HAS THE PRODUCTIVITY BOOM FINALLY ARRIVED?

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Shadow Open Market Committee Meeting
September 26-27, 1999
Washington, D.C.

In the past 3 1/2 years the U.S. has experienced strong economic growth, low inflation and productivity growth noticeably above the average of the previous two decades. In some corners there is a strong belief that this increase in productivity growth is the beginning of a resurgence in productivity and the end of the "productivity slowdown" that has plagued so many industrialized countries since 1973. The most enthusiastic proponents speak of a "new economy" driven by technology that is reshaping the way every industry produces goods and services. This technological revolution, the reasoning goes, will inevitably result in a boom in productivity and perhaps a new "golden age."

The enthusiasm is not without some justification. Between 1974 and 1995 real GDP growth averaged 2.49 percent, inflation 4.97 percent, and labor productivity growth in the nonfarm business sector averaged just 1.1 percent per annum. In the 14 quarters from 1996 through mid-1999 these numbers have been 3.79 percent, 1.46 percent, and 2.05 percent respectively. From 1951 through 1973 nonfarm business productivity grew at an average annual rate of 2.52 percent. Thus it appears, on the surface, that while the performance of the last three years is good, it does not bring the economy back to the rate of productivity growth that existed before the "slowdown," but does close about two-thirds of the gap. Figure 1 plots nonfarm business productivity as computed by the

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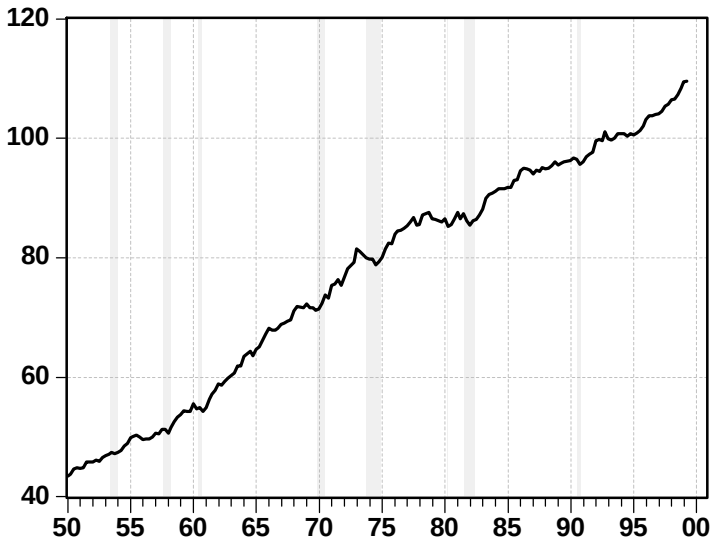
Bureau of Labor Statistics. These changes in the growth rate are readily apparent. Of course the more difficult question is whether this trend will be sustained in the future.

Figure 1
Productivity in the Nonfarm Business Sector
(1992=100)



The message of this note is that while there is reason for optimism about the future of productivity growth, the data do not yet support a strong case that the recent rebound in productivity growth is sustainable. One of the most important reasons is that the recent rebound in productivity growth is almost entirely confined to productivity improvements in the durable goods industry and according to Gordon (1999) it is even more narrowly confined to the manufacture of computer equipment.

Productivity Measures

Productivity is simply output per unit of input. Using a standard Cobb-Douglas production technology

$$Y_t = A_t K_t^{a} L_t^{1-a}, \tag{1}$$

where Y is a measure of aggregate real output in period t, K is the capital stock, L is labor input, α is a number between zero and one, and A is a technological factor, labor productivity can be measured as the ratio of output, Y, to labor inputs, L, or

$$Y_t/L_t = A_t K_t^{a} L^{-a}. \tag{2}$$

The Bureau of Labor Statistics (BLS) publishes three sets of productivity measures each using a different methodology. The most widely reported measures are quarterly estimates of labor productivity (Y_t/L_t) for the major output sectors of the U.S. economy. The output of the *business sector* is real GDP less production from the government sector, the foreign sector, nonprofit organizations, and the household sector. The *nonfarm business sector* further excludes the output from farming. The output of the *nonfinancial sector* is nonfarm output less the output of financial firms and sole-proprietorships and partnerships. In addition, quarterly estimates of labor productivity are provided for the major sectors of total, durable and nondurable manufacturing. For all of these measures of labor productivity, the denominator, L, is hours worked in the sector. Hours of labor input are treated as homogeneous units; no distinction is made among workers with different skill levels or wages. The output measure, Y, is computed slightly differently for the manufacturing sectors than for the broader measures. The business, nonfarm and nonfinancial sectors' output use the GDP concept of real value-added. The manufacturing sector measures use real gross output net of intrasector transactions.

The second set of measures represents estimates of *multifactor,* or *total factor, productivity* and is constructed annually. Conceptually, this measure is an estimate of A in equation (1). It is a technological factor that augments the combination of inputs, labor, L, and capital, K. The output measures are the same as used in the quarterly measures, but the input is an aggregate of hours worked and capital service flows. In these estimates much more attention is given to the characteristics of the inputs. The labor input can be thought of as quality-adjusted and the capital service flows are derived separately from many different categories of structures, equipment, inventories, and land.

The BLS publishes a third category of productivity estimates for individual industries. These measures of multifactor productivity differ from the other estimates in the way outputs and inputs are measured and constructed. Output measures in individual industries include shipments to both producers and final consumers. To be consistent with this output measure, the input includes intermediate inputs: labor, capital, and also

energy, nonenergy materials, and purchased business services. These measures are constructed annually for a comprehensive set of 20 manufacturing industries.

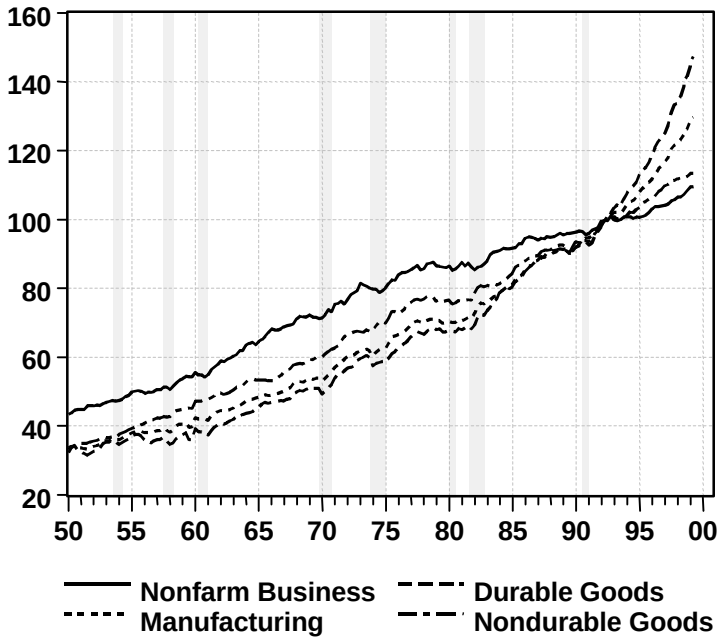
The Evidence

This section offers three reasons to be cautious in interpreting recent productivity gains as evidence of a sustainable change in the trend rate of growth. The first relates to the lack of breadth across sectors of the recent gains. The second deals with international evidence and the third addresses some measurement issues.

The Breadth of Recovery

The behavior of productivity in the post-war era is largely a well-known story: following a period of vigorous productivity growth in the 1950's and 1960's, the U.S., and many industrialized countries, experienced a marked slowdown beginning in about 1973. The reason for the slowdown continues to be a topic of debate with no real consensus. Figure 2 shows the productivity index for several of the key measures discussed above. Table 1 summarizes the growth rates for the broadest measures of labor productivity for various time periods. In all sectors except manufacturing, and durable goods manufacturing in particular, annual productivity growth from 1974 through 1999 was 1.6 percent to 0.7 percent below the growth experienced in the period 1951 to 1973. In durable goods

Figure 2
Labor Productivity Measures
(1992=100)



manufacturing there was no productivity slowdown. Productivity growth in the most recent period in the nondurable manufacturing sector is 1.96 percent, near its lowest of any period since the late 1970's.

Gordon (1999) breaks down the durable goods manufacturing sector into the manufacture of computer hardware and all other durable manufacturing. He finds that productivity growth in the manufacture of computers has accelerated dramatically. Between 1972 and 1995 he estimates that productivity growth in the manufacture of

Table 1
U.S. Output per Hour Worked*

Average Quarterly Percentage Rates of Change at Annual Rates

	51:1-99:2	51:1-73:4	74:1-99:2	51:1-60:4	61:1-70:4	71:1-80:4	81:1-90:4	91:1-99:2	96:1-99:2
Business Sector	2.11%	2.95%	1.35%	2.49%	3.36%	1.72%	1.20%	1.71%	2.29%
Nonfarm	1.84	2.52	1.23	1.90	3.00	1.67	1.00	1.61	2.05
Nonfinancial[1]	2.10	2.54	1.82	3.71	2.42	1.55	1.70	2.30	2.83
Manufacturing	2.78	2.63	2.91	2.20	2.82	2.41	2.80	3.81	4.50
Durables	3.07	2.56	3.56	1.32	3.16	2.74	3.12	5.37	6.67
Nondurables	2.46	2.94	2.03	3.28	2.69	2.04	2.15	2.11	1.96

*Source: U.S. Bureau of Labor Statistics.
[1]Nonfinancial business sector data begins in 1958.

computers has average 17.8 percent. Since 1996, however, the growth has been over 41 percent per annum. The noncomputer sector, on the other hand, has shown no acceleration in productivity growth in the last three years when it has grown by just 1.82 percent. This is actually slightly below the average for the period 1972-1995 of 1.88 percent. Computer hardware only makes up a small fraction of manufacturing. All of durable goods manufacturing accounts for about 12 percent of GDP and Gordon (1999) estimates that computer manufacturing accounts for about 10-12 percent of durable goods output. So computers, in all likelihood account for less than 2 percent of GDP.

The data on multifactor productivity tells a similar story. Figure 3 plots the annual measures of multifactor productivity constructed by the BLS. There appear to be significant gains in productivity in the last several years, but it is confined to the durable goods portion of the manufacturing sector. The growth rates reported in Table 2 further highlight the lack of breadth of the recent productivity gains. In manufacturing, only the durable goods sector shows significant gains, although not unprecedented. For example, multifactor productivity in the durable goods industry grew at an average annual rate of 3.09 percent between 1961 and 1965 and 3.05 percent between 1983 and 1988. This is comparable to the 2.92 percent growth rate from 1991 to 1996. Moreover, nondurable manufacturing shows no evidence of enhanced productivity in the 90's and is, in fact, doing worse than in the 1980's.

Figure 3
Multifactor Productivity Measures
(1992=100)

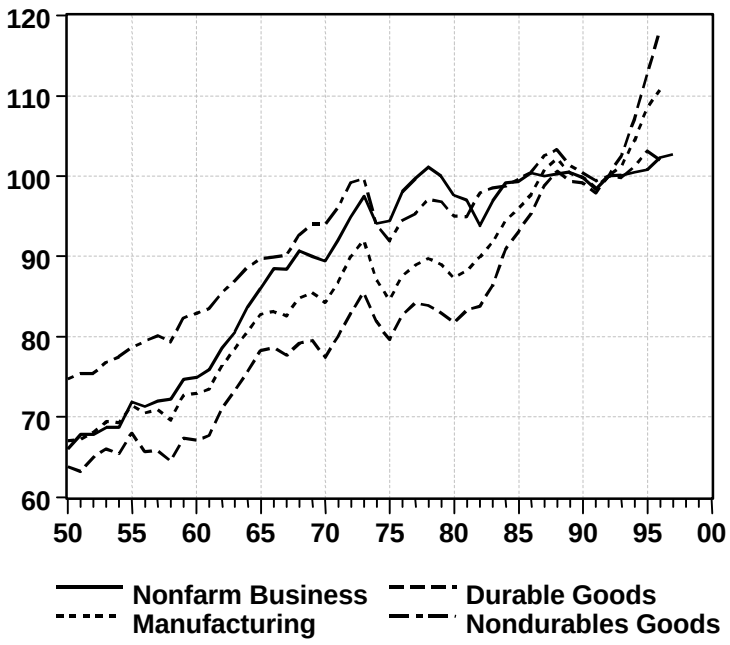


Table 2
U.S. Multifactor Productivity*

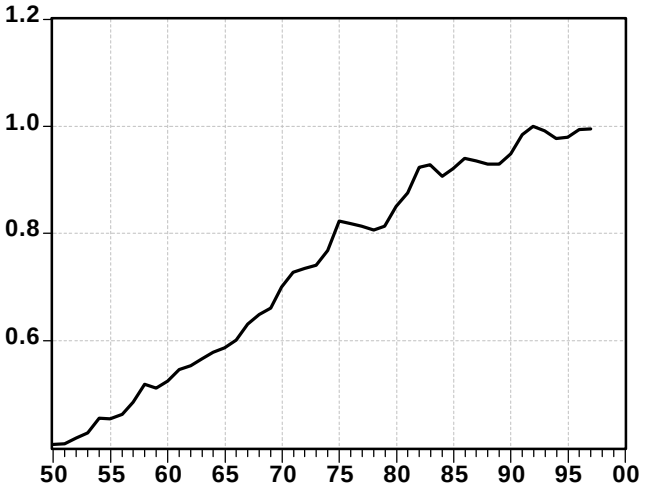
Average Annual Percentage Rates of Change

	1950-97	1950-73	1974-97	1950-60	1961-70	1971-80	1981-90	1991-97	1996-97
Business Sector	1.26%	2.13%	0.35%	2.02%	2.02%	0.97%	0.44%	0.49%	1.18%
Nonfarm	1.05	1.87	0.21	1.69	1.77	0.88	0.22	0.41	0.93
Manufacturing[1]	1.18	1.53	0.80	1.22	1.44	0.36	1.34	1.72	2.09
Durables[1]	1.44	1.48	1.40	1.03	1.43	0.54	2.11	2.92	4.76
Nondurables[1]	0.74	1.34	0.10	1.26	1.26	0.11	0.69	0.26	-1.07

*Source: U.S. Bureau of Labor Statistics.
[1]Data available only through 1996.

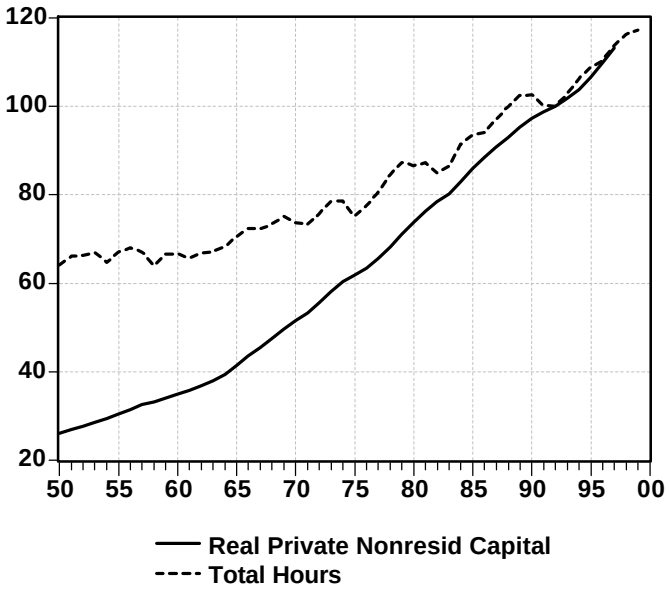
Another way of making the observation that labor productivity in the broader business sectors has not made significant strides is to look at the capital stock and the number of hours worked. Equation (2) indicates that an important factor behind increases in productivity is increases in the capital-labor ratio (*K/L*). The Bureau of Economic Analysis (BEA) constructs estimates of the capital stock on an annual basis. Using the index for real fixed private nonresidential capital and the BLS index for total hours worked in the private business sector, one can construct a proxy for the capital-labor ratio. This proxy is plotted in Figure 4. Consistent with continued slow labor productivity growth is the continued slow growth in the capital-labor ratio. This ratio shows no evidence of growing faster which would be consistent with more rapid labor productivity.

Figure 4
Capital-Labor Ratio for the Private Business Sector
(1992=100)



The reason for the lack of growth in the capital-labor ratio is puzzling given the fact that the U.S. has been experiencing an investment boom during

Figure 5
Capital and Labor for the Private Business Sector
(1992=100)



most of the 1990's.[1] Figure 5 shows why this investment boom has not led to significant capital deepening. Not only has the capital stock grown somewhat faster, but also total hours have grown faster as well. Thus it would appear that a substantial portion of the most recent period of rapid growth in real GDP has come from more rapid growth in inputs and somewhat less from using inputs more productively. Table 3 shows this rapid growth in factor inputs. Using a Cobb-Douglas technology and assuming labor's share is one-third, it can be shown that of the 2 percentage point increase in real growth in the 1995-98 period over the 1990-94 period, 1.7 percentage points are accounted for by increases in factor inputs and a 0.3 percentage points are due to an increase in productivity.

Table 3

Annual Growth Rates of Output and Factor Inputs*

	1990-94	1995-98
Real Output in the Business Sector	1.79%	3.77%
Private Fixed Nonresid. Capital	1.73	2.89
Total Hours in Business Sector	0.82	2.77

*Source: Bureau of Labor Statistics

There is one final observation that is relevant for understanding the rapid productivity gains in the manufacture of durables (i.e. computer hardware). A major reason for the productivity gains in this subsector of the economy arises from the very rapid fall in the price of computers. Real output of the computer hardware industry is created by dividing nominal computer expenditures by a price index. The very rapid fall in the price of computers implies that real output has expanded significantly which corresponds to a rapid increase in output per hour.

[1] During the 1980's the ratio of real fixed investment to real GDP averaged less than 10 percent. Since 1995 the ratio has averaged nearly 12 percent.

International Comparisons

The BLS also reports labor productivity in manufacturing for a number of other developed countries. If a technological revolution was ending the productivity slowdown, it should be observed outside the U.S. as well. Table 4 summarizes this

Table 4
International Measures of Manufacturing Output per Hour Worked*

Average Annual Percentage Rates of Change

	1961-98	1961-65	1966-70	1971-75	1976-80	1981-85	1986-90	1991-95	1996-98
U.S.	2.85%	2.97%	2.18%	3.45%	1.68%	3.25%	2.33%	3.25%	4.29%
Canada	2.66	5.24	2.25	2.83	1.98	3.52	1.19	2.67	0.85
France	4.65	6.39	7.24	4.50	4.22	3.41	3.34	4.05	3.58
Germany	3.87	5.94	5.60	4.74	3.17	2.87	2.11	2.32	4.45
Japan	5.66	8.30	11.67	5.77	4.63	3.81	4.21	2.72	3.25
Netherlands	5.07	5.26	8.34	5.87	6.06	5.10	1.98	3.91	3.41
U.K.	3.19	3.36	3.84	3.33	1.25	5.04	4.02	3.38	0.03

*Source: Bureau of Labor Statistics

international evidence. While some countries have witnessed modest improvements in labor productivity growth, many did not. Indeed, only the U.S. and Germany appear to have experienced growth rates substantially in excess of those they experienced on average in the 1980's. Others have seen their productivity growth in manufacturing actually deteriorate since 1995. Thus there does not appear to be evidence from outside the U.S. of a major turnaround in labor productivity.

Measurement Issues

The are several measurement issues that are worth discussing when interpreting the productivity numbers of recent years. The most important measurement issue that affects the most recent data is the improvement in the CPI. The improvements have lowered measured inflation and increased real output growth. By the arithmetic of the productivity calculation this results in an increase in measured productivity. Thus some of

the improvement in productivity in recent years simply reflects better measurement of inflation. Since the CPI was not recalculated for the period before 1990, earlier productivity numbers do not reflect the improvements.

There remain important measurement issues that pertain to the estimation of real outputs. Current measures still underestimate the level and rate of growth rate of productivity, particularly in the broader sectors. The problem comes when converting nominal spending into real spending. Despite the recent improvement in the CPI, there remains a downward bias in estimates of real spending. The bias comes from two primary sources: the difficulty in accounting for new goods and services and in recognizing the changing quality of items being measured.

Another source of error that biases productivity measures downward is that in some sectors, estimates of output services are not readily observable and so output is proxied by the expenditure on inputs. This is true of almost the entire government sector, for example. It is also true for many kinds of services for which direct measurement of output is difficult. This procedure implicitly assumes that productivity growth in these sectors or for these goods is zero. While the problem exists for some goods, it is much more problematic for services such as legal services, medical care, banking and consulting services of various kinds.

These problems of measurement have led some to argue that the U.S. is currently undergoing a productivity revival but that the data do not detect it. The argument is that productivity in the "unmeasurable" sectors is growing much faster than the data indicate. As a consequence, real GDP is growing faster than estimated and inflation is lower than reported. While it may be correct that true productivity and real output are growing faster than indicated by the official statistics, primarily because of difficulties in constructing reliable output measures for the service sector, that is not evidence of a technologically induced boom in productivity. If such a recovery was having widespread impact on the economy, productivity growth increases should also begin to appear in the "measurable" sectors of the economy. The evidence presented above suggests there is no productivity

boom in the "measurable" sector outside of the durable goods industries, and according to Gordon (1999), computer hardware manufacturing in particular.

Implications for Monetary Policy

There is good reason to believe that real growth has been underestimated, but some of the proponents of a productivity revival are seriously confused when they talk of the implications of the mismeasurement for monetary policy. The argument is that the Federal Reserve has been too restrictive and should just "let" the real economy grow faster. But this makes no sense. First, this presumes that the Fed has precise control over real output and thus its actions are pertinent for determining the long-run growth rate of the economy. The evidence is quite the opposite. Monetary policy does not have significant effects on long-run economic growth or productivity. But even if it did, this argument makes little sense. If the problem with GDP estimates is that they understate true long-term growth, by say 1 percent, and measured long-term growth is 2.5 percent, then the economy is really growing by 3.5 percent. For the Fed to "target" 3.5 percent measured real growth would be in effect attempting to achieve long-term growth of 4.5 percent which would be unsustainable and above the true long-term potential. Thus the mismeasurement of real outputs and productivity have little implication for monetary policy.

The mismeasurement of the CPI, on the other hand, suggests that inflation is lower than indicated and if it was of significant magnitude may influence monetary policy. With the improvement in the CPI and the construction of chain-weighted deflators the potential for mismeasurement has been greatly reduced. In any event, this is an issue of measuring inflation accurately, and its implications for real output and productivity are beside the point.

Conclusion

The evidence of a technologically driven recovery in productivity growth is weak. The recent spurt in productivity is not out of the ordinary. Quarterly estimates of

productivity can be volatile and thus brief periods of very slow or very rapid growth do materialize. Moreover, the improvements actually observed are highly concentrated in the durable goods sector of the economy. The nondurable goods sector and service sector continue to experience slow productivity growth. The rapid economic growth of the past few years seems to have been driven more by a rapid increase in capital and a more intense utilization of the labor force (i.e. more total hours worked) rather than surging productivity. The international evidence also fails to reveal a strong trend towards more rapid productivity growth.

It is hard not to be somewhat optimistic about the prospects technology brings for improved productivity. Work by David (1990) and Greenwood and Yorukoglu (1997), among others, have emphasized models where technological advances lead first to a period of slower productivity growth as society acquires the necessary skills to effectively use the new innovations. This slow growth period is then followed by a rapid increase in productivity growth. Nevertheless, the data suggest that the promise of a new trend seems to still remain in the future.

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