BLS modernizes industry labor productivity program

Revisions to growth rates of output per hour in a new BLS method for constructing such measures were small in most industries covered

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This article introduces a newly adopted method for constructing the output measures associated with industry labor productivity statistics generated by the Bureau of Labor Statistics. Little change in the long-term movements of labor productivity—output per hour—occurred as a consequence of switching from the original method to the new one. This suggests that the original, athough not consistent with modern developments in the economic theory of production, was providing reasonable measures of the trends in industry labor productivity.

BLS studies of industry productivity

Studies of productivity in individual industries have been carried out by the Bureau for many years. In 1898, the Bureau studied and reported on the displacement of human labor by machinery in 60 manufacturing industries.[1] The impact of productivity growth on employment remained a focus of research at the Bureau at the time of the Great Depression. During this era, the Bureau began to publish indexes of output per hour. The indexes were based on production data from the Bureau of the Census and BLS employment data. In 1940, Congress authorized the Bureau of Labor Statistics to undertake continuing studies of productivity and technological change. In response, the Bureau extended productivity measures that had been developed by the National Research Project of the Works Progress Administration[2] and published measures for selected industries.

The industry labor productivity program was cut back during World War II because of a lack of meaningful data on production and employee hours for many manufacturing industries. Additionally, the emphasis of the program shifted from problems of unemployment to concern about the most efficient use of scarce labor resources. The Bureau conducted several studies of labor requirements for defense industries, including the synthetic rubber and shipbuilding industries.

For several years after the war, the Bureau developed measures for a small number of industries from data collected at the plant for the explicit purpose of measuring labor productivity.[3] Because of its high cost, this program was terminated in the 1950's.

Since the 1940's, the industry productivity program has been expanded to cover 178 manufacturing and nonmanufacturing industries at the two-, three-, and four-digit Standard Industrial Classification (SIC) levels. Labor productivity measures for these industries are published on an annual basis and are provided for periods beginning as early as 1947. (See table 45 in the back of each issue of the *Review*.)

In addition to measures of industry labor productivity, the Bureau also publishes multifactor productivity statistics for certain industries. Industry multifactor productivity measures, which

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were first released in 1987, relate output to the combined inputs of labor, capital, and intermediate purchases. Multifactor productivity is equal to output per hour minus the effects of changes in capital per hour and intermediate purchases per hour. These effects are measured as the change in the ratio of nonlabor to labor inputs, weighted by the share of nonlabor input in the total cost of output. The capital effect, for example, is the change in the ratio of capital to labor, weighted by capital's share in the total cost of output. While multifactor productivity is free of the effects of changes in the ratio of capital to labor and the ratio of intermediate purchases to labor, labor productivity necessarily reflects these changes. However, an enormous amount of data is required to construct capital and intermediate purchases measures, and this has limited the number of industry multifactor productivity measures published.[4]

Original measures

The original output-per-hour indexes were developed to measure the effects of productivity on jobs. They were intended to answer questions about employment levels, such as those listed in the 1939 report on productivity by the National Research Project: "What relative volumes of labor time are required to produce a given composite of products at different times?" and "What relative volumes of production of a given composite of products are obtainable at different times with a given amount of labor time?"[5]

Wherever possible, the output measure in the numerator of the original labor productivity ratios used unit employee hour weights for combining the various categories of output of an industry.[6] A unit employee hour weight for a product, which is also called a unit labor weight, equals the hours expended in the production of a unit of the product. When unit employee hour weights were not obtainable at the detailed product level, substitute weights were found. The most common substitutes were unit values, which were acceptable if they were believed to be proportional to unit hours. A unit value is computed by dividing the value of production by the number of units produced. In some cases, a dual-level weighting system was used: unit value weights to combine individual products and employee hour weights to combine groups of products. The weights were related to fixed periods and were updated periodically, usually in conjunction with economic censuses, which are now conducted every 5 years.

With fixed weights, changes in the relative quantities of the various outputs do not affect the productivity indexes. Rather, the indexes are affected only by changes in unit labor requirements of the individual products. Thus, the productivity indexes show the changes in total labor requirements of the industry resulting from changing production processes for the various industry products.[7]

Recent literature stresses the use of index numbers that are consistent with the economic theory of production and costs. At the time of the development of the measures of output per hour, emphasis was not placed on this theory in the construction of the indexes. In fact, some of the literature explicitly rejected the consistency criterion.[8]

Decision to revise weights

The BLS Office of Productivity and Technology undertook a careful review of its methods of measuring industry productivity and decided, at the end of 1993, to revise these methods. The review, carried out by senior economists, examined the current status of the economic literature on productivity and the rationales for various productivity measures. The revision of the industry productivity measures included adopting new measurement methods and was carried out during 1994 and the early months of 1995.

Some important questions the Office grappled with were the following: What are the industry labor productivity measures supposed to mean? Should they be measures of the effects of productivity change on industry employment? Should they represent changes in overall efficiency by industry? The original series on output per hour were developed to measure the employment effects of productivity changes in individual industries, whereas the revised series are viewed as measures of efficiency in the industries.[9]

The revised measures of output per hour reflect the generally accepted innovations and refinements in the economic theory of production and costs of the past 30 years. There is a consensus among prominent scholars of the subject that productivity should be measured and analyzed in the context of the neoclassical theory of production and costs. At the core of this theory is the concept of a production function, which is a mathematical relationship between output and the inputs that generate it.

Modern index number theory provides the basis for aggregating industry outputs. Certain index number formulas are consistent with particular functional forms of the production function. The Törnqvist index, which is consistent with the translogarithmic production function, belongs to a class of so-called superlative index number formulas. A superlative index number is exact for a flexible aggregator function.[10] The translogarithmic production function is considered flexible, as it is less restrictive than other common functional forms, such as the Cobb-Douglas production function.[11] Changes in output consistent with the translogarithmic production function are exactly measured by changes in Törnqvist indexes.

The revised BLS measures of labor productivity incorporate Törnqvist indexes of output. A Törnqvist index of in-

dustry output aggregates the growth rates of the various industry products between two periods, with weights based on the products' shares in industry value of production—the weight for each product equals its average value share in the two periods.

The Törnqvist index addresses an "index number problem" that arises when constructing an output measure. Suppose we wish to construct an index of output comparing two periods: a base period and the current period. Suppose also that growth rates for heterogeneous outputs are to be combined with value weights. Then a fixed-weight scheme, such as the one used to construct the original BLS measures of output per hour, would not fully allow for the possibility that relative prices and the mix of products being produced can change from the base period to the current period. Because of large changes in these variables, the two periods' market baskets may be quite different. Hence, using weights based on values in the base period can yield a measure of output that is different from one based on values in the current period. This poses a dilemma when selecting one period's weights. The superlative indexes allow for the construction of an output aggregate in which the weights incorporate changes in prices and quantities occurring between the two periods.

A similar problem arises with respect to the constant-dollar measures of output that are used in the development of the major sector measures of output and productivity. These problems are addressed on pages 13–28, this issue.

Formulation of revised measures

The revised labor productivity indexes measure the changes in the relationship between output and the hours expended in producing that output. To calculate a labor productivity index, an index of industry output is divided by an index of hours:

$$P_t = \frac{Q_t}{Q_o} \div \frac{L_t}{L_o}.$$

Here,

P_t = the index of output per hour in the current year,

t = the current year,

o = the base year,

$\frac{Q_t}{Q_o}$ = the index of output in the current year, and

$\frac{L_t}{L_o}$ = the index of labor input in the current year.

For an industry producing a single uniform product or service, the output index is simply the ratio of the number of units produced in the current year divided by the number of units produced in the base year. Similarly, the employee hour index equals hours expended in the current year divided by hours expended in the base year.

More typically, industries produce a number of different products or perform a number of different services. For these industries, output is calculated with the Törnqvist formula[12]

$$\frac{Q_t}{Q_{t-1}} = \exp\left[\sum_{i=1}^{n} w_{i,t}\left(\ln\frac{q_{i,t}}{q_{i,t-1}}\right)\right],$$

where

$\frac{Q_t}{Q_{t-1}}$ = the ratio of output in the current year (t) to output in the previous year ($t - 1$)

n = the number of products,

$\ln\frac{q_{i,t}}{q_{i,t-1}}$ = the natural logarithm of the ratio of the quantity of product i in the current year to the quantity in the previous year, and

$w_{i,t}$ = the average value share weight for product i.

The average value share weight for product j is computed as

$$w_{j,t} = \left(S_{j,t} + S_{j,t-1}\right) \div 2$$

where

$$s_{j,t} = p_{j,t}\, q_{j,t} \div \sum_{i=1}^{n} p_{i,t}\, q_{i,t}$$

and

$p_{i,t}$ = the price of product i at time t.

The Törnqvist formula yields the ratio of output in a given year to that in the previous year. The ratios arrived at in this manner then must be chained together to form a series. If

t = 3 and the base year is denoted by o, then

$$\frac{Q_t}{Q_o} = \frac{Q_3}{Q_o} = \left(\frac{Q_3}{Q_2}\right)\left(\frac{Q_2}{Q_1}\right)\left(\frac{Q_1}{Q_o}\right)$$

The resulting chained output index, Q_t / Q_o, is used in the productivity formula. The employee hour index for an industry with multiple products is calculated in the same manner as in the single-output case.

The measures of output per hour relate output to one input—labor time; they do not measure the specific contribution of labor, capital, or any other factor of production. The

measures reflect the joint effect of a number of interrelated influences such as changes in technology, capital investment per worker, capacity utilization, intermediate inputs per worker, layout and flow of material, skill and effort of the work force, managerial skill, and labor-management relations.

New output methodology

Industry output indexes are developed from basic data collected by the Bureau of the Census and other sources. Output indexes are developed as a deflated value of production or physical quantity of production of an industry. Both of these methods are discussed in this section.

Deflated-value output indexes. More than two-thirds of the industry output indexes are derived from data on the value of industry output, adjusted for price change. Because the adjustment for price change is most often downward, the method is generally referred to as a *deflated-value* method. The resulting indexes are conceptually equivalent to indexes that are developed using data based on physical quantities of products. An index of these deflated values shows the change in the real value of output between the past and the current period.

The deflated-value output indexes are developed in two stages. First, comprehensive data from the Bureau of the Census' economic censuses are used to generate benchmark indexes covering the years for which economic censuses are conducted. Second, less comprehensive data are used to prepare the indexes for years that fall between censuses. The latter indexes are adjusted to the benchmark indexes by means of linear interpolation. For postcensus years, annual indexes are linked to the most recent benchmark index.

Benchmark index. For manufacturing industries, with the deflated-value methodology, current-dollar values of shipments are deflated with appropriate price indexes for each of the five-digit product class groups, resulting in unweighted quantities. Next, the unweighted quantity changes are calculated by taking the difference in the logarithms of the quantities in periods t and $t - 1$. The unweighted quantity changes are then combined with value share weights, averaged over periods t and $t - 1$, to derive weighted quantity changes for each five-digit product class group. Finally, the antilogarithms of the sum of the weighted quantity changes are taken and chained together to form the real-value-of-shipments index for the industry. This aggregation procedure is called the Törnqvist procedure. Additionally, to arrive at the final benchmark output index of production, adjustments are made to reflect net changes in inventories, changes in industry coverage, resales, and intraindustry transfers.[13] It should be noted that the original industry labor productivity measures were not routinely adjusted for changes in resales and intraindustry transfers. Benchmark indexes are developed every 5 years, based on data from the quinquennial *Census of Manufactures*. Benchmark indexes for the mining industries are computed from data reported in the *Census of Mineral Industries*.

For trade industries, benchmark indexes are computed from sales data reported in the *Census of Retail Trade*. With the deflated-value methodology, current-dollar sales are deflated with appropriate price indexes for each category of merchandise in the industry, yielding constant-dollar sales. The Törnqvist procedure is then used to calculate the real sales index for the industry. Additionally, to arrive at the final benchmark output index of production, an adjustment is made to reflect changes in industry coverage. Benchmark indexes are developed every 5 years, based on data from the quinquennial *Census of Retail Trade*.

Benchmark indexes for the service industries are computed from data reported in the *Census of Business*. The methodology is similar to that used in developing the indexes for the retail trade industries.

Annual indexes. For annual output indexes in manufacturing industries, the value of shipments for each primary product class (wherever the product is made) is deflated by an appropriate price index to obtain product class quantities. BLS industry-based product class price indexes are used if available. If they are not available, deflators are developed by weighting together individual BLS commodity price indexes with base-year value-of-shipments weights. The Törnqvist procedure is then used to calculate the real value-of-shipments index for the primary products of the industry.

For each year, ratios for the industry (total value of industry shipments to total value of primary products, wherever made) are used to adjust the wherever-made primary products indexes to the industry basis. The resultant industry indexes are further adjusted to reflect changes in inventory. This adjustment yields the estimated industry indexes of production. The annual indexes for the industry are adjusted to the benchmark levels of production by linear interpolation.

For industries in trade and services, data on the value of sales for each year are divided by an industry price index to derive a measure of the change in the industries' real output. These industry price indexes are, for the most part, producer and consumer price indexes developed by the Bureau. In the case of the retail trade industries, the industry price index is developed by combining current-year consumer price indexes with base-year sales for each category of merchandise.

Physical quantity output indexes. Most physical quantity

output indexes are based on quantities of products combined with average value share or unit value weights. The basic data on quantities are generally primary products of an industry classified into product groups. The finest level of detail is used. For some industries, the annual indexes are adjusted to deflated-value benchmark indexes by linear interpolation. The indexes for both the annual and benchmark series are developed using the Törnqvist procedure.

Data for the physical quantity output indexes come from numerous sources, including the *Current Industrial Reports* of the U. S. Department of Commerce and the reports of various trade associations. Physical quantity output indexes are used primarily for the mining and transportation industries.

Labor input

The labor input indexes that are used in the productivity measures have not been revised. These indexes are developed from basic data compiled by the Bureau of Labor Statistics, the Bureau of the Census, and other sources. Employment and hours indexes measure the change in the aggregate number of employees and hours, respectively, over a given time. Employees and hours are each treated as homogeneous and additive; hence, changes in qualitative aspects of employment, such as in the skills, education, and experience of persons constituting the aggregate, are not reflected in the indexes.[14]

The indexes of labor input are derived from production worker hours, the number of nonproduction workers, and an estimate of average annual hours paid for nonproduction workers. Production worker hours include all the hours paid for. Overtime and other premium pay hours are included on the basis of actual time spent at the plant. The estimates of nonproduction worker average annual hours are prepared by the Bureau of Labor Statistics at the two-digit SIC level and are derived primarily from studies undertaken by the Bureau.[15]

Average hours for nonproduction workers are multiplied by the number of nonproduction workers to obtain total nonproduction worker hours. Indexes based on nonproduction worker hours are subject to a wider margin of error than are indexes involving only production worker hours, because it is necessary to estimate the average hours of nonproduction workers. Errors in such estimates, however, would have a relatively insignificant effect on the trend in hours for all employees.

Estimates of all hours for manufacturing industries are derived by summing the aggregate hours for production worker hours and nonproduction worker hours. For trade and service industries, estimates of all-person hours are derived by summing the aggregate hours for paid employees and the estimated aggregate hours for partners, proprietors, and unpaid family workers. Hours indexes for the trade and services industries are based on data from the Bureau of Labor Statistics, the Bureau of the Census, and the Internal Revenue Service.

Original versus revised growth rates

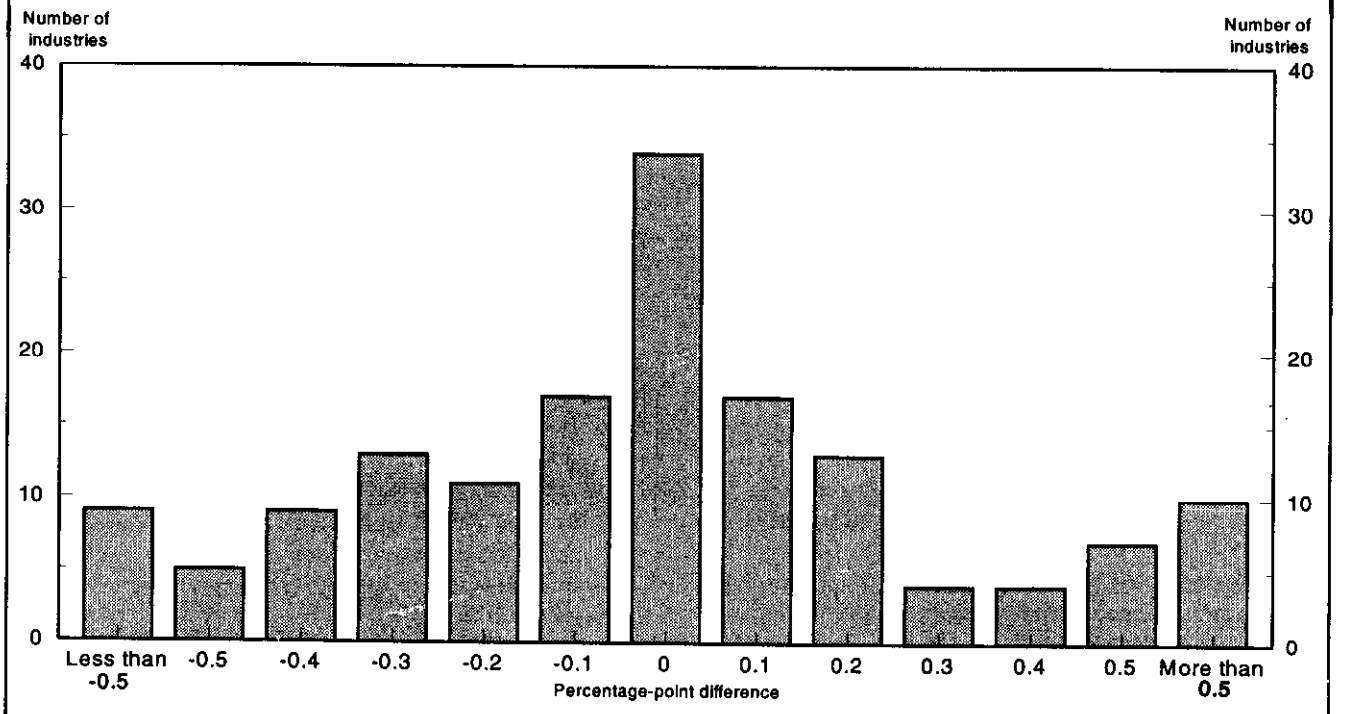
All of the 178 published BLS measures of industry labor productivity were reviewed for possible revision. Of these 178 measures, 23 are for single-product industries, which do not require any weighting of outputs. An example of such an industry is the copper mining industry. The output of this industry is simply the tons of ore recovered. The 23 single-product industries include 4 mining industries, 16 manufacturing industries, and 3 service-producing industries. The labor productivity indexes for these industries have not been revised. Following a review of the remaining 155 measures, 2 indexes were judged to be inappropriate for value share weighting of the outputs: the index for new and used car dealers and the index for commercial banks. Labor weights will continue to be used in the calculation of the output indexes for these two industries. The industry labor productivity indexes for the remaining 153 industries have been revised to incorporate Törnqvist indexes of output. The following discussion refers to the effect of the revisions on the rate of growth in labor productivity for these 153 industries.[16] Although the labor productivity measures are provided for periods beginning as early as 1947, only periods from 1973 to 1990 are discussed.[17] The years 1973 and 1990 are selected because they are both peak years in the business cycle.[18]

Long-term labor productivity growth rates, 1973–90. In nearly 90 percent of the industries, the average annual growth rates of output per hour for 1973–90 were revised by only 0.5 percentage point or less. In addition, the revisions were distributed fairly symmetrically around zero. (See chart 1.)[19] The changes were not predominantly positive or negative, indicating that there was no systematic bias in the original measures, compared with the new ones.

For 34 measures, which represent about one-fifth of the revised industry labor productivity statistics, incorporation of the superlative indexes of output resulted in no change in labor productivity growth for 1973–90. (See table 1, pp. 9–11.) Among this group are four of the largest industries, in terms of employment, that are measured by the BLS productivity program: eating and drinking places; grocery stores; hotels and motels; and motor vehicles and equipment.

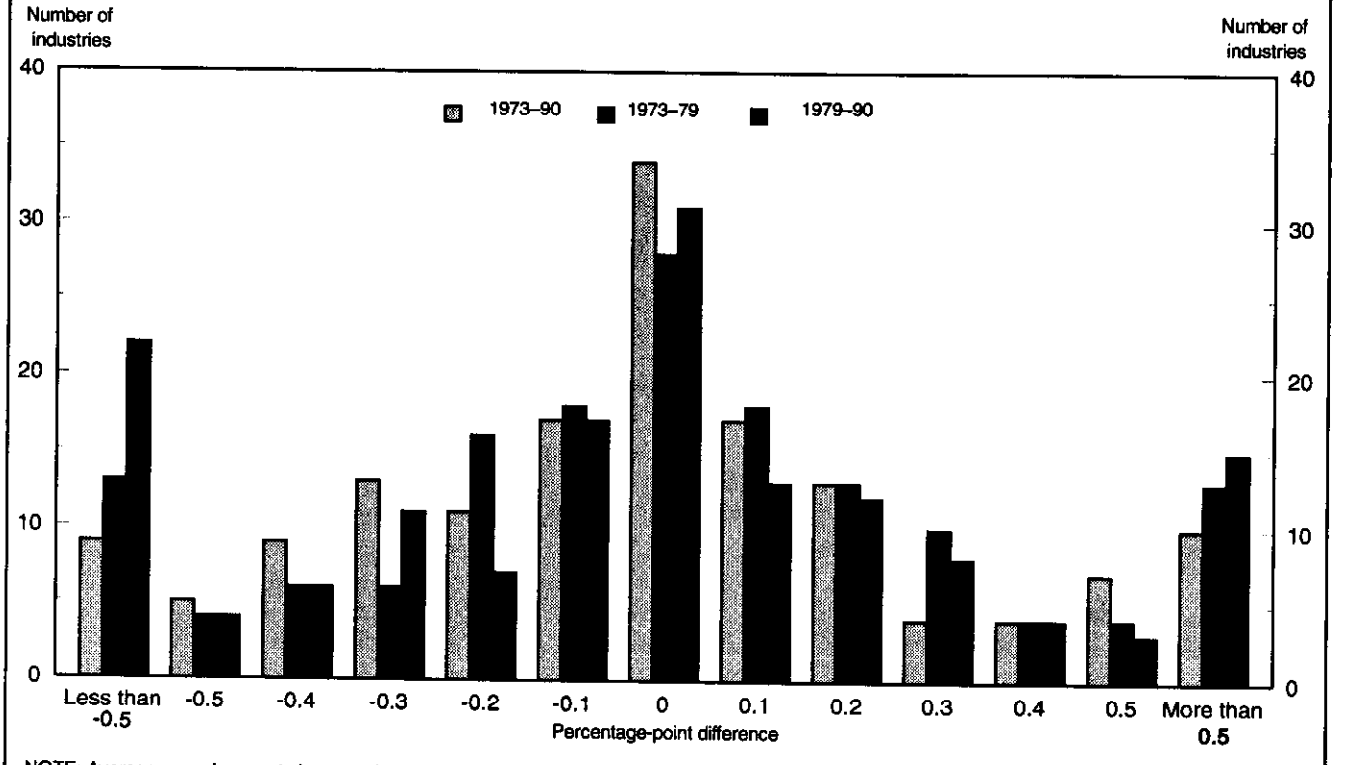
The labor productivity growth rates was revised by between 0.1 percentage point and 0.5 percentage point in 100 industries for the 1973–90 period. Forty-five of those revisions were positive and 55 were negative. Among the industries with *upward* revisions of one-half of a percentage point

Chart 1. **Output per hour in 153 selected industries, revised growth rate minus original growth rate, 1973–90**



NOTE: Average annual percent change using compound rate formula.

Chart 2. **Output per hour in 153 selected industries, revised growth rate minus original growth rate, selected periods, 1973–90**



NOTE: Average annual percent change using compound rate formula.

Table 1. **Output per hour in 153 selected industries, 1973–90**

[Average annual percent change]

SIC Code	Industry	Original index	Revised index	Revised index minus original index
	Mining			
101	Iron mining, usable ore	3.4	3.3	−0.1
12	Coal mining	3.2	3.2	.0
131	Crude petroleum and natural gas	−3.4	−3.4	.0
14	Nonmetallic minerals, except fuels	1.2	1.3	.1
142	Crushed and broken stone	1.5	2.0	.5
	Manufacturing			
2011,13	Red meat products	1.8	1.4	−.4
2011	Meat packing plants	1.8	2.1	.3
2013	Sausages and other prepared meats	1.9	2.0	.1
2015	Poultry dressing and processing	3.7	3.7	.0
202	Dairy products	3.2	3.6	.4
2022	Cheese, natural and processed	2.4	2.3	−.1
2026	Fluid milk	4.2	4.7	.5
203	Preserved fruits and vegetables	1.3	1.5	.2
2033	Canned fruits and vegetables	1.7	2.2	.5
2037	Frozen fruits and vegetables	.9	.8	−.1
204	Grain mill products	3.9	4.1	.2
2041,45	Flour (inc. flour mixes) and other grains	2.8	2.3	−.5
2041	Flour and other grain mill products	3.2	2.7	−.5
2047,48	Prepared feeds for animals and fowls	3.8	4.4	.6
2051,52	Bakery products	.8	.9	.1
2061,62,63	Sugar	.8	1.2	.4
2061,62	Raw and refined cane sugar	.6	1.6	1.0
2082	Malt beverages	5.6	5.7	.1
2092	Prepared fresh or frozen fish and seafoods	−.5	−.4	.1
211,2,3	Tobacco products	2.3	3.0	.7
211,3	Cigarettes, chewing and smoking tobacco	2.3	2.1	−.2
221,2	Cotton and synthetic broadwoven fabrics	3.7	3.8	.1
2251,52	Hosiery	2.9	3.1	.2
2281	Yarn spinning mills	4.0	3.9	−.1
231	Men's and boys' suits and coats	1.7	1.6	−.1
2421	Sawmills and planing mills, general	2.3	2.4	.1
2426	Hardwood dimension and flooring	.6	.8	.2
2431	Millwork	−.4	−.4	0
2434	Wood kitchen cabinets	.9	.9	0
2435,36	Veneer and plywood	3.1	2.3	−.8
2435	Hardwood veneer and plywood	2.7	.7	−2.0
2436	Softwood veneer and plywood	3.3	2.7	−.6
244	Wood containers [1]	2.3	2.5	.2
251	Household furniture	1.2	1.3	.1
2511,17	Wood household furniture	.4	.5	.1
2514	Metal household furniture	1.9	1.9	.0
2515	Mattresses and bedsprings	2.5	2.3	−.2
252	Office furniture	1.3	1.4	.1
2522	Office furniture, except wood	1.5	1.8	.3
261,2,3	Pulp, paper, and paperboard mills	2.6	2.5	−.1
2657	Folding paperboard boxes	1.3	.8	−.5
2673,74	Paper and plastic bags	.7	.0	−.7
28	Industrial inorganic chemicals	.6	1.5	.9
2812	Alkalies and chlorine	3.6	5.2	1.6
2816	Inorganic pigments	1.7	2.0	.3
2819 (part)	Industrial inorganic chemicals, n.e.c.[2]	−.1	1.0	1.1
2823,24	Synthetic fibers	4.0	4.0	.0
2841	Soaps and detergents	2.4	2.3	−.1
2844	Cosmetics and other toiletries	.8	.8	.0
285	Paints and allied products	3.2	3.4	.2
2869	Industrial organic chemicals, n.e.c.[2]	2.1	1.8	−.3
287	Agricultural chemicals	2.5	2.8	.3

Table 1. **Continued—Output per hour in 153 selected industries, 1973–90**

[Average annual percent change]

SIC Code	Industry	Original index	Revised index	Revised index minus original index
2873	Nitrogeneous fertilizers	3.7	3.0	–.7
2874	Phosphatic fertilizers	2.5	3.1	.6
2879	Agricultural chemicals, n.e.c.[2]	2.2	2.1	–.1
291	Petroleum refining	1.8	1.5	–.3
301	Tires and inner tubes	4.1	4.0	–.1
3052	Rubber and plastics hose and belting	1.2	1.4	.2
308	Miscellaneous plastics products, n.e.c.[2]	1.9	1.9	.0
314	Footwear	.0	.2	.2
324	Cement, hydraulic	2.7	2.7	.0
325	Structural clay products	1.7	1.3	–.4
3251,53,59	Clay construction products	1.7	1.5	–.2
3251	Brick and structural clay tile	.6	.7	.1
3271,72	Concrete products	1.0	.7	–.3
331	Steel	2.7	3.2	.5
3321	Gray and ductile iron foundries	1.0	.8	–.2
3324,25	Steel foundries	–.6	–.6	.0
3325	Steel foundries, n.e.c. [2]	.3	.3	.0
3331	Primary copper	5.9	5.9	.0
3351	Copper rolling and drawing	1.9	1.1	–.8
3353,54,55	Aluminum rolling and drawing	1.3	.9	–.4
3411	Metal cans	3.7	4.2	.5
3423	Hand and edge tools, n.e.c. [2]	–.5	–.7	–.2
3433	Heating equipment, except electric	2.1	2.1	.0
3441	Fabricated structural metal	.1	–.1	–.2
3442	Metal doors, sash, and trim	.6	.4	–.2
3452	Bolts, nuts, rivets, and washers	1.5	1.3	–.2
3465,66,69	Metal stampings	.9	.9	.0
3469	Metal stampings, n.e.c.[2]	.0	–.1	–.1
3491,92,94	Valves and pipe fittings	.6	.5	–.1
3519	Internal combustion engines, n.e.c.[2]	1.5	1.4	–.1
352	Farm and garden machinery	1.7	1.3	–.4
3523	Farm machinery and equipment	1.7	1.1	–.6
3524	Lawn and garden equipment	2.2	1.7	–.5
3531	Construction machinery	1.7	1.3	–.4
3532	Mining machinery	.1	–.2	–.3
3533	Oil and gas field machinery	–1.6	–1.9	–.3
3541,42	Machine tools	.3	–.1	–.4
3541	Metal cutting machine tools	.5	.1	–.4
3542	Metal forming machine tools	–.3	–.7	–.4
3545	Machine tool accessories	.1	.1	.0
3561,63,94	Pumps and compressors	1.6	1.3	–.3
3561,94	Pumps and pumping equipment	1.7	1.2	–.5
3562	Ball and roller bearings	–.6	–.9	–.3
3563	Air and gas compressors	1.3	1.3	.0
3585	Refrigeration and heating equipment	.5	.2	–.3
3592	Carburetors, pistons, rings, and valves	.7	.4	–.3
3612	Transformers, except electronic	1.1	.4	–.7
3613	Switchgear and switchboard apparatus	1.3	1.2	–.1
3621	Motors and generators	.8	.8	.0
3631,32,33,39	Major household appliances	2.6	2.4	–.2
3631	Household cooking equipment	3.3	2.9	–.4
3632	Household refrigerators and freezers	2.3	2.5	.2
3633	Household laundry equipment	2.4	2.2	–.2
3639	Household appliances, n.e.c. [2]	2.0	2.2	.2
3641	Electric lamps	3.8	2.4	–1.4
3645,46,47,48	Lighting fixtures and equipment	.7	.8	.1
3651	Household audio and video equipment	9.0	10.8	1.8
371	Motor vehicles and equipment	2.4	2.4	.0
3721	Aircraft	1.5	1.9	.4
3825	Instruments to measure electricity	2.7	3.2	.5
386	Photographic equipment and supplies	2.8	3.8	1.0

Table 1. **Continued—Output per hour in 153 selected industries, 1973–90**

[Average annual percent change]

SIC Code	Industry	Original index	Revised index	Revised index minus original index
	Service producing [3]			
4011	Railroad transportation, revenue traffic	5.8	5.5	–.3
4011	Railroad transportation, car miles	3.9	3.9	.0
411,13,14 (parts)	Bus carriers, class I [4]	–.7	–.7	.0
4213	Trucking, except local [4, 5]	2.9	2.9	.0
4213 (part)	Trucking, except local, general freight [4, 5]	3.4	3.4	.0
4512,13,22 (parts)	Air transportation [5]	2.7	3.2	.5
481	Telephone communications	5.8	5.5	–.3
491,2,3	Gas and electric utilities	.4	.1	–.3
491,3 (part)	Electric utilities	1.3	1.3	.0
492,3 (part)	Gas utilities	–2.5	–2.5	.0
5093	Scrap and waste materials[1]	1.8	1.8	.0
525	Hardware stores	1.6	1.7	.1
531	Department stores	2.5	2.6	.1
533	Variety stores	–.4	–.7	–.3
54	Food stores	–.9	–.8	.1
541	Grocery stores	–.8	–.8	.0
546	Retail bakeries	–2.2	–2.3	–.1
553	Auto and home supply stores	2.8	2.8	.0
554	Gasoline service stations	3.2	3.2	.0
56	Apparel and accessory stores	2.3	2.2	–.0
561	Men's and boys' clothing stores	1.6	1.6	–.1
562	Women's clothing stores	3.5	3.6	.1
565	Family clothing stores	1.7	1.7	.0
566	Shoe stores	1.6	1.6	.0
57	Home furniture, furnishings, and equipment stores	3.0	3.2	.2
571	Furniture and homefurnishings stores	1.4	1.3	–.0
572,3	Appliance, radio, television, and computer stores	5.4	5.8	.4
572	Household appliance stores	3.8	3.7	–.1
573	Radio, television, and computer stores	5.7	6.4	.7
58	Eating and drinking places	–.4	–.4	.0
591	Drug stores and proprietary stores	.9	.7	–.2
592	Liquor stores	.8	.9	.1
701	Hotels and motels	–.7	–.7	.0
721	Laundry, cleaning, and garment services	–.9	–.7	.2
723,4	Beauty and barber shops	.5	.7	.2

[1] 1977–90.
[2] n.e.c. = not elsewhere classified.
[3] Output per hour of all persons is used for all trade and service industries, except SIC's 531, 551, and 602.
[4] 1973–89.
[5] Output per employee.

or less were air transportation, aircraft manufacturing, department stores, and steel. Included in the group with *downward* revisions of one-half of a percentage point or less were apparel and accessory stores, gas and electric utilities, refrigeration and heating equipment, and retail bakeries. Classifying these 100 industries into five categories based on the *magnitude* of the change, regardless of the sign (absolute value of 0.1 to 0.5) results in the biggest group consisting of those industries with a revision of 0.1 percentage point (34 industries) and the smallest being made up of those with a revision of 0.5 percentage point (12 industries).

In the remaining 19 industries, the growth rate of output per hour from 1973 to 1990 was revised by more than 0.5 percentage point. Only 5 of those industries registered changes larger than 1.0 percentage point. The largest *increase* in a productivity growth rate was in the household audio and video equipment industry, whose average annual growth rate was revised to 10.8 percent per year from 9.0 percent. The greatest *drop* in a productivity growth rate was in the hardwood veneer and plywood industry, whose rate of growth of output per hour was revised from 2.7 percent to 0.7 percent. Notice that none of the 1973–90 revisions is above 2.0 percentage points in magnitude.

Revisions in the shorter periods, 1973–79 and 1979–90. The revisions to the rates of labor productivity growth for shorter periods tended to be larger than the revisions to the long-term rates of growth. (See chart 2, page 8.) A possible reason for this is that, in a long period, the weights in the original output measures were changed more times than in

one of the subperiods; the greater number of changes in weights in those long-term measures made them more like Törnqvist indexes, in which the weights change annually.

In the first subperiod, 1973–79, the growth rates for 28 industries were unchanged by the revision in methodology, compared with 31 in the second subperiod, 1979–90. Recall that in the long run, 1973–90, the rates of growth for 34 industries stayed the same. At the other extreme, changes in the growth rate of output per hour exceeding half a percentage point were observed in 26 of the industries in 1973–79 and in 37 industries for 1979–90, whereas the total for the long-term period was just 19. Additionally, in each of the shorter periods, there were changes in growth rates of more than 2.0 percentage points, which was not true in the long run. Even so, there were only five such changes in the first period and two in the second. The magnitude of the largest of those changes was 4.7 percentage points: the average annual growth rate of output per hour in household audio and video equipment was revised upward from 5.1 percent to 9.8 percent for 1973–79.

FOR EACH OF THE THREE PERIODS, 1973–79, 1979–90, and 1973–90, the vast majority of the revisions to the growth rates of output per hour were small: at least three-quarters of the changes in each period were less than or equal to 0.5 percentage point in magnitude. The new procedures yield results very close to those generated by the original BLS methodology. Overall, the modernization of the methodology has produced refinements, rather than dramatic changes, in the industry labor productivity growth rates. □

Footnotes

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[1] See C. D. Wright, *Thirteenth Annual Report* (Bureau of Labor Statistics, 1898).

[2] Harry Magdoff, Irving H. Siegel, and Milton B. Davis, *Production, Employment, and Productivity in 59 Manufacturing Industries, 1919–1936*, Report S–1, 3 vols. (Philadelphia, Works Progress Administration, National Research Project, 1939).

[3] See, for example, *Footwear, 1947 to 1948: Trends in man-hours expended per pair* (Bureau of Labor Statistics, October 1950); and *Gray Iron Foundries: Case study data on productivity and factory performance* (Bureau of Labor Statistics, August 1951).

[4] See *Productivity Measures for Selected Industries and Government Services*, Bulletin 2461 (Bureau of Labor Statistics, May 1995) for details on the methods underlying the calculation of industry multifactor productivity and for the most current multifactor productivity indexes.

[5] Magdoff, Siegel, and Davis, *Production, Employment, and Productivity*, p. 3.

[6] Irving H. Siegel, "On the Design of Consistent Output and Input Indexes for Productivity Measurement," in *Output and Productivity Measurement*, NBER Studies in Income and Wealth, vol. 25 (Princeton, NJ, Princeton University Press, 1961), pp. 23–46.

[7] Siegel, "Consistent Output and Input Indexes."

[8] *Ibid.*, especially p. 23.

[9] The multifactor productivity measures discussed in the opening section of this article are actually preferred measures of efficiency, because they take into account capital and intermediate purchases. Labor productivity statistics are regarded as the best measure of efficiency for those industries for which multifactor productivity statistics are not available.

[10] W. E. Diewert, "Exact and Superlative Index Numbers," *Journal of Econometrics*, vol. 4, 1976, pp. 115–45. See also Douglas W. Caves, Laurits R. Christensen, and W. Erwin Diewert, "The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity," *Econometrica* (November 1982), pp. 1393–1413.

[11] For more information on translogarithmic production functions, see Laurits R. Christensen, Dale W. Jorgensen, and Lawrence J. Lau, "Transcendental Logarithmic Production Frontiers," *Review of Economics and Statistics* (February 1973), pp. 28–45.

[12] Note that the growth rate of q_i in the Törnqvist formula is the natural logarithm of the ratio of the quantity of product i in the current year to the quantity in the previous year. This could also be expressed as the change in the natural logarithm of q_i.

[13] The real-value-of-shipments index is combined with a series of adjustment ratios to yield an industry output index. The ratios are as follows:

1. Inventory adjustment ratio = (value of industry shipments plus net additions to inventories) / (value of industry shipments).
2. Coverage adjustment ratio = (value of industry shipments) / (value of shipments of primary products of the industry).
3. Double-counting adjustment ratio = (value of industry shipments, plus net additions to inventories, minus value of shipments of intraindustry transfers, minus value of shipments of resales) / (value of industry shipments plus net additions to inventories).

[14] The effects of changes in workers' characteristics are reflected in the labor input indexes in the recent study, *Labor Composition and U.S. Productivity Growth, 1948–90*, Bulletin 2426 (Bureau of Labor Statistics, December 1993). The bulletin uses data on the heterogeneity of workers in the examination of productivity growth in the private business and private nonfarm business sectors. However, reliable data on workers' traits are not available at the industry level, and hours must be treated as homogeneous and additive in the industry labor productivity measures.

[15] The most recent survey was conducted in 1977.

[16] The term *rate of growth* refers to the rate of change. Thus, the rate can be a positive or a negative number.

[17] The entire time series has been revised for 123 of the industry labor productivity measures. For 20 manufacturing industries and 10 service-producing industries, not all of the time series could be revised, due to data limitations. For these measures, the original indexes of the early years are linked to the revised indexes of the later years.

[18] The period 1973–90 also encompasses all but five of the BLS industry labor productivity measures. Two measures begin in 1977, and three end in 1989. These five measures are included in the analysis of productivity growth rate changes for the long-term period, 1973–90, and the shorter term periods, 1973–79 and 1979–90.

[19] Chart 1, chart 2, and table 1 present results for the 153 revised industry labor productivity measures. Although the Bureau publishes productivity measures for 178 industries, 25 measures were not revised and are not included in the charts, table, or analysis.