The Impact of Technology on Labor in Four Industries

Textiles/Paper and paperboard/
Steel/Motor vehicles

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U.S. Department of Labor
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Preface

This bulletin appraises some of the major technological changes emerging among selected American industries and discusses the impact of these changes on productivity and labor over the next 5 to 10 years. It contains separate reports on the following four industries: Textiles (SIC 22); pulp, paper, and paperboard (SIC 2611,21,31,61); steel (SIC 331); and motor vehicles (SIC 371).

This publication is one of a series which presents the results of the Bureau's continuing research on productivity and technological developments in major industries. Previous bulletins in this series are included in the list of BLS publications on technological change at the end of this bulletin.

The bulletin was prepared in the Bureau's Office of Productivity and Technology, Jerome A. Mark, Associate Commissioner, under the direction of Charles W. Ardolini, Chief, Division of Industry Productivity and Technology Studies. Individual industry reports were written under the supervision of Rose N. Zeisel and Richard W. Riche, by A. Harvey Belitsky (textiles), Richard W. Lyon (pulp, paper, and paperboard), Charles L. Bell (steel), and Robert V. Critchlow (motor vehicles).

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Contents

Chapter 1. Textiles

Summary

Diffusion of advanced technologies is revitalizing the textile industry (SIC 22), enabling it to compete more effectively with imports. Almost every aspect of fiber and fabric manufacture is being affected by faster, more automated machinery requiring less unit labor and energy. Nevertheless, many small mills do not find it economically feasible to change over to newer, more expensive equipment.

Definitive measurements of textile industry productivity are not available, but output and hours data suggest that productivity growth during the period 1970–82 was relatively high—about 3½ percent. This was largely a function of a sharp reduction in hours and a modest increase in output. In contrast, productivity growth in the 1960's accompanied strong demand.

Large capital expenditures during the 1970's improved the productivity and effective competitiveness of the industry. A larger share of these outlays was required to meet Government health and safety standards than in many other industries. The outlook is for continued high outlays for new, more productive machinery.

Total textile employment declined at an average annual rate of -2.0 percent during 1970–83, reversing the growth trend of 1960–70. In 1983, employment stood at 744,000 persons, or 26 percent below the 1973 peak. The outlook for 1995, according to Bureau of Labor Statistics projections, is for modest employment advances for the industry as a whole, but with considerable variation among the industry's sectors.

Industry Structure

The textile industry is making significant strides in the adoption of modern technology, following the lead of Europe and Japan. Fundamental changes in textile processing in the United States are revitalizing the industry. But the catchup is not complete. Most small mills have not changed over to the newer, more productive spindles and looms, and even the larger mills are still in the transition stage.

About 5,500 companies convert fiber into some form of yarn or fabric, and some companies turn their fabric into finished consumer goods like sheets, towels, or carpets. Basically, it is still a fragmented, labor-intensive industry, although less so than 10 years ago. In the last decade, a strong shift toward greater capital intensity has occurred in a highly motivated effort to combat domestic and import competition, and to meet Federal cotton dust and noise standards.

In addition, the industry has contracted and consolidated as two major recessions resulted in the closure of less efficient plants. These changes will result in a smaller industry with improved productivity.

Technology in the 1980's

The technology of textile manufacture consists of transforming fiber into finished fabric. This requires many complex, integrated operations which may include opening and carding and/or combing the fiber; spinning or texturing the yarns; knitting, weaving, or tufting; dyeing, printing, and finishing; and processing into consumer goods, e.g., sheets.

Open-end spinning and shuttleless-loom weaving are probably the technologies of prime interest today, greatly affecting productivity and labor. However, almost every other step in fiber and fabric manufacture from texturizing[1] to printing is also being affected by faster, more automated machinery requiring less unit labor and energy.

In this section, selected developments in spinning, weaving, and electronic changes and their impact on labor are discussed; these are summarized in table 1.

Direct-feed carding

While in most mills yarn is still made on a series of discrete machines, more plants are adopting a continuous opening-blending-carding operation, known as direct-feed or chute-feed carding. This eliminates the handling of fiber from machine to machine and actually eliminates an entire process called picking. In the old system, the picking process rolls the fiber into large heavy "laps" which then must be moved manually or mechanically to the carding machine for the next process. Output with direct-feed carding is about 3 to 4 times greater per hour than the older manual system.

Direct-feed carding greatly reduces the need for unskilled and semiskilled labor compared to the conventional processes of opening, blending, picking, and card-

[1] A process which crimps filament yarn for use in knitting and some weaving.

Table 1. Major technology changes in textiles

Technology	Description	Labor implications	Diffusion
Direct-feed carding	Integrates several processes into a continuous operation; eliminates picker machines and associated processes; output per hour increased about 4 times.	Reduces unit labor for unskilled and semiskilled workers in opening and blending. Eliminates picker operator.	Conversion advancing relatively rapidly.
Open-end spinning	Integrates the conventional processes of roving, spinning, and winding. Can produce filling yarn at 4 or more times the output of conventional ring spinning.	Reduces unit requirements for semiskilled spinning, roving, and winding operators, and associated unskilled labor.	In use for 40 percent of the coarser filling yarn output but is still a small proportion of total yarn output.
Shuttleless-loom weaving	Operates at speeds 3 times that of the average shuttle loom, is quieter, and needs fewer auxiliary operations. New shuttleless looms are wider.	Reduces unit requirements for weaving operators; output per hour averages 2½ times that of shuttle loom.	In use for 30 percent of fabric output. Expected to be 40 percent by 1990.
Electronic controls	Sophisticated electronic process controls for operating and maintaining machinery; computer-controlled production in wrap preparation, finishing, and carpet production; robotic technology for materials handling.	Reduces unit labor requirements for laborers, operators, and maintenance personnel. Increases need for electronic specialists.	Small electronic controls widely used. More expensive sophisticated computer controls in large plants only, primarily in dyeing and finishing. Production robots in very early stages of development. Newest computer-controlled carpet printing used by at least one manufacturer.

ing. In this new continuous system, no picker operators are required nor are the laborers who move the heavy fiber laps. Without the fiber laps, labor for cleaning and maintenance is also greatly reduced. In addition to being considerably more productive than conventional operations, the direct-feed or chute-feed process also meets Federal requirements for lower cotton dust levels, since the opening-to-carding operations are the major areas of cotton dust generation.

Open-end spinning

The final step in yarn manufacture is spinning. Only 10 years ago, ring spinning was almost exclusively used in the United States, but today, open-end or rotor spinning produces about 40 to 50 percent of the coarser filling yarn. (Filling yarn used in weaving is the crosswise yarn.) While rotor spinning is now the method of choice for the coarser yarn, its diffusion in the United States has been slow compared to that in other major countries. In Europe, open-end spinning has been the major process for this type of filling yarn for many years.

Where applicable, the advantages of open-end spinning are manifold. It eliminates two processes of drawing, one of roving, and can produce 4 to 5 times the output per hour of the conventional spindle with less labor. It reduces space requirements, maintenance and cleaning requirements, and downtime. Altogether, it is less labor intensive, requiring less unskilled and semiskilled labor.

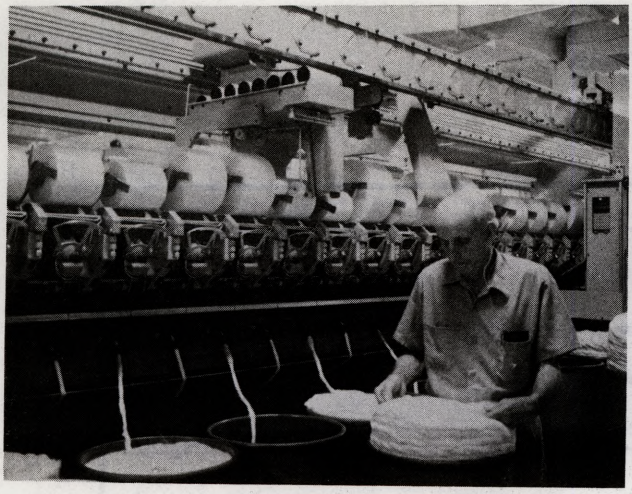
Moreover, automatic doffing machinery can be built with the new open-end spindles. Since doffing (removal of full bobbins) is one of the most labor-intensive operations in the mill, the successful automation of this process greatly improves productivity. With this automated process, the job of the doffing operator can be eliminated. Although commercially available for a dozen years, the application of automatic doffing to the older spindles was not efficient.

Rotor or open-end spinning, which has greatly improved since its introduction in the mid-1960's, will continue to replace ring spinning, but slowly. Now producing stronger yarn than previously feasible, new rotor spindles have automatic cleaning, doffing (removal of full packages), and piecing (repairing broken yarn) on many models. Moreover, new models of rotor spinning are now available for a wider range of yarns. Nevertheless, ring spinning will continue to be the major process.

Shuttleless-loom weaving

New shuttleless looms are faster, wider, quieter, cleaner, and require considerably less unit labor than shuttle looms. The U.S. industry was slow in accepting shuttleless looms, but now, diffusion is increasing rapidly in an effort to stay competitive. Also, Government regulations to reduce unhealthy noise levels of the old loom shed give additional motivation. In 1982, U.S. mills had in place or on order almost 5 times as many shuttleless looms as in 1973. Shuttleless looms are now producing about one-third of the total fabric output, and this ratio is expected to increase to 40 percent by 1990.

Unit labor requirements are lower than on a conventional fly shuttle, particularly for maintenance personnel and semiskilled operators and auxiliary workers. Shuttleless looms require less maintenance, and



The operator monitors the spinning machine.

downtime is reported to be less. Most shuttleless looms are self-lubricating, and electronic controls permit monitoring of the looms to aid maintenance personnel and supervisors. Unit requirements for operators are reduced because output per hour is greater. Moreover, since output per machine hour is greater than on the fly-shuttle loom, fewer machines are required for a given output. One mill of a major textile company replaced 6,600 older shuttle looms with about 1,150 shuttleless jet looms.

However, newer looms are relatively expensive and require more highly skilled technicians. It is not economically feasible for many smaller mills to replace older operating looms with the new shuttleless looms.

Many types of shuttleless looms are available to U.S. mills: Rapier (the largest number in place), missile, water jet (restricted to 100-percent synthetics), and air jet (currently very popular). As an example of the operation, the air-jet looms weave the cloth by propelling the filling (crosswise yarn) across the warp (lengthwise yarn) on high-pressure streams of air.

Electronic instrumentation

Extensive diffusion of electronic instrumentation is an integral part of the industry's changeover to a more capital-intensive system. Microprocessors and more sophisticated instrumentation are reducing labor requirements for machine operators, maintenance personnel, and unskilled laborers. They are reducing downtime and improving quality while upgrading requirements for repair technicians and electricians.

Electronic controls are widely used in large and small mills and are incorporated into the newer machines. But more expensive computer-controlled systems are generally used only in large plants. Dyeing and finishing operations, which lend themselves more readily to continuous operation, have been adopting these electronic technologies for some time. At least one manufacturer utilizes a computer-controlled system for carpet printing, which makes small batch operations economically feasible.

Solid-system controls (programmable controls) are performing many functions in the mill. They are being programmed with a "simple language" that requires little training, and they have a "memory." These controls are now being used in the mills for materials handling, management reporting, and process control.

A growing number of companies now have computer-controlled operations. In one mill, a computer-directed handling system moves material from truck unloading to the placement of heavy beams of yarn in racks. This eliminates much of the unskilled labor in the mill.

Robots have been introduced in some mills. While only a few mills have this newest technology, it is an indication of the industry's shift toward a capital-intensive system. In one mill, the robot, when directed to do so, places the filling yarn on a conveyor for delivery to the weaving shed.

Output and Productivity Trends

Output

Textile mill output (roughly measured by the deflated value of shipments[2]) fluctuated sharply during 1970-82. It followed the general cyclical pattern of the overall economy with sizable declines in the economic recessions of 1974-75 and 1980-82 (chart 1). The industry's average annual rate of increase in 1970-82 was less than 1.5 percent, compared with about 5.0 percent in 1960-70. While the textile rate of growth in 1970-82 was about one-half of the manufacturing rate, it was quite similar to the manufacturing rate in the earlier decade.

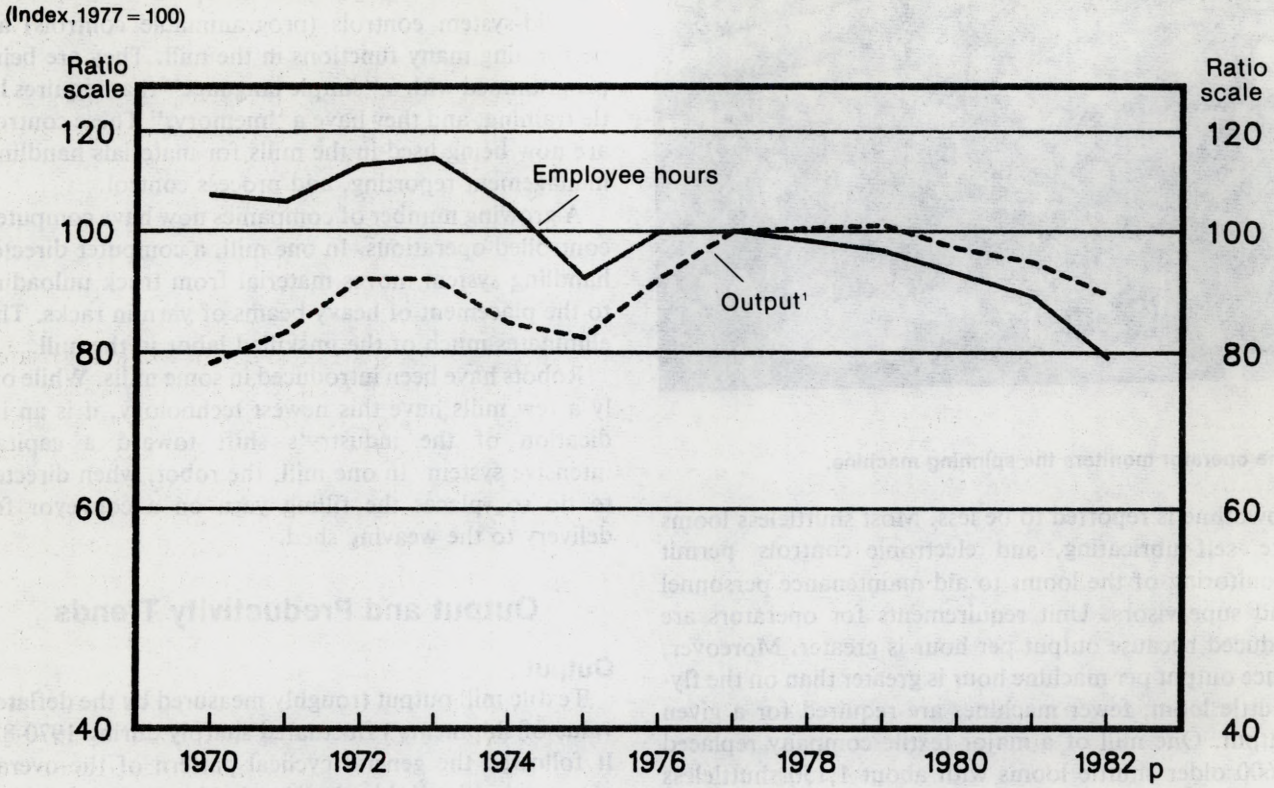
Peak output occurred in 1979, after increasing at an annual rate of about 2.5 percent from 1970. Output then declined in the following 3 years. Textile output in 1982 was more than 10 percent below the 1979 peak. However, the 1983 production index of the Federal Reserve Board indicates a sharp upward trend.

Although the industry recorded slow output growth overall, several sectors remained relatively strong during 1970-81 (data for 1981 are the latest available). The floor-covering sector grew at the fastest rate, about 4 percent, but this was only one-third the rate in the 1960's. Knitting, one of the strongest sectors in the past, increased at an average rate of less than 2 percent in 1970-81 compared with over 8 percent a decade earlier. Of the major sectors, only two showed a decline in output from 1970 to 1981: Cotton weaving (about -1 percent average annual rate) and wool weaving and finishing mills (about -3 percent).

Most sectors of the industry did not substantially change their share of total output between 1970 and

[2] Deflated value-of-shipments data (shipments data from the Bureau of the Census) are used to represent output for total textile mill products and the individual sectors of the industry.

Chart 1. Output and employee hours, textiles, 1970-82



[1] Deflated value of shipments, unpublished data.
p=preliminary.

SOURCE: Bureau of Labor Statistics.

1981. But important shifts did occur within the sectors. Knitting continued to account for about one-quarter of total output. The combined output of the weaving sectors was also about one-quarter of output in 1981, but that share had fallen from 30 percent in 1970. Within the weaving sector, sharp output declines occurred in cotton and wool, with only a slight increase in synthetics. The floor-covering sector increased its share to 13 percent, but the yarn and thread sector and the finishing sector remained relatively stable, with about 10 percent and 15 percent, respectively, of total output.

Basically, the outlook for textile demand depends on the strength of the economy, particularly on the apparel, auto, and housing markets. Demographic changes will also play a major role. For example, the number of persons in the age group 25-39—the largest consumers of apparel—will be increasing more rapidly than total population over the next decade. In addition, new industrial textile products are being developed; some of these replace older products, but some involve new applications. However, import penetration of textiles and apparel remains of prime importance in any evaluation of textile demand.

Imports

Imports continue to be a problem to the industry in spite of international agreements to control their growth. From 1972 to 1975, imports declined sharply, reflecting currency changes and fiber shortages. However, when economic conditions were reversed, imports started climbing. By 1983, the strong dollar and the worldwide recession brought imports of textile and apparel products to 16 percent of apparent domestic consumption (production plus imports minus exports; in pounds) compared with 9 percent 10 years earlier.[3] Most of the increase was in cotton products.

To control import growth, the Federal Government has entered into bilateral arrangements with countries around the world within the framework of the Multifiber Arrangement of 1974 extended in 1982. In 1983, the four largest suppliers of apparel and nonapparel textiles (in square yard equivalents) to the United States were Taiwan, South Korea, Hong Kong, and China. The new agreements are all more restrictive than in the past but no rollbacks were made.

Productivity

Because of the limitations of available data, the Bureau of Labor Statistics does not publish measures of

[3] U.S. International Trade Commission, *U.S. Imports of Textiles and Apparel Products Under the Multifiber Arrangement, 1976-83*, USITC 1539, June 1984.

productivity for the textile industry. However, the approximate trend in productivity growth can be estimated from available output (deflated value of shipments) and employee hour data. These data suggest that textile productivity growth has been relatively high in the last two decades. From 1970 to 1982, the average annual rate of growth of about 3.5 percent was not much below the rate in the 1960's. This was considerably stronger than the rate for all manufacturing of 2.3 percent for the period 1970-82 and 2.9 percent in the 1960's.

While productivity growth in the last decade was relatively high, it did not reflect the economic strength of the 1960's, when output grew sharply and hours rose moderately. The productivity advance between 1970 and 1982 was largely a function of reduced employee hours, as output fluctuated. In 1982, employee hours were at a very low level, having declined almost steadily since the peak in 1973.

Considerable variation in productivity growth patterns was evident among sectors of the industry during 1970-81 (1981, latest data), but the rate was relatively high for almost all sectors. Using deflated value of shipments as an output measure, the data show that 1981 was a year of peak productivity and sharply reduced hours in almost every major sector. Floor-covering mills and textile finishing mills had the largest productivity advances of all major sectors (about 5 percent) over those years. Productivity growth in the synthetic fiber weaving mills was also comparatively high, almost 4 percent for the same period, while knitting mills were only slightly lower. Although the wool weaving mills had a sharper decline in output than the cotton weaving mills, a very steep decline in employee hours in the former resulted in a productivity growth rate of over 3 percent, or twice the rate in the cotton weaving mills. Only cotton weaving and narrow fabrics had less than a 2-percent productivity growth rate.

Official BLS measures are available for two sectors of the textile industry, hosiery and nonwool yarn mills. While the hosiery industry's productivity advanced at the rapid average annual rate of 4.8 percent during 1970-83, nonwool yarn mills increased 2.5 percent. The productivity rates of these two industries were based on small average annual rates of increase in output over the period (2.2 percent in hosiery, and 1.5 percent in nonwool yarn mills), but their experiences with employee hours were quite different. Hours in the yarn industry declined relatively slowly (at an annual rate of -1.0 percent), while hours in hosiery moved down more sharply (-2.4 percent), responding to technological advances.

Investment

Capital expenditures

Large capital expenditures during the 1970's improved productivity and the effective competitiveness of the industry. Outlays for plant and equipment in the 5 years ending with 1983 averaged nearly $1.5 billion annually, 30 percent above the previous 5-year period. Even after adjustment for inflation, the industry's capital expenditures stood at relatively high levels in most years of the last decade. Nevertheless, in constant dollars, annual expenditures for the 5-year period ending with 1983 were 8 percent below the outlays of the previous 5 years.[4]

To meet the standards of the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA), the textile industry has had to allocate a larger share of its capital outlays for safety and health equipment than many other industries.

In some operations, such as in the opening-to-carding processes where cotton dust levels are highest, Federal regulations are difficult to meet without new or overhauled equipment. Although opinions differ, some industry specialists believe that Federal regulations for reduced cotton dust levels have been "contributing to the increased pace and intensity of modernization."[5]

While capital outlays for safety and health equipment are expected to decline in future years, large outlays for newer and more productive equipment will continue to be important. According to a McGraw-Hill survey of executives of large textile companies, 27 percent of textile equipment was technologically outmoded in 1980, compared with 11 percent in 1978. No later data are available, but as newer machines improve their performance, and if labor and energy costs rise, the proportion of equipment considered obsolete will continue to increase.

Research and development

In general, research and development (R&D) in the textile field is carried out by the chemical companies that produce synthetic fibers and the predominantly foreign companies that manufacture textile equipment. With few exceptions, domestic textile manufacturers of yarn and fabric spend only small amounts on R&D and concentrate instead on design, styling, and market research. According to the National Science Foundation, R&D outlays as a percent of net sales of textile and apparel companies performing R&D has been the lowest of the major manufacturing industries surveyed. (Data for the textile industry only are not available.) In 1981, textile and apparel company outlays were only 0.4 percent of net sales, compared with 3.2 percent for total manufacturing. Only the food industry was at this low a level.

[4] Bureau of Economic Analysis, U.S. Department of Commerce. The data include outlays for replacement of existing equipment, for expansion, and for major alterations, repairs, and improvements.

[5] Brian Toyne, et al., *The U.S. Textile Mill Products Industry: Strategies for the 1980's and Beyond* (University of South Carolina, Center for Industry Policy and Strategy, 1983), p. 3-2; and Ruth Ruttenberg, *Compliance With the OSHA Cotton Dust Rule, the Role of Productivity Improving Technology,* for Office of Technology Assessment, March 1983, p. 103.

Employment and Occupational Outlook

Employment

Total employment in the textile industry declined at an average annual rate of -2.0 percent during 1970-83, reversing the growth trend of 1960-70. Employment rose in only 3 of the last 13 years (chart 2). It fell sharply in the 1974-75 recession, and, after only 1 year's recovery, declined steadily during 1977-83. In 1983, employment stood at 744,000 persons, or 26 percent below the 1973 peak.

Employment declined in every major sector in the 1970-83 period, and the patterns were very similar, as shown on chart 2. Employment in the combined sectors of spinning and weaving fell -2.0 percent annually but the rates of decline within the sectors differed considerably. The cotton and wool weaving sectors had relatively large rates of decline while synthetic weaving had the slightest decline of any major sector. In the knitting sector, employment fell an average of -1.9 percent, but the finishing sector recorded a relatively larger rate of -2.5 percent. Floor-covering and miscellaneous textile sectors declined at slower average rates, -1.6 and -1.4 percent, respectively.

The 1982 recession caused many plant closings. In that year, 43 textile plants closed permanently in North and South Carolina alone. While these closings reflect the recession, the majority of the plants closed because they were too old to retrofit. According to a South Carolina public administrator, the plants "were in many ways victims of technological advances. They just couldn't effectively compete with textiles' progress today."[6]

The various sectors' shares of total textile employment generally showed only small shifts during 1970-83. Spinning and weaving accounted for 49 percent of the total; knitting, for 28 percent. The other major sectors, finishing and floor covering, made up about 9 and 7 percent, respectively. Miscellaneous textile goods accounted for 8 percent and included such diverse products as lace goods and tire cord and fabric.

Looking ahead to 1995, BLS projections, based on three versions of economic growth,[7] suggest modest employment advances for the industry as a whole, but with considerable variation among the industry's sectors. For the total industry, the BLS projections show an average annual rate of increase of between 0.8 and 1.2 percent from 1983 to 1995. Advances are projected for seven sectors, while two sectors—cotton weaving and wool weaving and finishing—are expected to incur relatively large declines.

[6] Douglas McKay III, South Carolina Statistics and Research Administrator, in *Textile World,* January 1983, p. 23.

[7] *BLS* projections for employment in 1995 are based on three alternative versions of economic growth for the overall economy. The alternative assumptions are described in the November 1983 issue of the *Monthly Labor Review.*

The ratio of production workers to all employees has remained relatively high. This is associated with the difficulty or cost of automating some processes, and the relatively limited diffusion of some new machinery. In 1983, production workers constituted about 86 percent of all textile workers, compared with 68 percent in all manufacturing.

The proportion of women in the textile industry's work force rose slightly from 1970 to 1983. It was at its peak of nearly 48 percent in 1983, considerably above the 32 percent for all manufacturing industries. Of the major textile sectors, knitting mills consistently had the highest proportion of women employees, about 65 percent, and the narrow fabrics sector followed with 58 percent.

Occupations

With mill modernization, greater demand has developed for more highly skilled workers. In some areas, skilled technicians and engineers are in short supply. Similarly, managers' jobs now require technical as well as managerial skills in order to make the best use of machines and labor. For example, computer information is available to the manager for every loom in the plant and requires skilled technical analysis.

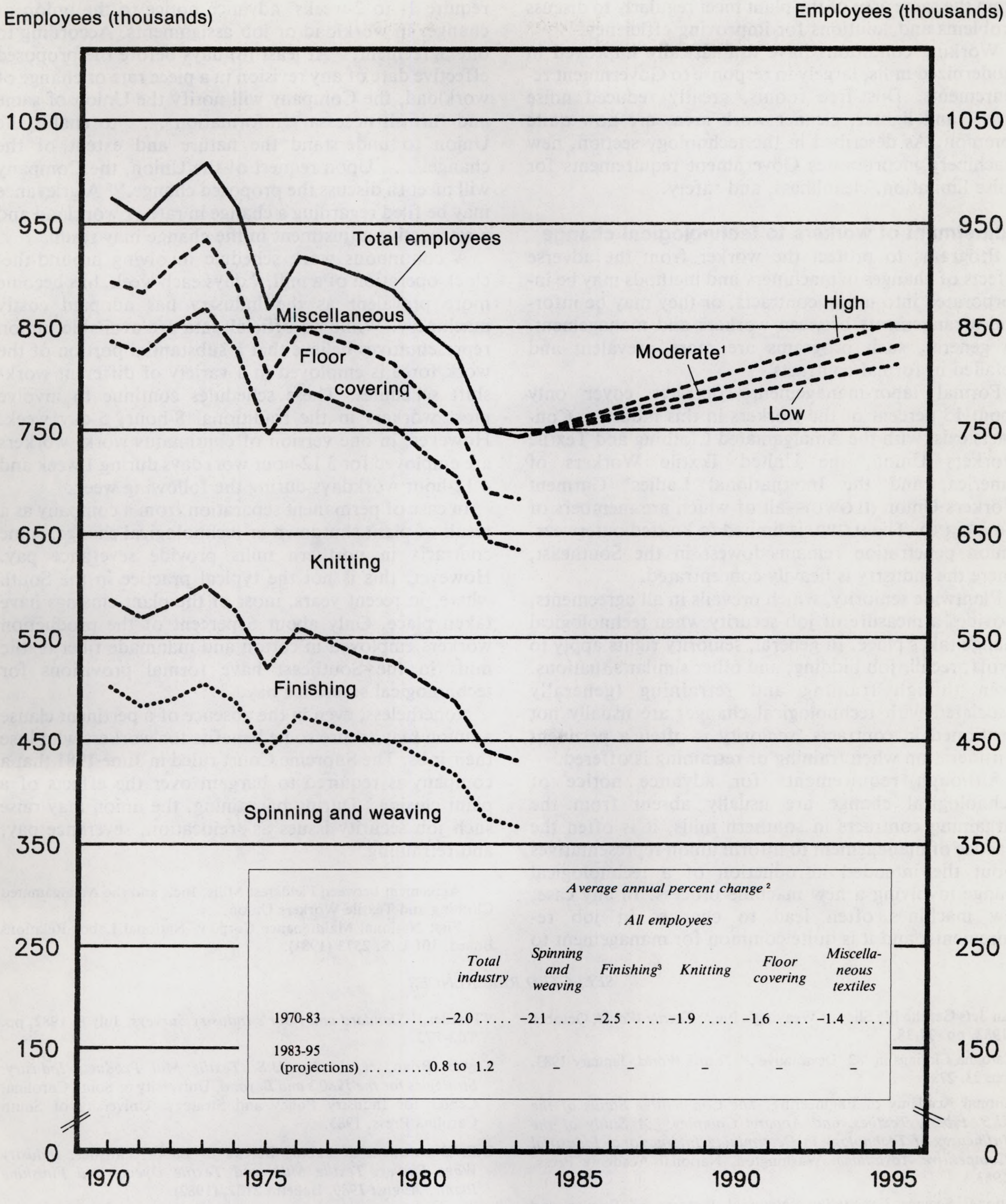
Although higher skill levels are required for technical and professional personnel, the skill requirements for some operators may actually be lower. For example, skills required to operate rotor open-end spinning equipment may be less than those required to operate conventional ring spinning. Although newer machines are more complex than those they replace, they are also more automated or mechanized and require less manual dexterity or speed.

Training for new equipment is usually offered by the machine manufacturer, and lengthier on-the-job training follows. Because the newer machines are more automated, training time is relatively shorter than on the older equipment. For example, retraining the operator from ring spinning to open-end spinning may require only several hours, according to one manufacturer. In contrast, retraining the fixer would take a couple of weeks. Training for computer operators and electronic technicians is often a joint venture of a vocational training school, the machine manufacturer, and the textile mill.

Unskilled jobs have been greatly reduced in the modern plant. Mechanization of materials handling and transport and warehouse operations is now quite common. Also, the use of unskilled maintenance workers has been reduced where vacuum devices on machines and mechanical means of cleaning have been installed to comply with OSHA regulations.

Worker involvement has increased in some plants. While not a new concept, worker participation has grown in an attempt to reduce defects or absenteeism

Chart 2. Employment in textiles, 1970-83, and projections, 1983-95



¹ See text footnote 7.
² Least squares trends method for historical data; compound interest method for projections.
³ Except wool.

SOURCE: Bureau of Labor Statistics.

and improve productivity. In one major yarn plant which has instituted quality circles, 8-12 employees from the same area of the plant meet regularly to discuss problems and solutions for improving efficiency.

Working conditions have dramatically improved in modernized mills, largely in response to Government requirements. Dust-free rooms, greatly reduced noise levels, and lighter, cleaner work areas are now quite common. As described in the technology section, new machinery incorporates Government requirements for noise limitation, cleanliness, and safety.

Adjustment of workers to technological change

Programs to protect the worker from the adverse effects of changes in machinery and methods may be incorporated into union contracts, or they may be informal arrangements between workers and management. In general, such programs are more prevalent and detailed in formal contracts.

Formal labor-management contracts cover only about 15 percent of the workers in this industry. Contracts exist with the Amalgamated Clothing and Textile Workers Union, the United Textile Workers of America, and the International Ladies' Garment Workers Union (ILGWU)—all of which are members of the AFL-CIO. The ILGWU is limited to knitted outerwear. Union penetration remains lowest in the Southeast, where the industry is heavily concentrated.

Plantwide seniority, which prevails in all agreements, provides a measure of job security when technological change takes place. In general, seniority rights apply to layoff, recall, job bidding, and other similar situations. Even though training and retraining (generally associated with technological change) are usually not mentioned in contracts, seniority is often a pertinent consideration when training or retraining is offered.

Although requirements for advance notice of technological change are usually absent from the bargaining contracts in southern mills, it is often the practice of management to inform union representatives about the intended introduction of a technological change involving a new machine process. In any case, new machines often lead to changes in job requirements, and it is quite common for management to inform the union about changes in workloads, job assignments, and related pay changes. Some contracts require 1- to 2-weeks' advance notice to the union of changes in workload or job assignments. According to one agreement: "At least (6) days before the proposed effective date of any revision in a piece rate or change of workload, the Company will notify the Union of same and furnish necessary information . . . to enable the Union to understand the nature and extent of the change. . . . Upon request of the Union, the Company will meet to discuss the proposed change."[8] A grievance may be filed regarding a change in rate or workload and a retroactive adjustment in the change may result.

A continuous work schedule involving around-the-clock operation of a mill, 7 days each week, has become more prevalent as the industry has adopted costly machinery. While no official data are available, union representatives believe that a substantial portion of the work force is employed in a variety of different work-shift schedules. These schedules continue to involve most workers in the traditional 8-hour, 5-day week. However, in one version of continuous work, workers are employed for 3 12-hour workdays during 1 week and 4 12-hour workdays during the following week.

In case of permanent separation from a company as a result of plant shutdown or technological change, some contracts in northern mills provide severance pay. However, this is not the typical practice in the South where, in recent years, most of the plant closings have taken place. Only about 6 percent of the production workers employed in cotton and manmade fiber textile mills in the Southeast have formal provisions for technological severance pay.

Nonetheless, even in the absence of a pertinent clause a union may secure some benefits for workers who lose their jobs. The Supreme Court ruled in June 1981 that a company is required to bargain over the effects of a plant closing.[9] During bargaining, the union may raise such job security issues as relocation, severance pay, and retraining.

[8] Agreement between Fieldcrest Mills, Inc., and the Amalgamated Clothing and Textile Workers Union.

[9] First National Maintenance Corp. *v.* National Labor Relations Board, 101 U.S. 2573 (1981).

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Chapter 2. Pulp, Paper, and Paperboard

Summary

The pulp, paper, and paperboard industry[1] is highly mechanized, and innovations underway primarily involve improvements in speed and capacity of basic conventional technology. Technological changes are being adopted in the major steps of production of pulp, paper, and paperboard, from the initial woodyard and woodroom operations to the end-stage finishing and shipping tasks. Major innovations include an increase in the capacity of papermaking machines and other basic production equipment, the more widespread use of computer process control and advanced instrumentation, and the installation of more highly mechanized materials handling and warehouse systems.

Productivity (output per employee hour) rose at an annual rate of 2.7 percent during the period 1970 to 1983, with the largest gains in the early and middle segments of this period. The productivity increase resulted when output increased at an annual rate of 1.6 percent over this period, and employee hours declined at an annual rate of 1.1 percent. Prospects for productivity gains into the mid-1980's appear improved, as output and capacity utilization increased as the economy recovered in 1983.

The industry has allocated substantial funds to modernize plant and equipment and to protect the environment through control of pollution. Between 1970 and 1981, expenditures for new plant and equipment totaled nearly $25 billion (current dollars), with spend ing by paper mills (SIC 2621) accounting for about one-half of total outlays. Investments increased during the late 1970's as the industry sought to lower manufacturing costs through modernization of facilities. The industry also spends millions of dollars annually on research and development (R&D), although expenditures are relatively low when compared to other manufacturing industries.

Employment in the pulp, paper, and paperboard mills industry has declined steadily since 1970. In 1983, employment totaled 253,700 workers, down by 36,000 from 1970 levels. The annual rate of decline over this period was 0.6 percent. Although the modernization of plant and equipment has not resulted in extensive industrywide displacement, significant reductions in unit labor requirements were reported by mills which installed high-speed papermaking machines and other improvements, and some high-cost facilities were closed down. Moreover, machine tenders and other operators increasingly monitor computer controlled and highly instrumented production equipment which reduces their manual tasks. Looking ahead, the industry is not expected to be a major source of new jobs through 1995; BLS projections indicate that employment may remain about the same, or increase only moderately.

The pulp, paper, and paperboard industry is highly unionized; nearly all the work force is employed in mills where collective bargaining contracts cover the majority of the work force. Provisions in these agreements pertaining to seniority, reassignments and layoffs, training, and related matters can facilitate adjustment to technological change. The training of maintenance employees to become skilled in several crafts and the creation of labor-management committees to promote productivity and other goals are major important developments.

[1] The pulp, paper, and paperboard industry covered by this report includes the following Standard Industrial Classification (SIC) industries: SIC 2611, pulp mills; SIC 2621, paper mills (except building paper mills); SIC 2631, paperboard mills; and SIC 2661, building paper and building board mills.

Technology in the 1980's

The technological changes underway in the pulp, paper, and paperboard industry, summarized in table 2, generally involve improvements in the size and capacity of papermaking machines and other conventional production equipment. The introduction of advanced computer control and instrumentation systems and major improvements in materials handling systems in finishing and shipping operations are among the most significant changes. Improvements in the basic processes to produce pulp will reduce pollution and utilize energy and raw materials more efficiently. Research to develop new paper products with special properties will continue to broaden markets. Although technological improvements are expected to continue to bring about productivity gains in key operations, widespread displacement of workers is not anticipated. However, training programs to provide workers with the skills required to operate and maintain advanced equipment will continue to be important.

Papermaking machines

The introduction of papermaking machines of greater speed and capacity is a major source of productivity

Table 2. Major technology changes in pulp, paper, and paperboard

Technology	Description	Labor implications	Diffusion
Improved papermaking machines	New machines are larger and faster and feature advanced computer control systems. Older machines, including smaller ones, are also being modernized. Auxiliary equipment such as devices to wind and slit paper rolls leaving the machine are being automated.	Technological improvements in papermaking machines have resulted in productivity gains. One mill with a new, high-capacity papermaking machine produced twice the volume of uncoated white paper with about the same size crew used on less advanced machines. Crew size generally remains unchanged on existing machines that are modernized but duties are different.	Data on use of new, modernized papermaking machines are not available; outlook is for more widespread adoption. New mills are installing advanced model machines. New machines are expensive, and their introduction will depend on market demand for paper and availability of funds for modernization.
	Some mills are getting more out of their high-output machines as part of an automation program that extends capacity and improves efficiency.	Crews are being trained to monitor and maintain the advanced process control and instrumenation systems. These duties are markedly different compared to less advanced machines where crew members located at stations along the machine make adjustments manually.	
Improved pulping technology	Improved methods increase yield, quality, and control of pollution. They include continuous digesters that produce pulp in uninterrupted flow rather than separate batches, batch pulping systems with advanced process control, and modification of equipment used to process pulp. Thermomechanical pulping systems, which prepare mechanical pulp under high operating temperatures, are being adopted more widely to produce groundwood pulp. Use of the chemical anthraquinone (AQ) in certain pulping processes has increased productivity and achieved other benefits.	Labor impact has been minimal; some modification of job duties associated with conversion to continuous pulping and computer process control has resulted. Labor requirements per ton of pulp are lower in new systems, but significant displacement of operators and other crew members has not occurred. Operators in continuous pulping systems monitor operations from central control centers, and the manual labor associated with tending and loading separate batch cooking vessels is no longer required.	About 50 percent of kraft pulp (the leading type) is prepared in continuous digesters, which are being installed in new plants and some existing mills. The proportion of pulp produced by continuous methods is expected to increase. Thermomechanical pulping systems are forecast to account for 30 percent of mechanical pulping capacity by 1985, up sharply from 2 percent in 1975. The technology to wash, bleach, and refine pulp will be modified, but radical departure from past methods is not anticipated.
Computers and instrumentation	Computers and advanced instrumentation are being introduced to control production throughout the cycle of making pulp, paper, and paperboard. Latest systems incorporate microelectronic devices that improve performance and reliability.	The impact of these changes on machine tenders and other operators generally involves a modification of job duties and training in new skills. New job duties involve more extensive monitoring from control centers, and less manual tasks. Displacement has been minimal, but crew size has been cut back in some installations.	The industry is a major user of process control equipment, and their purchases account for about 10 percent of the U.S. market. Computer control is used most widely on papermaking machines and on digesters. Programmable controllers and other types of instrumentation are being extended to more manufacturing operations. Outlook is for continued application of advanced control technology; some experts predict that millwide process control networks ultimately will tie together separate processes.
Materials handling and storage	Innovations in materials handling involve larger capacity conveyors and related equipment, and integrated control systems which mark a higher level of automation. They incorporate computer control, laser scanning devices, and other features which achieve economies. Computerized systems to transport and store products in warehouses also are increasing.	Advanced materials handling systems lower labor requirements of equipment operators and materials handlers. New technology modifies job requirements to include a greater degree of equipment monitoring from a central control station, and less manual handling of products and manipulation of control devices. One firm which introduced a state-of-the-art system to automate warehouse tasks eliminated 20 jobs and achieved other efficiencies.	Automation of sheet cutting and packaging is broadly diffused in paper mills, but advanced paper roll handling and wrapping systems which feature computer control and laser scanning technology are less widely used. Automated warehouse operations are in limited use.

gains. Plants which are modernizing facilities are introducing the latest model Fourdrinier and twin-wire machines. One large mill reportedly is spending $200 million to install a new papermaking machine which will turn out twice the volume of uncoated white paper using about the same size crews as the less advanced model—a substantial gain in productivity.

Advance computer control systems and improved instrumentation are features of the new papermaking machines. Machine crews are being trained to operate new process control computer systems which require changed job duties and skills. Increasingly, operators located in an air-conditioned control room monitor and control papermaking machines, a marked contrast to the former manual adjustments undertaken by the crew at stations located along the papermaking machine. Automated equipment to wind and slit paper leaving the papermaking machine feature advanced control systems which reduce labor requirements of the backtender or other crew members assigned these tasks. Quality also is improved by these new machines.

Improvements in smaller papermaking machines (with under a 130-inch wide forming wire) have failed to keep pace with those on the larger machines. Moreover, some technologies, such as twin-wire forming and high-load presses, are not economically feasible for small-size papermaking machines. However, recent developments in technology, such as drainage devices and controls, new types of press rolls, and high-efficiency dryer fabrics have achieved improvements in the approximately 600 smaller papermaking machines operating in the United States in 1983. One firm, for example, modified the main drive and dryer section of a small papermaking machine and initiated other improvements which resulted in a 15-percent increase in machine speed and a 19-percent increase in output.[2] Crew size and the structure of occupations generally remain unchanged on the smaller machines

Pulpmaking

Innovations are underway in the three basic methods used to prepare pulp: Chemical, mechanical, and semichemical. These include the limited use of new processes and modifications to the basic equipment to produce pulp, and in auxiliary equipment where the pulp is further treated prior to being transported to the papermaking machine. The major benefits of these changes include improved pulp yield, strength, and quality.

Continuous digesters (equipment that produces pulp continuously rather than in separate batches) are commonly used. Continuous digesters with automatic controls eliminate the intermittent flow of wood chips and the manual starting and stopping of each batch of pulp required in batch pulping. According to one major supplier of this technology, about 50 to 55 percent of kraft pulp (the leading type) is prepared in continuous digesters, with the proportion expected to increase over the next decade. New mills are using continuous digesters, and some older mills are converting batch systems. Advantages of continuous pulping include increased production, improved quality, steam savings per ton of over 50 percent, and higher yield.

Batch pulping systems incorporating advanced process control technology also are achieving operating economies and provide flexibility in production.

Thermomechanical pulp (TMP), which involves mechanical pulping using a refining process, is being used more extensively, and increasingly with a brief chemical pretreatment. Pulp produced by this process has stronger fibers compared with pulp prepared by the conventional mechanical, or groundwood, process. Thus, thermomechanical pulp can be used for newsprint without the customary addition of more expensive chemical pulp. Other advantages of TMP include lower labor requirements and less pollution. Moreover, both logs and sawmill waste can be utilized, and TMP pulp has excellent drainage which allows high-speed papermaking machine operation.[3] In the TMP process, heat can be recovered to generate power and for use in other mill operations.[4] Although TMP capacity comprises only about 4 percent of the total for all pulp grades, TMP's share of total mechanical pulping capacity has increased markedly, from 2 percent in 1975 to 30 percent forecast for 1985, according to the American Paper Institute (API).[5]

The use of anthraquinone (AQ), a chemical added to certain types of chemical pulpmaking processes, is another development in limited but growing use. AQ reportedly increases output of pulp per hour, lowers consumption of wood per ton of pulp produced, reduces energy requirements, and lowers pollution associated with emission of sulfide.[6]

Computers and instrumentation

The application of process control computers and instrumentation to pulp and papermaking is expected to continue to increase during the 1980's. The industry is reportedly the fourth largest purchaser of process control equipment, and accounts for about 10 percent of the U.S. market.[7] As indicated earlier, the impact of computer control and instrumentation on papermaking machine tenders and other operators primarily involves a change in job duties to more extensive monitoring of the process from control centers and reduced physical involvement in setting of control devices. Displacement is minimal, but training of operators and maintenance staff is becoming more important as process control is being diffused more widely.

Technology to improve control of production is being applied throughout the cycle of making pulp, paper, and paperboard. Computer control is most widely

[2] E. Richard Woodard, "Smaller Papermaking Machines: Improving Preformance Via Modern Technology," *Pulp and Paper*, April 1983, pp. 86–88.

[3] Jacques Bastien and Gilles Marquis, "Soucy's Six Years' Experience with 100 % TMP Furnish for Newsprint," *Pulp and Paper*, June 1983, pp. 78-80.

[4] *U.S. Industrial Outlook, 1982* (U.S. Department of Commerce, Bureau of Industrial Economics), p. 42.

[5] *1983 Statistics of Paper, Paperboard, and Wood Pulp*. American Paper Institute (New York, 1983), pp. 32-33.

[6] *Ibid.*, p. 42.

[7] "Paper—Key Market for Process Controls," *Paper Trade Journal*, Feb. 28, 1982, p. 3.

Modern crane removes logs from truck prior to processing.

from the recession. Demand for products of the paper industry generally increases at a rate above general business activity during the early stages of a recovery. However, combined capacity for paper and paperboard between 1983 and 1985 is projected to increase at a rate somewhat below the 2.2-percent gain achieved over the preceding 15-year span.[13]

Productivity

Productivity in the pulp, paper, and paperboard industry (output per employee hour) increased at an average annual rate of 2.7 percent during the period 1970–83. The productivity gain reflected an output increase at an annual rate of 1.6 percent over this period, and a decrease in employee hours at an annual rate of 1.1 percent. The largest year-to-year gain was 9.6 percent from 1975 to 1976 when output rose by over 16 percent as the paper industry recovered from recession.

However, the productivity rate varied within the period. Between 1970 and 1973, for example, the annual growth rate of output per employee hour averaged a substantial 6.0 percent; between 1973 and 1978, it slowed to 2.8 percent; and, during 1978–83, again slowed, to 1.7 percent.

[13] Peter Wuerl, "API Sees Annual Capacity Growth Drop Through 1984," *Paper Trade Journal*, Jan. 30, 1983, cover and pp. 45, 46, and 48.

employed on papermaking machines and on large steel vessels called digesters where pulp is prepared by cooking action. Computer control also is being extended to other pulping operations. However, programmable controllers and other types of instrumentation extend to a broader scope of manufacturing operations.

New technology to improve process control is achieving significant operating savings. At one mill undergoing modernization, computer control of two large power boilers is expected to save 50,000 barrels of fuel oil and 5,000 tons of coal per year, with further gains anticipated as the computer system is extended.[8]

Programmable controllers (PC's) are being used more extensively in key production tasks. An example of savings being achieved by PC's is illustrated at a mill which introduced a programmable controller to automate a digester which manufactures pulp. In this installation, the operator monitors the mixing of ingredients using a control panel, and manual participation in the process is reduced. Advantages of the control system include a cutback from two operators to one per shift, a reduction in errors, and the availability of reports on the status of the mixing system generated automatically by the controller.[9] The outlook is for diffusion of millwide process control systems that tie together separate processes to provide a broader scope of control and information gathering.[10]

Materials handling and storage

The manufacture of pulp, paper, and paperboard involves the movement of logs, chips, pulp and other fluids, and rolls of paper through highly mechanized production operations. Materials handling systems in woodyards, woodrooms, and finishing and shipping departments, where materials handling is labor intensive, are being improved and expanded. Some modern conveyor systems feature computer control and automatic equipment which move materials through processing steps with minimum manual intervention. At plants which have introduced advanced equipment, labor requirements of equipment operators and workers who handle materials generally are lowered.

In addition to conventional conveyors and production equipment of expanded capacity, some changes involve a significantly higher level of mechanization. These include automatic systems to transport and wrap paper rolls, automated warehousing systems, computer-controlled rewinders, and high-speed equipment to cut and package sheets which have eliminated several positions. Large portal-type gantry cranes are achieving savings in a few woodyards where high volume, layout of the woodyard, and log dimensions justify their introduction.

Computers and laser beam scanners are key components in some modern handling and storage systems. Automatic systems to transport and wrap rolls of paper, for example, feature automatic laser scanning of bar codes containing packaging instructions located on the rolls, improved conveyor networks that require less maintenance and cause less damage to rolls in transit, and devices that lubricate equipment automatically. In less mechanized roll handling systems that lack laser scanning and other advanced technology, an operator typically removes a card from the roll and inserts it into a card reader, or enters the data manually, to generate information on processing instructions.[11]

Computerized systems to handle warehousing operations also are beginning to be adopted by the paper industry. An integrated system to store and handle paper products at one large firm consists of a laser beam scanner, a computer, conveyors, transfer cars, a stretch wrap machine, and related devices. The company reported savings of $3 million following the elimination of 20 jobs, a 28-percent reduction in damaged cases, and improved inventory control.[12]

Output and Productivity Trends

Output

The market for the multitude of pulp, paper, and paperboard products is broadly diffused in the United States and the volume of shipments closely parallels the level of activity in the total economy. The United States leads the world in both production and per capita consumption of paper and paperboard, with about 50 percent of total output from mills located in the South.

The production of pulp, paper, and paperboard (BLS output index) increased at a relatively moderate average annual rate of 1.6 percent over the period 1970–83 (chart 3). However, the growth rate of output during the early 1970's was substantially higher than the rate for the later periods. Between 1970 and 1973, output increased at an annual rate of 4.8 percent and slowed appreciably during the middle period 1973–78 to an annual rate of only 1.5 percent. During 1978–83, the annual rate of change was zero. Between 1980–82, output declined at an annual rate of 3.4 percent. Over this period, the economy turned downward and demand for pulp, paper, and paperboard slackened.

Prospects for expansion in production appear more favorable into the late 1980's. Output in 1983 was 9.5 percent higher than in 1982 as the economy recovered

[8] "Westvaco Cuts Energy Costs Via Computers," *Paper Trade Journal*, May 15, 1982, p. 13.

[9] Michael K. Savelyev, "PC Regulates Mixing of Pulp Batches at Georgia-Pacific's Lyons Falls Mill," *Paper Trade Journal*, June 15, 1982, pp. 32–35.

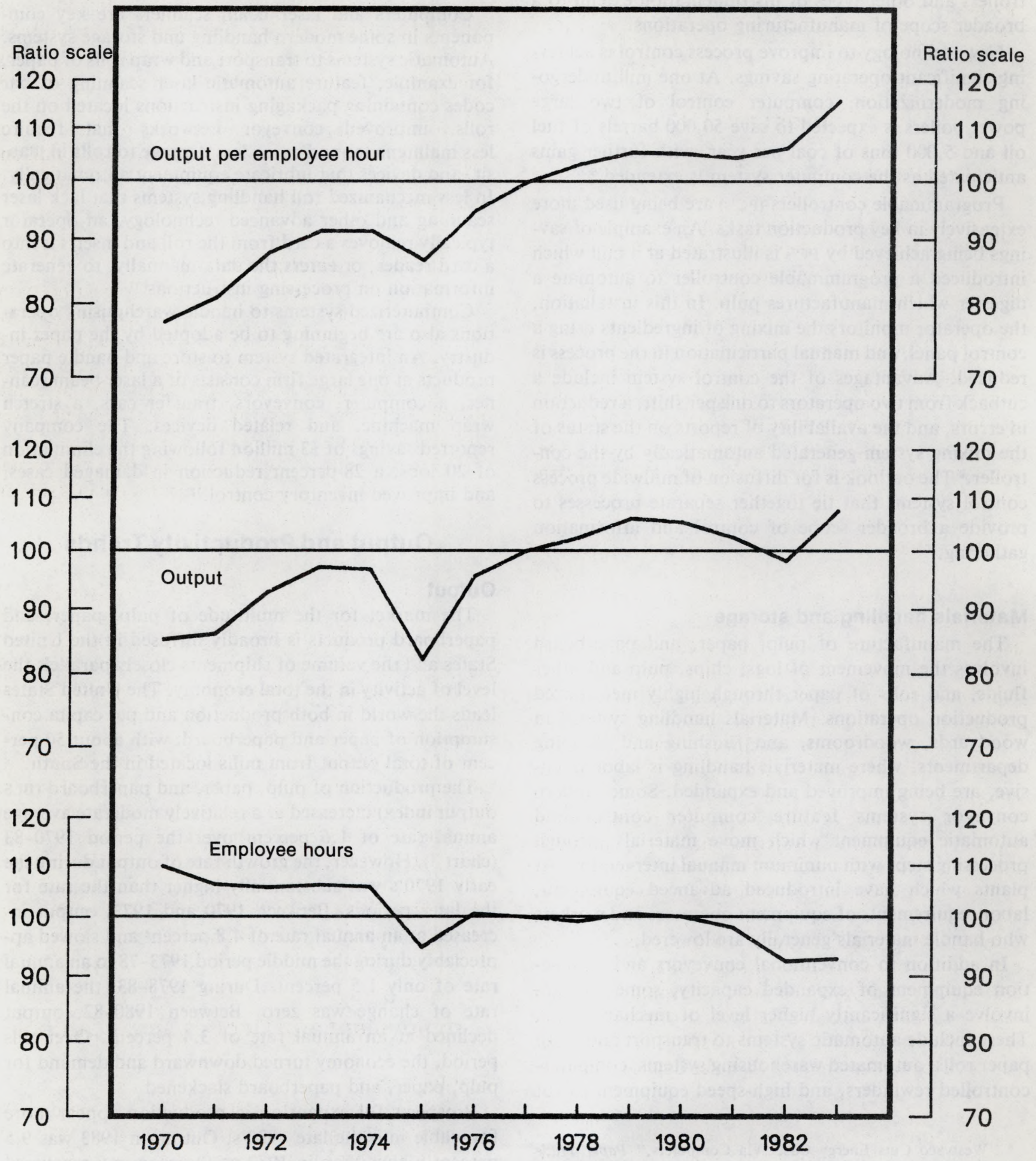
[10] W. L. Adams, "Significant Process-Automation Changes Expected in the Next Decade," *Pulp and Paper*, February 1982, p. 118.

[11] K. Griffiths, "Automated Roll Packaging Systems Reduce Costs, Manpower," *Pulp and Paper*, March 1983, pp. 120–21.

[12] Eugene Kittel, "Automatic Warehousing System Answers James River Mill Needs," *Pulp and Paper*, October 1983, pp. 79–81.

Chart 3. Output per employee hour and related data, pulp, paper, and paperboard, 1970-83

(Index, 1977 = 100)



SOURCE: Bureau of Labor Statistics.

As indicated earlier, the introduction of faster and more efficient equipment to turn out pulp and paper generally lowers unit labor requirements, and, if higher levels of investment in plant and equipment continue, productivity may improve. Moreover, the industry is expected to close down additional older, high-cost facilities, which should contribute to productivity improvements.

Investment

Total capital expenditures

The industry has allocated substantial funds to modernize plant and equipment and control pollution over the past decade. Between 1970 and 1981, capital spending totaled $24.7 billion, an average of $2.1 billion per year. The increase was substantially lower in constant 1972 dollars, however, with total spending over this period amounting to $16.4 billion, or an average of $1.4 billion annually.[14] Funds for plant and equipment in the paper mills (SIC 2621) component of the industry account for over 50 percent of total spending.

The pace of spending to modernize plant and equipment accelerated beginning in the late 1970's as firms sought to increase efficiency to compete more effectively in domestic and overseas markets. New and more highly mechanized facilities require substantially lower labor and energy per unit of output, and incorporate the latest technologies to protect the environment. Average efficiency is further improved as less efficient, older plants are closed. These new facilities are expensive—one large firm is well along in a $1.5-billion companywide modernization and expansion program. The centerpiece of modernization at one mill, a large new twin-wire papermaking machine, cost about $122 million and incorporates extensive new process control automation.[15]

The manufacture of pulp, paper, and paperboard involves large volumes of water and numerous chemicals, and the industry allocates substantial funds for technology to protect the environment. According to the National Council of the Paper Industry for Air and Stream Improvement (NCASI), the industry spent $4.9 billion over the period 1970 through 1982, an average of $379 million per year, for environmental protection related to water and air quality and disposal of solid waste from manufacturing processes.[16] Over this period, expenditures related to water quality accounted for 49 percent of the total; air quality, 46 percent; and solid waste disposal, 5 percent.

The highest levels of capital spending for environmental protection were during the years 1974–77, and these outlays, as a percent of total capital expenditures, declined over the period 1970–82. In addition to the volume of capital spending discussed above, the industry also allocates a considerable amount for fixed, administrative, and research costs related to protection of the environment.

According to NCASI, planned capital expenditures for environmental protection for 1983 are $323 million, with some preliminary estimates for 1984 suggesting that these expenditures may increase.

Research and development

Expenditures for research and development (R&D) by the broader paper and allied products industry (SIC 26) increased from $178 million in 1970 to an estimated $625 million in 1982, a gain of 251 percent, according to the National Science Foundation.[17] However, after adjusting for price increases, growth in R&D spending over this period was only 55 percent.

The paper industry ranks relatively low in R&D spending in comparison to other manufacturing industries. In 1980, only 15 full-time equivalent R&D scientists and engineers per 1,000 employees were employed by the industry, compared to an average of 29 for all U.S. industry, and 41 in chemicals and allied products and 21 in petroleum refining and extraction, two other leading process industries. However, the proportion of R&D scientists and engineers to total employment in the industry has risen markedly since 1970, when the National Science Foundation reported only 8 per 1,000 employees.

Although funds allocated to R&D and the relative importance of scientists and engineers in total employment have been increasing, R&D useful to the industry will continue to be undertaken by equipment suppliers, industry trade associations, private research groups, educational institutions, and the Federal Government. Major areas of R&D activity involve development of new products, control of pollution, and improvement in production processes.

Employment and Occupational Outlook

Employment

Employment in pulp, paper, and paperboard mills has been declining steadily (chart 4). Between 1970 and 1983, the number of employees in the industry fell from 289,900 to 253,700—an average annual rate of decline

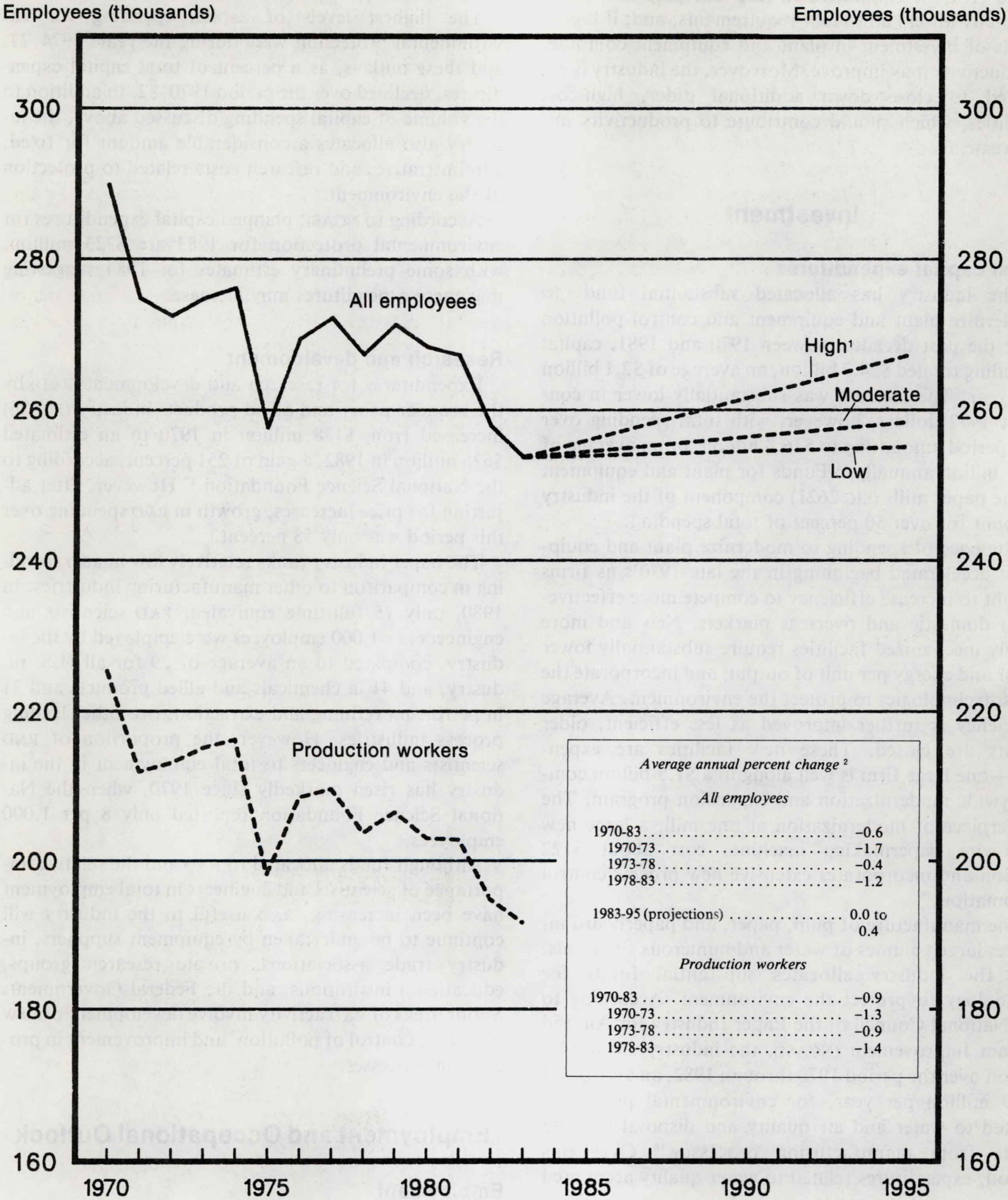
[14] U.S. Department of Commerce, Bureau of Industrial Economics, Office of Research, Analysis, and Statistics.

[15] Jeremiah E. Flynn, "Mead's 'Chief'—On Stream at Chillicothe Mill," *Paper Trade Journal*, July 15, 1982, cover and pp. 25–27.

[16] *A Survey of Pulp and Paper Industry Environmental Protection Expenditures—1982.* Special Report No. 83-07 (National Council of the Paper Industry for Air and Stream Improvement, Inc., New York), July 1983, 7 pp.

[17] National Science Foundation, *National Patterns of Science and Technology Resources—1982 and 1984* (forthcoming).

Chart 4. Employment in pulp, paper, and paperboard, 1970-83, and projections, 1983-95



[1] See text footnote 18.
[2] Least squares trends for methods of historical data; compound interest method for projections.

SOURCE: Bureau of Labor Statistics.

of 0.6 percent. Employment in 1983 fell to the lowest level since 1970 in both the pulp and paper and paperboard segments of the industry. The sharpest year-to-year decline in employment was between 1974 and 1975, a period of recession in the general economy. More recently, employment fell significantly from 1981 to 1982 as capacity was cut back in response to slack demand for paper and paperboard products.

The industry is not expected to be a significant source of new jobs over the next decade. BLS projections of employment to 1995 range from approximately the same level as in 1983 to only moderate growth.[18] The number employed by the mid-1990's will be well below the high in 1970, even under the most optimistic BLS projection.

Employment in pulp and paper mills is expected to increase by only 5,900 to 15,500 workers over the period 1983–95, or at an average annual rate of only 0.2 to 0.6 percent. The outlook is less favorable in the paperboard sector, with a decline ranging from 1,900 to 4,500 workers anticipated by 1995—an average annual rate of decline of 0.3 to 0.7 percent.

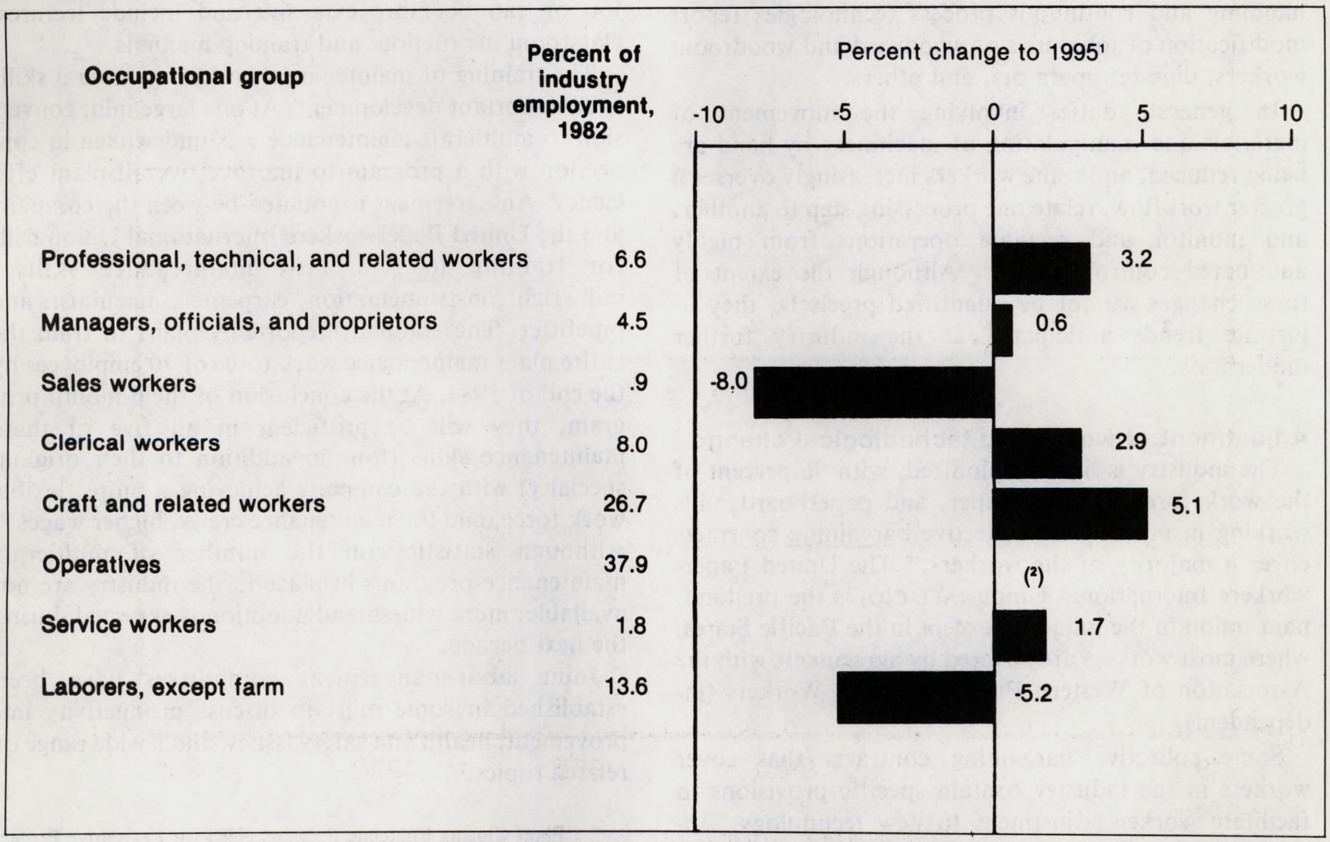
[18] BLS projections for industry employment in 1995 are based on three alternative versions of economic growth and include a low, moderate, and high projection. For details on assumptions and methodology used to develop these projections, see the *Monthly Labor Review*, November 1983.

Occupational trends

Technological changes are expected to contribute to further change in the structure of occupations in pulp, paper, and paperboard mills, although these shifts are expected to be moderate. According to BLS projections (chart 5), fewer sales workers and laborers will be employed in 1995, and employment in the other major occupational groups will increase moderately or remain relatively unchanged over this period.

Although employment in these broad occupational categories is expected to fluctuate in a narrow range, new technology may cause more significant changes in specific job categories within these groups. The number of computer systems analysts is expected to more than

Chart 5. Projected changes in employment in pulp, paper, and paperboard by occupational group, 1982-95



[1] Based on the moderate level of employment projected for 1995. BLS projects three levels of industry employment for 1995 based on alternative versions of economic growth: A low, moderate, and high level. For details on assumptions and methodology used to develop these projections, see the *Monthly Labor Review*, November 1983.

[2] No change.

SOURCE: Bureau of Labor Statistics.

double over the next decade, for example, as computer process control and office automation increase. More extensive mechanization in finishing and shipping operations, described earlier, is a factor in the projected 9-percent decline in employment of operators of packaging and inspecting equipment.

The most significant changes brought about by mechanization, however, involve a change in job duties, particularly in occupations included in the operatives group—the largest category, accounting for 38 percent of total employment. Since jobs which undergo change frequently retain the same title, an analysis of occupational change by examining changes in employment totals alone is incomplete.

Operatives control specialized pulp and papermaking equipment and finishing and converting machines. At mills which have adopted computer process control on pulp and papermaking equipment, as was pointed out in the technology section, machine tenders and other operators monitor the process from control stations, and the computer maintains temperature, pressure, flow rates, and other variables. Before computer control, workers located at various stations made adjustments manually. Mills which have introduced new materials handling and continuous process technologies report modification of job duties of woodyard and woodroom workers, digester operators, and others.

In general, duties involving the movement of materials and manipulation of machinery by hand are being reduced, and some workers increasingly oversee a greater workflow, relate one processing step to another, and monitor and regulate operations from highly automated control stations. Although the extent of these changes cannot be quantified precisely, they illustrate trends anticipated as the industry further modernizes.

Adjustment of workers to technological change

The industry is highly unionized, with 96 percent of the work force in pulp, paper, and paperboard mills working in mills where collective bargaining contracts cover a majority of the workers.[19] The United Paperworkers International Union (AFL-CIO) is the predominant union in the industry, except in the Pacific States, where most workers are covered by agreements with the Association of Western Pulp and Paper Workers (independent).

Some collective bargaining contracts that cover workers in the industry contain specific provisions to facilitate worker adjustment to new technology. According to BLS, 40 percent of the production workers are covered by agreements that provide severance pay to workers permanently separated from the company because of a technological change or plant closing. The proportion of production workers employed in mills covered by this adjustment provision varies considerably by geographic area, however, from a high of 59 percent in the Pacific States to only 3 percent in the Middle Atlantic States. Other provisions that facilitate adjustment and are contained in some agreements relate to training, crew projects, reassignment rights, advance notice, and relocation allowances. Other measures providing assistance to workers adversely affected by change result from legislation enacted by States. In Maine and Wisconsin, for example, State laws require that workers in paper and other industries to be laid off because of plant closings receive at least 60 days' advance notice and other consideration.[20]

Training to operate new equipment will continue to be one of the most important means for adjustment of workers to new technology. BLS and other plant studies disclose that most workers whose job duties have been modified and those reassigned to new positions are being retrained by the company and the equipment supplier. Depending upon the nature of the change and the job affected, training can be brief and provided on the job or can be more extensive and include lectures, classroom instruction, and training manuals.

The training of maintenance workers in several skills is an important development. At one large mill, conversion to multicraft maintenance was undertaken in connection with a program to improve overall plant efficiency. An agreement negotiated between the company and the United Paperworkers International Union calls for training in five basic maintenance skills—millwright, instrumentation, carpenter, machinist, and pipefitter. The company reportedly plans to train the entire plant maintenance work force of 70 employees by the end of 1984. At the conclusion of the 6-month program, they will be proficient in all five of these maintenance skills (four in addition to their original specialty) with the company achieving a more flexible work force, and the maintenance crews, higher wages.[21] Although statistics on the number of multicraft maintenance programs in place in the industry are not available, more widespread adoption is expected during the next decade.

Joint labor-management committees have been established in some mills to discuss productivity improvement, health and safety issues, and a wide range of related topics.[22]

[19] Bureau of Labor Statistics. *Industry Wage Survey: Pulp, Paper, and Paperboard Mills, July 1982,* Bulletin 2180, (1983). This survey excludes building paper and building board mills, SIC 2661.

[20] "Plant Closing Epidemic Prompts Need for Legislative Protection," *The Paperworker* (United Paperworker International Union, AFL-CIO, June 1983).

[21] "Mill Training Programs Change With the Times," *Paper Trade Journal,* Apr. 30, 1983, p. 44.

[22] *Resource Guide to Labor-Management Cooperation* (U.S. Department of Labor, Labor-Management Services Administration, October 1983).

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Chapter 3. Steel

Summary

A number of technological changes are being adopted by the steel industry (SIC 331) to reduce unit costs of labor, raw materials, and energy and to improve product quality. These include both radical innovations, which fundamentally alter the basic ironmaking and steelmaking processes, and incremental changes, which are improvements to existing technology and operating conditions. Diffusion of many of these technologies has been slow; the U.S. industry has lagged behind most major industrialized nations in adopting them.

A major restructuring is taking place in the steel industry to deal with shrinking markets and high import penetration. The major steel companies are substantially reducing their capacity and consolidating their remaining facilities. In contrast, small, low-cost producers known as minimills have experienced significant growth over the past decade, in large part due to their use of new technologies, product specialization, relatively low capital investment, and innovative management policies. The restructuring process is expected to continue during the 1980's, resulting in a smaller, more competitive industry.

Productivity in the steel industry increased at a low rate of 1.1 percent annually between 1970 and 1983. This figure is only half the rate registered for all manufacturing during the same period, and less than half the industry's own rate of growth for the 1960's. The very modest productivity gains from 1970 to 1983 are associated with declining output and somewhat greater reductions in employee hours. However, productivity soared by 28 percent in 1983, as output rose and employee hours were cut back substantially. Preliminary data for the first 6 months of 1984 suggest continued strong productivity growth.

Real capital investment during the 1970's was substantially lower than in the 1960's. Low industry profits, weak steel demand, and limited prospects for an adequate return on the enormous investment required have all contributed to depressed outlays.

The long-term decline in steel employment accelerated in the early 1980's as the industry adjusted to the extraordinary weakness in demand by reducing operating rates and by closing mills. In 1983, the industry employed 343,100 workers, less than half its postwar peak and the lowest level since the 1930's. While the outlook is unclear, most employment projections suggest that a large proportion of recent job losses could be permanent.

Industry Structure

The domestic steel industry is currently undergoing a major restructuring to improve its competitive position. New technologies and changing markets have facilitated the entry and growth of small, low-cost producers—known as minimills—in the last two decades. The historically dominant large steel companies, burdened with obsolete plant and equipment, could not compete against minimills in their product lines and, therefore, shifted out of those markets. Due to surging imports and depressed market conditions, the integrated mills have been forced to close plants, consolidate operations, abandon some products, and concentrate in those markets where they remain competitive. This restructuring process will likely continue through the 1980's, resulting in a smaller, more competitive, decentralized industry.

The steel industry is composed of three relatively distinct sectors: Integrated, minimill, and specialty steel. Companies in the integrated sector are directly involved in all steps of steel production from processing iron ore and coal to producing a wide range of carbon and alloy steel end products. It is by far the largest sector, accounting for more than 80 percent of domestic shipments in 1981. The second group, the minimill sector, accounts for about 16 percent of shipments. It produces a limited range of low-cost carbon steel products processed from scrap. A third, less clearly differentiated sector, specialty steel, accounts for only about 4 percent of all steel shipments. These independent mills primarily manufacture higher alloy and stainless steels, frequently using electric furnaces in small plants.

Rapid development of the minimill sector was made possible in part by its adoption of two technologies, the electric furnace and the continuous caster, which enable it to operate smaller scale plants than is possible in integrated production. Because minimills use scrap steel as a basic charge, they do not require the large-scale sintering plants, coke ovens, and blast furnaces which are used to process coal, limestone, and iron ore into steel in the integrated steelmaking process. Consequently, most minimills can operate economically with capacities ranging from as low as 50,000 to as high as 600,000 tons a year. By contrast, integrated steel mills with coke ovens and blast furnaces reach peak efficiency at an enormous scale of between 2 and 3 million tons a year.[1]

A number of other factors have contributed to the minimill sector's rapid expansion. Low unit labor and production costs are a function of efficient electric furnaces, continuous casting, and a simple product mix. Low energy consumption and a generally lower paid and more flexible work force than in the integrated mills are contributing factors. Efficiencies also result from product specialization. Most minimills have carefully matched product and process technology. By producing a limited range of products, they achieve economies of scale.

Consequently, some analysts expect the minimills to increase their market share to 25 percent of the total by 1990 from the current 16 percent.[2] Factors limiting greater market penetration by the minimill sector are the saturation of their current markets and the unavailability of a technology on a scale that would enable the minimills to produce high-quality, flat-rolled steel, the major steel product. More than half of the steel products consumed domestically are flat-rolled products which must now be manufactured in large-scale rolling mills with a minimum capacity ranging upward of 3 million tons. However, the minimills could expand into this market if a technology in the developmental stages—a continuous caster capable of producing slabs only 1½ inches thick—becomes practical. With this technology, rolling mill capacity requirements could be reduced to 400,000 tons or less. One minimill expects to be producing sheet steel by this method in the late 1980's.

In contrast to the expansion of the minimill sector, the large, integrated segment has been forced to severely reduce capacity. The eight largest steel companies which hold an overwhelmingly dominant position in steel production (65 percent of total industry shipments in 1977) reduced their aggregate raw steel capacity by 24 percent (30 million tons) between 1979 and early 1984.[3]

The retrenchment of the integrated mills has been selective. The large companies are becoming increasingly specialized, concentrating on those markets where they remain competitive, such as sheet, heavy structurals, seamless pipe, and plate. They have largely abandoned the low-end markets, like bar, rod, and small structurals to the minimills.

It is likely that the integrated sector will continue to reduce its capacity. According to several estimates,[4] as much as an additional 10 percent of production capacity could be cut within the next several years. Cutbacks are expected to result from a recently announced merger of two large integrated producers. It is anticipated that the merged companies will rationalize their facilities by shutting down the duplicative and least efficient mills.

Technology in the 1980's

A number of major technologies being adopted by the steel industry are reducing unit labor, material, and energy costs and, thereby, improving the industry's competitive position. They can be divided into two types. In the first category are radical technologies, which create entirely new methods of iron and steel processing and generally have a substantial impact on labor and productivity. The continuous caster is the most likely of these technologies to have a major impact during the 1980's. In the second category are incremental technologies, which modify existing production methods to improve efficiency. Among the technologies in this category which are likely to be more widely diffused during the 1980's are computer process control and ladle refining, as well as a number of new technologies which significantly improve the operating efficiency of the electric arc furnace. Because of the high capital cost of building new facilities, incremental changes are being adopted in many areas of existing mills as the most cost-effective means of making them competitive.

The major technologies, their labor impact, and diffusion are summarized in table 3.

Iron manufacture

The first step in integrated production is the reduction of iron ore to molten iron (hot metal) in the blast furnace, using coke as a reducing fuel. In this process, a mixture of iron ore, limestone, and coke is charged into a blast furnace and subjected to a very high temperature. In the reaction which follows, molten iron is separated from the impurities in the ore. The molten iron is then released from the furnace for use in steelmaking operations.

Only four new blast furnaces (two of super size) have been built in the United States within the last decade, and it is unlikely that any others will be built during the 1980's. This is due to the high cost of their construction, inflated by pollution control expenditures, and the depressed state of the industry. They are also competing directly with the highly efficient electric arc furnaces, which uses scrap as a charge and thereby avoid coke

[1] Robert Crandall, *The U.S. Steel Industry in Recurrent Crisis* (Washington, The Brookings Institution, 1981), p. 11.

[2] Donald F. Barnett, *Steel: Upheaval in a Basic Industry* (Ballinger Publishing Co., 1983), p. 278; and *Industry Week*, July 13, 1981, p. 58.

[3] Institute for Iron and Steel Studies (IISS) and Department of Commerce.

[4] Peter Marcus and Karlis Kirsis, "World Steel Dynamics," *The Steel Strategist*, No. 9, February 1984.

Table 3. Major technology changes in the steel industry

Technology	Description	Labor implications	Diffusion
Direct reduction (DR)	DR converts iron ore into highly concentrated iron pellets. In the most common processes, natural gas burns away oxygen from iron ore, producing sponge iron, which can be used as a substitute for scrap in electric arc furnaces.	Employee hours required to produce a ton of direct reduced iron are comparable to requirements for pig iron in a blast furnace. Most workers are semiskilled and can be easily trained to operate equipment. Plant and process engineers require extensive technical training.	High cost of direct reduced iron relative to scrap has hindered diffusion and caused the temporary shutdown of existing plants. Production unlikely to increase in the next few years.
Electric arc furnace (EAF)	Steelmaking process in which an enclosed vessel with charge is heated by an electric arc. Uses scrap and/or direct reduced iron as charge.	Unit labor requirements for EAF process are lower than for alternative basic oxygen process (BOP), taking preliminary steps into account. Skill levels are comparable to BOP requirements.	Accounted for 32 percent of production in 1983. Expected to be as high as 40 percent in 1990, assuming no serious problem of scrap availability.
Basic oxygen process (BOP)	Steelmaking process used by integrated mills in which a jet of pure oxygen is blown onto vessels containing molten iron. Process takes about 45 minutes, compared with 5 to 8 hours for older open hearth process (OHP).	Reduces unit labor requirements by almost half that of the older OHP.	BOP accounts for approximately 60 percent of total steel production; greater diffusion unlikely during 1980's, in view of electric furnace expansion.
Ladle refining	Molten steel is brought to final specifications in a ladle instead of inside the melting furnace.	Overall productivity effect uncertain. Productivity gains associated with reducing the time needed to make steel in melting furnace are at least partly offset by additional time required to refine steel in ladle. Process requires a skilled operator and helper.	Use increasing. Widespread diffusion expected due to expanded use of EAF and continuous casting.
Continuous casting	Molten steel is poured directly into caster, from which it emerges in semifinished form. At least 5 hours saved in production time compared with ingot method which it replaces, and up to 50-percent energy savings. Increases yields by 10 to 20 percent.	Reduces unit labor requirements by as much as 50 percent when compared to older ingot process. Skill levels generally higher than for older method.	Accounted for 31 percent of total steel production in 1983; expected to rise as high as 50 percent by 1990. Widely used in minimill and specialty steel sectors; use expanding in integrated mills.
Computer process control	Installed to automatically control operations. Results in increased yield, improved quality, and energy conservation.	Generally results in change of job responsibilities rather than any net change in total employment. Skill level for new positions is generally higher.	Greatest diffusion is in hot strip rolling mills and blast furnaces. Many first-generation systems are being replaced by newer computers.
Continuous annealing of sheet	Coils of sheet are continuously passed through a series of heating, soaking, and cooling steps in an annealer, replacing conventional methods in which sheet is subjected to temperature treatment over an extended period of time. Produces high quality sheet used in automobiles.	Substantial time savings reduce unit labor requirements. Only 8 to 10 hours are required to produce 20 coils of sheet with new method, compared to 7 days with conventional line.	Two continuous annealing lines have been built. Construction of additional lines has been planned but deferred.

oven-blast furnace operations.

Instead, a wide range of technologies is being applied to upgrade existing blast furnaces to make them more competitive. The retrofitting of existing units, construction of new superfurnaces, and the closing of the smaller and least efficient furnaces have caused a significant decline in the number of employee hours required to produce a ton of iron. The number of employee hours required to produce 1 ton (in direct labor, including materials handling) has declined from 0.6 in 1960, when the average capacity was 1,000 tons per day, to approximately 0.4 in 1979, when the average capacity was 2,500 tons per day.

Among the more significant technologies being adopted is external desulfurization. In this process, the sulfur content of the molten iron is reduced in a desulfurization unit located outside rather than inside the blast furnace. This allows the blast furnace itself to be operated at higher production rates, lower fuel rates, and with less slag. Other technologies which are being adopted to improve blast furnace efficiency include better blowing techniques, better heating of air, the use of higher pressures, and improved "burden" (charge) control. Improving the quality of raw materials fed into the blast furnace is also increasing efficiency. The changes in raw materials include the use of pellets in place of coarse iron ore, and better quality coke and sinter (clumps formed by a process which combines fine ores).

Unit labor requirements and unit costs are substantially reduced when existing furnaces are upgraded with these technologies. In 1980, one company reported that it was able to produce the same tonnage of pig iron from 25 furnaces as it had from 43 furnaces only 3 years earlier by applying a combination of these technologies. At another steel mill, substantial modernization of an existing 50-year-old furnace increased its ironmaking capacity from 2,800 to 3,400 tons per day.

Coke ovens. Coke is the primary fuel used in the blast furnace for iron smelting. On average, about 1,000 pounds of coke are consumed for every net ton of molten iron produced.

The financially strapped integrated steel companies have built little new cokemaking capacity in recent years. This is in large part due to the high capital costs of building new coke ovens, estimated in 1979 at between $198 to $220 per ton of capacity or roughly equivalent to the cost per ton of capacity for a new minimill that year. A high percentage of these costs—between 25 and 30 percent—would be required to meet environmental and occupational safety requirements.

As a consequence, more than one-third of coke oven capacity was more than 25 years old in 1979, even though capacity was substantially reduced during the 1970's. By contrast, no capacity was more than 25 years old in Japan in that year. Older ovens have higher labor requirements due to more downtime and greater maintenance. They also produce less coke, which can affect productivity and cost.

Direct reduction of iron. In contrast to the blast furnace process, a number of iron-producing processes, collectively known as direct reduction (DR), have been developed in the last 15 years which do not require coke as a reductant, i.e., fuel used to reduce iron ore to iron. The DR processes, which generally use natural gas as a reductant, produce iron or concentrated iron pellets which can be used in electric arc furnaces as a replacement or a substitute for scrap to make steel.

Labor requirements for steel production were estimated to be lower when the direct reduction-electric arc furnace method was compared to the coke oven-blast furnace-basic oxygen furnace alternative. For the former method, the range was estimated at 1.6 to 1.9 employee hours per ton versus 2.5 hours per ton for the latter.[5]

Direct reduced iron appeared to be a viable alternative to scrap during the 1970's, when scrap prices were rising and shortages were expected to develop. However, due to changed economic conditions, diffusion of the DR processes has been quite limited in this country. The rapidly escalating price of domestically produced natural gas and falling scrap prices in the early 1980's have made direct reduced iron too costly relative to scrap, forcing the shutdown of the few existing DR plants. In the future, however, the process could become economically feasible if a combination of rising steel demand and expanded electric arc furnace capacity drives scrap prices upward. Diffusion could also rise if coal-based reductants become a practical alternative to high-priced natural gas and electrical power cost remains stable.

[5] J.W. Clark, "Integrated Steelmaking Based on Coal Gasification and Direct Ore Reduction," Westinghouse R&D Center, Dec. 8, 1979.

Steel production

After the molten iron is smelted in the blast furnace, it is converted to steel by decreasing the silicon and carbon content with oxygen and by adding small amounts of other metals. There are three steelmaking processes used in this country: The basic oxygen (BOP) and open hearth furnaces are used for integrated production; the electric arc furnace (EAF) is used for nonintegrated (scrap based) production. The basic oxygen furnace became the dominant steelmaking technology in 1970 by replacing obsolete open hearth capacity.

In recent years, however, the electric arc furnace has had the greatest impact on steelmaking operations. More than 15 million tons of electric arc furnace capacity were added between 1975 and 1982,[6] compared to about 5 million tons of BOP capacity.[7] The proportion of total raw steel produced by the EAF process increased from 19 percent in 1975 to 32 percent in 1983. In this period, the BOP has accounted for a relatively stable 60 percent.

Electric arc furnace. While the electric arc furnace (EAF) is not a new development, recent technological advances have made it an increasingly efficient steelmaking process likely to have a major impact on steelmaking during the 1980's. Its diffusion has been continuously rising, from 15 percent of total raw steel production in 1970 to 28 percent in 1981 and 32 percent in 1983. In the expanding minimill sector, virtually all plants are being equipped with electric arc furnaces. The large, integrated companies are replacing their antiquated blast and open hearth furnaces with new EAF capacity in some of their plants. And in the specialty steel sector, the EAF process has long been recognized as the preferred method for making steel. Minimills currently account for about 46 percent of total EAF capacity; integrated mills, about 40 percent; and specialty producers, the remaining 14 percent.[8]

The electric arc furnace consists of a closed cylinder with electrodes mounted on its roof. Electricity flows through one electrode and the charge (of scrap) then

[6] *Iron Age*, Feb. 4, 1982.

[7] "33 Metal Producing," *World Steel Industry Data Handbook*, 1983, p. 69.

[8] William T. Hogan, "The Expanding Electric Furnace: A Threat to BOF?" *Iron and Steel Engineer,* October 1983, p. 18.

"arcs" back to the electrode. The charge is melted by the intense heat generated by the flow of electricity. To produce a "heat" generally takes more than 2 hours for a 200-ton unit compared to about 45 minutes for a similarly sized BOP furnace.

The major advantage of the EAF process is its use of scrap, rather than pig iron, as a charge. Because it is scrap based, it does not require the massive complex of raw material facilities, coke ovens, and blast furnaces needed to process iron ore in integrated production. Consequently, capital, labor, and maintenance costs for EAF are smaller than that for integrated facilities. Recent estimates indicate that the capital costs of installing EAF's are approximately one-third of that required for a blast furnace-basic oxygen combination.[9]

There could be problems associated with using scrap as a raw material, however. Because of sharply fluctuating demand for scrap, its prices are volatile. For example, between 1971 and 1974, the record year for steel production, the price per ton of the most widely used grade of scrap more than tripled. On balance, however, the generally low cost of scrap relative to hot metal has provided a substantial advantage to the EAF process.

Unit labor requirements tend to be lower for the EAF than the BOP, if preparatory operations are taken into account. That is, labor requirements for the EAF, including scrap handling operations, average about 0.75 to 1.2 employee hours per ton. By contrast, the BOF, including coke oven-blast furnace operations, requires about 2.5 employee hours per ton of steel produced.

Also contributing to the expansion of EAF usage during the 1970's and early 1980's were substantial improvements in operating technologies which have made the electric furnace increasingly attractive as a carbon steel producer. During the 1940's and 1950's, the EAF was generally considered a specialty steel producer because of its then high production costs. However, with improvements such as higher strength refractories, high-power transformers, water-cooled panels, oxygen lancing, and oxy-fuel burners, it has become the lowest cost producer. Together, these innovations increase the rate of production per hour (that is, reduce tap-to-tap times), decrease energy consumption, and allow for more efficient use of raw materials. As a result, a 100-ton furnace which could produce steel at the rate of 20 tons per hour 10 years ago might produce as much as 65 tons per hour today.[10] Moreover, these technologies have enabled the development of large-capacity furnaces ranging up to 350 to 400 tons, compared to the 15-to 50-ton units typical during the earlier stages of electric furnace development.

Use of the electric arc furnace is expected to continue to rise during the remainder of the 1980's. It has been estimated that the EAF could account for between 36 and 40 percent of total raw steel production by 1990.[11] Future growth of EAF capacity will be affected by the cost of renovating older integrated plants and the price, availability, and quality of scrap during this period, as well as the price of energy.

Basic oxygen furnace. The basic oxygen furnace is the most widely diffused steelmaking process, accounting for about 60 percent of total raw steel production since 1975. It is used by integrated producers to make carbon and low-alloy steels. In this country, steel was first produced by the basic oxygen process (BOP) in 1953, and its diffusion increased steadily in the 1960's and early 1970's. However, no BOP capacity has been added since 1978, and it seems unlikely that any will be added during the 1980's, in part due to depressed markets and competition from the electric arc furnace.

In the basic oxygen process, a high-speed jet of oxygen is blown directly on the surface of a charge or "heat" molten iron, scrap, and fluxes in the furnace. In the chemical reaction which follows, the oxygen combines with the impurities and leaves the solution as slag or gases. The entire process requires only about 45 minutes "heat-to-heat," compared to between 5 and 8 hours for the open hearth process.

Some incremental technologies are currently being adopted to improve the productivity and yield of the BOP furnace. The most significant of these technologies, bottom blowing, involves blowing oxygen from both the top and the bottom of the vessel simultaneously. A second technology, off-gas recovery, is being adopted as an energy conservation measure. It enables gases, which would otherwise be released, to be recovered and stored for use as fuel.

Ladle refining. Ladle refining is being extensively adopted by steel producers as a means of improving steel quality. Ladle refining refers to a variety of processes which clean, purify, and homogenize steel in a ladle located outside the steelmaking furnace (BOP or EAF) after it has been tapped. Before, these operations had been performed at the end of the steelmaking process inside the furnace. Refining operations which can be executed in the ladle include desulferization, oxygen and hydrogen removal, addition of alloys, and temperature control.

Separating refining from melting operations can boost the productivity of melting furnace operations, particularly for the EAF. For example, by using ladle refining, a 3-hour heat cycle in an EAF can be cut by at least 20 to 45 minutes. However, the overall effect on productivity is uncertain, since the ladle refining process itself can take nearly as long. This process generally re-

[9] *Ibid., p. 18.*

[10] Kenneth E. Caine, "A Review of New Electric Arc Furnace Technologies," *Iron and Steel Engineer*, October 1983, p. 47.

[11] William T. Hogan, "The Expanding Electric Furnace: A Threat to BOF?" pp. 17-18.

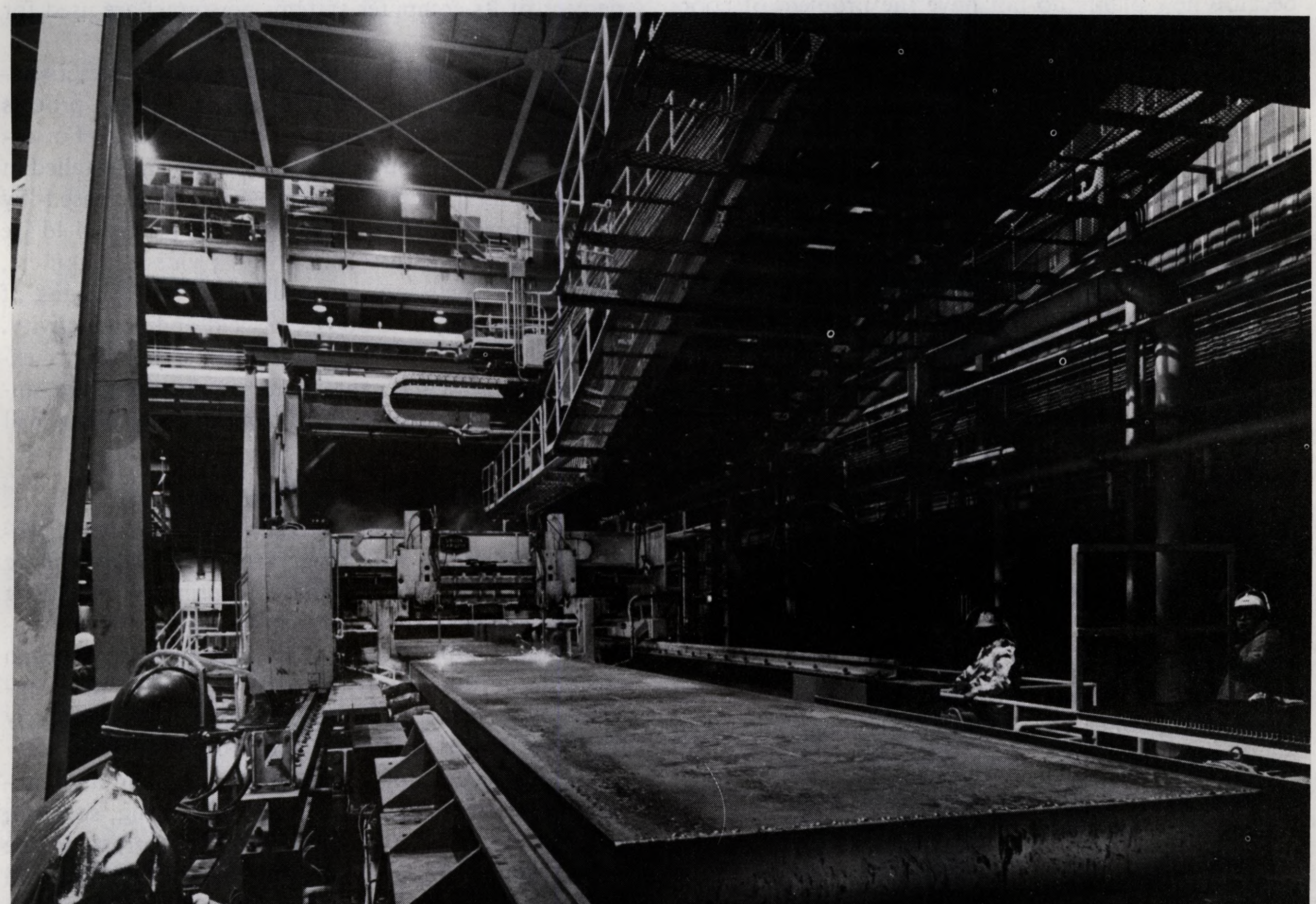
quires two workers: A skilled operator and a semiskilled helper.

Until recently, most ladle treatment of steel was associated with specialty grades. However, because of expanded use of continuous casting which is facilitated by ladle metallurgy, it is being applied to common carbon grades of molten steel as well.

Diffusion of ladle refining is expected to be widespread during the 1980's, in large measure due to expanded use of EAF and continuous casting technologies. Many steel companies are either now installing this technology or expect to do so during the mid-1980's.

Continuous casting. The continuous casting process, which converts raw steel into semifinished forms, is the technology likely to have the greatest impact on steel production during the 1980's. Continuous casting replaces with one operation the separate steps of ingot casting, mold stripping, heating of ingots in soaking pits, and primary rolling, which are required for the conventional ingot-teeming method of production. In continuous casting, molten steel is poured from a ladle into an open-ended mold, resulting in a continuous ribbon of steel which is subsequently cooled, then cut to form semifinished billets, slabs, or blooms. It has been estimated that production time is reduced by at least 5 hours compared with the ingot-teeming method from the time molten steel is poured from the ladle to the semifinished forms. Moreover, yields for continuous casting are between 10 and 15 percent higher than for the old process.

Labor requirements are sharply reduced for continuous casting since it does not require the many processing steps necessary for the conventional ingot-teeming method. With continuous casting, the number of employee hours required per net ton of cast steel is estimated to be only half of that required in the conventional ingot process. In one plant which recently installed a continuous caster, only 12 workers (including indirect labor) were required for its operation, compared to 20 for the older ingot-teeming method. The skill level for the continuous caster is generally higher than for the ingot-teeming method because the caster system is more



Steelworkers monitor a steel slab as it emerges from a continuous caster.

complex. It requires more skilled operators and maintenance workers. In addition, because the caster is generally more fully automated, there is a shift from manual control to monitoring the equipment.

Substantial energy savings of about 10 to 20 percent are an additional advantage of this process. Other reasons cited for its adoption include improved quality and lower pollution levels.

Despite its many advantages, continuous casting is not widely diffused in the United States except in minimills. The rate of adoption in the United States has lagged behind all other major industrialized nations during the 1970's. In 1983, for instance, only 31 percent of total raw steel production was produced on a continuous caster in this country, compared to 86 percent in Japan and a 61-percent average in Europe.[12]

However, this technology is extensively diffused in the small minimill and specialty steel sectors. According to one industry analyst, 78 percent of raw steel produced in minimills was continuously cast in 1981, compared to only 17 percent in the integrated sector.[13] It has been easier for the minimills to adopt continuous casting because new plants do not have the problem of coordinating new casters with existing obsolete equipment, which has posed major technological difficulties for integrated producers.

Diffusion is expected to increase significantly through the 1980's. Most major companies have plans to replace at least some of the obsolete equipment with continuous casters. In 1983, 20 major casting machines with a capacity of more than 16 million tons were being added, a 60-percent increase over existing capacity. It has been estimated that as much as 50 percent of steel production could be continuously cast by 1990.

Computer process control

Use of computers to control steelmaking operations has dramatically increased since oxygen furnaces and new generation strip mills were first equipped with them in the early 1960's. Computer process systems have become standard components in many areas of new and old mills. In addition, older equipment is being retrofitted with computer process controls. According to one 1981 survey, these accounted for between 50 and 85 percent of installations at that time.[14] And because of the rapid obsolescence of computer technology and rapid payback potential of new installations, many first-generation systems are being replaced by state-of-the-art technology.

Computer process control can significantly facilitate mill operation and result in time savings. In one hot-strip mill with a computerized setup, an operator punches out the number, width, and thickness of slabs required. The computer will in turn make the necessary calculations and adjust settings in the mill accordingly. It will direct the slabs through the rolling sequence and make adjustments to ensure proper operation. By contrast, without the computer, initial setup by the operator and processing of sheet through the mill would take considerably longer.

Some reduction in labor requirements can result from the adoption of computer process control, although the extent will differ with the production process. For example, one steel company official reports that in one fully computerized 84-inch hot strip mill, only 6 workers were required for operation, whereas a similar noncomputerized mill required 12 workers.

Frequently, however, no net reduction results from the introduction of the computers. Rather, more skilled workers, such as programmers, replace unskilled personnel, such as reporting clerks. A highly skilled maintenance team could also be required to service the computer system. One company reports that about 45 percent of its computer systems personnel are used for system upkeep.

Aside from labor savings, several other factors account for the rapid adoption of computer process technology. Energy savings can be substantial. For example, after a computer process system was installed in one soaking pit, energy consumption decreased by about 20 percent. Higher quality and improved yield are additional benefits associated with process computers, and capital costs are low relative to other means of achieving comparable boosts in yield and productivity.

Future growth of computer process control is expected to be significant. New applications are anticipated, and extensive retrofitting of older plants will likely continue.

Continuous annealing of sheet

After sheet steel has been cold-rolled, it must be processed through an annealing furnace to make it more formable. In the last decade, a continuous annealing process was developed in Japan to replace the conventional batch-type process, and two such lines began operating in this country in 1983. While not new conceptually, continuous annealing applications previously had been limited to tinplate and specialty steels.

In this process, coils of sheet are unwound and continuously passed through a series of heating, soaking, and cooling steps in an annealer. By contrast, in the conventional batch method, the coils are stacked and sealed in a furnace, then subjected to hot and cold temperatures over an extended period of time. Productivity is higher with continuous annealing because 20 coils can be processed in 8 to 10 hours by this method, compared with 7 days for the conventional method. The same number of workers are required on the new line as

[12] Merrill Lynch, *Steel Industry Quarterly*, October 1984.

[13] Joel Hirshhorn, *Continuing Success for United States Mini-Mills*, p. B-3.

[14] Based on a survey of membership of the International Iron and Steel Institute conducted for David H. Clark, Republic Steel Corp.

on the old, although workers on the older line may be responsible for other furnaces. Because the new equipment is more sophisticated, skill levels are generally higher.

In addition to reduced unit labor requirements, energy savings are also substantial with the new process. Another advantage of continuous annealing is that it can process some high-quality sheet steels which cannot be produced by the conventional batch method.

Further diffusion of this process is expected. Other continuous annealing lines have been planned, but their construction has been deferred due to the uncertain demand by the automobile sector for high-strength low-alloy steels. Also, since the two mills have only just begun operating, other manufacturers are waiting to see whether the high capital costs of new facilities are sufficiently offset by lower production costs.

Output and Productivity Trends

Output

About 85 million tons of steel were produced in 1983, only slightly more than half the peak level of 151 million tons in 1973. Nevertheless, this figure represented a slight improvement over the even lower 1982 level of 75 million tons, which was the lowest since 1946. While the industry's operating rate rose to 56 percent in 1983, from 48 percent in 1982, it has remained well below the average for the 1970's. Declining demand for steel products and rising imports are principally responsible for the sharp reduction in output (chart 6).

Sharply reduced demand for steel in two of its principal markets, automobiles and construction, account for a large part of the overall decline. From 1978 to 1982, shipments to the automobile industry fell from 21 to 9 million tons and to the construction industry, from 13 to 9 million tons. In 1983, shipments to these markets rebounded partially, to 12 million tons for autos and 10 million for construction.[15]

Adverse cyclical trends are a major cause of the weakness in the automobile demand, historically steel's largest market. Two recent severe recessions had a devastating impact on auto production, which fell by 5.9 million vehicles, or 46 percent, between 1978 and 1982.[16] Motor vehicle imports increased by 300,000, or 7 percent, during that time.

Also contributing to the decline in steel demand is product substitution. For example, plastics, aluminum, and lighter weight steels are replacing heavier carbon steels in autos as the industry attempts to increase fuel efficiency. By 1979, for instance, the average automobile utilized 200 pounds of plastic, compared to 25 pounds in 1960.[17] A third factor reducing demand for steel in this sector is the manufacture of smaller cars. As a result of smaller cars, product substitution, and use of lighter weight steel, one automobile company is making cars that contain 30 percent less steel than 5 years ago. Between 1978 and 1987, the company estimated that its purchase of steel would decline by 600 pounds per passenger vehicle.

Product substitution for steel is occurring in other markets also. In the important container market (beer and soft drinks), for instance, steel is being replaced by aluminum. In spite of an increase in total can output, steel shipments declined from 6.1 million tons in 1973 to less than 3.4 million tons in 1983.

In addition, steel demand has been affected by structural changes in the overall economy. Rapidly growing service industries, such as finance, health, and communications, are not steel-intensive. On the other hand, the capital goods industries (i.e., heavy construction, business vehicles, machinery, etc.), which historically have accounted for more than half of steel consumption, have been growing less rapidly.

As a result of these trends, domestic demand for steel (as measured by domestic shipments plus imports less exports, in net tons) declined at an average annual rate of 2.9 percent between 1973 and 1983, compared to an increase of 3.9 percent between 1960 and 1973. Measured in terms of tons consumed per $1 million of real gross national product, consumption declined from 97 tons in 1959 to 56 tons in 1983.

Due to the extreme sensitivity of steel to domestic and world economic conditions, the outlook for steel demand is uncertain. A mid-1982 forecast by the Office of Technology Assessment projected that U.S. steel demand would rise between 1 and 1½ percent annually during the 1980's. That would be above the 1970's rate but below the rate of the more prosperous 1960's.

Imports

While domestic production has been declining, imports have captured an increasing share of the U.S. steel market. Contributing to the surge of imports has been the rapid expansion of steel capacity worldwide in the last two decades and weak demand due to the prolonged global recession of the early 1980's. In 1982, steel imports represented a then record 22 percent of apparent consumption (domestic shipments plus imports less exports), but slipped slightly to 21 percent in 1983. To some extent, the high import share in these years was a reflection of the contraction of the domestic market; the import volume was actually greater in several earlier years. However, for the first 9 months of 1984, steel was being imported at a record volume and import penetration jumped to 25 percent.

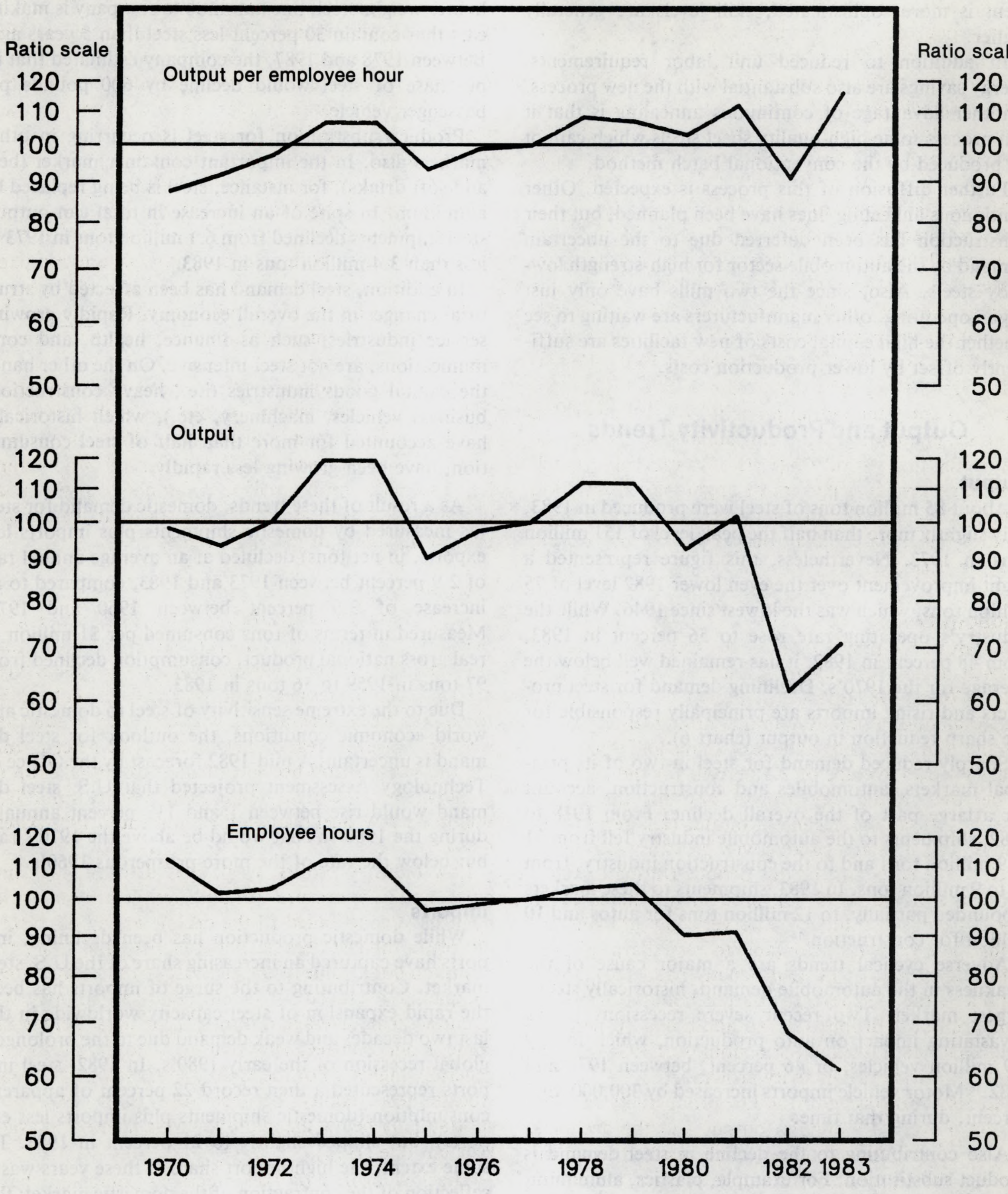
[15] American Iron and Steel Institute, *Annual,* p. 34.

[16] Data from Motor Vehicle Manufacturers Association.

[17] U.S. Congress, Office of Technology Assessment, *Technology and Steel Industry Competitiveness*, 1980, p. 175.

Chart 6. Output per employee hour and related data, steel, 1970-83

(Index, 1977 = 100)



SOURCE: Bureau of Labor Statistics.

A recently completed study by the Steel Advisory Committee to the Cabinet Council on Commerce and Trade, chaired by the Secretaries of Labor and Commerce, concluded that the major reason for rising import penetration was the low level of import prices relative to domestic prices, attributable to such factors as the appreciation of the dollar, unfair trading practices, the lower wages and benefits paid to foreign workers, and in some cases more modern mills overseas.[18]

Despite the substantial rise in imports, some imported products directly competitive with minimill products have actually decreased in quantity and as a proportion of the U.S. market. This is evident for two major minimill product markets, light-shape bars (minimills had a 90-percent market share in 1981[19]) and reinforcing bar (with a 75-percent minimill share in 1981). For instance, imports of light-shape bars decreased from 48 percent of apparent consumption in 1971 to 7 percent in 1981 and, in quantity, fell from 550,000 tons to 105,000 tons during that period. Imports of reinforcing bar fell from 10 percent to 1 percent of apparent consumption (domestic shipments plus imports less exports), and quantity fell from 515,000 tons to 53,000 tons during the same period.

Productivity

Output per employee hour in the steel industry edged upwards at an average annual rate of 1.1 percent between 1970 and 1983 (chart 6). This was less than half the rate for all durable goods manufacturing registered during the same period and less than half the steel industry's own average of 2.3 percent for the 1960's.

The low productivity growth rate for the period 1970–83 reflects the decline in output (2.2 percent annually). The strongest productivity growth was concentrated in the early part of this period. During the later part of the period (1979–83), productivity increased by only 0.4 percent annually. The very low growth rate during these years is attributable to very sharp shifts in output. However, in 1983, productivity soared 28 percent above the 1982 level, as output bounced back but employee hours dropped by an additional 10 percent. Preliminary data for the first 6 months of 1984 indicate continued strong productivity growth.

Factors contributing to the low productivity rate are the sharp cyclical swings in output and the declining level of capital expenditures, which resulted in an increase in the degree of obsolescence of plant and equipment. Moreover, as output declined precipitously, most plants have been operating considerably below their most efficient levels. Somewhat offsetting these negative influences in recent years were the closure of the the least productive mills and the expansion of the more efficient minimill sector.

Although productivity data for the minimill sector as a whole are unavailable, it was estimated that in 1980 the minimills required an average of only 3½ employee hours to produce a ton of wire rod compared to 6½ employee hours for the integrated mills. The major advantage of the minimills was the absence of primary processes (i.e., coke oven-blast furnaces operations).[20]

Better communication with workers in integrated mills through labor-management participation teams has also boosted productivity in plants where they have been established. With no capital outlays, one company was able to increase output from 2,900 to 4,400 tons per shift in one of its sheet mills, a rise attributed by management to improved communications between supervisors and workers.[21]

The outlook is for some improvement in productivity growth during the 1980's, depending on the degree to which economic conditions improve. The impetus will come from continued rationalization of production; i.e., specialization by mills and shutdown of the most obsolete mills. And some gains are anticipated from improved flexibility of the work force.

Investment

Real capital expenditures[22] for steel plant and equipment were 19 percent less during the 1970's than during the previous decade. Following 5 years of rapid growth, capital expenditures peaked in 1967 and, thereafter, the trend has been generally downward. Per production worker, however, real outlays declined 12 percent during the same period because of the substantial drop in employment. In current dollars, the industry spent $3.2 billion on new steel plant and equipment in 1981 (latest data).

Low industry profits, weak steel demand, high imports, and little prospect for adequate return on investment have contributed to the decline in capital expenditures in the last decade. Between 1970 and 1980, the return on book value of the eight largest integrated steel companies averaged 7 percent, only about half the manufacturing average return. (These data include income from nonsteel subsidiaries, whose returns are generally higher.) For the entire industry, the return on stockholders' equity between 1970 and 1982 was substantially below the manufacturing average in every year but one (1974).

The low profits of the integrated companies have hampered investment since they have largely financed capital projects through retained earnings and equity

[18] "The State of the Steel Industry," prepared by the Subcommittee of the State of the Industry of the Steel Advisory Committee.

[19] Donald F. Barnett, *Steel: Upheaval in a Basic Industry*, p. 88.

[20] Barnett, *Steel*, pp. 119, 135–36.

[21] *Business Week*, Oct. 12, 1981, p. 86.

[22] U.S. Department of Commerce, Bureau of Industrial Economics, Office of Research, Analysis, and Statistics.

financing. The industry has maintained that inadequate depreciation allowances have prevented it from recovering inflation-elevated costs. During the 1970's, the United States had the longest cost recovery period of any major industrial country. The Economic Recovery Tax Act of 1981, which established shorter depreciation schedules and increased tax credits for investment, should benefit the industry once it returns to profitability.

Because of the limited prospect for an adequate return on investment, a number of the integrated companies have diversified into other sectors, including chemicals, oil, and financial institutions. One leading steel company reported that only 25 percent of its total assets were deployed in steel in 1983, compared with about 57 percent in 1975.[23]

As investment in steel facilities has declined, the degree of obsolescence has increased. A 1978 survey by McGraw-Hill of executives of large companies concluded that 26 percent of the steel industry's plant and equipment was considered technologically obsolete—higher than that of any other major manufacturing industry.

Unlike the integrated sector, the minimill sector's high profitability has enabled it to more readily generate funds for investment. In a comparative financial study of four major minimills and four integrated companies, the return on stockholders' equity in the years 1972–81 averaged 16 percent for the minimill companies, or double the return of the integrated companies.[24] However, in 1982 and 1983, both sectors sustained substantial losses.

The relatively low construction costs of minimills have also facilitated investment. In 1979, six minimills were built for an average cost of $200 per ton of capacity. In the same year, one integrated company estimated that a new integrated mill would cost about $1,400 a ton. Moreover, because minimill capacities are quite small, total minimill construction costs are only a fraction of the cost of an integrated mill.

Expenditures for pollution control have been steadily declining since 1979 and now constitute a relatively small proportion of total capital outlays. In 1983, 4.3 percent of capital outlays were spent on pollution control compared to 19.3 percent in 1979.

Estimates differ on the size of expenditures needed for modernization of the industry. The American Iron and Steel Institute estimated that $4.9 billion (1978 dollars) would be required annually through 1988 for modernization and a modest expansion of capacity, conceived as essentially a "rounding out" option.[25] This figure, which also includes outlays to meet environmental and safety requirements, is almost double the expenditure level of the late 1970's. While some other estimates are lower, it is unlikely that investment will come anywhere near the amount required, due to existing low utilization and continuing financial losses of the major companies.

Employment and Occupational Outlook

Employment

The long-term decline in steel employment accelerated in the early 1980's as the integrated mills reduced operating rates to historically low levels and closed mills. Industry efforts to reduce costs by consolidating jobs and reducing the size of work crews are also contributing to the employment decline. In 1983, total industry employment slipped to 343,100, one-third below its 1981 level and less than one-half its postwar peak (726,000 in 1953). Since 1970, the employment decline averaged 3.1 percent annually (chart 7).

In contrast to the integrated mills, employment in the minimill sector grew rapidly during the last decade but remains a small percentage of the industry total. Although no precise data are available for this sector, estimates show an increase from under 5,000 employees in 1970 to between 25,000 and 30,000 in 1981, which was less than 8 percent of total steel employment. Because of the minimill sector's relatively high productivity and simple product mix, its employment share is considerably less than its output share. Employment probably decreased in 1982 due to the severity of the recession.

The decline has been far more precipitous for production workers than for nonproduction workers. Since 1970, production worker employment has declined by 3.5 percent annually, more than double the 1.6-percent annual drop for nonproduction workers. As a result, production workers slipped from 80 percent of total industry employment in 1970 to 75 percent in 1983, still considerably above the ratio for all durable goods industries.

While some employees are being recalled to work as the economy improves, it is likely that a large proportion of recent job losses are permanent. BLS projects that employment will rise by 30 percent between 1983 and 1995 to 447,330, assuming moderate growth in the economy,[26] but this figure is 22 percent lower than the 1979 level. Employment in the minimill sector is projected to nearly double from its 1981 level to about 50,000 by 1990.[27]

[23] United States Steel Corp., *Annual Report*, 1975 and 1983.

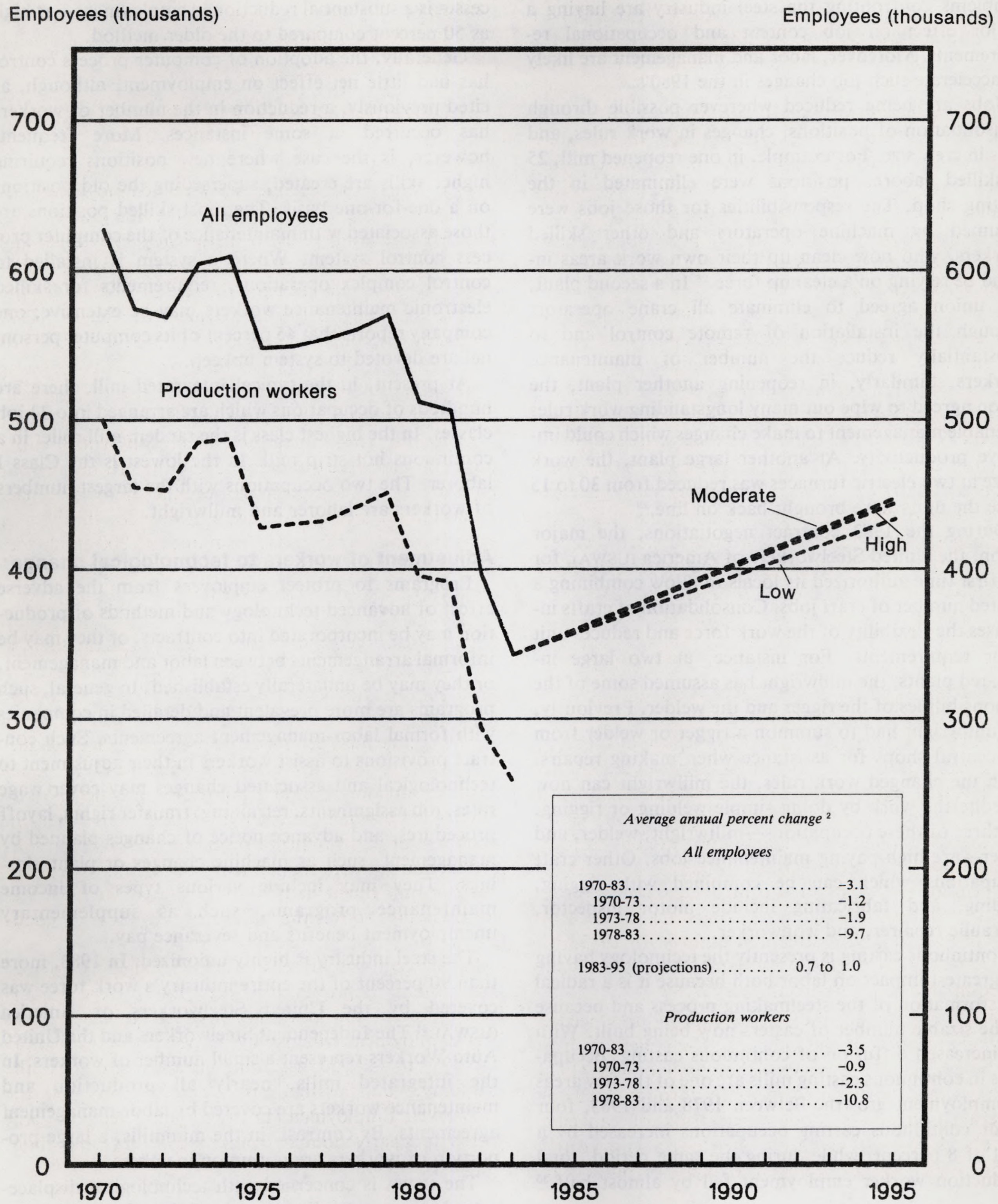
[24] Donald F. Barnett, *Steel: Upheaval in a Basic Industry*, p. 97.

[25] "Rounding out" is defined as increasing the capacity of an existing facility by removing production bottlenecks. For basis of estimate, see American Iron and Steel Institute, *Steel at the Crossroads: The American Steel Industry in the 1980's*.

[26] BLS projections for industry employment in 1995 are based on three alternative versions of economic growth and assume a low, moderate, and high projection. For details on assumptions and methodology used to develop these projections, refer to the *Monthly Labor Review*, November 1983.

[27] U.S. House of Representatives, *Crisis in the Steel Industry*, March 1982, p. 55.

Chart 7. Employment in steel, 1970-83, and projections, 1983-95



Average annual percent change [2]

All employees

1970-83	−3.1
1970-73	−1.2
1973-78	−1.9
1978-83	−9.7
1983-95 (projections)	0.7 to 1.0

Production workers

1970-83	−3.5
1970-73	−0.9
1973-78	−2.3
1978-83	−10.8

[1] See text footnote 26.
[2] Least squares trends method for historical data, compound interest for projections.

SOURCE: Bureau of Labor Statistics.

Occupations

Diffusion of new technology and the severe economic problems confronting the steel industry are having a major effect on job content and occupational requirements. Moreover, labor and management are likely to accelerate such job changes in the 1980's.

Jobs are being reduced wherever possible through consolidation of positions, changes in work rules, and cuts in crew size. For example, in one reopened mill, 25 unskilled laborer positions were eliminated in the casting shop. The responsibilities for those jobs were assumed by machine operators and other skilled workers, who now clean up their own work areas instead of relying on a cleanup force.[28] In a second plant, the union agreed to eliminate all crane operators through the installation of remote control and to substantially reduce the number of maintenance workers. Similarly, in reopening another plant, the union agreed to wipe out many longstanding work rules to enable management to make changes which could improve productivity. At another large plant, the work force at two electric furnaces was reduced from 30 to 15 once the units were brought back on line.[29]

During the 1983 contract negotiations, the major union, the United Steelworkers of America (USWA), for the first time authorized its locals to allow combining a limited number of craft jobs. Consolidation of crafts increases the flexibility of the work force and reduces unit labor requirements. For instance, at two large integrated plants, the millwright has assumed some of the responsibilities of the rigger and the welder. Previously, the millwright had to summon a rigger or welder from the central shops for assistance when making repairs. With the changed work rules, the millwright can now expedite the work by doing simple welding or rigging. All three of these occupations—millwright, welder, and rigger—are high-paying maintenance jobs. Other craft occupations which can be combined with rigging, welding, and fabricating include motor inspector, hydraulic repairer, and ironworker.

Continuous casting is presently the technology having the greatest impact on labor both because it is a radical transformation of the steelmaking process and because of the sizable number of casters now being built. With the increased diffusion of continuous casting, occupations in continuous casting mills are one of the few areas of employment growth. Between 1978 and 1983, four major continuous casting occupations increased by a total of 8 percent, while during the same period, total production worker employment fell by almost half.[30]

[28] *Wall Street Journal,* July 30, 1982, p. 12.

[29] *Ibid.*

[30] *Industry Wage Survey: Basic Iron and Steel, 1978–79,* BLS Bulletin 2064 (Bureau of Labor Statistics, 1980), p. 14; and *Industry Wage Survey: Basic Iron and Steel, August 1983,* BLS Bulletin 2221 (Bureau of Labor Statistics, 1984), p. 11.

However, the net effect of the adoption of continuous casting to replace ingot-pouring and associated processes is a substantial reduction in employment—as high as 50 percent compared to the older method.

Generally, the adoption of computer process control has had little net effect on employment, although, as cited previously, a reduction in the number of workers has occurred in some instances. More frequent, however, is the case where new positions requiring higher skills are created, superseding the old positions on a one-for-one basis. The most skilled positions are those associated with maintenance of the computer process control system. Where a system is installed to control complex operations, requirements for skilled electronic maintenance workers may be extensive; one company reports that 45 percent of its computer personnel are devoted to system upkeep.

At present, in the typical integrated mill, there are hundreds of occupations which are arranged into 34 job classes. In the highest class is the tandem mill roller in a continuous hot strip mill. In the lowest is the Class I laborer. The two occupations with the largest numbers of workers are laborer and millwright.

Adjustment of workers to technological change

Programs to protect employees from the adverse effect of advanced technology and methods of production may be incorporated into contracts, or they may be informal arrangements between labor and management, or they may be unilaterally established. In general, such programs are more prevalent and detailed in companies with formal labor-management agreements. Such contract provisions to assist workers in their adjustment to technological and associated changes may cover wage rates, job assignments, retraining, transfer rights, layoff procedures, and advance notice of changes planned by management, such as machine changes or plant closings. They may include various types of income maintenance programs, such as supplementary unemployment benefits and severance pay.

The steel industry is highly unionized. In 1983, more than 90 percent of the entire industry's work force was covered by the United Steelworkers of America (USWA).[31] The Independent Steelworkers and the United Auto Workers represent a small number of workers. In the integrated mills, nearly all production and maintenance workers are covered by labor-management agreements. By contrast, in the minimills, a large proportion of workers are not union members.

The USWA is concerned with technological displacement but has generally not resisted the adoption of new technology. Management has the right to change local work practices such as crew size, work rules, or job descriptions, when supported by "changed" conditions,

[31] *Industry Wage Survey: Basic Iron and Steel, August 1983,* BLS Bulletin 2221, p. 3.

including technological change.[32] Affected employees have recourse to arbitration.

An earnings protection plan included in the master contract covering most workers is designed to help workers adjust to technological change. "The purpose of the plan is to protect a level of earnings for hours worked by employees, with particular emphasis on employees displaced in technological change."[33] The plan provides additional compensation based on hours worked during a quarter if earnings fall below 85 percent of hourly earnings during a previous base period.

Strengthening supplementary unemployment benefits (SUB) was a major goal of the union in contract negotiations which were concluded in the spring of 1983. While a major proportion of workers are eligible for SUB payments,[34] SUB funds have been drained due to the sharp rise in laid-off workers drawing on the funds and the decline in the number of employed workers paying into the fund. In 1982, in most companies, only laid-off workers with more than 20 years service were receiving SUB payments. The new contract increases the companies' payments into the depleted SUB funds and guarantees minimum benefits for a set period for a greater proportion of employees.

The new steel pact also makes several improvements in an interplant job opportunities program, which was first established in 1962. These changes make it easier for laid-off workers to locate and fill vacant positions in other plants owned by their company. They include a waiver of waiting periods for transfer and liberalization of rules governing determination of continuous service.

During the past several decades, the USWA has developed the strength to bargain uniform wage patterns on an industrywide basis, effectively eliminating wages as a competitive factor. However, the shrinking market share of the large integrated producers may weaken the union's bargaining power.

[32] *Agreement Between United States Steel Corporation and the United Steelworkers of America,* p. 11.

[33] *Agreement,* p. 27.

[34] Supplementary unemployment benefits were provided by establishments employing more than 90 percent of workers in 1978 and 85 percent in 1983. See *Industry Wage Survey: Basic Iron and Steel, 1978,* p. 8, and *1983,* p. 29.

The USWA and seven large integrated companies renegotiated the existing master contract prior to its August 1983 expiration date. The new contract for the first time cut wages, which had been rising rapidly under the industry's Experimental Negotiating Agreement (ENA), in effect since 1973. (The ENA provided a cost-of-living adjustment and an annual wage increase in return for a no-strike clause.) In addition, several cost-of-living adjustment (COLA) payments were cancelled, and the COLA formula was modified. Some vacation time, holidays, and sabbatical leave were also cut. Savings from wage and benefit cuts will be used to support steel operations.

Additional concessions by both management and labor have been made at the local level to keep plants open. In one plant, for instance, local arrangements have included more substantial wage cuts, scheduling changes to allow 10-hour shifts with no overtime pay, and a relaxation of all seniority regulations governing layoff and recall. In return, management agreed to contribute 75 cents per employee hour for 2 years to a fund to be used to help train displaced steelworkers for jobs which might open up outside the plant.

The 1980 master contract provided for the establishment of labor-management participation teams (LMPT's) on a limited and experimental basis to deal with such issues as productivity, work arrangements, and quality control. By early 1982, about 100 teams, typically consisting of two to three supervisors and 10 to 15 workers, had been established in 13 plants belonging to 5 large integrated companies. Due to the full cooperation of both parties, the experiment has been considered helpful. For example, as a result of the worker input of one team in a rolling mill, a number of small changes were made which boosted productivity 19 percent during the first year after adoption of the task force recommendations.[35] Output increased by 30 percent at a second plant due to LMPT suggestions. The 1983 agreement extends LMPT's to plants of all seven large integrated companies.

[35] *Iron Age,* Feb. 2, 1981, p. 4.

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Chapter 4. Motor Vehicles

Summary

The motor vehicles industry (SIC 371) is adopting the latest technologies to increase productivity and improve quality to compete more effectively in domestic and overseas markets. The innovations range from the widely publicized use of industrial robots to less dramatic refinements in conventional machinery. The scope of diffusion is broad, with new technologies being adopted in all three of the major stages involved in the manufacture of autos and trucks: Design, engineering, and testing; production of parts and subassemblies; and final assembly. They include computer-aided design and computer-aided manufacturing (CAD/CAM) as well as computerized data processing and equipment monitoring; industrial robots for welding, materials handling, painting, assembly, and inspection; programmable controllers; and a wide range of improvements in basic production machines and transfer lines.

Output in the motor vehicles industry increased at an average annual rate of 1.6 percent over the period 1970–83, with the substantial gains in output during the early and middle years of this period offset by declines the later years, through 1982. Between 1978–83, output declined at an annual rate of 5.0 percent as the economy experienced inflation, high interest rates, growing unemployment, and recession. Moreover, imported cars captured an increasing share of the domestic market. Sales of autos and trucks moved sharply higher in 1983 and early 1984, however, as the economy strengthened, and workers were recalled as plants increased production. From 1982 to 1983, output increased by 30.6 percent.

Productivity in the motor vehicle industry (output per employee hour) increased at an average annual rate of 2.5 percent over the period 1970–83. The pattern of productivity change was uneven over this period, with output per employee hour increasing at an average annual rate of 6.4 percent during 1970–73 and of 4.1 percent during 1973–78. From 1978 to 1983, however, output per employee hour increased at a lower annual rate of 2.1 percent, due to a decline in productivity during 1978–80 followed by an increase during the more recent period 1980–83. Productivity increased strongly—by 14.2 percent—from 1982 to 1983. The outlook for productivity gains appears generally favorable, with the announced plans to spend billions of dollars during the 1980's to modernize plant and equipment expected to bring about labor and other cost savings.

The motor vehicles industry employed 772,700 workers in 1983 in about 3,000 plants ranging in size from huge assembly plants to small parts suppliers. Between 1978 and 1983, employment fell off sharply, from just over 1 million workers to 772,700 workers, as the economy slackened and competition from foreign producers intensified. The Great Lakes region, where a major portion of the work force is located, was particularly hard hit. The employment situation improved in 1983 as the economy strengthened, demand for autos increased, and many unemployed auto workers were recalled.

The outlook is for employment to move higher by 1995 but still remain below the record 1 million workers employed in 1978. New production technologies will continue to lower unit labor requirements, with machinists, welders, tool-and-die makers, assemblers, painters, and drafting employees among those most affected. Prospects for employment growth are favorable for some categories of workers, including computer personnel, scientists and engineers, electricians, and maintenance workers. The topic of job security will be prominent in labor-management negotiations during the 1980's, and training programs to facilitate work force adjustments will be implemented more extensively.

Technology in the 1980's

A number of technological changes are underway as the motor vehicle industry seeks to redesign product lines and modernize plants. Competition from Japan and elsewhere is intense, and the latest manufacturing technologies are being adoped to raise productivity, lower costs, and improve quality.

A wide range of technologies are being adopted. Computers are being used intensively in design applications and in CAD/CAM and other plant operations. The industry leads in the application industrial robots, and their use is increasing in welding, materials handling, painting, assembly, and inspection operations. Programmable controllers also are being used more extensively to regulate production processes more efficiently. Basic metal-cutting and metal-forming machines are being improved, and transfer lines are becoming more highly automated. The widely employed unit-body construction method facilitates automatic welding.

The major technologies, their labor impact, and diffusion are summarized in table 4.

Table 4. Major technology changes in motor vehicles

Technology	Description	Labor implications	Diffusion
Computers	Computer-aided design and manufacturing (CAD/CAM) systems assist in design of mechanical and structural components used in motor vehicles. Computer simulation of physical data used to test vehicle components and production line operations. Computer systems also used to control manufacturing processes and manage plant energy systems through direct control of individual machines or entire production lines. Plantwide data networks are built around computers which provide considerable statistical information on equipment performance, output, and quality levels.	CAD typically reduces by 50 percent the time required to design vehicle components and reduces requirements for drafting personnel. CAM and other forms of computer control are expected to reduce demand for equipment operators, will increase demand for maintenance and technical workers.	Data on extent of use are not available. However, computers are in general use for business and production applications, and CAD systems also are broadly deployed. Although already in place, continuous improvements in computers and CAD systems have increased their capability. CAM and computer-controlled plant data networks are less widely used and located primarily in new and redesigned plants.
Industrial robots	Spotwelding is most important application; robot welding fits very well with unit-body construction of passenger cars and light trucks. Materials handling is second most important application, including the transfer of parts from one place to another, and loading or unloading machines. Robots useful in painting where potentially hazardous conditions exist for human painters. A wide range of assembly and inspection operations are potentially available for robots when their capability improves and costs are lower.	Each robot performs the functions of about 1½ workers per shift for spot welding. In materials handling, the relationship may be more like one to one. Estimates of dislocation are more difficult to make in other applications. Robots require maintenance and repair services, which provide jobs for skilled craft workers—especially electricians, as most problems involve the electrical control panels that direct a robot's operations.	Approximately one-third of the estimated 13,000 robots used in the United States in early 1985 were in motor vehicle manufacturing plants. One estimate is for 31,350 robots by 1990. About half of all robots currently are used for spot welding. Number of robots is expected to grow in all applications by 1990, with growth rates lowest for welding operations (where already widely used) and highest for assembly tasks, where the largest number of workers are employed.
Unit-body construction	Vehicle bodies constructed from sheet-metal panels welded together to form a strong, rigid box. There is no separate frame onto which the body is mounted.	Method involves a substantial amount of welding, increasingly carried out by industrial robots and automatic methods displacing welders.	Most passenger cars and some light trucks are built from the unit-body concept.
Programmable controllers (PC's)	Solid-state electronic controls used to regulate machines and production lines. PC control functions can be easily changed to meet new manufacturing needs. Also, PC's are reliable and use logic symbols familiar to engineers, electricians, and other technicians.	PC's reduce time required for engineers and electricians to change control functions. Maintenance and repair requirements are also much lower, due to inherent reliability and electronic diagnostic capability available to electricians.	Data on number in use are not available. However, programmable controllers are diffused fairly extensively in modern plants. The auto industry worldwide reportedly accounts for about 40 percent of the total market for programmable controllers.
Changes in basic production machines	Improvements include higher operating speeds, automatic controls, coated edges on cutting tools, and faster die changing capability for stamping presses.	Labor requirements for machine operators are reduced. A modern quick die change (QDC) press, for example, can be operated by 1 operator at a master control panel compared to the 6 to 12 workers for conventional presses.	QDC presses are in limited use, but automatic controls, faster speeds, and improved cutting tools are more broadly used.
Improved transfer lines	Highly mechanized machine lines that manufacture or assemble automobile components. Improvements include greater use of automated equipment, including numerical and computer control; programmable controllers; industrial robots; and more automatic testing and inspection stations.	Decrease in number of semiskilled machine operators, assemblers, and inspectors. Some increase in craft and technical workers who program repair, and maintain equipment.	Most new manufacturing and assembly lines incorporate some of these improvements.

Computers

Computer-aided design (CAD) and computer-aided manufacturing (CAM). Computers, linked with display terminals and using sophisticated software, greatly enhance the ability of engineers to perform design work on vehicles. Mechanical and structural components can be designed or modified very quickly, and mathematical models of auto components can be tested by computer simulation. The concept extends even to simulating the operation of production lines. With computer simulation, engineers can anticipate potential problems and develop solutions in advance of actual production.

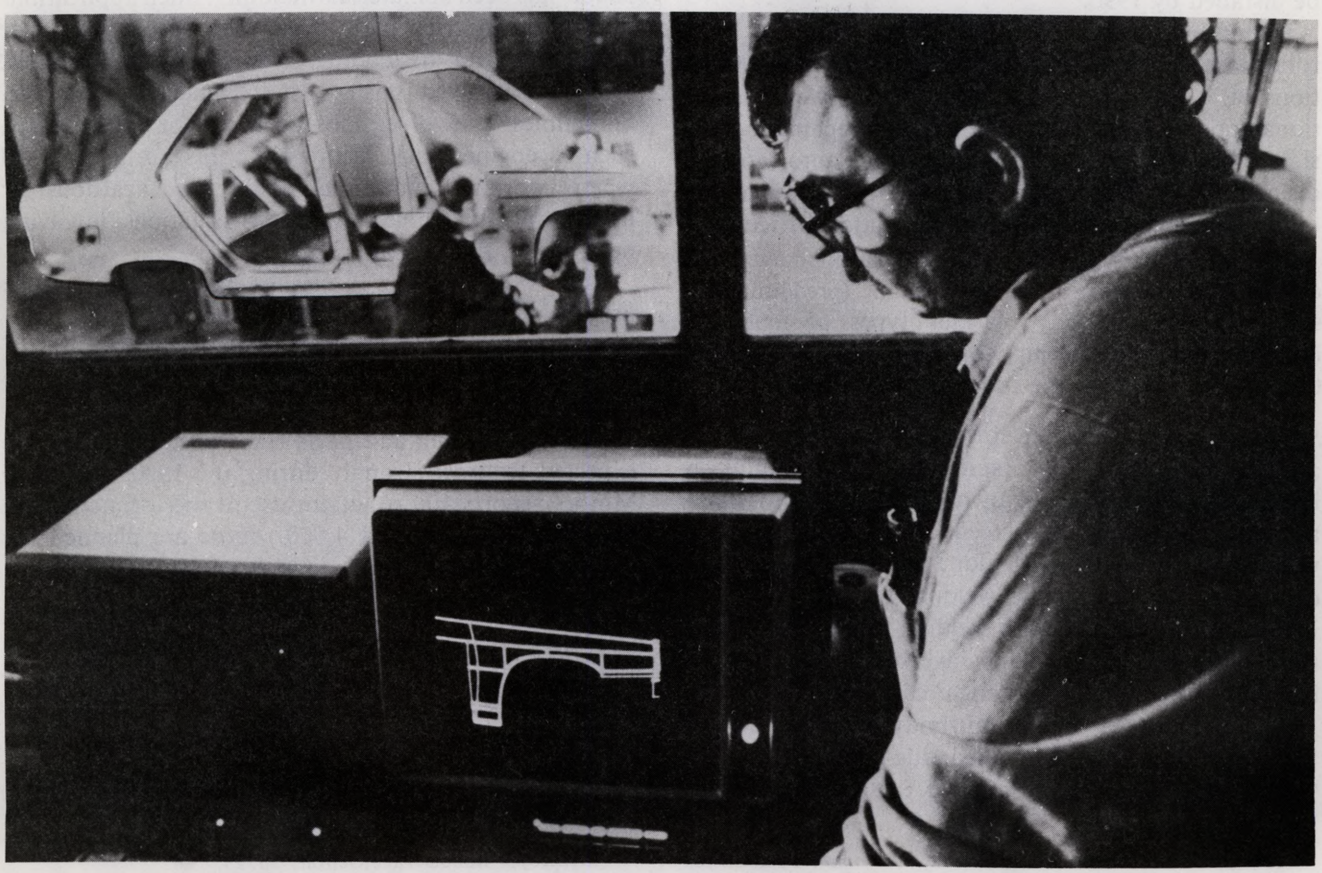
CAD makes large productivity gains possible for engineers and drafters, typically reducing by half or more the amount of time previously required in design tasks. As an example, the time required to produce drawings related to the clearance of the hood and engine components at one plant totaled only 80 hours with CAD, compared to 240 hours with conventional methods.[1] Once the design specifications for a component have been computerized, the information can be stored and used to operate machine tools, programmable controllers, and robots.

Combining CAD/CAM into a unified system can lead to improvements in design and testing work and in manufacturing operations. In one CAD/CAM system, body dies are made directly from computer data; the customary wooden models are eliminated. This method saves 6,000 hours of work, and tools made from these dies are of higher quality.[2] As a general assessment, CAD/CAM systems reduce unit labor requirements for engineers, drafters, machine operators, and tool-and-die makers. The number of manual tasks is reduced substantially.

Plant data networks. Computers are being used to establish plant-wide data communications networks to assist plant managers and technicians. In these systems, data are collected and stored for a wide range of variables, including the performance of production machinery, the results of tests performed on vehicles in production, and rosters of technicians and specialists presently on duty in the plant who can be alerted by CRT terminals and dispatched promptly to problem areas. Many other capabilities are possible with data communications networks, including statistical programs to assess the quality of components received from suppliers, as well as to track output and quality levels for the entire plant. The range of occupations affected by these data systems is broad, but the common result is greater efficiency and higher productivity.

[1] "U.S. Automakers Ease Toward CAD/CAM," *Automotive Industries,* December 1982, p. 29.

[2] Lester V. Ottinger, "Robots and Other Technologies in the Automated Factory," *Industrial Engineering,* September 1982, p. 28.



Layout technicians compare accuracy of a front fender to computer-generated blueprints.

Computers also are being used to manage energy systems. One automaker reported annual savings of $400 million by using computer controlled systems that require only 20 seconds to turn equipment on and off automatically throughout a plant at the beginning and end of work shifts. This is a fraction of the 4 or more hours required by maintenance or operating crews to perform this task manually.

Robots

The industrial robot is one of the most important technologies to be introduced in the motor vehicle manufacturing industry. Contemporary robots incorporate three basic components: (1) One or more arms that can move in several directions, (2) a manipulator or "hand" that holds the tool or part to be worked on, and (3) a controller that provides instructions on how the robot is to move. Robots are flexible and can be reprogrammed quickly and inexpensively to handle a variety of tasks associated with the manufacture of motor vehicles.

According to the Robot Institute of America, motor vehicle manufacturers use robots more intensively than any other industry, accounting for about one-third of the estimated 13,000 robot installations in the United States in early 1985. The number of robots in the industry is expected to increase substantially during the 1980's. One expert forecasts just over 31,000 robots to be installed by 1990.[3]

Robots are having a significant impact on jobs: Each robot installed on a production line performs the functions of at least one worker per shift. However, additional labor is required to maintain and repair robot installations. To date, welders and other auto workers dislocated by robots reportedly have been reassigned to other positions in the plant without major difficulty.

Several major types of robot applications have been developed in the auto industry: Welding (predominately spot welding), painting, various types of materials handling, and some assembly operations. These applications are described in the following paragraphs.

Spot-welding. This has been the most important robot application. Robots were first installed in large numbers in General Motors' Lordstown, Ohio, assembly plant around 1970. About 85 percent of all body assembly welding in this plant was done automatically—by a combination of automatic welding transfer lines and industrial robots fitted with welding tools.[4] The operations pioneered in this plant have become fairly standard in plants building passenger cars and light trucks.

A contemporary, small, unit-body passenger car (or light truck) is estimated by one industry official to have 2,400–2,500 spot welds. Some of these welds are difficult to make, and even the most simple welding operations are not pleasant jobs. Robot welding frees people from this type of work and is more consistent than human welding. All of the welds are completed, and the accuracy of each weld, from one car body to the next, hour after hour, is more precise than what can be achieved by most human welders.

The technology involved in robot welding developed at a faster pace than other robot applications over the past decade. General Motors estimates that 1,000 of its 2,300 robots in 1983 were used in welding operations.[5] Currently, about one-half of all robots sold to the auto industry are being used to spot weld on car bodies.[6]

Robot welding will continue to grow. General Motors plans to increase the number of welding robots from 1,000 in 1983 to 2,700 in 1990—a nearly threefold gain. The rate of growth, however, will be lower for welding than for any other major applications planned by GM—an indication of the fast pace of diffusion of robot technology planned for the 1980's. An official in one assembly plant estimates that about one-half of all assembly welding carried out by domestic auto manufacturers in 1983 performed by robots and other automatic welding equipment, while almost 90 percent of all welding in Japan was by automated methods.

Materials handling. The second most important use of robots has been in materials handling. Such applications include transferring parts from one pallet or conveyor to another, and the loading or unloading of machines. The work involved is usually simple and very repetitive. Sometimes it involves moving heavy or bulky parts, such as engine block castings. Robots are also useful where working conditions could be hazardous or unpleasant for human workers—situations involving heat, noise, flying sparks, etc.

Robots applied to materials handling operations usually interface with machines and conveyors in a manner similar to that of human workers. Dislocation of human workers is usually on a one-to-one basis, per shift.

Machine loading and parts transfer applications are expected to grow strongly during the 1980's. General Motors reports 100 robots in use in these functions in 1980, and an estimated 4,800 robots are planned for these operations by 1990.

[3] John McElroy, "Robots Take Detroit," *Automotive Industries,* January 1982, p. 28.

[4] Automatic welding machines have been in use for many years, so this part of the process is not new technology. It is referred to as "hard automation" because the machinery was built to do a specific welding operation and cannot be changed easily. Automatic welding is useful when the same welds must be made over and over—as on a vehicle floor pan.

Since robot welders can easily be programmed to perform a number of different welds, they are useful for doing the variety of welds necessary on several body styles that can be built on one floor pan.

[5] McElroy, "Robots Take Detroit," p. 29.

[6] *Ibid., p. 28.*

Painting. Robots are also being applied to painting operations. Spray painting automobile bodies in closed painting booths is necessary to produce a clean, dust-free coat of paint, but the closed booths must have costly ventilation systems to protect human workers from inhaling the hazardous solvents. Robots, however, can survive in an unventilated environment, and the higher temperature that can be used in unmanned, robot installations dries paint faster.

Automobile painters are among the most highly skilled operatives in an assembly plant. Training requirements are longer than for most other operative jobs, and the skill of the painter largely determines the quality of the paint application. A robot cannot produce a better paint job than a skilled human painter; but properly programmed, the robot can paint with greater consistency.

A substantial growth in the number of robots applied to painting operations is expected during the 1980's.

Assembly and inspection. Industrial robots have been applied to only a limited number of assembly and inspection operations. Such applications generally require more sophisticated equipment and software than is needed for welding or materials handling. Such sophistication is expensive and not always technically achievable. However, as robot capability is enhanced, experts foresee a sharp gain in their use for assembly and inspection during the 1980's.

Industrial robots presently carry out several assembly tasks. A robot in one modern plant applies sealant around the edge of auto windshields prior to the installation of the glass into the auto body. In an engine plant, robots deburr holes drilled into crankshafts and tighten spark plugs that have been placed in the engines by hand. In another example, robots equipped with lasers measure auto bodies with great precision to insure that body panels fit properly.

Over the past few years, electric robots have been developed as alternatives to the older, hydraulic-powered robots. Most electric robots are smaller and frequently less expensive than hydraulic models, and they operate at higher speeds and with greater accuracy. However, they generally cannot handle heavy parts.

Auto manufacturers are working on a number of potential robot assembly applications including: Installing piston rings, assembling engine oil pumps, inserting light bulbs into instrument panels and tail light assemblies, and installing wheel-and-tire assemblies onto autos and starting the wheel nuts. Robots can be used to put together "sub-assemblies" of door panels, instrument clusters, etc., that are carried by conveyor to major assembly areas. General Motors estimated that the number of assembly robots will grow from 17 in 1980 to 5,000 in 1990, and, in the process, will ultimately become the largest type of robot application.

The application of robots to assembly operations could have a significant impact because assembly operations are labor intensive. Thousands of semiskilled "small parts" assemblers are employed in the auto industry. If robot assembly is diffused at the rate forecast, a substantial number of workers could be affected. However, the total number of assembly robots in use in 1990 is expected to be small in relation to the total number of assembly jobs.

Robots are currently used in a limited number of inspection operations—for instance, probes or gauges can be attached to a robot's arm to ensure that parts have been installed on an assembly line, or that certain measurable parts are within the proper tolerances. Growing use of electric robots, which are often less expensive than other types of robots and are capable of accurate and finely tuned arm movements, should increase the opportunities for inspection applications.

Developments are underway to create a sense of "vision" and "touch" for robots—in fact, there are a limited number of robots with these capabilities already in use. Robots equipped with video cameras, pressure sensors, etc. can be applied to a number of inspection jobs. This will have an impact on labor by reducing manual inspection activities.

Programmable controllers

Programmable controllers (PC's) are replacing electromechanical relay controls which serve as "on-off" switches used to regulate the sequence of production steps on transfer lines or other manufacturing technologies. The primary advantage of PC's is that changing a manufacturing process is relatively simple and labor requirements of engineers and technicians are lowered. A circuit change that would require an hour or more to make on a conventional electromechanical relay can be done in minutes on a PC. To change an operation controlled by electromechanical relays, a new wiring diagram to accomplish the new process is developed by engineers, and the wiring in the relay panel is changed to fit the diagram. A large transfer line incorporates a substantial number of relays, each needing to be rewired. An hour or more of work on each relay adds up to a considerable amount of time and labor.

By contrast, a PC needs only to be reprogrammed. An engineer can write a new program into the PC memory, using a keyboard or some combination of keyboard and computer-prepared tape. Once entered, the PC will carry out this program until it is changed. Entering and implementing the new program requires only a few minutes. Modifications to the program are equally easy—as opposed to pulling wires loose from relay panel connections and relocating them. One PC can often do the work of several relays, further reducing the workload on engineers and technicians.

The experiences of one large firm which, in connection with a change in the production line, installed six

PC's to replace 60 conventional relays illustrates the types of savings being achieved by this technology. At this firm, electrical maintenance costs were reduced by about 30 percent, because programming and start-up operations involved less work with the PC's than the conventional relays would have required. Moreover, the PC's need less floor space than the relay panels which they replace, and they are far more reliable. In all, production downtime has been reduced significantly by the installation of PC's in place of conventional electromechanical relays.[7]

Another major advantage of PC's is that they use the same kind of logic symbols—"relay ladder logic"—that are used by mechanical relays. No special computer languages are necessary. Consequently, plant engineers, electricians, technicians, and other operating personnel understand and are comfortable with PC's. This similarity of language to mechanical relays is reported to be a primary reason for the initial success and acceptance of PC's.[8]

The range of PC applications is diverse and too numerous to discuss in detail. However, two examples illustrate their key role in the production of motor vehicles—both alone and in combination. In one application, a large number of PC's are used for in-process gauging of parts and to undertake automatic tool-wear compensating adjustments in the manufacture of transaxle housings. In another application, a single PC controls an automatic camshaft-straightening system, in which two camshafts at a time are rotated, gauged, and peened by a series of airhammers, at a rate of 220 camshafts per hour per machine.[9]

The potential of PC's to achieve productivity gains and other benefits is increasing. PC's being installed in manufacturing facilities in the early 1980's featured increased input/output capabilities, more data processing capacity, and expanded memories. PC's can be tied together in networks to control complex manufacturing operations. Moreover, these PC networks can be brought under computer control, and can be part of a plantwide data communications system.

The motor vehicle manufacturing industry will continue to be the major user of PC's. In 1980, sales to the auto industry accounted for over 40 percent of the PC market (worldwide), with some experts anticipating an annual growth rate of about 35 percent.[10]

[7] Jennifer M. George, "Minding Your PC's in Machine Control," *Automotive Industries,* March 1980, p. 54.

[8] Russell M. Loomis, "PC's Boost Quality Management Control and Productivity; Minimize Downtime," *Industrial Engineering,* September 1982, p. 34; and Robert J. Sibthrop, "Hybrid of Microcomputer and PC Is Control Solution," *Industrial Engineering,* September 1982, p. 55.

[9] *Ibid.,* p. 42.

[10] "PC's Adapt to Automakers' Needs," *Automotive Industries,* February 1982, p. 102.

Unit-body construction of passenger cars

Most passenger cars and small trucks are now built as unit-body vehicles—a manufacturing technique which is having an impact on employment of welders. In this process, the major body panels, such as floor pan and side panels, are welded together to form a strong and lightweight box. There is no separate steel frame to which the body is attached. Relatively small subframe assemblies are bolted into the front and rear of the unit body, to which engine, drive train, steering, and suspension components are attached.

Constructing an automobile by the unit-body process involves a considerable amount of spot welding—an estimated 2,500 to 3,500 individual welds. The process lends itself readily to automatic and robotic welding applications. As an example, at an assembly plant visited by BLS staff in the early 1970's, automatic welding accounted for 20 to 30 percent of the welds on a unit-body passenger car, and the remainder were done by human welders. At this same plant in the early 1980's, however, virtually all the welding is carried out by automatic and robot welding equipment.

Changes in basic production machines

Although robots and other advanced technologies have received widespread attention, a series of less dramatic but nonetheless significant improvements in conventional equipment has taken place. Auto manufacturers, in conjunction with machinery manufacturers, are improving productivity of basic production machines such as metal-cutting and metal-forming machines. The design of many of these machines is 20 to 50 years old; and, while some improvements have been made in durability, there has been little improvement in productivity. Contemporary models, however, are faster and incorporate automatic controls. As improved machinery becomes diffused more widely, a further shift toward more skilled technical and craft workers and a decline in semiskilled machine operator jobs are anticipated.

Cutting edges on some machines have been improved, which has increased productivity of machine operators. Machine tool cutting edges coated with titanium oxide, tungsten carbide, or ceramic composites remove metal up to twice as fast as conventional, uncoated cutting tools.

Quick die change (QDC) presses can reduce by 50 percent or more the time required by a press operator to change the dies in a major stamping press. QDC presses are considerably more expensive than conventional stamping presses, and they require more floor space because of the die-changing equipment that is part of the press assembly. But the additional costs and space requirements can be justified in situations where stamping dies must be changed frequently.

Improved transfer lines

Transfer lines—the highly mechanized machine lines that manufacture and assemble engines, transmissions, and other automotive components—are becoming more automated and flexible. More of the machines are being operated by numerical control, direct computer control, or programmable controllers. Robots are being used more extensively at stations within transfer lines, most frequently in materials handling operations. Automatic testing and inspection equipment allows more thorough and rapid operations, sometimes including the testing of all components on a line where only a sample had been tested previously. Statistical data on equipment performance and maintenance requirements are maintained to reduce machine downtime. Automated parts storage points between machining and assembly stations allow operations to continue if a station on the line shuts down.

In a highly automated transmission plant, bolts are inserted and torqued to specifications automatically, and valves and speed controls are automatically tested before being installed. A combination of automatic and mechanical checking stations, incorporating laser inspection technology, contribute to making assembly tolerances so close that transmission band adjustment is eliminated. Completed transmissions are tested on computer-controlled test stands.[11]

In an engine assembly plant where advanced technology is used, engine blocks are secured to pallets, and bolts for a number of engine parts—cylinder heads, rod caps, oil pumps, water pumps, oil pans, and other parts—are torqued automatically. Camshafts are balanced and inspected on equipment run by a programmable controller. Automatic hot test stands are used to test completely assembled engines at the end of the line. Engines are connected (by mostly automatic devices) to testing stands that provide fuel, electrical power, and cooling water; and engines are automatically fired up for the first time and checked in a number of operating conditions.[12]

Engine, transmission, and other mechanical component assembly plants have been highly automated for many years. But the degree of automation—automatic control and automatic assembly operations—is increasing. This trend is expected to further reduce labor requirements for semiskilled operatives. There will probably be a need for more craft and technical workers—but this increase may be smaller than the decline in operative positions.

Output and Productivity Trends

Output

Output in the motor vehicle industry varied significantly during the period 1970–83. (Chart 8). The dramatic swings in production that occurred over this period resulted from the interaction of a series of developments, including a major industry strike in 1970, higher prices for gasoline, competition from foreign automakers, and changes in the economy.

Output increased at a relatively modest average annual rate of 1.6 percent during 1970–83, with substantial gains in output during the early, middle, and final years of this period. Between 1970–73, output increased at an average annual rate of 16.2 percent, reflecting the strong demand for new cars and trucks during this period. Output continued to increase during 1973–78, increasing at a lower—but nonetheless substantial— annual rate of 5.9 percent. During these years, gasoline prices rose significantly, and imported cars captured an increased share of the domestic market. However, demand remained strong and output reached its highest level in 1978.

From the high point of 1978, output declined by an average of 10.6 percent a year through 1982. From 1982 to 1983, however, output increased by a substantial 30.6 percent as economic conditions improved. During the years of decline, the economy experienced inflation, high interest rates, growing unemployment, and recession—all of which had a negative impact on auto sales and production. Consumer fears about gasoline availability and price caused a strong market shift toward small, fuel-efficient cars. Small cars (subcompacts and compacts, domestic and imported) accounted for 47 percent of all new car sales in 1978 but increased to 63 percent in 1981.[13]

At the beginning of the 1978–83 period, the small cars being produced by domestic manufacturers were not strong competitors in the marketplace. Later in this period, however, a number of new and more competitive compact and subcompact models were introduced. These have generally been smaller and lighter than their predecessors for improved fuel economy. Most are front-wheel drive models powered by 4- and 6-cylinder engines.

During the several years that domestic manufacturers were setting up plants and beginning to produce new small car models, a number of attractive, marketable imported compacts and subcompacts already were available. The imported small cars sold well, taking potential sales away from domestic auto makers. It is significant that Japanese auto makers have been able to ship their cars to the United States with suggested retail prices lower than those for comparable domestic autos. Thus, the proportion of imported cars grew from 17.7 percent of total retail car sales in 1978, to an estimated 27.8 percent in 1982.

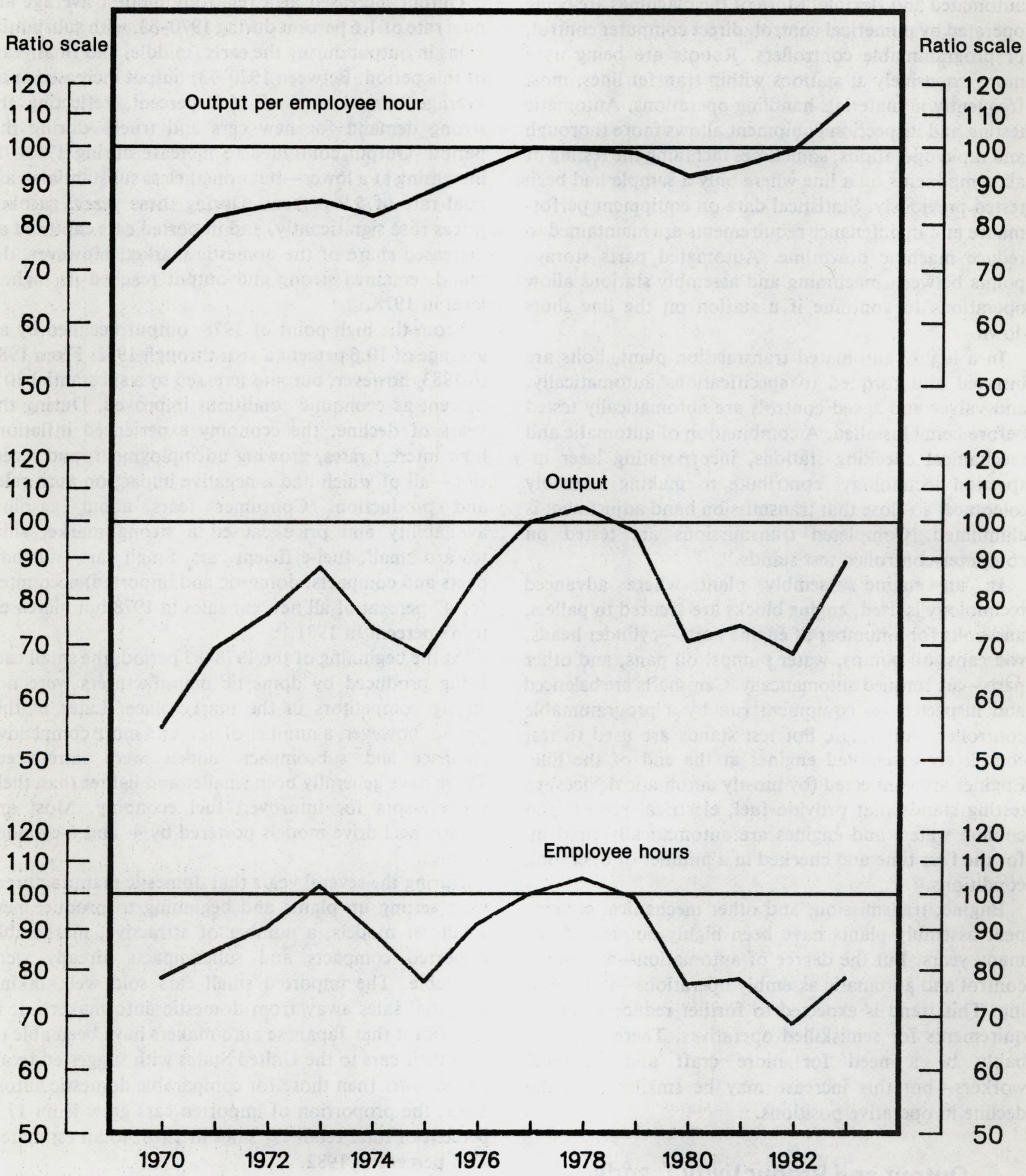
[11] John McElroy, "Making Production Pay Off," *Automotive Industries*, August 1979, p. 48.

[12] *Ibid.*, p. 54.

[13] *1983 U.S. Industrial Outlook* (U.S. Department of Commerce, Bureau of Industrial Economics, 1982), pp. 30–34.

Chart 8. Output per employee hour and related data, motor vehicle and equipment, 1970-83

(Index, 177 = 100)



SOURCE: Bureau of Labor Statistics.

The combination of bad economic conditions for the country and specific problems within the auto industry placed domestic auto makers in a very difficult position. Total auto sales declined every year between 1978 and 1982—but the decline primarily affected domestic auto makers. Sales of imported cars grew from 2 million in 1978 to a high of 2.4 million in 1980, then declined to 2.2 million in 1982. In contrast, sales of domestic cars dropped from 9.3 million in 1978 to 5.8 million in 1982. Sales of domestic trucks and buses also were lower over this period.

Auto sales rebounded sharply during 1983 and into 1984, leading to a strong increase in output (31 percent from 1982 to 1983) and a recall of many workers who had been laid off during the several previous years. An interesting market development was the resurgence in demand for large, less fuel-efficient autos—a result of gasoline prices stabilizing at levels that are high, but acceptable to consumers who prefer larger passenger cars.

Productivity

Output per employee hour in the motor vehicle industry increased at an average annual rate of of 2.5 percent over the period 1970-83 (chart 8). The pattern of productivity change over the period was uneven. Output per employee hour increased at an average annual rate of 6.4 percent during 1970-73 and 4.1 percent between 1973-78; productivity declined at an annual rate of 0.4 percent between 1978-82, then increased by 14.2 percent from 1982 to 1983.

Over the period 1970-78, when productivity gains were substantial, output per employee hour increased in 6 out of 8 years, with the gains in 5 of these years associated with output gains exceeding increases in employee hours. An exception was 1974-75, when the decline in employee hours exceeded the decline in output. Over this period of relatively strong productivity growth, gains in output per employee hour were particularly large in 1971—up by 16.2 percent—when output turned up sharply following the strike in 1970. The two periods of decline in output per employee hour during 1970-78 were in 1973-74, when output declined at a greater rate than employee hours during a slowdown in the economy, and 1977-78, when employee hours increased by slightly more than output.

During 1978-83, a span of years when output per employee hour increased at an annual average rate of 2.1 percent, the productivity record showed sharp contrasts, declining at an annual average rate of 3.8 percent during 1978-80 and increasing at an annual rate of 7.1 percent in 1980-83. During the first 2 year period of decline, output per employee hour fell by 1.2 percent from 1978 to 1979, and by a substantially higher 6.4 percent from 1979 and 80, when both output and employee hours fell sharply—by 27.2 percent and 22.2 percent, respectively.

Productivity moved higher during the second half of the period 1978-83. From 1980 to 1981, output per employee hour increased at an average annual rate of 3.0 percent, and from 1981 to 1982, by a sharply higher annual rate of 4.9 percent. The sources of these productivity gains were markedly different, however. The gain of 3.0 percent resulted when output increased more than twice as fast as employee hours; the gain of 4.9 percent occurred when the decline in employee hours substantially exceeded the fall in output.

When auto sales jumped upward in 1983, productivity increased dramatically. Output increased by 30.6 percent over 1982, and employee hours grew by a significantly lower 14.3 percent. The result was an increase of 14.2 percent in output per employee hour.

The outlook for productivity gains appears generally favorable, although forecasting productivity movement is difficult because new technology is only one of several factors, including levels of output and capacity utilization, which determine productivity change. The announced plans to spend billions of dollars for modernized plant and equipment during the 1980's, if realized, are expected to achieve labor and other cost savings and make U.S. producers more competitive in domestic and world markets.

Investment

Capital expenditures

Motor vehicle manufacturers are investing a considerable amount of money in new plants and production equipment. Capital expenditures (in constant 1972 dollars) totaled $3.6 billion in 1981, the first year in which expenditures exceed $3.0 billion. Expenditures in 1972 were $2.1 billion.[14]

Most of the capital expenditures over this period have been for new equipment, including special tools. New structures have accounted for 7 to 14 percent of the total. Generally, when a new assembly or manufacturing line is to be started up, an existing plant structure is stripped of its old equipment, and all new equipment is installed. By 1985, the industry will have retooled many of the engine and transmission plants and will have rebuilt a number of assembly plants.[15]

Capital expenditures per production worker (in constant 1972 dollars) nearly doubled between 1972 and 1981. In 1972, expenditures averaged $3,096 per production worker, reaching a level of $6,081 per production worker in 1981.

Capital expenditures should continue to be high through 1990. Domestic auto manufacturers plan to introduce a number of new, generally small-to-medium-

[14] U.S. Department of Commerce, Bureau of Industrial Economics, Office of Research, Analysis, and Statistics.

[15] "Detroit's Merry-Go-Round," *Business Week*, Sept. 12, 1983, p. 72.

sized autos during the 1980's. This will require stripping and refitting a number of older plants. To be competitive, these plants must be equipped with the latest and, usually, most expensive technology. This will require an estimated expenditure of $65 billion between 1978 and 1985.[16]

The domestic auto industry has generally raised its investment capital from internal sources (depreciation, retained earnings, and amortization allowances). But the large financial losses caused by low auto sales over the past several years have forced firms to use other financial sources, such as increased corporate indebtedness and sales of assets including unused plants and subsidiary companies.

Employment and Occupational Outlook

Employment

The number of employees in the motor vehicle industry declined by slightly more than 26,000 between 1970 and 1983, as demand for domestic cars and trucks slackened and the economy weakened during the latter part of this period (chart 9). Although total employment declined at an average annual rate of 0.8 percent over the period 1970–83, the trend in employment varied markedly.[17]

Employment moved generally higher during 1970–78, at an annual rate of 1.8 percent, as the industry added employees to the work force to accommodate higher levels of demand. The period 1970–73 was one of particularly strong employment growth, with the work force increasing at an average annual rate of 6.5 percent. Between 1973 and 1978, however, the annual growth rate fell sharply to 1.1 percent. During 1973–75, employment declined at an annual rate of 9.9 percent because of a downturn in the economy, before beginning a sharp and steady increase between 1975 and 1978 at an annual rate of 8.2 percent. By 1978, a record 1 million workers were employed in the industry, the majority in the Great Lakes region.

Employment moved sharply lower between 1978–83 as the economy slackened and competition from overseas producers slowed sales of domestic cars and trucks. Over this period, employment declined at an average annual rate of 6.5 percent, or by 232,000 workers, as operations were scaled back and less efficient plants were closed. By 1982, the number of workers had fallen to 704,800, the lowest level in two decades. The employment situation subsequently improved, however, and in 1983, total employment was increased to 772,700, up by almost 68,000 workers, or 9.6 percent, as some of the unemployed were recalled to meet higher demand.

The outlook is for employment to increase moderately between 1983 and 1995, but the total number employed will still be well below the 1978 high of just over 1 million workers. Most of the expected employment growth should take place by the mid-1980's; very little growth is expected after the current recovery. Productivity increases are expected to largely offset further increases in labor requirements due to future growth in output. According to BLS projections, the number employed in the motor vehicle industry is expected to range from 846,000 to 871,000 in 1995, an average annual rate of increase of between 0.8 and 1.0 percent over the period 1983 and 1995.[18]

Occupations

BLS projects that employment in each of the major occupational groups associated with the manufacture of motor vehicles will move to higher levels between 1982 and 1995 as production is expanded to meet higher demand (chart 10). Although the technologies described earlier will reduce unit labor requirements in such areas as data processing, design and engineering, welding, assembly, painting, and machine-tool operation, the prospects are for employment in affected occupations to increase nonetheless.

As a broad overview, professional and technical workers are expected to record the largest gains through 1995, with the operatives group expected to increase at the lowest rate. In the other six occupational groups which fall between these extremes, managers, officials, and proprietors and craft workers are expected to exceed the average rate of change for employment in all groups over this period and clerical workers are projected to increase at approximately the average rate. The categories of sales workers, service workers, and laborers are expected to show slower growth over the next decade.

The impact of technological change on specific occupations within these broad groups varies considerably. The category of operatives is the largest of the occupational groups, and includes machine-tool operators, welders, production painters, and assemblers, which are among the occupations most affected by new technology. In 1982, more than 300,000 workers were employed in the occupations that make up the operatives group, or nearly 50 percent of the total work force.

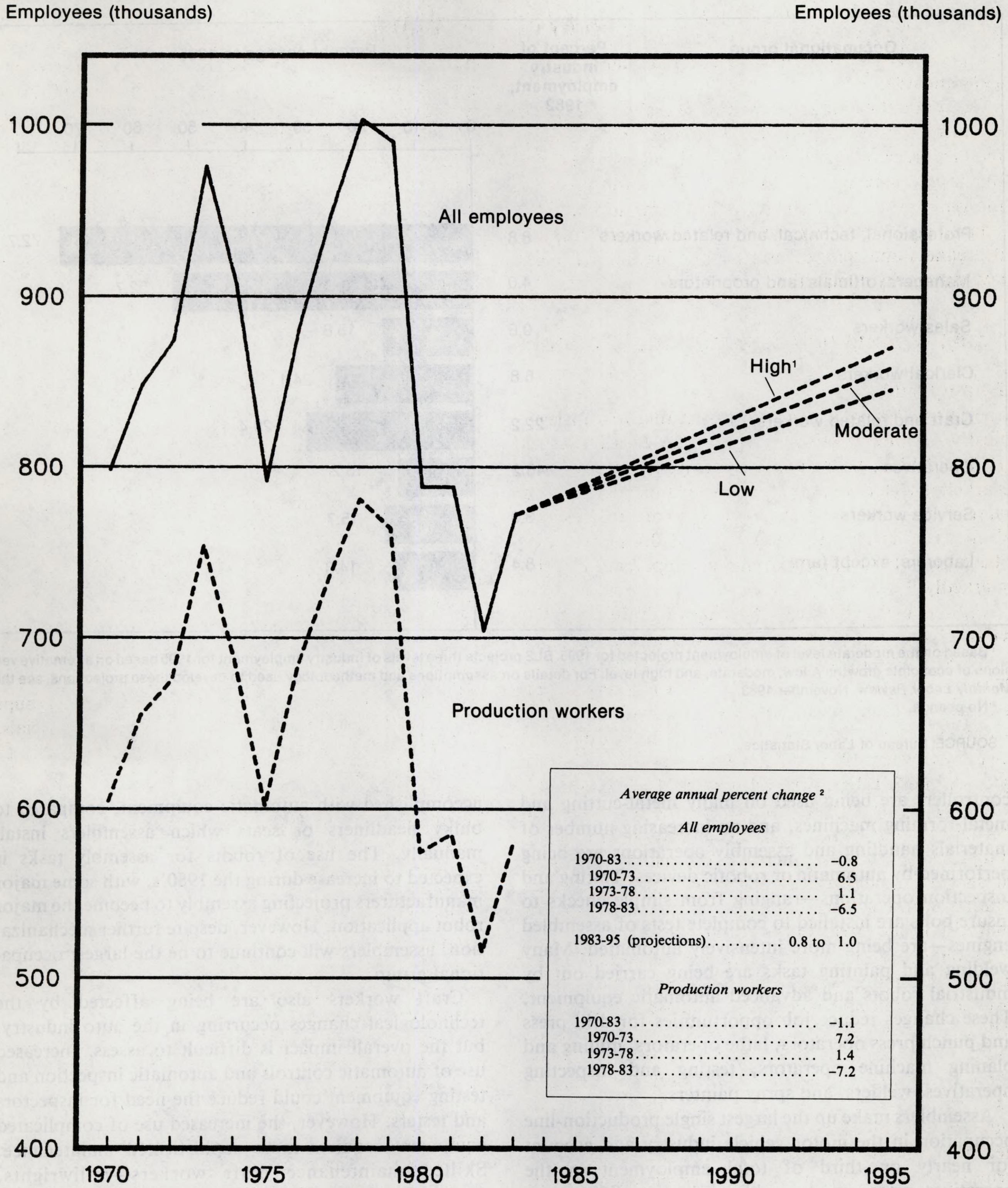
As indicated earlier, automated techniques are being applied to many production line operations where operatives are employed. Automatic and programmable

[16] *1983 U.S. Industrial Outlook* (U.S. Department of Commerce, Industry and Trade Administration, 1982), pp. 30–35.

[17] In evaluating these rates of change, it is important to keep in mind that the period began in 1970, a year in which employment was 12 percent below 1969 because of an industrywide strike.

[18] BLS projections for industry employment in 1995 are based on three alternative versions of economic growth and include a low, moderate, and high projection. For details on assumptions and methodology used to develop these projections, see the *Monthly Labor Review,* November 1983.

Chart 9. Employment in motor vehicles, 1970-83, and projections, 1983-95

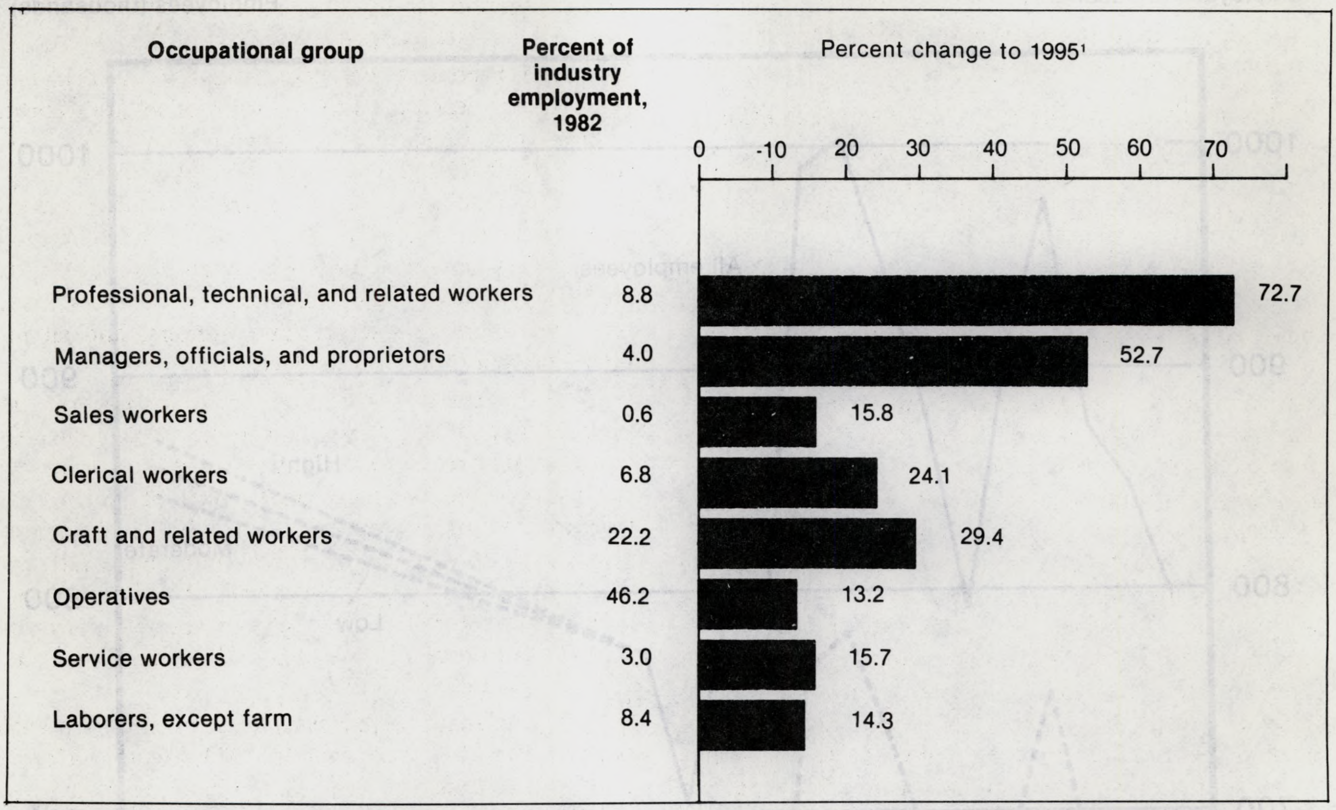


[1] See text footnote 18.

[2] Least squares trends method for historical data; compound interest method for projections.

SOURCE: Bureau of Labor Statistics.

Chart 10. Projected changes in employment in motor vehicles and equipment by occupational group, 1982-95



[1] Based on the moderate level of employment projected for 1995. BLS projects three levels of industry employment for 1995 based on alternative versions of economic growth: A low, moderate, and high level. For details on assumptions and methodology used to develop these projections, see the *Monthly Labor Review,* November 1983.

[2] No change.

SOURCE: Bureau of Labor Statistics.

controllers are being used on many metal-cutting and metal-forming machines, and an increasing number of materials handling and assembly operations are being performed by automatic or robotic devices. Testing and inspection operations—ranging from simple checks to insure bolts are installed to complete tests of assembled engines—are being more intensively automated. Many welding and painting tasks are being carried out by industrial robots and advanced automatic equipment. These changes reduce job opportunities for drill press and punch press operators, lathe operators, milling and planing machine operators, testing and inspecting operatives, welders, and spray painters.

Assemblers make up the largest single production-line occupation in the motor vehicle industry and account for nearly one-third of total employment in the operatives category. Assembly tasks are difficult to automate, and diffusion of new technology is expected to be slower than in other areas of motor vehicle manfacturing. Small assembly jobs—inserting piston assemblies into engine blocks, or turbine blades into transmission torque converters—are more easily accomplished with automatic equipment, compared to bulky headliners or seats which assemblers install manually. The use of robots for assembly tasks is expected to increase during the 1980's, with some major manufacturers projecting assembly to become the major robot application. However, despite further mechanization, assemblers will continue to be the largest occupational group.

Craft workers also are being affected by the technological changes occurring in the auto industry; but the overall impact is difficult to assess. Increased use of automatic controls and automatic inspection and testing equipment could reduce the need for inspectors and testers. However, the increased use of complicated equipment requires more sophisticated maintenance. Skilled maintenance craft workers—millwrights, maintenance mechanics, and especially electricians—will be needed to install, maintain, and repair robots, programmable controllers, and many other forms of automated equipment.

Increased use of computers, data networks, and statistical analysis techniques in manufacturing and assembly plants affect plant management, professional and technical staffs, and, to a lesser degree, craft workers and operatives. The use of these data collection and analysis networks requires training in computer and statistical techniques.

Adjustments of workers to technological change

Training and other techniques to facilitate work force adjustments are expected to be employed extensively during the 1980's. Although the rebound of auto sales in 1983 led to a recall of some unemployed auto workers and higher employment levels, plants which have modernized are not expected to require work forces as large as in the past for comparable levels of output. Moreover, foreign producers are expected to provide strong competition in domestic and overseas markets during the 1980's, and U.S. producers will further mechanize to lower labor and other costs.

Collective bargaining contracts contain provisions that ease the impact of new technology on employees. Almost all hourly paid employees in motor vehicle manufacturing plants are members of the United Automobile, Aerospace, and Agricultural Implement Workers of America (UAW) and are covered by such agreements; many employees of automotive equipment suppliers also are covered. The contracts contain general provisions concerning seniority, layoffs, retirement, and supplementary unemployment benefits that could be applied to job displacement resulting from technological changes. In addition, all national and local contracts with motor vehicle manufacturers contain clauses which require management to provide advance notice to the union concerning plans to introduce new technology and to meet with local union officials to discuss the impact of these changes.

In late 1984, the UAW reached agreement with General Motors and Ford in a new contract with very strong job security and retraining provisions. The agreement with GM provides for a $1 billion fund, financed by GM, over the 3-year contract period. This program will pay wages and benefits to employees while they are being retrained, if they are displaced by new technology, plant closings, productivity improvements, or parts outsourcing. The retraining may be for other jobs within GM, or for jobs outside of the company. Also, in some instances, early retirement is encouraged by providing financial incentives. While the agreement protects most of GM's employees, it gives the company considerable flexibility in outsourcing parts, closing plants, and bringing in new technology. The agreement between Ford and the UAW is similar, except that Ford has agreed not to close any plants during the contract period.

Training to provide workers with the skills required to operate new manufacturing technologies will be a major technique to facilitate adjustment during the 1980's. Training programs are being initiated in a number of plants, often involving space dedicated to classrooms and laboratories. Facilities of some junior colleges or technical schools located near manufacturing or assembly plants are beings used for training programs.

At least two manufacturers have established special centers for robotics where applications are developed and professional, technical, and craft personnel are trained.

In another example of training for new technology, more than 900 employees received in-plant training for job skills associated with a new production line to assemble light trucks. The new line is highly mechanized and makes extensive use of industrial robots—a technology that was new to most of the plant personnel, from managers to assembly-line workers, and an in-plant training program was developed.

Most attention was given to instruction in maintenance of solid-state electronic devices—a key component of robot control systems and programmable controllers—and the total work force of electricians received training. By bringing the skill levels of all plant electricians up to at least the minimum level necessary for working with robotic electronic controls and programmable controllers, the 80-hour training program resulted in a group of electricians of more uniform and generally higher skill levels.

Special training programs to assist unemployed auto workers are also underway. In 1983, General Motors and the UAW announced a joint program to retrain up to 9,300 former GM employees in areas such as computer systems operations, computer programs, electronics, building maintenance, medical technology, and machine operation. The goal is to retrain the unemployed for jobs both at GM and in other industries. A reported $7 million has been allocated to fund the program in the first year, with GM contributing 5 cents per employee hour worked in accordance with provisions of a renegotiated 1982 labor agreement. Ford Motor Company and UAW announced the employment development and training program in 1982. This program involves training and career planning for active and laid-off workers; funding is provided for in the agreement. Programs include tuition assistance for laid-off employees, a range of vocational, technical, and skill training projects, career and vocational counseling, and plant closing assistance.

There also are programs developed by several of the auto manufacturers and the UAW to promote greater employee participation in resolving problems concerning work environment, product quality, job satisfaction and morale, operational problems, training goals and programs, and other issues. These programs often take the form of small groups of skilled or operator employees meeting at regular intervals with supervisory or senior management personnel to resolve issues. Such programs have solved operational problems, improved productivity, and reduced absenteeism, among other accomplishments.

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Appraises major technological changes emerging in hosiery, folding paperboard boxes, metal cans, and laundry and cleaning, and discusses their current and potential impact on productivity, employment, and occupations.

The Impact of Technology on Labor in Five Industries (Bulletin 2137, 1982), 60 pp. Price, $5.

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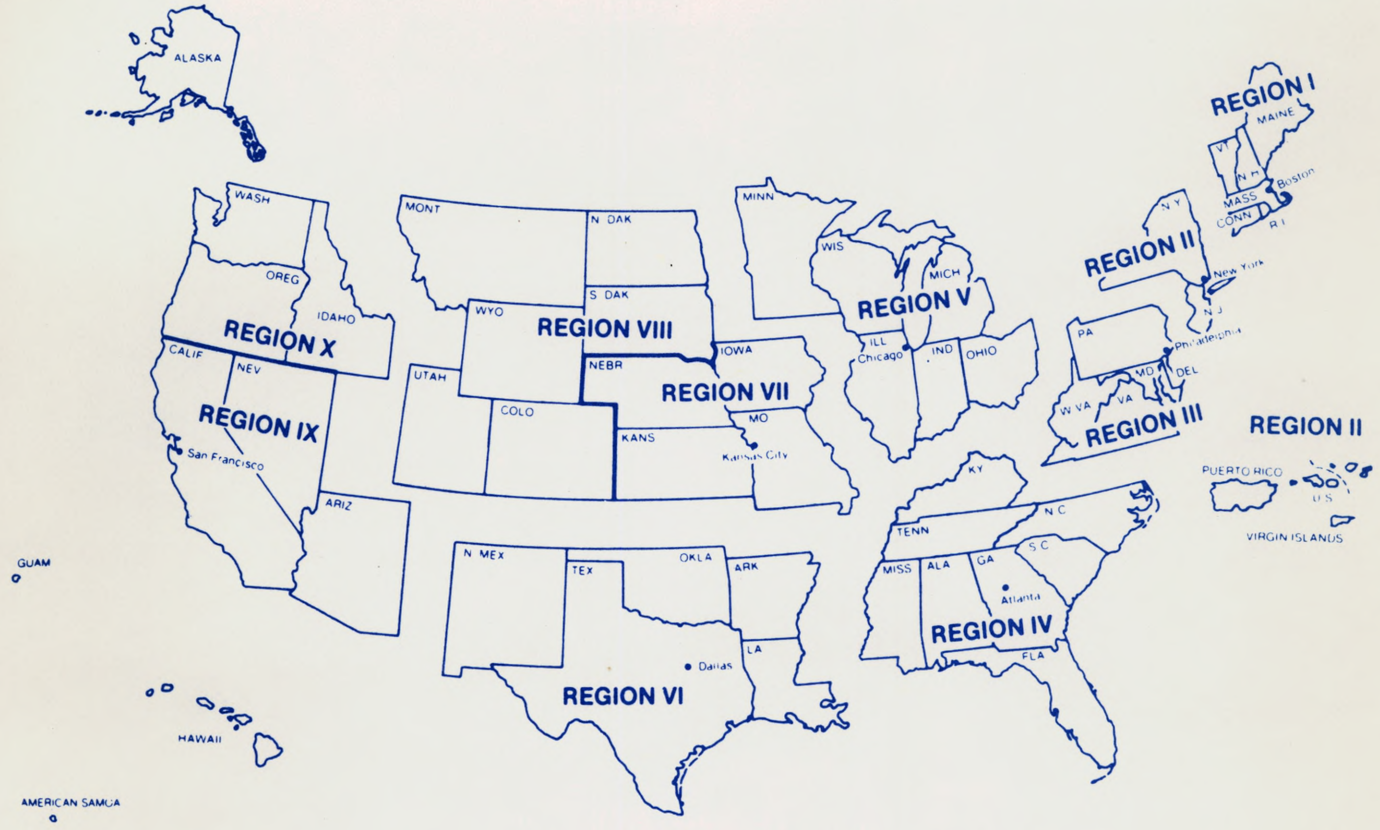

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