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Services Productivity in the United States:

Griliches' Services Volume Revisited

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Contents (Outline)

I. Introduction and Overview.[1]

Zvi Griliches (1992) reviewed services sector productivity trends, as well as issues in measuring services productivity, as these matters stood in the early 1990's (see also his American Economic Association presidential address, Griliches, 1994). In this paper, we analyze the rapid post-1995 productivity growth in services industries, which as we show have contributed greatly to the strength of U.S. productivity growth in recent years. We also review some of the major measurement issues that Griliches addressed, from roughly a dozen years on.

The contexts of the early 1990's and early 2000's are very different, yet at the same time similar. Griliches wrote in the context of the post-1973 U.S. productivity slowdown, which was the big puzzle of that day. He pointed out that services were crucial to the post-1973 slowdown, because productivity in services industries grew much more slowly than productivity in goods-producing industries after the late 1960s. Services, therefore, acted as a brake on U.S. productivity growth, a conclusion that was particularly unsettling because services have represented an increasing share of U.S. economic activity, a pattern that is also evident in Europe and other advanced economies.

The post-1973 puzzle was never resolved, just abandoned by economists when they were confronted with a new problem—the acceleration of U.S. productivity after about 1995. We find, in this paper and in our previous one (Triplett and Bosworth, 2002), that accelerating productivity in services industries played a crucial part in post-1995 U.S. productivity growth. Indeed, in recent years services industry labor productivity has grown as fast as labor productivity in the rest of the economy, which is why we have previously said that "Baumol's disease has been cured."[2] In this, our findings are a mirror image of the conclusions emphasized by Griliches: Both the post-1973 slowdown and the post-1995

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[1] We are very indebted to David Gunter and Kristin Wilson for their superb research assistance, and to Michel Harper, Mun Ho, Larry Rosenbloom, Daniel Sichel, Kevin Stiroh, and Robert Yuscavage for helpful conversations about the data and some of the technical issues.

[2] Triplett and Bosworth (2002). Baumol's disease is the presumption, or perhaps the consequence of the presumption, that it is inherently more difficult to increase services productivity than goods-producing productivity—see Baumol (1967).

acceleration in U.S. productivity growth—both labor productivity and multifactor productivity—is located disproportionately, though not entirely, in services.[3]

In Griliches' time and now, services industries are the industries that are the most intensive users of information and communication technology (IT) capital equipment. But unlike Griliches, who complained that the IT effect on services productivity was invisible in the data of his day, we find that IT investments now make a substantial contribution of labor productivity growth in services-producing industries. This, of course, is another change from the early 1990's, when lagging services productivity seemed a stifling problem for economic growth.

As in most of his writing on productivity, Griliches (1992, 1994) emphasized measurement issues. He was perhaps the foremost of his generation to insist that measurement is part of the science of economics (as it is in all other quantitative sciences), and not just a low-order task to be left to statistical agencies. Data collecting may not itself be part of the science of economics, but specifying what should be gathered and what is needed for economic analysis certainly is. In this regard, Griliches noted the inadequate state of U.S. services productivity statistics around 1990, which included (but was not limited to) a major deficiency in the conceptual design of the Bureau of Economic Analysis (BEA) industry database, as it then existed:

> "The double-deflation procedure (the subtraction of deflated intermediate purchases from deflated gross output to arrive at a real value-added concept) is itself troublesome, as is also the GNP by industry construction, which is based on a value-added measure of an industry's output…. For productivity measurement purposes we would be much better off with explicit and separate series on gross output and intermediate inputs in constant prices" (Griliches, 1992, pages 8-9).

The measurement of services sector productivity has advanced hugely since the early 1990s. The best indicator of the improvement that has taken place is displayed in our paper: We calculate multifactor productivity (MFP) for all two-digit services industries based on gross output, using a combination of government data bases from the Bureau of Economic Analysis (BEA) and the Bureau of Labor Statistics

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[3] Services MFP growth has not been emphasized in other research on the post-1995 resurgence in productivity,

(BLS)—and implicitly the Census Bureau, since the other two agencies' compilations rest heavily on data ultimately collected by the "economic directorate" part of the Census Bureau. These industry measures incorporate as inputs capital services from different kinds of assets, including separate measures for capital services from IT equipment, and deflated intermediate inputs, exactly along the lines that Griliches recommended.

With the new database, we can compare productivity trends in goods-producing and services-producing industries and we can aggregate the industry productivity estimates to be consistent with the aggregate productivity estimates that have appeared in "macro" studies such as Oliner and Sichel (2000, 2002), Baily and Lawrence (2001), Gordon (2000, 2002) and Jorgenson and Stiroh (2000). None of this was possible a dozen years ago when Griliches wrote. It has become possible largely because government agencies have implemented some of the recommendations of Griliches, and also taken notice of the substantial contributions to economic accounting of Dale Jorgenson and his collaborators (for example, Jorgenson, Gollop, and Fraumeni, 1987). With these great improvements to the government industry database, we can ask and answer questions about post-1995 productivity growth that were nearly impossible to confront for the post-1973 productivity slowdown.

Our results are rich and complex, and our conclusions conflict, to an extent, with interpretations of some previous research. Accordingly, it is appropriate to start with a summary of our findings.

It is now well known that aggregate U.S. labor productivity and multifactor productivity (MFP) accelerated after 1995, with the amount of the acceleration understandably depending on the end period. For this paper, we use 2001 because it is the last for which industry accounts are available. However, because 2001 was a recession year, using it as an end point gives a lower estimate of post-1995 productivity growth than using either 2000 or 2002. Using the most recent year (2002), for example, labor productivity rose at a 2.8 percent annual rate since 1995, compared to 2.4 percent over the 1995-2001 period. In order to reduce the sensitivity of our results to these end-point issues, we present mainly

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which has perhaps too strongly emphasized high productivity growth in electronics producing industries.

least-squares trend rates of change, which gives 2.5 percent per year for trend labor productivity growth for the 1995-2001 interval (table 1), compared with 1.0 percent for 1987-1995.

Our first major finding is that, over the post-1995 period, labor productivity in the services-producing sector has advanced more rapidly than labor productivity in the goods-producing sector. Table 1 presents a sector-level summary, in which aggregated value added (for private nonfarm, goods-producing and services-producing sectors, taken from the BEA industry accounts) is used to calculate the growth in labor productivity and MFP from aggregated inputs at the corresponding sector level.[4] Services labor productivity advanced at a 2.6 percent trend rate in 1995-2001, compared with 2.3 percent per year for the goods-producing sector. The post-1995 acceleration in the services sector (at 1.8 percentage points) also far exceeds the acceleration of labor productivity growth in the goods-producing sector (0.5 points)—see table 1.

Similarly, MFP growth in the services sector exceeded MFP growth in the goods-producing sector, post-1995 (1.5 percent per year, compared with 1.3 percent). Net, the services-producing sector accounts for all of the acceleration in U.S. MFP growth, because there was minimal acceleration in MFP growth in the goods-producing sector, taken as a whole (only 0.1 percentage point). With respect to the services industries, our major conclusions are broadly the same as in our previous paper (Triplett and Bosworth, 2002), though the addition of another year's data, the most recent GDP revisions, and our use of least-squares trends in this paper, rather than end points, all cause small differences.

The aggregations conceal much heterogeneity among the industries. We compute industry labor productivity and MFP for 25 goods-producing industries and 29 services-producing industries. In these lower-level industries, productivity is computed using a measure of gross output, rather than value-added. In both goods-producing and services-producing sectors, some industries experienced very high labor productivity growth, such as electronics in goods-producing and brokerage/finance among services industries. Labor productivity growth in the goods-producing sector is restrained by low productivity

growth in mining and negative productivity growth in construction. A number of services sectors also had negative productivity growth. These industries include hotels, entertainment and recreation, and education. It is important to recognize that the *net change* in sector productivity reflects the behavior of productivity in the individual industries within the sector, and within both services and goods-producing sectors, there are industries with negative, as well as positive productivity growth.

Our conclusions about services industry productivity conflict with a widely cited *interpretation* of previous macro-level studies. In the macro studies, researchers have "backed out" of the macro productivity change the contribution of IT producing industries. They concluded that the MFP contribution of IT-producing industries accounted for all or nearly all of the post-1995 acceleration of U.S. MFP growth and have said (or have been interpreted as saying) that no improvement in MFP growth took place in the other industries.

We show in this paper that post-1995 MFP growth resurgence is evident in many non-IT-producing industries, and was especially evident in a number of services industries. We do not disagree that MFP in the IT-producing industries was very high, as emphasized by other studies. It contributed greatly to the tremendous fall in IT prices and thus to the surge in IT investment (and in turn therefore to labor productivity growth through the standard channel of capital deepening). However, as we show in section V, there is no inconsistency in finding strong MFP contributions from both IT production and from services industries, because the total contributions of industries that have growing productivity are greater than the *net productivity growth* in the aggregate or sector (because of the offsets from industries that make negative contributions and because of reallocations across industries).

As a second major strand of our research, we estimate the contributions of IT capital to labor productivity growth. We confirm the finding of others about the strong contribution of IT capital deepening. We add to the previous research results in finding strong contributions of IT to labor productivity growth in the services industries, which are the industries where IT intensity is greatest. This

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[4] As explained in section II of this paper, these aggregations do not agree precisely with BLS published productivity

helps resolve a rather confused debate about whether the effects of IT can be found in the IT-using sectors.

Finally, we evaluate in our last section the U.S. industry database, as it now stands. Although it has been improved greatly over the past dozen years, it is hardly fully adequate. As we detail in this paper, results for some industries seem anomalous. Putting the database through the crucible of productivity estimation points to where, by exposing anomalous results, efforts toward improving the data would have their highest payoffs. In some of these cases, we have hypothesis about where the weaknesses in the data lie, and these are discussed briefly in the last part of the paper. We contend that weaknesses in the industry labor input measures urgently need attention; labor measurement is a neglected problem in estimating and understanding productivity change at the industry level.

II. The Industry Database and Aggregate Nonfarm Business Productivity Estimates

We use for this paper the recently expanded industry accounts of BEA, and combine them with data on capital service flows from the Bureau of Labor Statistics (BLS). The BEA industry data set has been improved substantially in recent years in ways that make it more suitable for productivity analysis. The data set now includes measures of output and purchased inputs to go with the prior measures of value added (formerly somewhat confusingly called "gross product") by industry. The industry-specific price indexes have been improved, particularly for the services-producing industries, because of expansion of price measures for services industries in the BLS Producer Price Index program. The database improvements are documented in Yuskavage (1996) and in Lum, Moyer, and Yuskavage (2000). An evaluation of the current data set and plans for its extension are outlined in Yuskavage (2001).[5]

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numbers.

[5] The BEA-BLS industry data set is an alternative to that developed by Dale Jorgenson and his various co-authors. While they share many of the same sources, the BEA data offer more disaggregation of the service-producing industries. On the other hand, the Jorgenson data are available for a longer time period, and they include measures of labor quality. As discussed in a later section, there are often considerable differences between the two data sets in the growth rates of output at the level of individual industries.

The BEA industry accounts are constructed to be fully consistent with the estimates of aggregate GDP. They exist for 66 industries, published annually, at roughly the 2-digit industry level of the old SIC classification system. After excluding government and the farm sector, and combining some industries for which the BLS does not estimate separate information on capital services, we have 54 industries (25 in goods-producing, and 29 in service-producing) within the private nonfarm business sector, spanning the period of 1987-2001.

We construct measures of labor and multifactor productivity for each of these 54 industries and various sub-aggregates. The results for all 54 individual industries are shown in appendix tables A1 and A2. We also estimate growth accounting equations for each of these industries in order to analyze the contributions of capital and materials deepening and multifactor productivity to the growth and acceleration of labor productivity:

(1) . $$\Delta \ln LP = w_{K_{IT}} \Delta \ln(K_{IT} / L) + w_{K_N} \Delta \ln(K_N / L) + w_M \Delta \ln(M / L) + \Delta \ln \tilde{MFP}$$

Within this model , capital services, K, are disaggregated into IT capital (K_{IT}) and non-IT capital (K_N), and intermediate inputs – combined energy, materials, and purchased services – are designated as M.

Our industry labor productivity and MFP estimates will, obviously, reflect the nature of the BEA database, so we need to emphasize several aspects of it. As we show, if one were to estimate labor productivity and MFP at the aggregate, private nonfarm business level *using the data from the BEA industry accounts,* both labor productivity and MFP would grow more rapidly after 1995 than the corresponding aggregate productivity numbers published by BLS. The reasons involve differences in both the output measure and the labor input measure.

Most importantly, BLS begins with aggregate GDP as measured from the *expenditure side* of the national accounts and excludes several sectors. In contrast, our measure of private nonfarm business value added is the result of adding up the value added of individual industries as measured by the *income side* of the national accounts. The difference between the income and expenditure sides is the statistical discrepancy, which has grown in recent years. The statistical discrepancy adds an average of 0.3

percentage points annually to the growth of nonfarm business output over the 1995-2001 period, measured from the income-side, which means that our productivity measures for the aggregate nonfarm sector grow faster, compared with the BLS labor productivity and MFP measures.

Additionally, the difference between the estimates of aggregate price change obtained from the expenditure-side measure of GDP and the double-deflation of industry value added is another frequently overlooked source of difference. The expenditure-based estimate of the GDP price index is based on a chain index in which the weights are the shares of individual components of final demand. In contrast, the industry measure of price change for value added is the difference between two chain indexes, gross output and purchased inputs. Each of those two indexes is constructed, in turn, on the basis of the composition of the industry's sales (final and intermediate) and purchases. The nonfarm sector is then an aggregation of these industry value added estimates. Not surprisingly, the two measures of aggregate real output and price change are not identical. These differences in deflation procedures add another 0.1 point to the annual growth of the BEA nonfarm aggregate.

As shown in table 2, the industry-based measure of aggregate nonfarm value added grows 4.3 percent annually after 1995, compared with 3.8 percent per year (second column of table 2) for the BLS measure.[6] The industry-based measure also shows more post-1995 acceleration, 1.4 versus 0.9 percent points per year, because 1987-95 income side and product side growth are the same.[7]

Because reliable measures of hours of work are not available for many of the services industries, we use the labor input in the BEA dataset—the number of persons engaged in production, which equals full-time equivalent employees plus the self-employed.[8] This is an incomplete adjustment for variations

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[6] This comparison table uses actual changes, as opposed to least-squares trend, so as not to confuse the comparison of the basic data.

[7] We also show the growth rate of the aggregation of industry gross output (first column of the lower panel of table 2: Although aggregated industry gross output may not be appropriate for computing aggregate productivity, it is useful to note that its overall growth (3.9 percent after 1995) is actually closer to the BLS value added measure after 1995 than is aggregated industry value added.

[8] The adjustment for full-time equivalents is done by multiplying total employment by the ratio of hours for all employees to hours for those on full-time schedules. Our measure differs from the treatment in Stiroh (2002a) where the labor measure excludes the self-employed.

in hours of work; at the level of total nonfarm business, it results in an index of labor services that grows slightly faster than that of the BLS—1.8 percent per year over the 1987-2001 period, compared to 1.5 percent (table 2, column 3), and it accelerates slightly, where the BLS measure shows the same rate of growth before and after 1995. This implies that hours have been falling, relative to full-time equivalent employment growth.

We adjusted the labor income data to include the compensation of the self-employed. One approach is to simply assume that the self-employed earn a wage equal to that of employees in the industry. However, that adjustment produces a negative residual estimate of capital income in several industries. The BLS makes a proportionate adjustment based on the average of two algorithms: equal rates of labor compensation and a rate of return on non-corporate capital equal to that for corporations in the same industry—eliminating the possibility of a negative return to either factor. We adopted the BLS estimate of the factor shares.

The measures of capital services are obtained directly from the BLS. Thus, the small discrepancies between the two aggregates (table 2, column 4) are due solely to the minor differences in the industries that are included in the aggregate measures.

Columns 5 and 6 of table 2 quantify the labor productivity and MFP implications of differences in the data. The upper panel presents the published BLS figures for the nonfarm business sector. The lower panel presents the nonfarm business labor productivity and MFP one gets when the value added aggregate is formed from the BEA industry accounts, and the labor input is employment, rather than hours.

Labor productivity growth based on aggregating the BEA industry accounts is significantly lower than that of BLS in the 1987-95 period because of faster growth in the labor input in our data (the two output measures being the same). However, the two series are very similar after 1995 (both at 2.3 percent per year), when the higher rate of growth in aggregated industry value added is offset by more rapid growth in the labor input. Thus, the aggregated BEA industry accounts produce a significantly larger estimate of the post-1995 acceleration, 1.2 versus 0.9 percent per year (column 5 of table 2). This result complements research of Baily and Lawrence (2001), and Baily (2002), who estimated productivity from

an average of income and product sides of the accounts, but it is a larger acceleration than the estimates in other studies that start from the BLS published aggregate numbers.

A comparison of alternative aggregate MFP estimates is also presented in column 6. In addition to the other differences in output and labor input already discussed, the published BLS measure of MFP incorporates an adjustment for improvement in the quality of the workforce. Improvements in labor quality account for about 0.4 percentage points of the increase in labor productivity over the 1987-2001 period, with an offsetting reduction in the residual estimate of MFP. However, we did not have the information required to distribute those labor quality improvements among the 52 industries. Instead, we adjusted the published BLS MFP measure of labor inputs to exclude the effect of improvements in workforce quality to gain comparability. On this adjusted basis, growth in the BLS measure of MFP is virtually the same overall (1987-2001) as that using the aggregated BEA industry data, as table 2 shows. But, as with labor productivity, differences between the two sub-periods result in a larger MFP acceleration after 1995 in the industry-based aggregate than in the published BLS numbers.

Manufacturing Productivity. The BLS also publishes estimates of labor productivity and multi-factor productivity growth for durable and nondurable manufacturing. Because several studies (Oliner and Sichel, 2002, and Gordon, 2002) have contended that large portions of the productivity acceleration are within manufacturing (particularly semiconductors and computers), it is important to assess the comparability of BLS and BEA manufacturing measures. In the manufacturing case, the BEA industry-based measures yield slower productivity growth after 1995 than in the BLS published numbers, and less acceleration, especially in durables.

Table 3 compares growth rates for output and labor productivity.[9] BLS relies on the same basic Census Bureau source data as BEA, and both BLS and BEA measures of manufacturing output are based on a concept of gross output, not value added, so the statistical discrepancy is not an issue. As shown in the top portion of the table, BLS estimates somewhat greater output growth after 1995 in both durables

[9] The BLS estimates of multi-factor productivity are only available through 2000.

and nondurables manufacturing (0.2 and 0.3 percentage points, respectively). In constructing its gross output measure for manufacturing, BLS removes an estimate of within manufacturing intra- and inter-industry shipments, to get an unduplicated total. We have aggregated the BEA industry data without this adjustment; the adjusted measure will grow faster than the unadjusted one when intra-manufacturing shipments are growing more slowly than shipments outside of manufacturing, but it is not clear that this was the case.[10] Both measures, as we understand them, add to industry output growth the BEA estimate of own-account software production, which is treated as investment in the national accounts. Thus, we do not know why the output measures differ. The patterns are similar before 1995 (that is, the BLS output measure grows more rapidly than our aggregation of the BEA data). However, the accelerations (decelerations for nondurables) in the two output measures turn out to differ more than do the growth rates within each of the periods.

We also report in table 3 a comparison with the Federal Reserve indexes of industrial production for durables and nondurables manufacturing. The FRB index agrees closely with the BEA measure for nondurables; but it shows a considerably larger acceleration of durables output growth after 1995. In fact, the FRB durables index grows more rapidly over the full 1987-2001 period than either the BEA or BLS measures.

The important point to carry away from of these comparisons is that the BLS manufacturing labor productivity measures grow more rapidly after 1995 than similar measures we constructed from the BEA data (by 0.6 percentage points in durables, and 0.5 points in nondurables—see the bottom panel of table 3). Moreover, the BLS measures show substantially more acceleration in durables: The BLS measures indicate accelerating labor productivity of 1.6 percentage points (4.8 minus 3.2), where the BEA data indicate very little acceleration after 1995 (only 0.2 percentage points). This reflects not only differences in the output measures, but also the BLS measure of hours, compared with our reliance on full-time

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[10] Intra-manufacturing shipments are intermediate goods. Our data indicate that intermediate input deepening occurred in both durables and nondurables manufacturing (appendix table A-1), that is, that intermediate inputs in manufacturing grew more rapidly than output. Of course, intermediate inputs include services as well as manufactured goods.

equivalent workers. For nondurables, both BLS and BEA measures show about the same acceleration in labor productivity (0.8 and 0.7, respectively). Taking durables and nondurables together, the BLS measures imply a slightly faster growth rate for output and labor productivity for total manufacturing over the whole period and substantially more acceleration after 1995.

The finding of greater acceleration in the aggregate nonfarm productivity measures—and less acceleration in manufacturing—in the BEA data is an important consideration in the evaluation of the detailed industry productivity measures that are reported in the following sections. It is also a factor in our comparison with other studies that are based on the aggregate nonfarm measures (section V). For our subsequent discussion of the aggregation of industry contributions to productivity growth, and for comparing our results with other studies, the aggregated LP and MFP numbers in the lower panels of table 2 are our "targets," that is, the aggregation of BEA industry data that corresponds to the income side of the national accounts.

III. Trends in Labor Productivity and MFP at the Industry Level

In this section, we report our estimates of labor productivity and MFP for the industries in the BEA industry database. We have constructed industry productivity measures using both gross output and value added, but we emphasis the results based on gross output at the industry level.[11]

Labor productivity is the output index divided by a simple index of the labor input. Multi-factor productivity is the ratio of the output index divided by a weighted average of the inputs, K, L, and M (capital and labor services and intermediate inputs), so the rate of change in gross output MFP is defined:

$$(2) \qquad d\ln MFP = d\ln Q - \left\{(1-v)\left[s_l d\ln L + s_k d\ln K\right] + v d\ln M\right\},$$

[11] Estimates of gross output back to 1977 are incomplete for services industries, largely because early economic censuses and surveys collected very limited information from service-producing firms. See our earlier paper (Triplett and Bosworth, 2002), which carried out separate analyses for the services industries for which data extend to 1977. The information on industry value added extends back to 1947 for the nominal measures and 1977 for real values.

where inputs include intermediate purchases (M) in addition to labor (L) and capital services (K), *v* equals the two-period average share of intermediate purchases in gross output, and s_l and s_k are the two-period averages of the share of capital and labor income in value added. We compute a Tornqvist chain index of the weighted annual changes in the inputs.[12] As noted earlier, we separate the capital input into IT and non-IT capital.

Tables 4A and 4B provide a detailed view of the changes in labor and multi-factor productivity for the services-producing industries. We focus on the services-producing industries because they play such a dominant role in the post-1995 productivity resurgence, and it is in this sector that the industry analysis offers a different interpretation of the resurgence compared to the macroeconomic analysis. The results for all 54 industries are provided in the appendix tables A1 and A2.

In the services-producing sector, the overall growth in labor productivity and MFP (presented in section IV) camouflages a wide disparity of trends within the individual 2-digit industries. Advancing labor productivity in four large services industries—telephone, wholesale trade, retail trade, finance (both brokerage and depository institutions)—drove the overall sector improvement. Labor productivity gains in these industries ranged from 3 to over 10 percent per year after 1995, in all cases representing acceleration over the corresponding rate before 1995. These four industries represent over a quarter of total value added in the private nonfarm business sector.

However, services sector labor productivity growth is not just a story of a small number of large industries. Of the 29 detailed services industries, 24 experienced labor productivity growth after 1995, and of the positive growth industries, 17 experienced acceleration.[13] In two industries, accelerations or decelerations were marginal (only 0.1 percentage point), so they might better be set as zero acceleration industries. Negative labor productivity growth occurred after 1995 in five industries (two fewer than

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[12] The output data of the BEA are assembled using Fisher indexes. We switched to Tornquist indexes only to take advantage of a slightly simpler algorithm.

[13] This contrasts with the goods-producing sector, where post-1995 labor productivity growth was positive in 24 out of 25 industries, but accelerated in only 14 of the 24.

before 1995), but in one of them labor productivity actually accelerated, that is, the negative productivity growth became less negative.

Multi-factor productivity growth shows a more mixed picture in services industries (table 4B). The 2001 recession is not a factor in this, as a similar mix was found in our previous paper, for which the post-1995 period ended with 2000.

MFP growth was actually negative in 12 of the 29 industries after 1995 (three marginally so), but grew rapidly in others. Strong MFP growth in a number of large industries—telephone, retail and wholesale trade and finance—was sufficient to offset negative productivity growth in other large industries, including hotels, health, education, entertainment/recreation, and the "other services" (which is a combination of several 2-digit SIC's).

More than half of the services industries experienced accelerating MFP after 1995. Acceleration after 1995 is associated with large swings from negative to positive MFP growth in several industries (see for example, local transit, pipelines, auto repair and legal services) and strong MFP growth in the big industries of trade and finance. However, the acceleration of MFP growth in medical care (though growth is still negative!) is one area where the result is influenced by a methodological break in the index of real output because new PPI measures of price changes begin in 1991. Methodological breaks also occur in other industries, such as miscellaneous services.

IV. The Aggregation of Industry Productivity Measures.

The 54 industries in the data set vary widely in size. Thus, while tables 4a and 4b report the changes in labor productivity and MFP at the industry level, it is not evident which of the industries made the largest contributions to the post-1995 surge of aggregate productivity growth. In this section, we aggregate the industry productivity measures and show the contributions of individual industry productivities to aggregate and sector level productivity measures. We find that the industries within the services sector account for the bulk of U.S. productivity growth after 1995, both labor productivity and

MFP, and for all of the post-1995 acceleration. The goods-producing industries, taken together, make no net contribution to the recent acceleration of U.S. productivity growth.

Industry and aggregate productivity relations. We discussed, in the introductory section of this paper, aggregating industry outputs and inputs and then computing productivity at the aggregate level (table 1). We call such measures "direct" aggregate-level (or sector level) productivity measures.

Computing industry productivity first and then aggregating the results raises a set of issues that we need to confront in order to compare our industry productivity figures with the direct aggregate-level productivity numbers, and with sector-level productivity measures, such as the goods-producing and services-producing sectors, manufacturing durables production, and so forth. In this section, it is important to bear in mind that the aggregate productivity numbers to which our industry productivity numbers correspond are those "targets" in the lower panel of table 2, that is, the direct aggregate-level productivity estimates formed from aggregating inputs and outputs in the BEA industry accounts, not the published BLS aggregate numbers in the top panel.

First, aggregate productivity is not just the aggregation of productivity changes within the individual industries. Aggregate productivity can also change because of reallocations across industries. As we (and others, including Stiroh, 2002a, and Jorgenson, Ho, and Stiroh, 2002) show, aggregated industry productivity estimates generally exceed direct aggregate-level productivity change because of reallocation of resources across industries. These reallocation effects are an important and interesting part of the productivity resurgence story that has been overlooked in some macro productivity studies.

A second issue concerns combining gross output productivity at the industry level with value added productivity at the aggregate level. Gross output is preferred for production analysis at the industry level because it requires the least restrictions on the relationship between intermediate inputs and output. The construction of a production relationship based on value added requires that the components of value added be separable from that of purchased inputs.[14] The value-added construct at the industry level also

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[14] Gross output at the industry level can be represented as

implies a specific way that productivity or technical change affects economies in the use of capital and labor, on the one hand, and of savings in intermediate inputs on the other.

Yet, value added is the appropriate focus at the level of the aggregate economy. As Gollop (1979) put it, the objective is to maximize society's deliveries to final demand—which corresponds with aggregate value added for a closed economy—subject to the constraint of limited supplies of the primary inputs. At this level, intermediate purchases net out (except for imports), and the aggregation of the industry gross outputs would involve repeated double-counting. Thus, a full consideration of the implications of productivity developments at the level of individual industries requires a means of linking gross output productivity at the industry level to the value-added concept of the aggregate.

Recent discussions of the aggregation of labor productivity are provided by Nordhaus (2002) and Stiroh (2002a). We rely on Stiroh's formula that relates the industry measures of gross output labor productivity to aggregate value added per worker:

$$(3) \qquad d\ln LP^V = \left[\sum_i w_i d\ln LP_i^Q\right] + \left[\sum_i w_i d\ln L_i - d\ln L\right] - \left[\sum_i m_i (d\ln M_i - d\ln Q_i)\right];$$

where

LP^V = aggregate value added per worker,

LP_i^Q = gross output per worker in industy i,

w_i = the two-period average of the share of industry i's nominal value-added in aggregate value-added, and

m_i = The two-period average of the ratio of industry i's nominal purchased inputs to aggregate value-added,

and of course, K,L, and M are the standard notations for capital, labor and intermediate inputs.

$Q = f[K, L, M, t]$,

where Q is output, and K, L, and M are capital, labor, and purchased inputs, respectively. Excluding purchased inputs and focusing on value-added is equivalent to assuming

$Q = f\lfloor g(K, L, t_1), M, t_2 \rfloor$, where g is separable from M, and t_1 and t_2 represent (different) shift factors.

In this formulation, we can think of $d\ ln\ LP^V$ as the direct aggregate-level labor productivity growth discussed in section II, and displayed in table 2. Equation (3) shows that the direct aggregate-level labor productivity estimate is a combination of: (1) an industry productivity effect equal to the weighted sum of the growth in the industry productivities, where the weights are the industry shares of total value-added; and (2) reallocation terms that capture the shift of output among industries with variations in their levels of labor productivity and intermediate input intensity.[15]

As an intuitive example, suppose industry A contracts out a portion of its activities to industry B. This intermediate deepening ($d\ ln\ M_i > d\ ln\ Q_i$) may raise labor productivity in industry A (presuming that industry A rids itself of labor employed in its own less productive activities), because less labor is required per unit of output in industry A. But contracting out cannot by itself raise aggregate labor productivity; it will only cause aggregate labor productivity to rise if industry B is more productive in the contracted activities than was industry A. The reallocation terms capture this effect. They will be positive when shifts in economic activity go from less productive to more productive industries, and will be negative in the opposite case.

Domar (1961) provided the link to aggregating industry gross output MFP by expressing the rate of aggregate MFP growth as a weighted average of the industry MFP growth rates, with weights equal to the ratios of industry gross output to aggregate value added. That framework was generalized and developed more fully in Hulten (1978) and Gollop (1979). The important point is that productivity improvements at the industry level contribute to the aggregate economy in two ways—first, through direct cost reductions for the industries' outputs that are part of final demand, and second, through reductions in the cost of intermediate inputs for other industries.

For the aggregation of MFP, we have relied on the generalization of the Domar weights given in Jorgenson, Gollop, and Fraumeni (1987):

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[15] This formulation differs from that of Nordhaus (2002) because it uses chain index weights (the v_i terms), eliminating what Nordhaus labeled the Baumol effect, and it adds an additional source of reallocation by measuring labor productivity at the industry level with gross output instead of value added.

$$(4) \qquad d\ln MFP^V = \left[\sum_i v_i d\ln MFP_i^Q\right] + \left[\sum_i v_i s_i^k d\ln K_i - \bar{s}^k d\ln K\right] + \left[\sum_i v_i s_i^l d\ln L_i - \bar{s}^l d\ln L\right]$$

where

v_i = two-period average of the ratio of industry i's gross output to aggregate value-added (Domar weights), and

s_i = the two-period average share in industry i of the designated factor's (K or L) income in nominal gross output.

The framework differs from Domar's because it does not net out the intra-industry shipments, and in the case of labor, the total is simply the sum of employment at the industry level rather than being weighted by the industry share of total compensation. In addition, our aggregations of both labor productivity and MFP use Tornqvist chain indexes, that is, the weights are averages of adjacent periods, not single period or base-period weights.[16] The Domar weights (the first element of equation 4) can best be though of as the product of two steps in the aggregation: (1) the scaling up of the change in MFP at the industry level by the ratio of gross output to value added at the industry level, and (2) the aggregation using value-added weights.[17]

Sector Aggregates of Industry Productivity. Using equations (3) and (4), a summary of the industry contributions to the growth in the direct aggregate value-added measures of labor productivity (shown in bold) and MFP are shown in table 5. A more complete accounting is in appendix table A3.

The aggregation of industry labor productivity estimates (the within industry effects, shown in italics in table 5) more than accounts for the growth of aggregate productivity in both periods. The contributions of industry productivity changes are offset by resource reallocations (the among industries effects) that reduce the aggregate gain. For example, in 1987-1995, the aggregation of industry labor productivity yields 1.93 percent growth per year, which is nearly twice as much productivity growth as is recorded at the aggregate level (1.01 percent).

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[16] Domar (1961) assumed a Cobb-Douglas function, which implies base period weights in a logarithmic index.

[17] At the level of individual industries, MFP computed from the gross output framework will always be less that MFP computed from the value-added data (see tables A1 and A2; however, the contribution to the aggregate MFP is the same for both concepts.

On the other hand, more of post-1995 labor productivity growth within the industries feeds through to the aggregate level because the reallocation terms have had a less negative influence in recent years—the weighted industry productivity changes (2.63 percent per year) total only 0.17 points higher than the direct aggregate estimate (2.46 percent). Put another way, the aggregate post-1995 acceleration of 1.45 (2.46 – 1.01) percentage points per year in labor productivity growth is boosted by changes in (i.e., less negative) reallocation terms. For this reason, the acceleration (1.45 points) in aggregate productivity growth is roughly twice as large as is evident from a straight aggregation of the 54 individual industries (0.70 points per year).[18]

The lower part of table 5 indicates that the reallocation terms are less important in the aggregation of the (gross output) industry measures of MFP growth. The aggregation of industry MFP is formed using Domar weights, as indicated in equation (4). The aggregation of industry MFP's is larger than direct aggregate-level MFP for both periods, but the reallocation term is small (only -0.14, for 1995-2001). Moreover, the acceleration in MFP is the same (about 0.9 points), whether calculated from the direct aggregate or by aggregating industry MFP's.

Industry contributions to aggregate productivity growth. We can now turn to the contributions of individual industries to aggregate productivity growth. These are shown, for all 29 services industries and for the major aggregates, in table 6. The industry contributions in table 6 sum to the totals that are given by the first terms in equations (3) and (4), that is, to the bottom line of table 5. This aggregation of the industry productivities is repeated as the top line in table 6. As we have already noted, the total industry productivity contribution is larger than the direct aggregate-level productivity change shown in table 5 for the nonfarm business aggregate, because the direct industry contributions are gross of reallocation effects.

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[18] This variation between the aggregate and the industry results is largely due to changes in the relationship between gross output and value added – what we have labeled reallocation of the intermediate inputs. If labor productivity is measured at the industry level using value added, the reallocation term is limited to changes in the distribution of labor among the industries, which does not change very much before and after 1995.

Similarly, the sector aggregations in table 6 (indicated in italic type) are the sums of the industry contributions within the sector. Accordingly, one should interpret industry (and sector) contributions in table 6 in the following way: They show the contribution of industry i (or the industries in sector j) to the total of all industry contributions to productivity change. For example, table 6 shows that the two machinery industries (within which are located computer and semiconductor manufacturing) contribute about 17 ½ percent of the total industry increase in labor productivity ((0.15 + 0.31) / 2.63) between 1995 and 2001, and 32 percent ((0.22 + 0.29) / 1.58) of the total industry MFP growth.

In contrast, the post-1995 resurgence in labor productivity can be traced largely to productivity growth in the services-producing industries. Of the total labor productivity growth of 2.63 percent per year after 1995, services industries account for 73 percent of the total (1.92 / 2.63), while goods-producing industries account for the rest (27 percent, or 0.71 / 2.63). Improvements within durables manufacturing are more than offset by slow productivity growth in mining and continued outright declines in construction.

Of the 54 industries, 30 industries show an increased contribution after 1995, and 19 of those are in services. Within services, the largest contributors to post-1995 labor productivity growth are retail and wholesale trade, finance (specifically, brokerage firms), business services, and a miscellaneous grouping of other services.[19] Each of the first three of these large services subsectors contributes as much or more to aggregate post-1995 productivity growth as either industrial machinery or electrical machinery, which have received so much attention because of their electronics components. These five services industries represent 70 percentage points of the post-1995 aggregate acceleration in labor productivity (see the "changes" column of table 6), and the next ten most important contributors to the acceleration (all of which are in services) add only 30 percentage points.

Many of the industries that made the largest contributions to the resurgence of growth in labor productivity also play a large role in the acceleration of MFP growth. Again, the improvements are

dominated by the gains in the services-producing industries, which contribute three quarters (1.20 / 1.58) of the MFP growth, post-1995, and 0.92 points of the net 0.88 points of acceleration (that is, more than the total). The top contributors to the post-1995 MFP acceleration (retail trade, wholesale trade, brokerage firms, and health) are all in services, closely followed by industrial machinery, which includes computers. As shown in the table, the contribution of durable goods manufacturing to the improvement is large, but it is offset by declines in other goods-producing industries, including nondurables manufacturing.

Twenty-seven of the industries show a post-1995 acceleration of the trend growth in MFP, and 17 are services-producing industries. Despite the similarity of the large contributing industries, the cross-industry correlation between the post-1995 acceleration of labor productivity and MFP is a surprisingly low 0.33.

There is also a large change in the role of business services, which was a major source of the rise of labor productivity, but makes a negative contribution to the improvement in overall MFP growth. Its positive contribution to labor productivity is largely the result of a rapid increase in its weight; labor productivity growth was high but not accelerating after 1995. However, a large increase in purchases of intermediate inputs results in a post-1995 decline in MFP.

The Role of IT Capital. A number of studies have reported that increasing use of IT capital contributed to the acceleration of labor productivity after 1995, in the standard paradigm of capital deepening, but that non-IT capital per worker did not accelerate after 1995 (see, for example, Oliner and Sichel, 2002). Using the labor productivity decomposition in equation (1), and applying it to the nonfarm value added data, we find the same result: Overall, increasing IT capital per worker contributed 0.8 points to labor productivity (value added per worker) growth after 1995, and 0.5 percentage points to acceleration (line 1 of table 7, and appendix table A2). Non-IT capital services contributed positively to growth, but only a little less than 0.1 point to acceleration.

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[19] As mentioned in the prior section, we believe that the improvements in health services and other services are

Most of the effect of IT capital deepening in the U.S. economy in recent years shows up in its contribution to labor productivity growth in the services industries. Again, as with so many aspects of recent U.S. productivity performance, most of the action is in the services industries. As shown in the left –hand side of table 7, the increased use of IT contributed 0.6 percentage points of labor productivity growth in the service-producing industries after 1995, which was 0.4 points more than the contribution of IT capital in the previous period. In contrast, IT contributed only 0.1 to the acceleration in the goods-producing industries. [20]

Furthermore, if we use the Domar weights to compute the contribution of IT capital in individual industries (the right side of table 7), we find that the service-producing industries are responsible for 80 percent (0.62/0.77) of the contribution of IT capital to post-1995 productivity growth in the nonfarm economy. The contributions were particularly large from wholesale trade, finance, and other services (primarily business services and health).

The contributions data are also useful for exploring the role of IT capital in the productivity revival. Following Stiroh (2002a), we rank industries by the proportion of capital services that are derived from IT capital.[21] We use the values for 1995, but they are essentially the same as the 1987-95 average, a correlation coefficient of 0.96. We can then relate this measure of IT capital services intensity to the growth of productivity after 1995.

Using the cross-industry averages of trend labor productivity growth from 1995-2001, we obtain a statistically significant correlation of 0.26 with the intensity of IT use. This is very much in line with the results reported by Stiroh, and it is essentially the same if we use the actual changes over the 1995-

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partly due to changes in the methodology for measuring the price deflators for output.

[20] As shown in Triplett and Bosworth (2002), the service-producing industries are also more intensive users of IT than the goods-producing industries (appendix table A5).

[21] For our earlier paper, we computed several different measures of IT capital intensity, using alternative definitions of IT and IT intensity. The industry rankings are not invariant to IT definition or to intensity measure, but the top industries appear on all the lists.

2001 period. It suggests, as we should expect, that the contribution to overall labor productivity growth has been more rapid in those industries that made extensive use of IT capital.

However, if we now apply the same analysis to the post-1995 growth of MFP, the evidence of a correlation with IT capital vanishes and the correlation coefficient declines to 0.05. This too is as expected. If IT capital investments earn a normal return and there are no substantial externalities associated with such investments, then IT capital should not be associated with MFP, which is after all the residual after taking account of all other inputs (including IT inputs). This is also the conclusion of Stiroh (2002b), who examined the manufacturing industries.

Growth accounting analyses of productivity change (of the type we apply to industry productivity analysis) apply the assumption that IT capital earns normal returns. This has often been criticized on various "IT capital is special" grounds. The lack of correlation between IT and MFP is evidence supporting the view that that IT can be analyzed in the same way as any other capital good.

V. Consistency With Other Studies: IT-producing and Services Industries.

Studies using macro approaches, including Oliner and Sichel (2000) and Gordon (2000, 2002), find MFP acceleration in the U.S. after 1995, but also estimate (in somewhat indirect ways) that two-thirds to all of the aggregate acceleration is accounted for by MFP acceleration in the industries that produce IT investment goods. For example, Gordon (2002, page 65) concludes: "There has been no acceleration of MFP growth outside of computer production and the rest of durable manufacturing."

The view that all recent MFP growth is in the IT-producing industries suggests that the post-1995 productivity acceleration is fragile, because it rests entirely in a single set of goods-producing industries. Additionally, it suggests that recent U.S. productivity performance differs from that of Europe mainly because the U.S. has a larger IT-producing sector. In contrast, our finding that MFP acceleration is broadly—though not universally—based in services industries leads to the view that something significant did change in the U.S. economy. Moreover, changes in IT-using industries probably explained

a good amount of the recent productivity differences between the U.S. and Western Europe. Thus, reconciling the apparently conflicting findings has considerable importance.

Existing macro and industry studies differ from ours in three dimensions: the output measures, the labor measures and the estimates of MFP in IT-producing industries. We discuss these below. But first, we address an essential methodological point.

A Note on "Exhausting" Total MFP. The macro studies "back off" estimates of MFP in IT-producing industries from the growth of *direct aggregate-level MFP*. Doing so seems to exhaust or nearly exhaust total MFP growth and to leave little "room" for MFP growth in the rest of the economy. For example, backing off Oliner and Sichel's IT MFP estimate (0. 77 percent per year) from the trend BLS MFP growth estimate (1.17 percent per year) appears to leave only 0.40 percent per year MFP growth outside the IT producing industries (see the first column of table 8, row 5).[22] This calculation is the basis for Gordon's statement, quoted above. If one backs the same IT estimate from the growth in the direct aggregate-level BEA MFP measure (which is greater, for the reasons discussed in section II), MFP growth outside IT appears a little greater because the overall MFP growth estimate is larger.

However, we showed in section IV that the sum of all industries' MFP growth exceeds growth in the direct MFP measure because of reallocations. If one wants to determine whether non-IT industries contribute to MFP growth, clearly the starting point is the aggregation of industry MFP growth rates, not the direct aggregate-level measure that includes reallocations. As the third column of table 8 shows, that "backing off" exercise leaves more room for non-IT MFP. For illustration, backing off our industry IT MFP measure (0.51) from the net industry MFP change leaves 1.07 percent per year contribution to net MFP growth from industries outside the IT-producing sector, more than twice the amount that originates inside the IT-producing sector.

One might think of column three as the answer to the question: "Has there been any *net* MFP growth outside the IT sector?" But if one really wants to determine whether there has been *any* MFP

growth outside the IT sector, then the starting point should be the sum of all the industries having positive MFP growth. This is shown in the last column of table 8. Positive MFP growth in industries outside the IT-producing sector contributes three times as much as the MFP growth in the IT industries, using our measure of IT MFP growth, and twice the IT contribution, using Oliner and Sichel's IT estimate. By any measure of MFP in IT production, MFP growth outside IT production is substantial, and exceeds the MFP contribution of IT production.

There is no necessary conflict between our finding of substantial MFP growth in services industries and the finding of high MFP growth in the IT-producing industries. The misinterpretation arises because some researchers, observing a large MFP contribution from the production of IT, have concluded incorrectly that there can be no other similar contributions of equal size from other industries. Jorgenson, Ho, and Stiroh (2002) make the same point (on page 43): The "conclusion…that all productivity growth originates in these two IT-producing industries…would be highly misleading, since the sum of the contributions of …agriculture and wholesale trade…also exhaust productivity growth for the economy as a whole."

Reconciliation. Two major alternatives to our study are the macro study by Oliner and Sichel (2002) and the industry study by Jorgenson, Ho, and Stiroh (2002). With respect to the contributions of IT capital deepening and of MFP in the IT-producing industries, Gordon's (2002) influential study relies on Oliner and Sichel's (hereafter O&S) estimates, though he also buttresses them with independent calculations of his own. Accordingly, we focus on the O&S and JHS studies, since our analysis of O&S also applies to Gordon's estimates.

Our study differs from the others in its output measure and its labor input measure, both of which are tied to our use of the BEA industry database. As already described, the O&S study relies on the BLS output measure (from the expenditure side of the accounts), which means that their output measure grows less rapidly after 1995 than our income side measure (see section II). Other things equal, the income side

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[22] For comparability, we show trend rates of MFP growth in table 8. Using Oliner and Sichel's average annual rate

gives more labor productivity after 1995, and more MFP growth. Until the next benchmark revision to GDP, no one knows whether the income side or the product side measure is better. Jorgenson, Ho and Stiroh (2002, hereafter, JHS) use a wider definition of output (it includes both government and the household sectors) than employed in our study or in O&S. It grows somewhat more slowly, implying less MFP growth, other things equal (partly because the way government output is measured assures low productivity growth in the government sector).

Additionally, the labor input in our study does not include a labor quality adjustment, as noted in section II, and it is based on employment, rather than hours. When labor quality is growing, this means that we have too much MFP growth, because the contribution of the mismeasured input falls into MFP.[23]

All studies estimate capital deepening, and distinguish IT capital deepening from improvements in the non-IT capital/labor ratio. JHS capital deepening and IT capital deepening estimates are by far the largest, mainly because of their different output concept (the growth in IT capital services in the household "industry" after 1995 is the largest of any industry). Our estimate of IT capital deepening is slightly smaller (by 0.17 points) than that of O&S. We do not know why, but this is not a major factor in the comparisons.[24] More capital deepening, of course, diminishes their aggregate MFP estimate, relative to ours.

Putting all this together, these three factors—difference in output measure, difference in estimates of IT capital deepening and our omission of labor quality—causes our MFP estimate to exceed that of O&S by around 0.4-0.5 points after 1995.[25] Our MFP estimate is more than twice that of JHS, mostly because of the effects of including the household and government sectors in their estimates.

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of MFP growth to the 2001 recession year (0.99) yields only 0.23 for the non-IT growth rate.

[23] As noted earlier, the differences in output measures and in labor measures coincidentally offset each other after 1995 (but not before 1995), so labor productivity is similar in the two datasets after 1995.

[24] We are both using the data on capital services from BLS, and our two non-IT capital deepening estimates are the same.

[25] The range is given because ours is computed from trend rates of change, O&S from end-period average annual rates, which will differ to an extent because 2001 was a recession year.

MFP in High Tech. The remaining point to consider is our smaller estimates of MFP in the IT-producing industries, compared with the O&S estimate, which is also relied on by Gordon.

We do not actually estimate MFP at the level of the computer, communications equipment and semiconductor industries (which are three and four-digit SIC) because we work with 2-digit industry detail. However, the IT data used in other studies are embedded in two of our 2-digit industries.

In the old U.S. industry classification system (SIC 1987) computer production was located in SIC 35 (industrial machinery) and semiconductors and communications equipment were located in SIC 36 (electronic and electrical machinery). As we have noted before, in the old SIC system computers were combined with drill bits, and semiconductors with Christmas tree lights. This means that the electronics producing industries, which are of major interest in analyzing the post-1995 economy, are buried within broad industrial categories that have little to do with electronics, the new economy, or high tech. The BEA industry database is still constructed around SIC 1987, which is actually far more than 15 years out of date (the reason is that BLS, the laggard among the statistical agencies, is just beginning to convert its statistical series to the new NAICS classification system, which has an electronics sector).

Jorgenson, Ho, and Stiroh (2002)—hereafter, JHS—have extracted the lower-level IT-producing industries from their concealment within the non-high tech sectors. We have aggregated their MFP estimates to produce two-digit machinery industry estimates comparable with our own (table 9). The table also compares output growth rates for relevant categories.

As table 9 shows, the JHS implied MFP for industrial machinery industry (4.4 percent per year) is two-tenths of a point greater than ours for the same 1995-2000 interval. The Census shipments data that underlie the BEA industry data show that computer output growth in our data and in the data of JHS are quite comparable, at over 30 percent per year (ours is slightly more rapid). In both data sets, nearly all the growth in industrial machinery between 1995 and 2000 was in computers. Indeed, JHS record very little MFP growth for non-computer industrial machinery. Our MFP estimate for industrial machinery thus incorporates the rapid growth in computer output that appears in the JHS data, and our contribution to

MFP from this 2-digit industry (in table 7) also incorporates the computer MFP that is explicitly estimated in JHS.

JHS's implied electrical machinery industry MFP, at 5.7 percent, is about a point higher than ours (4.7 percent). However, we combined instruments (SIC 38) with electrical machinery, on the grounds that instruments are increasingly electronics manufacturing (JHS combined instruments with miscellaneous manufacturing). Because the Census shipments data show that the output of the instruments SIC grew more slowly than did the output of the electrical machinery SIC (see table 9), the inclusion of instruments probably reduces the MFP of our sector. Note that the output of communications equipment and semiconductors in BEA data correspond fairly closely with JHS' output data (the BEA growth is actually a little larger). Of course, these high tech sectors far outstripped in output growth the other types of electrical equipment, in both data sets.

Thus, the output of each of the three high tech manufacturing industries (computers, semiconductors, and communications equipment) grows slightly faster in our data than in the JHS data set. Their MFP estimates for 2-digit high tech goods-producing industries are somewhat larger than our estimates, but not by a great amount. From this, we conclude that our estimate for the MFP contribution of industrial and electrical machinery (0.51—see table 8) is consistent with the very rapid MFP growth in IT production estimated by JHS, and as well as with their estimate of the (narrower) IT producing sectors' contributions (0.41 points) to total MFP growth.

We next need to ask whether our (and JHS) industry MFP estimates for IT production are consistent with the indirect IT estimate of macro-oriented studies. Two indirect approaches have been used.

Baily-Lawrence (2001—see Baily, 2002) recalculated constant-price GDP with IT deflators set to the same rate of price change as the other components of GDP (rather than falling 20-30 percent per year, as do the national accounts IT deflators) and compared the results with constant-price GDP as estimated by BEA. This is equivalent to estimating IT MFP by the ratio of the decline in IT prices to other prices.

Oliner and Sichel (2002) do this more explicitly: They infer relative MFP in IT-producing industries (they identify computers, communications equipment, software, and semiconductors) by the ratio of the respective IT prices to the prices of non-IT sectors (i.e., $MFP_i / MFP_j = (P_i / P_j) - C$), where C is an index of other input prices and all symbols should be interpreted as rates of change. They then calculate the MFP contribution from, e.g., computers by applying Domar weights to this MFP number. Gordon (2002) uses the Oliner-Sichel results[26]

The major alternative is, accordingly, the IT MFP growth estimate of Oliner and Sichel (2002). We think their indirect estimate is imprecise, and is inferior to estimating MFP for high tech production directly at the industry level.

O&S rely on the "dual" productivity estimation procedure for "high tech" products in Triplett (1996). The innovation in Triplett is not the dual itself, for productivity measurement by the dual (that is, use of input and output price indexes to estimate productivity change) dates back at least to Copeland and Martin (1938). Rather, the innovation might be called "one price dual" estimation: For example, in a chain of user-supplier industries, Triplett estimated MFP change in the computer industry from only the price index for semiconductors as an input to the computer industry and the price index for the output of computers. Other input prices to computers, semiconductors, and semiconductor manufacturing equipment industries (e.g., wages and energy costs) were assumed dominated by national forces outside the three industries. Put another way, whatever differences existed in price movements for non-technological inputs to these three industries, *they were minor in comparison to changes in semiconductor and computer prices*, which were falling at prodigious rates (on the order of 20-30 percent per year). Other input prices thus could be neglected, because the error from neglecting them would be small.[27]

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[26] In addition, Gordon's nonfarm MFP growth incorporated a cyclical correction that made it smaller than the growth rate that others had estimated, and because he did not remove any cyclical component from manufacturing durables, durables made up more of the MFP total than it otherwise would. Gordon's cyclical correction has been controversial, but his cyclically-corrected estimate of post-1995 labor productivity growth agrees exactly with our estimated trend (2.46 percent per year). We estimated the trend from data that included the recession year 2001, which Gordon of course did not have when he made his original trend estimate.

[27] Triplett shows that the procedure is very sensitive to input shares, but that is not the issue here.

O&S apply Triplett's "one price dual" method to industries that relate, not exactly as links in a vertical supply chain, but rather horizontally. There is some appeal to that: The relative price change in computers must be related to overall price change as is the relative MFP change in computer production to aggregate MFP. But the assumption that other input prices move together and can be neglected is more tenuous the more remote are the industries for which the calculation is done, and the greater is the difference in their input mixes.

In table 10, we compare the MFP estimates, Domar weights and contribution to aggregate MFP for computers, semiconductors, and communication equipment from O&S and JHS. For computers, both MFP and the Domar weight (and therefore contributions) are similar in O&H and JHS.[28] However, O&H's estimate for semiconductor MFP is very large, so their contribution from semiconductors is 3 ½ times that of JHS. For communications equipment and software, their contributions are positive and so swell IT MFP, where those of JHS are negative and shrink it.

In sum, the O&S estimate of the contribution of MFP in computer production is close to the industry estimate, despite their indirect method. However, they find far greater MFP in production of semiconductors, communications equipment and software than is evident in the industry data, which is we think consistent with the concerns we expressed above about the accuracy of the indirect method. In all, this suggests that O&S's estimate that IT MFP accounted for 0.77/0.99 share of the total is too high, as it is also in Gordon (2002), who depends on the work of O&S.

Conclusion. There is more acceleration in our measure of the private, non-farm business economy than is present in other studies (thus we have more "room" in our income side measure for contributions from both IT-producing and services industries). Additionally, our omission of labor quality from the input side swells our aggregate MFP, again producing more room for MFP in the services industries. Within that aggregate MFP measure, our estimates of industry MFP are consistent

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[28] The greater output in the numerator of JHS' MFP is balanced by the rapid growth of household IT.

with the rapid growth in IT MFP (and therefore in durable goods manufacturing) that has emerged in the other industry study of JHS.

However, despite the large contribution from IT production to aggregate MFP, it is also true that net MFP in the goods-producing industries has not grown. Net MFP growth in the services industries, on the other hand, has been a strong contributor to recent economic growth.

VI. Measurement Issues

The BEA industry data set has been substantially improved in recent years. The situation has changed significantly since Baily and Gordon (1988) and the Griliches (1992) volume on services drew attention to some of the measurement problems. As discussed previously, the most notable change has been the inclusion of measures of gross output and intermediate purchases in a system that previously relied exclusively on value-added (GDP originating) measures of output.[29] At the industry level, gross output provides a measure that is much more closely aligned with the microeconomic concept of a production function, and imposes fewer restrictions on the nature of the substitutions among factor inputs and technical change.

At the same time, the expanded usefulness of the data set has highlighted some of the remaining important problems. In the following sections we address four aspects: inconsistent data sources, a comparison of alternative output data sets, negative productivity growth industries, and and shortcomings in the labor input data.

Inconsistent Data Sources. At present, BEA constructs the industry measures of value-added and its components from sources that correspond to those used to measure the income side of the national

[29] The expansion was made possible by the increased information on services provided by the Census Bureau surveys and the expansion of the Producer Price Index program of the BLS to cover a large number of service industries.

accounts – i.e. IRS for profits and BLS for wages and salaries. Those data that are derived from company reports must be converted to an establishment basis. In contrast, the measures of gross output are constructed from the sources used to construct the input-output accounts, primarily the Census Bureau business censuses and surveys, which focus directly on establishments. Intermediate purchases are then estimated residually as gross output minus value added. This contrasts with the I-O accounts that provide direct estimates of both gross output and purchased inputs, with value added being the residual.

As shown in table 11, the industry estimates of value added (GDP originating) can differ substantially from those of the I-O accounts. Columns 1 and 2 show the estimates of value added from the industry accounts and the 1992 I-O table. The differences and percent differences are shown in columns 3-4. A time dimension is provided by including the percent differences from the 1996 annual I-O table. As noted by Yuskavage (2000), the differences are larger at the industry level with some offset within industry groups. Somewhat surprising, the percentage differences are larger and more volatile for the goods-producing industries; but that is partially a reflection of the more detailed division of the goods-producing industries.

The quantity (constant price) measures of gross output are computed at the 4-digit SIC level largely using price indexes from the BLS price programs and aggregated as chained indexes to the 2-digit industry level. Information about the composition of purchased inputs is taken from the I-O accounts, but it must be interpolated for non-I-O years. Thus, purchased inputs lack the compositional detail needed to compute high-quality chain indexes. The volume measure of value added is effectively computed as the difference between the quantity values of gross output and purchased inputs.

The concerns about measurement error are most evident in our measures of labor productivity. While we expect measures of labor productivity growth to vary between gross output and value added, the magnitudes are often vary large and volatile over time. For our group of 54 industries, the standard deviation of the difference between the two growth rates is 3.6 percentage points even though the average growth is 2 percent in each case. It is unlikely that the volatility could result solely from changing patterns of outsourcing. Instead, all of the inconsistencies between the income and I-O data sources are

concentrated in the residual calculations of each industry's intermediate purchases. Purchased inputs matter less for MFP, since the computation of MFP using either gross output or value added yields essentially the same estimates of its contribution to aggregate (value added) MFP.

In the long-run, the objective is to fully integrate the GDP by Industry and the I-O accounts. The integration is currently incomplete because of insufficient source information, and the problem is particularly severe for services. Census Bureau sources cover about 90 percent of gross output, but only 30 percent of purchased inputs. The business surveys of the Census Bureau are being expanded to provide more detail, and BEA is planning to achieve a partial integration of its GDP by industry and the annual I-O accounts over the next several years.

Alternative data sets. The BEA is not the only source of industry level data. Two different programs of the BLS—its productivity program and its employment projections program—also produce industry data that can be used for productivity analysis.

Previously we discussed the BLS measures of output and productivity at the level of durable and nondurable manufacturing; but the BLS productivity office also produces more detailed estimates within manufacturing. The manufacturing output series of BLS and BEA are both gross output and they both rely on Census Bureau shipments data. However, BLS constructs its own measures of output and excludes an estimate of intra-manufacturing shipments. At the level of two-digit SIC industries the difference in output growth can be quite substantial, ranging from –0.8 percent to +1.0 percent per year over the 1995-2000 period. The differences seem too large to explain by changes in the amount of intra-manufacturing shipments, but we do not know the sources.

More relevant for our focus on services, the employment projections program of BLS produces detailed industry measures of output and employment over the period of 1972 to 2000, covering both goods-producing and services-producing industries. This is a basic data source for the productivity studies of Dale Jorgenson and his colleagues. The data set includes output measures for a considerable number of the services-producing industries that we have used in our analysis. Table 12 provides a

comparison of the output growth rates over the 1987-2000 period for 28 of our 29 industries where it appears that the coverage by SIC codes is the same.

It is evident from the table that growth rates for individual industries often differ substantially between the BEA and BLS-projections data sets. The differences are large even for industries, such as transportation, communications, and utilities, where we would believe that the quality of the source data is quite high. For example, the BLS reports a substantial slowdown in airline output growth (comparing 1995-2000 with the previous period), where the BEA data indicate acceleration. The BLS measures also report less growth in the large retail and wholesale trade sectors, where we previously found a large acceleration of growth in both labor productivity and MFP. On the other hand, the BLS data show more output growth acceleration in depository banking, insurance, and the amusement and recreation industry (the latter is one of our negative productivity industries).

Using value-added weights, we find that the BEA data imply a slightly faster growth of output in the services-producing industries as a whole in both 1987-95 and 1995-2000; but the magnitude of overall post-1995 acceleration is the same. Thus, despite the large differences at the level of individual industries, the two data sets are in surprisingly close agreement about the overall acceleration of output growth in the services-producing sector. Since it has been our experience that the two agencies produce very similar employment estimates at the industry level, the BLS output measures seem to offer strong support for the finding in the BEA industry data of a large improvement of productivity growth in overall services, even though they conflict greatly at the detailed level.

We have been surprised by the degree of overlap between the industry programs of BEA and BLS; yet, it appears that there has been very little effort to compare and contrast their sources and methods. It seems evident that there would be substantial benefit to tracing down the sources of difference in the alternative output measures. It is confusing for the statistical agencies to publish such contradictory measures, particularly when the sources of variation are not documented. They clearly incorporate different source data or methods. While we are unlikely to see movement toward an integrated U.S. statistical system (where such redundancies would be eliminated by consolidation of these

statistical programs, thereby melding resources to improve the data), this is one area where there would be significant gains from greater coordination of research efforts between the two agencies.

The Negative Productivity Growth Industries. Negative productivity growth always attracts skepticism, and well it should. In our estimates, the following industries have negative labor productivity growth over the 1995-2001 interval:

- Education -0.95%
- Amusement and recreation -0.41%
- Hotels -0.57%
- Insurance carriers -1.66%
- Local transit -0.61%
- Construction -1.12%

Analyses of the negative productivity issue include Corrado and Slifman (1999) and Gullickson and Harper (2002). Both studies set the negative productivity industries (a larger number in their studies than in our results) equal to zero, and recomputed aggregate productivity growth. There is no doubt some value to this procedure as a "what if?" exercise. However, we see little reason for supposing that cutting off the left tail of the distribution of productivity changes improves the estimate of the mean.

Instead of mechanical "lopping off the tail" exercises, we believe that the statistical agencies should seek to identify the sources of the negative bias—that is, to take negative productivity growth as an indicator for allocating resources to improve measurement. From our experience with the Brookings economic measurement workshops, and from other information and research, we offer the following hypotheses.

1. Education. Educational output was the subject of a Brookings workshop in which two conclusions emerged. (1) No agreed on measure of the output of the educational function itself exists, and (2) universities, and to an extent perhaps secondary education as well, are classic multi-output firms, in the sense that the cost function for their different activities is not separable on the inputs. For universities, joint outputs include, in addition to education of students, research, lodging and meal services, and entertainment (sports). These outputs interact with educational decision making (Ehrenberg, 2000, provides numerous examples from his tenure as dean at a major university), but the output of these

other activities is not normally included in the "industry's" output, which is usually deflated only with an index of tuition. Interestingly, two of the joint products of universities (lodging and entertainment) also exhibit negative productivity (see our Table A1) even when located in specialized firms. We suspect that these relationships are neither coincidental nor insignificant, even after allowing for the fact that universities do not pay even the minimum wage to many workers in their entertainment activity. Moreover, at least in some universities the employment figures may be suspect, if faculty members devote an increasing amount of time to outside pursuits that do not directly contribute to the output of their employers.

One concludes from this that there are all kinds of measurement problems in computing productivity of the educational sector, covering the definitions of current price output, the deflators, and counting the labor input. Jorgenson and Fraumeni (1992) and also O'Mahoney and Stevens (2003) estimate the output of education by assessing its contribution to human capital, and therefore to lifetime earnings streams of graduates. Their estimates are far larger than the output that is presently recorded in national accounts, a result that is consistent with the hypothesis that educational productivity is biased downward because of mis-measurement of educational output.

2. Amusement and recreation. We know of no recent research on the output of the amusement and recreation industries.

3. Hotels. For hotels, McKinsey Global Institute (2001) found the poor labor productivity performance of hotels consistent with other evidence, including information from McKinsey's own consulting practice. Some of the quality improvements in hotel services, notably computerized reservation services, are unpriced outputs that have clearly created benefits to the customer, but are not captured in the output measures used in national accounts. Thus, properly measured hotel productivity might not have negative growth.

4. Insurance. We suspect that negative productivity for insurance carriers is the result of an inadequate and unworkable definition of insurance output in the NIPA and the SNA. The long international debate on this topic is reviewed in Triplett (2001). In the national accounts, insurance output

is defined as "premiums minus claims," which means that the insurance company is depicted as administering the policy on the behalf of the policy holders, and not as absorbing and managing risk. However, Triplett points out that because no contract exists for the "service" of managing the claims pool on behalf of the policyholders, no such service can be priced. Thus, the concepts underlying the PPI price index for insurance (they price the premiums, which we think makes economic sense—see Sherwood, 1999) are inconsistent with the national accounts view of insurance output.

Insofar as insurance companies have improved their management of risk—which ought, other things equal, to reduce the margin of premiums minus claims—these improvements are outside the scope of the national accounts' output measure. As additional evidence on this score, we note the peculiar behavior of the data for insurance carriers and insurance agents, considered together: At least one of them is almost always negative, but it is not always the same one, and improvements in the performance of one (or GDP revisions to one) are usually reflected in deterioration of the measured performance of the other.

5. Local transit. Although we are not sure the data are correct, on its face the negative productivity growth in local transit is consistent with substituting its own internal labor for previously purchased inputs. Presumably, this would be the result of regulation, union contracts and the general climate under which these services operate. The industry's multifactor productivity growth in the recent period is quite respectable (1.29% per year), and goes in the opposite direction from its labor productivity. It is also possible that the industry is an example of inconsistency in the source data.

6. Construction. Construction is an industry whose productivity performance has puzzled many economists (see Baily and Gordon, 1988, and Pieper, 1990). Ours is a paper on services, not on goods-producing industries, but we think that research on measuring the output of construction deserves high priority. Though major parts of construction output are deflated with hedonic price indexes and have been for many years, deflators for other parts are clearly inadequate. We understand that the producer price index program has turned attention to producing deflators for this industry. BEA will be introducing hedonic indexes for commercial construction in this year's benchmark revision, but these indexes rise

more rapidly than the deflators they replace, which would make the negative productivity in construction even more negative.[30]

Labor Hours and Input by Industry. The labor input in our study is persons engaged in production, and not hours, which are the labor input in the BLS productivity reports and in Jorgenson, Ho, and Stiroh (2002); and, in addition, we do not apply a labor quality adjustment. Neither of these aspects is included in the industry data set, and we lacked the resources to estimate an index of labor quality at the industry level. Our analysis indicates that omission of labor quality creates problems for measuring industry MFP.

The reliance on employment, rather than hours, is an equally serious problem. We have, however, little confidence in the estimates of hours across industries. The major source of industry hours is the BLS monthly establishment survey, known as the "current employment survey." The objective of this survey can only be described as archaic, for it persists in collecting hours and earnings information *only* for what it calls "production workers" in manufacturing and "nonsupervisory workers" in the rest of the economy.

The BLS productivity program estimates the hours of "nonproduction" and "supervisory" workers, using whatever information it can find. Hours of self-employed and salaried workers are obtained from the BLS-Census monthly household survey, the Current Population Survey, or CPS.

Why the BLS emphasizes "production" and "nonsupervisory" workers for its establishment employment surveys defies understanding. Even on statistical grounds, the decision is questionable. With the huge changes in workplace organization and management in recent years, the boundary between what is a "production" and a "nonproduction" worker has become so blurred that it has lost its meaning. The same statement applies to "supervisory" and "nonsupervisory" workers outside manufacturing, except there the distinction has always been unclear. This should not be news to a government statistical

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[30] Based on conversations with Bruce Grimm of BEA.

agency, for the line between what is a supervisory and a nonsupervisory worker within government has also provoked great controversy.

But even if the boundaries between what the BLS does and does not collect were sharply defined, devoting the huge amount of resources that are put into the BLS establishment program[31] to collecting hours and earnings data on only a fraction of the workers shows a profound disregard for the data that are important for economic analysis. Surely, we want to know employment, earnings and hours for all workers, not just for some fairly arbitrarily defined subset of them.

As we understand it, the BLS reasoning behind holding onto the "production worker/non-supervisory worker" definition for its establishment surveys rests on preserving time series comparability. Although we, too, value time series continuity, it should not be at the cost of a failure to collect the information that is most relevant for analysis, and in any event, blurring of the boundaries means that a constant definition does not produce comparability.

When "measurement problems" come up in the analysis of productivity, most economists immediately think about deflators. For industry productivity, the lack of a well-measured labor input is an equally serious problem, and more inexplicable because measuring worker hours in services industries is nowhere nearly so complicated as measuring services industries' output prices – an area where the BLS (in its PPI program) has made exemplary progress in recent years.

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[31] In both budgetary and sample size (so in respondent burden), this is one of the largest collections in the U.S. statistical system. Significantly, other countries seem to collect the same information at far less expense, Canada being one example.

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Table 1

Labor Productivity and MFP Growth
Goods-Producing and Service-Producing Industries
(Trend rates of growth, value added per worker, BEA industry accounts)

	1987-95	1995-2001	Change
Labor Productivity			
Private Nonfarm Business	1.0	2.5	1.5
Goods-Producing Industries	1.8	2.3	0.5
Service Producing Industries	0.7	2.6	1.8
Multi-factor Productivity			
Private Nonfarm Business	0.6	1.4	0.9
Goods-Producing Industries	1.2	1.3	0.1
Service Producing Industries	0.3	1.5	1.1

Source: table A2. As explained in section II of this paper, the aggregate productivity numbers differ from those published by BLS.

Table 2. Alternative Measures of Nonfarm Business Output and Productivity, 1987-2001

Average annual rates of change

Period	Output		Labor	Capital	Value Added per Worker	Multi-factor Productivity
	Gross Output	Value Added				
			Bureau of Labor Statistics			
1987-2001	n.a.	3.3	1.5	4.0	1.8	1.0
1987-1995	n.a	2.9	1.5	3.0	1.4	0.9
1995-2001	n.a	3.8	1.5	5.3	2.3	1.1
Change	n.a	0.9	0.0	2.3	0.9	0.2
			Industry Aggregate (BEA/BLS Data)			
1987-2001	3.4	3.5	1.8	3.9	1.6	1.0
1987-1995	3.1	2.9	1.7	2.9	1.1	0.7
1995-2001	3.9	4.3	1.9	5.2	2.3	1.3
Change	0.8	1.4	0.2	2.2	1.2	0.5

Note; The BLS published measures of the labor input and MFP have been adjusted to exclude changes in labor quality. The industry aggregate is an income-side measure that excludes the statistical discrepancy of the national accounts. The industry data set measures labor as persons, BLS uses hours.

Table 3. Alternative Measures of Manufacturing Output and Labor Productivity, 1987-2001

annual rates of change

Period	Durables			Nondurables		
	BLS	BEA	FRB	BLS	BEA	FRB
			Output Index			
1987-2001	3.6	3.7	4.7	1.5	1.0	1.0
1987-1995	3.1	3.5	3.9	2.1	1.5	1.4
1995-2001	4.1	3.9	5.8	0.7	0.4	0.4
Change	1.0	0.4	1.9	-1.4	-1.1	-1.0
			Labor Productivity			
1987-2001	3.9	4.1	n.a.	2.3	1.8	n.a.
1987-1995	3.2	4.0	n.a.	1.9	1.4	n.a.
1995-2001	4.8	4.2	n.a.	2.7	2.2	n.a.
Change	1.6	0.2	n.a.	0.8	0.8	n.a.

Note: Output measures are based on gross output. Labor productivity is an hours-based measure for BLS; and full-time equivalent employees plus the self employed for BEA. No productivity estimates are made with the FRB industrial production indexes.

Table 4a. Growth in Labor Productivity in 29 Service Industries, 1987-2001
annual trend rates of change based on gross output

INDUSTRY	Value Added Weight	Trend Growth in Output per worker		
		1987-95	1995-2001	Change
Railroad transportation.....	3.4	6.2	2.1	-4.1
Local and interurban passenger transit.....	2.6	-1.7	-0.6	1.1
Trucking and warehousing.....	0.7	4.2	0.8	-3.4
Water transportation.....	3.4	1.7	1.0	-0.7
Transportation by air.....	8.5	-1.9	0.4	2.3
Pipelines, except natural gas.....	11.3	-0.7	1.2	1.8
Transportation services.....	8.7	2.0	3.5	1.5
Telephone and telegraph.....	2.6	5.5	7.9	2.5
Radio and television.....	0.7	0.0	1.8	1.8
Electric, gas, and sanitary services.....	3.4	2.1	2.0	-0.1
Wholesale trade.....	8.5	3.4	4.2	0.8
Retail trade.....	11.3	1.3	3.4	2.2
Depository Institutions……	4.0	2.9	3.1	0.2
Nondepository Institutions……..	0.6	2.4	1.9	-0.6
Security and commodity brokers.....	1.4	7.2	10.3	3.2
Insurance carriers.....	1.9	-0.6	-1.7	-1.0
Insurance agents, brokers, and service.....	0.8	-3.3	2.8	6.1
Real estate (excluding owner-occupied housing).....	6.6	2.7	1.7	-1.0
Hotels and other lodging places.....	1.0	1.0	-0.6	-1.6
Personal services.....	0.8	1.0	1.5	0.5
Business Services	5.2	2.9	3.6	0.7
Auto repair, services, and parking.....	1.1	0.9	1.5	0.6
Miscellaneous repair services.....	0.4	1.9	1.8	-0.1
Motion pictures.....	0.4	0.1	0.3	0.1
Amusement and recreation services.....	0.9	1.6	-0.4	-2.0
Health services.....	7.1	-0.7	0.9	1.6
Legal services.....	1.7	0.0	1.5	1.5
Educational services.....	0.9	0.2	-1.0	-1.1
Other Services	4.9	-0.4	2.0	2.4

Source: Table A1

Table 4b. Growth in Multifactor Productivity in 29 Service Industries, 1987-2001
annual trend rates of change based on gross output

	Domar weight	Trend Growth in Multi-factor Productivity		
		1987-95	1995-2001	Change
Railroad transportation.....	*0.7*	3.4	1.5	-1.9
Local and interurban passenger transit.....	*0.4*	-1.0	1.3	2.3
Trucking and warehousing.....	*3.4*	1.2	-0.1	-1.3
Water transportation.....	*0.6*	1.6	0.2	-1.4
Transportation by air.....	*1.9*	1.8	-0.5	-2.3
Pipelines, except natural gas.....	*0.1*	-2.8	1.6	4.4
Transportation services.....	*0.6*	-0.3	0.2	0.5
Telephone and telegraph.....	*4.3*	1.7	1.2	-0.5
Radio and television.....	*1.2*	1.6	-4.5	-6.2
Electric, gas, and sanitary services.....	*5.6*	0.5	-0.6	-1.1
Wholesale trade.....	*12.4*	1.5	3.1	1.6
Retail trade.....	*17.4*	0.2	2.9	2.7
Depository Institutions……	*5.6*	0.2	1.5	1.3
Nondepository Institutions……	*1.4*	-0.2	2.1	2.4
Security and commodity brokers.....	*2.4*	3.1	6.6	3.5
Insurance carriers.....	*4.1*	-0.1	0.0	0.2
Insurance agents, brokers, and service.....	*1.3*	-3.6	-0.1	3.5
Real estate (excluding owner-occupied housing).....	*11.2*	0.4	1.4	1.0
Hotels and other lodging places.....	*1.7*	0.0	-1.3	-1.3
Personal services.....	*1.4*	-0.9	0.4	1.3
Business Services	*7.8*	0.9	-0.6	-1.5
Auto repair, services, and parking.....	*1.9*	-1.4	1.4	2.8
Miscellaneous repair services.....	*0.7*	-1.1	-1.6	-0.5
Motion pictures.....	*0.9*	-1.2	0.2	1.4
Amusement and recreation services.....	*1.6*	0.1	-1.1	-1.2
Health services.....	*10.7*	-1.7	-0.5	1.2
Legal services.....	*2.2*	-0.8	0.9	1.7
Educational services.....	*1.6*	-0.2	-0.8	-0.5
Other Services	*8.5*	-0.3	-0.1	0.2

Source: Table A1.

Table 5. Aggregation of Industry Contributions to Labor and Multifactor Productivity Growth, Nonfarm Business Sector, 1987 - 2001

Trend growth rates, except where noted

	Growth Rate		
	1987-95	1995-01	Change
	Labor Productivity		
Direct Aggregate Level[a]	**1.01**	**2.46**	**1.45**
Intermediate inputs reallocation(-)	-0.47	0.14	0.60
Labor reallocation	-0.44	-0.31	0.13
Value-Added Weighted Industry Aggregate	***1.93***	***2.63***	***0.70***
	Multi-factor Productivity		
Direct Aggregate Level	**0.56**	**1.44**	**0.88**
Input reallocation	-0.09	-0.14	-0.05
Domar Weighted Industry Aggregate	***0.65***	***1.58***	***0.93***

Source: Equations (3) and (4) of text, and appendix tables 3 and 4.

a/ Differs from table 2 because it is a trend rate of change.

Table 6. Industry Contributions to Labor and Multifactor Productivity Growth, Nonfarm Business Sector, 1987 - 2001

Trend growth rates

SIC CODE	INDUSTRY NAME	Aggregate	Labor Productivity: Value-added Weight	Labor Productivity: Contribution 1987-95	Labor Productivity: Contribution 1995-01	Labor Productivity: Contribution Change	Multi-factor Productivity: Domar Weight	Multi-factor Productivity: Contribution 1987-95	Multi-factor Productivity: Contribution 1995-01	Multi-factor Productivity: Contribution Change
	Private non-farm business	*yes*	***100.0***	**1.93**	**2.63**	**0.70**	***186.9***	**0.65**	**1.58**	**0.93**
GD	***Goods-producing industries***	*yes*	***29.6***	***0.77***	***0.71***	***-0.06***	***73.1***	***0.39***	***0.38***	***-0.01***
	Agricultural services, forestry, and fishing...	no	*0.6*	0.00	0.01	0.01	*0.9*	-0.01	0.00	0.01
	Mining.....	yes	***1.9***	**0.07**	**0.01**	**-0.06**	***3.1***	**0.04**	**-0.03**	**-0.06**
15-17	**Construction.....**	no	***5.3***	**-0.01**	**-0.06**	**-0.05**	***9.3***	**0.02**	**-0.05**	**-0.07**
	Manufacturing.....	yes	***21.7***	**0.72**	**0.76**	**0.04**	***59.7***	**0.34**	**0.45**	**0.11**
	Durable goods.....	**yes**	**12.3**	**0.58**	**0.60**	**0.02**	**31.7**	**0.35**	**0.59**	**0.23**
35	Industrial machinery and equipment.....	no	2.32	0.15	0.15	0.00	5.54	0.10	0.22	0.12
36,38	Electronic equipment and instruments	no	3.25	0.28	0.31	0.04	7.19	0.20	0.29	0.09
	Non-durable goods.....	**yes**	***9.4***	**0.14**	**0.16**	**0.02**	***28.1***	**-0.01**	**-0.13**	**-0.12**
SER	***Service-producing industries***	*yes*	***70.4***	***1.16***	***1.92***	***0.76***	***113.8***	***0.27***	***1.20***	***0.93***
	Transportation.....	yes	***4.0***	***0.08***	***0.04***	***-0.04***	***7.8***	**0.10**	**0.01**	**-0.09**
48	**Communications.....**	yes	***3.4***	**0.15**	**0.22**	**0.07**	***5.6***	**0.09**	**0.00**	**-0.09**
	Telephone and telegraph.....	no	*2.6*	0.15	0.21	0.05	*4.3*	0.07	0.06	-0.01
483-484	Radio and television.....	no	*0.7*	0.00	0.02	0.01	*1.2*	0.02	-0.06	-0.08
49	**Electric, gas, and sanitary services.....**	no	***3.4***	***0.07***	***0.06***	***-0.01***	***5.6***	**0.03**	**-0.03**	**-0.07**
50-51	**Wholesale trade.....**	no	***8.5***	***0.31***	***0.36***	***0.05***	***12.4***	**0.18**	**0.38**	**0.20**
52-59	**Retail trade.....**	no	***11.3***	***0.15***	***0.38***	***0.23***	***17.4***	**0.04**	**0.50**	**0.46**
	Finance and insurance.....	yes	***8.7***	**0.18**	**0.31**	**0.13**	***14.8***	**0.01**	**0.34**	**0.32**
60	Depository Institutions.....	no	*4.0*	0.12	0.13	0.01	*5.6*	0.01	0.09	0.08
61	Nondepository Institutions.....	no	*0.6*	0.01	0.01	0.00	*1.4*	-0.01	0.04	0.05
62	Security and commodity brokers.....	no	*1.4*	0.09	0.18	0.10	*2.4*	0.06	0.21	0.15
63	Insurance carriers.....	no	*1.9*	-0.01	-0.04	-0.02	*4.1*	0.00	0.00	0.00
64	Insurance agents, brokers, and service.....	no	*0.8*	-0.02	0.02	0.05	*1.3*	-0.04	0.00	0.04
65	**Real estate (excluding owner-occupied housing).....**	no	***6.6***	**0.16**	**0.11**	**-0.05**	***11.2***	**0.05**	**0.16**	**0.11**
	Other Service Industries.....	yes	***24.6***	**0.05**	**0.43**	**0.38**	***39.1***	**-0.23**	**-0.15**	**0.08**
70	Hotels and other lodging places.....	no	*1.0*	0.02	-0.01	-0.02	*1.7*	0.00	-0.02	-0.02
72	Personal services.....	no	*0.8*	0.00	0.01	0.01	*1.4*	-0.01	0.01	0.02
73	Business Services	no	*5.2*	0.11	0.22	0.11	*7.8*	0.06	-0.07	-0.12
75	Auto repair, services, and parking.....	no	*1.1*	0.01	0.02	0.01	*1.9*	-0.03	0.03	0.05
76	Miscellaneous repair services.....	no	*0.4*	0.01	0.01	0.00	*0.7*	-0.01	-0.01	0.00
78	Motion pictures.....	no	*0.4*	0.00	0.00	0.00	*0.9*	-0.01	0.00	0.01
79	Amusement and recreation services.....	no	*0.9*	0.01	0.00	-0.02	*1.6*	0.00	-0.02	-0.02
80	Health services.....	no	*7.1*	-0.07	0.06	0.14	*10.7*	-0.18	-0.06	0.13
81	Legal services.....	no	*1.7*	-0.01	0.02	0.03	*2.2*	-0.02	0.02	0.04
82	Educational services.....	no	*0.9*	0.00	-0.01	-0.01	*1.6*	0.00	-0.01	-0.01
83-87	Other Services	no	*4.9*	-0.02	0.10	0.13	*8.5*	-0.03	-0.01	0.01

Source: Apppendix tables A3 and A4

Table 7. Contributions of IT Capital to Labor Productivity Growth, Nonfarm Business Sector, 1987-2001

Trend rates of change

Industry	Domar Weight	Contribution to Industry			Contribution to Aggregate		
		1987-95	1995-2001	Change	1987-95	1995-2001	Change
Private non-farm business	**186.9**	**0.36**	**0.85**	**0.49**	**0.38**	**0.77**	**0.39**
Goods-producing industries	***73.1***	***0.12***	***0.19***	0.07	***0.09***	***0.15***	0.06
Mining	3.1	0.09	0.24	0.15	0.00	0.01	0.00
Construction	9.3	0.06	0.09	0.03	0.01	0.01	0.00
Manufacturing	59.7	0.11	0.18	0.07	0.09	0.13	0.05
Durable goods	31.7	0.12	0.24	0.12	0.04	0.08	0.04
Non-durable goods	28.1	0.15	0.23	0.08	0.04	0.06	0.01
Service-producing industries	***113.8***	***0.23***	***0.59***	0.37	***0.28***	***0.62***	0.34
Transportation	7.8	0.13	0.31	0.17	0.01	0.02	0.01
Communications	5.6	0.86	1.29	0.43	0.05	0.07	0.02
Electric, gas, and sanitary services	5.6	0.25	0.25	0.00	0.01	0.01	0.00
Wholesale trade	12.4	0.49	1.42	0.93	0.06	0.18	0.12
Retail trade	17.4	0.11	0.26	0.15	0.02	0.05	0.03
Finance and insurance	14.8	0.62	1.09	0.48	0.08	0.13	0.05
Real estate (excluding owner-occupied hou	11.2	-0.01	0.02	0.04	0.00	0.00	0.00
Other Service Industries	39.1	0.14	0.47	0.33	0.05	0.16	0.11

Source: The direct estimates of the contribution to industry labor productivity are from the gross-output estimates of table A1, except for the nonfarm aggregate which are value-added estimates of table A2. The contributions to the aggregate are computed using Domar weights at the industry level and aggregating up to the sub-sector and sector level.

Table 8. Alternative "Backing Out" Exercises for Comparisons of IT-producing and Other Industries' MFP
(trend rates of change, 1995-2001)

		BEA Dataset		
	BLS MFP	Direct MFP Estimate	Sum industry MFP's	Sum, positive industry MFP's
1. Nonfarm Business MFP (table 5)	1.17	1.44	1.58	2.09a/
Contribution of:				
2. Machinery industries MFP (table 6)	0.51	0.51	0.51	0.51
3. Oliner and Sichel (2002) IT-industry MFP	0.77	0.77	0.77	0.77
4. Remainder (row 1 – row 2 = "MFP outside IT")	0.66	0.93	1.07	1.58
5. Remainder (row 1 – row 3 = "MFP outside IT")	0.40	0.67	0.87	1.32

Note:
a/ Sum of positive (only) industry MFP growth, from table 6.

Table 9. Estimates of MFP for Computers, Semiconductors, and Other Machinery, 1995-2000
This study, compared with Jorgenson, Ho, and Stiroh (2002)

(average annual rates of change)

Industry	JHS (1995-2000)			This study (1995-2000)	
	Domar Weights	MFP 1995-00	Output growth	MFP 1995-00	Output growth
1. Industrial machinery, except computers	0.034	0.23	3.88	na	1.1
2. Computers	0.012	16.75	31.5	na	34.4
3. Total, industrial machinery	0.046	4.40	na	4.19	9.4
4. Other electrical machinery	0.017	0.93	3.56	na	0.4
5. Communications equipment	0.007	-0.38	14.52	na	18.8
6. Electrical components (including semiconductors)	0.011	18.00	28.65	na	34.0
7. Total, electrical machinery	0.035	5.66	na	na	18.0
8. Total, electrical machinery and instruments	na	na	na	4.68	13.2

Sources: Lines 1, 2, 4, 5 and 6: Jorgenson, Ho, and Stiroh (2002), table 18.
Lines 3 and 7: Computed by the authors, using sum of the Domar weights to define the 2-digit industry total.
This study: Computed as the average annual rate of change over the period 1995-2000. The values differ from the least square trends for 1995-2001, from table A1.

Table 10. Post-1995 MFP Estimates, IT-producing Industries
(average annual rates of change)

	Computers	Communication Equipment	Semi-conductors	Software
Jorgenson, Ho and Stiroh (2002)				
MFP	16.75	-0.38	18.00 [a]	-2.79 [b]
Contribution	0.16	0.01	0.12 [a]	-0.01 [b]
Domar weight	0.012	0.007	0.011 [a]	0.013 [b]
Oliner and Sichel (2002)				
MFP	14.0	2.5	45.2	4.3
Contribution	0.19	0.05	0.42	0.11
Domar weight	0.0132	0.0183	0.0091	0.027

Notes:

a/ Electronic components

b/ Computer services

Table 11. Comparison of Gross Domestic Product by Industry and I-O Value Added, 1992 and 1996

	Industry Value Added					
	1992				1996	
	Gross Product	I-O Table	Difference IO-GP	Percent Difference	Percent Difference	Change 1992-96
Private industries	**5369.8**	**5354.7**	**-15.1**	**-0.3**	1.9	**2.2**
Goods-Producing Industries	***1504.2***	***1572.2***	***68.0***	***4.5***	***7.2***	**2.6**
Agriculture, forestry, and fishing	**111.6**	**99.2**	**-12.4**	**-11.1**	**7.7**	**18.8**
Farms	80.5	74.1	-6.4	-8.0	8.6	16.6
Agricultural servs, forestry, &	31.2	25.1	-6.1	-19.6	4.1	23.7
Mining	**87.4**	**91.9**	**4.5**	**5.1**	**4.8**	**-0.3**
Metal mining	5.6	4.5	-1.1	-19.6	2.4	22.0
Coal mining	12.0	15.9	3.9	32.5	-15.1	-47.6
Oil and gas extraction	62.0	63.2	1.2	1.9	10.2	8.3
Nonmetallic minerals, except fuels	7.7	8.3	0.6	7.8	-1.8	-9.6
Construction	**234.4**	**220.9**	**-13.5**	**-5.8**	**52.5**	**58.2**
Manufacturing	**1070.8**	**1160.2**	**89.4**	**8.3**	**0.4**	**-8.0**
Durable goods	**587.1**	**618.5**	**31.4**	**5.3**	**0.4**	**-5.0**
Lumber and wood products	32.2	32.3	0.1	0.3	6.2	5.8
Furniture and fixtures	16.5	19.9	3.4	20.6	0.9	-19.7
Stone, clay, and glass	25.9	29.8	3.9	15.1	0.2	-14.8
Primary metal industries	39.3	42.9	3.6	9.2	-1.0	-10.2
Fabricated metal products	69.2	71.5	2.3	3.3	0.2	-3.1
Industrial machinery and equipment	111.5	108.9	-2.6	-2.3	0.2	2.5
Electronic and other electric	106.3	99.0	-7.3	-6.9	-0.8	6.1
Motor vehicles and equipment	58.5	51.6	-6.9	-11.8	0.4	12.2
Other transportation equipment	57.2	68.3	11.1	19.4	1.2	-18.2
Instruments and related products	51.0	76.7	25.7	50.4	-0.6	-51.0
Miscellaneous manufacturing industries	19.5	17.8	-1.7	-8.7	2.6	11.4
Nondurable goods	**483.8**	**541.7**	**57.9**	**12.0**	**0.4**	**-11.6**
Food and kindred products	105.2	122.9	17.7	16.8	0.6	-16.3
Tobacco manufactures	13.8	25.7	11.9	86.2	-0.3	-86.5
Textile mill products	25.6	23.8	-1.8	-7.0	-0.4	6.7
Apparel and other	27.3	25.4	-1.9	-7.0	0.3	7.2
Paper and allied products	45.3	51.3	6.0	13.2	-0.6	-13.9
Printing and publishing	77.8	93.4	15.6	20.1	0.7	-19.4
Chemicals and allied products	118.0	125.1	7.1	6.0	1.1	-5.0
Petroleum and coal products	27.8	20.3	-7.5	-27.0	-0.1	26.9
Rubber and miscellaneous plastics	38.2	50.0	11.8	30.9	0.2	-30.7
Leather and leather products	4.9	3.7	-1.2	-24.5	0.0	24.5
Service-Producing Industries	***3821.9***	***3790.4***	***-31.5***	***-0.8***	**-1.2**	**-0.4**
Transportation	**192.9**	**193.3**	**0.4**	**0.2**	**-0.6**	**-0.8**
Railroad transportation	21.6	22.1	0.5	2.3	-5.2	-7.5
Local and interurban passenger	10.9	12.4	1.5	13.8	15.7	1.9
Trucking and warehousing	74.5	82.4	7.9	10.6	-1.2	-11.8
Water transportation	10.6	13.3	2.7	25.5	-2.7	-28.2
Transportation by air	50.0	42.1	-7.9	-15.8	0.7	16.5
Pipelines, except natural gas	5.5	5.3	-0.2	-3.6	1.3	4.9
Transportation services	19.8	15.7	-4.1	-20.7	-4.8	15.9
Communications	**162.8**	**142.1**	**-20.7**	**-12.7**	**-2.8**	**9.9**
Telephone and telegraph	127.8	116.5	-11.3	-8.8	-3.7	5.1
Radio and television	34.9	25.5	-9.4	-26.9	0.4	27.3
Electric, gas, and sanitary	**179.5**	**160.6**	**-18.9**	**-10.5**	**-2.0**	**8.5**
Wholesale trade	**406.4**	**405.6**	**-0.8**	**-0.2**	**1.4**	**1.6**
Retail trade	**547.1**	**510.1**	**-37.0**	**-6.8**	**-1.4**	**5.3**
Finance, insurance, & real estate	**1126.3**	**1175.1**	**48.8**	**4.3**	**-4.3**	**-8.6**
Depository institutions	198.9	165.7	-33.2	-16.7	-3.9	12.8
Nondepository institutions	24.8	24.9	0.1	0.4	-33.6	-34.0
Security and commodity brokers	54.2	52.6	-1.6	-3.0	-1.7	1.3
Insurance carriers	77.8	63.4	-14.4	-18.5	-15.2	3.3
Insurance agents, brokers, etc.	39.2	40.5	1.3	3.3	10.1	6.8
Real estate	724.7	820.9	96.2	13.3	-1.9	-15.2
Holding and other investment	6.7	7.1	0.4	6.0	58.4	**52.5**
Services	**1206.9**	**1203.6**	**-3.3**	**-0.3**	**0.9**	**1.2**
Hotels and other lodging	50.3	52.2	1.9	3.8	-1.6	-5.4
Personal services	40.6	37.8	-2.8	-6.9	0.6	7.5
Business services	222.0	229.0	7.0	3.2	8.2	5.0
Auto repair, services, and	51.3	48.0	-3.3	-6.4	-0.1	6.4
Miscellaneous repair services 76	17.5	24.4	6.9	39.4	-1.9	-41.4
Motion pictures	18.0	18.8	0.8	4.4	0.7	-3.7
Amusement and recreation services	45.1	43.9	-1.2	-2.7	1.8	4.5
Health services	376.7	371.8	-4.9	-1.3	-1.2	0.1
Legal services	92.1	84.2	-7.9	-8.6	-0.4	8.2
Educational services	46.4	44.0	-2.4	-5.2	-1.7	3.4
Social services	37.3	40.1	2.8	7.5	-6.8	-14.3
Membership organizations	39.9	40.8	0.9	2.3	-1.5	-3.7
Other services	159.5	158.6	-0.9	-0.6	0.1	0.6
Private households	10.1	10.1	0.0	0.0	2.5	2.5
Statistical discrepancy +iva	**43.7**	**-8.0**	**-51.7**			

Source: Yuskavage, 2000.

Table 12. Differences in Growth Rates of Industry Output, BEA Industry Accounts and BLS Office of Employment Projections, 1987-200(
average annual rates of change

Industry	1987-1995			1995-20000			Change		
	BEA	BLS	Difference	BEA	BLS	Difference	BEA	BLS	Difference
Railroad transportation	3.6	1.0	-2.5	0.7	-0.6	-1.3	-2.9	-1.6	1.2
Local and interurban passenger transit	1.5	1.6	0.2	2.4	1.2	-1.1	0.9	-0.4	-1.3
Trucking and warehousing	5.7	4.0	-1.7	4.1	4.6	0.6	-1.7	0.6	2.2
Water transportation	2.7	1.4	-1.3	4.7	-0.5	-5.2	2.0	-1.9	-3.9
Transportation by air	3.6	4.8	1.3	5.4	1.5	-3.9	1.8	-3.3	-5.2
Pipelines, except natural gas	-1.6	-0.4	1.2	0.1	-3.0	-3.2	1.7	-2.6	-4.3
Transportation services	6.2	5.7	-0.5	6.2	5.7	-0.5	0.0	0.0	0.1
Telephone and telegraph	5.4	4.5	-0.9	13.4	7.6	-5.8	8.0	3.1	-4.9
Radio and television	2.3	1.9	-0.4	4.7	2.7	-2.0	2.4	0.7	-1.6
Electric, gas, and sanitary services	2.5	0.4	-2.1	1.5	1.6	0.1	-1.0	1.2	2.2
Wholesale trade	4.4	4.0	-0.3	6.0	4.3	-1.8	1.7	0.2	-1.5
Retail trade	2.9	1.9	-1.1	5.5	4.3	-1.3	2.6	2.4	-0.2
Depository institutions	1.5	3.4	1.9	2.9	6.4	3.5	1.4	3.1	1.6
Nondepository institutions[a]	8.2	1.0	-7.2	12.3	9.5	-2.8	4.1	8.4	4.4
Security and commodity brokers	9.5	7.2	-2.3	23.4	22.0	-1.3	13.8	14.8	1.0
Insurance carriers	0.7	1.3	0.6	-1.5	0.6	2.2	-2.3	-0.7	1.6
Insurance agents, brokers, and service	-1.8	1.2	3.0	4.1	4.0	-0.1	5.9	2.8	-3.0
Real estate	4.0	2.1	-1.8	3.5	2.1	-1.3	-0.5	0.0	0.5
Hotels and other lodging places	2.4	2.0	-0.4	3.2	2.7	-0.5	0.8	0.7	-0.1
Personal services	3.2	2.8	-0.4	2.7	3.9	1.2	-0.5	1.1	1.6
Business services	8.6	6.8	-1.8	11.1	9.5	-1.6	2.5	2.7	0.2
Auto repair, services, and parking	3.2	3.8	0.6	4.1	5.2	1.1	0.9	1.4	0.5
Miscellaneous repair services	3.7	2.3	-1.4	1.0	1.7	0.8	-2.7	-0.6	2.2
Motion pictures	4.4	5.7	1.3	3.0	6.6	3.6	-1.5	0.8	2.3
Amusement and recreation services	7.4	5.6	-1.8	3.9	6.7	2.8	-3.5	1.1	4.6
Health services	3.2	3.0	-0.1	2.6	2.8	0.2	-0.6	-0.3	0.3
Legal services	1.4	1.4	0.0	2.9	2.0	-0.9	1.5	0.6	-0.9
Educational services	3.3	2.2	-1.1	2.7	2.9	0.2	-0.6	0.7	1.3
Value-added weighted sum	2.5	2.1	-0.5	3.5	3.0	-0.5	1.0	1.0	0.0

Source: Gross output measures from the BEA industry data set and the employment projections program of BLS at http://www.bls.gov/emp/home.htm

a. The BLS measure includes SIC 67(Holding and other investment offices).

Table A1. Components of the Growth in Gross Output per Worker, 1987-2001
Least squares trend growth

SIC CODE	INDUSTRY NAME	Growth in Output per worker		*Contribution of:* Capital		Intermediate Inputs		MFP		Contribution of: IT Capital		non-IT Capitai	
		1987-95	1995-2001	1987-95	1995-2001	1987-95	1995-2001	1987-95	1995-2001	1987-95	1995-2001	1987-95	1995-2001
	Private non-farm business	1.31	2.14	0.23	0.53	0.81	0.85	0.28	0.76	0.18	0.44	0.04	0.09
GD	***Goods-producing industries***	***2.14***	***2.09***	***0.23***	***0.38***	***1.43***	***1.19***	***0.48***	***0.53***	***0.12***	***0.19***	***0.11***	***0.19***
	Agricultural services, forestry, and fishing...	0.10	1.18	0.29	0.60	0.68	0.19	-0.86	0.40	0.10	0.13	0.19	0.46
10-14	**Mining.....**	**3.54**	**1.61**	**0.68**	**0.72**	**1.75**	**1.89**	**1.11**	**-1.00**	**0.09**	**0.24**	**0.58**	**0.47**
10	Metal mining.....	5.82	5.64	-0.50	1.13	2.40	-2.68	3.92	7.19	0.31	0.26	-0.80	0.88
12	Coal mining.....	7.37	5.54	0.21	0.96	3.37	1.97	3.79	2.60	0.12	0.19	0.10	0.77
13	Oil and gas extraction.....	2.72	0.16	0.84	0.20	1.53	2.72	0.35	-2.76	0.07	0.25	0.77	-0.04
14	Nonmetallic minerals, except fuels.....	1.48	1.35	0.52	0.92	0.82	-1.30	0.14	1.73	0.12	0.28	0.40	0.64
15-17	Construction.....	-0.37	-1.12	-0.08	0.49	-0.50	-1.06	0.21	-0.55	0.06	0.09	-0.14	0.40
	Manufacturing.....	**2.77**	**3.64**	**0.26**	**0.37**	**1.91**	**2.29**	**0.60**	**0.98**	**0.11**	**0.18**	**0.14**	**0.19**
	Durable goods.....	**3.88**	**4.79**	**0.29**	**0.49**	**2.52**	**2.42**	**1.07**	**1.89**	**0.12**	**0.24**	**0.17**	**0.25**
24	Lumber and wood products.....	-0.63	0.80	-0.10	0.13	0.98	1.09	-1.51	-0.42	0.06	0.08	-0.16	0.06
25	Furniture and fixtures.....	1.77	1.84	0.12	0.23	1.26	1.39	0.39	0.22	0.07	0.12	0.05	0.11
32	Stone, clay, and glass products.....	1.02	0.88	-0.01	0.54	-0.24	0.71	1.27	-0.37	0.03	0.20	-0.03	0.34
33	Primary metal industries.....	2.82	0.52	0.04	0.12	1.87	-0.30	0.92	0.70	0.02	0.06	0.02	0.06
34	Fabricated metal products.....	1.45	1.44	0.12	0.32	0.88	1.29	0.45	-0.17	0.10	0.17	0.02	0.15
35	Industrial machinery and equipment.....	6.20	6.92	0.40	0.64	3.97	2.36	1.83	3.92	0.23	0.49	0.17	0.15
37	Motor vehicles and other transportation equipment.....	3.15	3.23	0.13	0.28	2.81	2.31	0.21	0.64	0.05	0.12	0.08	0.16
36,38	Electronic equipment and instruments	7.61	10.04	0.81	0.91	3.99	5.09	2.82	4.04	0.25	0.37	0.56	0.54
39	Miscellaneous manufacturing industries.....	0.87	2.44	0.14	0.44	0.68	-0.06	0.05	2.06	0.12	0.16	0.03	0.28
	Non-durable goods.....	**1.41**	**2.39**	**0.32**	**0.55**	**1.10**	**2.27**	**-0.01**	**-0.43**	**0.15**	**0.23**	**0.16**	**0.32**
20	Food and kindred products.....	1.25	1.21	0.15	0.28	0.92	2.03	0.18	-1.09	0.05	0.09	0.10	0.19
21	Tobacco products.....	2.81	0.16	0.60	0.18	4.72	7.93	-2.51	-7.95	0.09	0.11	0.51	0.07
22	Textile mill products.....	2.83	2.91	0.15	0.47	1.47	2.34	1.20	0.11	0.10	0.15	0.05	0.33
23	Apparel and other textile products.....	2.31	7.35	0.26	0.82	1.51	5.80	0.54	0.74	0.09	0.15	0.18	0.67
26	Paper and allied products.....	1.44	1.04	0.30	0.39	1.02	0.91	0.12	-0.26	0.10	0.12	0.20	0.28
27	Printing and publishing.....	-0.61	0.58	0.37	0.55	0.61	0.72	-1.59	-0.69	0.33	0.57	0.04	-0.02
28	Chemicals and allied products.....	1.42	1.68	0.58	0.68	0.47	1.18	0.37	-0.18	0.30	0.31	0.29	0.37
29	Petroleum and coal products.....	1.47	3.09	0.30	0.14	1.85	2.54	-0.68	0.41	0.15	0.05	0.15	0.08
30	Rubber and miscellaneous plastics products...	2.99	3.09	0.16	0.53	1.61	1.82	1.22	0.75	0.07	0.15	0.09	0.38
31	Leather and leather products.....	1.63	4.72	0.99	0.66	-0.35	4.75	0.99	-0.69	0.09	0.30	0.89	0.35

A1 continued

SIC CODE	INDUSTRY NAME	Growth in Output per worker 1987-95	Growth in Output per worker 1995-2001	*Contribution of:* Capital 1987-95	Capital 1995-2001	Intermediate Inputs 1987-95	Intermediate Inputs 1995-2001	MFP 1987-95	MFP 1995-2001	Contribution of: IT Capital 1987-95	IT Capital 1995-2001	non-IT Capitai 1987-95	non-IT Capitai 1995-2001
SER	***Service-producing industries***	***1.26***	***2.41***	***0.25***	***0.64***	***0.85***	***0.89***	***0.16***	***0.88***	***0.23***	***0.59***	***0.02***	***0.04***
	Transportation	**1.91**	**0.75**	**-0.12**	**0.39**	**0.83**	**0.33**	**1.21**	**0.03**	**0.13**	**0.31**	**-0.26**	**0.09**
40	Railroad transportation	6.22	2.14	0.31	0.27	2.50	0.33	3.42	1.54	0.03	0.04	0.28	0.22
41	Local and interurban passenger transit	-1.71	-0.61	-0.43	0.04	-0.31	-1.94	-0.97	1.29	0.01	0.04	-0.44	0.00
42	Trucking and warehousing	4.22	0.78	0.05	0.19	2.94	0.68	1.23	-0.10	0.10	0.08	-0.05	0.11
44	Water transportation	1.74	1.01	-0.20	-0.15	0.38	0.99	1.56	0.17	0.03	0.05	-0.23	-0.21
45	Transportation by air	-1.87	0.42	-0.32	0.79	-3.38	0.08	1.83	-0.45	0.08	0.52	-0.39	0.27
46	Pipelines, except natural gas	-0.67	1.15	0.75	1.84	1.35	-2.33	-2.78	1.64	0.61	0.91	0.14	0.93
47	Transportation services	1.99	3.53	0.05	1.80	2.23	1.56	-0.29	0.17	0.70	1.56	-0.65	0.24
48	**Communications**	**4.12**	**6.68**	**1.59**	**1.60**	**0.86**	**5.11**	**1.68**	**-0.04**	**0.86**	**1.29**	**0.73**	**0.32**
	Telephone and telegraph	5.49	7.95	1.58	1.11	2.22	5.63	1.69	1.21	0.89	0.97	0.69	0.14
483-484	Radio and television	0.01	1.77	1.93	3.23	-3.56	3.07	1.64	-4.53	1.03	2.31	0.90	0.92
49	**Electric, gas, and sanitary services**	**2.14**	**2.05**	**0.75**	**0.81**	**0.85**	**1.84**	**0.54**	**-0.60**	**0.25**	**0.25**	**0.51**	**0.56**
50-51	**Wholesale trade**	**3.43**	**4.19**	**0.63**	**1.78**	**1.31**	**-0.66**	**1.49**	**3.07**	**0.49**	**1.42**	**0.14**	**0.35**
52-59	**Retail trade**	**1.27**	**3.44**	**0.35**	**0.30**	**0.72**	**0.23**	**0.20**	**2.92**	**0.11**	**0.26**	**0.24**	**0.04**
	Finance and insurance	**1.82**	**3.60**	**0.88**	**1.40**	**0.99**	**0.58**	**-0.06**	**1.61**	**0.62**	**1.09**	**0.26**	**0.31**
60	Depository Institutions	2.91	3.12	1.46	1.36	1.27	0.30	0.19	1.47	0.85	1.24	0.60	0.12
61	Nondepository Institutions	2.44	1.86	0.38	1.78	2.31	-2.04	-0.25	2.12	1.10	1.61	-0.72	0.17
62	Security and commodity brokers	7.17	10.35	0.50	0.35	3.55	3.37	3.12	6.63	0.06	0.20	0.44	0.15
63	Insurance carriers	-0.63	-1.66	0.57	0.87	-1.08	-2.56	-0.13	0.03	0.31	0.63	0.26	0.24
64	Insurance agents, brokers, and service	-3.35	2.79	0.10	0.54	0.13	2.35	-3.58	-0.10	0.07	0.25	0.02	0.29
65	Real estate (excluding owner-occupied housing)	2.74	1.71	0.29	0.06	2.01	0.24	0.44	1.41	-0.01	0.02	0.30	0.03
	Other Service Industries	**0.42**	**1.54**	**0.16**	**0.53**	**0.87**	**1.45**	**-0.61**	**-0.43**	**0.14**	**0.47**	**0.02**	**0.06**
70	Hotels and other lodging places	1.02	-0.57	0.38	0.29	0.63	0.47	0.01	-1.33	0.06	0.13	0.32	0.16
72	Personal services	1.00	1.54	0.27	0.28	1.64	0.88	-0.91	0.38	0.12	0.11	0.14	0.17
73	Business Services	2.86	3.56	0.03	1.00	1.93	3.17	0.90	-0.60	0.15	1.08	-0.12	-0.09
75	Auto repair, services, and parking	0.85	1.46	1.03	0.25	1.24	-0.18	-1.41	1.39	0.04	0.11	0.99	0.14
76	Miscellaneous repair services	1.90	1.81	0.20	0.57	2.81	2.84	-1.11	-1.60	0.16	0.34	0.04	0.23
78	Motion pictures	0.12	0.26	0.36	0.32	0.96	-0.26	-1.21	0.20	0.20	0.14	0.16	0.19
79	Amusement and recreation services	1.57	-0.41	-0.31	0.31	1.74	0.40	0.14	-1.11	-0.04	0.07	-0.27	0.24
80	Health services	-0.69	0.92	0.19	0.48	0.78	0.95	-1.66	-0.51	0.19	0.34	0.01	0.14
81	Legal services	0.00	1.49	0.07	0.28	0.76	0.29	-0.82	0.91	0.14	0.28	-0.07	0.00
82	Educational services	0.19	-0.95	0.01	0.05	0.42	-0.22	-0.24	-0.79	0.02	0.07	-0.01	-0.01
83-87	Other Services	-0.44	1.95	0.05	0.22	-0.19	1.87	-0.30	-0.13	0.10	0.25	-0.05	-0.03

Source: Least squares applied to log changes. Reported values are log changes.

Table A2. Components of the Growth in Value Added per Worker, 1987-2001
Least squares trend growth

SIC CODE	INDUSTRY NAME	Growth in Value Added per worker 1987-95	Growth in Value Added per worker 1995-2001	*Contribution of:* Capital 1987-95	*Contribution of:* Capital 1995-2001	*Contribution of:* MFP 1987-95	*Contribution of:* MFP 1995-2001	Contribution of: IT Capital 1987-95	Contribution of: IT Capital 1995-2001	Contribution of: Non-IT Capital 1987-95	Contribution of: Non-IT Capital 1995-2001
	Private non-farm business	1.01	2.46	0.44	1.02	0.56	1.44	0.36	0.85	0.08	0.17
GD	***Goods-producing industries***	***1.81***	***2.28***	***0.58***	***0.96***	***1.23***	***1.31***	***0.30***	***0.48***	***0.27***	***0.49***
	Agricultural services, forestry, and fishing...	-0.72	1.39	0.40	0.84	-1.12	0.56	0.14	0.19	0.27	0.65
	Mining.....	**3.39**	**-0.36**	**1.27**	**1.21**	**2.12**	**-1.57**	**0.18**	**0.42**	**1.09**	**0.78**
10	Metal mining.....	7.62	16.25	-1.02	2.44	8.64	13.81	0.68	0.57	-1.70	1.87
12	Coal mining.....	10.30	9.30	0.60	2.81	9.70	6.48	0.33	0.57	0.27	2.24
13	Oil and gas extraction.....	2.28	-4.00	1.46	0.16	0.82	-4.15	0.13	0.38	1.33	-0.23
14	Nonmetallic minerals, except fuels.....	1.28	4.35	0.96	1.54	0.32	2.81	0.22	0.47	0.74	1.07
15-17	Construction.....	0.22	-0.09	-0.15	0.85	0.37	-0.95	0.11	0.16	-0.26	0.69
	Manufacturing.....	**2.42**	**3.84**	**0.72**	**1.06**	**1.70**	**2.77**	**0.32**	**0.53**	**0.40**	**0.54**
	Durable goods.....	**3.50**	**6.34**	**0.74**	**1.30**	**2.76**	**5.04**	**0.31**	**0.65**	**0.43**	**0.66**
24	Lumber and wood products.....	-3.88	-0.71	-0.29	0.37	-3.59	-1.07	0.14	0.21	-0.42	0.16
25	Furniture and fixtures.....	1.33	1.21	0.31	0.61	1.02	0.60	0.18	0.32	0.13	0.29
32	Stone, clay, and glass products.....	3.04	0.42	-0.01	1.29	3.05	-0.87	0.07	0.47	-0.08	0.82
33	Primary metal industries.....	3.34	2.88	0.14	0.43	3.20	2.45	0.06	0.22	0.08	0.21
34	Fabricated metal products.....	1.33	0.34	0.28	0.74	1.05	-0.40	0.23	0.38	0.05	0.36
35	Industrial machinery and equipment.....	5.23	11.91	0.90	1.68	4.34	10.23	0.51	1.29	0.38	0.39
37	Motor vehicles and other transportation equipment.....	1.07	3.02	0.45	0.90	0.62	2.13	0.18	0.40	0.27	0.49
36,38	Electronic equipment and instruments	7.74	11.75	1.71	2.15	6.03	9.61	0.52	0.87	1.19	1.28
39	Miscellaneous manufacturing industries.....	0.41	4.79	0.28	0.85	0.14	3.94	0.24	0.33	0.04	0.52
	Non-durable goods.....	**0.96**	**0.44**	**0.99**	**1.69**	**-0.03**	**-1.25**	**0.48**	**0.70**	**0.52**	**0.99**
20	Food and kindred products.....	1.30	-2.99	0.61	1.12	0.69	-4.11	0.20	0.36	0.41	0.75
21	Tobacco products.....	-3.63	-17.22	2.37	0.78	-5.99	-18.00	0.35	0.42	2.02	0.35
22	Textile mill products.....	4.00	1.85	0.47	1.50	3.53	0.35	0.31	0.46	0.16	1.03
23	Apparel and other textile products.....	2.14	4.77	0.70	2.48	1.45	2.29	0.23	0.45	0.47	2.02
26	Paper and allied products.....	1.22	0.40	0.89	1.16	0.33	-0.77	0.30	0.34	0.59	0.82
27	Printing and publishing.....	-2.68	-0.33	0.81	1.22	-3.49	-1.55	0.73	1.29	0.08	-0.07
28	Chemicals and allied products.....	2.38	1.21	1.50	1.65	0.88	-0.44	0.77	0.74	0.73	0.90
29	Petroleum and coal products.....	-2.00	2.41	1.60	0.80	-3.60	1.61	0.80	0.31	0.80	0.49
30	Rubber and miscellaneous plastics products...	4.14	3.81	0.50	1.58	3.64	2.23	0.22	0.45	0.28	1.13
31	Leather and leather products.....	3.68	0.36	1.86	1.62	1.82	-1.26	0.18	0.68	1.68	0.94

A2 continued

SIC CODE	INDUSTRY NAME	Growth in Output per worker 1987-95	Growth in Output per worker 1995-2001	*Contribution of:* Capital 1987-95	*Contribution of:* Capital 1995-2001	*Contribution of:* MFP 1987-95	*Contribution of:* MFP 1995-2001	Contribution of: IT Capital 1987-95	Contribution of: IT Capital 1995-2001	Contribution of: Non-IT Capital 1987-95	Contribution of: Non-IT Capital 1995-2001
SER	***Service-producing industries***	***0.75***	***2.56***	***0.41***	***1.08***	***0.33***	***1.48***	***0.38***	***1.01***	***0.04***	***0.07***
	Transportation.....	**2.19**	**0.84**	**-0.24**	**0.78**	**2.43**	**0.06**	**0.27**	**0.61**	**-0.52**	**0.17**
40	Railroad transportation.....	6.25	3.21	0.51	0.48	5.74	2.73	0.04	0.08	0.47	0.40
41	Local and interurban passenger transit.....	-2.69	2.09	-0.83	0.04	-1.86	2.05	0.02	0.07	-0.84	-0.03
42	Trucking and warehousing.....	2.80	0.20	0.08	0.45	2.72	-0.25	0.22	0.18	-0.15	0.26
44	Water transportation.....	3.85	0.23	-0.61	-0.49	4.46	0.72	0.08	0.16	-0.69	-0.66
45	Transportation by air.....	2.36	0.54	-0.68	1.34	3.05	-0.80	0.14	0.89	-0.83	0.45
46	Pipelines, except natural gas.....	-2.52	4.51	1.10	2.50	-3.61	2.01	0.89	1.24	0.20	1.26
47	Transportation services.....	-0.20	3.18	0.08	2.86	-0.28	0.33	0.99	2.47	-0.91	0.39
48	**Communications.....**	**5.09**	**3.41**	**2.52**	**3.01**	**2.56**	**0.40**	**1.36**	**2.42**	**1.16**	**0.59**
	Telephone and telegraph.....	5.08	5.00	2.43	2.22	2.65	2.78	1.37	1.93	1.06	0.29
483-484	Radio and television.....	6.24	-1.75	3.47	5.28	2.76	-7.03	1.85	3.78	1.63	1.50
49	**Electric, gas, and sanitary services.....**	**2.26**	**0.51**	**1.32**	**1.45**	**0.93**	**-0.94**	**0.44**	**0.45**	**0.89**	**1.00**
50-51	**Wholesale trade.....**	**3.39**	**6.81**	**1.00**	**2.72**	**2.38**	**4.09**	**0.79**	**2.19**	**0.22**	**0.54**
52-59	**Retail trade.....**	**0.98**	**4.95**	**0.58**	**0.49**	**0.40**	**4.46**	**0.19**	**0.43**	**0.39**	**0.06**
	Finance and insurance.....	**1.47**	**5.14**	**1.54**	**2.42**	**-0.07**	**2.71**	**1.07**	**1.89**	**0.46**	**0.53**
60	Depository Institutions……	2.38	3.85	2.02	1.87	0.36	1.98	1.19	1.70	0.83	0.16
61	Nondepository Institutions……	0.49	9.68	1.09	4.75	-0.60	4.93	2.43	4.33	-1.34	0.41
62	Security and commodity brokers.....	6.08	12.39	0.74	0.66	5.35	11.74	0.06	0.37	0.67	0.28
63	Insurance carriers.....	1.03	1.38	1.51	1.74	-0.48	-0.36	0.81	1.28	0.70	0.46
64	Insurance agents, brokers, and service.....	-5.31	0.71	0.15	0.86	-5.46	-0.15	0.11	0.40	0.04	0.47
65	Real estate (excluding owner-occupied housing).....	1.50	2.67	0.50	0.11	1.00	2.56	-0.02	0.04	0.52	0.06
	Other Service Industries.....…	**-0.68**	**0.20**	**0.25**	**0.86**	**-0.93**	**-0.67**	**0.22**	**0.76**	**0.03**	**0.10**
70	Hotels and other lodging places.....	0.72	-1.64	0.66	0.49	0.06	-2.13	0.11	0.23	0.55	0.26
72	Personal services.....	-0.99	1.14	0.45	0.48	-1.45	0.66	0.20	0.20	0.25	0.29
73	Business Services	1.39	0.66	0.04	1.54	1.35	-0.88	0.22	1.67	-0.18	-0.13
75	Auto repair, services, and parking.....	-0.51	2.79	1.85	0.45	-2.36	2.34	0.08	0.20	1.77	0.24
76	Miscellaneous repair services.....	-1.69	-2.03	0.42	1.26	-2.11	-3.29	0.34	0.75	0.08	0.51
78	Motion pictures.....	-1.86	1.15	0.84	0.75	-2.70	0.40	0.47	0.32	0.36	0.43
79	Amusement and recreation services.....	-0.20	-1.47	-0.56	0.61	0.35	-2.08	-0.08	0.14	-0.48	0.47
80	Health services.....	-2.19	-0.02	0.29	0.74	-2.48	-0.77	0.28	0.52	0.01	0.23
81	Legal services.....	-0.97	1.59	0.08	0.37	-1.06	1.22	0.17	0.37	-0.09	0.00
82	Educational services.....	-0.40	-1.29	0.02	0.09	-0.42	-1.38	0.03	0.12	-0.01	-0.02
83-87	Other Services	-0.43	0.18	0.09	0.39	-0.52	-0.22	0.18	0.45	-0.09	-0.06

Source: Least squares applied to log changes. Reported values are log changes.

A3. Industry Contributions to the Growth in Nonfarm Labor Productivity, 1987-2001
trend growth rates, gross output

			1987-94	1995-2001	Change	1987-95	1995-2001	Change	1987-95	1995-2001	Change
Nonfarm Business (BLS Published)			1.45	2.32	0.88						
Nonfarm Business (direct calculation)			1.01	2.46	1.45						
Intermediate inputs reallocation(-)	Aggregate	**Value-added**	-0.47	0.14	0.60						
Labor reallocation		**Weight**	-0.44	-0.31	0.13	**Materials Reallocation**			**Labor Reallocation**		
Non-farm business (aggregated)	**yes**	***100.0***	**1.93**	**2.63**	**0.70**	**-0.47**	**0.14**	0.60	**-0.43**	**-0.31**	0.12
Goods-producing industries	**yes**	*29.6*	**0.77**	**0.71**	**-0.06**	**-0.10**	**0.01**	**0.11**	**-0.61**	**-0.42**	**0.19**
Agr. Services, Forestry, and Fishing	no	*0.6*	0.00	0.01	0.01	-0.01	0.00	0.01	0.01	0.01	0.00
Mining	yes	***1.9***	0.07	0.01	-0.06	0.00	-0.03	-0.03	-0.08	-0.03	0.05
Metal mining	no	*0.1*	0.01	0.00	0.00	0.00	0.01	0.01	0.00	-0.01	-0.01
Coal mining	no	*0.2*	0.02	0.01	-0.01	0.01	0.01	0.00	-0.02	-0.01	0.01
Oil and gas extraction	no	*1.4*	0.04	0.00	-0.05	-0.01	-0.05	-0.04	-0.06	-0.01	0.05
Nonmetallic minerals, except fuels	no	*0.2*	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Construction	no	***5.3***	-0.01	-0.06	-0.05	0.03	0.06	0.02	-0.07	0.11	0.18
Manufacturing	***yes***	***21.7***	**0.72**	**0.76**	**0.04**	**-0.12**	**-0.02**	**0.10**	**-0.47**	**-0.50**	**-0.04**
Durable goods	**yes**	**12.3**	**0.58**	**0.60**	**0.02**	**-0.08**	**0.15**	**0.23**	**-0.33**	**-0.23**	**0.10**
Lumber and wood products	no	*0.7*	0.00	0.01	0.01	-0.02	-0.01	0.01	-0.01	-0.01	0.00
Furniture and fixtures	no	*0.3*	0.01	0.01	0.00	0.00	0.00	0.00	-0.01	0.00	0.00
Stone, clay, and glass products	no	*0.5*	0.01	0.01	0.00	0.01	0.00	-0.01	-0.01	-0.01	0.01
Primary metal industries	no	*0.8*	0.02	0.01	-0.02	0.00	0.01	0.01	-0.02	-0.02	0.00
Fabricated metal products	no	*1.5*	0.02	0.02	0.00	0.00	-0.02	-0.01	-0.02	-0.02	0.00
Industrial machinery and equipment	no	*2.3*	0.15	0.15	0.00	-0.02	0.11	0.13	-0.05	-0.05	-0.01
Motor vehicles, other transportat equip	no	*2.5*	0.08	0.08	-0.01	-0.05	0.00	0.05	-0.09	-0.04	0.05
Electronic equipment and instruments	no	*3.3*	0.28	0.31	0.04	0.00	0.05	0.04	-0.11	-0.06	0.05
Miscellaneous manufacturing industries	no	*0.4*	0.00	0.01	0.01	0.00	0.01	0.01	0.00	-0.01	0.00
Non-durable goods	**yes**	***9.4***	**0.14**	**0.16**	**0.02**	**-0.04**	**-0.16**	**-0.13**	**-0.14**	**-0.27**	**-0.13**
Food and kindred products	no	*2.0*	0.02	0.02	0.00	0.00	-0.07	-0.07	-0.02	-0.03	-0.02
Tobacco products	no	*0.3*	0.01	0.00	-0.01	-0.02	-0.04	-0.02	-0.01	-0.01	0.00
Textile mill products	no	*0.4*	0.02	0.01	-0.01	0.01	0.00	-0.01	-0.01	-0.03	-0.01
Apparel and other textile products	no	*0.5*	0.01	0.03	0.01	0.00	-0.01	-0.01	-0.02	-0.04	-0.02
Paper and allied products	no	*0.9*	0.01	0.01	-0.01	0.00	0.00	0.00	-0.01	-0.03	-0.02
Printing and publishing	no	*1.5*	0.00	0.01	0.01	-0.03	-0.01	0.02	-0.02	-0.03	-0.02
Chemicals and allied products	no	*2.4*	0.04	0.04	0.01	0.03	-0.01	-0.05	-0.03	-0.05	-0.02
Petroleum and coal products	no	*0.6*	0.01	0.01	0.01	-0.04	-0.01	0.03	-0.02	-0.02	0.00
Rubber and miscellaneous plastics products	no	*0.8*	0.02	0.02	0.00	0.01	0.01	-0.01	0.00	-0.02	-0.02
Leather and leather products	no	*0.1*	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	0.00

table A3 continued

		Value-added Weight	Labor Productivity 1987-94	Labor Productivity 1995-2001	Labor Productivity Change	Materials Reallocation 1987-95	Materials Reallocation 1995-2001	Materials Reallocation Change	Labor Reallocation 1987-95	Labor Reallocation 1995-2001	Labor Reallocation Change
Service-producing industries	**yes**	***70.4***	**1.16**	**1.92**	**0.76**	**-0.37**	**0.13**	**0.50**	**0.18**	**0.11**	**-0.08**
Transportation	**yes**	***4.0***	**0.08**	**0.04**	**-0.04**	**0.01**	**0.00**	**-0.01**	**0.02**	**0.01**	**-0.01**
Railroad transportation	no	*0.4*	0.03	0.01	-0.02	0.00	0.00	0.00	-0.02	-0.01	0.01
Local and interurban passenger transit	no	*0.2*	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
Trucking and warehousing	no	*1.6*	0.04	0.01	-0.03	-0.02	-0.01	0.01	0.00	0.01	0.01
Water transportation*	no	*0.2*	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00
Transportation by air	no	*1.1*	0.00	0.01	0.00	0.04	0.00	-0.04	0.03	0.02	-0.02
Pipelines, except natural gas	no	*0.1*	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Transportation services*	no	*0.4*	0.01	0.01	0.01	-0.01	0.00	0.01	0.01	0.00	-0.01
Communications	**yes**	***3.4***	**0.15**	**0.22**	**0.07**	**0.04**	**-0.11**	**-0.14**	**-0.05**	**0.08**	**0.12**
Telephone and telegraph	no	*2.6*	0.15	0.21	0.05	-0.02	-0.08	-0.06	-0.05	0.07	0.12
Radio and television	no	*0.7*	0.00	0.02	0.01	0.06	-0.03	-0.08	0.00	0.01	0.01
Electric, gas, and sanitary services	**no**	***3.4***	**0.07**	**0.06**	**-0.01**	**0.00**	**-0.05**	**-0.05**	**-0.04**	**-0.09**	**-0.05**
Wholesale trade	**no**	***8.5***	**0.31**	**0.36**	**0.05**	**0.00**	**0.23**	**0.23**	**-0.07**	**-0.09**	**-0.02**
Retail trade	**no**	***11.3***	**0.15**	**0.38**	**0.23**	**-0.03**	**0.17**	**0.20**	**-0.01**	**-0.04**	**-0.03**
Finance and insurance	**yes**	***8.7***	**0.18**	**0.31**	**0.13**	**-0.03**	**0.19**	**0.22**	**-0.10**	**-0.03**	**0.07**
Depository institutions	no	*4.0*	0.12	0.13	0.01	-0.02	0.03	0.06	-0.11	-0.10	0.01
Nondepository institutions	no	*0.6*	0.01	0.01	0.00	-0.01	0.06	0.08	0.02	0.03	0.02
Security and commodity brokers	no	*1.4*	0.09	0.18	0.10	-0.01	0.04	0.05	0.01	0.08	0.06
Insurance carriers	no	*1.9*	-0.01	-0.04	-0.02	0.03	0.07	0.04	-0.01	-0.03	-0.02
Insurance agents, brokers, and service	no	*0.8*	-0.02	0.02	0.05	-0.02	-0.02	0.00	0.00	-0.01	-0.01
Real Estate (less owner-occupied housing)	**no**	***6.6***	**0.16**	**0.11**	**-0.05**	**-0.08**	**0.06**	**0.14**	**-0.05**	**-0.05**	**0.00**
Other Service Industries	**yes**	***24.6***	**0.05**	**0.43**	**0.38**	**-0.26**	**-0.36**	**-0.10**	**0.48**	**0.32**	**-0.16**
Hotels and other lodging places	no	*1.0*	0.02	-0.01	-0.02	0.00	-0.01	-0.01	0.00	0.00	0.01
Personal services	no	*0.8*	0.00	0.01	0.01	-0.02	0.00	0.02	0.00	-0.01	-0.01
Business services	no	*5.2*	0.11	0.22	0.11	-0.07	-0.18	-0.12	0.14	0.24	0.10
Auto repair, services, and parking	no	*1.1*	0.01	0.02	0.01	-0.01	0.02	0.03	0.00	0.00	0.00
Miscellaneous repair services	no	*0.4*	0.01	0.01	0.00	-0.01	-0.01	0.00	0.00	-0.01	-0.01
Motion pictures	no	*0.4*	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	-0.01
Amusement and recreation services	no	*0.9*	0.01	0.00	-0.02	-0.01	-0.01	0.00	0.03	0.01	-0.02
Health services	no	*7.1*	-0.07	0.06	0.14	-0.11	-0.07	0.04	0.18	-0.02	-0.19
Legal services	no	*1.7*	-0.01	0.02	0.03	-0.02	0.00	0.02	-0.01	-0.01	-0.01
Educational services	no	*0.9*	0.00	-0.01	-0.01	-0.01	0.00	0.00	0.01	0.01	0.00
Other services	no	*4.9*	-0.02	0.10	0.13	0.00	-0.09	-0.09	0.11	0.09	-0.02

Source: Equation (3) in the text. The basic data is the same as used to construct table A1.

Table A4. Industry Contributions to the Growth in Nonfarm Multi-factor Productivity, 1987-2001
Trend growth rates

SIC CODE	INDUSTRY NAME		Multi-factor Productivity Domar Weight	Contribution 1987-95	Contribution 1995-01	Change
	Nonfarm Business (direct calculation)	Aggregate		0.56	1.44	0.88
	Resource reallocation			-0.09	-0.14	-0.05
	Non-farm business (aggregated)	**yes**	***186.9***	**0.65**	**1.58**	**0.93**
GD	**Goods-producing industries**	**yes**	***73.1***	**0.39**	**0.38**	**-0.01**
	Agricultural services, forestry, and fishing...	no	*0.9*	-0.01	0.00	0.01
	Mining.....	yes	***3.1***	**0.04**	**-0.03**	**-0.06**
10	Metal mining.....	no	*0.2*	0.01	0.01	0.00
12	Coal mining.....	no	*0.5*	0.02	0.01	-0.01
13	Oil and gas extraction.....	no	*2.1*	0.00	-0.05	-0.05
14	Nonmetallic minerals, except fuels.....	no	*0.3*	0.00	0.00	0.00
15-17	**Construction.....**	no	***9.3***	**0.02**	**-0.05**	**-0.07**
	Manufacturing.....	***yes***	***59.7***	**0.34**	**0.45**	**0.11**
	Durable goods.....	**yes**	**31.7**	**0.35**	**0.59**	**0.23**
24	Lumber and wood products.....	no	*1.7*	-0.03	-0.01	0.02
25	Furniture and fixtures.....	no	*0.9*	0.00	0.00	0.00
32	Stone, clay, and glass products.....	no	*1.3*	0.02	0.00	-0.02
33	Primary metal industries.....	no	*2.9*	0.03	0.02	-0.01
34	Fabricated metal products.....	no	*3.4*	0.01	-0.01	-0.02
35	Industrial machinery and equipment.....	no	*5.5*	0.10	0.22	0.12
37	Motor vehicles and other transportation equipment.....	no	*7.9*	0.01	0.05	0.04
36,38	Electronic equipment and instruments	no	*7.2*	0.20	0.29	0.09
39	Miscellaneous manufacturing industries.....	no	*0.8*	0.00	0.02	0.01
	Non-durable goods.....	**yes**	***28.1***	**-0.01**	**-0.13**	**-0.12**
20	Food and kindred products.....	no	*7.6*	0.01	-0.07	-0.09
21	Tobacco products.....	no	*0.7*	-0.02	-0.05	-0.03
22	Textile mill products.....	no	*1.3*	0.02	0.00	-0.02
23	Apparel and other textile products.....	no	*1.3*	0.01	0.01	0.00
26	Paper and allied products.....	no	*2.6*	0.00	0.00	-0.01
27	Printing and publishing.....	no	*3.3*	-0.06	-0.02	0.04
28	Chemicals and allied products.....	no	*5.9*	0.02	-0.01	-0.03
29	Petroleum and coal products.....	no	*2.8*	-0.03	0.00	0.03
30	Rubber and miscellaneous plastics products...	no	*2.3*	0.03	0.02	-0.01
31	Leather and leather products.....	no	*0.2*	0.00	0.00	0.00

table A4 continued

SIC CODE	INDUSTRY NAME	Aggregate	Multi-factor Productivity: Domar Weight	Contribution 1987-95	Contribution 1995-01	Change
SER	**Service-producing industries**	**yes**	***113.8***	**0.27**	**1.20**	**0.93**
	Transportation.....	**yes**	***7.8***	**0.10**	**0.01**	**-0.09**
40	Railroad transportation.....	no	*0.7*	0.03	0.01	-0.02
41	Local and interurban passenger transit.....	no	*0.4*	0.00	0.00	0.01
42	Trucking and warehousing.....	no	*3.4*	0.04	0.00	-0.04
44	Water transportation.....	no	*0.6*	0.01	0.00	-0.01
45	Transportation by air.....	no	*1.9*	0.04	-0.01	-0.04
46	Pipelines, except natural gas.....	no	*0.1*	0.00	0.00	0.01
47	Transportation services.....	no	*0.6*	0.00	0.00	0.00
48	**Communications.....**	**yes**	***5.6***	**0.09**	**0.00**	**-0.09**
	Telephone and telegraph.....	no	*4.3*	0.07	0.06	-0.01
483-484	Radio and television.....	no	*1.2*	0.02	-0.06	-0.08
49	**Electric, gas, and sanitary services.....**	**no**	***5.6***	**0.03**	**-0.03**	**-0.07**
50-51	**Wholesale trade.....**	**no**	***12.4***	**0.18**	**0.38**	**0.20**
52-59	**Retail trade.....**	**no**	***17.4***	**0.04**	**0.50**	**0.46**
	Finance and insurance.....	**yes**	***14.8***	**0.01**	**0.34**	**0.32**
60	Depository Institutions……	no	*5.6*	0.01	0.09	0.08
61	Nondepository Institutions……..	no	*1.4*	-0.01	0.04	0.05
62	Security and commodity brokers.....	no	*2.4*	0.06	0.21	0.15
63	Insurance carriers.....	no	*4.1*	0.00	0.00	0.00
64	Insurance agents, brokers, and service.....	no	*1.3*	-0.04	0.00	0.04
65	**Real estate (excluding owner-occupied housing).....**	**no**	***11.2***	**0.05**	**0.16**	**0.11**
	Other Service Industries.....	**yes**	***39.1***	**-0.23**	**-0.15**	**0.08**
70	Hotels and other lodging places.....	no	*1.7*	0.00	-0.02	-0.02
72	Personal services.....	no	*1.4*	-0.01	0.01	0.02
73	Business Services	no	*7.8*	0.06	-0.07	-0.12
75	Auto repair, services, and parking.....	no	*1.9*	-0.03	0.03	0.05
76	Miscellaneous repair services.....	no	*0.7*	-0.01	-0.01	0.00
78	Motion pictures.....	no	*0.9*	-0.01	0.00	0.01
79	Amusement and recreation services.....	no	*1.6*	0.00	-0.02	-0.02
80	Health services.....	no	*10.7*	-0.18	-0.06	0.13
81	Legal services.....	no	*2.2*	-0.02	0.02	0.04
82	Educational services.....	no	*1.6*	0.00	-0.01	-0.01
83-87	Other Services	no	*8.5*	-0.03	-0.01	0.01

Source: Equation (4) of the text. The contributions to the aggregate are computed using domar weights at the industry level and aggregating up to the sub-sector and sector level. the industry data is the same as for table A1. The target values for the total nonfram sector are based on value added data.

A5. Industry Distribution of Value Added and Capital, 1996-2001
average percent share

Industry	Value added	Capital Income	IT-Capital Income
Nonfarm Business	**100.0**	**100.0**	**100.0**
Goods-Producing Industries	***27.9***	***31.2***	***21.6***
Agricultural services, forestry, and fishing...	**0.7**	**0.6**	**0.3**
Mining	**1.6**	**3.9**	**1.3**
Metal mining	0.1	0.1	0.1
Coal mining	0.2	0.1	0.1
Oil and gas extraction	1.2	3.3	1.1
Nonmetallic minerals, except fuels	0.2	0.3	0.1
Construction	**5.4**	**3.1**	**1.0**
Manufacturing	**20.2**	**23.6**	**18.9**
Durable goods	**11.6**	**11.8**	**9.4**
Lumber and wood products	0.6	0.6	0.2
Furniture and fixtures	0.3	0.3	0.1
Stone, clay, and glass products	0.5	0.6	0.3
Primary metal industries	0.7	0.7	0.3
Fabricated metal products	1.4	1.7	0.7
Industrial machinery and equipment	2.1	1.6	2.4
Motor vehicles and other transportation equipment	2.4	2.5	1.5
Electronic equipment and instruments	3.1	3.4	3.7
Miscellaneous manufacturing industries	0.4	0.5	0.2
Non-durable goods	**8.6**	**11.8**	**9.5**
Food and kindred products	1.8	2.6	1.2
Tobacco products	0.3	0.3	0.1
Textile mill products	0.4	0.3	0.2
Apparel and other textile products	0.4	0.3	0.2
Paper and allied products	0.8	1.1	0.6
Printing and publishing	1.4	1.2	2.0
Chemicals and allied products	2.3	4.3	4.2
Petroleum and coal products	0.5	0.9	0.6
Rubber and miscellaneous plastics products...	0.8	0.7	0.4
Leather and leather products	0.1	0.1	0.0
Service-producing industries	**72.1**	**68.8**	**78.4**
Transportation	**4.0**	**4.0**	**3.0**
Railroad transportation	0.3	0.4	0.1
Local and interurban passenger transit	0.2	0.2	0.1
Trucking and warehousing	1.6	1.5	0.7
Water transportation	0.2	0.2	0.1
Transportation by air	1.2	1.0	1.1
Pipelines, except natural gas	0.1	0.3	0.1
Transportation services	0.4	0.4	0.9
Communications	**3.4**	**6.4**	**17.9**
Telephone and telegraph	2.6	4.7	14.1
Radio and television	0.8	1.7	3.8
Electric, gas, and sanitary services	3.0	6.7	4.3
Wholesale trade	**8.6**	**7.1**	**14.4**
Retail trade	**11.2**	**8.5**	**4.8**
Finance and insurance	**9.7**	**8.5**	**16.0**
Depository and nondepository institutions	5.0	6.1	11.9
Depository	4.2	2.9	4.6
Non-Depository	0.8	3.2	7.3
Security and commodity brokers	1.8	0.7	0.9
Insurance carriers	2.1	1.6	2.9
Insurance agents, brokers, and service	0.8	0.2	0.3
Real estate (excluding owner-occupied housing)	**6.3**	**16.1**	**0.6**
Other Service Industries	**25.8**	**11.5**	**17.4**
Hotels and other lodging places	1.1	1.1	0.3
Personal services	0.8	0.6	0.4
Business Services	6.2	3.0	8.3
Auto repair, services, and parking	1.2	1.6	0.3
Miscellaneous repair services	0.3	0.2	0.2
Motion pictures	0.4	0.3	0.4
Amusement and recreation services	1.0	0.7	0.1
Health services	7.1	2.8	4.5
Legal services	1.7	0.3	0.7
Educational services	1.0	0.1	0.0
Miscellaneous other services	5.2	0.9	2.0