Productivity in the rubber and plastics hose and belting industry

Although new technology and plant reorganization aided an average 1.3-percent increase in productivity, stagnant demand and rising import penetration kept the rise moderate over the 1972–87 period

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Advances in rubber technology, improvements in machinery, plant reorganization, and the adoption of computer technology have all contributed to the rise in productivity in the rubber and plastics hose and belting industry. However, stronger growth was inhibited by weak demand for hoses and belts, and stagnant capital spending by the industry.

Productivity, or output per employee hour, rose at an average annual rate of 1.3 percent from 1972 to 1987.[1] This trend was well below the rate for all manufacturing, which grew 2.5 percent per year during the same period. Declining industry output combined with this modest productivity growth has led to a reduction in work force hours. The growth in industry productivity reflected an average decline in output of 1.2 percent per year and a larger decline in employee hours of 2.5 percent per year. As the following tabulation shows, the most notable declines in industry productivity occurred in the late 1970's.

	Output per employee hour	*Employee hours*
1972–87	1.3	–2.5
1972–76	4.3	–3.5
1976–80	–3.3	3.3
1980–87	2.2	–3.1

Productivity trends in the rubber and plastics hose and belting industry can be divided into three distinct periods. From 1972 to 1976, productivity rose at an average annual rate of 4.3 percent. Productivity advanced in each year during this period. Output increased 0.6 percent per year, while hours fell 3.5 percent per year. The industry's capital expenditures contributed to the growth in output per hour.

From 1976 to 1980, productivity declined at a rate of 3.3 percent per year. This resulted from a 0.2-percent annual decline in output while hours increased 3.3 percent per year. Demand for the industry's products was weak and the industry operated at uneven rates of capacity utilization during this period. In the recession year of 1980, output plummeted (by 24.5 percent), as did hours (by 18.1 percent), resulting in a 7.7-percent decrease in productivity.

During the 1980–87 period, productivity rebounded, increasing at an average annual rate of 2.2 percent. This was largely the result of the industry's adoption of new technology. Output fell 0.9 percent per year while hours decreased at a faster rate of 3.1 percent per year.[2] (See table 1.)

Industry description

The rubber and plastics hose and belting industry includes establishments primarily engaged in manufacturing rubber and plastic hose and belting for transportation, industrial, agricultural, mining, and construction uses, as well as con-

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Table 1. **Productivity and related indexes for the rubber and plastics hose and belting industry, 1972–87**

Year	Output per employee hour			Output	Employee hours		
	All employees	Production workers	Nonproduction workers		All employees	Production workers	Nonproduction workers
1972	88.7	84.3	100.0	84.5	95.3	100.2	84.5
1973	94.6	88.4	111.9	82.6	87.3	93.4	73.8
1974	101.4	93.1	126.2	93.1	91.8	100.0	73.8
1975	104.0	100.5	112.6	81.4	78.3	81.0	72.3
1976	104.5	104.5	104.6	87.9	84.1	84.1	84.0
1977	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1978	97.7	98.2	96.6	109.7	112.3	111.7	113.6
1979	97.0	97.8	95.3	110.1	113.5	112.6	115.5
1980	89.5	93.4	81.9	83.1	92.9	89.0	101.5
1981	115.5	105.3	146.2	89.5	77.5	85.0	61.2
1982	100.7	98.6	106.0	69.4	68.9	70.4	65.5
1983	111.1	107.5	120.1	70.0	63.0	65.1	58.3
1984	118.3	110.4	140.5	84.6	71.5	76.6	60.2
1985	113.3	106.7	131.2	77.7	68.6	72.8	59.2
1986	114.1	106.8	134.2	76.9	67.4	72.0	57.3
1987	111.1	104.8	127.9	77.0	69.3	73.5	60.2
Average annual rates of change (in percent)							
1972–87	1.3	1.2	1.6	–1.2	–2.5	–2.4	–2.8
1972–76	4.3	5.7	1.0	.6	–3.5	–4.8	–.3
1976–80	–3.3	–2.4	–5.2	–.2	3.3	2.3	5.4
1980–87	2.2	1.4	4.2	–.9	–3.1	–2.2	–4.9

sumer products. Products of the industry include conveyor belts for mining and manufacturing; elevator belting; power transmission belts for motor vehicles and for industrial, agricultural, and appliance uses; hydraulic hose; and garden, automobile, fire, and other industrial hoses. Most of the products are made from rubber; plastic is mainly used in garden hose. Ohio, North Carolina, Nebraska, and Colorado are the leading States in employment in this industry, accounting for slightly more than one-half of the industry's employment in 1982 (the latest year for which data are available).

Establishments in the industry are large, but have significantly declined in size during the study period. In 1972, 19 establishments with 500 employees or more accounted for 21 percent of all establishments, 76 percent of employment, and 75 percent of the value of shipments. In 1982, by comparison, nine establishments with 500 employees or more accounted for only 6 percent of all establishments, 44 percent of employment, and 39 percent of the value of shipments. Over the entire study period, the average number of employees per establishment decreased from 354 in 1972 to 124 in 1987.[3] By comparison, all manufacturing industries averaged 51 employees per establishment in 1982 (the latest year for which data are available).

Improving productivity

The reduction in establishment size has been a byproduct of the industry's efforts to reorganize production and improve productivity. In the early years of the study period, major manufacturers in the rubber and plastics hose and belting industry operated huge plants in which they mass-produced a wide variety of products. To tighten control of production and achieve the benefits associated with specialization, huge plants were reorganized and manufacturing focused on particular products. In some cases, satellite plants were built in which only one product is produced. In other cases, plant space was reorganized so that the huge plant became a collection of smaller factories producing only one product under their own management.[4]

An adjunct to the industry's production reorganization was the adoption of computer technology. Computerization has occurred in the areas of management information systems, computer-aided design, and computer-aided manufacturing. Management uses data bases for inventory, orders, materials, equipment, and staffing to schedule the flow of work in the most efficient manner. In the area of product design, computers have replaced paper and pencil as the tools of design engineers. Using a computer ter-

minal, the engineer can combine lines and curves to draw a product and illustrate its specifications. The collection of digitized drawings in the computer's memory serves as a design data base. With the computer, the designer is able to quickly call up a previous design and modify it. Specifications and the process for manufacturing the product can be transmitted to production workers or directly to equipment from the computer terminal.[5]

Output and demand

Reduction in establishment size has been a byproduct of efforts to reorganize production and improve productivity.

The three major product groups in the rubber and plastics hose and belting industry are flat belts, *V*-belts or transmission belts, and hose. Flat belts are primarily purchased by mining and industrial conveyor users. The level of production in the motor vehicle industry is one of the major determinants of the level of production of *V*-belts. Output of hose depends largely on demand from motor vehicle manufacturers, demand from other industries, and specialty needs such as firehose and garden hose.

Over the 15-year period 1972–87, industry output declined at an average annual rate of 1.2 percent. Modest growth in demand was offset by rising imports. During the early 1970's, imports accounted for 3 to 4 percent of apparent consumption (shipments minus exports plus imports). By the mid-1980's, imports accounted for 9 to 13 percent of apparent consumption. Contributing to the increase in import penetration was the increase in industry unit labor costs as rising wages were only partially offset by productivity advances. From 1972 to 1987, prices increased an average of 7 percent per year.

The trend in industry output was marked by much volatility, rising in 9 of the years studied and falling in 6. The most pronounced fluctuations occurred in the 1980's: the industry recorded its largest increase in output, 20.9 percent in 1984; the largest decreases—24.5 percent and 22.5 percent—occurred in the recession years 1980 and 1982, respectively.

From 1972 to 1976, industry output grew at a sluggish 0.6-percent average annual rate. Output increased significantly in 1974, followed by a reversal in 1975, in response to escalating petroleum prices. Transmission belts, associated with automobile manufacturing and other energy-dependent fully driven machinery were most adversely affected by the 1975 downturn. A recession in the motor vehicle industry, stagnation in the level of mine production, and a slow rate of growth in output of the manufacturing sector of the economy all contributed to the small growth rate in industry output. In addition, imports crept upward to 5 percent of apparent consumption.

During the 1976–80 period, the market weakened for rubber and plastic hose and belting. Industry output remained virtually unchanged, decreasing 0.2 percent per year. Shipments of flat belts and hose declined, while sales of *V*-belts rose slightly. Underlying the falloff in demand was a recession in the motor vehicle industry and a rise in apparent consumption of imports to nearly 7.5 percent.

From 1980 to 1987, industry output fell 0.9 percent per year. Contributing to the falloff in production were the slowdown in mining and the continuing competitive pressure from foreign manufacturers, as imports rose to nearly 13 percent of apparent consumption. Sharp fluctuations characterized industry output during this period. In 1980 and 1982, output registered declines in excess of 20 percent. The industry felt the harsh impact of high petroleum prices in 1980 and its consequent effect on demand. In 1982, the industry shared in the severe economic downturn of the economy. Nonhydraulic hose sustained the largest sales decline, followed closely by long-length hydraulic hose and transmission belts. Sharply increased demand for garden hose, conveyor and elevator belts, and hydraulic hose resulted in a 20.9-percent rise in industry output in 1984. Reduced demand for transmission belts, garden hose, and hydraulic hose contributed to an 8.2-percent decline in output in 1985. Industry output stabilized in the 1985–87 period.

Employment and hours

Industry employment decreased at an average annual rate of 2.5 percent from 1972 to 1987. Employment increased from 31,900 in 1972 to a high of 38,700 in 1979, and declined to 23,200 by 1987. The number of production workers decreased from 22,600 in 1972 to 16,600 in 1987. Nonproduction worker employment declined at a faster rate of 2.7 percent per year as the number of nonproduction workers fell from 9,300 in 1972 to 6,600 in 1987. The proportion of production workers to total employment grew from 70.8 percent in 1972 to 71.6 percent in 1987.

Although data on average hourly earnings are not available for the rubber and plastics hose and belting industry, data are available for the reclaimed rubber and rubber and plastics hose and belting industry. (The rubber and plastics hose and belting industry represents about 95 percent of the work force of the reclaimed rubber and rubber and plastics hose and belting industry.) Average hourly earnings in the reclaimed rubber and rubber and plastics hose and belting industry rose from $3.84 in 1972 to $8.94 in 1987. By comparison, hourly wages in all manufacturing registered $3.82 in 1972 and $9.91 in 1987.

Capital expenditures

Reduced demand for hose and belts dampened capital expenditures in this industry and may account for some of the below-average growth in output per hour. Measured in constant dollars,[6] the industry's capital expenditures were virtually unchanged from 1972 to 1987, although year-to-year fluctuations were quite volatile. In contrast, real capital spending of all manufacturing industries rose 2.8 percent annually between 1972 and 1987.

Investment in plant and equipment by the industry increased at a relatively high annual rate of 7.6 percent from 1972 to 1980. During the same period, all manufacturing industries increased their capital spending by 5.2 percent per year. After 1980, capital spending slowed throughout the manufacturing segment of the economy, growing at an average annual rate of 0.6 percent. This was a reflection of the two recessions that occurred in the early 1980's. However, real capital expenditures actually declined 4.8 percent per year in the rubber and plastics hose and belting industry, as capacity utilization rates fell from 79 percent in 1980 to 64 percent in 1987.[7]

While real capital expenditures remained unchanged in the rubber and plastics hose and belting industry, there was an increase in real capital expenditures per employee during the study period. From 1972 to 1987, investment in plant and equipment per employee grew at an average annual rate of 2.3 percent. This was slightly below the 2.8-percent rate for all manufacturing industries.

From 1972 to 1980, real industry capital spending per employee increased 5.0 percent per year. In 1980, the rubber and plastics hose and belting industry spent $2,924 on plant and equipment per employee. The comparable figure for all manufacturing industries was $2,885. After 1980, industry capital spending per employee declined at an average annual rate of 1.1 percent, compared to a 1.9-percent rate of growth for all manufacturing. In 1987, the industry spent $2,727 on plant and equipment per employee, compared to $3,189 by all manufacturing industries.

Technology

In general, the steps in the manufacture of rubber products are compounding, mixing, forming and building, and vulcanization.[8] Productivity has been boosted by gradual improvements in the various stages of production.

Compounding—the process of determining the rubber formula of a product and of weighing out the components in preparation for mixing is called compounding. Natural rubber, obtained from the latex of the rubber tree, accounts for less than one-fourth of the rubber consumed in the United States. The remainder is synthetic rubber. Many rubber products are less than one-half rubber by weight, the other half consisting of nonrubber components of the compound and the reinforcing materials. The other components of the compound are fillers, extenders, and processing chemicals. Ongoing research and development activities have centered on refining rubber compounds so that production is more efficient and the resulting product is of high quality. Some of the newer rubber compounds are firm enough to hold their own shape when extruded, eliminating the need for a mandrel. In addition, vulcanization times are lower for some of the newer rubber compounds.

Mixing—rubber stocks are mixed in internal mixers. The mixer operates with two- or four-winged rotors and an external ram that forces the compound ingredients into the rotor. Productivity has been boosted by improved mixer motors that have resulted in reduced mixing times and greater output. Also aiding productivity have been improvements in the instrumentation by which the mixer is monitored.[9]

Forming and building—forming operations usually involve either 1) calendering, a process in which rubber and fabric are pressed between rollers to form a sheet of material to some specific gage (as in belt production), or 2) extruding the mixture into some desired shape (as in hose production).

In belt manufacturing, productivity has been increased by the computerization of the calendering system. The calender is used to produce the tacky, rubberized cloth wrapping material or stock used to make belts. Computerization has resulted in less waste and more output. Equipped with a memory, the computer reduces start up time and also reduces the time needed to change the calender for different types of belt stock.

Industry employment decreased at an average annual rate of 2.5 percent from 1972 to 1987.

In a conventional calender system, the rubber coating is put on by unrolling the cloth into a calender, with dry neoprene rubber applied to one side of the fabric and then the other. Next, the material is cut on a 45-degree bias and spliced into a bias oriented sheet. The fabric passes through the calender three times. The final product has lapped splices, resulting in areas of uneven thickness in the plied-up belt. The sheets of belt stock are measured by hand. If the thickness does not fall within the tolerance range, then the operator adjusts the calender by hand.

Some manufacturers have modified the calender by installing a computer system. The primary functions of the computerized system are to control the speed of the calender and to control the thickness of the resulting belt stock. As the material rolls off the calender, a scanning head passes over it. The thickness is measured by computing the number of beta rays from the scanner that have passed through the stock. The fewer the number of rays, the thicker the belt material. If the stock thickness does not fall within the tolerance range, then the computer automatically adjusts the calender.[10]

Major manufacturers will continue to allocate significant funds to research and development.

Some belt manufacturers have boosted productivity by producing belt stock with a water-based application system known as latex processing. Latex processing uses one-third the labor required for calender processing of belt stock. Rather than simply forming rubber onto cloth, the latex process impregnates the fiber with rubber, creating a significant mechanical bond. Production begins with square-woven fabric that is unwound while being slit on a helical or spiral angle, attaining a 45-degree continuous bias. Next, the fabric is dipped into a neoprene latex bath and sent through a mangle or rollers which control the volume of latex that is picked up. A mangle forces the latex into the material. The belt stock is then fed onto a tenter frame and stretched to alter the angle of the weave to around 120 degrees. An additional neoprene compound is applied to the top and bottom of the fabric at this time. After these coats dry, the stock receives a tack compound that facilitates belt manufacturing. The belt material produced by this process is a continuous bias material without splices.[11]

After the belt stock is formed by either calendering or the latex process, the stock is cut to the desired size belt. Prior to the 1970's, cutting was a manual operation. Belts are now cut by machine, saving labor and raising productivity.

Hose construction consists of an extruded tube overlayed with a second extruded cover or jacket. Extrusion is somewhat analogous to squeezing toothpaste through a tube. State-of-the-art extruders are more productive than earlier extruders and are characterized by higher output, lower temperatures, and consistency of product. Between the inner tube and the cover are fabric, cord, or wire reinforcements that have been spiral wrapped, crosswrapped, or braided.

Small-diameter hose is generally made by the extrusion process. Soft compounds are extruded over a mandrel which is removed after curing. Increasingly, firmer compounds have been developed which do not require a mandrel to hold their shape. For hose manufactured with these compounds, labor requirements are lower and, hence, productivity is higher. Next, cord or wire braiding for reinforcement is applied. Crosshead extrusion of the cover or jacket compound completes the hose.

Traditionally, the manufacture of large-diameter hose has been a costly handbuilding operation. Automation has taken place during the study period, resulting in increased productivity. The automated hosemaking and stripping machine is flexible in that it is capable of producing hoses of various widths and lengths. The machine is able to handle all the standard reinforcement materials. One operator regulates the hosemaker, determining the speed at which materials are wrapped, the angle of tension of the mandrel, and the rotation speed of the mandrel.[12]

Vulcanizing—the process that converts the plastic, raw rubber mixture to an elastic state. In conventional vulcanization steam, hot air, salt bath, or other sources of heat are used. Heat is transferred from the outside edge to the core of the product. The time and temperature required to vulcanize any particular product may vary depending on the selection of the vulcanizing system. Manufacturers are attempting to boost productivity by using the fastest system that can be tolerated without premature vulcanization or scorching of the product.

There are several alternatives to conventional vulcanization. One method uses ultra-high frequencies (UHF) or microwaves. Heat is transferred via electromagnetic waves. In a fully automated system, the temperature of the product is continuously monitored by infrared sensors. Energy transmission is controlled by an automatic tuning device. If the energy transmission rises above admissible levels and the automatic tuner cannot lower it, then the whole system will shut down. The most modern UHF lines are equipped with energy recovery systems. However, microwave vulcanization cannot be used on all rubber compounds.[13]

Outlook

Moderate improvement in productivity is indicated for the rubber and plastics hose and belting industry.[14] Although the rubber industry is a mature industry, major manufacturers will continue to allocate significant amounts of funds to research and development on rubber technology.

The use of computers is expected to infiltrate additional operations in the manufacture of hose and belts as the industry moves toward computer-integrated manufacturing. Computer-integrated manufacturing involves the integration and coordination of design, manufacturing, and manage-

ment using computer-based systems. It is an approach to enhancing factory organization and management. Engineers design products using a computer-aided design system which translates the design into instructions for production on computer-aided manufacturing equipment. Management information systems are then used to control and monitor production.[15] □

Footnotes

[1] The rubber and plastics hose and belting industry is designated by the U.S. Office of Management and Budget as SIC 3052 (formerly SIC 3041) in its *Standard Industrial Classification Manual 1987*. This industry comprises establishments engaged primarily in the manufacture of rubber and plastics hose and belting, including garden hose.

The average annual rates of change presented in the text are based on the linear least squares trend of the logarithms of the index numbers. These rates reflect the trend rate of growth for all annual observations for the periods examined and are in contrast to compound rates of change which represent an average rate of growth between beginning and ending years.

Extensions of the indexes will appear annually in the BLS bulletin, *Productivity Measures for Selected Industries and Government Services*. A technical note describing the methods used to develop the indexes is available from the Office of Productivity and Technology, Division of Industry Productivity and Technology Studies.

[2] The overall rate is not necessarily the average of the year-to-year rates of change or an average of the subperiod rates of change.

[3] *Census of Manufactures* (U.S. Department of Commerce, 1972, 1977, 1982, 1987).

[4] Industry sources.

[5] *Ibid.*

[6] Capital expenditures were deflated by the implicit price deflator for producers' durable equipment; see *The Economic Report of the President* (Washington, U.S. Government Printing Office, January 1989).

[7] *Current Industrial Report*, MQ-C1 (U.S. Department of Commerce, 1989).

[8] *Encyclopedia of Science and Technology* (McGraw-Hill, 1987), vol. 15, pp. 562–72.

[9] "The Internal Batch Mixer: Recent Developments in Designs and Controls," *Rubber World*, February 1989, pp. 34–38.

[10] "Computerized Calendering Improves Quality," *Rubber World*, December 1978, pp. 44–45.

[11] "Latex Process 'Revolutionizes' *V*-belt Design," *Design News*, Aug. 20, 1984.

[12] "Significant Advances in Hose-fabrication Technology," *Rubber World*, May 1979, pp. 30–33; and "Selection of Polymers for Automotive Hose and Tubing Application,"*Rubber World*, December 1987, pp. 21–27.

[13] "Profile Extrusion and Vulcanization," *Rubber World*, March 1988, pp. 16–23.

[14] The Bureau of Labor Statistics Office of Employment Projections has projected a 2.6-percent annual growth rate for productivity in the rubber products and plastics hose and footwear industry. The rubber and plastics hose and belting industry is a part of this industry.

[15] *Computerized Manufacturing Automation: Employment, Education, and the Workplace*, OTA-CIT-235 (U.S. Congress, Office of Technology Assessment, April 1984).

APPENDIX: Measurement techniques and limitations

Indexes of output per employee hour measure changes in the relation between the output of an industry and employee hours expended on that output. An index of output per employee hour is derived by dividing an index of output by an index of industry employee hours.

The preferred output index of manufacturing industries would be obtained from data on quantities of the various goods produced by the industry, each weighted (multiplied) by the employee hours required to produce one unit of each good in some specified base period. Thus, those goods which require more labor time to produce are given more importance in the index.

In the absence of adequate physical quantity data, the output index for this industry was developed using a deflated value technique. The value of shipments of the various product classes was adjusted for price changes by appropriate Producer Price Indexes and Industry Sector Price Indexes to derive real output measures. These, in turn, were combined with employee hour weights to derive the overall output measure. The result is a final output index conceptually close to the preferred output measure.

The annual output index series was then adjusted (by linear interpolation) to the index levels of the "benchmark" output series. This benchmark series incorporates more comprehensive, but less frequently collected economic census data.

The employment and employee hours indexes used to measure labor input were derived from data published by the Bureau of the Census and the Bureau of Labor Statistics. Employment and employee hours are each considered homogeneous and additive, and thus do not reflect changes in qualitative aspects of labor, such as skill and experience. The indexes of output per employee hour do not measure any specific contributions such as that of labor or capital. Rather, they reflect the joint effect of such factors as changes in technology, capital investment, capacity utilization, plant design and layout, skill and effort of the work force, managerial ability, and labor-management relations.