"BAUMOL'S DISEASE" HAS BEEN CURED:

IT AND MULTIFACTOR PRODUCTIVITY IN U.S. SERVICES INDUSTRIES

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This paper addresses two major issues from the recent productivity literature. The first question concerns the contributions of information technology (IT) and of multifactor productivity (MFP) to the extraordinary performance of the U.S. economy in the last half of the 1990s. Unemployment fell to historically low levels, without generating the inflationary consequences many economists predicted. Labor productivity (output per hour) emerged from its twenty-year period of stagnation, doubling after 1995 its anemic 1.3% average annual growth between 1973 and 1995 (Chart 1). These developments have been characterized as the emergence of a "new economy," which economists and others have often associated in some manner with the increased use of IT.

We look for the impact of IT in the portions of the economy where the IT is. The most IT intensive industries are services industries. We find a substantial contribution of IT to services industries' labor productivity growth, but the impact of IT is not notably greater after

1995 than before. On the other hand, MFP in the services industries grew much more rapidly after 1995.

A second set of research issues concerns what is sometimes called "Baumol's Disease," the belief that the inherent nature of services makes productivity improvements less likely than in the goods producing sectors of the economy (Baumol, 1967). Services industries have long been the sick industries in terms of productivity growth.

We estimate services industry productivity growth for twenty-seven "2-digit" services industries. We find that labor productivity in services industries has grown as fast recently as it has in the rest of the economy, and that the major contributor was an unprecedented acceleration in multifactor productivity. Baumol's Disease has been cured.

I. Previous Research and Comparison with Our Study

Labor productivity (LP), as calculated by the U.S. Bureau of Labor Statistics (BLS), equals output growth divided by an index of hours. Chart 1 shows the acceleration in labor productivity in the U.S. non-farm business sector after 1995. Non-farm labor productivity in the U.S. grew about 1.3% per year between 1973 and 1995. After 1995, the productivity growth rate rose to 2.6%.[1]

In the now standard productivity-growth accounting framework that originates in the work of Solow (1957), as implemented empirically by Jorgenson and Griliches (1967) and extended by both authors and others, labor productivity can be analyzed in terms of contributions of collaborating factors, including capital and intermediate inputs, and of multifactor productivity (MFP). To analyze the effects of IT within this model, capital services, K, are disaggregated into IT capital (K_{IT}) and non-IT capital (K_N), and the two kinds of capital are

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[1] These data do not incorporate the GDP revisions announced in the summer of 2002.

treated as separate inputs to production. Thus, designating intermediate inputs—combined energy, materials, and purchased services—as M:

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

A number of researchers have calculated the contributions of IT and MFP to the post-1995 acceleration of labor productivity growth at the aggregate, economy-wide level (at the aggregate level, of course, the intermediate inputs net out, except for imports, which are normally ignored). The most prominent examples are Jorgenson and Stiroh (2000, hereafter, JS), Oliner and Sichel (2000, hereafter, OS), Gordon (2000) and the Council of Economic Advisors (2000). Results of these studies are summarized in table 1.

Although methodologies and definitions of output differ to an extent among the four studies, they show broadly similar findings.[2] A major portion of the acceleration in LP came from increased growth in capital services per worker (capital deepening). Those studies that separated the contribution of IT capital from that of non-IT capital (OS and JS) found that IT capital (K_{IT}) is responsible for all of the acceleration in the capital contribution to LP. Although non-IT capital (K_N) contributed to growth after 1995, its contribution to LP growth did not accelerate, it was similar before and after 1995.

All studies agree that accelerating MFP in the IT-producing industries also accounts for a substantial amount of the total acceleration. Perhaps more controversy should have surrounded this finding than has actually emerged. What the authors term the "IT-producing" industries are

[2] Jorgenson and Stiroh use a broad measure of output that includes housing and services of consumer durables. Oliner and Sichel use the output concept that corresponds to GDP and the published BLS productivity measures. The Council of Economic Advisers (2000) uses an income-side measure of output growth that shows even greater acceleration than the conventional measures of nonfarm business output (from the national accounts) that are used in the other studies. Gordon (2000) bases his estimates on quarterly measures and he obtains a lower estimate of the acceleration in labor productivity and MFP because he attempts to adjust separately for cyclical influences, a factor which is not explicitly dealt with by the other studies. Jorgenson, Ho and Stiroh (2002) have updated the findings in Jorgenson and Stiroh (2000). We have not incorporated their updated results into table 1.

actually the 2-digit machinery producing industries in the old U.S. SIC system. Semiconductors are located in the SIC electrical machinery industry, but so are Christmas tree lights. Computers in this old classification system are grouped with drill bits. It is probably true that the electronics portions of the machinery industries account for a major portion of their MFP growth, but the available data do not actually permit us to say that.[3]

In contrast, estimates of trend MFP in IT-using sectors (properly, in these studies all sectors other than the two machinery producing industries) vary substantially. As table 1 shows, those “IT-using” sectors accounted for 0.2 (the estimate of Gordon) to 0.7% per year (CEA), with JS and OS in the middle, roughly in agreement at about 0.5%. The controversy about the contribution of IT and of MFP in IT-using industries provides part of the motivation for the research reported in the present paper.

Several industry-level studies have focused on the post-1995 productivity acceleration in the U.S. Stiroh (2001) examined 61 industries, using data from the Bureau of Economic Analysis (BEA). An industry is a group of establishments that have similar production functions; approximately, each industry has a different production function from some other industry. Accordingly, one can ask: Is there evidence that a large number of production functions shifted after 1995?

Stiroh reported that two-thirds of the 61 industries showed a positive shift in labor productivity after 1995. Moreover, he found that the industries that had positive productivity shifts were more intensive users of IT capital than those industries that did not have upward productivity shifts—that is, the capital deepening effects of *past* IT investments on labor productivity showed up strongly in the industry data. Thus, looking across the range of

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[3] The new NAICS industry classification system separates electronics producing industries and groups them together, which is exactly what economic analysis requires.

industries, something changed in the U.S. economy that affected a large number of different production processes, and IT investment had a substantial role in that labor productivity change.

The McKinsey Global Institute (2001, hereafter, MGI) study asked a different question: Which industries accounted for the net, economy-wide, U.S. acceleration in labor productivity after 1995? Although a large number of industries showed productivity improvement (the MGI study agreed with Stiroh's findings in this respect), many of those industries have small shares of GDP, so their contribution to the aggregate post-1995 U.S. productivity acceleration is also small. MGI found that six large industries accounted for nearly all of the net, economy-wide labor productivity acceleration, and indeed a large portion of the gross acceleration.[4]

If one is interested in the causes of the *aggregate* productivity acceleration, looking at contributions is the appropriate metric (as it is in the McKinsey study). On the other hand, if one is asking whether IT makes a widespread impact, then the number of industries is the appropriate metric (as it is in the Stiroh study). These two studies are complementary, not conflicting.

MGI (2001) emphasized the importance of managerial innovations, where IT might be a facilitating tool, as well as competitive pressures that forced widespread imitation of managerial innovations that occurred. The MGI study usefully reminds us that no new capital good is simply inserted into the production environment without a great amount of managerial initiative. This is as true of IT investment as it was of the steam engine two centuries ago. Just because the U.S. now has a large stock of IT does not assure that productivity will continue in the future to grow at its post-1995 rate, contrary to views of some new economy partisans.

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[4] The net acceleration (taking account of positive, accelerating industries and also of industries that experienced decelerating productivity) was 1.4 index points, measured relative to the 1987-95 period . This estimate is comparable with those of Table 2, though constructed differently. The gross acceleration (considering only the industries that experienced productivity accelerations) was 1.8 index points.

Nordhaus (forthcoming) estimated labor productivity for 67 industries, using the BEA industry database, as did Stiroh. Nordhaus computes value added labor productivity, where the other studies (and ours) compute labor and multifactor productivity per unit of output (in national accounts jargon, "gross output").

None of the existing studies reports separate information on services industries. We concentrate on services for two reasons. First, we have been leading a Brookings Institution project on the measurement of output and productivity in the services industries, and services industry productivity remains a challenging issue with many unresolved puzzles. An earlier report on this was Triplett and Bosworth (2001).

Second, as we noted in our earlier paper, a very large proportion of U.S. IT investment goes into services industries, and indeed, into the services industries whose output poses the most difficult measurement problems. This association between IT and difficult to measure industries was first pointed out by Griliches (1994). As noted earlier, much of the controversy over the sources and interpretation of the post-1995 spurt in productivity growth in the U.S. concerns IT-using industries. Examining services industries provides information on the role of IT-using industries in the U.S. economy.

We explore the impact of IT and of MFP on services industries by estimating equation (1) separately for each of twenty-seven 2-digit services industries. Although our study uses the same level of 2-digit detail employed in the Stiroh and Nordhaus studies (and begins as well from the BEA database they used), our research approach is most nearly similar to that of Jorgenson, Ho, and Stiroh (2002) who estimated labor productivity, MFP and IT contributions for 39 sectors. Their services sectors are much more aggregated than ours, and their data differ in a number of respects.

II. The Services Industries Productivity Database

As in our earlier paper, we rely primarily on data from the Bureau of Economic Analysis (BEA) industry output and input program (often referred to as "GDP by industry"). This program contains industry data at the 2-digit level SIC detail for: output (in national accounts language often called "gross output"), with output price deflators, labor compensation, and purchased intermediate inputs, with intermediate input deflators. Of the industries in the BEA database, we excluded the membership organizations and social services industries because of difficulties surrounding the treatment of capital in nonprofit organizations, in response to a discussion with Michael Harper of BLS, and the "other services" industry because its data are sometimes combined with the other two. We excluded the holding company industry because it has no natural definition of output under national accounts conventions (interest in national accounts cannot be a payment for a service, nor interest received an income for a producing unit). We combined depository (banks) and nondepository financial institutions because after examining the data it appeared to us that a shift of savings and loan institutions to the depository institutions industry in the 1987 SIC revision was not handled consistently in all the data items; aggregating these two financial industries increases consistency.

The BEA industry data have been improved substantially recently, and the improvements make them more suitable for industry productivity analysis. New at the industry level are measures of industry output and purchased intermediate inputs. Formerly, this BEA database contained only value added, which is conceptually less appropriate for estimating productivity. The improvements are documented in Yuskavage (1996), and in Lum, Moyer, and Yuskavage (2000). Certain problems that are apparent only in the improved data are discussed in Yuskavage (2001); we consider these below.

For labor input, we take the BEA series on persons engaged in production, because it is consistent with the other BEA data. BEA makes an adjustment for part-time workers and adds an estimate for self-employed labor.[5] The BEA database contains an estimate of compensation for employees, and an estimate of proprietors' income, but no estimate for the labor earnings of the self-employed.

For capital, the BEA database contains property income. However, we estimate the capital share by industry from the BLS estimate of capital income, which is adjusted to yield consistent estimates of the capital income of the self-employed, as described in the appendix. Labor compensation is then estimated as a residual in order to get a consistent allocation of capital and labor income for the self-employed.[6] The share of intermediate inputs is based on BEA data.

In our earlier paper, we used BEA data on capital stock at the industry level as a measure of capital input. It is of course well established that the BEA "wealth" capital stock that is appropriate for national accounts purposes is not the appropriate capital input measure for productivity analysis. Productivity analysis depends on the concept of the "productive" capital stock, from which one can derive a measure of the capital services the stock renders to production.[7] At the time we did our earlier paper, the theoretically appropriate capital services measures were not available for the services industries we wished to explore.

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[5] The BLS labor productivity and multi-factor productivity programs estimate worker hours by industry, not just employment, and in principle hours are a better measure of labor input. BLS also adjusts for labor quality, which is missing from our labor input data. Jorgenson, Ho and Stiroh (2002) also estimate quality-adjusted labor hours.

[6] Imputing capital returns and labor compensation to the self-employed from data on employed and employers in the same industry results in a total that exceeds proprietors' income. Thus, BLS constrains capital and labor income of the self-employed so that it combines to reported proprietors' income.

[7] The development of "productive stock" concepts for production analysis stems from the work of Jorgenson (1963), and the empirical implementation in Jorgenson and Griliches (1967). Reviews of national accounts and productivity concepts for capital are contained in Hulten (1990), Triplett (1996), Schreyer (2001), and also the OECD manual on capital (2001).

Now, however, BLS has computed capital service flows by industry that are consistent with the revised BEA capital stock data reported in Hermann and Katz (1997). BLS capital service flow estimates for services industries are presently unpublished and have been provided by Michael Harper. Thus we meld the BLS series on capital services with the BEA data on output and other inputs.

We split our capital share weight to separate IT and non-IT capital shares using BLS capital income proportions. The BLS capital services data also disaggregate IT capital to a lower level than has been available previously. Many studies have investigated the effect of IT, narrowly defined, which means computers and related (peripheral) equipment. Others have broadened the definition of IT to include software. In the U.S., software investment has in recent years been larger than investment in computer hardware. Yet other studies have further broadened the definition of IT to include communication equipment, leading to the term information and communication technology equipment (or ICT).

An additional category of IT equipment exists in the BLS capital service flows data: "other IT equipment." Other IT equipment includes copy machines and so forth, whose use is integral with the management of information. The electronic-driven technological change that characterizes much computer and communications equipment is also evident in such equipment. For this reason, we also work with an IT category that we call ICOT (information, communication and other information technology) equipment.

Capital services for all these definitions of IT (that is, narrow IT, ITC and ICOT) are available in the BLS data for our 27 services industries. We separate capital services (and capital shares) alternatively into IT, ICT and ICOT, and into other (nonIT) capital. We settle, however, on the ICOT definition of IT.

Table 2 ranks the ten most IT-intensive U.S. industries, defined here as IT capital's share of value added, according to our three alternative IT definitions. There are some variations in these rankings, and also some surprises. One does not usually think of pipelines, for example, as an IT-intensive industry, nor utilities (electric, gas and sanitation services). But the table makes clear that the most intensive IT industries in the U.S. economy are overwhelmingly services industries. Indeed, for our broadest measures of IT, the chemicals industry is the only non-services industry in the top 10. We also calculated IT intensity as a proportion of total capital services and as a proportion of total cost.[8] Again, the rankings do not remain entirely unchanged, but the overall picture is the one shown in table 2: Most of the highly intensive IT-using industries are in the services sector.

Actually, these IT intensive industries are in the portions of the services sectors where measurement problems are severe. Of the nine services industries that appear in some column of table 2, five of them have been subjects of Brookings economic measurement workshops.[9]

III. Services Industries: Labor Productivity Growth

We begin by addressing labor productivity, which in our measure is output per person engaged in production. The services industries for which we calculate productivity are given in table 3, where they are ranked according to their rate of labor productivity growth over the 1995-1999 interval, and in the Appendix, where they are arrayed by SIC code.

First, how did labor productivity in these 27 services industries compare with the performance of the aggregate economy after 1995? We summarize the industry labor productivity changes in table 4.

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[8] There is no natural way to define "IT intensive." The ratio of IT to output will be greater, other things equal, in more capital intensive industries. The ratio of IT to total capital may be misleading for industries that use little capital. Our estimation (below) uses the share of IT in total costs because that is appropriate for estimating productivity contributions. Stiroh (2001) presents data on the ratio of IT to labor, which is another measure of IT intensity that is of interest for some purposes.

The unweighted average of the 27 industries exhibits an average labor productivity growth rate, post-1995, of 2.5% per year, nearly identical to the economy-wide average of 2.6%. In the lower panels of table 4, we weight these 27 industries using output, value added, and employment weights.[10] Whatever the weights, the average labor productivity growth rate for the 27 services industries is a bit higher than the unweighted average, and accordingly equal to or a bit higher than the economy-wide average. Labor productivity growth in services is considerably greater after 1995 than before, which means that the services industries are consistent with the economy-wide story (chart 1).

We have reservations about the measure of output in the brokerage industry, which shows a huge labor productivity increase, post-1995 (table 3). BEA measures brokerage output essentially by the number of shares traded. MGI (2001) weighted trades with brokerage fees. Because the greatest growth has been in low-fee trades, this gives a lower rate of output growth than the unweighted trades that make up the national accounts measure of output for this industry.

Accordingly, we excluded brokerage and its 20 percent per year labor productivity growth and recalculated table 4—see table 4A. The result, predictably, lowers all the average rates of services industry labor productivity, to an unweighted average of 1.9 percent per year, and an output weighted average of 2.4 percent per year. Even without brokerage, services industries have weighted average labor productivity growth that is about at the national rate, post-1995.[11]

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[9] http://www.brook.edu/dybdocroot/es/research/projects/productivity/productivity.htm

[10] The correct *aggregation* of industry productivity uses Domar (1961) weights, which are the ratio of industry *i*'s output to final output, in our case aggregate services sector output. We lack a measure of services industries output that excludes intra-industry transactions, and for this reason do not use Domar weights in table 4.

[11] We also performed the calculations excluding both brokerage and insurance carriers (the industry with the largest negative productivity growth). The results were not much changed, compared with table 4.

The right-most columns of tables 4 and 4A show that services industries labor productivity, on average, accelerated after 1995, in step with the economy-wide acceleration in labor productivity (table 1). Using the longer 1977-1995 interval as the base, labor productivity growth in the 22 industries for which output data extend to 1977 accelerated by 1.4 percentage points (unweighted), post-1995, which about equals the aggregate acceleration reported in table 1. On a weighted basis, acceleration is greater: 1.7 to 2.0 points. Without brokerage (table 4A), the weighted post-1995 acceleration is still around 1.4 points compared with 1977-95, again nearly equal to the aggregate acceleration reported in table 1 (though the unweighted acceleration is lower).[12]

Table 4 also implies that some productivity acceleration in services industries took place before 1995 (because labor productivity growth is greater for 1987-1995 than for 1978-95, for the industries for which a comparison can be made). We do not explore here whether 1995 is the appropriate break point for analyzing the recent productivity acceleration in services industries.[13]

Although our results have been anticipated by Sharpe (2000), strong services industry labor productivity growth is nevertheless news, because service sector productivity has long been regarded as the laggard in industry productivity measures. Our earlier paper (Triplett and Bosworth, 2001) was consistent with the slow growth in services productivity idea: We calculated implied non-manufacturing productivity numbers and showed that the post-1973 productivity slowdown was greater in the non-goods producing parts of the economy than in

[12] For the full set of 27 industries, the labor productivity acceleration can only be computed relative to 1987-95. At 0.9 percentage points, unweighted (i.e., 2.5 – 1.6), it is a little below the economy-wide acceleration of 1.3 percentage points, but the periods over which acceleration is calculated are different. In all cases, excluding brokerage lowers the average acceleration. Note that post-1995 labor productivity growth is not appreciably different for the full set of 27 industries and the smaller set of 22 (table 4).

[13] Stiroh (2001) performed statistical tests on data for 61 industries, and concluded that 1995 was the appropriate break point for annual data. Parham (2002), on the other hand, contends that productivity acceleration should be measured with respect to productivity peaks. Productivity peaks analysis gives lower acceleration in the US than does use of 1995 as a break point, and 1973-95 or 1987-95 as a comparison interval.

manufacturing. Slow growth in the earlier period is also indicated by the entries in tables 4 and 4A that show, for example, labor productivity growth rates of one percent or less for the interval extending from 1995 back to 1977.

In the most recent period, services industries, on average, have done about as well as the rest of the economy, both in their average rate of labor productivity improvement and in their post-1995 acceleration. This finding is likely to change a great amount of thinking about productivity and about productivity measurement. The remainder of this paper provides an initial exploration of the new developments in services industry labor productivity.

IV. Labor Productivity Acceleration: The Detailed Industry Results

Averages always conceal. Not all services industries performed at the sector-wide average. On the other hand, the sector averages are not caused by the performance of one or two large industries, the improvement in labor productivity is broadly based.

For the twenty-two industries for which output data extend to 1977, fifteen (marked with asterisks in the 1977-95 column of table 3) experienced productivity accelerations after 1995, compared with their 1977-95 experiences. Large accelerations (more than 3 percentage points) occurred in security and commodity brokers, in insurance agents (from a negative labor productivity number in the earlier period to 3 ½ % in the latter), in pipelines and in legal services. One industry (local and inter-urban transit) had negative productivity throughout, but its performance improved greatly after 1995 (that is, its productivity growth became less negative), so we put it in the accelerating group. Indeed, local transit has the sixth largest acceleration (2.7 points) in services industries.

In contrast, seven industries experienced decelerations of labor productivity after 1995. Of these, the largest declines were rail transportation (-4.9 percentage points), trucking (-2.1

points), and a group at the bottom of table 3, consisting of insurance carriers, education, amusement and recreation, and motion pictures, whose labor productivity deteriorated by –1.4 to –1.7 percentage points.

For another five of our 27 industries, output data are available only after 1987. Using 1987-1995 as the comparison period, the picture is again mixed. Brokerage and insurance agents experienced very large accelerations after 1995. Trucking, railroads, and amusement and recreation show big declines in productivity. Overall, using the 1987-95 period for the comparison, thirteen industries experienced accelerations after 1995, five industries recorded changes of only 0.1, positive or negative, so are better recorded as unchanged, and nine were marked by decelerations. Local transit again showed negative productivity in both periods, but its productivity improved greatly after 1995.

These results are similar to those of Stiroh (2001). He reports that in 38 out of 61 industries labor productivity accelerated post-1995, so it did not accelerate in 23 industries. Stiroh does not separately report goods producing and services producing industries.[14]

V. Contributions to Labor Productivity Growth in the Services Industries

We next analyze accelerations and decelerations of labor productivity using the growth-accounting model. That is: Each industry's change in labor productivity is explained by capital deepening, both from IT capital and from non-IT capital, by increased use of purchased materials

[14] However, he notes that the security and commodity brokers industry has a very high productivity growth rate, and comments that strong productivity growth in this industry may be an artifact of the way that output is measured. We agree with his assessment. He also included holding and investment companies in this remark, an industry we excluded on the basis that its output is particularly ill-defined. Had we included it, it would have been in the accelerating group. This underscores that errors in measuring output do not always bias downward output growth and productivity. Corrado and Slifman (1999), in a widely noticed paper, adjusted negative industry productivity rates upward on the grounds that negative productivity indicated measurement errors, especially when, as they emphasized, profits were positive. They are likely right, at least in some cases. But chopping off one tail of a distribution on the grounds that outliers are signs of measurement errors cannot produce a better estimate of the mean unless one is certain that measurement errors are absent elsewhere in the distribution.

and purchased services (intermediate input deepening), and by MFP—see equation (1). We perform the contributions to growth exercise for each of the 27 industries.

The full results are displayed in the Appendix. An extract for the ten highest-performing services industries appears in table 5, where they are arrayed by the size of their labor productivity growth, post-1995. The ten industries in table 5 are the services industries that have labor productivity growth that exceeds (more than marginally) the economy-wide labor productivity growth since 1995.

As one might expect, each of those 10 top performers experienced productivity acceleration, compared with either of the previous two periods (1987-1995 or 1977-1995). The sole exception is the financial institutions industry, which has slightly lower productivity growth after 1995.

In these 10 industries, labor productivity growth arises from many sources. ICOT capital deepening was a big contributor to labor productivity growth in wholesale trade, transportation services, and banks, and to a lesser extent, in pipelines and business services.

Non-IT capital services were as important as ICOT services in raising labor productivity in pipelines. In other industries, however, non-IT capital was usually less important a contributor to acceleration than was IT capital.

MFP accounted for half or more than half of labor productivity growth in the following industries: brokerage, wholesale trade, retail trade, and pipelines. But MFP was inconsequential in transportation services (which includes travel agents) and business services, even though labor productivity growth was high in those industries. MFP was negative in miscellaneous repair.

The really striking information in table 5 concerns the contribution to labor productivity of increasing use of intermediate inputs. In two industries—brokerage and telephones—

purchased materials and services contributed more than 4% annually to labor productivity growth. In transportation services, miscellaneous repair, and business services, purchased intermediate inputs contributed half or more of the growth in labor productivity, and a little bit under half in the insurance agents industry. On the other hand, intermediate inputs made negative contributions in pipelines.

Increasing purchased intermediate inputs suggests "contracting out." These activities contributed mightily to labor productivity growth in some of these services industries, though inconsequentially in others. The result suggests that productivity in the services industries has advanced because of the reallocation of economic activity towards more specialized, and hence more productive, producers. Jorgenson, Ho, and Stiroh (2002) examine the effects of reallocation among industries on aggregate economic performance.

As we noted earlier, an active research literature on the U.S. labor productivity acceleration (see table 1) has focused mostly on the roles of IT capital and of MFP as contributors to high labor productivity growth. In the services industries, is it MFP or IT capital that accounts for labor productivity growth?

The answer from table 5 is: Sometimes one, sometimes the other, sometimes both (brokers, wholesale trade, pipelines), but seldom neither. Sometimes, however, the *major* factor was neither—the cases where purchased intermediates deepening was a major factor in labor productivity growth include telephone, insurance agents, transportation services, and business services.

Additional insight comes from examining the services industries that had low productivity growth. Table 6 arrays the lowest-performing services industries, ranked on their post-1995 labor productivity change.

What accounts for poor industry labor productivity performance? Again, no single factor emerges. The range of causes in table 6 is perhaps best illustrated by two industries near the middle of the list—local transit and hotels. Local transit has excellent MFP performance (at 2.2% annually, it is the best of this low-performing group and among the leaders in the group of 27 industries). But this industry has reduced its use of cooperating factors so much that its labor productivity has turned negative. Hotels, on the other hand, have increased their use of cooperating inputs, including ICOT; but that has done them little good, because their MFP has declined greatly. The performance of the hotel industry, including the failure of its investment in IT to raise labor productivity, is analyzed in McKinsey Global Institute (2001).

In contrast to the high productivity growth services industries, contracting out in the form of intermediate input deepening is not prominent in the group of industries included in table 6, radio and TV excepted. Several industries substituted internal production against intermediate inputs, which predictably lowered labor productivity. The ICOT contributions are also mostly low, again with the exception of radio and TV.

One should also note the substantial break between the group of industries at the top of table 6, all of which have labor productivity growing at positive rates, and the group of negative productivity industries at the bottom of the table. Although all of these 10 industries are below the national average labor productivity growth of 2.6% for the post-1995 period, growth rates for some industries at the upper end of table 6 would have looked quite respectable in the recent past. Negative productivity industries in the U.S. and Canada are analyzed in Sharpe, Rao, and Tang (2002).

Overall: Contributions of ICOT, Intermediate Inputs, and MFP. We noted at the beginning of this section that much recent research on the U.S. productivity acceleration has examined contributions of IT and of MFP. We have emphasized the diversity in performance in services industries, and especially how diverse are these industries with respect to the factors that have raised their productivity growth. We provide some summary measures in tables 7 and 7A.

Table 7 shows average contributions to labor productivity acceleration across the 22 industries for which data exist since 1977. To economize on space and calculations, we show contributions to the unweighted average labor productivity acceleration. Note that, as shown in tables 4 and 4A, weighted averages uniformly give higher post-1995 labor productivity accelerations than the unweighted averages we present in table 7. We also calculate contributions excluding the brokerage industry, for the reasons given above.

MFP is the major contributor to acceleration—well over half, whether of not brokerage is excluded. Naturally, both the acceleration itself and the MFP contribution to the acceleration are lower when brokerage is excluded, as already indicated earlier in the paper.

Increased use of IT capital services also plays a major role in boosting labor productivity, and IT provides a larger relative portion of the acceleration when brokerage is excluded. The reason that IT does not play a larger role in the analysis of post-1995 labor productivity *acceleration* is that its contribution to labor productivity in these services industries was already prominent before 1995. Investment in IT is not new, and it has long been known that much IT investment took place in services (Griliches, 1992; Triplett and Bosworth, 2001). McKinsey Global Institute (2001) contains a compatible result in its detailed examinations of a small number of services industries: It was often not new IT, or new IT investment, that was associated with rapid productivity change, but instead IT capital technology that had been around for a decade or two. Our analysis supports this part of the MGI conclusion: IT capital was a major contributor to LP growth post-1995, but its effects are visible well before.

We also display in table 7 contributions to labor productivity acceleration for those thirteen industries that actually experienced acceleration. For those industries, the average labor productivity acceleration is of course considerably larger than for the whole group of 22. Again, MFP is the main contributor to acceleration, accounting for well over half. All the other factors also play a role, but IT actually follows intermediate deepening in the in the size of its contribution. As before, this is not because IT does not contribute to growth, but because its contribution to growth was already evident in the services industry data before 1995.

In table 7A, we perform the same calculations for the full set of 27 industries, but we are constrained by data availability to analyzing the post-1995 acceleration relative to the shorter 1987-95 base. Though the unweighted average acceleration is lower for the shorter period, the results of the contributions exercise are very similar: Accelerating MFP is the major engine of labor productivity acceleration, with increased use of IT capital services trailing increased use of intermediates as a tool for accelerating labor productivity growth. Excluding the brokerage industry has the same effects as for the previous analysis that used the longer 1977-95 base.

Average MFP growth for services industries is shown in table 8. MFP shows a marked acceleration after 1995 in services industries, whether judged by unweighted or weighted averages. On a weighted basis (all weighting systems give similar results), MFP was close to zero in the earliest period (1977-95), picked up a bit for the 1987-95 interval (0.4 percent per year for the broadest group of industries), and exceeds one percent per year after 1995 (on a weighted basis). Excluding brokerage (not shown) gives similar results.

MFP growth is thus a major contributor to services industry labor productivity growth and to post-1995 acceleration. MFP is also the major source of the post-1995 acceleration of LP in services industries.

VI. Caveats and Questions

In the analysis for this paper, we have "pushed" the industry data very far. Even though the production function paradigm applies best to industry data, concern has long been expressed that the consistency of U.S. industry-level data creates formidable problems for carrying out productivity analysis at the detailed level—Baily and Gordon (1988), and Gordon (2001). Our data are at the "subsector" level (two digits of the old SIC system), rather than at the "industry" level (four digit SIC). Nevertheless, the concern has validity.

We should first note, however, that the concern applies to any use of the industry data, it does not apply solely to our estimation of contributions to labor productivity. It also applies, for example, to attempts to group industries into "IT intensive" and "non-intensive" industries, a popular approach to analyzing the impact of IT. If the industry data do not prove consistent, then analyzing the industry data grouped in some way or other suffers from the same data deficiencies.

Earlier, we noted that the BLS industry labor productivity program prepares estimates that differ from ours in some aspects of methodology. BLS output measures are different from those of BEA, they compute output per labor hour instead of output per worker (as we do), and other differences occur in certain industries. We use the BEA database mainly because it provides comprehensive coverage of industries. The BLS data are available only for selected industries, so it is impossible to get from them an understanding of economy-wide or sectoral labor productivity trends.

Table 9 compares our labor productivity estimates with an alternative published BLS industry labor productivity series that presents output per worker, so it is conceptually closer to our table 3. As table 9 suggests, in many cases the BLS data are published only for selected 3- or 4-digit industries that account for only a fraction of the 2-digit industries to which they belong. After allowing for the differences in coverage, the correspondence is reasonably close in some cases (trucking, telephone, radio-TV, and personal services), less so in others. Many of these differences in productivity growth rates are no doubt due to coverage differences. However, methodological and date inconsistencies do exist between BEA and BLS databases, and in some cases affect the conclusions. Gordon (2001) emphasizes these inconsistencies. Bosworth (2001) contains a detailed discussion of inconsistencies in the data for transportation industries.

Some of the major inconsistencies of industry data have been discussed quite openly by the statistical agencies themselves. Yuskavage (2001) has provided an important analysis. One can estimate industry value added two ways. Industry purchases of intermediate inputs can be subtracted from industry gross output, leaving value added as residual. Then, industry labor compensation (usually considered the most accurately estimated input) can be subtracted from value added, leaving capital income as a residual. Alternatively, value added can be estimated directly from labor compensation and information on capital income; then intermediate input purchases are obtained residually by subtracting value added from gross output. These two methods do not yield consistent results. Inaccuracy in the first arises because intermediate input purchases collected in the economic censuses and other Census Bureau surveys are less accurate than the output information collected from the same surveys. The limitation in the second approach is the potential inaccuracy of measuring the capital input. As noted in the Appendix, self-employed income creates another inconsistency, and our use of BLS capital shares (in order to use the BLS adjustment for self-employment income) creates an inconsistency with BEA capital and labor shares.

If labor input and gross output are measured well (and this includes the deflators for output), then labor productivity would be measured accurately, regardless of inaccuracy in the other inputs. This is the reason why many analyses at the industry level have considered only LP. If any of the other inputs were measured inaccurately, this creates mismeasurement in MFP. To the extent that purchased services are inaccurately measured in Census Bureau collections, for example, the result is mismeasured MFP, so input measurement problems inherently limit the accuracy of our industry MFP measures.

As well, the productivity growth model imposes by assumption the condition that capital earns its marginal product. If that assumption is incorrect, then capital's contribution to production is misstated and MFP is mismeasured. These errors would also bias our estimates of capital's contribution to labor productivity growth.

Moreover, the allocations of capital services across industries may be problematic. As described earlier, we use detailed IT capital services data for our 27 industries, which are available for each year of our study. However, the basic information for allocating IT capital by industry is the BEA capital flow table; the latest year for which this is available is 1992 (Bonds and Aylor, 1998). If IT capital flowed to different industries in the last half of the 1990's, our IT intensity and IT capital services variables would be mismeasured. Even for 1992, the basis for allocating high tech capital across using industries is weak: Triplett and Gunter (2001), for example, point to the puzzling presence of medical scanners in agriculture and business services industries in the BEA capital flow table (apparently an artifact of balancing input-output tables), and similar anomalies may be present for IT capital. If so, IT capital is inaccurately allocated to using industries in our data, which creates consequent errors in the contribution of IT capital services and of MFP.

Michael Harper of BLS has suggested to us that the allocation of capital across non-profit organizations may create inconsistencies in some of the industries. We have excluded the membership organizations industry from our analysis for this reason, but some other industries may also be affected by this data problem.

Then, there is the age-old problem of deflators, not only for output but also for purchased inputs. How does one measure the price, and therefore the output, of a service industry? Or of the purchased services that are a growing part of intermediate inputs? These are not idle questions. The difficulties, both conceptual and practical, are many, and have long been considered thorny problems (see the volumes on these topics edited by Griliches, 1992, and Fuchs, 1969). Indeed, McGuckin and Stiroh (2001) contend that increasing mismeasurement of output in the U.S. economy amounts to half a percentage point in economic growth.[15] An assessment of output measurement in some of the services industries that are IT intensive is Triplett and Bosworth (2001). See also the various papers and workshop agendas on the website for the Brookings Program on Economic Measurement (http://www.brook.edu/es/research/projects/productivity/productivity.htm), as well as the discussions of services measurement issues in the Eurostat handbook on price and output measures in national accounts (Eurostat, 2001).

Against all this, we feel that the U.S. statistical system has recently made substantial improvements to industry-level data. These improvements have not widely been noticed. No

[15] However, they introduce the implicit assumption that improving the measurement of output will raise output growth rates. This has sometimes been the case, empirically. But we are not convinced that services sector output was measured better in the U.S. in the 1950's and 1960's, as their assumption must imply if it is applied to the 1973-95 era.

doubt measurement problems remain, but the situation today is far better than it was when Baily and Gordon (1988) reviewed consistency of the industry data for productivity analysis.

First, the BEA GDP by industry accounts now include a full accounting for inputs and outputs. That full accounting imposes the discipline of a check that was not present when the accounts focused only on value added. Put another way, when only an estimate of value added was available at the industry level, the problems discussed by Yuskavage (2001) were simply unknown to researchers, unless they dug deeply beneath the veneer of the published statistics.

Second, the Census Bureau, in the 1997 economic censuses, collected more penetrating information on purchased services than had been the case in earlier economic statistics for the United States. Information on purchased inputs at the industry level is still a problem for productivity analysis, but the state of the statistics is much improved over earlier years.

Third, the Bureau of Labor Statistics, in its Producer Price Index (PPI) program, has moved aggressively in the 1990s into constructing output prices for services industries. A number of these initiatives have been discussed in the series of Brookings workshops on economic measurement. All the problems of services sector deflation have not been solved, and for some services industries the difficulty of specifying the concept of output limits the validity of deflators. But the remaining problems should not obscure the progress. Tremendous improvement has occurred since the discussion of measurement problems in the services industries in Griliches (1994).

Does improved measurement account for the acceleration in service industry productivity? That is, is the productivity surge in services in some sense a statistical illusion? Perhaps the cure for Baumol’s Disease was found years ago, only the statistics didn’t record it, or perhaps the services industries were never sick, it was just, as Griliches suggested, that the measuring thermometer was wrong.

A full answer to that question is beyond the scope of this paper. For one accelerating industry, however, the answer is clearly yes: The acceleration in medical care labor productivity (-0.5 before 1995, +0.7 percent after, with MFP "accelerating" from -1.5 to -0.4) is undoubtedly the effect of the new BLS medical care PPI industry price indexes that began in 1992 and replaced the old CPI-based medical care deflators in national accounts (see Berndt, et al, 2001). The PPI indexes rose more slowly than the CPI indexes they replaced (an overlap period confirms that it was methodology, not health care cost containment, that accounts for the difference).

Medical care productivity was understated by a large amount before 1992. Triplett (1999) calculates an account for one portion of medical care (mental health care services), using a combination of the difference between the new PPI and the old CPI mental health care components, and new price indexes for depression from Berndt, Busch and Frank (2001). The "backcasted" result increased the estimated rate of growth of mental health care services, which is –1.4 percent annually, calculated from available government data, to +5.0 percent for the 1990-95 period. If the results for mental health carried over to the entire medical care sector, they imply a proportionate increase in medical care labor productivity (which we estimate as -0.5 percent annually for 1987-95, from table 3) and MFP (-1.5 percent annually for the same 1987-95 period). Accordingly, the improvements in PPI price indexes account for the improved measured productivity in medical care, but medical care productivity is probably still understated substantially. Negative MFP for the health care industry (-0.4, see industry 80 in the Appendix) may be one indication.

VII. Conclusion.

In their labor productivity and MFP performance, services industries have long appeared unhealthy, especially so since the great productivity slowdown after 1973. With some exceptions, they appear lively and rejuvenated today.

We find that post-1995 services industries labor productivity growth has proceeded at about the economy-wide rate. Moreover, services industries have experienced an acceleration of labor productivity after 1995 that is comparable with the aggregate acceleration that has received so much attention. These changes are broadly based, they are not just the effects on the average of a small number of large industries. For example, of the 22 industries for which data exist for the whole period of our study, 13 experienced accelerating LP after 1995.

With respect to the sources of labor productivity improvement in services industries, growth in MFP, IT capital deepening, and increased use of intermediate inputs (especially in the fastest growth services industries) all played a role. With respect to the post-1995 acceleration of labor productivity, however, MFP is the dominant factor in the acceleration, because IT capital deepening was as prominent a source of labor productivity growth before 1995 as after.

Finally, Griliches (1992, 1994) suggested that measurement difficulties, particularly conceptual problems in defining and measuring output and price deflators, might have made these industries' productivity performance in the past seem less robust than it actually was. In our assessment, much improvement has been made in the U.S. industry database in the last decade, and the improved database makes us more confident in industry productivity estimates, even though much measurement work remains to be done to improve our understanding of productivity trends in services industries.

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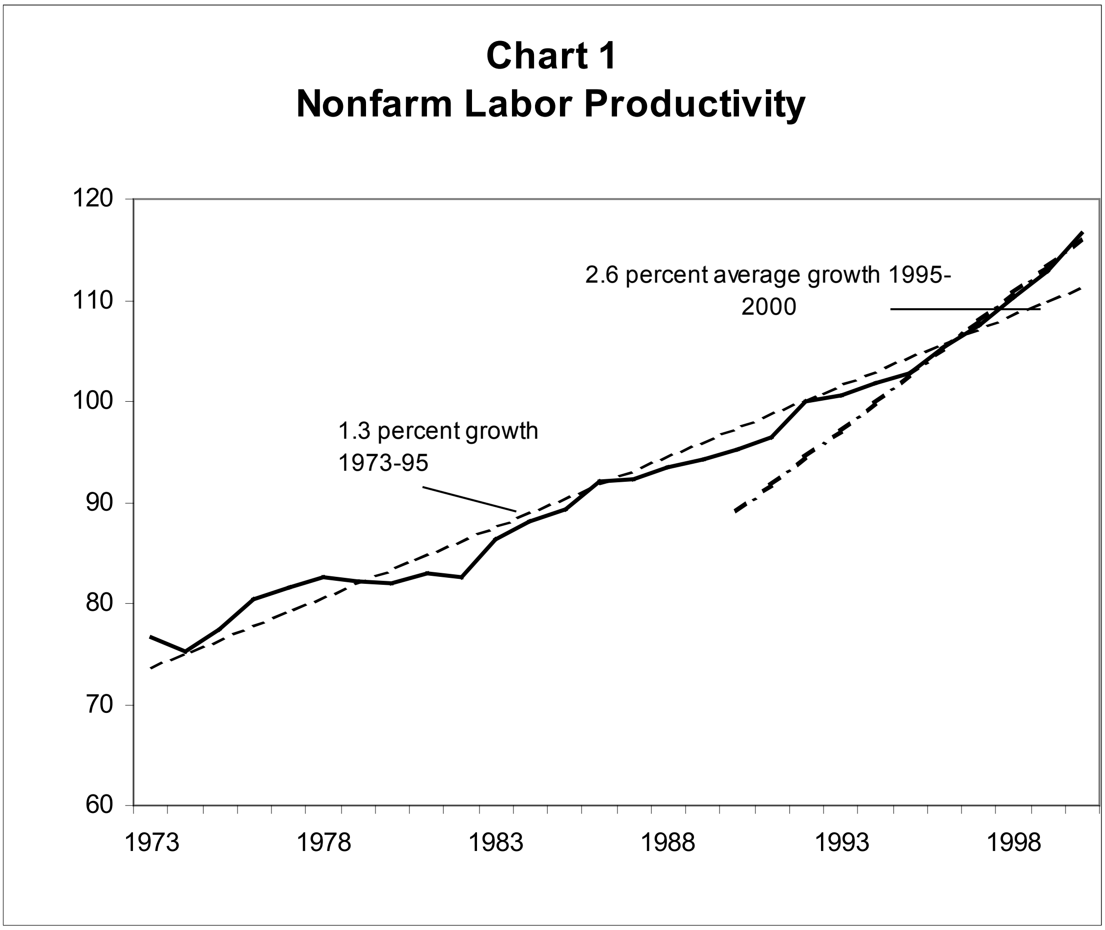
Chart 1
Nonfarm Labor Productivity
120
110
100
90
80
70
60
1973
1978
1983
1988
1993
1998
2.6 percent average growth 1995-2000
1.3 percent growth 1973-95

Table 1

Alternative Estimates of the Acceleration of Productivity Growth, Post-1995

Annual Rates of Change

Category	Jorgenson and Stiroh	Oliner and Sichel	Council of Economic Advisors	Gordon
Labor Productivity	0.9	1.2	1.5	1.4
Cycle	n.a.	n.a.	n.a.	0.4
Trend	0.9	1.2	1.5	1.0
Contribution of:				
Capital per worker	0.3	0.3	0.5	0.4
IT capital	0.3	0.5	n.a.	n.a.
Other capital	0.0	-0.2	n.a.	n.a.
Labor Quality	0.0	0.0	0.1	0.0
Multi-factor Productivity	0.7	0.8	0.9	0.5
Production of IT	0.3	0.3	0.2	0.3
Other sectors (IT using)	0.4	0.5	0.7	0.2

The post-1995 acceleration is measured relative to a base of 1973-95. The estimates of Jorgenson-Stiroh extend only through 1998.
Sources: see text.

Table 2
The Ten Most IT Intensive Industries, Economy Wide

(Alternative Definitions of IT Capital Services as a Percent of Value Added: 1995-2000 Average)

	IT / VA /1	Rank	ICT / VA /2	rank	ICOT / VA /3	Rank
Depository and Nondepository Institutions	10.8	1	12.0	3	13.5	3
Wholesale Trade	9.4	2	10.6	4	11.5	4
Business Services	6.5	3	7.3	7	8.3	10
Insurance Carriers	6.0	4	6.7	8	8.3	9
Printing and Publishing	5.4	5	6.5	9	8.0	
Industrial Machinery and Equipment	5.0	6	5.6		6.2	
Transportation Services	4.8	7	9.5	5	10.4	7
Pipelines, Except Natural Gas	4.7	8	8.5	6	10.7	5
Electronic and Other Electric Equipment	4.5	9	5.6		6.9	
Telephone and Telegraph	4.2	10	32.8	1	33.6	1
Chemicals and Allied Products	2.9		3.6		10.5	6
Electric, Gas, and Sanitary Services	2.8		5.9	10	9.4	8
Radio and Television Broadcasting	2.6		24.2	2	25.6	2

/1 IT = computer equipment and software
/2 ICT = computer equipment, software, and communications equipment
/3 ICOT= computer equipment, software, communications equipment, and other information technology equipment

Ratios of capital income from the BLS to value added minus indirect business taxes from the BEA GDP by industry file.

Table 3
Labor Productivity Growth, Service Industries

	1977-1995	1987-1995	1995-2000	1995-2000 Change: Relative to 1977-95	1995-2000 Change: Relative to 1987-95	Output Share: 1995-2000 Average
Security, Commodity Brokers and Services	5.4	7.2	20.2	14.8 *	13.0 *	3.1
Telephone and Telegraph	6.3	5.8	6.7	0.5 *	0.9 *	4.0
Wholesale Trade	2.1	3.3	4.4	2.2 *	1.1 *	9.7
Transportation Services		2.3	3.8		1.6 *	0.6
Retail Trade	0.7	1.2	3.5	2.8 *	2.3 *	13.8
Pipelines, Except Natural Gas	0.4	0.7	3.5	3.1 *	2.9 *	0.1
Insurance Agents, Brokers, and Services	-2.6	-3.3	3.5	6.1 *	6.8 *	1.2
Business Services		3.0	3.5		0.5 *	8.4
Depository and Nondepository Institutions		3.3	3.1		-0.1	6.8
Miscellaneous Repair Services	0.9	2.6	2.7	1.8 *	0.1	0.7
Railroad Transportation	7.5	6.5	2.6	-4.9	-4.0	0.5
Legal Services	-1.2	0.1	2.2	3.0*	2.1 *	2.0
Water Transportation		2.3	2.2		-0.1	0.5
Real Estate		2.4	2.0		-0.4	16.3
Electric, Gas, and Sanitary Services	-0.3	2.5	1.9	2.2*	-0.5	4.1
Personal Services	-0.1	1.7	1.8	1.9*	0.1	1.2
Transportation by Air	0.4	-3.4	1.3	0.8 *	4.7 *	1.7
Radio and Television Broadcasting	0.6	0.2	1.2	0.6 *	1.0 *	1.2
Trucking and Warehousing	3.1	4.9	1.0	-2.1	-3.9	3.2
Auto Repair, Services, and Garages	-0.3	1.4	0.9	1.2 *	-0.5	1.7
Health Services	-0.2	-0.5	0.7	1.0 *	1.2 *	9.9
Hotels and other Lodging Places	0.9	0.7	0.3	-0.6	-0.4	1.5
Local and Interurban Passenger Transit	-2.8	-1.6	-0.2	2.7 *	1.4 *	0.3
Motion Pictures	1.3	-0.3	-0.5	-1.7	-0.1	0.8
Amusement and Recreation Services	0.6	1.9	-0.8	-1.4	-2.7	1.6
Educational Services	0.3	0.5	-1.2	-1.5	-1.7	1.5
Insurance Carriers	0.2	0.0	-1.4	-1.6	-1.4	3.6

* Post-1995 accelerating industries.

Labor productivity is output (excluding indirect business taxes) per person engaged in production.

The output share is the sum of industry output (excluding indirect business taxes) from 1995-2000 divided by the sum of all services outputs (excluding IBT) over the same period.

Table 4
Average Service Industry Labor Productivity

	1977-1995	1987-1995	1995-2000	Acceleration 1995-2000, Relative to: 1977-1995	1987-1995
A. Unweighted Average					
27 Industries		1.6	2.5	n.a.	0.8
22 Industries	1.0	1.4	2.4	1.4	1.0
B. Weighted by Output					
27 Industries		1.9	2.9	n.a.	1.0
22 Industries	1.0	1.6	3.0	2.0	1.4
C. Weighted by Value Added					
27 Industries		2.0	2.9	n.a.	0.9
22 Industries	1.1	1.6	3.0	1.9	1.4
D. Weighted by Employment					
27 Industries		1.5	2.6	n.a.	1.1
22 Industries	0.8	1.3	2.5	1.7	1.2

The 27 industries group includes all industries listed in the appendix table and described in the data appendix. The 22 industries group is the subset of the 27 industries group with gross output data available before 1987.

For each paired years t and $t+1$, the output weight for industry i is the average share for industry i in the two years, where the share in t equals the output (excluding IBT) of industry i in year t over the sum of all services outputs (minus IBT) in year t.

For each paired years t and $t+1$, the value added weight for industry i is the average share for industry i in the two years, where the share in t equals the value added (excluding IBT) of industry i in year t over total services industries value added (minus IBT) in year t.

For each paired years t and $t+1$, the employment weight for industry i is the average share for industry i in the two years, where the share in t equals persons engaged in production in industry i in year t over persons engaged in production in all services industries in year t.

The weighted average annual growth rate of labor productivity is

$$100 * \left[\{ \prod_t \exp(\sum w_{it} * [\ \ln(Q_{it} / Q_{i,t-1}) - \ln(L_{it} / L_{i,t-1})\ ]\ \}^{1/T} - 1 \right]$$

where w_{it} is the weight of industry i in year t, Q_{it} is industry i's output in year t, and L_{it} is the number of persons engaged in production in industry i in year t.

Table 4A
Average Service Industry Labor Productivity, Excluding Brokers

	1977-1995	1987-1995	1995-2000	Acceleration 1995-2000, Relative to: 1977-1995	1987-1995
A. Unweighted Average					
26 Industries		1.4	1.9		0.4
21 Industries	0.8	1.2	1.6	0.8	0.5
B. Weighted by Output					
26 Industries		1.8	2.4		0.6
21 Industries	.9	1.4	2.3	1.3	0.8
C. Weighted by Value Added					
26 Industries		1.9	2.4		0.6
21 Industries	1.0	1.5	2.3	1.3	0.9
D. Weighted by Employment					
26 Industries		1.5	2.4		1.0
21 Industries	0.8	1.2	2.3	1.5	1.1

Excluding security and commodity brokers.

Weights constructed as in Table 4.

Table 5
The Top 10 Labor Productivity Growth Services Industries, 1995-2000

	LP	Contribution to Labor Productivity (Percentage Points)				Percent of Contributions			
		MFP	ICOT	Non-ICOT	Intermediate Inputs	MFP	ICOT	Non-ICOT	Intermediate Inputs
Security, Commodity Brokers and Services	20.2	11.2	0.2	0.1	7.8	58	1	0	41
Telephone and Telegraph	6.7	1.6	0.5	0.0	4.5	24	8	0	68
Wholesale Trade	4.4	2.4	1.4	0.3	0.2	56	32	7	4
Transportation Services	3.8	0.3	1.4	0.0	2.0	9	37	1	53
Retail Trade	3.5	3.0	0.3	0.0	0.3	84	8	1	7
Pipelines, Except Natural Gas	3.5	2.9	1.3	1.8	-2.5	83	37	52	-72
Insurance Agents, Brokers, and Services	3.5	1.3	0.2	0.2	1.7	37	6	7	50
Business Services	3.5	0.0	1.0	0.0	2.4	0	30	1	69
Depository and Nondepository Institutions	3.1	0.5	1.5	0.3	0.8	16	49	11	25
Miscellaneous Repair Services	2.7	-1.2	0.4	0.3	3.3	-45	14	10	121

All contributions are average annual growth rates of inputs multiplied by value shares. The contributions do not sum to labor productivity because they are growth rates, which are multiplicative and not additive (e.g. 1.202=1.112*1.002*1.001*1.078). The percentage distribution of the contributions to labor productivity is calculated from the aggregation of log differences over the time period. If *i* is the input, α is the share, *L* is the labor input, and *Q* is output, then the percentage of the contribution of input *i* to labor productivity growth over time *t* is:

$$\frac{100 * \sum_t \alpha_t (\ln(i_t / i_{t-1}) - \ln(L_t / L_{t-1}))}{\sum_t (\ln(Q_t / Q_{t-1}) - \ln(L_t / L_{t-1}))}$$

Table 6
The Bottom 10 Labor Productivity Growth Service Industries, 1995-2000

		Contributions to Labor Productivity (Percentage Points)				Percent of Contributions			
	LP	MFP	ICOT	Non-ICOT	Intermediate Inputs	MFP	ICOT	Non-ICOT	Intermediate Inputs
Radio and Television Broadcasting	1.2	-5.5	2.2	0.9	3.9	-467	180	74	313
Trucking and Warehousing	1.0	0.3	0.1	0.2	0.5	27	10	17	47
Auto Repair, Services, and Garages	0.9	1.0	0.1	-0.1	-0.1	106	12	-9	-10
Health Services	0.7	-0.4	0.2	0.1	0.8	-53	31	11	110
Hotels and other Lodging Places	0.3	-1.1	0.2	0.1	1.2	-436	60	34	443
Local and Interurban Passenger Transit	-0.2	2.2	0.0	0.0	-2.3	1215	22	-22	-1315
Motion Pictures	-0.5	0.3	0.2	0.2	-1.2	60	48	50	-258
Amusement and Recreation Services	-0.8	0.0	0.1	0.0	-0.9	-3	6	0	-103
Educational Services	-1.2	-0.8	0.0	0.0	-0.4	-68	2	0	-34
Insurance Carriers	-1.4	-1.0	0.6	0.2	-1.2	-70	40	15	-85

Definitions are the same as in Table 5.

When labor productivity growth is negative, the signs of the percentage contributions are multiplied by –1, so a positive percentage corresponds to a positive contribution labor productivity, Thus, in these cases, the percents sum to –100.

Table 7
Contributions to Labor Productivity Acceleration
(1995-2000 Relative to 1977-1995)

	Labor Productivity Acceleration	Contribution to Labor Productivity Acceleration			
		MFP	IT Capital	Non-IT Capital	Intermediate Inputs
Unweighted Average, 22 Service Industries	1.4	0.9	0.2	0.1	0.2
Unweighted Average, 21 Service Industries (Excluding Brokers)	0.8	0.5	0.2	0.1	0.0
Unweighted Average, 15 Accelerating Industries	3.0	1.7	0.3	0.1	0.9
Unweighted Average, 14 Accelerating Industries (Excluding Brokers)	2.2	1.1	0.3	0.2	0.7

For each industry, i, acceleration is calculated as: accel i = $AAGR_{i,\ 95\text{-}00} - AAGR_{i,\ 77\text{-}95}$
Group accelerations are the average of each industry's acceleration in the group, that is: $\sum_i$ accel i /n, i.e. the labor productivity acceleration is the difference in the average annual labor productivity growth rates in the two time periods, or

$$\frac{100}{n} * \sum_i \left\{ \left[\prod_t \exp[\ln(Q_{it} / Q_{i,t-1}) - \ln(L_{it} / L_{i,t-1})] \right]^{1/T} - 1 \right\}$$

where for the 1995-2000 time period, t=1996, 1997,…2000 and T=5. Likewise, for the 1977-1995 period, t=1978, 1979,….1995 and T=18.

Table 7A
Contributions to Labor Productivity Acceleration
(1995-2000 Relative to 1987-1995)

	Labor Productivity Acceleration	Contribution to Labor Productivity Acceleration			
		MFP	IT Capital	Non-IT Capital	Intermediate Inputs
Unweighted Average, 27 Service Industries	0.9	0.6	0.2	0.1	-0.1
Unweighted Average, All 26 Service Industries (Excluding Brokers)	0.4	0.3	0.2	0.1	-0.2
Unweighted Average, 13 Accelerating Industries	3.0	1.6	0.4	0.2	0.8
Unweighted Average, 12 Accelerating Industries (Excluding Brokers)	2.2	1.0	0.4	0.3	0.5

Accelerations calculated as in table 7, except for substituting 1987 for 1977 where relevant.

Table 8

Average Service Industry Multifactor Productivity

	1977-1995	1987-1995	1995-2000
	A. Unweighted MFP Average		
27 Industries		0.1	0.7
22 Industries	-0.1	0.0	0.8
	B. MFP Weighted by Output		
27 Industries		0.4	1.2
22 Industries	0.1	0.2	1.4
	C. MFP Weighted by Value Added		
27 Industries		0.4	1.2
22 Industries	0.1	0.2	1.4
	D. MFP Weighted by Employment		
27 Industries		0.1	1.2
22 Industries	-0.1	0.1	1.4

Industry Groups and weights constructed as in Table 4.

Table 9
Comparison of Authors' Calculations and BLS Industry Labor Productivity Data

SIC Number	Industry Name	Average Annual Growth Rates, 1995-2000	
		Authors' Calculations	BLS
40	Railroad Transportation	2.6	
4011	Railroad transportation		3.8
42	Trucking and Warehousing	1.0	
4213	Trucking, except local		0.9
45	Transportation by Air	1.3	
4512,13,22(PTS)	Air transportation		0.4
481, 482, 489	Telephone and Telegraph	6.7	
481	Telephone communications		6.3
483-484	Radio and Television Broadcasting \1	1.2	1.0
49	Electric, Gas, and Sanitary Services	1.9	
491-493	Electric and Gas Utilities \1		9.2
52-59	Retail Trade \1	3.5	4.0
60-61	Depository and Nondepository Institutions	3.1	
602	Commercial banks		2.6
70	Hotels and other Lodging Places	0.3	
701	Hotels and motels		0.8
72	Personal Services	1.8	1.7
75	Auto Repair, Services, and Garages	0.9	
753	Automotive repair shops		0.9
78	Motion Pictures	-0.5	
783	Motion picture theaters		1.6

BLS labor productivity is output per employee.

\1 BLS average annual labor productivity growth is the unweighted average of more detailed industry components. The BLS retail trade labor productivity growth is the average growth rate of all 2-digit SIC retail trade industries.

Appendix

The Decomposition of Labor Productivity

SIC Number			1977-95	1987-95	1995-2000
40	Railroad Transportation	Labor	7.5	6.5	2.6
		MFP	4.3	3.2	0.9
		Capital Deepening	0.8	0.3	0.3
		ICOT Capital	0.0	0.0	0.1
		NonICOT Capital	0.7	0.3	0.2
		Intermediate Input Deepening	2.3	2.9	1.4
41	Local and Interurban Passenger Transit	Labor	-2.8	-1.6	-0.2
		MFP	-1.1	-1.0	2.2
		Capital Deepening	-0.5	-0.5	0.0
		ICOT Capital	0.0	0.0	0.0
		NonICOT Capital	-0.5	-0.5	0.0
		Intermediate Input Deepening	-1.2	-0.1	-2.3
42	Trucking and Warehousing	Labor	3.1	4.9	1.0
		MFP	0.5	1.1	0.3
		Capital Deepening	0.2	0.2	0.3
		ICOT Capital	0.1	0.1	0.1
		NonICOT Capital	0.1	0.1	0.2
		Intermediate Input Deepening	2.4	3.6	0.5
44	Water Transportation	Labor		2.3	2.2
		MFP		1.5	-0.2
		Capital Deepening		-0.2	-0.1
		ICOT Capital		0.0	0.1
		NonICOT Capital		-0.3	-0.2
		Intermediate Input Deepening		1.0	2.5
45	Transportation by Air	Labor	0.4	-3.4	1.3
		MFP	1.2	1.4	0.4
		Capital Deepening	-0.3	-0.6	0.9
		ICOT Capital	0.1	0.1	0.6
		NonICOT Capital	-0.4	-0.6	0.3
		Intermediate Input Deepening	-0.5	-4.2	0.0
46	Pipelines, Except Natural Gas	Labor	0.4	0.7	3.5
		MFP	-2.0	-3.9	2.9
		Capital Deepening	1.2	1.5	3.1
		ICOT Capital	0.3	0.7	1.3
		NonICOT Capital	0.8	0.8	1.8
		Intermediate Input Deepening	1.3	3.2	-2.5
47	Transportation Services	Labor		2.3	3.8
		MFP		-0.5	0.3
		Capital Deepening		0.0	1.4
		ICOT Capital		0.7	1.4
		NonICOT Capital		-0.7	0.0
		Intermediate Input Deepening		2.8	2.0
481, 482, 489	Telephone and Telegraph	Labor	6.3	5.8	6.7
		MFP	1.6	1.5	1.6

		Capital Deepening	2.1	1.6	0.5
		ICOT Capital	1.1	0.9	0.5
		NonICOT Capital	1.0	0.7	0.0
		Intermediate Input Deepening	2.5	2.5	4.5
483-484	Radio and Television Broadcasting	Labor	0.6	0.2	1.2
		MFP	-1.1	2.0	-5.5
		Capital Deepening	1.4	1.8	3.1
		ICOT Capital	0.8	1.0	2.2
		NonICOT Capital	0.6	0.8	0.9
		Intermediate Input Deepening	0.4	-3.4	3.9
49	Electric, Gas, and Sanitary Services	Labor	-0.3	2.5	1.9
		MFP	0.1	0.8	0.4
		Capital Deepening	0.7	0.9	1.0
		ICOT Capital	0.3	0.3	0.3
		NonICOT Capital	0.3	0.6	0.7
		Intermediate Input Deepening	-1.0	0.8	0.5
50-51	Wholesale Trade	Labor	2.1	3.3	4.4
		MFP	1.0	1.1	2.4
		Capital Deepening	0.8	0.6	1.7
		ICOT Capital	0.6	0.5	1.4
		NonICOT Capital	0.2	0.1	0.3
		Intermediate Input Deepening	0.3	1.5	0.2
52-59	Retail Trade	Labor	0.7	1.2	3.5
		MFP	0.2	0.4	3.0
		Capital Deepening	0.3	0.3	0.3
		ICOT Capital	0.1	0.1	0.3
		NonICOT Capital	0.2	0.2	0.0
		Intermediate Input Deepening	0.2	0.5	0.3
60-61	Depository and Nondepository Institutions	Labor		3.3	3.1
		MFP		0.0	0.5
		Capital Deepening		1.4	1.9
		ICOT Capital		1.0	1.5
		NonICOT Capital		0.4	0.3
		Intermediate Input Deepening		1.9	0.8
62	Security, Commodity Brokers and Services	Labor	5.4	7.2	20.2
		MFP	1.6	2.9	11.2
		Capital Deepening	0.6	0.6	0.2
		ICOT Capital	0.3	0.1	0.2
		NonICOT Capital	0.3	0.5	0.1
		Intermediate Input Deepening	3.1	3.6	7.8
63	Insurance Carriers	Labor	0.2	0.0	-1.4
		MFP	-2.1	-0.2	-1.0
		Capital Deepening	0.8	0.7	0.8
		ICOT Capital	0.4	0.4	0.6
		NonICOT Capital	0.4	0.3	0.2
		Intermediate Input Deepening	1.6	-0.5	-1.2
64	Insurance Agents, Brokers, and Services	Labor	-2.6	-3.3	3.5
		MFP	-1.7	-3.3	1.3
		Capital Deepening	-0.1	0.1	0.4
		ICOT Capital	0.0	0.1	0.2

		NonICOT Capital	-0.1	0.0	0.2
		Intermediate Input Deepening	-0.9	0.0	1.7
65	Real Estate	Labor		2.4	2.0
		MFP		1.0	1.4
		Capital Deepening		0.1	0.0
		ICOT Capital		0.0	0.0
		NonICOT Capital		0.1	0.0
		Intermediate Input Deepening		1.2	0.6
70	Hotels and other Lodging Places	Labor	0.9	0.7	0.3
		MFP	-0.5	0.1	-1.1
		Capital Deepening	0.3	0.3	0.2
		ICOT Capital	0.1	0.1	0.2
		NonICOT Capital	0.3	0.3	0.1
		Intermediate Input Deepening	1.0	0.3	1.2
72	Personal Services	Labor	-0.1	1.7	1.8
		MFP	-0.7	-0.6	0.3
		Capital Deepening	0.1	0.3	0.2
		ICOT Capital	0.0	0.1	0.1
		NonICOT Capital	0.0	0.2	0.1
		Intermediate Input Deepening	0.5	1.9	1.2
73	Business Services	Labor		3.0	3.5
		MFP		0.8	0.0
		Capital Deepening		0.0	1.1
		ICOT Capital		0.2	1.0
		NonICOT Capital		-0.2	0.0
		Intermediate Input Deepening		2.2	2.4
75	Auto Repair, Services, and Garages	Labor	-0.3	1.4	0.9
		MFP	-0.6	-1.0	1.0
		Capital Deepening	0.4	1.0	0.0
		ICOT Capital	0.1	0.1	0.1
		NonICOT Capital	0.3	0.9	-0.1
		Intermediate Input Deepening	-0.1	1.5	-0.1
76	Miscellaneous Repair Services	Labor	0.9	2.6	2.7
		MFP	-0.4	-0.4	-1.2
		Capital Deepening	0.1	0.2	0.7
		ICOT Capital	0.1	0.2	0.4
		NonICOT Capital	0.0	0.0	0.3
		Intermediate Input Deepening	1.2	2.9	3.3
78	Motion Pictures	Labor	1.3	-0.3	-0.5
		MFP	0.1	-1.2	0.3
		Capital Deepening	0.1	0.3	0.4
		ICOT Capital	0.1	0.2	0.2
		NonICOT Capital	0.0	0.1	0.2
		Intermediate Input Deepening	1.1	0.6	-1.2
79	Amusement and Recreation Services	Labor	0.6	1.9	-0.8
		MFP	0.7	0.1	0.0
		Capital Deepening	-0.4	-0.3	0.1
		ICOT Capital	0.0	0.0	0.1
		NonICOT Capital	-0.4	-0.2	0.0
		Intermediate Input Deepening	0.3	2.1	-0.9
80	Health Services	Labor	-0.2	-0.5	0.7
		MFP	-1.2	-1.5	-0.4

		Capital Deepening	0.2	0.1	0.3
		ICOT Capital	0.1	0.1	0.2
		NonICOT Capital	0.1	0.0	0.1
		Intermediate Input Deepening	0.8	0.9	0.8
81	Legal Services	Labor	-1.2	0.1	2.2
		MFP	-1.6	-0.3	0.4
		Capital Deepening	0.1	0.1	0.3
		ICOT Capital	0.1	0.1	0.3
		NonICOT Capital	0.0	-0.1	0.0
		Intermediate Input Deepening	0.3	0.4	1.5
82	Educational Services	Labor	0.3	0.5	-1.2
		MFP	-0.2	-0.1	-0.8
		Capital Deepening	0.0	0.0	0.0
		ICOT Capital	0.0	0.0	0.0
		NonICOT Capital	0.0	0.0	0.0
		Intermediate Input Deepening	0.5	0.6	-0.4

All numbers are average annual percentages.

Data Appendix

The data are obtained from two sources; the BEA GDP by industry file and unpublished capital input and capital services data from the BLS. Value added in the GDP by industry file is the sum of the compensation of employees, indirect business taxes, and property-type income. Gross output, which is value added plus intermediate inputs, is not available before 1977, and for some industries, is not available before 1987.

The real value of gross output is obtained from the BEA industry file. As measures of the growth in the real value of the inputs, we use persons engaged in production for labor, the quantity index for intermediate inputs from BEA for intermediate inputs, and the real capital input index from BLS for capital.

The income shares used in the growth accounting calculations are all expressed as shares of output minus indirect business taxes (GDP at factor cost). Capital share and its distribution among different types of capital is obtained from the BLS data set, and intermediate inputs are from BEA. The labor compensation share of output is calculated as a residual for reasons discussed below.

The BEA compensation data does not include the labor earnings of the self-employed, which are all assigned to capital. The BLS uses an elaborate algorithm to adjust their capital and labor income shares for the self-employed. Thus, we used their estimates of capital income and obtained labor compensation by subtracting the capital income from GDP at factor cost. This does introduce one source of inconsistency in the current data set. Because the BLS methodology includes property and motor vehicle taxes as part of capital income, our measure, which excludes all indirect business taxes, understates the amount of labor income. This problem will be corrected in a future revision.

Our broad definition of service industries includes the SIC groups transportation, communications, trade, FIRE, and services. We exclude the following service industries from the analysis: holding and other investment offices, social services, membership organizations, and other services. In those cases we lacked consistent measures of output and all of the inputs.