CHAPTER 9

Employment Effects

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Overview

Shifts in the competitiveness of an industry like electronics—or for that matter technical change alone—have both direct and indirect consequences for employment. In addition to changes in the labor force requirements both of firms within the industry and firms that supply it, the effects can spread broadly across the economy. Job opportunities within the United States appear or disappear with changes in demand for electronics products, with shifts in international competitive position, and with increases in productivity. These forces interact in complex fashion.

Will continuing developments in electronics —computers, office and factory automation, information services—cause employment to increase or decrease? Such questions have been debated for years, in the context of this and other industries, The conventional response is that technical change creates, in the aggregate, more jobs than it destroys. While the kinds of jobs available will change—as terminals appear on more desks, opportunities for systems analysts (who plan and help operate data processing installations) replace those for keypunch operators, for one instance—new technology creates new demand fast enough that total employment goes up. The conventional response assumes that such patterns will continue, But, just because in the past technical change created more jobs than it destroyed does not mean that this will be true in the future. Such questions are broader than can be addressed here, Too many forces affect levels of employment, not to mention skill requirements. Analysis on a detailed, disaggregated basis sufficient to isolate the influences of electronics (and upon it) would be extraordinarily difficult. This chapter has more limited aims: to summarize what is presently known about employment in electronics, both past trends and future prospects.

within the industry, changes in competitiveness have immediate consequences for employment, If the U.S. electronics industry declines in competitiveness, and sales fall in domestic and/or foreign markets, employment will follow, If rates of increase of sales drop, employment may also decline—depending on increases in labor productivity. Similarly, if U.S. electronics firms expand their overseas production activities—for re-import or for sales in foreign markets—changes in domestic employment normally follow, As competitive advantages shift internationally, labor market dislocations can occur even if the total number of jobs remains the same. Such dislocations can include geographical shifts in demand for workers, along with changes in educational and skill requirements; as computers and other electronic systems have become more sophisticated, white- and grey-collar jobs have expanded much more rapidly than openings for unskilled or semiskilled workers.

Shifts in the international competitiveness of American electronics firms also affect other parts of the economy. Moreover, structural unemployment can be created by changes in electronics technology that alter the ways goods are designed and manufactured. Electronic typesetting has reduced the need for skilled workers in newspaper publishing. Technological change may create new jobs for supervisory and maintenance workers, but it is hard to imagine that as many people will be employed in designing, manufacturing, and maintaining industrial robots as are displaced by them. Still, net effects—particularly over extended periods of time—-can seldom be disentangled from the other factors on which employment depends. If aggregate economic growth is slow, and productivity rises—e.g., because of investments in labor-saving equipment like robots, or computer-integrated manufacturing more generally —jobs will be lost unless other sectors of the economy, such as services, compensate.

The preceding chapter explored the education and training of American workers, as well as management practices which determine how effectively the talents of the labor force are utilized and the possibility of shortages of those with specialized skills. Chapter 8 included extensive comparisons between the United States and Japan. Here, the focus is primarily on the United States, beginning with a review of the automation debates of earlier years. Next, data on employment trends in electronics are examined in the context of import penetration, as well as offshore manufacturing by American firms. The chapter surveys employment forecasts for electronics, along with case studies of impacts on other manufacturing and service industries, While there is no way of knowing how aggregate employment will fare, technological change—together with shifts in the competitive positions of American electronics firms—will clearly have major impacts on *some* industries and *some* job categories.

Impacts of Technical Change in Electronics on Employment

The Automation Debate of the 1950's and Since

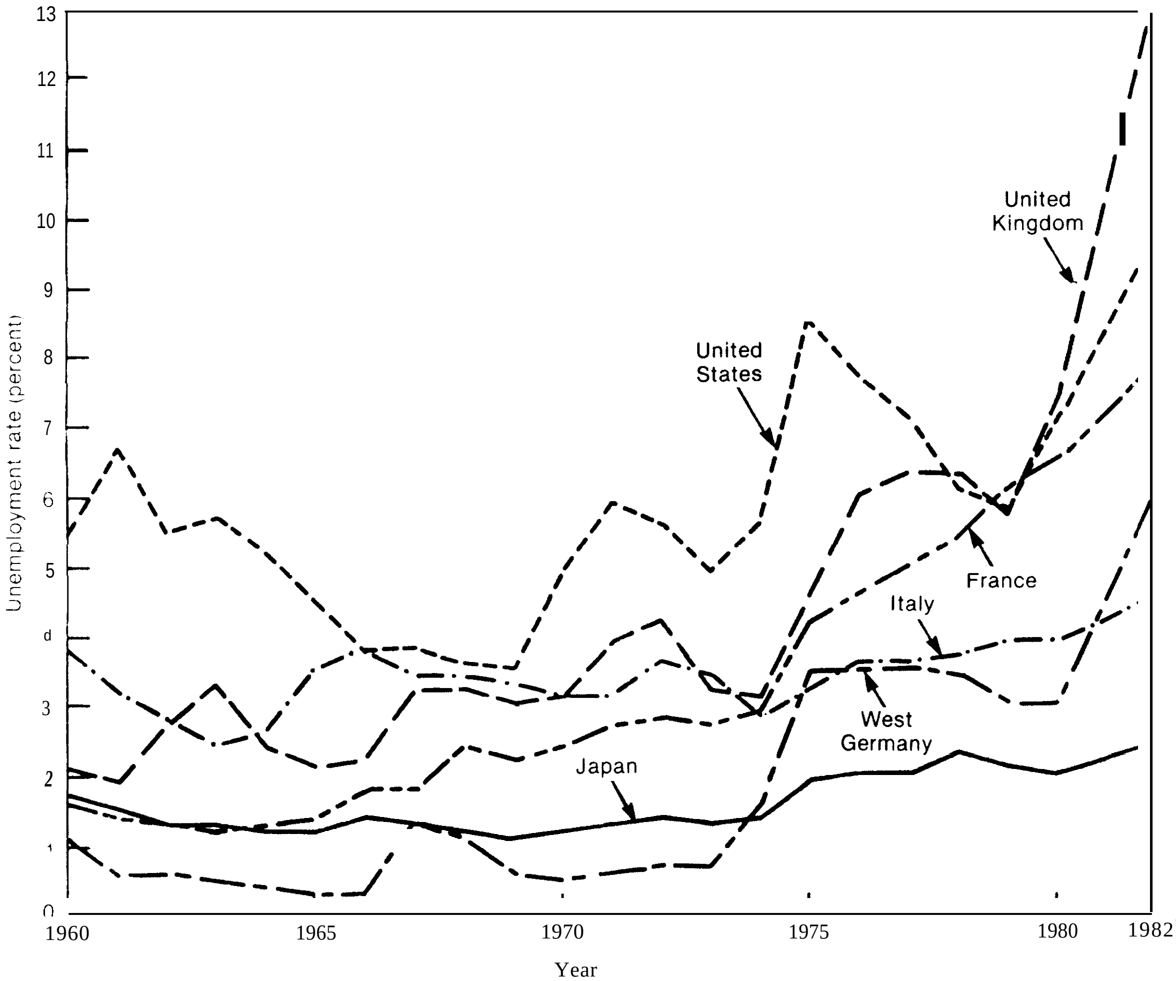
People have worried over technological change because of its impacts on employment —and sometimes actively resisted new technologies—at least since the beginnings of the industrial revolution. The automation scare of the 1950's focused on computers taking over the workplace—a fear that has resurfaced, more so in Europe than the United States. Twenty-five years ago, some commentators predicted steadily rising unemployment due to automation; others were skeptical that computers alone would have such grave consequences. Throughout the 1960's, a number of international groups, including the Organization for Economic Cooperation and Development (OECD) and the International Labour Office, continued to study the effects of computers and automation on employment. As it happened, the industrial nations experienced an upswing in economic growth during the 1960's that put the automation debate temporarily to rest. Falling levels of unemployment were sufficient indication to many that overall demand was the key to jobs, with structural aspects decidedly secondary; so long as aggregate demand grew, new jobs would be created to offset the losses resulting from labor-saving technologies,

The 1970's brought renewed concern; economic growth slowed and unemployment rose, The trend was sometimes masked by the ups and downs of the business cycle, but by the end of the decade, as figure 55 shows, it was clear that unemployment had been steadily rising in most of the industrialized West. Now the question has become: Will this trend persist?

Rather than mainframe computers as in the 1950's, people now point to microprocessors and microcomputers as the new technologies with the greatest potential job-displacing effects.[1] As was the case 25 years ago, optimists and pessimists view the consequences of such developments quite differently. To the optimists, labor-saving technology is nothing new. Many more jobs will be created than lost, they say. Moreover, in the short term the impacts of microelectronics will not be that dramatic because most investments in automated equipment come during periods of economic growth, when capital is available. As a result, workers may be redeployed but only rarely will lose their jobs. The optimists view structural

[1] See, for example, C. Norman, *Microelectronics a t Work: Productivity and Jobs in the World Economy,* Worldwatch Paper 39 (Washington, D. C.: Worldwatch Institute, October 1980); *Advances in Automation Prompt Concern Over Increased L? S. Unemployment,* GAO/AFMD-82-44 [Washington, D. C.: General Accounting office, May 25, 1982).

Figure 55.— Unemployment in Industrial Nations[a]



[a]Unem[illegible] t Fit. US concept Data for the United Kingdom exclude Northern Ireland
[b]1982 [illegible] the United States and [illegible] based on first 9 months

SOURCE *Economic Report of the President* (Washington D C U S Government Printing Office, February 1983), p 287

transformation as a process that creates jobs in newer sectors of the economy: employment in manufacturing may shrink but opportunities will increase in services; as the proportion of manual workers declines, the number of white-collar employees grows. Automation, furthermore, will free people from some of the worst jobs: dirty, boring, dangerous factory work; sorting and filing; processing checks; perhaps even delivering the mail. To the pessimists, of course, some of these jobs are not so bad – and many of the least attractive will remain (custodial work, fast foods, selling insurance). Still, from the optimist's viewpoint, the expansion of high-technology industries means more opportunities for an educated labor force. Competition from low-wage, newly industrializing countries (NICs) need not cause great concern; so long as the world economy continues to grow, industrialized nations can concentrate on advanced products made by better paid and better training workers, leaving the lower technology sectors to the NICs. Everybody should benefit.

Others are less sanguine, their skepticism rooted in the belief that the world economy is now fundamentally different than in the 1950's and 1960's. "Structuralists" argue that permanent shifts spelling chronic unemployment and underemployment have taken place, Fundamental to this view is the slow economic growth of the 1970's; to the pessimists, sudden rises in energy prices and other shocks to the international economy are not enough to explain the slowing pace of growth, They argue that, at least in manufacturing, the expansion in output needed to maintain current employment levels has been increasing—i.e., that output must grow more rapidly than in the past in order to maintain a constant number of jobs. If true, and if this trend persists, it will become more and more difficult to *expand* employment by stimulating demand.' Since labor productivity in the manufacturing sectors of industrial nations has risen consistently faster than gross national product (GNP), the pessimists emphasize that compensating expansion in employment must come from sectors other than manufacturing. Many also argue that structural unemployment in advanced industrial nations results from a permanent shift of labor-intensive production to lesser developed countries and NICs, where wages are low. In the longer term, this might be a positive force; if international specialization takes place, the more advanced nations should be able to concentrate on capital- and knowledge-intensive industries, and expand their employment in these sectors, But in the short run it leads to severe dislocations, already evident, for example, in consumer electronics or steel.

The same causes and effects—technological change, productivity growth, shifts in international comparative advantage, technology gaps —are thus viewed differently by the optimists and the pessimists. The latter see them as signals of persisting unemployment. Unlike the optimists, they emphasize obstacles to adjustment such as mismatches between the skills and capabilities of workers and the requirements of industry (ch. 8), They argue that employment statistics for the United States already underplay the extent of *real* unemployment, not to mention underemployment. a

The debate between the optimists and pessimists ranges far beyond the electronics industry. But electronics technology has been a natural locus of concern because it so clearly embodies labor-saving advances by which machines perform tasks that people did in the past. No wonder labor unions—in the United States but particularly in Western Europe—have continued to raise questions about automation and electronics, and sometimes actively resisted new production methods,

The question: "How will electronics technology affect employment?" is unanswerable, Posing the question more narrowly helps a little: Will continued developments in electronics drastically reduce the number of workers needed in the manufacturing sectors of advanced economies? Will the effects be beneficial through elimination of burdensome tasks while creating new and more interesting jobs? These phrasings still cannot be treated with any precision, but at least are more suggestive. The problem is that no methods exist for determining employment shifts caused exclusively by technical change. Too many other forces are at work, A second analytical problem relates to the type of employment impact. Advances in electronics may eliminate a job in one plant—but a similar job may open in a nearby firm or in a distant city, Alternatively, a displaced worker might be able to find employment only after retraining, or even reeducation.

'R. Rothwell and W. Zegveld, *Industrial Innovation and Public Policy: Preparing for the 1980's and the 1990's* (Westport, Corm,: Greenwood Press, 1981), p. 207, In Europe, the term "jobless growth" has come to describe this phenomenon.

[3]One study has claimed that 80 percent of American workers are "misemploy ed''-i.e., are doing jobs for which they are ill-suited. See W. W. Harman, "Chronic Unemployment: An Emerging Problem of Postindustrial Society, " *The Futurist,* August 1978, p. 213,

Leontief paints a grim picture of the effects of technological change, mismatch, and misemployment:

> To argue that workers displaced by machines should necessarily be able to find employment in building these machines does not make more sense than to expect that horses displaced by mechanical vehicles could have been directly or indirectly employed in various branches of the expanding automotive industry.

See W. Leontief, "Employment Policies in the Age of Automation," *Science and Public Policy,* December 1978, p. 452.

From the perspective of the individual, geographical moves or retraining can aggravate what is already a severe blow on psychological as well as more tangible grounds.

Factors Affecting Employment Levels

Directly or indirectly, the ability of American firms to compete internationally links many of the forces that affect employment, Increasing sales here and abroad provide the foundation for a growing labor market, with aggregate expansion creating new job opportunities unless labor productivity goes up even faster. Conventional methods of forecasting labor market demand begin with output projections, In a given sector, output and employment will depend in complex fashion on aggregate demand; in a period of economic downturn, job opportunities can still increase in some industries. While this has often been true in electronics, recessionary pressures during 1981 and 1982, as in 1974 and 1975, show that the semiconductor industry is far from immune from sales slumps and layoffs.

For years, the interrelation between employment and inflation was pictured in terms of the well-known Phillips curve, which showed that high rates of inflation tended to correspond to low rates of unemployment, and vice versa. But by the end of the 1970's, the American economy seemed prone to simultaneous inflation and unemployment—another gloomy portent to those on the pessimistic side of the structural unemployment question. One reason is wage and price rigidity. When demand falls, companies are reluctant to cut prices as a means of expanding output, workers reluctant to accept pay cuts to reduce costs. Rather than greater output and employment at lower wage and price levels, prices stay high—aggravating inflation-sales drop, output must be cut, and workers are laid off. Nonetheless, recent wage concessions in the steel and automobile industries show that adjustment is possible if the slump is serious enough.

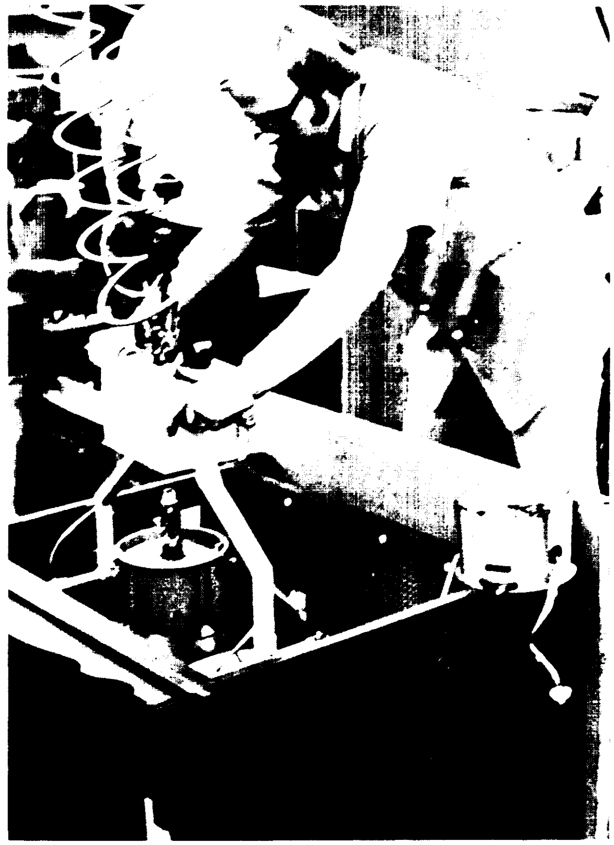


Photo credit *RCA*

Final adjustments during color TV assembly

Employment is closely linked to labor productivity—commonly measured in terms of output per man-hour. If firms can produce more with the same amount of labor, the economy as a whole expands and so does individual purchasing power. Growth in purchasing power can create new demand which will in turn create new jobs; thus *increases in productivity do not of themselves result in employment losses.* But if the overall economy is stagnant or growing only slowly, productivity growth in a given industry can well lead, not only to decreasing job opportunities in that industry, but to net job losses within the economy.

As this implies, sectoral shifts must be considered. A worker displaced by rising productivity and foreign competition in consumer electronics finds little solace in growth elsewhere in the economy. Similar patterns appear at higher levels of aggregation. As pointed out in chapter 5 (see fig. 32), employment in both manufacturing and agriculture has shrunk relative to services in the OECD nations. The service sector makes an ever-growing contribution to U.S. GNP, and the rate of job expansion there has been high. What of productivity in services? Since productivity has grown less rapidly in services than in manufacturing [although productivity in many service sector categories is notoriously difficult to measure), overall employment levels have been maintained in part by transfers of labor from manufacturing to lower productivity service sector jobs. Of course, factory workers cannot **always** quickly move to service jobs, nor may they want to—particularly if the jobs available are low-paying or menial. The point is that sectoral shifts always imply some degree of dislocation.

The impacts of technological change take several forms. Automation, interpreted broadly **as** extending to jobs outside the traditional manufacturing sector, cuts into the need for labor. Computers eliminate jobs for file clerks; banking machines displace tellers; instead of three people in the cockpit, new commercial aircraft need two. Great Britain's telephone system provides a quantitative example: when electromechanical equipment was phased out in favor of electronic switching during the 1970's, employment dropped from over 90,000 to 65,000.[4]

The effects of new technology depend in large measure on the motives for its introduction. Investments aimed at rationalizing the production process by cutting costs, improving efficiency, or adjusting to new conditions tend to cause net declines in job opportunities. The British telephone system is a case in point. On the other hand, technical change may expand output or create new markets, resulting in many more jobs. Henry Ford's moving assembly line is a classic historical example; labor productivity increased and costs were cut to the point that vastly greater numbers of people could afford to buy cars. Likewise, the introduction of color television cut into sales of black-and-white sets but expanded overall demand for TVs. Many examples could be drawn from the computer industry.

The export competitiveness of domestic firms, as well as market penetration by imports, directly affect employment. Greater sales in export markets mean more jobs at home. On the other hand, an influx of foreign goods may put Americans out of work. In recent years, considerable attention has focused on jobs lost to foreign low-wage industries making products such as TVs or textiles and apparel. Nevertheless, competition with advanced nations can be equally important—evident in products ranging from automobiles and machine tools to integrated circuits and aircraft, As industries like electronics become more thoroughly international in character, it is seldom easy to disentangle the costs and benefits flowing from shifts in competitive strength. Overseas production by American firms can be viewed as a loss in domestic job opportunities; it can also be seen, in at least some cases, as an entree into new and expanding foreign markets (see app. B on offshore manufacturing for an outline of the complexities of such judgments).

Finally, employment levels always depend to some extent on the fit between the demand for manpower and the skills and capabilities of the work force. Structural shifts affect not only the employment levels in various economic sectors, but the kinds of people needed. In the United States, the unemployed Youngstown steelworker may neither be qualified nor desire to move into a Silicon Valley electronics company, especially since the pay is unlikely to be very high. In advanced economies, growth in services has led to a variety of changes in labor markets. In Sweden, for example, as the economy has grown and the service sector expanded, labor force participation among older men has declined. One explanation is that this group has become redundant—older men do not bother to look for work because they be-

[4] R. Roth well and W. Zegveld, *Technical Change and Employment* (New York: St. Martin's Press, 1979), p. 152.

lieve that none is available. ' At the same time, women have joined the labor forces of the industrialized nations in greater numbers, taking many of the service sector jobs.

The match between supply and demand in the labor market—never perfect—is thus an intrinsic part of the employment question, To some extent, problems of skills and training are those of response time; people's choices may lag new opportunities, as may programs of study in educational institutions (ch. 8). Shortages of entry-level electrical engineers in the United States have reflected, not only rapid growth in demand for the products of the electronics industry, but slow response within the educational system to new labor market demand. This is one way in which employment is affected by public policies, at least to the extent that schools and universities depend on governments (including State and local) for resources. Government programs can also help men and women who find themselves unemployed or underemployed develop new skills and find new jobs. Adjustment is but one of several avenues; during the 1930's, the Federal Government instituted many programs to *expand* employment. These massive public works efforts drew support from Keynesian theory, which held that demand stimulation could help ensure full employment.

Despite the experiences of the Depression, and the many job programs since, the United States does not have a comprehensive manpower policy at the national level. Although some States have set up worker training programs to help attract industry, retraining has never been approached systematically, in striking contrast to nations such as West Germany; in addition to the vocational programs mentioned in the preceding chapter, the German Labor Market Office matches unemployed workers with openings through a nationwide computer survey.[6] There are no parallels in the United States.

This brief review illustrates the difficulty of assessing the consequences of changes in technology 01 competitive position even in a single industry like electronics. First, many of the factors are interrelated. How can shifts in competitiveness be isolated from the effects of aggregate economic growth, which determines demand for the industry's products? How directly must gains or losses of jobs elsewhere in the economy be linked to changes within the electronics industry (e. g., new technologies] to justify an attribution to electronics? Should vir*tual* employment and unemployment—jobs that would or would not exist in the *absence* of changes in electronics technology—be included? Finally, which impacts are most significant? Those on individuals? On companies? On entire industries? Or are all three of comparable importance? What of regional dislocations? There can be no easy answers to the general question of whether continuing developments in electronics will have positive or negative consequences for employment in the United States,

The following sections look in more detail first at changes within the electronics industry, then at effects on other sectors.

[5] H. Berglind, "Unemployment and Redundancy in a 'Post-Industrial' Labor Market, " *Work and Technology*, M. R. Haug and J. Dofny (eds.), *Sage Studies in International Sociology* 10 (Beverly Hills: Sage Publications, 1977), p. 201,

[6] L. Dobyns, "America Works When America Works, " *NBC White Paper*, June 25, 1981,

Employment Trends in the U.S. Electronics Industry

Changes in employment within any one industry take place in a larger context. Employment in U.S. manufacturing as a whole has been essentially static since the late 1960's. Over the period 1972-82. manufacturing jobs declined from 26.0 to 21,8 percent of the nonagricultural work force.[7] Of course, these broad trends tell little about employment on a

[7] *Economic Report of the President* (Washington, D.C .: U.S Government Printing C) ffice, February 1983), p. 205.

sectoral basis; the number of jobs in the U.S. consumer electronics industry has declined, while in computers and semiconductors expanding output has brought rising employment.

Analysis of such trends depends on how the industry is defined and subdivided. For instance, data published by the Electronic Industries Association (EIA) show 1.6 million workers in the entire industry in 1982.[8] EIA, however, bases its tabulation on very broad SIC (Standard Industrial Classification) categories. Among these is SIC 367, "electronic components and accessories, " which has nine subdivisions. Only one–3674, "semiconductors and related devices''—is among the portions of the electronics industry that OTA has focused on, others—e.g., "electronic coils, resistors, and capacitators" —being less illuminating in terms of international competition. Therefore, discussion of employment in the rest of this chapter is limited to the following four SIC categories?

- 3651—Radio and Television Receiving Sets, Except Communication Types, (Despite the title, this SIC group includes more than just radios and TVs, extending to nearly all home entertainment or consumer electronic products; consumer audio equipment, public address systems, and amplifiers for musical instruments all fall within SIC 3651.)
- 3674—Semiconductors and Related Devices. (This category includes virtually all types of microelectronic components, ranging to solar cells and bubble memories, those manufactured by captive plants as well as merchant firms,)
- 3671—Radio and Television Receiving Type Electron Tubes, Except Cathode Ray. (Virtually all vacuum tubes are included except for TV picture tubes and other cathode ray tubes, and special purpose devices such as klystrons or X-ray tubes.)
- 3573—Electronic Computing Equipment. (Processors and peripherals of all types fall into SIC 3573.)

In referring below to these SIC categories, more inclusive names—e.g., consumer electronics for SIC 3651—have been adopted. Both semiconductors (3674) and the vacuum tubes they have largely replaced (3671) are examined, so that growth in the first category can be compared to contraction in the second.

During the 1970's, employment grew in two of these four SIC categories, as table 74—based on data gathered by the Bureau of Labor Statistics (BLS)—shows. In microelectronics, employment has doubled, and in computers it has gone up even faster, while the consumer electronics category has shrunk, (Most of the contraction in vacuum tube production predates 1972.) In 1982, the nearly 800,000 workers covered by the SIC codes in table 74 totaled slightly more than 4 percent of the 19 million men and women in the U.S. manufacturing

[8] *Electronic Market Data Book 1983* (Washington, D. C.: Electronic Industries Association, 1983), p. 144. This is the total of Labor Department employment figures for four Standard Industrial Classification categories: SIC 3651 (radio and TV receivers), 366 (communications equipment), 367 (components), and 3573 (computers). Communications, with more than 550,000 employees in 1982, makes up one-third of the total.

[9] Defined in *Standard Industrial Classification Manual 1972* (Washington, D. C.: Office of Management and Budget, 1972), pp. 190 (SIC 3651), 193 (SIC 3674), 192 (SIC 3671), and 180 (SIC 3573).

Table 74.—Employment in Selected Portions of the U.S. Electronics Industry

SIC category	Number of employees and percentage of production workers (in parentheses) 1972	1980	1982a
3651, consumer electronics	114,500 (740/.)	85,900 (70°/0)	74,400 (670/o)
3674, microelectronics	115,200 (51%)	226,900 (44°/0)	230,000 (40°/0)
3671, vacuum tubes	46,400 (70°/0)	42,600 (620/o)	43,400 (61 '/0)
3573, computers and peripherals	182,300 (360/.)	350,200 (40°/0)	418,300 (380/.)
	458,400	705,600	766,100

aFirst 10 months.

SOURCE Bureau of Labor Statistics

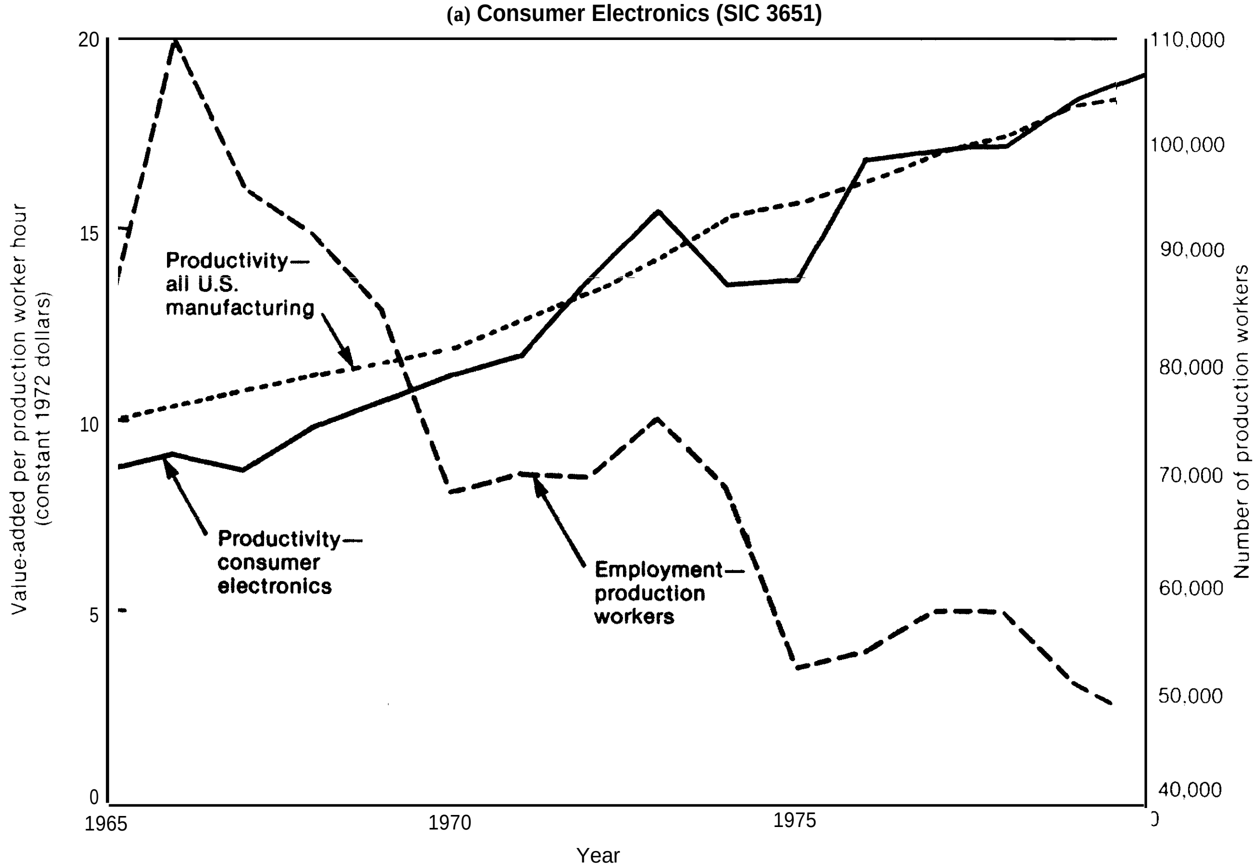
work force, making even this portion of the electronics industry larger than, say, steelmaking—which employs half a million. *

Figure 56 compares trends in labor productivity and employment (for production workers only) over the past decade for each of the categories except vacuum tubes, In all three charts, productivity is given as value-added per production-worker hour in real, inflation-adjusted terms. Productivity growth in consumer electronics, figure 56(a)—where employment declined—has paralleled the all-manufacturing average, growing slightly faster in earlier years. In contrast, computer manufacture–fig. 56(c) —shows the most rapid rise in employment; the number of jobs doubled, with productivity rising almost as fast until the mid-1970's. Past this point productivity growth has slowed—but, as pointed out in chapter 5, productivity trends in terms of value can be misleading when technical change is as rapid as it has been in the data processing industry. Even so, value-added productivity in computer manufacturing has risen much more rapidly than for U.S. manufacturing as a whole. Many jobs have also been created in semiconductors, fig. 56(b), where productivity gains were again substantially above the all-manufacturing average. The cyclical nature of employment in the semiconductor industry distinguishes it from both consumer electronics and computers; the sensitivity of semiconductor production to recession is magnified by the tendency of purchasers to quickly cut back on orders when their own out-

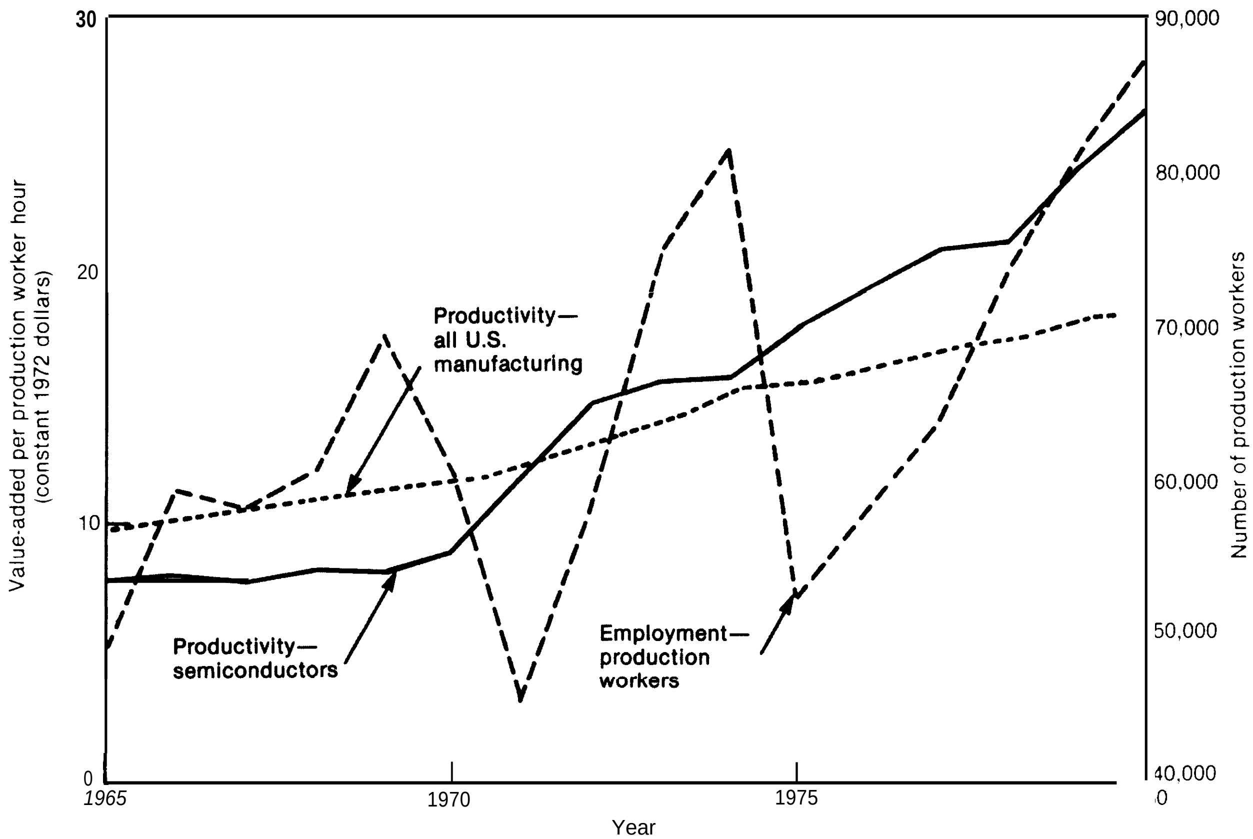
*BLS figures for the first 10 months of 1982 show 18.9 million workers in manufacturing—l 1.2 million in durable goods, 7.7 in nondurables.

Figure 56.—Labor Productivity and Employment by Sector of the U.S. Electronics Industry

(a) Consumer Electronics (SIC 3651)



(b) Semiconductors (SIC 3674)



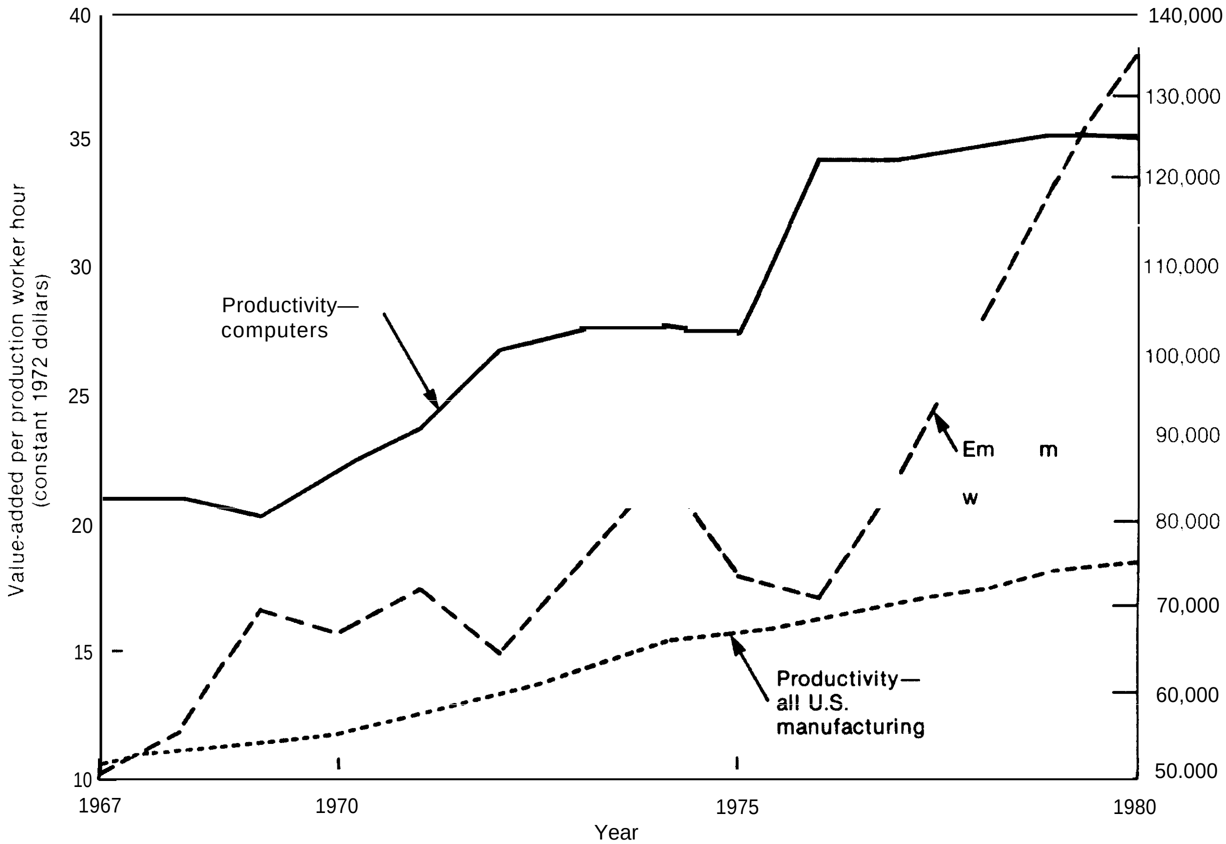
put drops, sometimes to double-order in upswings for fear of shortages.

As the plots in figure 56 demonstrate, the portions of the electronics industry that showed the highest rates of productivity growth also experienced the highest rates of employment growth. Increases in productivity were associated with the creation of jobs, not their elimination. The reason is simple: output in computers and semiconductors grew at very high rates, spurred by exports as well as domestic sales. The domestic market for radios and TVs grew more slowly, exports were small, and import penetration has been severe.

As the cases of computers and microelectronics illustrate, when rates of change in technology and productivity are high, employment may rise. Similar correlations sometimes follow at the aggregate level; unemployment may drop while productivity climbs, particularly if coupled with rapid technical change and high investment. But as the examples from electronics in figure 56 illustrate, there can be a great deal of variation across sectors: productivity rises at different rates; sometimes employment goes up, sometimes down. Still, over time, technologically progressive U.S. industries have generally experienced—not only above-average productivity gains, decreasing real prices, and increases in sales—but relative increases in employment as well.[10] While an increase in em-

[10]Denison and others have studied the contributions of technological change to economic expansion—for example, E. Denisen, *Accounting for United States Economic Growth* (Washington, D. C.: Brookings Institution, 1974). For an analysis of trends in electronics, see W. Kendrick, "Impacts of Rapid Technological Change in the U.S. Business Economy and in the Communications, Electronic Equipment and Semiconductor Industry Groups," *Microelectronics, Productivity and Employment* (Paris: Organization for Economic Cooperation and Development, 1981], pp. 25ff.

(c) Computers (SIC 3573)



NOTE Census Bureau figures for employment may not agree exactly with BLS figures cl fed elsewhere in this chapter BLS figures are collected at the plant level and may include some workers from other SIC categories if a plant makes products that fall under several categories Census figures are used in these charts for consistency with productivity data from the Census Bureau Value-added figures have been converted to constant dollars using the implicit price deflator for consumer durables

SOURCES 1965.77— 1977 *Census of Manufactures 1978.80— 1980 Annual Survey of Manufactures*

ployment is not inviolably associated with the development of new technologies and productivity growth, the pattern is not an uncommon one. That employment goes up does not, of course, mean that adjustment problems disappear—but it can provide leeway to deal with them. The next sections examine employment by sector in more detail.

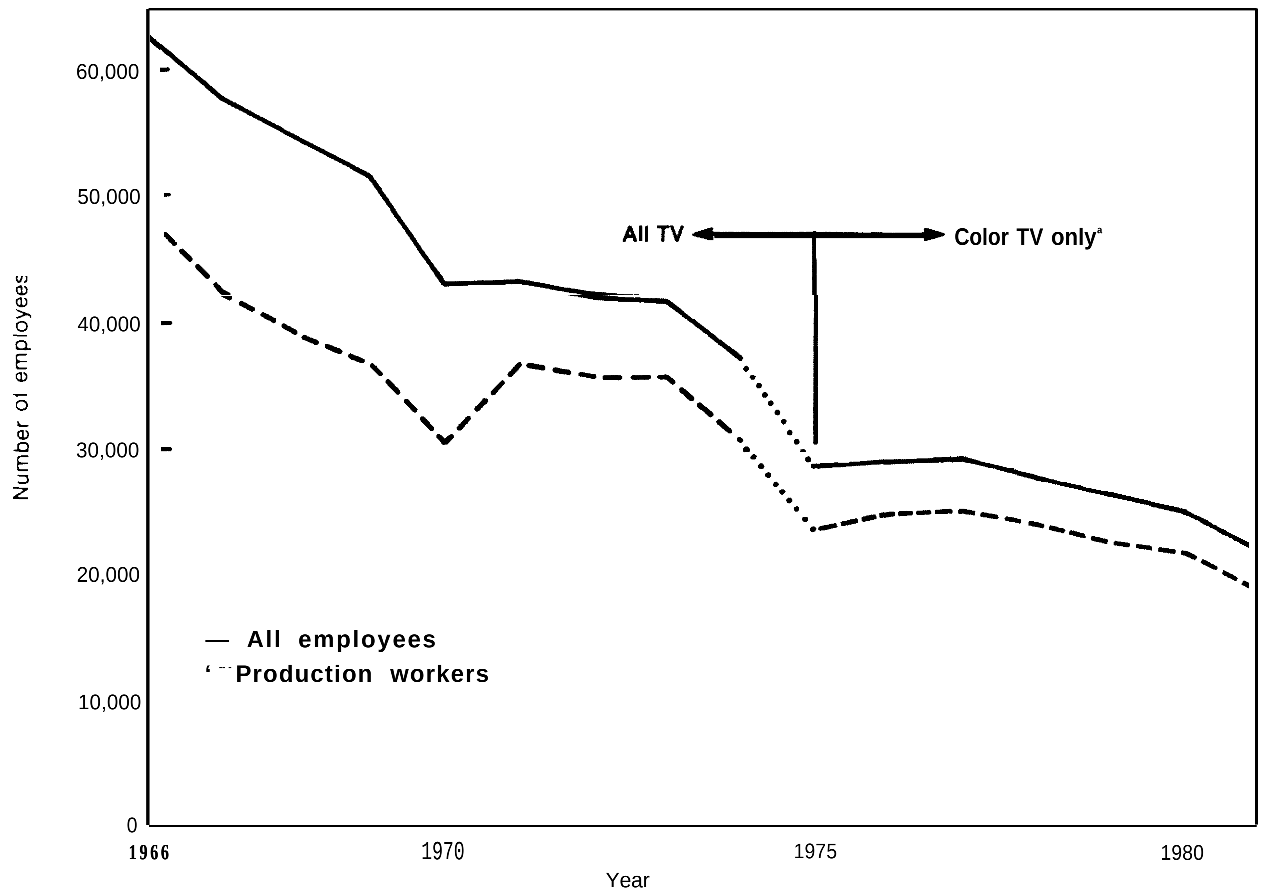
Consumer Electronics

Trends in Employment

Domestic employment levels in TV manufacturing have been falling rather steadily since the mid-1960's, despite a doubling of production volumes. Figure 57 illustrates the decline, which was especially precipitous over the early 1970's (as noted on the plot, the data cover TVs only, not consumer electronics as a whole]. Jobs for production workers dropped by half between 1971 and 1981. Over these years, a number of U.S. manufacturers either merged with Japanese or European producers or left the business. On the other hand, the industry now includes more than 10 foreign companies with assembly operations in this country that contribute to the employment totals in the figure,

For reasons discussed in more detail below, and ranging from automation to simpler chassis designs, labor productivity in U.S. TV manufacture is much greater now than a few years

Figure 57.— U.S. Employment in Television Manufacturing



a Monochrome production in the United States had dropped to low levels by 1975

SOURCES 1966-70— *Television* Receivers *and Certain Parts Thereof* (Washington, D C U S Tariff Commission Publication 436 November 1971) p A 70 1971 -75— *Television Receivers, Color and Monochrome, Assembled or Not Assembled, Finished or Not Finished and Subassemblies Thereof* (Washington, D C U S International Trade Commission Publication 808, March 1977), p A-117 1976, 1977– *Color Television Receivers* U S *Production, Shipments, Inventories Imports, Employment, Man Hours, and Prices, Fourth Calendar Quarter 1977* (Washington D C U S International Trade Commission Publication 866 March 1978), table 5 1978, 1979— *Color Television Receivers* U S *Production, Shipments, Inventories, Imports, Employment, Man-Hours, and Prices, Fourth Calendar Quaffer 1979* (Washington, D C U S International Trade Commission Publication 1036 February, 1980) p A 7 1980, 1981 —*Color Television Receivers" U.S. Production, Shipments, Inventories, Exports, Employment, ManHours, and Prices, First Calendar Quarter 1982* (Washington, D.C U.S International Trade Commission Publication 1245, May 1982), table 5

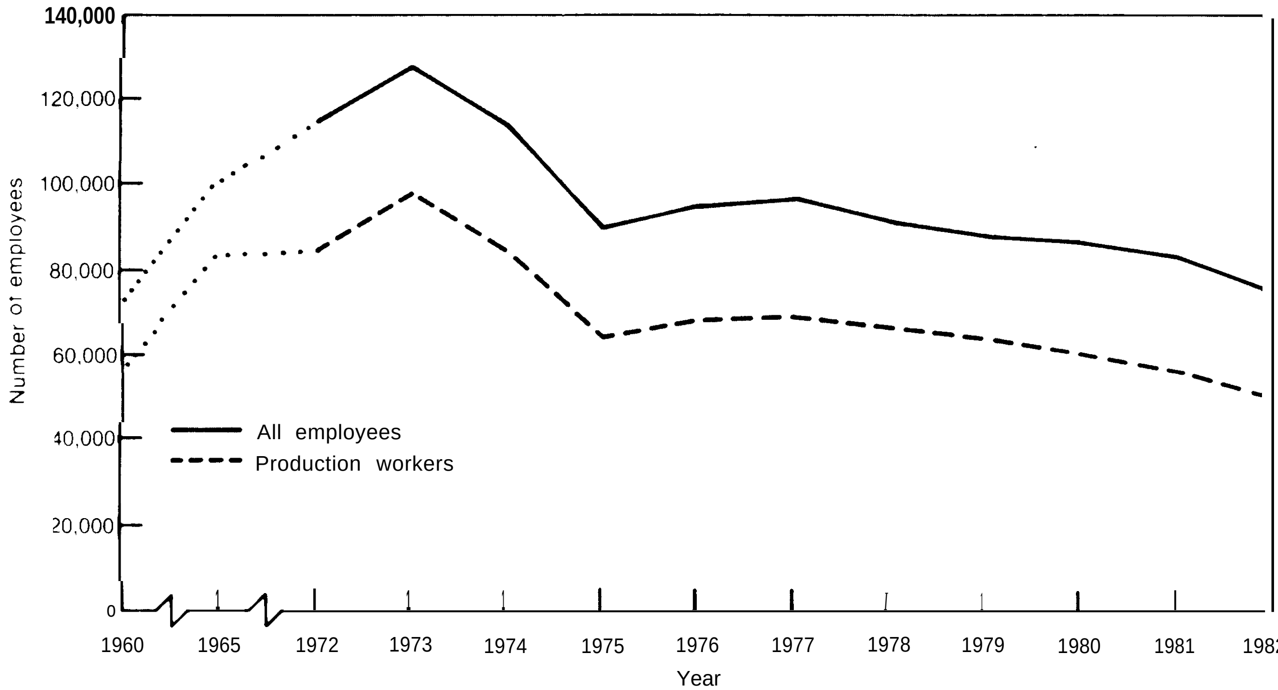
ago; the causes of the employment declines in figure 57 extend well beyond import competition or offshore assembly, with technological change a major force. Although the contributions of the various factors cannot be quantified with any precision, the spread of solid-state chassis designs and associated manufacturing methods dramatically reduced employment requirements in the industry.

Figure 57 includes only those people involved in TV manufacturing. Television accounts for roughly half the U.S. consumer electronics market (ch. 4, table 8), and rather less in terms of jobs. Total employment in SIC 3651—which covers many other consumer electronics products—is considerably greater, as shown in figure 58. Still, the number of workers here has been in decline since 1973, for similar reasons.

Productivity

As domestic output of TVs grew over the years covered by figure 57 (see ch. 4, table 9), apparent productivity—measured by annual

Figure 58.— U.S. Employment in Consumer Electronics (SIC 3651)



SOURCES 1960-1 965— 1977 Census of Manufactures 1972-82—Bureau of Labor Statistics

output divided by the number of production workers—jumped from 150 sets per worker in 1971 to 560 in 1981, In terms of value-added per production worker, productivity was up by about 40 percent during the decade—a trend not far different from that for the broader consumer electronics category seen in figure 56(a). * During this period, the proportion of domestic value-added dropped as American manufacturers shifted labor-intensive operations to developing countries; whether made by American- or foreign-owned companies, TVs produced in the United States now include more imported components and subassemblies. Because of these trends (table 13 in ch. 4 illustrates the rise in imports of incomplete sets and subassemblies over the latter part of the 1970's) simply dividing the total output of TVs by the number of employees considerably overstates productivity y gains. However, the value-added productivity measures adjust for this.

Thus, there is no question that productivity increased considerably during the 1970's, the result of design changes and automation driven by competitive pressures (ch. 6). As manufacturers moved from monochrome to color production, they shifted to more highly automated manufacturing facilities. Somewhat later, redesigned solid-state chassis cut the number of parts, hence the labor content; only 6 percent of the color TVs made in the United States were solid-state models in 1970, but by 1976 essentially all had been redesigned around transistors.[11] A good part of the productivity growth over the 1970's resulted from changes

*In terms of constant 1972 dollars, annual value-added per production worker in TV manufacturing went from $22,2oo in 1971 to $31,600 in 1977, falling to $27,300 in 1981. See 1977 *Census of Manufactures: Communication Equipmen t, Including Radio and TV*, MC77-I-36D (Washington, D. C.: Department of Commerce, June 1980), p. 36 D-5 and 1982 U.S. *Industrial Outlook* [Washington, D.C.: Department of Commerce, January 1982), p. 343. Conversions to 1972 dollars were made using the implicit price deflator for consumer durables—*Economic Report of the President* (Washington, D C.: U.S. Government Printing Office, February 1 982), p. 236.

[11]Data presented at International Trade Commission hearing on Investigation No. TA-201-19, January 1977.

in chassis design and associated manufacturing methods.

Although productivity gains in consumer electronics have contributed to declining employment, the *composition* of the work force has not changed greatly. As table 74 and figure 58 both illustrate, the ratio of production workers to nonproduction workers has decreased relatively slowly. In TV manufacture rather than consumer electronics as a whole, the shift has been greater, mostly taking place by the mid-1970's (fig. 57). The semiconductor industry, for one example, has seen more rapid changes in skill mix (table 74).

Imports and Offshore Manufacture

Earlier chapters described the inroads made by imported TVs, both monochrome and color, Few black-and-white sets are now manufactured here. Orderly Marketing Agreements (OMAs) restricted imports of color sets during the period 1977 to mid-1982, but figure 57 shows that the quotas did not arrest employment declines. Still, jobs would have been lost even faster without OMAs.

American consumer electronics firms relocated many of their manufacturing operations to low-wage offshore locations during the 1970's, While there are no precise figures on foreign workers employed in these plants, the Department of Labor believes that the number may be over 30,()()&-more than employed in domestic TV operations.[12] These people substitute quite directly for American workers.

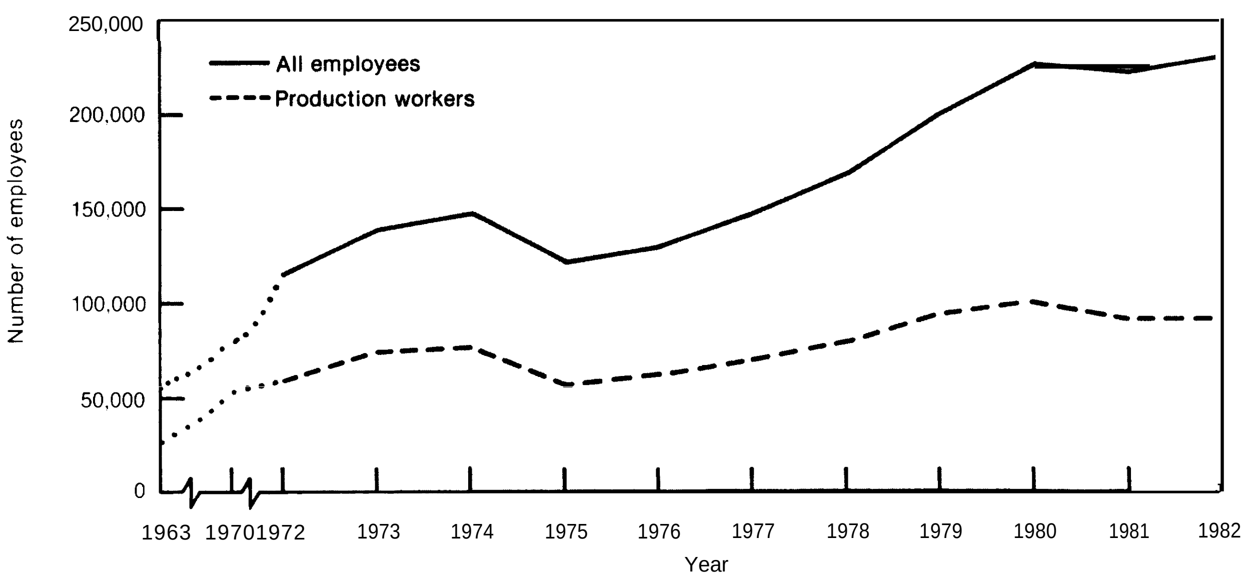
Semiconductors

Since the mid-1950's, employment in semiconductor manufacture has grown rapidly, from a few thousand when production of semiconductor devices was just getting underway, to well over 200,000—figure 59. These totals include captive manufacturing. During two periods—1969-72 and 1974-76—employment dropped sharply as a result of recession.

As figure 59 also shows, the proportion of production workers in the domestic industry has declined–from 66 percent of the total work force in 1963 to 40 percent in 1982. Major causes include the transfer of production operations offshore and advancing technology. More complex manufacturing methods—including automation—have increased the relative need for technicians and other nonproduc-

[12] Information from Department of Labor.

Figure 59.— U.S. Employment in Semiconductors and Related Devices (SIC 3674)



SOURCES 1963, 1970— 1977 *Census of Manufactures* 1972-82—Bureau of Labor Statistics tion workers. High levels of research and development have contributed to expansion in nonproduction ranks; the number of man-hours devoted to integrated circuit design has been increasing exponentially—figure 60. Technological advance in microelectronics has thus been paralleled by a decrease in semiskilled and unskilled employees relative to skilled workers and professionals in U.S.-based manufacturing. The result has been an "upskilling" of the domestic labor force. Employment opportunities for technical personnel—engineers, scientists, technicians—have grown rapidly. As these trends continue, the proportion of production workers in domestic semiconductor operations will fall even more,

American semiconductor firms transferred "back-end" operations overseas at a rapid pace during the 1960's, with more than 50 foreign manufacturing plants established during the decade.[13] While point-of-sale plants have arguably small impacts on domestic employment, offshore investments driven by lower wages directly displace American workers, just as in consumer electronics. Offshore manufacturing also contributes to the declining proportion of production employees in the United States. Unskilled assembly labor accounts for most of the jobs overseas; U.S. firms employ about three-quarters as many people in their foreign plants as they do here: around 180,000, of which more than 80 percent—as many as 150,000—are production workers.[14] Among U.S. merchant semiconductor firms, perhaps 90 percent of all assembly work is performed overseas. 15

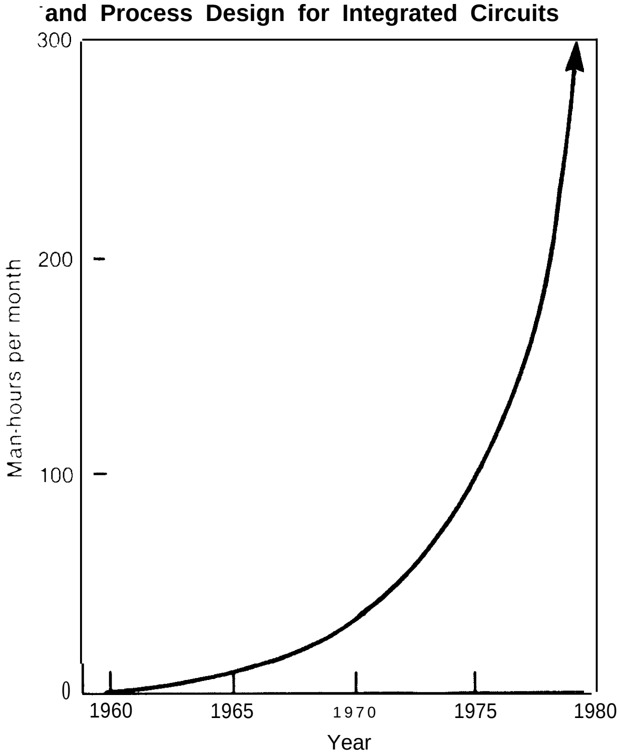
Many U.S. companies make semiconductors solely for internal use, but no disaggregation of employment data is available for these captive facilities. While most produce specialized devices in relatively low volumes, with considerable variation in month-to-month levels, IBM is a large producer and large employer. Because some of the overhead and administrative tasks associated with captive manufacturing may be performed elsewhere in the firm, the proportion of production workers is probably higher than in merchant manufacturing.

As semiconductor production grew, the vacuum tube industry (excluding cathode ray tubes, hence TV picture tubes) declined—figure 61, While tubes still find specialty applications, by the early 1970's, substitution of semiconductors had caused domestic employment to drop by one-third from the peak level of 1966. Although jobs in tube manufacturing have been lost to technical change, far more people are now employed in making semiconductors than were *ever* employed in making vacuum tubes.

Computers

Computer manufacturing, like microelectronics, has seen rapid employment growth with simultaneous productivity improvement —although, as emphasized in chapter 5, productivity measures can be misleading where

Figure 60.— Effort Levels Associated With Product and Process Design for Integrated Circuits



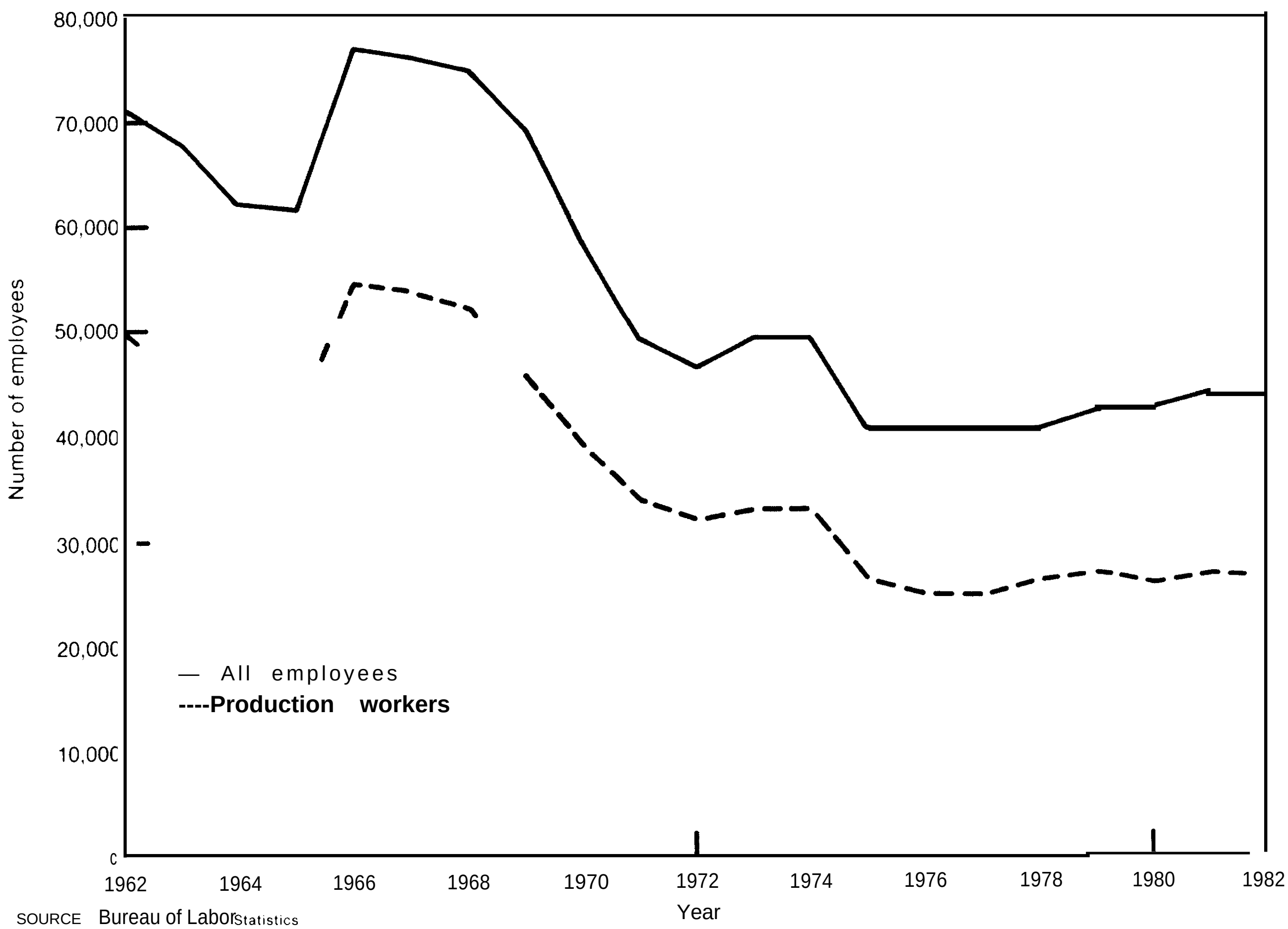
SOURCE VLSI Some Fundamental Challenges —Scoping Its Future *IEEE Spectrum*, April 1979 p 35

[13] *A Report on the U.S. Semiconductor Industry* (Washington, DC; .: Department of Commerce, September 1979), p. 84.

[14] *Summary of Trade and Tariff Information, Semiconductors* (U.S. International Trade Commission Publication 841, Control No. 6-5-22, July 1982], p. 8.

[15] J. R. Lineback, "Automation May Erase of ffshore Edge," *Electronics*, Apr. 21, 1982, p. 94.

Figure 61.—U.S. Employment in Vacuum Tube Manufacturing (SIC 3671)



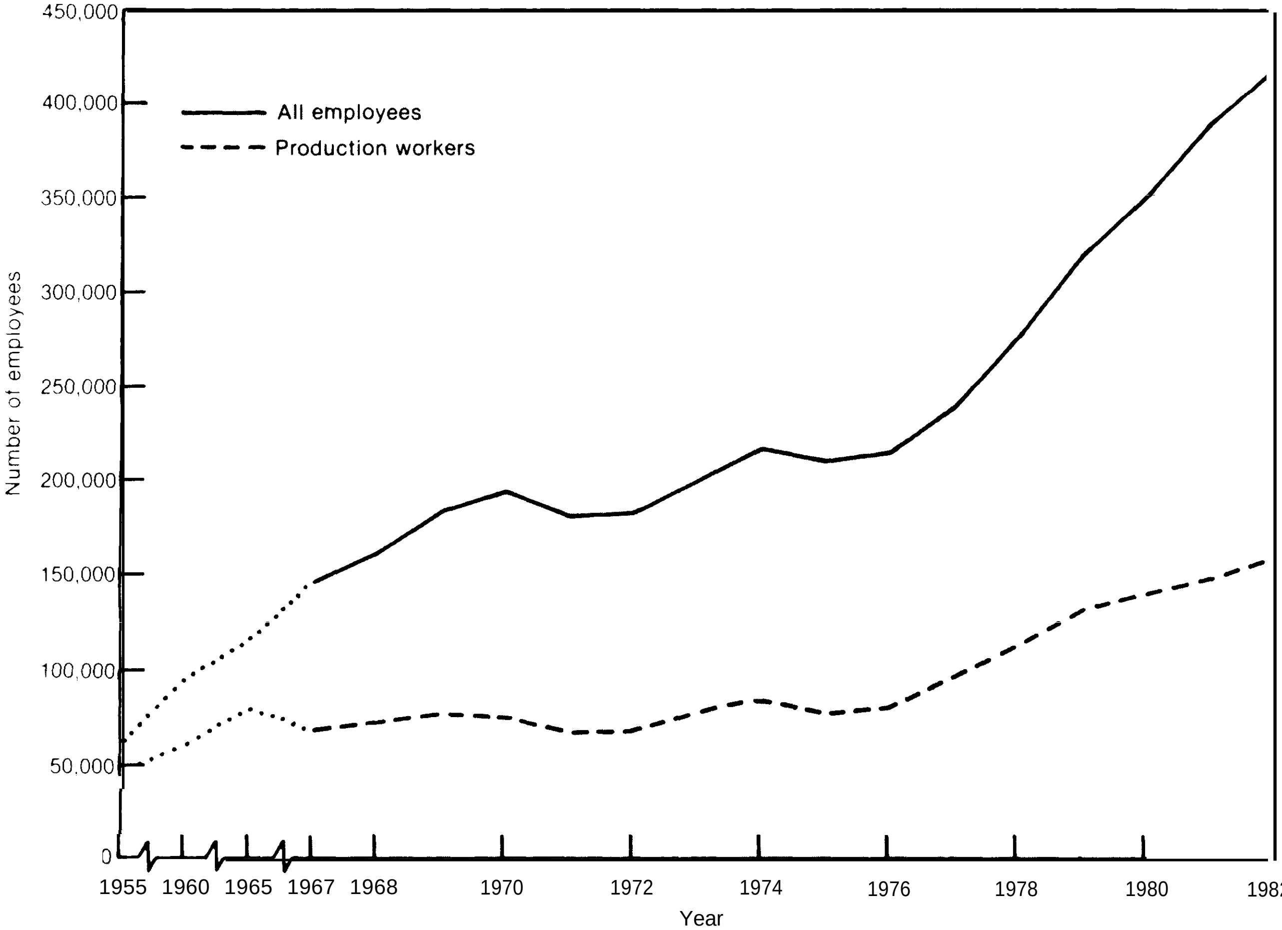
SOURCE Bureau of Labor Statistics

the product changes so much. Regardless, advances in computer systems have *created* vast numbers of jobs—not all in computer manufacturing. Many of these new jobs have originated in the user community, and in software production. Figure 62 illustrates job growth in the industry itself, including peripherals, Even more so than in microelectronics, the trend has been away from production employees and toward skilled workers and white-collar professionals.

Unlike either semiconductors or consumer electronics, employment in computers and peripherals has not been greatly affected by import penetration or offshore production. Many American computer firms have invested overseas, but foreign manufacturing facilities have generally served foreign markets. As in semiconductors, some of this foreign production may substitute for exports from the United States, but overseas sales are often tied to local production, limiting the extent to which point-of-sale plants displace domestic jobs.

The summary above of employment trends by sector in the domestic electronics industry shows that the number of jobs has increased, but not everywhere or uniformly. Increases in semiconductors and computers have more than offset—in magnitude—the declines in consumer electronics and vacuum tubes. The composition of the work force has changed; *employment gains have been greatest for nonproduction workers.*

Figure 62.—U.S. Employment in Computer (and Peripheral Equipment) Manufacturing (SIC 3573)



SOURCES 1955-65— 1977 Census *of Manufactures* 1988-82-Bureau of Labor Statistics

Effects of Import Penetration and Offshore Assembly

An increase in imports or a transfer of manufacturing operations offshore can cut into domestic job opportunities. The United States is importing more manufactured goods of all types, not only consumer electronics and semiconductors, making the import penetration question especially timely. Moreover, to labor unions, offshore production amounts to the export of jobs. For policy makers, both phenomena—but especially imports—have been a growing concern.

The employment consequences of import penetration and offshore assembly are felt in a context of global shifts in market structure, implying long-term changes as well as immediate impacts on people, firms, and industries. The dynamics are important on both time scales. In expanding markets, firms that can respond quickly to new opportunities anywhere in the world may be able to increase exports and consolidate their positions, aided by products that take advantage of new technologies. This happened during the 1970's, when American semiconductor firms capitalized on the shift toward metal oxide semiconductor integrated circuits ahead of their overseas rivals. Today, Japan's avowed goal of capturing more than 30 percent of the world computer market by 1990 (along with 18 percent of the U.S. market) reflects a belief that longstanding patterns can be disrupted when growth is rapid,

This section looks more closely at the effects of imports and offshore production on employment in consumer electronics and semiconductors (neither is important at the moment in computers). As pointed out in chapter 5, industries do not rise or decline in competitiveness simultaneously; looking at employment on a sectoral basis gives only part of the picture, and then an equivocal one. Still, the sectoral approach is a valid starting point, for reasons that are discussed in some detail in appendix B.

The first question is: What are the *causes* of import penetration? Imports may rise because demand exceeds domestic capacity or consumer preference shifts to foreign-made goods. Japanese penetration of U.S. markets for dynamic random access memories (RAMs) is an example of the first case, TV imports at least in part the second (imported automobiles are a more obvious example). In the first case, jobs may not be lost because of imports, but the rate of increase in domestic job opportunities may slow. In the second case, immediate decreases in employment are likely.

The full consequences of import penetration depend on the industry, Declining output in some industries—a prominent recent instance again being automobiles—can have major spillover effects elsewhere in the economy. As sales of domestic cars lagged, jobs were lost in firms making steel, tires, and components. Sometimes companies can limit impacts on individuals by allowing employment to decline through attrition rather than layoffs; even so, the overall pool of job opportunities shrinks.

The effects of offshore production are no more straightforward. On the one hand, all wages and salaries paid overseas could be viewed as a loss to American labor and the U.S. gross domestic product. But what if firms can only lower their costs and maintain or expand their markets by moving offshore—whether to take advantage of low-cost labor and be better able to compete with imports, or simply to manufacture their products nearer the ultimate market? Firms weigh a variety of such factors in deciding whether to invest overseas, although ultimate decisions generally turn on cost savings. From the standpoint of the Nation as a whole, rather than a particular company, the costs and benefits may be quite different. Appendix B discusses the impacts of offshore manufacturing on the aggregate economy and outlines the range of effects compared with alternatives available to the firm. This appendix includes a case study drawn from the experience of an American company which invested in a subsidiary in Taiwan. Briefly, the conclusion of the case illustration is that the offshore plant—established to assemble automobile radios—helped maintain competitiveness vis a vis Japanese manufacturers and prevented even more U.S. jobs from eventually being lost. As this suggests, in consumer electronics the movement offshore by American producers can be viewed as a defensive reaction to imports. In contrast, the motivation for overseas manufacturing in the semiconductor industry has been cost reduction and market expansion driven by domestic competition. The consequences for employment have been much different.

Consumer Electronics

Almost half the consumer electronics market in the United States has been taken by imports; in addition, many products assembled here depend heavily on imported components and subassemblies. Penetration of consumer electronics markets has coincided with employment decline, as shown in figures 57 and 58. Imports of black-and-white TVs rose from one-quarter to three-quarters of U.S. sales over the period 1967-77. Color TV imports peaked in 1976 at a level nearly tenfold greater than in 1967, then dropped because of OMAs. A third round of imports followed, the influx of video cassette recorders from Japan.

Today, all U.S. TV manufacturers operate foreign production facilities. In addition to the attraction of low-wage labor, Items 806.30 and 807,00 of the U.S. tariff schedules encourage offshore assembly (ch. 11). During the last half of the 1970's, 30 to 45 percent of all color TV imports entered under Item 807, although final assembly remains concentrated hem-in part because of foreign investments to avoid the OMA-imposed quotas.

Despite limits on imports, employment in TV manufacturing did not recover. In testimony before the U.S. International Trade Commission, the International Brotherhood of Electrical Workers reported that 20,000 workers had lost their jobs in the TV industry due to imports.[16] To what extent are imports to blame, given that domestic productivity improvements and offshore investments by U.S. firms have also contributed to employment decline?

It is oversimple to argue that the total number of foreign workers engaged in production for shipment to the United States—whether employed by U.S. or foreign firms– represents domestic employment loss, In most cases, U.S. consumer electronics firms had little choice concerning offshore production. Movement abroad was a defensive reaction, not a strategy aimed at expanding markets and improving profitability. To assume that jobs overseas substitute directly for U.S. employment is tantamount to assuming a stable competitive environment--which was not the case. Rather, employment declines followed losses in competitiveness; American firms had higher costs than their rivals, and little scope for developing strategies that would preserve domestic jobs. They pursued the obvious route: increased automation to raise productivity at home, combined with transfers of labor-intensive operations offshore, Only some companies survived; the others were purchased by more successful manufacturers or left the industry. In this sense—as part of a more complex chain of *events—import competition must indeed be counted as the primary cause of job losses in consumer electronics.* [17]

But this is not the whole story: Is it possible that the ready availability of Item 807.00 reduced incentives for American managers to cut costs and improve labor productivity at home? Might U.S. firms have avoided offshore production by adopting more capital-intensive automated manufacturing processes here? Jobs still might have been lost, but the costs and benefits would have shifted. The behavior of American executives is often contrasted with that of their Japanese counterparts, who recently have faced similar difficulties-i. e., competition from countries with much lower labor costs. Some observers have claimed that Japanese consumer electronics firms have invested more rapidly and more boldly in mechanized production technologies such as automatic component insertion (see ch. 6 for a further discussion of rates of adoption of automation).

As with many such questions, the truth probably lies somewhere between. The availability of Item 807 reduces the pressure to find cheaper manufacturing methods at home. It is also true that the Japanese, when themselves confronted with the rather sudden emergence of competition from other Far Eastern countries, transferred some of their production to lower wage sites. In part, such transfers were also caused by the 1977 OMA—which, by limiting shipments from Japan, created incentives for Japanese firms to move to export platforms--but Japanese managers exhibit little reluctance to take whatever steps seem necessary' for preserving hard-earned market positions. Along with developing new production methods-–an uncertain business —Japanese firms would probably have shifted labor-intensive production abroad in any case, simply for insurance. In this respect, Japanese managers have behaved much like Americans.

[16] "Testimony Before the U.S. International Trade Commission on TV Receivers (TA-201-19)," International Brotherhood of Electrical Workers, 1977. See also "Petition for the Extension of Import Relief," submitted to the U.S. International Trade Commission, Dec. [illegible], 1979.

[17] For a generally contrary view, see A. O. Krueger, "Restructuring for Import Competition From Developing Countries, I: Labor Displacement and Economic Redeployment in the United States," Journal of Policy Modeling vol 2, 1980, p. 165

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Photo credit: Control Automation

Robot set up for assembling electronic components

While U.S. employment would have dropped even faster without OMAs, the lesson—repeated in other industries—is that controlling levels of imports to provide companies a respite during which they can take measures to enhance their competitiveness is unlikely to improve employment prospects, Indeed, just the opposite tends to be true, as manufacturers strive to cut costs by improving labor productivity, To the extent that they succeed, employment probably will decline, even in situations where modest growth in output takes place. As a result, trade protection seldom functions as a substitute for assistance to displaced workers.

Semiconductors

U.S. imports of semiconductor devices have increased steadily, exceeding imports by 1982 (ch. 4, fig. 24); in earlier years, the United States exported many more semiconductors than it imported. Do such trends portend job losses? More to the point, with Japanese manufacturers holding half or more of the burgeoning 64K RAM market, will employment in this portion of the electronics industry suffer as in consumer electronics? There is a major difference: semiconductor production is still expanding rapidly, Furthermore, American semiconductor manufacturers have exported much more actively than consumer electronics firms.

Figure 59 showed the steadily growing employment in the U.S. semiconductor industry. Domestic jobs more than doubled during the **1970's**; offshore employment probably expanded even faster. The question again is: Do imports, or foreign workers employed in the overseas operations of U.S. firms, stand for job opportunities lost to Americans? Imports and offshore manufacturing are more closely coupled for semiconductors than for consumer electronics. Nearly 40 percent of U.S. semiconductor sales are classed as imports, but more than three-quarters of these are re-imports by American firms under Items 806 and 807 of the tariff schedules. Offshore production is central to the U.S. industry. Still, shipments from Japan have also risen swiftly over the last 5 years.

The offshore facilities of U.S. semiconductor manufacturers concentrate on the labor-intensive steps in the production process—primarily assembly. In the mid-1970's, Finan estimated that manufacturing costs for integrated circuits could be cut in half through offshore assembly.[18] Cost/price competition has thus been the primary motive for foreign investments; *American semiconductor firms moved offshore to reduce costs and expand markets.* Moreover, the competition has been largely among domestic firms; investments predate Japanese competition by a decade and more. If in the case of consumer electronics, offshore manufacturing was a reaction to import competition, in semiconductors the primary motivations were offensive. Capital investment requirements have been one of the forces at work. In order to keep up with demand, semiconductor firms have been under continual pressure to add new capacity (ch. 7). Offshore assembly offered flex-

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[18] W. F. Finan, "The International Transfer of Semiconductor Technology Through U.S.-Based Firms, " Working Paper No. 118, National Bureau of Economic Research, December 1975, p. 60. The savings are greater for simpler integrated circuits and discrete devices than for complex circuits—as illustrated in app. B—because the assembly cost is a larger fraction of the total cost for simple devices.

ibility; firms could avoid the risks of investments in automated equipment that might soon be outdated, expanding capacity without taking funds from capital-intensive wafer fabrication and testing equipment.

What are the implications for job opportunities? As the case study in appendix B illustrates, these depend in part on the time horizons. Given rising foreign competitiveness in microelectronics, offshore production now helps meet international as well as intranational competition. If overseas manufacturing helps U.S. firms maintain their competitiveness, the net impact on domestic employment might be positive over the longer term. Furthermore, point-of-sale plants are sometimes able to sell in markets to which the U.S. parent would have difficulty in exporting because of trade barriers. In some instances at least, American firms may thus be able to strengthen their long-term competitive position by investing overseas, enlarging domestic as well as foreign employment. Still, in the short term, offshore investments cut the number of job opportunities for Americans. In this respect, questions of the impact of Items 806 and 807 of the tariff schedules are similar to the more general problem—isolating the consequences of foreign direct investment of any type on employment. Such matters have been investigated extensively over the years. The most common conclusion is that direct investment by American corporations has increased net employment in the United States; nevertheless, the opposite result is sometimes reached, again depending on the particulars. In the end, implications—both short and long term—can only be evaluated on a case-by-case basis, and depend on assumptions concerning the future competitive environment for American firms.

Foreign Investment in the United States

Foreign investments here bring yet another dimension to questions of domestic employment. Japanese investment in the United States has grown rapidly, from a cumulative $152 million in 1973 to $4.2 billion by 1980.[19] The desire to open new markets and to ease trade frictions are among the forces behind this influx. Japanese-owned firms now assemble nearly 4 million color TVs here each year. North American Philips adds well over a million.

As this suggests, most of the past investments in electronics have been limited to consumer products, Japanese interests seem bound to widen, however, with plants for assembling integrated circuits the next step. In typical foreign-owned manufacturing plants, only a few upper management slots are reserved for executives from headquarters. Viewed strictly from an employment perspective, therefore, onshore manufacturing has positive consequences for the United States. Viewed more broadly, the picture becomes mixed: many of the skilled and professional jobs remain overseas.

Generalizations about employment that would apply to all parts of the electronics industry are impossible. In the case of consumer electronics, import penetration is closely associated with job loss. In contrast, employment has grown steadily in both domestic and foreign operations of U.S. semiconductor firms; overseas investments have helped cut costs, expand markets, and increase competitiveness. Simply in terms of numbers of jobs, expansion in semiconductors and computers has more than offset declines in consumer electronics. This does not mean, of course, that such trends will persist indefinitely. Nor is it any consolation to people who find themselves out of work. The rest of the chapter looks to the future.

[19] "Japanese Manufacturing operations in the United States," Japan External Trade organization, September 1981.

Projections of Employment Within the Electronics Industry

Before examining impacts on other parts of the economy, this section treats the industry itself, in the context of Bureau of Labor Statistics (BLS) employment projections to 1990. The perspective is much broader than the discussion of possible shortages of engineers and skilled workers in the previous chapter.

Ideally, projections of future trends would be based, not only on a model for aggregate economic expansion, but also on sector-specific variables—growth in particular product markets, demand for workers with certain kinds of skills, levels of imports and exports. Unfortunately, this much detail is seldom attempted. BLS projections, virtually the only analyses available with industry-specific output, are based on an econometric model—a limited tool, although representative of the state of the art.[20]

BLS began making econometrically based employment projections two decades ago, introducing a macroeconomic demand model in 1975. Their current procedure includes five basic steps: 1) projections for the economy in the aggregate; 2) disaggregation of GNP by demand categories; 3) distribution of demand by categories to producing industries; 4] output projections by industry sector based on an input-output table; and 5) forecasts of labor productivity, total labor hours, and number of people employed at the sectoral or industry level. A critical input in terms of employment is the estimated gross demand for the products of an industry, This gross output is divided by an estimated productivity level (output per employee-hour) to yield the labor hour projection for the industry, and thus employment. The model as a whole is sensitive to a wide range of assumptions, most fundamentally those for GNP growth. BLS's recent projections have been based on GNP increases ranging from 2.4 percent annually (the "low trend") to 3,8 percent (the "high trend"). These assumptions compare with a 1973-79 average of 2.8 percent per year. BLS has assumed growth in labor productivity to stabilize at the rather low levels of recent years.[21]

On this basis, BLS predicts that aggregate growth in U.S. employment will range from 1.6 to 2.0 percent annually over the decade of the 1980's, considerably below the 2.7 percent yearly rise for 1975-79. Women will get two-thirds of the new jobs. The durable goods portion of manufacturing is expected to grow faster than the all-industries average, nondurable slower.

Output increases in computers and related equipment should lead all other manufacturing industries; employment in the computer industry will grow from about 420,000 in 1982 to perhaps 600,000 by the end of the decade. If these projections prove realistic, employment in the computer and peripherals sector will comprise as much as 3.1 percent of the total manufacturing work force by 1990, compared to 1.6 percent at the end of the last decade. Employment in the electronic components sector (SIC 367) is expected to grow at about 2.2 percent per year in both low- and high-growth scenarios, well above projections for manufacturing as a whole. In the low-growth scenario, 33 of the 150 industries examined show employment drops, One of these is radio and TV manufacturing, with an anticipated decline averaging 1.4 percent per year over the period 1979-90. Thus, if BLS projections prove realistic, past employment trends in electronics will persist: there will be continuing decline in consumer electronics, rapid growth in computer manufacturing, and con-

[20] "Methodology for Projections of Industry Employment to 1990, " Bulletin 2036, Department of Labor, Bureau of Labor Statistics, February 1980.

[21] For more; detail, see V. A. Person ic k, "The outlook for Industry Output and Employment Through 1990, " *Monthly Labor Review*, August 1981, pp. 28ff. Also *Occupational Outlook Handbook*, 1982-83 *Edition*, Bulletin 2200" (Washington, 1), C.:Department of Labor, Bureau of Labor Statistics, April 1982).

siderable expansion in components. Together, these three portions of electronics might, under the most favorable circumstances, account for more than 7 percent of U.S. manufacturing employment in 1990. The projections are all conditional, needless to say, and BLS's approach shares the principal limitation of virtually all forecasting techniques: current trends are expected to continue, breaks with the past seldom anticipated.

BLS also estimates employment by occupational category across industries; in all scenarios, white-collar jobs grow faster than total employment, blue-collar jobs slower. White-collar workers will make up slightly more than half the 1990 labor force—the fraction is slightly less now—with notable increases in the professional and technical category. [22]

Table 75 lists occupations in electronics for which BLS predicts the greatest percentage increase during the 1980's. All are grey- or white-collar jobs. The nonelectronics categories are included for comparison; 5 of the 10 fastest growing occupations in the complete BLS listing are electronics-related. Despite the high growth rates, categories starting from a modest base will not account for large numbers of new jobs.

[22] M. L. Carey, "Occupational Employment Growth Through 1990," *Monthly Labor Review*, August 1981, p. 45.

Table 75.— Predicted Growth Rates by Occupational Category Over the 1980's

Occupation[a]	Predicted increase in employment (1980-90)
Paralegal	109%
Data processing machine mechanic	93
Computer operator	72
Computer systems analyst	68
Business machine service technician	60
Computer programer	49
Employment interviewer	47
Computer peripheral operator	44
Psychiatric aide	40

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

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

Photo credit Western Electric Co

Semiconductor wafers being loaded into furnace

As shown earlier, the electronics industry experienced a more-or-less gradual shift toward fewer production workers and more white-collar workers during the *1970's*, with the biggest change in semiconductor manufacturing (fig. 59). Table *76* gives occupational breakdowns in consumer electronics, components, and computers according to BLS data for **1980.** While BLS expects some further upskilling during the 1980's, the projections (not shown)--which may or may not be well-founded-indicate these to be mostly matters of a percentage point or two. Note that the SIC categories in table 76 are broader than used earlier; the consumer electronics data cover SIC 365, rather than the "home entertainment" subdivision, 3651; electronic components, SIC 367, includes all types of components, not just microelectronics; and the computer category referred to earlier, 3573, is a subdivision of SIC 357. Moving the boundaries of these categories outward probably makes little difference for consumer electronics and computers, but components as a whole are not nearly as skill-intensive as microelectronics; thus the proportions of technical professionals in table 76 are considerable underrepresentations for semiconductor firms (compare table 74).

Table *76* points quite graphically to the high skill requirements of the computer industry, where about 60 percent of the work force falls

Table 76.—Occupational Distributions in Electronics as of 1980

	Consumer electronics (SIC 365)	Electronic components (SIC 367)	Computers (Sic 357)
White- and gray-collar workers	*27.90/.*	*32.00/.*	*59.00/0*
Professional and technical:			
Engineers (and scientists)	3.6	6.2	11.3
Engineering technicians	2.8	6.1	9.3
Computer specialists	0.6	0.6	6.2
Other	3.0	2.8	5.7
Managers	4.7	5.4	9.4
Salesworkers	0.7	0.7	1.0
Clerical	12.5	10,2	16.1
Blue-collar workers	*62.1 0/0*	63.60/o	38.20/o
Craft	17.3	14.8	12.1
Assemblers and machine operators	44.8	48.8	26.1
Service ***workers and others.***	10,0 "/0	4.3 "/0	2.90/o

SOURCE: Bureau of Labor Statistics

in the ranks of white-collar workers (not all with high levels of education or training) or skilled, grey-collar technicians—in contrast to consumer electronics and components, where these jobs make up less than a third of the total. Employment expansion in computers will continue to be most rapid in skilled categories (table 75); numbers of service and repair technicians and systems operators will increase, while jobs for keypunch operators—whose skills are becoming obsolete—will dwindle, as will work for those without special training. Likewise, in components, BLS estimates that the number of professional and technical workers will grow from 87,700 in 1980 to over 117,000 in 1990. In the more mature consumer electronics industry, the absolute number of blue-collar workers is likely to decline, as well as the proportion. Taken together, the trends indicate a continued shift toward more highly skilled jobs in electronics. Computer manufacturing, in particular, will be a leader in employment growth and in demand for new skills over the next decade; the picture for this industry foreshadows trends expected elsewhere in the U.S. economy,

Future Employment Patterns in Other Industries

If analysis of past trends in electronics is problematic, looking ahead to the impacts of electronics on other industries is a still more tenuous exercise. Yet it is a vital one, for future developments in electronics have far-reaching implications for the entire economy, Useful policy guidance could flow from an understanding of how technological change affects employment patterns. Public and private training and retraining programs would benefit if vulnerable job categories, as well as those for which demand will rise, could be more reliably identified, unfortunately, there are no substitutes for painstaking case-by-case analysis based on disaggregated data and carefully defined occupational categories, This is expensive and time-consuming, demanding a sophisticated appreciation of how industry uses technology; in consequence, such studies are seldom attempted.

Uncertainties abound. First, past trends—including examples of technical change in industries other than electronics–can offer only a general guide; there are no guarantees that current employment patterns—outcomes of large numbers of incremental and evolutionary changes—will persist. Second, many impacts will be several levels removed from the electronics industry itself. Computer-controlled production of consumer goods such as clothing—to take one example—may increase employment in firms designing and building the equipment used, decrease employment in the apparel industry, but perhaps have positive impacts on employment at the retail level (one reason might be that custom design would become cheaper, with smaller runs of styles and sizes sold in specialty shops). Attempting to trace such second and third level effects involves the interplay of business decisions, economic and product cycles, imports and exports—not to mention the unpredictable nature of consumer demand. The following sections do not attempt to answer the question of whether electronics technologies will have net positive or negative impacts on U.S. job opportunities, but simply illustrate some of the forces at work.

European governments, sensitive to the potentially negative employment consequences of electronics and automation, have commissioned numerous reports on the subject, with uniformly disappointing results, Micro-level analyses exploring impacts on a particular craft or industry are difficult to integrate with macro-level studies and aggregate economic forecasts. Yet this coupling–the complex and evolving interplay among technical advance, utilization within various economic sectors, and the response of the labor market—is critical on both supply and demand sides. For example, companies typically install labor-saving equipment in periods of economic expansion, when workers can be transferred to other jobs rather than laid off. Over the longer term, then, a given firm can often use normal attrition to help manage the size of its work force. Where this is the case, direct attribution of decreases or increases in employment opportunities to new technology can be difficult to defend. [23]

While forecasting methods do a reasonable job of predicting employment within either aggregate or disaggregate categories as long as change is slow and past trends supply precedents, the unexpected consequences of new technologies escape forecasting methodologies virtually by definition. Examples *from the past illustrate little beyond the seeming randomness of the impacts of technological change.* This in itself is an important lesson, but means that the state of the art is such that even well-documented historical case studies can seldom provide direct policy guidance.

The basic problem is that, even if it were possible to predict how technical change in electronics would affect some other industry, there is no necessary relationship between these findings and the consequences for the economy as a whole. Building up the picture on a detailed, sector-by-sector basis would be a vast undertaking. Most of the past attempts—whether dealing with manufacturing or services or both—have been more limited, falling into one of two categories: 1) elaborate but abstract analytical frameworks, typically econometric; or 2) case studies outlining impacts on particular sectors. The first, exemplified by the BLS analyses discussed earlier, have seldom been very illuminating in terms of real-world experience. The second often yield insights that are useful but limited to relatively narrow segments of the labor force–bank tellers, coal miners, postal workers—as illustrated by the case examples that follow.

Manufacturing

Many of the studies addressing manufacturing begin by distinguishing between product and process applications. These overlap in the sense that computer-based process control systems, to take one example, can be viewed in either light. As a "product, " they are developed and sold by firms in the capital goods industry. In the alternate view, automated process control is one aspect of an ongoing transformation of production in many industries. Employment impacts follow in both views, although typically of very different magnitudes.

As a further organizing principle, it helps to consider employment effects by product and

[23] The authors of a British study write: " Mic roelectronics technology will affect manufacturing industry in so many ways that it is impossible to be exhaustive, and difficult even to find a coherent framework for analysis. " See J. Sleigh, B. Boatwright, P. Irwin, and R. Stanyon, *The Manpower Implications of Micro-Electronic Technology* (London: Her Majesty's Stationery office, 1979), p. 14.

by market.[24] In theory, the greatest gains come where new *products* are introduced into new *markets*. Pocket calculators and video games are examples. While they may replace other goods—electromechanical calculators, for example—to the extent that new products expand markets or create new ones, employment will rise. *Existing products* introduced into new *markets* have parallel effects. The "personal" computer is not a new technology or a new product so much as an adaption of microprocessor-based data processing systems to the needs of individual households and small businesses. Low-end minicomputers of the early 1970's, such as the PDP-8, were similar in many respects to current personal computers, but the PDP-8 was never marketed as such. In contrast, the introduction of new or replacement technologies into *old* markets often cuts into job opportunities. Recent and well-publicized illustrations include electronic switching in telecommunications—principally telephone systems—and electronic typesetting in the printing industry. In essence, these technologies caused step changes in labor productivity, with subsequent employment declines, In such cases, output may expand, but not rapidly enough to compensate, In between the extremes of the examples above fall many which have more moderate impacts on employment.

Several case studies are outlined below, including those of telecommunications and typesetting, to illustrate typical impacts of electronics-related technologies on employment patterns,

The British Telecommunications Industry

The introduction of electronic switching in the British telephone system exemplifies the replacement case. Employment dropped from 90,000 in 1973 to 65,000 by the end of the decade, Jobs were lost both in manufacturing and among those employed running the system. Declining export sales contributed to job loss in the manufacture of telecommunications equipment; within the system, fewer installers, service personnel, and operators were needed. Further reductions may be in store, with fully electronic equipment—expected around 1990—cutting the work force to as little as one-tenth its former size.[25]

Printing

Computerized typesetting provides a second example of the introduction of new products into old markets. High-speed photo-typesetting equipment, along with typesetting computers, have transformed the printing industry. The equipment is much less labor-intensive than the hot-metal typesetters that have been replaced, and productivity has jumped. With electronic typesetting, an operator selects type size and style, column width, spacing, and other layout specifications on a video screen, composing an entire page at a time; the older linotype machines, stemming from the end of the 19th century, produced one line of type at a time. After electronic photocomposition had been introduced at the *New York Times*, the Sunday classified section could be completed in 20 minutes rather than 3 days, Over the mid-1970's, the staff in the composing room declined from 830 to 685 employees, and would have dropped much further except for the ability of the printer's union to maintain many jobs that were in fact redundant.[26] (Of course, if one looks at media as a whole, electronics has created vast numbers of jobs.)

Unfortunately, while productivity is now much higher, demand for books and newspapers has not changed much, Between the mid-1960's—when only about 2 percent of all typesetting in the United States was performed

[24] Following M, McLean and H. Rush, "The Impact of Microelectronics on the U. K.: A Suggested Classification and Illustrative Case Studies," Occasional Papers Series, No. 7, Science Policy Research Unit, University of Sussex, June 1978.

[25] M. Wilkinson, "System X: The Need to Shake-up the 'Phonemakers, " *Financial Times*, Oct. 18, 1978.

[26] The union at the *Times* was more successful than most at holding on to jobs for its members. For a detailed treatment of this case, see "The Impacts of Robotics on the Workplace and Workforce, " Carnegie-Mellon University, School of Urban and Public Affairs, June 14, 1981, pp. 35ff. Other examples of applications of electronics technologies in printing can be found in J. R. Werner, "The Role of Electronics in The Modern Newspaper, " and J. L. Boyd, R. E. Robey, and J. S. Richards, "Automating Newspaper Production, " sess. 21, The Role of Electronics in the Graphic Arts, 1979 Electro Professional Program, New York, Apr. 24-26, 1979.

by the new machines—and the end of the 1970's, penetration rose until about 90 percent of all newspapers were composed using computerized equipment. The impacts on printers as craft workers have been severe. Not only are fewer people needed for photocomposition, but they must have different skills, Few printers have found jobs as computer programmers or service personnel. Unions have been less concerned with the total number of job opportunities than with protecting individuals. Work forces have been reduced through attrition; the pension system created incentives for early retirement. Printers, proud of their traditional craft skills, were not very receptive to retraining, although this had always been a central part of the union's philosophy. While the strategies adopted by organized labor when confronted with such problems have varied, the example of the printing industry is not untypical of instances where replacement technologies have been introduced into existing markets; labor-management relations tend to be critical factors in coping with job-displacement effects.

Electronic Watches

In the watchmaking industry, an example from consumer goods manufacturing, electronically based products took more than half the total market within the space of a decade. In Switzerland alone, 20 to 30 percent of existing assembly labor was displaced.[27] Skill requirements for assembling electronic watches are negligible. Along with deskilling of the production work force, international shifts occurred as firms in the Far East took over markets for lower priced watches; most of the relatively simple integrated circuits needed are also made in Asia. Managements of Swiss watchmakers reluctant to switch to the new technology found their firms rapidly losing ground, with effects on employment that were even more devastating than among manufacturers choosing to embrace electronics.

[27] *Technical Change and Employment*, op. cit., p. 136.

Computer-Aided Manufacturing and Design

Continuing integration of computer technology into manufacturing operations—computer-aided manufacturing (CAM)—will eventually have major consequences for employment (ch. 6). Nonetheless, such developments--including robots and software-programmable automated equipment of many kinds—should generally be viewed as evolutionary steps in the automation of the workplace, continuing down paths originating many years ago. Much the same is true of computer-aided engineering design (CAD), which consists in part of automating tasks—ranging from drafting to numerical analysis-formerly done manually. In addition, both CAM and CAD make possible work that could not be performed at all in earlier years. Examples include machining parts without the aid of drawings, continuous balancing of rotors with material removed by lasers, or finite-element analyses of stresses and deflections.

As computers spread through manufacturing, impacts on employment will be, at least at first, incremental and random-seeming. In the longer run, productivity will be greatly improved; labor-intensity will drop, and large numbers of manufacturing jobs will disappear, particularly those with lower skill levels. In this sense, the long-term effects will in fact be revolutionary. The work force will face continuing structural shifts, and labor-management relations will be under strain as accommodations are sought. Changes in employment patterns in a given industry will depend on the characteristic production processes--how susceptible they are to automation—as well as growth in markets and shifts in competitiveness. Computers will have their greatest impacts when accompanied by large-scale reorganization of the work place, as happened in continuous process industries with the introduction of computerized process control.

Numerically Controlled Machine Tools

The diffusion of numerically controlled (NC) (ch. **6]** machine tools illustrates the results of incremental improvement in manufacturing technology. A survey of 24 American firms revealed comparatively limited impacts on employment.[28] NC machines were generally purchased when business was good and output expanding; the new equipment helped firms produce more without hiring extra workers. Nor were many employees displaced; most moved on to other production jobs, although skilled craftsmen sometimes found the transition to NC machines difficult. Management also had to learn to operate in a new environment. Overall employment remained more-or-less static, but the skill mix changed and some individuals were faced with entirely new jobs. If the impacts of NC machine tools have been mild, it would be misleading to generalize this to future developments in CAD/CAM. NC machining is a major step in metal cutting, but a much more modest development from the viewpoint of manufacturing technology as a whole; the next two or three decades of advances in CAD/CAM will bring more radical change to the factory floor.

Pet Foods

In an example of automated process control, a British firm with a large share of the pet food market invested in a computer-controlled production system.[29] Instituted with the goal of rationalizing the production process, the system was expected to cut employment by three-quarters over a 5-year period. The proportion of unskilled production workers dropped precipitously, while more management and engineering personnel were needed. An absence of unions, combined with an extensive campaign to convince workers that the new equipment would eliminate the least desirable jobs, appear to have been critical factors in the acceptance of the new equipment. The small group of workers selected by management to run this equipment expressed considerable satisfaction with their greater responsibilities, The rest of the production work force lost their jobs.

Are the Case Studies Typical?

None of these examples can be taken as representative. They are anecdotal accounts of events that have followed the introduction of electronics-related technologies. Technical change generally proceeds in piecemeal fashion, with pace and impact that vary from case to case; given hindsight, of course, such seemingly random and incremental events may show patterns invisible at the time.

In the examples recounted, the jobs created generally called for different skills. Typical new openings were for computer operators, or service and repair personnel trained to work on the latest generation of equipment. While patterns of job loss and job creation vary across industries, production jobs—unskilled, semiskilled, or skilled—disappeared in all cases except NC machining. Future employment impacts will be influenced, not only by the technology itself, but by the general state of the economy at the time new technologies are introduced, by the attitudes of workers and unions to automation, and by the choices of corporate managers, In some cases, job losses will be mitigated by expanding markets, particularly if workers are retrained, Overall, however, *a shrinking work force in manufacturing points to continuing displacement and adjustment problems.*

Services

The service sector has been growing more rapidly than manufacturing. Can the U.S. economy continue to generate new jobs in services at a high rate? Office work has been a major source of past expansion. With the electronic office on the horizon, will this source dry up? If office automation begins to cut deeply into employment opportunities, the ability of the service sector to compensate for losses in manufacturing will be seriously impaired.

Office Automation

Fortunately, this seems unlikely—at least in the near term. Office work, breeding ground for Parkinson's Laws, will probably continue to expand. At least some white-collar jobs seem

[28] R. T. Lund, et al., "Numerically Controlled Machine Tools and Group Technology: A Study of U.S. Experiences, " Report CPA 78-2, Center for Policy Alternatives, Massachusetts Institute of Technology, Jan. 13, 1978.

[29] K. Dickson, "Petfoods by Computer: A Case Study of Automation, " *The Microelectronics Revolution,* T. Forester (cd.) (Cambridge, Mass.: MIT Press, 1981).

relatively impervious to automation in the sense that people can find other things to occupy their time. This is partly a consequence of the lack of output indicators or other measures of white-collar productivity. Nevertheless, beyond office work, electronics may reduce job opportunities (or the rate of job creation) in sectors like transportation, retailing, banking, and the postal system.

Less is known about the effects of automation in services than in manufacturing. Over the past two decades, the xerographic copier has probably had greater impacts on office work than any other piece of technology, yet these seem hardly to have been studied. Has the office copier created jobs? What have been the effects on organizational efficiency? No one seems to know. It has saved so much drudgery, however, that few are likely to care.

More concretely, studies of the application of electronics to services generally find—not revolutionary change, but gradual evolution best viewed as an extension of computer applications already in place. Such studies emphasize the extent to which workers such as typists or clerks whose job skills may become obsolete can be redeployed, seeing, for example, word processing as a straightforward extension of typing.

The central features of the electronic office—expanded applications of data processing equipment, including communications and word processing—have thus far been introduced into existing or conventional office environments, In this respect, the analogy with NC machines and industrial robots is close. While office automation promises to reduce staffing needs in conventional jobs, new tasks are at the same time created in operating and maintaining the systems, as well as using them. Since office work is seldom very efficient or well-organized, computerization is likely to have its first effects at the margins of these people-centered activities, rather than leading to sudden and major shifts. Wholesale reorganizations of the workplace will be slower than in manufacturing.

Photo credit Wang Laboratories

Word processing: one of the early steps in office automation

Examining occupational categories makes it clear that the mode of utilization of the new technology is just as important as the speed of adoption, again as in manufacturing. If new technology is instituted primarily as a substitute for narrowly defined functions such as inventory recording, bank telling, or filing, employment is likely to drop over the longer term unless jobs expand in other areas (such as sales). Where computers facilitate more effective and extensive information processing, new jobs may be generated. Where demand for new types of services is created, employment will rise.

Consider the proliferation of word processing equipment, which affects the tasks now performed by a well-defined group of employees. Based on the results of work-measurement tests conducted in organizations that have switched from typewriters to word processors, productivity often more than doubles. While this might suggest that half the typing work force faces unemployment, in practice nothing like this has happened, Indeed, some firms have invested in word processors in response to a shortage of typists. In other instances, where typists have been made redundant they have moved to other parts of the organization. In many cases, people just write more words.

In fact, since word processors make it easier to produce multiple revisions of the same document, productivity cannot be measured simply in terms of words or drafts typed, The characteristics of the technology lead directly to an increase in the number of slightly modified versions prior to a final copy, whether this is a short letter or a report hundreds of pages in length, While the benefits of this maybe questioned, the point is that oversimple estimates of productivity gains—achieved or potential—overstate the probable employment consequences.

Eventually, offices will be structured in substantially different ways, Some jobs will be eliminated, others modified. Interactions among people, individually and in groups, will change. Matters of timing and approach to the installation of new office equipment will, as in the case of factory work, affect employee support or resistance, thus the effectiveness with which the equipment is utilized, and people's satisfaction with their work.

Other Services

Service sector jobs outside the office include health care, retailing and selling of all types, banking, transportation, and postal services (more broadly, communications). In principle, electronics could alter many of these, but where and when—or whether— is another matter.

In banking, computer processing of magnetically encoded checks has made it possible for the same number of employees to handle an ever-growing volume of transactions. Electronic funds transfer remains costly, and thus far has seen only limited use in retail banking; applications to interbank transactions have been much more prominent, Such developments have not led to work force reductions; during the 1970's, the number of people employed in banking in the United States grew by half, confounding predictions of employment losses.[30] Two interpretations are possible: the first is that growth in job opportunities slows under these circumstances; the second, that electronics allows banks to expand their functions in ways that would otherwise be precluded, These interpretations are not mutually exclusive; both have some validity. Clearly, electronics technology has modified and extended banking functions—an obvious example is the automated 24-hour teller. Nonetheless, in Europe, employment growth in banking and insurance has already begun to slow; a well-known report to the French Government predicts that one-third of all jobs in banking and insurance might be eliminated over the decade ahead.[31] While perhaps overly dramatic, such predictions point to the concern these issues have aroused, particularly in Western Europe.

Like electronic funds transfer, electronic mail has been viewed with some apprehension. The U.S. Postal Service has made notable strides in productivity over the past decade, even reduced its labor force—but seldom as a result of electronics. In the future, electronic mail may cut deeply into job opportunities for postal workers; employment could drop by 20 to 25 percent over the next 20 years.[32]

[30]See J. Henize, "Evaluating the Employment Impact of Information Technology," *Technological Forecasting and Social Change, vol. 20,* August 1981, p. 41.

[31]*Microelectronics* at *Work: Productivity and Jobs in the World Economy,* op. cit., pp. 36-37. The French report is S. Nora and A. Mine, *The Computerization of Society* (Cambridge, Mass: MIT Press, 1980).

[32]*Implications of Electronic Mail and Message Systems for the U.S. Postal Service* (Washington, D. C.: U.S. Congress, office of Technology Assessment, OTA-CIT-183, August 1982), ch. 6. The postal service employed nearly **700,000** people in **1980.**

Summary and Conclusions

Examples from both manufacturing and services can be interpreted either optimistically or pessimistically; in the absence of more systematic studies, the question of employment impacts resulting from technical change in electronics on the economy as a whole cannot be answered. But regardless of the view one takes, *unprecedented adjustments lie ahead for* *both individual and firms.* Should aggregate employment increase, the introduction of new technology will alter the jobs that people do and change their interactions with one another. should total employment increase only slowly compared to growth in the labor pool, or decrease, the adjustment problems will be extraordinarily severe, more so in a country like the United States which has little experience with manpower policies, and where many people have come to view adjustment assistance as a failure.

In recent years, the number of new job opportunities generated by the U. S. economy has slowed, A good deal of the future expansion will be in computer-related fields; only those with appropriate training and skills will be in a position to take advantage of these opportunities. Upskilling in the computer industry has been going on for years, as indicated by the increasing proportion of white-collar employees compared to production workers. In fact, the white collar-blue collar distinction no longer carries much meaning; the labor force is becoming increasingly stratified. Distinguishing those with specialized skills from those without is only a starting place for examining the many new gradations.

A common notion, for example, is that computers will bring "user-friendliness" to many jobs so that unskilled workers can perform them, This is potentially misleading. User-friendliness permits people with *good* skills to work with complex and sophisticated systems that otherwise would demand highly specialized expertise. User-friendliness also tends to change the abilities required in the labor force. Efficient utilization of a word processor depends on different skills than manual typing. Mistake-free entry is not so important, but taking advantage of the full range of capabilities of the system requires a certain grasp of its logic and capabilities-mental skills, not manual (and different from the spelling and grammar now learned in school). Productivity in many types of jobs will increasingly depend on such abilities; it would be doubly unfortunate if the U.S. electronics industry were to suffer shortages of trained people at the same time that large numbers of Americans find themselves without work because they lack the capabilities that this and other industries depend on.

Like all technical change, advances in electronics will bring a mix of positive and negative effects; at present, there is little factual basis for either an optimistic or a pessimistic view of the longer run impacts, Firms manufacturing electronics products will, for some years, continue to create substantial numbers of new jobs. In U.S. manufacturing as a whole, the rate of growth of job opportunities has already slowed, and jobs may go down in absolute terms. A major source of declines will be computer-assisted automation. Will job growth elsewhere compensate? Anticipating events in the service sector, where productivity growth has been low, is more problematic than in manufacturing. While there may be only a few cases of employment impacts as severe as in newspaper printing, there will be a multitude of adjustment problems for individuals; these are likely to accelerate as electronics technology continues to permeate both manufacturing and services. in the end, much will depend on overall rates of economic growth.

Job opportunities also depend on competitiveness. Employment typically falls when industries lose ground in either domestic or international markets. Even if aggregate economic growth brings greater demand, only the more efficient companies can take full advantage. Generally speaking, *firms and industries that make effective use of new technologies will generate new jobs, or if jobs are lost, this will come more slowly;* indeed, companies seldom have any choice but to adopt new technologies if they wish to remain competitive. Those that move quickly (but not too quickly) can often gain an edge over their competitors via new products or productivity improvements in existing lines of business. Ultimately, the greatest numbers of jobs may disappear where firms, industries, or nations do not keep pace with technological advance.

Firms or industries whose competitive position is already in decline may be forced to automate or pursue other routes to lower costs and higher productivity simply to survive, In some cases, then, declining employment is associated with attempts to revive competitive advantage, particularly when an industry or firm is threatened with competition from low-wage countries. But it would be a mistake to attribute the accompanying job losses solely to imports. In consumer electronics, U.S. corporations have automated their production facilities and moved offshore; this costs U.S. jobs in the short term, but may expand or help maintain the total market for American products over the longer term. Moreover, as the electronics industry becomes more and more international—with American firms producing goods overseas for foreign markets as well as re-importation, and foreign firms setting up assembly plants here—it becomes increasingly difficult to evaluate impacts on the American labor force in isolation.

Most fundamentally, only by using labor efficiently—which often means investments in automation—can U.S. firms maintain their international competitiveness. Improvements in *productivity-a path way to increased competitiveness—can have serious employment impacts on particular groups of workers, graphical regions, and industrial sectors*. The essential question is: How can the negative impacts on employment be minimized while capitalizing on the potentials of new technology?

Only where the market is expanding rapidly can employment growth parallel productivity advances. This has been the case in the semiconductor and computer industries, but not in consumer electronics. To the extent that the American economy continues to grow only slowly, many of the productivity gains flowing from applications of electronics and computers will have negative first-order effects on employment, Still, few practicable alternatives exist; once robots or other automated technologies become cost effective, the pressures to use them become virtually irresistible. More jobs could ultimately be lost through failure to adopt such technologies than by pursuing them,

The implication is straightforward: *some* people, companies, industries, and regions will lose competitiveness and lose jobs. The relationships between technical change, employment, and international competition may be complex, but *from the standpoint of public policy, the negatives are wholly predictable.* They cannot be avoided, but *the country could prepare for them, both to ease the inevitable adjustments and to help maintain U.S. competitiveness*, Because changes in industrial structure bring new job requirements, policy measures aimed at encouraging both public and privately funded education and training are central to effective adjustment policy.