

# FRBSF ECONOMIC LETTER

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## Will Fast Productivity Growth Persist?

Strong productivity growth is essential for improving living standards and can have an important impact on economic policy, yet economists are far from being experts at predicting when the trend of productivity growth might shift. In the 1960s, productivity growth boomed, growing at an average annual rate of 2½%. It weakened in the early 1970s, and for the next two decades or so averaged an annual growth rate of only about 1¼%. Then, in the mid-1990s, productivity growth boomed again, averaging about a 3% annual rate from the last quarter of 1995 through the middle of 2004. These shifts were not predicted and were generally not widely recognized until years after they occurred. Considering that, since the middle of 2004, productivity growth has averaged only about 1½% per year, it may be time to ask whether this is just a “pause” in the boom that started in the mid-1990s or a shift back to the growth rates seen in the 1970s and 1980s. This *Economic Letter* begins to answer this question by focusing on the factors that underlay the most recent productivity boom and what they may portend for the future.

### Information and communications technology and the productivity surge

Technological innovation is often associated with productivity booms. The most obvious such innovations in recent decades have been in the production of information and communications technology (ICT), such as computers, software, communications equipment, and the like. But the channels for ICT to affect the overall economy are complex.

Economists identify three proximate or direct sources of higher labor productivity. First, workers have more and better capital to work with, also known as “capital deepening.” Second, the workforce gains more education and skill. Third is total factor productivity, or TFP, a comprehensive term for everything not otherwise explained; the main reason TFP rises over time is innovation in products and processes.

Oliner and Sichel (2006) decompose labor productivity growth using annual aggregate data through 2005. They find that in the 1995–2000 period, both faster

TFP growth and an increased contribution of capital-deepening raised labor productivity growth relative to the 1973–1995 period. Thereafter, however, investment was relatively weak, and the pace of capital deepening—especially of ICT capital—fell substantially. Yet labor productivity growth remained strong in the early 2000s because TFP growth accelerated even further.

Economists generally agree that a TFP acceleration in ICT production was a significant contributor to the acceleration in overall TFP during the 1990s, and the causes of the former are reasonably well understood. New product development, resulting especially from research and development, led to rapid improvements in computer technology; for example, competition between Intel and AMD led to a faster introduction of new semiconductor chips in the post-1995 period. This faster pace of technological rollout appears to explain a large share of the ICT productivity acceleration.

Many earlier studies argued that the acceleration in overall TFP was largely, if not entirely, due to innovations in sectors producing ICT goods. These innovations, in turn, raised labor productivity in the sectors that used ICT because of capital deepening; in particular, falling ICT prices reduced the effective cost to a user of purchasing high-tech capital, leading firms to increase their desired capital stock. From this perspective, there is no reason to expect an increased pace of innovation outside of ICT production.

Basu, Fernald, and Shapiro (2001), however, argue that the overall TFP acceleration was broad-based—not narrowly located in ICT production—and more recent studies (including Bosworth and Triplett 2003) have emphasized the TFP acceleration in the services sector. Over time, major official data revisions have affected the apparent size and timing of the acceleration in different sectors but haven’t changed the general picture. Oliner and Sichel (2006) find that, in the 2000–2005 period, TFP in ICT production slowed and estimate that the acceleration in overall TFP is completely explained by non-ICT-producing sectors. A number of other studies have found similar results.



To explain how ICT can affect measured production and productivity in other sectors, a number of papers highlight the notion of ICT as a “general purpose technology” (GPT), much like electricity or steam power, in that it has pervasive and wide-ranging effects on how firms do business or even how people live. They also note that adopting new GPTs is neither easy nor instantaneous. First, firm-level studies suggest that benefiting from ICT investments requires substantial, costly investments in intangible capital, such as reorganization; for example, faster information processing might lead firms to think of new ways of communicating with suppliers or arranging distribution systems. These investments may include resources diverted to learning or purposeful innovation arising from research and development (R&D).

Second, the GPT literature suggests the likelihood of sizeable spillovers from ICT. For example, successful new managerial ideas—such as using ICT to build a new business information system—seem likely to diffuse to other firms. Imitation is often easier and less costly than invention, because you learn by watching and analyzing others’ experimentation, successes and, importantly, mistakes. Indeed, firms that *don’t* use computers intensively may also benefit from spillovers of intangible capital created by firms that use computers more intensively. For example, if R&D has sizeable spillovers, and if R&D is more productive with better computers, then even firms that don’t use computers intensively may benefit from the knowledge created by computers.

Brynjolfsson et al. (1997) study the experience of a large medical products company following its decision to deploy computer-based flexible machinery. Management recognized that the project would involve not only the purchase of new machines but also a substantial amount of learning and a reorganization of the production process. While ultimately successful (so much so that the company painted factory windows black to prevent competitors from imitating its organizational and technical innovations), various hurdles led to an extended and costly period of experimentation and false starts; for example, production workers continued to use the new machinery as they had used the old, resulting in large inventories of work in process and finished goods. Ultimately, the firm physically isolated one section of its plant to experiment with different methods of reorganizing the production line.

Another study of about 500 large U.S. firms found that it took at least five to seven years for the full benefits of computers to be realized. At the industry level, Basu and Fernald (2007) find that the data are reasonably consistent with the predictions that in sectors that use ICT, ICT capital growth should,

with long lags, be positively associated with TFP growth. In particular, they find evidence that ICT capital investments in the late 1980s and 1990s are positively correlated with the TFP acceleration in the 2000s. They conclude that these results are reasonably consistent with the firm-level evidence.

### **Is the era of rapid productivity growth over?**

To begin to answer this question, it is useful to look first at whether the pace of innovation in the ICT sector has slowed. Though this is not easy to measure, some have argued that the relative price of ICT sector output provides a (rough and ready) indicator of technical progress in this sector (see Doms (2005), for instance). Other things remaining the same, the faster the rate of technical progress in the ICT sector, the faster the rate at which the price of ICT goods falls against other prices in the economy. It turns out that the price of information processing equipment and software (relative to the GDP deflator) fell at close to a 6½% rate over the 1973:Q1–1995:Q3 period; the rate of decline accelerated to 8¾% over the 1995:Q4–2000:Q4 period but has fallen back to 6% since. Based on this evidence, as well as the studies mentioned earlier, one could argue that the pace of technical progress in the ICT sector has slowed, but there is no way to tell whether this slowdown is temporary or permanent.

If the productivity slowdown in ICT production is permanent, should we then expect productivity growth in the ICT-using sectors to fall back to the rates seen before the boom? The GPT literature suggests that the answer is no. DeLong (2002) points out that, even though the period of double-digit annual productivity increases in steam-power and textile-spinning machinery ended in the early 1820s, these technologies made their major contribution to economic growth in Great Britain in the subsequent 50 years. Similarly, David (1991) emphasizes that the benefits of the electric motor took nearly half a century to spread, as firms learned how to make more efficient use of the technology.

Is ICT likely to have the same impact that earlier GPTs did? At least one metric suggests that it could. It has been pointed out that ICT prices have fallen far more dramatically than prices of GPTs like electricity and the internal combustion engine, and the resulting decline in the price of capital goods is unprecedented. This suggests that we might expect productivity growth to remain elevated for a while yet.

Furthermore, recent data for nonfinancial corporations suggest that productivity growth might not have slowed quite as much as the nonfarm business sector data indicate. It has been argued that data for nonfinancial corporations (whose output amounts

to about 70% of nonfinancial business sector output) is better measured than for the noncorporate and financial sectors of the economy. As Figure 1 shows, productivity growth in nonfinancial corporations has tended to track that in the overall nonfarm sector reasonably well, but the former has not slowed as much over the past year. (At press time, we have data for nonfinancial corporations through 2006:Q3 and for nonfarm business through 2006:Q4.) The reasons for the divergence are not clear. The underlying source data are different, since nonfinancial corporate output is measured from data on income, whereas nonfarm output is measured from data on expenditure. While the national accounts are designed so that, in principle, income and expenditure necessarily grow at the same rate, the two measures rely on different surveys, so there can be a “statistical discrepancy” between them.

### Conclusion

At the peak of the “New Economy” hype of the late 1990s, many claimed, “The Internet changes everything,” and, by implication, that it happened overnight. But the history lessons from GPTs, like electricity and steam power, as well as recent theoretical and empirical work, suggest that the necessary complementary investments and innovations that drive change unfold only slowly over time. Thus, it could be that the promise of recent technological advances will continue to be realized. To the extent that ICT is, indeed, a GPT on a par with the electric dynamo, the returns to innovation (whether managerial in-

novations or the development of new products and processes) might remain high for some time to come. The strength of productivity growth in nonfinancial corporations provides another reason for hope that underlying productivity trends remain strong.

None of this is meant to argue that trend productivity growth will revert to the 3% rate seen around the turn of this century; we are arguing instead that—in the near term—trend productivity growth is unlikely to revert to the rates seen during the 1970s or 1980s. But these are not statements that can be made with a high degree of certainty. As we confessed at the outset, economists, including us, do not have a winning record in predicting the path of productivity growth.

**John Fernald**  
Vice President

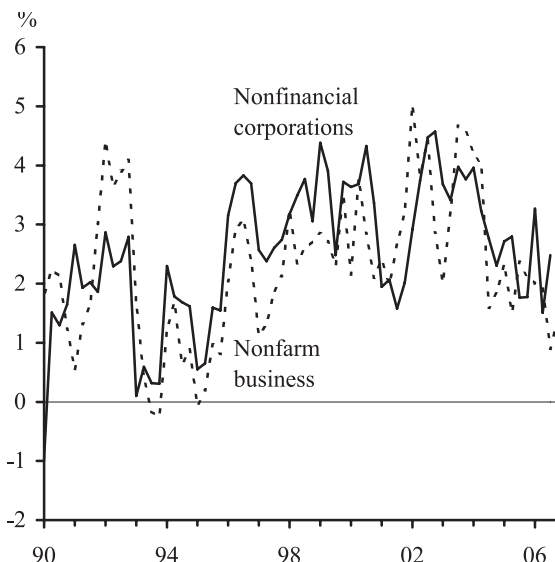
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**Figure 1**  
Labor productivity (year-over-year growth)



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