Productivity growth in plastics lower than all manufacturing

During 1972–81, output per hour increased at an annual rate of 1.4 percent, slowing to less than 1 percent after 1976; growth in productivity has been linked to improved technology

JAMES D. YORK

Despite rapid output growth during 1972–81, productivity in the miscellaneous plastics products industry increased at a somewhat slower rate than that for all manufacturing. Productivity rose at an average annual rate of 1.4 percent over the period, while the rate for all manufacturing was 1.8 percent.[1] The rapid rise in output, at an average annual rate of 5.5 percent, was accompanied by an increase in employee hours of 4 percent annually. (See table 1.) Industry productivity benefited from improvements in resins and faster processing equipment, and from the growing use of microprocessor controls for production machinery.

Productivity trends fluctuated during 1972–81, as output and hours responded to cyclical forces in the economy. The output of the plastics industry encompasses a wide range of products consumed in many sectors of the economy. Consequently, industry output tends to be strongly influenced by trends in the overall level of economic activity. A sharp downturn in the economy led to sizable declines in the output of plastics products: 9.0 percent in 1974 and 12.5 percent in 1975. Reductions in employee hours lagged initially, with a decrease of only 1.1 percent in 1974. With output declining much more than hours in that year, productivity posted a 7.9-percent decrease. In 1975, however, the rate of decline in hours accelerated to 12.6 percent, virtually matching the decrease in output. With the changes in output and hours offsetting each other, productivity showed no change for that year.

With an improving economy, output increased very rapidly in 1976 and 1977, rising by 18.9 percent and 24.4 percent. These gains outpaced the corresponding increases in hours of 14.5 and 11.4 percent and productivity consequently rose by 3.8 and 11.7 percent. In 1978, output still showed a sizable increase of 10.7 percent but this was more nearly matched by the rise in hours of 9.8 percent, resulting in a productivity gain of only 0.8 percent. Employee hours continued increasing in 1979, by 4.7 percent, despite a decrease in output of 1.5 percent, yielding a 6-percent drop in productivity. The economy experienced another downturn in 1980 and industry output decreased by 5.1 percent. Hours were reduced even more, however, by 6.1 percent, and productivity managed to post a gain of 0.9 percent. The economy began to improve after the sharp downturn in the first half of 1980 and this improvement continued into 1981. Industry output benefited, rising 6.9 percent, which outpaced the 3.9-percent increase in hours and resulted in a productivity gain of 2.9 percent.

Employment and plant size

Employment in the industry grew quite rapidly during 1972–81, rising from 342,500 to 477,200, equivalent to an

James D. York is an economist in the Division of Industry Productivity Studies, Bureau of Labor Statistics.

average annual rate of increase of 4.0 percent. Employee hours advanced at the same rate during this period. By comparison, the rate of increase for all manufacturing employment was 0.7 percent and the rate for hours was 0.6 percent.

Because the output of plastics products serves such a wide range of markets, trends in the industry's employment are strongly influenced by cyclical swings in the overall economy. Despite rapid employment growth in plastics products during the 1972–81 period as a whole, there were declines of 0.1 percent in 1974 and 12.7 percent in 1975—years in which the economy was in recession. Employment growth was strong in each of the following years until 1980, the next recession year. In that year, employment dropped 5.5 percent. It recovered again in 1981, however, rising by 3.5 percent.

Most of the establishments in the plastics industry are small. Data available for 1977 indicate that about 57 percent of the industry's establishments employ fewer than 20 employees. Most of the employment, however, appears to be concentrated in medium size establishments. Nearly half of total industry employment in 1977 was in establishments with 50 to 249 employees. The establishments with fewer than 20 employees accounted for only about 7.5 percent of industry employment, despite their large share of the total number of establishments. Very large establishments are unusual, with less than 0.2 percent of all establishments employing 1,000 or more workers in 1977. The average number of employees per estabishment hardly changed during 1972–77, declining from 45 employees in 1972 to 44 in 1977.

Data on the skill composition of employment are available for broad occupational groups in the miscellaneous plastics products industry for 1980. These data indicate that operatives are the major occupational group, constituting almost 56 percent of total industry employment, as compared with the all-manufacturing average of just over 43 percent. This job category includes such occupations as assemblers and machine operatives. Craft and related workers, which include machinists and tool-and-die-makers, were another substantial category with almost 16 percent of total industry employment, slightly less than the all-manufacturing proportion of just under 19 percent. Professional, technical, and related workers constituted a somewhat lower proportion of total employment than for all manufacturing—less than 4 percent in the plastics industry compared with over 9 percent for all manufacturing. By contrast, the share of industry employment composed of managers, officials, and proprietors was nearly the same as that for all manufacturing—about 6 percent.

Table 1. Productivity and related indexes for miscellaneous plastics products, 1972–81

[1977 = 100]

Year	Output per empoylee hour	Output	Employee hours	Employees
1972	86.6	70.3	81.2	81.0
1973	93.6	84.9	90.7	91.0
1974	86.2	77.3	89.7	90.9
1975	86.2	67.6	78.4	79.4
1976	89.5	80.4	89.8	90.2
1977	100.0	100.0	100.0	100.0
1978	100.8	110.7	109.8	109.6
1979	94.8	109.0	115.0	115.5
1980	95.7	103.4	108.0	109.1
1981	98.5	110.5	112.2	112.9
	Average annual rates of change (in percent)			
1972–81	1.4	5.5	4.0	4.0
1976–81	0.8	4.9	4.1	4.2

Major markets

An important reason for the rapid growth of industry output is that new markets for plastics products have been continually opening up. The development over time of new and improved resins has been an important underlying factor in making this possible. Plastics made from these improved resins have been able to meet more stringent performance criteria in areas such as strength and heat resistance. With these improved properties. plastics became suitable for the manufacture of many products from which they had previously been excluded. As a result, plastics began penetrating product markets formerly dominated by other materials. For example, plastic pipe has increasingly been substituted for other types of pipe, such as copper and cast iron, as building codes have been altered to acknowledge its suitability. The greater ease of installation of plastic pipe has also meant that semiskilled workers could be employed to install it. The benefits of plastics in terms of such factors as price, weight, and corrosion resistance have made them a popular alternative to competing materials in many product lines.

Building and construction. The building and construction industry is an important market for plastics products. Plastics products for this market include such items as panels, doors, moldings, pipes, and insulation. By far, pipes are the most popular item: shipments nearly tripled during 1972–77. The advantages of plastic pipe (such as corrosion resistance) have helped it to penetrate markets previously dominated by other materials.

Agriculture. Agricultural uses are an important market for plastic pipe. The need to increase food production during the 1970's served as a stimulus to the demand for agricultural pipe. Plastic was promoted in drainage and irrigation systems. For example, corrugated polyethylene tubing began to replace more expensive and cumbersome concrete drainage tile. The use of plastic pipe in irrigation has benefited from increased emphasis on agricultural efficiency.[2]

One of the biggest markets for plastics products is in film, sheets, and sheetings. There are a number of types of these items such as cellulosic, polyethylene, polypropylene, polystyrene, and vinyl and vinyl copolymer. Useful for mulching applications, when spread upon an agricultural bed, film controls moisture evaporation, prevents leaching of fertilizer, accelerates growth, and increases yield.

The value of shipments of film and sheet proucts for all markets, including agriculture, increased considerably from 1972 to 1977. Shipments of polypropylene film and sheet more than quadrupled during this period. Cellulosic and polystyrene also increased rapidly and polyethylene, one of the biggest categories, more than doubled. Sheets are also produced in laminated form. Data for laminated sheets, which are available in combined form with data for laminated rods and tubes, indicate that shipments nearly doubled during 1972–77.

Plastics products have found a growing number of applications in agriculture besides sheeting and pipe. Injection molded plastic parts on many types of agricultural equipment are increasingly substituted for metal parts. Parts for seed drills, combines, planters, and tractors are more frequently being made of plastic. Some of the advantages of plastics include cost and weight reduction and corrosion resistance.

Packaging. Another important market for plastics has been packaging applications. Blow molded milk containers, for example, which are large, break-resistant, and light weight, have achieved a high level of market penetration because of their advantages. Plastic containers for other types of food products have also grown in popularity. Shipments of jars and tubs for food products nearly tripled during 1972–77. Advances in blow molding technology around the beginning of this period helped push plastic drums into competition with steel, offering advantages in reusability and resistance to denting and corrosion as well as lighter weight.

Transportation equipment. Much of the output of the plastics industry is used in the manufacture of transportation products. By far the largest portion of this output goes into the production of motor vehicles. In 1977, nearly 80 percent of plastics output, by value of shipments, going into the transportation market, was used for motor vehicles. The remaining 20 percent went into aircraft, space and missile, and other transportation equipment. About two-thirds of the portion going into motor vehicles was in the form of components, housing, accessories, and parts. The rest was in the form of foam products for such items as seating and dash. Substitution of plastics for metals has contributed to output growth. Light weight has helped make plastics products suitable for a multitude of applications in the automotive area.

Smaller markets. A smaller but still sizable market for plastics is the electrical and electronic products market. One of the biggest segments of this market—household and commercial appliances—showed little change in output during 1972–77 but items in the computing and data processing category grew rapidly. Furniture components and furnishings also represent a fairly sizable market for industry output.

Technological advances

The plastics industry produces an extremely wide assortment of products. The resins used as raw material can be formed into a wide variety of shapes using various processes such as molding and extrusion.[3] The equipment used in these processes has been improving over time, aiding industry productivity gains.

One of the most widely used production processes is injection molding. This process involves heating and working plastics granules or compounds until they are able to flow. This plasticized material is then forced under pressure into a closed mold cavity where it can cool or cure to form the desired part. Productivity in this process has benefited from the adoption of equipment which utilizes a rotating screw to perform the injection operation. Raw material is fed from a hopper onto the screw which is kept rotating by a motor. The material is forced over the flights of the screw and is heated by the barrel and friction from the turning screw. This process heats and plasticizes the material. As the hot material forces its way to the front of the screw, it drives the screw backward. The screw stops turning when the right amount of material reaches the tip. The screw is then forced forward and injects the hot plastic material through the nozzle of the barrel and then through a sprue and runner system into the mold cavities. Use of the screw has resulted in the material being more plasticized when it enters the mold, reducing cycle time. Better resins tailored to injection molding have become available and these have facilitated plasticization and have reduced problems arising when plastic material sets up in the barrel and must be removed.

In recent years, a type of injection molding known as reaction injection molding (RIM) has come into use.[4] RIM involves the injection of two liquid plastic materials into a mold. This is done at low pressure rather than the usual high pressure. Many improvements in RIM equipment use have contributed to productivity growth. Improved output metering units have resulted in more rapid mold fill, and press speeds have also been increased. The introduction of faster-cure materials has largely eliminated the need for presses with tilt features which extend the cycle time.[5]

Machine controls have continually improved over the years. An important development in this regard has been the increasing adoption of microprocessor controls as they have become more affordable. They provide an integrated system of controls over such production variables as time, temperature, position, and pressure. They offer production monitoring capabilities and can maintain various parameters such as injection velocity and cavity pressure at optimal, preset levels in spite of fluctuations in operating conditions. The ability of microprocessors to detect and adjust for changes in operating conditions enables them to keep production machinery operating at peak efficiency. Their preprogramming capabilities reduce the needed startup time and their precise control reduces the reject rates.

Reductions in molding cycle time have also aided productivity. Improvements in mold cooling systems have contributed to reduced molding time. More sophisticated mold designs have also reduced the time required for the molding operation. Continual improvements in resins have made important contributions to productivity gains in molding. Improved resins offer such advantages as faster flow, easier ejection, and reduced mold deposit. The advantages of these resins have reduced the cycle time in many molding operations.[6]

A significant development in materials handling has been the adoption of robots for the performance of operations involving such activities as lifting, tilting, twisting, positioning, aligning, or transferring of items. Robots have been used for a number of premolding and postmolding operations, such as loading and unloading presses and the handling and orienting of finished parts for takeaway. Robots offer the advantage of working tirelessly without interruption, improving product quality and shortening cycle time. In addition to their role with molding machines, robots are also being used in such downsteam processes as trimming and deflashing. Robots have also proven beneficial for spray coating plastic parts. The robots offer more uniform and accurate coating weights and fewer rejects, while performing at higher levels of productivity.

The use of lasers has been growing in the plastic processing industry. Lasers have been adopted for cutting and drilling uses and also for their capacity to measure and inspect accurately and quickly. Measuring systems can use interruption of laser scans to determine dimensions while inspection units detect disruptions of the beam when it hits defects, such as bubbles or other flaws, in the surface. Analysis of the reflected/refracted light, generally by computer control, provides information on the defects. The laser can be connected with process controls, thus permitting adjustment of process parameters in response to detected defects. Lasers can cut thick plastics in a single step, providing clean, smooth edges which do not require abrasive finishing. The speed and precision of lasers and their ability to replace manual operations have enabled them to contribute to industry productivity gains.

Outlook for technology

More frequent adoption of microprocessor controls for production equipment probably will be an important part of the future automation of the industry. A move toward almost total computer control of many plants appears to be a very real possibility. Microprocessor controls for individual machines could be linked to central computers which coordinate and control the overall manufacturing operation.[7]

Increased adoption of robots also appears likely as part of the push for greater efficiency; not only will there be more robots but the capabilities of those robots almost certainly will expand. Laser systems will probably also continue to be adopted.

Improvements in resins have been an important factor in productivity growth and the industry should continue to benefit from the development and introduction of better resins. Modifications in production machinery to take advantage of new resins may also be beneficial to productivity gains.

Demand for industry output should grow relatively well in coming years, as plastics are substituted for other materials in the manufacture of various products. Any further declines in petroleum prices would also benefit the price competitiveness of plastics products by reducing the cost of raw materials. □

——*FOOTNOTES*——

[1] Average annual rates of change are based on the linear least squares trends of the logarithms of the index numbers. The miscellaneous plastics products industry is composed of establishments primarily engaged in molding primary plastics for the trade and fabricating miscellaneous finished plastics products. The industry is designated as SIC 3079 in the *Standard Industrial Classification Manual*, 1972 Edition, issued by the Office of Management and Budget. Extension of the indexes appears in the annual BLS Bulletin, *Productivity Measures for Selected Industries*.

[2] For more information on the subject of pipe, see "Agpipe Picks Up," *Modern Plastics*, March 1975, pp. 54–55; and "Volume Pipe Resin: A Million-Ton 1977 Market Will Grow 30 percent by 1980," *Modern Plastics*, December 1977, pp. 34–37.

[3] For descriptions of the various processes and definitions of many of the terms used in the miscellaneous plastics products industry, see *Standards and Practices of Plastics Molders and Plastics Molded Parts Buyers Guide* (New York, The Society of the Plastics Industry, Inc., 1965), pp. 35–46.

[4] See "Many New Developments in RIM Machines," *Plastic World*, September 1979, pp. 49–51.

[5] "New High-Productivity Equipment Transforms Conventional Processing," *Modern Plastics*, December 1980, pp. 52–54.

[6] See "High Productivity and Economy in New Grades of Engineering Resins," *Modern Plastics*, October 1980, pp. 52–53.

[7] See Frank Nissel, "Extrusion's Next Goal Should Be More Productivity," and Jack Alger, "The New World of Computer-Integrated Production Systems," *Modern Plastics*, June 1982, pp. 90 and 94–95.

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 for 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 constructed by a deflated value technique. The value of shipments of the various product classes were adjusted for price changes by appropriate Producer Price Indexes to derive real output measures. These, in turn, were combined with employee hour weights to derive the overall output measure. These procedures result in a final output index that is conceptually close to the preferred output measure.

Employment and employee hour indexes were derived from BLS data. Employee and employee hours are each considered homogeneous and additive, and thus do not reflect changes in the 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 factors such 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.

Errata

In "Labor market contrasts: United States and Europe" by Janet L. Norwood in the August *Monthly Labor Review*, two lines were inadvertently dropped from the paragraphs beginning at the bottoms of page 3 and page 4. The paragraphs are reproduced below with the missing lines in boldface.

Paragraph beginning at the bottom of page 3:

The differences and their effects on attitudes toward policy were discussed at a recent conference in England by experts from Western Europe and North America. The ques**tion "Has Full Employment Gone Forever?" was answered** far more pessimistically by the Europeans than by the Americans. The attitudes at the conference were shaped by the historical framework and expectations of future developments. The Western European countries had very little job growth during the decade of the 1970's; and in most of the European countries, there was little if any expansion of the labor force.

Paragraph beginning at the bottom of page 4:

Youth unemployment high. Young people also tend to be concentrated in low-paying jobs—when they work. Youth unemployment rates are at very high levels in both Europe and in the United States. More than 1 of 5 teenagers in the U.S. labor force is unemployed, as is 1 of 7 young adults **aged 20 to 24. Unemployment rates among British, French,** Italian, and Dutch youth now meet or surpass these high U.S. levels, while West Germany manages to maintain much lower rates, especially for teenagers. (See table 3.)

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