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PRODUCTIVITY GROWTH, INFORMATION TECHNOLOGY, AND MONETARY POLICY

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TO WHAT EXTENT CAN ONE RELATE THE ACCELERATION IN LABOR PRODUCTIVITY OBSERVED IN THE UNITED STATES IN THE SECOND HALF OF THE 1990S TO THE PRODUCTION AND IMPLEMENTATION OF ICT?

After a quarter century of lackluster gains, the U.S. economy experienced a remarkable resurgence in productivity growth during the second half of the 1990s.[2] From 1995 to 2001, output per hour in nonfarm business grew at an average annual rate of about 2-1/2 percent, compared with an average increase of only about 1-1/2 percent per year from 1973 to 1995. A substantial body of work – including Oliner and Sichel (2000, 2002), Jorgenson and Stiroh (2000), Jorgenson, Ho, and Stiroh (2002), and Whelan (2002) – linked this improved performance to the revolution in information and communication technology (ICT) that has spread through the U.S. economy.[3] These analyses traced the productivity effects from the *use* and *production* of ICT and identified important contributions from both sources to the pickup in labor productivity growth that began in the mid-1990s. By 2000, this emphasis on the role of ICT had become the consensus view.

Shortly after this consensus emerged, the technology sector of the economy went into a tailspin as demand for ICT products fell sharply. With the ICT sector in retreat, questions were raised about the robustness of the earlier results and about the sustainability of the pickup in productivity growth. However, productivity growth has held up remarkably well over the past few years. Indeed, from 2001 to 2003, labor productivity surged at an average annual rate of roughly 4-1/2 percent, although ICT – as conventionally measured – did not

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The views expressed in this note are those of the authors alone and should not be attributed to the Board of Governors of the Federal Reserve System or to other members of its staff.
2. This material draws heavily from Oliner and Sichel (2002) and from Sichel's comment on Gordon (2003).
3. For more skeptical views of the role of ICT written at that time, see Gordon (2000).

make any direct contribution to this further pickup. This surge, along with the apparently minimal direct role of ICT, has posed a further puzzle to productivity researchers and policy makers.

Many hypotheses have been put forward to explain the recent strength in labor productivity growth.[4] One frequently discussed explanation is that unusual uncertainty about the strength and persistence of the recovery from the 2001 recession caused firms to be very reluctant to hire new workers. In this explanation, employees already on the payroll worked harder to generate the additional productivity. Many analysts also have highlighted a related explanation – that the acquisition of ICT or intangible capital has a delayed effect on productivity. This delay might arise because it takes time to fully realize the benefits of new technology or because the installation of new ICT systems initially disrupts the normal work routines in an organization. Such lags would imply that some of the productivity benefits of ICT investments made in the late 1990s and in 2000 would have been realized in subsequent years. Another possible explanation is that the official productivity statistics understated the growth of labor hours during the recovery and hence overstated productivity growth. However, Gordon (2003) casts doubt on the importance of this explanation, as well as the claim that greater outsourcing of white-collar jobs has been a major source of productivity improvement in recent years. Researchers continue to debate the merits of the various explanations, and further clarity is likely to require at least a couple more years of data. That said, when examining the entire period since the mid-1990s, few researchers doubt that ICT has played a significant role in the step-up of productivity growth from the sluggish gains recorded over the preceding 25 years.

Why did European economies miss such an acceleration in labor productivity?

In contrast to the speed-up in the United States, labor productivity has decelerated since the mid-1990s in almost all European countries. A common explanation for this divergence is that European firms have been slow to invest in information technology. However, to test this hypothesis, one must first place the European and U.S. data on a comparable basis. In most European countries, the price indexes for ICT capital goods control less completely for quality improvements than in the United States, which implies that real investment in ICT capital is understated.

Employing data that adjust for this difference, Jorgenson (2003) calculates that real ICT capital input per capita in France, Germany, and Italy grew about 12 percent (at an annual rate) during 1995-2000, up from the roughly 9 percent pace during 1989-95. This step-up implies a small increase in the growth contribution from ICT capital across the two periods.

4. For a recent discussion, see Gordon (2003) and the published comments on his paper by Daniel Sichel and Martin Baily.

Jorgenson also estimates that multifactor productivity (MFP) growth quickened after 1995 in the ICT-producing industries in these countries. Thus, the use and production of ICT capital are estimated, all else equal, to have *raised* productivity growth after 1995 and cannot account for the observed slowdown. Instead, Jorgenson's accounting system largely attributes the deceleration to weaker investment in non-ICT capital and to slower MFP growth outside the ICT-producing sector.

Nonetheless, Jorgenson estimates that the boost to productivity growth from the use of ICT capital has been much smaller in Europe than in the United States. The detailed industry-level data analyzed by Van Ark *et al.* (2003) suggest a similar conclusion. Van Ark *et al*. show that much of the recent difference in productivity trends can be traced to a few key industries that intensively use ICT capital – retail trade, wholesale trade, and financial services. After 1995, productivity growth in these industries rose sharply in the U.S. but not in Europe.

A leading hypothesis for the lackluster productivity performance in Europe is that heavy regulation has impaired the adoption of new technology. Gust and Marquez (2004) document a negative correlation between measures of the restrictiveness of a country's regulatory environment and its rate of both ICT investment and productivity growth. The McKinsey Global Institute (2002) conducted a series of sectoral studies to explain why French and German firms have invested less in ICT than U.S. firms. The McKinsey studies suggest that the key inhibitor to the diffusion of innovation has been insufficient competition resulting from burdensome regulation. Scarpetta and Tressel (2002) reached similar conclusions based on harmonized data for 23 manufacturing and services industries in 18 countries over the past two decades.

While product and labor market rigidities surely play an important role, they cannot explain why countries with comparable regulatory environments have sharp differences in productivity growth. Specifically, the United Kingdom and the United States share a similar regulatory framework but in the United Kingdom, as in the rest of Europe, productivity decelerated in the late 1990s. Basu *et al.* (2004) show that the acceleration in ICT spending occurred with a lag in the United Kingdom and argue that the full effect of ICT on productivity growth will take time to be realized. The paper does not explain, however, why ICT investment spending lagged in the United Kingdom. Krueger and Kumar (2003) present one possible explanation, arguing that the U.S. education system, which emphasizes general education and greater flexibility in educational choices at the upper levels, may produce workers who are better poised to adapt to ICT investment and the new organizational structures it entails.

Finally, although greater deregulation likely would be beneficial in Europe, some of the recent labor-market reforms – specifically the widespread introduction of temporary workers and fixed-term contracts – may have damped productivity so far. These reforms encouraged the employment of less-skilled workers, and Daveri (2002) argued that worsening labor quality has had a negative impact on productivity.

To what extent can an acceleration in productivity influence monetary policy?

Both theory and historical evidence suggest that a rise in the trend rate of productivity growth has important implications for monetary policy. However, many factors influence the response of aggregate spending and inflation to such an event, especially in the short run. In fact, macroeconomic stability may be consistent initially with either a rise or a fall in short-term interest rates. In the longer run the situation is less ambiguous, as theory implies that faster productivity growth raises the economy's equilibrium real rate of interest. Nevertheless, the magnitude of the steady-state increase is difficult to predict.

Long-run effects

After an increase in trend productivity growth, aggregate demand will tend to rise relative to aggregate supply (all else equal) for three reasons.[5] First, faster growth increases the present value of future labor income relative to the level of current labor income, causing a rise in the ratio of consumption to current income. Second, the extra wealth generated by faster expected growth in corporate earnings will also lift consumption relative to income. Finally, assuming that the cost of capital is unchanged, the growth of the economy's capital stock will move up with the trend growth of output. To support the faster growth of capital stock, the share of investment in aggregate output must rise (as can be seen from the standard identity linking capital stock, investment, and depreciation). Given these productivity-induced increases in consumption and investment, the monetary authority must eventually boost the average level of the real policy rate to equate supply and demand and thereby maintain macroeconomic stability.

However, the magnitude of this rise in the real policy rate is less clear. A key source of uncertainty is that estimates of the interest elasticity of private saving and investment vary considerably. In addition, the extent of the rise in domestic real interest rates will depend on whether the productivity acceleration is shared by a country's trading partners. If the pickup is not worldwide, exports will tend to fall relative to domestic output, mitigating the upward pressure on real interest rates. A similar consideration applies to government saving, which may endogenously increase following a shift to faster trend growth, thereby checking the rise in real interest rates unless offset by adjustments to government spending and tax rates.[6] Finally, upward pressure on domestic interest rates may be eased by international capital flows, especially if the pickup in trend growth also prompts a real appreciation of the cur-

5. This discussion presumes that the upward shift in trend productivity growth is unanticipated, which clearly applies to the acceleration in the United States in the mid-1990s. If, to the contrary, the acceleration had been anticipated for a considerable time, forward-looking households and businesses already would have adjusted their spending plans, and aggregate demand would change little, if at all, with the observed rise in productivity growth.

6. For discussions of the influence of recent changes in U.S. productivity growth on government revenues, see the Congressional Budget Office's annual "The Budget and Economic Outlook" reports to Congress produced since 1998.

rency. Taken together, these various offsets may be large enough to yield only a modest net increase in the equilibrium real interest rate.

Short-run effects

The short-run effects of accelerating productivity on the macroeconomy, and hence monetary policy, are highly uncertain. This uncertainty arises mainly because the initial response of aggregate spending to the improvement in supply-side conditions depends on the speed at which households, firms, and investors recognize that a persistent increase in trend growth has occurred. If the public rapidly revises its growth expectations, then a capital spending boom may ensue in which both households and firms seek to increase stocks of durable goods and structures. This boom may be exacerbated by conditions in financial markets: If the revision in growth expectations does not lead to an offsetting rise in long-term interest rates, then corporate equity valuations will jump, increasing household wealth and boosting consumer spending further.[7] Under these conditions, aggregate demand will increase faster than potential output, causing labor and product markets to tighten, similar to what happened in the United States during the late 1990s. By contrast, if the public initially views the productivity acceleration as temporary, then growth in spending will tend to lag behind the rise in productivity as households and firms only gradually bring the level of their spending in line with the perceived higher level of permanent income.[8] In this case, the amount of economic slack will increase in the short run.

Also of concern to policymakers is the short-term response of wages and prices to faster productivity growth. As originally discussed by Braun (1984) and more recently by Ball and Moffitt (2001), real wages in the United States historically have been slow to adjust to sustained accelerations or decelerations in output per hour. As a result, unit labor costs fall as productivity growth increases, initially boosting profits but then leading fairly quickly to a decline in prices. The slow adjustment of real wages allows labor and product markets to run unusually tight for a considerable period of time without any increase in inflation.

Given these various output and inflation effects, it is unclear whether monetary policymakers, in seeking to stabilize the economy, will need to raise or lower the policy rate in the short run. If the pickup produces a sufficiently strong spending boom, keeping inflation constant may entail some rise in short-term rates. Alternatively, if the acceleration yields only a modest rise in aggregate spending, then a policy easing would be called for to prevent both a rise in unemployment and a decline in inflation.

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7. Although theory suggests that faster trend growth raises the equilibrium real short-term interest rate, long-term rates may not increase immediately because, as discussed below, the acceleration in output per hour initially puts downward pressure on inflation. As a result, short-term interest rates can remain unchanged initially, leading investors to be unsure about the need to raise rates in the longer run.

8. The Federal Reserve Board's FRB/US model predicts a range of demand responses to a productivity surprise when the model is run under different assumptions about the speed at which agents learn; see Reifschneider, Tetlow, and Williams (1999) for an overview of the FRB/US model. Similar behavior is predicted by stochastic general equilibrium models that incorporate learning, as demonstrated by Edge, Laubach, and Williams (2003).

More specifically, can you identify any change in the Fed's monetary policy attributable to the acceleration in productivity?

The effects on monetary policy cannot be identified with any precision because, as always, policy has needed to cope with a variety of shocks and other developments in addition to shifts in productivity trends. Nonetheless, the faster productivity growth since the mid-1990s certainly has been an important consideration in policy formulation.

The Federal Reserve recognized early on that productivity growth may have been strengthening and that the acceleration potentially had implications for monetary policy. For example, in his February 1996 monetary policy testimony to the Congress, Chairman Greenspan took note of the decline in unit labor costs that had recently resulted from an acceleration in productivity and hypothesized that advancing technology could boost productivity growth over a longer period of time. Over the remainder of the 1990s and so far in this decade, the incoming evidence increasingly supported that hypothesis. Moreover, the faster productivity gains clearly had the potential to put downward pressure on inflation. Against this backdrop, the Federal Reserve kept policy at a setting that was consistent with rapid economic growth during the second half of the 1990s.

By the end of the decade, growth in aggregate demand had outstripped that in aggregate supply by a wide enough margin to leave resource utilization extremely tight – a development that posed some risk of higher inflation. Indeed, the Federal Reserve appreciated that, as explained in the response to the previous question, stronger productivity growth boosts aggregate demand as well as aggregate supply and eventually calls for an upward adjustment to policy interest rates, measured in real terms. In Congressional testimony in July 1999, Chairman Greenspan noted that robust growth in aggregate demand had been driven in part by high prices in equity markets, which in turn partly reflected investors' expectations that strong productivity growth would continue.

Productivity in the United States has accelerated even further in recent years. However, with the slide in equity prices from early 2000 to early 2003, and with other negative shocks to the economy, aggregate demand was relatively weak over much of this period, and a sizable output gap consequently developed. The downward pressure on prices resulting from the output gap brought inflation to a very low level by 2003. In view of the persistent output gap and the low inflation, both of which are due in some measure to strong productivity, the Federal Reserve maintained a highly accommodative stance of monetary policy through 2003.

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