News

MULTIFACTOR PRODUCTIVITY TRENDS IN MANUFACTURING, 2005

The Bureau of Labor Statistics of the U.S. Department of Labor today reported multifactor productivity data—output per unit of combined inputs—for the manufacturing sector and for durable goods, nondurable goods, and three-digit (NAICS) manufacturing industries for the year 2005.

In manufacturing, the annual rates of multifactor productivity change for 2005 were:

    3.4 percent in the manufacturing sector and
    3.3 percent in the durable goods manufacturing sector and
    3.2 percent in the nondurable goods manufacturing sector.

At 3.4 percent, multifactor productivity growth in the manufacturing sector slowed somewhat compared to 2004 (3.8 percent). This was due to a deceleration in durable goods manufacturing productivity growth from 4.5 percent to 3.3 percent. A small acceleration in nondurable goods manufacturing productivity growth from 2.5 percent to 3.2 percent partially offset the slower growth of multifactor productivity in durable goods manufacturing. The 2004-05 annual changes are summarized in table A, and further detail and historical measures are shown in tables 1 through 3.

Multifactor productivity is designed to measure the joint influences on economic growth of technological change, efficiency improvements, returns to scale, reallocation of resources, and other factors, allowing for the effects of capital, labor, and in the case of the manufacturing sector, intermediate inputs (energy, materials, purchased business services). Multifactor productivity, therefore, differs from labor productivity (output per hour worked) measures that are published quarterly by BLS since it includes information on capital services and other data that are not available on a quarterly basis.

The data sources and methods used in the preparation of the manufacturing series differ from those used in preparing the private business and private nonfarm business multifactor series and therefore the measures are not directly comparable. See BLS News Release USDL 07-0758, Preliminary Multifactor Productivity Trends, 2006 for information on multifactor productivity measurement in the private business and private nonfarm business sectors.

Table A. Compound average annual rates of growth for multifactor productivity, output per hour of all persons, output per unit of capital services, and related measures in the manufacturing sector for selected periods, 1987 to 2005

	1987-05	1987-90	1990-95	1995-00	2000-05	2004-05
Productivity						
Multifactor productivity[1]	1.6	0.2	1.2	2.0	2.5	3.4
Output per hour of all persons	3.7	1.7	3.4	4.7	4.3	4.7
Output per unit of capital services	0.2	-0.1	0.6	0.4	-0.1	3.9
Sectoral Output	2.5	2.1	3.3	4.5	0.1	3.5
Inputs						
Hours[2]	-1.2	0.4	-0.1	-0.2	-4.1	-1.1
Capital services	2.3	2.2	2.7	4.1	0.1	-0.3
Energy	-1.3	1.9	1.6	-2.5	-4.7	-3.3
Non-energy materials	1.8	1.6	3.6	4.9	-2.9	1.0
Purchased business services	2.2	5.4	3.0	2.4	-0.7	1.3
Combined inputs[3]	0.9	2.0	2.1	2.4	-2.4	0.1

1. Output per unit of combined hours, capital, energy, materials, and business services inputs.
2. Hours at work of all persons.
3. The growth rate of each input is weighted by its share of nominal costs.

Manufacturing sector

Multifactor productivity in the manufacturing sector rose 3.4 percent in 2005 (see table A). This is the fourth consecutive year that multifactor productivity rose in manufacturing (see table 2). The multifactor productivity gain in 2005 reflected a 3.5 percent increase in sectoral output and a 0.1 percent increase in combined inputs, which, while modest, was the first increase since 1999. Capital services declined 0.3 percent in 2005, after having also declined in 2004. Hours declined 1.1 percent in 2005, materials rose 1.0 percent and purchased business services rose 1.3 percent.

Historical trends in manufacturing

Labor productivity (output per hour worked) differs from multifactor productivity (output per unit of combined inputs) in the treatment of both capital and intermediate inputs (energy, materials, and business services). Labor productivity measures do not explicitly account for the effects of capital nor do they account for changes in the effects of intermediate inputs on output growth. As a result, changes in input intensity (the input-hours ratio) can influence labor productivity growth. In contrast, multifactor productivity treats capital and intermediate inputs as explicit factors of production and, therefore, is net of changes in input intensity. Historical trends in labor productivity growth can be viewed as the sum of five components: multifactor productivity growth, and the contribution of the intensity of the following inputs: capital, energy, materials, and business services (see table B).

The contribution of input intensity equals the change in the input-hours ratio multiplied by the input's cost share. Historically the labor share is about a third of total cost, the capital share about a sixth, the materials share a little over a fourth of total cost, and the business services share a little less than a fourth. The energy share is historically only about 3 percent of total cost.

Multifactor productivity in manufacturing grew 1.6 percent annually between 1987 (the starting point of the series) and 2005 (see table A). Sectoral output increased at a 2.5 percent annual rate over the period, and combined inputs rose an average of 0.9 percent per year. Of the 3.7 percent growth rate in output per hour (labor productivity), 1.6 percent can be attributed to increases in multifactor productivity, 0.6 percent to the contribution of capital intensity, 0.8 percent to changes in materials intensity, and 0.7 percent to changes in business services intensity (see table B). The remaining input, energy, was a very small share of total inputs; therefore, it made no discernable contribution to output per hour.

From 1995 to 2000, multifactor productivity in manufacturing accelerated more rapidly than in previous periods, averaging growth of 2.0 percent per year. Sectoral output growth increased to an average of 4.5 percent per year (see table A), while combined inputs advanced at an average of 2.4 percent per year, a slightly higher rate than in the early 1990s. In the 2000-2005 period, multifactor productivity growth increased faster than in the 1995-2000 period, averaging growth of 2.5 percent per year. Labor productivity slowed to a still-robust average annual growth rate of 4.3 percent per year. The contribution of capital intensity growth was unchanged in the 2000-2005 period from the 1995-2000 period, growing at an average annual rate of 0.7 percent (table B). The contribution of other capital services rose 0.5 percent during the 2000-2005 period, while the contribution of information processing equipment grew 0.2 percent. The contribution of materials dropped to an average growth rate of 0.3 percent from 1.4 percent in the 1995-2000 period, while the contribution of business services intensity accelerated slightly, averaging 0.8 percent.

Among detailed manufacturing industries, most durable goods and nondurable goods industry groups experienced multifactor productivity gains in 2005 (see table 3). The exceptions were petroleum and coal products, and furniture and related products. In these two industries multifactor productivity growth declined in 2005. The manufacturing industries that showed the largest multifactor productivity growth in 2005 were textile mills and textile product mills, which increased 9.7 percent, and printing and related support activities, with an 8.7 percent increase.

Table B. Compound average annual rates of growth in output per hour of all persons and the contributions of capital intensity, labor composition, and multifactor productivity, manufacturing sector, 1987 to 2005

	1987-05	1987-90	1990-95	1995-00	2000-05	2004-05
<u>Manufacturing</u>						
Output per hour of all persons	3.7	1.7	3.4	4.7	4.3	4.7
Contribution of capital intensity[1]	0.6	0.3	0.4	0.7	0.7	0.1
Contribution of information processing equipment and software[2]	0.2	0.1	0.2	0.4	0.2	0.0
Contribution of all other capital services	0.3	0.1	0.2	0.4	0.5	0.0
Contribution of energy intensity[3]	0.0	0.0	0.0	-0.1	0.0	-0.1
Contribution of materials intensity[4]	0.8	0.3	1.0	1.4	0.3	0.6
Contribution of business services intensity[5]	0.7	0.9	0.6	0.6	0.8	0.5
Multifactor productivity[6]	1.6	0.2	1.2	2.0	2.5	3.4

1. Growth rate in capital services per hour multiplied by capital's share of current dollar costs.
2. Growth rate of information processing equipment and software per hour multiplied by its share of total costs.
3. Growth rate in energy services per hour multiplied by energy's share of current dollar costs.
4. Growth rate in materials services per hour multiplied by materials' share of current dollar costs.
5. Growth rate in business services per hour multiplied by business services' share of current dollar costs.
6. Output per unit of combined inputs.

Over the full 1987-2005 period, multifactor productivity advanced most rapidly in the computer and electronic products industry. This industry's 9.6-percent average annual growth rate during this period is 7.8 percentage points higher than the industry with the next highest growth rate, textile mills and textile product mills. In the 1995-2000 period, multifactor productivity grew very rapidly in the computer and electronic products industry, 15.8 percent per year. In the 2000-2005 period, the growth rate slowed to 6.3 percent. Three industries experienced a decline in multifactor productivity over the 1987-2005 period: food, beverage and tobacco products; machinery; and electrical equipment, appliances and components.

Summary of Methods for the manufacturing sector and manufacturing industries

The manufacturing multifactor productivity measures describe the relationship between output in real terms and the inputs involved in its production. They do not measure the specific contributions of labor, capital, or any other factor of production. Rather, multifactor productivity is designed to measure the joint influences on economic growth of technological change, efficiency improvements, returns to scale, reallocation of resources due to shifts in factor inputs across industries, and other factors. The multifactor productivity indexes are derived by dividing an output index by an index of the combined input of labor, capital services, energy, non-energy materials, and business service inputs.

The multifactor productivity measures for manufacturing differ in several ways from those for private business and private nonfarm business in their treatment of labor input, output, and classes of factor inputs. First, the manufacturing measure of labor input is a direct aggregate of hours. This is in contrast to the major sector measures for which estimates of the effects of changing labor composition have been developed.

Next, the output concept used for multifactor productivity in manufacturing is "sectoral output." Sectoral output is similar to gross output, but excludes shipments from one establishment to another within the same manufacturing industry or sector. In contrast, the output concept used for private business and nonfarm business is "gross product originating". Gross product originating in private business equals gross domestic product in the economy less general government, government enterprises, private households (including the rental value of owner-occupied real estate), and non-profit institutions. Gross product originating excludes intermediate transactions between businesses.

The output index for manufacturing is computed using a chained superlative index (Tornqvist) of 3-digit NAICS industry outputs. Industry output is measured as sectoral output, the total value of goods and services leaving the industry. Wherever possible, the indexes of industry output are calculated with a Törnqvist formula. This formula aggregates the growth rates of the various industry outputs between two periods, using their relative shares in industry value of production averaged over the two periods, as weights. Industry output measures for manufacturing industries are constructed using data from the economic censuses and annual surveys of the Bureau of the Census, U.S. Department of Commerce, together with information on price changes, primarily from BLS.

The resulting manufacturing multifactor productivity measure compares what is produced in the manufacturing sector for use outside of manufacturing with the inputs used in the manufacturing process obtained from outside of manufacturing. The comparison excludes flows of intermediate inputs between manufacturing establishments from measures of both output and inputs. However, the comparison does include capital service inputs and capital goods produced, even when these goods are produced and consumed in manufacturing.

Multifactor productivity in manufacturing compares "sectoral output" to three classes of inputs: 1) hours at work of labor employed within manufacturing; 2) capital services employed by manufacturing establishments; and 3) purchases of energy, materials, and business services from outside of manufacturing (intermediates).

Hours paid of production workers are largely obtained from the Current Employment Statistics (CES) survey. These hours of employees are then converted to an at-work basis by using information from the Employment Cost Index (ECI) of the National Compensation Survey (NCS) and the Hours at Work Survey. Hours at work for nonproduction workers are derived using data from the Current Population Survey (CPS), the CES, and the NCS. The hours at work of proprietors are derived from the CPS. Hours at work data reflect Productivity and Costs data as of the March 6, 2007 news release. Therefore, it does reflect benchmark revisions to the CES survey and other revisions to hours released on February 2, 2007. The construction of hours at work follows the methods used in the private business sector described in USDL 07-0758, Preliminary Multifactor Productivity Trends, 2006, http://www.bls.gov/news.release/pdf/prod3.pdf, except that hours in manufacturing are directly aggregated and do not include the effects of changing labor composition.

Capital input measures the services derived from the stock of physical assets and software. The assets included are fixed business equipment, structures, inventories, and land. Among equipment, BLS provides additional detail for information processing equipment and software (IPES). IPES is composed of four broad classes of assets: computers and related equipment, software, communications equipment, and other IPES equipment. Computers and related equipment includes mainframe computers, personal computers, printers, terminals, tape drives, storage devices, and integrated systems. Software is comprised of pre-packaged, custom, and own-account software. Communications equipment is not further differentiated. Other IPES includes medical equipment and related instruments, electromedical instruments, nonmedical instruments, photocopying and related equipment, and office and accounting machinery.

The aggregate capital input measures are obtained by Tornqvist aggregation of the capital stocks for each asset type within each of the eighteen manufacturing NAICS industry groupings using estimated rental prices for each asset type. Each rental price reflects the nominal rate of return to all assets within the industry and rates of economic depreciation and revaluation for the specific asset; rental prices are adjusted for the effects of taxes. Data on investments in physical assets and software are obtained from BEA. Nonfarm industry detail for land is based on IRS book value data. Current-dollar gross product originating (GPO) data, obtained from BEA, are used in estimating capital rental prices.

In manufacturing, intermediates are the largest input in terms of costs. Furthermore, research has shown that substitution among inputs, including intermediates, affects productivity change. Therefore, it is important to include intermediates in productivity measures at the level of manufacturing. In contrast, the more aggregate productivity measures compare "value-added" output with two classes of inputs, capital and labor. Because of these differences in methods, productivity change in manufacturing cannot be directly compared with changes in private business or private nonfarm business.

Intermediate inputs (energy, materials, and purchased business services) are obtained from BEA based on BEA annual input-output tables. Tornqvist indexes of each of these three input classes are derived at the 3-digit NAICS level and then aggregated to total manufacturing. As with the sectoral output measures, materials inputs are adjusted to exclude transactions between establishments within the same sector.

The five input indexes (capital services, hours, energy, materials, and purchased business services) are combined using Tornqvist aggregation, employing weights that represent each component's share of total costs. Total costs are defined as the value of manufacturing sectoral output. The index uses changing weights: The share in each year is averaged with the preceding year's share.

Multifactor productivity data for the 1987-2005 period reflect a number of changes in source data. For example, current NAICS input-output tables and revised BEA chain-type price and indexes for intermediate inputs (energy, materials, and business services), (see tables at http://www.bea.gov/Industry/Index.htm , Gross Domestic Product by Industry) have been incorporated.

BLS built multifactor productivity measures from three-digit NAICS detail. Most of the critical data used to calculate these measures were not reported on a NAICS basis for years prior to 1998. Detailed GDP by industry data were available from 1998 forward but from 1987 to1997 many of the income components needed to construct capital rental prices were obtained by applying 1997 SIC-to-NAICS conversion factors to SIC data and adjusting to the estimated NAICS totals. A similar procedure was applied to manufacturing inventories, energy, materials, and business services. Land data were only available from 1998 to 2003 on a NAICS basis. As a consequence, land estimates from 1987 to 1997 were calculated using a combination of SIC to NAICS conversion factors and more detailed IRS data. Data for 2004 and 2005 were extrapolated using detailed IRS data for 2002.

Comprehensive tables containing additional data beyond the scope of this press release are available upon request at 202-691-5606 or at http://www.bls.gov/mfp/mprdload.htm . More detailed information on methods, limitations, and data sources of capital and labor are provided in BLS Bulletin 2178 (September 1983), "Trends in Multifactor Productivity, 1948-81." Methods for measuring manufacturing multifactor productivity are discussed in "Measurement of productivity growth in U.S. manufacturing" in the July 1995 issue of the *Monthly Labor Review* (see http://www.bls.gov/mfp/mprgul95.pdf). Additional data not contained in the release can be obtained in print at 202-691-5606 or at http://www.bls.gov/mfp .

Table 1. Manufacturing Sector: Productivity and related measures, 1987-2005

Indexes
(2000=100)

| Year | Productivity | | | | | Inputs | | | | |
	Output per hour of all persons	Output per unit of capital	Multifactor Productivity[1]	Sectoral Output[2]	Hours[3]	Capital Services[4]	Energy	Materials	Purchased business services	Combined units of all Inputs[5]
1987	63.9	95.4	84.8	64.1	100.3	67.2	99.3	62.9	65.3	75.6
1988	65.2	98.7	86.3	67.4	103.4	68.3	103.3	63.8	71.0	78.1
1989	65.9	98.2	85.8	68.5	104.0	69.8	103.0	65.1	75.3	79.9
1990	67.3	95.2	85.2	68.3	101.5	71.7	105.2	66.0	76.6	80.1
1991	69.1	91.5	85.0	67.1	97.2	73.4	104.8	65.6	76.0	79.0
1992	71.7	92.3	84.5	69.4	96.7	75.1	103.8	71.3	81.5	82.1
1993	73.5	93.6	86.7	72.1	98.0	77.0	107.1	71.9	81.7	83.1
1994	76.1	96.6	89.0	76.4	100.3	79.0	110.4	74.8	84.7	85.8
1995	79.4	98.2	90.6	80.4	101.2	81.8	113.7	78.8	88.9	88.7
1996	82.4	97.6	91.0	83.1	100.8	85.2	110.3	86.0	88.5	91.3
1997	86.9	100.2	93.6	89.2	102.6	89.0	108.2	92.9	92.1	95.3
1998	91.7	100.5	95.8	93.8	102.3	93.4	105.4	97.7	95.0	98.0
1999	95.8	100.3	96.5	97.4	101.6	97.1	105.5	102.6	100.0	100.9
2000	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2001	101.5	93.6	98.7	94.9	93.5	101.4	90.6	93.3	100.7	96.2
2002	108.6	92.5	102.4	94.3	86.8	101.9	89.3	88.3	98.2	92.1
2003	115.3	93.5	105.3	95.2	82.6	101.8	84.4	87.7	99.1	90.5
2004	117.9	95.9	109.2	96.9	82.2	101.1	81.1	85.5	95.2	88.7
2005	123.4	99.6	113.0	100.3	81.3	100.7	78.5	86.3	96.5	88.8

See footnotes following table 2.   Source: Bureau of Labor Statistics

Table 2. Manufacturing Sector: Productivity and related measures, 1988-2005

Percent change

| Year | Productivity | | | | | Inputs | | | | |
	Output per hour of all persons	Output per unit of capital	Multifactor Productivity[1]	Sectoral Output[2]	Hours[3]	Capital Services[4]	Energy	Materials	Purchased business services	Combined units of all Inputs[5]
1988	2.1	3.4	1.7	5.2	3.1	1.7	4.0	1.4	8.7	3.4
1989	1.0	-0.6	-0.5	1.6	0.6	2.2	-0.3	2.0	6.0	2.2
1990	2.2	-3.0	-0.7	-0.3	-2.4	2.7	2.1	1.4	1.7	0.4
1991	2.6	-3.9	-0.3	-1.7	-4.2	2.3	-0.4	-0.6	-0.7	-1.4
1992	3.9	0.9	-0.6	3.3	-0.5	2.4	-0.9	8.7	7.2	4.0
1993	2.5	1.4	2.6	3.9	1.4	2.4	3.2	0.9	0.3	1.2
1994	3.5	3.2	2.7	5.9	2.4	2.7	3.1	3.9	3.8	3.2
1995	4.3	1.6	1.7	5.2	0.9	3.6	3.0	5.4	4.9	3.4
1996	3.9	-0.6	0.5	3.4	-0.4	4.0	-3.0	9.2	-0.4	2.9
1997	5.4	2.7	2.8	7.4	1.8	4.5	-1.9	8.0	4.0	4.4
1998	5.5	0.2	2.3	5.2	-0.3	4.9	-2.7	5.2	3.2	2.8
1999	4.4	-0.2	0.8	3.8	-0.6	4.0	0.1	5.0	5.3	3.0
2000	4.4	-0.3	3.6	2.7	-1.6	3.0	-5.2	-2.6	0.0	-0.8
2001	1.5	-6.4	-1.3	-5.1	-6.5	1.4	-9.4	-6.7	0.7	-3.8
2002	6.9	-1.1	3.8	-0.7	-7.1	0.5	-1.5	-5.3	-2.5	-4.3
2003	6.2	1.0	2.8	1.0	-4.9	0.0	-5.5	-0.8	0.9	-1.8
2004	2.3	2.6	3.8	1.8	-0.5	-0.8	-3.9	-2.5	-3.9	-2.0
2005	4.7	3.9	3.4	3.5	-1.1	-0.3	-3.3	1.0	1.3	0.1

See footnotes following table 2.   Source: Bureau of Labor Statistics

Footnotes, Tables 1-2

Source: Output data are from the Bureau of the Census, U.S. Department of Commerce, and modified by the Bureau of Labor Statistics (BLS), U.S. Department of Labor. Compensation and hours data are from BLS. Capital measures are based on data supplied by BEA. See also Summary of Methods in this release.

(1) Sectoral output per combined units of capital, hours, energy, non-energy materials, and purchased business services.

(2) Manufacturing gross output excluding transactions between manufacturing establishments, superlative chained index.

(3) Hours at work of all persons.

(4) A measure of the flow of capital services used in the sector.

(5) Combined units of capital services, hours, energy, non-energy materials, and purchased business services, superlative chained index.

Table 3. Compound average annual rates of growth in the multifactor productivity measures for manufacturing industries in selected periods. 1987-2005

Average annual growth rates

Industry	1987-05	1987-90	1990-95	1995-00	2000-05	2004-05
Manufacturing	**1.6**	**0.2**	**1.2**	**2.0**	**2.5**	**3.4**
Nondurable manufacturing	**0.6**	**-0.6**	**0.7**	**- 0.3**	**2.0**	**3.2**
Food, beverage, and tobacco products	-0.1	-1.7	1.6	- 1.8	1.0	4.5
Textile mills and textile product mills	1.8	0.9	0.7	1.4	3.7	9.7
Apparel, leather, and allied products	1.3	0.1	2.8	0.7	1.1	0.0
Paper products	0.6	-0.4	-0.1	0.2	2.2	3.1
Printing and related support activities	0.8	0.6	-0.4	0.4	2.7	8.5
Petroleum and coal products	0.3	-0.1	0.6	0.3	0.3	-4.8
Chemicals products	0.4	-0.8	-0.8	0.0	2.9	5.4
Plastics and rubber products	1.0	0.7	0.6	1.3	1.2	0.1
Durable manufacturing	**2.3**	**0.8**	**1.6**	**3.6**	**2.7**	**3.3**
Wood products	0.4	1.0	-1.3	0.1	2.1	4.2
Nonmetallic mineral products	0.9	0.3	1.0	0.9	1.2	0.6
Primary metals	1.1	1.1	0.1	0.5	2.6	2.1
Fabricated metal products	0.8	-0.1	1.0	0.1	1.8	4.6
Machinery	-0.1	1.0	-1.8	-0.7	1.6	1.6
Computer and electronic products	9.6	5.6	9.5	15.8	6.3	5.7
Electrical equipment, appliances, and components	-0.7	-2.2	-1.9	-1.1	1.6	1.0
Transportation equipment	0.1	-1.7	-0.3	0.3	1.2	1.8
Furniture and related products	0.6	-0.8	0.6	0.7	1.4	-1.5
Miscellaneous manufacturing	1.7	2.4	0.3	1.9	2.6	5.8

Note: Multifactor productivity measures by industry are not directly comparable to measures for aggregate manufacturing because industry measures exclude transactions only within the specific industry while the aggregate manufacturing measures also exclude transactions between all manufacturing industries.