs, there is less proprietary knowledge than for product designs.

While it is difficult to locate sufficient information for sound judgments on the technological results of the VLSI program, there

Table 17.—Areas of Concentration of Japan's VLSI Program

Process technologies
Electron-beam and X-ray lithography
Super-clean facilities
Large-diameter perfect crystals
Improved evaluation techniques for crystals
Oxide growth and removal techniques
Device technologies
Logic design
Simulation
Circuit layout

SOURCE: VLSI Technology Research Association

[18] "Seven Private Firms Turn Attention to Making VLSI Circuits,' " *Japan Economic Journal*, Aug. 12, 1980, p. 7.

[19] *A Report* on the *U. S. Semiconductor Industry* (Washington, D.C.: Department of Commerce, Industry and Trade Administration, September 1979), p. 100.

seems to be a consensus in the American technical community that the Japanese have made substantial progress. Although they probably did not reach the goals originally set, the work of the VLSI laboratories in lithography and lithographic equipment is particularly well known.

Nor is it clear to what extent the VLSI program itself was responsible for advancing Japanese capabilities, as compared to the progress that would have been made anyway. The five firms involved are leaders in the Japanese industry, with active R&D programs and excellent capability. Most likely, the cooperative program did not have extraordinary impact— at least in terms of direct technological payoffs, For one thing, the funding level—somewhat more than $50 million a year—was simply not that high (only half of what some individual companies in the United States, such as Texas Instruments, spend annually on R&D),

In judging the results of the VLSI program, one might also question the extent to which the participating firms would have contributed their best people and best ideas. Japanese firms normally compete strongly with one another, There is no reason to believe that they would willingly share knowledge that might give competitive advantages. Because of the goal-oriented nature of government-industry relations in Japan, the psychological influence of the VLSI program was perhaps as important as the technical outcomes. That is, by providing a highly visible unifying locus for Japan's semiconductor R&D efforts, the program may have helped stimulate the technological progress of the entire industry, The anxiety aroused within the United States by the VLSI program would have strengthened this effect.

What, then, is the current state of Japanese IC technology relative to the United States? While not an inclusive listing (e.g., it refers primarily to digital MOS technologies), table 18 gives comparisons on several dimensions, based largely on discussions with American engineers. Comparisons, as in this table, always come down to matters of judgment, and there are bound to be disagreements; for example, some sources claim that Japan is ahead in silicon materials—i.e,, the ability to understand and control the properties of the crystals from which ICs are made. The breadth of the categories also obscures important distinctions—for example, U.S. firms clearly lead in some types of memory circuits. These caveats do not alter the primary message— that Japan has made considerable progress toward closing the technology gap in ICs.

The United States is ahead of Japan in 2 of the 10 categories included in table 18, behind in only l—deep ultraviolet lithography, a technology American firms have largely chosen not to pursue. (The quality question is discussed more fully below.) The majority of the categories in the table deal with processing. Much of the equipment used to make semiconductors is designed and built by independent firms— mostly American—selling on a worldwide basis, Therefore the Japanese have access to essentially the same process technology as U.S. semiconductor manufacturers. However there is a good deal of knowledge and experience needed to use the equipment to best advantage; the table refers in large measure to this sort of capability.

The judgments in the categories for design of memory circuits (e. g., RAMs) and microprocessors are generalizations concerning

Table 18.—Comparison of the United States and Japan in Digital Integrated Circuit Technology

Process technologies	
Electron-beam lithography	=
X-ray lithography	=
Deep ultraviolet lithography	–
Resists	=
Quality control	?
Silicon materials	=
Automated assembly,	=
Product technologies	
Computer-aided design capability	+
Memory circuit designs.	=
Microprocessor designs	+

+ United States ahead
United States behind
= Rough parity
~ See text

SOURCE H C Lin for OTA electronics study relative capability to design and develop new circuits, not to manufacture them. Designing and building memory circuits is demanding; nonetheless, these ICs are relatively standardized, commodity-like devices—the sort of product in which the Japanese have often proved their strength. At the same time, new standard memory circuit designs have always come from U.S. firms. While Japanese manufacturers have proved they can keep up

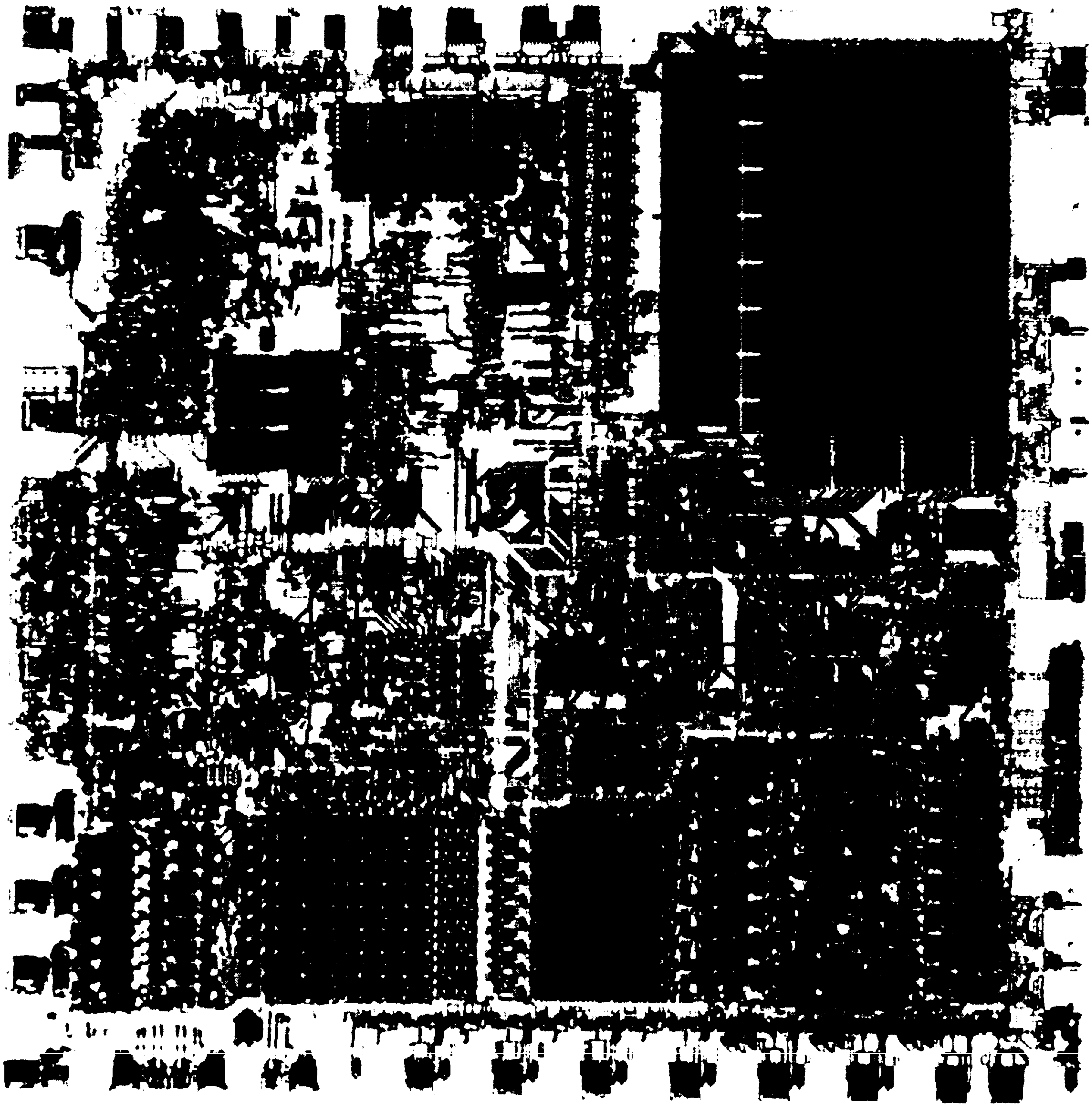


Photo *credit Intel Corp.*

8-bit microprocessor

in this technology, they have yet to design a circuit that has become accepted as a standard,

Microprocessors are more difficult to design than memory. The evolution of memory circuits is relatively predictable, at least at present. Microprocessors make greater demands on ingenious design, capacity to innovate, and marketing ability, One of the keys to designing and marketing a successful microprocessor is anticipating the needs of the user; programing ease and flexibility of application —which in turn depend on factors such as instruction sets, architecture, and speed—are important attributes. The United States has always been strong in these areas; thus, it is no surprise that it leads Japan in microprocessors, While it would be wrong to assume that the Japanese cannot innovate in microprocessors or digital logic, there is little evidence that they have yet done so.

One other technology in table 18 might be singled out—computer-aided design (CAD). Designing ICs becomes much more complex, time consuming, and expensive as levels of integration go up. CAD can improve design productivity. This technology—which uses computer software developed especially for circuit design applications—is also one in which the United States is now ahead. CAD will be extremely important for future competitiveness; the present lead is reassuring but needs to be maintained,

The question of IC quality and reliability will be treated at length in the OTA electronics study, but also deserves mention here. Quality refers to the percentage of ICs which meet specifications and function properly on delivery. Reliability refers to frequency of failure in service or average life before failure. Ample evidence exists that, in the past, Japanese ICs sold in the merchant market had higher quality.[10] However, the reliability of U.S. as compared to Japanese ICs is a more clouded issue. American firms claim that their reliability has always been as good as the Japanese; however, the Hewlett-Packard data—as well as some but not all of the data developed for the OTA electronics study—indicate that Japanese firms may also have had better reliability (for RAMs). Unfortunately, no information is available concerning the quality and reliability achieved by large-scale captive producers in the United States—one reason for the question mark in table 18. Firms making semiconductors for their own use have high incentives to maximize quality and reliability because the costs of downstream failures escalate rapidly.

While almost everyone concedes that Japanese quality was at one time better, the U.S. industry claims now to be matching Japanese levels of quality, This assertion cannot be verified; but it does seem that the Japanese remained slightly ahead into early 1981. The reasons for the (past) differences are several, but in the end come down to the strength of management's commitment to quality as a goal of production. Whether improvements in quality add significantly to net manufacturing costs is an important question but one that cannot be answered without a great deal of proprietary data.

The most important facet of the quality issue for competitiveness in semiconductors is the parallel with Japanese penetration of U.S. TV markets. There too, Japanese firms entered the United States with higher quality (and higher reliability) products that helped them gain market share. Although the U.S. TV manufacturers eventually caught up, the Japanese had already established themselves —and remain strong competitors. It appears that the same pattern is being followed in ICs—at least for memory products. (Japanese success in automobiles is also linked to quality and perceptions of quality as selling points.)

Although quality does not appear to have been a particular goal of the Japanese VLSI program, several of the technologies listed in table 17 are important for making ICs to high standards of quality and reliability, And, regardless of final judgments on the success

[10] The most dramatic data has been presented by an executive of an American firm, Hewlett-Packard. See R. Connolly, "Japanese Make Quality-Control Pitch," *Electronics*, Apr. 10, 1980, p. 81. Also "HP's Anderson Calls Quality Competition a Horse Race," *Electronics*, May 19, 1981, p. 128,

of the VLSI program, table 18 indicates that Japan is at or near technological parity with the United States in many important aspects of semiconductor technology. It seems unlikely that Japan will outstrip the United States in R&D-intensive devices such as microprocessors. However, in the more straightforward memory circuits—and in productivity and quality control—the Japanese have already demonstrated their technological competitiveness. Where success depends heavily on the ability to mass produce semiconductors to high standards, Japan will be strong.

In addition to the privately funded follow-ons to the VLSI program mentioned above—aimed at applications—MITI is sponsoring a new Japanese cooperative effort in computer software. Like VLSI technology, software is critical for competitiveness in computer systems. Japan has been weak in software; this effort is further evidence of her intent to become a strong global competitor in computers. Japanese firms already have adequate capability in hardware, as discussed below.

The U.S. Government also funds semiconductor R&D. The Defense Department has recently begun a major effort in VLSI, the Very High Speed Integrated Circuit (VHSIC) program. VHSIC is to be funded at about $210 million over 6 years; thus, it is comparable in spending level to Japan's VLSI effort, The basic difference is that VHSIC emphasizes applications to military systems. The Japanese program—as with government support for semiconductor technology in other nations—is directed at commercial technologies, Some of the VHSIC R&D will yield spinoffs in the commercial portion of the U.S. industry; however, it is too early to judge their potential significance.

Vertical Integration.—As discussed previously, considerable forward integration has been taking place in the U.S. semiconductor industry. While firms such as Texas Instruments and Motorola have always been integrated, other merchant manufacturers are also moving into end-product markets. At the same time, other companies have been integrating backwards into semiconductors, usually to be able to supply some fraction of their own needs. And, in several recent cases, formerly independent semiconductor firms have been purchased, sometimes by foreign concerns. The purchased companies—e. g., Mostek, Fairchild, Intersil—are expected to remain in the merchant market. But the loss of their independence, in the view of some, may threaten the spirit of aggressive entrepreneurship and innovation that has characterized the merchant semiconductor sector in the United States. Although many observers welcome vertical integration as a positive competitive response to changing market conditions—bringing with it infusions of capital and management experience—to others it represents a potential loss of the characteristics that have made the U.S. industry so successful,

There is little question that integration will continue; it is in the strategic interests of the managements of firms that are now in the merchant market, as well as those making end products. More basic questions deal with the capabilities of semiconductor firms to finance further expansion, including forward integration and entry into new markets.

Capital Supplies.—The semiconductor industry has been growing so rapidly that some firms have been hard pressed to generate sufficient cash flow to keep up with internal needs. At the same time, according to many industry spokesmen, external capital has not been available or has been too expensive.

In many respects, the capital needs of the semiconductor sector follow the classical pattern of an industry expanding so fast that it outstrips its capacity for internal funding. Cash flow shortfalls are compounded by VLSI process technologies that are increasingly capital intensive. The capital needs of the U.S. semiconductor industry for the decade of the 1980's have been estimated at $25 billion to $35 billion, compared to $4 billion to $5 billion for the 1970's,[21] This level of funding

[21] J. F. Bucy, "Semiconductor Industry Challenges in the Decade Ahead, " IEEE Solid-State Circuits Conference, San Francisco, Calif., Feb. 13-15, 1980.

may not be available from the capital market on terms the companies find acceptable, Industry leaders contrast this situation with that of their Japanese competitors. Not only does the Japanese Government provide direct R&D assistance for commercial technologies, but capital is said to be less costly than for American electronics firms,[22]

The same basic argument—that capital costs in Japan are low compared to the United States, in part because of policies followed by the Japanese Government—is made by other American industries. At its root, the argument rests on the structure and organization of the Japanese financial system, its impact on capital formation and, not least, the capital structure of Japanese firms.[23] These are complex topics, which are deferred to the forthcoming OTA electronics study. Here it is simply suggested that while external sources of capital—primarily debt—do seem available on more favorable terms, the advantages of Japanese firms in terms of internally generated capital may be overstated—except as a function of their relative size (large firms have more flexibility in allocating capital internally). For example, the cash flow available to Japanese electronics companies—basically the sum of net profits and depreciation—appears generally comparable to American firms. The low profits characteristic of Japanese industry are in many cases counterbalanced by rapid depreciation, That the government channels funds—primarily in the form of bank loans—to support some sectors of Japanese industry is another matter, While this is certainly an important aspect of Japanese industrial policy (see app, D), capital allocation by the Government is a mechanism which U.S. industries would presumably oppose. Likewise, the high debt/equity ratios still characteristic of Japanese firms—though use of debt has been gradually decreasing—would be unacceptable to both managements and lenders in the United States.

Computers

The international computer industry is similar to the semiconductor industry in several respects. Both have depended for many years on technologies developed primarily in the United States. In both industries, U.S.-based multinationals operate manufacturing facilities in many parts of the world, although there is far less reimporting of computers after foreign assembly than for semiconductors or consumer electronics, Computers, like semiconductors, have been targeted by foreign governments as sectors in which independent strength (i.e., independent of the United States) is a matter of national interest. Although the world computer industry has historically relied on technology licensed from the United States, foreign governments have been uncomfortable with this relationship, Thus, for computers as for semiconductors and steel, there has been considerable government intervention in other parts of the world.

Efforts by foreign countries to strengthen their computer industries have had mixed results, In Europe, despite financial assistance and government-fostered mergers, American manufacturers retain about two-thirds of all sales, U.S. computer technology is more advanced, with European manufacturers often emulating older American developments. Even in Japan, which has restricted both imports and direct foreign investment, U.S. computer firms still account for 45 percent of the market.[24] If there is an industry in which the United States is internationally competitive par excellence, it would have to be computers.

Any significant changes in these longstanding patterns of competition are again likely to emanate from Japan. The Japanese strategy in computers parallels that used in consumer electronics and semiconductors (as

[22] "U.S. and Japanese Semiconductor Industries: A Financial Comparison," prepared for the Semiconductor Industry Association by Chase Financial Policy, June 9, 1980.

[23] For the first of these, see Y. Suzuki, *Money and Banking in Contemporary Japan* (New Haven, Conn.: Yale University Press, 1980). For the latter, *Japanese Corporate Finance: 1977-1980* (London: International Business Information Inc., The Financial Times Ltd., 1977).

[24] "Computers: Can the U.S. Recapture Its Japanese Market," Business Week, Aug. 25, 1980, p. 72,

well as automobiles). Japanese firms have started by building a basic technological capability, largely through licensing arrangements with U.S. firms, They have then proceeded to establish a viable presence in particular market niches, from which more complete market coverage can be attempted. In computers, countervailing strategies by American firms have made this more difficult.

To illustrate, Japanese firms (Mitsubishi, Fujitsu, Hitachi, Toshiba) began by licensing computer technology from the United States, as well as from Europe, In 1960, IBM apparently exchanged its patent rights for permission to begin manufacturing computers in Japan.[25] IBM now accounts for some 30 percent of Japanese computer sales, a low figure compared to its share in other industrialized nations—where IBM typically has half the market—but impressive for Japan. Thus, the Japanese did not succeed, as they had in consumer electronics, in using entry barriers to protect their fledgling computer industry from foreign competition.

Still, the Japanese have managed great strides since 1970, when they began giving greater attention to computers. Japanese hardware now seems to be largely competitive with American, although until recently their main strength had been in small- and medium-sized systems.[26] While, in contrast to the consumer and semiconductor sectors, Japanese computer firms have yet to establish any real presence in the U.S. market, they clearly intend to try,

Although Japanese firms have achieved parity or near parity in hardware, they lag significantly behind the United States in software. Because software is a major source of competitive strength in the computer industry, American companies retain an important advantage. Software, and software support, along with customer service in a more general way, have always been among the strong points of the U.S. industry, especially IBM.[27]

As one might expect, the Japanese were quick to recognize their weakness in software. It is too early to judge the success of the MITI-orchestrated software R&D effort. The plan, which began during 1980, centers around the cooperative Computer Basic Technology Research Association, which has a 5-year budget of about $235 million and involves the leading Japanese computer manufacturers. Among the thrusts of the program are networking and data base management, as well as operating systems and Japanese language information processing capability.” Based on their past success with other technologies, it seems probable that Japanese computer firms will, one way or another, succeed in largely rectifying their software deficit. Software technology is widespread internationally; just as Japan’s automakers have begun to hire American and European stylists, so its computer manufacturers could hire software specialists from other countries if they have difficulty developing indigenous capabilities.

Technical Personnel

Before leaving electronics, one other potential constraint on the competitiveness of U.S. firms should be mentioned—the supply of technical manpower, particularly electrical engineers, computer scientists, and technicians. This has perhaps been of most concern to semiconductor firms, but also applies to

“Y. Kimizuka, *Densanki Gyokai* (The Computer Industry) (Tokyo: Kyoikusha, 1977), pp. 98-99.

[26] A. Durniak and C. Cohen, “U.S. Beachhead for Japanese Computers Is Only the Start, ” *Electronics*, Mar. 27, 1980, p. 113.

·Many observers have attributed IBM's market positinn to nonhardware factors. See, e.g., B. T. Ratchford and G. T. Ford, “A Study of Prices and Market Shares in the Computer Mainframe Industry, ” *Journal of Business*, vol. 49, April 1976, p. 194.

}’[4]’Electronic Computer Industry, ” *Japan Report No. 115*, Joint Publications Research Service, JPRS 77203, Jan. 19, 1981, p. 58. Software costs, particularly for applications programing, are escalating rapidly compared to hardware costs (in all parts of the world) because the productivity of programmers has not been increasing, Generation of software is becoming a significant entrepreneurial activity in the United Slates, with many new en t rants striving to establish themselves in the marketplace. Major innovations in software might tend to unsettle the industry: on the other hand, new programing languages such as Pascal, and now Ada, are forces for standardization and stability.

computers, indeed to all high-technology sectors of the industry.

At present, recent college graduates in electrical engineering and computer science are in short supply, The problem is one of absolute numbers; but there are also shortages of graduates with particular skills—e.g., the ability to deal with both hardware and software. Demand by employers for new graduates in electronics and computer specialties is expected to rise by as much as 35 percent in 1981.[29]

Part of the reason for the current shortages can be laid to the relatively poor job market for engineering graduates during the early to mid-1970's. The widely publicized slump discouraged many students from enrolling in technical fields. While enrollments have now picked up, the cutbacks in engineering school faculties and facilities that accompanied earlier enrollment declines have not been reversed, in part because engineering enrollments have proven cyclical in the past. Shortages of faculty and teaching equipment presently exist in many fields of engineering —a situation which, if allowed to persist, could have serious long-term consequences for competitiveness in virtually all U.S. industries, as well as for national security.

Japan is now graduating significantly larger numbers of electrical engineers than the United States—one-third more for 1977-— the reverse of the situation at the beginning of the decade, and a foreboding sign. [30] However, the United States has large numbers of mid-career engineers, some of whom are underutilized. There appears to be ample scope and incentive for retraining efforts which would help meet the needs of U.S. industry while also improving career prospects for such people. Many of these engineers missed the IC revolution, and, more importantly, the software revolution. They could benefit greatly from retraining that emphasized a mix of advanced hardware/software skills.

Comparing the Sectors

Several of the more important similarities and differences among the three sectors of electronics that have been examined are listed below:

1. The United States no longer has an overwhelming technological lead in any of these sectors, but semiconductor and computer markets are still rapidly growing and volatile; technological change is much faster than in consumer electronics. Major innovations in consumer electronics might or might not upset the current competitive situation in that sector. But the pace of technical change in semiconductors and computers virtually guarantees future shifts in the competitive positions of some firms—e.g., those making products such as microcomputers,
2. In the sectors experiencing rapid growth and technical change—semiconductors and computers —U. S. firms remain highly competitive, Important reasons are their long-standing strength in innovation and their skill at adapting to changing conditions. In contrast, American consumer electronics firms are having difficulty competing on a cost basis in mature products with Japanese and other Far Eastern producers—a similar problem to that afflicting the U.S. steel and automobile industries,
3. Again because of the rapid market growth in semiconductors and computers, employment is rising despite productivity increases. In the mature segments of consumer electronics markets, such as TVs, employment has declined— though it may now have stabilized. New generations of consumer electronics products could change this, but not if foreign firms take the initiative and become the successful innovators.
4. American semiconductor and computer firms are competing aggressively on a

[29] P. Hamilton, " 1981 Outlook Seen as Bountiful," *Electronics*, Jan. 27, 1981, p. 174.

[30] "The Electrical Engineering Gap: The United States Versus Japan," *The Rosen Electronics Letter*, Feb. 21, 1980, p. 7,

worldwide basis with all comers. Furthermore, major U.S. firms, particularly in computers, have achieved a significant presence in the domestic Japanese market. This may be a necessary ingreclient for maintaining global competitiveness. As long as American firms can actively compete inside Japan—which from time to time may demand the support of the U.S. Government-they should be able to remain competitive, though perhaps not dominating world markets as in the 1960's.

Automobiles

The motor vehicle (automobile and truck) industry in the United States entered a deep recession in sales and employment in 1980, when domestic automakers lost more than $4 billion. Production of passenger cars has been falling since 1977, much more steeply in 1980, Sales of domestic cars were lower in 1980 than in any year since 1961. Several hundred thousand autoworkers found themselves laid off. For trucks, the decline was even steeper, with production off by 46 percent. Even for subcompacts, domestic capacity utilization fell; the U.S. industry could have produced as many as 1 million more subcompact and compact cars during 1980.[31] But as sales of American-made cars dropped, imports from Japan continued to rise (table 19).

While sales of Japanese cars increased steadily through the 1970's, imports from Europe remained more-or-less stable (in the case of West Germany, they have decreased considerably—in part because Volkswagen now assembles cars in the United States). As table 19 shows, Japan's proportion of imports to the United States doubled from 40 percent in 1973 to 80 percent in 1980.

The past year was exceptional because in previous depressed markets, sales of both domestic and imported automobiles dropped. For 1980, total passenger car sales fell 13 percent—but import sales went up by 3 percent, while domestic sales were down by 21 percent (table 5 in ch. 4). Sales of Japanese imports increased by 8 percent. Even domestic subcompacts experienced 5 percent lower sales (U.S. full-size cars were down 37 percent).[32] Such a rise in sales of Japanese cars in the face of recession is striking—and to some observers prima facie evidence of the American industry's loss in competitiveness, The next section considers this question in more detail.

Imports and the U.S. Industry

Large declines in output are not unusual in the motor vehicle industry, which has a long history of such behavior—associated with

[31] "The Automobile Crisis and Public Policy: An Interview With Philip Caldwell,'" *Harvard Business* Review, January/February 1981, p. 73.

[32] *Ward's* Automotive *Reports,* Jan. 12, 1981.

Table 19.—U.S. Automobile Imports by Country of Origin (thousands)

Year	United Kingdom	West Germany	Italy	Sweden	Japan	Other	Total
1973	64	677	56	59	625	84	1,566-
1975	67	370	102	52	696	54	1,341
1977	56	423	55	39	1,342	23	1,940
1978	54	376	70	56	1,563	33	2,123
1979	46	323	72	66	1,617	29	2,156
1980	32	305	43	70	1,908	40	2,398

NOTE West German figures exclude production by Volkswagen of America Totals may not sum due to rounding Since 1977, most of the Other" Imports have been from France 1980 figures are for sales

SOURCES 1973.79—Department of Commerce, Bureau of the Census
1980—Ward's Automotive Reports, Jan 12, 1981

the business cycle. Furthermore, production tends to fluctuate more than sales, as dealer inventories periodically increase and decrease.

Table 20 and the discussion following treat automobiles and trucks together. The table shows domestic production, plus sales of both domestics and imports, for 1978 through 1980. The peak sales year for passenger cars and trucks together was 1978, slightly above 1973 (1973 was the peak for passenger cars alone). From 1978 to 1979, total sales dropped by 1.4 million (9 percent). Sales of American-made cars and trucks fell by 1.76 million (14 percent), production by somewhat less because of inventory buildups. Thus much of the decrease in production and sales of domestic vehicles was the result of slackening demand; regardless of imports, sales and production in 1979 would have dropped.

Much the same was true last year, though the decline in domestic production and sales was steeper. For 1980, total sales, including imports, fell a further 17 percent. However, sales of American-made cars and trucks fell by 23 percent (table 20), Again, a slackening in total demand is responsible for much of the drop in domestic production and sales.

If import penetration had remained at the 1979 level of 19.8 percent, domestic car and truck sales during 1980 would still have reached only 9.2 million—assuming domestics substituted for all the extra imports, This compares to the actual level of 8.6 million, If imports displaced a maximum of 600,000 American cars and trucks, then they can account for only one-quarter of the decline in domestic production and sales.

The 23-percent sales decline for American cars and trucks in 1980 is large compared to the decline from 1978 to 1979 but comparable to that associated with the 1974 recession. Likewise, sales fell by 21 percent from 1969 to 1970. Thus, the drop in sales of domestic vehicles during 1980 is not by itself unprecedented, A major difference is that import sales continued to increase in 1980, while in the earlier recession of 1974-75 they decreased along with sales of American cars. As table 5 showed, import sales fell 20 percent between 1973 and 1974,

A primary reason for increases in sales of imports— even in the face of recession and overall slackening of demand—is the shift in the market to small, fuel-efficient cars triggered by rising gasoline prices, as well as shortages and gas lines during 1979. This is a change with important implications for the current and future competitiveness of American firms. Tables 21 and 22 give distributions by size of sales of all passenger cars in the United States—domestics and imports—and of production by U.S. firms. The data show that domestic production (table 22) has been heavily skewed toward large vehicles compared to market demand (table 21). In 1980, 45 percent of sales were subcompacts, but these accounted for less than 30 percent of U.S. production. Small cars have always predominated among imports, When this segment of the market became more important (table 21), foreign producers—particularly the Japanese, who have done a better job overall than the Europeans in building strong dealer networks and meeting the desires of American consumers—found themselves with, in effect, a windfall.

The shift of the U.S. automobile market towards small cars has not been clear-cut and unambiguous, There was a movement towards small, high-mileage vehicles as a

Table 20.—Motor Vehicle Production and Sales Figures (thousands of cars and trucks)

Year	U.S. production	Sales			Import penetration
		Domestics	Imports	Total	
1978	**12,875**	**12,890**	**2,320**	**15,210**	**15.3%**
1979	11,471	11,132	2,743	13,875	19.8
1980	8,012	8,581	2,883	11,464	25.1

SOURCE Tables 5 and 6 in ch. 4

Table 21 .—Distribution by Size of Sales in the U.S. Passenger Car Market (domestics plus imports, percent of total sales)

Year	Subcompact'	Compact	Intermediate	Full size	Luxury
1967	9.3%	15.7%	23.6%	47.9%	'3.1 0/0
1970	17.1	19.8	23.5	36.8	2.9
1973	26.6	16.8	23.4	29.8	3.9
1974	26.5	22.7	24.4	22.7	3.7
1975	30.6	22.9	23.9	17.9	4.7
1976	24.7	24.1	27.8	18.8	4.7
1977 ....,	27.1	21.2	26.4	20.4	5.0
1978 ....,	26.4	22.9	26.6	18.4	5.6
1979	34.7	20.9	23.8	15.1	5.5
1980 ...., ...	45.3	18.6	20.5	12.0	3.6

aIncludes all Imports

SOURCES Through *1979—Automotive News 1980 Market Data Book issue,* p 16
1980– *Ward's Automotive Reports,* Jan 12, 1981

Table 22.—Distribution by Size of U.S. Passenger Car Production (percent of total production)

Year	Subcompact	Compact	Intermediate	Full size	Luxury
1973 ......, . .	10.20/.	18.8%	28.0%	37.8%	5.170
1974	15,4	27.5	*28.4*	23.6	5.1
1975 .., ...	12.7	30.6	*27.2*	23.0	6.6
1976	7.6	33.6	*30.8*	22.2	5.9
1977. , ...	7.7	26.9	*32.0*	26.5	7.0
1978 ..., ...	16.4	24.4	30.1	22.5	6.5
1979	23.8	23.4	25.9	20.4	6.5
1980	28.3	29.6	24.0	13.3	4,7

SOURCES *1973-79—Petition for Relief Under Section 201 of the Trade Act of 1974 From Import Competition From Imported Passenger Cars, Light Trucks, Vans, and Utility Vehicles* submitted by the International Union, United Automobile, Aerospace, and Agricultural Implement Workers of America (UAW), before the U S International Trade Commission, June 12, 1980
1980— Ward's Automotive Reports, Jan 12, 1981

result of the "energy crisis" of the mid-1970's—when subcompact sales reached 32 percent—then a reversal, as the market for large cars picked up again. This is evident in the domestic production figures for subcompacts and full-size cars in table 22, as well as in the sales figures.

U.S. automakers have made lower profits on small cars than on large because costs—both fixed and variable—have not been as strong a function of size as prices. This situation is changing as new small cars begin to sell at higher prices than the larger models they replace. Despite a reluctance to lose some of the profitability that came with big cars, the failure of American manufacturers to move more rapidly and consistently into small cars was not so much poor judgment as a reflection of contradictory market signals. These signals resulted in part from two concurrent Governmental policies-corporate average fuel economy standards, and continued price controls on oil (as well as low taxes on gasoline) which in turn held down gasoline prices (ch. 6). These juxtaposed policies confused the market and heightened uncertainty among the automakers. The result in 1980 was a mismatch between domestic production and market demand—which is now strongly oriented toward small cars, the Japanese mainstay.

Some American firms have also had difficulty marketing their small cars—particularly those of older design. Ford and Chrysler had considerable unsold dealer inventory in subcompacts during 1980.[33] High inventories of small American cars existed despite lower prices for some U.S. models—a price difference which was even greater when discounts

[33] *Auto Situation: 1980* [Washington, D.C.: Subcommittee on Trade, Committee on Ways and Means, U.S. House of Representatives, June 6, 1980], pp. 25-26.

for American cars, and surcharges for Japanese imports (occasionally as much as $1,000) are included.[34] But while sales of domestic subcompacts actually dropped in 1980, there have been few signs of slackening demand for Japanese cars. American manufacturers are counting on newly designed 1981-model and later small cars to reverse these trends.

Employment

Production cutbacks such as those that occurred in the U.S. industry in 1980 are always accompanied by layoffs—the unemployed autoworker is not a new phenomenon. From the peak production work force in 1973 to the 1974 trough, employment in the auto industry declined by one-third. This is not to minimize the very real problems created by unemployment in this industry, accentuated by the concentration of automobile manufacture in the industrial Midwest. Furthermore, it is quite possible that the current round of unemployment is more than a short-term problem, But from a policy standpoint, this point is important: Restricting imports of automobiles (from Japan) might ameliorate current employment decline, although the extent of this is by no means obvious (it depends on the number of consumers who would purchase American cars if imports were not available). Restricting imports will not alter in any fundamental way the highly cyclical nature of the industry, nor will it necessarily blunt the difficult, longer term competitive problems faced by U.S. automakers and parts suppliers.

Long-run employment expectations for automobiles are similar to those for the steel industry; the same basic conflict exists between productivity and job opportunities. Were domestic motor vehicle production to recover completely, maintaining or improving U.S. competitiveness would still imply raising productivity —which reduces employment opportunities. Based even on optimistic assumptions for future sales, some analysts believe auto industry employment could drop permanently by 100,000 or more workers over the next 10 years—to which job losses in supplier firms would add. Slower than expected market growth, along with cyclical down-turns, could raise the figure substantially, Note that this potential employment loss is comparable to *total* employment in the U.S. consumer electronics industry.

Factors in Competitiveness

Consumer purchases of Japanese cars are results of product mix, perceived value in terms of design features and equipment, styling, perceptions of differences in quality, and other factors— as well as fuel economy. The competitive situation in automobiles appears to be similar in a number of respects to that in consumer electronics, especially TVs, In both cases, the Japanese entered the United States in particular market niches—small screens, small cars, They established a reputation for well-designed, high-quality products at reasonable prices. In this, they have succeeded in ways that European automakers have seldom managed (Volkswagen is the principal exception), The Japanese have also established strong dealer networks—an important source of their ability to steadily increase sales in the United States.

Much of the product appeal of Japanese consumer goods in general—whether TVs, automobiles, motorcycles—does seem to be nonprice. The Japanese are aggressive marketers—at home, in the United States, and in other parts of the world. They now hire stylists from Europe and the United States, and have rapidly moved from producing cars that were perceived as overornamented and underfunctional to being among the leaders in design.

At the same time, there is nothing new or unusual about Japanese automobiles— whether in appearance and packaging, or engineering. Many of the more successful imports are quite conventional, with front engines and rear-wheel drive, While Japanese firms are now building more front-wheel

[34] "Current Problems of the U. S. Automobile Industry and Policies to Address Them," staff working paper, Congressional Budget Office, Natural Resources and Commerce Division, July 1980, pp. 16-17.

drive models, they lagged the Europeans markedly in this trend. However it has not hurt them in the American market. Toyota did not have a front-wheel drive car in the United States until 1980. Datsun entered a few years earlier, but with a car—the F-10—which was widely considered a poor design and which did not sell. The F-10 was quickly replaced by the 310—a model perceived as considerably superior. This is a typical example of Japanese response to consumer preferences. Products that meet with poor response are dropped, generally to be replaced by better ones. The Japanese did not quit the American market when their first offerings proved unappealing to American consumers; they persisted, and steadily improved their sales. This is the real significance of table 19.

Except for fuel economy, the success of Japanese imports does not then rest on their technology. In fact, relative technological capability—as opposed to engineering design —does not at present play a major role in the worldwide automobile market. Both product and process technologies are well diffused, with developments such as three-way catalytic converters or robots for automated spot-welding available to all manufacturers. In this respect, the automobile industry is more

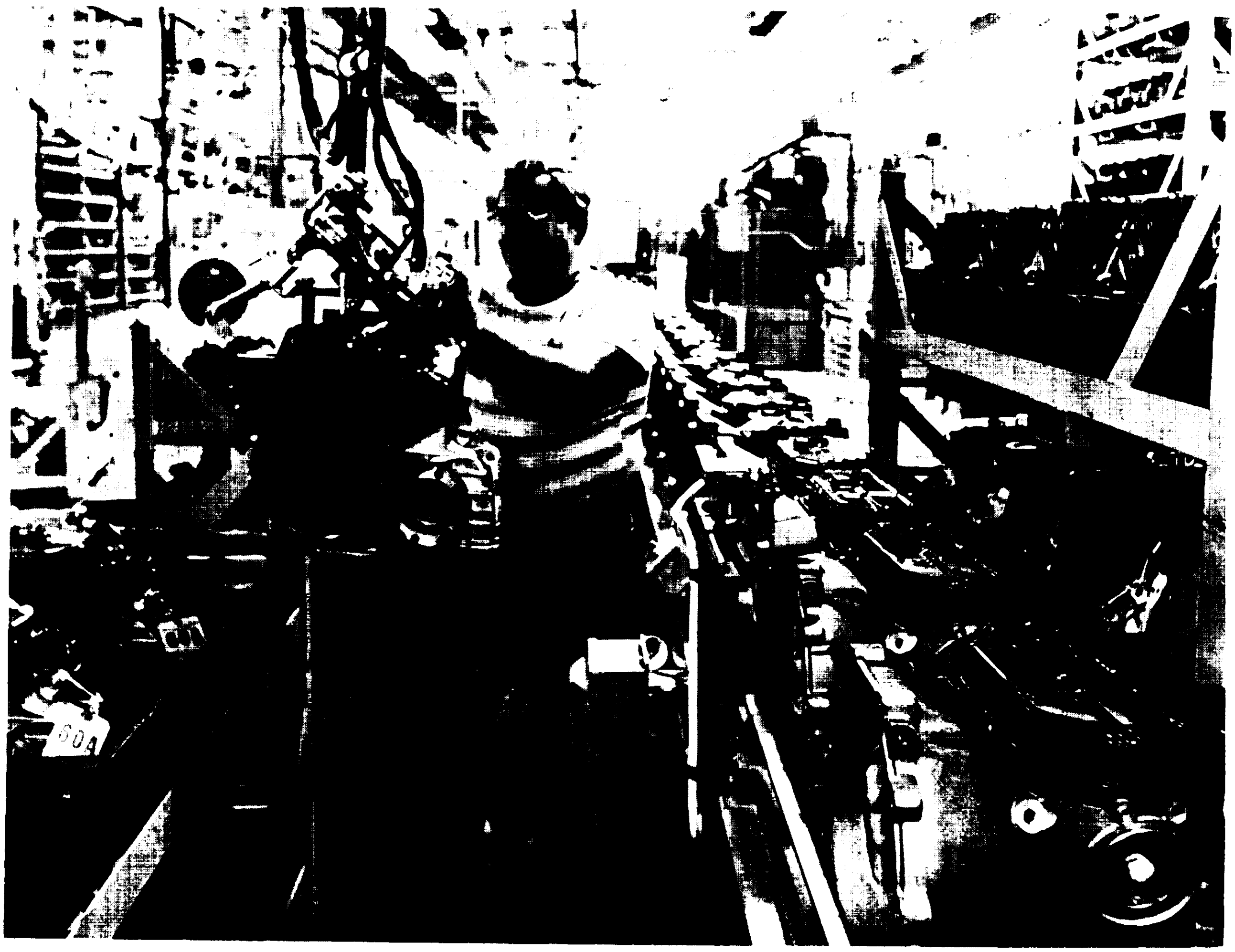


Photo credit Ford Motor Co

Automatic transaxle assembly

like steel than it is electronics. In steel, the technology is also a universal one, although there are always pockets of special knowledge. In contrast, for semiconductors and computers, the United States has maintained a technological lead in some areas. This gives U.S. electronics firms competitive advantages that do not exist in automobiles.

Japanese automakers do appear to have significantly lower costs of production than their American counterparts. A cost advantage gives flexibility in developing competitive strategies; for example, quality can be upgraded through better paint and trim, or more standard equipment included for the same price. Most important, lower production costs mean greater margins for cutting prices when sales are slow, as well as higher potential profits for reinvestment or attracting outside capital.

The actual magnitude of the Japanese advantage is uncertain. For subcompact cars, the manufacturing cost differential appears to be of the order of $1,000. While shipping may add $500 or more, many Japanese imports would still have lower delivered costs than cars made here.

Lower manufacturing costs in Japan stem in part from lower wage rates— especially among suppliers and subcontractors, but also in the Japanese automobile firms themselves —in part from labor productivity that may be somewhat higher than in the United States, and perhaps also from economies of scale. Wage rate differences are probably most important. Other cost elements also vary between the two countries—for example, the Japanese can take advantage of their cheaper steel, Moreover, costs depend critically on production volume—cost curves for automobile manufacture are notoriously steep. The huge losses sustained by U.S. automakers in 1980 stem in large part from low production levels.

For such reasons, estimates of cost differentials are complex and should be approached with caution. Even "comparable" subcompact cars are not the same; costs can be cut by careful engineering design, as well as a good working relationship between product engineering and manufacturing functions. Costs also depend on the extent of vertical integration within a company, which varies considerably between and within the two countries, Japanese automakers subcontract much of their manufacturing; just as for American Motors and Chrysler, they are generally not highly integrated. In Japan, even assembly may be subcontracted.[35] Japanese automakers rely on extensive networks of affiliated firms and suppliers; they also use contract labor within their own plants. The relationships between the manufacturers and their suppliers are certainly different from those in the United States; in some cases the ties may be close enough that the operations should be considered functionally integrated. But arms-length relationships such as are common in the United States also exist in Japan. Both wage levels and labor productivity are likely to vary among the parent firm, its subsidiaries and affiliates, and other subcontractors and suppliers. Within a given firm in either country, there will be differences from plant to plant and car line to car line.

In the absence of better information, several past estimates of manufacturing cost differentials have assumed that labor content (essentially productivity) for U.S. and Japanese cars was roughly the same, and that most of the Japanese cost advantage came from lower wage rates. On this basis, manufacturing costs in Japan would be $500 to $1,000 lower than in the United States, [36]

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[35] "Japan's Big Automakers Farm Out Work," *Japan Report*, Joint Publications Research Service L 9290, Sept. 8, 1980, p. 34.

[36] R. A. Leone, W. J. Abernathy, S. P. Bradley, and J. A. Hunker, "Regulation and Technological Innovation in the Automobile Industry," report to OTA under contract No. 9333800.0, May 1980, pp. 52-53; A. Katz, "Statement of the Department of Commerce," *World Auto Trade Current Trends and Structural Problems*, hearings (Washington, D. C.: Subcommittee on Trade, Committee on Ways and Means, U.S. House of Representatives, Mar. 7, 18, 1980), p. 232. one American firm has estimated labor productivity in the Japanese industry to be 10 percent higher than in the United States—"Response of Ford Motor Company," *World Auto Trade*, op. cit., p. 96. The Federal Trade Commission was unable to verify a productivity

More recently, some observers have claimed that Japanese subcompact cars embody substantially lower labor content, hence a production cost advantage of $1,200 to $2,000.[37] Such estimates are based on reports that Japanese automakers achieve markedly superior labor productivity and manufacturing efficiency through a variety of production engineering and quality control techniques. This seems contrary to the implications of the patterns of productivity growth in motor vehicles shown in table 8 (ch. 4)—36 percent for the United States for the period 1970-79, 77 percent for Japan. Mindful that productivity figures of this sort are not directly comparable, it still appears that the more rapid increase in Japan would, on the average, bring the absolute labor productivity for automobile manufacture in that country closer to, but not necessarily ahead of, that in the United States. Nonetheless, the very high rates of capacity utilization in Japanese auto plants over the past 2 years—coupled with low capacity utilization in the United States—could result in substantially greater cost advantages for Japanese automakers than would exist if the two industries were operating at comparable levels.

Although there is currently no real consensus on whether labor productivity in the Japanese automobile industry is significantly different than in the United States, some of the concerns now emerging are remarkably similar to those expressed earlier for industries such as steel and consumer electronics. There too, the apparent competitive advantage of Japanese firms was at first attributed to cheap labor (and often to unfair trade practices). Later, factors such as productivity, the Japanese work ethic, and the management systems of Japanese firms came to the fore. These are complex and poorly understood topics—several of which will be explored in more depth in the OTA electronics study. But questions of manufacturing efficiency and labor productivity—and their sources—deserve further mention.

Japanese manufacturing industries have in a number of instances demonstrated productivity levels equal and sometimes superior to U.S. industries. Japanese firms have also shown that they can make products of high quality. Relatively high productivity and relatively high quality characterize Japanese manufacturers in industries as diverse as cameras, steel, electronics, and motor vehicles. While some observers stress cultural factors among the attributes contributing to the high performance of Japanese corporations in such industries, it is easy to overemphasize their importance. Many aspects of labor relations in Japan—the multitier labor market, the so-called lifetime employment system, seniority-based pay scales—are based on rational organizational principles.)" Patterns of education and training for employees of large corporations—whether factory workers, technical professionals, or managers—have their sources in the historical development of the Japanese economy, particularly the rapid industrialization which began in the late 19th century.[39]

Corporate management in Japan differs in various ways from that in the United States, but here too cultural factors are only one among the many forces that have shaped the modern Japanese manufacturing organization. To say that Japanese firms achieve high productivity because their employees work hard and long, or that they maintain high

(continued from page 97)

advantage for the Japanese—M. P. Lynch, et a 1., "Comments of the Staff of the Federal Trade Commission Before the International Trade Commission, Certain Motor Vehicles and Certain Chassis and Bodies Therefor.' '" Oct. 6, 1980, p. 9 and app. A, pp. 11 ff.

[37] The Department of Transportation estimate is $1.500 to $2,000—The *U.S. Automobile Industry, 1980: Report to the President From the Secretary of Transportation*, publication No. D(YI'-(3-1O-8 1-2 (Washington, D.C.: DOT, January 1981), pp. 40-44: Professor W. J. Abernathy of the Harvard Business School now estimates $1,200 to $1,800—N. Call, "It's Later Than We Think" (interview with Abernathy), *Forbes*, Feb. 2, 1981, p. 65. Both estimates are based on the same unpublished report of a consulting firm.

[38] H. Shimada, *The Japanese Employment System* (Tokyo: The Japan Institute of Labor, 1980); R. E. Cole, *Work, Mobility, and Participation: A Comparative Study of American and Japanese* industry (Berkeley, Calif.: University of California Press, 1979).

[39] S. B. Levine and H. Kawada, *Human Resources in Japanese Industrial Development* (Princeton, N. J.: Princeton University Press, 1980).

quality because factory personnel are painstaking and diligent, does little to illuminate sources of competitiveness. After all, most of the techniques of quality control practiced in Japanese factories, along with manufacturing engineering methods of all types, are based on principles developed in the West, imported to Japan, and adapted to Japanese organizations, These methods continue to be taught in American schools of engineering and management, Like product technologies in the steel and automobile industries, they are part of a common body of knowledge available to firms all over the industrialized world.

To leave manufacturing costs and return to the ingredients of successful automobile marketing in the United States, one of the critical factors is certainly the dealership system. When imports—both European and Japanese —lacked large, aggressive, and loyal dealer networks, they were not perceived as serious threats, For many years sales of imports suffered because dealers were few and scattered, spare parts unavailable, service poor, and resale value low. The primary exception was Volkswagen, which established a strong group of dealers during the 1960's. The major Japanese importers have now done the same, as table 23 shows. In many respects, the establishment of a viable network of dealers has been at the center of the strategy of Japanese importers. No doubt they learned from the example of Volkswagen, and the failures of other European firms to establish themselves in the U.S. market. As the table indicates, over the last 5 years the numbers of dealers for U.S. cars have declined slightly, but all the Japanese makes have increased their representation (many dealers sell both imports and domestics). While there are still far fewer dealers for imports, those handling Japanese cars may be healthier. Dealers for Honda, Datsun, and Toyota sell more cars on the average than American car dealers. '(' Their current profit margins should also be high because popular import models have often been in short supply and selling for premium prices,

"Automotive News 1980 Market Data Book Issue, pp. 19, 48.

Table 23.—Numbers of Dealerships by Manufacturer

Firm	Dealerships 1975	Dealerships 1980	Percentage change 1975-80
General Motors	.11,860 -	11,425	– 3. 7%
Ford,	6,773	6.514	- 2 4
Chrysler	5,193	4,419	– 15.0
American Motors	1,862	1,701	– 8 6
Datsun. . . .	940	1,069	+ 13.7
Toyota. .	947	1,062	+ 12.1
Volkswagen	1,201	1.015	- 7 2
Mazda	375	759	+ 102.4
Honda .	409	740	+ 80.9
Subaru .	568	738	+ 461
Fiat	691	640	– 7.2

SOURCES: 1975— Ward's 1976 Automotive *Yearbook (38th* ed. Detroit. Mich. 1976) pp 34 119
1980—Automotive News 1980 Market Data Book issue pp. *48 54*
For both years the number of dealers is that on January 1st

Small Car Strategies of U.S. Firms

In planning their corporate strategies, domestic automakers did not anticipate that consumer preferences would shift so rapidly toward small cars with good fuel economy, Nor did importers; Japanese firms had large inventories in the United States prior to the doubling of gasoline prices during 1979 and 1980, Before this, big cars had been selling well.

While American automakers have been introducing new-generation subcompacts— GM's Chevette in 1976, Chrysler's Omni/Horizon in 1978—their product lines in small cars remain thin. Even with the introductions of the Chrysler K-car and Ford's Escort/Lynx for the 1981 model year, the Japanese manufacturers still offer many more small cars and a broader selection of subcompacts.

Historically, manufacturers outside the United States have stressed small, inexpensive, and economical vehicles. In both Europe and Japan, high gasoline prices and a variety of public policies—e.g., steep taxes on weight, engine displacement, or horsepower—have encouraged small size and good fuel economy. Increasingly, U.S. automakers—who have, after all, been quite successful in many foreign countries—are being forced away from their traditional product strategies in their home market, These strategies emphasized comfort and ride, size, du-

Photo credit Ford Motor Co

Final assembly area for Ford Escort/Lynx

rability, and at times performance. Optional equipment, whether functional or cosmetic, has also been important. Now American manufacturers have to compete in terms of fuel economy and space utilization here as well as overseas, The changes, helped along by Government fuel economy standards [ch. 6), have been sharp. By 1979 the production-weighted average fuel economy of a new domestic car had reached 19.2 miles per gallon, compared to 12.9 miles per gallon in 1974."

Initial efforts to improve fuel economy focused on weight reduction. The average domestic car weighed 4,35o lb in 1975, 3,7oo lb in 1979. These reductions were accomplished by "downsizing" and shifting to lighter materials—replacing iron and plain carbon steel with plastics, aluminum, and high-strength steel. More front-wheel drive cars are now appearing. These save weight primarily by allowing overall vehicle size to be decreased for given interior dimensions.

During the 1970's, American firms also began more actively marketing captive imports—small cars produced by wholly or par-

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"'"Innovation and Fuel Economy Among Domestic and Imported Cars, " *World Auto Trade: Current Trends and Structural Problems*, op. cit., p. 24.

tially owned foreign firms. As American manufacturers are currently unable to count vehicles in their corporate average fuel economy figures unless the value-added in the United States is greater than 75 percent (scheduled to be reduced to 50 percent for the first 150,000 cars by the Automotive Fuel Efficiency Act of 1980), the incentives to sell captives have not been great.

A side-by-side comparison of U.S. and imported cars by weight class, table 24, reveals that American automakers are competitive in fuel economy. However, the table also shows how slim American product lines are (or were in 1979) in the lower weight classes and smaller sizes. While the domestic manufacturers had no models in the lowest weight class—2,000 lb—there were 10 imports. As it happens, two-thirds of import sales in 1979 were in the 2,500-lb weight class and below, against only 7 percent of domestic sales. In contrast, almost 80 percent of domestic sales were in the 3,500- to 4,500-lb classes. The average fuel economy of domestic cars does exceed that for imports in each category where comparisons are possible except the 2,50()-lb weight class, where the difference is small.

It appears that a significant part of the current difficulties of American firms stems from the thinness of their product lines in the small car classes which are becoming more and more popular (e.g., table 24, also tables 21 and 221. Even for the 1981 model year, the top **20** cars in EPA mileage rating are foreign in manufacture and/or design (the Volkswagen Rabbit diesel is made here but was developed in Germany). Furthermore, many consumers, faced with a choice among two or three variations on a domestic subcompact, or half-a-dozen Toyota models, might well find a particular Toyota that was more appealing to them, The product strategies of the Japanese firms— emphasizing variety, as well as quality and fuel economy—thus seem to be working well (many buyers now rate imports distinctly superior in quality”),

Table 24.— Fuel Economies of Domestic and Imported Automobiles, 1979

Weight class	Domestic: Number of models	Domestic: Average mpg	Imported: Number of models	Imported: Average mpg
2,000 lb	0	—	10	32:6
2,500 lb	11	281	34	28.3
3,000 lb	47	224		21.4
3,500 lb	65	197	20	18,5
4,000 lb	56	17.4	9	15.1

SOURCE: *World* Auto *Trade Current Trends and* Structural *Problems* hearings (Washington D C Subcommittee on Trade Committee on Ways and Means U S House of Representatives Mar 7 and 18 1980) p 25
Averages are not sales weighted

To keep up with the changing market—and with Government regulations for fuel economy, emissions control, and safety —U.S. automakers continue to face large capital expenditures. These have been estimated at $70 billion for the period 1979-85 [43] —more than half to be spent in the United States. It seems likely that even GM will need to borrow—perhaps $5 billion to $10 billion—to accomplish the redesign and retooling required. Ford has already borrowed, and has also announced cutbacks on planned expenditures because of disappointing cash flow. Chrysler's precarious financial situation is well known. Foreign firms do not have to invest at comparable levels because they already produce mostly small cars.

Assuming investment funds were available, would U.S. firms be able to compete effectively with imports in the compact and subcompact classes? Past experience indicates that this may not be as easy as some have assumed. To begin with, the import market share is now 25 percent nationally—and considerably higher for subcompacts. Import sales have been at 50 percent in California, a bellwether automobile market. ” History suggests that market share losses are not easily reversed in the short run. Furthermore, the Japanese have clearly established their credibility with the American consumer, They have reputations for building high-quality

[42] R. Irvin, “Japan: Quality Cars. ” *Autoweek,* July 21, 1980. p. 10.

[43] *The U. S, Automobile Industry, 1980: Report to the President From the Secretary of Transportation,* op. cit., pp. 65-66.

“P. E. Hollie, “Foreign Car Surge in California. ”' *New York Times,* Mar. 26, 1980, p. 111,

Photo credit Ford Motor Co

Robots welding automobile subframes

cars at reasonable prices—cars that do not require frequent repairs and that have good resale value. Their dealer organizations are strong. Lower manufacturing costs give them freedom to cut prices to maintain sales. American automakers have proved that they can compete in Europe and elsewhere with small cars; the extent to which overseas experience can be transferred back to the United States will be an important element in their long-run competitive prospects.

Summary and Conclusions

The competitive positions of firms in each of these industries result from complex sets of factors—some quantifiable, others intangible. Each sector is increasingly challenged by competitive pressures on a worldwide basis —a common theme for U.S. industry.

A distinguishing feature of the steel industry is its wage pattern. That pattern shows a tendency, accelerating in recent years, for wages to increase faster than the national average in manufacturing. Wages in foreign steel industries have also been going up. But while the American steel industry has achieved productivity gains similar to those of European steelmaker, productivity increases have been greater in Japan. Most U.S. firms have been unable to effectively compete for export sales with the lower priced (but sometimes higher cost) products offered by foreign steelmaker. They have also been in a poor position to combat imports and dumping at home,

Although steelmaking costs in Europe are generally higher than for American firms, the marginal cost export pricing strategies followed by many European steelmaker lead to import sales in the United States at dumping prices. In contrast to the Europeans, Japan's steelmaker have a production cost advantage—stemming from factors such as more modern plant and equipment, lower wages, exchange rate effects, and a well-developed raw material supply network, The hard fact is that the Japanese have become very efficient and aggressive competitors.

Employment in the American steel industry has declined by more than 20 percent since 1965. However, the major cause of falling employment has not been rising imports, but rising productivity. Moreover, to increase the competitiveness of the steel industry its productivity will need to be further increased—for example, by modernizing its plant and equipment, Employment will thus continue to decrease unless production expands. Because of slow domestic market growth, the only way to expand production sufficiently would be through exports —which is unlikely, given excess world steel capacity (there may be promise in exports of alloy/specialty steels). At current production levels, then, goals of improved international competitiveness and stable or rising employment in this industry are fundamentally opposed.

This tradeoff between employment and productivity is a subset of a larger group of domestic and international economic problems. Economic growth is the single most important determinant of demand for steel; in a climate of domestic and international economic slowdown, it is especially difficult for the U.S. industry to increase its share of a sluggish world market. With excess capacity the current norm in industrialized nations, and increased capacity the trend in newly industrializing countries such as South Korea and Mexico, the American steel industry is likely to continue to diminish in importance relative to the rest of the world.

Among the positive signs is the scope in the United States for modernization, and for process R&D aimed at lower costs and higher productivity (which would however decrease employment opportunities). Changing demand patterns—toward higher strength, more expensive steels—also provide opportunity for the domestic steelmaker. Increasing the technological content of the industry's offerings is one way for it to compete against international rivals who can sell standard products more cheaply.

Imports and foreign production have had greater impacts on consumer electronics than on any other sector OTA has examined. Over the last 15 years the size of the work force has been cut in half and the overall position of U.S. companies in the domestic market has declined markedly, The success of Japanese TV manufacturers in penetrating particular market niches, and then expanding through emphasis on low-priced, high-quality products has been remarkable. Were it not for OMAs set up to regulate the flow of imports, the position of American color TV manufacturers would have eroded even further.

A renewed commitment to R&D in high-technology consumer products could be one path to enhanced competitiveness for U.S. manufacturers, New products that rely on semiconductor devices may provide opportunities for the stronger U.S. firms in the old-line home entertainment sector, as well as for new entrants from other parts of the electronics industry. While there are potential disadvantages as well as advantages to vertical integration, forward integration by semiconductor firms may be increasingly attractive as the value-added in consumer electronics becomes more heavily concentrated in integrated circuits.

It is probably not an exaggeration to say that the semiconductor industry—and particularly, the applications of semiconductor

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technology—are now the ingredients most vital for the future of an advanced industrial economy. From the U.S. perspective, the semiconductor industry is also notable in that, while American firms are currently extremely competitive worldwide, there is concern about the future because foreign firms and governments have set out to systematically advance their technological capabilities, as well as their market positions,

In semiconductors, more than steel and autos, technology is a primary focus of concern. American companies were responsible for the initial development of most types of semiconductor devices, but recently the technology gap between the United States and Japan has narrowed. Japanese firms are now at or near parity with the United States in many areas, helped by R&D support from the Japanese Government. Although Japanese companies are unlikely to overtake their U.S. rivals in ICs such as microprocessors that depend on clever design, the Japanese have already demonstrated their capabilities in more straightforward circuits.

While Japan's cooperative VLSI program has been important, the major impact of this government-sponsored effort was perhaps less a matter of technology than psychology, By providing a unifying focus for R&D, such cooperative projects contribute to the technical capability of Japanese firms both directly and indirectly.

A deserved reputation for high quality has also contributed to the competitiveness of the Japanese electronics industry. This is an area where U.S. firms have renewed their efforts; but the Japanese will undoubtedly also continue to progress.

U.S. semiconductor firms face rapidly escalating capital requirements for R&D and to meet the growing demand for their products. Vertical integration will continue in the United States; it is in the strategic interests of the managements of firms now in the merchant market, as well as those that make end products. Mergers and backward or forward integration can give complementary product lines, captive markets, synergistic environments for R&D and product development, and sometimes capital,

In computers, American firms have always been extremely competitive. Here, as for semiconductors, the real question is whether U.S. firms will be able to maintain their positions. Past efforts by foreign firms to compete directly with IBM and other U.S. computer manufacturers have seldom had much success. Even in Japan, where measures were taken to promote domestic firms and discourage imports, U.S. producers still account for 45 percent of the market.

The advantages of U.S. computer manufacturers have come from extensive service and support capabilities and broad product lines, as well as their technology, American firms have dominated hardware as well as software developments, and have also become skilled at marketing on a world scale, These determinants of competitive success are unlikely to change, even amidst the market shifts associated with the increasing relative importance of minicomputers and microcomputers, and the blurring of boundaries between the computer and the communications industries. Software will continue to grow in significance— an area in which the Japanese industry has been weak, but one which it has targeted for development.

For automobiles, as for steel, import penetration is nothing new. While the recent downturn in sales of domestic cars has precedents, given the cyclical behavior characteristic of the industry, the important fact is that more than 25 percent of the U.S. market is now taken by imports (and import penetration is even higher in the most popular subcompact class). The Japanese have led this wave of imports; since 1973 the Japanese share of all imported cars sold in the United States has gone from 40 to 80 percent.

While some have argued that imports are the primary cause of the apparently declining competitiveness of U.S. automobile firms, it is difficult to make this case. Although Japan's automakers have real advantages in lower manufacturing costs, some Japanese cars—like some Japanese TV sets—have the proven ability to command premium prices in the American market. Among the reasons for lower production costs in Japan are the extensive use of affiliated and subsidiary firms and subcontractors—which may depress average wages.

A considerable portion of the difficulty experienced in 1980 by U.S. automakers was the result of economic recession and nonprice factors, including the sudden shift in consumer demand to small cars—caused by recent jumps in gasoline prices. Still, much of the sales decline since 1978 can be attributed to a shrinking market, with perhaps one-quarter representing domestic production displaced by imports. A major part of the problem has been a mismatch between product design and market demand. The product lines of the American firms are thin in small cars, particularly subcompacts-which are taking a much larger share of the market than as recently as 1978. Imports offer wider selections of subcompact models. Moreover, consumers regard them as high quality, well designed, and good values. U.S. companies remained in a reactive position in this portion of the market through 1980, While new 1981 U.S. models may reverse some of the losses of the last 2 years, Japanese imports are now well established in the United States; American firms can expect difficulty in regaining market share.

The costs of the current decline fall heavily on unemployed American automobile workers. The magnitude cf employment losses, and the regional concentration of the problem, suggest a need for public policy measures to more effectively deal with such dislocations (ch. 8). Because of the tradeoff between productivity and employment, jobs in the domestic automobile industry will not regain their former levels even in good sales years.

Despite the differences among these industries, there are common themes. All three, like their counterparts abroad, are now more exposed to the rigors of international competition. The U.S. market in these sectors is also a much smaller fraction of the total world market than in the 1950's. American firms which do not export or manufacture overseas are bound to shrink in relative importance.

Profits have declined—in some years disappeared—in steel, consumer electronics, and automobiles. This cuts into the cash flow available for modernizing and rebuilding competitiveness. Statements focusing on the need for capital to foster competitiveness have come from leaders of all three industries, and from other sectors of the American economy. If universally true, they would be a severe indictment of domestic capital markets—usually thought to be the best developed in the world. However, each industry has different reasons to advance for the causes of its capital shortfall. In semiconductors, it is primarily rapid growth and the rising capital-intensity of VLSI. In steel, expenditures are needed to meet environmental and workplace standards, as well as to replace outmoded plant and equipment. The automobile industry must spend large amounts on redesign and retooling to produce small, high-mileage cars, In each instance there does in fact appear to be a good possibility that the market will not supply all the funds that industry desires. This is typically because expected returns are lower than for alternative investments.

The problems that have been described typify the dilemmas which other U.S. manufacturing industries face, or will face in the not-too-distant future. Perhaps the most important conclusion, illustrated by all three industries, is that the technological advantages possessed by American firms in the earlier postwar period have now been significantly eroded, Even in electronics, where American companies have been world competitors par excellence, the U.S. technological lead is in many cases now marginal.

A second and related theme is the cost of declining competitiveness. The benefits of international trade and competition are significant—e.g., in bringing new products to consumers, often at lower prices. Increased competitiveness and productivity can raise living standards and slow inflation, But there are also serious losses. Declining employment opportunities in steel and automobiles stem mostly from productivity growth, Nonetheless, imports always cost U.S. jobs, The loss in employment opportunities has its most serious impacts on particular regions and groups. The inescapable fact is that the structural changes underway in the United States and the world economy entail long-term employment declines in traditionally important sectors of the economy,