Productivity Puzzles

University of Tennessee
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Almost everyone is aware by now of the fact—and I believe it is a fact—that U.S. productivity growth has risen substantially. The painful period of unusually slow productivity growth in the 1970s and 1980s is behind us. The increase in output per hour of labor input has been high enough over the last few years that it is increasingly reasonable to believe that the United States has indeed turned the corner on productivity growth. This picture is reinforced by extensive anecdotal reports from across the country.

I have been struck, however, by the extraordinary degree of uncertainty we face on this subject. My purpose today is to outline the puzzles of the 1970s slowdown in productivity growth slowdown and to discuss more extensively the puzzles surrounding the rising productivity growth of the 1990s. In thinking about these puzzles, common sense and basic economic reasoning are a good deal more helpful than hype about the "new economy."

Before I get into these issues, it is important that I issue a disclaimer. The views I express here are my own and do not necessarily reflect official positions of the Federal Reserve System. I've had a lot of help with these remarks from colleagues—especially Joe Ritter—in the research department of the St. Louis Fed; they deserve credit for the strengths of my argument. I retain responsibility for the errors.

WHY PRODUCTIVITY MATTERS

The importance of productivity growth is easy to demonstrate. The simplest productivity statistic is output per hour of labor input, usually called "labor productivity." During the 1950s and 1960s, labor productivity in the nonfarm business sector grew by about 2.8 percent per year. At that rate, productivity doubles in about 25 years. From 1973 to 1990, labor productivity grew at a rate of only 1.04 percent per year. At that rate, it takes 67 years for output per hour to double. Currently, it appears that output per hour is growing at a rate of about 2 percent per year, which doubles in 35 years. Even a small amount of extra growth yields astonishing gains for the United States. With an extra quarter percentage point of labor productivity growth, GDP would be about $300 billion higher after a little more than 10 years. The impact on the federal budget alone would be a shift toward surplus on the order of $60 billion.

Because the growth in real wages and, therefore, the standard of living depends on productivity growth, the time it takes for productivity to double at various growth rates translates quite easily into per capita income. It makes an enormous difference to our society whether income is doubling every 25 years or every 67 years. Individuals, and society as a whole, are much better off when the median-income family can enjoy a standard of living that the upper-income family enjoyed a generation or two earlier.

MONETARY POLICY AND ECONOMIC GROWTH

Let me explain why this topic concerns me as a monetary policymaker. A proposition universally accepted by monetary economists is that

monetary policy has relatively little to do with long-term economic growth, as long as the inflation rate remains modest. I believe that low inflation is better than not-so-low inflation, but I am not one who makes the extravagant claim that zero inflation yields enormous benefits over some modest rate of inflation. Monetary policy can contribute to general economic stability; and a stable, less cyclical economy probably raises long-term growth somewhat. Central banks also make valuable contributions to the efficiency and safety of the payments system, which is an essential piece of infrastructure for a modern economy.

Still, as important as these central bank responsibilities are, it is clear that the central *government's* activities have far more to do with growth than anything the central bank does. The soundness and efficiency of the legal system, the degree of safety of citizens, tax policy, government spending, and regulation—all these affect productivity growth to a vastly greater degree than central bank policy.

Productivity growth, however, is terribly important to monetary policy in a different way. Here is the monetary policy issue as I see it. *If* we knew how to set the rate of inflation directly, then we should just choose a zero rate and be done with it. (My guess is that zero inflation, properly measured, translates to something like a 1 to $1\frac{1}{2}$ percent annual increase in the consumer price index as the Bureau of Labor Statistics constructs that index today.) But the Fed can't set the rate of inflation directly; that is not possible in a market-based economy.

So, the Fed has to work indirectly. In a broad sense, we alter the inflation rate by controlling growth in the stock of money, though, from meeting to meeting, the Federal Open Market Committee focuses on the federal funds rate. But when is the federal funds rate too low, leading to too much money growth and, in turn, to inflation? If the U.S. economy were static, we could just experiment a bit and find the right number (as many macroeconomics textbooks imply). But in the real world, figuring out the right level for the federal funds rate is a tough issue. Among other things, we need to track actual GDP growth against the economy's underlying growth potential. Three percent GDP growth could be sustainable, or it could be a harbinger of accelerating inflation, and the answer might change from quarter to quarter. The answer depends, to a large degree, on the underlying growth of productivity.

High-frequency economic data are not accurate enough, comprehensive enough, or timely enough to answer the question with any degree of reliability. Thus, there is far less science behind our decisions than I would like. I think I can safely say that every member of the FOMC would like to feel more certain about when and how much to adjust the intended federal funds rate. The bottom line, though, is that in the course of fulfilling our FOMC responsibilities, we have to judge the probable strength or weakness of the economy. We want the economy to grow as fast as its resources and productivity permit; thus, ongoing evaluation of underlying productivity growth trends is an important part of the art of making monetary policy.

A FRAMEWORK FOR ANALYZING PRODUCTIVITY

Adam Smith, in his *Wealth of Nations* published more than 200 years ago, was the first to argue with clarity that a nation's wealth was in the output of its people, not the gold in its vaults. And Smith certainly understood the tremendous importance of productivity growth; he sought to convince his readers that competitive markets generated wealth and that restrictive government policies made England poorer.

Since Smith's day, we've filled in some of the details on how the economy grows and have amassed a huge amount of empirical information. We have not, however, improved upon Smith's fundamental framework for understanding economic growth. As with so many things, Smith had it right.

Let me put Adam Smith's analysis into modern language: There is broad agreement among economists that the main factors that enable an economy to grow are

- the growth of the quantity of *labor* input;
- the growth of the quantity of *capital* input;
- the rate of improvement in the processes that turn inputs into outputs.

The only amendment flowing from advances in economic knowledge this century—and it is an important amendment—is our greatly increased understanding of the importance of human capital.

It's not hard to understand that the total value of what an economy produces will increase if the number of people working increases or if some people acquire human capital through education or on-the-job learning. Similarly, providing workers with more physical capital will increase their output; a worker can dig a longer ditch in a day with a backhoe than with a shovel. Economists have a pretty good handle on these things, both conceptually and quantitatively.

The mystery lies in that third category, "improvements in processes." One might call it "technological progress" or "innovation," but that does little more than rename it. It's not the same thing as labor productivity. In fact, the output-per-hour data combine the effects of all of these factors except labor hours.

It's helpful to keep this framework in mind, because people often talk about productivity growth as though it's just technological progress. That's partly because we have no direct way to measure the contribution of that third category other than by subtracting the contributions of increased quantities of labor and capital from output. That exercise gives us the residual category that economists call "total factor productivity."

What ends up in that residual category? Well, it's a little like art—we know it when we see it. Total factor productivity soaks up the effects of everything from rearranging a warehouse so that popular items are near the loading dock to sweeping changes introduced by innovations like electricity or computers. It shouldn't surprise us that it is difficult to measure the contents of the pigeonhole where we dump the effects of fuzzy but profound concepts like creativity and innovation.

So where has U.S. growth come from? First the big picture—the past 50 years. By 1997, output in the private business sector was five times its 1948 level. Increasing quantities of labor and capital each accounted for roughly 30 percent of that increase, leaving about 40 percent of postwar growth "explained" by growth of this mysterious residual category we call total factor productivity.

Growth of the labor force washes out of the labor productivity statistics—it affects both the numerator and denominator of output per hour by the same percentage. So something like 70 percent of postwar growth has "come from" the growth of labor productivity. But keep in mind that labor productivity is not an independent economic force: It measures the combined effects of investment, learning, and innovation.

Before I dig into the puzzles, I'll digress briefly to make an observation that illustrates very nicely why productivity is a complicated and difficult subject. In one of his recent books, Stephen Jay Gould takes up the question of why the .400 batting average has disappeared—nobody has accomplished this feat in the major leagues since 1941. Mark McGwire, Sammy Sosa, and home runs aside, are batters less productive than they used to be? "The problem," Gould writes, "seems so obvious in outline: something terrific, the apogee of batting performance, was once reasonably common and has now disappeared. Therefore, something profoundly negative has happened in baseball." But Gould doesn't really believe that; he spends the next 50 pages expanding on the following idea: The .400 average is not a part of the game itself, but a very simple statistic produced by a complex and dynamic system, major league baseball. Since 1941, rules, pay scales, training regimens, schedules, and stadiums have all changed. Imagine the difficulty of trying to pin down exactly how, and to what extent, each of these factors contributed to the decline in batters' averages. And baseball is surely simple compared to the entire U.S. economy!

THE 1970s PRODUCTIVITY PUZZLES

The fact that labor productivity accounted for about 70 percent of growth over the last half

century hides one of the most important and longest-running stories in macroeconomics, the productivity slowdown that started around 1970. Starting in the early 1970s, the trend rate of productivity growth fell by almost 60 percent in the nonfarm business sector. After 1975, it gradually became apparent that productivity growth had slowed to a crawl, compared with the rapid pace of the 1950s and 60s. Some experts flagged the changed trend quickly; others insisted for several years that lower productivity growth was likely a temporary phenomenon. Not until 1978 or so did most economists agree that something serious had in fact taken place.

Economists have debated the causes of the slowdown for years, and the issue is still unresolved. Part of the slowdown was clearly due to slower capital accumulation, but that only pushes the question back a step. In any case, slower capital accumulation was certainly not the whole story; total factor productivity—that residual category—slowed dramatically as well.

Some people are convinced that the explanation lies in the energy crises of the 1970s; some believe that a policy environment unfriendly to business bears much of the blame. Others point to the higher inflation rate of the 1970s, and still others to environmental controls. We have more theories than data points. To this day, the decline in productivity growth that occurred after 1972 is a puzzle.

THE 1990s PRODUCTIVITY PUZZLES

The second set of productivity puzzles has been unfolding for the past several years. They are summarized in the famous quip by Robert Solow: "You can see the computer age everywhere but in the productivity statistics."

Did the productivity slowdown truly end in the 1990s? At first glance, the answer appears to be "partly." The last few years have certainly seen stronger labor productivity growth. But if we look at the data in more detail, things don't look as reassuring. It appears that growth of total factor productivity has not increased. That means the higher growth of labor productivity in recent years primarily reflects the investment boom of recent years—more capital—but not a higher growth rate of total factor productivity. The slowdown in the 1970s showed up on both dimensions—capital accumulation and total factor productivity—but our productivity recovery seems to be reversing only one dimension of the slowdown.

But wait. It gets worse. The deeper we dig, the more puzzles we find, and computers are at the center of these puzzles. In an effort to understand what is going on, productivity experts drill down into the data. The data I've been discussing so far refer to the entire economy except for the government sector, for which no overall productivity measures are available.

For the manufacturing part of the total business sector, it is apparent that most of the productivity slowdown *has* evaporated. In manufacturing, both labor productivity and total factor productivity have been growing rapidly for several years. But, and this is truly astonishing, Robert Gordon in his recent research argues that *within* manufacturing, after allowing for normal cyclical effects, almost all of the labor productivity growth has been in the sector that produces computers. When you take out the durables manufacturing sector, where computers come from, and look at what's left, productivity growth looks downright tepid. In other words, there is productivity growth where computers are made, but not where they are used. The first part of this is entirely credible—we don't need government statisticians to tell us that productivity gains in the electronics industry have been astonishing.

To understand just how amazing this puzzle is, I'll put the point this way: All, or most—depending on your choice of expert—of the increase in productivity growth for the entire U.S. economy can be attributed to a single industry—computer manufacturing—that amounts to about 1¼ percent of the economy! That is a truly remarkable finding, and it really doesn't matter much whether the truth is "all" or "most."

The idea that the recovery of productivity growth has been lackluster among computer-using

firms doesn't seem right, though, does it? We see productivity improvements all around us. And we see innovation, not just the capital deepening implied by the investment boom. There is a more technical way to express this discomfort: Remember that labor productivity combines the effects of capital investment and innovation. Since we've been in an investment boom, slow labor productivity growth implies that total factor productivity is completely stalled or going backwards! This just does not make sense. Furthermore, why would businesses invest billions of dollars in computers that don't increase productivity? That is, why should businesses now be investing so heavily in information technology if the rate of return to such investments were no higher than in the 1970s and 1980s? If the rate of return is higher today, that higher return should show up in total factor productivity.

So here is the crux of our second productivity puzzle: Outside manufacturing, productivity growth, as measured by government statistics, looks slow. Within manufacturing, productivity growth is concentrated in the manufacturing of computers. Although the workers who produce computers have become immensely productive, the overall productivity data don't seem to support the idea that computers enhance productivity growth. But this conclusion doesn't seem consistent with businesses choosing to invest in computers. And the overall picture doesn't seem consistent with a thriving, healthy economy.

There are two ways to interpret this discrepancy. A hard-core data hound might conclude that the numbers are correct; manufacturing, in general, and durables manufacturing, in particular, really has been more innovative—streamlining production processes and so forth. There is probably some truth to that, but if it's the whole story, the rest of the private sector is doing very badly, indeed. As I said, my observations suggest that innovation and improved productivity are all around us—in manufacturing and elsewhere. It is useful to remember that it took economists almost a decade to recognize the productivity slowdown of the 1970s; the data are very noisy and very cyclical, making it difficult to extract trends from small numbers of observations. It's not inconceivable that it will take us a long time to be sure of a turnaround in the 1990s.

A second angle on these numbers is to think about whether the measurement of productivity is distorted. Zvi Griliches, who is one of the leading researchers in this area, argues that the part of the economy he calls "reasonably measurable" has declined from about half to less than 30 percent since World War II. The problem is that much of the economy produces things that are extremely difficult to measure, and the share of this sector—services, broadly speaking—keeps growing. Moreover, the productivity slowdown appears to be persisting in these difficult-to-measure industries. Griliches' bottom line is that outside of sectors like agriculture and manufacturing, where it's more or less possible to count things in order to measure output, we should be extremely suspicious of productivity numbers.

Beyond this conceptual problem, it's no secret that statistical agencies have a hard time keeping up with innovations in the economy. In particular, it takes a while to figure out how to measure new kinds of output. Just this month, in fact, the Commerce Department has significantly updated how it measures the contribution of software to the U.S. economy. So, in a broad sense, it shouldn't surprise us very much that output and productivity statistics are a bit slow to capture rapid innovation.

As you can see, we policymakers have a real problem. We have to decide how much weight to give to our eyes and ears and how much to formal statistics. We know the statistics may be misleading, but we also know that the discipline imposed by statistics is our main bulwark against eyes that look through rose-colored glasses and ears that turn to tin when they hear what we do not want to hear—wishful thinking of all sorts.

THE FUTURE OF PRODUCTIVITY

I've talked a bit about the statistics, and so let me now turn to our eyes and ears and how we might best think about what we see and hear. We

see new electronic technology all around us. News stories about the Internet are incessant. One would surely be justified in suspecting that all of this represents a productivity revolution of sorts. And I am partly sympathetic to this view. Do I think then, that the productivity data have nothing to tell us? Do I think that, despite the evidence, we are seeing the birth of some sort of "new economy," beyond the bounds of historical experience and the laws of economics? Hardly. In fact, I think that history and sensible economics can tell us a lot about the future of productivity.

First, it's my belief that the policy environment is considerably more hospitable to the economic activities that generate productivity growth than it was in the 1970s. There is wider understanding than in the past that bad policy—tax policy, financial policy, environmental policy, trade policy—can profoundly affect a firm's incentive to invest in productive assets. Too often in the past, conflicting policy goals have been resolved without regard for economic efficiency. Although I think we still have a long way to go in this regard, today we are more likely to see innovative policies like tradable pollution permits. This kind of market-based approach is far less damaging to productivity than the style of regulation that says simply, "Thou shalt not pollute more than 3 parts per billion." In short, we have learned a lot about how to protect the environment at less cost than in the past.

Turning to the innovation process itself, we should start by recognizing that, in the macroeconomic sphere, revolutions take decades. Most people call that evolution. I believe that information technology will be a genuine engine of growth for decades, but there hasn't been and won't be a sudden swerve toward some sort of "new economy." It is important to understand that some of the new technologies reduce the productivity of older technologies. For example, for the economy as a whole, productivity growth will reflect the high productivity of Internet commerce and the declining productivity of the huge existing investment in bricks and mortar and people engaged in traditional retailing.

The history of "general-purpose technologies," as economists call them, tells us why evolution is a better word than revolution. One such general-purpose technology, electricity, has been studied extensively by economic historian Paul David. According to David, less than 5 percent of mechanical power in the nation's factories was provided by electric motors in 1899. It took about 20 years for that number to rise to 50 percent. David addressed two interrelated questions about the spread of electricity use in general and the use of electric motors in particular. First, why was the adoption rate so low? Second, what is special about the spread of a general-purpose technology like electricity?

Think about what a factory was like before the electric motor. There was typically a single source of mechanical energy: a water wheel or, later, a steam engine. This energy had to be distributed around the plant by mechanical means—gears, drive shafts, belts, and pulleys. Because of the number of interconnected moving parts, this system was expensive to build, inflexible, and dangerous. But the initial expense was a sunk cost, and once in place the system didn't cost much to run. So in most cases it didn't make sense to scrap an old plant until it physically wore out, even though the new technology was markedly superior. Electric motors spread rapidly in industries that were expanding, but elsewhere the old technology continued to prevail. There is a tremendous amount of inertia in this sort of thing. That is the first lesson about the spread of technology: It's simply too expensive for an industrial economy to rearrange its production and scrap a large part of its capital stock overnight, no matter how exciting the new technology is.

But the ramifications of the electric motor for manufacturing, when it was finally adopted, were immense. Mechanical energy didn't have to be distributed from a central source; you just put a motor where you needed it, so you could easily reconfigure the production process. The production process could be physically stretched out, allowing the development of a true assembly line. New factory structures needed only to keep the rain off; they no longer needed bracing for heavy,

rapidly moving power-distribution machinery. Maintenance could be performed on a single machine, without shutting down the entire factory.

All of these advantages were clear *in principle* at the turn of the century, but each business had to figure out how to adapt the technology to its needs (as well as needing to amortize older investments). Thus, though the impact of electricity on manufacturing and daily life was profound, it was spread over many years.

A more recent example illustrates a slightly different theme. When the laser was invented in 1957, no one recognized it as a general-purpose technology. Indeed, Bell Labs didn't even patent its invention. For some years, the laser was regarded as an extremely specialized tool. In fact, it was biding its time, waiting for complementary developments in the semiconductor industry. When inexpensive semiconductor lasers became available, the laser became ubiquitous. Although we tend to connect the laser with gee-whiz inventions and weapons, probably its most profound effect on the U.S. economy has been via the humble bar-code reader, which was not practical before cheap lasers. This innovation has altered the economic landscape in retail stores, libraries, the post office, even Red Cross blood collection. Virtually anywhere we need to keep track of the movement of physical objects, you'll see bar codes of one sort or another.

Of course, cheaper and cheaper computing power enables wider spread of bar-code scanners, just as bar-code scanners allow businesses to bring computing power to bear on inventory control, marketing, and sales. Who'd have imagined that their combined power would be most visible in the grocery checkout lane? That's the second big lesson about technological change that I take from economic history: It's hard to predict the biggest effects until you're right in the middle of them.

Let me give you a final example, directly related to the Internet. A few months ago the *New York Times* ran a long story about difficulties faced by the online sales operations of Recreational Equipment Inc., an outdoor equipment retailer. REI's online operation has been profitable, though not wildly so. An Internet retailer that makes money is a peculiar animal, but the real reason I found this story interesting is that very little of it had anything to do with the Internet, per se. Instead, the things that REI has found difficult are problems any retailer would understand. Already, the problems of fast servers and broadband connections are looking similar to the problem of renting a store that has electrical service. The real problem is figuring out what to do with them. REI, for example, found that pictures taken for its print catalog didn't work well on the Internet. To me this sounds more like older problems such as learning how to sell things in malls than like a "new economy."

I don't feel as curmudgeonly about new technology as that sounds. Today we are in the middle of the adoption cycle for a remarkable set of technological innovations in microprocessors and communications. It is difficult to believe that these things will not spur economic growth. But let's not kid ourselves: We have yet to figure out what to do with all of this computer power and the Internet, and it's going to take time to figure out what works and what doesn't. In effect, we must write the economic software for this technology. That will take a long time, and we won't understand how it has shaped our economy until it has already happened. That seems to be the way these things have always been.

What is the bottom line for U.S. growth prospects? Optimists and pessimists among serious students of economic growth are not as far apart as the popular press would have you believe. Pessimists believe that the recent higher productivity growth reflects a transitory cyclical phenomenon and that the underlying or trend growth of labor productivity remains bogged down at about the level of the 1970s and 1980s. That rate is in the range of 1 to 1½ percent per year and yields likely trend GDP growth of about 2½ percent per year. Optimists believe that the growth rate of productivity has risen to the 2½ to 3 percent range, which translates into average GDP growth in the 3 to 4 percent range over the next few years. Although I am an optimist on growth, my instincts as a policymaker compel me to concentrate on the midrange of informed opinion—pro-

ductivity growth of about 2 percent per year and trend GDP growth of about 3 percent per year. That to me is the appropriate basis for monetary policy decisions. But I do want to emphasize the importance of the word "about" in these judgments. With all I've said, it should be clear that analysts should not lock in their view of these estimates.

SUMMARY

Productivity growth is a terribly important subject for the United States, indeed for every country. But this is not an easy subject. The puzzles of the 1970s slowdown in productivity growth have not been resolved. The puzzles of the 1990s increase in productivity growth seem only to deepen with further research into what is going on. It is amazing, but still a fact at this time, that most of the reported increase in productivity growth can be attributed to the computer-producing industry and little to the computer-using industries—that is, the whole rest of the economy.

The central bank is really a bit player in the growth process, provided inflation is kept relatively low. Nevertheless, the Federal Reserve, in setting the intended federal funds rate, cannot avoid making some judgments about the productivity growth.

The crude state of our knowledge about current and future productivity trends is uncomfortable for me as a policymaker. I see little reason for pessimism, however. My best judgment is that the productivity slowdown of the 1970s and 1980s is over. However, we have to be realistic about the magnitude of the improvement. With all of the optimism that so marks U.S. culture, and with our satisfaction about the fine performance of the economy in recent years, we must not allow ourselves to be lulled into wishful thinking about productivity and economic growth. Even modest improvements in productivity growth are important, particularly if they can be sustained for the long run. And we certainly do not want our eyes and ears and heads to be closed to the possibility that trend productivity growth might now be high enough that economic historians may in time refer to the 1990s as the beginning of a new age. What a wonderful outcome that would be.