Technology and Its Impact on Labor in Four Industries

Lumber and wood products/Footwear
Hydraulic cement/Wholesale trade

U.S. Department of Labor
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U.S. Department of Labor
William E. Brock, Secretary

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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: Lumber and wood products (SIC 24), footwear (SIC 314), hydraulic cement (SIC 3241), and wholesale trade (SIC 50,51).

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.

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Chapter 1. Lumber and Wood Products

Summary

New equipment being introduced in the labor-intensive lumber and wood products industry (SIC 24) is reducing labor requirements. The rate at which new equipment is being adopted varies among different sectors of the industry. Logging operations are done primarily by small contractors who have limited capital resources for new technology and go in and out of active business as the demand for logs fluctuates. Within the various mill operations (sawmills, planing mills, plywood mills), automated equipment such as computer-assisted sawing and material handling equipment is being used in medium-sized to large establishments. Computers and other solid-state electronic devices are becoming more widely used in all portions of the industry.

Productivity and employment varied considerably in the segments of the lumber and wood products industry for which BLS measures are available. Output of the sawmill and planing mill portion grew only very slightly between 1970 and 1984, while it grew slowly for veneer and plywood mills and somewhat more rapidly for wood kitchen cabinets. Output of millwork declined slightly from 1970 to 1983. Over the period, output per employee hour increased at an average annual rate of 1.7 percent for sawmills and planing mills, declined at an annual rate of 1.0 percent for millwork, and increased by an annual rate of 2.5 percent for veneer and plywood mills and 1.8 percent for wood kitchen cabinets.

Investment increased from $535 million in 1970 (1972 constant dollars) to more than $1 billion a year in 1977, 1978, and 1979, then declined, amounting to only $448 million in 1982. Investment in sawmills and planing mills accounted for about 40 to 45 percent of the total.

A total of 700,300 workers were employed in the lumber and wood products industry in 1985, compared to 645,500 in 1970. The average annual rate of increase was 0.5 percent over this period. Employment in logging operations increased at an annual rate of 1.1 percent, while the number employed in sawmills and planing mills declined by an average of 0.6 percent a year. Employment in the millwork, plywood, and structural members sector (the largest sector, which accounts for nearly one-third of industry employment) rose at an annual rate of 1.2 percent. BLS projects employment to grow by 0.3 percent a year until 1995.

Employment is projected to increase in most major occupational groups, with the highest growth rates anticipated for managers, engineers, carpenters, precision woodworkers, and skilled handwork occupations. Demand should be strong for mechanics who can repair logging vehicles, and for sawmill maintenance personnel—especially those who have experience with solid-state electronics.

Specific reference to technological change is rare in collective bargaining contracts. Several cooperative agreements have been worked out between certain union local chapters and the management of individual mills and plants that involve production and productivity improvements.

Technology in the 1980's

Technological improvements have contributed to increased productivity in a number of areas. In the logging sector, most changes involve improvements in the vehicles used for cutting and moving timber. Computers and electronic controls are being used more extensively in sawmills, veneer and plywood mills, and millwork and cabinet plants. There also have been improvements in material handling systems, saws, fasteners, gluing operations, and other areas.

Table 1 describes major innovations in the lumber and wood products industry, their impact on labor, and prospects for further diffusion.

Logging

Logging is the first step in converting trees to commercially useful wood products. A considerable amount of mechanization has been introduced into logging operations over the past several decades. However, the process remains labor intensive. Some of the results of mechanization have been offset by the need for logging crews to travel farther to find uncut timber and—to cut the smaller trees that are now more generally available. This means that logging crews must cut a larger number of trees to obtain the same quantity of wood available from the larger trees harvested in earlier years.

Logging operations, and the equipment used to ac-
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<th>Technology</th>
<th>Description</th>
<th>Labor implications</th>
<th>Diffusion</th>
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<td>Logging</td>
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<tr>
<td>Timber management</td>
<td>Computers are being used to maintain data files and project economic scenarios. Electronic data recorders store information in the field for computer data files. Aerial and satellite photography provides data on large forest areas.</td>
<td>Timber management tools provide foresters with greater control over timber production.</td>
<td>Limited but growing use.</td>
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<tr>
<td>Tree felling</td>
<td>Feller bunchers harvest small to medium-size trees in nonmountainous areas. Chainsaws still widely used in situations where feller bunchers cannot operate.</td>
<td>Skill required for operating a feller buncher are very different from those for chainsaw felling, as feller bunchers are vehicles that must be driven, and cutting is done by positioning the cutting head.</td>
<td>Feller bunchers are widely used where tree size and topography permit.</td>
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<tr>
<td>Yarding operations</td>
<td>Tractors and skidders pull freshly cut logs to loading areas. Recent models have increased hauling capacity. Spar and cable yarding equipment is used for difficult terrain. Highly productive mobile yarding cranes are now available. Helicopters and balloons can make logging work possible in otherwise inaccessible areas.</td>
<td>High capacity skidders and mobile yarding cranes can reduce yarding crew size. Helicopters and balloons can make logging work possible in otherwise inaccessible areas.</td>
<td>Improved skidders are in growing use. Mobile yarding cranes are in limited use due to high cost. Yarding by helicopter or balloon is only rarely used.</td>
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<tr>
<td>Mechanical support</td>
<td>Maintenance trucks equipped with tools and spare parts that accompany logging vehicles in the field and make on-the-spot repairs.</td>
<td>Productivity of logging crews is improved when equipment downtime is reduced. Increased demand for maintenance personnel.</td>
<td>In growing use.</td>
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<tr>
<td>Sawmills</td>
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<tr>
<td>Log handling</td>
<td>Lifting vehicles and cranes are used to unload and move logs prior to sawing. Singulators unscramble stacks of logs and feed them into sawmills one at a time.</td>
<td>Increased capacity for a number of front-end loaders, cranes, and related equipment reduces labor requirements for log handling crews.</td>
<td>All sawmills use some log handling equipment, but there is too much variation from one mill to another to allow generalization.</td>
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<tr>
<td>Computerized sawing</td>
<td>A system of scanners, computers, and software packages designed to cut wood in such a way as to maximize yield. Actual cutting operations range from manual to automatic, but decisionmaking about how to cut the wood is computerized.</td>
<td>Reduces the amount of decisionmaking required of saw operators. Maintenance requirements have increased and become more complex. Greater need for electrical and electronic skills.</td>
<td>Commonly used in new and renovated mills.</td>
</tr>
<tr>
<td>Improved saws</td>
<td>Thin-kerf saws make very thin cuts in wood, reducing waste. Stellite tipping of saw teeth increases the amount of time a saw blade can be used before requiring resharpening, and also increases cutting accuracy.</td>
<td>Thin-kerf saws require more maintenance than regular-kerf saws. New semiautomatic methods of applying Stellite to saw teeth reduce application times.</td>
<td>Thin-kerf saw blades are in growing use. Semiautomatic Stellite tipping processes are new and presently in only limited use.</td>
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<tr>
<td>Lumber sorting</td>
<td>Automated systems, including scanners and computers or programmable controllers, sort cut lumber by size and quality as it emerges from the sawmill.</td>
<td>Highly automated sorter systems can eliminate most of the manual work involved in sorting and stacking lumber.</td>
<td>Automatic sorters are expensive and most frequently used only in high labor cost areas and in large, high-output mills.</td>
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### Table 1. Major technology changes in lumber and wood products—Continued

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<tr>
<th>Technology</th>
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<tr>
<td><strong>Veneer and plywood mills</strong></td>
<td>Automatic controls for hot water vats: Programmable controllers that automatically control water temperature and drive pumps to circulate water in the vats.</td>
<td>Labor needed to monitor and regulate water temperature is reduced.</td>
<td>Limited but growing use.</td>
</tr>
<tr>
<td><strong>X-Y charger and digital lathe controls</strong></td>
<td>Computerized control system that automatically scans and centers a block of wood in a lathe to ensure maximum yield. Digital hydraulic knife carriage provides fast, accurate cutting.</td>
<td>Labor requirements for lathe operators are reduced.</td>
<td>Limited but growing use.</td>
</tr>
<tr>
<td><strong>Automated clippers</strong></td>
<td>High-speed cutting machines that trim sheets of wood to be made into plywood panels.</td>
<td>High cutting speeds improve productivity.</td>
<td>Automated clipper controls are in fairly widespread use. Recent models operate at higher speeds.</td>
</tr>
<tr>
<td><strong>Jet veneer drying and mechanical layup cabinets</strong></td>
<td>Drying and gluing together of veneer sheets to form plywood panels.</td>
<td>Mechanized operations reduce labor requirements.</td>
<td>Widely used.</td>
</tr>
<tr>
<td><strong>Wood kitchen cabinets</strong></td>
<td>Computerized cabinet design: Computer software systems that calculate materials and costs for cabinet systems.</td>
<td>Reduces time and work required to design cabinets.</td>
<td>Limited use.</td>
</tr>
<tr>
<td><strong>Improved fasteners</strong></td>
<td>Concealed hinges and other fasteners that can be installed at least partially by automated equipment.</td>
<td>Large reduction in labor requirements for cabinet assembly.</td>
<td>In growing use.</td>
</tr>
<tr>
<td><strong>Millwork</strong></td>
<td>Automated control systems: Numerical and microcomputer systems control conveyors, robot transfer equipment, and other automatic machinery.</td>
<td>Some reduction in labor requirements.</td>
<td>Limited use, due to cost.</td>
</tr>
<tr>
<td><strong>Miscellaneous equipment</strong></td>
<td>High-speed molding machines, remotely controlled saws, air-powered handtools, and high-speed gluing and curing processes.</td>
<td>Some reduction in labor requirements.</td>
<td>In growing use.</td>
</tr>
<tr>
<td><strong>Reconstituted wood panels</strong></td>
<td>Computer-controlled machinery mixes wood chips and resins. Mechanized conveyor belts and presses move and compress the panels.</td>
<td>Mechanized operations reduce labor requirements and increase technical skill requirements.</td>
<td>Widely used in this part of the industry.</td>
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</table>

To accomplish them, vary considerably from one part of the United States to another. In the South and East, trees of small diameter are prevalent, environmental regulations are less stringent, and the terrain is usually not steep. Highly mobile harvesting equipment with the capacity to handle large volumes of small logs is used. In the West, there are large areas where terrain is relatively flat and cutting conditions are similar to those in the East. But in the mountainous terrain that is more common in the West (including Alaska), environmental regulations are more strict and trees are often larger—factors which require different cutting and hauling procedures.

Diffusion of technology in logging operations is closely tied to industry structure. Most logging contractors employ fewer than 6 full-time employees. Heavy machinery is usually adapted from agricultural or construction vehicles, although some equipment manufacturers—especially of skidding and loading vehicles—direct their basic equipment primarily toward the logging market.

**Timber management.** Foresters who manage timber-producing lands are using computers and other electronic and optical equipment more extensively. Computer data files are being maintained for acreage planted or cut, types of wood available, market prices, etc. Models of different cutting scenarios can be run and the resulting market values calculated. Small electronic data recorders are available that can be carried into the field to record information on the type, size, and quantity of trees, as well as slope and soil conditions. The
recorded information is electronically entered into computer files. Data on forest areas are available through the use of aerial and satellite infrared photography.

Tree felling. Most trees are cut down by hand-held chainsaws or by mechanized feller bunchers. The feller bunchers are more productive but cannot be used in all situations. Feller bunchers are vehicles that move through a forest on tires or caterpillar tracks. They use hydraulically powered shears, or one of several types of saws (chain or circular) mounted on a boom, to cut tree trunks. The shears, which operate in a manner similar to a pair of scissors, work well on small- to medium-diameter trees, but not on large trees. Often there is some damage to the tree trunk when it is cut with shears. Feller bunchers work best on level ground, and usually cannot be used on slopes with a grade of more than 25 to 30 percent. Feller bunchers are probably the dominant method of felling trees in the southern and eastern parts of the country, where terrain is not mountainous and most timber (especially pine) is of small to moderate size. Chainsaws remain the dominant means of felling trees in the more mountainous areas of the West and Northwest.

One southern logging company increased productivity by an estimated 30 percent when chainsaw operations were replaced by a feller buncher. Logging crews had cut an average of 550 to 650 tons of timber a week with chainsaws. When the feller buncher was put into use, output increased to 920-970 tons per week.\(^1\)

Yarding operations. Moving logs from cutting areas to roads where they can be loaded onto log trucks is called “yarding.” Most yarding is done with ground-based equipment, which essentially means dragging the logs (with limbs and branches cut off) from one area to another. More complex aerial yarding operations are used where ground-based systems are not feasible—but the cost is much higher, ranging from $15 per thousand board feet using ground-based skidders under optimum conditions to over $200 per thousand board feet when helicopters are used.\(^2\) Most ground-based yarding involves the use of vehicles such as tractors and skidders.


that can move large volumes of timber over terrain, except steep slopes. Improvements in equipment can increase productivity for logging crews. A very productive arrangement involves using a feller buncher and a grapple skidder (a skidder fitted with a claw device for holding logs). The feller buncher cuts trees and leaves them in small stacks (or bunches). The grapple skidder, following along, picks up one end of the bunch and drags it to the loading area.

A new model of skidder, equipped with a crane to provide self-loading capability, increases output and productivity in several ways: The self-loading feature, combined with a large hauling capacity, makes it possible for this skidder to replace two or three conventional tracked skidders and to reduce crew size from eight workers to five or six. With fewer skidders, the number of skidder trips is lowered, fuel consumption is reduced, and there is less disruption of operations at the area where logs are removed from skidders and loaded on logging trucks. Also, since this type of skidder can haul logs over a longer distance, roadbuilding requirements for logging trucks are reduced.3

Where ground-based yarding is not feasible because of terrain conditions, more expensive aerial yarding operations are required. The predominant method utilizes a spar and cable arrangement which resembles a fishing rod and reel. Steel cables run from a drum at the base of the spar, up the spar, and out to the felling area, which might be 1,000 to 1,500 feet away. Yarding spars can move logs up and down steep slopes and across ravines.

One of the most important developments in yarding spar technology has been the development of a mobile yarding crane. These new-model yarding cranes incorporate most of the refinements used on other types of spars. One model, for example, combines a small operating crew (two people), high operating speed, high mobility, and a yarding capability of up to 1,500 feet, which often allows the yarding crane to operate from roadside. The result is an expensive, but high-capacity yarder.4

Helicopters and balloons sometimes are used for logging, but applications are limited because of the expense involved. These vehicles allow logging operations to be conducted in areas inaccessible to other logging systems or in localities where surface vehicles would cause an unacceptable amount of environmental damage.

Maintenance support. Logging crew productivity has sometimes been increased by providing maintenance for logging equipment while it is in the field. Equipment breakdowns slow production, especially when the logging crew is working a long distance from its home base. Maintenance trucks—equipped with handtools, spare parts, and heavy equipment such as an air compressor, impact wrenches, and grinding and welding equipment—can accompany logging vehicles into the field and make on-the-spot repairs.

Sawmills

Sawmills convert logs into lumber for commercial use. A number of technological developments have been introduced that increase productivity and mill efficiency, including advances in log and lumber handling equipment, the introduction of computers into mills (primarily in sawing operations), and improvement in saw cutting edges. To some extent, the decline in the size of logs received by sawmills has stimulated the development of new technology. But some of the improvements would have been introduced (although perhaps more slowly) regardless of log size.

Log handling. Logs brought into a sawmill need to be unloaded, moved to storage areas, and eventually transported to the mill. Vehicles with hydraulic lifting arms—including front end loaders and log stackers—are commonly used. Cranes are used less frequently. Since sawmills vary in size, layout, storage space, and type and size of logs used, it is difficult to generalize about the most efficient method of moving logs. Overhead cranes on straight tracks or boom-type cranes on rotary tracks are very productive where tree-length logs are cut to length in the mill (many mills require that logs be cut to certain maximum lengths before delivery to the mill).

Logs are moved from storage areas to log decks—platforms located adjacent to the mill that contain conveyors which carry logs into the mill. The pile of logs in front of the log deck has to be loaded onto the log deck conveyors and fed into the sawmill one log at a time. One conventional way to load a log deck is for an operator, using a log stacking vehicle or small crane, to carry one log at a time to the deck.

A more productive method is to use a machine—developed fairly recently—that unscrambles the logs and places one log at a time on the log deck. This machine, called a singulator, consists of a large rotating drum with metal fingers or flutes welded around the circumference of the drum. When logs are stacked against the rotating drum, the flutes pick up single logs and lift them onto the log deck. During the late 1970's, a number of singulators were developed that would handle logs up to 45 feet in length. New singulators that are large enough to handle tree-length logs are being introduced. One model has a drum that is 70 feet long and has 8 flutes. This singulator, which rotates at 4 rpm, can handle 64 tree-length logs a minute—much more

than an operator using a crane or front end loader can accomplish.5

Computerized sawing. Logs must go through a number of cutting operations in a sawmill before they are converted into wood products for commercial use. Central to all cutting operations, regardless of sawmill size and extent of mechanization, is the need to select the best method to cut the wood to achieve maximum yield and minimum waste. Logs are not uniform—lengths, diameters, amounts of taper from top to bottom, and straightness vary. The best cutting pattern for one log will probably not be the best pattern for the next one. Sawdust and scrap wood represent decreased revenues to a sawmill.

Traditionally, cutting decisions are made by workers at each cutting station, with the most crucial decisions made by the head sawyer, who makes the first cuts on logs as they come into the mill. Individual skills are very important in determining how much useful wood is recovered from each log.

Automated sawing operations have been developed to assist the sawyer in maximizing the yield from each piece of wood. The process involves using optical, infrared, or laser scanners to determine the configuration of each piece of wood just before it goes into a sawing station. That information is sent to a computer, which uses software incorporating models of wood configurations and instructions on the best way to cut a particular piece to maximize yield. The computer compares the configuration of the scanned wood with the models in its memory, and selects the cutting pattern that best fits the piece of wood that has been scanned.

Computer cutting decisions can be fully automated in systems that are available where the wood is scanned on its way to the saw, and put into the proper sawing position by hydraulic or pneumatic controls, as the saw blades are adjusted automatically. Then the wood is fed into the saw. In a fully automated system, the operator has manual override control. In less automated systems, the computer provides an operator with data on how to cut the wood, sometimes by display on a TV-like screen in the sawyer cubicle, but more often by focusing laser guide beams in front of the saw blades. The operator aligns the wood according to the guides, and feeds it into the saw.

Computerized sawing is used most frequently on a mill’s headsaw. This is where a log is first cut, the most complex sawing operation in the mill. Many new and renovated mills use computerized sawing operations on their headsaw. Other sawing operations—bucking, edging, trimming, etc.—are less frequently automated, although this is changing rapidly. Edger and trimmer optimizers, using scanners and computer control, position boards for the most economical cutting and trimming. Edger and trimmer saws are usually automated, and their control systems are sometimes linked to headsaw and sorter controls.

Some changes in skill requirements and productivity have resulted from using automated sawing procedures, and the number of people required for some jobs may be reduced. In older, less automated mills, head sawyers are among the most highly skilled employees. But with computerized sawing, less decisionmaking is required of the head sawyer. There is disagreement in the industry as to whether skills needed by a head sawyer are reduced. But it does appear that someone can be trained for this position in less time in a sawmill that uses computerized sawing.

Faster training also is possible for workers in other sawing operations in computerized systems: Edger and trimmer operators spend less time deciding the best method to cut each piece of lumber and concentrate more on visually inspecting wood for quality. However, maintenance operations have increased and have become more complex—especially electronic maintenance associated with computers, scanners, and programmable controllers. Mill electricians increasingly need a strong background in solid-state electronics. The number of auxiliary people needed to keep wood moving along the conveyors from one sawing station to another may be reduced in the most advanced mills.

Improved saws. Thin-kerf saws are narrow, highly accurate saw blades that make very thin cuts in a piece of wood, leaving more wood intact and less waste on the sawmill floor in the form of sawdust. While thin-kerf saws allow a mill to get more useful lumber from a log, they require increased maintenance. Saw filing must be performed carefully, and the spacers and guides for the saw blades (which work at close tolerance) require precise machining. A mill that changes to thin-kerf saw blades may have to increase the size of its saw filing crews or add more automated saw filing equipment.

Stellite tipping on saw teeth reduces saw filing costs and increases cutting accuracy. Saw teeth that have been treated with Stellite can be used 4 times as long before changing and resharpening compared to untreated saw teeth. Until recently, Stellite had to be applied by hand, which was time consuming and yielded inconsistent results. Several semiautomatic methods to apply Stellite have been developed which require an operator to run the machinery but accomplish the tipping operation with greater speed and consistency than is possible with hand applications. After the saw teeth have been coated with Stellite, they must be shaped on a grinding machine for accurate cutting (the grinding

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operation increases accuracy for a saw blade whether it is coated with Stellite or not, but is often not done on uncoated saw blades).

**Lumber sorting.** Cut lumber leaves a sawmill on a conveyor (called a "green chain") that takes it to a storage area where it is sorted by size and quality and stored in bins. Lumber sorting is one of the most labor-intensive operations in a sawmill. The traditional and most common method of sorting is entirely manual: A sorter pulls a piece of lumber off the conveyor, decides where it should go, and carries it to the proper stack or bin. A small mill might have 3 or 4 people sorting; a large mill might have 15 or 20.

Highly automated lumber sorters are available that can eliminate most of this manual work. The automated sorting systems use scanners connected to computers or programmable controllers to determine lumber size. The computer or controller directs the mechanized sorting system to place the lumber in the proper storage area. Automatic sorters are expensive but are being used more extensively in high labor cost areas to achieve large reductions in labor requirements. In areas where labor costs are low, the technology used varies by mill size: Large, high-output mills may use automatic sorters, but small and moderate-sized general-purpose mills may not find automated sorters to be cost effective.

**Veneer and plywood mills**

Technological changes have been introduced into this portion of the wood products industry in response to the growing use of small-diameter logs and, for softwoods, to changes in the types of woods used. The mechanized and automated equipment being introduced primarily affects softwood plywood production, which is a high-volume operation. Hardwood veneers and plywood are more expensive and difficult to handle. They are often used in making furniture where careful handling is required to protect the appearance of the wood. Consequently, high-speed operations are generally not compatible with hardwood veneers and plywood.

Softwood plywood mills make use of the same log handling equipment—including cranes, singulators, debarkers, and bucking saws—used by sawmills. These mills experience the same improvements in log handling operations as already described for sawmills.

After the logs are cut into proper lengths, they are soaked in hot water vats. This softens the wood and facilitates peeling off of thin layers for plywood and veneer. Programmable logic controllers (PLC’s) maintain water temperature at 120 degrees or higher and operate pumps that continually circulate the water.

Logs—or peeler blocks—are then mounted in lathes to be cut. The blocks can be automatically centered in the lathes by a recently developed process called an X-Y lathe charger. This equipment, introduced in the late 1970’s, rotates each block in the lathe and scans the block at a number of points around its circumference and length (the X and Y points). The data are analyzed by computer, and the position of the block is automatically set to yield the maximum amount of sliced wood. Most of the scanners used are optical (one model is capable of scanning the block at 120 points in one second) and some are ultrasonic. X-Y chargers are credited with wood recovery improvements of 5-10 percent over the older method, in which a lathe operator (or spotter) had to center the block by hand using a shadow-line guide.

Peeling speed and accuracy are further increased by use of a PLC-controlled digital hydraulic knife carriage and digital-powered backup roll, which provides part of the torque necessary to turn the block. The solid-state controls used to operate this equipment can be preset to handle blocks of different sizes. This adds an estimated 2 percent to wood recovery rates, and makes possible faster changes of peeler blocks in the lathes.6

The peeled wood then goes through high-speed rotary or guillotine clippers controlled by electronic scanners. Some clippers are designed to operate at 500 feet per minute and have controls that include display terminals and printers to record operating data.

Jet veneer drying of veneer sheets, and mechanized panel layup (gluing together of veneer sheets to form panels) are commonly found in modern, high-output mills. Although these technologies have been in use for some time, improvements in solid-state controls continue to be introduced.

**Wood kitchen cabinets**

Computer systems are available to cabinetmakers to provide data on materials and costs. Using these systems, a cabinetmaker enters the dimensions of each cabinet in a customer order, and the computer program calculates and prints out the manner in which each piece of wood needed to make the cabinet is to be cut, the total materials list, and a job cost report. At least one new system includes a terminal which can display a complete cabinet in any size or configuration. The data from the screen and keyboard are then translated into a list of materials, sizes, and prices. These systems provide sales personnel with rapid estimates for jobs, and reduce the amount of time and work required to design cabinets.

Improved fasteners and fastening systems also have been developed to reduce assembly time for cabinets. The use of concealed hinges, for example, has resulted in significant gains in output. The hinge components can be easily inserted into holes which have been drilled into flat panels by automatic methods.

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Millwork

Millwork consists of cutting, shaping, and constructing wood to specified dimensions. Millwork products include doors, wood awnings and louver windows, wood moldings and panel work, staircases and railings, window frames and trim, and many other products. Sawing, shaping, sanding, glueing, and glazing are part of millwork operations.

Although millwork has been highly mechanized for several decades, automated systems are being introduced in some mills. Numerical and microcomputer controls for machinery and for material handling systems are being used more frequently. Carousels that interface with conveyors, and robot transfer palletizing equipment are being introduced. Diffusion of these automated systems is currently rather slow—and may remain so, given the capital requirements and the predominance of small firms in the industry.

Technologically advanced equipment designed specifically for millwork is in growing use. High-speed machines are being introduced that fabricate a large variety of moldings. Ripsaws with cutting patterns that are controlled by the shadows of an overhead wire are available. Abrasive planers equipped with solid-state controls for machinery and for material handling systems are being used more frequently. Carousels that interface with conveyors, and robot transfer palletizing equipment are being introduced. Diffusion of these automated systems is currently rather slow—and may remain so, given the capital requirements and the predominance of small firms in the industry.

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Reconstituted wood panels

Small pieces of wood are loaded together with resin and pressed into sheets of wooden panels that are about 3/4-inch thick. Wood for the panels commonly comes from sawmill and plywood mill scraps—wood chips and other residues. Logs of low-quality softwoods and inexpensive hardwoods are also used as raw materials when wood panel manufacturers need more control over the size of wood chips used. Particleboard is made of wood chopped down into small granules. For waferboard, larger wood chips are used. Oriented strandboard consists of strands of wood in criss-crossed layers for greater strength.

Wood chips and resins are mixed in computer-controlled machines, then deposited, in the form of 4-inch thick panels, onto moving belts. The belts carry the panels through a series of platen-type presses where heat and pressure are used to compress the panels, in stages, down to 3/4-inch thickness. Mixing, moving, and compressing operations are fairly automatic—one operator in a control room and a few people at the presses. Some final sanding of the panels is done, which is the most labor-intensive and least skilled job.

The production of reconstituted wood panels is more mechanized and less labor intensive than plywood panel production. Employees need somewhat more technical aptitude and training to operate the equipment and to work with the formaldehyde-base resins used as adhesives (emissions of which are regulated by both the Environmental Protection Agency and the Department of Housing and Urban Development).

Output and Productivity Trends

Output

In the sawmill and planing mill sector, annual output changed very little between 1970 and 1984, increasing at an average annual rate of only 0.4 percent (see chart 1). There was growth early in this period—averaging 4.9 percent a year from 1970 to 1973 and 1.0 percent between 1973 and 1978. Output declined after 1978, going down by an average rate of 0.7 percent a year through 1984. Despite the decline in output after 1978, the level was still noticeably higher in 1984 than in 1978. Output reached both its highest level (1979) and its lowest level (1982) for the entire 1970-84 period during the final 5 years. Sawmill and planing mill output is very dependent upon construction activity, which was low in 1981 and 1982 and improved from 1983 to early 1986. The U.S. Department of Commerce estimates that the output of sawmills and planing mills should decline later in 1986. The strength of the U.S. dollar has affected import and export levels for lumber. Exports of lumber declined in 1983, while imports from Canada increased. This dampened the increase in domestic output that has taken place since 1982.

Output for millwork declined very slightly, by an average annual rate of 0.4 percent, between 1970 and 1983 (see chart 2). Output grew strongly (11.9 percent a year) from 1970 to 1973, but after this high point industry output has been much slower. Output continued to grow, but just barely, at an average annual rate of 0.3 percent from 1973 to 1978, then declined by 3.3 percent a year from 1978 to 1983. Output dropped to its lowest point in 1982, then increased in 1983 due to growth in residential construction and renovation activities. Most millwork production involves wooden doors, window frames, moldings, and architectural and exterior millwork. Output in this sector of the industry, therefore, rises and falls with construction activity.

Output for wood kitchen cabinets increased at an av-

BLS does not have an output index for the entire lumber and wood products industry. Indexes are available for sawmills and planing mills (SIC 2421), millwork (SIC 2431), wood kitchen cabinets (SIC 2432), and veneer and plywood mills (SIC 2435, 2436).
Chart 1. Sawmills and planing mills: Output per employee hour and related data, 1970-84

Chart 2. Millwork: Output per employee hour and related data, 1970-83

average annual rate of 4.5 percent from 1972 to 1983 (see chart 3). Growth between 1973 and 1978 averaged 8.9 percent a year; output declined to its lowest point in 1975, then grew strongly through 1978. But from 1978 through 1983, output declined at an average annual rate of 2.9 percent, reaching its highest level in 1979, declining during each succeeding year through 1982, then turning sharply upward in 1983.

Output for veneer and plywood mills grew very slowly, at an average annual rate of 0.7 percent, from 1970 to 1984 (see chart 4). Growth was strong between 1970 and 1973, averaging 6.4 percent, and continued at an annual rate of 3.7 percent from 1973 to 1978. After 1978, output declined at an annual rate of 0.8 percent a year through 1984. Output increased in 1983 and 1984, propelled by growing construction activity. This was particularly true for softwood veneer and plywood in 1984, as capacity utilization for this portion of the industry averaged 90 percent or better.

Productivity

Productivity (as measured by output per employee hour) increased in 3 out of the 4 segments of lumber and wood products for which BLS has data.

Output per employee hour in sawmills and planing mills increased by an average annual rate of 1.7 percent a year from 1970 to 1984. This productivity gain occurred in spite of little change in output over the period as a whole because employee hours declined by an average of 1.3 percent a year. Both output and employee hours reached their highest levels in 1979, and both measures declined through 1982 (with employee hours declining much more rapidly than output). In 1983 and 1984, both measures turned upward again, with output growing a little more rapidly than employee hours.

In millwork, output per employee hour declined at an annual rate of 1.0 percent during 1970-83, as output declined slightly (-0.4 percent annually) while employee hours increased slightly (0.5 percent annually). Output per employee hour rose from 1970 to 1977—but at an increasingly slower rate—after which it declined steadily.

Output per employee hour for wood kitchen cabinets increased at an average rate of 1.8 percent a year between 1972 and 1983, as output grew almost twice as rapidly as employee hours. This pattern prevailed from 1973 through 1978, then changed as productivity declined by 0.4 percent a year from 1978 through 1982—a result of output declining a little more rapidly than employee hours.

Productivity gains were greatest in the veneer and plywood mills sector where output per employee hour increased by an average annual rate of 2.5 percent between 1970 and 1984. This increase followed from a small increase in output (0.7 percent annually) and a larger decline (1.8 percent annually) in employee hours.

Investment

The lumber and wood products industry spent $535 million (in constant 1972 dollars) on plant and equipment in 1970. The amount invested grew each year through 1974, declined in 1975 and 1976, then jumped to slightly more than $1 billion each year from 1977 through 1979. This 3-year period was the high point for investment between 1970 and 1981. Investment declined in 1980, 1981, and 1982 (reaching a low point of $488 million), reflecting the recession in the U.S. economy.

Logging operations (SIC 241) have accounted for 18-34 percent of total investment over the 1970-82 period and a fairly consistent 24-30 percent each year since 1977. About 90 percent of logging expenditures are for equipment.

Sawmills and planing mills (SIC 242) have absorbed the largest portion of investment expenditures, ranging from 40 percent to 53 percent of the total over the entire 1970-82 period and a stable 41-45 percent each year since 1977. About 20 percent of these expenditures were for new plants and structures and 80 percent for new equipment.

Millwork, wood kitchen cabinets, and veneer and plywood mills (SIC 243) received 17-28 percent of expenditures and were consistently in the low- to mid-20 percent range since 1977. In the early 1970's, 30 percent of expenditures were for plant and 70 percent for equipment, but by the late 1970's and early 1980's, these ratios had changed so that equipment expenditures were taking 81-84 percent.

Employment and Occupational Outlook

Employment

Employment in lumber and wood products grew from 645,500 workers in 1970 to 700,300 in 1985—an average annual growth rate of 0.5 percent (see chart 5). Industry employment expanded rapidly during the early 1970's, dropped rather abruptly by 1975, then began to grow again. Employment reached its highest level in 1979—767,000—then declined to its lowest point of the 1970-84 period—597,500—during the recession in 1982. After 1982, employment began to increase again, although there was a decline between 1984 and 1985.

9 U.S. Department of Commerce, Bureau of Industrial Economics, Office of Research, Analysis and Statistics. 1982 is the latest year for which these data are available.
Chart 3. Wood kitchen cabinets: Output per employee hour and related data, 1972-83


Digitized for FRASER
http://fraser.stlouisfed.org/
Federal Reserve Bank of St. Louis
Chart 4. Veneer and plywood mills: Output per employee hour and related data, 1970-84

Ratio scale (Index, 1977 = 100)

Chart 5. Employment in lumber and wood products, 1970-85, and projections, 1985-95

Average annual percent change¹

<table>
<thead>
<tr>
<th>Period</th>
<th>All employees</th>
<th>Production workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-85</td>
<td>.5</td>
<td>.4</td>
</tr>
<tr>
<td>1970-73</td>
<td>.6</td>
<td>.5</td>
</tr>
<tr>
<td>1975-78</td>
<td>-.1</td>
<td>.7</td>
</tr>
<tr>
<td>1978-85</td>
<td>-1.1</td>
<td>-1.4</td>
</tr>
<tr>
<td>1985-95 (moderate projection)²</td>
<td>.2</td>
<td></td>
</tr>
</tbody>
</table>

¹Compound interest method.
²See text footnote 9.


14
According to BLS projections, the outlook is for employment to remain almost flat, growing by an average annual rate of only 0.3 percent. 

Production worker employment increased at an annual rate of 0.4 percent a year from 1970 to 1985. The pattern of increases and declines was similar to that for all employees, although the proportion of production workers has declined for the total industry and the sectors discussed in this report. 

Employment for the logging portion of this industry rose from 70,300 in 1970 to 82,700 in 1985—an average annual increase of 1.1 percent. Employment declined slightly in 1971 and 1972, turned upward in 1973, and then remained fairly high (except for drops in 1975 and 1982) through 1984. The decline in the proportion of production workers to total employment was most pronounced in this sector—declining from 86 percent to 80 percent. 

Sawmills and planing mills accounted for about 28 percent of industry employment in 1985, or 195,800 workers. This represents a decline averaging 0.6 percent a year from 1970. Employment has been particularly weak since 1980, with a number of mills closing due to poor market conditions.

The millwork, plywood, and structural members portion, which includes millwork, wood kitchen cabinets, and plywood and veneer mills, has grown slightly in importance within the wood products industry. Employment grew from 197,400 in 1972 (the first year for which separate employment data are available) to 231,300—or at an average rate of 1.2 percent a year. The proportion of industry employment increased from 27 percent in 1972 to 33 percent in 1984. 

**Occupations**

BLS projects an increase in employment in most of the major occupational groups between 1984 and 1995. Employment increases of about 10 percent or more are anticipated for managerial and engineering occupations, construction trades, precision production occupations, and skilled handworking occupations—which, together, accounted for 26 percent of 1984 employment. Smaller increases are projected for technicians; mechanics, installers, and repairers; machine setters, set-up operators, operators, and tenders; and laborers and material moving helpers. This group, accounting for 40 percent of industry employment, contains several important woodworking occupations: Head sawyers; operators, set-up operators, and tenders for sawing machines and woodworking machines; machine feeders; and people who move material by hand. Employment increases are projected for all of these individual occupations except head sawyers (one of the highest skilled jobs in this group) and some of the most unskilled laborers who move stock and other materials by hand. 

Employment declines are projected for several occupations, the most important of which is the group of forestry and logging occupations: Choke setters, fellers and buckers, forest and conservation workers, logging tractor operators, log graders and scalers, and log handling equipment operators. This group, which constituted 10 percent of 1984 industry employment, is projected to decline in size by almost 10 percent by 1995. Declines are also projected for administrative support personnel (which includes clerical occupations); service occupations; and occupations involved with transportation, material moving, and vehicle operations. The declining occupational groups account for about 27 percent of employment. 

Industry sources indicate that demand is high for several logging and sawmill occupations. In the logging portion, there is need for mechanics who can maintain feller bunchers, skidders, and other logging vehicles; and for skilled feller buncher and skidder operators (but not for chainsaw operators). Maintenance operations in sawmills are becoming more specialized. The "general handyman" maintenance worker is no longer sufficient in modern sawmills. Demand is particularly strong for electrical and electronic maintenance workers, for whom an understanding of solid-state electronics has become increasingly important.

**Adjustment of workers to technological change**

There appears to be little specific emphasis on adjustment to technological change in this industry. The emphasis is primarily on increasing productivity, whether within the framework of collective bargaining contracts or through more informal company programs. 

Union representation is strong in some parts of the country—mainly in the West and Northwest where the International Woodworkers of America is the predominant union. Seniority is the principal form of job security in IWA contracts. Retirements, layoffs and recalls, plant closings, transfer rights, and training opportunities are based primarily on seniority, or on a combination of seniority and skill qualifications.

The IWA also proposes a cooperative union-management program to increase productivity and save jobs. This program involves worker participation in solving problems of safety, productivity, quality, and service. Joint committees would be staffed by union and management personnel, and decisions would be reached by consensus. The program also involves financial rewards for workers when cost savings result from these proposals. 

Union-management committees have been established in several wood products mills and plants; some have been in operation for a decade or more. A union-management committee was begun in the 1970's by an IWA
local and the management of a hardwood lumber and veneer sawmill. The problems on which this committee has worked include job training and improvements in productivity and product quality. The plant also developed a plan in 1982 to provide employee bonuses for output improvements. Another IWA local and sawmill management committee made provision for plant employees to have a voice in a company decision to acquire a computer.

A local chapter of the United Brotherhood of Carpenters and Joiners of America developed an employee involvement plan with a manufacturer of wood doors and plywood products in 1981. This program accomplished a reduction in materials costs and increased productivity and quality, as well as paying bonuses to employees in 1982. The program requires a commitment of time and effort from everyone involved and, after a 2-year trial period, has been renewed.11

There is little union representation in this industry in the South. In this area, labor costs are generally lower, and there may be less effort by mills to substitute automated and mechanized equipment for labor. In this environment, individual companies (which sometimes means individual mills) make their own policies concerning training, layoffs and recalls, etc. One large company with several southern sawmills has an employee involvement program which gives each employee several opportunities each month to discuss problems or ideas with fellow employees and supervisors. Quality circle meetings are used, as well as informal one-to-one meetings between each employee and his or her supervisor.


SELECTED REFERENCES


Chapter 2. Footwear

Summary

The footwear industry (SIC 314) remains highly competitive, but it also has become more concentrated with the closing of many smaller plants. Twenty-three firms, or less than 10 percent of the total, produced about half of the industry’s footwear in 1984.

With some exceptions, the adoption of automated machinery has not advanced rapidly, and the outlook is not much more promising in view of the high cost of equipment and growing imports. Nevertheless, some technologies are gaining acceptance. For example, the diffusion of computer-aided design is expected to increase steadily as a result of the development of small, cost-effective computers. Similarly, microprocessor-controlled machines in several processes that are highly labor intensive are also likely to be adopted rapidly, at least by the larger firms.

Output of footwear in 1984 was about 300 million pairs, the smallest quantity since the early 1930's. Imports grew substantially in all but 3 years during 1970-84. The import penetration ratio more than doubled, from 30 percent in 1970 to 63 percent in 1983 to an estimated 72 percent in 1984.

Productivity increased very slightly over the period 1970-84, as output and employee hours fell at almost the same rate. In the period 1980-84, productivity advanced at an average annual rate of 1.4 percent, with a sharper decline in employee hours than in output.

Capital expenditures (in constant 1972 dollars) averaged $34 million annually during 1970-82, virtually the same average outlay as in 1960-70, but the trend for the immediate years ahead is uncertain.

During 1970-85, employment declined rapidly, at an annual rate of 4.0 percent. In 1985, an average of 99,900 persons were working in footwear manufacturing, the smallest number since 1939 (earliest data available). The Bureau of Labor Statistics projects continuation of the sharp employment decline in footwear during 1985-95, with employment in 1995 25 percent lower than in 1985.

A measure of job security is provided by the plantwide seniority which prevails in labor-management contracts covering between 25 and 50 percent of the workers in this industry. Some contracts also have special provisions to deal with the many layoffs resulting from plant shutdowns.

Industry Structure

Although the footwear industry remains highly competitive, the largest firms have consolidated their competitive position during the past 10 years and now account for a substantial share of the industry's output. While no single footwear manufacturer accounts for more than 8 percent of total footwear output, the industry has become more concentrated as 23 firms, or less than 10 percent of the total, produced about half of the industry's footwear in 1984. Some of the largest manufacturers also own and operate many retail footwear establishments. Most of the firms are very small: About 70 percent of the firms account for less than one-fifth of total output. Since 1965, when the number of plants peaked at 990, a great number of closings have reduced the total, to about 450 plants in 1984.

Manufacturing plants for footwear are located in 41 States in all regions of the country. Among the States, Maine accounts for the highest proportion (12 percent) of total output. About 25 percent of domestic output is produced in the New England States, about 45 percent in the North Central and Middle Atlantic States, and approximately 30 percent in the South and West.

In recent years, the larger firms have concentrated production of certain shoe parts in separate plants. Such specialization has enabled the firms to install more advanced machines for volume production.

Some shoe companies are purchasing soles produced outside of the shoe manufacturing industry. These soles, known as molded “unit bottoms,” are purchased by shoe manufacturers and cemented to shoe uppers, thereby eliminating labor which would be required in the shoe factory. About one-fourth of domestic shoes are made with such unit bottoms.

Some 100 footwear manufacturers are also importers, who contract for the manufacture of shoes or parts of

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1 Imports as a percent of domestic production plus imports minus exports.

2 The industry (SIC 314) covers all nonrubber footwear. It includes women's footwear, men's footwear, all other nonrubber footwear, and house slippers.
shoes in foreign countries. In 1983, the imports of these U.S. firms represented about one-third of total shoe imports.

**Technology in the 1980’s**

The diffusion of automatic controls has not been widespread in this industry. Computer controls, microprocessor controls, and numerical controls have been adopted by only a small proportion of the industry, primarily the larger firms. The incentive to automate is lessened by the high cost of such machinery, the frequent changes in shoe styles, and the growth in imports of shoes and parts of shoes. The fact that most domestic shoe factories work only one shift can also make the purchase of automated equipment difficult to justify.

Microprocessor-controlled instruments (MCI’s) control functions in any programmable sequence and have several operating advantages over an instrument comprised of extensive relay controls, or mechanical switches that control electrical current. An MCI, consisting of a large-scale integrated circuit or a set of integrated circuits, performs the functions of a central processing unit and may be used in combination with sensor devices. However, in footwear manufacture, the cost effectiveness of MCI’s depends on how extensive the tooling (work-holding devices) requirements are for a particular operation.

The principal improvements with the use of MCI’s are usually apparent in the reduction of machine setup time and are associated with lower unit labor requirements. Materials savings and energy conservation are additional benefits.

Moreover, operators can adapt quite readily to MCI’s. The MCI often has a programmable controller, and the machine’s operator only needs to select a combination of letters and numbers in order to make changes. In addition, the variables of a process usually only require the monitoring of measurements that are on continuous display. The MCI is simpler than a network of relay controls, which may require considerable labor for wiring, debugging, and maintenance. However, maintenance personnel usually need a knowledge of electronics to maintain MCI equipment.

The major technologies, their labor impact, and their diffusion are summarized in table 2.

**Computer-aided systems**

Computer-aided systems in footwear manufacturing involve applications of computer-aided design (CAD) and computer-aided manufacturing (CAM). Most of the computerized technologies in the industry still consist of only one or a few distinct applications of CAD or CAM functions. The applications of CAM usually entail stand-alone machines that perform a single operation, although a small number of the larger firms have joined several types of CAM equipment with their CAD. Technology that combines more than a single operation is expected to receive somewhat greater emphasis in the future by the largest companies.

**Computer-aided design.** The use of CAD in designing and pattern grading reduces unit labor requirements and improves quality. Most modern footwear CAD systems utilize similar modes of operation. In the initial design operation, the last, a three-dimensional form which represents the foot on which the shoe is constructed, is numerically defined by “digitizing” the surface of the last. Through the use of special computer software, this is turned into a two-dimensional surface. A footwear designer, using a graphic cathode ray tube (CRT), designs a new pattern style on the two-dimensional surface, which can be easily modified on the CRT during the development process.

Footwear designer using 3D color computer-aided design system.

After a new style is accepted and developed for production, the pattern must be “graded,” involving the production of patterns for all the different sizes and widths in which the footwear will be manufactured. Whereas manual grading by specialists could require several weeks, the production of patterns on the CAD system can be achieved within hours, and with greater accuracy.
Table 2. Major technology changes in footwear

<table>
<thead>
<tr>
<th>Technology</th>
<th>Description</th>
<th>Labor implications</th>
<th>Diffusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer-aided design (CAD)</td>
<td>Shoe styles can be depicted rapidly on a screen. CAD is also used to derive measurements for component parts of a shoe prior to its production.</td>
<td>Unit labor requirements can be greatly reduced compared to the manual process.</td>
<td>Used by 45 firms; use is expected to grow with small, cost-effective computers.</td>
</tr>
<tr>
<td>Computer-controlled stitching</td>
<td>Most advanced stitching is on microprocessor-controlled machines. The machines—used for functional and fancy stitching—stitch automatically with plug-in modules that contain stitching patterns.</td>
<td>A productivity increase of at least 25 percent is associated with some decline in employment and replacement of skilled workers by semiskilled operators. A machine can often become qualified to program the modules.</td>
<td>Diffusion during the next 5-10 years is expected to increase, as new machines with improved stitch quality and functional capability are developed.</td>
</tr>
<tr>
<td>Numerically controlled (NC) upper roughing machine</td>
<td>NA machine automatically directs a brush in roughing part of the shoe upper to provide a base for cementing.</td>
<td>Unit labor requirements are slightly lower than for manual roughing, since operator may perform other work after machine is set in motion. Operator skill requirements reduced.</td>
<td>Rapid diffusion anticipated, especially among larger firms.</td>
</tr>
<tr>
<td>Forepart pulling and lasting machine, with microprocessor control</td>
<td>Automatic size determination and positioning assure precise cementing of upper to the insole.</td>
<td>Unit labor requirements and skill requirements of operators are reduced. Programming can be easily mastered by workers with experience in lasting.</td>
<td>Increased use is expected by larger and medium-sized firms during the next 5 years.</td>
</tr>
<tr>
<td>Injection molding machine with microprocessor control</td>
<td>Automatically molds a shoe bottom from thermoplastic or polyurethane to the upper. Machine parameters—e.g., temperature—can be set through simple digital input.</td>
<td>Injection molding eliminates steps and is therefore much less labor intensive. Automatic loading feature may eliminate one operator on a molding machine.</td>
<td>Moderate expansion in use expected, especially among large and medium-sized firms during the next 5 years.</td>
</tr>
<tr>
<td>Sole laying press</td>
<td>Machine automatically determines the contour of shoe’s bottom and adjusts for heel height to assure that shoe is accurately positioned before permanent attachment of sole to shoe bottom.</td>
<td>Less operator skill is required, and quality of output is improved over that of machines without automatic adjustments.</td>
<td>Continued diffusion from current level of about 15 percent is likely during the next 5 years.</td>
</tr>
</tbody>
</table>

About 45 firms have CAD in their plants, and the technology’s diffusion is expected to increase steadily within the next 5 years as a result of a recent very sharp decline in the price of computers. It is estimated that the number of firms with CAD more than tripled between 1983 and 1985, as firms installed small, but powerful and cost-effective computers. Unlike the early years, when CAD was limited to large firms, further investment in the technology is expected to take place among some medium-sized and even small manufacturers.

**Computer-aided manufacture.** The pattern grading data and tapes developed in the CAD process can be used in manufacturing processes, including computer-controlled cutting and stitching. However, most firms, with the exception of the largest, have purchased only limited types of computer-aided machinery. As an alternative, business enterprises known as “service bureaus” are available to perform the cutting (and the pattern grading) service for many manufacturers who either cannot afford or prefer not to assume the cost of such capital outlays. Only two large firms in a 1983 survey of shoe manufacturers planned to invest in two newly available computer-controlled technologies for making molds and lasts, which entail various shaping operations. In addition, computer-controlled machinery is not available (or else not thoroughly proven) in a great number of the still separate functions that make up shoe manufacturing. For example, the minicomputer-controlled knife has received limited application in cutting synthetic materials.

**Computer-controlled stitching.** The most advanced stitching machinery is usually controlled by microprocessor,
based computers. The operations include major functional stitching such as vamping (attachment of the vamp or front part of a shoe’s upper to the quarter or back part), as well as fancy design stitching.

These machines stitch automatically and rapidly with plug-in modules that contain stitching patterns. The modules, technically identified as erasable-programmable-read-only-memory (EPROM) cards, can be programmed directly on the machine. An operator loads work pieces and pushes a button, and the EPROM card carries out an operation automatically for a whole range of footwear sizes. Footwear manufacturers can purchase from the machine’s manufacturer either the equipment to make programs in-house or the software.

Computer stitching in vamping reduces unit labor requirements and improves the quality of the product through greater accuracy and consistency. In contrast, older conventional processes of vamping are very labor intensive. It is estimated that computer stitching used for long production runs results in a productivity increase of at least 25 percent. However, these machines are not efficient for short production runs because of the costs involved.

Some dilution of skill requirements permits skilled workers to be replaced by semiskilled workers. In certain plants, a mechanic with a high school education plus some additional mathematics can qualify for the programming position after 2-3 months of instruction. Mechanics who maintain the machines require only a modest knowledge of electronics. Some machines contain built-in systems that diagnose most operational problems.

Computer-based machines for functional and fancy stitching are found in firms of all sizes. Increased use is expected in the next 5 to 10 years as new machines are developed with improved capability and stitch quality.

**Numerically controlled upper roughing machine**

The process of roughing consists of scouring the margin area of the fitted shoe upper with a rough brush (usually wire) to provide a good base to which cement can adhere. The traditional, and still most common method (for over 90 percent of output), is manual, with reliance on the operator’s hand-eye coordination. Another method used is one in which the shape of a shoe is formed on a metal template and the upper is roughed with a wire brush that follows the outline of the shoe template.

The newest technology involves the use of an NC machine. The shape of the bottom of the shoe is “digitized,” which involves securing some 20 points corresponding to the shape of the shoe’s bottom. The NC machine can automatically make the calculations to direct a wire brush in the roughing of right and left shoes in all shoe sizes. The NC machine has advantages over both the manual method and the automatic machine utilizing templates, including the possibility of operating on a wider range of shoe types and greater speed in shifting from one shoe style to another. Better quality of roughing can also improve the process of sole attachment which follows.

Unit labor requirements are slightly lower for roughing with the NC machine than with the manual process, in part because of the decrease in the number of damaged shoes. Shoes are sometimes damaged in the manual process when the operator holds a shoe incorrectly in applying it to the rotating brush. Also, unit labor requirements may be lower with the NC machine because, in some cases, the operator performs other work after the machine is set in motion.

An operator with limited job experience can quickly learn to use the NC machine. While maintenance of the NC machine is not simple, a digital readout screen does indicate the site of any operational problem.

Over the next 5 to 10 years, the number of NC upper roughing machines is expected to increase sharply, particularly among larger firms, from the small number currently in operation.

**Forepart pulling and lasting machine with microprocessor control**

This recently introduced machine assures precise last- ing for the process of stretching the upper over the last and cementing it to an insole. In addition to automatic size determination and positioning, it is possible to adjust rapidly to various shoe styles constructed with different materials.

The machine can be programmed to eliminate the need for manual adjustments, and this greatly improves the efficiency of the lasting operation. When a shift is made from one shoe last to another, downtime is reduced because the many machine changes required can be readily accomplished by the computer program.

Unit labor and skill requirements of operators are greatly reduced with the automatic lasting machine. According to one machine manufacturer, a reduction in unit labor requirements of nearly 50 percent is possible when the operator of the automatic lasting machine also tends other types of lasting machines. Moreover, the required skill of programming for this machine can be mastered after about 1 week’s instruction by persons with experience in lasting. While maintenance workers generally have skills in the electrical, pneumatic, and hydraulic fields, they also need some knowledge of electronics to service the machine. A technician employed by the machine’s manufacturer is available for instruction during the 1 or 2 weeks following the acquisition and installation of the lasting machine.

This microprocessor-controlled machine is relatively costly but is likely to be considered cost effective by large and medium-sized firms that expect to remain
competitive with foreign imports during the next 5 to 10 years. Some small firms may also purchase the machines.

**Injection molding machine with microprocessor control**

The injection molding machine automatically molds a shoe bottom from thermoplastic or polyurethane material to the upper part of the shoe. It is considerably less labor intensive than the major alternative processes of cutting, stitching or cementing, and associated intermediary steps. The quality of output is also higher with injection molding because of the considerable uniformity of the units produced. More than 20 percent of domestically produced shoes have soles made by injection molding. The machines consist of rotary mold stations, with a 12-station machine equipped to handle 6 pairs of shoes per cycle. On the most advanced machines—microprocessor-controlled and, very recently, computer-controlled—all the machine's parameters (e.g., temperature) can be set on a control cabinet that has a visual display unit. Numerous automatic features, ranging from mixing materials to fault diagnosis, are available on some machines. Moreover, recently developed polyurethane compounds can be processed much faster than the usual polyurethane compound.

Labor requirements for injection molding are relatively low, and only modest skills are required to operate the machines. Two operators with only some mechanical experience are used on a machine with 12 or 18 stations to load, unload, and periodically examine units of production so as to minimize the number of defective parts arising from an occasional error in the process. The optional feature of automatic loading further eliminates labor requirements. Loading and unloading can be carried out by robots on at least one kind of computerized machine.

Use of microprocessor-controlled molding machines, primarily by large and medium-size shoe manufacturing firms, is expected to increase moderately. Currently, less than 15 percent of all injection molding machines contain these technologies, but at least some of the numerous firms involved in importing shoe uppers are likely to acquire the machines. The remaining firms will continue, for at least the next 5 years, to use machines that are controlled by rather cumbersome electrical controls which require regular maintenance by a skilled electrician and a hydraulic technician.

**Sole laying press**

While cementing a sole to the upper part of a shoe is still labor intensive, automatic adjustments on some sole laying presses substantially improve the uniformity of production. An operator, who receives the uppers and soles with cement already applied to them, uses heat to reactivate the cement and then temporarily "spots" the soles to the uppers. In the newer sole laying presses, the operator uses a self-adjusting pad box that automatically determines the contour of a shoe's bottom and, also, a toe and heel rest that automatically adjusts for heel height to assure that the lasted shoe is held in an accurate position. After loading and initial adjustment, the operator then starts a high-pressure cycle to secure a permanent attachment of the sole to the shoe bottom.

While unit labor requirements are not reduced significantly by this machine, less operator skill is required and quality of output is improved. On a traditional machine lacking the automatic adjustments, an operator may break a last when high pressure is applied or fail to secure precise adhesion of the shoe's parts.

Currently, about 15 percent of the shoe manufacturers have sole laying presses with automatic controls. Continued diffusion is likely during the next 5 years.

**Output and Productivity Outlook**

**Output**

In 1984, total footwear production was about 300 million pairs, the smallest quantity since the early 1930's. From 1970 to 1984, output declined at an average annual rate of 3.8 percent, considerably greater than the rate of decline (0.3 percent) in the 1960's. Declines took place in all years of the period, with the exception of 1976 and 1978 (chart 6). By 1984, output was only about half the level in 1960.

Production declined consistently for both women's and men's shoes, which together account for almost three-fifths of all footwear produced. Women's shoes declined 55 percent between 1970 and 1984, while the decline for men's shoes was nearly 40 percent. Even sharper declines took place for youth's and boys' shoes and misses' and children's shoes, which, together, declined to less than 9 percent of the footwear produced in 1984. Substantial declines also occurred in infants' and babies' shoes and house slippers; these two groups together accounted for about 26 percent of all footwear produced in 1984. Only a miscellaneous product class which includes athletic shoes exhibited growth between 1970 and 1984; its share rose steadily to about 7 percent of the total. A so-called "athleisure" shoe that is classified in this industry is manufactured with leather uppers, a molded outer sole, and soft inner padding. This shoe may continue to receive growing acceptance by both young persons and adults.

While domestic output has dropped sharply over the years, total consumption has, in fact, risen. Per capita consumption, however, has been relatively stable: 4.30 pairs in 1984, the first time the ratio was above 4 pairs since 1968. Imports have filled the gap between output and consumption.
Chart 6. Output per employee hour and related data, footwear, 1970-84

Ratio scale (1977 = 100)

The outlook for domestic production will be primarily a function of the industry’s effectiveness in competing with foreign producers. In addition, rubber and plastic footwear (SIC 302) is also likely to continue to affect nonrubber footwear output. Rubber and plastic footwear—especially the footwear used widely by boys, girls, and many young adults for athletic and casual occasions—has been considered “directly competitive” with nonathletic footwear by the U.S. International Trade Commission.5

**Imports**

In contrast to the trend in domestic production, imports grew substantially in all but 3 years during 1970-84. Consequently, import penetration increased almost steadily over the 14-year period. The import penetration ratio more than doubled, from 30 percent in 1970 to 63 percent in 1983 to an estimated 72 percent in 1984 (quantity basis). Since most footwear imports are still relatively low priced, the import penetration ratio is considerably lower on a dollar-value basis than on a quantity basis. The dollar-value ratio was 45 percent in 1983 (latest available figure).

Imports have nearly doubled since the Orderly Marketing Agreements with Taiwan and South Korea, the two largest exporters to the United States, expired in June 1981. Over 725 million pairs of shoes and house slippers were imported in 1984, 25 percent higher than the total of only a year before.

Exports of nonrubber footwear are only a small fraction of domestic production. They totaled only 8.9 million pairs in 1984, or about 3 percent of domestic shipments.

As is evident from the import penetration data, many domestic shoe manufacturers have been unable to compete with foreign producers. To improve their position, some domestic manufacturers have themselves been importing shoes or the labor-intensive shoe uppers.6

In 1985, the United States International Trade Commission (ITC) determined that imports were a substantial cause of serious injury to the industry and recommended that the President impose quantitative restrictions for a 5-year period on imported footwear valued at more than $2.50 by the U.S. Customs Service.7 The President did not accept the recommendation of the ITC.

**Productivity**

Productivity increased very slightly in the period 1970-84, as output and employee hours fell at almost the same rate. Over the period, productivity increased at an average annual rate of 0.2 percent; output and employee hours fell 3.8 and 4.0 percent, respectively, annually.

In the period 1980-84, productivity advanced at an average annual rate of 1.4 percent. This recent productivity increase was associated with a decline in output of 5.4 percent, but a sharper fall (6.7 percent) in employee hours. The decline in hours largely reflected the diffusion of new technology and the closing of older plants.

In 1984, productivity was near its levels in 1975 and 1976, while output and hours were at their lowest points since 1947 (earliest available data). Productivity reached its postwar peak in 1982, as hours dropped almost 12 percent in that year.

The industry’s slight productivity increase during 1970-84 followed a period of similar growth in the 1960’s (an annual average of 0.4 percent). In those two periods, the trends in output and employee hours differed markedly. Whereas output and employee hours fell 1.0 percent or less during 1960-70, both output and hours declined more than three times as rapidly during 1970-84.

**Investment**

**Capital expenditures**

Real capital expenditures (in constant dollars)8 by the footwear industry in 1982 (latest data) were only 59 percent of the peak in 1968, although in current dollars they were 47 percent higher. In 1981, however, real outlays approached the peak. Over the period 1970-82, real outlays (1972 dollars) averaged $34 million annually, almost equal to the annual outlays in 1960-70.

However, in view of the widespread industry practice of renting equipment, data on capital expenditures do not include all of the industry’s outlays for new machinery. Census data for 1982 indicate that rental payments for machinery and equipment were more than two-thirds as large as new capital expenditures for machinery and equipment. In manufacturing as a whole, rental payments were only 13 percent as large as new capital expenditures in 1981 (latest data).

The outlook for growth in capital expenditures in the years ahead is uncertain. On the one hand, investment is likely to receive considerable emphasis by major manufacturers interested in capital-intensive equipment to reduce unit labor cost and remain competitive. On the other hand, the high cost of new equipment for many processes, coupled with growing imports, discourages long-term investment.

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6 "The company . . . expects that its importation of shoe uppers will favorably impact operating margins . . . ." from Suave Shoe Corporation Report to the Shareholders for the Third Quarter Ended June 30, 1985.


8 Data deflated for price changes by the U.S. Department of Commerce, Office of Business Analysis.
Research and development

Research and development (R&D) in this industry is generally limited to the suppliers of machinery and the largest shoe manufacturers. Even several of the larger firms do not engage in R&D. Other firms reported that their R&D includes marketing surveys and product testing.9

The Footwear Industries of America (FIA), an association of shoe manufacturers, is promoting R&D. The FIA has been conducting seminars in which the machine suppliers and material suppliers discuss with footwear manufacturers the improvements needed in key processes. Manufacturers can make suggestions that may be incorporated in new machinery during these regional seminars. Traditionally, suppliers of machinery have contacted shoe manufacturers individually, who then had relatively little participation in the R&D process.

Employment and Occupational Trends

Employment

In 1985, an average of 99,900 persons were working in footwear manufacturing, the smallest number in any year since 1939 (earliest data available). In the period 1970-85, employment declined rapidly, at an average annual rate of 4.0 percent (chart 7). With the exception of 1976, 1978, and 1981, employment fell each year during the 15-year period. By 1985, employment was only 47 percent of the 1970 level (212,700), and 41 percent of the 1960 level (242,600). The rate of decline was considerably faster in the 1970's and through the first half of the 1980's than in the 1950's and 1960's.

The Bureau of Labor Statistics, on the basis of its moderate-growth projection for the economy, projects a continuation of the sharp employment decline in footwear, at a rate of 2.8 percent annually from 1985 to 1995.10 On the basis of this projection, employment in 1995 would be 25 percent lower than in 1985.

Production worker employment has remained high relative to total employment, as the industry continues to be highly labor intensive. The ratio of production workers to all footwear employees was 85 percent in 1985, or only 2 percentage points below the 1970 figure. The comparable ratio in all manufacturing in 1985 was about 68 percent.

The proportion of women in the footwear industry's work force was 65 percent in 1985, or double the average for all manufacturing industries. It has risen slightly since 1970 following a considerably more rapid rate of increase in the previous decade.

Occupations

According to a recent Department of Labor survey,11 the distribution of the industry's production and related workers by level of skill was as follows:

<table>
<thead>
<tr>
<th>Percent</th>
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<tr>
<td>Highly skilled</td>
</tr>
<tr>
<td>Skilled</td>
</tr>
<tr>
<td>Semiskilled</td>
</tr>
<tr>
<td>Unskilled</td>
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</tbody>
</table>

As is evident from the table, more than 2 out of 5 workers are skilled or highly skilled. Their jobs are associated with the continuing high utilization of non-automatic/noncomputer-controlled machines. Where such machines predominate, e.g., in the fitting and stitching and lasting/bottoming operations, almost half of the workers are skilled or highly skilled. In contrast, of the workers who are in occupations utilizing automatic/computer-controlled machines, only 22 percent are skilled or highly skilled.

Cutting operations, which are among the least automated of the footwear operations, have the highest proportion of skilled workers: 21 percent are highly skilled and 42 percent are skilled.

Employment is expected to decrease in each of the major occupational groups between 1984 and 1995, according to BLS. The smallest proportional declines are anticipated for precision production occupations and the engineering and technician occupations—20 and 28 percent, respectively. By 1995, precision production workers are expected to account for 22 percent of all employees, up from 18 percent in 1984, while the small engineering and technician group will still represent only about 1 percent of all footwear employees.

The largest projected declines (about 40 percent) from 1984 to 1995 are expected to take place in machine setter, setup operator, and tender occupations; in administrative support occupations, including clerical; and for blue-collar worker supervisors. While machine setters, setup operators, and tenders—by far the largest single occupational group—will decline in relative importance, they will still account for more than one-third of the industry's employment in 1995.

Adjustment of workers to technological change

Programs to protect workers 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 gen-

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10 BLS projections for industry employment in 1995 are based on three alternative versions of economic growth. For details on assumptions and methodology used to develop these projections, see the Monthly Labor Review, November 1985.


Employees (thousands)

Employees (thousands)

220

200

180

160

140

120

100

80

60

40

20

0

1970 72 74 76 78 80 82 84 86 88 90 92 94 0

Average annual percent change

All employees

1970-85

1970-73

1973-76

1978-85

1985-95 (moderate projection)

Production workers

1970-85

1970-73

1973-78

1978-85

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

See text footnote 10.

eral, such programs are more prevalent and detailed in formal contracts. Both formal and informal labor-management arrangements are influenced by the state of the economy and, in particular, the condition of the industry in which collective bargaining takes place.

Formal labor-management agreements cover between 25 and 50 percent of the workers in this industry. The unions are the Amalgamated Clothing and Textile Workers,12 The United Food and Commercial Workers13—the two major unions—and the United Rubber, Cork, Linoleum and Plastics Workers of America. All three are members of the AFL-CIO. The independent unions include the Brotherhood of Shoe and Allied Craftsmen and the International Brotherhood of Teamsters.

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

Requirements for advance notice of technological change are typically absent from bargaining contracts in this industry. Union stewards generally learn about such changes by being informed of new and altered job requirements associated with a new machine or a new method. This takes place when wage classifications and rates on new and changed operations are established by the company. The union can question changes in earnings through the grievance procedure, including any failure of operators to achieve their former average earnings.

When an employee is displaced as a result of a change in operations or method of manufacture, some agreements require the union and company to confer and attempt to assist the worker in securing and adapting to another position. If an employee's position is terminated, but an opening for the same position is available in another plant, the employee can transfer with seniority intact. When a job is discontinued and replaced in whole or in part by another operation, displaced employees have first claim to the new operation, or they may be placed on a preferential employment list. Laid-off workers may be on a preferential employment list for a maximum of 18 months for jobs that are filled on the basis of seniority.

In at least one major contract, the company agrees not to open and operate a new plant prior to considering the feasibility of increasing production at its existing plant through second and third work shifts. This can insure greater stability of employment at the plant until the need for greater output from a new plant has been firmly established.

Some provisions deal with layoffs that result from plant shutdowns. Representative agreements provide severance pay of $30 per year of continuous service, with a minimum of 15 and a maximum of 30 years ($450 to $900). In recent years, a bargaining provision in contracts has enabled vested employees who are displaced by plant closure and are unable to secure employment with the company to apply for reduced pensions if they are at least 55 years of age.

Footwear workers who lose their jobs or whose hours are reduced may have recourse to a Federal program of assistance if the Office of Trade Adjustment Assistance of the Department of Labor determines that increased imports contributed importantly to job loss or earnings reduction. Cash allowances were paid to over 64,800 workers between April 1975 and August 31, 1985. Over 6,250 of the workers who received allowances also were enrolled in training programs.

In September 1983, the President requested that the Secretary of Labor provide additional financial assistance for the dislocated workers in lieu of imposing restrictions on imports. The assistance is intended to aid about 2,300 dislocated workers to find jobs through job search, retraining, and relocation.

SELECTED REFERENCES

Footwear Industries of America (Cooperator) and J.B. Kaplan and Company, Inc. (Consultant). Survey of the State of the Art in Footwear Manufacturing and Identification of Priorities and Mechanisms to Accelerate the Development and Application of Advanced Technology in the U.S. Footwear Manufacturing Industry. Two volumes. Under a grant/cooperative agreement from the Department of Commerce, April 1983.


Chapter 3. Hydraulic Cement

Summary

The hydraulic cement industry (SIC 3241) consists of about 146 plants which produce portland, masonry, and other types of hydraulic cement that are essential to the construction industry.

Innovations in technology to manufacture hydraulic cement are being introduced in all major production steps, from the initial stages of preparing limestone and other raw materials obtained from quarries to the final tasks of grinding clinker into finished cement and storing it for shipment. Major technologies being adopted include suspension preheaters and precalcining furnaces, which greatly increase kiln capacity and fuel efficiency; roller mills, which combine the separate steps of drying, crushing, and grinding of raw materials prior to burning in the kiln; and advanced computer process control and instrumentation systems that regulate kiln operations and other key production tasks. Major incentives to the introduction of these innovations and other changes discussed in this report include meeting the requirements of environmental regulations, lowering energy costs, and reducing labor and other expenses to become more competitive with domestic and foreign suppliers of cement.

Employment in the cement industry totaled 23,400 workers in 1985, down by 30 percent from 1970. The sharpest declines were between 1978 and 1985—during which time the number of employees declined at an average annual rate of 5.1 percent. The reduction in the number of cement plants and the decline in output associated with periods of slack demand for cement have been the major factors in lower levels of employment since 1970.

New technology has brought about changes in some key occupations at plants undergoing extensive modernization, with control room operator and maintenance occupations increasing in complexity and relative importance and semiskilled operative and laborer positions generally declining. The introduction of computer process control systems and the use of high-capacity, single-kiln systems featuring preheating and precalcining towers have centralized and combined operations and changed the mix of occupations.

The majority of the work force in the cement industry is covered by collective bargaining agreements, and provisions relating to seniority, advance notice of change, training, and reassignment of workers have been applicable in plants adopting laborsaving innovations. Training has been extensive in some plants—particularly when computer process control systems have been introduced.

Structure of the Industry

The output of the hydraulic cement industry is essential for a wide range of construction activities. Thus, demand for the industry's products is closely related to changes in the volume and mix of construction activities. Portland cement accounts for about 95 percent of total production, and masonry cement makes up most of the balance. In terms of end-use, residential construction typically consumes about one-third of the total output of portland cement, and commercial construction about 20 percent.

In 1984, 141 plants turned out portland cement (U.S. Bureau of Mines data); nearly one-half of the total volume of shipments went to States in the South, where construction activity has been strong. Two out of three plants also produced masonry cement—a non-portland type of hydraulic cement. Nearly 70 percent of the output of masonry cement also was shipped to this area. About five plants produced masonry and other types of hydraulic cement exclusively.

The cement industry ranks among the leading industries in consumption of energy, which accounts for between 35 and 65 percent of the total cost of cement, depending upon the age and type of plant. Thus, capital expenditures for technologies to reduce energy consumption are substantial. The industry also allocates considerable funds for new equipment and processes to comply with regulations on surface mining and air and water pollution.

Imports of hydraulic cement have been increasing sharply and in 1985 amounted to about 14 million tons, 5 times greater than in 1982.¹

The cement industry had 23,400 employees in 1985, 78 percent of whom were production workers. A significant number of workers are located in the leading producer States of Texas, California, and Pennsylvania.

Technology in the 1980's

The manufacture of portland cement requires large and powerful equipment to convert limestone and lesser quantities of other materials to cement through a series of physical and chemical processes. The four basic steps in the manufacture of portland cement are: Quarrying and crushing limestone and other raw materials; grinding and homogenizing the raw materials; converting the raw materials to clinker in a rotary kiln and associated cooler; and grinding the clinker with additives to produce cement ready for shipment.

The most important new technologies being introduced in modern cement plants include preheating and precalcing kiln systems, which reduce processing time and fuel consumption, thereby increasing kiln capacity and fuel efficiency; roller mills, which combine the formerly separate steps of drying, crushing, and grinding of raw material prior to burning in the kiln; air-swept ball mills that perform raw grinding with greatly increased efficiency; and advanced computer process control systems that monitor and control key production steps throughout the plant from a central location. The use of more powerful equipment to crush rock in quarry operations, and improvements being incorporated in ball mills used in finish grinding also are significant innovations. The cement industry is subject to strict environmental regulations, and a major incentive to the adoption of new technology is to improve air quality to conform to required standards.

Although the major cost associated with the production of Portland cement is for energy, the new technologies discussed in this section nonetheless have had an impact on employees in the cement industry. In modern cement plants that feature computers, programmable controllers, and central control rooms incorporating closed-circuit TV, a single operator and a helper can control the major production units—a significant saving in labor compared to older plants. In one of the most advanced new facilities, for example, output of cement per employee more than doubled after a major modernization. These savings suggest that broad industry adoption of these innovations could have an impact on production and the work force. Moreover, the duties and staffing requirements of kiln operators, maintenance workers, and other employees in cement plants have changed as computer process control and other innovations have been adopted. Thus, training programs to prepare employees to operate new equipment, described later, are an important feature of modernization programs.

In this section and in table 3, innovations in cement technology are described, their impact on productivity and employment is examined, and prospects for further adoption in the industry are assessed.

Improved kiln technology

Substantial improvements in technology related to the kiln operation are underway. In the kiln, the blend of limestone and other material is subjected to high temperatures as it passes through a rotating and slightly inclined cylindrical steel shell. In this process, the raw material is changed chemically by the high temperature, fusing into clinker—a hard substance which subsequently is cooled and ground into finished cement.

Modern cement kilns have greater capacity than earlier models, and kilns presently being installed utilize high-capacity, preheater/precancer dry process technologies, discussed below, which are substantially more energy efficient. According to the U.S. Bureau of Mines, average kiln capacity in the United States increased by 90 percent between 1970 and 1984. As an example, the Portland Cement Association reports that the 4 largest kilns constructed since 1980 have the same capacity as the 57 smallest kilns. Moreover, the association reports that the proportion of total cement capacity using the dry process has risen to about two-thirds of the total, with further gains anticipated.

Preheater and precalciner systems are being used in a growing number of cement plants to reduce costs in the kiln operation. In 1984, plants with 36 percent of total U.S. capacity used preheaters, and 19 percent used precalciners. All the precalciners and 94 percent of the preheaters have been added since 1971. Although further diffusion of these technologies is anticipated, the United States lags behind some countries, including Japan, where precalciners are associated with about 60 percent of total kiln capacity.

The major incentive to introducing preheater and precalciner technology is to reduce energy costs. However, labor requirements for operators and other staff also are lowered by the greater capacity of the new production equipment. In one plant which modernized extensively, including the use of preheater and precalciner technology, one short rotary kiln in a new section of the plant has twice the capacity of three conventional kilns that were closed down. In the new kiln, energy requirements per ton of cement are lower by one-third.

The trend to constructing kilns of greater length has

2 Cement kilns are of two basic types, wet process and dry process, depending on whether the raw material being fed into the kiln is a slurry or a dry powder. The trend is to a greater use of dry process kilns because they can utilize the new preheater and precalciner technologies, which consume up to 50 percent less energy per ton of cement than the wet process kiln systems. This new technology cannot be applied to wet kiln systems.


5 Ibid.
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<th>Technology</th>
<th>Description</th>
<th>Labor implications</th>
<th>Diffusion</th>
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<tr>
<td>Improved kiln technology</td>
<td>New-model kilns have greater capacity and are more efficient than older kilns. Suspension preheaters and precalciner furnaces are being used in dry process kiln systems to lower fuel costs and increase output. The preheater is a large tower adjacent to a short rotary kiln and feeds into it. The preheater uses hot exit gases from the kiln to suspend, heat, and partially calcine (remove carbon dioxide) the raw material as it descends through the tower, into the precalciner furnace, where nearly all the remaining carbon dioxide is removed, and through the kiln for conversion to clinker.</td>
<td>Although the major purpose of installing preheater/precalciner kiln systems is to save fuel, output per employee is higher in plants which have introduced this technology. In a representative installation, one short rotary kiln has twice the capacity of an older facility—now closed—that had three conventional kilns.</td>
<td>The use of preheater/precalciners is expected to increase through 1995. In 1984, plants with 36 percent of total U.S. cement capacity used preheaters and 19 percent used precalciners. All of the precalciners and 94 percent of the preheaters have been adopted since 1971.</td>
</tr>
<tr>
<td>Supplemental fuel for cement kilns</td>
<td>Industrial waste solvents are being used as a supplemental fuel for kiln operations. Liquid waste fuel costs per Btu reportedly are below those for coal and other conventional fuels. A typical supplemental fuel installation consists of storage tanks, tank trucks that supply these tanks, and systems that deliver the liquid to the kiln, where it is introduced simultaneously with conventional fuel.</td>
<td>The major impact of supplemental fuel systems is an increase in the duties of kiln operators and maintenance employees, and the additional employment of laboratory technicians.</td>
<td>Average kiln capacity increased by 50 percent between 1970 and 1984, with further gains anticipated over the next decade as the proportion of dry process kilns using preheaters and precalciners continues to increase.</td>
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<tr>
<td>Improved grinding equipment</td>
<td><strong>Raw grinding.</strong> In new dry process plants, grinding of raw materials prior to the kiln operation is being accomplished by a single large roller mill or ball mill. Both mills have their economic advantages, and the type of raw material determines which mill is used. The roller mill used in the dry process stands upright and grinds by the action of large steel rolls. Hot kiln gases blown upward through the mill remove moisture during grinding. Roller mills can process raw material with a higher moisture content than can single-unit airswept ball mills. However, airswept ball mills, which grind by the tumbling action of steel balls in a rotating cylinder, are not limited in the kinds of raw materials that may be processed.</td>
<td>Labor requirements in both roller mills and modern ball mills are lower than in older model tube mills (both ball and rod). In the most advanced plants, roller and ball mills of 6,000 horsepower are controlled by a single operator in a central control station. These latest grinding technologies reportedly match the output of six 1,000-horsepower ball mills in use in the 1950’s which, in total, required two operators and two helpers to oversee.</td>
<td>Both single-unit roller mills and ball mills were incorporated in the last two new cement plants constructed in the United States and further adoption of these technologies in raw grinding is anticipated.</td>
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### Table 3. Major technology changes in hydraulic cement—Continued

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<th>Technology</th>
<th>Description</th>
<th>Labor implications</th>
<th>Diffusion</th>
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<tr>
<td><strong>Improved grinding equipment—Continued</strong></td>
<td><strong>Finish grinding.</strong> Raw material converted to clinker in the kiln next undergoes final grinding. Improvements in final grinding mills include the introduction of high-efficiency air separators, larger grinding units that replace several smaller ones, and improved variable-speed drives for ball mills.</td>
<td>Productivity in finish grinding has increased because of high-efficiency air separators and other innovations. Finish grinding units in plants constructed in the 1980’s, for example, reportedly turn out 140 tons per hour, more than double the output of the more labor-intensive grinding units in place in the 1960’s.</td>
<td>The outlook is for further technological improvements in grinding mills to lower labor and electrical energy costs. In 1985, for example, 20 new high-efficiency separators were installed, with additional units planned.</td>
</tr>
<tr>
<td><strong>Improved quarrying and crushing equipment</strong></td>
<td>The capacity of equipment to load, haul, and crush quarried limestone and other materials has been increasing. Power shovels have been replaced by larger capacity front-end loaders, and the conveyances used to transport rock to the crushers also are larger. Impactor crushers which handle large rocks at high volume also are being adopted.</td>
<td>Productivity has increased as capacity of equipment has risen and crew requirements have declined. Front-end loaders of 10- to 13-cubic-foot capacity manned by a single operator have replaced power shovels of 3- to 5-cubic-foot capacity which required two operators. Conveyances used to haul stone to crushers have tripled in capacity, with a corresponding increase in tons hauled per operator. More powerful crushers also have reduced labor requirements and achieved other savings.</td>
<td>Innovations in quarrying and crushing equipment are being adopted in modernized and newly constructed cement plants.</td>
</tr>
<tr>
<td><strong>Computer process control and instrumentation</strong></td>
<td>Computers and advanced instrumentation are being applied to all phases of cement production. Typically, the main computer and associated instrumentation are located in a central control room with computer-controllers located in major production units. The central computer monitors plant operations through this network of computer-controllers and undertakes automatic or operator-assisted changes in production variables as required. In the most advanced installations, major processing and material handling operations are under computer control—from crushing through the storage of finished cement.</td>
<td>The installation of computer process control and related instrumentation has eliminated some positions and created others. In one example, the centralization of control instrumentation associated with the adoption of computer process control eliminated several categories of operator positions, and the subsequent adoption of computer process control resulted in the creation of new positions of computer operator and technician. Moreover, computer process control results in an increase in operator monitoring of equipment and less manual manipulation of control devices associated with control of the kiln and other equipment.</td>
<td>Computer process control is an integral feature of many new plants and those undergoing modernization. Moreover, computer control is being extended to a broader network of operations within the plant as technology has improved.</td>
</tr>
<tr>
<td><strong>Improvements in shipping operations</strong></td>
<td>Technological improvements in the shipping department include bag-filling machines, automatic palletizing, forklifts, and automation of recordkeeping. These developments have improved efficiency in the filling, handling, and loading of cement.</td>
<td>Labor requirements have declined markedly in plants which have adopted these innovations. A fully automated bag-packing line will lower labor requirements by more than two-thirds compared to conventional, less mechanized facilities.</td>
<td>Improvements in shipping operations are being adopted in many new and modernized plants to increase efficiency in the handling of the 10 percent of output that is shipped in bags.</td>
</tr>
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</table>
been reversed by the diffusion of preheater and precalciner technology. The suspension preheater is an advance in dry process technology which consists of a series of funnels or cyclones in a vertical arrangement supported in a tower structure and emptying into a kiln. Raw material enters the top of the preheater and is suspended briefly in each of the cyclone stages and heated by rising exhaust gases from the kiln and clinker cooler, undergoing partial calcining (removal of carbon dioxide) in the process. The precalciner is an additional furnace located near the base of the preheater tower through which the preheated material passes before entering the kiln. The combined preheater/precalciner technologies accomplish as much as 95 percent of the raw material calcination. Thus, kilns are shorter because they do not perform the calcining function. In some conversions to preheater/precalciner technology, kilns have been shortened to half their former lengths.

The outlook is for kiln systems incorporating the precalcining preheaters to continue to replace the older long kilns. In addition to fuel savings, output per employee is higher in precalcining preheater kiln systems because of larger capacity equipment and computer-aided central control.

**Supplemental fuel for cement kilns**

Industrial waste solvents are being used as a supplemental fuel for kiln operations, primarily in wet process plants. Liquid waste fuel costs less per Btu than coal and other fuels, and its use has the potential to make the wet process more competitive with modern dry process plants. Waste solvents reportedly constitute between 15 and 25 percent of total fuel requirements in user plants, with a higher substitution rate anticipated in the future.

A typical supplemental fuel installation consists of a series of storage tanks, tank trucks that supply these tanks, and piping and plumbing systems that deliver the liquids to the kiln where they are introduced simultaneously with the normal kiln fuel.

According to the International Brotherhood of Boilermakers, the major union representing workers in the cement industry, supplemental fuel systems have not adversely affected workers. The major impact has been an increase in the duties of kiln operators and maintenance employees, and additional employment to attend the systems—primarily in the area of laboratory analysis.

**Quarrying and crushing**

Innovations in the loading, hauling, and crushing of quarried limestone and other materials used as raw material for cement have increased productivity of equipment operators. Power shovels of 3- to 5-cubic-foot capacity manned by two operators have been replaced by front end loaders of 10- to 13-cubic-foot capacity manned by a single operator. The conveyances used to haul the stone to the crusher also have been increased in capacity, from about 25 tons to 80 tons, with a corresponding increase in tons hauled per operator.

Accompanying the larger loading and hauling equipment has been an increase in the size and capacity of crushers used to reduce the rock prior to grinding. Impactor crushers which have the capability to handle large rocks at high volume are being adopted in modernized and newly constructed cement plants. The size and type of crusher being used at a particular cement plant depends on the type of raw material being used to make the cement.

**Innovations in grinding**

Following crushing, the raw materials used to make cement are further reduced in size by grinding to prepare them for conversion to cement compounds in the kiln process. Technologies including roller mills and improved, high-capacity ball mills are increasing efficiency in raw grinding. In new dry process plants, for example, raw grinding is accomplished by a single large roller mill or ball mill. Each type of mill has advantages and disadvantages, and the characteristics of the raw material determine which mill is used.

Roller mills were introduced into the U.S. cement industry in the early 1970’s for raw material grinding, and they are being installed in a growing number of cement plants. The roller mill is a dry process technology and differs from tube mills (ball mills and rod mills)—the conventional method of grinding used in both wet and dry plants. The roller mill stands upright and grinds by the action of large rolls which turn around a vertical axis at the bottom of the mill. Roller mills utilize hot kiln exhaust gases, blown upward through the mill to remove moisture during grinding. The roller mill can process raw materials with a higher moisture content than large, single-unit air-swept ball mills. However, air-swept ball mills, which grind by the tumbling action of steel balls in a rotating cylinder, are not limited in the kinds of raw material that may be processed.

Both roller mills and modern ball mills are more powerful and use less labor and electric power than the older model tube mills (both ball and rod). Modern roller and ball mills of 6,000 horsepower in the most advanced plants are controlled by a single operator at a central control station and match the output of six 1,000-horsepower ball mills in use prior to 1950 which, in total, would require two operators and two helpers to oversee.

**Improved finish grinding technology**

In the end-stage finish grinding of clinker, a series of improvements in conventional ball mills—although not dramatic—nonetheless is increasing capacity, lowering unit labor requirements, and reducing electrical energy
consumption. Plants constructed in the 1980’s feature finish grinding departments that incorporate high-efficiency air separators and other innovations that make possible production rates of about 140 tons per hour, more than double the output of finish grinding units built in the 1960’s that used conventional separators. Another source of gains in efficiency is the construction of larger units that replace several smaller ones, thereby lowering capital, maintenance labor, and building space requirements. Moreover, computer process control systems reportedly can be utilized more readily on larger, single units. Other innovations in ball mills include improved variable-speed drive motors which maximize efficiency with varying mill loads, and new types of liners for the interior of the ball mill which direct the larger steel balls (the medium which grinds the clinker) to the larger particles that remain to be processed. These liners reportedly improve grinding efficiency and lower electric power consumed in the energy-intensive finish grinding operation.

**Computer process control and instrumentation**

Computers and advanced instrumentation are improving efficiency in all phases of cement production—processing, material handling, and quality control. The more precise control provided by computers and instrumentation facilitates optimum performance from equipment, resulting in increased productivity, reduced energy consumption, lowered maintenance requirements, and improved product quality.

Broad application of computer control is generally an integral part of most new plant construction and major modernization programs. A microprocessor-based control system at one of the most modern new cement plants—typical of recent installations of this technology—includes a main computer with console and displays located in a central control room and additional computers located at the major production units. The central computer monitors plant operations through the network of computer-controllers programmed to carry out functions at various plant locations and automatically signal the central computer if a change in programming or instructions is required. All processing and material handling operations are under computer control, from crushing through the storage of finished cement. Equipment also is wired for manual control from the central location, permitting plant operation independent of the computer if the need arises.

This single-kiln plant incorporating the latest technology was constructed alongside an existing multi-kiln facility which continued to operate until startup, and the changes in crew requirements in the old and new plants were significant. In all, 17 former kiln, raw mill, and finish mill operator occupations no longer exist in the new plant. However, two new classifications—control room operator and electronics technician—were created by the change. Lengthy in-house training was provided to employees chosen for the operator positions. The technician jobs were filled by applicants from a nearby community college. These reductions in labor requirements are attributable, mainly, to the establishment of centralized control which, in turn, was facilitated by the installation of computers and state-of-the-art processing equipment.

Microprocessor-based control systems also are being used in the cement industry to upgrade the performance of older kilns. In one recent installation, continuous monitoring of kiln operations by the new system enables the operator to see immediately the effect of any control actions on kiln production and fuel efficiency. As a result, output has increased 10 percent, kiln operations are more uniform, fuel efficiency has increased, and clinker quality has improved.

New, continuous analyzers and computer control are being installed on-stream before the raw grinding process to achieve economies in labor, fuel, and other cost items. Computers also are being used in quality control tasks. As an example, X-ray analyzing equipment in some plants is being incorporated into a program to control raw material blending. The data provided by the computer enable personnel to undertake precise and fast control steps, resulting in reduced raw material consumption and increased equipment utilization.

**Improvements in material handling in shipping operations**

Technological improvements in the shipping department have improved productivity in the filling, handling, and loading of bags of cement. Although about 90 percent of cement is shipped in bulk carriers, the balance is transported in bags, which involves a series of labor-intensive operations to fill, handle, and load them. Developments in bag-filling machines, automatic palletizing, forklifts, and automation of recordkeeping have reduced labor requirements significantly. A fully automated bag-packing line reportedly will lower labor requirements by more than two-thirds compared to conventional, nonautomated facilities.

**Output and Productivity Trends**

**Output**

Demand for hydraulic cement is tied closely to the level of construction activity. Over the period 1970-84, output of hydraulic cement (BLS measure) rose in 9 years and declined in 5 years (see chart 8). However, the overall result was that output declined at an average annual rate of 0.7 percent over the entire period.

During 1970-73, for example, output of hydraulic cement increased at an annual rate of 5.0 percent, as the...
Chart 8. Output per employee hour and related data, hydraulic cement, 1970-84

value of construction put in place rose sharply. However, after 1973, output growth turned around and, during 1973-78, declined at an annual rate of 0.3 percent. It fell more sharply during the more recent period, 1978-84, at an annual rate of 2.7 percent. The declines were particularly pronounced during the recession years 1974-75 and 1981-82, when the decline in output in both periods exceeded 10 percent. In the recovery after 1982, output reversed direction and increased at an annual rate of 10.7 percent from 1982 to 1984.

According to the U.S. Department of Commerce, the value of cement shipments is projected to increase an average of about 2 percent a year as construction activity intensifies—particularly in the South and West. The cement industry has long been characterized by cycles of oversupply and acute shortage—a situation which may be moderated because of recent additions to capacity in the South and West, where demand for cement is projected to be strong, and cutbacks in areas where demand will likely be lower.  

**Productivity**  
Productivity in the cement industry has increased relatively slowly. Between 1970 and 1984, output per employee hour (BLS index) rose at an average annual rate of 1.7 percent—well below the 2.3-percent annual growth rate in manufacturing over the same period. During 1970-73, output per employee hour increased sharply—by an annual rate of 5.2 percent. This gain resulted when output increased at an annual rate of 5.0 percent, and employee hours fell at an annual rate of 0.2 percent.

With the falloff in output after 1973, productivity growth also fell sharply. During 1973-78, output per employee hour increased at a substantially lower annual rate of 1.2 percent. Over the following 6-year period, 1978-84, however, output per employee hour rose at an annual rate of 3.3 percent due to the strong annual rate of increase of 14.5 percent during 1982-84 as the economy recovered from recession and demand for cement rose significantly.

The largest annual decline in output per employee hour—9.4 percent—was from 1979 to 1980, when output moved lower by 11.2 percent and employee hours fell by 2.0 percent.

The outlook for productivity change in the cement industry is difficult to assess. However, several trends underway suggest that prospects for productivity growth may be more favorable in the latter part of the 1980's. These include projected higher levels of output and utilization of capacity and further outlays for new technology, including the more efficient preheater/precal-

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7 U.S. Department of Commerce, Bureau of Industrial Economics, Office of Research, Analysis and Statistics. 1982 is the latest year for which these data are available.
and new production technology was introduced (chart 9). In 1985, 23,400 workers (BLS data) were employed in U.S. cement plants—9,900 fewer than in 1970. The decline in nonproduction workers (down 33 percent) was more severe than for production workers (down 29 percent). Over the period 1970-84, the number of plants manufacturing portland cement declined by 21 percent from 178 to 141.1

The trend in employment for selected periods followed the trend in output. Over the broad span of years 1970-85, employment declined at an average annual rate of 2.0 percent. For the periods 1970-73 and 1973-78, employment declined at an identical annual rate of 0.8 percent. Over the more recent period 1978-85, however, the rate of decline was much more severe—down by an annual rate of 5.1 percent as output fell off sharply. The largest year-to-year declines were associated with the recession years of 1974-75 and 1981-82, when employment declined by 6.0 percent and 10.0 percent, respectively. The number employed in the cement industry in 1985 was the lowest since 1970.

The longer term outlook is for employment in hydraulic cement to continue to decline. BLS projects that employment may fall to 19,210 in 1995 (moderate-growth projection)—an average annual rate of decline of 2.0 percent between 1985 and 1995.9

Occupations

New technology appears to have resulted in changes in the structure and content of some key occupations, including operator and maintenance positions, where job requirements have changed after modernization. Specific production worker occupations affected by new technology and declining in importance include semiskilled operatives, transport equipment operatives, and laborers. In contrast, control room operators and skilled maintenance workers have increased in relative importance as more complex technologies have been adopted.

The introduction of computer process control is an innovation which has had a significant impact on occupations at plants visited by BLS. At one of the most advanced cement plants in the United States, for example, an extensive modernization program in the early 1980's featured a state-of-the-art computer process control system, a preheater kiln, a roller mill, and other innovations being adopted more extensively throughout the industry. Among new jobs created was control room operator, whose major responsibility is to operate the cement plant from a central control room. This is a highly skilled job which requires a thorough knowledge of all aspects of cement production. Employees assigned to these new positions received training as described in the following section on adjustments to new technology. Prior to computer control, operators monitored panels immediately adjacent to various production processes located throughout the cement plant. New positions also were added in the laboratory and in rock storage and process operations. In accordance with the general industry trends mentioned earlier, the complex of innovations at this plant also resulted in the elimination of semiskilled operator, helper, and other positions in the kiln, finish mill, raw mill, and other plant units.

The maintenance work force in cement plants also has been affected by new technology. New equipment frequently incorporates sensors which provide advance notice of impending costly breakdowns so that corrective action can be taken. Maintenance requirements in modern cement plants also are lower because fewer machines are in place compared to older facilities. However, maintenance tasks associated with advanced technology are more complex and involve a knowledge of electronics.

Adjustment of workers to technological change

A substantial majority of the work force in the cement industry is covered by collective bargaining agreements with the Cement, Lime, Gypsum and Allied Workers Division of the International Brotherhood of Boilermakers—the major union representing workers in the cement industry. Provisions in these agreements such as those that relate to seniority, advance notice of impending technological change, training, and reassignment of workers are applicable when employees are affected by the introduction of computer process control and the other innovations described in this report.

The implementation of training programs has been a major method of adjustment of the work force to the changing requirements of new technology. At one new cement plant which features an advanced computer process control system, for example, the training program developed by the company to prepare employees to staff new control room operator positions was successful in preparing employees to function with the new equipment. At this facility, applicants for the new operator positions who passed a vision examination and qualifying tests administered by the State were selected, on the basis of seniority, to receive intensive on-the-job and classroom training extending over 9 months. Training was at company expense and provided during duty hours. Those who completed the training course were promoted to the relatively high-paying new control room operator positions.

In addition to technological changes in operating...

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9 BLS projects three levels of industry employment for 1995 based on alternative versions of economic growth: A low, moderate, and high level. The low projection for hydraulic cement is 18,380; the high projection is 19,740. For details on assumptions and methodology used to develop these projections, see the Monthly Labor Review, November 1985.

Employees (thousands)

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Annual Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>All employees</td>
<td></td>
</tr>
<tr>
<td>1970-85</td>
<td>-2.0</td>
</tr>
<tr>
<td>1973-78</td>
<td>-0.8</td>
</tr>
<tr>
<td>1978-85</td>
<td>-5.1</td>
</tr>
<tr>
<td>1985-95 (moderate projection)</td>
<td>-2.0</td>
</tr>
<tr>
<td>Production workers</td>
<td></td>
</tr>
<tr>
<td>1970-85</td>
<td>-1.9</td>
</tr>
<tr>
<td>1973-78</td>
<td>-0.5</td>
</tr>
<tr>
<td>1978-85</td>
<td>-5.5</td>
</tr>
</tbody>
</table>

1 Least squares trends method for historical data; compound interest method for projections.
2 See text footnote 9.

plants, workers in the cement industry have been affected by the closing down of less-efficient facilities as a result of foreign imports of cement, high energy costs, expenses related to air pollution control requirements, and related factors. As indicated earlier, the number of cement plants declined by 21 percent between 1970 and 1984.

As a recognition of these problems, bargaining between the union and cement producers to renegotiate expired contracts, which began in 1984 and continued with considerable conflict into 1985, resulted in some concessions by the union in benefits and work practices. The single issue of technological change was not paramount over this period. The negotiations have been prolonged compared to past bargaining sessions in the cement industry, with the departure from longstanding pattern bargaining reported to be a major issue of contention.

SELECTED REFERENCES


Chapter 4. Wholesale Trade

Summary

The wholesale trade industry (SIC 50,51) is undergoing changes in marketing techniques and warehouse technology. These developments are largely associated with the availability of computer-based information and technology systems which make possible geographic expansion, better management controls, and enlarged wholesale distribution functions. Increased competition has accelerated the need to improve productivity and reduce costs. However, computer technologies are still not widely diffused, except for inventory control systems.

Definitive measurements of wholesale trade productivity are not available, but output and hours data suggest that productivity growth during the period 1970-85 averaged about 1.0 percent annually. However, industry representatives suggest that improved productivity through 1990 is likely, with fuller use of resources associated with a wider range of functions and product diversification by many firms.

Employment grew almost steadily during 1960-85 and stood at the relatively high level of about 5.7 million persons in 1985. The industry’s employment is projected to grow through 1995, but at a slower rate than during the 1970's. Increases are projected through 1995 for all major occupational groups. Occupations dealing with data processing require training, and some shortages in these occupations are a possibility.

Description of Industry

In addition to their primary function of selling merchandise, wholesalers perform many other services for their suppliers and customers. These include inventory control for customers, extension of credit, physical assembly, sorting and grading of goods in large lots, technical advice, and various types of promotion. Manufacturing firms which perform the wholesaling function usually provide some, but not all of the same services.

The industry is comprised of three major sectors. Merchant wholesalers, who sell and move goods from producers to retailers or to commercial, industrial, or other users, accounted for slightly more than 80 percent of the establishments in 1982. The second group, manufacturers’ sales branches and offices, accounted for less than 10 percent of the establishments. The third group engaged in wholesale trade consists of agents, brokers, and commission merchants, and they accounted for slightly more than 10 percent of the total.

In terms of sales, however, the relative shares were more evenly distributed between merchant wholesalers and manufacturers. Merchant wholesalers held 58 percent in 1982, while the manufacturers’ share was 31 percent. (The share of the third group mentioned above was about 11 percent.) Over the decade 1972-82, wholesalers increased their share while manufacturers reduced theirs. With the exception of chemicals, the merchant wholesalers held a larger share of sales than manufacturers in the major durable and nondurable goods sectors. Manufacturers were involved in the wholesaling of all goods except farm product raw materials and accounted for more than one-third of the products distributed in many of the sectors.

Technology in the 1980's

The industry’s major technologies involve the application of computers or computer-like devices to the important functions of processing data, controlling equipment, and managing information. The improved efficiency and accuracy in carrying out these functions expedite the receipt of products, their movement within warehouses, and their shipment to final destinations. Lower unit labor requirements are often the result. Computerized technologies also make it possible to serve broader and more varied markets.

However, except for drug wholesalers, computer technologies are still not widely diffused. Most firms that have computers only utilize them in inventory management and accounting. A very small percentage of all firms utilize computers or microprocessors in two other functions—equipment control and information management—while a still smaller proportion have systems that integrate control of all three functions with a hierarchy of computers and microprocessors. Nevertheless, many firms have reduced their labor as well as space requirements through automation of a limited area of their facilities that contains frequently moved small items.

In addition, deliveries are being provided virtually on call ("just-in-time" inventory) through the applica-
tion of advanced warehouse technologies. These services are being provided for those manufacturers who prefer that wholesalers assume a greater role in managing inventories in order to reduce their own inventories.

Industry representatives cite the major factors that are associated with the utilization of the most advanced automated technologies by all wholesaling firms. The largest firms (annual sales of over $100 million) and firms which must provide service with rapid turnaround time are most likely to adopt the latest, costly technologies that utilize only minimum work forces. However, even when there is a premium on providing rapid service, some factors—such as picking and filling orders from split cases and/or lack of uniformity in size of parts—make it economically feasible to adopt only semiautomatic equipment.

Major technological changes in wholesale trade are discussed below and presented in table 4 together with their labor impact and diffusion. In general, these data are limited to wholesaler-distributors.

**Computerized data processing**

Two of the principal applications of computerized data processing are inventory control, and delivery scheduling and vehicle load planning.

**Computerized inventory control system.** Computers and appropriate software have made it economically advantageous to devise inventory control systems that greatly improve the speed and accuracy of sales orders and warehouse operations. With a computerized inventory system, an inside salesperson, in telephone contact with a prospective customer, can utilize a nearby keyboard terminal and display screen for information on an item's availability, price, and closest location. Computer terminals provide the same instantaneous or on-line information for warehouse workers involved in the storage and retrieval of goods. The system permits centralized warehouses to supply satellite warehouses with only

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**Table 4. Major technology changes in wholesale trade**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Description</th>
<th>Labor implications</th>
<th>Diffusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computerized inventory control system</td>
<td>Computer terminals in the sales office and warehouse make it possible to generate online information on a screen regarding the availability, price, and location of any product.</td>
<td>Unit labor requirements are sharply reduced for sales and clerical workers. Reduction is smaller among warehouse workers.</td>
<td>Currently in use by 25-40 percent of wholesaler-distributors; expected to rise to 50-75 percent in 1990.</td>
</tr>
<tr>
<td>Microprocessor-controlled conveyor system</td>
<td>Microprocessors control the warehouse functions of storage and retrieval and recording of selected information.</td>
<td>Unit labor requirements are reduced at least 25 percent. Only modest amount of programming needed.</td>
<td>Systems installed primarily by the largest firms; will continue to be utilized by the largest firms only.</td>
</tr>
<tr>
<td>High stackers</td>
<td>Some stackers have computerized retrieval machines that are programmed to store and retrieve objects automatically, but the most common form of stacker is a specialized forklift.</td>
<td>Computerized stackers sharply reduce unit labor requirements for travel within warehouse and in picking materials. Operators require specialized training for non-computerized stackers having a side-loading capability.</td>
<td>Computer-controlled stackers are widely diffused only in the largest firms. Limited by high cost and specialized functions.</td>
</tr>
<tr>
<td>Automatic guided vehicles (AGV’s)</td>
<td>A battery-powered, driverless vehicle that follows a low-frequency signal transmitted through a guidepath or wire installed on a warehouse floor. Control is usually via an onboard microprocessor that may be linked to a central computer. AGV’s can interface with conveyors and form a crucial link in an automated storage and retrieval system. Replaces forklifts.</td>
<td>Labor requirements in warehouses are reduced by about one-third; less product damage and reduction in required inventory are additional advantages.</td>
<td>Currently these vehicles are being used primarily by the largest firms. Greater diffusion is likely to occur only among the largest firms.</td>
</tr>
</tbody>
</table>
fast-moving items. Some customers even find it economical to subscribe to the computer-based systems of their wholesalers for the management of their own inventories.

A major impact on labor is evident in a computerized inventory system. Lower unit labor requirements are associated with quicker turnaround time by sales, clerical, and warehouse personnel. This is especially evident when order entry terminals are located on the premises of a wholesaler's customers. This computerized system enables customers to input orders themselves, and installation of such systems is expected to increase rapidly through 1990. In some industries, e.g., drugs, this process is already very widely utilized. Orders via electronic mail are also expected to increase rapidly in some industries.

In addition, the automated inventory system enables inside salespersons to assume some of the duties of outside salespersons. The inside sales force will receive more telephone sales training, while the outside sales force will receive promotional and marketing training. Also, improved inventory management allows a lower level of inventory because it provides warehouse workers with accurate data rapidly.

Utilization of computerized inventory control systems is expected to increase among merchant wholesalers. About 10-20 percent of wholesaler-distributors used these systems in 1980 and an estimated 25-40 percent in 1985. The proportion is expected to rise to 50-75 percent in 1990.4

Computerized scheduling and vehicle load planning. A substantial share of all wholesale deliveries consists of items of low volume, wide variety, and frequent delivery. Many wholesaler-distributors have therefore decided that the most profitable and efficient operations are likely to take place with the assistance of computerized systems for delivery route scheduling and vehicle load planning.

This use of computers is expected to increase in importance. Industry representatives estimate that by 1990, 50 percent of the wholesaler-distributors will use computerized systems for delivery route scheduling and vehicle load planning. In 1980, a very small percentage of wholesalers used such systems.

Storage and retrieval equipment in warehousing

The wide variety of equipment used in warehouses includes mechanical, electrical, computer-driven, and almost fully automatic equipment involving a high degree of electronic control. However, only the easier warehouse functions have been automated by the great majority of firms in the industry. Most merchant wholesalers still rely upon such mechanical equipment as forklifts and flow racks, with which the movement of materials is actuated by the force of gravity. The combination of microprocessor and computer-controlled equipment with fully integrated storage and retrieval systems requiring a minimum work force has not been adopted widely.

Most of the work hours in a typical warehouse are related to the movement of goods. An estimated 75 percent of labor's activity is associated with such movement. It is these work hours that are very sharply reduced by automated systems which expedite handling and distribution of goods.

Identification technologies, such as bar coding, in conjunction with computer-controlled equipment, greatly increase the speed and accuracy of processing information and the movement of goods into and out of the warehouse. According to the experience of one wholesale distributing firm, the number of cartons handled daily increased more than 50 percent after bar code scanning was introduced, and such improvement would have been impossible with a manual system.5

Automatic identification technologies were estimated by a survey to be in use in only 10 percent of the firms in 1985, but accounted for a much higher proportion of the industry's sales. The survey projected that 25 percent of wholesaler-distributors would be utilizing automatic identification devices in 1990.6

Microprocessor-controlled conveyor system

Conveyors with microprocessor controls greatly enhance the range of functions that can be performed by making it possible to automate functions in a step-by-step fashion. These functions include not only the usual one of moving materials, but also the generating, monitoring, recording, and reporting of operational data.

However, the versatile advanced conveyors, which function with automatic loading/unloading, are very expensive and have only been applied by firms that handle a huge volume of products. A large distributor may initially utilize a conveyor as a sorting system with software and code scanners that identify products and move them efficiently and at high speeds. Next, systems could be introduced, for example, to monitor the time required to select items for a shipment or to check whether or not a shipment matches an original order. More sophisticated systems combine with robots in order to operate within a limited space or to reduce labor requirements in slow, complex operations.

4Andersen, Future Trends, p. 33.
7Andersen, Future Trends, p. 33.
Warehouse workers use a microprocessor-controlled conveyor system for storage, retrieval, and shipment of drugs.

The conveyor's synchronization of data with the flow of materials reduces unit labor requirements at least 25 percent and affects the skills in several occupations, according to an industry specialist. In some cases, requirements for clerical workers, who basically perform a bookkeeping function, are reduced, and these workers usually do not move into the newly required position of programmer. Generally, the operatives involved in material handling become monitors of the conveyors' operations and must acquire the limited knowledge of handling information and product flow that enables them to make needed occasional adjustments on the conveyors. Maintenance personnel must have enough knowledge of how the computer operates to be able to maintain and repair the conveyors.

Miniloads. Microprocessors or computer-controlled equipment (including conveyors) are also being applied to so-called miniload storage and retrieval systems, in which more frequently moved small items are handled separately.

While a miniload system may improve efficiency even when manually operated, the improvement is maximized when the system has microprocessor or computer controls of storage and retrieval equipment. For example, in one automobile parts warehouse, the computerized miniload system contained one-third of the parts in the entire inventory, but those parts accounted for 60 percent of the firm's inventory transactions. The labor requirements for the miniload system were only one-seventh of the labor that was involved with the total inventory system. While only one picker was needed for the miniload system, six pickers were needed for the rest of the inventory in this warehouse.8

Microprocessor-controlled conveyors are estimated to be in use by 75 percent of the largest wholesalers. Their rate of diffusion is expected to increase but will remain limited to the largest firms.

Usage of the standard, semiautomatic conveyor is expected to triple between 1982 and 1990. Diffusion of this conveyor will increase from 17 percent to about 50 percent of the wholesaler-distributors.9

**High stacker**

Semiautomated and computerized machines that are programmed to store or retrieve objects in any predetermined location with reduced labor input are among the most technically advanced of various types of high stackers. The semiautomated stackers, which have a sideloading capability, increase the utilization of cubic space by traveling operatorless on wire guides within narrow aisles. An operator is needed to steer this type of stacker only when it travels on the main aisles of a warehouse.

The semiautomatic, computerized stackers decrease storage and retrieval time within a warehouse and can sharply reduce the unit labor requirements for operators by two-thirds to three-fourths, according to an industry representative. The stacker's contribution to improved productivity is evident when several orders are filled automatically and simultaneously with items stored in a high, inaccessible area of a warehouse.

Efficiency is also enhanced on a noncomputerized high stacker (a specialized forklift with a 25- to 30-foot reach), although operators of these stackers may require specialized training for sideloading.

The semiautomatic computerized stackers are rather widely diffused, but only among the largest merchant wholesalers and manufacturing firms, and it is likely that more of these firms will introduce fully automated machines into some of their operations. Even the noncomputerized stackers are in use by only the larger merchant wholesalers, and their diffusion is likely to increase to only about 25 percent in 1990. The considerable cost of these high stackers and their specialized functions limit diffusion.

**Automatic guided vehicle (AGV)**

AGV's are battery-powered and driverless vehicles, but they vary in their controls for picking and delivering materials. Some AGV's are controlled by central computer, but, increasingly, the preferred vehicles are controlled by an onboard microprocessor, which may be linked to a central computer. The vehicles follow a low-frequency signal that is transmitted through a guidepath or wire installed on a warehouse floor. AGV's can interface with conveyors, vertical lifts, or other equipment, forming a link with the automated portions of a storage and retrieval system.


9 Andersen, Future Trends, p. 33.
The microprocessor-controlled AGV's maximize efficiency through faster movement of materials. This involves avoiding collisions and routing over optimum routes. Usually, the operations of AGV's are monitored on a terminal screen in a supervisor's area.

AGV's reduce unit labor requirements by about one-third because of elimination of forklift drivers and the reduced storage and retrieval time. Less product damage, greater accuracy in filling orders, and reduction in required inventory could also be advantages of the vehicles. Maintenance is simplified if onboard microprocessors provide diagnostic information about the AGV's operations.

These vehicles are likely to be substituted increasingly for forklift trucks among the larger firms.

Output and Productivity Outlook

Output

Although reliable output data are not available for the wholesale trade industry, the value that wholesale trade adds to the gross national product (adjusted for price changes) may be used as a rough measure of output. These data suggest an average annual growth rate of about 3 percent in 1970-85, considerably slower than the growth rate of the 1960's of more than 5½ percent (chart 10). Output declined in the 2 recession years, 1974 and 1980. The industry recovered in 1984 and 1985, with sharp increases of more than 12 and 5 percent, respectively.

Looking ahead to 1990, wholesaler-distributors expect to add several new services for their suppliers (usually manufacturers) and customers that will contribute to output growth. While inventory management for suppliers and customers will remain the most frequently performed service by wholesalers, a wider range of services will be offered. These will include educational seminars and training for their customers, market research and analysis, product marketing, and financial management services. The primary reason for suppliers and customers to turn to wholesalers for these services is the belief that wholesalers can perform them more cost effectively. It is interesting to note, however, that extension of credit, which used to be very important, may be reduced by 1990.

Productivity

Because of the limitations of available data, the Bureau of Labor Statistics does not publish measures of productivity for the wholesale trade industry. However, the trend in productivity change can be approximated from estimated output and hours data for all persons. These data suggest that productivity in wholesale trade grew at an average annual rate of about 1 percent during 1970-85, similar to the rate for the entire business sector of the economy.

The industry's productivity increased at an average rate of about 4½ percent during 1970-73, but had virtually no growth during 1973-80, as productivity declined in 4 years—1974, 1976, 1979, and 1980. In 1980-85, however, productivity advanced about 3.0 percent annually, or about 80 percent of the rate in the 1960's. This growth in the first half of the 1980's reflected an increase in output of nearly 5.0 percent and an associated hours increase of less than 2.0 percent.

The outlook for productivity growth in 1985-90 is not clear, but industry representatives anticipate that output will grow at about the rather high level of the first half of the decade. At the same time, laborsaving technologies (previously considered) are expected to be more widely utilized. These technologies, according to 91 percent of the respondents to a survey of members of the National Council of Physical Distribution Management, are mainly responsible for higher productivity.

The wholesalers' fuller use of their resources through the handling of an increased diversity of products, geographic expansion, and the performance of more marketing functions is also likely to increase sales and improve productivity. For some firms, this would require investments in computers for inventory control and microprocessor-controlled equipment in the warehouse.

Leading to improved productivity are new sales and management techniques, incorporating sophisticated information systems, which make servicing possible via the telephone. The continued growth in the application of such computer systems increases the efficiency of sales personnel.

Also, more widespread use of national standardized order systems would increase efficiency, but would require greater cooperation of efforts of wholesalers, suppliers, and customers. One of the components of such systems—standard product numbering and marking—is expected to be used by over 90 percent of manufacturers and wholesaler-distributors by 1990.

Investment

Capital expenditures

Capital expenditures in wholesale trade (data available only for merchant wholesalers at 5-year intervals) increased sharply for each of the years 1967, 1972, 1977,
and 1982, even when account is taken of price changes. Real capital expenditures (in constant 1972 dollars)\textsuperscript{15} by the merchant wholesalers in 1982 (latest data) totaled about $6.6 billion, 2.6 times more than in 1972. By comparison, 1982 real investment by the private business sector for equipment and structures was only 39 percent higher than in 1972 (BLS data).

Moreover, in view of the extensive practice of leasing and renting in this industry, data on capital expenditures do not include all of the industry's outlays for buildings and structures, and machinery and equipment. Census data for 1982 (most recent data available) indicate that lease and rental payments were as much as 60 percent as large as new capital expenditures.

Capital expenditures are expected to increase through 1990 to accommodate internal growth and mergers and acquisitions. This will include substantial outlays for laborsaving equipment such as warehouse mechanization and computer equipment. Some of the equipment will be related to the development of new products and markets. Investment for new warehouses is expected to decline, in part because space requirements will fall as a result of improved inventory management.\textsuperscript{16}

**Employment and Occupational Trends**

**Employment**

Wholesale trade employment increased at an annual rate of 2.5 percent during 1970-85 (chart 11), approximately the same rate as in 1960-70. Employment rose almost steadily through the two decades but the rate of growth slowed in 1978-85 to 1.6 percent annually. This reflected employment declines in 1982 and 1983. Since 1960, employment had fallen only twice before, in 1961 and 1975. However, by 1985, employment stood at 5.7 million persons, a new peak. This represented 7.0 percent of total private nonagricultural employment.

Employment grew somewhat faster in the durable goods sector than in the nondurable goods sector of wholesale trade from 1972 (earliest data available) to 1985. In 1985, 59 percent of all wholesale trade employees were in the durable goods sector.
Chart 11. Employment in wholesale trade, 1970-85, and projections, 1985-95

Employees (millions)

<table>
<thead>
<tr>
<th>Year</th>
<th>Projected Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-85</td>
<td>2.5</td>
</tr>
<tr>
<td>1970-73</td>
<td>2.4</td>
</tr>
<tr>
<td>1973-76</td>
<td>2.8</td>
</tr>
<tr>
<td>1978-85</td>
<td>1.6</td>
</tr>
<tr>
<td>1985-95 projections (moderate)</td>
<td>1.4</td>
</tr>
</tbody>
</table>


^Least squares trends method for historical data; compound interest method for projections.

^See text footnote 17.
Women employees increased 77 percent from 1970 to 1985. By 1985, they accounted for 28 percent of the industry’s total employment, compared with an average of 51 percent in all private service-producing industries.

The percentage of nonsupervisory workers in wholesale trade has shown a gradual, steady decline since 1960. In 1985, they accounted for about 80 percent of all wholesale employees, compared with 86 percent in all private service-producing industries.

Looking ahead—from 1985 to 1995—BLS, on the basis of its moderate-growth projection, projects an average annual increase in employment of 1.4 percent.17 Advances are projected to be considerably greater for the durable goods sector than for the nondurable goods sector.

**Occupations**

Despite sharp differences in growth rates among the major occupational groups, the occupational distribution will show little change from 1984 to 1995. Employment in each group is expected to increase, according to BLS (table 5). The two major occupational groups—marketing and sales, and administrative support, including clerical—are expected to continue to account for more than 55 percent of all employees in 1995. While the administrative support group is expected to increase at the slowest rate over the period for any group (by less than 7 percent), an increase of over 28 percent is projected for marketing and sales workers.

Two smaller occupational groups—managerial and management-related occupations, and transportation and material-moving machine and vehicle operators—are expected to increase 24 and 16 percent, respectively. However, they will each continue to account for 10 percent of all employees.

Two comparatively small occupational groups—engineers and computer systems analysts, and the technician occupations—are expected to experience the most rapid advance during 1984-95. Each group will expand by over 40 percent, but together the groups will still account for less than 5 percent of all employees. To some extent, this growth reflects expanded computer applications. Helpers, laborers, and manual material handlers, will be among the slowest growing occupations, projected to increase by about 8 percent over the period.

A radical shift in the composition of the sales occupations is expected by 1990, when the number of inside salespersons may increase to roughly the same number as outside salespersons. Currently, outside salespersons constitute about 60 percent of the total in sales occupations. The shift is expected to result from the increasing cost of field sales operations and the availability of advanced information and marketing systems to service customers from multiple distribution outlets. As mentioned earlier, job skill requirements are likely to change with the diffusion of the new technologies.

**Adjustment of workers to technological change**

Programs to protect workers 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.

In the wholesale trade industry, the International Brotherhood of Teamsters, the Food and Commercial Workers International Union, and the International Longshoremen's and Warehousemen's Union represent about 15 percent of the employees. Worker coverage is considerably higher in warehouse-related operations, for such occupations as freight handler, forklift operator, and truckdriver, than in office operations.

Seniority provides a measure of job security in the agreements of this industry when technological change results in the permanent layoff of workers. This security is likely to be enhanced when an agreement also contains a clause requiring notification of the union in advance of the introduction of new machinery or methods, and discussion by labor and management of the impact of any layoffs upon employees. A clause of this sort is often found in agreements covering 1,000 or more employees. Notification of a union representative before the usage of new equipment is generally required for the purpose of negotiating a wage scale for the equipment.

Reemployment rights are also generally based on seniority in labor-management contracts and extend up to 24 months at the same location. Typically, seniority rights do not extend to another location of the firm because contracts provide for separate seniority lists for each branch or warehouse. However, in case of permanent transfer of workers to another location of a firm (e.g., when separate distribution centers are merged) and also if a location is permanently closed, seniority does apply. Workers who lose their jobs because an employer goes out of business or terminates operations may receive a lump-sum severance payment that is commonly made on the basis of years of service.

Training and retraining may be specified in a union contract as means of aiding worker adjustment to technological change or improving worker earnings. In one contract, the driver-salespersons are expected to attend “sales and training” sessions. Another contract requires the employer to assume the cost of training for driving a tractor-trailer.

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17 BLS projections for 1995 are based on three alternative versions of economic growth for the overall economy. The alternative assumptions are described in the November 1985 issue of the *Monthly Labor Review*. 

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45
Table 5. Projected changes in employment in wholesale trade by occupational group, 1984-95

<table>
<thead>
<tr>
<th>Occupational group</th>
<th>Number of employees (thousands)</th>
<th>Percent of industry employment</th>
<th>Percent change in number of employees 1984-95</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total....................................................</td>
<td>5,549.8</td>
<td>100.0</td>
<td>18.5</td>
</tr>
<tr>
<td>Managerial and related occupations</td>
<td>530.3</td>
<td>9.6</td>
<td>24.2</td>
</tr>
<tr>
<td>Engineers and computer systems analysts</td>
<td>60.6</td>
<td>1.1</td>
<td>42.2</td>
</tr>
<tr>
<td>Technician occupations</td>
<td>139.2</td>
<td>2.5</td>
<td>41.5</td>
</tr>
<tr>
<td>Marketing and sales occupations</td>
<td>1,451.4</td>
<td>26.2</td>
<td>28.1</td>
</tr>
<tr>
<td>Administrative support occupations, including clerical</td>
<td>1,717.7</td>
<td>30.9</td>
<td>6.5</td>
</tr>
<tr>
<td>Blue-collar worker supervisors</td>
<td>81.5</td>
<td>1.5</td>
<td>21.3</td>
</tr>
<tr>
<td>Mechanics, installers, and repairers</td>
<td>366.9</td>
<td>6.6</td>
<td>26.3</td>
</tr>
<tr>
<td>Precision production occupations</td>
<td>59.5</td>
<td>1.2</td>
<td>16.3</td>
</tr>
<tr>
<td>Machine setters, set-up operators, operators, and tenders</td>
<td>141.6</td>
<td>2.5</td>
<td>19.2</td>
</tr>
<tr>
<td>Transportation and material moving machine and vehicle operators</td>
<td>574</td>
<td>10.4</td>
<td>16.3</td>
</tr>
<tr>
<td>Helpers, laborers, and material movers, hand</td>
<td>250.9</td>
<td>4.5</td>
<td>8.9</td>
</tr>
<tr>
<td>All other occupations</td>
<td>165.1</td>
<td>3.0</td>
<td>18.2</td>
</tr>
</tbody>
</table>


More often, however, training and retraining are conducted in the absence of particular specification in the agreement. For instance, a wholesaler-distributor of electrical items has a "high tech" facility in one of its locations that is utilized to provide demonstration as well as instruction on the capabilities of new products—for example, programmable controllers—to the firm's sales personnel, as well as to prospective customers. Since sales personnel have to learn about new products continuously, they may also be sent to suppliers' factories for instruction.

In general, training for most occupations will continue to be provided on the job. However, training for data processing will be largely provided by professional training firms, colleges and universities, and trade associations. According to an industry-sponsored study, a shortage of data processing personnel is a possibility in the near future.18

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"Computer-Integrated Warehousing: Trucks Are the Key at Shaw's," Modern Materials Handling, November 5, 1984, pp. 40-44.


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