Trends of labor productivity in metal stamping industries

Overall growth in the annual rate of output per employee hour was sluggish from 1963 to 1983, but performance was stronger during 1972–83 for producers of automotive stampings, while it weakened in the nonautomotive stampings industry

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Labor productivity, or output per employee hour, in the metal stamping industry rose at an average annual rate of 1 percent over the two decades, 1963–83.[1] Output rose at about the same rate, while employee hours remained on balance unchanged over the period. Between 1963 and 1973, productivity advanced more rapidly (1.2 percent a year) than over the following decade (0.7 percent). The earlier annual improvement was associated with fairly strong output and employment gains, while the subsequent advance resulted from a declining trend in output being exceeded by a declining trend in employment. The longer term productivity performance in terms of average annual rates of change was much lower than for all manufacturing.

	Metal stampings	*All manufacturing*
1963–83	1.0	2.4
1963–73	1.2	2.6
1973–83	0.7	1.9

The productivity trend for the 20-year period examined here was marked by much volatility. In almost half of the 20 years, productivity declined, although by small magnitudes. These declines were almost invariably associated with larger drops in output than in employee hours—a pattern frequently encountered in durables manufacturing industries during business slumps. In only 7 years of the period did productivity rise because output gains topped employee hour increases. All these years occurred during an expansionary phase of the business cycle (table 1).

Year-to-year fluctuations in productivity ranged from a fall of 4.0 percent (in 1964) to a rise of 8.6 percent (in 1971), with the more typical movements running between plus or minus 3 percent. However, underlying these movements were often large swings in output and employee hours. For example, the productivity increase of 4 percent in 1976 was linked with output and employee hour rises of 22 and 17 percent. Both of these variables had plummeted by 19 and 16 percent the preceding year—with productivity receding by only 3 percent.

Component industries

Data for metal stampings industry establishments were treated as one industry until 1972. The industry was then reclassified into three separate industries, for two of which

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separate measures for productivity and related variables are published and discussed here—automotive and nonautomotive metal stampings.[2] The productivity trends for these two industries diverged considerably over the 1972-83 span, rising at an average annual rate of 1.8 percent for the former, and declining 0.7 percent a year for the latter. These movements reflect much stronger average annual growth for automotive metal stampings after 1977, and a much sharper decline for nonautomotive stampings.

	Automotive	*Nonautomotive*
1972–83	1.8	−0.7
1972–77	0.7	−0.4
1977–83	2.5	−2.2

The productivity improvement in the automotive metal stamping industry reflected a long-term decline in output of 1.5 percent annually, accompanied by a 3.2-percent-a-year drop in employee hours. The downward trend in nonautomotive metal stampings, on the other hand, resulted from moderately rising output (0.7 percent a year), and a somewhat higher employee hour rate (1.3 percent). The high productivity growth after 1977 for automotive metal stampings was associated with sharply declining output and even more pronounced decreases in employee hours. The productivity drop in nonautomotive metal stampings was also associated with falling output, but employee hours fell less.

Output and demand

The automotive metal stampings industry manufactures fenders, roofs, exhaust systems, brake shoes, trim, and other motor vehicle stamping components. These larger stampings are usually made in establishments operated by automobile companies. The industry also manufactures such products as brackets, valves, and other smaller items. These products are usually made by smaller, independent suppliers. Nonautomotive stampings consist of a vast array of job stampings often made in comparatively small batches; kitchen, household, and other utensils; pressed metal for such uses as storefronts, curtain walls, and refrigerators; and enclosures for electronic or electrical apparatus. Nonautomotive metal stampings are made mostly by smaller firms. (See below.)

Output of the combined metal stamping industries rose at an average annual rate of 0.9 percent over the 1963–83 span, but its rise during the first decade, 2.3 percent a year, was replaced by a drop during the second (−0.7 percent annually). This slowdown in the industries' output typified the output pattern of all durable manufactures over the period: for these, the annual rate of growth averaged 5 percent for 1963–73, but only 0.7 percent for 1973–83.

Demand for metal stampings stems mostly from other hard goods industries.[3] Thus, while the number of domestically made motor vehicles rose 1.8 percent a year during the 1963–73 period, it dropped 3.4 percent annually thereafter—these trends being closely matched, first, by a 4.1-percent-a-year rise, then by a 1.4-percent-a-year fall in the output of automotive metal stampings. (The larger output rates of automotive metal stampings stem from the demand for replacement stampings in addition to original equipment stampings.)

Output of automotive metal stampings was probably also slowed by imports of motor vehicles during the 1970's and early 1980's. As a proportion of new supplies of motor vehicles, imports rose from 13.6 percent in 1972 to 23.8 percent in 1981. Import penetration of parts of motor vehicles, which often embody metal stampings, rose from 7.7 to 9.1 percent. The import penetration of automotive metal stampings as such rose but slightly, barely exceeding 1 percent in 1981. However, imports classified as metal stampings are likely to have been dwarfed by imports of automotive products, of which metal stampings are an integral component.

Hard goods industries other than motor vehicles, and for which the Bureau of Labor Statistics has computed measures, likewise experienced slower growth (or declines) during the 1973–83 decade, as compared with 1963–73—a development that accounts for the parallel output trend pattern of nonautomotive metal stampings (a 2.3-percent-a-year rise followed by a 2.1-percent-a-year drop). Included in such hard goods industries are construction machinery, agricultural equipment, pumps and compressors, internal combustion engines, and refrigeration and heating equipment.[4] All these industries purchase job stampings, which accounted for nearly one-half of the total value of nonauto-

Table 1. Indexes of output per employee hour, output, and employee hours in metal stamping industries, 1963–83
[1977 = 100]

Year	Output per employee hour			Output	Employee hours		
	All employees	Production workers	Nonproduction workers		All employees	Production workers	Nonproduction workers
1963....	87.5	87.5	87.8	67.5	77.1	77.1	76.9
1964....	84.0	83.1	89.1	68.6	81.7	82.6	77.0
1965....	88.8	88.2	92.4	79.1	89.1	89.7	85.6
1966....	87.1	85.6	96.3	82.6	94.8	96.5	85.8
1967....	87.7	87.8	87.0	81.0	92.4	92.3	93.1
1968....	91.0	90.0	96.6	89.1	97.9	99.0	92.2
1969....	89.4	89.2	90.5	88.9	99.4	99.7	98.2
1970....	86.4	88.4	77.6	76.9	89.0	87.0	99.1
1971....	93.8	95.2	86.9	79.7	85.0	83.7	91.7
1972....	97.6	97.6	97.5	89.7	91.9	91.9	92.0
1973....	97.1	96.5	100.6	98.7	101.6	102.3	98.1
1974....	96.3	97.7	90.0	89.1	92.5	91.2	99.0
1975....	93.2	96.3	79.6	72.3	77.6	75.1	90.8
1976....	97.2	98.0	93.2	88.0	90.5	89.8	94.4
1977....	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1978....	101.3	100.8	103.5	102.5	101.2	101.7	99.0
1979....	102.3	102.4	101.4	99.6	97.4	97.3	98.2
1980....	99.9	102.3	88.6	85.4	85.5	83.5	96.4
1981....	101.4	103.5	91.4	85.5	84.3	82.6	93.5
1982....	98.1	103.5	76.7	76.2	77.7	73.6	99.4
1983....	104.0	106.9	91.1	88.3	84.9	82.6	96.9
	Average annual rates of change (percent)						
1963–83.	1.0	1.1	0.0	0.9	0.0	−0.2	0.9
1979–83.	0.1	1.0	−3.5	−3.5	−3.6	−4.4	0.0

Table 2. Indexes of output per employee hour, output, and employee hours in the automotive stamping industry, 1972–83

[1977 = 100]

Year	Output per employee hour: All employees	Output per employee hour: Production workers	Output per employee hour: Nonproduction workers	Output	Employee hours: All employees	Employee hours: Production workers	Employee hours: Nonproduction workers
1972....	95.9	97.3	88.6	89.3	93.1	91.8	100.8
1973....	94.8	95.5	90.5	97.9	103.3	102.5	108.2
1974....	94.9	97.3	81.9	83.0	87.5	85.3	101.4
1975....	94.1	96.9	79.5	70.8	75.2	73.1	89.1
1976....	96.4	97.3	90.5	87.8	91.1	90.2	97.0
1977....	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1978....	101.9	102.0	101.3	102.1	100.2	100.1	100.8
1979....	102.9	104.1	96.1	91.4	88.8	87.8	95.1
1980....	101.6	105.9	80.7	69.7	68.6	65.8	86.4
1981....	105.0	108.5	86.5	69.3	66.0	63.9	80.1
1982....	106.7	111.3	84.5	68.2	63.9	61.3	80.7
1983....	121.5	122.7	114.5	89.2	73.4	72.7	77.9
	Average annual rates of change (percent)						
1972–83.	1.8	1.9	1.0	-1.5	-3.2	-3.4	-2.5
1979–83.	3.9	3.9	4.0	-0.7	-4.4	-4.4	-4.6

motive metal stampings shipped in 1982, according to the Census of Manufactures.

The output slowdown in metal stampings noted for the 1972–83 period occurred largely between 1977 and 1983 (average annual rates in percent):

	1972–83	*1972–77*	*1977–83*
All hard goods	1.7	1.7	−0.5
Automotive metal stampings	−1.5	0.2	−5.0
Number of domestic motor vehicles	−3.4	0.5	−8.8
Nonautomotive metal stampings	0.7	−0.4	−2.8

Employment and hours

In 1983, the metal stamping industries employed close to 194,000 persons. Levels of employment ran 13 percent higher than in 1963, but they had receded 18 percent from their peak in 1978. Much of the rise in total 1963–83 employment, and little of the drop that occurred in recent years, took place among nonproduction workers. Production worker employment ran 10 percent higher in 1983 than in 1963, but in 1983 it still stood 20 percent below 1978.

On balance, however, the long-term trend in employment and hours in the metal stamping industries was flat. Employee hours rose at an average annual rate of 1.3 percent over the first decade of the review period, then dropped by a like magnitude over the second. Employment increased slightly faster in 1963–73 (1.9 percent a year) than employee hours, and declined a bit slower in 1973–83 (1.1 percent annually). Employment and hours in hard goods manufacturing generally paralleled these trends.[5]

The long-term trend in production jobs did not increase significantly over the 20-year span, while nonproduction employment rose at a 1-percent-a-year rate. Whereas a gain in production jobs during the 1963–73 decade was reversed thereafter, the increase in nonproduction workers merely leveled off.

The following illustrates the evolution of employee hours during the 1970's in both metal stampings industries (average annual rates of change, in percent):

	Automotive	*Nonautomotive*
1972–83	−3.0	3.3
1972–77	−0.5	0.0
1977–83	−7.3	−0.6

Production worker hours declined somewhat more than nonproduction worker hours in automotive metal stampings. But in nonautomotive metal stampings their decline contrasted with a considerable and sustained increase in nonproduction worker hours. By the end of the period, the proportion of nonproduction workers in nonautomotive metal stampings had expanded to 29 percent of total employment from 20 percent in 1972—a pattern similar to all durable manufacturing, in which the proportion of nonproduction workers had grown to 34 percent from 27 percent in 1972. In automotive metal stampings, nonproduction workers accounted for 15 percent of all employment, not much different from 11 years earlier. The employment of women progressed in relative terms—from 10 to 15 percent of the total in automotive metal stampings, and from 26 to 29 percent in nonautomotive stampings. (In all of durable manufacturing, women's employment grew from 21 to 26 percent over the 1972–83 period.)

Attesting the highly cyclical nature of the demand for automotive metal stampings, and evidently also management policies that linked output (or demand) fluctuations with employment practice, labor turnover rates in the industry ran well above the manufacturing average from 1972 to 1981[6]—as well as above the average for nonautomotive stampings. High labor turnover tends to dilute the levels of skill and experience of the work force. Such dilution (or loss) was made up to an extent by high overtime schedules in automotive metal stampings that averaged 35 percent above manufacturing for the 11 years examined here. In nonautomotive stampings, overtime ran 7 percent below.[7]

	Automotive	*Nonautomotive*
	(Manufacturing = 100)	
Accessions	119	108
Separations	124	111
Layoffs	264	118

The occupational composition of the two metal stamping industries is more heavily weighted toward production workers than manufacturing as a whole. In 1982, professional, technical, and managerial personnel accounted for 4 percent of total employment in industry group SIC 346

Table 3. Indexes of output per employee hour, output, and employee hours in the nonautomotive metal stamping industry, 1972–83
[1977 = 100]

Year	Output per employee hour: All employees	Output per employee hour: Production workers	Output per employee hour: Nonproduction workers	Output	Employee hours: All employees	Employee hours: Production workers	Employee hours: Nonproduction workers
1972....	100.0	98.2	107.7	89.3	89.3	90.9	82.9
1973....	99.8	97.1	113.0	99.7	99.9	102.7	88.2
1974....	98.4	98.0	100.2	96.6	98.2	98.6	96.4
1975....	91.7	95.2	79.5	72.6	79.2	76.3	91.3
1976....	98.0	98.8	94.9	87.1	88.9	88.2	91.8
1977....	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1978....	100.2	98.8	106.7	103.4	103.2	104.7	96.9
1979....	101.5	99.6	109.9	111.3	109.7	111.8	101.3
1980....	98.1	97.6	100.7	106.1	108.1	108.7	105.4
1981....	98.0	97.4	100.5	106.4	108.6	109.2	105.9
1982....	89.3	94.4	73.0	85.7	96.0	90.8	117.4
1983....	88.6	91.8	77.3	88.6	100.0	96.5	114.6
	Average annual rates of change (percent)						
1972–83.	−0.7	−0.3	−2.0	0.7	1.3	1.0	2.8
1979–83.	−3.6	−1.9	−9.7	−6.5	−3.0	−4.6	3.6

(metal forgings and stampings).[8] The corresponding percentage for manufacturing as a whole was 10 percent. Craft and related workers represented 27 percent of the group's employment, compared with 19 percent for all manufacturing. The differences stemmed in part from the two industries' high proportion of tool and die makers (6 percent versus 1 percent). Forty-four percent of the industry group's workers were operatives (versus 41 percent in manfacturing)—with machine tool and punch press operators making up the bulk of the employees in this category (35 percent versus 6 percent for manufacturing).

The level of, as well as the trend in, relative hourly wages was not quite so favorable in nonautomotive stampings as in automotive stampings. In 1983, these amounted to 87 percent of the durables manufacturing average, down from 94 percent in 1972. In automotive stampings, by contrast, the wage relative stood at 130 in 1983, not much different from its 1972 level.

Technological change

Both metal stamping industries discussed here convert steel mill products of varying thicknesses into a vast range of components used in capital goods and consumer durables.[9] Examples have been noted. The basic apparatus used in both industries consists of production presses. Such presses are considered to be metalforming machine tools, although unlike metalcutting machine tools they cannot reproduce themselves. Production presses have been defined as being essentially power-operated clamps that close one or more dies at a proper speed and pressure.[10] The die or dies with which a press is equipped shear, bend, or otherwise "distort" the sheet or strip fed to it, forming the desired shape. The metal is generally worked cold.

Presses vary widely in size and in the amount of power— usually expressed in terms of tonnage of pressure— they bring to bear. The die may be single purpose, as when a workpiece is simply cut out or shaped, or it may be a "progressive" or a transfer die, imparting complex shapes to the workpiece. Progressive dies, which may consist of as many as nine work stations, subject the workpiece to several sequential strokes or punches. In such operations, the steel is usually fed automatically from coils through the several work stations as a continuous ribbon of material up to the last station of the die, where the part is sheared off. Manual feeding of strip steel remains widely prevalent.[11]

According to the most recent *American Machinist* inventory of metalworking machinery, 30 percent of the metalcutting and 20 percent of the metalforming machine tools installed in the industry sector to which the two metal stamping industries belong were less than 10 years old in 1983—a somewhat lower proportion of such relatively up-to-date equipment than had been reported in the *American Machinist*'s 1973 inventory.[12] About one-third of the two industries' stock of machine tools was between 10 and 20 years old in 1983, also a lower proportion than a decade earlier. Close to two-fifths of metalcutting and nearly one-half of metalforming machine tools were 20 or more years old in 1983, considerably higher than in 1973.[13] There has thus occurred a degree of aging in the two industries' basic equipment. However, industry sources believe that such aging may have been partially offset by rebuilding and retrofitting of the older machine tools with updated components. The importance of rebuilding and retrofitting may be inferred from the rise in machine tool manufacturers' shipments of parts of metalforming machine tools, from 19 to 24 percent of total shipments between 1967 and 1972, and to around 29 percent in recent years.[14] Also confirming the importance of retrofitting is the fact that about one-third of all metalcutting machine tools and one-fourth of all metalforming machine tools in the two metal stamping industries feature numerical controls. The production capabilities of machine tools so equipped are generally higher than those without numerical controls. (See below.)

The advent of numerical controls, first applied in metalforming in the punching of flat metal in the 1950's, stimulated new press designs. It probably also contributed to a shift of some metalworking from metalcutting to metalforming machine tools, inasmuch as it helped in improving the precision of the latter. Thus, metal stampings made for automotive castings and forgings, which formerly were finished by metalcutting, came to be completed in one operation by means of metalforming. Filter system components, brake and wheel components, gasoline engine mufflers, oil filter caps, engine mounts and brackets, some kinds of gear, as well as metal cabinets for computers and other electronic devices have come to be made by stamping presses.[15] The shift evidently improved productivity significantly, for per-unit costs were reportedly reduced by as much as one-half.[16]

Numerical controls, in addition to enhancing the precision of production presses, have also made higher production speeds possible. For turret punch machines (a type of power press), setup time has been virtually eliminated, as numerical controls can automatically change punch configurations. Unit costs of short production runs have been drastically reduced as manual setups have been replaced by taped programs fed to the mechanism that controls the punch magazine.[17] Numerical controls have also facilitated rapid alternation of punching movements between the x and y or other coordinates of a workpiece. The introduction of computer numerical controls in the early 1970's, where installed, has done away with the coordinate calculation required by numerical controls.[18]

There exist tens of thousands of smaller punch presses operated manually or by foot, and equipped with an auxiliary electrical motor. Technological advances have evidently been minor here, particularly where little power is needed and production runs are short, as, for example, in crimping or embossing. Mechanical feeding devices, however, do raise the speeds of hand- or foot-operated punch presses somewhat (such presses average 15 to 20 stampings per minute).[19]

Where the use of coil stock is feasible, automated feeding of the press has been widely introduced. With continued improvement in the physical stability and accuracy of presses, as many as 1,800 strokes per minute are attained in some jobs. Automatic ejection of parts, as well as automatic chopping and removal of scrap, becomes necessary at such speeds.[20]

Partly because of the shift of some metal fabrication from metalcutting to metalforming machine tools, partly because of the needs of such industries as computers, robotics, and instrumentation, and also because of international competition, the quality control requirements of the metal stamping industries became increasingly stringent during the review period. Hence, presses had to be designed to accommodate closer tolerances. For example, some 50-ton punch presses have had to operate within 5/1000 of an inch of accuracy, without sacrificing speed, hence, productivity.[21] Quality control devices, such as coordinate measuring instruments, have come to be linked directly to computers, which correct developing inaccuracies by way of feedback systems. Such installations have tended not only to economize on the labor inputs of quality control personnel, they have also tended to reduce rejects, and have made product improvements possible—for example, the removal of burrs on small metal parts.[22]

Notwithstanding the advances sketched here, and the competitive pressures to which both metal stamping industries are subject, both retain an expensive investment in older, at times outdated equipment (as the *American Machinist* inventory data cited also indicate). Thus, the generally lower capabilities of automotive metal stamping presses in the United States than in Japan are linked largely to the enormous inventories here of older dies which must be bolted into the press, and which are transported by cranes or forklift trucks. The Japanese, who built much of their metal stamping plant in the 1970's, clamp dies hydraulically, and move them to the press by means of tracked cars. Dies are removed from the press by being pushed from their trolleys into one of these cars, while a new die is loaded from the opposite side. American press dies cannot be retrofitted to accommodate this labor-saving setup. This is but one reason for the difficulty of adopting—or adapting—updated metal stamping technologies here in the near term.[23]

Capital investment

In terms of constant dollars,[24] automotive metal stamping establishments raised their capital expeditures at an average annual rate of about 9 percent, more than triple the rate for nonautomotive stamping establishments. Trends in the real value of capital investment in machinery and equipment also differed considerably between the two industries:

	Total	*Machinery and equipment*	*Structures and buildings*
Automotive metal stamping	9.2	11.8	−4.0
Nonautomotive metal stamping	2.6	4.7	−3.3
All manufacturing	4.5	–	–

A breakdown of capital expenditure data for all manufacturing is available only for 1972–81. Constant-dollar expenditures for machinery and equipment over that period rose by 7 percent a year, and a comparison with the rates for the two metal stamping industries suggests that the captial intensity of automotive metal stamping establishments increased at an above-average rate, while the reverse was true of nonautomotive metal stamping firms. As regards structures and buildings, while the rates for the two metal stamping industries declined, the rate for all manufacturing, at least for the 1972–81 period, rose 0.7 percent a year. The relative increase indicated in the capital intensity of automotive metal stamping shops is documented by the rise in their fixed assets per employee, from 134 to 153 of the manufacturing average (=100) over the 1972–82 span. In nonautomotive metal stamping firms, assets per worker declined slightly, from 68 to 66.

The long-term rates shown obscure the exceedingly large year-to-year fluctuations in the constant-dollar capital spending of both metal stamping industries. For example, capital spending by automotive metal stamping firms ranged from a rise of 69 percent (in 1977) to a drop of 48 percent in 1982. Gyrations in outlays for structures and buildings were even more pronounced. Comparable movements for all of manufacturing were much more moderate. It should be noted that nearly all of the decline in the two industries' spending rates for structures and buildings stems from cutbacks after 1978.

Structure of the metal stamping industries

The number of establishments in the two metal stamping industries together rose 25 percent between 1972 and 1982. All of the increase occurred among smaller firms with up to 49 employees, while a decline took place among firms with 100 workers or more. In automotive metal stampings, establishments with up to 49 employees accounted for 65 percent of the total in 1982, as against 46 percent in 1972; for nonautomotive shops, the comparable proportions read 82 percent versus 80 percent. However, the percentage of total employment in the smaller firms, while also higher in 1982 than a decade earlier, remained modest. It rose from 5 to 9 percent in automotive metal stampings, and from 27 to 34 percent in nonautomotive stampings.

Larger metal stamping establishments continued to account for a predominant share of employment in automotive stamping shops, and for close to one-half of it in the nonautomotive stamping industry. In the former, establishments with 100 workers or more represented 82 percent of the work force in 1982, in the latter 47 percent. Automotive stamping firms have, for the most part, been large employers, but nonautomotive stamping firms have been typically of modest size, with firms employing 500 workers or more accounting for but 12 percent of this industry's workers.

Automotive metal stamping averaged 135 employees per establishment in 1982, nonautomotive stamping shops, 37. The great differences in both employment size distribution as well as in average number of workers per establishment reflect in part the difference between fixed assets per worker, hence, the extent of business opportunities for persons knowledgeable in the trade. The figure was $23,773 for nonautomotive metal stampings, and $55,265 for automotive metal stampings in 1982 (for all manufacturing the figure read $36,146). Investment per worker in structures also was much lower in the former industry (around $5,400) than in the latter (about $10,800). (Here, the manufacturing average was $8,700.)

Outlook

Industry analysts generally foresee advances in stamping press technology which would raise operating time owing to such factors as improved ease of maintenance, and greater precision without loss of press speed. Robotic transfer and assembly too is likely to be introduced more widely. In turn, output per unit of labor input would be expected to rise. Among anticipated improvements, as well as improvements already on stream but not as yet broadly diffused are devices (such as die cushions) that slow the downward speed of the press. Downward speed accelerates after the punch has penetrated the upper portion of a given workpiece and resistance to the punch's force weakens. Unless the speed is inhibited, the press destabilizes, and this can lead to severe maintenance problems. Also, overload protection, which is designed into the clutch or hydraulic system controlling the press stroke, will likely be adopted by more metal stamping shops.[25]

Wider diffusion of solid state press controls is also expected. Such controls, which have no moving parts, usually eliminate the maintenance chores and problems associated with electromechanical controls. Diagnostic and self-check circuits are more easily incorporated in such controls, and at lower cost than in their electromechanical counterparts.[26]

Continuous-operating presses, equipped with progressive (or transfer) dies, and fed by automatic coil feed systems, are also seen to be more widely adopted. Such presses, with their high production capabilities, require but a single operator who monitors them. They completely fabricate a part with each stroke; that is, they permit the elimination of all secondary operations and multiple handling.[27] The reduction of die changing time from hours to a few minutes is also likely to become more widely prevalent. As noted, however, this requires the scrapping of existing presses, and large investments in technically more advanced ones, featuring quick die changing mechanisms. In addition, new die transportation systems would have to be installed.[28] The obsolescence of older presses and their dies, together with the force of international cost competition, may in time compel these investments.[29]

Precision requirements for metal stampings (as for other types of metalworking products) are expected to become more exacting in the years ahead, and small-batch production more frequent.[30] These developments spell increasing reliance of metal stamping establishments upon automated and computerized metalforming systems, as well as on die technologies that minimize setup changes. Electronic controls and digital readouts in the shearing, bending, and punching of blanks are also likely to be adopted by more shops. The pace of diffusion depends in some measure upon prospects of production cost savings, which, to be sure, in the two metal stamping industries tend to be clouded by demand cyclicality.

Marrying metal stamping to assembly processes for the thousands of fabrications the two industries produce (or will produce) remains a test of the innovativeness of the designers and builders of presses and their accessories.[31] The trend toward eliminating manual assembly, and of integrating the metalforming with the assembly process seems likely to become more pronounced.[32] This tends to do away with transfer operations. Thus, when two or more parts of a given workpiece are to be joined to make up a given fabrication, this can often already be done without loss of press stroke speed.[33]

Nevertheless, robotics as transfer devices are bound to continue to replace human labor in metal stamping—both automotive and nonautomotive. Where the size and complexity of some workpieces necessitate multistation press production lines, that is, where progressive dies are not feasible, transfer of the workpiece from one press to the next is increasingly likely to be done by robots.[34] Of course, short-run stamping operations will remain routine in many metal stamping operations, and these, so industry observers hold, will not soon become susceptible to robotics. Currently, 4,000 to 5,000 stampings of the same configuration are required to yield a reasonable payoff on any investment in robotizing feeding or tailing the press.[35] Where longer runs justify the introduction of robots, they are believed likely also to make a broader program of punch press automation economical.[36]

For the 1984–95 period, BLS has projected a rise of between 5 and 15 percent in the wage and salary employment of the industry group to which the two metal stamping industries belong. The occupational mix of the industry group is expected to shift somewhat toward more highly skilled workers. The proportion of operatives, such as punch press and assembly workers, has been projected to decline from 44 to 42 percent of the industry group's total employment, while that of craft and related workers rises from 27 to 29 percent. The projections presuppose that the technological advances anticipated in metalforming will not be significantly labor-displacing, or obviate the need for skilled personnel in the years ahead. □

FOOTNOTES

[1] The metal stamping industries discussed in this article include automotive metal stampings, designated by the Office of Management and Budget as SIC 3465 in the *Standard Industrial Classification Manual, 1972*; and metal stampings, not elsewhere classified (nonautomotive metal stampings), as SIC 3469. In addition to SIC 3465 and SIC 3469, the measures presented with this article also include crowns and closures (SIC 3466). Automotive stampings consist of such products as hubs, trim, and other parts of motor vehicles. Nonautomotive stampings include job stampings, household appliance housings and parts, and other porcelain enameled products; and cooking and other kitchen utensils. Crowns and closures include bottle caps made of stamped metal, and jar crowns, similarly made.

Average annual rates shown in the text and tables are based on the linear least square trend of the logarithms of the index numbers. The indexes for productivity and related variables will be updated annually, and published in the annual BLS bulletin, *Productivity Measures for Selected Industries*.

[2] Prior to 1972, establishments manufacturing all categories of metal stampings were designated as SIC 3461 by the Office of Management and Budget. Beginning in 1972, metal stamping products were regrouped in accordance with the classifications described in footnote 1. Crowns and closures, for which no separate measure has been published here, account for about 3 percent of the employment of the three industries together.

[3] See *The Detailed Input-Output Structure of the U.S. Economy, 1977* (U.S. Department of Commerce, Bureau of Economic Analysis, 1984). See also the tables pertaining to SIC 346. The pertinent industry chapter of the *1982 Census of Manufactures*, table 6a-1, also yields relevant information.

[4] Major industrial consumers of metal stampings where average annual rates in output declined between 1963–73 and 1973–83 include:

	1963–73	*1973–83*
Internal-combustion engines	6.2*	−0.7
Farm and garden machinery	3.2	−3.6
Construction machinery	4.1	−4.6
Machine tools	−1.6	−4.2
Pumps and compressors	3.7	1.1
Refrigeration and heating equipment	12.3*	−0.2
Transformers	7.5	−0.7
Motors and generators	1.7	−0.9
Major household appliances	4.0	0.7
Radio and TV receiving sets	3.3	1.8
Motor vehicles and equipment	4.6	−5.1

*1967–73.

[5] Trends in employment and hours in durable goods manufacturing (average annual rates in percent):

	Employment	*Employee hours*
1963–83	0.6	0.5
1963–73	2.1	2.2
1973–83	−0.9	−1.2

[6] Data for years after 1981 are not available. See John Duke and Horst Brand, "Cyclical behavior of productivity in the machine tool industry," *Monthly Labor Review*, November 1981, p. 30.

[7] Overtime in automotive and nonautomotive metal stamping (all manufacturing = 100):

	Automotive	*Nonautomotive*
1972	128	103
1973	136	100
1974	126	97
1975	104	81
1976	163	100
1977	162	84
1978	145	92
1979	114	100
1980	107	100
1981	136	86
1982	123	82
1983	183	93
1984	169	97

[8] BLS employment by industry and occupation matrix, 1982 and 1995 alternatives. Automotive and nonautomotive metal stampings account for 80 to 82 percent of the employment of the industry group (SIC 346) to which they belong.

[9] According to the Bureau of the Census, nonferrous metals and plastics represent a very small proportion of the materials consumed by the two metal stamping industries.

[10] *Modern Machine Tools*, p. 197.

[11] Industry information.

[12] "13th *American Machinist* Inventory of Metalworking Equipment," *American Machinist*, November 1983, various pagings.

[13] "11th *American Machinist* Inventory of Metalworking Equipment," *American Machinist*, November 1977.

[14] National Machine Tool Builders Association. Data on parts shipments from the Bureau of the Census, Census of Manufactures.

[15] *Metal Stamping*, August 1969, pp. 18–19; and industry information.

[16] *Ibid.*

[17] Industry information.

[18] *American Machinist*, April 1977, p. SR-6.

[19] *Ibid.*, p. SR-7. Also, information from J. Winship, Wordsmith Enterprises, Allendale, NJ.

[20] *Metal Stamping*, May 1970, p. 14. Also, *American Machinist*, January 1983, p. 117.

[21] *American Machinist*, April 1977, p. SR-13 ff. The Minster Machine Co. recently advertised a press capable of meeting tolerances of as low as

±.005″ with impacts of 20 and 30 tons. The press is required to run up to 537,000 strokes per shift. See *Metal Stamping,* January 1985, back flap.

[22] Industry information.

[23] *Japanese Automotive Stamping: Observations, Conclusions, and Recommendations of the American Metal Stamping Association Study Team and a Report to Members* (Cleveland, OH, American Metal Stamping Association, 1981).

[24] Capital expenditures were deflated by the implicit price deflators published in *The Annual Report of the Council of Economic Advisers,* February 1985, table B-3, p. 236. See *Economic Report of the President,* transmitted to the Congress, February 1985.

[25] Leo R. Rakowski, "Press advances spur stamping productivity gains," *Machine Tool Blue Book*, November 1979, pp. 177–83. See also Donald J. Hennelgarn and Charles Gregorovich, "Stamping Systems Automation," a paper presented at the Biennial International Machine Tool Technical Conference, Chicago, Sept. 5–13, 1984. See Donald F. Wilhelm, "New Developments in Press Force Monitoring," a paper presented at the Biennial International Machine Tool Technical Conference, Chicago, Sept. 5–13, 1984.

[26] Rakowski, "Press advances spur productivity gains."

[27] *Ibid*.

[28] *Ibid.* See also *Japanese Automotive Stamping*.

[29] *Japanese Automative Stamping* and industry information.

[30] *Metal Stamping*, September 1985, p. 3.

[31] See, for example, Robert Rice, "Manufacturing with the use of transfer systems," *The Fabricator,* November-December 1984; and John T. Winship, "Form compression heads in one pass," *American Machinist,* May 1980, reprint. See also the advertising brochure of Willett Transfer Systems, published by M. S. Willett, Cockeysville, MD.

[32] *Metal Stamping,* July 1985, p. 13.

[33] *Ibid*.

[34] *Metal Stamping,* November 1984, pp. 8–11.

[35] Hennelgarn and Gregorovich, *Stamping Systems Automation,* pp. 12–106.

[36] James R. Hunter, "New Punch Press Technologies," a paper presented at the Biennial International Machine Tool Technical Conference, Chicago, Sept. 5–13, 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 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 that require more labor time to produce are given more importance in the index.

In the absence of adequate physical quantity data, the output indexes for the industries discussed here were 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 overall output measures. The result is a final output index conceptually close to the preferred output measure.

Employment and employee hours indexes were derived from data published by the Bureau of the Census. 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 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.