Discussion Paper

Multifactor Productivity Contributions of U. S. Non-Manufacturing Industry Groups: 1987-2005

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This paper was developed for presentation at the meetings of the World Congress on National Accounts and Economic Performance Measures for Nations, Arlington Virginia, May 13-18, 2008. The paper reports progress on ongoing research. The methodology is subject to revision and the results are very preliminary. In the past, researchers at the Bureau of Labor Statistics produced similar data on non-manufacturing productivity, but concluded that many of the measures were implausible due to inadequate supporting data. In recent years many improvements have been made to the available data, but we still lack consensus among researchers as to how to measure some outputs. The authors are seeking comments on the usefulness of the current dataset and suggestions on possible further improvements. Additional detailed data supporting the calculations in this paper can be obtained by email from Steven Rosenthal (Rosenthal.Steve@BLS.gov). The authors would like to thank Lucy Eldridge and Susan Powers for helpful comments and Lisa Usher for supplying data from the BLS Industry Productivity program. The authors are responsible for any remaining errors.

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Abstract:

Numerous studies in the 1990s connected low measured trends in U.S. productivity to data deficiencies for the growing service sector. Gradually the federal statistical agencies received new funding and they began to design and collect many new series. Notable are expansions in coverage of services in the Bureau of Labor Statistics' Producer Price Index and in the Census Bureau's surveys of businesses. This paper updates two earlier BLS studies that used a "production account" framework to assess how measurement problems may have affected productivity trends for the United States. The framework also is designed to attribute private business productivity to industry groups. This paper develops illustrative multifactor productivity estimates for non-manufacturing sectors. The measures are similar to those used in the earlier BLS studies, but in this paper we make use of new data on intermediate inputs prepared by the U.S. Bureau of Economic Analysis (BEA). Fewer industry groups are exhibiting negative productivity trends than was the case in the past. This result probably reflects bona fide increases in productivity trends since 1995 as well as selected improvements in the measurement process in recent years. Nevertheless, many trends remain negative and some differences remain concerning the measurement of output for non-manufacturing industries.

I. Introduction

The share of U.S. employment devoted to services has increased steadily. Manufacturing now represents only 12 percent of business sector employment. During the decades of the 1950s, 60s, 70s and 80s, while the service-producing sectors were becoming dominant, federal data collection continued to focus mainly on the goods-producing industries, most notably the manufacturing and farm sectors. The main obstacles to measuring services were the heterogeneity of service commodities and the related conceptual difficulties in identifying measurement units. In these problematic sectors, the national accounts and productivity statistics either did not issue measures or did so by measuring outputs with data on inputs or input costs, resulting in no productivity growth.

During the 1990s there were several important efforts to draw attention to the consequences of weak data for the service sectors. [1] Zvi Griliches' [1994] presidential address to the American Economic Association concerned the mystery of the absence of aggregate productivity growth (at the time) in spite of sustained expenditures on research and development and of rapid progress in information technology. Griliches pointed to the fact that "over three quarters of this investment [in computers] has gone into our 'unmeasurable' sectors [construction, trade, finance, insurance and real estate, other services, and consumer and government purchases]". Griliches called for better funding of statistical agencies coupled with greater attention on the conceptual issues by the academic research community. Other developments focusing on these issues included a report by Michael Boskin [1996] and others to a U.S. Senate "Advisory Commission to Study the Consumer Price Index" and a paper by Carol Corrado and Larry Slifman [1999] of the Federal Reserve Board presenting evidence in support of Alan Greenspan's statements that productivity trends, mired near one percent from 1973-1995, were being underestimated.

Concerns about the data led to increased funding of the statistical agencies for work in the areas of services and high tech capital. In particular, many new Producer Price Indexes have been developed by BLS for the service producing industries since 2001, while the Census Bureau has expanded the coverage, detail and frequency of data collected for services. Since 2001, time series information has accumulated and this has permitted the expansion and improvement of

[1] This situation was of course noticed earlier. Griliches [1994] provided a list of earlier studies including: "the Stigler committee report on government price statistics (National Bureau of Economic Research [1961]); …the Ruggles [1977] report,… the Rees productivity report (National Academy of Sciences [1979])" and others.

industry datasets maintained by the BLS Office of Productivity and Technology (OPT) and the U.S. Bureau of Economic Analysis (BEA). All of these efforts were guided by increased attention from the research community, most notably a series of seminars at the Brookings Institution organized by Jack Triplett and Barry Bosworth [2004] and summarized in their book. Having continued to monitor developments, Triplett and Bosworth [2007] recently updated their recommendations.

The measures in this paper are illustrative.[2] They are designed to supplement the multifactor productivity (MFP) measures BLS is currently publishing in order to provide a complete picture of the private business sector. The published BLS MFP measures are formulated using growth accounting equations developed for the aggregate economy by Solow [1957], and Jorgenson and Griliches [1967]. The Solow approach was expanded to study industries by Domar [1961], Berndt and Wood [1975], and Jorgenson, Gollop and Fraumeni [1989]. The Solow approach involves the use of chained superlative index numbers, as described by Diewert [1975]. The first BLS MFP measures were published in 1983. These were aggregate level measures which built on an earlier research study by Norsworthy, Harper and Kunze in 1979. Regular publication of MFP for manufacturing industry groups began in 1996, again based on a line of research begun by Gullickson and Harper in 1986. Recently published trends in labor productivity are shown in Table 1, while published MFP trends are in Table 2. These trends are the most current and extend through 2007 (labor productivity) or 2006 (MFP).

This paper renews another line of BLS research, on *non-manufacturing* MFP, started by Gullickson and Harper [1999, 2002]. The conclusion, as of 2002, was that available data implied many productivity trends that were negative, implausible, and likely the result of the weak data. The data in the 2002 study covered the period 1977-1997 while the data in this paper cover 1987-2005. The data in this paper were constructed using the same approach as the published BLS MFP studies, that is, it uses tools developed earlier by Solow, Domar, Jorgenson and Griliches, and Diewert.

BLS has not abandoned the goal of regularly producing MFP data for a set of industry groups that cover the full private business sector. Recognizing that the data situation was improving,

[2] There are alternative data sources available for measuring output in production accounts, as we will be discussing near the end of this paper.

Fraumeni, Harper, Powers and Yuskavage [2006] (FHPY) proposed that BEA and BLS work towards completing "production accounts" for which they defined an ambitious and fully integrated set of relationships involving measures of outputs, inputs and prices for aggregate sectors, detailed industries and detailed commodities. The production account is a framework designed to unify concepts underlying BEA's National Income and Product Accounts (NIPA), BEA's input-output tables and BLS's MFP measures. The production account assumes that establishments have been grouped into industries; traces nominal flows for a detailed array of commodities; describes deflation of outputs and intermediate commodities using corresponding price indexes; and describes the construction of aggregate productivity trends from the detailed information.

II. Multifactor Productivity for Non-manufacturing Industry Groups

II.a The Model

The present paper computes illustrative MFP measures using the same growth accounting methods of the earlier studies and with coverage of non-manufacturing industries very similar to that of Gullickson and Harper [2002]. However, the data underlying the new work are improved in many ways, including use of improved raw data, use of BEA's new annual industry accounts as the source for intermediate inputs as well as outputs, and the removal of intra-sector transactions, consistent with the FHPY production account model.

MFP for the NAICS non-manufacturing industry groupings in this paper use a) published Bureau of Labor Statistics (BLS) measures of intra-industry proportion estimates (from the BLS domestic use Table), capital and labor inputs, productive capital stock, non-profit estimates, and own account software output; and b) data obtained from BEA, including output, intermediate inputs, and input-output tables. The paper uses a growth accounting approach that estimates MFP growth as a residual, calculating it as the observed rate of change of an industry's output that cannot be accounted for by the rate of change of combined inputs.

In the process of building up an index of combined inputs, the rates of change of capital, labor, and intermediate inputs (energy, materials and business services) are weighted together using factor income shares as weights. The shares for each period are the average of those for the previous and current years and then re-calculated for every period. The resulting intermediate series are chained and combined with the rates of change of factor inputs in order to obtain an index of combined inputs. The rate of change in multifactor productivity[3] is then measured as:

$$\frac{\dot{A}}{A} = \frac{\dot{Q}}{Q} - \left(w_k \frac{\dot{K}}{K} + w_l \frac{\dot{L}}{L} + w_e \frac{\dot{E}}{E} + w_m \frac{\dot{M}}{M} + w_s \frac{\dot{S}}{S} \right)$$

A dot over a variable reflects a time derivative. The variables and weights[4] used for factors in these equations are as follows:

A = Multifactor productivity
Q = Output
K = Capital input
L = Labor input
E = Energy input
M = Materials input
S = Purchased business services input
w_k = weight for capital
w_l = weight for labor
w_e = weight for energy
w_m = weight for materials
w_s = weight for business services

The non-manufacturing industry MFP measures describe the relationship between output in real terms and the inputs involved in their production. MFP 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. Non-manufacturing industry MFP measures use similar methodology to the manufacturing industry measures published annually by BLS [2007b]. One difference is that for non-manufacturing industries, intermediate inputs (energy, materials, and purchased services) are only available separately from 1997 forward. Before 1997, energy, materials, and purchased services are combined a single category, “intermediate inputs”, and are based on BEA’s “backcast” of these results for years prior to 1997.

The MFP measures for non-manufacturing industries differ from those for the more-aggregate private business sector in two important ways: their treatment of labor input and of intermediate inputs. First, the non-manufacturing industries’ measures of labor input are a direct aggregation

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[3] The multifactor model is explained in the appendix.
[4] The sum of the weights is assumed to be equal to one.

of hours. This is in contrast to the major sector measures for which estimates of the effects of changing labor composition have been developed. Second, the industry data treat intermediate inputs purchased from outside of the industry as inputs, while the private business measures exclude all intermediate flows from both output and input.

II.b The Data

Our illustrative MFP measures are developed and presented for 42 non-manufacturing industries classified according to the NIPA industry classification. This is comprised of two- to three-digit NAICS industries. Starting with the BEA gross output data described by Strassner, Medeiros, and Smith [2005], we calculated sectoral output measures that are consistent with private business sector output. Sectoral output is different from BEA's gross output by industry in that it excludes shipments of intermediate inputs from one establishment to another within the same industry. We removed these intra-industry transactions using proportions estimated by the BLS Division of Industry Employment Projections. We also estimated and removed output associated with nonprofit institutions using proportions based on nonprofit labor compensation in each industry.

Our MFP measures[5] for non-manufacturing industries compare sectoral output to an input measure that combines:

1) Hours at work of labor employed by establishments classified in the industry (not adjusted for composition change);
2) Capital services employed by non-manufacturing establishments; and
3) Purchases of energy, materials, and business services by establishments from outside the industry.

Data on the paid hours of production workers are obtained from the BLS Current Employment Statistics program. The hours of employees are converted to an at-work basis by using

[5] There are several important differences between the current dataset and those used by Gullickson and Harper [1999, 2002]. Most important is that the data on output and purchased intermediate inputs are now based on new data published by BEA. There is no longer a need to create these real time series from input-output tables, as BEA now does this. In addition the new work is based on the North American Industrial Classification System while the earlier was based on the Standard Industrial Classification system. Finally, the current study removes intra-sector transactions from outputs and inputs, while they were not removed in the Gullickson and Harper studies of non-manufacturing. (Intra-industry flow of intermediates have been removed in all BLS KLEMS estimates for *manufacturing* going back to Gullickson and Harper [1986].)

information from the National Compensation Survey (NCS) and the Hours at Work Survey. Hours at work for nonproduction workers are estimated using data from the Current Population Survey (CPS), the CES and the NCS. The hours at work of proprietors and unpaid family workers are derived from CPS microdata and incorporate separate information on the hours worked on primary and other jobs.

Estimates of capital services by industry come directly from the capital database used at BLS to measure MFP for the private business sector. Since the late 1980s, these capital measures have spanned non-manufacturing and have been constructed in the same industry detail as is published by BEA in the National Income and Product Accounts. Capital reflects equipment (including software), structures, inventories and land. BLS uses BEA data on investment by detailed asset-type for each industry. The BLS capital model for each industry aggregates across vintages (for depreciable asset types) and then across asset types. Aggregation across asset types involves estimating rental prices and constructing chained Tornqvist indexes[6], along the lines originally described by Jorgenson and Griliches [1967]. The BLS uses detailed BEA data on the components of property income in constructing these rental prices. Further specifics on the BLS aggregation methods are provided by Harper [1999]. Within equipment, the BLS provides additional details 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 (medical equipment and related instruments, electro-medical instruments, non-medical instruments, photocopying and related equipment, and office and accounting machinery).

Intermediate inputs of energy, materials, and purchased business services for 1997 forward were obtained from the BEA annual industry accounts, again from the dataset described by Strassner, Medeiros and Smith [2005].

The five input indexes for each industry group (capital services, hours, energy, materials, and purchased business services) are combined into an “input index” using Tornqvist aggregation. Labor’s cost share is based on labor compensation and capital share is derived from capital

[6] The chained Tornqvist index is a chain of the antilogs of growth rates computed as follow: weighted averages of differences in successive logarithms of the input indexes. The weights are two-year averages of respective inputs shares in total input costs, for the two years being compared. The weights change each year.

income[7]; both are part of industry value added. Total costs are constrained to equal the value of the non-manufacturing industry group's sectoral output.

For non-manufacturing industries, only a few of the series are available from their sources on a NAICS basis for years prior to 1997. In preparing data for this paper, numerous adjustments were needed for the earlier time period. For example, many of the property income series are unavailable before 1997. For 1987 to 1997 we estimated these by applying 1997 SIC-to-NAICS conversion factors to SIC data and adjusting to the estimated NAICS totals for 1997. A similar procedure was applied to the data used to calculate inventories and land. Intermediate inputs are published by BEA for 1987-96 in a single combined category (rather than separately for energy, nonenergy materials and services). Accordingly, the KLEMS measures for 1987-96 in this study were calculated using this more aggregate grouping, and then linked to the 1997 total for the three types of intermediate inputs.

In order to provide a complete picture of the private business sector, this paper also presents the regularly published BLS [2007b] data for manufacturing industries (starting with Table 5).

II.c Basic Results for Non-manufacturing Multifactor Productivity

Our illustrative MFP measures for the NAICS NIPA-level non-manufacturing industry groupings (111 to 811) for the time period 1987 to 2005 are shown in Table 3 and illustrated graphically in Figure 1. The average annual compound MFP growth rates for 42 non-manufacturing industries were positive or zero for 26 industries and negative for 16 industries over the 1987 to 2005 time period. The large number of persistently negative MFP trends is a troubling result and echoes findings of earlier studies. Gullickson and Harper [2002] found negative MFP trends in 13 of 32 non-manufacturing industries for 1977-1997.[8] Among the 42 industries, three industries had

[7] Labor compensation includes wages and salaries of employees plus employers' contributions for social insurance and private benefit plans and all other fringe benefits in current dollars. An estimate of the wages, salaries, and supplemental payments for the self-employed and unpaid family workers is included. Capital income is corporate capital income plus imputed noncorporate capital income. Corporate capital income includes corporate capital consumption allowances plus corporate profits plus corporate inventory valuation adjustment plus corporate net interest plus business transfer payments plus the part of indirect business taxes associated with capital (property taxes and motor vehicle taxes). Noncorporate capital income equals total cost less corporate capital income less total labor compensation.

[8] Aside from the difference in time periods, the new list is based on the NAICS classification instead of the SIC. The NAICS provides more detail, particularly for NAICS industries numbered in the 50s and 60s, where many of the negative trends occur, and so this affects a comparison of proportions of industries.

average annual growth rates of 3.0 percent per year or higher. Securities, commodity contracts, and investments (NAICS 523) had by far the highest growth rate at 7.1 percent, also a troubling result. Warehousing and storage (NAICS 493) and computer systems design (NAICS 5415) also had strong growth, 3.0 and 3.2 percent per year, respectively. Four industries recorded declines in MFP of more than 1.0 percent per year. Rental and leasing industry (NAICS 532 & 533) had the lowest growth rate declining 2.3 percent per year. Legal services (NAICS 5411), Federal Reserve banks, credit intermediation & related activities (NAICS 521 & 522), and support activities for mining (NAICS 213), and forestry, also showed steep declines of 1.5, 1.0, and 0.9 percent per year, respectively.

It is interesting to look at changes in the time trend. Table 3 offers data for three subperiods, 1990-1995, 1995-2000 and 2000-2005. Each subperiod is five years long. The 1990 and 2000 are regarded as business cycle peaks, while 1995 is recognized as the beginning of a notable acceleration in private business productivity. For 1990-95, 21 of 42 industries exhibit negative MFP trends, while the number is 20 for 1995-2000 and only 13 for 2000-2005. For comparison, private business MFP (Table 7) rose 0.53 percent per year from 1990-95, 1.32 percent per year from 1995-2000 and 1.78 percent per year for 2000-2005.

Table 5 presents illustrative MFP measures for non-manufacturing at a more aggregate level for the full 1987-2005 period. It also provides information on growth in outputs and on specific input categories.

III. Contributions of Industries to the MFP Growth Rate of the Private Business Sector

III.a The Domar Model

Aside from an interest in specific industries, it is natural to try to account for aggregate productivity in terms of contributions from the economy’s constituent industries. Evsey Domar [1961] applied the Solow growth accounting framework to industry data. He noted that, while intermediate inputs flowing from one industry to another can be disregarded in thinking about aggregate productivity, they become important at the industry level. He proposed a measurement convention in which, when studying productivity for a particular group of industries, one should include only outputs delivered to establishments outside of that industry group and include only inputs obtained from sources outside that group. In particular, deliveries of intermediates from one establishment to another within the industry group are excluded from both outputs and inputs. Gollop [1981] called outputs and inputs, which are consistent with these definitions, "sectoral" output and inputs, terminology which BLS later adopted. Noting that this led to a narrower scope of output and inputs at higher levels of aggregation, Domar derived weights that could be used to account for aggregate MFP in terms of industry contributions. Each industry's MFP trend is weighted by the ratio of the value of the industry's sectoral output to the value of the private business sector's sectoral output.

III.b Domar Contribution Results

Domar contributions of the NAICS NIPA-level non-manufacturing industries to private business sector MFP growth are presented in Table 4 and illustrated in Figure 2. Over the 1987-2005 period, the three non-manufacturing industries that made the greatest contributions to private business sector MFP were retail trade (NAICS 44 & 45), securities and investments (NAICS 523), and wholesale trade (NAICS 42), with contributions of 0.24, 0.20, and 0.17 percent, respectively. The three industries that made the largest negative contributions were construction (NAICS 23), rental and leasing services and lessors of intangible assets (NAICS 532 & 533), and Federal Reserve banks, credit intermediation, and related activities (NAICS 521 & 522). The contributions to the private business sector's MFP growth rate were -0.07, -0.06, and -0.06 respectively.

Table 4 also illustrates the main industries that contributed to the speedup in MFP that took place in the late 1990's. The major non-manufacturing industry contributors were wholesale trade, retail trade, securities and investments. From 2000-2005 another major contributor to multifactor productivity change was broadcasting and telecommunications (NAICS 513). These industries together with the manufacturing NAICS industry 334, computers and electronics (see Table 6) were the major contributors to the multifactor productivity speedup of the late 1990's.

III.c Domar Results Validate Consistency Between Industry and Aggregate Data

The BEA-BLS collaborative project conducted by Fraumeni, Harper, Powers and Yuskavage [2004] showed how industry and aggregate MFP measures, constructed from the same underlying data on real flows of inputs and outputs, could be precisely consistent. Many of the data underlying our industry-group measures in this paper are built from the same sources as the data underlying the published BLS MFP measures for the private business sector.

Table 7 sums up the total of the industry Domar "contributions" for nonmanufacruring and for manufacturing. It also compares them to our regularly published BLS [2007a] private business MFP measures. For each time period, the industry contributions add up to faster trend than the published aggregates. The differences are only about one or two tenths of a percent. Table 7 also illustrates an adjustment to the published MFP trends to include the effects of labor composition with MFP. Our new industry-group MFP data are not adjusted for labor composition. In the aggregate dataset, a labor composition adjustment is made --- the effects of labor composition are removed from the MFP trend. Table 7 shows an "adjusted" aggregate MFP measure. This does not improve the measure, but it does improve the conceptual basis for comparing the two datasets. The industry contributions actually sum up to slightly less than this adjusted trend, again by only one or two tenths of a percent. We believe the industry dataset provides a reasonably good tool for assessing private business productivity in terms of industry contributions. There are many small differences in how these datasets are constructed, and therefore small discrepancies in this comparison are not surprising. In principle these discrepancies could be eliminated through a fully integrated approach to the calculations.

III.d Information Technology

Like similar datasets constructed by Oliner and Sichel [2000] and by Jorgenson, Stiroh and Ho [2005] the BLS data can be used to estimate two separate types of contributions of Information Technology to aggregate MFP growth. These are illustrated in Table 8. One type is the Domar contribution of NAICS 334[9], computers and electronics industry, which accelerated from 0.5 in 1990-1995 to 0.9 in 1995-2000 before falling to just 0.2 during 2000-2005. Drawing on the BLS [2007a] data for the private business sector, the "Solow" contribution of growing IT capital per worker was 0.4 percent from 1990-1995, 0.9 percent from 1995-2000 and 0.6 percent from 2000-2005. The 1995-2000 increases in IT contributions were found to explain much of the productivity speedup during that period, but the post-2000 reductions in the IT effects leave the further acceleration of MFP unexplained, at least in a growth accounting context. Oliner, Sichel

[9] These contributions are based on BLS [2007b] and they are shown to two decimal places in Table 6 of this paper.

and Stiroh [2007] report a similar finding and examine some possible explanations of the continued strength of productivity since 2000.

IV. The Quality of the Measures: Are We There Yet?

IV.a The Plausibility of Negative MFP trends and Implications for the Aggregate

Industry productivity trends have been viewed as one test of the plausibility of the measures of real output upon which they are based. The reasoning is something like the following: when there is evidence of technological progress in an industry, productivity can be expected to rise. A negative productivity trend may be an indication that something is amiss in the measurement process. Input measurement (particularly labor hours), while difficult, can be straightforward compared to output measurement. Suspicion falls more heavily on the output measures if the methodology is revealed to involve assumptions. The same can be said if output measurement is problematic for conceptual reasons. These circumstances are often present in non-manufacturing. Under this reasoning, the sign of the productivity trend would be a "razor test" for the data.

There are various circumstances that can lead to bona fide declines in productivity. Productivity often declines during cyclical downturns, perhaps due to "labor hoarding", lost efficiencies of scale, or other reasons. One way to avoid this issue is to apply the razor test to longer time spans, perhaps a decade or more. Another case where productivity trends really are negative is when industries experience declining demand. When declines persist due to newer technologies or competition from imports, firms may not make the investments to acquire new technologies. A third case where the productivity of an industry group might be negative is when there are substantial structural changes within the industry group, which result in relatively more growth in less productive industries.

Carol Corrado and Larry Slifman [1999] disaggregated business sector output per hour into contributions from major industry groups. The resulting labor productivity trends for 1977-1997 were negative for nine of eleven industry groups within business and personal services, and also for construction. In a "benchmark thought experiment" they raised all of the negative productivity industries to zero and concluded this would have raised business sector productivity trends by about 0.4 percent per year. Gullickson and Harper [1999] found significant negative multifactor productivity (MFP) trends for 1977-1992 for construction, banks, utilities and health services and they also found an analogous "thought experiment effect" of 0.4 percent per year on business productivity.

In late 1999, BEA made several improvements to the national accounts that raised the trend in GDP. These included using the historically consistent "research" consumer price indexes, reclassifying software from intermediate inputs to capital investment outputs, and employing BLS indicators of banking output. "Revisiting" the productivity topic in 2002 with the improved NIPA data, Gullickson and Harper [2002] found that the significant negative MFP trends for 1977-1997 for construction and health services were still present. The negative trends for banking and utilities, while still present, had moderated, but insurance carriers had developed an important negative trend. Overall, the "thought experiment effect" still raised productivity trends by about 0.3.

Triplett and Bosworth [2004] also calculated some negative productivity trends. For 1995-2001, they found negative trends in labor productivity for education, amusement and recreation, hotels, insurance, local transit and construction. They found negative MFP in some industries, notably health and educational services.

As we noted in section II.c (basic results) there are still negative MFP trends for a troubling proportion of non-manufacturing industries, even during 2000-2005. We conduct the "thought experiment", of raising the negative MFP trends to zero, with the new data, to see whether the situation has improved. As in the past, we accounted for the fact that some industry level outputs are shipped to other industries --- to the extent this happens, measurement error would have no impact on aggregate output or MFP. To account for this, we multiplied the (negative) Domar contribution for each negative-MFP industry by the ratio of a) the industry's shipments to final demand to b) its sectoral output. We then summed up these reduced negative contributions.

Using our new dataset, we identified industries with negative MFP trends over the 1987-2005 period and determined the extent to which each contributed to slowing aggregate MFP trends over time. We calculated the adjustments of industry output trends that are sufficient to pull up the negative industry MFP trends to zero and then we estimated how much this would have raised the aggregate MFP trends. Results are shown in Table 9. For the entire 1987-2005 period, this would have raised aggregate trends by 0.23 percent. The effect was 0.27 percent for 1987-2000, and only 0.19 percent for 2000-2005. This pre-2000 period rate is very close to the most recent Gullickson-Harper [2002] result (0.3 percent for 1977-1997). The reduction in this thought experiment effect for 2000-2005 compared with earlier years is probably related to the reduction of the proportion industries with negative MFP trends (Table 3) mentioned earlier (16 for 1987-2005 and 13 for 2000-2005). There are two good candidate explanations for the slight reduction in negative tendencies after 2000. One explanation is that "all boats may have risen with the recent tide" of higher productivity, leading to fewer and milder cases of negative trends. The other explanation is that improvements to the source data made since 2000 may be starting to perceptibly affect the trends in some industries. The result may reflect either or both of these, or it may reflect other factors. In spite of the improvement since 2000, many negative trends remain, and this may be an indication that problems remain in measuring some outputs.

IV.b Differences Remain in Methods and Results

Triplett and Bosworth [2004] see little value in setting the negative trends to zero and recalculating aggregate productivity, as Slifman-Corrado and Gullickson-Harper had done (and as we just did, once again). While Triplett and Bosworth do recommend that "statistical agencies should take negative productivity growth as an indicator of areas in which they need to allocate resources to improve measurement" (p. 331), they also emphasize that a positive productivity trend does not validate the data.

There are still significant disagreements among researchers on how to measure output for many industries, including fundamental issues about measurement concepts. Among the more problematic industries, from a conceptual standpoint, are industries in the health care (NAICS 621-623) and financial sectors (NAICS 521-525). The MFP trends for these industries are puzzling, with many negatives, but also a 7.1 percent long term trend for securities, commodities and investments (NAICS 523). The issues for banking and credit intermediation (NAIC 521 and 522) are particularly difficult and researchers seem to be divided as to the best approach. In many industries it is easy to measure the nominal value of output, but removing price change is problematic. In the case of banking, the nominal output is also difficult to define.

In working on this paper, we were concerned that nominal output data for the financial sectors (NAICS 521-525) are difficult to reconcile with input costs. Our preferred method of calculating capital asset weights involves calculating a rate of return that allocates property income among asset classes. For banking (NAICS 521 and 522), the BEA gross operating surplus far exceeds a reasonable estimate of income earned by physical assets. In fact for each of the financial sectors, the income estimates in the industry accounts are poor matches for the physical capital asset data we have, and imply rates of return that are implausible. In these cases we assume a rate of return (a 3.5 percent real rate of return) to determine capital weights. These inconsistencies underlie our calculations of MFP for the private business sector, but they are of greater concern for the validity of MFP measures for the specific industries involved. We need to do further research aimed at better understanding the reasons for these inconsistencies and their implications.

There are also empirical differences in the trends for output and productivity that various researchers calculate. This traces to the fact that the industry programs at BEA and BLS calculate industry output measures independently, and in some cases the concepts or data sources differ significantly. Investigating these differences was a major emphasis of Fraumeni, Harper, Powers, and Yuskavage [2006] and the effort to understand and narrow the differences has been continued by Powers and Yuskavage [2006].

In Table 10, we compare output trends for industries where there the BLS industry program has complete coverage, or substantially complete coverage, of the industry group results for non-manufacturing reported in Table 3. Table 10 first compares BEA output measures to those used in this paper. For this paper, we remove two items from the BEA output measures: nonprofit institutions and intra-industry flows of intermediate inputs. These deductions are important for keeping our input and output accounting consistent so as to help us develop input weights and Domar weights. While these adjustments are sometimes substantial in nominal terms, a quick inspection of Table 10 reveals that they usually have almost no effect on the output trends.

Table 10 also compares the BEA trends in output to trends in output developed by BLS [2007c, d] for published measures of industry productivity. As a visual aid with the comparison, we include Figure 3 (comparisons for 1987-2005) and Figure 4 (comparisons for 2000-2005). There are significant differences in output trends in many time periods, particularly 2000-2005 (Figure 4). There are also sharp differences in the acceleration of output between time periods, such as

2000-2005 compared to 1995-2000. A series of studies thoroughly analyzing the sources of these differences has been conducted by Powers and Yuskavage. While there are differences, the similarities in output trends for the full 1987-2005 are striking (Figure 3).

There are at least five reasons to expect differences between the BLS and BEA output measures. One reason is that there are some major differences in concepts, notably for trade where BLS uses a gross sales concept and BEA uses a gross margin concept. We do see differences in trends for wholesale and retail trade in Table 10, but they tend to be half a percent or less.

A second reason to expect differences is that there are differences in data sources. These include some mining industries, utilities, railroads, and air transport, where BLS uses physical counts of outputs (such as ton miles, passenger miles) and BEA uses a deflated revenue approach. In view of these differences, results for these industries in Table 10 are surprisingly similar. There is also a difference for accommodation, where BLS makes more use of PPIs and less use of CPIs in deflation than does BEA. The BLS trend in real output is 1.2 percent higher prior to 2000 and 2.1 percent lower from 2000-2005. While this industry exhibits the weakest consistency of those in Table 10, the results are not radically different, the difference being only 0.3 for the overall 1987-2005 period.

A third reason is that there are differences in coverage for some industries. For rail transportation, the BLS measures are for line haul railroads while the BEA data also include short haul railroads. We do see the BLS trend growing 1.4 percent faster for 1995-2000, and coverage may be a factor. We have not determined whether coverage or data sources are more important.

A fourth reason is that, in cases where BEA and BLS both use deflated Census shipments to measure output, adjustments are made. BEA often includes adjustments for sales and excise taxes, misreporting or coverage adjustments, or own account construction that the BLS industry productivity program does not include. We cannot identify specific industries in non-manufacturing where these are likely to be most important. In any event, most differences in Table 10 are small.

A fifth reason to expect differences is one of timing. The most current BEA and BLS estimates often differ because of the timing by which revisions to source data (such as data from the Census Bureau) are introduced and because of differences in how the agencies estimate the most recent year. The production schedules of each agency's industry group are somewhat different. In Table 10, the differences tend to be largest for 2000-2005. The vintage of data that we used may be a contributing factor.

The fact that the differences, for 1987-2005, in Table 10 are fairly small may seem comforting, but this result includes a selection bias. The BLS industry productivity program does not cover all non-manufacturing industries. The BLS industry program has a 70 year tradition of publishing measures for "selected" industries. The main criterion for including an industry is whether there are source data available that reflect a credible measure of the industry's output. The BLS does have complete coverage for detailed industries in manufacturing and for wholesale and retail trade, and also for some industries within sectors that are covered in Table 1 but not in Table 9. Notably BLS measures productivity for commercial banks, which represents roughly half of NAICS 512. The industry program has expanded its service sector coverage by around 40 industries since 2000 and may be able to continue this expansion as some of the newer PPIs accumulate significant time series. But many of the industries covered in Table 1 do not yet meet the traditional criterion for inclusion in our industry program and there are legitimate concerns about some of the results.

In view of this, we took a look at the prevalence of negative MFP trends (as measured by us in Table 3) for the non-manufacturing industries where BLS has substantial coverage (specifically, for those industries for which we have compared *output* trends in Table 10). Only 2 of the 11 BLS-covered industries had negative trends for 1987-2005, while negative trends are concentrated in 14 of the other 31 industries. Looking at 2000-2005, again only 2 of the 11 BLS-covered measures had negative trends, while 11 of the other 31 had negative trends. This result strongly suggests that the BLS industry program has successfully avoided publishing measures for the most problematic industries, and it also suggests that the available source data continue to limit our ability to measure real output and productivity for some industries. In terms of our confidence level in a complete set of MFP trends, we probably are not there yet, but we are getting closer than we were in 2002.

V. Conclusions and Future Directions

The production account framework provides a straightforward tool with which to attribute private business MFP trends to specific industries. The BEA Industry Accounts provide complete coverage and the resulting industry and aggregate data are fairly consistent. We have used them to complete a production account exercise in this paper that does a reasonable job of attributing private business MFP to industry sources. While we have generated a complete set of measures, there are many industries where output measurement remains problematic. In addition to the many long term negative trends we continue to find, this conclusion is supported by the unresolved conceptual and methodological issues and the resulting weaknesses in the available data. There is some evidence to suggest that the measurement situation may have improved since 2000. Many new service sector measures have become available from the Census Bureau and from the BLS Producer Price Program, and the lower number of negative trends may be, in part, a reflection of these data. In a future revision of this paper, we plan to take a careful look at MFP trends for specific industries where new data have been introduced recently.

The production account framework involves a “bottom up” approach to constructing aggregate measures from industry data. It provides a framework to introduce alternative (and hopefully improved) output measures and then to quickly test their implications for industry productivity measures and for aggregate-level measures of output or productivity. In a future revision of this paper, we hope to look at alternatives such as the introduction of output from the BLS Industry Productivity program. At the same time, we would like to periodically update the results in this paper using output from the BEA industry program, as they extend their series. This would allow us to continue to provide a consistent decomposition of the private business sector MFP trends. The authors of this paper also plan to continue a separate collaborative project with BEA that would extend the production account framework beyond the private business sector to cover the full scope of GDP. Like this industry dataset, matching inputs with output estimates for government and nonprofit institutions will involve generating implicit productivity measures. While these productivity measures may not be particularly meaningful, it will be useful to have an accounting of the capital and labor inputs used by governments and nonprofits. In general, matching up hard-to-measure outputs with inputs, as we would do for productivity measurement, can lend value and transparency to the measurement process.

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Table 1. Average annual rates of growth based on compound annual rates of change: 1987 to 2007

(Output per hour of all persons)

Time Period	Business Sector	Manufacturing Sector
1987-2007	2.2	3.7
1990-1995	1.5	3.4
1995-2000	2.7	4.6
1987-2000	2.0	3.5
2000-2007	2.6	4.2

Source: BLS (2008a)

Table 2. Average annual rates of growth based on compound annual rates of change: 1987 to 2006

(Multifactor Productivity)

Time Period	Private Business Sector	Manufacturing Sector
1987-2006	1.0	1.4
1990-1995	0.5	1.2
1995-2000	1.3	2.0
1987-2000	0.8	1.3
2000-2006	1.5	1.6

Sources: BLS (2008b) and BLS (2008c)

Table 3. Illustrative Multifactor Productivity measures for 42 Non-Manufacturing Industries: 1987 to 2005

(Compound annual rates of change)

1997 NAICS Code	Industry	Multifactor Productivity				
		1987-2005	1990-1995	1995-2000	1987-2000	2000-2005
111, 112	Farms	1.3	-0.2	3.5	1.5	0.9
113-115	Forestry, fishing, and related activities	-0.9	-3.3	1.1	-1.8	1.6
211	Oil and gas extraction	-0.3	2.2	-1.8	0.3	-1.7
212	Mining, except oil and gas	2.0	3.4	4.5	3.5	-1.9
213	Support activities for mining	-1.0	0.9	-1.7	0.1	-3.8
22	Utilities	1.1	0.8	0.8	1.1	1.0
23	Construction	-0.6	-0.3	-1.3	-0.6	-0.6
42	Wholesale trade	1.8	1.8	2.7	1.8	1.7
44, 45	Retail trade	2.1	1.5	2.9	2.1	2.2
481	Air transportation	2.0	2.5	2.5	1.6	3.3
482	Rail transportation	2.0	4.4	0.6	2.2	1.5
483	Water transportation	0.7	2.0	0.3	1.6	-1.5
484	Truck transportation	1.1	2.0	-0.7	1.3	0.6
485	Transit and ground passenger transportation	-0.8	-1.0	-0.4	-0.7	-0.9
486	Pipeline transportation	1.0	-0.3	1.2	0.8	1.3
487, 488,	Other transportation and support activities	0.3	-1.3	1.8	-0.2	1.4
493	Warehousing and storage	3.0	4.0	2.5	3.4	2.0
511	Publishing industries (includes software)	2.7	1.7	3.5	2.0	4.7
512	Motion picture and sound recording industries	-0.4	-2.1	-0.7	-1.6	2.8
513	Broadcasting and telecommunications	1.6	1.8	-0.3	1.1	2.9
514	Information and data processing services	0.0	-0.8	-4.7	-2.1	5.7
521, 522	Federal Reserve banks, credit intermediation, and related activities	-1.5	-2.9	-2.9	-1.9	0.3
523	Securities, commodity contracts, and investments	7.1	7.3	12.7	7.6	5.8
524	Insurance carriers and related activities	0.1	0.1	-0.3	0.3	-0.5
525	Funds, trusts, and other financial vehicles	-0.4	-0.2	-1.5	-0.8	0.8
531	Real estate	0.3	0.7	0.3	0.0	1.3
532, 533	Rental and leasing services and lessors of intangible assets	-2.3	-1.3	-3.7	-1.6	-4.2
5411	Legal services	-1.6	-2.8	-1.4	-1.2	-2.8
5415	Computer systems design and related services	3.2	3.5	5.2	4.0	1.4
5412-5414, 5416-5419	Miscellaneous professional, scientific, and technical services	0.4	-0.8	0.9	0.3	0.7
55	Management of companies and enterprises	0.3	-0.7	-0.5	0.0	1.1
561	Administrative and support services	-0.2	-1.1	-1.5	-0.8	1.4
562	Waste management and remediation services	0.7	-0.7	1.3	0.5	1.1
61	Educational services	-0.1	0.1	0.2	0.0	-0.2
621	Ambulatory health care services	-0.6	-2.9	-0.3	-1.2	1.1
622, 623	Hospitals and nursing and residential care facilities	-0.8	-1.2	-1.3	-1.1	-0.1
624	Social assistance	1.0	0.7	0.4	0.3	2.8
711, 712	Performing arts, spectator sports, museums, and related activities	0.6	1.0	0.0	1.0	-0.5
713	Amusements, gambling, and recreation industries	-0.2	-1.4	-0.3	0.0	-0.6
721	Accommodation	0.2	1.5	-0.1	0.2	0.3
722	Food services and drinking places	0.2	-0.9	0.9	0.1	0.2
81	Other services, except government	-0.5	-0.3	-1.3	-0.7	0.2

Table 4. Contributions of 42 Non-Manufacturing Industries to Private Business Multifactor Productivity: 1987 to 2005

(Compound annual rates of change)

1997 NAICS Code	Industry	Contributions				
		1987-2005	1990-1995	1995-2000	1987-2000	2000-2005
111, 112	Farms	0.05	0.01	0.11	0.05	0.02
113-115	Forestry, fishing, and related activities	-0.01	-0.02	0.00	-0.01	0.01
211	Oil and gas extraction	-0.01	0.03	-0.03	0.00	-0.04
212	Mining, except oil and gas	0.02	0.03	0.03	0.03	-0.01
213	Support activities for mining	0.00	0.00	-0.01	0.00	-0.02
22	Utilities	0.05	0.04	0.03	0.05	0.04
23	Construction	-0.07	-0.03	-0.14	-0.06	-0.07
42	Wholesale trade	0.17	0.16	0.27	0.17	0.16
44, 45	Retail trade	0.24	0.17	0.33	0.24	0.25
481	Air transportation	0.03	0.04	0.04	0.03	0.04
482	Rail transportation	0.01	0.03	0.00	0.02	0.01
483	Water transportation	0.00	0.01	0.00	0.01	-0.01
484	Truck transportation	0.02	0.05	-0.02	0.03	0.01
485	Transit and ground passenger transportation	0.00	0.00	0.00	0.00	0.00
486	Pipeline transportation	0.00	0.00	0.00	0.00	0.01
487, 488, 492	Other transportation and support activities	0.00	-0.01	0.02	0.00	0.02
493	Warehousing and storage	0.01	0.01	0.01	0.01	0.01
511	Publishing industries (includes software)	0.07	0.04	0.10	0.05	0.13
512	Motion picture and sound recording industries	0.00	-0.01	0.00	-0.01	0.02
513	Broadcasting and telecommunications	0.08	0.07	-0.01	0.05	0.16
514	Information and data processing services	0.01	-0.01	-0.04	-0.02	0.07
521, 522	Federal Reserve banks, credit intermediation, and related activities	-0.06	-0.13	-0.12	-0.09	0.01
523	Securities, commodity contracts, and investments	0.20	0.14	0.41	0.21	0.19
524	Insurance carriers and related activities	0.01	0.00	0.00	0.01	-0.01
525	Funds, trusts, and other financial vehicles	-0.01	0.00	-0.02	-0.01	0.01
531	Real estate	0.03	0.05	0.02	0.00	0.11
532, 533	Rental and leasing services and lessors of intangible assets	-0.06	-0.03	-0.09	-0.04	-0.10
5411	Legal services	-0.04	-0.07	-0.03	-0.03	-0.07
5415	Computer systems design and related services	0.04	0.03	0.09	0.05	0.02
5412-5414, 5416-5419	Miscellaneous professional, scientific, and technical services	0.04	-0.05	0.07	0.03	0.07
55	Management of companies and enterprises	0.01	-0.03	-0.02	0.00	0.04
561	Administrative and support services	-0.01	-0.04	-0.08	-0.04	0.08
562	Waste management and remediation services	0.00	0.00	0.01	0.00	0.01
61	Educational services	0.00	0.00	0.00	0.00	0.00
621	Ambulatory health care services	-0.03	-0.15	-0.01	-0.06	0.07
622, 623	Hospitals and nursing and residential care facilities	-0.03	-0.05	-0.05	-0.04	0.00
624	Social assistance	0.01	0.00	0.00	0.00	0.02
711, 712	Performing arts, spectator sports, museums, and related activities	0.00	0.01	0.00	0.00	0.00
713	Amusements, gambling, and recreation industries	0.00	-0.01	0.00	0.00	-0.01
721	Accommodation	0.00	0.02	0.00	0.00	0.01
722	Food services and drinking places	0.01	-0.04	0.04	0.01	0.01
81	Other services, except government	-0.02	-0.01	-0.06	-0.03	0.01
	Total non-manufacturing contribution	0.72	0.20	0.74	0.54	1.20
	Private Business Sector MFP	1.12	0.53	1.31	0.86	1.78

Table 5. Illustrative trends in Multifactor Productivity (MFP), Outputs & Inputs, and the Point Contribution of specific input categories to the trend in input growth: 1987 to 2005

(Compound annual rates of change)

Sector	Trends			Point contributions to input growth			
	MFP	Output	Input	Information processing equipment & software	Other Capital	Labor	Intermediate inputs
Farm	1.3	1.8	0.5	0.03	0.35	-0.19	0.31
Mining	0.2	0.5	0.3	0.11	-0.16	-0.33	0.67
Construction	-0.6	1.9	2.6	0.15	0.20	0.83	1.36
Manufacturing	1.6	2.5	0.9	0.21	0.16	-0.38	0.91
Transportation	1.2	3.3	2.1	0.31	0.03	0.68	1.08
Communications	1.7	6.6	4.8	1.20	0.39	0.32	2.84
Utilities	1.1	1.4	0.3	0.27	0.40	-0.25	-0.13
Trade	2.0	4.3	2.3	0.30	0.40	0.34	1.22
Finance, insurance, and real estate	0.5	3.9	3.4	0.68	0.82	0.43	1.48
Services	-0.1	4.0	4.0	0.46	0.29	1.29	1.94

Table 6. Contributions of Manufacturing Industries to Private Business Multifactor Productivity: 1987 to 2005

(Compound annual rates of change)

1997 NAICS CODE	Industry	Contributions				
		1987-2005	1990-1995	1995-2000	1987-2000	2000-2005
311, 312	Food, Beverage and Tobacco	-0.01	0.12	-0.13	-0.03	0.06
313, 314	Textiles	0.02	0.01	0.02	0.01	0.03
315, 316	Apparel and Leather	0.01	0.04	0.00	0.02	0.01
321	Wood	0.00	-0.02	0.00	0.00	0.02
322	Paper	0.01	-0.01	0.00	0.00	0.04
323	Printing	0.01	-0.01	0.00	0.00	0.03
324	Petroleum and Coal	0.00	0.02	0.00	0.01	-0.01
325	Chemicals	0.02	-0.05	0.00	-0.03	0.00
326	Plastics and Rubber	0.02	0.01	0.03	0.02	0.02
327	Leather	0.01	0.01	0.01	0.01	0.01
331	Primary metals	0.02	0.00	0.01	0.01	0.04
332	Fabricated metals	0.02	0.03	0.00	0.01	0.05
333	Machinery	-0.01	-0.06	-0.03	-0.03	0.04
334	Computers and Electronics	0.50	0.51	0.91	0.61	0.23
335	Electrical equipment	-0.01	-0.03	-0.02	-0.03	0.02
336	Transportation equipment	0.00	-0.02	0.02	-0.03	0.07
337	Furniture	0.01	0.01	0.01	0.00	0.01
339	Miscellaneous Manufacturing	0.02	0.00	0.03	0.02	0.04
	Total manufacturing contribution	0.62	0.54	0.80	0.53	0.86
	Private Business Sector MFP	1.10	0.53	1.32	0.84	1.78

Source: BLS [2007b]

Table 7. Multifactor Productivity Growth, Contributions of Non-manufacturing, Manufacturing and Labor Composition to the Private Business Sector: 1987 to 2005

(Compound Annual Rates of Change)

	Multifactor productivity, contributions (manufacturing, non-manufacturing and labor composition)				
	1987-2005	1990-1995	1995-2000	1987-2000	2000-2005
Non-manufacturing contribution	0.72	0.20	0.74	0.54	1.20
Manufacturing contribution	0.62	0.54	0.80	0.53	0.86
Total industry contribution[1]	1.34	0.74	1.54	1.07	2.06
Private business MFP (published)	1.10	0.53	1.32	0.84	1.78
Labor composition effects	0.37	0.43	0.26	0.36	0.39
Private business MFP plus labor composition effects	1.47	0.97	1.58	1.21	2.17
Total industry contribution[1]	1.34	0.74	1.54	1.07	2.06
Private business MFP plus labor composition effects	1.47	0.97	1.58	1.21	2.17

[1] Manufacturing contribution plus non-manufacturing contribution

Table 8. Compound average annual rates of growth in ouput per hour of all persons and the contributions of capital intensity, labor composition, and multifactor productivity for private business, 1987 to 2005

(percent per year)

	1987-2005	1990-1995	1995-2000	1987-2000	2000-2005	2004-2005
Private Business[1]						
Output per hour of all persons	2.3	1.5	2.7	2.0	3.2	2.1
Contribution of capital intensity[2]	0.9	0.6	1.1	0.8	1.0	0.3
Contribution of all other capital services	0.2	0.1	0.2	0.2	0.4	0.0
Contribution of information processing equipment and software[3] (Solow contribution of IT)	0.6	0.4	0.9	0.6	0.6	0.3
Contribution of labor composition[4]	0.4	0.4	0.3	0.4	0.4	0.1
Multifactor Productivity[5]	1.1	0.5	1.3	0.8	1.8	1.7
Contribution of computers and electronics (NAICS 334) (Domar Contribution of IT)	0.5	0.5	0.9	0.6	0.2	0.2
Total contribution of IT[6]	1.1	0.9	1.8	1.2	0.8	0.5

Sources: BLS (2007a) and BLS (2007b)

[1] Excludes government enterprises.

[2] Growth rate in capital services per hour multiplied by capital's share of current dollar costs.

[3] Growth rate of information processing equipment and software per hour multiplied by its share of total costs.

[4] Growth rate of labor composition (the growth rate of labor input minus the growth rate of the hours of all persons) multiplied by labor's share of current dollar costs.

[5] Output per unit of combined labor and capital inputs.

[6] Total IT contribution - the contribution of information processing equipment and software plus the contribution of computers and electronics, NAICS 334 - to output per hour of all persons.

Table 9. Total of weighted[1] negative contributions of Non-manufacturing Industries to Private Business Multifactor Productivity: 1987 to 2005 (Compound annual rates of change)

1987-2005	1990-1995	1995-2000	1987-2000	2000-2005
-0.23	-0.40	-0.41	-0.27	-0.19

[1] Weights are calculated as the ratio of final demand to value of production. The sum of these weights is taken for all industries that have a negative contribution values in a specified time period.

Table 10. A Comparison of Output Trends for Non-Manufacturing Industries*: 1987 to 2005

1997 NAICS Code	Industry / Source	Output				
		1987-2005	1990-1995	1995-2000	1987-2000	2000-2005
211	Oil and gas extraction					
	BEA	-0.9	-0.5	-0.5	-0.6	-1.6
	This paper	-0.8	-0.4	-0.5	-0.6	-1.6
	BLS	-1.1	-0.7	-0.6	-0.9	-1.7
212	Mining, except oil and gas					
	BEA	1.4	0.9	0.9	1.8	0.4
	This paper	1.5	1.0	0.9	1.8	0.5
	BLS	1.1	0.3	0.1	1.3	0.6
22	Utilities **					
	BEA	1.3	1.8	1.5	2.1	-0.7
	This paper	1.4	1.8	1.6	2.2	-0.7
	BLS	1.2	2.5	1.4	2.2	-1.2
42	Wholesale trade					
	BEA	4.0	4.7	5.5	4.7	2.3
	This paper	4.0	4.7	5.5	4.7	2.3
	BLS	4.1	4.1	6.0	4.9	2.0
44,45	Retail trade					
	BEA	4.5	4.1	6.0	4.7	3.9
	This paper	4.5	4.0	6.0	4.7	3.9
	BLS	4.2	3.8	5.8	4.3	3.9
481	Air transportation					
	BEA	4.0	3.1	5.0	4.1	4.0
	This paper	4.1	3.2	5.2	4.1	3.8
	BLS	3.6	3.5	4.9	4.0	2.5
482	Rail transportation**					
	BEA	2.1	3.1	0.1	2.1	2.3
	This paper	2.2	3.1	0.0	2.1	2.3
	BLS (excludes 482112)	2.5	3.3	2.0	2.6	2.1
511	Publishing industries (Includes software)					
	BEA	5.5	5.5	9.9	6.8	2.1
	This paper	5.5	5.5	10.0	6.8	2.1
	BLS	5.0	5.2	10.3	7.1	-0.3
721	Accommodation **					
	BEA	2.6	2.9	3.6	3.0	1.7
	This paper	2.6	2.8	3.6	3.0	1.7
	BLS	2.9	4.2	5.3	4.2	-0.4
722	Food services and drinking places					
	BEA	2.8	1.6	3.7	2.9	2.5
	This paper	2.8	1.6	3.7	2.9	2.5
	BLS	2.4	1.6	2.9	2.4	2.5
81	Other services except government**					
	BEA	2.3	2.3	2.8	3.0	0.8
	This paper	2.6	2.4	3.5	3.2	1.0
	BLS (excludes 813, 814)	2.0	2.5	2.2	2.6	0.4

* This Table includes industries for which the BLS Industry Program (BLS) publishes measures with either the same coverage, or substantially the same coverage as the BEA Industry Accounts. The output for this paper is derived from BEA output, but this paper removes estimates of nonprofit output and output associated with sales between establishments within the industry. The BLS Industry Program data are constructed independently, often using different concepts or different data sources than the BEA data. The BLS Industry program excludes intraindustry sales and nonprofits where they are substantial.

** BLS/DIPS covers publishes output and productivity for a detailed industry which constitutes a substantial majority of the three-digit NAICS sector.

Figure 1. Illustrative trends in Multifactor Productivity for Farm and Non-manufacturing Industries: 1987-2005
(Compound annual rates of change)

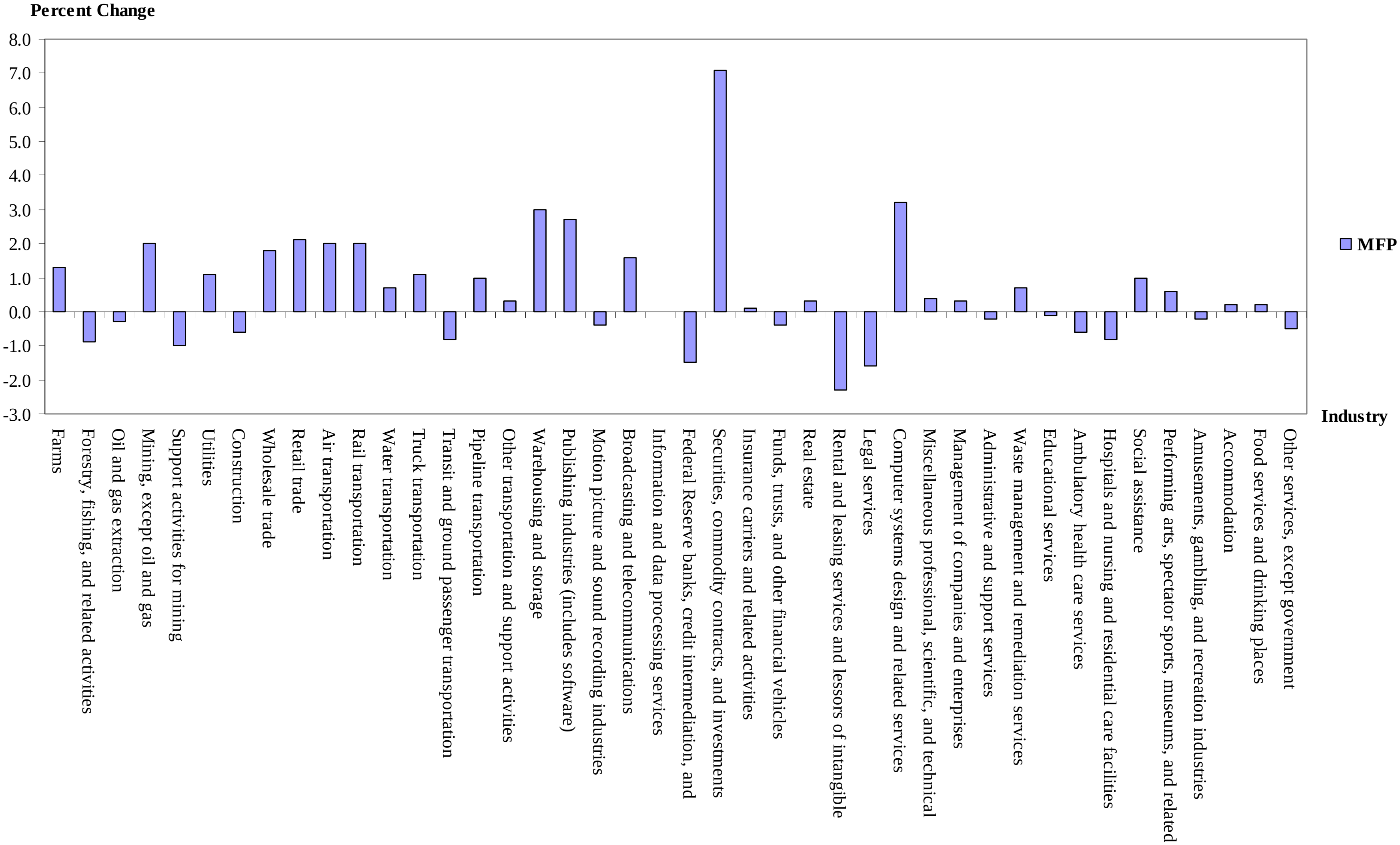


Figure 2. Contributions of Non-manufacturing Industries to Private Business Multifactor Productivity: 1987-2005

(Compound annual rate of change)

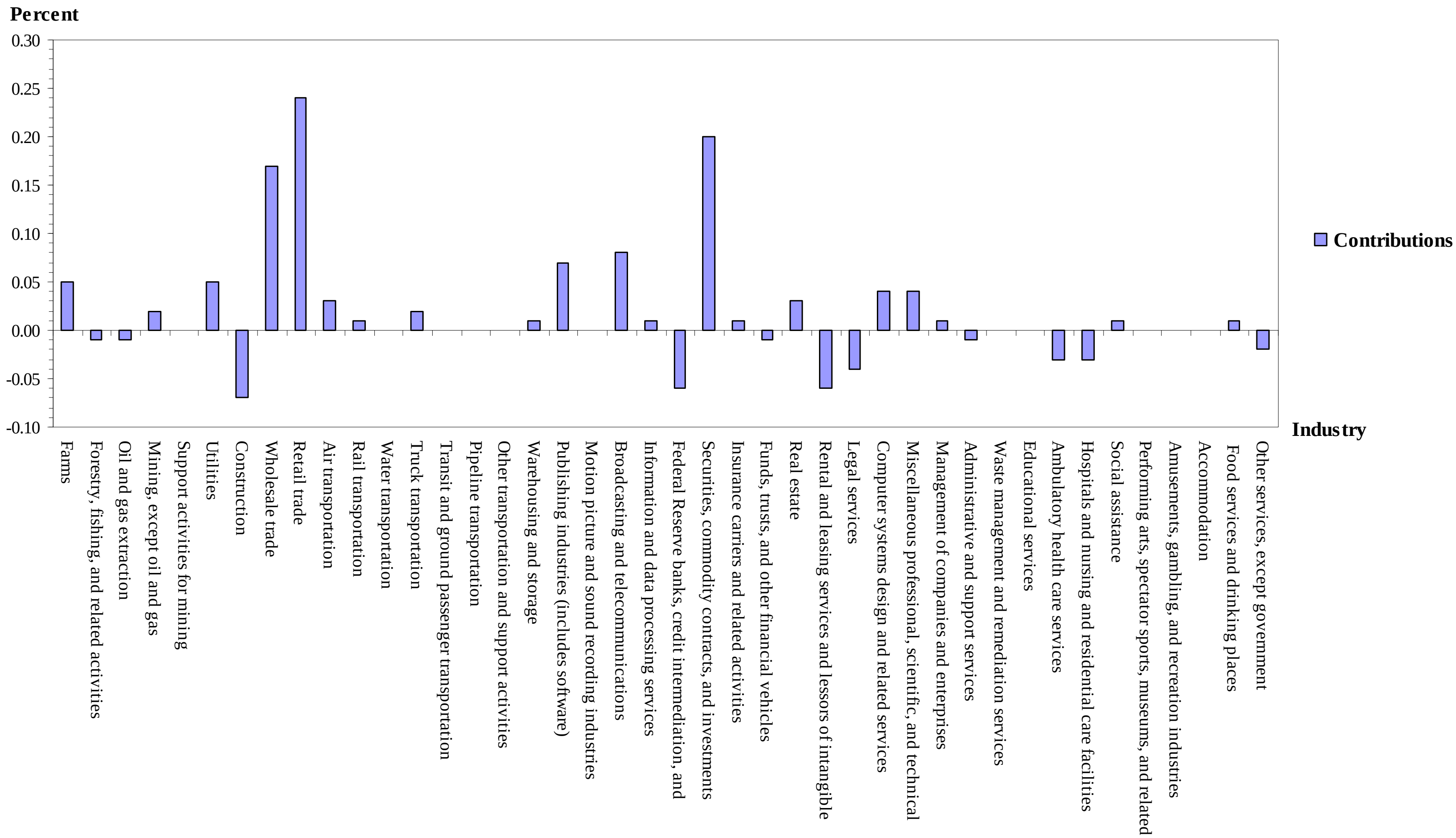


Figure 3. A Comparison of Output Trends for Non-manufacturing Industries: 1987-2005

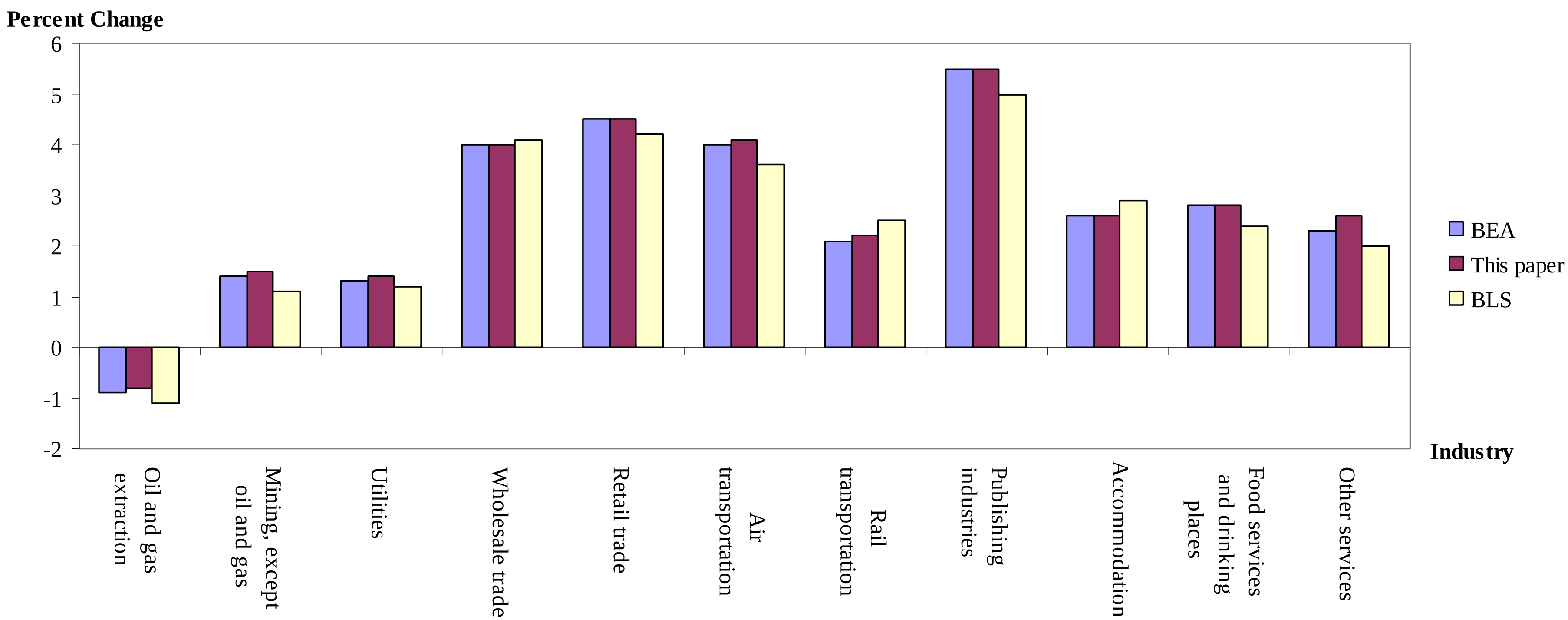
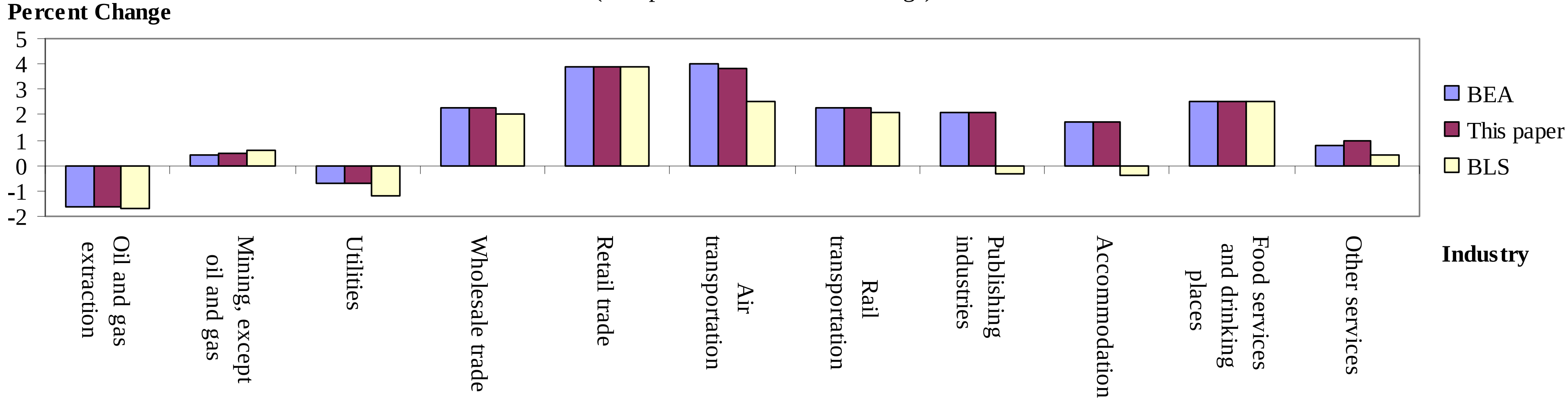


Figure 4. A Comparison of Output Trends for Non-manufacturing Industries: 2000-2005

(Compound annual rates of change)



Appendix

Explanation of Labor Productivity Growth in Terms of Multifactor Productivity (MFP) Growth and Factor Substitution:

$$\frac{\dot{A}}{A}=\frac{\dot{Q}}{Q}-w_k\frac{\dot{K}}{K}-w_l\frac{\dot{L}}{L}-w_e\frac{\dot{E}}{E}-w_m\frac{\dot{M}}{M}-w_s\frac{\dot{S}}{S}$$

This equation illustrates multifactor productivity as a residual, being a difference between the rate of growth of final output and the combined growth rates of the factors of production such as capital, labor, energy, business services, and materials.

$$\frac{\dot{Q}}{Q}=\frac{\dot{A}}{A}+w_k\frac{\dot{K}}{K}+w_l\frac{\dot{L}}{L}+w_e\frac{\dot{E}}{E}+w_m\frac{\dot{M}}{M}+w_s\frac{\dot{S}}{S}$$

The relation between aggregate MFP and aggregate labor productivity

Labor productivity growth = MFP growth + Capital effect + Energy effect + Business services effect + Materials effect.

$$\frac{\dot{Q}}{Q}=\frac{\dot{A}}{A}+w_k\frac{\dot{K}}{K}+\left(1-w_k-w_e-w_m-w_s\right)\frac{\dot{L}}{L}+w_e\frac{\dot{E}}{E}+w_m\frac{\dot{M}}{M}+w_s\frac{\dot{S}}{S}$$

$$1-w_k-w_e-w_m-w_s=w_l$$

$$\frac{\dot{Q}}{Q}=\frac{\dot{A}}{A}+w_k\frac{\dot{K}}{K}+\frac{\dot{L}}{L}-w_k\frac{\dot{L}}{L}-w_e\frac{\dot{L}}{L}-w_m\frac{\dot{L}}{L}-w_s\frac{\dot{L}}{L}+w_e\frac{\dot{E}}{E}+w_m\frac{\dot{M}}{M}+w_s\frac{\dot{S}}{S}$$

Subtracting $\frac{\dot{L}}{L}$ from both sides of the equation

$$\frac{\dot{Q}}{Q}-\frac{\dot{L}}{L}=\frac{\dot{A}}{A}+w_k\frac{\dot{K}}{K}+\frac{\dot{L}}{L}-w_k\frac{\dot{L}}{L}-w_e\frac{\dot{L}}{L}-w_m\frac{\dot{L}}{L}-w_s\frac{\dot{L}}{L}+w_e\frac{\dot{E}}{E}+w_s\frac{\dot{S}}{S}+w_m\frac{\dot{M}}{M}-\frac{\dot{L}}{L}$$

$\frac{\dot{L}}{L}$ on the right side of the equation cancels out

$$\frac{\dot{Q}}{Q}-\frac{\dot{L}}{L}=\frac{\dot{A}}{A}+w_k\frac{\dot{K}}{K}-w_k\frac{\dot{L}}{L}-w_e\frac{\dot{L}}{L}-w_m\frac{\dot{L}}{L}-w_s\frac{\dot{L}}{L}+w_e\frac{\dot{E}}{E}+w_m\frac{\dot{M}}{M}+w_s\frac{\dot{S}}{S}$$

Rearranging the equation

$$\frac{\dot{Q}}{Q}-\frac{\dot{L}}{L}=\frac{\dot{A}}{A}+w_k\left(\frac{\dot{K}}{K}-\frac{\dot{L}}{L}\right)+w_e\left(\frac{\dot{E}}{E}-\frac{\dot{L}}{L}\right)+w_m\left(\frac{\dot{M}}{M}-\frac{\dot{L}}{L}\right)+w_s\left(\frac{\dot{S}}{S}-\frac{\dot{L}}{L}\right)$$

Nonmanufacturing industry contributions to multifactor productivity, 1987â€“2006.Â The largest share of non-manufacturing industries, the service sector has grown at the expense of the manufac-turing sector, which now represents 12 per-cent of business sector employment.Â In 1996, regular publication of multifactor productivity measures for manufacturing industry groups that match National Income and Product Accounts (NIPA) sectors began, based on a line of research followed by William Gullickson and Michael Harper.10 Efforts to expand these results by using the same methodology for difficult-to-measure industries in the nonmanufacturing sector have been limited by data of. In economics, total-factor productivity (TFP), also called multi-factor productivity, is usually measured as the ratio of aggregate output (e.g., GDP) to aggregate inputs. Under some simplifications about the production technology, growth in TFP becomes the portion of growth in output not explained by growth in traditionally measured inputs of labour and capital used in production. TFP is calculated by dividing output by the weighted average of labour and capital input, with the standard weighting of MFP for total manufacturing and 18 3-digit NAICS manufacturing industry groups and 86 4-digit NAICS manufacturing industries, the air transportation industry, the railroad transportation industry, and the utility and gas industry. It is for the second set of estimates that we present prototype integrated estimates.Â changes in these variables as well as multifactor productivity, which represents the change in. output that cannot be accounted for by the change in combined inputs of labor and capital. These.Â Industry-specific internal rates of return (as calculated by BLS for private businesses engaged in similar activities) are used in generating rental prices for non-profit institutions. "Multifactor productivity" (sometimes more ambitiously called "total factor productivity") is calculated as the level of output for a given level of several inputs, typically labor, capital and materials. In principle, multifactor productivity is a better measure of a firm or industry's efficiency because it adjusts for shifts among inputs, such as substituting capital equipment for labor.Â Industry-Level Studies of Information Technology Productivity. The last section has shown that contrasting the economy-wide productivity slowdown with increasing IT investment is an obtuse approach, because so many other factors may intervene.Â Before about 1970, service and manufacturing productivity growth rates were comparable, but since then the trends have diverged significantly.