Perspectives on Productivity Growth

By Robert Arnold and Robert Dennis*

Growth of labor productivity has accelerated in the past few years, which is unusual late in an expansion. The upturn in productivity growth has led to widespread speculation about a "new era" of productivity advance. However, the recent acceleration hardly takes productivity growth above its trend since 1973, and in any case it is easily explained by: measurement changes that attribute more of nominal GDP's growth to the real component, and hence to productivity; and the boom in capital goods spending we have experienced in the 1990s. Productivity growth remains well below the extraordinary rates of the 1950s and 1960s.

THE U.S. ECONOMY has surprised forecasters in recent years. Rapid growth, falling unemployment, low interest rates, and falling inflation were all very unusual for what was presumed to be the late stage of an expansion. Little wonder that analysts termed it the "Goldilocks economy," because it was "not too hot and not too cold." (Of course, that tale didn't turn out too well—let's hope the economy has better luck.) The behavior of productivity in particular was unusual for the late stages of an expansion, growing at an average annual rate of nearly 2 percent since early 1995. Some commentators have even suggested that the recent performance heralds the beginning of a "new era" for growth—although as yet the vaunted upturn is far from bringing us back to the high productivity growth of the 1950s and 1960s.

How reasonable are the claims for a new era for productivity growth? This paper will evaluate those claims and conclude that they are somewhat premature. After a brief discussion of the sources of productivity growth, we will tell the story of productivity growth from different temporal perspectives. A short-term perspective examines the current business cycle, but that approach misses some of the stories that only show up when the frame is widened. Consequently, we look also at a medium-term perspective (the postwar period), a long-term perspective (since the nineteenth century), and an ultra-long-term perspective (since the dawn of mankind). Finally, we draw the conclusions appropriate to projecting productivity growth.

FUNDAMENTAL SOURCES OF PRODUCTIVITY GROWTH

It is difficult to overstate the importance to society of growth in labor productivity. Arguably, no single economic indicator is more central, because productivity growth is the fundamental source of increasing standards of living. In spite of that importance, and in spite of considerable effort, not all of the sources of productivity growth are either well measured or understood. Be that as it may, economic historians generally agree that the following three factors are relevant for explaining productivity growth, even if they disagree about the precise role played by each.

First, during the Industrial Revolution, a country's endowment of natural resources was crucial. The United States is a good example: economic historians attribute America's dramatic increase in labor productivity to bountiful resources, including land, which supported a vast population (including many immigrants) that allowed for economies of scale in production. Natural resources are less important these days—some would argue that abundant resources can cause a debilitating reliance on agriculture or extractive industries—but they are still a factor.

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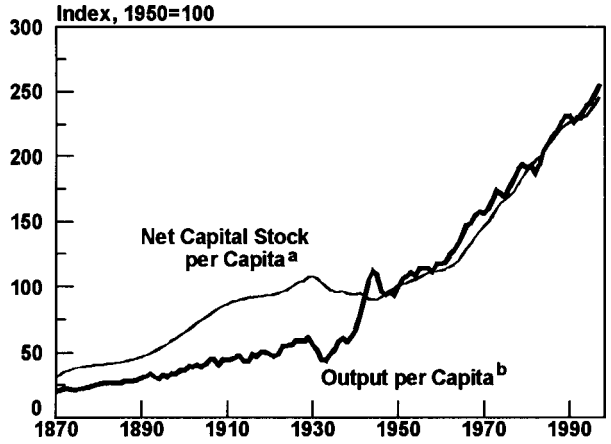
The second factor is capital accumulation. In spite of arguments about how important capital is to the growth process, few dispute the idea that countries with more capital per worker are generally more productive than those with lower amounts of capital per worker. Over long periods, there is a clear correlation between labor productivity, measured as GDP per person, and capital per person (see Figure 1). Some analysts go farther, arguing that it is impossible to exploit the benefits of technological progress without investment in capital goods, while others have argued that capital goods convey external effects. Also, capital should be defined broadly to include human capital, or investments in education or training. Countries with more human capital should be better able to absorb new technology.

Figure 1
Productivity and Capital



Sources: Department of Commerce, Bureau of Economic Analysis; Congressional Budget Office using data from Maddison (1982, 1994).
Note: Population data before 1929 are linked to data found in Maddison (1994).
[a] Net stock of fixed nonresidential capital per member of the population. Before 1925, the data for the capital stock series are linked to data found in Maddison (1982).
[b] Real GDP per population members. Before 1925, the data for the capital stock series are linked to data found in Maddison (1982).

The last factor is technological progress, which includes any advance that allows more output to be produced with the same amount of labor and capital. There is little theoretical reason to suppose that technological progress, or the implementation of innovations, will continue at a constant rate; yet it seems as though the rate has in fact (or at least, as measured) remained fairly stable for substantial periods. That's an oddity that cries out for an explanation. Of course, as forecasters, we make use of that regularity, but we're not confident that technological progress will continue at a constant rate. Thus, for the past two years, the Congressional Budget Office (CBO) has included in its annual economic projections alternative scenarios that imply different growth rates of (total factor) productivity.

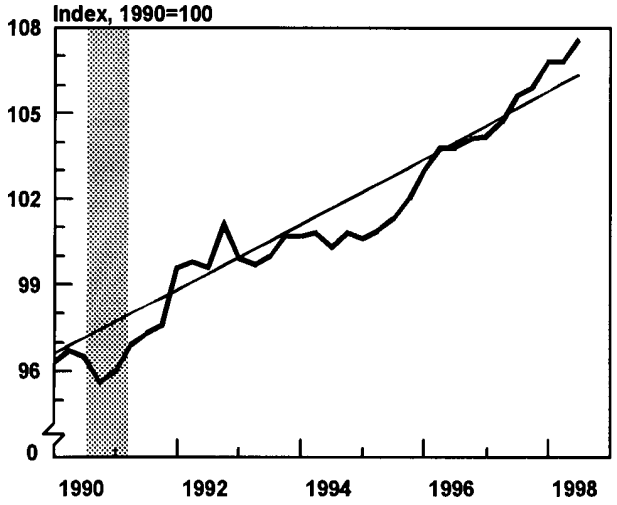
SHORT-TERM PERSPECTIVE: PRODUCTIVITY AT BUSINESS CYCLE FREQUENCIES

The behavior of productivity growth varies across business cycles. However, there are some "stylized facts" that encompass much of the postwar history:

1. The growth of labor productivity (output per hour in the nonfarm business sector) largely mirrors overall growth in the business cycle, i.e., it is substantially weaker or even negative during recessions and picks up as the economy expands.
2. Labor productivity growth generally slows toward the end of a business cycle's expansion.

The current business cycle has not closely mirrored the patterns of previous cycles. Productivity growth usually picks up rapidly early in a recovery, but in 1992 and 1993, both productivity growth and the expansion seemed to lag. Chairman Greenspan, and CBO's forecasts, attributed the sluggishness of the recovery at that time to a variety of "headwinds." Later in the expansion, moreover, productivity growth accelerated when it usually slows (see Figure 2). By this time, the headwinds had diminished and the rise in the stock market brought with it a sense of wealth and optimism that boosted both consumption and investment.

Figure 2
Labor Productivity and Trend Since 1990



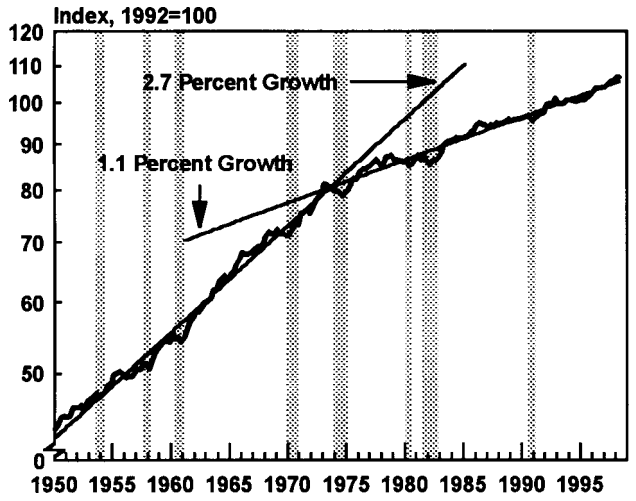
Sources: Congressional Budget Office: Department of Labor, Bureau of Labor Statistics.

A standard explanation for this pattern is available: the surge in productivity growth reflects the extraordinary boom in capital equipment spending that has taken place in the past few years. Practical economists used to be cautious about attributing too much significance to real equipment investment, because until recently, the role of spending on computers was grossly overstated in the national income and product accounts

(NIPAs). The recent boom, however, was not just computers; noncomputer equipment also has been booming. In addition, the new method used to calculate real quantities in the NIPAs, in place since 1996, does a much better job of putting the contribution of computers in perspective. At CBO, we go another step, measuring computers' contribution to the capital input in a way that reflects their rapidly declining marginal product. The 1990s' boom in capital spending means a correspondingly rapid growth in capital services that matches fairly closely the acceleration in labor productivity growth in the past few years.

But whatever has so far occurred, anyone looking at the data must concede that no large shift is evident. Although labor productivity has grown faster than trend in the past few years, it is not very far above the trend it has followed consistently since 1973 (see Figure 3). It looks very much, in fact, as if the acceleration in productivity growth that has occurred simply mirrors the pattern of demand in this expansion, which also started slow and then boomed later than usual.

Figure 3
Labor Productivity and Trend



Sources: Congressional Budget Office: Department of Labor, Bureau of Labor Statistics.

Another reason to be suspicious of the surge in labor productivity growth is the spate of changes in the measurement of real output caused by recent revisions in the consumer price index (CPI). Those changes correct a variety of problems in CPI measurement that cause the CPI to overstate inflation. CBO estimates that the corrections made between 1994 and 1998 probably reduced measured inflation, and correspondingly increased measured productivity growth, in the nonfarm business sector by between 0.3 and 0.4 percentage points.

There is one important caveat: the quality of overall measures of productivity growth depends, of course, on the reliability of the output measures on which it is based. That reliability has been called into question by the large statistical discrepancy of the past few years, which may suggest that GDP understates actual production. (The recent discrepancy is not really out of line with past discrepancies, but usually it takes several revisions of the NIPAs before the discrepancy gets that large.) Several lines of evidence—including Okun's law calculations—suggest that output measures may be biased down, producing a corresponding downward bias in the level of productivity in recent years. Some analysts try to correct for that bias by taking the mean between productivity measures calculated on the product and income sides of the accounts. We tried that approach and found that it made little difference to CBO's projections of the things that count for us—nominal GDP and taxable incomes. So we stick with the published measures, though with some caution.

MEDIUM-TERM PERSPECTIVE: PRODUCTIVITY GROWTH SINCE WORLD WAR II

The most prominent feature of productivity growth during the postwar period is the sharp slowdown that occurred during the early 1970s. Trend growth in labor productivity averaged 2.7 percent between 1947 and 1973, before dropping to 1.1 percent during the 1973-98 period (see Figure 3). A drop in labor productivity occurred worldwide: productivity growth slowed in virtually all advanced countries at about the same time and was generally more severe in countries other than the United States.

Why did growth in productivity slow sharply in so many countries at the same time? In spite of the staggering volume of research devoted to that question, economists have not settled on a conclusive answer. Many promising candidates for an explanation have been suggested, and it is likely that a combination of factors has contributed. Energy prices are the candidate mentioned most often, in part because the timing of the first oil price shock coincides with the slowdown but also because energy-dependent sectors of the economy fared worse than the average after 1973. Using econometric models of individual industrial sectors, Dale Jorgenson concludes that "higher energy prices are important in explaining the [post-1973] slowdown in U.S. economic growth."(Jorgenson, 1995)

Edward Denison (1986) has cataloged a list of other factors that may have contributed to the slowdown. A partial list of those factors:

1. Capital accumulation: Until recently, the capital stock has generally grown more slowly than during the pre-1973 period.
2. Resource allocation: The rate at which resources, particularly labor, shifted out of farming slowed during

the post-1973 period.

3. Regulatory environment: The 1970s saw an increase in requirements imposed on businesses to protect the environment as well as the health and safety of their workers.
4. Demographics: A flood of relatively inexperienced workers entered the labor market during the 1970s as the baby boom came of age and women increased their rates of labor force participation.
5. Research and development: Investment in R&D slowed at about the same time as productivity growth, though Zvi Griliches (1988) found the slower investment did not explain much of the slowing of productivity.
6. Inflation: High and variable inflation increases the cost of gathering information, making decisions, and conducting transactions. It can also require monetary polices that hold output below potential.

One argument that is fairly easy to reject is that the productivity slowdown might merely be an artifact of incorrect measurement. As we saw in the discussion of the current business cycle, mismeasurement of output prices can have a big effect on measured productivity growth. But if such mismeasurement is to explain the slowdown since 1973, something must have happened, in many countries at roughly the same time, to produce a steadily growing degree of mismeasurement. One possible candidate, the growing share of (poorly measured) services in the economy, seems capable of explaining only a tiny part of the slowdown. Moreover, the slowdown also affected the manufacturing sector, in which measurement should be most reliable, and it shows up in measures of productivity that are based on physical output.(Sichel,1997, and Clark and Haltmaier, 1985)

LONG-TERM PERSPECTIVE: PRODUCTIVITY GROWTH SINCE 1820

The increase in living standards since the nineteenth century is nothing short of astounding. In the United States, for example, output per person increased nearly sevenfold, while the typical workday and typical workweek shrank and many jobs became much less physically taxing. At the same time, infant mortality plummeted, average life expectancy soared, and the share of family income required to meet the bare necessities was cut nearly in half. In addition, much more time became available for leisure activities, and goods that were once considered luxuries came within reach of the middle class.

Economists who use a longer perspective to analyze productivity growth are much less concerned about the post-1973 slowdown than are those who focus on postwar data. Rather than viewing the post-1973 period as anomalous, they argue that productivity growth during the 1940s, 1950s, and 1960s was unusually strong. (Baumol et al., 1989, Baumol, 1986, Darby, 1984, Kendrick, 1977)

Data compiled by Angus Maddison (1994), shown in Table 1, illustrate that argument. Maddison computed estimates of GDP per population member back to 1820 for a sample of forty-three countries. Per capita GDP is a slightly different measure of productivity than the traditional measure—output per hour—but it is arguably more appropriate for long-term analysis, and it is at least available where the narrower measure is not. When viewed in the context of Maddison's data, the post-1973 slowdown looks less like an aberration and more like a return to longer-term rates of growth. Other advanced countries experienced an even larger increase in their growth rates after World War II and endured a sharper slowdown after 1973 than did the United States

Table 1
Growth in GDP Per Capita

	1820-1870	1870-1913	1913-1950	1950-1973	1973-1989
United States	1.2	1.8	1.6	2.2	1.6
14-Country Average[a]	0.9	1.4	1.2	3.5	2.1

Source:Maddison (1994).

[a] Average growth rate for 14 European capitalist countries, Canada, and the United States.

A reasonable interpretation of the productivity experience since the 1930s focuses on the effects of the Great Depression and World War II. Slack demand restrained both domestic investment and overall production during the Depression years, slowing the growth in the stock of productive capital and productivity during the 1930s.[1] Moreover, investment was diverted toward war production during the first half of the 1940s, leaving the United States relatively capital poor. Immediately after the war, America was able to boost production quickly because, unlike other participants in the war, it could bring unused capacity back on line without having to rebuild physical plant. Furthermore, the backlog of unfulfilled demand for consumer goods spurred investment and growth during the 1950s and 1960s, which allowed the United States to make up the shortfall in capital accumulation during the 1930s and 1940s. All of those factors serve to explain the rapid productivity growth from 1947 to 1973.

Productivity growth among European nations during the postwar period was even stronger than in the United States. Partly, that growth was the result of U.S. aid funneled to Europe, but it was also the result, ironically, of the degree of destruction wrought by the war. One prediction of the neoclassical model of long-run growth, called the convergence hypothesis, is that poorer countries (i.e., those with low capital-labor ratios) will, under certain conditions, catch up to richer countries in terms of per capita GDP. Since World War

[1] See footnotes at end of text.

II destroyed a large chunk of Europe's physical plant, lowering the capital-labor ratio, the neoclassical model would predict that European productivity would grow more rapidly than U.S. productivity after the war. The post-1973 slowdown affected the European nations, but their growth rates were still higher than America's because they were still follower nations, i.e., their productivity had not yet reached the level attained by the United States

One problem with the long-run analysis described above is that the quality of the data deteriorates as one goes further back in history. In the United States, for example, annual data in the NIPAs extend back as far as 1929 and are considered to be reliable, while the quarterly data that begin in 1947 are considered even more reliable—among the best in the world. For the years before 1929, the data are generally retrospective (the data were inferred rather than collected), so the quality becomes more suspect. Nevertheless, the estimates are based on careful research by distinguished economic historians and are probably not unduly misleading. Also, they are all we have, because the data were not collected and never can be.

MILLENIAL PERSPECTIVE: PRODUCTIVITY GROWTH SINCE THE DAWN OF MANKIND

With sufficient imagination, it is possible to adopt an even longer perspective on productivity growth. Economic historians have estimated per capita income and used that, together with the price (in terms of labor hours expended) of various goods, to estimate productivity growth. When compared with previous millennia, the increase in productivity during the past century or two has been nothing short of amazing. The idea that living standards will improve perceptibly within a single lifetime is a relatively recent phenomenon. Indeed, it is easy to forget that until about "the seventeenth century all of human history entailed an unending struggle with starvation...[and] even this marginal existence typically required some 90 percent of the employed population to be engaged in agricultural pursuits." (Baumol et al., 1989)

Maddison (1982) has compiled estimates of productivity growth since the sixth century, which show that advances in living standards were negligible prior to the Industrial Revolution. He estimates that the growth in European GDP per head averaged about 1.6 percent annually between 1820 and 1980. During the 1700-1820 period, however, growth in European GDP per head averaged only 0.2 percent per year, a rate that was twice as fast as the 0.1 percent annual growth posted between 1500 and 1700. Perhaps more striking, Maddison estimates that between 500 and 1500, GDP growth crawled along at 0.1 percent per year, but it was matched by population growth that left GDP per head constant during that period.

A paper written by William Nordhaus (1997) is narrower in focus but potentially even more illuminating. He examined the effects of technological change on a single product, light, since the dawn of mankind. The advantage of focusing on light is that the service it provides, illumination, has remained more or less constant since the discovery of fire. Since that time, there have been advances in the technology associated with lighting that have considerably reduced the cost of a lumen. By calculating the price in terms of labor hours expended, Nordhaus was able to show dramatic decreases in the cost of a lumen as the preferred method of illumination changed from open fires to oil lamps, then to candles, then to gas lamps, and finally to electric bulbs. The point of Nordhaus's article was to show that traditional price indexes drastically understate the pace of technological change, but it also shows how the pace of change has accelerated since the early 1800s. Table 2 shows the average growth in the "true" price of light that resulted from technological change through the millennia. Note that the more rapid the pace of technological change, the faster the price will fall.

Table 2
Change in the Price of Light (In terms of labor)

Date	Method of Illumination	Labor Price[a]	Average GrowthRate (Percent)
500,000 BC	Open Fire	58	n.a.
1750 BC	Babylonian Lamp	41.5	-0.0001
1800	Tallow Candle	5.387	-0.0575
1900	Filament Lamp	0.2204	-3.146
1990	Filament Lamp	0.0006	-6.345

Source: Nordhaus (1997).
[a] Hours of work required to produce 1,000 lumen-hours of light.

Comparing living conditions across centuries provides further perspective on very long run productivity growth. Some have argued, for example, that the standard of living in ancient Rome was not much lower and in some respects may have been higher than in eighteenth-century England. (Baumol et al., 1989) Were it possible to transport an upper-class Roman citizen to the home of a wealthy Englishman in the 1700s, he would be baffled by only a few of the products on display. In contrast, were it possible to transport an eighteenth-century Englishman to modern-day Europe, he would be completely flummoxed by the range of advanced products that even lower-class citizens enjoy. This is not to say that there was no technological advance during the centuries preceding the Industrial Revolution. There were many new inventions—chronometers, lenses, printed books, firearms—but these spurts of innovation were isolated and did not add up to a broad-based advance in living standards.

LOOKING FORWARD: PROSPECTS FOR FUTURE PRODUCTIVITY GROWTH

CBO's projections don't take very seriously the history of productivity growth since the dawn of time. However, projections of productivity do play a central role in our outlook for the next ten years, and they must be sensitive to the history of productivity change. (We also extend those projections to look at budget forces developing over the next seventy years, but the economic assumptions underlying those extremely long-term projections need to be taken with several handfuls of salt.) The brief discussion that follows refers to the CBO projections published at the end of January 1998 in the *Economic and Budget Outlook* (available at our Web site, www.cbo.gov/).

We currently project average labor productivity growth of 1.8 percent during the next ten years, which is of course substantially greater than the 1.1 percent trend since 1973. If that sounds odd, given what we have said about the lack of evidence for a real upturn in productivity growth, hear us out.

- Four-tenths of the seven-tenths difference is the result of the changes in price measurement, some of which have already occurred and some of which are scheduled to occur over the next few years. That's just a measurement change and has no effect on nominal GDP or CBO's budget projections (although the CPI changes do, of course, affect the budget directly through effects on COLAs).
- The remaining three-tenths comes from the surge in capital discussed above. That acceleration does affect nominal GDP projections and helps account for the relatively optimistic outlook for the budget that CBO and the Administration currently share.[2]

Our current projections do not make allowances for any "new era" arguments, as the acceleration is fully explained by the two factors cited. There is no strong theoretical reason to suppose the new era arguments are wrong, but they just haven't shown up convincingly in the data yet.

FOOTNOTES

[1] During the 1930s, productivity growth dipped below 1 percent, suppressed, no doubt, by the effects of the Great Depression. In contrast, World War II and its immediate aftermath propelled productivity growth to record heights—nearly 4 percent between 1938 and 1950. For details, see Maddison, 1982.

[2] Some economists argue that projections of productivity growth should not reflect growth in the capital stock, because trend productivity growth has remained stable since 1973 in spite of significant variation in the pace of capital accumulation. But a careful look at the data, excluding short-term variations, reveals the relationship between capital growth and productivity growth that the standard neoclassical growth model predicts. For more details, see Congressional Budget Office, 1999, p.28.

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