Has the "New Economy" Rendered the Productivity Slowdown Obsolete?

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ABSTRACT

When the period since 1995:4 is compared to 1950-72 and 1972-95, growth in output per hour in the most recent (third) period has recovered more than two-thirds of the productivity growth slowdown registered between the first and second periods. This paper shows that *all* of this productivity rebound can be explained by three factors, (1) improved methods for measuring price deflators, (2) the normal procyclical response of productivity in periods like 1997-99 when output grows faster than trend, and (3) the explosion of output and productivity growth in durable goods, entirely due to the production of computers.

There has been *no* productivity growth acceleration in the 99 percent of the economy located outside the sector which manufactures computer hardware, beyond that which can be explained by price remeasurement and by a normal (and modest) procyclical response. Indeed, far from exhibiting a productivity acceleration, the productivity slowdown in manufacturing has gotten worse; when computers are stripped out of the durable manufacturing sector, there has been a further productivity slowdown in durable manufacturing in 1995-99 as compared to 1972-95, and no acceleration at all in nondurable manufacturing.

However, taking account of the productivity explosion in computers, the paper arrives at relatively optimistic estimates of growth in potential GDP and benign implications for the misnamed Social Security "crisis."

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I. Introduction and Summary

The more enthusiastic proponents of a "new economy" revolution based on computer hardware, software, telecommunications, and other hi-tech products have declared a death sentence on the slowdown in productivity growth that began in 1972 or even earlier. The cheerleader of these apostles of the revolution is *Business Week*, which recently declared "At least for now, even formerly skeptical forecasters and economists have acknowledged the reality of the productivity revolution."[1] A recent Wall Street newsletter from Chase Securities concurs that "recent data . . . have wiped away these doubts . . . . Suddenly, the argument about whether productivity growth has accelerated has quieted."[2]

The more circumspect *Economist* writes that "the latest data strengthen the `new economy' lobby against hawkish traditionalists . . . . Perhaps workers are not spending all their days trading shares on the Internet and e-mailing their friends after all, and are doing something productive online instead."[3] Alan Greenspan himself has joined the technological enthusiasts by saying "A perceptible quickening in the pace at which technological innovations are applied argues for the hypothesis that the recent acceleration in labor productivity is not just a cyclical phenomenon or a statistical aberration, but reflects, at least in part, a more deep-seated, still developing, shift in our economic landscape."[4]

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1. *Business Week* editorial, May 31, 1999, p. 190.

2. "Productive Confusion," Chase Securities U. S. Economic and Policy Research, U. S. Outlook Update, May 20, 1999, p. 4.

3. "Another miracle: productivity," *Economist*, May 15, 1999, p. 30.

4. Speech given by Alan Greenspan at the Federal Reserve Bank of Chicago, May 6, 1999.

Both the *Economist* and Greenspan support the view that the benefits of electronic technology are finally spilling over to the economy as a whole, creating a structural break with the dismal slowdown years of 1972-95 during which the overall rate of productivity growth barely exceeded one percent per annum. The Chase Securities newsletter cites approvingly the "seminal" work by Paul David (1990) in predicting that the benefits of computers were being delayed, just as were the benefits of electric motors at the turn of the century, but after some period would finally begin to boost economywide productivity just as electric motors caused a productivity acceleration in U. S. manufacturing in the 1920s.

Skeptics must admit that the raw numbers are impressive. Choosing as break points the cyclically neutral quarter at the cusp of the slowdown (1972:2), and the last quarter before the acceleration began (1995:4), there is clear evidence of a productivity growth recovery. As shown in Table 1, annual growth rates of nonfarm private business (hereafter NFPB) output per hour in the three intervals extending between 1950:2, 1972:2, 1995:4, and 1999:1 were, respectively 2.63, 1.13, and 2.15 percent. The recovery over the last three years does not bring the U. S. economy back to the pre-1972 “golden age” but appears to recover roughly two-thirds of the lost ground (with a recovery of 1.02 points equaling 68 percent of the 1.50 point slowdown between 1950-72 and 1972-95).

Even these raw figures may disappoint the revolution enthusiasts, who sometimes write as if all of the lost ground has been recovered rather than merely two-thirds. However, that is only the beginning of the story. Examined more closely, the productivity revival, however impressive, does not provide any evidence of a "broad" new economy revolution created by the benefits of computers

and other electronic equipment *spilling over* to the sectors of the economy that have invested so heavily in them, as contrasted to a "narrow" new economy revolution consisting simply of rapid productivity growth *in the manufacture of electronic equipment itself with no spillover to the rest of the economy*. The undeniably impressive facts of a productivity growth recovery can be explained entirely by three factors, two of which involve pure arithmetic and the third of which involves a simple econometric relationship.

Measurement Improvements in the National Accounts Deflators. As is now widely recognized, a series of improvements in the measurement of the CPI starting in the early 1990s has reduced measured inflation relative to true inflation. Some of these improvements implemented as recently as January, 1999, in the CPI itself have been "backcast" in the national income and product accounts (NIPA) to apply to the entire period beginning in 1995:1. Further, there have been measurement changes in the national accounts deflators that go beyond those in the CPI, particularly the 1993-95 shift in the deflation of half of medical care spending from the CPI to the slower-rising PPI. The "dual" to the price measurement improvements has been a corresponding change in the measuring rod for real GDP and productivity that has boosted measured productivity growth relative to actual productivity growth.

The Productivity Explosion in Durable Manufacturing. The NIPA measure of the output of computer hardware is created by dividing nominal computer expenditures by a hedonic price index. The rapid rate of decline in the computer deflator, at a rate of 37 percent per year during 1997-99, translates into a very rapid increase in output per hour in the part of the economy that manufactures

computer hardware.[5] While quarterly productivity data do not exist for the computer hardware industry, all of the computer output is located within the durable manufacturing sector, for which quarterly data do exist.[6] Because productivity growth in durable manufacturing between 1995:4 and 1999:1 has more than doubled from its 1972-95 trend, as shown in Table 1, the portion of the productivity recovery remaining to be credited to the nonfarm nondurable (hereafter NFND) business sector is correspondingly less than when durables are included.[7] The growth rates of NFND output per hour in the intervals cited above (1950-72, 1972-95, and 1995-99) are, respectively, 2.68, 0.80, and 1.50 percent. Thus the recovery in NFND is not 69 percent of the slowdown, as is the case for the total nonfarm business economy, but a much smaller 37 percent (0.70/1.88).

Productivity is Normally Procyclical. When output grows faster than trend, output per hour also grows faster than trend because hours adjust incompletely to an acceleration in output. This part of the story, unlike (1) and (2) above, involves more than mere arithmetic, because there is that nagging question "what are the trends in output and hours that are relevant in assessing the procyclical productivity effect?" This paper updates estimates of the cyclical response of hours to output estimated in two of my earlier papers in a way that uncovers the underlying 1995-99 trends

5. The BEA deflator for the final sales of computers in GDP declined at an annual rate of 36.9 percent per year over the period 1997:1-1999:1.

6. Below in Table 2 we develop a proxy for productivity growth in the computer part of durables and the remaining non-computer portion of the manufacturing durables sector.

7. As explained in the Data Appendix, real GDP in durables cannot simply be subtracted from that in the NFPB sector, since chain-weighted indexes of real GDP are not additive. All indexes for sub-sectors described in this paper are derived as a Tornqvist index, using nominal shares in the total to derive the growth rate of output in one sub-sector given data on output growth in the other sub-sector.

in output and in productivity in the three sectors (NFPB, durable manufacturing, and NFND).[8]

To anticipate the conclusion, the acceleration of productivity growth in the NFND sector can be explained entirely by remeasurement of the deflators and the normal procyclical response. There is no room left for a "new economy" revolution in the sense of a revolution in productivity in the 87 percent of the NFPB economy lying outside of durable manufacturing, or in fact in the 99 percent of the NFPB economy lying outside the manufacture of computers.[9] The productivity revival can be explained entirely by remeasurement of the deflators, the normal procyclical response of productivity, and the explosion of computer power that has pushed productivity growth in durable manufacturing to unprecedented rates without spilling over to provide any productivity payoff outside of the manufacturing of durables, or indeed outside of the manufacturing of the computers themselves..

The paper is structured to provide a complete decomposition of the productivity acceleration of the NFPB economy in each of the three sectors into the following four categories: (1) the cyclical effect that is predicted by an equation based on past history, (2) the unexplained residual in that equation, (3) the part of the acceleration in the productivity trend that can be attributed to deflator remeasurement, and (4) the remaining "true structural" acceleration in trend when 1995-99 is compared with 1972-95. We will be looking for evidence that the "true structural" acceleration implicit in the above quotes from *Business Week*, the *Economist*, and Alan Greenspan is in fact supported by the facts.

However, despite its pessimism about the "new economy" revolution, the paper also leads to

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8. See Gordon (1979, 1993).

9. Durable manufacturing was 12.6 percent of NFPB nominal GDP in the base year of 1992.

some strikingly optimistic conclusions that are relevant for the big macroeconomic issues that concern government forecasters. As measured, trend productivity growth for the total NFPB economy has clearly accelerated, even if much of this is occurring in the sector of the economy *making* the computers as contrasted to the sectors *using* the computers. Potential real GDP is currently growing at about 3.0 percent per year, significantly faster than the 1987-95 average rate of 2.3 percent.

Another optimistic implication of this paper is that the so-called "crisis" in Social Security is put off for another century if recent trends in potential GDP growth were to continue. There do not appear to be any implications of the results of this paper for the issue of forecasting the future of the Federal government budget. The current growth rate of potential real GDP of roughly 3.0 percent appears to be consistent with the current estimates being used by the CBO in their budget forecasting exercises, and also consistent with the current estimates in use at the Fed. The outlook for the Federal budget in the *short-run* and *medium run*, of course, depends on whether the economy returns from its current above-trend levels of output, hours, and productivity back to alignment with the trends estimated here.

II. Remeasurement of the GDP Deflator

As stressed above, the role of changing measurement methodology as a cause of the productivity acceleration does not involve simply the size and calendar of measurement changes in the CPI. The size and calendar of measurement changes in the GDP deflator is quite different, and this is what matters for the productivity growth acceleration. Measurement improvements in the CPI began well before the release of the Boskin Commission report on December 4, 1996. What

was originally called "formula bias" was discovered by BLS researchers back in 1993-94 and was estimated at that time to account for a CPI overstatement of roughly 0.5 percent per annum. The improvements in CPI measurement that eliminated formula bias (later relabelled as "lower-level substitution bias") occurred in two stages. The first steps occurred in 1995-96 and eliminated about 0.25 points of the bias, and this was taken into account in the Boskin report. That is, the highly publicized Boskin Commission estimate of an overall CPI bias of 1.1 percent per year applied to the period subsequent to the 1995-96 improvements, and the Boskin bias assessment would have been 1.35 percent if applied to 1994 or earlier years.

The second stage of the repair of the formula bias problem occurred in January, 1999, when the BLS switched to geometric weights for most of the lower-level categories in the CPI. This and several smaller improvements were "backcast" in the construction of NIPA output measures and the corresponding BLS productivity measures going back to 1995:1 (see Seskin, 1998). There were also small changes in CPI methodology in the 1991-95 period that carved an additional 0.1 out of measured inflation relative to true inflation.

The cumulative improvements in CPI measurement are estimated to have reduced measured inflation in the PCE deflator relative to true PCE inflation by 0.65 points in 1996-99 compared to the rate that would have been determined using pre-1992 methodology.[10] Recently Eldridge (1999, Table 3, p. 39) has shown that the CPI is used for the deflation of 57.3 percent of business sector output, implying a cumulative remeasurement factor of 0.37 percent per annum for the private business

10. Gordon (1998, pp. 333) provides a detailed explanation of the methodology that leads to the 0.65 estimate and the citations on which this estimate is based. The 0.65 figure used in this paper is the average of the three figures given on p. 333 — 0.73 for 1996, 0.49 for 1997, and 0.73 for 1998.

sector.

Some analysts have arrived at slightly smaller estimates of the measurement effect, e.g., the CBO currently refers to a "technical adjustment factor" for potential GDP growth during the 1998-2003 interval of 0.3 as compared to the 0.37 used here.[11] Some also confuse the timing and extent of adjustments in the CPI with those in the GDP deflator; it is only the latter that matter for the current paper. However, the adjustments discussed above neglect an important change in measurement in the deflators for consumption and GDP which does not involve the CPI itself. This is the shift by the deflators to use the PPI for medical care in preference to the CPI for medical care beginning in 1993.[12] The effect of the shift, illustrated in Figure 1, is to reduce inflation in the for-profit and government hospital sector of medical care by slightly more than 2 percent per annum in 1993 and subsequent years.

A BEA source indicates that 49 percent of PCE on medical care services is now deflated by a PPI source rather than a CPI source.[13] Also, a comparison indicates that over the period 1995:1 - 1999:1 the PPI for hospitals rose 2.39 percent slower than the CPI for hospitals at an annual rate, while over the same period the PPI for physician services rose 1.63 percent slower than the CPI for

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11. CBO, "The Economic Outlook: Staff Forecast," June 2, 1999.

12. In Gordon (1998) about one-third of the deceleration in medical care inflation in the 1990-95 period is misattributed to the managed care revolution rather than to this change in the measurement source for the deflators. The PCE deflator shifted from a CPI source to a PPI source on the following calendar: for-profit and government hospitals, January 1993; Physicians, January 1994; Medical labs, eye examinations, and for-profit nursing homes, January 1995.

13. E-mail from Aaron Catlin of the BEA, June 8, 1999.

physician services.[14] Since medical care services currently represent 10.3 percent of GDP, this additional source of measurement shift could explain roughly 0.10 percent of the recent productivity growth acceleration.[15]

When the base estimate of a 0.37 percent measurement effect applying after 1991 is added to the 0.10 percent medical care effect, we arrive at a sum of 0.47 percent for the effect of all measurement changes on productivity growth in the NFPB sector. Of this change, some had occurred before 1995:4 and applies to productivity growth during the period 1972:2-1995:4. A rough estimate is that 0.04 applies to 1972:2-1995:4 and 0.47 applies to 1995:4-1999:1, so that remeasurement explains 0.43 points of the acceleration in productivity growth in the NFPB sector when 1995:4-1999:1 is compared to 1972:2-1995:4.

Since there is no detail available to allocate deflator remeasurement effects among the NFPB, durable manufacturing, and residual NFND sectors, we will take the 0.43 acceleration impact to apply equally to the three sectors. We will be looking at the comparison between the 0.43 point measurement impact on the productivity acceleration with the 0.74 point post-1995 acceleration in the NFND sector shown in Table 1. Can procyclical productivity effects explain the remaining acceleration of 0.31 percentage points?

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14. The PPI index for hospitals is series PCU806_ and "offices and clinics of doctors of medicine" is series PCU8011, both obtained from the BLS web site. The corresponding CPI indexes were kindly provided by Ken Stewart of the BLS.

15. We take an average growth rate of -2.0 percent for the relevant PPI indexes relative to the same CPI indexes, times 10 percent of GDP, times 0.49 percent of medical care services that switched from the CPI to the PPI in the 1993-95 period.

III. The Productivity Explosion in the Manufacturing of Durables

The "conventional wisdom" on the productivity slowdown has long recognized that the slowdown is entirely located outside of manufacturing, and that there has been no productivity growth slowdown in manufacturing at all. Indeed, Griliches (1994) emphasized the role in the slowdown of the shift in economic activity away from manufacturing and other "easier-to-measure" sectors like mining, transportation, and utilities, to sectors where output is "harder-to-measure," including construction and most of the services.

But what has been less widely recognized is that the admirable performance of productivity growth in manufacturing is entirely located within durables, and within durables is entirely located in the production of computers. As shown in Table 1, the acceleration in manufacturing productivity growth after 1995 disguises the fact that there was no significant acceleration in nondurable manufacturing output per hour, which exhibits a 1972-95 growth rate of 2.03 percent and a 1995-99 growth rate of 2.05 percent. Far from merely maintaining the growth rate of labor productivity in the pre-slowdown period of 1950-72, the durables sector in the last three years has far surpassed any sustained growth rate of productivity over a comparable time period, at least since the productivity miracle of World War II.[16]

One reaction to the striking numbers in Table 1 is to point out that there is much else going on in durables besides computers. It may appear that data do not exist currently that are suitable for the purpose of isolating the effect of computer production, and indeed the first version of this paper

16. The growth in output per hour in the durables sector during the Korean war between 1950:Q2 and 1953:Q3 was an unimpressive 2.35 percent per annum.

treated the internal behavior of the durables sector as a black box. However, it is possible to create proxy indexes which reveal the role of computer manufacture as the overwhelming influence on the performance of the durables sector. Putting together time series on nominal and real computer output, we can use these indexes to create Tornqvist indexes of output growth in the durables manufacturing sector for the total of that sector, the computer component, and the non-computer segment.[17] The ingredients in these calculations are presented in Table 2 and are summarized in Table 1. The remarkable aspect of the productivity numbers in Table 1 is that, when stripped of computers, the productivity performance of the durable manufacturing sector is abysmal, with no revival at all and a further slowdown in 1995-99 compared to 1970-95.

The explosion of computer power and its counterpart, the acceleration of productivity growth in the durable manufacturing sector, requires that we use care in discussing the "new economy" hypothesis. There can be no doubt that rapid growth is occurring in the capabilities of computer hardware and telecommunications equipment. But the "new economy" advocates have in mind much more than that. They believe, following Paul David's famous (1990) analogy between electric motors and computers, that the benefits in the *use* of computers (outside of the industries which manufacture computers) has been long delayed but has finally arrived, in spades. It is this evidence that computers are being used efficiently to create faster growth in the rest of the economy, as we shall see, that is

17. Details are presented in the Data Appendix. The concept of computers used to adjust durable manufacturing for 1987-99 is the BEA series on "final sales" of computers, which includes consumption, investment, government, and net export expenditures on computers. Thus the computer measure takes into account that the U. S. runs a large trade deficit on computers and parts; total 1997 nominal computer expenditures of $93 billion in these calculations would have been $115 billion if the $21 billion trade deficit in computers and parts had not already been subtracted. Prior to 1987 the adjustment uses the "computer and peripherals" component of PDE, which in 1987 had a nominal value of $35.8 billion as contrasted to $52.4 billion for final sales of computers.

totally absent in the data.

Questions about measurement can naturally be raised here; aren't the computers producing new services that provide benefits that escape measurement in the output and productivity accounts? The first and most obvious response is that the enthusiastic quotes by the "new economy" advocates and others at the beginning of this paper are based on observations of the behavior of *measured* productivity growth and do not rely on any assumption that the fruits of electronic technology are mismeasured.

A second response involves speculation about mismeasurement that to explore fully would take us far beyond the scope of this short paper. A brief version of this response is that ever since the first industrial revolution the benefits of new products have been missed by standard price deflators and, as a separate flaw, initial price declines in new goods have been understated or overlooked entirely due to the late introduction of new products into the price indexes. The automobile was introduced at the turn of the century but not included in the CPI until 1935. The benefits of air conditioning were missed in the 1950s and 1960s; the benefits of color television were missed in the 1960s and 1970s; the benefits of ATM machines were missed in the 1970s and 1980s; the benefits of VCRs were missed during their first decade of rapid price decreases when they were excluded from the CPI (1978-87). It is difficult to argue that our current deflators understate quality change and the benefits of new products to a greater extent than in previous decades.

IV. The Procyclical Behavior of Productivity

There is a longstanding literature on the procyclical behavior of productivity, dating back to

at least to Hultgren (1960). In periods when output is growing more rapidly than trend, growth in hours accelerates but with a lag and an elasticity well below unity. As a result, output per hour usually grows most rapidly when output is growing fastest relative to average or trend.

In two papers I have estimated the normal response of cyclical changes in hours to cyclical changes in output. Equations estimating this normal response reveal an unusual pattern of the residual errors that imply a systematic tendency for productivity growth to grow more slowly than predicted in the final stages of a business expansion. This phenomenon, which I have dubbed the "end-of-expansion" effect, occurs in the last stages of the business expansion when productivity grows more slowly than would otherwise be expected but is reversed in the subsequent cyclical recovery when productivity grows more rapidly than would be otherwise expected.

To keep this paper as brief and nontechnical as possible, the details of the specification of the econometric equation are not repeated here. The quarterly change in the log ratio of hours to its trend is regressed on four lagged values of the dependent variable, on the current and three lagged values of the change in the log ratio of output to trend, and on a set of end-of-expansion dummy variables.[18] This equation provides a set of fitted coefficients that can be used to create a series on the predicted behavior of hours in any interval, given the actual behavior of the deviation of output from trend.

Three quite separate issues about this econometric specification require discussion. First, the "normal" cyclical response of productivity to a movement of output above or below trend depends

18. See Gordon (1993, p. 291, equation 1). In the current paper the error-correction term is excluded, while the end-of-expansion dummy variables are defined as in the 1993 paper, with the 1988-92 effect taken to be the "early" alternative variable specified on p. 300.

both on the pattern of the lagged coefficients and on the long-run response of the hours ratio to a change in the output ratio, which is about 0.76 percent in the equation for the 1973-99 period. Second, the estimated end-of-expansion effects help to explain the peculiar behavior of productivity in specified intervals in previous business cycles but are not currently relevant. Third, the estimation relates two sets of variables that are both defined as the growth rate of deviations from trend (alternatively, the growth rate of actual values minus the growth rate of trend values). Clearly, our conclusions may be sensitive to the method by which the trends in output and hours are determined.

The Normal Procyclical Effect. The set of estimated coefficients of the response of hours deviations to output deviations involves both a set of lagged effects and a sum of coefficients of hours on output that is significantly less than unity. Because the adjustment of hours lags modestly behind any shock to the output deviation, output per hour rises and then declines by part of the previous increase in response to a positive output shock. Figure 2 plots the estimated adjustment for the NFPB sector of hours and output per hour to a hypothetical shock to the deviation of output from trend (the "output gap") that boosts the gap by 1.0 percent within one year at a uniform rate of 0.25 percentage points per quarter. As shown in the figure, the level of productivity is boosted by a maximum amount of 0.36 percent in quarter 4, after which the productivity response diminishes gradually to its steady state value of 0.24 percentage points in response to the 1.0 percent increase in the output gap.

End-of-Expansion Effects. The end-of-expansion ("EOE") effect analysis in Gordon (1979, 1993) helps to explain why productivity growth was so low in 1988-89 and relatively rapid in 1991-

92, and in similar episodes going back to 1956.[19] It is too early to assess any possible impact of the EOE effect in the current business expansion, because the EOE decline in productivity growth occurs over the interval between the peak in the output gap (sometimes called the peak in the "growth cycle") and the subsequent "NBER peak" (at which point real GDP begins an absolute decline). In 1999:1 the U. S. economy had not reached the point at which the EOE effect has in the past begun to bite, since the output gap grew steadily through 1998 and early 1999 and had not yet reached any clearly-defined peak. From the current perspective, the only relevance of the EOE effect is to refine the estimates and interpretation of productivity behavior prior to 1993.

Choice of Trends. By far the most important issue in assessing the recent behavior of productivity is to separate the data for each of the three sectors (NFPB, durable manufacturing, and NFND) into separate trends and deviations from trend. These choices are discussed in the next section.

V. Method of Choosing Trends

Two methods for establishing trends that are frequently used are the Hodrick-Prescott filter and a set of loglinear trends through "benchmark" quarters. I have previously argued (1993, pp. 282-

19. The explanation of the end-of-expansion effect is that firms seem consistently to overhire workers during the last phase of the business cycle when output growth is slowing down from above-trend rates to below-trend rates, and that this overhang of labor is eliminated in the subsequent recession and recovery. The end-of-expansion effect is specified so that there is no net effect on the growth rate of productivity in a particular cycle, just a shift in timing — below-expected productivity growth at the end of the expansion is balanced by above-expected productivity growth at the end of the recession and the early stages of the recovery. This phenomenon would not be particularly interesting if it were a fluke related to one particular business cycle, but instead it has occurred in six postwar business cycles. The end-of-expansion effect occurred between specified quarters in 1955-57, 1959-60, 1968-69, 1973-74, 1978-80, and 1988-90. The subsequent productivity rebound occurred in 1957-58, 1960-62, 1970-71, 1974-76, 1981-82, and 1991-93.

83) that the crucial disadvantage of the Hodrick-Prescott method is that results can be sensitive to the choice of an arbitrary "smoothing" parameter which determines whether the smoothed trend series at one extreme exactly mimicks the actual series or at the other extreme is a single trend from the beginning of the sample period to the end, with no variation or break in that single trend growth rate. The case for using loglinear trends through benchmark quarters is that economic criteria can be used in choosing those quarters to have similar rates of unemployment and capacity utilization, and to be quarters when unemployment is declining rather than rising. As in my past work on cyclical productivity effects, the benchmark quarters prior to the current decade are 1950:2, 1954:4, 1963:3, 1972:2, 1978:3, and 1987:3.

The benchmark quarter for productivity in the 1990s is chosen to be 1995:4. This quarter exhibits an unemployment rate of 5.6 percent and a capacity utilization rate of 83.4 percent, and the unemployment rate at that point was declining as in previous benchmark quarters. The results of this paper would be little different if the benchmark quarter were chosen to be some other quarter in the interval 1994-96. Dating the benchmark quarter later would credit more of the post-1995 productivity acceleration to the pre-benchmark interval and less to the recent interval. This would reduce the size of the recent acceleration and thus would work in favor of the conclusion of this paper that there has been no "true structural" acceleration of productivity in the NFND sector.

The subtlety in establishing the exact values of the trend between the benchmark quarters of 1987:3 and 1995:4 is that improvements in price measurement were introduced during that interval. The growth rates of the trend over that interval reflect the previous discussion of measurement improvements; the trend for the NFPB sector is 0.88 percent for 1987:3-1991:4, 0.94 percent from

1991:4 to 1994:4, and 1.18 percent from 1994:4 to 1995:4. The same adjustment factors for measurement are introduced into the data for manufacturing durables, and the trend for NFND falls out as an arithmetic residual. In all three sectors the deviation of productivity from trend is zero in 1995:4.[20]

But what is the trend in 1995:4 - 1999:1? Our solution to this central problem is to adopt an econometric criterion that leads to a trend that falls between two extremes. One optimistic extreme would be to assume that trend productivity growth in this interval is equal to actual productivity growth, i.e., that actual and trend productivity were equal at the very high levels achieved in 1999:1. The opposite and pessimistic extreme would be to assume that there was no acceleration in productivity in the NFPB sector in this interval beyond that which can be accounted for by price measurement.

In contrast to the two extremes, we establish the NFPB productivity trend as that which minimizes the *mean error* in the predicted change in detrended hours (given the change in detrended output) in our regression equation that explains the cyclical behavior of the change in detrended hours. In searching for that trend, we take the hours trend as fixed (as explained below) and perform a grid search for the output trend that minimizes the mean error in the predicted change in hours. Similar results are obtained if instead of minimizing the mean error, we minimize the root-mean-squared error.

When this same criterion is applied to durable manufacturing, it leads to the choice of a

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20. The minor impact of the shift in the GDP and PCE deflators from the CPI to PPI source for medical care services was discovered after the regression research was concluded and is used only to interpret the results, not to adjust the trends used in creating the regression variables.

productivity trend that is too rapid, in the sense that the actual value of productivity remains below trend for the entire 1995-99 period. For this sector, which does not exhibit consistent cyclical patterns in the 1990s, we choose the productivity trend that makes the mean level of the deviation of actual from trend productivity equal to zero in the final four quarters, 1998:2 - 1999:1. Then the productivity trend in NFND is derived as a residual from the calculated levels of trend output and hours in the NFPB and durables manufacturing sectors.

The hours trend was established for all three sectors by simply running a loglinear trend from the previous benchmark quarter (1987:3) through 1996:4 and assuming that the growth rate of the hours trend after 1996:4 continued the 1987-96 growth rate. The quarter 1996:4 was chosen because its average unemployment rate of 5.27 percent was close to the most optimistic estimate of the time-varying NAIRU presented in Gordon (1998). If 1995:4 had been chosen instead, trend hours growth in the NFPB sector would have been 1.46 instead of 1.56 percent per year, and a slightly less optimistic estimate of the growth rate of potential output would have emerged.

VI. The Resulting Decomposition of the Productivity Acceleration

The choices made in the previous section for the post-1995 behavior of the trends in labor productivity and in hours for each sector leads to the display in Table 3 of the trends for 1972-87, 1987-95, and 1995-99. This yields the striking conclusion that the trend for trend NFPB output in 1995:4-1999:1 was 3.41 percent per year, far faster than the 2.5 percent average annual growth rate of real GDP for the NFPB sector between 1987:3 and 1995:4. The chosen trends imply that actual output was 2.76 percent above trend in 1999:1 for the NFPB sector, a mere 0.67 percent in durable

manufacturing, and a higher 3.09 percent in the NFND sector. The choice of a slower trend for durable manufacturing output would have reduced the implied extent of the positive output gap in NFND and raised the output trend in the NFND sector.

A time-series plot for each sector showing actual and trend productivity, and the log ratio of actual to trend productivity, is shown in Figures 3, 4, and 5. For the NFPB sector the positive productivity deviation in 1999:1 was actually smaller than the positive deviations reached previously in several quarters of 1987 and 1992. In durable manufacturing there was a tight correspondence between actual and trend productivity during 1996-99. In the NFND sector the positive deviation in 1999:1 was also considerably smaller than in 1987 and in 1992.

Table 4 decomposes the post-1995 productivity growth acceleration for each sector. This table demonstrates concisely the conclusions summarized at the beginning of this paper. Productivity grew faster than trend in each sector, and most of this cyclical effect corresponds to the predictions of time-series equations based on data going back to 1973. There is a clear acceleration of trend in each sector, and in the NFPB and durable manufacturing sectors only part of this is explained by changes in price measurement, leaving a modest "true structural" acceleration in the NFPB sector and an enormous acceleration in the durable manufacturing sector.

However, the structural acceleration in the total NFPB economy is more than explained by the structural acceleration in durable manufacturing, leaving nothing left over for the 87 percent of the private business economy located outside of durable manufacturing, that is, the NFND sector. Indeed, there is an estimated structural *deceleration* for the NFND sector of 0.07 percentage points. The conclusion that there is no significant acceleration in the NFND sector, i.e., that the acceleration

is less than, say, 0.10 points, would survive a number of possible small changes in the methodology of this paper, including reducing the assumed trend growth rate of productivity in durables or reducing somewhat the assumed magnitude of the deflator measurement effect.

VII. Potential Real GDP Growth in 1999 and in the Future

Potential GDP growth refers to the entire economy, while the universe studied thus far in this paper is the nonfarm private business sector less housing, comprising 74.5 percent of nominal GDP in 1997. Thus an adjustment must be made to translate the estimated 1999 trend output growth in the NFPB sector into an estimate of the current growth in potential real GDP. It is typical for output in the NFPB sector to grow faster than real GDP as a whole, since the excluded components of real GDP that lie outside the NFPB sector (e.g., government) typically grow more slowly. Over the period 1987-99:1 the growth rate of real GDP was 0.26 percent less than the growth rate of NFPB real GDP (2.73 vs. 2.99 percent), and accordingly our estimate of the current trend in potential real GDP is reduced from 3.41 percent per annum to 3.15 percent per annum.

Another adjustment needs to take account of the fact that our trend for NFPB hours is drawn through two quarters with different unemployment rates. Over 1987:3-1996:4 the civilian labor force grew 0.10 points slower than civilian employment, and this reduces our constant-unemployment-rate measure of potential real GDP growth further to 3.05 percent per annum. Partly by coincidence and partly because of complementary methodologies, this figure is almost identical to the current CBO estimate of 3.1 percent potential GDP growth for 1999.[21]

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21. CBO "Staff Forecast," June 2, 1999.

The CBO predicts that potential real GDP growth will decline in the subsequent period (2003-2009) to 2.6 percent per annum. This slowdown largely reflects the anticipated reversal of the unusual recent upsurge in the ratio of NFPB hours to civilian employment. This ratio, which exhibits a growth rate of 0.0 percent per annum during the period 1960-87, grew at 0.18 percent per annum during 1987-96 and 0.51 percent during 1996:4-99:1. If one were to subtract the average 0.28 point 1987-99 growth in the ratio of NFPB hours to civilian unemployment from our prior estimate of potential real GDP growth, we would arrive at a "final" estimate of future potential GDP growth of 2.77 percent per annum. Obviously this final adjustment is based on an arbitrary reversal of a trend computed over an arbitrary set of years. Pending further research on the history of this ratio of NFPB hours to civilian employment, and the causes of its recent acceleration, the future growth of potential output consistent with recent trends in productivity and the civilian labor force could be anything from 2.5 percent to 3.0 percent.

VIII. The Social Security Non-Crisis

There has been insufficient attention in public discussions of the Social Security "crisis" that the official assumptions about future growth by the Social Security Administration are unbelievably pessimistic. As summarized by Bernstein (1999), these assumptions are for growth over the next 75 years in real GDP of 1.4 percent, in the labor force of 0.3 percent, and in business productivity of 1.3 percent. Bernstein cites an estimate that instead of running out of money in 2028, the Social Security Administration has an alternative forecast of 2.14 percent growth in real GDP that puts off the "day of reckoning" until 2072. Potential output growth of 2.9 percent would put off the day of reckoning

until the year 2116, well into the 22nd century, and far enough away so that we don't need to worry about it within our lifetimes.

IX. Conclusion

This paper concludes that the impressive acceleration of productivity growth, 1.02 percentage points at an annual rate when 1995:4-1999:1 is compared with the slowdown period (1972:2-1995:4), can be explained by three factors. These are changes in the measurement of the GDP deflator that goes beyond the remeasurement of the CPI and differs in timing; the explosion of computer power which has created exponential growth in productivity in the 1.2 percent of the economy devoted to the production of computers; and the procyclical increase of productivity which normally occurs when output grows faster than trend. The paper concludes that the "true structural" acceleration in productivity growth in the nonfarm private business sector has been 0.29 percentage points per year in the period 1995:4-1999:1, and more than all of this can be explained by deflator remeasurement, computers, and the normal procyclical effect. The remaining acceleration in the nonfarm nondurable segment of the economy is *minus* 0.07 percent per annum. While some of the choice of trends for labor productivity and hours were arbitrary, those choices can be varied across a fairly wide range without changing the conclusion that there has been no significant structural acceleration in productivity growth in the 87 percent of the total nonfarm private business economy located outside of durables manufacturing. Our baseline results indicate a structural deceleration of 0.07 percent, and the trend lines could be moved around quite a bit without implying a structural acceleration in NFND of more than 0.10 percent.

Everything in this paper refers to labor productivity, not to multi-factor productivity. The rapid growth in investment and in capital input over the past half-decade indicates that a MFP index for the NFND sector, if it were available, would exhibit even less of an acceleration than in output per hour and would support even more strongly our conclusion that there has been no structural acceleration in productivity outside of the 13 percent of the U. S. private business economy engaged in the manufacture of durable goods, or indeed outside of the 1.2 percent of the economy engaged in the manufacture of computers.

A final conclusion is that every observer of the economy, from *Business Week* to Alan Greenspan, has been misled about the economy's performance by focussing on measures of prices, output, and productivity that include computers. The huge positive exponential growth rates of computer output, and negative growth rates of computer prices, have managed to contaminate the statistics, despite the admirable move of the BEA in 1996 to chain-weighted indexes of price and output changes. One of the most surprising results in this paper is that the productivity performance of the manufacturing sector of the U. S. economy since 1995 has abysmal rather than admirable. Not only has productivity growth in nondurable manufacturing *decelerated* in 1995-99 when compared to 1972-95, but productivity growth in durable manufacturing stripped of computers has *decelerated even more.* The BEA and BLS would do a great service to commentators and policymakers if they were to design as soon as possible a set of accounts of output and productivity growth, and of inflation, which refer on a consistent basis to the 98.8 percent of the economy engaged in activities

other than the manufacture of computers.[22]

22. In 1999:1 nominal final sales of computers were $105.2 billion; nominal GDP was $8807.9 billion.

DATA APPENDIX

Note: *ERP99* stands for the *Economic Report of the President*, February 1999. *NIPA92* stands for NIPA, vol. 2, 1959-88, September 1992, and *NIPA86* stands for NIPA, 1929-82, September 1986. *BSTAT98* stands for *Business Statistics 1998*. Both NIPA volumes and *BSTAT98* are hardcopy published by the U. S. Department of Commerce.

NFPB is the nonfarm private business sector as reported by the BLS and the nonfarm private business sector less housing as reported by the BEA. NFND is the NFPB sector excluding durable manufacturing. DNC is the durable manufacturing sector excluding computers output, where the later is proxied by final sales of computers during 1987-99 and by the "computers and peripherals" component of PDE during 1959-86.

Output: Quarterly indexes of output for NFPB, manufacturing, durable manufacturing, and nondurable manufacturing are taken from the BLS web site. These are converted into indexes in 1992 dollars through multiplication by the levels of 1992 GDP for NFPB from *ERP99*, Table B-10, and for manufacturing from *ERP99*, Table B-12.

The quarterly log change in output for the NFND sector is constructed as a Tornqvist index. Nominal and real GDP are constructed for NFPB with quarterly data from the BEA web site back to 1992 and annually before, and for durable manufacturing on an annual basis for 1977-97 from *ERP99*, Tables B-12 and B-13. Nominal and real GDP for durable manufacturing before 1977 are taken from *NIPA86*, Tables 6.1 and 6.2. Nominal GDP for durable manufacturing after 1997 is computed by assuming that the implicit deflator for that sector declines at a 2.0 percent annual rate, the same as observed in 1995-96 and 1996-97. Then the log change in output for the NFND sector is computed by the formula $x_2 = (x - s_1x_1)/s_2$, where x, x_1, and x_2 are the log changes in output in the NFPB, durable manufacturing, and NFND sectors, respectively, and s_1 and s_2 are the average shares in nominal GDP for the two sub-sectors in the current and previous quarter.

Nominal and real final sales of computers for 1987:1-1999:1 were obtained from Christian Ehemann of the BEA. The equivalent nominal sales of computers for 1959-86 were taken as the "computers and peripherals" component of PDE from *ERP99*, Table B-18. The real chain-weighted counterpart of this series is available from *ERP99*, Table B-19, only back to 1982. This series was extrapolated backwards at a logarithmic growth rate of 20 percent per year. The quarterly log change in output for the "DNC" portion of durable manufacturing excluding computers was obtained

as a Tornqvist index, using the same formula as in the previous paragraph, and nominal shares of computers and non-computers within the durable manufacturing sector. For the period 1950-72 the growth rate of DNC was computed as a weighted average of durable manufacturing for 1950-59 and DNC for 1960-72 (since the BEA series on the computer component of PDE starts from zero in 1959)..

Hours: Quarterly indexes of hours for the NFNB, manufacturing, durable manufacturing, and nondurable manufacturing, were obtained from the BLS web site. Total hours in 1992 were obtained through multiplication of these indexes by the absolute value of 1992 hours from the *Survey of Current Business*, August 1997. Hours in the NFND sector were obtained by subtraction. Hours in the computer industry were assumed to grow 2.0 percent per annum faster than hours in durable manufacturing. This allowance for a surplus of growth in computer hours is probably generous, based on *BSTAT98* pp. 195 and 227, which shows that the annual growth rate of payroll employment in the "Electronic and Electric Equipment" industry exceeded that in all of Durable Manufacturing by only 0.32 percent per annum over the period 1969-97.

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Table 1

Output per Hour, by Sector, Alternative Intervals 1950-99 (Percentage Growth Rate at Annual Rate)

Sector	1950:2-1972:2 (1)	1972:2-1995:4 (2)	1995:4-1999:1 (3)	Slowdown (2)-1) (4)	Recovery (3)-(2) (5)	Recovery/ Slowdown (percent)
1. Nonfarm Private Business	2.63	1.13	2.15	-1.50	1.02	-68.0
2. Manufacturing	2.56	2.58	4.58	0.02	2.00	10000.0
a. **Durables**	2.32	3.05	6.78	0.73	3.73	511.0
i. Computers	-.--	17.83	41.70	-.--	24.22	--.-
ii. Non-computers	2.23	1.88	1.82	-0.35	-0.06	17.1
b. Nondurables	2.96	2.03	2.05	-0.93	0.02	-2.2
3. **Nonfarm NonDurables**	2.68	0.80	1.50	-1.88	0.70	-37.2

Sources: Lines 1, 2, 2a, 2b from BLS web site. Lines 2.a.i and 2.a.ii from Table 2, lines 3b and 3c. The technique for calculating the residual sectors (lines 2.a.ii and 3) is described in the Data Appendix.

Table 2

Output, Hours, and Output per Hour, by Sector, Alternative Intervals 1972-99

(Percentage Growth Rate at Annual Rate)

Sector	1950:2-1972:2	1972:2-1987:3 (1)	1987:3-1995:4 (2)	1972:2-1995:4 (3)	1995:4-1999:1 (4)
1. Output					
a. Durable Manufacturing	3.74	2.97	3.19	3.05	7.26
b. Computers	[a]	20.00	19.54	19.83	44.19
Durable Non-Computers	3.62	1.98	1.23	1.72	2.03
2. Hours					
a. Durable Manufacturing	1.42	0.06	-0.11	0.00	0.49
b. Computers	[a]	2.06	1.89	2.00	2.49
c. Durable Non-Computers	1.39	-0.05	-0.35	-0.16	0.21
3. Output per Hour					
a. Durable Manufacturing	2.32	2.91	3.30	3.05	6.77
b. Computers	[a]	17.94	17.65	17.83	41.70
c. **Durable Non-Computers**	2.23	2.03	1.58	1.31	1.82

Notes: a. Computer output was extrapolated backwards at an assumed 20 percent annual rate of growth for 1960-82. Output growth for durable non-computers was calculated as a weighted average of growth in durables output for 1950-59 and a Tornqvist index of durables output excluding computers for 1959-72. Hours growth for durable non-computers was calculated as a weighted average of hours growth in durables for 1950-59 and a growth rate of hours 2.0 percent faster than hours growth in durables for 1959-72.

b. The nominal share of computers in manufacturing durables during the periods 1950-72, 1972-87, 1987-95, and 1995:4-99:1 are, respectively, 0.66, 4.95, 10.58, and 12.41 percent.

Sources: See Data Appendix.

Table 3

Trends for Alternative Intervals, 1972-99 and Log Ratio of Actual to Trend in 1999:1

(Percentage Growth Rates at Annual Rate)

Variable and Sector	Trend Growth		Optimal Trend	Log Ratio Actual/Trend, (Percent)
	1972:2-87:3	1987:3-95:4	1995:4-99:1	1999:1
Output per Hour				
Nonfarm Private Business	1.24	0.94	1.85	0.98
Durable Manufacturing	2.91	3.31	6.56	0.94
Nonfarm Nondurables	0.92	0.58	1.16	1.09
Hours				
Nonfarm Private Business	1.80	1.56	1.56	1.78
Durable Manufacturing	0.05	0.08	0.08	-0.27
Nonfarm Nondurables	2.13	1.79	1.77	2.00
Output				
Nonfarm Private Business	3.04	2.50	3.41	2.76
Durable Manufacturing	2.97	3.39	6.64	0.67
Nonfarm Nondurables	3.05	2.36	2.95	3.09

Source: See Data Appendix.

Table 4

Decomposition of Growth in Output Per Hour, 1995:4-1999:1, Into Contributions of Fitted and Residual Cyclical Effects, and Contributions to Trend Acceleration of Price Measurement and True Structual Change

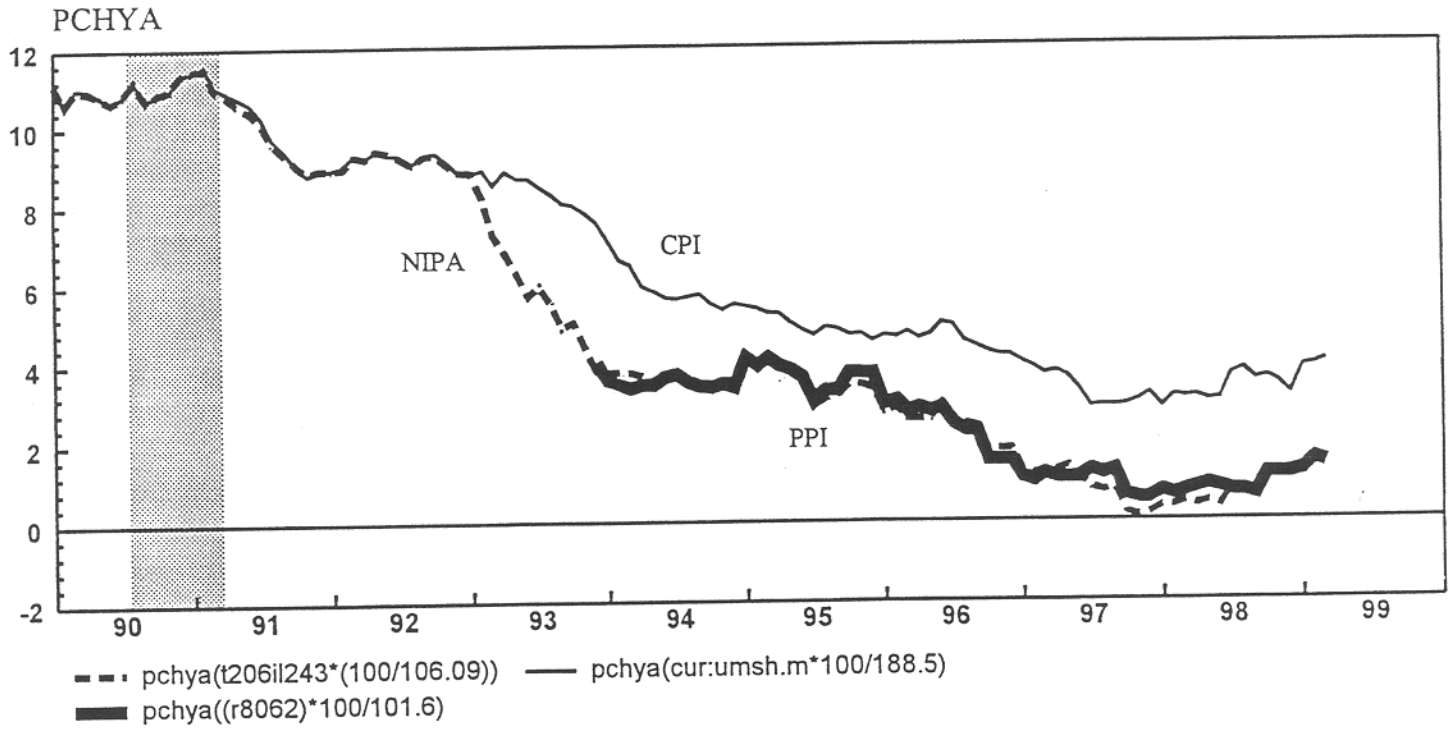
(Percentage Growth Rates at Annual Rate)

	Nonfarm Private Business	Durable Manufacturing	Nonfarm Nondurables
Actual Growth	2.17	6.78	1.50
Contribution of Cyclical Effect	0.30	0.22	0.34
Fitted	0.47	0.11	0.51
Residual from Estimation	-0.17	0.11	-0.17
Contribution of Trend	1.85	6.56	1.16
Trend, 1972:2 - 1995:4	1.13	3.05	0.80
Acceleration of Trend	0.72	3.51	0.36
Contribution of Price Measurement	0.43	0.43	0.43
Contribution of True Structural Acceleration	0.29	3.08	-0.07

Source: See Text and Data Appendix

Figure 1

Price Measures for Government Hospital Services



NOTE: All price measures reindexed, 1993:01=100.

Price Measures for Private For-Profit Hospital Services

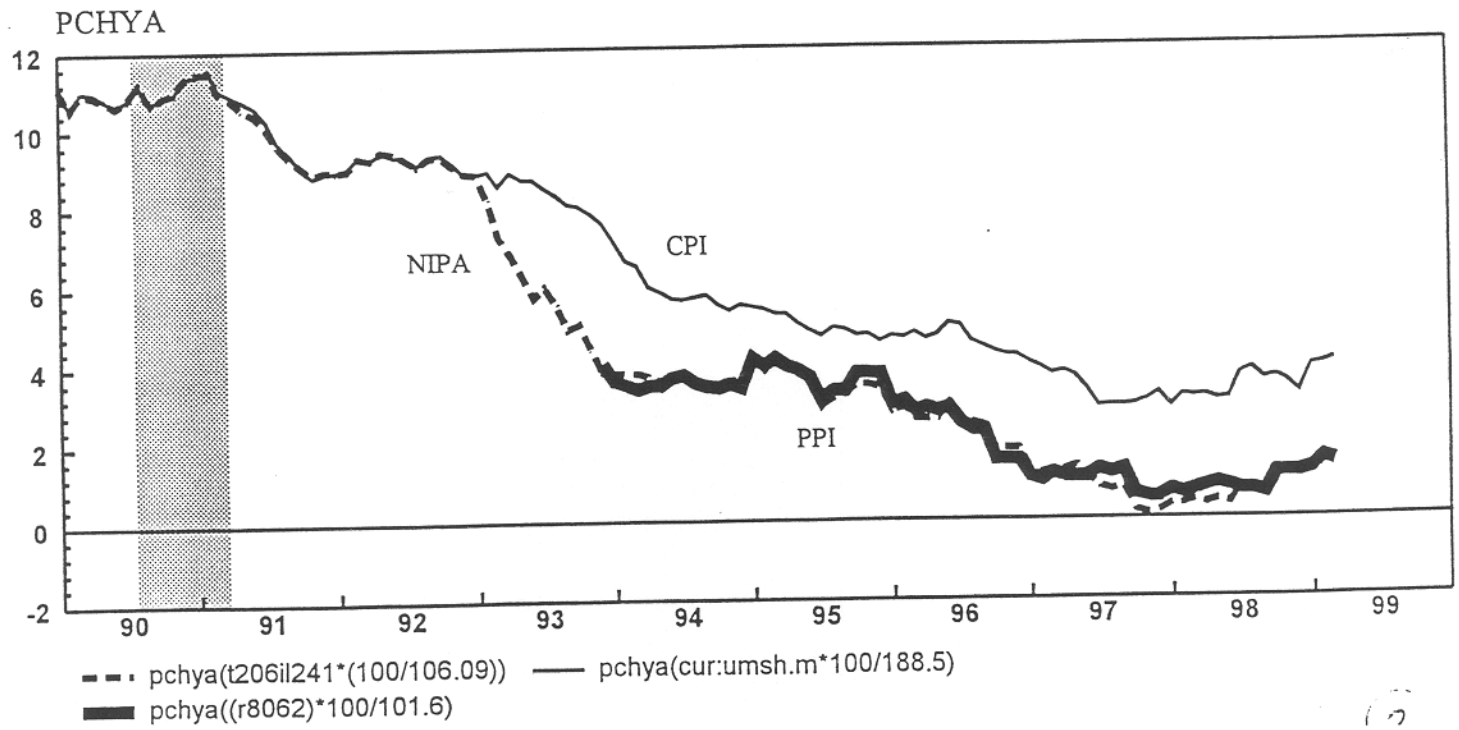


Figure 2
Response of Hours and Productivity to
a Permanent Four-Quarter Rise in Output
Cumulating to 1.0 Percent beginning in quarter 5

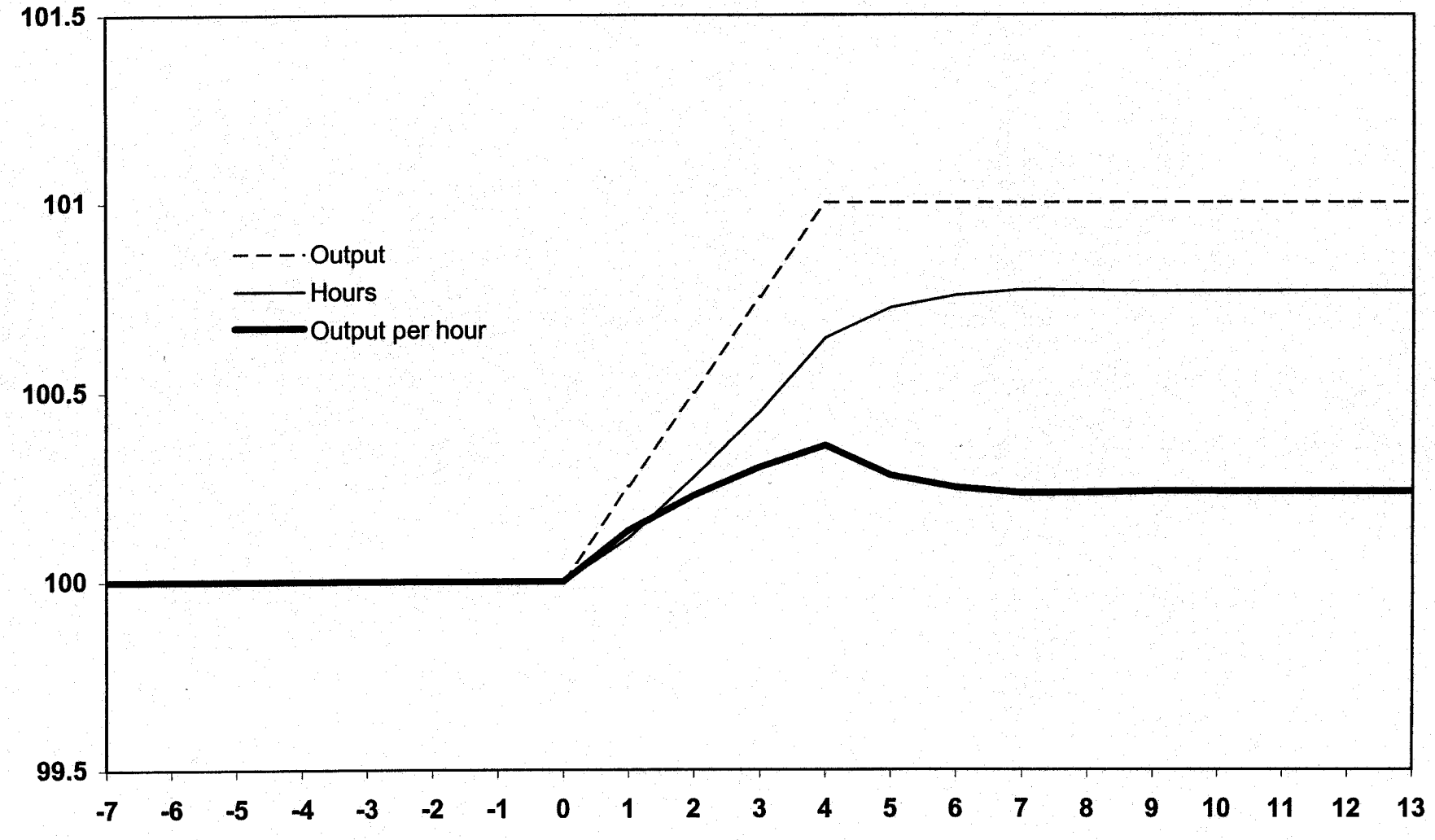
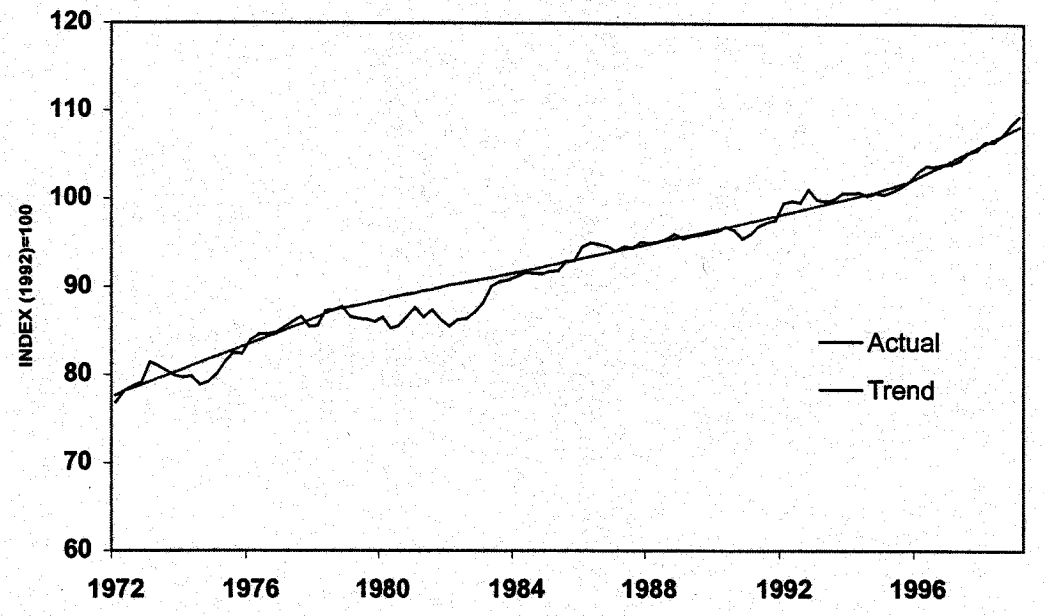


FIGURE 3
NONFARM PRIVATE SECTOR ACTUAL AND TREND PRODUCTIVITY
1972-1999



NONFARM PRIVATE SECTOR LOG RATIO OF ACTUAL
TO TREND PRODUCTIVITY (IN PERCENT), 1972-99

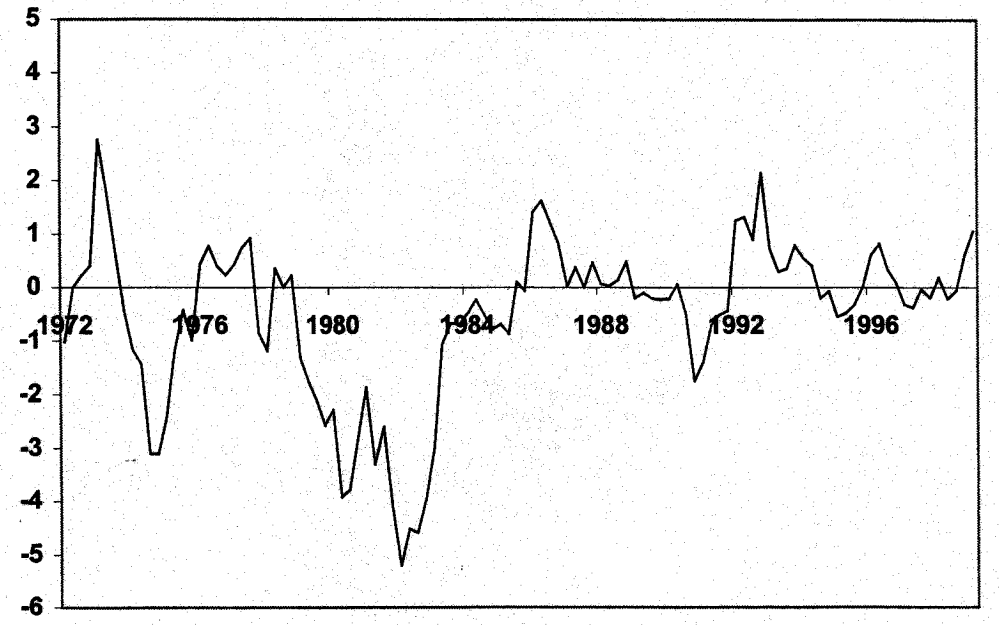
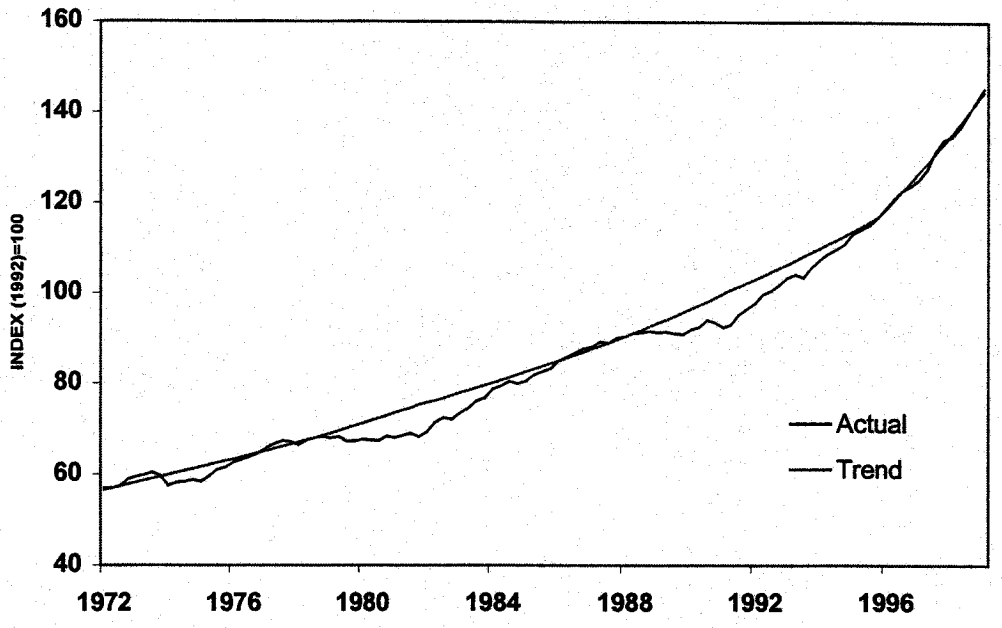


FIGURE 4
MANUFACTURING DURABLES SECTOR ACTUAL AND TREND PRODUCTIVITY 1972-1999



MANUFACTURING DURABLES SECTOR LOG RATIO OF ACTUAL TO TREND PRODUCTIVITY (IN PERCENT), 1972-99

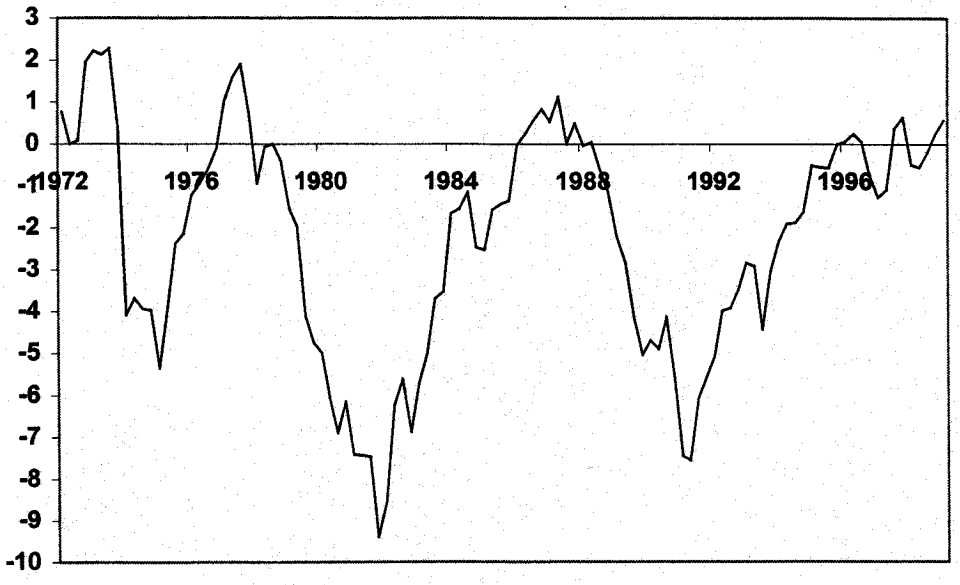
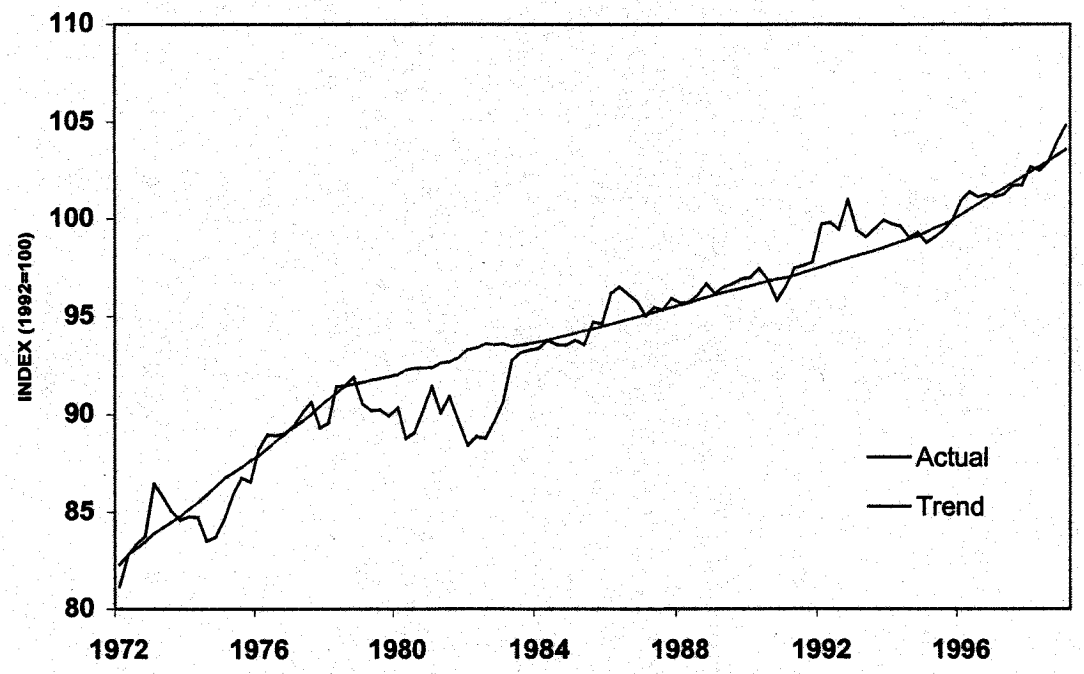


FIGURE 5
NONFARM NONDURABLES SECTOR ACTUAL AND TREND PRODUCTIVITY 1972-1999



NONFARM NONDURABLES SECTOR LOG RATIO OF ACTUAL TO TREND PRODUCTIVITY (IN PERCENT), 1972-99