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The 21st Century Productivity Expansion Is STILL in Services

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Abstract

Labor productivity grew two and a half percent per year during the 1995-2005 period, nearly double its growth rate over the previous two decades. But services sector LP and MFP grew more rapidly and substantially exceeded productivity accelerations in the goods-producing sector. We show that the services sector contributed three-quarters of U.S. in MFP growth after 1995, and within services the contribution of MFP to LP growth exceeded the vaunted contribution of IT investment. We also find that the services sector has become even more significant as the primary source of sustained productivity growth after 2000.

In this study, we compute LP, MFP and contributions to growth accounts for 57 industries within the goods and services-producing sectors, using the new NAICS-based data set. We also show that resource reallocations, which are a newly important factor in productivity analysis, have changed the relation between increases in industry productivity rates and aggregate and sector rates in surprising ways, as explained in the paper.

Introduction and Summary

The 20th century ended with an unexpected surge in U.S. productivity growth. Labor productivity grew two and a half percent per year during 1995-2000, nearly double its growth rate over the previous two decades. In the opening years of the 21st century, nonfarm labor productivity has grown at three percent per year in Bureau of Labor Statistics data, and somewhat less in the data we use for this paper.

In Triplett and Bosworth (2006), Bosworth and Triplett (forthcoming) and Triplett and Bosworth (2004),[2] we advanced an interpretation of the post-1995 U.S. productivity expansion that differed from previous research (Oliner and Sichel, 2000; Jorgenson, Ho and Stiroh, 2000; and Gordon, 1999). Earlier studies focused on impressive multifactor productivity (MFP) growth in computer and semiconductor production, its resulting feedback into information technology (IT) investment in the rest of the economy, and the subsequent labor productivity (LP) growth in "IT-using" industries because of IT capital deepening.[3]

Unlike previous researchers, we examined productivity in services industries. We showed that strong MFP growth in the services sector transformed American economic performance after 1995. During the previous (1973-1995) years of slow aggregate productivity growth, the services industries were marked by productivity stagnation, in both LP and MFP, as Griliches (1992, 1994) pointed out. After 1995, services productivity accelerated strongly. In the revised Bureau of Economic Analysis/ Bureau of Labor Statistics (BEA/BLS) data used for this paper, services sector LP and MFP growth rates more than doubled after 1995 (Table 1). Services sector acceleration substantially exceeded the more modest productivity accelerations in the goods-producing sector. [4]

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[2] These studies are cited in the order written, which is of course, not the order published—our last work got into print well in advance of the two conference volumes.

[3] In this paper, IT investment follows the BEA definition of Information processing equipment and software: Computer and peripheral equipment, software, and other information processing equipment (which includes communications equipment, instruments, copying machines and so forth). In 2005, software (43%) and other (38%) were the largest categories, computer and peripheral equipment (19%) the smallest. Though some writers have used "ICT," this is not a very descriptive acronym for the content of information processing equipment.

[4] For this paper, "goods producing industries" include manufacturing, mining and construction. "Services industries" include all other industries in the nonfarm business economy, as defined by BLS and BEA. Government, of course, is not included. The BLS definition excludes nonprofit organizations from the business economy, but BEA's industry data do not; the largest implication is that the medical care and education industries in our dataset.

Strong services industry MFP growth is real news—and significant news. The services sector contributed three-quarters of the economy-wide acceleration in MFP after 1995, a contribution that is without historical precedent. Moreover, within services the contribution of MFP exceeded the vaunted contribution of IT investment: More than half of the newly robust services sector LP growth came from the post-1995 acceleration of MFP growth.

Our results—that the services sector became the source of economic growth in the U.S. after 1995—spawned a subsequent research topic: Why did European countries, and to a lesser extent Canada, not experience similar services-industries productivity growth? See, for example, O'Mahoney and Van Ark (2003) and Inklaar and Timmer (2006).[5]

Confounding the predictions of some economists, U.S. productivity continued to advance in the new century, even though the late-90s IT investment boom ended and despite the recession of 2001. In this paper, we extend our industries-based approach to consider the post-2000 period. We find that the services sector has also maintained strong productivity growth in the post-2000 period. The late 20th century and 21st century labor productivity growth was driven both by accelerating MFP in services and capital deepening. Productivity growth in the two periods has similar sources, and the second productivity advance is just an extension of the first.

On the other hand, *at the industry level* the picture has become more complex. Aggregation of industry productivities into sector and economy-wide levels requires allowances for resource reallocations. Productivity has greatly increased in services industries, but in recent years reallocation effects have been large and variable within the sector. For this reason, changes in productivity at the sector and aggregate levels differ from aggregated productivity change at the *industry* level. Reallocations are a new factor in the analysis of productivity growth.

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include nonprofit hospitals, universities and so forth, but the industry definitions do not include government hospitals, for example, nor government primary and secondary education.

[5] A subtopic grew out of this, mainly in the European policy-making setting: Is differential U.S.-E.U. services industry growth biased or illusionary because of differences in data across countries? The answer seems to be "no" (Inklaar and Timmer, 2006), though the stage of data development for industry productivity analysis differs greatly among OECD countries.

I. 20th Century and 21st Century Productivity Expansions

A. Data.

Recently, the Bureau of Economic Analysis has substantially improved its methodology for constructing its industry dataset, revised the data, and introduced the North American Industry Classification System (NAICS) to replace the old SIC system (Moyer et al., 2004; Moyer, Reinsdorf and Yuscavage 2006). These improvements, which incorporate improvements in the basic source data from the Bureau of Labor Statistics and the Census Bureau, add to earlier improvements (Lum, Moyer, and Yuscavage, 2000), and have transformed the U.S. industrial database to make it more useful for economic analysis than was in the past. The industry classification changes and the pertinent data revisions have been introduced into the BLS capital services measures, which provide the capital input measures for our MFP computations. Our data set covers 57 industries and the period of 1987-2005.

Our estimates of labor productivity for the aggregate of nonfarm business differ somewhat from the published BLS series. The two measures differ because the BEA industry data set includes nonprofit enterprises, which are excluded from the BLS measure. More important are some problems matching the employment data produced by BLS with the industry output measures, which are largely based on data originally collected by the Census Bureau. Differences in the industrial classification of enterprises between the business lists of Census and BLS raise concerns about the industry comparability of the data on employment and output. These concerns have been heightened by the different processes used by the agencies to convert the historical data to the new NAICS.

Previously, we relied on a measure of full-time equivalent employees plus the self-employed that was produced by the BEA. We believed it to be most consistent with the output data of the BEA and were distrustful of the industry-level data on hours worked. However, the BEA limited its conversion of the employment data prior to 1998 to a single series on the total number of employees. In addition, there are some problems with the post-1998 data on the self-employed and full-time equivalents that are yet to be resolved.

Alternatively, the Office of Employment Projections (OEP) of the BLS has produced estimates of employees, the self-employed and total hours for the earlier years, but it has not yet been updated to 2005. We also noted that there are substantial differences in the number

of employees for some industries as reported by the two agencies (Triplett and Bosworth, 2007). Thus, we opted to use the basic employee estimates of BEA multiplied by the ratio of total hours to employees for each industry from the BLS OEP. We held the estimate of hours per employee constant between 2004 and 2005.

As noted in the introduction, the data inconsistencies do create a discrepancy in the measures of labor productivity at the aggregate level of nonfarm business. These differences are documented in Table 1 for the interval of 1987 to 2005. While the differences are inconsequential in the early years, they are more significant for the 2000-05 period where our measure of output per hour rises at 2.5 percent per year compared to 3.1 percent for the published BLS measure. Most of this difference arises from a faster rate of growth in the labor input measure in our industry data set. The differences in LP growth are persistent over the 5 years, but they result from significant differences in employment growth in 2000-03 and 2005, and differences in output growth over the last two years. The BEA estimates of employment growth show a smaller decline in the 2001-02 recession and a larger increase in 2005. Coincidentally or not, the latest difference seems consistent with the recent benchmark adjustment to the CES employment estimate.

On the other hand, the two series show similar short-run trends. Through 2004, they both indicated that post-2000 LP growth exceeded growth in 1995-2000, and they both record slowdowns since 2004 (the latest BLS release reports LP growth of 2.1 and 1.6 percent for 2005 and 2006).

B. Productivity Change in the 1995-2000 Period

We first use the revised BEA-BLS data to re-estimate the productivity change analysis for the pre- and post-1995 periods covered in our book (Triplett and Bosworth, 2004). The major Triplett and Bosworth (2004) finding—that productivity in services accelerated much more after 1995 than productivity in the goods sector—is confirmed, even though revisions and the changes incorporated in the shift to NAICS have changed magnitudes of the estimates considerably.[6]

[6] For our book, data were only available through 2001. We now use the year 2000 as the break year, a more natural end point than 2001, which was a recession year. The results do not depend on the break year.

Private nonfarm productivity growth nearly doubled after 1995 (Table 2). Part of this originated in the goods-sector, where LP and MFP growth accelerated after 1995 by about 30 percent. Services sector productivity, however, grew much more. The growth in services sector LP and MFP more than doubled. This dramatic change in the services sector drove much of the famed revival of U.S. productivity growth.

At the sector level, data revisions, methodological improvements, and classification changes raised LP and MFP growth rates in the goods sector and lowered both the productivity growth rates and the amount of acceleration in the services sector. In the revised data, services sector productivity grew more slowly over 1995-2000 than the productivity of goods sector industries, but services were clearly catching up.[7] Because in the pre-1995 period the services sector was by far the lagging sector, its emergence as a contributor to productivity advance—particularly to MFP growth—was the most striking aspect of the new post-1995 era. The extraordinary acceleration of services sector productivity has been too little noted and too much neglected.

C. Productivity Change in the 21st Century—the Aggregate and Sector Data

Defying many predictions, aggregate U.S. LP continued to advance after recovery from the 2001 recession, as Table 2 shows. The much-discussed second round of acceleration that some researchers believed that they could detect in the BLS measure is less evident in the industry dataset. However, it shows that nonfarm LP has advanced in the opening five years of the 21st century at the same rapid rate as in the last five years of the 20th century—2.5 percent per year. We calculate that aggregate MFP growth has held up as well, at 1.7 percent per year, a healthy rate for an advanced economy.

The aggregated sectoral data in Table 2 indicate that the 21st century U.S. productivity growth has again taken place largely in the services sector, as it did in the closing years of the 20th century. Indeed, goods sector LP and MFP growth both declined after 2000—see the right-hand columns of Table 2. Services sector LP and MFP, on the other hand, continued to accelerate after 2000, to 2.4 percent per year for LP and 1.5 percent for MFP. The post-2000 services sector MFP acceleration is not as dramatic as in 1995-2000, but still its post-2000

[7] Previous data suggested that services industries' productivity growth exceeded that of the goods industries. The revised data show this is not yet the case. Classification changes account for part of the revision to the goods/services growth ratio.

growth is three times its pre-1995 growth rate. Nonfarm LP and MFP rates have held up in the face of declines in the goods sector rates because the services sector has made up the gap.

Services sector productivity rates still lag those of the goods sector, but the sector rates are converging: In the 21st Century, services sector LP and MFP are about 80 percent of the corresponding rates for the goods sector (e.g., for LP, 2.43/2.85 = 0.85, see Table 2). In the pre-1995 period, services productivity growth rates were from two-fifths (LP) to only one-quarter (MFP) of the goods productivity rates. For the services sector to have approached parity in such a short time is one of the most remarkable—and overlooked—economic transformations of any era.

II. Sources of Productivity Growth

A. Sector Level Analysis

We use standard growth accounting methodology to decompose aggregate, sector, and industry LP growth into contributions from capital services, partitioned into IT capital services and other capital services, and from MFP (and for industry estimates, intermediate inputs). Our sectoral estimates are in table 3, we discuss our industry estimates later.

In the years 1995-2000, the U.S. experienced an investment boom, most of which was IT investment. Not surprisingly, then, nearly all of the capital contribution to nonfarm LP growth during this period came from IT capital, as IT investment doubled its contribution to LP, compared to 1987-1995 (its contribution went from 0.4 to 0.8 points—see upper panel of table 3). The IT contribution increased in both goods and services sectors by comparable amounts, but in the services sector, IT made up a larger part of the total capital contribution (nearly all—lower panels of table 3).[8]

The capital contribution to nonfarm LP growth in 2000-2005 is the nearly the same as in 1995-2000 (to two digits, the contributions are 0.89 and 0.83). However, the composition of

[8] Revised data have not changed the aggregate picture for 1995-2000, but they have changed the allocations between goods and services. Goods sector LP has been revised up sharply, and services LP revised down, but less so (services LP growth is now estimated at 2.3 percent for the 1995-2000 interval, it was 2.6 percent in the old data). The capital contribution has been revised down marginally in both sectors, but the IT portion has been revised up. In the new data, IT contributes relatively more to services LP than it did in the old data, and MFP contributes less. Compared to the new estimates for 1995-2000 in Table 3 (1.0 and 1.3 percentage points, for services sector IT and MFP contributions), the old were estimates were 1.0 and 1.5, respectively (Triplett and Bosworth, 2004, Table A-2, page 346).

investment changed after 2000. The IT boom ended and as others have observed, non-IT investment picked up some of the slack.[9] This was most strongly true of the goods industries, where the IT contribution fell in half, but where the overall capital contribution rose. In services industries the IT contribution also fell, as did the overall capital contribution, though only by 0.2 points.

Increasing IT investment in 1995-2000 has been well documented. But if IT boomed, MFP in services boomed more.

Within the services sector, the MFP contribution to services LP, at 0.5 points previously, went to 1.3 points in 1995-2000 (table 3). MFP made an even larger contribution to services LP growth than provided by IT (1.1 points).

Not surprisingly, given the proportion of services in the nonfarm economy, the strong contribution of services MFP carried over to nonfarm LP. Services MFP contributed more than a third of nonfarm LP growth (0.9 points of the 2.5 percent per year nonfarm LP growth), about the same as the contribution to LP growth made by MFP in the production of IT.

Much of the recent productivity literature has examined accelerations, that is, the determinants of the increase in LP, from 1.4 percent before 1995 to 2.5 percent after. Accelerations in growth contributions can be computed by reading across the rows in table 3. Accelerating services sector MFP growth after 1995 contributed about the same to LP acceleration as the much more widely acclaimed acceleration of MPF in IT: Both contributed 0.5 points of the 1.1 point acceleration.[10] In this metric, as in others, MFP in services was a striking component to the advance in U.S. LP growth after 1995.

Turning now to the 21st century expansion (right hand column of table 3), all of the modest increase in nonfarm MFP, post-2000, took place in the services sector, where MFP continued to accelerate, though by a lesser amount (0.2 points, from 1.3 to 1.5 percent per year).. Moreover, growth in the MFP contribution, especially from services MFP, continued to drive nonfarm LP growth after 2000. Indeed, services MFP advance was the sole source that supported aggregate LP growth. Every other contributor to LP growth made a smaller contribution after 2000.

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[9] The growth in capital intensity after 2000 also reflects a substantial slowing of the growth in employment.

[10] The total acceleration from accelerating components exceeds 1, because there are components that decelerated. Thus, there is nothing inconsistent in the fact that the contributions of services MFP, IT MFP, and IT capital deepening add to more than the total acceleration.

Judging from the aggregate and sector data, continued U.S. productivity growth in the post-2000 period is no surprise: It is just as an extension of the trends we described for the 1995-2000 period. Services sector MFP acceleration and economy-wide capital deepening continue to drive the nonfarm LP advance. The main difference in the 21st century is the changed composition of investment—more contribution from non-IT investment—since the size of the total capital contribution remains nearly as high as it was at the end of the 20th century (and substantially greater than what is was before 1995).

Others who have contended that the 20th and 21st century productivity expansions were different have overlooked strong services sector productivity growth, the tie that binds them together. In particular, they have focused on the declining IT contribution after 2000. But as we have shown, though IT was a large contributor to LP acceleration after 1995, it was not the only one. Services MFP was also a major factor, and services MFP is the sole contributor to growth that held up and even accelerated after 2000. Overemphasis of the IT effect carries into economic analysis the "dot com" overemphasis from the period before 2000. IT is important. But it is not the only thing that is important. Crucially, IT is not the major contributor to recent productivity advance; MFP in services is.

B. Industry Productivity Growth Rates and Resource Reallocations.

Tables 2 and 3 show *direct* productivity measures—we aggregate value added to the sector and aggregate levels and then divide by the appropriate (aggregated) input concept. These tables do not show aggregated *industry* productivity growth rates.

We also compute industry productivity measures for LP and for MFP, for 24 goods industries and 33 services industries, using output in the numerator, rather than value added.[11] Indeed, we compute growth accounts for each of these 57 industries according to equation (1). This permits us to analyze productivity performance within sectors and across industries. We use gross output in our industry growth equations because value added implies very stringent

[11] The old BEA dataset had 25 goods-producing industries and 29 services-producing industries. Triplett and Bosworth (2004, Appendix Tables A-1 and A-2) present industry productivity results for these industries. Some activities (publishing, for example) were transferred across sectors in NAICS, so the goods-services boundary is not the same in the new and old data, and the BEA list of services industries differs appreciably.

conditions on the structure of production that have been decisively rejected empirically (for example, Berndt and Wood, 1975).[12]

$$(1)\quad \Delta \ln LP = s_{K_{IT}} \Delta \ln(K_{IT} / L) + s_{K_N} \Delta \ln(K_N / L) + s_M \Delta \ln(M / L) + \Delta \ln \tilde{MFP}$$

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 – and the *s*'s denote two-period averages of the input shares.

We aggregate industry LP and MFP measures to goods and services sector levels and to the aggregate level. For the aggregation of industry LP growth measures, we use Stiroh's (2002) system:

$$(2)\quad d\ln LP^V = \left[\sum_i w_i d\ln LP_i^Q\right] + \left[\sum_i w_i d\ln L_i - d\ln L\right] + \left[\sum_i m_i (d\ln Q_i - d\ln M_i)\right]$$

where

LP^V = aggregate value added per worker,

LP_i^Q = gross output per worker in industry 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.

For the aggregation of MFP change, we use the generalization of the Domar weighting system presented in Jorgenson, Gollop and Fraumeni (1987):

$$(3)\quad d\ln MFP^V = \left[\sum_i v_i d\ln MFP_i^Q\right] + \left[\sum_i v_i s_i^k d\ln K_i - \bar{s}^k d\ln K\right] + \left[\sum_i v_i s_i^l d\ln L_i - \bar{s}^l d\ln L\right]$$

where

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

[12] At the sector level, we used the value-added measure because the gross output concept begins to incorporate a high degree of double counting of purchased inputs.

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

MFP^V is aggregate MFP (computed on value added),

MFP^Q is industry MFP, for industry i, using gross output,

and other variables are defined in equation (2).

As the equations show, the direct nonfarm and sector productivity measures discussed in the previous section reflect two forces—the effects of weighted changes in industry productivities and the effects of reallocations among industries. For the LP case in equation (2), the first terms on the right-hand side are weighted industry LP estimates. The second and third terms measure inter-industry shifts in labor and intermediate materials usages, respectively. Note that the second term is the weighted average of industry labor input *growth* relative to overall labor input growth, and similarly for the intermediate inputs term.

Interpretations of the reallocation terms are not immediately intuitive. Consider a technological shock in industry A that raises MFP and thereby LP, and for the sake of the illustration we specify that technologies in other industries are unchanged. Unless the demand elasticity for industry A's output is high, industry A will use fewer resources. If the released resources go to industries with lower productivity growth rates, the reallocation reduces aggregate and sector productivity rates (the direct rates). Reallocations thus provide a partial offset to the direct impact on the sector rates from industry A's productivity gain.[13]

Reallocation effects have been large in recent years, and have changed signs from one period to the next. They have thus shifted the relation between aggregate and industry productivity growth in unpredictable ways. Our estimates are in Table 4.

Begin with the top panel of Table 4, which pertains to the nonfarm business economy. The top line records the aggregation of LP growth in the 57 industries in our dataset, where individual industry LPs are aggregated using value added weights—the first term of equation (2). Aggregated industry LPs grew 1.9 percent per year in the 1987-95 period, rising to 3.4 percent in 1995-2000, then falling back to 2.5 percent in 2000-2005. If industries roughly correspond to production functions, and ignoring the well-known non-technological factors that shift MFP,[14]

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[13] This is not an index number problem. We weight industry productivities with the 2-period average of value added. The reallocation problem concerns reallocations of inputs, not of the value added that serves as the weights.

[14] MFP is famously a residual. It can change with, in addition to technological shifts, measurement errors in outputs and inputs and changes in omitted variables, particularly intangibles and the coinvestments considered in much of

the aggregated industry LP rate provides an estimate of the aggregated combinations of factor substitutions and technological shifts on LPs in the 57 industries.

The second and third lines of Table 4 show reallocations of labor and of intermediate materials, the second and third terms of equation (2). Subtracting the reallocations from the first line gives in the fourth line the direct sector productivity rates from table 3. For the direct rates, aggregated value added is divided by aggregated labor.

Reallocations have typically reduced the direct productivity rates: For example, in the 1995-2000 period both reallocation terms had negative impacts. Together, they reduced aggregate LP by 0.9 points. During 1995-2000, the LPs of industries in the nonfarm economy expanded considerably faster than did aggregate nonfarm LP.

Nearly all of the discussion of post-1995 LP productivity growth in the U.S. has put that growth at 2.5 per cent per year (see table 2); yet, technological change and factor substitution at the industry level actually raised LP growth by 3.4 percent per year in the 1995-2000 interval. Productivity at the industry level (which is where the productivity paradigm makes the most sense) was growing even faster than the aggregate number that received so much attention.

Similar calculations for sector productivity are presented in the other panels of table 4. These reallocations again use equation 2, but applied only within in the sector (the reallocations within sectors do not add to total reallocations, because the latter include also reallocations between the sectors). At the sector level as well, the aggregated industry rates for 1995-2000 were substantially higher than the direct sector rates because the reallocations terms subtract from the aggregated industry LP growth rates. For example, services industries' LPs grew 3.5 percent per year during 1995-2000, nearly double their pre-1995 rates, but services sector LP grew only 2.3 percent per year.

Few productivity researchers have paid attention to resource reallocation effects (an exception is Stiroh 2002, 2006). For the question that most economists were exploring—how much did productivity improve after 1995?—reallocations did not matter. Using either the direct rates or the aggregated industry rates, LP growth roughly doubled after 1995, and the post-1995 accelerations in goods and services sectors were likewise similar. That reallocations reduced the

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the computer impact literature. See, among the large number of items that could be cited, Corrado et al (2005) and Brynjolfsson and Hitt (2000).

sector and aggregate rates well below the industry rates was an intriguing curiosity, but one that suggested little of interest for the analysis of productivity growth.

In contrast, reallocations do matter for the most recent period. Net reallocations, a large negative number before 2000, were nil at the economy-wide level over 2000-2005. Substantial declines occurred in the industry LP rates, which fell from 3.4 to 2.5 percent per year. But reallocations in 2000-2005 subtracted much less from the industry rates than they had earlier. Indeed, the decline in the magnitudes of the reallocation terms after 2000 coincidentally equaled the decline in the aggregated industry productivity rates, and left (as we noted earlier) the nonfarm direct LP rate constant (at 2.5 percent). Comparing 2000-2005 with 1995-2000, the direct nonfarm LP rate held up, even as the aggregated industry LP rates declined from 3.4 percent to 2.5 percent, annually.[15]

The same thing was true of direct sector and aggregated industries rates in goods and services. In both cases, the direct sector rates held up after 2000 even as the aggregated industries LP rates fell because in both sectors the reallocation terms became less negative. Indeed, in the goods sector reallocations turned positive, led by strong positive intermediate materials reallocations, and boosted the direct LP rate (2.9 percent) above the aggregated industries LP rates (2.2 percent). To our knowledge, this is the first time net reallocations have been positive for any sector. In services, the decline in reallocations turned a decline in the industries' LP rates (of 0.8 points) into an increase of 0.1 point in the direct LP rate.

Shifts in reallocation terms interject a perplexing new variable into the analysis of post-2000 productivity growth. One can ask: Have U.S. LP rates held up since 2000? The industry rates indicate that the answer to that is negative, for industry LP rates have fallen from 3.4 percent to 2.5 percent. But the direct rate has been maintained at 2.5, because the reallocations across industries have become less negative. In the early years of the 21st century, the U.S. economy is no longer shifting resources, as it did in previous times, toward the industries that have lower productivity growth.

Similar questions about goods and services sectors yield similar answers. As we have noted earlier, when measured by direct productivity rates, services sector LP accelerated slightly after 2000 (from 2.3 to 2.4 percent), and goods sector LP decreased imperceptibly (from 3.0 to

[15] Note that aggregation of the industry productivity rates (equals 2.5 percent) equals the direct rate, because reallocations net out in 2000-2005. This was not the case earlier.

2.9 percent). However, aggregating the goods industries' and services industries' LPs, we find (bottom two panels of Table 3) that they both fell, compared to end of the 20th century rates. Goods industries' LPs dropped more (from 3.2 to 2.2 percent), but services industries' LPs also fell (from 3.5 to 2.7 percent).

C. Interpretation.

The sustainability of recent U.S. productivity performance is a current question of some interest. Much of the analysis of sustainability has employed reasoning that draws on the factor substitution contribution to LP growth (for example, through IT capital deepening), and secondarily on technical change at the industry level. But since resource reallocations have recently made substantial, and fluctuating, contributions to sector and aggregate productivity growth, reallocations are a third factor that must be brought into consideration.

Possibly more favorable reallocation effects are also part of the complex of favorable circumstances that the U.S. economy enjoyed in recent years, and somehow the country is now experiencing more favorable (for productivity growth) resource reallocations than it has in the recent past. Denison (1962) emphasized the shift of labor out of (then) low productivity agriculture as a force for improving U.S. productivity. The U.S. may have returned to a period where resource shifts play once again a positive role in U.S. productivity growth. But this, as with much discussion of productivity prospects that others have entertained, is speculative.

Because so little attention has been paid to reallocation effects, it is worth noting that BEA data and procedural revisions have greatly increased the post-1995 estimated values of them. The revisions left the overall 1995-2000 direct LP rate relatively unchanged. However, the industry LP rates were raised, especially within the services sector, as were the sizes of the reallocation effects. Because BEA's methodological changes caused more integration of the industry accounts and the input-output accounts, they may have improved the measurement of inter-industry flows in the industry accounts. The new estimates of reallocation effects may be revealing an economic phenomenon that was probably always important in industry productivities, but was hidden by the less effective methodology of the past.[16]

We think that more analysis of reallocation effects is needed. For example, recent U.S. productivity performance relative to the E.U. has provided much fodder for policy discussions. -

[16] Triplett and Bosworth (2004, Table 2-5) computed reallocation terms and discussed them, but they appeared smaller in the data that were available at the time.

The frequently-encountered idea that less regulation in the U.S. (relative to the E.U.) is the source of its better productivity performance rests on the interpretation that *aggregate and sector* LP growth is the result of production function shifts and capital-labor substitution. Some of it, instead, reflects the U.S. economy's recent more favorable shift of resources into subsectors that have higher productivity growth. Until we know more about the nature of those resource shifts, one cannot claim that deregulation (or other favored nostrums) will augment them favorably, no matter how attractive are the intellectual cases to be made for less regulation.[17]

III. Services Industry Productivity Measures.

As we have used it, the BEA industry dataset contains 23 goods-producing industries and 34 services industries, at roughly the 3-digit level of the NAICS classification. Productivity advance, post-2000, remains broadly based both in goods and in services industries.

As table 5 shows, 70 percent (16 of 23) and 65 percent of services industries (22 of 34) experienced more rapid LP growth after 1995, considering the whole 1995-2005 period together.[18] For MFP, the picture is similar: 57 percent of the goods-producing industries and 65 percent of the services-producing industries showed accelerating productivity, again considering the whole period 1995-2005 compared with pre-1995. Thus, goods and services industries advanced in MFP in roughly similar proportions for the whole period after 1995. Productivity advance in U.S. industries—MFP as well as LP—was not narrowly located in electronics, contrary to assertions that have often been repeated.

Non-accelerating industries. There are 10 contrary services industries—those for which LP and MFP over the combined 1995-2005 interval failed to accelerate, compared with pre-1995 rates (The growth accounting results for all 57 industries are in an appendix available from the authors). Four are in transportation. They deserve further study. Only trucking has any kind of productivity literature—our trucking industry measures derived from BEA and BLS data seem inconsistent with Hubbard's (2003) results.

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[17] Lest we be mis-interpreted, we share the usual economists' presumption against excessive regulation. What we are saying is that the empirical case linking deregulation to accelerating U.S. sector and aggregate LP and MFP measures is weak, and is weaker still when the substantial roles of reallocation effects are considered.

[18] The old BEA dataset used for our book contained 29 services industries. We reported in our book that productivity growth increased in 17 of the 29, comparing 1995-01 to the pre-1995 period, and one additional industry had negative LP growth that became less negative after 1995 (Triplett and Bosworth, 2004, page 17). Allowing for the changed number of industries (choice of end point—2000 or 2001—made no difference), this is essentially the result noted above.

Of the other six, a number present measurement problems. The Federal reserve and credit intermediation industry (negative MFP or LP rates in at least one period) is not only a somewhat miscellaneous grouping, it is likely infested with the error created by the inappropriate national accounts measure of the output in financial institutions (see chapters 5 and 7 of our book and Basu, Inklaar and Wang, 2006). Education is the sick child of services productivity, with measured LP and MFP that is negative and growing more so; the output of the industry, and therefore its productivity, may be mis-measured, as we point out in chapter 9 of our book, but education may also be the archetypal "Baumol's disease" industry (Baumol 1967). Performing arts and amusements are now also negative productivity growth industries; no research exists on productivity in these growing industries. The negative rates in "other services except government" are hard to assess.

Better output measurement would likely turn some of these seeming laggards into better productivity performers. On the other hand, we also suspect mis-measurement in some industries that show high measured LP growth rates. Airline transport—whose measured LP became strongly positive, post-2000—is one example.

MFP and Lagged Investment in IT

Basu and Fernald (2006) and some other authors explore whether MFP growth is a function of lagged investment in IT. They reason that increasing (measured) MFP may result from omission from the capital input measures of unobserved intangible capital and "coinvestments" that are associated with investment in IT (many other authors have advanced the same hypothesis). They take the share of IT in industry value added as what they call a proxy for the unobserved investments. Basu and Fernald report evidence that they characterize as "somewhat consistent" with the lagged hypothesis. Basu et al (2004), in a paper that uses a version of the data for our book, reported similar findings for the 1995-2000 period.

We looked at this question briefly in our book (Triplett and Bosworth, 2004, pages 29-31). We found no relation between the IT intensity of an industry (we used the share of IT in capital services) and its subsequent MFP growth. We examine the question again with our new data.

We computed several regressions of industry MFP change on its lagged IT: In the one whose results were most favorable to the lagged IT hypothesis, we used the ratio of IT capital income to value added as the measure of industry IT intensity (this measure is close to the Basu

and Fernald measure).[19] Thus, our regression includes as right-hand variables the current five-year period's IT intensity (expected to have a negative sign, on the grounds that resources are being diverted to coinvestments without a current payoff), the IT intensity of the previous period (e.g., for 1995-2000 the lagged IT for 1987-1995, expected to have a positive sign, as coinvestments begin their payout), and IT intensity lagged two periods (available for the post-2000 period only). Table 6 shows the results.

Scanning down the columns, most of the signs are consistent with the hypothesis—negative on current IT, positive on lagged IT, but coefficients are mostly insignificant. At the all industries level, signs are correct and significant only for post-2000, not for 1995-2000. Possibly Basu et al's significant findings for 1995-2000 are casualties of data revisions.

We then disaggregated our investigation, running separate regressions for goods industries and services industries. For services industries, signs were correct in both periods, but t-values were weak. For goods, as in the all-industries regression, signs were correct for post-2000 (but not for 1995-2000), and t-values for post-2000 were highly significant. Examination of the data for individual industries suggested running another goods industry regression with the computer and electronics industry deleted: The results resemble the results for services—signs for the post-2000 period (only) remain correct but t-values drop to insignificance. When the second lagged variable is included in this regression, it has the expected sign, but the first lagged variable becomes negative. In any case, however, none of the coefficients is significant.

We conclude from this that the computer and electronics industry is not only an outlier, but that it has a tremendous impact on the goods industries and all industries regressions. Computer and electronics production has the highest MFP in our dataset (11.00 and 6.17 percent per year for, respectively, 1995-2000 and 2000-2005), and it is not IT nor capital intensive by our value added measure. Outside of this industry, the lagged IT hypothesis has no statistical support in the industry data set. If the hypothesis describes something about IT investment, then empirically it *must* reveal itself in services industries because 80 percent of U.S. IT investment is in the services sector.

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[19] In another, we used the IT capital contribution to industry LP as the measure of IT intensity. Entered into a lagged regression it yielded very low t-values and essentially zero adjusted R^2, so we did not consider this formulation further. There is no natural measure of IT intensity (Triplett and Bosworth, 2006 discuss nine alternatives), and rankings of industries by IT intensities are not invariant to the measure chosen.

Undoubtedly, investment in computers requires coinvestment. Lags are likely before the full potential of these investments are realized. However, we think these are properties of all investment and not particular or unique properties of computers.

Many of the management changes that have launched the revival of U.S. productivity growth are IT-enabled changes—computer equipment and software were required to put into effect the innovations that managers sought to make.[20] However, for the management resources used to make thousands of different innovations across our 57 diverse industries to be strongly correlated with the amount of IT used in each of these innovations would be an unlikely coincidence. The contribution of management inputs, coinvestment and intangible investment to recent productivity advance needs exploration. Indeed, our findings of major acceleration in MFP in services industries serves to confirm the importance of looking for other input variables, since growth in MFP can be a sign that something is omitted from the analysis. We believe, though, that finding the sources of the surge in MFP that has marked the U.S. economy over the last decade will require a great effort to enumerate and measure those omitted variables. Tempting as it may be to short-circuit the measurement process with ever more elaborate econometrics on the measures we already have, it is unlikely (as Zvi Griliches was fond of pointing out) to work.

Computers and Semiconductors

In the previous literature on the post-1995 productivity advance, a great amount of ink was spilled recording indirect estimates of the rate of productivity advance in the electronics sector. The estimates had to be indirect because in the old U.S. SIC classification system, computers were buried, as we have remarked before, with drill bits in industrial machinery, while semiconductors were in the same industry as Christmas tree lights. The new NAICS classification system contains a computer and electronics manufacturing subsector, so in our data we can form a direct estimate of LP and MFP for this important industry. Our estimates are in Table 7.

MFP growth in computers and electronics has been dazzlingly rapid. Even before 1995, it exceeded 5 percent per year, and reached 11 percent during 1995-2000 (MFP calculated

[20] Eric Brynholfsson remarked at the Chicago American Economic Association session on this topic that one could think of IT investment being a function of management innovation equally well as coinvestment being a function of IT and computers. The investments and the associated changes in organization and methods of doing business are all wrapped up in one decision process.

consistently with the gross output growth accounting equation (1)). This estimate is somewhat below that of Jorgenson, Ho and Strioh's (2002), who estimated 16.75 percent per year for computers and 18.00 for electronics. Oliner and Sichel (2002) estimated 14.0 for computer MFP growth and 45.2 for semiconductors; both are components of the present BEA industry, but other elements are included as well. Using our present data, at its height this one industry's MFP contributed 0.70 to nonfarm LP growth, which is not far from the contribution that Oliner and Sichel got from quite indirect methods. [21]

One service industry had comparable LP and MFP growth rates—securities and commodities exchanges. Brokerage MFP, at nearly 11 percent, had the second fastest MFP growth 1995-2000, and again in 2000-2005. Its contribution to nonfarm LP was lower because it is a smaller industry, about half the size of computer and electronics manufacturing.

IV. Conclusion

In an otherwise excellent recent review of the post-1995 productivity expansion, Anderson and Kliesen (2006, page 181) state: "...economists have reached a consensus that...the underlying cause of that increase [in U.S. labor productivity in the 1990s] was technological innovations in semiconductor manufacturing...." If this is indeed economists' consensus, we contend it is wrong.

Two forces, not one, drove the 1995-2000 productivity expansion: Investment (much of it in IT) and MFP, much of the latter in services industries. Anderson and Kliesen focus, as did the researchers who preceded our work, on the contribution of IT investment (capital deepening) and MFP in IT production, without considering at all the contribution of MFP acceleration in services industries.[22] The advance in productivity that began in 1995 is a wide-spread phenomenon that was caused by more far-reaching economic forces than merely the rate of

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[21] The entries for contributions in table 7 differ from the corresponding ones in table 2 because table 2 presents direct nonfarm LP, and the direct LP rate is based on value added. In interpreting these numbers, the reader should bear in mind that because productivity decelerated in some industries, the industries in which productivity accelerated contributed more than 100 percent of the total acceleration.

[22] On services productivity, Anderson and Kliesen (2006, page 184) state: "Increased use of ICT capital was the primary cause behind the productivity acceleration." They then quote from our book a passage in which we said that IT capital deepening in the U.S. was a services industry story. But we did not say that services productivity was an IT story—a very different thing. IT made a contribution to services labor productivity but more remarkable was the acceleration of MFP growth in the services industries (see Triplett and Bosworth, 2004, Table A-2: In the data then available, services LP grew 2.56 percent per year, of which IT contributed 1.01 points and MFP 1.48 points).

technical advance in the production of semiconductors (though we do no minimize the importance of technical change in electronics production and of capital deepening in raising U.S. LP).

We examine in this paper the post-2000 productivity expansion, using our industry productivity approach. We again find that productivity growth was driven by capital deepening, this time not primarily in IT, and by productivity advance in services industries, especially MFP in services. The notion that the U.S. productivity revival rests fragilely on possibly transitory technological changes in one technologically dynamic industry is not consistent with the U.S. industry productivity data and has led to mistaken analysis and too pessimistic forecasts.

However, the industry productivity aggregations have brought to the fore a new factor: Resource reallocations have fluctuated in recent years, and estimates of their size have increased with BEA revisions to its industry accounts. Since 2000, reallocations have boosted services sector productivity change relative to services industry productivity change. It is still true that the foremost transition in the U.S. economy after 1995 was the revival of U.S. services industries. But whether 21st century productivity growth has held up (to 1995-2000) or whether it has fallen short, depends on how one asks the question: Measured at the sector level, productivity growth has held up; at the industry level, LP has fallen.

MFP is a residual, after accounting for all contributing inputs. If variables are not measured appropriately, or if crucial inputs are omitted, then MFP growth may indicate where mismeasurement is worsening. The mismeasurement hypothesis (initially explored by Jorgenson and Griliches, 1967) provides the bridge to our complementary paper (Triplett and Bosworth, 2007), where we assess the adequacy of services sector data.

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Table 1. Comparison of BEA and BLS Nonfarm Business Labor Productivity, 1987-2005

annual percentage change

Component	1987-95	1995-2000	2000-05
Output per hour			
BEA/BLS dataset	1.4	2.5	2.5
BLS	1.5	2.5	3.1
Output			
BEA/BLS dataset	3.0	4.8	2.4
BLS	3.0	4.7	2.6
Hours			
BEA/BLS dataset	1.6	2.3	-0.1
BLS	1.5	2.1	-0.5
Employment			
BEA/BLS dataset	1.7	2.5	0.2
BLS	1.5	2.2	-0.1

Source: computed by authors as explained in text

Table 2. Productivity Growth in Nonfarm Business, Goods and Services-Producing Sectors, 1987-2005

Directly measured, average annual rate of change

	1987-95	1995-00	2000-05
Labor Productivity			
Private Nonfarm	1.4	2.5	2.5
Goods-Producing Sector	2.4	3.0	2.9
Services-Producing Sector	1.1	2.3	2.4
Multifactor Productivity			
Private Nonfarm	0.9	1.6	1.7
Goods-Producing Sector	1.8	2.3	1.9
Services-Producing Sector	0.5	1.3	1.5

Source: computed by the authors from the new NAICS-based industry data set, December 2006 release.

Table 3. Nonfarm Business and Sector Labor Productivity Growth and Contributions, 1987-2005

Annual percentage rate of change

Sector	1987-95	1995-00	2000-05
Private Nonfarm			
Labor productivity	1.4	2.5	2.5
Capital contribution	0.5	0.9	0.8
of which: IT	0.4	0.8	0.5
Multifactor Productivity	0.9	1.6	1.7
of which: Computers	0.3	0.7	0.3
of which: Services	0.3	0.9	1.1
Goods-producing sector			
Labor productivity	2.4	3.0	2.9
Capital contribution	0.5	0.7	0.9
of which: Computers	0.3	0.5	0.3
Multifactor Productivity	1.8	2.3	1.9
Services-producing sector			
Labor productivity	1.1	2.3	2.4
Capital contribution	0.6	1.1	0.9
of which: Computers	0.5	1.0	0.6
Multifactor Productivity	0.5	1.3	1.5

Source: computed by the authors from the new NAICS-based industry data set, December 2006 release.

Table 4. Labor Productivity by Major Sector and Reallocations, 1987-2005
Gross Output

	1987-95	1995-2000	2000-05
Nonfarm business (aggregated)	1.9	3.4	2.5
Labor reallocation	-0.3	-0.1	-0.4
Intermediate input reallocations	-0.2	-0.8	0.4
Nonfarm business (direct calculation)	1.4	2.5	2.5
Aggregated goods-producing industries	2.3	3.2	2.2
Labor reallocation	-0.1	-0.3	-0.1
Intermediate input reallocations	0.2	0.1	0.7
Goods-producing sector (direct calculation)	2.4	3.0	2.9
Agregated services-producing industries	1.8	3.5	2.7
Labor reallocation	-0.3	0.1	-0.5
Intermediate input reallocations	-0.4	-1.2	0.2
Services-producing sector (direct calculation)	1.1	2.3	2.4

Source: computed by the authors from the new NAICS-based industry data set, December 2006 release.

Table 5. Industry Productivity Accelerations, 1987-2005

	1995-00/ pre-1995	2000-05/ pre-1995	1995-2005/ pre-1995
Number of goods industries	23	23	23
Percent increasing LP rates	57%	74%	70%
Percent increasing MFP rates	43%	70%	57%
Number of services industries	34	34	34
Percent increasing LP rates	62%	68%	65%
Percent increasing MFP rates	53%	65%	65%

Source: computed by the authors from the new NAICS-based industry data set, December 2006 release.

Table 6. OLS Regression of MFP on IT Intensity[a]

		IT Intensity	Lagged IT Intensity	Double Lagged IT Intensity	Adjusted R-squared	Observations
All Industries	1995-00	-12.17	13.82		-0.03	57
		(0.31)	(0.37)			
	2000-05	-128.00*	146.94*		0.16	57
		(3.48)	(3.59)			
	2000-05	-128.00*	124.69*	23.46	0.17	57
		(3.46)	(2.71)	(1.05)		
Services	1995-00	-42.12	38.43		-0.02	34
		(1.17)	(1.12)			
	2000-05	-44.60	55.61		-0.02	34
		(0.98)	(1.09)			
	2000-05	-38.87	21.26	30.39	0.01	34
		(0.86)	(0.38)	(1.38)		
Goods	1995-00	98.02	-13.86		-0.01	23
		(0.62)	(0.07)			
	2000-05	-246.00*	257.59*		0.41	23
		(3.85)	(4.11)			
	2000-05	-233.00*	189.17	84.33	0.40	23
		(3.48)	(1.68)	(0.74)		
Goods ex. Computers	1995-00	87.67	-104.00		0.01	22
		(1.52)	(1.34)			
	2000-05	-89.53	100.58		-0.05	22
		(0.9)	(1.02)			
	2000-05	-50.60	-23.27	129.51	-0.02	22
		(0.49)	(0.16)	(1.21)		

Source: Authors' calculations as explained in text.

a/ IT Intensity is the ratio of IT capital income to Value-Added.

Notes: The items in parentheses are t-statistics. The regressions also included a constant term (not shown).

* indicates significance at the 1% level of a two-tailed t-test.

Table 7. MFP in Selected Industries, 1987-2005

Annual percentage rate of change

	1987-95	1995-00	2000-05
Computers			
Industry MFP growth	5.7	11.0	6.2
MFP contribution to non-farm LP	0.33	0.70	0.27
Brokerage Firms			
Industry MFP growth	4.9	10.8	4.9
MFP contribution to non-farm LP	0.09	0.35	0.17

Source: Authors calculations from the new NAICS-based industry data set, December 2006 release.

Table A1. Sources of Growth in Output per Worker, 1987-2005
Average annual percentage change

	Gross output per worker			Contribution of: Capital per worker			IT capital per worker		
Industry title	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**
Private Nonfarm (except real estate)	**1.46**	**3.15**	**1.89**	**0.24**	**0.45**	**0.42**	**0.21**	**0.41**	**0.26**
Goods-production	**2.28**	**2.74**	**2.02**	**0.19**	**0.26**	**0.34**	**0.11**	**0.19**	**0.09**
Forestry, fishing, and related activities	-1.73	-2.66	-0.18	0.11	-0.73	-0.49	0.16	-0.07	-0.06
Mining	2.65	2.73	-1.58	0.79	0.56	-0.14	0.18	0.21	0.14
Oil and gas extraction	3.27	3.94	-2.28	1.15	1.31	-0.12	0.04	0.12	-0.03
Mining, except oil and gas	4.20	2.77	1.79	0.02	0.68	0.25	0.17	0.37	0.13
Support activities for mining	1.05	7.39	-0.49	-0.14	-0.20	-1.16	0.06	0.17	-0.06
Construction	-0.28	0.71	0.76	-0.07	0.49	0.23	0.07	0.22	0.09
Manufacturing	2.93	3.96	3.67	0.27	0.43	0.46	0.14	0.25	0.12
Durable goods	3.94	5.55	4.16	0.23	0.44	0.39	0.14	0.27	0.12
Wood products	-0.21	1.51	1.65	-0.05	0.12	0.09	0.08	0.09	0.04
Nonmetallic mineral products	0.69	1.35	2.60	-0.05	0.14	0.45	0.07	0.18	0.14
Primary metals	2.47	0.41	6.08	-0.01	-0.03	0.28	0.03	0.04	0.03
Fabricated metal products	1.44	1.19	0.71	0.09	0.20	0.38	0.12	0.17	0.11
Machinery	2.47	2.58	3.61	0.30	0.96	0.58	0.20	0.62	0.29
Computer and electronic products	13.51	19.74	8.11	0.55	0.74	0.05	0.25	0.40	0.02
Electrical equipment, appliances, and components	3.29	3.15	2.94	0.56	0.31	1.10	0.16	0.13	0.17
Transportation Equipment (NAICS 336)	2.38	3.26	4.37	0.14	0.41	0.31	0.10	0.25	0.13
Furniture and related products	1.06	2.98	4.60	0.20	0.36	0.53	0.07	0.14	0.10
Miscellaneous manufacturing	2.92	2.24	5.38	0.20	0.19	0.47	0.15	0.18	0.14
Nondurable goods	1.70	2.24	3.13	0.31	0.49	0.54	0.14	0.23	0.12
Food and beverage and tobacco products	1.40	0.43	1.73	0.16	0.06	0.16	0.06	0.09	0.05
Textile mills and textile product mills	2.38	2.25	4.28	0.10	0.20	0.37	0.03	0.04	0.01
Apparel and leather and allied products	2.57	5.49	-0.71	0.49	0.93	1.07	0.06	0.14	0.09
Paper products	1.67	0.76	3.00	0.29	0.27	0.28	0.11	0.14	0.07
Printing and related support activities	0.46	1.55	1.08	0.19	0.44	0.65	0.12	0.27	0.18
Petroleum and coal products	3.24	4.02	0.75	0.31	0.22	0.23	0.13	0.12	0.16
Chemical products	1.36	2.20	2.23	0.56	0.86	0.47	0.34	0.53	0.14
Plastics and rubber products	1.98	2.37	3.27	0.13	0.46	0.65	0.06	0.11	0.08

Table A1. Sources of Growth in Output per Worker, 1987-2005
Average annual percentage change

	Gross output per worker			Contribution of: Capital per worker			IT capital per worker		
Industry title	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**
Service-production	**1.37**	**3.59**	**2.21**	**0.34**	**0.61**	**0.51**	**0.29**	**0.57**	**0.36**
Utilities	3.58	3.43	1.78	1.18	1.25	1.94	0.31	0.36	0.46
Wholesale trade	3.49	4.29	2.96	0.34	1.08	0.64	0.21	0.64	0.34
Retail trade	2.78	3.94	3.65	0.42	0.35	0.33	0.17	0.21	0.14
Transportation and warehousing	1.28	1.88	1.50	-0.27	0.44	0.10	0.13	0.50	0.17
Air transportation	0.58	3.62	7.70	0.09	1.43	0.72	0.19	1.29	0.53
Rail transportation	5.80	3.23	5.44	0.30	0.53	0.36	0.08	0.11	0.01
Water transportation	3.04	2.32	-2.58	-0.08	0.21	-0.13	0.07	0.37	0.22
Truck transportation	3.19	2.21	-0.40	-0.28	0.19	-0.19	0.08	0.21	0.10
Transit and ground passenger transportation	-0.32	-1.72	-2.13	-0.09	0.55	0.20	0.08	0.35	0.19
Pipeline transportation	1.17	5.52	5.38	0.23	1.06	0.38	0.32	0.43	0.06
Other transportation and support activities	-1.48	1.51	0.33	-0.70	0.31	-0.16	0.21	0.71	0.09
Warehousing and storage	2.02	2.18	2.70	-0.42	0.22	0.13	0.17	0.25	0.36
Information	3.27	5.64	8.02	0.84	0.91	1.24	0.63	1.14	0.91
publishing and data processing	3.46	4.30	7.30	0.54	0.29	1.11	0.55	0.59	0.78
Motion picture and sound recording industries	-0.40	-0.35	2.25	0.23	-0.08	-0.28	0.20	-0.10	-0.07
Broadcasting and telecommunications	4.07	7.54	9.29	1.36	1.51	1.58	0.91	1.73	1.21
Finance and insurance	1.72	6.22	1.77	1.33	1.44	0.67	0.79	0.83	0.36
Federal Reserve banks, credit intermediation, and relate	1.86	2.97	-0.36	2.94	2.68	0.21	1.70	1.78	0.36
Securities, commodity contracts and investments	8.69	21.89	5.57	0.22	0.10	-0.10	0.15	0.14	-0.09
Insurance carriers and related activities	-0.17	-0.02	3.04	1.14	0.91	0.66	0.67	0.45	0.41
Funds, trusts, and other financial vehicles	-2.46	9.17	5.85	-0.10	0.34	0.57	0.00	0.03	0.00
Rental and leasing services and lessors of intangible ass	2.93	5.47	2.80	1.67	6.02	2.75	1.08	3.19	1.12
Professional and business services	0.31	3.74	3.23	0.24	0.33	0.77	0.22	0.52	0.61
Professional, scientific, and technical services	1.05	5.10	4.49	0.26	0.32	0.69	0.23	0.56	0.63
Legal services	-0.22	1.62	3.02	0.06	0.10	0.16	0.03	0.11	0.12
Computer systems design and related services	2.71	4.56	3.16	0.74	0.87	0.96	0.29	1.16	0.90
Miscellaneous professional, scientific, and technical serv	1.32	6.29	5.17	0.32	0.21	0.80	0.27	0.51	0.73
Management of companies and enterprises	-0.49	-0.10	1.99	0.23	0.19	0.80	0.21	0.22	0.66
Administrative and waste management services	1.14	3.69	1.49	0.21	0.47	0.95	0.24	0.62	0.56
Administrative and support services	1.31	4.13	1.59	0.25	0.61	1.03	0.25	0.70	0.60
Waste management and remediation services	1.81	2.49	-0.39	0.36	-0.13	0.05	0.24	0.11	0.16
Educational services, health care, and social assistance	-0.34	0.40	1.23	0.26	0.07	0.24	0.28	0.19	0.32
Educational services	0.41	0.01	-0.32	0.05	0.17	0.26	0.07	0.15	0.15
Health care and social assistance	-0.48	0.50	1.43	0.27	0.08	0.23	0.30	0.21	0.33
Ambulatory health care services	-1.17	0.83	1.61	0.10	-0.04	0.22	0.25	0.22	0.48
Hospitals and nursing and residential care facilities	-0.14	0.29	1.00	0.27	0.26	0.20	0.28	0.22	0.18
Social assistance	0.11	1.50	1.64	-0.14	-0.19	0.05	0.07	0.11	0.07
Arts, entertainment, recreation, accommodation, and food se	0.73	0.92	0.19	0.08	0.08	0.08	0.07	0.10	0.08
Arts, entertainment, and recreation	3.33	1.45	-1.02	-0.04	0.65	0.42	0.01	0.09	0.09
Performing arts, spectator sports, museums, and related	4.44	3.43	-1.18	0.14	0.24	0.44	0.02	0.10	0.11
Amusements, gambling, and recreation industries	2.19	-0.04	-0.82	-0.31	0.72	0.43	0.01	0.09	0.08
Accommodation and food services	0.09	0.83	0.52	0.10	0.36	0.11	0.05	0.07	0.08
Accommodation	0.89	0.58	0.29	0.30	0.51	-0.16	0.06	0.07	0.07
Food services and drinking places	-0.15	0.90	0.65	0.06	0.29	0.25	0.05	0.07	0.09
Other services, except government	1.65	1.82	0.45	0.29	-0.24	0.10	0.15	0.18	0.09

Table A1. Sources of Growth in Output per Worker, 1987-2
Average annual percentage change

	Contribution of:					
	Intermediate inputs per worker			Multifactor productivity		
Industry title	**1987-95**	**1995-00**	**2000-05**	**1987-95**	**1995-00**	**2000-05**
Private Nonfarm (except real estate)	**0.74**	**1.91**	**0.59**	**0.46**	**0.77**	**0.87**
Goods-production	**1.40**	**1.61**	**0.92**	**0.67**	**0.85**	**0.74**
Forestry, fishing, and related activities	0.21	-2.66	0.76	-2.04	0.74	-0.45
Mining	0.57	2.62	0.98	1.27	-0.44	-2.39
Oil and gas extraction	0.43	4.53	-0.67	1.66	-1.86	-1.50
Mining, except oil and gas	1.61	-1.85	3.11	2.52	4.00	-1.52
Support activities for mining	0.57	9.68	4.68	0.62	-1.90	-3.83
Construction	-0.29	1.32	1.09	0.08	-1.09	-0.55
Manufacturing	1.86	2.22	1.77	0.78	1.26	1.40
Durable goods	2.46	2.75	1.82	1.22	2.27	1.89
Wood products	0.43	1.77	0.71	-0.59	-0.38	0.83
Nonmetallic mineral products	-0.70	0.66	1.06	1.45	0.54	1.07
Primary metals	1.74	-0.34	3.96	0.73	0.73	1.75
Fabricated metal products	0.77	0.99	-0.43	0.58	-0.01	0.76
Machinery	2.18	2.14	1.71	-0.02	-0.52	1.28
Computer and electronic products	6.83	7.08	1.78	5.67	11.00	6.17
Electrical equipment, appliances, and components	2.09	2.55	0.46	0.60	0.23	1.35
Transportation Equipment (NAICS 336)	2.35	2.73	3.31	-0.12	0.10	0.72
Furniture and related products	0.82	2.11	2.49	0.04	0.43	1.53
Miscellaneous manufacturing	1.02	0.77	2.10	1.67	1.27	2.74
Nondurable goods	1.11	1.80	1.73	0.28	-0.05	0.83
Food and beverage and tobacco products	0.73	1.34	1.44	0.51	-0.96	0.12
Textile mills and textile product mills	1.13	1.71	1.95	1.14	0.34	1.91
Apparel and leather and allied products	1.21	3.97	-2.86	0.86	0.54	1.14
Paper products	1.62	0.53	1.04	-0.23	-0.04	1.66
Printing and related support activities	0.25	1.24	-0.68	0.03	-0.13	1.12
Petroleum and coal products	3.34	2.88	0.27	-0.41	0.83	0.24
Chemical products	0.81	1.34	0.34	-0.02	-0.01	1.41
Plastics and rubber products	0.99	1.00	1.82	0.85	0.90	0.76

Table A1. Sources of Growth in Output per Worker, 1987-2(
Average annual percentage change

Industry title	Contribution of: Intermediate inputs per worker 1987-95	1995-00	2000-05	Multifactor productivity 1987-95	1995-00	2000-05
Service-production	**0.75**	**2.28**	**0.79**	**0.28**	**0.67**	**0.89**
Utilities	0.94	1.53	-1.05	1.42	0.62	0.91
Wholesale trade	1.68	0.29	0.84	1.44	2.83	1.44
Retail trade	0.68	1.04	1.29	1.67	2.50	1.99
Transportation and warehousing	0.45	0.62	0.31	1.09	0.81	1.08
Air transportation	-1.13	-0.05	3.54	1.64	2.22	3.27
Rail transportation	2.40	1.25	3.30	3.00	1.42	1.70
Water transportation	0.85	1.73	-1.20	2.26	0.36	-1.26
Truck transportation	1.91	2.21	-0.88	1.54	-0.19	0.67
Transit and ground passenger transportation	0.09	-2.70	-1.28	-0.32	0.46	-1.06
Pipeline transportation	0.57	2.87	3.67	0.37	1.51	1.26
Other transportation and support activities	0.23	-0.05	-0.74	-1.02	1.25	1.24
Warehousing and storage	0.78	-0.30	0.60	1.66	2.27	1.95
Information	1.34	4.50	3.51	1.06	0.18	3.07
publishing and data processing	2.16	2.99	1.72	0.73	0.93	4.34
Motion picture and sound recording industries	0.68	0.33	0.17	-1.30	-0.59	2.37
Broadcasting and telecommunications	0.95	6.33	5.14	1.70	-0.36	2.33
Finance and insurance	0.45	4.26	0.30	-0.06	0.44	0.79
Federal Reserve banks, credit intermediation, and relate	1.23	3.42	-1.60	-2.24	-3.04	1.05
Securities, commodity contracts, and investments	3.37	9.72	0.75	4.92	10.79	4.89
Insurance carriers and related activities	-1.21	0.08	3.19	-0.09	-1.00	-0.80
Funds, trusts, and other financial vehicles	-2.47	12.70	4.39	0.11	-3.46	0.83
Rental and leasing services and lessors of intangible ass	1.46	3.83	3.73	-0.23	-4.18	-3.55
Professional and business services	0.78	2.99	1.32	-0.70	0.39	1.11
Professional, scientific, and technical services	0.98	3.36	2.00	-0.20	1.36	1.74
Legal services	0.18	1.42	1.72	-0.46	0.10	1.11
Computer systems design and related services	1.92	3.15	-0.55	0.63	0.49	2.75
Miscellaneous professional, scientific, and technical serv	1.19	4.09	2.57	-0.19	1.89	1.72
Management of companies and enterprises	0.27	0.95	0.83	-0.98	-1.22	0.35
Administrative and waste management services	1.32	3.71	0.21	-0.38	-0.48	0.33
Administrative and support services	1.43	4.12	0.23	-0.36	-0.60	0.33
Waste management and remediation services	1.65	1.68	-0.57	-0.20	0.93	0.14
Educational services, health care, and social assistance	0.83	1.16	0.63	-1.43	-0.82	0.36
Educational services	0.87	0.75	-0.21	-0.51	-0.90	-0.36
Health care and social assistance	0.83	1.23	0.74	-1.56	-0.80	0.44
Ambulatory health care services	0.97	1.46	0.53	-2.21	-0.59	0.85
Hospitals and nursing and residential care facilities	0.93	1.16	1.16	-1.32	-1.12	-0.36
Social assistance	-0.09	1.15	-0.17	0.34	0.53	1.76
Arts, entertainment, recreation, accommodation, and food se	0.79	0.42	0.28	-0.15	0.42	-0.17
Arts, entertainment, and recreation	2.29	0.75	-0.70	1.06	0.04	-0.74
Performing arts, spectator sports, museums, and related	2.60	1.56	-1.22	1.65	1.59	-0.40
Amusements, gambling, and recreation industries	1.95	0.11	-0.23	0.55	-0.86	-1.02
Accommodation and food services	0.42	0.33	0.57	-0.43	0.14	-0.16
Accommodation	0.39	0.59	1.16	0.19	-0.52	-0.71
Food services and drinking places	0.41	0.24	0.34	-0.61	0.37	0.06
Other services, except government	1.25	2.43	0.70	0.10	-0.35	-0.34

Table A2. Sources of Growth in Value Added per Worker, 1987-2005
Average annual percentage change

	Value added per worker			Contribution of: Capital per worker			IT capital per worker			Multifactor productivity		
Industry title	**1987-95**	**1995-2000**	**2000-2005**	**1987-95**	**1995-2000**	**2000-2005**	**1987-95**	**1995-2000**	**2000-2005**	**1987-95**	**1995-2000**	**2000-2005**
Private Nonfarm (except real estate)	**1.40**	**2.49**	**2.51**	**0.48**	**0.89**	**0.83**	**0.42**	**0.82**	**0.52**	**0.92**	**1.58**	**1.67**
Goods-production	**2.36**	**3.01**	**2.85**	**0.52**	**0.70**	**0.91**	**0.30**	**0.53**	**0.25**	**1.83**	**2.29**	**1.93**
Forestry, fishing, and related activities	-3.88	-0.21	-1.36	0.25	-1.56	-0.97	0.33	-0.14	-0.12	-4.12	1.38	-0.90
Mining	3.99	0.53	-4.35	1.60	1.11	-0.17	0.35	0.41	0.28	2.35	-0.57	-4.19
Oil and gas extraction	5.26	-0.59	-2.61	2.27	2.49	-0.12	0.09	0.23	-0.05	2.92	-3.01	-2.50
Mining, except oil and gas	5.63	8.92	-2.07	0.05	1.39	0.45	0.36	0.76	0.26	5.58	7.43	-2.50
Support activities for mining	0.85	-2.85	-10.89	-0.24	-0.28	-2.55	0.11	0.35	-0.12	1.09	-2.58	-8.56
Construction	0.03	-1.18	-0.60	-0.14	0.98	0.45	0.14	0.44	0.17	0.17	-2.13	-1.05
Manufacturing	3.13	5.07	5.57	0.80	1.23	1.37	0.41	0.74	0.36	2.31	3.74	4.14
Durable goods	3.96	7.70	6.39	0.61	1.25	1.08	0.37	0.76	0.33	3.33	6.37	5.26
Wood products	-1.96	-0.78	2.67	-0.19	0.37	0.29	0.22	0.28	0.10	-1.77	-1.15	2.37
Nonmetallic mineral products	3.43	1.54	3.22	-0.09	0.30	0.95	0.19	0.40	0.30	3.52	1.24	2.25
Primary metals	2.58	2.57	7.15	-0.04	-0.08	0.96	0.09	0.15	0.10	2.62	2.65	6.13
Fabricated metal products	1.50	0.43	2.55	0.20	0.44	0.87	0.27	0.38	0.25	1.30	-0.01	1.66
Machinery	0.73	1.09	4.82	0.69	2.43	1.46	0.47	1.61	0.74	0.04	-1.35	3.31
Computer and electronic products	17.38	35.27	18.66	1.45	2.08	0.15	0.67	1.10	0.05	15.71	32.52	18.49
Electrical equipment, appliances, and components	2.58	1.47	5.41	1.22	0.77	2.46	0.35	0.32	0.37	1.34	0.69	2.88
Transportation Equipment (NAICS 336)	0.07	1.88	3.54	0.49	1.43	1.08	0.35	0.89	0.46	-0.41	0.39	2.44
Furniture and related products	0.55	1.98	4.71	0.47	0.84	1.22	0.17	0.32	0.23	0.09	1.13	3.44
Miscellaneous manufacturing	4.37	3.15	6.73	0.44	0.41	0.98	0.33	0.38	0.30	3.91	2.73	5.70
Nondurable goods	1.94	1.45	4.49	1.03	1.53	1.78	0.47	0.74	0.39	0.90	-0.13	2.67
Food and beverage and tobacco products	2.62	-3.17	1.25	0.69	0.26	0.62	0.27	0.38	0.21	1.92	-3.42	0.63
Textile mills and textile product mills	3.97	1.80	7.43	0.31	0.66	1.19	0.10	0.12	0.03	3.64	1.13	6.17
Apparel and leather and allied products	3.45	4.13	4.95	1.24	2.60	2.51	0.16	0.40	0.22	2.19	1.49	2.38
Paper products	0.15	0.68	5.87	0.86	0.80	0.87	0.34	0.41	0.22	-0.71	-0.12	4.96
Printing and related support activities	0.46	0.65	3.61	0.40	0.94	1.36	0.26	0.58	0.38	0.06	-0.28	2.22
Petroleum and coal products	-0.42	7.49	3.98	2.01	1.63	1.59	0.82	0.85	1.09	-2.38	5.77	2.34
Chemical products	1.55	2.25	5.06	1.64	2.35	1.28	0.98	1.43	0.37	-0.09	-0.10	3.73
Plastics and rubber products	2.69	3.61	3.85	0.36	1.21	1.75	0.17	0.30	0.22	2.32	2.37	2.07

Service-production	**1.06**	**2.34**	**2.43**	**0.55**	**1.06**	**0.89**	**0.48**	**0.98**	**0.64**	**0.50**	**1.27**	**1.53**
Utilities	4.39	3.20	4.43	2.03	2.10	3.41	0.54	0.61	0.80	2.31	1.08	0.98
Wholesale trade	2.99	5.91	3.16	0.54	1.71	1.00	0.33	1.02	0.53	2.44	4.13	2.14
Retail trade	3.19	4.46	3.83	0.65	0.56	0.55	0.26	0.33	0.24	2.53	3.88	3.26
Transportation and warehousing	1.70	2.46	2.29	-0.54	0.83	0.19	0.26	1.02	0.34	2.25	1.56	2.09
Air transportation	4.14	7.19	9.35	0.19	3.10	1.64	0.47	2.81	1.25	3.95	3.96	7.60
Rail transportation	5.36	3.33	3.43	0.48	0.91	0.60	0.12	0.19	0.01	4.86	2.40	2.81
Water transportation	8.78	2.75	-4.62	-0.36	0.81	-0.49	0.29	1.53	0.89	9.18	1.92	-4.15
Truck transportation	2.64	0.06	1.00	-0.58	0.42	-0.38	0.18	0.46	0.22	3.24	-0.35	1.39
Transit and ground passenger transportation	-0.96	1.87	-1.48	-0.21	1.01	0.35	0.19	0.66	0.33	-0.75	0.85	-1.83
Pipeline transportation	2.03	8.85	6.61	0.77	3.82	1.48	1.08	1.54	0.23	1.25	4.84	5.05
Other transportation and support activities	-2.50	2.31	1.41	-1.06	0.43	-0.22	0.32	1.10	0.14	-1.46	1.83	1.64
Warehousing and storage	1.63	3.48	2.85	-0.56	0.30	0.18	0.22	0.34	0.49	2.20	3.17	2.67
Information	3.45	2.53	9.62	1.53	1.87	2.74	1.15	2.32	2.01	1.89	0.65	6.69
publishing and data processing	2.51	2.61	11.28	1.06	0.60	2.25	1.09	1.20	1.59	1.44	2.00	8.82
Motion picture and sound recording industries	-2.42	-1.56	4.68	0.51	-0.19	-0.65	0.46	-0.26	-0.17	-2.92	-1.37	5.37
Broadcasting and telecommunications	5.09	3.10	9.28	2.30	3.03	3.60	1.53	3.44	2.73	2.73	0.07	5.48
Finance and insurance	2.24	3.63	2.57	2.40	2.60	1.19	1.42	1.50	0.63	-0.15	1.01	1.36
Federal Reserve banks, credit intermediation, and related activities	0.98	-0.56	1.93	4.40	4.43	0.36	2.53	2.94	0.56	-3.28	-4.78	1.57
Securities, commodity contracts, and investments	7.84	20.30	8.48	0.31	0.13	-0.17	0.21	0.25	-0.15	7.51	20.08	8.67
Insurance carriers and related activities	2.13	-0.16	-0.02	2.39	1.63	1.30	1.40	0.83	0.81	-0.26	-1.80	-1.30
Funds, trusts, and other financial vehicles	-0.22	-14.65	6.18	-0.56	1.95	2.81	0.02	0.15	0.01	0.34	-16.28	3.28
Rental and leasing services and lessors of intangible assets	2.32	2.92	-1.66	2.70	10.67	5.66	1.73	5.72	2.26	-0.37	-7.17	-6.93
Professional and business services	-0.64	1.19	3.08	0.34	0.52	1.25	0.31	0.80	0.99	-0.97	0.67	1.81
Professional, scientific, and technical services	0.10	2.56	3.96	0.35	0.43	1.11	0.30	0.83	1.00	-0.26	2.07	2.82
Legal services	-0.50	0.30	1.78	0.08	0.13	0.22	0.04	0.15	0.17	-0.58	0.17	1.56
Computer systems design and related services	0.90	1.87	4.94	0.16	1.13	1.29	0.33	1.56	1.20	0.74	0.69	3.60
Miscellaneous professional, scientific, and technical services	0.19	3.37	4.51	0.45	0.34	1.41	0.37	0.80	1.28	-0.26	3.02	3.05
Management of companies and enterprises	-1.18	-1.68	1.88	0.37	0.32	1.29	0.34	0.37	1.07	-1.55	-1.99	0.58
Administrative and waste management services	-0.21	0.08	2.11	0.29	0.77	1.58	0.35	0.98	0.93	-0.50	-0.69	0.52
Administrative and support services	-0.12	0.09	2.21	0.33	0.97	1.68	0.34	1.07	0.99	-0.46	-0.88	0.52
Waste management and remediation services	0.41	1.74	0.29	0.70	-0.28	0.09	0.47	0.23	0.32	-0.30	2.02	0.20
Educational services, health care, and social assistance	-1.79	-1.20	0.97	0.41	0.12	0.39	0.44	0.31	0.51	-2.19	-1.31	0.58
Educational services	-0.79	-1.29	-0.21	0.10	0.31	0.44	0.13	0.28	0.27	-0.89	-1.60	-0.65
Health care and social assistance	-1.95	-1.13	1.10	0.41	0.13	0.38	0.45	0.33	0.54	-2.36	-1.26	0.72
Ambulatory health care services	-2.74	-0.83	1.58	0.12	-0.04	0.32	0.33	0.32	0.71	-2.86	-0.79	1.25
Hospitals and nursing and residential care facilities	-1.84	-1.53	-0.27	0.47	0.47	0.36	0.50	0.41	0.33	-2.30	-1.99	-0.63
Social assistance	0.31	0.60	2.96	-0.25	-0.31	0.08	0.13	0.18	0.11	0.55	0.91	2.88
Arts, entertainment, recreation, accommodation, and food services	-0.04	0.98	-0.14	0.17	0.15	0.16	0.14	0.20	0.15	-0.20	0.83	-0.29
Arts, entertainment, and recreation	1.77	1.25	-0.59	-0.06	1.15	0.71	0.02	0.16	0.15	1.83	0.09	-1.29
Performing arts, spectator sports, museums, and related activities	2.95	3.21	0.00	0.24	0.42	0.72	0.03	0.18	0.18	2.71	2.78	-0.71
Amusements, gambling, and recreation industries	0.57	-0.23	-1.01	-0.51	1.23	0.74	0.01	0.16	0.13	1.08	-1.49	-1.74
Accommodation and food services	-0.60	0.99	-0.03	0.21	0.73	0.22	0.10	0.13	0.16	-0.80	0.26	-0.25
Accommodation	0.81	0.09	-1.29	0.51	0.81	-0.33	0.11	0.11	0.11	0.30	-0.71	-0.96
Food services and drinking places	-1.13	1.43	0.65	0.13	0.66	0.55	0.10	0.15	0.19	-1.26	0.76	0.11
Other services, except government	0.76	-0.90	-0.41	0.52	-0.43	0.18	0.26	0.34	0.17	0.24	-0.48	-0.60