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NEW DATA AND OUTPUT CONCEPTS FOR UNDERSTANDING PRODUCTIVITY TRENDS

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Abstract

The present study is the second is a series of three papers devoted to issues in the measurement of productivity and productivity growth. The contributions of the present paper are three. First, it introduces a new approach to measuring industrial productivity based on income-side data that are published by the Bureau of Economic Analysis (BEA). The data are internally consistent in that both inputs and outputs are income-side measures of value added, whereas the usual productivity measures combine expenditure-side output measures with income-side input measures. Second, because of interest in the "new economy," we have also constructed a set of new-economy accounts. For the purpose of this study, we define the new economy as machinery, electric equipment, telephone and telegraph, and software. Finally, because of concerns about poor deflation in the current output measures, this study constructs a new output concept called "well-measured output," which includes only those sectors for which output is relatively well measured. We present a brief summary of the behavior of the alternative measures.

I. Introduction and Summary

Productivity measurement has itself enjoyed significant productivity advances over the last half century. Among the major advances are improvements in data, development of new methods (particularly improved techniques in measuring price and output indexes), and the availability of friendly software and powerful computers to construct new measures and analyze the data.

Among the more interesting new possibilities is the use of disaggregated data on productivity. The Bureau of Economic Analysis makes data available on output, inputs, compensation, and prices for approximately 80 one-digit and two-digit industries. For unexplained reasons, BEA does not, however, provide productivity statistics that correspond to its income-side input and output data.

The present paper is the second in a trilogy of papers analyzing recent productivity behavior.[2] The first paper examined the welfare-theoretic basis for measuring productivity growth and showed that the ideal welfare-theoretic measure is a chain index of productivity growth rates of different sectors which uses current output weights. It also laid out a technique for decomposing productivity growth which separates aggregate productivity growth into three factors — a pure productivity effect,

[1] The author is grateful to Steve Landefeld, Kurt Kunze, and Bob Yuskavage for helpful comments. All errors are due to the author. Version is [d1286.wpd].

[2] The first paper is entitled "Alternative Methods for Measuring Productivity Growth," October 23, 2000 available at www.econ.yale.edu/~nordhaus/ homepage/writings_and_presentations_on_th.htm .

the effect of changing shares, and the effect of different productivity levels. Finally, it showed how to apply the theoretically correct measure of productivity growth and indicated which of the three different components should be included in a welfare-oriented measure of productivity growth. The study concluded that none of the measures generally used to measure productivity growth are consistent with the theoretically correct measure.

The purpose of the present paper, which is the second paper in the trilogy, is to describe and present an analysis of productivity using new data from the national income and product accounts (NIPA). It is highly data intensive and is essentially devoted to describing and deriving an alternative data set for measuring productivity and productivity growth. The third paper in this series, which is currently in draft, will apply the concepts in the first paper and the data in this second paper to current issues in the measurement of productivity.

Because the present study is heavily methodological and data-intensive, we summarize the approach and major results in this introductory section.

1. The present study introduces a new approach to measuring aggregate and industrial productivity. It develops an income-side data base on productivity relying on data that are published by the BEA. The data are internally consistent in that both inputs and outputs are income-side measures of value added, whereas the usual productivity measures combine expenditure-side output measures with income-side input measures. The advantage of the income-side measures is that they present a consistent set of industrial accounts. The disadvantages are that they are only available for the period 1977–98 and that they do not contain a set of capital accounts, so we can only examine labor productivity.

2. Because of interest in the "new economy," we have also constructed a set of new-economy accounts. For the purpose of this study, we define the new economy as machinery, electric equipment, telephone and telegraph, and software. These sectors grew from 3 percent of real GDP in 1977 to 9 percent of real GDP in 1998. These sectors are somewhat more inclusive than a narrow definition of the new economy but are the narrowest definition for which a complete set of accounts is available.

3. This study considers three different output concepts which can be used in productivity studies. One set is standard GDP (measured from the income side of the accounts). A second output concept is what the Bureau of Labor Statistics (BLS) defines as "business sector output." A third concept responds to concerns in productivity studies about the poor quality of the price deflation in several sectors. For this purpose, we have constructed a set of accounts called "well-measured output," which includes only those sectors for which output is relatively well measured.

II. Data and Concepts

This study introduces a new data set that can be used for industrial and aggregate productivity studies. While the underlying data come from the usual sources, the output data are value added and are derived from income-side estimates. They are aggregated in a different fashion as well. This section describes the approach used here.

The underlying data

This study relies upon the industry data prepared by the Bureau of Economic Analysis. The details are thoroughly described in the background sources, but we will describe the major points here. The major industries are shown in Table 1. The data for each industry include nominal output, real output, and prices by industry. In all cases, the data are constructed as chain price and real output indexes. Moreover, for each industry, the BEA calculates gross output, value added (or gross

product originating), and intermediate inputs (which equal gross output minus value added). In addition, the BEA prepared series on compensation, employment, and hours worked for each major industry.

The methodology for creating the different series will be briefly described.[3] For the most part, real output is never directly measured. Rather, the fundamental building blocks are measures of nominal output and price indexes or deflators. Gross product originating (GPO) is calculated from the income side of the accounts as the sum of factor incomes (wages, profits, etc). Gross output is generally measured from the product (expenditure) side. As a result, intermediate inputs are the difference between product-side gross output and income-side gross product originating. Intermediate inputs therefore include not only the usual errors but also the statistical discrepancy between income and product accounts.

Real output is calculated by deflating nominal output by price indexes. For the most part, deflation takes place at the level of the five-digit SIC code. The BEA relies extensively on price indexes prepared by the Bureau of Labor Statistics (BLS) for deflation. In a few cases, BEA uses its own price deflators.

Definition of the "new economy"

This study also develops input and output data for the "new economy." For purpose of this study, I use the following formal definition of the new economy. The new economy involves acquisition, processing and transformation, and distribution of information. The three major components are the hardware (primarily computers) that processes the information, the communications systems that acquire and distribute the information, and the software which, with human help, manages the entire system.

Which sectors are included in practice under this definition? Table 2 shows the new-economy sectors as defined by the Commerce Department for its study *The Emerging Digital Economy*. The definition overlaps with that given in the last paragraph, although the Commerce Department's definition includes some old-economy sectors as well as some sectors with questionable price indexes.

For purposes of this study, we are hamstrung because comprehensive data are limited to the major industries shown in Table 1. We therefore include in the new economy those major industries which contain the new-economy sectors, which is limited to four industries: Industrial machinery and equipment (SIC 35), Electronic and other electric equipment (SIC 36), Telephone and telegraph, and Prepackaged software. Table 3 shows the share of the new economy in real GDP. Clearly, the new economy has become quantitatively important in recent years.

This definition of the new economy is somewhat broader than would be ideal for the present purposes. For example, SIC 35 contains computers and office equipment, but the computer sector comprises less than 25 percent of the total 1996 value added in that sector. Other parts of SIC 35 include ball bearings and heating and garden equipment, whose prices are probably not well measured and which are dubious candidates for the new economy. SIC 36 contains prominently semiconductors, which is central to the new economy, but semiconductors constitute only 8 percent of the 1996 value added in SIC 36. This sector includes communications equipment, one part of which has hedonic deflation. This sector also contains many old-economy industries, including

[3] For a full description of the data, see *Survey of Current Business*, June 2000, pp. 24-63 and the references contained in that article. The article can be found at www.bea.doc.gov/bea/pub/0600cont.htm .

incandescent bulbs, and a wide array of consumer electronics, whose prices are almost surely poorly measured.

Similarly, while telephone and telegraph is central to the communications components of the new economy, that sector includes some paleoindustries like telegraph, whose commercial applications date from 1844, and telephone, which premiered in 1878.

Software is genuinely a new economy industry. However, only the prepackaged component (slightly larger than one-third of the total) has hedonic deflation at present. As noted below, the data on software are incomplete and some crude assumptions are necessary to fit that into the present data base.

Because of the importance of the new economy in the present analysis, it is worth emphasizing that relatively few industries use hedonic price indexes that systematically attempt to capture new goods and components or quality change. The BEA reports that only four major industries (all in new economy sectors) use systematic hedonic prices: computers and peripheral equipment, semiconductors, prepackaged software, and digital switching equipment. As Table 4 shows, hedonic indexes are used in industries that comprise about 2.2 percent of GDP. We can compare Tables 3 and 4 to get a rough idea of the extent to which the broad industry groups included in the "new economy" sectors defined in Table 3 may overstate the narrower definition. In 1998, the larger sectors were approximately 4 times larger than the narrow definition.

Adjustments of data for the present study

The industrial data prepared by BEA are the cornerstone for the present study. However, some adjustments were necessary, particularly those needed to measure the impact of the new economy.

1. Data on real output for 1977–98 are published only as index numbers. These are converted into 1996 dollars by using 1996 dollar values for each industry.

2. Because of changes in the SIC definitions, BEA prepares data for the period up to 1987 based on the 1972 SIC codes, and for 1987–98 based on the 1987 SIC codes. For most industries, the matches in levels for the two SIC codes were either exact or very close; that is, the measurements of output using old and new definitions, which can be compared only for 1987, differed by less than 0.25 percent in most industries. Of the major (one-digit) industries, the redefinition of SIC codes changed the 1987 values by less than 0.3 percent. Not surprisingly, some of the new-economy sectors that we are dealing with in this study changed more dramatically. One two-digit industry (electric and electronic equipment in the 1987 definition) had a major change in definition in 1987. Because of changes in the definition, the dollar value of the industry was reduced by 13 percent. The 1987 value of telephone and telegraph was reduced by 3.3 percent, while machinery except electrical was increased by 1.4 percent. For all data sets which did not match, the data were spliced together at 1987.

3. For each of the four new-economy industries, some significant adjustments and assumptions are necessary. We list the major ones here.

a. For industries 1, 2, and 3 in Table 4, BEA publishes data on all key variables except total hours. The underlying unpublished data were provided by BEA. For hours and employment, as for output, there were definitional changes for the industries in 1987. BEA provides estimates of employment under the old and new SIC code definitions, and these match closely with the changes in hours and output. We have therefore spliced the employment data using the ratio of employment under the two definitions (this being the same technique as employed for real and nominal GDP).

For total hours, we have taken the ratio of total hours to persons engaged for each year; this ratio changed relatively little around the year in which SIC definitions changed, 1987.

b. The change in SIC codes in 1987 led to a major redefinition for Electric and electronic equipment. The redefinition in 1987 led to an decrease in nominal GPO by 13 percent. We have spliced together the two different periods, but there remains a potential concern about whether the behavior of the industry in the two periods was similar. This revision is probably unimportant for the results of the present study because the share of Electric and electronic equipment was relatively small before 1987 (0.57 percent of GDP in 1977 as compared to 2.61 percent in 1998).

c. The BEA does not publish complete industry estimates for software. The only publicly distributed data are for real GPO and the chained price index for 1987–98, and nominal GPO for 1977–1998. A background paper by the BEA was the source of the estimates.[4] For these purposes, we have included only private production of software. Software is a very small component of services and cannot be separated out as we can the other three new-economy sectors. To complete the accounts for software, we assume that labor productivity is equal to aggregate labor productivity plus the rate of decline in the output price relative to the overall output price (this is essentially the same as assuming that the share of compensation in the two sectors move proportionally). We also assume that hours in the software industry move proportionally with nominal GPD in that industry. This assumes that the shares of compensation are the same in the two industries and that compensation per worker in software is equal to the aggregate rate. There is no obvious way to verify or improve on this assumption.

d. The BEA does not publish real GPO estimates for a few industries in the period before 1987 (although it does publish nominal GPO estimates). Presumably, this reflects the lack of price indexes in the earlier period.[5] To remedy this, we have assumed that the relative price movements in the 1977–87 period were equal to the rate for the 1987–1990 period. This assumption was used for the new economy sector, Electric and electronic equipment. It was also used for Instruments. Note that this assumption is of only modest importance for the estimates of aggregate productivity growth because the nominal output shares of these industries are relatively small in the period before 1987.

Construction of "BLS business sector output"

One of the most commonly followed measures of productivity is the Bureau of Labor Statistics's estimate of labor productivity. The most inclusive measure is what BLS defines as "business sector output." Business sector output is derived from the product side and consists of an annual-weighted index constructed after excluding from gross domestic product the output and inputs of general government, nonprofit institutions, paid employees of private households, and the rental value of owner-occupied dwellings.[6] We designate these as "BLS output" or "BLS data" because these data are the ones used by BLS in their calculations of productivity. In reality, the data are constructed and provided by BEA.

We have constructed an approximation of BLS business sector output from the income side

[4] See the paper by Robert Parker and Bruce Grimm at www.bea.doc.gov/bea/papers.htm .

[5] BLS producer price indexes for the two-digit industry which corresponds to Electric and electronic equipment do not resemble the price index constructed by BEA for that industry.

[6] See stats.bls.gov/news.release/prod2.tn.htm .

as follows. We take income-side GDP and subtract private households, government, nonfarm housing services, and an estimate of the share of nonprofit income in the major relevant services (75 percent of social services and membership organizations, 90 percent of educational services, 43 percent of health services, and 16 percent of amusement services.) [7]

Figures 1 and 2 show the results of the construction. Figure 1 shows indexes of the BLS index for the business sector along with the income-side estimate prepared for the present study. Figure 2 shows the error in the estimate (equal to the ratio of the two minus one) along with the ratio of the statistical discrepancy divided by business output. Table 5 shows a comparison of the different series for three subperiods.

Two points are worth noting. First, the differences in growth rates in output are relatively small for most of the period but have been extremely large in the most recent period. In the last subperiod, 1996-98, BEA income-side business output ("BEA output") is estimated to have grown at 1.08 percentage points per year more rapidly than product-side business sector output ("BLS output"). Second, recall that BEA output is measured from the income side, and that the statistical discrepancy has moved sharply negative over the recent period. In part, it seems likely that the difference between BLS output and BEA output measures reflects the fact that the statistical discrepancy is included in the BEA output measure used here. Figure 2 shows the discrepancy between the BLS and BEA output measures along with the normalized statistical discrepancy. The year-to-year movements in the two series are clearly very close. In the last three years, however, note that the difference between BLS and BEA measures of business real GDP is 2½ times the change in the statistical discrepancy ratio.

"Well-measured output"

The final construct for the present study is the concept of "well-measured output." It is widely accepted today that in many sectors real output is poorly measured in the national economic accounts. In some cases, such as general government, there is no serious attempt to measure output and the indexes of activity are inputs such as employment. In other cases, the BEA (or the BLS, which prepares the underlying price data) uses deflation techniques that are potentially defective.

The idea of well-measured v. poorly-measured sectors was introduced by Zvi Griliches in his 1994 Presidential address:

> Imagine a "degrees of measurability" scale, with wheat production at one end and lawyer services at the other. One can draw a rough dividing line on this scale between what I shall call "reasonably measurable" sectors and the rest, where the situation is not much better today than it was at the beginning of the national income accounts.[8]

Defective deflation occurs for two quite different reasons. In one case, for which construction or banking might be good examples, BEA does use price indexes for deflation of nominal magnitudes, but the prices indexes are for goods or services which may not be representative of the range of outputs in that sector. A second reason, which has received much more attention, is that the underlying price index may not adequately capture quality change or new

[7] These estimates are from L. Slifman and C. Corrado, "Decomposition of Productivity and Unit Costs," Federal Reserve Board, Occasional Staff Paper, November 18, 1996, Table 5.

[8] Zvi Griliches, "Productivity, R&D, and the Data Constraint," *American Economic Review*, vol. 84, no. 1, March 1994, p. 10.

goods and services. An excellent historical example of this syndrome is computers. Before hedonic techniques were introduced, the government assumed that the price of computers was constant in nominal terms. When hedonics were introduced, this assumption was found to overstate the "true" price increase by around 20 percent per year for the last two decades.

It is difficult for an outsider to assess the quality of the deflation of each sector included in the industrial accounts. There are many studies of this issue.[9] Nonetheless, after discussion with experts inside and outside of BEA, we have constructed a new measure of output for sectors that have relatively well-measured outputs.[10] The sectors included in well-measured output are:

1. Agriculture, forestry, and fishing
2. Mining
3. Manufacturing
4. Transportation and public utilities
5. Wholesale trade
6. Retail trade

These sectors are composed largely of well-defined and relatively simple goods or services. There are undoubtedly areas in the well-measured sector for which quality change is not adequately captured (such as scientific instruments, consumer electronics, automobiles, communications equipment, or e-commerce), but for the most part it seems likely that the statistical system can identify the commodities sufficiently well so that the proper items are priced.

There are four major sectors that are excluded from well-measured output. We list those below with a brief annotation about the reasons for their omission.

7. Construction is omitted because of the well-established problems of finding good price indexes for various components. The Boskin Commission identified numerous difficulties in measuring the quality of the housing stock and argued for a 0.25 percent per year upward bias in the price index for housing.[11]

8. Finance, insurance, and real estate are excluded for two different reasons. First, real estate is largely capital income and can substantially bias the estimate of labor productivity. In addition, there are severe difficulties in measuring output in this sector. A substantial part of the output of the financial sector is imputed income from banking services, which has only recently used output measures for deflation. Composite indexes of input data are used to deflate life insurance and the bulk of investment in nonresidential structures.

9. Services is a mixed bag, with some services probably pretty well measured (haircuts), while others are moderately defective (health), to others which are largely input based (private households). One of the major difficulties is that many services (such as education and health care) are extremely complex commodities whose output defies routine measurement. Slifman and Corrado found negative trends in labor productivity in most service industries and argue that price

[9] See the reference in footnote 11 for a particularly important study.

[10] Griliches's definition of "measurable" sectors is identical to that of "well-measured" output except that he puts trade in the unmeasurable sector. (See the reference in footnote 8.)

[11] See "Toward A More Accurate Measure Of The Cost Of Living," Final Report to the Senate Finance Committee from the Advisory Commission To Study The Consumer Price Index, December 4, 1996.

measurement error is the "likely statistical explanation for the implausible productivity."[12]

10. Government is omitted because deflation is largely input based.

This separation into well-measured and not-so-well-measured sectors is quite tentative and might be refined by moving to the two-digit level. That step would require further research by experts into the details of deflation in the different sectors.

Figures 3 and 4 compare the three concepts in terms of their trends and shares of GDP. Both business sector output and well-measured sectors were relatively stable shares of GDP until the early 1990s, but have since then increased their shares of total output.

III. Preliminary Estimates of Productivity Trends

The question of productivity trends will be discussed in the third companion paper to this one, but it will be useful to present some data on productivity to gauge the credibility of the data and show some tentative findings.

We begin with a comparison between the labor productivity in the business sector using the BEA (income-side) and BLS (output-side) approaches. We have discussed the numerator (real value added) above. Both the BEA and the BLS rely on BLS data on employment and hours, but the concepts and definitions are slightly different.

Figures 5 and 6 and Table 6 show a comparison of estimates of productivity growth using the BEA (income-side) and BLS (output-side) approaches. There are substantial discrepancies between the productivity estimates of the two sources. The BLS output-side series yields higher productivity growth rate numbers in the early period, but in the most recent period the BEA income side estimates are 0.56 percentage per year more rapid. The difference between the two estimates comes both from the output and the hours data. BEA output is estimated to have grown about 1 percentage point faster in the last 3 years, while hours are estimated to have grown about 0.5 percent more rapidly.

Figure 7 and Table 7 show the results by comparing productivity growth for the three different concepts: total GDP from the income side, business sector, and well-measured output. Two conclusions are readily apparent. First, productivity growth for the well-measured sectors is about twice that in the business sector or for total GDP. Second, for the last three years of the period, productivity growth in the well-measured sectors has been impressive, averaging more than 4½ percent per year in 1996–98. Third, there was a sharp productivity acceleration in the late 1990s, with productivity growth in the well-measured sectors rising more than 2 percentage points above the earlier period.

It would be interesting to know whether the most recent data for the well-measured sectors return productivity growth in that sector back to the pre-1973 rate. We do not have complete date for the period before 1977.[13] We can, however, use Griliches's estimates from his study of "measurable" sectors, although these are conceptually different from current estimates. The Griliches measurable sectors had a rate of labor productivity growth of slightly below 3 percent per year for the 1948–73 and 1948–77 periods, so it seems likely that productivity in the well-measured sectors is actually above that in the "golden age" from 1948 until 1973.

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[12] See Slifman and Corrado, *op. cit.*

[13] It should be noted that the BEA does not regard the earlier data as reliable. For this reason, they do not publish the sectoral output data for the period before 1977 and discourage its use because reliable deflators for that period are not available.

We next present new data on productivity growth by industry in Tables 8 through 10. These show gross product originating per hour worked by industry for major manufacturing industries. (Current labor productivity measures prepared by BLS are generally total output per hour worked.) While the series are somewhat noisy, they show a reasonable trend for most industries. Figure 10 shows two problem children, petroleum and tobacco, which have wild productivity growth estimates. This deviant behavior is caused by very low shares of labor in petroleum, and by high indirect taxes for tobacco. This behavior is a warning that productivity measures which do not allow for strange behavior in some industries may give misleading results.

Finally, Figure 11 shows estimates of productivity growth in the new economy as a whole as well as in its four sectors. The major conclusion is that productivity in the new economy has been extremely impressive in the last few years, rising from around 5 percent per year in the early 1990s to over 10 percent per year in the late 1990s. The results for the period before 1990 are relatively noisy and probably reflect poor underlying data.

To summarize, the present study presents new data on measuring output and labor productivity, concentrating on the income side of the national accounts. The data show somewhat larger output and productivity growth in recent years, and confirm the impressive growth in the new economy sectors.

The next paper in this series will apply the theoretical concepts derived in the first paper as well as the data presented in the present paper to examine current hypotheses about productivity and estimate the contribution of the new economy to the recent productivity rebound. It will also present a new measure of labor productivity growth which applies the data derived in this paper to the new welfare-theoretic measure derived in the first paper in this series.

Table 1

Major Industries for BEA Industrial Output and Input Data

- Gross domestic product
  - Private industries
  - Agriculture, forestry, and fishing
    - Farms
    - Agricultural services, forestry, and fishing
  - Mining
    - Metal mining
    - Coal mining
    - Oil and gas extraction
    - Nonmetallic minerals, except fuels
  - Construction
  - Manufacturing
    - Durable goods
      - Lumber and wood products
      - Furniture and fixtures
      - Stone, clay, and glass products
      - Primary metal industries
      - Fabricated metal products
      - Industrial machinery and equipment
      - Electronic and other electric equipment
      - Motor vehicles and equipment
      - Other transportation equipment
      - Instruments and related products
      - Miscellaneous manufacturing industries
    - Nondurable goods
      - Food and kindred products
      - Tobacco products
      - Textile mill products
      - Apparel and other textile products
      - Paper and allied products
      - Printing and publishing
      - Chemicals and allied products
      - Petroleum and coal products
      - Rubber and miscellaneous plastics products
      - Leather and leather products
  - Transportation and public utilities
    - Transportation
      - Railroad transportation
      - Local and interurban passenger transit
      - Trucking and warehousing
      - Water transportation
      - Transportation by air
      - Pipelines, except natural gas
      - Transportation services
    - Communications
      - Telephone and telegraph
      - Radio and television
    - Electric, gas, and sanitary services

Table 1 (cont.)

Major Industries for BEA Industrial Output and Input Data

- Wholesale trade
- Retail trade
- Finance, insurance, and real estate
  - Depository institutions
  - Nondepository institutions
  - Security and commodity brokers
  - Insurance carriers
  - Insurance agents, brokers, and service
  - Real estate
    - Nonfarm housing services
    - Other real estate
  - Holding and other investment offices
- Services
  - Hotels and other lodging places
  - Personal services
  - Business services
  - Auto repair, services, and parking
  - Miscellaneous repair services
  - Motion pictures
  - Amusement and recreation services
  - Health services
  - Legal services
  - Educational services
  - Social services
  - Membership organizations
  - Other services
  - Private households
- Government
  - Federal
    - General government
    - Government enterprises
  - State and local
    - General government
    - Government enterprises

Table 2

Commerce Department Definition of Digital Economy

Information Technology Industries:
Share of the Economy and Contribution to Economic Growth

Industry	SIC	1995 [Value added; $millions except as not	1998
Total Gross Domestic Product (GDP)*		**7,293,600**	**8,461,644**
Hardware			
Computers & equipment	3571,2,5,7	32,931.2	45,081.8
Computers & equipment wholesale sales	5045 [part]	50,756.0	74,173.3
Computers & equipment retail sales	5734 [part]	2,513.8	3,441.3
Calculating & office machines, nec.	3578.9	3,036.2	3,478.1
Electron Tubes	3671	1,472.9	1,716.8
Printed circuit boards	3672	5,718.5	7,602.8
Semiconductors	3674	51,272.0	70,092.2
Passive electronic components	3675-9	19,097.6	29,801.9
Industrial instruments for measurement	3823	4,998.5	5,546.9
Instruments for measuring electricity	3825	7,512.3	8,399.0
Laboratory analytical instruments	3826	4,270.6	4,780.9
Total Hardware		183,579.6	254,115.0
Software/Services			
Computer programming services	7371	26,178.3	n.a.
Prepackaged software	7372	19,971.7	n.a.
Prepackaged software wholesale sales	5045 [part]	2,564.0	n.a.
Prepackaged software retail sales	5734 [part]	126.1	n.a.
Computer integrated systems design	7373	15,025.1	n.a.
Computer processing & data preparation	7374	17,924.5	n.a.
Information retrieval services	7375	3,768.5	n.a.
Computer services management	7376	2,135.2	n.a.
Computer rental and leasing	7377	1,329.0	n.a.
Computer maintenance and repair	7378	5,023.7	n.a.
Computer related services, nec	7379	8,549.1	n.a.
Total software and services	7371-9	102,595.2	151,999.3
Communications			
Household audio & video equipment	3651	2,343.0	2,767.6
Telephone & telegraph equipment	3661	14,925.2	17,373.7
Radio & TV & communications equipment	3663	19,862.0	27,854.3
Magnetic & optical recording media	3695	2,787.8	3,293.0
Total Communications Hardware		39,918.0	51,288.6
Telephone and telegraph communications	481,22, 99	144,100.0	163,674.4
Radio broadcasting	4832	6,149.6	8,695.8
Television broadcasting	4833	17,102.7	20,975.6
Cable and other pay TV services	4841	24,247.7	31,838.3
Total Communications Services		191,600.0	225,184.0
Total All Information Technology Industries		517,692.8	682,586.9
Share of the Economy (%)		7.1%	8.1%

Source: U.S. Commerce Department, *The Emerging Digital Economy*

Table 3

Share of New Economy in Real GDP

		Gross product originating, billions, 1996 prices		
		1978	1987	1998
	New Economy Sectors			
1	Machinery, except electrical	45	73	194
2	Electric and electronic equipment	25	54	222
3	Telephone and telegraph	66	103	209
4	Software	13	39	157
	Total, new economy sectors	148	269	782
	Item: Total as % of real GDP	3.1%	4.4%	9.1%

Source: GDPTab: revised industry 110300.wb3

Table 4

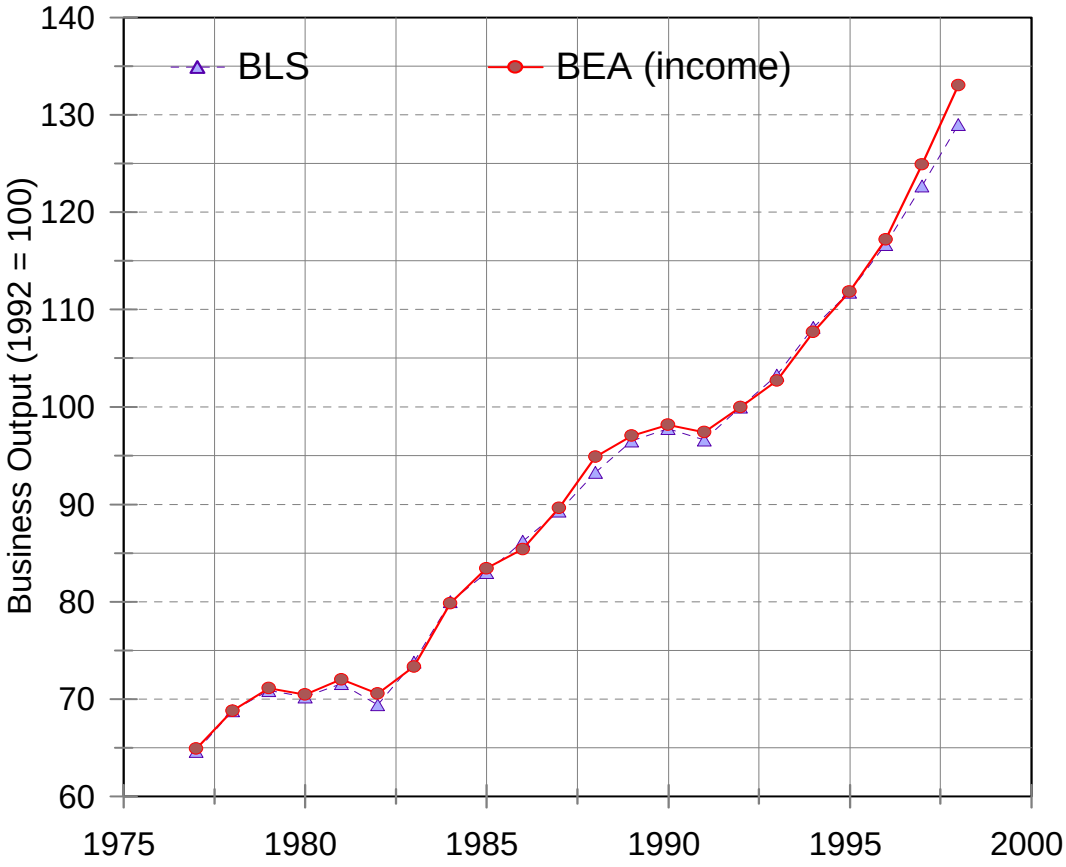
Important Industries That Use Hedonic Price Indexes to Deflate Nominal Output

Industry	1998 Value added or GPO (billions)	Percent of GDP 1998
Computers and equipment, wholesale sales (a)	$ 74	0.8%
Semiconductors	70	0.8
Prepackaged software	35	0.4
Telephone and telegraph equipment (b)	17	0.2
Total, major industries with hedonic adjustment to prices	$196	2.2%

(a) Some components of this sector may not use hedonic pricing.
(b) Note that only digital switching equipment uses hedonic pricing. The share of this is not published.

Figure 1

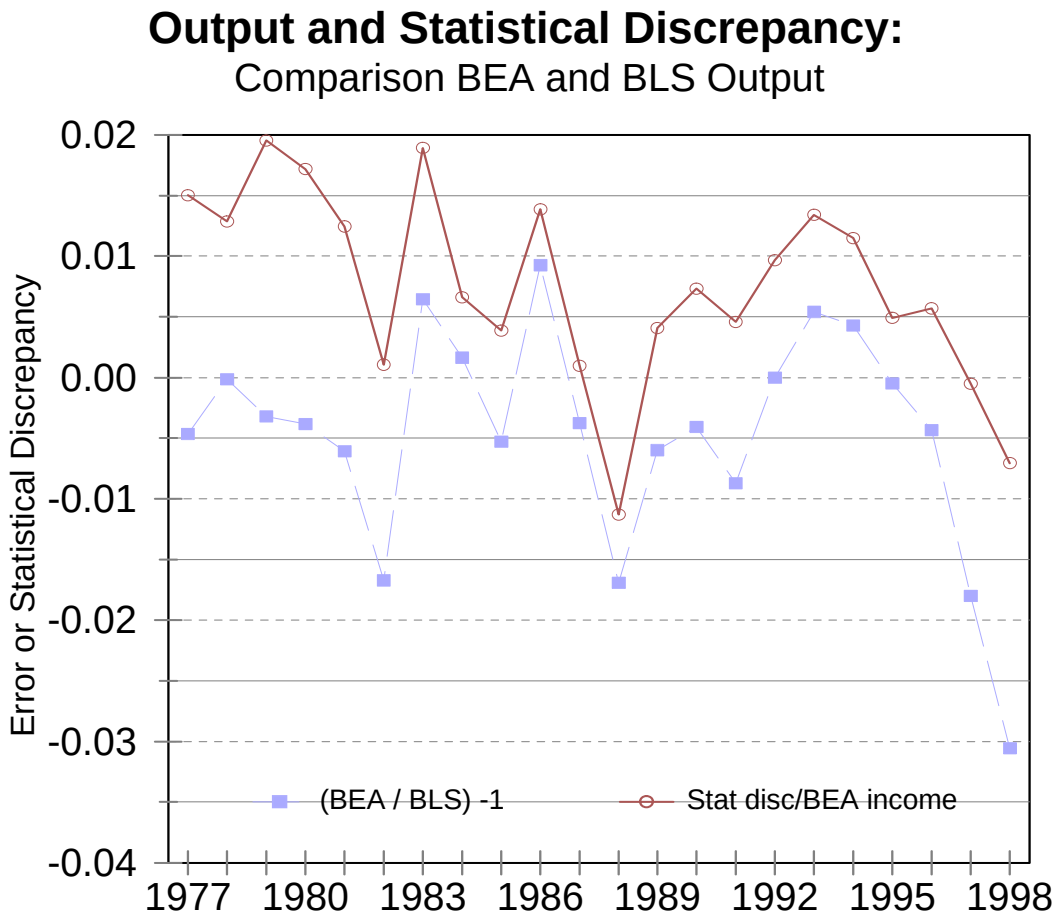
Comparison of Business Sector Output:
BLS and BEA Constructed



Note: "BLS" is the output-side product of the business sector used by BLS in its business sector productivity measures. "BEA" is the income-side output measure as derived in this paper.

Source: Tables: revised industry 110300.wb3

Figure 2



Note: "BEA/BLS -1" is the ratio of BEA to BLS business sector output minus one. "Stat disc/BEA income" is the ratio of the statistical discrepancy to BEA income-side GDP. "BLS" is the output-side product of the business sector used by BLS in its business sector productivity measures. "BEA" is the income-side output measure as derived in this paper.

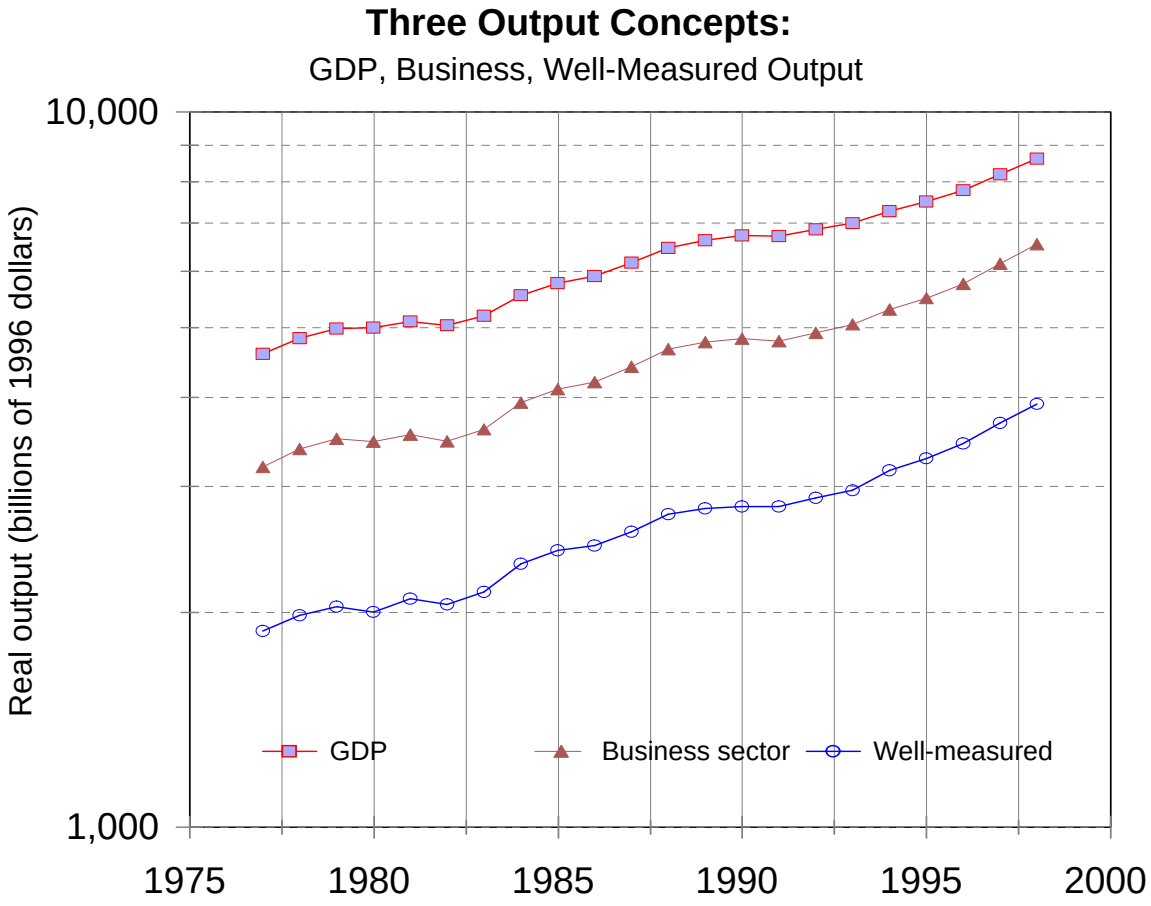
Table 5

Comparison of BEA and BLS Measures of Business Sector Output

	1978-89	1990-95	1996-98
Growth rates			
BLS	3.45%	2.50%	4.89%
BEA	3.45%	2.40%	5.96%
Difference	-0.01%	0.10%	-1.08%
Change in ratio of statistical discrepancy to BEA output	-0.09%	0.01%	-0.40%

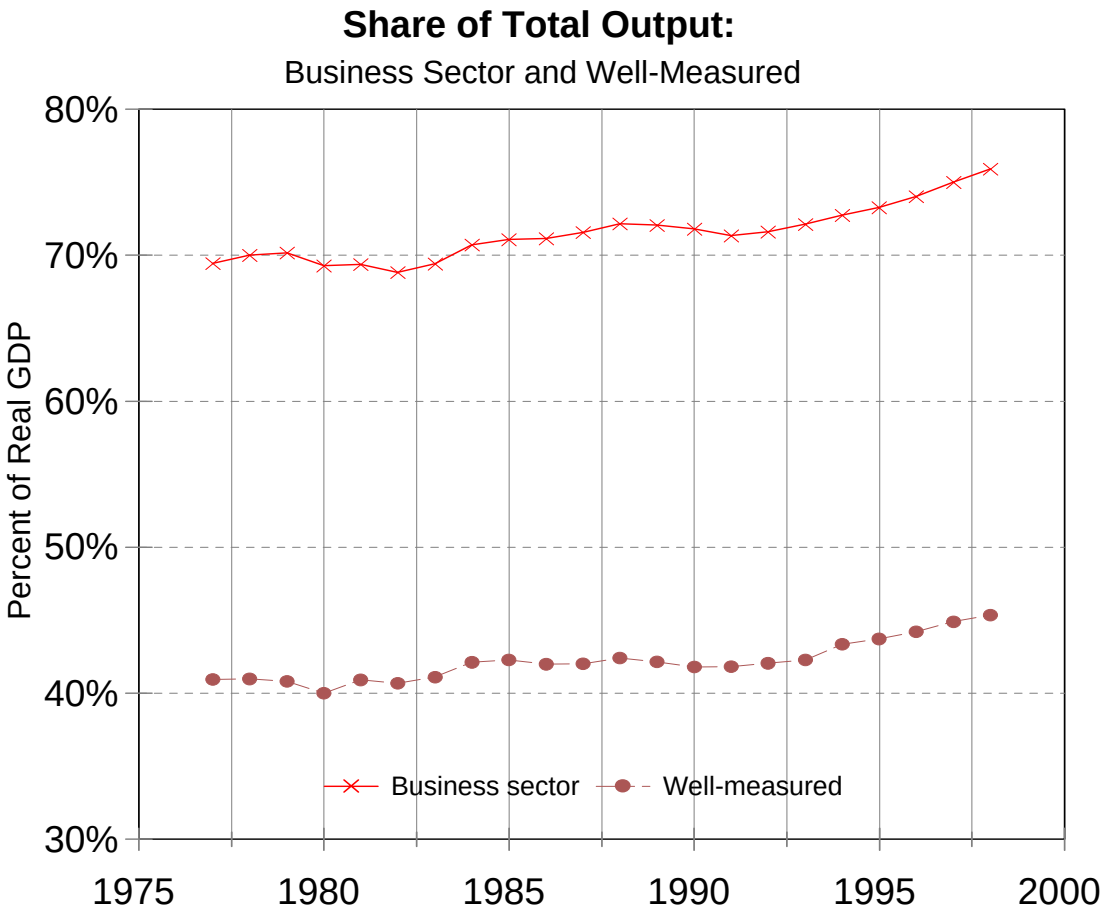
Note: "BLS" is the output-side product of the business sector used by BLS in its business sector productivity measures. "BEA" is the income-side output measure as derived in this paper.

Figure 3



Source: WMOut: revised industry 110300.wb3

Figure 4



Source: WMOut: revised industry 110300.wb3

Table 6

Comparison of BEA and BLS Measures
of Labor Productivity Growth in the Business Sector Output

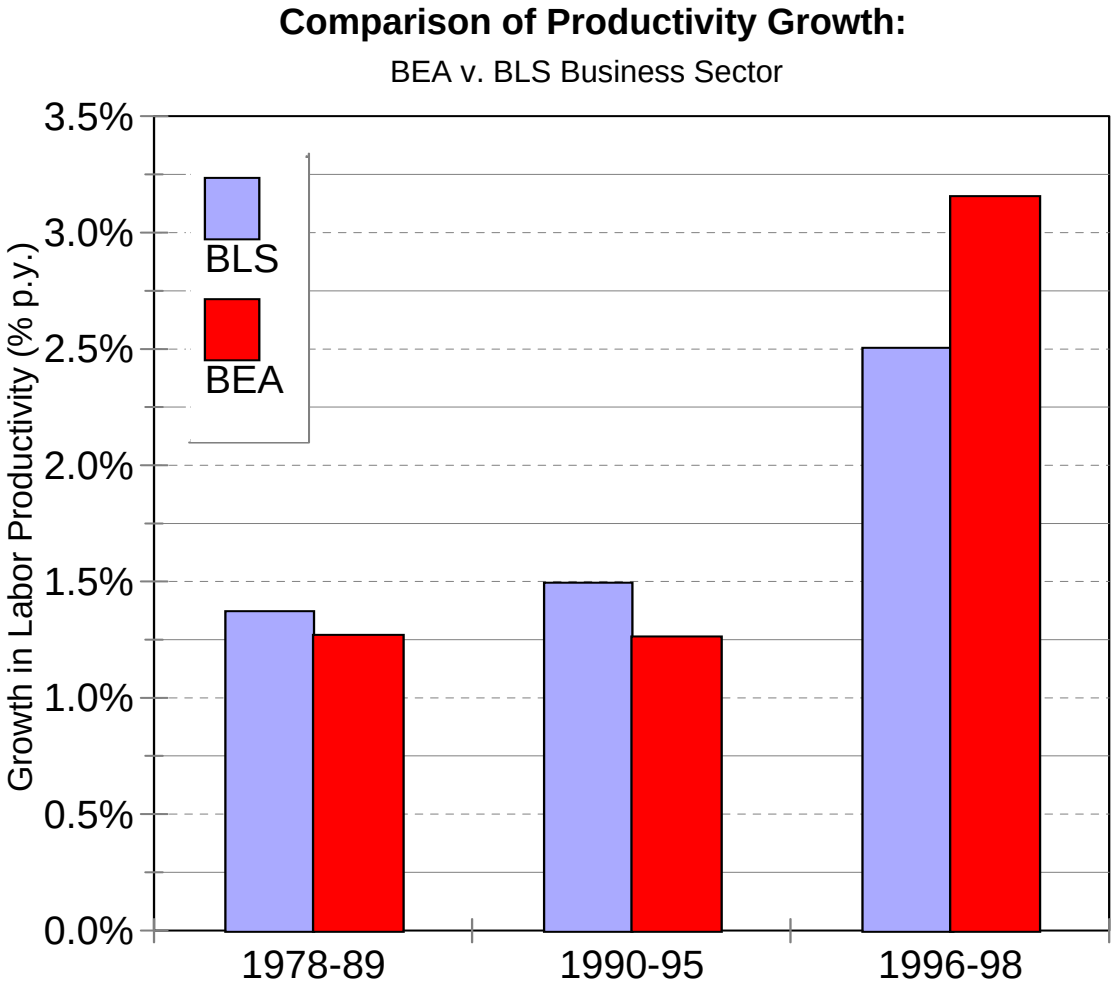
Business Sector

	[1] 1978-89	*[2] 1990-95*	*[3] 1996-98*	*Change from earlier period [2] - [1]*	*[3] - [1]*
Output of Business Sector					
BEA	1.27%	1.26%	3.16%	-0.01%	1.89%
BLS	1.37%	1.49%	2.50%	0.12%	1.13%

Source: BusSec: revised industry 110300.wb3

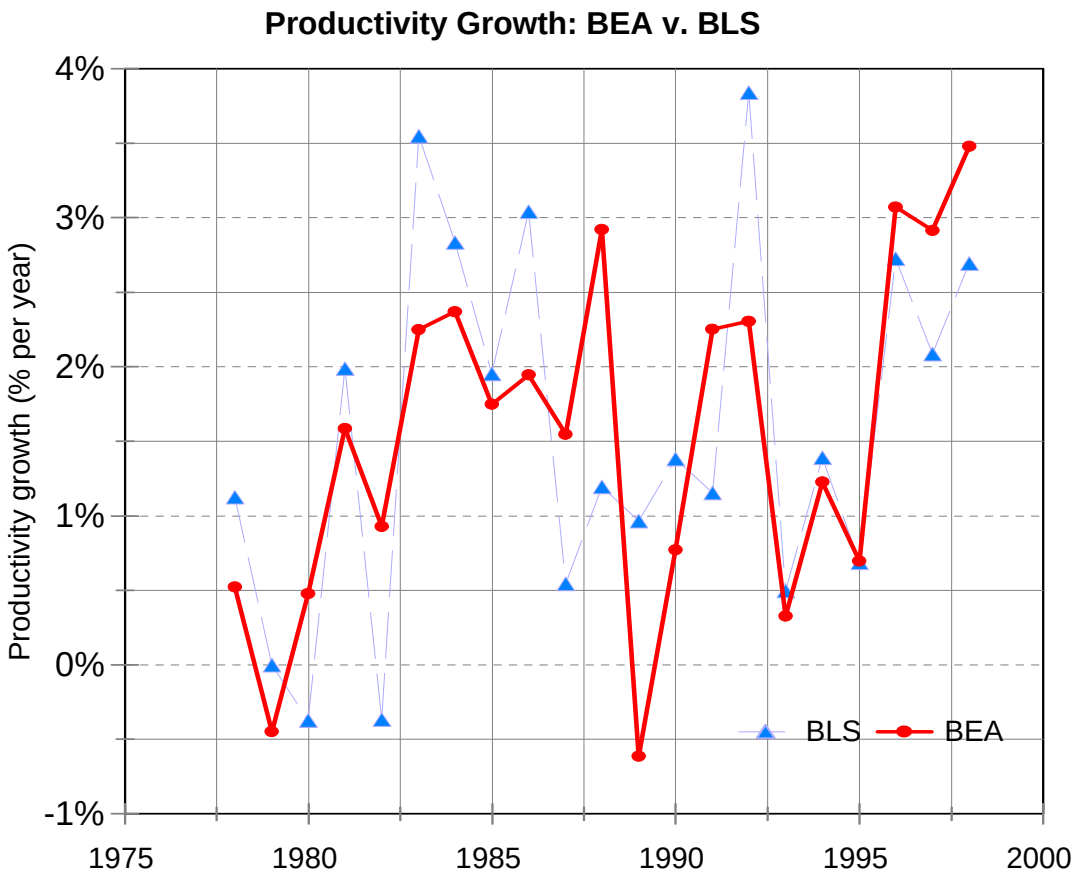
Note: "BLS" is the output-side product of the business sector used by BLS in its business sector productivity measures. "BEA" is the income-side output measure as derived in this paper.

Figure 5



Note: "BLS" is the output-side product of the business sector used by BLS in its business sector productivity measures. "BEA" is the income-side output measure as derived in this paper.

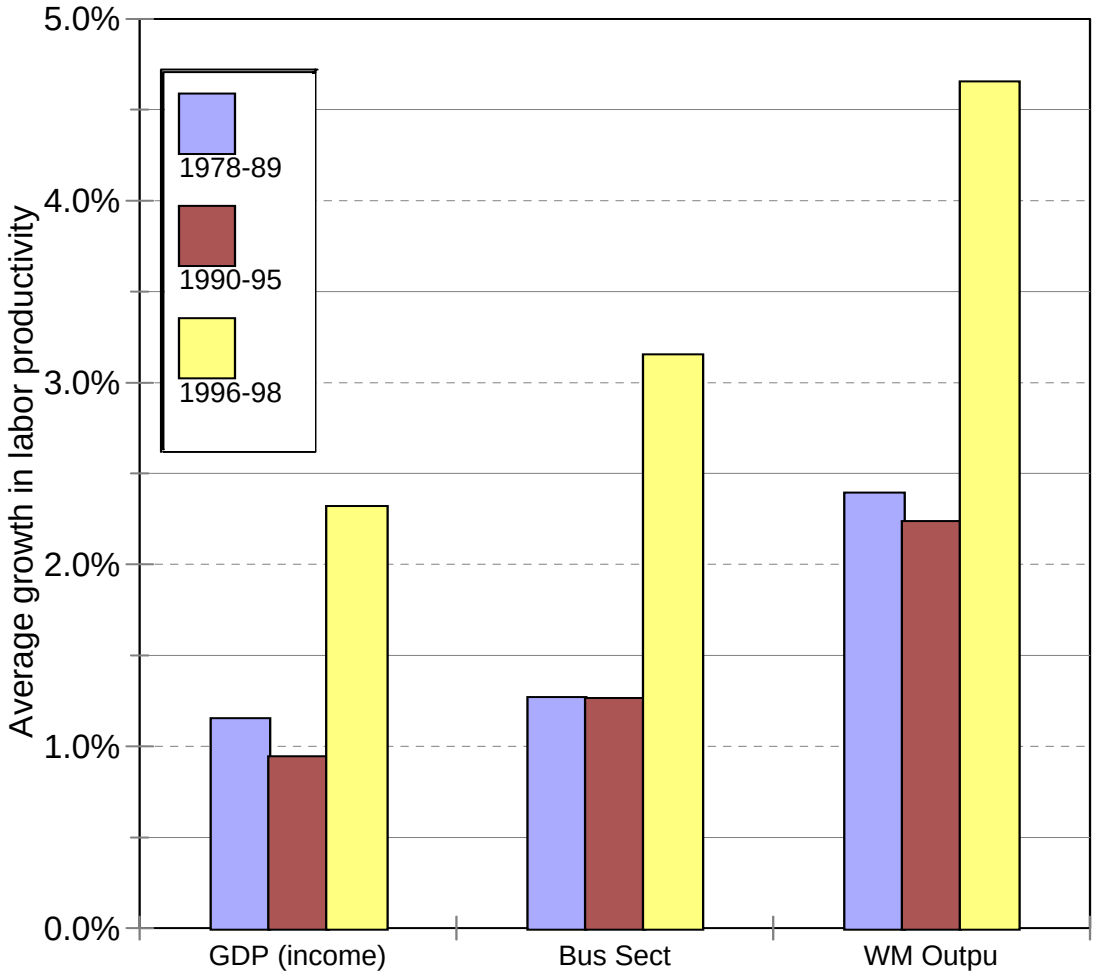
Figure 6



Note: "BLS" is the output-side product of the business sector used by BLS in its business sector productivity measures. "BEA" is the income-side output measure as derived in this paper.

Figure 7

Growth in Labor Productivity in Different Sectoral Definition



Note: "GDP (income)" is total GDP measured from the product side.
"Bus Sect" is the income-side measure of business output.
"WM output" is well-measured output as defined in text.

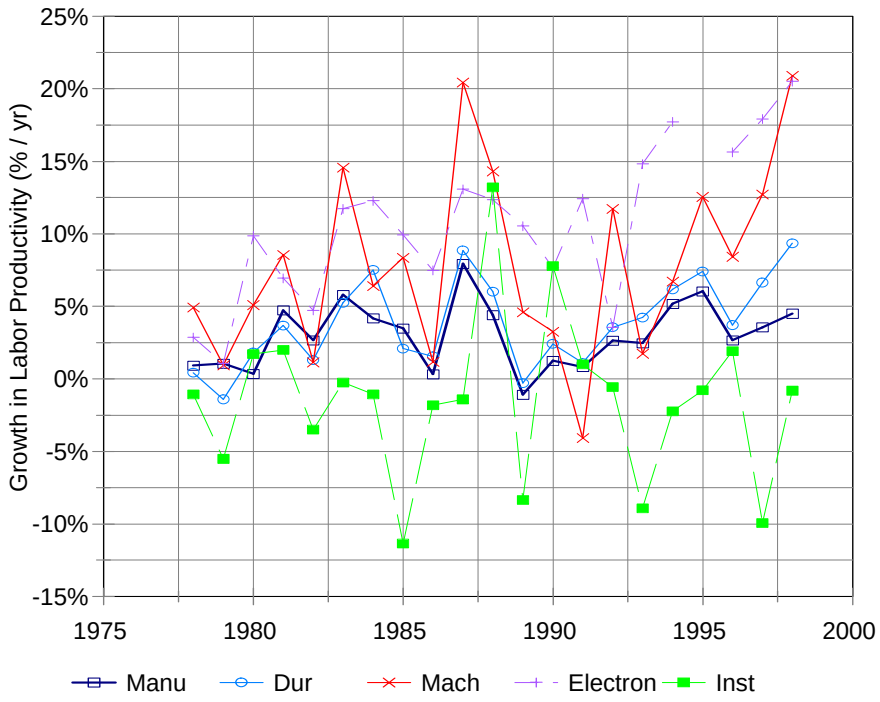
Table 7

Labor Productivity Growth
Alternative Concepts and Periods

Sector	*1978-89* *[1]*	*1990-95* *[2]*	*1996-98* *[3]*	*Change from earlier period* *[2] - [1]*	*[3] - [1]*
Total GDP (income side)	1.15%	0.95%	2.34%	-0.21%	1.18%
Business output	1.37%	1.27%	3.19%	-0.10%	1.82%
Well-measured business output	2.39%	2.24%	4.49%	-0.16%	2.09%
New economy	6.53%	7.31%	13.30%	0.78%	6.77%

Figure 8

Productivity Growth in Major Durable Manufacturing Industries



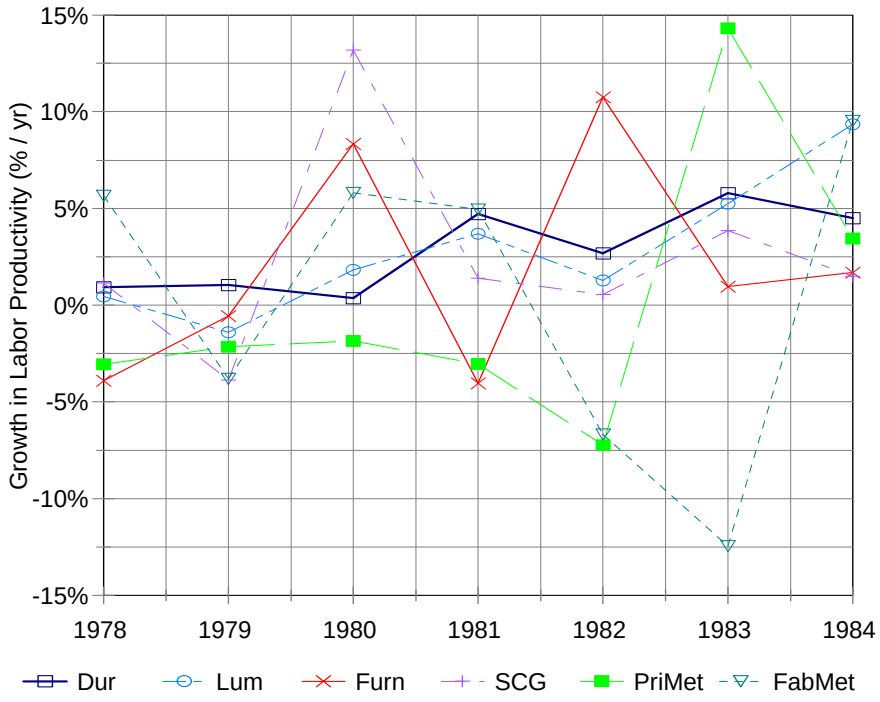
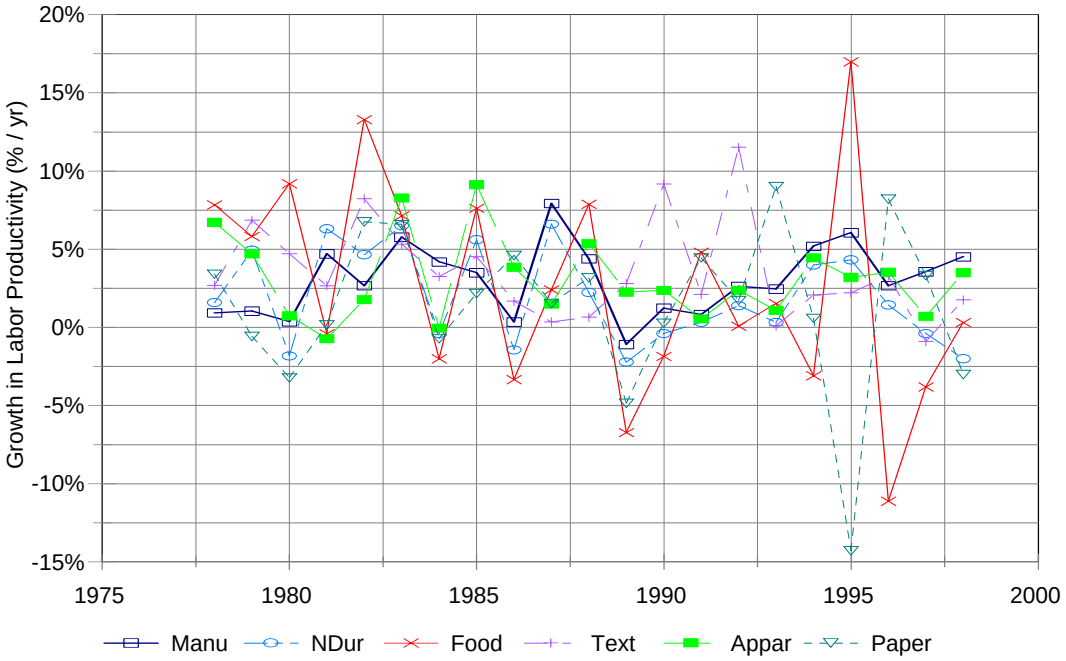


Figure 9

Productivity Growth in Major Nondurable Manufacturing Industries



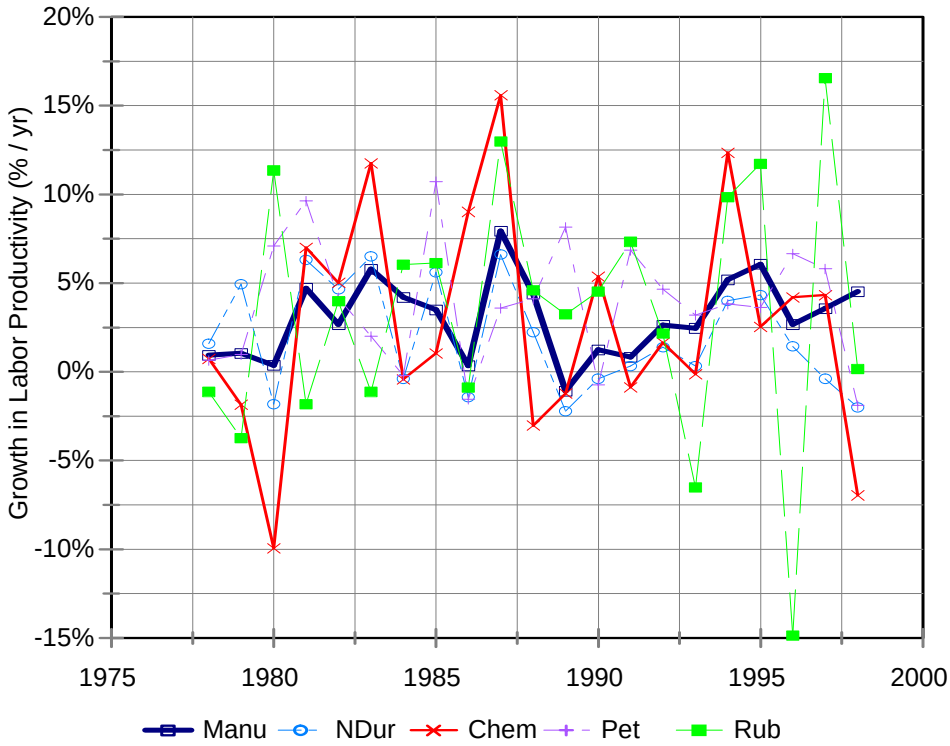
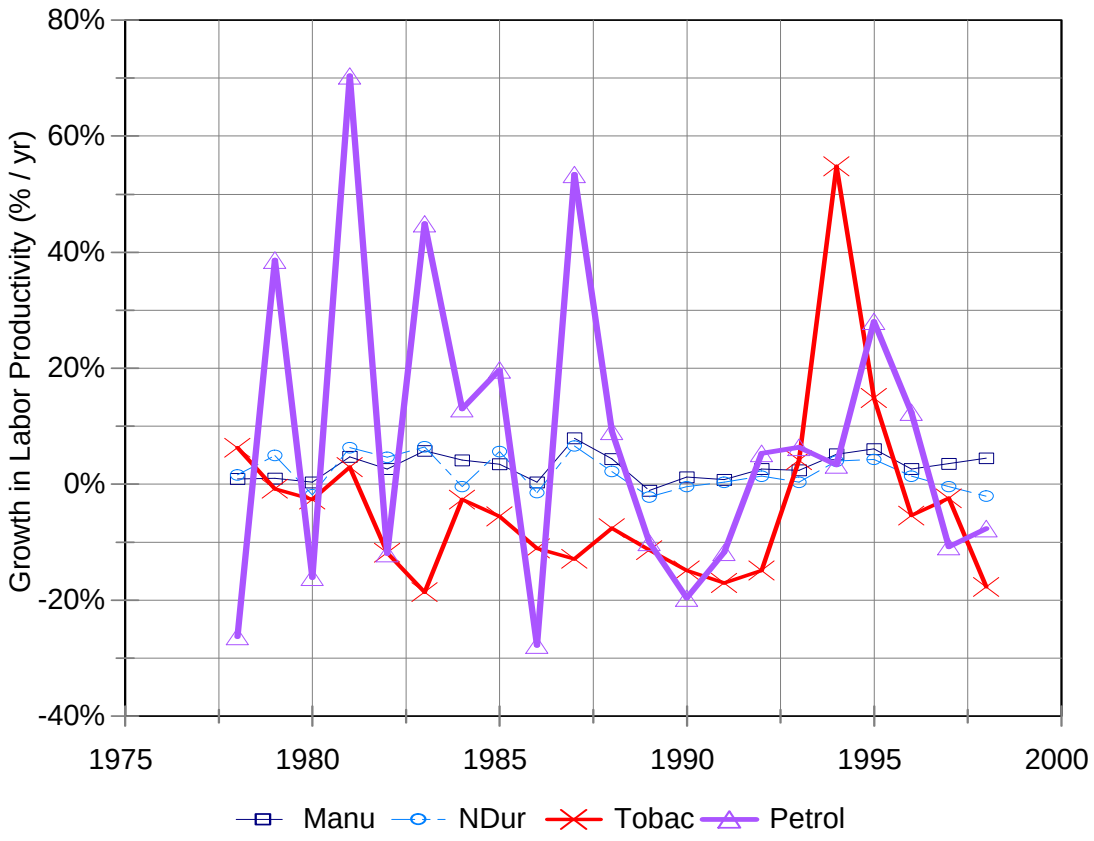


Figure 10

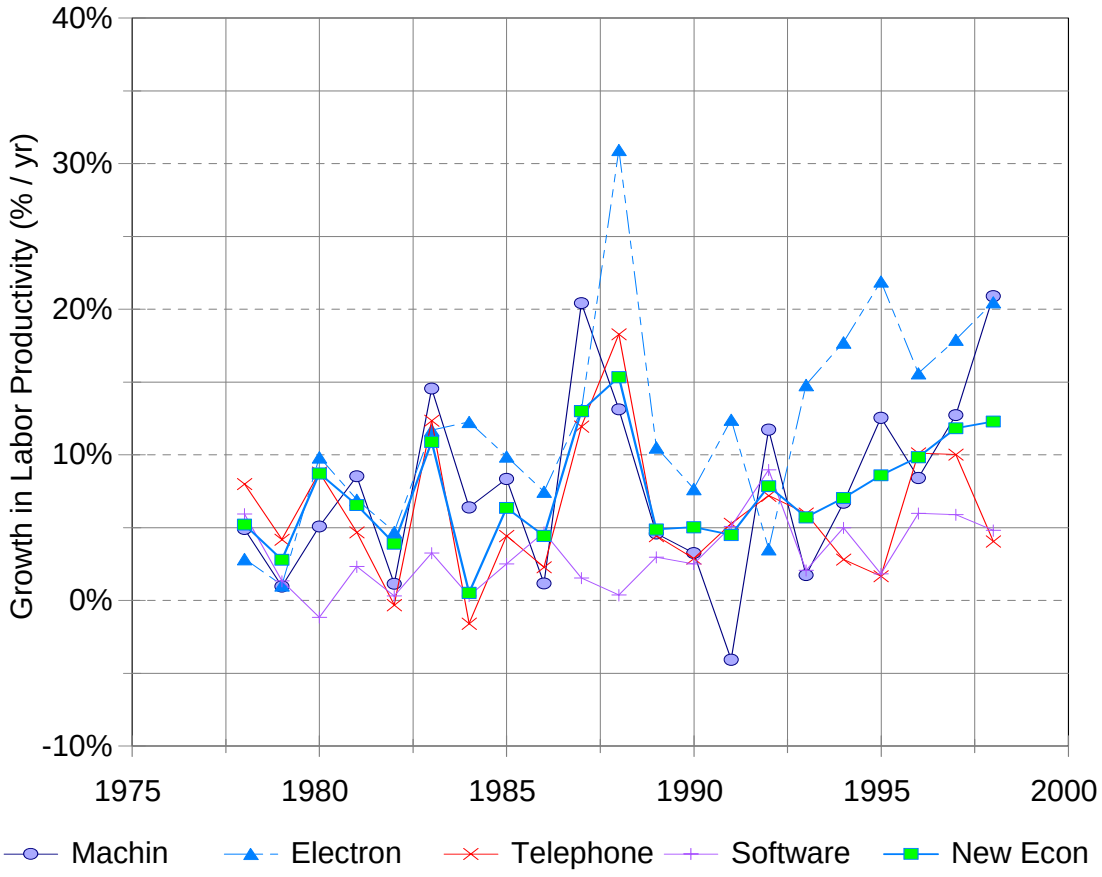
Problem Children: Petroleum and Tobacco



Source: ProdManu: revised industry 110300.wb3

Figure 11

Productivity Growth in New Economy Sectors



Source: ProdManu: revised industry 110300.wb3