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Productivity

Remarks by

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Almost certainly, the most important economic development in the United States in the past decade has been the sustained increase in the rate of growth of labor productivity, or output per hour of work. From the early 1970s until 1995, productivity growth in the U.S. nonfarm business sector averaged about 1-1/2 percent per year--a disappointingly low figure relative both to historical U.S. experience and to the performance of other industrial economies over the same period.[1] Between 1995 and 2001, however, the rate of productivity growth picked up significantly, to about 2-1/2 percent per year--a figure that contributed to a growing perception that the United States might be entering a new economic era. Talk of the "new economy" faded with the sharp declines in the stock valuations of high-tech firms at the turn of the millennium; yet, remarkably, productivity growth continued to rise. The pace of productivity gains averaged better than 4 percent per year since 2001 despite adverse developments that included the 2001 recession, the September 11 terrorist attacks, corporate governance scandals, and, most recently, a sharp rise in energy costs.

Why is the rate of productivity growth so important? Economists agree that, in the long run, productivity growth is the principal source of improvements in living standards. The link between productivity growth and the standard of living of the average person is somewhat looser in the short-to-medium run, as factors such as the share of the population that is employed and the division of income between capital and labor also play a role. Nevertheless, the rate of productivity growth influences the

[1] I will use "labor productivity" and "productivity" interchangeably in my remarks today. An alternative productivity concept, multifactor productivity, measures the quantity of output that can be produced by a fixed combination of capital and labor. Changes in labor productivity generally reflect changes in both multifactor productivity and the amount of capital per worker.

economy in important ways even in the short run, affecting key variables such as output growth, employment growth, and the rate of inflation.

In my remarks today, I will discuss the pickup in U.S. productivity growth and its implications for the economy. I will first review our current understanding of the causes of the recent productivity resurgence. With that background, I will next consider the near-term prospects for productivity growth. Finally, I will discuss briefly how the evolving productivity picture affects both the economic outlook and the appropriate stance of monetary policy. As always, my remarks today do not necessarily reflect the views of my colleagues at the Federal Reserve.[2]

The U.S. Productivity Resurgence and Its Causes

Why has productivity growth increased? The favored explanation of the rise in productivity growth since about 1995 has evolved somewhat over time. By 2000 or so, an emerging consensus held that the pickup in productivity growth was, for the most part, the product of rapid technological progress and increased investment in new information and communication technologies (ICT) during the 1990s (Jorgenson and Stiroh, 2000; Oliner and Sichel, 2000). According to this view, rapid developments in ICT promoted U.S. productivity growth in two ways. First, technological advances allowed the ICT-producing sectors themselves to exhibit rapid productivity growth. For example, the development of more reliable semiconductor manufacturing equipment and faster wafer-inspection technologies increased the rate at which companies such as Intel were able to produce microprocessors. In part as a reaction to heightened competitive pressures, Intel also shortened its product cycle and increased the frequency of new chip releases, shifting

[2] I thank Board staff members Flint Brayton, Charles A. Fleischman, Paul Lengermann, and Dan Sichel for excellent assistance and comments.

its product mix toward more-powerful (and, consequently, higher-value) chips. Both the more-rapid pace of production and the higher average quality of output raised productivity at Intel and competing firms.

Second, ICT advances also promoted productivity growth outside the ICT-producing sector, as firms in a wide range of industries expanded their investments in high-tech equipment and software and used the new technologies to reduce costs and increase quality (McKinsey, 2001). For example, some large retailers, most notably Walmart, developed ICT-based tools to improve the management of their supply chains and to increase their responsiveness to changes in the level and mix of customer demand. Securities brokers and dealers achieved substantial productivity gains by automating their trading processes and their back-office operations. In the durable goods sector, General Motors and other automobile producers developed programmable tooling systems to increase the flexibility of their manufacturing processes--for example, to permit vehicles based on different platforms to be produced on the same assembly line. One study found that nearly two-thirds of U.S. industries, comprising about 70 percent of total employment, experienced an acceleration of productivity in the latter part of the 1990s. Significantly, the study also found the gains to be the greatest in industries using ICT capital most intensively (Stiroh, 2002).

Undoubtedly, the ICT revolution and the productivity resurgence in the United States after 1995 were closely connected, but several puzzles have arisen that challenge the view that ICT investment leads mechanically to higher productivity. First, the United States was not the only country to see a rapid expansion in ICT investment, as other industrial countries also invested heavily in these technologies in the 1980s and 1990s.

Yet, with a few exceptions, productivity growth in other advanced countries has not increased recently to the extent seen in the United States. The comparison with the member states of the European Union is particularly interesting. Throughout most of the post-World War II period, labor productivity growth in Europe exceeded that in the United States, reflecting, first, rapid gains during the postwar reconstruction and then a gradual convergence of European technology and business practices to American standards. By one estimate, on average, European productivity increased from 44 percent of the U.S. level in 1950 to 94 percent in 1995 (Gordon, 2004). However, since about 1995, productivity growth in Europe has slowed, in contrast to the U.S. experience, and productivity levels in the United States and Europe have begun to diverge.[3]

Researchers have made the important point that U.S.-European differences in productivity growth do not appear to have been particularly large in the ICT-*producing* sectors, where U.S. strengths in the development of information technologies have been offset by European leadership in communications. Rather, the U.S. advantage has been most evident in the ICT-*using* sectors, which have performed better in the United States than elsewhere. What accounts for the apparent U.S. advantage in applying ICT to a wide range of industries?

One popular hypothesis, put forth by Alan Greenspan (2000) and Martin Feldstein (2001), holds that European economies have been less successful in applying new technologies because of a relatively heavy regulatory burden that inhibits flexibility. For example, taking full advantage of new information and communication technologies may require extensive reorganization of work practices and the reallocation of workers among

[3] Correcting for national differences in productivity measurement in some cases reduces the apparent differential in recent productivity growth but does not eliminate it. See Ahmad and others (2003) and Gordon (2004).

firms and industries. Regulations that raise the cost of hiring and firing workers and reduce employers' ability to change work assignments, as exist in a number of European countries, may make such changes difficult to achieve. Likewise, the presence of government-owned firms with a degree of monopoly power, together with restrictions on the entry of new firms, may diminish competitive pressures that often foster innovation and greater efficiency (Nicoletti and Scarpetta, 2003). Recent empirical research has generally found that economies with highly regulated labor and product markets are indeed less able to make productive use of new technologies (Gust and Marquez, 2004). Industry-specific regulations may also be an important barrier to productivity improvement; for example, some writers have argued that restrictions on land use and on shopping hours in Europe have impeded the development of "big box" retail outlets, denying European firms the economies of scale that have been important for productivity growth in the U.S. retail sector (Gordon, 2004).

Differences in regulatory burden do not appear to be a complete explanation of comparative productivity performance, however. For example, the United Kingdom, whose approach to the regulation of labor and product markets is closer to that of the United States than to that of continental Europe, has not done noticeably better in the productivity arena than other advanced European countries (Basu, Fernald, Oulton, and Srinivasan, 2003). A shortage of workers with appropriate skills may be part of the problem in the United Kingdom, as average educational attainment in that country is lower than in many other industrial countries. Skill shortages may have also been a factor in continental Europe, possibly because high youth unemployment has reduced opportunities for workers to acquire new skills on the job. Other suggested explanations

for the relatively better productivity performance of the United States in recent years include the depth and flexibility of U.S. capital markets, its relatively open immigration policies (at least before 9/11), and the role of U.S. research universities in fostering innovation. Further study of the productivity differentials among the United States, Europe, and other regions clearly is warranted.

A second puzzle that challenges the conclusion that advances in ICT are the primary source of recent productivity gains is the observation that, over the past twenty years or so, increases in ICT investment have not been followed reliably and in short order by increases in productivity growth. Instead, the lag between investments in new technologies and their putative productivity benefits appears to be long and variable. For example, ICT investment in the United States began in earnest in the 1980s, but productivity did not begin to accelerate until the mid-1990s. Indeed, an oft-quoted quip by economist Robert Solow held that, as of the late 1980s, "computers are everywhere except in the productivity statistics."[4] Likewise, although ICT investment declined sharply after the meltdown in tech stocks in 2000, productivity growth has continued to rise in recent years, as I have already noted. Perhaps the link between investment in high-tech capital and improving productivity is not so tight as we thought.

In attempting to explain the relatively loose temporal link between ICT investment and productivity growth, economists have emphasized that much more than the purchase of new high-tech equipment is needed to achieve significant gains in productivity. First, managers must have a carefully thought-out plan for using new technologies before they acquire them. Case studies of individual industries show that, in

[4] In fairness to ICT proponents, Solow's claim that computers were "everywhere" in the 1980s is somewhat exaggerated. Aggregate ICT investment was considerably higher in the 1990s than in the 1980s.

some cases, the planning for technological modernization has not always been adequate, with the result that some purchases of high-tech equipment and software have not added much to productivity or profits. The idea that managers can buy the hardware first and then decide what to do with it--sometimes heard as an explanation for the apparently delayed effects of ICT investments made during the late-nineties boom--does not square with the case-study evidence.

Effective planning alone does not guarantee that ICT investments will be beneficial, however. Some observers have characterized the new information and communications technologies as *general-purpose technologies* (GPTs), which means that--like earlier GPTs such as electrification and the internal combustion engine--they have the potential to revolutionize production and consumption processes in a wide variety of contexts (Bresnahan and Trajtenberg, 1995). To make effective use of a GPT within a specific firm or industry, however, managers must supplement their purchases of new equipment with investments in research and development, worker training, and organizational redesign--all examples of what economists call *intangible capital*. For example, to realize the benefits of its ICT investments, Walmart had to reorganize work assignments, retrain workers, develop new relationships with suppliers, and modify its management systems. Although investments in intangible capital are (for the most part) not counted as capital investment in the national income and product accounts, they appear to be quantitatively important.[5] One recent study estimated that, by the late 1990s, investments in intangible capital by U.S. businesses were as large as investment in traditional, tangible capital (Corrado, Hulten, and Sichel, 2004).

[5] Software is one intangible investment that is treated as part of business fixed investment in the U.S. national accounts.

Recognizing the importance of intangible capital has several interesting implications. First, because investment in intangible capital is typically treated as a current expense rather than as an investment, aggregate saving and investment may be significantly understated in the U.S. official statistics. Second, firms' need to invest in intangible capital--and thus to divert resources from the production of market goods or services--helps to explain why measured output and productivity may decline initially when firms introduce new technologies. Finally, the importance of intangible investment explains to some degree why the lags between ICT investment and the resulting productivity gains can be long and variable. Because investments in high-tech capital typically require complementary investments in intangible capital for productivity gains to be realized, the benefits of high-tech investment may become visible only after a period of time.

Medium-Term Prospects for Productivity Growth

Historical analysis of the sources of the productivity acceleration is challenging, but not nearly so challenging as trying to predict how productivity will evolve over the next few years. However, because the rate of productivity growth is a primary determinant of economic performance, policymakers have few options other than to try to forecast future productivity gains. What can be said about the medium-term prospects for productivity growth?

The task of trying to predict the medium-term behavior of productivity is complicated by the fact that productivity growth tends to vary with the business cycle. According to one popular hypothesis, this tendency reflects cyclical variations in the

intensity with which labor is utilized.[6] Because adjusting the size of a company's labor force may involve significant fixed costs (including training costs as well as costs of hiring and firing), employers are generally reluctant to add or subtract workers at the first sign of a change in the demand for their products. Thus, in the earliest stages of a contraction, for example, employers may choose not to dismiss workers but instead to use them less intensively or assign them tasks that do not involve current production, such as maintenance or training. Measured productivity growth consequently declines when the economy enters a recession. Similarly, during the early stages of an economic recovery, employers may hesitate to add new workers and instead may ask existing employees to work harder, at least until the expansion seems better established. Output per hour of work thus tends to rise faster than its secular (long-run) rate early in the recovery. Finally, as the expansion matures and hiring picks up, productivity growth tends to slow again as the level of employee effort returns to normal and as the need to devote firm resources to hiring and training new workers detracts from current production. At present, three years from the official end of the 2001 recession, the U.S. economy has likely entered this latter stage, as productivity growth appears to be falling from its recent high levels to a rate that is likely below its longer-term trend.

Cyclical factors tend to unwind, however; and so, looking ahead a couple of quarters, say, to the second half of 2005, we can reasonably assume that productivity growth will approach its secular trend. What is that trend? Using various econometric methods, together with a liberal dose of judgment, several leading economists have recently offered estimates for secular productivity growth of about 2-1/2 percent per year, close to the rate of productivity growth achieved during 1995-2001 (Baily, 2003; Gordon,

[6] See Basu and Fernald (2001) for a discussion.

2003; Jorgenson, Ho, and Stiroh, 2004). If these estimates turn out to be correct--and they are certainly subject to a great deal of uncertainty, as I will discuss--then the increase in productivity growth of the mid-1990s may come to be seen as having initiated a new era for the U.S. economy.

Of course, as the saying goes, past returns are not a guarantee of future results; not all the evidence supports the emerging consensus that secular productivity growth will remain at its current elevated level. For example, although spending on high-tech equipment and software has recovered smartly from its recent lows, growth in ICT spending still remains well below rates seen before the 2001 recession. Some industry participants have suggested that less-rapid growth in ICT spending reflects the absence of major new business applications for ICT--"killer apps,"as they are called--and that ICT investment for the foreseeable future will largely reflect replacement demands. Researchers have also found some evidence that the technological frontier may not have advanced as quickly recently as it did in earlier years; as one indicator, the price of computing power has recently declined more slowly than it did in the 1980s and 1990s.

These caveats notwithstanding, I think the productivity optimists have a good case. Computing power may not be falling in price quite so rapidly now as in the late 1990s, but a dollar nevertheless buys a great deal more computational capacity today than it did even five years ago. And if rapidly improving information and communication technologies are truly general-purpose technologies, history suggests that they will continue to stimulate new ways of producing and of organizing production (DeLong, 2002). In particular, the enormous expansion in available computing power has already contributed to advances in other emerging fields, such as biotechnology.

Moreover, even if the technological frontier advances more slowly during the next few years, further diffusion of the existing technologies and applications can continue to raise aggregate productivity. The available evidence suggests that this diffusion process is not complete. For example, a survey conducted in 2003 by the Institute of Supply Management and Forrester Research found that most managers consider their company to be at a relatively early stage in exploiting the potential gains from using the Internet for their purchasing activities. In a more formal analysis, Jason Cummins and Giovanni Violante constructed a measure of the "technological gap" in U.S. industry, defined as the difference in efficiency between state-of-the-art capital equipment and the actual mix of equipment held by firms (Cummins and Violante, 2002). As of 2000, the last year included in their study, the authors found this gap to be 40 percent and rising, suggesting that substantial opportunities remain for increasing productivity. This gap is unlikely to have declined much since 2000, for even if the rate of technological progress has slowed, so has the pace of ICT investment.

I draw two conclusions: First, on the whole, the relatively optimistic estimates of secular productivity growth espoused by leading scholars in the field do not seem unreasonable, so that, for the longer term, continued growth in productivity in the range of, say, 2 percent to 2-1/2 percent per year probably represents a good baseline assumption. Second, qualifying the first conclusion, the range of uncertainty in forecasts of productivity growth is inevitably quite wide. For example, a 2004 study by three leading scholars produced an estimate of trend productivity growth of 2.6 percent, but with a range of plausible outcomes between 1.4 percent and 3.2 percent (Jorgenson, Ho, and Stiroh, 2004). This qualification naturally leads us to ask: Suppose that, over the

next year, the incoming evidence suggests that the trend rate of productivity growth is either substantially higher or substantially lower than we currently expect. How would that development affect the economy and monetary policy? In the final portion of my remarks, I will address this important question.

Implications for the Economy and Monetary Policy

For concreteness, suppose that the pace of productivity gains in the latter part of 2005 and in 2006 proves disappointing, sufficiently so to suggest that current estimates of the sustainable rate of productivity growth may be overoptimistic. Let us first consider what this information would likely imply for the medium-term economic forecast. To anticipate the conclusion, we will see that the strength of the response of aggregate demand to productivity developments is the key determinant of their overall impact.[7]

In the first instance, incoming evidence of a secular slowdown in productivity would likely result in slower growth in consumption spending, capital investment, and aggregate output relative to what would have been otherwise expected. Consumption growth would weaken as downwardly revised profit expectations limit stock market gains, thereby reducing household wealth, and as more-foresighted consumers perceive that smaller productivity gains portend lower real wage growth. Lower expected rates of productivity growth should also tend to moderate growth in business investment by reducing the prospective return to capital. As consumption and investment spending make up more than four-fifths of aggregate output, slower productivity growth would perforce reduce output growth as well.

What about inflation? In principle, the medium-term effect of slowing productivity growth on inflation is ambiguous. As a number of analysts have noted,

[7] Kohn (2003) explores some of the issues of this section in greater detail.

under the reasonable assumption that nominal wages adjust slowly, slower productivity growth results in a more rapid rise in unit labor costs (the nominal-wage cost of producing a unit of output).[8] All else equal, a more rapid increase in unit labor costs will tend to increase inflation as well. However, the effect of higher unit labor costs may be offset if the decline in consumption and investment spending induced by the productivity slowdown is particularly sharp. Indeed, a large deceleration in spending could conceivably cause inflation to slow following a productivity slowdown, as firms' markups contract more than unit labor costs rise.

The effect of a productivity slowdown on employment growth is likewise ambiguous in the medium term. Slower output growth depresses employment growth as firms face weaker demand, but slower productivity growth implies that firms need more workers to produce a given level of output. As in the case of inflation, the strength of the spending response is crucial. The more sharply spending and output decline following a productivity slowdown, the more adverse the effects on employment will be.

Both the late 1990s and the more recent period illustrate the central role of the spending response in determining the macroeconomic effects of a change in productivity growth, although (as I have discussed today) in both of these episodes the productivity surprise was to the upside rather than the downside. The rise in productivity growth after 1995 was accompanied by surges in both consumption and investment spending, supported by a booming stock market. Employment rose and unemployment fell, as the strength of aggregate demand induced employers to hire, the increases in productivity notwithstanding. Inflation remained fairly stable during this period, as upward pressures

[8] Braun (1984) and Ball and Moffitt (2001) discuss the effect on inflation of a change in the rate of productivity growth.

from increased aggregate demand were balanced by downward pressures on unit labor costs (for any given level of wages) and by the increase in aggregate supply created by higher productivity.

In contrast to the experience of the late 1990s, during the early part of the new millennium the response of spending to rising productivity growth was comparatively weak. Investment spending was particularly slow to respond to the further increase in productivity growth, for reasons that are still debated. Possible explanations for the weak investment response include an unusually high degree of corporate caution, cost-cutting pressures, and the after-effects of the corporate governance scandals of 2002. An explanation suggested by my discussion today is that, for most of this period, companies were enjoying the fruits--in terms of higher productivity--of earlier investments in both tangible and intangible capital. The extra productive capacity created by those investments, together with a recovery whose durability in the early stages was not assured, may have implied little need for further investment, at least until relatively recently. Whatever the cause, the weaker response of spending in the more-recent period, coupled with impressive gains in productivity, helped to generate both a pattern of slow job growth (the "jobless recovery") and the worrisome decline in inflation in 2003.

What are the implications of these observations for current monetary policy? Certainly, monetary policy makers should pay close attention to developments on the productivity front, as the effects of changing productivity trends permeate the economy. However, as we have seen, the appropriate policy response to any perceived change in the trend rate of productivity growth will depend to a significant degree on the response of private-sector spending. For example, if productivity growth appears poised to

decelerate, but (for whatever reason) aggregate private spending does not slow materially in response, then inflation risks would rise, but employment would not be adversely affected. The appropriate response in this case would be a tightening of monetary policy (or a more rapid removal of accommodation). On the other hand, if slower productivity growth were accompanied by a sufficiently large slowdown in aggregate demand and economic activity, then easier monetary policy (or a slower removal of policy accommodation) might be called for.

My best guess--and it is only a guess--is that future responses of consumption and investment spending to changes in the pace of productivity growth are likely to be less powerful than those of the late 1990s, if for no other reason than that we may have learned to be more careful in our enthusiasms. If so, then the principal effect of an unexpected slowdown in productivity growth during the next few years would likely be higher inflation, with the short-term impact on the growth of output and employment likely to be relatively minor. In this scenario, the appropriate monetary policy response would be toward less accommodation. By similar reasoning, if productivity growth were to accelerate in the next few years, then easing inflation pressures and slowing employment growth would likely allow for less-restrictive policies. As I have emphasized, however, these conclusions depend on other developments in the economy, most importantly on how strongly aggregate spending responds to any perceived change in secular productivity growth.

Of course, it should go without saying that the world is more complicated than theoretical arguments suggest. Notably, imperfect data and the difficulties of distinguishing permanent from temporary changes will make changes in secular

productivity growth exceptionally difficult to identify in real time, both for the private sector and for the Federal Reserve. The need to discern the underlying economic forces and to react appropriately in an environment of incomplete information makes monetary policy an exceptionally challenging endeavor.

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