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Is the 21st Century Productivity Expansion Still in Services?

And What Should Be Done About It?

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Introduction and Summary

The 20th century ended with an unexpected surge in U.S. productivity growth. The 21st century has opened with another. Labor productivity grew two and a half percent per year during 1995-2000, nearly double its growth rate over the previous two decades, and has exceeded three percent per year since 2000, in Bureau of Labor Statistics data.

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 in several respects 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.

Unlike previous researchers, we examined productivity in services industries. The post-1995 IT investment boom did create a capital deepening effect on services industry LP (IT investment goes overwhelmingly to services industries). In this, our services industry results parallel aggregate results of others.

We also 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.

Strong services industry MFP growth is real news—and significant news. The services sector contributed three-quarters of the economy-wide acceleration in MFP, a contribution that is

[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.

without historical precedent.[3] More than half of the newly robust services sector LP growth came from the unprecedented post-1995 acceleration of MFP growth in services, and much of the economy-wide LP growth is attributable to increasing MFP in services.

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).[4]

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 again accounts for the post-2000 surge in productivity. The 21st century and late 20th century productivity surges were both driven by strong investment that increased U.S. LP though capital deepening and by accelerating productivity (particularly by MFP) in services. The two surges have similar sources, the second productivity surge is just an extension of the first. The main difference in the two surges is in the composition of investment.

On the other hand, *at the industry level* the picture is 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 in the services sector. For this reason, the 21st century surge of services productivity at the *sector* level exceeds the increase at the services *industry* level. The same thing is true of the goods sector, but to a lesser degree. Reallocations matter if one intends to draw policy implications from, for example, differences between service sector performance in the U.S. and E.U.

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

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[3] Services industries also accounted for a substantial part of the economy-wide acceleration in LP. 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. Also, goods-producing industries include more than just manufacturing.

[4] 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.

Jorgenson and Griliches, 1967) provides the bridge to Part II of our paper, where we assess the adequacy of services sector data.

Part I

20th Century and 21st Century Productivity Expansions

A. Productivity Change in the 1995-2000 Period

Recently, BEA 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, Reinsdorf and Yuscavage 2006). 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.

We first use the revised BEA-BLS data to repeat the productivity change analysis for the pre- and post-1995 periods covered in our book (Triplett and Bosworth, 2004).[5] The two left-hand columns in Table 1 summarize.

Private nonfarm productivity growth nearly doubled after 1995 (Table 1). Goods-sector LP and MFP growth expanded after 1995, by about 30 percent. Services sector productivity grew much more. Services sector LP expanded from 1.0 percent per year before to 2.3 percent per year after 1995; services MFP growth expanded by a factor of 2.4, from 0.5 percent to 1.2 percent per year. Productivity in the services sector accelerated much more after 1995 than it accelerated in the goods sector, and this dramatic change drove much of the famed revival of U.S. productivity growth.

At sector aggregation levels, 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. However, the major Triplett and Bosworth (2004) finding—that productivity in services expanded much more

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[5] 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.

after 1995 than productivity in the goods sector—is unchanged, even though magnitudes of the estimates have changed considerably.

In the revised data, services sector productivity grew a bit more slowly over 1995-2000 than the productivity of goods sector industries, but services were clearly catching up.[6] Because in the pre-1995 period the services sector was by far the lagging sector, emergence of the services sector as a contributor to productivity advance—particularly to MFP growth—was the most strikingly different aspect of the post-1995 era. The extraordinary acceleration of services sector productivity has been too little noticed.

B. 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 1 shows, aggregate LP grew even faster through 2004 than it did during the post-1995 period that made so much news, advancing to nearly 3 percent per year, in BEA data (LP from the BEA industry database is slightly lower than the published BLS nonfarm LP number—see the discussion in Triplett and Bosworth, 2004, chapter 2, pages 9-13). We calculate that aggregate MFP has accelerated as well, to nearly 2 percent per year, a prodigious rate for an advanced economy.

The aggregated data indicate that the 21st century acceleration in U.S. productivity has again taken place largely in the services sector, as it did in the closing years of the 20th century. Indeed, goods sector LP increased imperceptibly after 2000 (remaining at 3.1 percent per year) and goods sector MFP has declined (the right-hand columns of Table 1). Services sector LP and MFP, on the other hand, continued to advance after 2000, to 2.8 percent per year for LP and 1.8 percent for MFP, the latter another big acceleration. Post-2000 services sector MFP growth is half again as high as its then-record 1995-2000 rate, and more than three and a half times the pre-1995 services MFP growth rate.

Although services sector productivity rates still lag those of the goods sector, the sector rates are converging: In the 21st Century, services sector LP and MFP are about 90 percent of the corresponding rates for the goods sector (e.g., for LP, 2.84/3.15 = 0.9, see Table 1). 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 reached near

[6] Previous data suggested that services industries' productivity growth exceeded that of the goods industries. The revised data show this is not yet the case.

parity in such a short time is one of the most remarkable—and overlooked—economic transformations of any era.

Turning now to the sources of strong LP growth, we use standard growth accounting methodology to decompose aggregate and sector LP growth into contributions from capital services, partitioned into IT capital services and other capital services, and from MFP. Our estimates are in Table 2.

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 LP growth during this period came from IT capital, as IT investment doubled its contribution to LP, compared to its 1987-1995 contribution (that is, its contribution went from 0.42 to 0.82 points). The IT contribution increased in both goods and services sectors, but in the services sector, IT made up a larger part of the total capital contribution (nearly all).[7]

Strong investment marked both 1995-2000 and 2000-2004. Indeed, the capital contribution to LP is the nearly the same in both intervals, and roughly double its contribution before 1995 (Table 2). However, the composition of investment changed after 2000. Others have observed correctly that non-IT investment picked up the slack created by the end of the IT boom. 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 fell, but not as much (to 0.7 points), the overall capital contribution remaining the same, at 1.0 points.

Strong IT investment in 1995-2000 has been well documented. But if IT boomed, MFP in services boomed more and its contribution to services LP more than doubled. The services sector MFP contribution, at 0.5 points previously, went to 1.2 points after 1995.

Strong growth in the MFP contribution to services LP also drove its increase after 2000. All of the 21st century increase in services LP is accounted for by the 50 percent increase in services industry MFP (from 1.2 to 1.8 points), as capital only retained its contribution in the

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[7] 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 1 (1.0 and 1.2 percentage points, for services sector IT and MFP contributions), the old were estimates were 1.0 and 1.52, respectively (Triplett and Bosworth, 2004, Table A-2, page 346).

sector. Since MFP in goods production slowed, all of the net economy wide increase in MFP, post-2000, took place in the services sector.

Judging from the aggregate and sector data, continued improvement in U.S. productivity in the post-2000 period is just as an extension of the trends we documented in our book for the previous period: Capital deepening economy wide and services sector MFP acceleration are driving the productivity advance. The main difference is the changed composition of investment, since the size of the total capital contribution remains as high as it was at the end of the 20th century (and double what is was before 1995).

Others who have contended that the two productivity surges were different have overlooked strong services sector productivity, the tie that binds them together.

C. Industry Productivity Growth Rates.

Tables 1 and 2 show *direct* productivity measures—value added is aggregated to the sector and aggregate levels and then divided 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.[8] Indeed, we compute growth accounting equations for each of these 57 industries. This permits us to analyze productivity performance within sectors and across industries. We aggregate the industry productivity measures to goods and services sector levels and to the aggregate level.

For the aggregation of industry LP measures, we use Stiroh's (2002) system:

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

where

LP^V = aggregate value added per worker,

LP_i^Q = gross output per worker in 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,

[8] 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.

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

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

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

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,

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, direct economy-wide and sector productivity measures reflect two forces—the effects of changes in the 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.

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, other things equal. If the released resources go to less productive industries, the reallocation reduces aggregate and sector productivity rates (the direct rates), and provides at least a partial offset to the direct impact on the sector rates from industry A's productivity gain. As another intuitive example, medical care is an industry with below average LP and MFP growth (though its productivity performance has been improving in recent years). Increasing the resources that go to medical care (for whatever reason) will shift the composition of resource use toward an industry with below average productivity change, and thereby subtract from aggregate and sector productivity.[9]

Few productivity researchers have paid attention to resource reallocation effects (an exception is Stiroh 2002, 2006). However, reallocation effects have been large in recent years, and have changed signs from one period to the next, thus shifting the relation between aggregate and industry productivity growth in unpredictable ways. Our estimates are in Table 3.

Begin with the top panel of Table 3, 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, in accord with equation (2). Aggregated industry LPs grew 2.0 percent in the 1987-95 period, rising to 3.4 percent in 1995-2000, then falling back to 2.9 percent in 2000-2004. If industries roughly correspond to production functions, and ignoring the well-known non-technological factors that shift MFP,[10] the aggregated industry LP rate estimates the aggregated combinations of factor substitution and technological shifts on LPs in the 57 industries.

The direct productivity rates from Table 1 are repeated in the fourth line of Table 3. For the direct rates, aggregated value added is divided by aggregated labor. The difference arises from reallocations of labor and of intermediate materials, which are shown in the second and third lines of Table 3. Reallocations have typically reduced the direct productivity rates: For example, for the 1995-2000 period both reallocation terms were negative and together they reduced aggregate LP by 0.9 points. During 1995-2000, the LPs of industries in the economy expanded considerably faster than economy-wide LP.

Similar calculations for sector productivity are presented in the other panels of Table 3. 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).

Taking the same 1995-2000 time period, services industries' LPs grew 3.5 percent per year, nearly double their pre-1995 rates. The services sector rate, however, showed even more

[9] Note that 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.

[10] 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 co-investments considered in much of the computer impact literature. See, among the large number of items that could be cited, Corrado et al (2004) and Brynjolfsson and Hitt (2000).

acceleration—2.3 times its pre-1995 rate—as the reallocations terms increased somewhat less rapidly than the industries' productivity rates, allowing more of the industry productivity advances to flow through into the services sector rate. Goods industries LPs and goods sector LP advanced by about the same amount, roughly 30 percent, in this period.

In the most recent period (2000-2004), net reallocations were nil, at the economy-wide level. Aggregation of the industry productivity rates (equals 2.9 percent) equals the direct rate. But because reallocation terms in 1995-2000 were large (and negative), smaller reallocation terms in 2000-2004 caused the aggregate rate to grow more rapidly post-2000 (at 2.9 percent, up from 2.5 percent), even as the industry rates declined from 3.4 percent to 2.9 percent, annually.

The same thing was true of sector and industries rates in goods and services. In both cases, reallocation terms became less negative after 2000. In both cases, comparing post-2000 with post-1995, sector rates rose (goods only narrowly), even as the industries LP rates fell. Goods industries productivities advanced after 2000, at 2.8 percent per year, but this was only by 88 percent of their rate of increase between 1995 and 2000. Services industries productivities advanced by 3.0 percent per year after 2000, which was 87 percent of their rate of increase for the previous period. By the industries LP rate (but not by the sector rate), services industries LP growth surpassed goods industries LP growth in the 21st century (3.0 percent annually, compared with 2.8 percent).

Note that reallocations within the good sector turned positive after 2000, led by strong positive intermediate materials reallocations. To our knowledge, this is the first time net reallocations have been positive for any sector.

Thus, one can ask: Have U.S. LP rates accelerated since 2000? The industry rates indicate that the answer to that is negative, for industry LP rates have fallen from 3.4 percent to 3.0 percent. But the direct rate has accelerated, from 2.5 percent to 2.9 percent, because the reallocations across industries have become less negative. In the years of the 21st century, the U.S. economy has shifted less than it did in previous times toward the industries that have lower productivities.

Similar questions about goods and services sectors yield similar answers. As we have already explained in section B, when measured by direct productivity rates, services sector LP accelerated after 2000 (from 2.3 to 2.8 percent), and goods sector LP increased imperceptibly (remaining at 3.1 percent). However, aggregating the goods industries' and services industries'

LPs, we find (middle panel of Table 3) that they both fell, compared to end of the 20th century rates. Goods industries' productivities dropped more (from 3.2 to 2.8 percent), but services industries' productivities also fell (from 3.4 to 3.0 percent).

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, one might speculate that they improved the measurement of economic interindustry flows in the industry accounts. If so, then the new estimates of reallocation effects are revealing an economic phenomenon that was probably always important in industry productivities, but was hidden by the less effective methodology of the past.[11]

We think that more analysis of reallocation effects is needed. For example, recent U.S. productivity performance relative to the E.U. has given much fodder for policy discussions. 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 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.[12]

D. Services Industry Productivity Measures.

As we have used it, the BEA industry dataset contains 24 goods-producing industries and 33 services industries, at roughly the 3-digit level of the NAICS classification. Analysis of the industry data reveals that productivity advance in both goods and services industries, post-2000, remains broadly based.

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[11] 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.

[12] 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.

As table 4 shows, 23 of those 33 services industries (70 percent) experienced more rapid LP growth after 1995. Of the 23 industries whose LP accelerated post-1995, 17 of them experienced an *additional* acceleration after 2000, even though in this period the proportion that advanced over their pre-1995 rates declined. Taking both subperiods periods together, 23 of the 33 services industries (70 percent) had higher LP growth over the 1995-2004 interval, compared with their pre-1995 rates, and in only 6 of the 33 services industries (3 of them in transportation) did LP fail to advance over pre-1995 rates in at least one of the two post-1995 subperiods.[13]

On the other hand, measured by this metric goods-producing industries did as well in the revised data, especially after 2000. Of the goods industries, 79 percent (19 of 24) advanced, comparing 1995-2004 LP rates to their pre-1995 rates. Productivity advance in the goods-producing industries was not narrowly located in electronics. [14]

MFP shows less regularity in the revised data. As Table 5 shows, less than half of services-producing industries (42 percent) had higher MFP growth at the end of the 20th century, a percentage matched exactly by the proportion of goods-producing industries whose MFP rates expanded. But considering the whole period 1995-2004, goods and services industries advanced in MFP in about the same proportion (three-fifths) for the whole period after 1995.[15]

It is instructive to review the 10 contrary services industries—those whose LP and MFP over the *combined* 1995-2004 interval failed to accelerate, compared with pre-1995 rates. Four are in transportation. One of these (rail) actually had above average LP growth over the whole period (4.6 percent per year) and fairly strong MFP growth as well, but it did not attain its (high) pre-1995 rates. LP and MFP growth in three other transport industries (water, truck and transit) turned negative. They deserve further study. Only trucking has any kind of productivity literature—government trucking industry measures seem inconsistent with Hubbard's (2003) results.

[13] 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.

[14] In both goods-producing and services-producing industries, there was to an extent reversion toward the mean in the post-2000 data. The really striking LP rates in 1995-2000—19.7 percent per year in computers and electronics and 21.7 percent per year in brokerage—were not repeated post-2000.

[15] Using the old data, we found that about 60 percent of services industries advanced. In this, data revisions have weighed in, reducing the proportion of services industries that advanced in the initial productivity surge, but in the end, the proportion is restored for the 1995-2004 period as a whole.

Of the non-transportation industries that have not experienced accelerating productivity growth, a number present measurement problems. The Federal reserve and credit intermediation industry (negative MFP or LP rates in each of the periods) 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 that is discussed in chapters 5 and 7 of our book (see also 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 mismeasured, as we point out in chapter 9 of our book, and education may also be the archetypal "Baumol's disease" industry (Baumol 1967). Performing arts and amusements are now also negative productivity growth industries, both LP and MFP, for reasons that are not clear (we pointed out in our book that there is virtually no research 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 mismeasurement in some industries that show high measured LP growth rates. Airline transport—whose measured LP became strongly positive, post-2000—is one example and telecommunications possibly another.

We interpret the wide diffusion of LP advance across industries as more support for our major finding: 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 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). The U.S. economy has been blessed by a fundamental change in its productivity performance that was as unexpected at the time it occurred as it is difficult to explain now. 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.

Conclusion to Part I

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. In our findings, the contributions of services productivity were larger than the other two factors.[16]

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. On the other hand, 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. Reallocations have boosted services sector productivity relative to services industry productivity. It is still true that the foremost change in the U.S. economy after 1995 was the revival of U.S. services industries. But whether there was a 21st century productivity surge (over 1995-2000), and whether it was a surge in services, depends on how one asks the question: At the sector level both are true; at the industry level they are not, or at least not entirely.

Part II

The State of Data for Services Productivity Measurement

In this part, we discuss data needs and important improvements in the statistical base for analyzing productivity. However, we do not wish to slight the enormous changes that the

[16] 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).

statistical agencies have made over the past decade and a half, beginning roughly with the "Boskin Initiative," former CEA chairman Michael Boskin's effort to improve services sector data (see its description in the note in *Survey of Current Business*, January, 1991). The situation on services data is far better today than it was when Martin Baily and Robert Gordon (1988) reviewed the consistency of industry data for productivity analysis or when Zvi Griliches (1992, 1994) reviewed the state of the data on output and productivity measurement in the services industries. A tremendous amount has been accomplished.

The major improvements include the following:

- The Bureau of Economic Analysis has made vast improvements in the industry accounts, which now include (for some 60 industries) measures of output and intermediate inputs (not just value added, as in the old days). The BEA industry accounts can be linked to BEA capital stock and (with some difficulty) to capital and labor services estimated by the Bureau of Labor Statistics.
- The BLS Producer Price Index (PPI) program has extended its price measures to cover a large and ever-growing number of services industries. The PPI has not only moved into an area that needed attention, it has done so with noteworthy innovation and commendable professional analysis.
- The Census Bureau enlarged the coverage of the periodic Economic Censuses in 1992, and expanded its annual services surveys. Additional information on the output of services industries and on purchased services inputs are among the outcomes from these expansions.
- Continuing work on deflators for high-tech capital goods has been carried out in BEA, BLS and the Federal Reserve Board. IT and other high-tech capital is prominent in the services industries, and the improvements in the deflators have made it possible to estimate the impact of IT investment on labor productivity in services (and in goods-producing) industries.
- BEA greatly improved its measures of capital stock, especially by modernizing its measures of depreciation, and BLS has used those improved capital stock measures to estimate capital services. Thus, we now have capital services measures for all using industries that distinguish between different types of investment, such as IT.

With the background of these substantial improvements, it is appropriate to assess where data development should be heading.

A. Inconsistent Labor Input: The Statistical System's Implementation of NAICS[17]

Data improvements often bring to the fore data problems that, though possibly existing before, were either hidden or less consequential. One major example occurred when the BEA industry accounts were initially improved several years ago: Discrepancies between alternative approaches to value added (see Triplett and Bosworth, 2004, pages 9-11 and 323-327), would not have been transparent to users before BEA revised and improved the industry accounts to construct them on the basis of gross output. This problem is one that has received attention of late (Moyer, Reinsdorf and Yuscavage, 2006), and is one of the major improvements described in the next section.

A second example has arisen recently, and affects our own productivity analysis, as well as the productivity estimates of others. BLS and Census have always assigned industry classifications independently, based on different data, and it has always been known in the statistical literature that industry classifications carried out by the two agencies differ, in some cases by substantial amounts. In the past, economists lived with these differences and hoped they did not affect their results.

In the changeover from the old U.S. SIC system to NAICS, however, the old dual BLS-Census classification problem has become worse. The following summary represents our understanding at the time of writing, but may need revision after additional consultation with the agencies.

Following past practices for industry classification revisions, Census prepared a NAICS-SIC bridge table from data collected for the 1997 Economic Census—that is, for a single year, but on an annual basis. Subsequently, an FRB project (Bayard and Klimek, 2003) used Census establishment microdata to reclassify manufacturing establishments in previous Economic Censuses to NAICS; by providing a series of SIC to NAICS bridges, it created a more nearly consistent NAICS industry time series than was ever the case for earlier SIC classification system changes (which were limited by a single bridge period). BEA adopted at least part of the Bayard-Klimek reclassifications in its industry accounts, so that BEA's NAICS time series for

[17] A personal disclaimer: Triplett was chair of the U.S. committee that designed and negotiated NAICS 1997 with the statistical agencies of Canada and Mexico.

industry outputs, intermediate inputs and capital services has much more time series consistency in it than has ever been true in the past.[18]

Improvement in the consistency of the non-labor variables, however, heightens the long-standing Census-BLS coding inconsistency, for the BEA industry file gets its labor data from BLS. For its establishment employment and earnings series (often called the 790), BLS carried out its NAICS-SIC bridge with data for the first quarter of 2001. Not only is the BLS employment bridge a bridge for a single quarter, it is not even the same year as the Census bridge. The time series of NAICS employment by industry was then "ratioed" backward to 1990 by the bridge for this single quarter.[19]

BLS used its first quarter 2001 information in another way, to reclassify the establishments in its universe (which is constructed from employer Unemployment Insurance reports filed with the states). It then followed these reclassified establishments back to 1990, with imputations for establishments that were not in the 2001 database (information obtained from BLS). These reclassified establishments created another NAICS employment series in the BLS Quarterly Census of Employment and Wages (QCEW, formerly called the 202). The reclassified QCEW employment series, with some additional information from the Census Bureau's Country Business Patterns, forms the basis for the employment data in the BEA industry file.

The two methods used by BLS (ratioing by the proportions observed in 2001 and reclassifying establishments by their activities in 2001) will not yield the same NAICS industry time series. BLS has told us that they gave surprisingly close results in most industries and that in industries where the two methods differed, they considered the QCEW results in constructing NAICS series for the 790.

Nevertheless, we compared annual employment estimates in the BEA industry file (which are based on QCEW data) and employment data maintained by the BLS Office of

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[18] The 1987 SIC revision restricted changes in classifications that crossed the old 2-digit boundaries, roughly the level of detail in BEA industry accounts. Accordingly, earlier industry classification changes created fewer problems for BEA industry accounts than did NAICS, where classification changes were not so restricted. Offsetting this, industries the old BEA input-output accounts did not match SIC industries, so much reallocation was required, for which data were frequently sketchy. Such reallocations have been reduced under NAICS because NAICS classifications match I-O principles.

[19] "Ratios established for March 2001 were used to map employment from SIC to NAICS in order to form the NAICS-based history for each series…. These ratios were used to reconstruct the series back to its stating date of 1990." Morisi (2003, page 4). The article suggests that establishments were contacted over a number of years to obtain their NAICS codes. See also Strifas (2003), who provides a similar description of the BLS bridge.

Employment Projections (which come from the 790 series). We chose these two sources of employment data because they are used by many productivity researchers. In our studies, we employ BEA data. Other industry researchers (for example, Stiroh 2006 and Jorgenson, Ho and Stiroh 2005) have used OEP employment data. It is important to understand whether the two industry employment series are incompatible in order to assess whether incompatibility affects results obtained by different productivity researchers.

Results of our analysis are summarized in the upper panel of Table 6.[20] Using annual data for 1990-2004, we first computed for each industry annual ratios of the two employment series. We then computed the mean value of the ratio for each industry: For example, the mean value of the ratio of 790 to QCEW employment in the wood products industry is 97.8 (the 790 is 2.2 percent lower) and for rail transport is 106.5 (6.5 percent higher). We also computed the standard deviation of the ratio and its range: Referring again to rail transport, the range is 16.9. For productivity analysis the range may be more important, because large deviations could produce anomalies in LP numbers where mere variability in the employment series may simply combine with other variability.

Finally, we computed least square trends for each ratio. As Table 6 indicates, a very large number of these trend coefficients are statistically significant (highly so), and some of them are quite large. For example, rail transport has an average drift of 1.0 points per year, motion pictures and brokerage 1.3 points, and so on.

Our analysis suggests serious inconsistencies between the employment data that we use for our industry LP and MFP measures (the BEA file) and the employment data used by, for example, Stiroh (2006), the OEP file. This is true even though both datasets were obtained ultimately from BLS. We have not computed alternative LP estimates using the two employment series, but the variability and trend differences in some of these industries are a cause for concern. For example, the average drift in the motion picture and sound recording industry is 1.3 points per year; over the 15 years of our study, this amounts to a 21 percent difference in the labor input, more than enough to alter one's perception of LP growth in this industry (which we estimated, using BEA data, at only 1.2 percent per year from 1995-2004—though 3.2 percent per year for 2000-2004).

[20] One should not make too much of the entries for the Agriculture group, since BLS does not actually survey most of these industries for its employment programs. They are in the OEP file, and hence would be used by any researcher who used that file. Presumably, OEP supplements BLS data with data for other sources.

An additional question is whether BEA's output, intermediate input and capital services measures are consistent with either BLS employment series. BEA obtains the former from Census Bureau information (annual surveys and 5-year Economic Censuses). The Census Bureau classified establishments to NAICS using different information from that used by BLS, and for different time periods. The Census and BLS data may differ, as well, for other reasons—differences in their sampling frames, for example, but we do not explore that directly here.[21]

Bayard and Klimek (2003) produced bridges for Census data on employment (also production worker employment) in manufacturing industries, using reclassified establishments for Economic Censuses back to 1982. We understand that additional bridges for wholesale and retail trade and for some services have been created. Corrado, et al (2006) used the Bayard-Klimek employment time series in their industry productivity study.

We obtained the Corrado et al. data (many thanks to the authors). We carried out an identical comparison to the one we carried out for the BEA and OEP employment estimates. Results are in the right-hand columns of Table 6.

Again, trends differ across the two employment series and for a large number of industries, trend differences are highly significant. The two panels of Table 6 look very similar, suggesting substantial inconsistency among the alternative industry employment series.

Corrado, et al (2006) point especially to the management of companies and enterprises industry (a new one under NAICS). The level difference is particularly great for the Census-BEA comparison. However, the variability and trend difference for the BEA-Census comparison are matched by equally large values for the two BLS series. This industry appears problematic even within the BLS tabulations.[22]

The Economic Census contains the production and output data necessary for industry classification of establishments and BLS data do not (a special survey is required). Accordingly,

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[21] A joint project is underway to resolve these differences (the Business Register project), or at least to understand them.

[22] Though this is a new industry in NAICS, the inconsistency in its coding is not a new statistical result, but rather one that has only become apparent with the new industry classification system. Many of the establishments in the management of companies and enterprises industry would have been classified as "auxiliaries" in the old SIC system and placed in the industries they supposedly served (e.g., the management office of some conglomerate enterprise would have been put in an industry where its largest sales occur). But abundant evidence existed that BLS and Census were not classifying auxiliaries in the same industries, though these classification differences were often hidden in the detailed industry data produced under the old SIC system. The change in NAICS has not made the data worse, rather it has high-lighted a problem that existed before but did not get sufficient attention because it was not generally known among users of industry data.

we think that Census assignments of industry codes are more accurate, regardless of the merits of the long-standing inter-agency dispute over which establishment frame is better. Set against this, the accuracy of the codes may decline as the Economic Census recedes into the past, and some codes are assigned from other data, such as Social Security filings, particularly for smaller establishments. Indeed, we have been told (communication from BLS) that BLS recently provided some 2.4 million codes to Census to supplement Census information.

B. The Data Recommendations Table.

Triplett and Bosworth (2004) culminated a five-year Brookings Institution Program on Economic Measurement. The program hosted 15 workshops, each one devoted to a services sector measurement topic—either measurement problems in specific industries, such as measuring the output of retail trade or of transportation, or discussion of some issue that affects services industries broadly, such as the workshop on deflators for high tech equipment. Each workshop contained presentations from academic and research institution economists and also presentations from the statistical agencies. The full list of workshops, with the names of participants, appears in Appendix B of Triplett and Bosworth (2004). Many of the papers are posted on the Brookings Institution website: http://www.brookings.edu/es/research/projects/productivity/workshops.htm.

Because the comments, general discussion, and exchange of views at the workshops became so valuable a part of their output, Triplett and Bosworth prepared summaries of most of them; the summaries are also posted on the Brookings website. The content of these summaries, in turn, combined with conclusions from our own research, informed the data critiques and needs discussions in the individual chapters of our book.

Chapter 11 (“Data Needs”) of Triplett and Bosworth (2004) lists major data recommendations, most of which cut across services industries. Other, more specific, recommendations occur in the other chapters. However, no convenient summary appears in the book. The present paper provides that summary, in the form of Table 7, which also gives some indication of improvements that the agencies have made since our book was written. The table thus provides our assessment of the state of measurement in services industries. When read in conjunction with the list of agency accomplishments, it assesses the state of data development at the time that the Brookings Program on Economic Measurement ended.

Notes in the right-hand column of Table 7 record where the agencies have made additional improvements in the interim. However, no doubt some relevant work in statistical agencies has escaped our attentions.[23]

Although the first 18 items in the table have some priority because they are, for the most part, cross-cutting matters that affect a large number of services industries, we do not rank our recommendations. We have not tried to set priorities for the agencies, but rather to give them a wish list that arises out of the needs for productivity research.

The list is, obviously as well, a list of data needs for productivity measurement and analysis and takes no account of priorities for other purposes. For example, Census and BEA put quarterly measures of services output, needed for quarterly GDP estimates, ahead of expansion of detail (particularly, of purchased inputs by services industries) in the annual services industries surveys. The latter would have ranked higher for productivity analysis. We do not necessarily contend that the BEA and Census decision was the wrong one (though we wish that it had been more widely discussed). Rather, we are pointing out that data needs and priorities may conflict among important uses of services data. Productivity analysis, though an important topic and one that provides an integrating framework for assessing data adequacy and consistency, is not the only statistical priority.

As a final remark, our list clearly represents only our own views, though they have been informed by the participation of a large number of economists in the Brookings workshops. Others might devise a somewhat different list. But in any event, our list can serve as the basis for discussion of priorities for future data development in the services sector.

The Recommendations. With respect to our detailed recommendations, it is noteworthy that some of the topics where we cited the agencies for excellent work (above) also appear in Table 7—PPI indexes for services, Census collection of purchased inputs, improved deflators for high tech goods (numbers 1, 2, and 36-40 in the table) are examples. The statistical system was a very late starter on measuring the services economy (services first accounted for more than half US employment in 1940, but serious services data collection only began in the 1980s and 1990s). Much has been done in a relatively short time, but much difficult work remains.

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[23] We appreciate reviews of the information in this table by Roslyn Swick and Michael Holdway of BLS and Ruth Bramblett of BEA, who have updated some of the agency plans in the "work underway" column.

Only two of our recommendations have been rejected by the agencies to date (though others have not been acted upon). Our #13, to add cost of disease accounting to the National Health Expenditure (NHE) Accounts, has been rejected by the compilers of these accounts, even though their own advisory committee endorsed our recommendation last year. The importance of the cost of disease dimension is great: At present, the NHE tells us who provides the money for medical care and who gets the money, but not what is purchased with medical care expenditures. We literally do not know, from the NHE, whether medical costs are increasing because of cancer treatments or because of setting broken bones. Any sensible debate about medical care costs cannot proceed without information about what we are spending the money for and where the costs have been rising. Additionally, all the relevant economic research on medical deflators, and all the scientific research on which the economic research relies, occurs at the disease level. Improved deflators for, e.g., heart attacks and mental health (Cutler et al, 1998; Berndt, Busch and Frank, 2001) have lesser value without matching expenditure categories to deflate, which the national health accounts have refused to provide. We hope for progress, however. BEA has taken up our recommendation and is progressing toward producing cost of disease accounting in a projected health care "satellite account."

Our recommendation #16, to change the national accounts concepts for the output of banking and of insurance has been rejected rather emphatically by BEA. In this case, BEA follows the System of National Accounts (SNA), the international guidelines for national accounts. BEA shows no inclination to push for change, rather it has vigorously defended the SNA approach in professional presentations. We remain hopeful that BEA will reconsider, particularly since we have shown that the BEA concept for insurance causes understatement of insurance industry productivity growth, which is very low in the presently published data (Triplett and Bosworth, 2004, chapter 6). On the issues in finance output, see Triplett and Bosworth (2004, chapter 7) and Basu, Inklaar and Wang (2006).

Where no action has been taken, a number of reasons no doubt exist. Agencies might not agree with some of our recommendations (but have not told us so), they might agree but the item might be lower on their priorities, or because a number of our recommendations will require substantial research and development, agencies might not yet have had time to implement them. Nevertheless, we believe our list has value as a basis for discussion, which is the purpose of presenting it here.

Conclusions to Part II

The title of our paper has two questions. To the second one (What should be done?), our answer is: Improve, still further, the data.

References

Aizcorbe, Ana, Kenneth Flamm, and Anjum Khurshid. "The Role of Semiconductor Inputs in IT Hardware Price Decline: Computers vs. Communications." In Ernst R. Berndt and Charles M. Hulten, eds. *Hard-to-Measure Goods and Services: Essays in Memory of Zvi Griliches*. University of Chicago Press. forthcoming

Anderson, Richard G. and Kevin L. Kliesen. "The 1990s Acceleration in Labor Productivity: Causes and Measurement." *Federal Reserve Bank of St.Louis Review*, May-June, 2006, pp. 181-202.

Baily, Martin N., and Robert Gordon. 1988. "The Productivity Slowdown, Measurement Issues, and the Explosion of Computer Power," *Brookings Papers on Economic Activity* 1988(2): 347–420.

Basu, Susanto, Robert Inklaar, and Christina Wang. 2006. "The Value of Risk: Measuring the Services of U.S. Commercial Banks." Paper presented at the NBER Summer Institute, Cambridge, Mass.

Bayard, Kim and Shawn Klimek. "Creating a Historical Bridge for Manufacturing between the Standard Industrial Classification System and the North American Industry Classification System." *2003 Proceedings of the American Statistical Association, Business and Economic Statistics Section* [CD-Rom, 2004], pp.478-84.

Baumol, William J. 1967. "Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis." *American Economic Review* 57 (3): 415–26.

Berndt, Ernst R., Susan Busch and Richard G. Frank. 2001. "Treatment Price Indexes for Acute Phase Major Depression." In David Cutler and Ernst R. Berndt, eds. Medical Care Output and Productivity. :NBER Studies in Income and Wealth, Vol. 62. University of Chicago Press.

Bosworth, Barry P., and Jack Triplett. forthcoming. "Services Productivity in the United States: Griliches' Services Volume Revisited." In Ernst R. Berndt and Charles M. Hulten, eds. *Hard-to-Measure Goods and Services: Essays in Memory of Zvi Griliches*. University of Chicago Press. Forthcoming

Brynjolfsson, Eric, and Lorin Hitt. 2000. "Beyond Computation: Information Technology, Organizational Transformation, and Business Performance." Journal of Economic Perspectives. Vol. 14, no. 4.

Corrado, Carol, Dan Sichel and Charles Hulten. 2005. "Measuring Capital and Technology: An Expanded Framework." In Carol Corrado, John Hultiwanger and Dan Sichel, eds. *Measuring Capital in the New Economy.* University of Chicago Press.

Corrado, Carol, Paul Lengermann, Eric Bartelsman, and J. Joseph Beaulieu. 2006. "Modeling Aggregate Productivity at a Disaggregate Level: New Results for U.S. Sectors and Industries." Paper presented at the NBER Summer Institute, Cambridge Mass.

Cutler, David M., and others. 1998. "Are Medical Prices Declining? Evidence from Heart Attact Treatments." *Quarterly Journal of Economics* 113 (4): 991–1024.

Doms, Mark. 2005. "Communications Equipment: What Has Happened to Prices?" In Carol Corrado, John Hultiwanger and Dan Sichel, eds. *Measuring Capital in the New Economy*. University of Chicago Press.

Gordon, Robert. 2000. "Does the 'New Economy' Measure up to the Great Inventions of the Past?" *Journal of Economic Perspectives* 14 (4): 49–74.

Griliches, Zvi. 1992. "Introduction." In Zvi Griliches, ed., *Output measurement in the service sectors*, National Bureau of Economic Research Studies in Income and Wealth, Vol. 56. Chicago: University of Chicago Press, pp. 1-22.

Griliches, Zvi 1994. "Productivity, R&D, and the Data Constraint." *American Economic Review* 84 (1): 1–23.

Hubbard, Thomas N. 2003 " Information, Decisions and Productivity: On Board Computers and Capacity Utilization in Trucking." *American Economic Review*, vol 94, no. 4 (September): 1328-1353.

Inklaar, Robert and Marcel P. Timmer. 2006. "Accounting for Growth in Retail Trade: An International Productivity Comparison." Gronigen Growth and Development Centre, University of Gronigen. March.

Inklaar, Robert, Mary O'Mahoney and Marcel Timmer. "ICT and Europe's Industry-level Growth Account Comparisons with the United States." Gronigen Growth and Development Centre, Research Memorandum GD-68, December, 2003.

Jorgenson, Dale W. 2001. "Information Technology and the U.S. Economy." American Economic Review, Vol.91 No. 1 (March): 1-32.

Jorgenson, Dale W. and Zvi Griliches. 1967. "The Explanation of Productivity Change." *The Review of Economic Studies,* 34(3) (July), pp. 249-83.

Jorgenson, Dale W., Frank M. Gollop, and Barbara M. Fraumeni. 1987. *Productivity and U.S. Economic Growth*. Harvard University Press.

Jorgenson, Dale W., and Kevin J. Stiroh. 2000. "Raising the Speed Limit: U.S. Economic Growth in the Information Age." *Brookings Papers on Economic Activity* (2): 125–211.

Jorgenson, Dale W., Mun S. Ho and Kevin J. Stiroh. 2005. "Information Technology, Education, and the Sources of Economic Growth across U.S. Industries." In Carol Corrado, John Hultiwanger and Dan Sichel, eds. *Measuring Capital in the New Economy.* University of Chicago Press.

Morisi, Teresa L. "Recent Changes in the National Current Employment Statistics Survey. *Monthly Labor Review*, June 2003, pp. 3-13.

Moyer, Brian C., Marshall Reinsdorf and Robert E. Yuscavage. 2006. "Aggregation Issues in Integrating and Accelerating the BEA's Accounts: Improved Methods for Calculating GDP by Industry." In Dale W. Jorgenson, J. Steven Landefeld and William D. Nordhaus, eds. A New Architecture for the U.S. National Accounts. NBER Studies in Income and Wealth, Vol. 66. University of Chicago Press.

Oliner, Stephen D., and Daniel E. Sichel. 2000. "The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?" *Journal of Economic Perspectives* 14 (Fall): 3–22.

O'Mahony, Mary, and Bart van Ark. 2003.EU Productivity and Competitiveness: An Industry Perspective. Luxembourg: Office for Official Publications of the European Communities.

Stiroh, Kevin. 2002a. "Information Technology and U.S. Productivity Revival: What Do the Industry Data Say?" *American Economic Review* 92 (5): 1559–76.

Strioh, Kevin. 2006. "The Industry Origins of the Second Surge of U.S. Productivity Growth." Federal Reserve Bank of New York Working Paper. July.

Strifas, Sharon. "Revisions to the Current Employment Statistics National Estimates Effective May 2003." *Employment and Earnings,* June 2003, pp. 3-13.

Triplett, Jack E. and Barry P. Bosworth. 2006. "'Baumol's Disease' Has Been Cured: IT and Multifactor Productivity in U.S. Services Industries." In Dennis W. Jansen, ed. *The New economy. How New? How Resilient?*

Triplett, Jack E. and Barry P. Bosworth. 2004. *Services Productivity in the United States: New Sources of Economic Growth*. Washington, D.C.: Brookings Institution Press.

Table 1. Productivity Growth in Goods and Services-Producing Sectors, 1987-2004

Directly measured, average annual rates of change

	1987-95	1995-00	2000-04
Labor Productivity			
Private Nonfarm	1.41	2.48	2.91
Goods-Producing Sector	2.40	3.07	3.15
Services-Producing Sector	1.02	2.30	2.84
Multifactor Productivity			
Private Nonfarm	0.92	1.57	1.92
Goods-Producing Sector	1.86	2.33	2.02
Services-Producing Sector	0.47	1.24	1.81

Source: New NAICS-based industry data set with BEA post-2003 revisions.

Table 2. Aggregate and Sector Labor Productivity Growth and Contributions, 1987-2004

Average annual percentage rates of change

	1987-95	1995-00	2000-04
Private Nonfarm			
Labor productivity	1.41	2.48	2.91
Capital contribution	0.48	0.89	0.97
of which: IT	0.42	0.82	0.57
Multifactor Productivity	0.92	1.57	1.92
Goods-producing sector			
Labor productivity	2.40	3.07	3.15
Capital contribution	0.53	0.72	1.11
of which: IT	0.30	0.53	0.29
Multifactor Productivity	1.86	2.33	2.02
Services-producing sector			
Labor productivity	1.02	2.30	2.84
Capital contribution	0.55	1.05	1.01
of which: IT	0.47	0.98	0.69
Multifactor Productivity	0.47	1.24	1.81

Source: New NAICS-based industry data set with BEA post-2003 revisions

Table 3. Labor Productivity by Major Sector and Reallocations, 1987-2004

Sector	1987-1995	1995-2000	2000-2004
Nonfarm business (aggregated)	1.95	3.39	2.95
Intermediate input reallocations	-0.25	-0.83	0.42
Labor reallocations	-0.31	-0.10	-0.47
Nonfarm business sector (direct)	1.41	2.48	2.91
Aggregated goods-producing industries	2.31	3.21	2.81
Intermediate input reallocations	0.15	0.15	0.42
Labor reallocations	-0.05	-0.29	-0.09
Goods producing sector (direct)	2.40	3.07	3.15
Aggregated services-producing industries	1.80	3.45	2.99
Intermediate input reallocations	-0.41	-1.19	0.41
Labor reallocations	-0.38	0.04	-0.57
Services producing sector (direct)	1.02	2.30	2.84

Table 4
Industry Labor Productivity Accelerations, 1987-2004

Number of goods industries with:	1995-00/ pre-1995	2000-04/ pre-1995	1995-2004/ pre-1995
Increasing LP rates	13	16	19
Decreasing or unchanged LP rates	11	8	5
Total	24	24	24
Percent increasing	54%	67%	79%
Number of services industries with:			
Increasing LP rates	23	12	23
Decreasing or unchanged LP rates	10	12	10
Total	33	33	33
Percent increasing	70%	64%	70%

Table 5
Industry MFP Accelerations, 1987-2004

Number of goods industries with:	1995-00/ pre-1995	2000-04/ pre-1995	1995-2004/ pre-1995
Increasing MFP rates	10	17	14
Decreasing or unchanged MFP rates	14	7	10
Total	24	24	24
Percent increasing	42%	71%	58%
Number of services industries with:			
Increasing MFP rates	14	22	20
Decreasing or unchanged MFP rates	19	11	13
Total	33	33	33
Percent increasing	42%	67%	61%

Table 6. Comparison of Wage and Salary Employees by Industry, BLS, BEA, and FRB, Summary Statistics [a]

		Annual data covering 1990-2004							
		Ratio of BLS to BEA				Ratio of FRB to BEA			
Code	Industry	Mean	Standard Deviation	Max minus min	OLS Trend Line	Mean	Standard Deviation	Max minus min	OLS Trend Line
2	**Private industries**	96.9	0.3	0.8	0.0**	100.1	0.0	0.1	-0.0***
	Non-farm goods	97.8	0.9	2.3	-0.2***	95.7	0.4	1.4	-0.1***
	Services less real estate	96.6	0.6	1.7	0.1***	101.4	0.1	0.3	0.0
3	**Agriculture, forestry, fishing, and hunting**	89.8	8.8	24.8	-1.4**	97.9	2.1	4.9	0.4***
4	Farms	126.4	10.5	33.7	-1.1	99.8	0.3	1.3	0.0
5	Forestry, fishing, and related activities	34.7	2.7	9.2	-0.5***	94.8	5.6	13.0	1.2***
6	**Mining**	100.5	1.3	4.6	-0.2***	88.9	0.8	2.9	-0.1*
7	Oil and gas extraction	98.0	1.0	4.5	0.1	63.0	5.2	13.6	1.1***
8	Mining, except oil and gas	99.9	1.2	4.8	-0.2***	92.9	0.7	2.6	-0.1***
9	Support activities for mining	103.9	3.9	13.0	-0.7***	107.8	10.7	26.3	-2.2***
10	**Utilities**	99.9	0.6	1.9	0.0	108.6	4.0	10.9	0.8***
11	**Construction**	97.0	0.5	1.5	-0.1*	93.0	1.0	2.7	-0.2***
12	**Manufacturing**	100.2	0.6	2.1	-0.1***	97.0	0.3	0.9	-0.1***
13	Durable goods	100.2	0.6	1.9	-0.1***	96.9	0.3	0.9	-0.1***
14	Wood products	97.8	0.7	2.1	-0.1***	93.7	0.6	1.6	-0.1***
15	Nonmetallic mineral products	100.2	0.8	2.7	-0.1*	95.5	0.3	1.4	0.0
16	Primary metals	101.6	1.2	3.5	-0.2***	97.4	0.4	1.4	0.1**
17	Fabricated metal products	100.8	1.2	4.0	-0.2***	106.4	1.7	4.1	-0.3***
18	Machinery	99.5	0.6	2.0	0.1**	95.2	0.9	3.5	0.0
19	Computer and electronic products	101.1	0.7	2.2	-0.1***	92.8	1.5	6.2	0.1
20	Electrical equipment, appliances, and components	101.5	1.6	5.2	-0.3***	100.6	2.5	6.4	0.5***
21	Motor vehicles, bodies and trailers, and parts	99.5	2.0	7.0	0.3**	92.1	0.8	2.8	0.1*
22	Other transportation equipment	102.1	2.3	7.7	-0.5***	94.0	1.1	3.8	-0.2**
23	Furniture and related products	98.8	1.5	5.0	0.3***	93.7	1.4	4.1	0.3***
24	Miscellaneous manufacturing	98.7	1.7	5.7	-0.3**	103.2	4.7	14.0	-1.0***
25	Nondurable goods	100.1	0.7	2.5	-0.1**	97.1	0.4	1.4	-0.1**
26	Food and beverage and tobacco products	100.3	1.1	3.5	-0.2***	93.3	0.4	1.8	0.0
27	Textile mills and textile product mills	99.8	1.0	3.5	0.0	97.4	3.3	8.2	-0.7***
28	Apparel and leather and allied products	98.4	1.3	4.1	-0.2*	99.8	4.5	10.9	0.9***
29	Paper products	100.6	0.6	2.3	0.0	91.1	0.5	1.7	0.1*
30	Printing and related support activities	97.7	0.9	3.1	0.1**	101.6	0.8	2.9	-0.1**
31	Petroleum and coal products	101.2	2.0	9.1	0.2	84.6	1.5	6.5	0.2
32	Chemical products	101.2	1.5	4.1	-0.3***	92.0	1.1	3.3	-0.2***
33	Plastics and rubber products	101.7	1.8	5.4	-0.4***	111.2	2.4	6.8	-0.5***
34	**Wholesale trade**	98.5	1.2	5.3	0.2*	99.6	1.1	3.4	0.2***
35	**Retail trade**	98.2	0.9	2.8	-0.1**	96.4	0.2	0.9	0.0
36	**Transportation and warehousing**	99.6	0.7	2.6	-0.1**	99.5	0.8	3.1	-0.1
37	Air transportation	102.6	2.5	7.5	-0.5***	98.1	4.4	11.9	0.8***
38	Rail transportation	106.5	5.4	16.9	1.0***	100.1	0.1	0.5	0.0
39	Water transportation	97.0	2.5	7.9	0.4***	131.8	9.1	25.8	1.9***
40	Truck transportation	98.8	0.8	2.4	-0.1**	99.0	1.4	4.5	0.3***
41	Transit and ground passenger transportation	93.8	2.4	8.4	0.3*	89.0	4.6	12.4	0.9***
42	Pipeline transportation	99.5	2.5	8.2	0.3*	100.0	3.8	10.2	0.7***

43	Other transportation and support activities	98.3	0.8	2.9	0.1	91.6	4.6	14.0	-0.8***
44	Warehousing and storage	103.0	5.8	21.0	-0.9**	125.8	11.1	37.5	-1.9**
45	**Information**	99.8	0.7	2.7	0.1**	98.2	1.7	4.3	0.3***
46	Publishing industries (includes software)	0.0	0.0	0.0		100.1	1.0	2.8	0.1*
47	Motion picture and sound recording industries	92.9	6.0	16.3	1.3***	70.6	3.7	9.9	0.7***
48	Broadcasting and telecommunications	101.1	0.7	2.2	-0.1**	103.5	0.4	1.3	-0.1***
49	Information and data processing services	0.0	0.0	0.0		99.2	10.5	25.7	2.2***
4649	Publishing industries (includes software) and information and data processing services	100.3	0.8	2.8	0.0	100.1	3.4	8.4	0.7***
50	**Finance, insurance, real estate, rental, and leasing**	97.2	1.2	4.2	0.2***	99.4	0.7	2.4	0.1***
51	**Finance and insurance**	97.8	1.1	3.9	0.2***	102.9	0.3	1.6	0.0
52	Federal Reserve banks, credit intermediation, and related activities	100.4	0.7	2.8	0.0	107.0	0.5	2.0	0.1
53	Securities, commodity contracts, and investments	87.1	6.1	16.9	1.3***	89.8	0.8	2.7	0.1**
54	Insurance carriers and related activities	98.3	1.2	4.5	0.0	102.6	0.4	1.5	0.0
55	Funds, trusts, and other financial vehicles	95.5	7.2	24.8	1.3***	102.6	3.4	10.2	-0.6**
56	**Real estate and rental and leasing**	95.4	1.7	5.8	0.3***	89.3	2.5	7.1	0.5***
57	Real estate	93.6	1.8	6.1	0.3***	88.5	1.5	3.9	0.3***
58	Rental and leasing services and lessors of intangible assets	99.2	1.5	4.9	0.2**	90.8	4.9	13.9	1.0***
59	**Professional and business services**	93.2	3.0	7.4	0.6***	103.1	1.1	3.9	-0.2***
60	**Professional, scientific, and technical services**	88.3	4.3	11.7	0.9***	93.6	2.9	8.2	0.6***
61	Legal services	80.2	4.6	12.9	0.9***	85.3	3.5	9.1	0.5*
62	Computer systems design and related services	94.8	5.9	15.8	1.2***	88.3	2.5	6.6	0.5***
63	Miscellaneous professional, scientific, and technical services	89.4	3.6	10.2	0.8***	97.1	3.4	9.5	0.7***
64	**Management of companies and enterprises**	107.6	7.6	25.3	-1.5***	163.6	8.0	27.6	-1.5***
65	**Administrative and waste management services**	94.4	4.3	9.8	0.8***	98.0	2.5	7.8	-0.5***
66	Administrative and support services	94.4	4.4	10.1	0.8***	98.0	2.6	7.9	-0.5***
67	Waste management and remediation services	95.6	5.7	15.7	1.2***	97.2	1.4	5.2	-0.2**
68	**Educational services, health care, and social assistance**	96.4	1.3	3.7	0.2*	108.0	0.9	2.5	0.2***
69	**Educational services**	94.4	3.4	10.5	0.6***	99.5	0.3	0.8	0.0
70	**Health care and social assistance**	96.7	1.0	3.1	0.1	109.6	1.0	2.9	0.2***
71	Ambulatory health care services	95.7	1.8	5.2	0.4***	103.4	1.4	3.9	0.3***
72	Hospitals and nursing and residential care facilities	99.9	0.7	2.5	0.1**	117.4	1.6	4.1	0.3***
73	Social assistance	88.4	3.1	8.3	-0.1	96.4	0.8	2.6	0.2***
74	**Arts, entertainment, recreation, accommodation, and food services**	100.1	1.3	4.1	-0.3***	99.4	0.9	2.7	-0.2***
75	**Arts, entertainment, and recreation**	96.3	3.2	10.9	0.1	94.8	2.1	6.8	0.4***
76	Performing arts, spectator sports, museums, and related activities	94.4	5.8	18.4	1.1***	86.0	6.1	16.8	1.2***
77	Amusements, gambling, and recreation industries	97.2	3.4	8.7	-0.2	98.5	0.5	1.7	0.0
78	**Accommodation and food services**	100.8	1.5	4.8	-0.3***	100.1	1.4	4.1	-0.3***
79	Accommodation	101.2	1.2	3.5	-0.2***	98.5	0.9	2.6	-0.2***
80	Food services and drinking places	100.7	1.7	5.4	-0.4***	100.5	1.6	4.6	-0.3***
81	**Other services, except government**	89.0	1.0	3.0	0.2***	101.5	1.6	4.8	-0.3***

a/ For FRB and BEA, series is entitled "full-time and part-time workers" (ftpt).

Sources: BLS, Employment Projections; BEA, GDP by industry accounts; FRB, Corrado and others (2006).

Significance levels: *, **, *** indicate significance at the .05, .01, .001 levels, respectively.

Summary of Data Recommendations,

from Triplett and Bosworth (2004), Chapter 11 and Individual Industry Chapters, Updated in December 2006

Change	Agency	Impact	Status or work underway
1. Continue and accelerate PPI indexes for services	BLS	A major source of improvements so far, much to be done	In progress
2. Continue and accelerate Census collection of inputs for services industries and of purchased services for all industries	Census	A major source of improvements for MFP and for GDP, much to be done	Some progress, but funding grossly inadequate and may not have sufficiently high priority
3. Integrate I-O and GDP accounts	BEA	Remove inconsistency in estimates of VA and intermediate inputs	Partial in 2004, further work underway
4. Integrate BLS and BEA output measures	BEA/BLS	Remove inconsistencies, rationalize and improve output measures	Partial; report due in 2007
5. Allocate resources to negative productivity industries	All	By resolving puzzles, improve output and input measures	Some work done in BEA
6. Change hours measures to all employees, rather than (as in the past), production and nonsupervisory wkrs	BLS	More meaningful measure, better hours by industry	Done 2005?
7. More detail, better classifications for ITC products	Census/BEA/ BLS	Improve high tech deflation; independent of improving deflators	Some
8. Research on capital flow table methods	BEA	Allocation of K-services by industry is inexact, needs improvement	Review of Statistics Canada method by BEA
9. Implement NAICS in industry tables	BLS/BEA	Will (finally) create industry file by new (1997!) classification system[1]	Done
10. Create additional SIC-NAICS bridge tables	Census/BLS	Permit consistent backward extrapolation of NAICS industry series	Partial, by Fed
11. Bring medical equipment into NHA investment	CMS	Close gap, equipment not in NHA definition of investment	Done (using new BEA medical equipment data)
12. Improve medical price and output measures	BLS/BEA/CMS	"Quality adjustments" for improvements in medical treatments	Much work remains; PPI work underway
13. Combine cost of disease and NHA accounts	CMS	Closes missing dimension in NHA, shows what money is spent on, links expenditures with economic and medical research	Rejected by CMS (but being addressed by BEA)
14. Research on output concepts for business services	BEA/BLS	Improve output measures	Some by BLS PPI, much work remains
15. Integrate business services inputs forward to using industries	BEA	Insight into output measurement problems; for intermediate purchases, "evades" output measurement problem	None
16. Change SNA concepts for finance and insurance	BEA	More realistic output concepts will improve output measures; in particular, risk is central to finance and insurance, concept should focus on how to measure it and incorporate risk into output, not (as in present SNA and NIPA) how to exclude it from output	None, BEA does not agree
17. Research on output concept for SNA 'margin industries' (trade, finance and insurance)	BEA	Determine if gross margin (and analogs) provides advantages for measuring output, compared with usual gross output concept	BEA paper presented at 2006 NBER workshop
18. Develop better self-employment income methods	BEA/BLS	Split into labor and property income problematic, affects K and L shares	None

Some of the following, from the individual industry chapters (chapters 3-10), are implicit in the analysis and criticism in those chapters; here rendered as explicit recommendations.

Chapters 3 and 4: Transportation and Communication

Change	Agency	Impact	Status or work underway
19. Evaluate PPI indexes for rail and trucking for compositional changes in industry outputs	BLS	Improved deflators and output (NB: PPI indexes are Laspeyres formula)	PPI 'directed substitution' project
20. Add passenger-based quality changes to air transport indexes	BLS/BTS	Improved deflators and output (many quality changes in air transport)	None, except BLS-BTS paper
21. Research on adding highway inputs into trucking productivity measures	BLS/BTS	Overcome bias to MFP for trucking because of omitted government infrastructure contributions	None

[1] But note: Output and nonlabor inputs use Census NAICS-SIC bridge for the year 1997, plus additional bridges for earlier Economic Census years constructed by FRB. Labor inputs uses BLS QCEW. Substantial inconsistency discussed in text.

22. Integrate BLS and BEA approaches to airline output and inputs	BLS/BEA	Coverage, capital measures, purchased inputs cloud productivity comparisons	BEA-BLS project underway
23. Develop better deflators for transport equipment	BLS/BEA	Better K and MFP measures (usual quality change issues)	None
24. Research on communications services prices	BLS/BEA	CPI and PPI telephone indexes problematic (discounts, change in mix, fixed weights)	CPI change recently; PPI changed to unit value to capture discounts
25. Research on communications equipment prices	BLS/BEA/FRB	Better deflators for K-input	Some research incorporated into GDP
Chapters 5-7: Banking, Finance, and Insurance			
26. Review flows between insurance carriers and agents	BEA	Inaccurate flows of intermediates perhaps causing negative productivity	None
27. Collect insurance data in Census and annual surveys	Census	AM Best data, used in absence of gov. data, appear faulty	In progress
28. Conduct research on new financial products	BLS/BEA	Current SNA definitions (see #16), above, impedes progress	Some OECD studies
29. Improve allocation of self-employment income	BLS/BEA	Allocation method leads to wide fluctuations in K-share and MFP in finance and insurance (see also #18, above)	None
30. Research on allocation of indirect bus. taxes	BLS/BEA	Remove inconsistency in present treatments	In progress
NB: Many other detailed recommendations in chapters 6 and 7, but subordinate to the SNA-NIPA output concepts matter (see #16, above)			
Chapter 8: Retail trade			
31. Review BEA use of gross output price to deflate gross margin	BEA	Part of gross output vs gross margin question (#17, above)	BLS now produces gross margin PPI index; BEA 2006 paper on trade
32. Develop explicit measures of retailing services bundled into gross margin	BEA/BLS	Improve output, whether gross margin or gross output	Underway in PPI, needs evaluation
33. Research on capturing changes in store format in price indexes	BLS	Reduce “outlet substitution bias”	Some CPI changes
Chapter 9: Other Services			
34. Review “model pricing” for business services	BLS	Innovative method, but needs testing or outside evaluation for validity	None
NB: For business services, see also #14 and 15, above			
NB: For medical, see #11-13, above			
35. For education, research on output concept, price and quality indicators, inputs, and implications of educational institution as a multi-product firm	All	Little agreement on any of these issues; education productivity measures most unsatisfactory	Recent BEA paper, many problems remain
Chapter 10: High-tech Capital Inputs for Services			
NB: For this topic, see also #7, 8, and 11, above			
36. More aggressive incorporation of weight shifts for new ITC products in PPI and of improved deflators for Communications equipment in investment measures	BEA/BLS	Improved capital measures and improved MFP	Partially done
37. Research on accounting for fibre optics	BEA/BLS	Little is known, many problems exist, tho shares are small	None
38. Research on classification of software	BEA	Current 3-way (packaged, custom, own account) may distort	None
39. Better data on software expenditures	BEA/Census	Shares of software not firmly known, and therefore bias MFP	None?
40 Better deflators for software	BEA/BLS	PPI has indexes for packaged software; much less is known for custom and own-account	Some research, BEA 2006 paper, but Brookings and NAS workshops unsuccessful at pointing to research directions; quality change problems remain even with packaged software
41. Improved deflators for high-tech medical equipment	BLS/BEA/CMS	Little is known, still only a single study (Trajtenberg)	None

Source: Drawn from Jack E. Triplett and Barry P. Bosworth. *Productivity in the U.S. Services Sector: New Sources of Economic Growth*. Brookings Institution (2004), supplemented in December 2006 with information from BLS and BEA on their new statistical initiatives.