# Bias in Aggregate Productivity Trends Revisited

William Gullickson
Michael J. Harper

Bureau of Labor Statistics

July, 2001

This paper was prepared for a joint meeting of the National Bureau of Economic Research program on productivity and prices and the Conference on Research in Income and Wealth, July 30-31, 2001. An earlier version of this paper was presented to the Federal Economic Statistics Advisory Committee, December 14-15, 2000. Since then, all of the tables have been revised to reflect more recent data, and there have been text revisions.

# Bias in Aggregate Productivity Trends Revisited

William Gullickson
Michael J. Harper
Bureau of Labor Statistics
July, 2001

This paper updates results presented in our February 1999 *Monthly Labor Review (MLR)* article, "Possible Bias in Aggregate Productivity Growth."[1] That study determined that manufacturing could account for all of the multifactor productivity (MFP) growth during the 1979-96 period within the private business sector. It then identified industries outside of manufacturing with negative MFP trends and assessed their effects on aggregate productivity. That study concluded that the negative MFP trends seemed at least somewhat implausible and might have reflected service output measurement problems.

This paper reprises the methodology, summarizes the earlier results, and presents new results. Besides including data up through 1997, the new results reflect the comprehensive revisions of the National Income and Product Accounts (NIPA) published by the Bureau of Economic Analysis (BEA) in October 1999. Aggregate productivity now is growing faster and it is less clear that there is an aggregate bias, but we still see negative MFP trends for some of the same industries. For other industries, we see find surprisingly low MFP trends. This is probably indicative of problems with the measurement of some service industry outputs. It may also reflect the rapid growth in high tech inputs used by these industries.

[1] This paper is available at http://stats.bls.gov/opub/mlr/1999/02/art4full.pdf .

**Outline of Procedures Used**

In the earlier paper, we described the construction of estimates of MFP trends at both the industry and aggregate levels using available statistical agency data. MFP measures compare output trends to the trends in several inputs. A formal framework for MFP emerged from a 1957 paper by Robert Solow that discussed how to separate substitution among inputs from shifts in a production function. MFP growth is designed to measure the joint influences on economic growth of things people would associate with productivity, such as technological change, efficiency improvements, returns to scale, and reallocation of resources. At the aggregate level, the principal inputs are labor and capital, while at the industry level, inputs also include materials and services purchased from other industries. Data are organized in a framework proposed by Evsey Domar in 1961. Domar showed how data on the inputs and outputs of various industries that buy goods and services from one another can be used to (a) measure industry MFP trends and (b) account for aggregate MFP trends.[2]

[2] In an unpublished paper supplementing the earlier article, we described an "ideal" set of data and also a model that could use these data to calculate industry and aggregate productivity in a consistent manner. Ideally we would have (a) an annual set of nominal input-output tables defined consistently over time, (b) a complete set of price indexes for each product, and (c) complete data on real capital and labor inputs used by each industry. All of this would be consistent with published aggregate data on output and inputs. Of course, the available data fall short of this ideal. Construction of this data-set would be expensive because it would involve reconciling a lot of conflicting information and estimating a lot of incomplete information. In the economic censuses, in BEA's input-output and NIPA work and in the BLS's MFP work, however, much of what would be needed to construct this ideal data-set is already effectively estimated. To get the results in the *MLR* article and the new results here, we have made assumptions and adjustments to reconcile various data with the framework we have in mind. By using many shortcuts, we have attempted to infer what MFP trends might emerge if the ideal data set were really constructed.

The unpublished paper also spelled out the rationale for the model used in terms of production functions. We had this model and these "ideal" data in mind in formulating the industry exercise. It is important to be able to relate real economic growth measurement procedures to formal production theory. It is not the case that describing the link to theory forces a lot of assumptions onto the data. To the contrary, we are assuming a lot in any event, and careful links to theory help us understand what it is we are assuming, and by doing so, to guide the way to less rigid assumptions.

**Earlier Findings**

In the earlier work we carried out two main data exercises. One was a "top side" exercise, which showed that all of the private business MFP growth between 1979 and 1996 could be accounted for by MFP growth in manufacturing. This implied that the rest of the private business sector had no overall MFP growth.

The second "industry exercise" constructed estimates of MFP trends at roughly the 2-digit industry level. In our earlier paper, we identified the goal of determining which non-manufacturing industries had negative MFP trends. After we identified industries with negative MFP trends, we sought to determine the extent to which each contributed to the relatively slow aggregate MFP trend. Working on the premise that *output* in these industries was measured with error, we simulated the adjustment of industry *output trends* enough to pull the negative industry *MFP trends* up to zero. This would have raised the aggregate MFP trend for 1979-1992 by 0.44 percent.

In this earlier work, the industries with significant negative MFP trends, in order of their downward effects on aggregate MFP, were construction, insurance, banking, utilities, and health services. We argued that long term negative MFP trends were implausible for these industries. We did consider some alternative measurement problems that might have led to negative MFP trends, but concluded that "…there is good reason to suspect that bias in output quantity/price (trend) allocation is a dominant explanation…".

**Examination of New Results**

The tables accompanying this note correspond to the tables in the *MLR* article. Tables 1 and 2 present measures of output per hour and MFP, respectively, at the aggregate level.

It has been widely noted that the 1999 BEA revisions raised the productivity trends. The size of the "raise" varied by period, but it was generally between 0.3 and 0.6 percent per year in various selected periods since 1979. The "raise" is attributable to three changes made by BEA: the introduction of "research CPI's" to the deflation process; the reclassification of software as capital; and the use of BLS data on banking transactions in measuring banking output. The BEA revisions partially address the issues we raised in our *MLR* article. In the aggregate exercise worked out in the new Table 3, we now find non-manufacturing contributing 0.5 percent per year to the business MFP trend between 1990 and 1995 and 0.6 percent during 1995-1999. These trends are up from zero in the earlier data in the *MLR*.

Turning to the "industry exercise", the methodology first develops what we call "BLS output based" MFP trends from input and output estimates for each industry.[3] We also develop what we call "BEA output based" MFP trends by adjusting the BLS MFP trends for consistency with the latest data on gross output from the BEA "gross product originating" program.[4] In the discussion here we will emphasize the "BEA output based" MFP trends.

[3] On a quinquennial basis, we estimate a full set of inputs and outputs in both nominal and real terms. These are based in part on input-output tables and on industry gross output and output price series that the authors obtained from the BLS Office of Employment Projections (OEP). The OEP starts with BEA's benchmark input-output tables and makes adjustments for "time series consistency". At this point, the most recent benchmark table available is for 1992. The tables in the current paper reflect new OEP work which in turn reflects the 1999 comprehensive revisions to BEA's National Income and Product Accounts.

[4] This involves substituting the BEA output trends for the BLS output trends and using the input-output data to adjust the input trends estimates for compatibility with the BEA output levels. The BEA-based trends are based on adjustments to BLS trends, and we never develop a full set of inputs and outputs consistent with the BEA-output based MFP trends.

The overall increase in the MFP trend appears to be supported by the revised "industry exercise", summarized in Table 4.[5] As in the earlier article, we would like to caution readers that the data associated with our industry exercise (presented in tables 4, 5 and 6) should not be taken at face value. Rather, the point of the industry exercise is to help determine how weaknesses in economic statistics may affect the aggregate productivity picture. The following text table compares one-digit industry data in the new Table 4 to those in the "old" Table 4 from the *MLR* article:

Estimates of MFP Trends

| | ---BEA Output Based--- | | ---BLS Output Based--- | | | |
|---|---|---|---|---|---|---|
| | Old 1977-1992 | New 1977-1997 | Old 1977-1992 | New 1977-1992 | New 1992-1997 | New 1977-1997 |
| Farms | 1.7 | 2.3 | 1.8 | 2.1 | 1.3 | 1.9 |
| Mining | -1.5 | -0.8 | -1.2 | -1.7 | 1.2 | -1.0 |
| Construction | -0.9 | -0.9 | -0.4 | -0.4 | -1.0 | -0.5 |
| Manufacturing | 0.7 | 0.6 | 0.5 | 0.5 | 1.5 | 0.7 |
| Transportation | 0.2 | 0.2 | 0.4 | 0.2 | -0.2 | 0.1 |
| Communications | 0.9 | 0.1 | 0.4 | -0.6 | 0.7 | -0.3 |
| Utilities | -1.1 | -0.1 | -0.3 | -0.7 | -0.1 | -0.5 |
| Trade | 1.2 | 1.1 | 1.1 | 0.9 | 0.3 | 0.7 |
| Finance, Insurance & Real Estate | -1.3 | -0.5 | -1.2 | -0.4 | -0.4 | -0.4 |
| Services | 0.2 | -0.5 | 0.1 | 0.0 | -0.6 | -0.2 |

In the first two columns, four of the ten sectors (farms, mining, utilities, and finance) have "BEA output based" MFP trends for 1977-97 that are between 0.6 and 1.0 percent per year higher than the trends for 1977-1992 reported in the earlier *MLR* article. We

[5] For those unfamiliar with the MLR article, we will note the major data sources used to estimate these MFP trends in Table 4. These are the 1977 and 1992 input-output tables from BEA, adjustments to these tables for consistent definitions made by the BLS Office of Employment Projections (OEP), an estimate of the 1997 table made by the OEP and the authors using data from the 1997 Economic Censuses; BEA's data on nominal and real gross output associated with their gross product originating measures; and data on capital and labor from the dataset supporting the published BLS MFP measures for the private business sector.

might have expected the upward revisions to the aggregates to carry over broadly to the industry level---the BEA revisions tended to boost aggregate output trends and the extension of the time period to 1997 captures two years of the post-1995 productivity surge. In the final four columns of the text table, we were able to use the more complete "BLS output based" data-set to examine the separate effects of (a) revisions and (b) extension of the time period. It is somewhat surprising to find MFP growing more slowly in five sectors during 1992-1997 than it did during 1977-1992. This is reminiscent of Robert Gordon's finding that the productivity acceleration of the late 1990s is confined to a limited number of sectors.

Perhaps more surprising is the observation that, in the first two columns, the "BEA output based" MFP trends for 1977-1997 are 0.7 and 0.8 percent per year *lower* in two sectors, services and communications, than they were for 1977-1992 in the old data. In the same vein, there were only small trend revisions (of a tenth of a percent or zero) for construction, manufacturing, transportation and trade. MFP compares output trends with input trends, and it occurred to us that strong input growth may help account for some of these low MFP trends. The first three columns of the following text table break out the BLS MFP trends into output and input trends.

Sectoral "BLS-Output Based" Trends in Multifactor Productivity (MFP), Outputs and Inputs, and the Point Contributions of Specific Input Categories to the Trend in Input Growth
1977-1997, annual rates

| Sector | ---------- Trends ---------- | | | ------ Point Contributions to Input Growth ------ | | | |
|---|---|---|---|---|---|---|---|
| | MFP | Output | Inputs | IPES* | Other Capital | Labor | Intermediate Inputs |
| Farm | 1.9 | 1.7 | -0.2 | 0.02 | -0.18 | -0.16 | 0.14 |
| Mining | -1.0 | 0.3 | 1.3 | 0.29 | 0.41 | -0.29 | 0.94 |
| Construction | -0.5 | 1.2 | 1.8 | 0.05 | -0.03 | 0.76 | 0.98 |
| Manufacturing | 0.7 | 2.5 | 1.8 | 0.15 | 0.18 | -0.01 | 1.50 |
| Transportation | 0.1 | 2.9 | 2.8 | 0.21 | 0.15 | 0.72 | 1.82 |
| Communications | -0.3 | 4.2 | 4.5 | 1.13 | 0.68 | 0.28 | 2.14 |
| Utilities | -0.5 | 0.4 | 1.0 | 0.45 | 0.68 | 0.14 | 0.14 |
| Trade | 0.7 | 3.1 | 2.4 | 0.51 | 0.49 | 0.76 | 0.91 |
| Finance, Insurance, and Real Estate | -0.4 | 4.1 | 4.5 | 0.39 | 0.84 | 0.73 | 2.32 |
| Services | -0.2 | 4.3 | 4.5 | 0.30 | 0.29 | 1.97 | 1.86 |

* Information Processing Equipment and Software

Services and communications have 4.5 percent input growth trends. High tech inputs (information processing equipment and software) contributed[6] much of this input growth in communications, while their contribution was less noteworthy in services. It is possible that there was over-investment in communications. However we suspect that the methods used to measure and price the outputs in communications do not capture quality change as well as the methods used to measure and price the inputs they employ. We shall return to the high tech issue shortly.

As in the earlier study, Table 5 contains estimates of the contributions of each industry's productivity to private business MFP. These "Domar" contributions weight each

[6] To simplify processing, the "point contributions" of specific input categories to "input growth" were computed by multiplying each category's input quantity trend, for 1977-1997, by the arithmetic mean of its cost shares in 1977 and 1997. Since the aggregate input growth trends are built up by chaining quinquennial trends, the sum of point contributions sometimes differs from the input growth rate by several tenths of a percent.

industry's MFP trend by a ratio indicative of the industry's relative importance in the aggregate sector.[7] *If all of the underlying data were assumed to be correct, the Domar contributions would be the bona fide contributions of the industries to aggregate productivity.*

Table 5 shows results to the nearest one-tenth of one percent and shows only those industries that make nonzero contributions in at least one time period.[8] As we see, some industries (construction; the finance, insurance and real estate sector; and business services) make negative contributions. This would mean they appear to be pulling aggregate MFP down. MFP is designed to measure the effects of things like technology, efficiency and returns to scale. For a growing industry, MFP is unlikely to decline over long time periods. Furthermore we know that real output measurement is problematic in these sectors. These negative Domar contributions therefore may be symptomatic of measurement problems.

As noted in our earlier work, the Domar framework allocates some aggregate productivity growth to industries that sell some of their output to other industries. Except for sales of capital goods, these "intermediate" sales do not enter "final demand" in the NIPAs, and are not counted in aggregate output. For that reason, any error in measuring

---

[7] The ratio is the nominal value of the industry's "sectoral output" divided by the nominal value of private business gross product originating. The term "sectoral output" is attributable to Frank Gollop. It expresses Domar's preferred concept of an industry's output: it includes all sales to final demand plus all sales to other industries, but deducts from that the value of intermediate inputs purchased from within the industry in question. Note that the scope of the measure depends on the degree of aggregation: as we examine progressively more aggregate industrial sectors, successively more intermediate inputs are excluded. As we noted in our *MLR* article, the sum of these ratios is more than one because the industries sell intermediate products to one another. The intuition as to why the weights would add up to more than one can be illustrated by the following example. If the productivity of steel makers improved by one percent, and the productivity of auto makers improved by one percent, then the productivity with which the economy created cars would have increased by more than one percent.

[8] When contributions are added up (with more precision than shown), these new calculations approximately replicate the published MFP trends for the private business sector (compared in two lines near the bottom of the table). For 1977-1997 the new detailed contributions are consistent with an aggregate MFP trend of 0.7.

the real output trends associated with these sales would not affect business sector productivity. Such an error would, however, lead to the wrong story on the industry allocation of productivity growth. Table 6 reports on "what if" simulations designed to isolate the effects of negative (and presumably incorrect) output trends on the aggregate productivity trends. The simulations, similar to those we did in our earlier work, estimate what would happen if we adjusted industry output trends enough to raise the MFP of all industries with negative measured MFP trends up to zero (top panel) or up to one percent (bottom panel).

We focus on the third column of the top panel, which shows the effects on raising negative "BEA output based" MFP trends up to zero. (We show these numbers in bold.) The total effect is 0.34 on the trend for 1977-1997. In our earlier work, the effect had been 0.44 on the trend for 1977-1992. Furthermore, the same four industries contribute to the problem. Raising construction MFP to zero (by adjusting its output) would now increase the aggregate MFP trend by 0.12. This is followed by insurance (0.08), health services (0.05) , and banking (0.03). Negative MFP in auto repair also "contributes" .03.

A little discussion of banking is in order.[9] In our earlier work we had highlighted banking, which then had an MFP trend of –2.3 percent per year. At the time, the BEA banking output trends were measured, mainly, by using employment trends. This implied there was no change in labor productivity. In the 1999 NIPA revisions, BEA adopted the BLS banking output measures, which are based on counts of transactions. It now looks as though this change raised banking MFP almost enough to eliminate the negative MFP

[9] Note that the category we refer to as "banks" includes private, for-profit financial institutions within SICs 60, 61, and 67. Among the more important types of institutions in these industries are commercial banks, savings and loans, credit agencies, bank holding companies, certain trusts, and royalty administrators. Commercial banks accounted for about 57% of the employment in this category in 1995.

trend.[10] Banks have been investing heavily in capital, and the new output trends come much closer to accounting for the quality adjusted input growth. Still, the relative output and input trends give no indication of MFP *gains*.

**High Tech Equipment**

In these new data, we see two unexpected results. First, as we just outlined, we see these persistent and significant negative MFP trends in construction, insurance, health, and, to a lesser extent, banking. Second, as mentioned earlier, we also see lower MFP trends in services and communications than in the old data. This was surprising since now we are including data through the prosperous mid-1990s.

In a paper written earlier this year, Oliner and Sichel point out that high tech capital affects aggregate labor productivity growth twice*: first when the capital is made and again when it is used*. As Solow showed in 1957, wherever capital input is ***used***, it can contribute to labor productivity. As Domar showed in 1961, the industries where capital goods are ***made*** can experience productivity improvements and can contribute to aggregate productivity growth. We have estimates of each of these effects for high tech capital. In May 2001 BLS reported that increased "capital intensity" associated with the ***use*** of information processing equipment and software inputs accounted for 0.9 percent of the 2.6 percent labor productivity trend in private business during 1995-1999. For this paper we have prepared a new table (Table 7) that shows the "Domar contributions" of two-digit manufacturing industries to the private business MFP trends.[11] The striking result in Table 7 is that SICs 35 and 36, where semiconductors and computers are ***made***,

[10] In Table 4, the trend is –1.6 percent per year from 1977-1997. We also calculated the trend for 1987-1997 and this was –0.8 percent per year.

[11] These results are based on MFP trends which BLS publishes, and so they are not subject to quite so many qualifications as the non-manufacturing estimates.

account for about half of the 1.3 percent per year MFP trend for the entire private business sector during 1995-99 (and nearly three-fourths of the 2.5 percent trend of manufacturing MFP during the same period). Together, both high tech effects -- manufacture and use -- account for 1.6 percent per year of the 2.6 percent labor productivity trend during 1995-1999.[12] In other words, high tech capital appears to be the dominant explanation for productivity growth in the late 1990s.

These findings rest on estimated trends for high tech inputs and outputs that incorporate adjustments to account for changes in their quality.[13] Many of the high tech input and output growth rates are well up in the double-digit percentage range. These extraordinary trends, in turn, rest on the use of quality adjusted price indexes in deflation. These indicate that prices for high tech goods of constant quality have fallen very rapidly. These price trend estimates have withstood much scrutiny, but we must emphasize their importance for our conclusions. While it is likely that real output trends have been underestimated in many or all of the service sector industries with negative MFP trends, it is also possible that the growth trends for high tech inputs have been overestimated. While either source of bias would tend to push service industry MFP trends down, the two would have opposite effects on the aggregate MFP trend. Underestimating service sector output trends would bias the aggregate productivity trend downward. Overestimating high tech input and output trends would bias the aggregate productivity trend upward.

With the results of this paper, we can neither prove that service output growth rates are too low, nor determine that high tech input and output growth rates are too high. We can, however, express a concern that the "measurement playing field" may not be level. We

[12] Oliner and Sichel found similarly large effects from both the making and the use of high tech items.
[13] Both of Oliner and Sichel's effects are directly dependent on the measured growth rate of high tech quality change.

have very intricate means of making quality adjustments to high tech goods but we have few means to make quality adjustments to service outputs.

**Summary and Conclusions**

In our earlier work, the bottom line was that aggregate productivity trends were probably downward biased. In light of the new evidence presented here, a firm conclusion about aggregate bias may be more difficult. Recent aggregate productivity trends are higher than they were when we published the earlier analysis. This is due to improvements made by BEA to the NIPAs (affecting the aggregate productivity trends prior to 1995), and also to a significant speedup in productivity growth since 1995.

In spite of the measurement improvements, it is clear that the problem of "difficult to measure" service outputs has yet to be solved. In our tables, most of the MFP anomalies noted in the earlier work remain and several new ones have appeared. There are conceptual barriers to measuring the outputs of some service industries. Present methods probably still fail to capture many important quality improvements occurring in these industries. If, however, the growth in high tech capital quality is somewhat overstated, it would serve to confuse efforts to sort out where the productivity improvements really are and to assess the direction of any overall bias in the measured productivity growth rate.

Since many of the results in the "industry exercise" may reflect measurement problems, we may be hampered in our ability to understand fully the sources of productivity change. There is a need to continue to scrutinize the procedures for measuring price, output and quality trends in ever-changing industries in both the service and technology sectors.

**Table 1. Output per Hour in Major U.S. Sectors Compound Annual Rates of Change**

| | Business | Nonfarm Business | Manufacturing |
|---|---|---|---|
| 1947*-2000 | 2.5 | 2.2 | 2.9 |
| 1947*-1960 | 3.3 | 2.7 | 2.0 |
| 1960-1973 | 3.3 | 3.0 | 3.0 |
| 1973-1979 | 1.3 | 1.2 | 2.2 |
| 1979-2000 | 1.9 | 1.7 | 3.4 |
| 1979-1990 | 1.5 | 1.4 | 2.6 |
| 1990-1995 | 1.5 | 1.5 | 3.3 |
| 1995-2000 | 3.0 | 2.8 | 5.3 |

* Trends for manufacturing trends begin in 1949.

**Table 2. Multifactor Productivity Trends in Aggregate U.S. Sectors**

| | Private Business | Private Nonfarm Business | Manufacturing |
|---|---|---|---|
| 1949-1999 | 1.4 | 1.2 | 1.2 |
| 1949-1973 | 2.1 | 1.9 | 1.5 |
| 1973-1979 | 0.6 | 0.4 | -0.6 |
| 1979-1990 | 0.5 | 0.3 | 1.1 |
| 1990-1995 | 0.6 | 0.6 | 1.2 |
| 1995-1999 | 1.3 | 1.1 | 2.5 |

**Table 3. Multifactor Productivity (MFP) Growth in the U.S. Private Business (PB) Sector and the Contributions of Labor Composition Effects (LCE), Manufacturing (Mfg) MFP Growth, and Nonmanufacturing (Non-mfg) MFP Growth**

| | (1) PB MFP | (2) PB LCE | (3) Unadjusted PB MFP | (4) Mfg MFP | (5) Contributions to PB of: Mfg | (6) Non-mfg |
|---|---|---|---|---|---|---|
| 1949-1999 | 1.4 | 0.2 | 1.6 | 1.2 | 0.6 | 1.0 |
| 1949-1973 | 2.1 | 0.2 | 2.3 | 1.5 | 0.8 | 1.5 |
| 1973-1979 | 0.6 | 0.0 | 0.6 | -0.6 | -0.3 | 0.9 |
| 1979-1990 | 0.5 | 0.3 | 0.8 | 1.1 | 0.5 | 0.3 |
| 1990-1995 | 0.6 | 0.4 | 1.0 | 1.2 | 0.5 | 0.5 |
| 1995-1999 | 1.3 | 0.3 | 1.6 | 2.5 | 1.0 | 0.6 |

Table 4. Estimates of multifactor productivity trends in U.S. industries, selected periods

| | 1947-63 | 1963-77 | 1977-97 | 1977-97 |
|---|---|---|---|---|
| Main source of output estimates: | ---------BLS--------- | | | BEA |
| Compound annual growth rates of MFP: | | | | |
| Farms (SIC 1,2) | 2.0 | 0.8 | 1.9 | 2.3 |
| Mining (10-14) | 1.0 | -1.4 | -1.0 | -0.8 |
| Metal mining (10) | | -1.3 | 2.1 | 2.0 |
| Coal mining (11, 12) | | -1.9 | 3.0 | 2.9 |
| Oil and gas extraction (13) | | -1.5 | -2.2 | -1.8 |
| Nonmetallic minerals, exc. fuels (14) | | -0.1 | 0.5 | 0.5 |
| Construction (15-17) | 1.1 | -1.1 | -0.6 | -0.9 |
| Manufacturing (20-39) | 0.8 | 0.6 | 0.7 | 0.6 |
| Durable manufacturing (24, 25, 32-39) | 0.6 | 0.7 | 1.1 | 1.1 |
| Nondurable manufacturing (20-23, 26-31) | 0.9 | 0.5 | 0.3 | 0.2 |
| Transportation (40-47) | 1.6 | 1.4 | 0.1 | 0.2 |
| Railroad transportation (40) | | 2.0 | 1.4 | 4.7 |
| Local and interurban pass. transit (41) | | 2.2 | -0.6 | -1.5 |
| Trucking and warehousing (42) | | 0.7 | -0.5 | 0.6 |
| Water transportation (44) | | 1.1 | 0.7 | 0.9 |
| Transportation by air (45) | | 1.8 | 0.4 | 0.7 |
| Pipelines, exc. natural gas (46) | | 1.8 | 0.1 | -1.0 |
| Transportation services (47) | | -0.2 | 0.1 | 0.0 |
| Communications (48) | 3.2 | 2.4 | -0.3 | 0.1 |
| Electric, gas, and sanitary services (49) | 3.5 | 0.7 | -0.5 | -0.1 |
| Trade (50-59) | 1.7 | 2.2 | 0.7 | 1.1 |
| Wholesale trade (50, 51) | | 2.1 | 1.6 | 1.3 |
| Retail trade (52-59) | | 2.1 | 0.0 | 1.0 |
| Finance, insurance, and real estate (60-67) | 0.7 | 0.6 | -0.4 | -0.5 |
| Credit agencies, holding co.’s (60, 61, 67) | | 0.6 | 0.1 | -0.5 |
| Security, commodity brokers (62) | | -1.1 | 0.3 | 1.5 |
| Insurance carriers (63) | | 1.5 | -2.4 | -0.8 |
| Insurance agents, brokers, and services (64) | | 2.8 | -1.1 | -4.9 |
| Real estate (65-66) | | 0.5 | 0.1 | 0.1 |
| Services (7-9, 70-89) | 0.4 | -0.6 | -0.2 | -0.5 |
| Agricultural services, forestry, fishing (7-9) | | 0.3 | 1.1 | 0.8 |
| Hotels and other lodging places (70) | | 0.8 | -2.2 | -1.3 |
| Personal services (72) | | 1.5 | 0.2 | 0.6 |
| Business and misc. repair services (73, 76) | | -0.7 | -1.0 | -1.0 |
| Auto repair, services, and garages (75) | | -1.4 | -0.4 | -1.4 |
| Motion pictures (78) | | -1.0 | 0.5 | 0.4 |
| Amusement and recreation services (79) | | -0.1 | 0.4 | 1.0 |
| Health services (80) | | -1.7 | -0.6 | -0.6 |
| Legal & other professional services (81,83-89) | | -0.5 | 1.0 | -0.2 |
| Educational services (82) | | -0.8 | 0.0 | 0.8 |

Table 5. Estimates of private business sector multifactor productivity and estimates of its attribution to industries, selected periods

| | 1947-63 | 1963-77 | 1977-97 | 1977-97 |
|---|---|---|---|---|
| Main source of output estimates | ----------BLS---------- | | | BEA |
| **Estimated Industry Point Contributions to private business sector trends** | | | | |
| Farms (SIC 1,2) | 0.3 | 0.1 | 0.1 | 0.1 |
| Mining | 0.1 | -0.1 | -0.1 | -0.1 |
| Oil and gas extraction (13) | | -0.1 | -0.1 | -0.1 |
| Construction (15-17) | 0.2 | -0.2 | -0.1 | -0.1 |
| Manufacturing (20-39) | 0.7 | 0.6 | 0.6 | 0.6 |
| Durable manufacturing (24, 25, 32-39) | 0.3 | 0.4 | 0.5 | 0.5 |
| Nondurable manufacturing (20-23, 26-31) | 0.5 | 0.2 | 0.1 | 0.1 |
| Transportation (40-47) | 0.1 | 0.1 | -0.0 | 0.1 |
| Communications (48) | 0.1 | 0.1 | -0.0 | 0.0 |
| Electric, gas, and sanitary services (49) | 0.1 | 0.1 | 0.0 | 0.0 |
| Trade (50-59) | 0.6 | 0.7 | 0.2 | 0.3 |
| Wholesale trade (50, 51) | | 0.3 | 0.2 | 0.2 |
| Retail trade (52-59) | | 0.4 | 0.0 | 0.2 |
| Finance, insurance, and real estate (60-67) | 0.1 | 0.1 | -0.0 | -0.1 |
| Credit agencies, holding co.’s (60, 61, 67) | | 0.0 | 0.0 | 0.0 |
| Insurance carriers (63) | | 0.0 | -0.1 | 0.0 |
| Real estate (65-66) | | 0.1 | 0.0 | 0.0 |
| Services (7-9, 70-89) | 0.1 | -0.1 | -0.1 | -0.2 |
| Business and professional services (73, 76) | | -0.0 | -0.1 | -0.1 |
| Health services (80) | | -0.1 | -0.0 | -0.0 |
| Legal and other professional services (81, 89) | | -0.0 | 0.1 | 0.0 |
| **Total contributions:** Private business trend derived by “Domar” aggregation | 2.4 | 1.4 | 0.7 | 0.7 |
| | 1948-63 | 1963-77 | 1977-97 | |
| **Private Business Sector MFP Trend Estimates** (compound annual rates of change) | | | | |
| …Published BLS estimates | 2.2 | 1.8 | 0.6 | |

Note: Industries and sectors with absolute contributions rounding to less than 0.1 in each time period have been omitted from table 5.

Table 6. Effects on aggregate MFP trends from adjusting output trends for those industries which exhibit negative MFP growth and also adjusting input trends for industries buying the outputs of the industries with negative MFP, 1977-1997

| | -BLS Output Based- | | -BEA Output Based- | |
|---|---|---|---|---|
| | On private business MFP | On manufacturing MFP | On private business MFP | On manufacturing MFP |
| *Adjustments sufficient to produce zero industry MFP growth* | | | | |
| Total effects: | 0.30 | -0.14 | **0.34** | -0.11 |
| Industry adjusted and the total effects of the adjustment: | | | | |
| Oil and gas extraction (13) | -0.02 | -0.07 | **-0.01** | -0.05 |
| Construction (15-17) | 0.08 | -0.00 | **0.12** | -0.00 |
| Local and interurban passenger transit (41) | 0.00 | -0.00 | **0.01** | -0.00 |
| Trucking and warehousing (42) | 0.01 | -0.01 | **0.00** | -0.00 |
| Communications (48) | 0.01 | -0.00 | **0.00** | -0.00 |
| Electric, gas, sanitary services (49) | 0.03 | -0.02 | **0.01** | -0.01 |
| Credit agencies, etc. (60, 61, 67) | 0.00 | 0.00 | **0.03** | -0.00 |
| Insurance carriers (63) | 0.09 | -0.01 | **0.08** | -0.00 |
| Hotels and other lodging (70) | 0.02 | -0.01 | **0.01** | -0.00 |
| Business services (73, 76) | 0.01 | -0.03 | **0.01** | -0.03 |
| Auto repair, etc. (75) | 0.01 | -0.00 | **0.03** | -0.01 |
| Health services (80) | 0.05 | -0.00 | **0.05** | -0.00 |
| *Adjustments sufficient to produce 1% industry MFP growth* | | | | |
| Total effects: | 0.68 | -0.27 | 0.72 | -0.23 |
| Industry adjusted and the total effects of the adjustment: | | | | |
| Oil and gas extraction (13) | -0.03 | -0.10 | -0.02 | -0.09 |
| Construction (15-17) | 0.21 | -0.00 | 0.24 | -0.00 |
| Local passenger transit (41) | 0.01 | -0.00 | 0.01 | -0.00 |
| Trucking and warehousing (42) | 0.02 | -0.03 | 0.00 | -0.00 |
| Communications (48) | 0.04 | -0.00 | 0.00 | -0.00 |
| Electric, gas, sanitary services (49) | 0.07 | -0.04 | 0.06 | -0.03 |
| Credit agencies, etc. (60, 61, 67) | 0.00 | 0.00 | 0.07 | -0.01 |
| Insurance carriers (63) | 0.14 | -0.01 | 0.13 | -0.01 |
| Hotels and other lodging (70) | 0.02 | -0.01 | 0.02 | -0.00 |
| Business services (73, 76) | 0.02 | -0.06 | 0.02 | -0.06 |
| Auto repair, etc. (75) | 0.04 | -0.01 | 0.06 | -0.01 |
| Health services (80) | 0.12 | 0.00 | 0.12 | -0.00 |

**Table 7. Contributions of Manufacturing Industries to Private Business Multifactor Productivity**

| SIC | Industry | 49-73 | 73-79 | 79-90 | 90-95 | 95-99 |
|---|---|---|---|---|---|---|
| 20 | Food | 0.09 | 0.01 | 0.03 | 0.05 | -0.02 |
| 21 | Tobacco | 0.00 | -0.01 | -0.03 | 0.02 | -0.05 |
| 22 | Textiles | 0.06 | 0.06 | 0.03 | 0.02 | 0.02 |
| 23 | Apparel | 0.02 | 0.04 | 0.01 | 0.01 | 0.02 |
| 26 | Paper | 0.03 | -0.03 | 0.00 | 0.00 | 0.03 |
| 27 | Printing | 0.01 | -0.02 | -0.03 | -0.04 | -0.02 |
| 28 | Chemicals | 0.11 | -0.13 | 0.04 | -0.01 | 0.04 |
| 29 | Petroleum | 0.03 | -0.03 | -0.01 | 0.01 | 0.02 |
| 30 | Rubber | 0.02 | -0.04 | 0.03 | 0.03 | 0.03 |
| 31 | Leather | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 24 | Lumber | 0.03 | 0.01 | 0.04 | -0.02 | -0.01 |
| 25 | Furniture | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 |
| 32 | Stone, Clay and Glass | 0.02 | -0.03 | 0.02 | 0.01 | 0.01 |
| 33 | Primary Metals | 0.02 | -0.11 | 0.01 | 0.02 | 0.04 |
| 34 | Fabricated Metals | 0.02 | -0.05 | 0.02 | 0.03 | 0.00 |
| **35** | **Industrial & Commercial Machinery** | **0.04** | **0.01** | **0.20** | **0.16** | **0.35** |
| **36** | **Electrical Machinery** | **0.08** | **0.05** | **0.13** | **0.23** | **0.34** |
| 37 | Transportation Equipment | 0.12 | -0.05 | 0.01 | 0.03 | 0.09 |
| 38 | Instruments | 0.03 | 0.03 | 0.04 | 0.00 | 0.02 |
| 39 | Miscellaneous Manufacturing | 0.02 | -0.01 | 0.01 | 0.00 | 0.01 |
| | Total Manufacturing Contribution | 0.77 | -0.32 | 0.57 | 0.55 | 0.93 |
| | Private Business Sector Multifactor Productivity | 2.10 | 0.60 | 0.50 | 0.60 | 1.30 |