CHAPTER 3

Steel, Electronics, and Automobiles: Industrial Structure

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Overview

The many differences exhibited by the steel, electronics, and automobile industries illustrate the difficulties of attempting to generalize about the state of U.S. competitiveness. Together, these three sectors include much of the Nation's industrial base, providing employment for a substantial fraction of the work force. They cover a span of technological levels from low (some steel products, much of consumer electronics) to high (specialty steels, large-scale integrated circuits, computers), There are differences in competitiveness among the industries, among firms within each industry, and even among product lines within individual firms. Furthermore, all three industries are undergoing structural change.

Integrated steel firms in the United States are burdened by capital plant that is, on the average, older than that of most of their foreign competitors. While other countries, particularly Japan and several West European nations, rapidly expanded and modernized their steel capacities after the Second World War, U.S. capacity increased only slowly, Up to 25 percent of U.S. steel capacity now appears to be obsolete. [1] At the same time, the industry as a whole remains a reasonably efficient producer of steel, probably second in costs only to Japan—which has more modern, larger scale plants, as well as lower labor costs. The nonintegrated segment of the U.S. industry, in particular, is efficient and growing,

There is now excess capacity in world steel markets. One result of overcapacity is to create incentives for producers in many countries to cut export prices and "dump" steel while attempting to maintain domestic price levels. Dumping and other unfair trade practices have been important concerns of the American steel industry,

The steel industry is not monolithic, but the typical disaggregation into integrated producers, nonintegrated firms, and alloy/specialty steelmaker is straightforward compared to the diversity exhibited in electronics. In many respects the three sectors of the electronics industry covered in this report—consumer electronics, semiconductors, and computers —comprise three distinct industries. They exhibit different levels of technology, different levels of competitiveness, and different Government policy impacts.

Except for consumer electronics, most of the U.S. electronics industry remains strong; nonetheless, there is increasing concern because of shrinking U.S. technological advantages and the support other countries are providing their own industries, The Japanese, in particular, have targeted electronics as a cornerstone of future industrial expansion and are pursuing policies directed at that goal. Some observers feel that if the United States does not respond, its remaining competitive advantage may disappear.

During 1980, the automobile industry had the most visible set of problems, with imports taking more than 25 percent of the market and hundreds of thousands of workers unemployed. American automakers are going through a period of rapidly changing product mix, which is straining their capital resources. The domestic automobile firms differ markedly in their competitiveness, and in the resources which they can bring to meet-

[1] *Technology and Steel Industry Competitiveness* (Washington, D.C.: Office of Technology Assessment, U.S. Congress, June 1980), p. 129.

ing future needs—whether demanded by the market or by Government regulations.

As in the case of steel, the U.S. automobile market is now a smaller proportion of the total world market than in the early postwar period. The share of world auto sales accounted for by firms based in the United States has dropped from three-quarters in 1950 to less than one-third at present, despite their extensive foreign operations. But American firms have been and continue to be strong in some foreign markets; now they find themselves using knowledge (and sometimes profits) gained overseas in their home market.

In the remaining sections of this chapter, these industry sectors are described in more detail, together with aspects of their structure that affect competitiveness (many of these are amplified in ch. 5). This chapter is devoted primarily to understanding the diversity of the industries and its consequences. The approach is comparative, pointing out both similarities and differences. No attempt is made at complete descriptions, but factors that influence competitiveness are emphasized.

Industry Definitions

Products

An indication of market sizes, for the United States and the world, is given in table I. The industry subdivisions in the table are expanded on below.

The disaggregation for steel is that adopted in the OTA steel study; this divides the industry into producers that are primarily integrated steelmaker, nonintegrated firms, and manufacturers of alloy/specialty products. The basic distinctions are as follows. Integrated steelmaker begin with iron ore. They make iron, convert it to steel, and then to final products such as sheet, plate, and structural shapes. Nonintegrated firms typically begin with steel scrap and produce only a limited range of final product types—e. g., reinforcing bar. Alloy/specialty products have particular combinations of properties, such as high strength (aerospace alloy steels), high hardness and wear resistance (tool steels), or corrosion resistance (stainless steels); they typically sell for much higher prices than plain carbon steels. Most alloy/specialty firms use scrap as the main input.

Table 1.–World Markets and U.S. Share, 1979

Industry	United States	World	United States as percent of world
Steel			
Total production of raw steel (millions of tonnes)	123	748	17%
Integrated producers	108	na	na
Nonintegrated[a]	12.2	na	na
Alloy/specialty[a]	4.2	na	na
Electronics			
Total consumption ($ billions)	$85.7	$168[b]	51
Consumer electronics	11.8	31.8	37
Semiconductors	5.0	11,5	43
Computers	22.8	44.6	55
Other electronics	46.1	83.3	55
Motor vehicles			
Total production (millions of units)	11.5	41.5	28
Passenger cars	8.4	30.7	27

na = not available
[a]Disaggregated figures are for 1978
[b]United States, Europe, and Japan only

SOURCES *Steel—Annua/ .Statistical Report, 1979* (Washington. D C American Iron and Steel Institute, 1980), pp. 92-93, *Technology and Steel Industry Competitiveness* (Washington, D C Office of Technology Assessment, June 1980), p 248
Electronics—" 1981 World Market Forecast, ' *Electronics,* Jan 13, 1981, pp. 121-144 (World production figures for electronics are not available)
Motor vehicles —J. Evers, Motor Vehicle Manufacturers Association, personal communication, August 1980

The three sectors of the electronics industry covered in this report—consumer electronics, semiconductors, and computers—contain only a fraction of the 5,000 to 7,000 firms in the U.S. electronics industry; however, they are among the most important. [2]

Consumer electronics products include radios, televisions, audio equipment such as stereo receivers, electronic watches, and electronic toys and games. Home entertainment products such as TVs and video-cassette recorders receive the most attention in the following chapters.

Semiconductor devices can be discrete circuit elements such as transistors, or integrated circuits (ICS) containing several tens of thousands of circuit elements on a single monolithic "chip' of silicon a few millimeters on a side. ICS, and particularly digital ICS, are the most dynamic portion of the semiconductor industry, both in terms of technological advance and in terms of sales growth, ICS are used in a wide range of products made by many industries; an important current application is engine control electronics for automobiles, While the biggest single market for ICS is the computer industry, semiconductor technology is important to virtually the entire breadth of U.S. manufacturing and service industries.

The computer sector spans firms ranging from those that make mainframe machines selling for several million dollars to those that build microcomputers using a single IC chip as the processor. The computer industry is important not only in itself, but because of the rapidly expanding applications of dedicated computers in other products to make them "smart." Manufacturers of peripherals such as memory and terminals are included within the computer sector.

[2] Communications is the largest of the sectors omitted from this report and from the full OTA electronics study. It was excluded prim:] rily to keep the two studies more manageable.

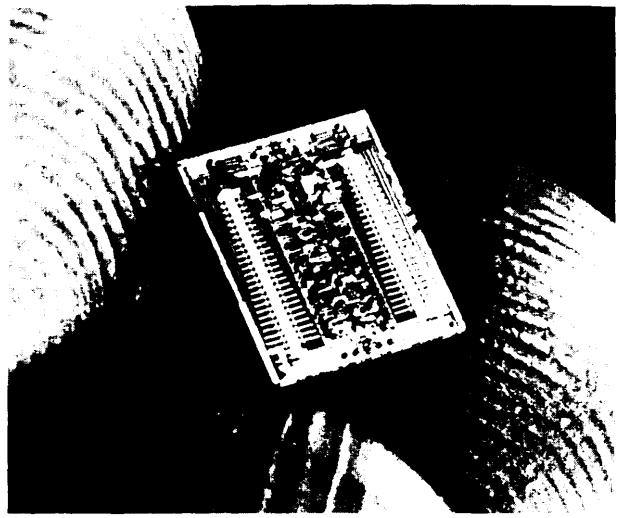

Photo credit: IBM Corp.

This IC—a 64K RAM memory chip—can hold 64,000 bits of information

The automobile industry as a whole embraces large numbers of sales and service firms, as well as suppliers of component parts. This report concentrates on manufacturers of passenger cars and light trucks, many of the latter being used interchangeably with passenger cars. Where the term "motor vehicles" is used, it refers to both cars and trucks,

Geography

The geographical boundaries of these industries must be defined before U.S. competitiveness can be assessed. Given the tendency toward internationalized production, what are the bounds of American industry and the limits of Government interest?

Many U.S. industries include firms that confront their foreign competitors not only through exports and imports, but also through manufacture and sales by overseas subsidiaries, This is common in electronics and automobiles, though rare for steel, There are several patterns of investment. In automobiles and computers, foreign subsidiaries

sell mostly in foreign markets, This is also common in semiconductors; but in addition, many American semiconductor firms have overseas manufacturing facilities which re-export to the United States. Offshore assembly is also widespread in consumer electronics.

In one sense, these overseas subsidiaries are foreign firms, not a part of U.S. industry. On the other hand, they are often inextricably linked to the domestic operations of the parent company. Not only may these linkages be difficult to disentangle, but the subsidiaries may be profitable while the U.S. parent languishes—giving the parent more freedom in developing strategies to extricate itself from competitive difficulty, In 1979, for example, Ford was able to offset losses in the U.S. market with profits overseas. Further, one can ask if Japanese-owned TV plants in the United States—such as Quasar—should be viewed as domestic producers,

Some decision is needed to define the boundaries of U.S. industry and hence U.S. competitiveness. In general, this study has attempted to stay with convention (and convenience) by defining U.S. industries to be those operating within the geographic confines of the United States. Thus, in each of the three industries, U.S. firms are those employing U.S. workers; Quasar is an American firm, as is Volkswagen of America. Domestic manufacturing by Ford or IBM receives more attention than their overseas production. At many points, however, such distinctions break down, and overseas operations must be considered.

Major competition in each of these industries has recently come from Japan. This is not to say that other rivals are insignificant. Certainly West Germany and France are important factors in steel and automobiles, as are Korea and Taiwan in consumer electronics and steel, Nor is this meant to imply that Japan is the primary competitor in all industries. Japanese firms have not been successful in aircraft, and only about a third of U.S. imports of steel come from Japan, West Germany is a leader in machine tools (along with Japan), and other Far Eastern nations are major producers of apparel. Although attention has with reason focused on the Japanese, Japan does not constitute the rest of the industrial world.

The Steel Industry[3]

Steel has a unique combination of low cost and desirable physical characteristics that make it virtually the only material suitable for many applications. Among the most important of these are: automobiles (around 20 percent of domestic steel consumption), machinery and equipment (10 percent), and containers such as cans (7 percent). In addition, significant amounts of steel are used in construction, appliances, pipe, rail cars and locomotives, wire products, and military equipment, Industrial societies as they are known today could hardly exist without steel.

Almost all steel products are manufactured to standard specifications, There is little difference in the steel produced by various firms—a given type of sheet, plate, or structural shape will be much the same whether it comes from the United States or Korea. While there are specialty products and proprietary grades—e.g,, various tool-and-die steels—substantial product differentiation as occurs in industries such as automobiles is seldom possible. Competition, therefore, is largely based on relative prices and customer service, Important elements of the latter are timely and dependable delivery, and technical advice, Such service is important and should not be minimized; it is not necessarily true that only prices determine sales. In fact, many customers maintain familiar and reliable sources of supply even when lower prices are available elsewhere.

[3]Most of the information in this section is drawn from the OTA steel study.

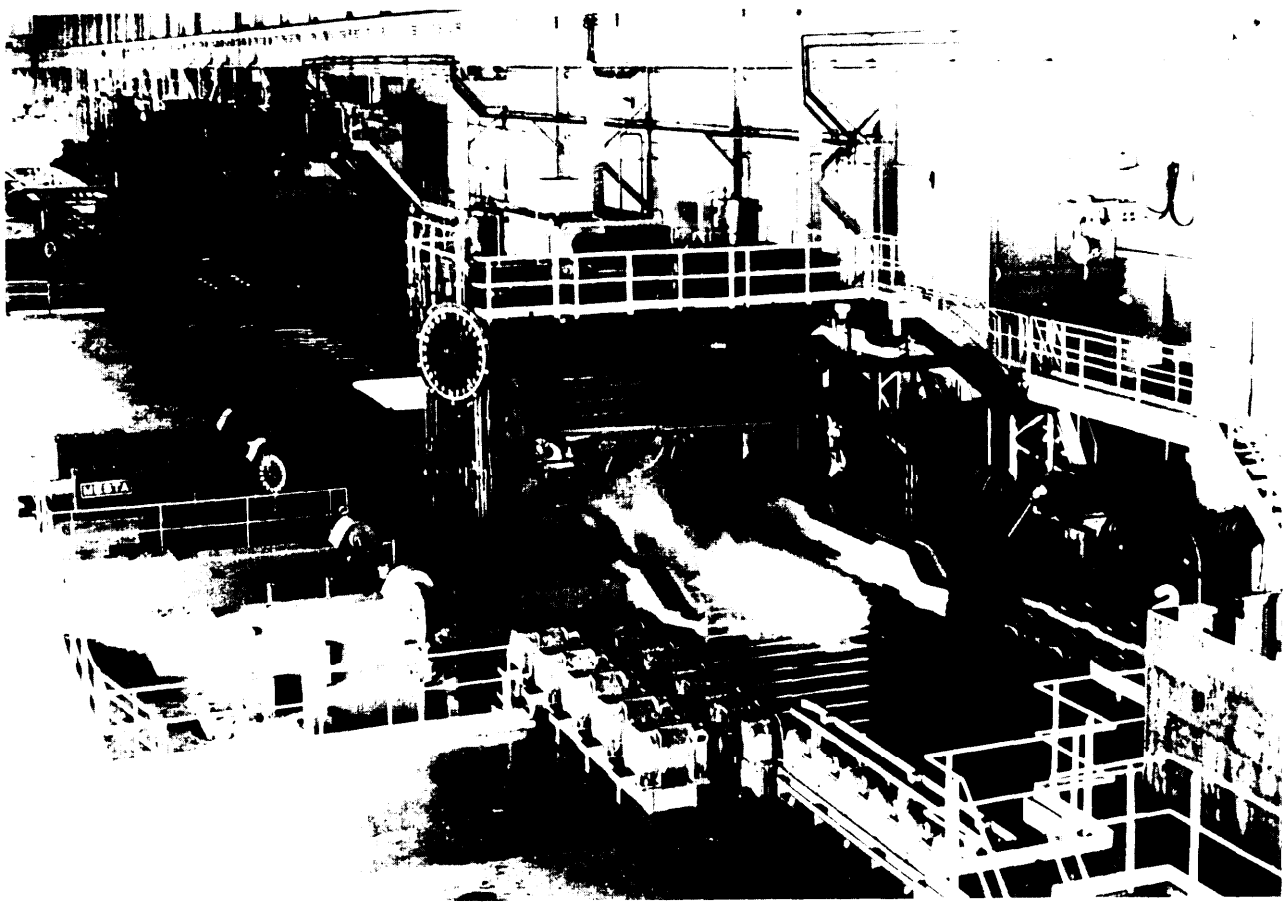

Photo credit: American *Iron and Steel Institute*

Slab casting of steel

From the standpoint of industry structure, steel has experienced a declining level of concentration over the years. U.S. Steel, still the largest producer, today accounts for barely more than one-fifth of the domestic industry's sales. Market share losses by the traditional leaders have been taken partly by imports but partly also by other domestic firms, including nonintegrated producers and specialty steelmaker. These companies occupy market niches for which the benefits of large-scale operation are less important.

Nonintegrated companies now account for some 15 percent of industry shipments. The OTA steel study estimates that such companies may account for as much as 25 percent of domestic production by the end of the decade, provided adequate supplies of scrap and electricity are available at reasonable costs.

Price is a critical determinant of competitive ability in steel, particularly for sales to firms which themselves sell in highly competitive markets. Therefore, costs of production are also crucial. American steelmaker face both problems and opportunities in their efforts to achieve low costs. On the positive side is the close proximity of a large and diversified market. On the other hand, this country's technological advantages in steel have largely eroded. Technology for making iron and steel is now well-diffused internationally and available to all who can pay for it.

As might be expected for a commodity-like market, the industry engages in comparative-

ly little R&D. American firms tend to be more active in introducing product innovations such as dual-phase or microalloyed steels than in process innovations. In recent years, many of the latter have come from foreign firms. U.S. Steel, for instance, recently concluded an agreement with Sumitomo Metal Industries, a Japanese steelmaker, to purchase technology for computer-controlled production equipment.' The industry also relies on suppliers of machinery and equipment for many process developments.

The OTA steel study concluded that a number of significant innovations in making iron and steel might come into general use within the next 20 years. Moreover, many technologies already available and proven have not been as widely adopted in the United States as in some other countries. Not only computerized process control, but also continuous casting and a variety of improvements in basic oxygen steelmaking could raise yields and productivity, as well as save energy, if they were more pervasive in the American industry. Finding the capital required to implement new technologies or to modernize using existing technologies is a major hurdle for most portions of the American industry; the OTA steel study estimates capital needs for modernization and expansion at $3 billion per year (in 1978 dollars) over the next 10 years, $5.3 billion per year for total capital requirements,

There are factors beyond technology and investment capital which are important for the international production and sale of steel. Some work to the benefit of the U.S. industry, others to its detriment, An obvious benefit is the low value-to-weight ratio of steel, making it costly to ship, particularly overland; relatively little steel moves more than 300 miles from a domestic mill or port-of-entry. Imports must bear significant transportation costs.

On the other hand, the industry's large fixed capital requirements encourage "unfair" pricing practices. Operating a mill below capacity results in high unit costs. Often the problem is worse abroad than in the United States because labor costs may be more nearly fixed in the short term. This can arise because of lifetime employment (Japan—although there is flexibility in Japanese labor costs because of the widespread use of contract workers and also the large fraction of wages paid as bonuses) or a social and political climate—often coupled with strong unions—that makes layoffs difficult (Europe). In any case, efforts of foreign firms to operate close to capacity without cutting prices at home may lead to dumping of excess production overseas.' This practice, together with the industry's cyclical demand pattern, has created difficult conditions for American steel firms, even though their average costs of

Photo credit American Iron and Steel Institute

Pouring hot metal

'"Japanese Steel Maker to Computerize Production Lines of U.S Steel Mill," *Japan Report* No. 97, Joint Publications Research Service 75611, May 11.1980, p. 48.

'Dumping refers to export sales at prices below those charged in the home market, or in some cases to sales at prices below cost.

production may be fully competitive, There have been more dumping cases brought in the United States in steel than in any other industry. (The industry points out that other countries shield their steel industries from foreign competition and need not resort to antidumping measures.)

Despite intense price competition, the U.S. steel industry remains more profitable than other major national steel industries. But profits have suffered compared to other sectors of the American economy, Returns on equity for the steel industry in the United States have been significantly below the average for all manufacturing in every year but one since 1958.

Finally, it is noteworthy that the steel industry, in the United States and in other countries, has faced increased costs because of government regulation, In the United States, environmental controls and workplace health and safety standards have raised costs of production. Ironmaking and steelmaking have been inherently polluting of both air and water; when Federal policy began to reflect environmental concerns, the burden of change fell heavily on this industry. The OTA steel study found that meeting environmental and workplace standards took about 17 percent of new investment in the industry during the 1970's. To the extent that such regulations do not apply abroad, the domestic industry is placed in a less competitive position by virtue of public policy alone.

The Electronics Industry

As pointed out previously, this study addresses only three sectors of the electronics industry: consumer electronics, semiconductors, and computers.

Consumer Electronics

Most of the products of this sector—e.g., radios, TVs—are sold through wholesale/retail distribution channels, mainly to households. A relatively high proportion of the consumer electronics products marketed in this country now originate in the Far East, Videocassette recorders (VCRs), for example, including those marketed under American brand names, are produced almost exclusively in Japan. Color TVs are assembled in the United States by both American and foreign firms; regardless of the home of the parent firm, many of the manufacturing operations are carried out in regions with low labor costs, primarily Mexico and the Far East. In the newest product categories, such as video disks and home computers, American firms are mounting strong efforts to maintain leadership. However, it is likely that in the long run, even if they are successful, the more labor-intensive production processes will move overseas,

Continuing competitive strength in consumer electronics depends, much as for steel, on maintaining low prices in mature products and staying abreast of technological developments that might have major impacts on the industry's future direction. The latter include the video disks and home computers mentioned above: in the future, such potential new products as flat screen TVs and integrated home entertainment centers may become large markets.

The Orderly Marketing Agreements for color TVs negotiated by the U.S. Government and beginning in 1977 function as import quotas. They have protected U.S. labor to some extent, and have also encouraged Japanese producers to locate plants here. In effect, the weaker U.S. firms that were driven from the market by import competition have been replaced by foreign firms manufacturing in the United States. The Japanese are being followed to the United States by companies based in Taiwan and South Korea.

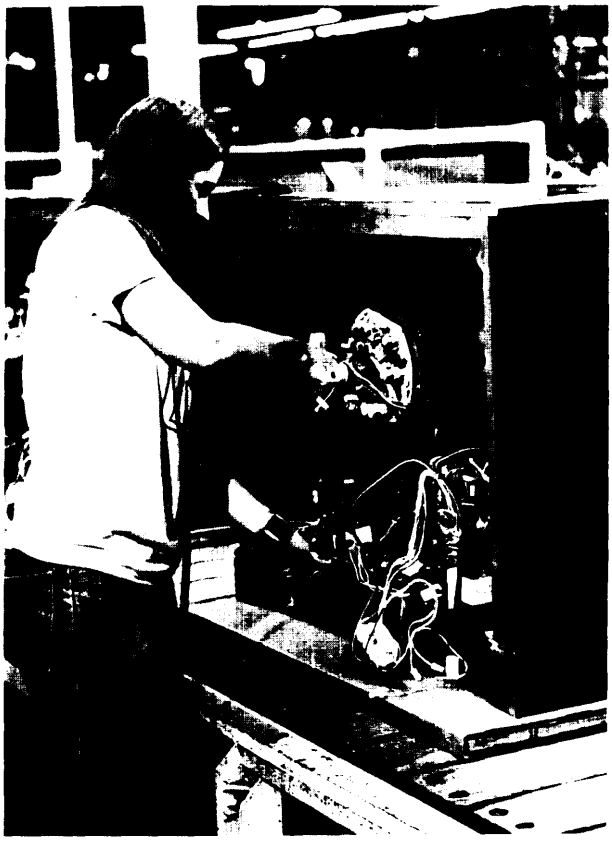

Photo credit RCA

Final assembly of color TVs

While the largest U.S. firms have retained market share, the real questions deal with future products. Will these be developed and manufactured by American firms, or will foreign manufacturers capture the market as they did for VCRs? Will the United States become simply a site for assembly plants, with management control and R&D remaining overseas? Given the low profit margins in this sector, the high risks, and the past history of strong import competition in products based on U.S. technology, the domestic consumer electronics industry may, like the steel industry, have trouble finding the capital necessary to compete.

Retail distribution systems, and product quality and reliability, also affect competitiveness. Consumer electronics products are sold through a wide variety of retail outlets. Historically, this meant that manufacturers attempting to establish and maintain recognized brand names paid close attention to distribution. Retailers not only were responsible for product sales, but also, and perhaps more importantly, for aftersales servicing.

This pattern has changed in recent years, partly as a result of imports, and partly because of improved product quality and reliability. Importers did not have extensive retail distribution networks. They countered by developing new marketing channels (e. g., discount stores) and—to avoid the need for frequent servicing—by emphasizing reliable, trouble-free products. As one result, product quality and reliability have also improved for domestic products. Higher reliability has diminished the role once played by retail servicing, and greatly expanded the number of possible retail outlets.

Semiconductors

Solid-state TVs are only one of the many near-revolutionary effects of semiconductor technology on the rest of the electronics industry. Many electronics products and systems now in widespread use would be quite impossible without semiconductors. Moreover, semiconductors are also having profound impacts on the products of many industries outside of electronics.

The semiconductor industry includes scores of firms, many specializing in narrow market segments; there are thousands of different types of semiconductors capable of performing many different circuit functions. Perhaps the most important feature for international competitiveness—impinging on all other aspects—is the technology itself, and its rate of change. Future applications of semiconductors in industries ranging from communications systems to home appliances will dwarf present accomplishments, if only because applications always lag the availability of technology; advances in semiconductor devices could stop now and the stream of new applications would continue basically unhindered for several years, Of course new applications also suggest new needs. The

Photo credit Westinghouse

Machine dictation/word processing center

microprocessor is a classic case—a product rapidly adapted to uses unforeseen by its developers, these new uses in turn spawning new microprocessor designs. (Microprocessors are ICS containing a complete computer processing unit on a single chip.)

Another important aspect of the semiconductor industry is the continuing decrease over time in manufacturing costs for equivalent circuit functions. These cost reductions have two basic causes. First, the ability to pack more and more circuit elements onto a single chip has dramatically reduced the cost per function—e.g., per logic gate or per bit of computer memory. As a result, the total cost of the circuitry for performing a given task has fallen rapidly. This has been a major cause of the decreases in the cost of computing power over the past 20 years—by a factor of more than a hundred since the mid-1950's. [6] It has also made possible many applications that previously would have been impossible, impractical, or simply too expensive.

·f I 1,. (Caswell, eta 1,, "'[1[1S11 rr(tllloll)-v," Computer, vol. 11, September 197[1, p. 10.

A second reason for cost decreases is the so-called learning curve phenomenon. The costs of the chips themselves drop as more of a given type are made, both from the experience gained in making them and because higher volumes justify more efficient processing equipment. As a firm's cumulative production of a given device goes up, the yield—the percentage of chips that meet specifications—also tends to go up, and costs decline rapidly.

The promise of cost savings through experience is so well embedded in the industry's history that prices of new semiconductor devices have frequently been established with future savings in mind. That is, producers of a new device may set prices below their current manufacturing costs, confident that costs will fall as higher volumes are reached. One of the purposes of such a forward pricing strategy is to increase sales and achieve high production volumes as quickly

Photo credit National,

A silicon wafer for making ICS being handled with a vacuum pencil

as possible. The advantages accruing to innovators first on the market with new products explain much of the emphasis the semiconductor industry places on R&D.

In many firms, however, this R&D is confined almost exclusively to process engineering and circuit design. Basic research is limited to a few of the larger manufacturers, some of which—such as Western Electric (Bell Laboratories) and IBM–do not sell semiconductors on the open market, making them only for internal use.

Possibly because of its history of aggressive pricing combined with heavy R&D costs, the semiconductor industry has not been notably profitable, particularly in terms of return on sales. Nor does the dollar volume of sales keep pace with the level of physical output. As a result, internally generated cash flows have often been inadequate to finance the rapid plant expansions needed to serve growing markets. This problem has lately been exacerbated because the newest generations of ICS demand a considerably higher level of capital expenditure for design and manufacture. Capital requirements per dollar of sales are said to have risen 50 percent between 1970 and 1980, ' An upward shift in capital needs is common as industries mature, but in semiconductors the capital requirements are only partly for new production equipment. Additional funds are needed because of the higher level of technology itself—particularly the rapidly escalating costs of circuit design as ICS approach and exceed 100,000 elements per chip.

There is another feature of the industry worth exploring briefly, one common to industries early in their evolutionary histories. Semiconductor firms, especially the larger ones, are attempting to integrate forward into final products. Much of the incentive results from a natural desire to internalize more of the end-product value-added. Thus, semiconductor firms have, at various times, tried to integrate forward into consumer products such as electronic watches and calculators, and also into computers.

There are strategic reasons for integration as well. End-product manufacture offers diversification and a measure of protection against the possibility of customers integrating backwards, In fact, backward integration—i, e., end-product manufacturers making their own semiconductors—has also been taking place quite rapidly, again primarily for strategic reasons. Firms whose products range from electronic toys and games to mainframe computers, as well as diversified industrial concerns, have been adding semiconductor capability, both to gain some measure of stability in supply, and to have the ability to design and produce unique devices which might be required for their own products but not in large enough quantities to attract merchant firms.

As a result, the structure of the sector is changing rapidly. Much of the spectacular success of the semiconductor industry in the United States has been built on innovative products and processes coming from independent firms—often small and entrepreneurial—serving the merchant market, This is just the type of firm that has seemed to be disappearing. It remains to be seen whether the structural changes taking place in the U.S. industry will result in a slackening of the pace of innovation and in competitiveness.

The major determinants of competitive ability in semiconductors are the capacity to innovate, and, as products mature, to manufacture at low cost. Neither of these demands will change in the foreseeable future, Maintaining competitiveness—interna tionally or domestically—will continue to require a much higher proportion of technically skilled personnel such as engineers than is true for most other industries, In addition to high-cost technical professionals, semiconductor firms need low-cost assembly labor to be competitive. As a result, virtually all the larger firms have transferred labor-intensive operations overseas.

J. B. Brinton. . . Chip Makers to Shrug off Recession,'" E]ectronics, Apr. 10, 1980, p. 42.

Beyond these two requirements—innovative capability and low-cost manufacture—is another factor important to competitiveness: product quality and reliability. In this, semiconductors are more like consumer electronics products than steel. While it is not quite true that all steel made to the same specification is the same, there are certainly larger variations in quality and reliability for semiconductors than for many other commodity-like products. Relative levels of quality and reliability y of Japanese and American ICS have been hotly debated. This issue, which depends on both process and product technologies—the latter because some ICS can be designed to tolerate flaws and partial failures—is discussed in more detail in chapter 5,

Quality and reliability are important because they affect costs to purchasers, Other cost factors which are important in some industries are only minor concerns for semiconductors. For example, the value-to-weight ratio of semiconductors is among the highest of all manufactured products, Consequently, transportation costs are insignificant. Moreover, the industry is environmentally clean so that, unlike the steel industry, costs of complying with environmental and workplace standards have not been burdensome.

Computers

While the mainframe and minicomputer segments of the computer industry seem at the moment structurally stable, other portions are changing rapidly. Microcomputer firms—those building machines based on microprocessors-have experienced a shakeout over the last few years associated with a transition from a hobbyist market to one dominated by small business applications. A number of pioneering microcomputer firms have disappeared through bankruptcy or acquisition. The peripherals sector—companies making auxiliary storage, terminals, and related equipment—is also volatile. Furthermore, software has become an important entrepreneurial area. Even in mainframes, the incius try structure has not been static, as plug-compatible manufacturers have entered the market—and in some cases, left it again. (Plug-compatible machines are interchangeable with equipment manufactured by IBM. but typically offer lower prices and/or higher performance.)

IBM is the largest manufacturer of mainframe computers—with manufacturing and sales operations around the world, It has a substantial market share in virtually every country in which it sells. Along with other American firms, IBM has dominated large computers worldwide since the inception of the industry in the 1950's, In fact, the computer industries of almost every country (Japan and Great Britain are the major exceptions) have had at their cores the overseas subsidiaries of American computer firms. over the years, the U.S. computer industry has become the archetype of the high-technology industry for which this country has been envied.

While some new entrants into the computer industry—namely the manufacturers of plug-compatible mainframes—have chosen to compete head-on with IBM, the manufacturers of micros and minis have, in effect, pioneered market niches left vacant by the mainframe companies, Increasingly, minicomputers are providing all the performance needed for particular applications. With markets for both plug-compatible and small machines being aggressively pursued by a varie!y of firms—including a number of successful semiconductor manufacturers—the structure of the computer industry will continue to change.

The market structure for computers remains simple compared with products such as consumer electronics or automobiles. Most computer manufacturers sell directly to final users, generally employing their own sales forces, Nonetheless, change is taking place here as well. Smaller computers intended for use in homes or businesses are now sold at the retail level. (Home computers can also be considered part of the consumer electronics sector.) Regardless of the type of computer—

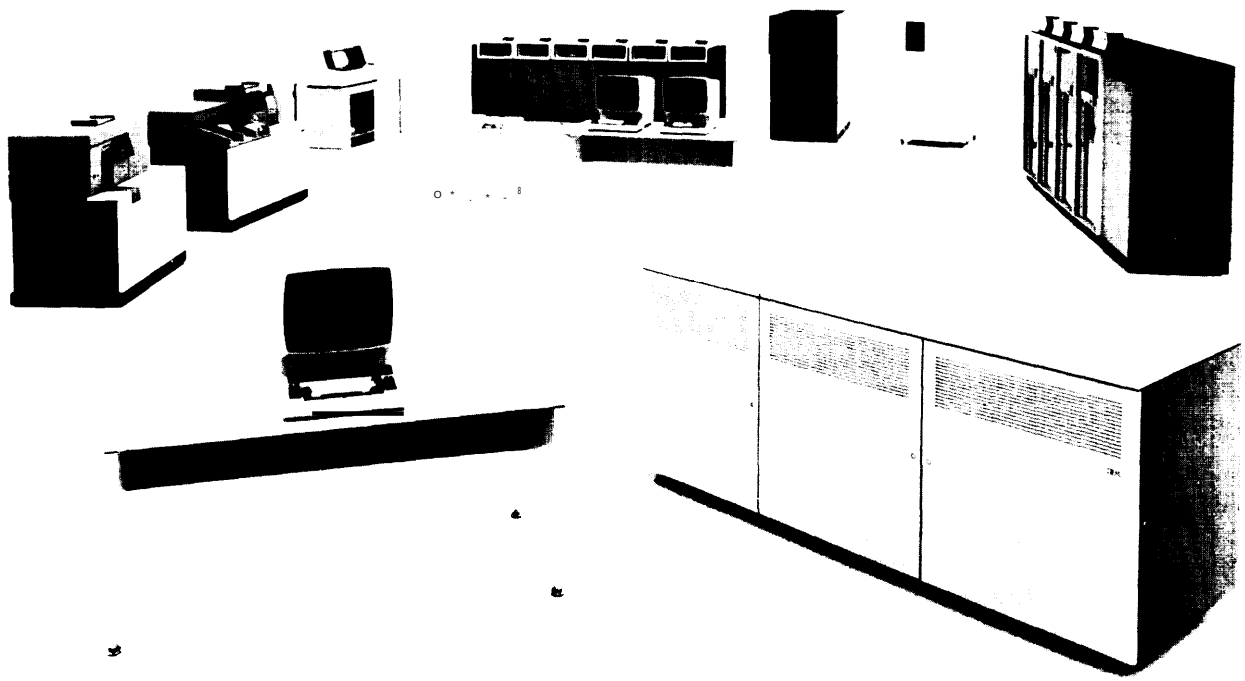

Photo cred(l IBM Corp

IBM 4341 Computer System

micro, mini, or mainframe—ancillary services such as software development, and maintenance of both hardware and software, are important for market acceptance. Sometimes the costs of such services are included in the price of the computer system, making direct price comparisons between competing products difficult.

The Automobile Industry

Because of its size alone, the motor vehicle industry occupies a unique position in the economy of the United States, and for that matter the world. The industry is responsible for the employment of more than 2 million people in this country in manufacturing alone, including supplier firms making component parts and accessories. Several million more are employed in sales and service activities.*

Despite its size, the industry is one of the Nation's (and the world's) more concen-

*The U.S. *Automobile Industry, 1980: Report to the President from the Secretary of Transportation* (Washington, D.C.: Department of Transportation, DOT-P-10-81-02, January 1981), p. 84.

trated. One company, General Motors, manufactures over half of the cars and trucks produced in the United States; virtually all of the remainder are made by two other firms, Ford and Chrysler. Although a foreign competitor, Volkswagen, has recently begun assembly here, about 30 percent of its value-added is tied to imports of components from abroad; when its U.S. assembly plant is operating, Honda will probably also import major subassemblies such as engines.

Concentration in the automobile industry on a global basis is nonetheless decreasing, largely because of the rapid growth of Japanese automakers. These firms were insignificant in the early postwar period but have been gaining market share in many parts of the world. Imports have had the effect of reconcentrating the U.S. market.

Both Japanese and European automakers tend to have a greater share of their sales in markets outside their home countries than do U.S. firms. Whether through subsidiaries or exports, one-half or more of the sales of most foreign firms occur outside their domestic markets. For American automakers, the proportion is generally one-third or less. Therefore U.S. firms have a greater dependence on home market sales than do foreign manufacturers.

In the United States, most automobiles are purchased as replacements for vehicles already in the fleet, which now numbers well

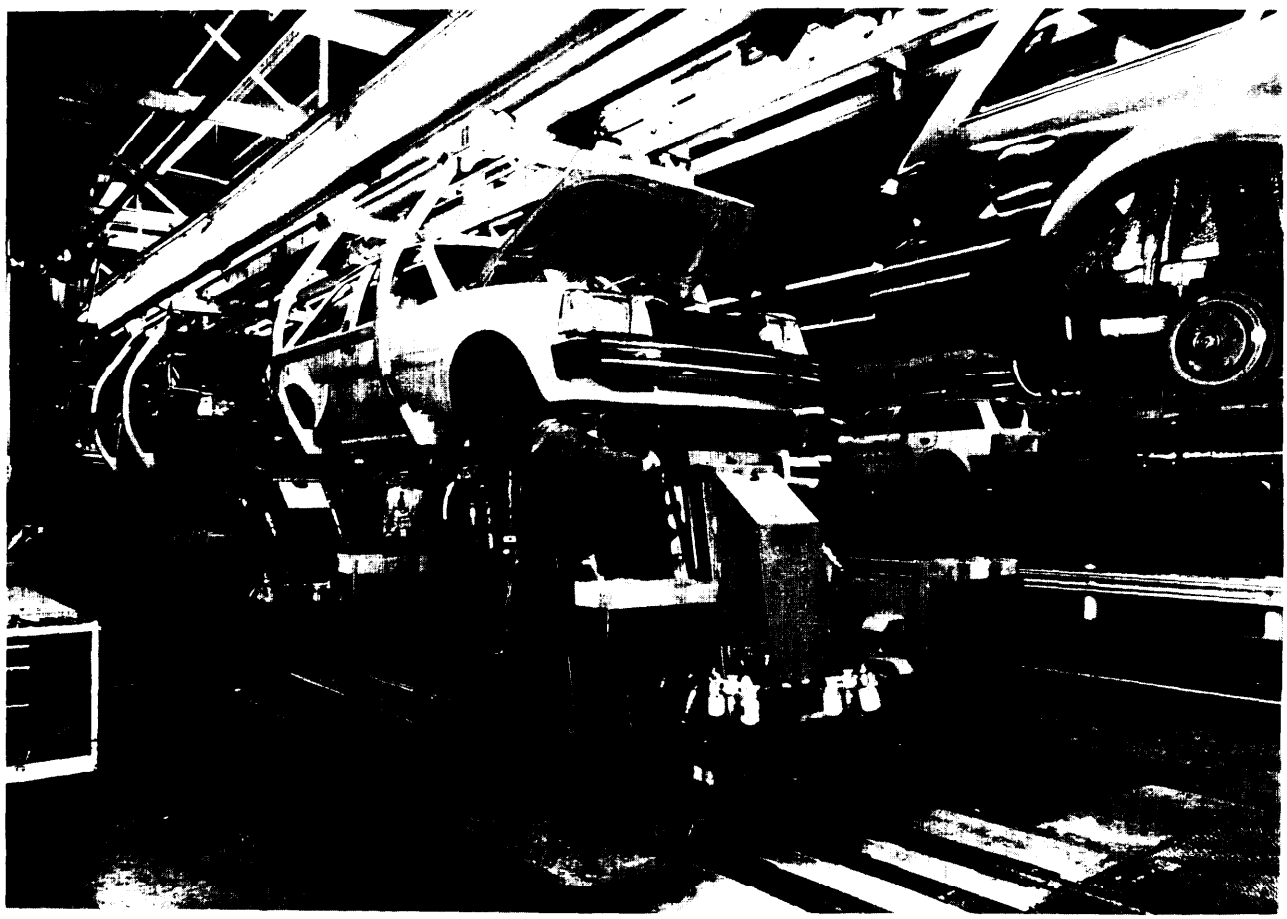

Photo credit: Ford Motor Co.

Engine installation on small-car assembly line

over 100 million. For the typical purchaser, buying a car is a substantial outlay of funds; two-thirds buy on credit, Thus, the availability and cost of financing is an important factor in sales. Furthermore, most buyers can defer purchase of an automobile, new or used, simply by keeping the old one longer. Therefore, when economic conditions appear uncertain, and when interest rates are high, the market for automobiles is drastically affected, Much of the precipitous decline in sales of American-made cars during 1980 can be attributed to such factors. Returns on equity of U.S. automakers have generally been comparable to other U.S. manufacturing industries, but tend to drop more in recession years such as 1974-75 or 1980,

The producers of finished vehicles by no means constitute the entire industry. Autos are assembled from components—some made internally and some purchased from other firms, While all manufacturers make their own bodies, and most build the engines and drivetrains, American Motors buys its transmissions from Borg-Warner and Chrysler uses Volkswagen engines in some models. On rare occasions, manufacturers have integrated even further upstream: Ford operates a steel mill; Chrysler makes glass. For many other components, U.S. automobile companies rely on some 50,000 supplier firms. Often the automaker will produce only a certain fraction of its needs for a particular part, purchasing the rest outside. This "tapered vertical integration" allows the company to achieve scale economies while shifting the risk of variable demand to others. Value-added by the automakers is highest for GM —around 50 percent—lowest for Chrysler and AMC—3O percent or less.[q]

[q]R.A. Leone, W.J. Abernathy, S. P. Bradley, and]. A. Hunker, *'Regulation and Technological Innovation in the Automobile Industry," final report to OTA, contract No. 933-3800,0, May 1980, p. 2-55.

Automobile manufacturers sell through extensive networks of independent franchised dealers. Financially sound and loyal dealers are of great importance to the automakers, who also depend on them to provide service and used car sales.

Market strategies of U.S. auto manufacturers have traditionally stressed upgrading of models and optional equipment, which offer opportunities to increase profits. Differentiating basic models through design features, and standard equipment, along with periodic styling changes, were cornerstones of industry marketing for decades, Recently, year-to-year styling changes have been deemphasized. Cars now remain in production for 10 years or more with little alteration. In the 1970's, the variety of products represented in the marketplace nonetheless increased. Not only did domestic firms introduce new models, and imports proliferate, but light trucks and vans became more important as passenger vehicles.

Government regulations—concerned with safety, exhaust emissions, and fuel economy—have increasingly constrained the designs of vehicles sold in the U.S. market. The pace of technological change has accelerated in the industry—partly as a result of regulations, partly as a result of the demands of the marketplace. Automobiles built in the United States are evolving toward designs more like those in the rest of the world.

Regulatory uncertainty and demanding timetables for new standards have created difficult conditions for all automakers selling in the United States, Domestic firms have been affected much more heavily than foreign producers by regulatory and market demands for high fuel economy because most imports have been small cars with good gas mileage. Large investments are needed for U.S. automakers to redesign and retool their fleets to meet the new conditions.

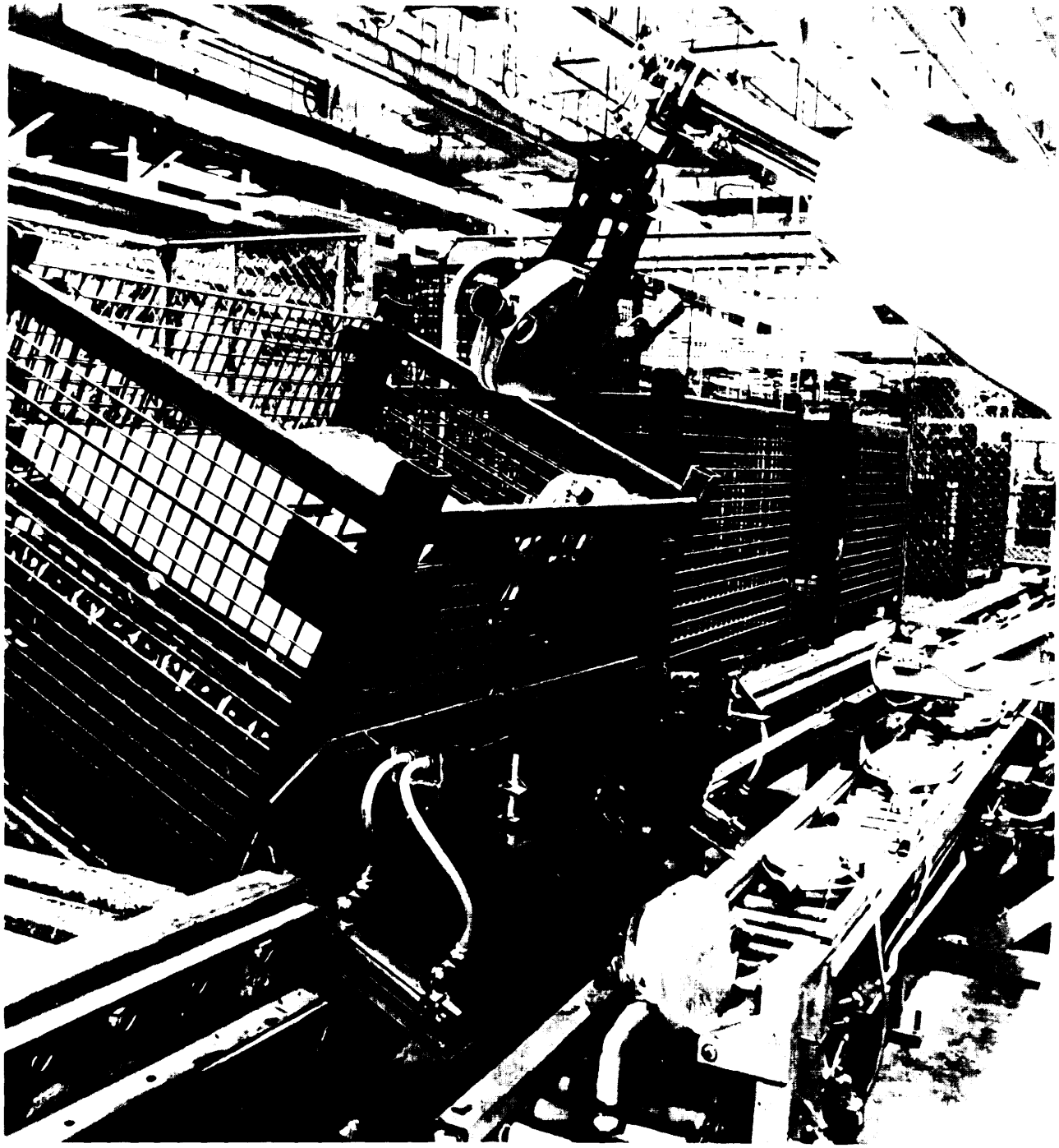

Photo credit: General Motors

Robot loads catalytic converters as they roll off assembly line

Summary and Conclusions

Steel, electronics, and automobiles differ in technological levels, markets, and industry structures. The more advanced process technologies in any of the industries can be quite demanding, and might well be called "high technology, " This is as true of computer-controlled rolling mills or integrated manufacturing systems for automatic transmissions as it is for the wafer fabrication lines used to make large-scale integrated circuits,

There is more variation in levels of product technologies. While most steel products are commodity items—and would be considered "low technology" compared to, for instance, aerospace alloys—electronics virtually defines the high-technology industry. Nevertheless, product technologies for TVs exhibit a pattern of relatively routine development and refinement which is quite different from the rapid advances characteristic of semiconductors or computers. For many years, technological change in automobiles was similar to that in TVs-a matter of continued refinement but few major innovations. In many respects, the turn to smaller cars making more efficient use of both fuel and interior space is no more than an acceleration of this process of refinement. At the same time, there is now much greater technological variety in the marketplace than in the recent past. Front-wheel drive, electronic engine controls, and diesel engines are examples. While not always new, these have certainly increased the diversity of technologies represented in the U.S. automobile fleet.

In all three industries, manufacturing costs are important. But for many electronics products, and for automobiles, product characteristics and consumer appeal—whether embracing real differences in performance (as indicated by computing power or fuel economy) or relatively superficial variations—are major determining factors of the competitiveness of individual firms, Such characteristics include product quality—both the reality and the perception—as well as design. Thus, the competitiveness of U.S. firms in all three industries depends on a complex of factors ranging from technological capability to marketing skills and management.

Structural change is taking place in all three industries, In steel, integrated firms are shutting down less efficient mills as nonintegrated firms increase their market share. In consumer electronics, the changes are directly associated with foreign competition. This competition came first from imports, then from foreign firms assembling their products in the United States, The semiconductor sector is experiencing acquisitions and vertical integration. Product mixes are changing in both computers and automobiles.

Structural change has been only one of the forces creating large capital needs in these industries, In steel, capital investment is required to meet environmental regulations, as well as workplace health and safety standards, and to replace outdated plant and equipment. In semiconductors, expansion of demand is outstripping the abilities of some firms to raise funds for R&D and new capital investment. Automobile companies are spending large sums both to develop new models and to purchase the plant and equipment to make them. The patterns and outcomes of these changes will have important effects on the competitive futures of all three U.S. industries, topics which are addressed in later chapters.