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Information Technology and Productivity

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Productivity growth in the U.S. has picked up noticeably in recent years. From 1996 to 1999, average labor productivity, or ALP, in the private, nonfarm U.S. economy grew at a 2.8% annual rate, more than twice the rate that prevailed between 1980 and 1995. Many observers have linked this acceleration in productivity to the explosive growth of computers and information technology (IT), claiming that we now have a "New Economy"–that is, they believe that the widespread adoption of the new technologies has led to fundamental improvements in the way business is done throughout the economy.

Yet some well-known economists challenge such an interpretation, arguing that there is little evidence of the New Economy outside the sectors that manufacture computers and IT equipment. In this *Letter* we examine these arguments, discuss U.S. data in light of them, and then look at some data from abroad.

An old economy interpretation

Gordon (2000) argues that despite the growing use of computers and other information technology, the trend (or long-term) growth rate of ALP outside the durable goods manufacturing sector has not accelerated significantly in recent years. He begins by calculating the difference in the growth rate of ALP in the nonfarm private economy between two periods–1972-1995 and 1995-1999–and finds that it equals 1.35%. He then decomposes this difference into its main components. He calculates that a little more 0.5 percentage point of the increase represents an acceleration in productivity growth that usually occurs when an economy is in a business cycle upswing. Of the remaining 0.8 percentage point, approximately 0.2 is attributable to changes in labor quality and changes in the measurement of prices. About 0.3 percentage point of the increase is the result of "capital deepening," that is, of an increase in capital per worker (which reflects the increased investment in computers).

The remaining 0.3 percentage point of the increase in the trend is attributable to multi-factor

productivity (MFP), which basically means improvements in the way all inputs work together. According to Gordon, the increased MFP is localized in the durables manufacturing sector, which includes computers. In the rest of the economy, which accounts for 88% of total output, MFP growth over this period has been negative and large enough to offset the effects of capital deepening on ALP, so that the trend growth of ALP (outside of durable manufacturing) has increased by less than 0.1 percent.

Gordon's result is troubling for the New Economy hypothesis, according to which business investment in computers should boost ALP not only through capital deepening (the "direct" effect), but also through increases in MFP (the "spillover" effect). These numbers are especially surprising because the sectors producing nondurable goods have invested most heavily in information technology. According to one estimate, nearly 80% of the computer investment in the early 1990s was concentrated in three industries: trade, FIRE (finance, insurance and real estate), and services.

Gordon argues that these findings should not be surprising, since the IT "revolution" is simply not as important as it has been made out to be. He enumerates several "great inventions" from about a hundred years ago–the electric lightbulb, the internal combustion engine, the telegraph, and indoor plumbing–that fundamentally transformed the economy and ushered in a period of robust, economy-wide MFP growth from 1913 to 1972. He argues that advanced software and the Internet do not have the same potential to engender such an extended period of prosperity because they primarily substitute for and duplicate other activities, while the "great inventions" truly broke new ground.

It is not hard to disagree with some of Gordon's claims. For instance, his adjustment for the state of the business cycle is based on the assumption that this expansion is just like every other one. If one believed that information technology played a larger role in the boom during the late 1990s than it did during the average expansion, then Gordon's cyclical adjustment would amount to throwing the baby out with the bath water. Oliner and Sichel (2000) make no such adjustment and find that over the 1996-1999 period, the average rate of MFP growth in the nonfarm business sector *excluding computers and semiconductors* exceeded the rate achieved over 1974-1995 by 0.4%. In another study, Jorgenson and Stiroh (2000) reach mixed conclusions about productivity growth outside the IT sector. While they do find an acceleration in MFP outside the IT sector during the late 1990s, the extent of this increase depends upon price indexes that are not necessarily reliable right now.

Some evidence from abroad

The debate in the U.S., then, revolves around the contribution that increased use of computers might have made to the observed acceleration in productivity. Since this debate appears difficult to settle on the basis of U.S. data alone, it is useful to look at the experience of a group of developed countries to see what light can be shed on the issue. Because of data limitations, we confine ourselves to the G-7 countries–Canada, France, Germany, Italy, Japan, the U.K., and the U.S. The small size of the sample means that our conclusions will be tentative.

Figure 1 (pdf 2.5 KB) shows ALP growth in these countries during 1980-1995 and 1995-1998. (To allow for consistent comparisons across countries, we use an OECD data set; the cost of doing so is that some key data series are not available beyond 1998.) The U.S. is the only country that has experienced an increase in the growth rate of productivity between these periods. Averaged over the remaining six countries, productivity fell at an annual rate of just over 1% between these periods.

Clearly, the "New Economy" has not led to a productivity surge in these countries. One can think of several explanations for this. For example, it may be that IT has not penetrated these countries as deeply as it has penetrated the U.S. In fact, OECD data show that while the U.S. had 0.33 computers per capita in 1995, Italy had only 0.08, while the values for the remaining members of the G-7 were between 0.13 and 0.19. Alternatively, cyclical factors may have been at play; as mentioned above, the behavior of productivity varies over the cycle. In fact, however, an examination of output data shows

that–with the exception of Japan–none of these countries were in or near recessions in the later period; instead they had suffered recessions in the early 1990s.

More generally, it is difficult to build a complete model that controls for all the factors that may be responsible for the differences in productivity growth across countries. A simpler, though necessarily less complete, way to assess the contribution made by computers is to focus just on the two variables that are of interest: changes in productivity growth and computer use.

Figure 2 (pdf 2.5 KB) plots the change in productivity growth between the two periods shown in Figure 1 against the number of computers per capita in the G-7 countries in 1995. The figure shows that greater computer use in 1995 was associated with a greater acceleration in productivity in the subsequent period. A somewhat more formal way to measure the strength of the relationship between these variables is to look at the correlation coefficient, which has an absolute value between 0 and 1. It is useful to keep in mind, however, that a finding that two variables are correlated does not prove causality. The correlation coefficient for the G-7 countries turns out to be 0.92. When the U.S. is excluded, the correlation coefficient is 0.68.

Why employ lagging data for computer use, instead of data that cover the same period as the change in productivity growth that we are trying to explain? We do this to avoid simultaneity. Specifically, if we were to find a positive correlation using contemporaneous data on computers, we would be unable to tell if this was because the New Economy hypothesis was true–that is, greater computer use had caused faster productivity growth–or because the causation was, in fact, the reverse–that is, fast productivity growth had led to higher profits and incomes allowing firms and households to buy and use more computers.

Another issue has to do with the best measure of computer use. Since it is hard to determine what the most appropriate measure may be, we tried a number of alternatives. As one proxy for business use, we looked at data on business spending on information and communications technology (ICT). The correlation coefficient between the change in productivity growth and the share of ICT expenditures in total investment during 1996 for the G-7 countries was 0.76 (0.59 excluding the U.S.). Thus, countries that invested more in ICT equipment relative to total investment in 1996 tended to have a larger acceleration in productivity growth subsequently. As another alternative, we used data from a survey that measured Internet use by businesses in 1999. The correlation coefficient this time was 0.62 (0.58 excluding the U.S.). Note that this last result suffers from the simultaneity problem discussed above.

Another question, important in view of the U.S. debate, is whether the correlation between computer use and productivity merely reflects the correlation between computer production and productivity. To answer this question we would have liked to decompose the acceleration in productivity over this period into the contribution made by the contemporaneous production of computers as well as other factors. Unfortunately, we do not have the contemporaneous data that we need. To get some sense of the kind of relationship that may exist, we did look at some results using data on IT production through 1996. The correlations between IT production and productivity tended to be rather small.

Summing up

With the rapid growth in U.S. productivity in recent years, the debate about the contribution of information technology to productivity growth has shifted. There is no dispute about the efficiency gains in the production of computers and related equipment; instead, the debate between the believers in the New Economy and the skeptics centers on the benefits of using IT outside the IT production sector.

We have looked at some international evidence which suggests that there is some room for optimism about the benefits associated with the use of IT in the rest of the economy. While this conclusion must be regarded as tentative (for various reasons discussed earlier), this *Letter* illustrates the potential of using data outside the U.S. to analyze the contribution that recent technological changes may have

made to productivity growth.

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