# Productivity growth low in the oilfield machinery industry

*Output per employee hour increased an average of only 1.2 percent annually in the oilfield machinery industry between 1967 and 1983, with output going through several boom and bust cycles*

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Output per employee hour in the oilfield machinery industry[1] grew at an average annual rate of 1.2 percent between 1967 and 1983, compared with a 2.4-percent rate for the entire manufacturing sector. During this period, output grew at an average annual rate of 8.1 percent, while average annual growth in employee hours was 6.8 percent.

This industry has been strongly influenced by worldwide changes in the price of oil with resulting shifts in production of crude oil and natural gas. Increases in oil prices and expectations of future oil price increases have led to spurts in activity in the oilfield machinery industry, followed by periods of slower output growth or output declines as oil prices stabilized or dropped.

Long-term gains in productivity have reflected some innovations in machining techniques, such as numerical control and improvements in handling and storing materials. However, this industry is rather labor intensive, making a variety of products with highly specific requirements for individual customers. Large increases in output have generally been offset by similar jumps in employment, leading to overall modest productivity growth. Sharp gains in capital expenditures, spurred by rapidly increasing oil prices, were more in the nature of duplicating facilities to meet growth in demand rather than expenditures for more advanced types of technology.

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The oilfield machinery industry produces equipment for the drilling of oil and gas wells and equipment to control the flow of oil and gas from producing wells. This includes surface and subsurface drilling equipment for both rotary and cable tool types of drilling operations. Waterwell and blasthole drilling equipment are made in this industry, as is portable drilling equipment. Equipment for offshore oil drilling is produced and sold to the shipbuilding industry, which manufactures the offshore platforms. Subsea wellhead equipment is also produced.

## Trends in productivity and output

The productivity trend in this industry recorded a distinct change between the 1967–73 period and that of 1973–81. This change can be related to the impact of the Mideast oil embargo, which began in 1973. In 1982, a third period began, characterized by a sharp drop in demand. (See table 1.)

During 1967–73, productivity grew at a rate of 3.5 percent, with its greatest gains at the end of the period, in 1972 and 1973. The productivity trend reflected an average annual gain of 4.8 percent in output and 1.2 percent in employee hours. During this period, productivity declined in only one year—1969.

After 1973, there was a turnaround and productivity fell off. Despite a boom in output, productivity recorded a decline over 1973–81. Spurred by oil shortages in 1973–74 and again in 1979, the price of crude oil quintupled during

**Table 1. Output per employee hour and related indexes in the oilfield machinery and equipment industry, 1967–83**

[1977 = 100]

| Year | Output per employee hour | | | Output | Employee hours | | |
|---|---|---|---|---|---|---|---|
| | All employees | Production workers | Non-production workers | | All employees | Production workers | Non-production workers |
| 1967 | 86.3 | 86.6 | 85.4 | 49.1 | 56.9 | 56.7 | 57.5 |
| 1968 | 87.2 | 86.3 | 89.1 | 52.5 | 60.2 | 60.8 | 58.9 |
| 1969 | 82.1 | 80.3 | 86.0 | 54.5 | 66.4 | 67.6 | 63.4 |
| 1970 | 86.4 | 87.2 | 84.7 | 54.7 | 63.3 | 62.7 | 64.6 |
| 1971 | 90.7 | 95.1 | 82.0 | 52.5 | 57.9 | 55.2 | 64.0 |
| 1972 | 99.7 | 103.1 | 92.8 | 59.7 | 59.9 | 57.9 | 64.3 |
| 1973 | 105.7 | 107.3 | 102.2 | 70.6 | 66.8 | 65.8 | 69.1 |
| 1974 | 121.4 | 120.4 | 123.5 | 92.5 | 76.2 | 76.8 | 74.9 |
| 1975 | 107.9 | 105.0 | 115.0 | 98.4 | 91.2 | 93.7 | 85.6 |
| 1976 | 100.7 | 100.9 | 100.6 | 94.5 | 93.8 | 93.7 | 93.9 |
| 1977 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 1978 | 109.3 | 107.2 | 114.8 | 124.1 | 113.5 | 115.8 | 108.1 |
| 1979 | 105.6 | 104.6 | 107.6 | 128.8 | 122.0 | 123.1 | 119.4 |
| 1980 | 104.0 | 102.7 | 107.3 | 147.4 | 141.7 | 143.5 | 137.4 |
| 1981 | 104.7 | 101.1 | 114.5 | 191.9 | 183.2 | 189.9 | 167.6 |
| 1982 | 98.4 | 99.7 | 95.6 | 157.2 | 159.7 | 157.7 | 164.4 |
| 1983 | 100.7 | 112.8 | 80.6 | 94.1 | 93.4 | 83.4 | 116.7 |
| | Average annual percent change[1] | | | | | | |
| 1967–83 | 1.2 | 1.4 | 1.1 | 8.1 | 6.8 | 6.7 | 7.0 |
| 1967–73 | 3.5 | 4.2 | 2.1 | 4.8 | 1.2 | 0.5 | 2.7 |
| 1973–81 | −0.8 | −1.1 | 0.1 | 10.9 | 11.8 | 12.1 | 10.8 |
| 1981–83 | −1.9 | 5.6 | −16.1 | −30.0 | −28.6 | −33.7 | −16.6 |

[1]Based on the linear least squares trend of the logarithms of the index numbers.

this period. Output in the oilfield machinery industry increased at an average annual rate of 10.9 percent from 1973 to 1981. Average annual increases of 11.8 percent in employee hours, however, led to an overall average annual decline of 0.8 percent in productivity.

There were very large output increases in 1974—31.0 percent—and in 1978—24.1 percent. Toward the end of the period, very rapidly increasing oil prices and expectations of continuing oil price increases beginning in 1979 led to another boom in demand for industry products. Output increased 14.4 percent in 1980 and 30.2 percent in 1981, when demand peaked.

Many industry products, especially the oil drilling rigs themselves, are reused in the exploration for oil and therefore can be stockpiled. When drilling activity slows and the need for oilfield machinery is filled, industry demand slumps rapidly. Periods of strong output growth are usually followed by periods of more modest growth or declines. Therefore, during 1973–81, despite the overall high rate of growth, output posted only moderate gains in 1975, 1977, and 1979. In 1976, output declined 4.0 percent. However, employee hours had gains in every year and very large increases in 1974, 1975, 1978, 1980, and especially 1981 (23.9 percent). Therefore, there were only three productivity increases during this period: 14.9 percent in 1974, 9.3 percent in 1978, and a modest 0.7 percent in 1981. The remaining years had productivity declines with large drops in 1975 (−11.1 percent) and 1976 (−6.7 percent).

During the boom period, the industry's major interest was satisfying burgeoning demand for oilfield equipment.[2] New plant and equipment were added rapidly. In this period, the industry's customers—drilling contractors and oil companies—were more concerned with their ability to search for and find oil than with the cost of equipment. Prices for oilfield machinery increased drastically. The price index for the industry more than tripled from 1973 to 1981. Despite the price gain, capital expenditures (in constant 1972 dollars) by the crude petroleum and natural gas industry increased by almost 500 percent between 1972 and 1981. The products made in this industry tend to be expensive relative to other industrial equipment: for example, a standard-sized carbide drill bit currently costs around $6,000 and a subsea well Christmas tree (complicated wellhead valve) could cost as much as $320,000.[3] However, in relation to the overall costs of exploring for oil or the return on investment of a successful well, the equipment cost is low. This is also true for wellhead equipment, such as "Christmas trees," where a subsea blowout can cause serious environmental problems. Therefore, rapidly increasing equipment prices were less important to the oil exploration industry than the need to provide oil during this period.

The boom in demand for industry products halted abruptly in 1981.[4] Worldwide oversupply of oil began depressing oil prices. Uncertainty about continued increases in oil prices caused a sharp decline in drilling rig activities. In the United States alone, the number of rotary oil rigs in use fell from a high of more than 4,500 in 1981 to fewer than 2,400 in 1982.[5] There was an oversupply of usable oil rigs. Industry output fell 18.1 percent in 1982 and plummeted 40.1 percent in 1983. A large reduction in employee hours in 1982 did not keep pace with output, and productivity fell 6.0 percent. However, in 1983, employee hours dropped more than output, falling 41.5 percent, and productivity recorded a gain of 2.3 percent.

## Exports and employment boom

The U.S. industry is the leader in worldwide oilfield machinery production. It supplies nearly all of domestic demand and much of the equipment used by foreign nations. Exports have been a large part of the industry's shipments, and this segment grew substantially during the period measured. In 1967, 26 percent of oilfield machinery produced in the United States was exported. By 1972, this percentage had grown to 45.2 percent. Exports have remained at least 40 percent of shipments since 1972, and reached peaks of 65 percent in 1975 and 63 percent in 1976.[6] The United States has few international competitors in oilfield equipment. For example, while Japan and Korea produce offshore oil barges and platforms, the drilling equipment installed on these units tends to be supplied by the United States.[7]

Total employment in the oilfield machinery industry increased from 39.9 thousand in 1967 to a high of 122.3 thousand in 1981 and then fell off sharply to 68.3 thousand

in 1983. This growth is equivalent to the very high rate of 6.8 percent per year during 1967–83. In fact, this is the highest rate of employment gain among all the industries with published productivity measures, and can be contrasted with the low growth rate of 0.1 percent per year for the total manufacturing sector over the same period.

The employment gain in this industry paralleled the changes in demand for equipment by the oil-producing industry. Employment remained fairly level between 1967 and 1972 and was not affected much by the recession of 1970. In 1973, however, employment started to expand rapidly. Employment was up 8.8 percent between 1972 and 1973, it grew 13.9 percent more by 1974, and was up 20.3 percent by 1975. These large gains were in contrast to the employment situation in the total manufacturing sector, which was negatively affected by the 1974–75 recession and recorded employment declines in both 1974 and 1975. Employment in the oilfield machinery industry continued to grow strongly from 1975 to 1978. The energy crisis in 1979 accelerated demand for oilfield equipment and employment expanded even more rapidly, growing 9.4 percent from 1978 to 1979, an additional 14.3 percent to 1980, and jumping 26.5 percent to its peak in 1981. However, in 1982, the sharp falloff in drilling activity hit the industry drastically, and employment dropped 7.7 percent between 1981 and 1982 and another 39.5 percent between 1982 and 1983.

Employment of production workers grew at about the same high rate (6.7 percent per year) as total employment during 1967–83. Employment of nonproduction workers increased at the slightly higher rate of 7.0 percent over the period. Production workers accounted for about two-thirds of total employment in 1967. This proportion remained fairly stable over the study period.

The growth in hours of all employees, production workers, and nonproduction workers was quite similar to the employment growth in these categories from 1967 to 1983. Therefore, average annual hours did not change much over the period.

## Wages above average

Average hourly earnings of production workers were somewhat higher for the oilfield machinery industry than for the average of all-manufacturing industries during the study period. In 1967, the earnings of production workers in the oilfield machinery industry were about 6 percent higher than the all-manufacturing average. This earnings advantage remained approximately the same until 1973 and then began to increase during the period of accelerating demand for oilfield equipment. So, by 1983, average hourly earnings of production workers at $10.41 were about 18 percent higher in this industry than in manufacturing as a whole.

These higher earnings are one indicator that the skill levels of the workers in this industry are somewhat higher than in manufacturing as a whole. Data on occupations tend to substantiate this. Occupational data exactly matching this industry are unavailable. However, data on occupations are available at a broader level of aggregation for the construction and related machinery and equipment group. In 1982, employment in the oilfield machinery industry accounted for the largest proportion of this group. Therefore, the aggregate data should be indicative of the occupational distribution in the industry.[8] Although the proportion of craft workers was slightly higher in all manufacturing than in this group, in key craft occupations the group including oilfield machinery accounted for a higher percentage than manufacturing as a whole in 1982. For example, metalworking craft workers were 5.2 percent of all workers, compared with 3.1 percent in manufacturing. Within the metalworking category, machinists and layout markers accounted for 2 percent of employment, compared with 0.9 percent for manufacturing.

For operatives, the proportions were quite similar, 41 percent for the group including oilfield machinery, compared with 40 percent for manufacturing. However, metalworking operatives were significantly greater in this group at 23.3 percent, compared with only 6.8 percent for manufacturing as a whole. Within metalworking, machine tool operators at 13.2 percent were much higher than all manufacturing at 4.7 percent, while welders were also significantly higher at 9.9 percent in this group versus 1.7 percent for manufacturing.

Although the proportion of engineers was slightly higher for manufacturing as a whole, mechanical engineers in the industry group including oilfield machinery accounted for 1.5 percent, compared with 0.6 for manufacturing. In addition, drafters at 2.2 percent were significantly above the 0.6 percentage for manufacturing.

## The industry expands

Rapid industry growth during the post-1973 output boom can be seen in the increase in the number of establishments. In 1967, there were 360 establishments in the industry and this number declined to 315 by 1972. In 1977, however, the number of establishments had grown to 478, and by 1982 there were 1,011.

The size of establishments in this industry also increased rapidly during the post-1973 period. In 1967, there were 69 establishments with 100 employees or more. By 1972, the number of these establishments had risen to only 71; however, in 1977, there were 103 of these larger establishments and by 1982, 172.

The industry is located for the most part in oil-producing States. In 1982, more than half of the establishments—537—were in Texas. Oklahoma had the next highest number of establishments, 132; Louisiana had 83; and California, 75.

## Capital expenditures

Capital expenditures per employee for this industry were below the average for all-manufacturing industries in 1967

and 1968 and roughly equal to all-manufacturing levels during 1969–73. Industry expansion after 1973, however, caused a sharp increase in capital expenditures, which nearly tripled in terms of current dollars from 1973 to 1974. From 1974 forward, average capital expenditures per employee were well above all-manufacturing levels. For example, capital expenditures per employee were $9,116 in 1982, more than double the all-manufacturing average of $3,923.

Although capital expenditures increased sharply during the post-1973 period, many of the plants and much of the equipment installed was duplicative rather than innovative. The industry's major concern was rapidly increasing production capacity in order to satisfy soaring demand. Efficiency of operations was not emphasized as long as production could be maximized. Employment increased sharply and productivity was negative from 1973 to 1981.

## Technological change

The products made in this industry include items such as drill bits, drawworks, mud pumps, wellhead valves (such as Christmas trees), derricks, as well as complete stationary and truck-mounted drilling rigs. The manufacture of these items generally involves some form of metalworking. Materials used usually are iron and steel castings and forgings and steel shapes. Most of the products made tend to be fairly unique and are not made in long runs. Therefore, manufacturing consists mainly of batch operations limiting the opportunities for efficiencies related to assembly line production. Many of the manufacturing operations are very labor intensive. Much of the new technology in use was introduced for product changes and tighter tolerances rather than for labor savings.[9]

In most cases, production equipment tends to be situated in cell-type layouts in which machine tools of a similar type are grouped together, rather than in workflow layouts. This has occurred because of frequent product changes, resulting in workflow shifts, making it more economical to move the product to a specialized machine tool center than to dedicate specific machine tools to a rigid workflow pattern. In some cases, for example, the manufacture of tool joints, workflow layouts have been set up to increase efficiency.

Numerical control of machine tools has been one of the most important innovations in this industry. Numerically controlled machining equipment is particularly suited to the batch type operations common to the industry, and such equipment is in widespread use. Computerized numerically controlled machine tools, a fairly recent innovation, are being used to some extent. Computerization increases the flexibility of the units being controlled and results in continuously produced shapes and tolerances not otherwise feasible.[10] However, manually operated machine tools continue to be used for many industry operations because of the low-volume nature of the products made.

Numerical control has also been applied to welding, which is an important manufacturing operation in this industry. Computer-controlled electron beam welding also is in use, as is friction welding. Numerically controlled flame-cutting equipment has also been operating in this industry.

Computer-assisted design and computer-assisted manufacturing (CAD–CAM) is another important innovation that is beginning to be utilized in the industry. These techniques allow quick changes in the design of products to meet specific needs. CAD–CAM is particularly useful in making items such as specialized valves, Christmas trees, and other wellhead equipment that must be tailored to fit severe operating conditions, such as for subsea or arctic wells. Using CAD, designs that might have taken months are now completed in weeks.[11] CAD is in more widespread use in the industry than CAM. However, in some cases the computer system used produces tapes to run numerically controlled machine tools (CAM). For example, one drill bit manufacturer uses CAD–CAM to create new designs or modify existing designs three to twenty times faster than using conventional design-drafting techniques. The specifications for all their products are in their data base for immediate access, and tapes are produced to run numerically controlled machine tools making parts for the final product.[12]

An important innovation is the use of computers for scheduling workflow and for inventory control. Computerized high-rise warehouses have been installed by a number of firms in the industry. Also, computers are being used for testing, for example, in checking subsea and artic wellhead valves.

## Future productivity uncertain

Lower levels of industry activity that began in 1982 are expected to continue through the mid-1980's. Demand for industry output is likely to vary by product. For products such as drill bits and tool joints, which wear out with use, industry experts project some increases in demand as drilling activity resumes modest long-term trends. However, demand for drill rigs, which can be stockpiled, will be affected by the oversupply of usable rigs, and output is expected to be low in the next few years. Much of limited demand for drill rigs should come from Third World nations and the People's Republic of China.[13]

Output of oilfield machinery is greatly influenced by expectations of demand for oil and future oil prices. A large drilling project, requiring a number of drill rigs, may not produce oil for up to 2 years after the equipment is ordered. In the past, demand for oil could be gauged by projections of U.S. and worldwide economic growth. This relationship, however, has been upset by conservation efforts. The effect of possible changes in the tax laws regarding oil depletion allowances has added to the financial uncertainty in oil well drilling. In addition, many smaller exploration companies were hard hit by the slump.[14] Because of these factors, drilling activity in the near future will probably continue to remain well below the recent peak period and demand for industry products is expected

to be low.[15] This situation, however, could change rapidly if there is another oil crisis.

During the current slowdown, many firms are emphasizing efficiency in an effort to cut costs. Inefficient capacity in operating plants has been shut down. Some plants have been completely closed, and firms have gone out of business. Therefore, the industry's inability to increase productivity has been enhanced. However, the continued low level of output growth that is expected will make substantial productivity growth unlikely. □

*FOOTNOTES*

[1] The oilfield machinery and equipment industry is classified as Standard Industrial Classification (SIC) 3533 in the *Standard Industrial Classification Manual 1972* and its 1977 supplement, issued by the U.S. Office of Management and Budget. This industry includes establishments primarily engaged in manufacturing machinery and equipment for use in oil and gas fields or for drilling waterwells.

[2] "Equipment Supplies Tighten as U.S. Drilling Rises," *Oil and Gas Journal*, Mar. 17, 1980, p. 86.

[3] Information obtained from industry representatives.

[4] Rick Hagar, Glenda E. Smith, and Roger Vielvoye, "World Production of Oil Sinks to Lowest Volume in a Decade," *Oil and Gas Journal*, Mar. 14, 1985, pp. 23–26.

[5] *Hughes Rig Count* (Hughes Tool Company, 1983).

[6] *U.S. Industrial Outlook 1985* (Washington, U.S. Department of Commerce, International Trade Administration), pp. 23–26.

[7] Information obtained from industry representatives.

[8] *BLS Industry—Occupational Employment Matrix, 1982, 1995 Alternatives* (Bureau of Labor Statistics), pp. 154–65, 385–90.

[9] Information obtained from industry representatives.

[10] *Oilfield Catalog, 1984* (Hughes Tool Division), p. 76.

[11] Information obtained from industry representatives.

[12] *Oilfield Catalog, 1984* (Hughes Tool Division), p. 71.

[13] Information obtained from industry representatives.

[14] "Significant Surge in U.S. Drilling Seen at Least One Year Away," *Oil and Gas Journal*, July 11, 1983, pp. 25–28.

[15] "U.S. Drilling Outlay Down 36.3 Percent in 1983," *Oil and Gas Journal*, Dec. 17, 1984, pp. 48–50.

## 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.

Because data on physical quantities are not reported for the oilfield machinery industry, real output was estimated by a deflated value technique. Changes in price levels were removed from current-dollar values of production by means of appropriate price indexes at various levels of subaggregation from the variety of products in the group. To combine segments of the output index into a total output measure, employee hour weights relating to the individual segments were used, resulting in a final output index that is conceptually close to the preferred output measure.

Employment and employee hour indexes were derived from data published by the Bureau of Labor Statistics. 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 relate total output to one input—labor. The indexes do not measure the specific contribution of labor or capital, or any other single factor. 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.

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