Productivity trends in the machine tool accessories industry

During 1963–82, annual productivity increased an average of 1.4 percent, somewhat below manufacturing as a whole; continued improvements have characterized the industry

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As measured by output per employee-hour, productivity in the machine tool accessories industry grew at an average annual rate of 1.4 percent during the 1963–82 period, somewhat below the growth rate of 2.4 percent for all manufacturing.[1] During this period, the annual rate of increase in output was 2.4 percent and the rate of increase in hours was 1.0 percent. (See table 1.) Continued improvements in production machinery and the adoption of numerical control equipment to run the machinery have enabled productivity to improve at a gradual rate for the past two decades.

During the first half of the 1963–82 period, productivity growth rose at an average annual rate of 2.4 percent from 1963 to 1973. Output averaged 2.1 percent a year, while hours *declined* at an average rate of 0.3 percent. During the second half of the period, 1973–82, productivity declined at an average annual rate of 0.7 percent. Output grew at a rate of 0.9 percent, but this growth was exceeded by the 1.7 percent annual average increase in hours.

Year-to-year fluctuations in output per employee-hour have been influenced by cyclical trends in the economy. The output of the machine tools accessories industry is consumed by such producers as automobile and aircraft manufacturers and by individual consumers. Consequently, changes in these markets can affect movements in output and hours. Shifts in industry output have often been quite sharp. However, corresponding adjustments in employee hours have acted to dampen swings in productivity.

As noted earlier, the most rapid productivity growth occurred from 1963 to 1973. Output per employee-hour exhibited sharp fluctuations in individual years as shifts in the economy affected industry markets which, in turn, had an impact in industry output and hours. In 1970, for example, as the economy experienced a downturn, productivity declined 7.8 percent. This drop reflected sharp declines in output (18.8 percent) and hours (11.9 percent). The largest increase was in 1971, when industry productivity rose by 12.7 percent. Industry output actually declined by 8.2 percent, but this was more than offset by a large reduction in employee hours of 18.5 percent. Productivity continued to improve in 1972, rising by 8.3 percent. Underlying this increase in productivity was a large increase in output: 18.2 percent, twice the increase in employee hours.

In the 1972–82 subperiod, average annual growth in output was 1.9 percent, outpacing the earlier years. However, the growth in employee hours exceeded the growth in output, and output per employee-hour declined on an average annual basis. Employee hours declined in 1975, 1981, and 1982. In 1975, the economy was in recession and both industry output and hours posted steep declines. However, the decline in output (16.3 percent) exceeded the decline in hours (13.5 percent), and productivity declined by 3.2 percent. In 1981, the drop in hours of 3.9 percent exceeded the decline in output of 0.7 percent, and productivity rose by 3.4 percent. The largest productivity decrease of the entire study period occurred in 1982, also a year of reces-

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Table 1. Productivity and related indexes for the machine tool accessories industry, 1963–82

[1977 = 100]

Year	Output per employee hour: All employees	Output per employee hour: Production workers	Output per employee hour: Non-production workers	Output	Employee hours: All employees	Employee hours: Production workers	Employee hours: Non-production workers
1963...	80.0	78.2	85.3	62.9	78.6	80.4	73.7
1964...	81.2	79.2	86.7	68.5	84.4	86.5	79.0
1965...	82.0	78.5	92.8	78.8	96.1	100.4	84.9
1966...	82.0	77.1	98.7	90.7	110.6	117.7	91.9
1967...	85.2	81.1	97.9	94.7	111.2	116.8	96.7
1968...	83.0	81.8	86.6	87.5	105.4	107.0	101.0
1969...	88.9	87.4	93.3	91.6	103.0	104.8	98.2
1970...	82.0	82.3	81.4	74.4	90.7	90.4	91.4
1971...	92.4	96.2	83.7	68.3	73.9	71.0	81.6
1972...	100.1	101.0	97.8	80.7	80.6	79.9	82.5
1973...	105.7	102.7	115.0	103.0	97.4	100.3	89.6
1974...	104.2	101.5	112.4	108.6	104.2	107.0	96.6
1975...	100.9	102.8	96.2	90.9	90.1	88.4	94.5
1976...	98.8	100.1	95.6	90.7	91.8	90.6	94.9
1977...	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1978...	104.0	103.5	105.5	113.6	109.2	109.8	107.7
1979...	101.7	100.3	105.6	120.1	118.1	119.8	113.7
1980...	100.3	100.4	100.1	120.3	119.9	119.8	120.2
1981...	103.7	105.5	99.4	119.5	115.2	113.3	120.2
1982...	91.5	99.8	75.2	86.8	94.9	87.0	115.5
	Average annual rates of change (in percent)						
1963–82..	1.4	1.8	0.5	2.4	1.0	0.6	1.9
1977–82..	−1.3	0.1	−4.6	−1.6	−0.2	−1.7	3.2

sion. Industry output was hit hard by the economic downturn and dropped by 27.4 percent, more than offsetting a 17.6-percent decline in hours. The resulting drop in productivity was 11.8 percent. The decrease in productivity during 1972–82 appears to reflect, in large part, the effects of the recession years, 1974, 1975, 1980, and 1982 which saw productivity declines of 1.4 (1974), 3.2 (1975), 1.4 (1980), and 11.8 percent (1982).

Employment and plant size

From 1963 to 1982, industry employment grew by 28 percent, from 46,200 to 59,000. The average annual rate of increase was 1.2 percent. The employee hours increased at a rate of 1.0 percent, reflecting a slight decline in average weekly hours. At an average annual rate of 1.7 percent, the number of women employees has been increasing at a faster rate than total employment. As a result, the proportion of women employees increased from 18.0 percent in 1963 to 19.7 percent in 1982. Production workers increased 18 percent during this period, equivalent to an average annual increase of 0.9 percent. Consequently, production workers have declined slightly as a percent of total employment—from 72.9 percent in 1963 to 67.1 percent in 1982. The average weekly hours of production workers decreased during 1963–82, declining at an average annual rate of 0.3 percent.

Employment growth was not steady, and exhibited large year-to-year fluctuations. During the 1968–71 period, employment dropped annually, with the largest decline—16.9 percent—occurring in 1971. These declines caused employment to register average annual reductions during 1963–72. The largest increase, 17.2 percent, occurred in 1973. There was another large increase in 1974, followed by a sharp drop in 1975, a recession year. Increases occurred in 1977–80, however, and during 1972–82, employment rose at an average annual rate of 2.8 percent.

Most of the industry's employment is concentrated in small and mid-sized establishments. About 38 percent of industry employment is in establishments with 100 to 499 employees, despite the fact that they constitute only about 7 percent of the total number of establishments. However, they produce about 35 percent of total industry shipments. Another 30 percent of the employment is concentrated in establishments with 20 to 99 employees. These establishments are more numerous, account for about 27 percent of the industry total, and produce about 30 percent of industry shipments. The largest establishments (500 employees or more) are also important. Even though they represent less than 1 percent of all establishments, they produce 25 percent of industry shipments and employ 21 percent of the work force. There has been a slight trend away from large plants. Establishments employing 500 employees or more constituted 1.3 percent of the total number in 1963, compared with less than 1 percent in 1977. Those employing 100–499 employees declined from 8 percent of the total in 1963 to 7 percent in 1977. The average number of employees per establishment declined from 45 in 1963 to 38 in 1977.

Diverse industry markets

The machine tool accessories industry produces a wide range of products. The industry's largest product group is cutting tools, which accounted for over 60 percent of all product shipments in 1977. Cutting tools include drills, broaches, countersinks and counterbores, reamers, hobs, milling cutters, slitting saws, and taps. In addition to sales to the industrial market, many cutting tools are sold to consumers. Foreign producers have made inroads into the consumer end of the market in such high volume items as twist drills.

The industry's other two product groups are precision measuring tools (which include such instruments as dial indicators, micrometers, and calipers) and attachments and accessories for machine tools and metalworking machinery. The latter group includes such devices as turning tool holders and chucks. No individual segment of the market has been predominant in determining trends in industry output, but some segments do stand out in relative importance such as the motor vehicle industry and the aerospace industry.

The motor vehicle and related industries have been the largest consumers of machine tool accessories. Data for consumption of machine tool cutting tools by individual industry are available back to 1967, and these data indicate that the motor vehicles and equipment industry has been the largest single purchaser of the industry's output over the years. From 1963 to 1978, the output of the motor vehicles and equipment industry increased fairly rapidly, at an average annual rate of 4.3 percent, and as a consequence helped to promote output growth in the machine tool accessories industry. In 1980, however, the motor vehicle industry felt the effects of both a cyclical downturn and increased foreign competition which have continued to have a depressing effect on this market subsequently.

Another very large market consists of manufacturers of aerospace equipment. This has generally been the second largest market, but it has been growing in relative importance. This group includes manufacturers engaged in the production of aircraft, guided missiles, space vehicles, and related components and parts. Metal cutting tools for this market must often meet very demanding tolerances. The machine tool industry, which manufactures both metal forming and metal cutting equipment, is another major consumer of industry output. This industry uses the various machine tool accessories as parts in the manufacture of complete machine tools. It is a very important market, but its output declined, on an average annual basis, during 1963–82, and its consumption of machine tool accessories has consequently been declining.

A major growth market has been the internal combustion engine industry. Its purchase of machine tool cutting tools increased more than fivefold (in current dollars) during the 1967–77 period. Other industries which have been major purchasers of machine tool accessories include construction machinery and power driven handtools. The oilfield machinery industry is also an important market, and its purchases of metal cutting tools increased by about 160 percent during 1967 to 1977.

Competition from imports has been increasing in recent years. Data for metal cutting tools indicate that imports as a percent of new supply (domestic shipments plus imports) increased considerably during the 1972–82 decade, rising from slightly over 2 percent to nearly 5 percent in 1982. However, the export market has shown some relative improvement during this same period. Exports as a percent of domestic product shipments rose from 3.5 percent in 1972 to about 4.5 percent in 1982.[2]

Capital expenditures

The gradual rate of modernization in this industry is reflected in the modest level of capital expenditures and the trend in those expenditures. Capital expenditures per employee were much lower throughout the 1963–82 period than for all manufacturing. In 1963, such expenditures amounted to only $485 per employee for the industry compared with $700 per employee for all manufacturing. By 1981, the industry's expenditures had risen to $3,130 per employee, but the all-manufacturing total was $4,156 per employee. From 1963 to 1981, the rate of growth of capital expenditures and capital expenditures per employee was faster for all manufacturing than for the machine tool accessories industry. The average annual rate of increase in capital expenditures was 8.8 percent for the industry, and the annual rate of growth of capital expenditures per employee was 7.9 percent. By comparison, the rate of increase for all manufacturing was 10.2 percent for capital expenditures and 9.5 percent for capital expenditures per employee.

Technological improvements

Productivity in the manufacture of machine tool accessories has benefited greatly from advances in controls for certain types of production machinery. Numerical control has provided an important source of improvement in the machine tools used to produce the industry's output. Numerical control provides automatic operation of machine tools by means of electronic devices and coded instructions on tape. This automation reduces downtime for setup and greatly contributes to a reduction in the labor time required to produce the final output.[3] Numerical control also provides important advantages in flexibility where small volume production is involved. Before its advent, changes in the production runs necessitated many changes in hardware. The shift to numerical control meant that the same hardware could, in some cases, be used when changing production runs since tapes with new cutting instructions replace old tapes.

The advantages of numerical control have contributed importantly to productivity growth. Improvements in computer technology have provided a solution to problems associated with tape preparation. Early computers were too slow in their processing speeds and too expensive to be useful in controlling machine tools. Instead, they were used to prepare tapes to operate numerically controlled machine tools. As computer speeds and storage capacity increased (and their costs declined), it became feasible to use them to provide direct control of machine tools, without the intervention of tapes. When the desired parameters are fed into the computer, it can make the necessary computations for operating the machine tools. The adoption of direct computer control for machine tools by some manufacturers has benefited productivity by eliminating tape preparation and by providing greater speed and flexibility of operation.[4]

Multipurpose machine tools, or machining centers, have also aided productivity gains. The machining center is a machine tool that can perform a variety of operations on a part. This contrasts with more conventional techniques where the part is transferred from one machine to another with each performing a specialized function. Machining centers provide more complete machine utilization, since more time is spent cutting metal. They require less skilled operators and reduce operator errors. One machining center can replace a number of specialized machines and their operators, thereby significantly increasing productivity.[5]

Electrochemical and electrical discharge machining have both contributed to productivity gains. Electrochemical machining uses a reverse electroplating process to remove metal. In grinding a workpiece, an electrolytic solution is squirted on a grinding wheel and allowed to flow between the wheel and the workpiece. The solution conducts electricity, which deplates (strips) the workpiece. Electrochemical machining provides increased speed in metal removal and offers good performance in the grinding of carbide products. Electrical discharge machining utilizes the eroding action of an electrical spark on metal to produce the desired shape. The desired final shape of the product can be put on the electrode. This is particularly advantageous for complex shapes, since the necessary metal removal can take place at once, rather than requiring many different motions as would be the case with more conventional cutting tools. Both electrochemical and electrical discharge machining are useful in situations where a fine tolerance is required, and they are also useful in applications which would be uneconomical or very difficult for conventional machining processes.

Grinding operations have benefited from the substitution of the cubic boron nitride grinding wheel for the aluminum oxide wheel. These wheels are very good for grinding heat treated steel. They cut cleaner, run cooler, and last longer, thus reducing downtime. In the production of drill bits, the substitution of grinding for milling, where feasible, has speeded the production process because grinding can be done faster.

Evolutionary improvements in conventional machines have aided productivity growth. These improvements include increased power and faster operating speeds and reductions in setup time and downtime. The capacity of some machines has been increased. Improvements in some milling machines, for example, permit them to cut more workpieces simultaneously while still maintaining the necessary tolerances. However, the contribution of such improvements has been limited. They have taken place gradually and reflect an improvement in the quality of production machinery rather than any major innovations.

The use of automated materials handling systems, where feasible, has boosted productivity. Productivity has also benefited where the layout of production machinery has been improved to speed the workflow. Mechanical equipment which moves production pieces through the different stages of the heat treatment process—preheating, heating, and quenching—has improved efficiency in this operation.

Outlook for productivity

Productivity should continue to benefit from a trend toward more direct computer control of production machinery. The increasing capability of computers, combined with their declining cost, is making their use for production tasks increasingly affordable. The development of microprocessors, which provide the necessary computer capabilities in a more compact and affordable package, has been an important step in this regard. As computer control of production machinery becomes more widespread, productivity should increase. The integration of computers and machine tools offers the possibility of substantial productivity gains.[6] The continued development and adoption of robot devices appears likely and should further reduce the labor requirements involved in the manufacturing process. Much of the technology for a more automated production operation already exists and may be increasingly adopted in the future.[7] Evolutionary improvements in production machinery should also continue to take place and enhance productivity growth.

Computer-aided design and computer-aided manufacturing (CAD–CAM) systems are already popular in some industries, and should gain increasing acceptance in the machine tool accessories industry as they continue to become cheaper and easier to use. This technology enables designers and engineers to improve their productivity by automating the mechanical aspects of design.[8] Engineers can create and alter designs electronically. These systems will reduce design time and also encourage experimentation since some computer programs can analyze designs to see how they respond to changes in certain variables.[9]

Some producers have been shifting their emphasis from the consumer end to the industrial end of the market, where they can often compete more effectively with foreign producers. Many of these industrial products may involve shorter production runs. Flexible manufacturing systems, which integrate numerically controlled machine tools, computer aided design, and automated materials handling systems, are expected to be adopted in an effort to keep unit production costs down where small volume production is involved. The high cost of such systems is a barrier to their adoption but changing circumstances, for example, increasing competition from foreign producers, make their adoption a real possibility.[10] □

———*FOOTNOTES*———

[1] The machine tool accessories industry is composed of establishments primarily engaged in manufacturing cutting tools, machinist's precision measuring tools, and attachments and accessories for machine tools and for other metalworking machinery. The industry is designated as SIC 3545 in the Standard Industrial Classification Manual, 1972. All average annual rates of change are based on the linear least squares trends of the logarithms of the index numbers. Extension of the indexes will appear in the annual BLS Bulletin, *Productivity Measures for Selected Industries*.

[2] *U.S. Industrial Outlook* (U.S. Department of Commerce, 1984), p. 20–9.

[3] See Lloyd T. O'Carroll, "Technology and Manpower in Nonelectrical Machinery," *Monthly Labor Review*, June 1971, pp. 58.

[4] *U.S. Industrial Outlook*, pp. 20–6, 20–7.

[5] O'Carroll, "Technology and Manpower," pp. 58–60.

[6] See Sari Horwitz, "Chalk Embarks on Venture With Computerized Tools," *Washington Business*, Aug. 20, 1984, p. 27.

[7] Gene Bylinsky, "The Race to the Automatic Factory," *Fortune*, Feb. 21, 1983, pp. 52–60.

[8] See "IBM's Grand Design to Become a Force in the Factory," *Business Week*, May 7, 1984, pp. 142 C, F, and J.

[9] See Bob Davis, "Computers Speed the Design of More Workaday Products," *The Wall Street Journal*, Jan. 18, 1985, p. 25.

[10] Bylinsky, "The Race," pp. 52–60. See also *U.S. Industrial Outlook* (U.S. Department of Commerce, 1983), p. 20–5 and 1984, p. 20–5.

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 was adjusted for price changes by appropriate Producer Price Indexes and Industry Sector Price Indexes to derive the 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. Employees 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.