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Is the 21st Century Productivity Expansion Still in Services?

And What Should Be Done About It?

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Part I

The 21st Century Productivity Expansion and Comparison with the End of the 20th Century

The great productivity slowdown that began in the U.S. around 1973 ended abruptly in the mid-1990s. Labor productivity grew roughly two and a half percent per year during 1995-2000, double its growth rate over the previous two decades.

In Triplett and Bosworth (2006), Bosworth and Triplett (forthcoming) and Triplett and Bosworth (2004),[1] we advanced an interpretation of the post-1995 U.S. productivity expansion that was in several respects different from the explanation in previous research (such as Oliner and Sichel, 2000; Jorgenson and Stiroh, 2000; and Gordon, 1999):

- Services industries productivity, both labor productivity (LP) and multifactor productivity (MFP), accelerated more strongly after 1995 than did productivity change in the goods-producing industries, taken together. Earlier studies focused on the undeniably impressive productivity growth in computers and semiconductor production (in the goods-producing sector) and its resulting feedback into IT investment in the rest of the economy.
- In consequence, the post-1995 productivity acceleration at the aggregate level was mostly a services industry story. Services industries accounted for 73 percent of the economy-wide acceleration in LP and 75 percent of the acceleration in MFP.[2] In the data available

[1] 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.
[2] In interpreting these numbers, the reader should bear in mind that because productivity decelerated some industries, the industries in which productivity accelerated contributed more than 100 percent of the total acceleration.

at the time we wrote our book, little acceleration was observed in goods-producing industries' MFP, overall.

- All researchers agree that capital deepening, mainly in IT, was one major factor post-1995. We showed that the contribution of IT to U.S. labor productivity growth was also a services industry story. Four-fifths of IT's contribution to growth occurred in the services industries, which makes sense since those industries account for the bulk of IT investment (in the growth accounting framework we use, the return to IT is necessarily equal across industries).
- However, the main contributor to services industry LP growth and to acceleration was acceleration in MFP in the services industries. We found that the services industry MFP contribution to services industry LP growth was fully as important as the contribution of IT.

Our results—that services industries had become the sources of economic growth in the U.S., post-1995, and that a major acceleration of services MFP was the cause—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), Basu, et al (2003), Inklaar, O'Mahoney and Timmer (2003).[3]

On the other hand, some U.S. researchers have ignored or misinterpreted our services-industry findings. For example, in a 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

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

innovations in semiconductor manufacturing…." Thus, they 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, which in our findings were as important as the other two factors.[4] Similarly, Jorgenson, Ho and Stiroh (2006) analyze recent aggregate LP and MFP and remark: "The first surge of productivity growth after 1995…is now well documented with a consensus view that the production and use of information technology (IT) were the driving forces." They do not mention our result that the post-1995 productivity expansion was mainly located in services industries, and do not consider at all the unprecedented post-1995 acceleration of services industries' MFP.[5]

In this paper, we provide, in a very preliminary analysis, two extensions of our earlier work:

1) Substantial data revisions to the BEA industry accounts have been made since our book was completed, and the whole dataset has been shifted over to the North American Industry Classification System (NAICS) from the old U.S. SIC. Do our results for the post-1995 period stand up to the new data? In short, they do in the broad outline though the new data do change elements of the picture we presented earlier, some of them substantially.
2) Despite the ending of the late-90s IT investment boom and despite the recession of 2001, productivity continued to advance in the U.S. in the new century, confounding the predictions of many observers. We extend our industries-based approach to consider the

[4] On services, Anderson and Kliesen (2006, page 184) suggest "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 our Table A-2: Services LP grew 2.56 percent per year, of which IT contributed 1.01 points and MFP 1.48 points).

[5] Indeed, Jorgenson, Ho and Stiroh (2006) remark further that the 21st Century productivity expansion is "quite different" from the one at the end of the 20th Century. We argue, instead (see below) that they are quite similar: Increasing services productivity drives both of them.

post-2000 period, to determine if services industries are still providing the sources of economic growth.[6] We find that services industries contribute mightily to the post-2000 productivity expansion, indeed their LP and MFP growth post-2000 is substantially stronger than for 1995-2000.

It is well known that MFP is a residual, after all contributing inputs are accounted for. If variables are not measured appropriately, or if inputs are missing (for example, the intangible capital that Corrado, Hulten, and Sichel, 2005 explored), then MFP may indicate where differential mismeasurement exists. Hence, our finding that strong MFP growth in services characterized the post-1995 period (but not the previous period) might indicate mismeasured services sector output, or that missing or poorly measured inputs in the services sector have grown more rapidly in the post-1995 period. The mismeasurement hypothesis (explored by Jorgenson and Griliches, 1967) provides the bridge to Part II of our paper, where we assess the adequacy of services data.

A. Productivity Change in the 1995-2000 Period

The two left-hand columns in Table 1 present a summary of the findings in our book, based of course on the data that were available at the time. Though goods-sector LP and MFP expanded after 1995, services sector productivity grew much more: For both LP and MFP, services industry productivity after 1995 was more than 3 times its growth rate for previous years (for LP, that is, it expanded from 0.7 percent per year before to 2.6 percent after 1995). Productivity in the goods sector accelerated, but much less. Indeed, in the data we used, services sector productivity grew faster than the productivity of goods sector industries (though the

[6] To our knowledge, the only other exploration so far of industry productivity for the 21st Century period is Stiroh (2006), who estimates labor productivity change by industry, but he does not explore the goods-services distinction.

differences were small). Because in the pre-1995 period the services sector was by far the lagging sector, this emergence of the services sector as a contributor to productivity advance—particularly to MFP growth—was the most strikingly different part of the post-1995 era.

Table 1 shows *direct* productivity measures—value added is aggregated to the sector and the aggregate levels and then divided by the appropriate input concept. In our book, we also computed industry productivity measures for LP and for MFP, for 25 goods industries and 29 services industries, using gross output as the output concept, rather than value added. This permitted us to analyze differences in productivity performance across industries, which were substantial—see our Tables 2-4A and 2-4B. We aggregated those industry productivity measures to goods and services sector levels and to the aggregate level. Though the numbers differ, the qualitative results of the industry aggregations were the same as for direct value added productivity measures: Services industries led the post-1995 advance. We feature the direct measures in the present paper. Work on the individual industry measures and their aggregation is proceeding.

For our book, the then available data extended to 2001, which was a recession year. In order to avoid too much influence for terminal years, we computed trend rates of growth, which are shown in the left-hand columns of Table 1.

The industry data can now be assembled through 2004, and the year 2000 provides a better break for the periods of interest. The middle columns of Table 1 recast the published results from our book, using 1995-2000, instead of 1995-2001, and with growth computed as average annual rates of change over the period, rather than trend rates, as before. Though the numbers differ and AARG are predictably sensitive to end dates and to exclusion of the recession year, the qualitative results are not changed, as the table shows. In particular, the strong post-1995 acceleration in LP and MFP in the services industries are striking. Post-1995 rates are multiples of services productivity growth before 1995.

Data Revisions. In the interval since our book was completed, several revisions have affected the BEA industry accounts. First, the industry classification system has changed: Our results used data classified by the old 1987 SIC industry codes. The data have now been converted to NAICS. Second, GDP revisions have changed the data, as they always do, independent of the industry classification changes.[7]

Thus, we first ask the question: How did revisions to the BEA industry accounts affect our conclusions about the 1995-2000 productivity expansion? A summary of the effects of the data revisions appears in the two right-hand columns of Table 1. Compared with the old data (middle columns), the revisions did not much change the aggregate picture: Productivity growth was lowered slightly, 1995-2000, compared with estimates based on the old data, but the magnitude of the accelerations is nearly the same.

Changes were larger, however, at the sector level: Goods sector LP, at 3.3 percent annually, and MFP, at 2.3 percent, are substantially larger after 1995 in the new data than in the old data, and because both rates were revised down for 1987-95, the acceleration in goods sector productivity now appears stronger than it did before. Correspondingly, services sector LP and MFP were both revised downward (in both periods), with the result that the acceleration of services sector productivity appears weaker in the new data than it did in the old. Moreover, the classification and data revisions leave services productivity growth lower than that of the goods

[7] Anderson and Kliesen (2006) present a nice historical discussion of data revisions over the years and their often substantial impacts on economists' knowledge and perceptions about productivity change. As they correctly point out, we ourselves did not understand how much post-1995 services industry productivity had surged until we reviewed the release of the 2001 revised BEA industry accounts.

sector, which revises away one of our more widely reported findings (that services productivity growth had surpassed that of the goods-producing sector).

However, the revisions leave intact what we regard as our main finding: The post-1995 acceleration in U.S. productivity growth, both LP and MFP, was disproportionately in the services sector. Though goods sector productivity (LP and MFP) growth nearly doubled, according to the new data, services sector productivity growth was more than three (LP) and five (MFP) times faster than it was before 1995. The revisions have not changed our conclusion that the most striking difference after 1995 was the emergence of the services sector as a contributor to aggregate MFP growth, compared with its nearly nil contribution in earlier.

Nevertheless, we were surprised at the size of the revisions. Some changes are predictable. For example, some activities were transferred out of manufacturing (including the separation of publishing—now in the information sector—from printing, and moving head offices and so forth out of manufacturing and other industries into their own subsector); these were undoubtedly not leading productivity industries, so their transfer raises goods producing productivity. Another factor in the revisions arises because BEA is at mid-point in its longer-term plan for integrating and its input-output accounts with its industry accounts (see Part II of this paper), so some revisions before 1998 are perhaps still not as integrated as one would like, and also none of the old BEA industry data incorporated results of the 1997 I-O table, which is built into the new data. We will continue to look into the revisions, after additional discussions with BEA.

B. Productivity Change in the 21st Century

Defying many predictions, aggregate U.S. LP continued to advance after recovery from the 2001 recession. As Table 2 shows, aggregate LP growth through 2004 was even faster than it was during the post-1995 period that made so much news (the first two columns of Table 2 are from Table 1). We calculate that the aggregate MFP rate has accelerated as well, to 2 percent per year, a prodigious rate for an advanced economy.[8]

We also present in Table 2 goods-sector and services-sector productivity growth rates. As in the closing years of the 20th century, the 21st century acceleration in U.S. productivity has again taken place largely in the services sector. Indeed, goods sector LP has remained the same as it was before 2000 and goods sector MFP has declined. Services sector LP and MFP, on the other hand, continued to advance after 2000, to 2.9 percent per year for LP and 1.7 percent for MFP. The continued improvement in services sector productivity in the post-2000 period appears just as an extension of the trends we documented in our book for the previous period—compare the appropriate entries in the columns of Table 2.

Although services sector productivity rates still lag those of the goods sector in the new BEA data, the sector rates are converging: In the 21st Century, services LP is only 0.4 percentage points lower, and MFP 0.2 percentage points lower, than the corresponding rates for the goods sector. In the pre-1995 period, services productivity growth rates were from one-third (LP) to one-seventh (MFP) the goods productivity rates. For the services sector to have reached near parity in such a short time is one of the most remarkable—and overlooked—economic transformations of any era.

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[8] For the reasons discussed at length in chapter 2 of our book, aggregate productivity growth computed from the BEA industry accounts, which are presented in our tables, will differ from published BLS productivity growth rates. BLS estimates MFP growth for 2000-2004 at 1.9 percent per year.

We intend to do more analysis of the industry and sector productivity growth rates in subsequent work.

C. Computers, Semiconductors and Electronics

As we noted earlier, some economists regard IT as almost the only factor in the post-1995 productivity acceleration. Very high MFP growth has indeed occurred in the manufacture of electronics of all sorts, but especially of semiconductors and computer equipment, with correspondingly sharp rates of price decline. Indeed, price declines of 20 percent per year and more have characterized the computer market since the dawn of the computer age more than 50 years ago, which suggests MFP growth at double-digit figures for half a century or more.[9]

MFP growth in computer equipment boosted economy-wide productivity in two ways: First, it directly raised aggregate MFP as soon as the share of the industry in total output became sufficiently large. Second, the consequent fall in the prices of this equipment led to accelerating investment in computer equipment, which produced its own effect on aggregate labor productivity through the standard mechanism of capital deepening.

Capital Deepening. Oliner and Sichel (2000) and Jorgenson and Stiroh (2000) estimated the capital deepening effect of investment in IT, using BEA-BLS investment, capital stock and capital services data, or similar alternatives. These estimates were carried out in the growth accounting framework that has been used so extensively for productivity analysis. In our book, we followed a similar approach in constructing growth accounting equations for individual industries. We found an equivalent aggregate contribution of IT capital deepening, but we added

[9] Triplett (1987 and 2005) and also Gordon (1990) present price indexes for computers than extend to the first commercial sales of computers in the U.S., in 1953-54, and Nordhaus (200x) estimated a price index for *computing* for more than a half century before that. Doms (2003) and also Aizcorbe, Flamm and Khurshid (2002) not only show that the rates of price decline are lower for other semiconductor using manufacturing, such as communications equipment, but also explain why.

the new finding that IT's contribution was largely in services industries. We update these estimates in Table 3.

Considering first 1995-2000 productivity growth, IT investment contributed one-third of the 2.4 percent per year advance of labor productivity and MFP contributed two-thirds.[10] In goods production, MFP accounted for an even greater proportion of LP advance, fully two-thirds.[11] In services (where most of IT investment is located), the contributions of IT and of MFP are the same.[12]

But for the subsequent period, 2000-2004, where labor productivity growth accelerated even more, IT's capital deepening contribution fell in both goods production and services production, as the rate of IT capital stock build-up slackened. In contrast, MFP in services played an even greater role than it did in 1995-2000 (this is apparent in Table 2). Non-IT investment became more important in the goods sector, more than compensating for the drop in IT investment.

MFP Contribution of IT Production. Oliner and Sichel (2000) and Jorgenson and Stiroh (2000) also estimated the contribution of MFP in the production of IT to aggregate MFP. However, in the old SIC system, computers were located in industrial machinery with drill bits and semiconductors in electrical machinery with Christmas tree lights—that is, mixed in with non-high tech equipment that had nothing to do with IT. Extracting the impact of IT MFP required roundabout estimation procedures with a high probability of great inaccuracy.

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[10] In our book, we explain how certain properties of the industry accounts increase our estimate of the contribution of MFP relative to, for example, Jorgenson and Stiroh (2000). Our estimates are controlled to the national accounts, but theirs have other advantages, particularly in a better labor input measure. For the present paper, we use labor hours because the BEA industry employment data that we used in our book are not available, even though we still have strong reservations about the accuracy of the hours data.

[11] And as we note below, MFP in the electronics industry amounted nearly to the total MFP in goods production in this period.

[12] In the data used for our book, the MFP contribution exceeded the IT contribution. The difference is entirely attributable to the data revision that lowered services MFP, as shown in Table 1.

In NAICS, computers and semiconductors are grouped with similar equipment in an electronics manufacturing industry. This allows more precise estimates of MFP in this industry than was possible before. Table 4 contains the relevant information.

In the electronics industry, LP advanced by 35 percent per year, over the 1995-2000 interval, and MFP by 33 percent. These are the largest productivity growth rates for any industry. Productivity slowed in the industry in the subsequent period (to 18 percent), but remained unusually high for industry productivity growth rates.

These high productivity growth rates contributed a large proportion of goods sector LP and MFP from 1995-2000, and a smaller, though still large, share post-2000. LP in the electronics industry contributed 85 percent of total goods sector LP growth in 1995-2000, and electronics MFP 114 percent of total MFP growth in the goods sector. As the latter proportion implies, declines elsewhere in the goods sector offset part of the great contribution of electronics production (the total of all positive contributions exceeds 100 percent). The electronics industry still contributed 86 percent of goods-sector MFP after 2000, but the industry's contribution to LP growth returned to its pre-1995 level.

Estimates from the NAICS industry are hard to compare with previous estimates, which referred either to broader categories (industrial machinery and electrical machinery) or narrower ones (computers and semiconductors, estimated separately by indirect methods. All the MFP estimates were very high, ranging (depending on the author and the definition of the industry) from 18 to 45 percent per year, so in a sense the NAICS-based estimate confirms what could only be estimated inaccurately before.

The Roles of IT and of Services MFP. Other research, and our own results, show that IT is important. However, the extreme focus on IT on the part of many analysts of the post-1995

LP advance resulted in many forecasts that productivity growth would slacken after the IT investment boom ended. Those forecasts have been wrong, an inevitable consequence of "consensus" that *the* "underlying cause" of the post-1995 productivity acceleration was semiconductor price decline and IT price decline, and especially the notion that these rates were unprecedented.[13] We agree that IT was *one* of the major causes. But more attention to the role of MFP in the services industries would likely have reduced the forecasting errors that were made. On the other hand, it is also true that strong MFP growth is unexplained productivity growth (since MFP is a residual after all other factors that are known and quantified have been taken into account), and unexplained growth is particularly hard to forecast.

D. Conclusions.

We have found that MFP grew very rapidly in services industries after 1995 and again after 2000. Before 1995, very little MFP growth in the services industries was apparent. This is the greatest transformation in the productivity performance of the U.S. economy before the mid-1990s and after.

The research and data development implications of our findings are clear, and grow out of the fact that MFP is a residual. What is driving MFP, particularly in services, but also in electronics?

A popular hypothesis has MFP driven by IT. Strictly, that makes no sense, precisely because MFP is a residual, because IT is already in the capital input measure, and because the many improvements in the measurement of IT in recent years do not suggest huge

[13] IT prices did decline more rapidly between 1995 and 2000 than they did over 1987-1995. However, Triplett (2005, table 5) shows that computer and peripheral equipment prices declined less over 1987-95 (11 percent per year) than in most other intervals in the history of the computer (1959-2002: 17 percent per year). For computer equipment, the 1987-95 period was the unique one for its slowing of the computer's historical price decline. Though price decline in 1995-2000 was faster than average, part of that was catching up to the historical norm.

understatements of investment in IT. Moreover, there is little correlation across industries in the rate of MFP advance and their stocks of IT.

We are inclined to the view that in terms of investment, IT is just another investment good. But MFP can be a measure of innovation. Installing IT is not necessarily an innovation, but innovators may well need IT in order to innovate, a position consistent with the McKinsey Global Institute (2110) study's insistence that it was a combination of management innovation with IT that mattered in the industries they studied.

MFP, whether a measure of innovation or not, will rise when inputs are omitted or mismeasured. Our finding that MFP accelerated in services industries highlights the importance of improving the data on services industries, particularly on services industries inputs. We are not contending that all the ancient problems of measuring services output are solved, far from it, but it seems unlikely that rapidly increasing MFP is caused by upward errors in the measurement of services output in recent years. Accordingly, we think that the statistical agencies should redouble their efforts in measuring inputs in the services industries, and that this would be a fruitful area of economic research as well.

Part II

The State of Services Productivity Measurement

Triplett and Bosworth (2004) culminated the five-year Brookings Program on Economic Measurement. The program hosted 15 workshops, each one devoted to a measurement topic pertaining to the services sector—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 hedonic indexes. 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. 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. The authors note at the end of the chapter that 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 the attached table, which also gives some indication of improvements that the agencies have made since our book was written. It thus provides our assessment of the state of measurement in services industries.

Though we focus on data needs and important improvements in the statistical base for analyzing productivity, we do not wish to slight the enormous changes that the 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 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 accounts can be linked to BEA capital stock and 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 program has not only moved into an area that needed attention, it has done so with commendable innovation and professional analysis.
- The Census Bureau has expanded its annual services surveys and collected more information about purchased services than existed before.
- 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 appears predominantly in the services industries, and the improvements in the deflators have

made it possible to estimate the impact of investment in IT 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 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.

Our table summarizes our recommendations, which arise out of our own research and which use as well the input from others at the Brookings workshops and elsewhere. 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 the table record where the agencies have made additional improvements in the interim, though we are quite sure that some relevant work in statistical agencies has escaped our attentions. More information on these individual recommendations appears in Chapter 11 and the other chapters of our book, as noted in the table.

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. 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 data needs, is not the only statistical priority.

In interpreting our list of recommendations (indeed, any list), one should bear in mind that data improvements often bring to the fore other data problems that, though possibly existing before, were previously either hidden or less consequential. Our book notes one major example in the industry accounts, where 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.

Another example has arisen recently, and affects our analysis in Part I of this paper: It has always been true that BLS and Census assign 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 at the same time that improvements have been made in the time series consistency of industry data, compared with industry classification changes in the past. 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. Using Census establishment microdata, an FRB-Census Bureau project (Bayard and Klimek, 2003) reclassified manufacturing establishments in previous Economic Censuses to NAICS, creating a more nearly consistent NAICS industry time series than was ever the case for earlier SIC classification system changes. BEA adapted the Bayard-Klimek reclassifications in its industry accounts, so that the NAICS time series for industry outputs, intermediate inputs and capital services has much more time series consistency in it than has ever been true in the past.[14]

This improvement in the time series consistency of the non-labor variables, however, heightens the long-standing Census-BLS inconsistency, for BLS carried out its NAICS-SIC bridge only for the first quarter of 2001. Not only is the BLS bridge for the employment variable 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 by the bridge for this single quarter (ref BLS).[15] Census and BLS employment measures may be inconsistent for other reasons, for example, because their respective sampling frames differ.[16] But we

[14] Note that the 1987 SIC revision restricted changes in classifications that crossed the old 2-digit boundaries, roughly the level of detail in BEA industry accounts, so in that sense earlier classification changes created fewer problems for BEA industry accounts than did NAICS, where classification changes were not so restricted. Offsetting this, industry classifications in the old BEA input-output accounts did not match SIC industries, so much reallocation was required. NAICS classifications match I-O principles.

[15] "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.

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

suspect that that the employment data that we use for our industry LP and MFP measures is less consistent with the output, intermediate input and capital services measures than has been the case in the past.

The only solution to this inconsistent classification problem is to adjust BLS employment by industry by the NAICS-SIC bridges for Economic Census years, as has been done for the other variables. Bayard and Klimek (2003) contains a bridge for employment (also production worker employment) in manufacturing industries, and we understand that additional bridges for wholesale and retail trade and for some services have been created in the Census Bureau. It is true that BLS counts of employment by industry in Economic Census years differ from employment by industry recorded in the Economic Census, and so far as we are aware no reconciliation of those divergent totals has been successful. Because the Economic Census contains the production and output data necessary for industry classification of establishments and BLS data do not, 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. Regardless, the Bayard and Klimek bridges are the only information available, and the only information that is likely to become available, so they must be used.

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.

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Table 1. Effects of Data Revisions and Classification Changes, Valuea-Added Measures, 1987-2000

annual percentage rate of change

	Old Published (trend)		Old Data (AAR)		New Data (AAR)	
	1987-95	1995-01	1987-95	1995-00	1987-95	1995-00
Labor Productivity						
Nonfarm	1.0	2.5	1.1	2.6	1.0	2.4
Goods-Producing	1.8	2.3	2.1	2.6	1.9	3.3
Services-Producing	0.7	2.6	0.8	2.7	0.6	2.2
Multifactor Productivity						
Nonfarm	0.6	1.4	0.7	1.7	0.7	1.6
Goods-Producing	1.2	1.3	1.7	1.7	1.4	2.3
Services-Producing	0.3	1.5	0.4	1.7	0.2	1.1

Source:Old Published columns are from table A-2 of Triplett and Bosworth (2004). Old Data columns are from the same data set but show average annual rates (AAR) of changes ending in 2000. New Data columns are the revised data based on the NAICs classification, with post-2003 revisions of BEA..

Table 2. Productivity Growth in Goods and Service-Producing Industries, 1987-2004

Average annual rate of change

Sector	1987-95	1995-00	2000-04
Labor Productivity			
Nonfarm	1.0	2.4	3.0
Goods-Producing	1.9	3.3	3.3
Services-Producing	0.6	2.2	2.9
Multifactor Productivity			
Nonfarm	0.7	1.6	2.0
Goods-Producing	1.4	2.3	1.9
Services-Producing	0.2	1.1	1.7

Source:New Data. See table 1.

Table 3. Labor Productivity and Its Components, Value-Added Concept

annual percentage rate of change

Sector	1987-95	1995-00	2000-04
Private Nonfarm			
Labor productivity	1.0	2.4	3.0
Capital contribution	0.4	0.9	0.9
of which: IT	0.4	0.8	0.5
Multifactor Productivity	0.7	1.6	2.0
Goods-producing industries			
Labor productivity	1.9	3.3	3.3
Capital contribution	0.4	0.9	1.4
of which: IT	0.3	0.6	0.4
Multifactor Productivity	1.4	2.3	1.9
Service-producing industries			
Labor productivity	0.6	2.2	2.9
Capital contribution	0.5	1.2	1.1
of which: IT	0.5	1.1	0.8
Multifactor Productivity	0.2	1.1	1.7

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

Table 4. Contribution of Computer and Electronic Industry to Productivity in Goods-Producing Industries

annual percentage rate of change

	1987-95	1995-00	2000-04
Labor Productivity (goods)	1.9	3.3	3.3
Contributioution of computers and electronics	0.7	2.8	1.3
Percentage of total goods	39%	85%	38%
Mulit-factor Productivity (goods)	1.4	2.3	1.9
Contributioution of computers and electronics	0.8	2.7	1.7
Percentage of total goods	53%	114%	86%

Source: Authors' calculations.

Table 5

Summary of Data Recommendations,

from Triplett and Bosworth (2004), Chapter 11 and Individual Industry Chapters

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	Underway (2007?)
4. Integrate BLS and BEA output measures	BEA/BLS	Remove inconsistencies, rationalize and improve output measures	Partial
5. Allocate resources to negative productivity industries	All	By resolving puzzles, improve output and input measures	None
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	Collection began 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	None?
9. Implement NAICS in industry tables	BLS/BEA	Will (finally) create industry file by new (1997!) classification system[1]	Soon
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
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
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	None
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			
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)	None
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 bridge for first quarter, 2002. Substantial inconsistency created (see discussion in text).

22. Integrate BLS and BEA approaches to airline output and inputs	BLS/BEA	Coverage, capital measures, purchased inputs cloud productivity comparisons	None
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
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
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 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	Too little has been accomplished
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	Even prices for packaged software poorly measured; and much less is known for custom and own-account	Some research, but Brookings and NAS workshops unsuccessful at pointing to research directions
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).